Report to Congress on the U.S. Department of Energy's Environmental Management Science Program

Research Funded and Its Linkages to Environmental Cleanup Problems

Volume I of III Report and Appendix A

April 1998

**U.S. Department of Energy
Office of Science and Technology
Office of Environmental Management**

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Volume I of III Report and Appendix A

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April 1998

MASTER

**U.S. Department of Energy
Office of Science and Technology
Office of Environmental Management
Washington, D.C. 20585**

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Executive Summary

The Conference Report 105-271, accompanying the Energy and Water Development Appropriations Act, 1998 (P.L. 105-62), requested the Department to provide to the Committees on Appropriations a list of each research grant that has been funded by the Defense Environmental Restoration and Waste Management's Environmental Science Program, a description of what cleanup problem is to be addressed, and how the grantee is to interact with the Department and field sites to address the specific problem. This report is submitted in response to this Congressional request. It is also intended to communicate the nature, content, goals, and accomplishments of the Environmental Management Science Program (EMSP) to interested and affected parties in the Department and its contractors, at Federal agencies, in the scientific community, and in the general public.

The EMSP was started in response to the Galvin Report, "Alternative Futures for the Department of Energy National Laboratories," when Congress requested that the Department of Energy (the Department) mount an effort in longer term basic science research to seek new and innovative cleanup methods to replace current conventional approaches which are often costly and ineffective.¹ Accordingly, the Department's Office of Environmental Management, in partnership with the Office of Energy Research, has designed, developed, and implemented the EMSP as a directed basic research effort to establish the scientific and engineering understanding required to solve the most challenging technical problems facing the government's largest, most complex environmental cleanup program. The objectives of the EMSP are to:

- Provide scientific knowledge that will revolutionize technologies and cleanup approaches to significantly reduce future costs, schedules and risks.
- "Bridge the Gap" between broad fundamental research that has wide-ranging applications such as that performed in the Department's Office of Energy Research, and needs driven applied technology development that is conducted in Environmental Management's Office of Science and Technology.
- Focus the nation's science infrastructure on critical Department of Energy environmental problems.

Research applications for the EMSP are solicited on the basis of an extensive site specific needs identification process conducted by the Environmental Management Program. Linkages between environmental challenges faced by the Environmental Management Program and the EMSP basic research efforts are guaranteed by the relevance component of the selection process. Preapplications for financial assistance are submitted by potential applicants and are screened for

¹ H.R. Conf. Rep. No. 293, 105th Congress, 1st Sess. (1996).

scientific questions and their relevance to Environmental Management's environmental mandate. Successful preapplications result in requests for formal applications to perform fundamental research in specific environmental science program areas. This process provides interested investigators with early input and is conducted to save time and costs for both investigators and Department staff. Formal application review and selection is a two-phase process. A peer review by panels of external scientific experts evaluates the applications for scientific excellence. In addition, panels of scientists and engineers from Departmental sites, who will be the end users of research results, evaluate applications for their relevance to identified Environmental Management problems. Funding is recommended only for those applications which are successful in both reviews.

To date a total of \$143.7 million has been appropriated: Fiscal Year 1996 - \$48.9 million; Fiscal Year 1997 - \$48.7 million; Fiscal Year 1998 - \$46.1 million. However awards have only been made in Fiscal Years 1996 and 1997; Fiscal Year 1998 awards are planned for Summer 1998. The cost of Fiscal Years 1996 and 1997 awards total over \$160 million, though many of the awards are funded over multiple years, subject to available funds. Therefore, it is important to note that the Department's laboratory awards from Fiscal 1996 bear costs in Fiscal Years 1997 through 1999. Similarly, the Department's laboratory awards from Fiscal Year 1997 bear costs through Fiscal Year 2000. Scientists funded through the EMSP are currently conducting research at 70 universities, 13 Department of Energy laboratories, and 12 other governmental and private laboratories. These are located in 34 states, Canada, and Australia. All awards, other than the Department's laboratories, are fully funded in the year of the award. The Department's laboratory awards are phase-funded over three years and, therefore, carry mortgages.

The EMSP portfolio of research awards is targeted to address the most significant technical problems faced by the Environmental Management Program. The 202 awards funded to date for over \$160 million are in the following major science categories:

- Actinide Chemistry: 10 awards for \$8.2 million
- Analytical Chemistry and Instrumentation: 27 awards for \$18.7 million
- Biogeochemistry: 6 awards for \$4.2 million
- Engineering Science: 17 awards for \$13.9 million
- Geochemistry: 17 awards for \$14.1 million
- Geophysics: 12 awards for \$10.3 million
- Health Science: 17 awards for \$14.8 million
- Hydrogeology: 15 awards for \$11.8 million
- Inorganic Chemistry: 17 awards for \$13.0 million
- Materials Science: 21 awards for \$20.6 million
- Microbial Science: 9 awards for \$10.6 million
- Plant Science: 8 awards for \$4.4 million
- Separations Chemistry: 26 awards for \$16.8 million

When linked to major Environmental Management problem areas, these research investments are distributed as follows:

- High Level Waste: 48 awards for \$38.3 million
- Decontamination and Decommissioning: 9 awards for \$7.6 million
- Remedial Action: 82 awards for \$66.9 million
- Mixed Waste: 32 awards for \$22.2 million
- Nuclear Materials: 8 awards for \$7.9 million
- Spent Nuclear Fuel: 5 awards for \$4 million
- Health/Ecology/Risk: 18 awards for \$14.5 million

Total life cycle costs for Office of Environmental Management cleanup projects have been estimated to be approximately \$147 billion in the year 2007 and beyond, when EMSP research results have potential to begin making an impact. In that time period, high level waste projects are estimated at \$34.9 billion; decontamination and decommissioning projects are estimated at \$7.3 billion; remedial action projects are estimated at \$6.1 billion; and mixed waste projects are estimated at \$7.1 billion.²

The EMSP is taking the steps necessary to capitalize on the Department's scientific research investments. A major objective of the Department is to facilitate communication of research results to the sites. While present activity focuses on informal contact between EMSP principal investigators and site staff along with appropriate distribution of research reports, formal communication of research results between EMSP researchers and site staff will begin at the end of the second year of research effort (in July 1998) with a scientific meeting of EMSP researchers and site staff. The Environmental Management Advisory Board Science Committee held a series of programmatic review meetings to obtain information from site management, laboratory management, university and laboratory principal investigators, site staff, and other stakeholders. The Committee collected perceptions on the quality of the application selection process, the quality of the output of the program, and the impact of the program on existing Environmental Management activities. The EMSP's role in support of the Office of Environmental Management mission is to serve as a catalyst for the application of scientific discoveries to the development and deployment of technologies that will lead to reduction of the costs and risks associated with cleaning up the nation's nuclear complex.

² *Accelerating Cleanup: Paths to Closure Draft*, U.S. Department of Energy, Office of Environmental Management, March 1998.

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Introduction

This report is submitted in response to Conference Report 105-271, accompanying the Energy and Water Development Appropriations Act, 1998 (P.L. 105-62) for information on the Department of Energy's Environmental Management Science Program (EMSP):

"The conferees agree that the Department is to provide to the Committees on Appropriations a list of each research grant that has been funded, a description of what cleanup problem is to be addressed, and how the grantee is to interact with the Department and field sites to address the specific problems."³

This document is also intended to communicate the nature, content, goals, and accomplishments of the EMSP to interested and affected parties in the Department and its contractors, at other Federal agencies in the scientific community, and in the general public.

Section I, "Background of the Program," provides information on the evolution of the EMSP and how it is managed, and summarizes recent accomplishments. Section II, "Research Award Selection Process," provides an overview of the ongoing needs identification process, solicitation development, and application review for scientific merit and programmatic relevance. Section III, "Linkages to Environmental Cleanup Problems," provides an overview of the major interrelationships (linkages) among EMSP basic research awards, Environmental Management problem areas, and high cost projects. Section IV, "Capitalizing on Science Investments," discusses the steps the EMSP plans to use to facilitate the application of research results in Environmental Management strategies through effective communication and collaboration.

Appendix A contains four program notices published by the EMSP inviting applications for grants. Appendix B contains descriptions of the 202 funded research awards organized by state and institution. Appendix C contains high cost Environmental Management cleanup project descriptions organized by Department of Energy Operations Offices.

³ H.R. Conf. Rep. No. 271, 105th Congress, 1st Session 93 (1997).

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I. Background of the Program

The U. S. Department of Energy's (the Department's) Environmental Management Science Program (EMSP) is a collaborative partnership between the Offices of Environmental Management and Energy Research to sponsor basic research that will lead to reduction of the costs and risks associated with cleaning up the nation's nuclear complex. EMSP was initiated in 1996 and, during the first two years, has issued 202 research awards for over \$160 million in 34 states, Canada and Australia. Exhibit 1 presents the number of EMSP research awards by state. The EMSP research portfolio addresses the most challenging technical problems of the Environmental Management Program related to high level waste, spent nuclear fuel, mixed waste, nuclear materials, remedial action, decontamination and decommissioning, and health, ecology or risk.

The Office of Environmental Management program historically has identified 134 "geographic sites" (distinct geographic locations that generated waste or were contaminated by DOE or predecessor agency activities) as part of its scope. These sites are located in 31 states and one territory and encompass an area over two million acres, equal to the size of Rhode Island and Delaware combined. At the beginning of 1998, cleanup responsibility for 21 sites managed by Environmental Management under the Formerly Utilized Sites' Remedial Action Program (FUSRAP) was transferred to the U.S. Army Corps of Engineers. At the end of Fiscal Year 1997, 60 of the 113 contaminated sites had been cleaned up. An additional 43 sites are estimated to be cleaned up between 1998 and 2006 for a total of 103 cleaned up sites by 2006. Long-term cleanup activities will continue at the remaining 10 sites.

In the *Accelerating Cleanup: Paths to Closure Draft*, March 1998 (hereafter referred to as *Paths to Closure*) the Department estimated that cleanup of the weapons complex will cost approximately \$147 billion and take several decades to complete.⁴ The EMSP is the principal investment in and provides the scientific foundation for technologies to address the nation's most challenging environmental cleanup problem.

The EMSP was established in response to a mandate from Congress in the Fiscal Year 1996 Energy and Water Development Appropriations Act. Congress directed the Department to provide "sufficient attention and resources to longer-term basic science research which needs to be done to ultimately reduce cleanup costs" and directed the Department to "develop a program that takes advantage of laboratory and university expertise" and to "seek new and innovative cleanup methods to replace current conventional approaches which are often costly and ineffective."⁵

⁴ *Accelerating Cleanup: Paths to Closure Draft*, U.S. Department of Energy, Office of Environmental Management, March 1998, pages 4, 8, and 20.

⁵ H.R. Conf. Rep. No. 293, 104th Congress, 1st Session 70 (1995).

Exhibit 1. Environmental Management Science Program Research Awards by State

A major impetus for the EMSP was the special report to the Secretary of Energy Advisory Board by the Galvin Commission:

“Probably the most important reason behind the slow pace of assessment and cleanup [of Department of Energy waste sites] is the low quality of science and technology that is being applied in the field . . . There is a lack of realization that many — and some experts believe most — existing remediation approaches are doomed to technical failure. Others would require unacceptable expenditures and much extended time to reach their stated objectives . . . There is a particular need for long term, basic research in disciplines related to environmental cleanup . . . Adopting a science-based approach that includes supporting development of technologies and expertise . . . could lead to both reduced cleanup costs and smaller environmental impacts at existing sites and to the development of a scientific foundation for advances in environmental technologies.”⁶

The EMSP also responds to needs identified by regulators, scientists, other stakeholder groups, experts from the National Academy of Sciences, and citizen advisory groups.

Mission, Goals, and Objectives

The mission of the EMSP is to develop and fund a targeted long-term basic research program that will result in transformational or breakthrough approaches for solving the Department’s environmental problems. EMSP research is explicitly focused on Departmental cleanup problems and has explicit links to problem holders at the sites.⁷

The goals of the EMSP are to support research that will:

- Lead to significantly lower cleanup costs and reduced risks to workers, the public, and the environment over the long term.
- Bridge the gap between broad fundamental research that has wide-ranging applicability, such as that performed in the Department’s Office of Energy Research, and needs-driven applied technology development that is conducted in the Department’s Office of Environmental Management’s Office of Science and Technology.

⁶ Secretary of Energy Advisory Board, *Alternative Futures for the Department of Energy National Laboratories* February of 1995. Task Force on Alternative Futures for the Department of Energy National Laboratories, Washington, D.C.

⁷ Problem holders are defined as “the technical staff, managers, and stakeholder advisory groups at the sites who have some understanding of cleanup issues.” *Building an Effective Environmental Management Science Program*, Final Assessment Report, National Research Council, June 1997, page 3.

- Serve as a stimulus for focusing the nation's science infrastructure on critical national environmental management problems.

The goals of the EMSP will be achieved through accomplishment of the following overall program objectives:

- Develop and implement a research agenda to focus on the most serious Department of Energy environmental management problems for which no adequate solution has been found.
- Support the application of research results to Department of Energy environmental management problems.
- Use existing scientific resources internal and external to the Department.

Department of Energy Partnership

The EMSP mission, goals, and objectives are accomplished through a partnership between two key Departmental organizations, the Office of Environmental Management and the Office of Energy Research. Environmental Management has the lead for soliciting research needs, ensuring that research projects selected have application to the Department's cleanup problems, and ensuring that results of the research are communicated to Department and contractor personnel with cleanup responsibilities. Environmental Management also manages the financial aspects of the EMSP. Energy Research manages the solicitation of research applications, the scientific review process and technical management of the research program. The Department of Energy's Idaho Operations Office provides assistance to the EMSP in conducting needs analysis, financial management and procurement, and serves as an interface with other Department of Energy field offices and Environmental Management Program technology development activities.

The synergism of this partnership has enhanced the effectiveness of the EMSP. Directed by Congress in November of 1995 to establish a long-term basic science research program, the Department issued the Fiscal Year 1996 Request for Application in February, and distributed the first-year funding by September 30, 1996, less than 12 months later. By using existing staff and established programmatic resources, the costs of running the EMSP have been kept low. Only about 4 percent of the total EMSP Fiscal Years 1996 and 1997 appropriations has been used for program management. This figure includes program review activities; arrangements for and facilitation of site-specific workshops; travel, stipends, and logistics in support of peer review; and general program management costs.

EMSP Advisory Groups

Since its inception, the EMSP has been supported by advisory groups, both internal and external to the Department, each performing specific functions to enhance the quality and productivity of the EMSP. These groups are the Science Committee of the Environmental Management Advisory Board, the Strategic Laboratory Council, and the National Academy of Sciences/National Research Council Committee on Building an Effective Environmental Management Science Program.

The Environmental Management Advisory Board Science Committee, a Federal Advisory Committee, serves as the standing advisory group for the EMSP, focusing on issues related to program policy and progress toward program goals. The Committee is comprised of experts in several fields related to the environmental management mission of the Department of Energy. During Fiscal Year 1998, the Committee has been charged to advise the Department on: how to establish the communication between researchers and Department problem holders; how to ensure that research results are used to solve the Department's environmental management problems; and how to improve the peer review process. As recommended by the National Research Council, the Environmental Management Advisory Board Science Committee functions as an independent panel for conducting periodic reviews of the performance and effectiveness of the EMSP.

The Strategic Laboratory Council is made up of representatives from Department of Energy Laboratories. The Council played a consultative role in the early development of the EMSP and has continued to support the effort by providing the national laboratory perspective, serving as facilitator for information exchange, and assisting in planning for conferences and workshops related to the EMSP.

The National Academy of Sciences/National Research Council Committee on Building an Environmental Management Science Program has served as a link for the Department of Energy with the larger science community for review, evaluation, and recommendations specific to setting the Department's environmental management research agenda and implementing and managing the EMSP. The Committee completed a review of the Program, entitled *Building an Effective Environmental Management Science Program at the Department of Energy: Final Assessment*, in June 1997.

Success of the EMSP to Date

Over the past two years, the Department has established and implemented the EMSP to sponsor basic research with potential to address environmental cleanup problems requiring plausible or more cost-effective solutions. The EMSP is also working to reduce the time required to move results from basic research to new technology development and the implementation of solutions. EMSP research results may aid decisionmakers in selecting effective solutions for problems.

The EMSP has identified and funded 202 research awards which were based on research needs identified by Department of Energy field sites and selected through a competitive, two-phase review process. The EMSP has also begun to facilitate the transfer of research results to Department of Energy cleanup problem holders.

The EMSP is using quality scientific resources both in the United States and internationally. Scientists funded through the EMSP are currently conducting research at 70 universities, 13 Department of Energy laboratories, and 12 other governmental and private laboratories. These are located in 34 states, Canada, and Australia. Of the 202 research awards, over 100 are collaborative efforts involving funding at two or more institutions. Other relevant research programs at the Department and other agencies are being identified and coordinated with the EMSP as appropriate.

In addition to the funding of the research awards, the EMSP can point to success in a number of its other activities:

- Establishment of the successful management partnership between the Offices of Environmental Management and Energy Research ensures that quality research focused on the Department of Energy cleanup mission is supported.
- Establishment of a process for ongoing consultation with environmental management problem holders aids the program in clearly understanding problems and focuses the solicitation and research award selection on identified needs.
- Rigorous and focused research project selection process ensures that the research selected/funded is both scientifically meritorious and relevant to environmental cleanup problems.
- Researchers have access to the information they need to understand and address the environmental cleanup problems.
- Plans for ensuring prompt dissemination and use of research results will aid the Department in more effectively accomplishing its cleanup mission.

The first phase of the plan to disseminate results will be implemented in July 1998 when a workshop will be held at which both researchers and site problem holders will present research results, research needs and site problems.

In a resolution submitted in May of 1997, the Environmental Management Advisory Board Science Committee stated, "The Committee finds that, with limited resources and time, the EMSP has accomplished a great deal in the short time it has been in place, that sound procedures

have been put in place, and that program results are likely to be of significant value” to the Environmental Management Program at the Department of Energy.⁸

Early Research Results

Early reports on research funded to date indicate progress in each of the seven Environmental Management problem areas related to the Department of Energy cleanup efforts. Researchers funded through the EMSP are working to help the Department develop new ways to:

- Effectively clean up subsurface contamination for less cost than baseline pump-and-treat methods.
- Safely handle, separate, and treat high level and mixed wastes to reduce volumes and risks.
- Securely stabilize or dispose of spent nuclear fuel and nuclear materials used in weapons production.
- Efficiently decontaminate and decommission nuclear facilities.
- Accurately assess the health and ecological risks associated with options and activities in waste management and environmental restoration.

A few examples that illustrate how EMSP projects address and are linked to science needs and problem areas in the Department of Energy cleanup efforts include the following.

Plant and Microbial Remediation of Underground Contamination. EMSP scientists are isolating the genes and documenting the mechanisms by which plants uptake metals, radionuclides, and chlorinated hydrocarbons from contaminated soil and groundwater systems. Several projects are also showing how bacteria can be used to biotransform contaminants to less toxic or less mobile chemical states in the environment. Such studies could lead to “natural” environmental cleanup methods for soils and groundwater at contaminated Department of Energy sites.

Iron-Oxides and Colloids Governing Contaminant Dispersal and Fate. EMSP scientists have shown that the sorption/desorption behavior, dispersal, and fate of many metals, radionuclides, and organics in soil/groundwater systems and in waste streams are controlled by the biogeochemical cycling of iron between its reduced (more soluble) state and its oxidized (more insoluble) state, as colloids or surface coatings. Research collaborations between EMSP scientists using Department of Energy facilities (such as the Environmental Molecular Sciences

⁸ Resolution on the Environmental Management Science Program, DOE Environmental Management Advisory Board Science Committee, May 2, 1997.

Laboratory and the Stanford Synchrotron Radiation Laboratory) have succeeded in preparing single-crystal films of iron oxides in several crystal orientations and then determining their surface structures and biogeochemical interactions with contaminants. This information is important for designing new cost-effective strategies for treating wastes and for preventing the migration of contaminants in the environment.

Ligand Design for Selective Complexation and Contaminant Separations in High Level and Mixed Wastes. EMSP Scientists have made significant progress in designing ligand- and crown-compounds that have extreme selectivity to bind with specific metal ions and radionuclides in order to separate and remove these contaminants from tank wastes, mixed waste streams, or groundwater. One of the EMSP projects in this area combines expertise from four U.S. National Laboratories and several universities. Research on ligand design, solvent extraction, and ion exchange will be an essential component in the development of the next generation of efficient and cost-effective separation processes for solving waste treatment and environmental problems.

Materials for Stabilizing and Storing Nuclear Fuel. EMSP scientists have examined the effects of radiation damage and microbubble formation on the physical, chemical, and structural properties of the various borosilicate, iron-phosphate, and aluminosilicate glasses that have been developed for the safe encapsulation and storage of nuclear materials. The solubility and phase-partitioning of high level waste constituents are also being studied at atomic, molecular, micro, and macro levels to model and predict the leaching behavior of long-lived radionuclides under high temperatures and over geologic time scales. One of the EMSP projects in this science area involves collaborations among two National Laboratories, one university, and the Australian Nuclear Science and Technology Organization.

Laser Ablation and Spectrometric Techniques for Monitoring Waste Streams and Decontaminating Surfaces. EMSP Scientists have coupled laser ablation and spectrometric methods to characterize and monitor contaminants on surfaces, and in waste streams and incinerator effluents. Laser ablation techniques can also decontaminate surfaces without the generation of secondary wastes or cleaning solutions. The research, development, testing, automation, and implementation of these techniques to characterize surface contamination, monitor waste streams, or clean material surfaces may significantly reduce the costs, time, and risks associated with monitoring effluents, and decontaminating and decommissioning nuclear facilities.

Biomarkers and Risk Assessments to Ensure Health and Safety. EMSP scientists have identified biomarkers (T-lymphocytes) that can be used to improve human-sensitivity immunoassays for exposures to Beryllium and other toxic metals used at Department of Energy production facilities. Several EMSP scientists are also improving human and ecological risk assessments by: developing better measurement techniques for estimating exposure and dose; incorporating the effects of genetic repair mechanisms in dose/response calculations; and

including new biological uptake pathways in risk models, such as estimating the bioavailability of organic solvents that can pass through the skin of humans during the handling of wastes or contaminated soils and groundwater.

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II. Research Award Selection Process

The Environmental Management Science Program (EMSP) process for the submission of applications for financial assistance is published in the Federal Register. Selection of research awards is designed to ensure the funding of the most competitive and scientifically meritorious research application with the greatest potential to lead to new and improved solutions to environmental cleanup problems at the Department of Energy. Solicitation of research grant applications is based on identified research needs and ongoing efforts which focus the EMSP-funded research on intractable cleanup problems or problems needing better solutions. A peer review by panels of external scientific experts evaluates the applications for scientific excellence. In addition, panels of scientists and engineers from Departmental sites, who will be the end users of research results, evaluate applications for their relevance to identified Environmental Management problems. Funding is recommended only for those applications which are successful in both reviews. Exhibit 2 provides an overview of the EMSP research awards selection process.

Research Needs Identification

The first step in making research awards is the identification of research needs that affect Environmental Management's ability to address its cleanup responsibilities. Research needs identification is a dynamic process, requiring the program to continually update the research needs as some of Environmental Management's problems are solved and others emerge, evolve, or change.

A number of information sources were used to identify research needs: site-specific workshops, a complex-wide research needs survey, an evaluation of the needs identified by the Department's Environmental Management Technology Focus Areas, and analyses of the Baseline Environmental Management Report and Project Baseline Summary information developed for the *Paths to Closure*. Site-specific workshops provided a forum for Environmental Management managers, researchers, site stakeholders and others to share information on Environmental Management's site-specific problems and research needs. The complex-wide research needs survey served as an instrument for gathering information from Department project managers on environmental problems lacking viable solutions or requiring more scientific knowledge. Identification of needs by the technology development programs highlighted information/knowledge gaps that limit the Department's ability to develop needed technologies. Analysis of the Baseline Environmental Management Report and Project Baseline Summaries identified and provided information on Environmental Management's high cost and high risk projects and activities for which better solutions are needed.

EMSP Research Awards Selection Process

Research needs were organized into seven Department of Energy Environmental Management problems areas: high level waste, remedial action, mixed waste, decontamination and decommissioning, nuclear materials, spent nuclear fuel, and health, ecology, or risk.

Solicitation Development

EMSP solicitations for basic research are published in the Federal Register in accordance with 10 CFR Part 600, and developed based on information gathered through the needs identification process. Solicitations for grant preapplications and applications will normally describe broad, general, technical problems and areas of investigations for which the Department may award grants or cooperative agreements to successful applicants. The four solicitations developed to date are found in Appendix A. The Fiscal Year 1996 Request for Applications, issued in February 1996, covered a broad range of representative need areas. The Fiscal Year 1997 Request for Applications, issued in December 1996, was more focused to address areas identified through discussions with problem holders, an analysis of research funded in Fiscal Year 1996, and an examination of relevant research sponsored by other programs. Research areas targeted in Fiscal Year 1997 were:

- High Level Radioactive Waste Tanks
- Spent Nuclear Fuel
- Fissile Materials
- Mixed Hazardous and Radioactive Low Level Waste
- Waste Disposal Forms
- Health/Ecology/Risk

Two solicitations issued in Fiscal Year 1998 focus on two areas for which further understanding is needed:

- Decontamination and Decommissioning
- High Level Radioactive Waste

The research portfolio is reviewed annually to determine future needs.

Review and Selection of Awards

The EMSP uses a process by which preapplications and formal applications are evaluated for scientific merit and relevance to Department of Energy environmental cleanup needs. A financial assistance application will include basic, identifying information, a detailed narrative description of the proposed project, including the objectives of the project and plans for carrying it out, a budget with supporting justifications, and any required pre-award assurances. All internal and external reviewers are provided with briefings of Environmental Management challenges and research needs prior to the start of the evaluation process. All internal and

external reviewers must sign conflict of interest and confidentiality statements prior to participation in the evaluation process, and must comply with the regulations at 10 CFR 600.14, 10 CFR 1010, and Executive branch-wide employee responsibilities and conduct pursuant to 5 CFR Part 735.

Preapplication Screening

A preapplication is an optional vehicle that constitutes a potential applicant's intent to submit a formal grant application. A preapplication allows the potential applicant to receive a response from the Department regarding the suitability of his/her proposed research project to the Department's interests. All preapplications are screened by the Office of Energy Research to ensure that applications will focus on basic science, and by the Office of Environmental Management to ensure that the applications address questions relevant to the environmental problems identified by the sites. Preapplications are encouraged, but not required. In Fiscal Year 1996, approximately 2,200 preapplications were evaluated for scientific merit and relevance to the cleanup mission. Approximately 775 applicants were encouraged to submit formal applications for financial assistance. In Fiscal Year 1997, 1,200 preapplications were received, and 420 of these applicants were encouraged to submit formal applications. In Fiscal Year 1998, 290 preapplications were received for decontamination and decommissioning and 94 were encouraged; 279 preapplications were received for high level waste and 87 were encouraged.

Providing early input to interested investigators has saved time and costs for both the investigators and Department staff. Response to preapplications also provides an assurance to the Department that the investigators understood the Request for Applications.

Application Review

To ensure that the most scientifically meritorious and relevant applications are selected, the Department has a two-phase formal application review process. The first phase, or "initial review" involves external peer reviewers who are experts in specific scientific disciplines. Evaluation during the first phase is advisory. The second phase involves environmental management scientists and engineers who are most familiar with the Department's Environmental Management problems and may be the potential end users of the research results.

Scientific Merit Review. Scientific merit review is performed by peer reviewers who are selected on the basis of their professional qualifications and expertise. These reviewers perform a rigorous, formal external peer review and evaluation of each application. Evaluation criteria for the scientific merit review are codified in 10 CFR 605.10(d) and are listed as follows in descending order of importance:

- Scientific and/or technical merit of the project.

- Appropriateness of the proposed method or approach.
- Competency of applicant's personnel and adequacy of proposed resources.
- Reasonableness and appropriateness of the proposed budget.
- Other appropriate factors set forth in the solicitation. In addition, the recipient's past performance on similar projects may be considered.

Applications found to be of scientific merit proceed to the next phase of the selection process.

Relevance Review. The relevance review is performed by the environmental management scientists and engineers familiar with Environmental Management cleanup problems. The Environmental Management Advisory Board has provided guidance regarding factors to consider during the relevance review process. These criteria include potential to:

- Reduce time required to achieve Environmental Management's mission goals.
- Decrease risk for public and workers, or the environment.
- Provide opportunities for major cost reductions.
- Address problems that are considered intractable without new knowledge.

A total of 810 formal applications were submitted in Fiscal Year 1996, 185 of which were recommended for funding through the external scientific merit review process. From the 185, 136 research awards were funded based on both scientific merit and Departmental relevance.

From the 540 applications submitted in Fiscal Year 1997, 144 were recommended for funding through the scientific merit review process. Of these, 66 were funded as a result of the relevance review. This two-phase review process ensures that only high quality and relevant research is funded through the EMSP.

Review Feedback

In response to the National Academy of Sciences/National Research Council assessment and recommendations on the EMSP, the Department made changes in 1997 to increase the transparency and technical credibility of the application review process. All reviewer comments are provided to unsuccessful candidates. Lists of the names of both merit and relevance reviewers are now made available. In addition, as part of the feedback process, abstracts from all

awards are available on the Internet. Improvements will be made as needed based on lessons learned and input from external advisory groups. The Environmental Management Advisory Board Science Committee provides continued assistance to the EMSP for improving the review process and finding ways to ensure that research results reach end users.

III. Linkages to Environmental Cleanup Problems

The *Paths to Closure* data provide a baseline of projects to be addressed by the Department's environmental cleanup program. The Environmental Management Science Program (EMSP) portfolio of research awards is organized by Environmental Management problem areas corresponding to the major work scope categories in the *Paths to Closure*, and by science categories in scientific disciplines of the research community. This section provides an overview of the problem areas and science categories, followed by the details of how the EMSP research portfolio relates to each. Correlation between the research awards and the costs of cleanup in the year 2007 and beyond is also described. Each problem area is described along with related EMSP awards and related Environmental Management high cost projects. It is important to recognize that because of the length of time required for completion of research, basic research results are more likely to have an effect on long-term cleanup problems, those that extend from the year 2007 and beyond.

Cleanup Problems and Research Needs

The Department of Energy's Environmental Management cleanup effort, has been funded at approximately \$6 billion per year. Research needs indicate programmatic and technical challenges for which new or improved knowledge from basic research is required. Research needs identified by the EMSP have been grouped into the seven Environmental Management problem areas:

- High Level Waste
- Spent Nuclear Fuel
- Mixed Waste
- Nuclear Materials
- Remedial Action
- Decontamination and Decommissioning
- Health/Ecology/Risk

Site Cleanup Projects

Paths to Closure includes 353 discrete cleanup projects broadly described in the Project Baseline Summaries.⁹ Most of these projects are concentrated at the Department's four major cleanup sites: Hanford Site, Idaho National Engineering and Environmental Laboratory, Oak Ridge Reservation, and Savannah River Site. Each project involves multiple activities as outlined in *Paths to Closure*. Of these 353 projects, 82 have expected life-cycle costs of \$50 million or

⁹ *Accelerating Cleanup: Paths to Closure Draft*, U.S. Department of Energy, Office of Environmental Management, March 1998, page 30.

more from the year 2007 and beyond, in constant 1998 dollars, and can be associated with an Environmental Management problem area.¹⁰ *Paths to Closure* data also indicate, on a year-by-year basis, the level of risk managed by each project. There are 38 high cost projects that manage high risks in the year 2007 and beyond. These 38 projects are included in the health/ecology/risk Environmental Management problem area. The costs for this problem area are included in costs from the other six problem areas.

Exhibit 3 shows the site-by-site breakdown of life-cycle costs by Environmental Management problem area from the year 2007 and beyond. The projects included in the health/ecology/risk problem area are the projects evaluated as both high cost and high risk.

Exhibit 3. 2007 and Beyond Life-Cycle Costs (\$B in constant 1998 dollars) by Site and Environmental Management Problem Area¹¹

Operations Office	High Level Waste	Spent Nuclear Fuel	Mixed Waste	Nuclear Materials	Remedial Action	Decontamination and Decommissioning	Health / Ecology / Risk*
Albuquerque			\$0.4		\$0.1		\$3.8
Chicago			\$0.1				
Idaho	\$4.2	\$0.7	\$0.2		\$1.5	\$0.1	\$3.9
Nevada					\$0.1		
Oak Ridge			\$2.8		\$0.7	\$0.3	\$8.0
Oakland			\$0.4			\$0.1	
Ohio					\$0.1		\$0.1
Richland	\$24.1	\$0.4	\$2.9	\$1.1	\$2.5	\$2.4	\$24.8
Rocky Flats			\$0.1		\$0.1	\$0.1	\$0.1
Savannah River	\$6.5	\$1.2	\$0.2	\$0.4	\$0.8	\$4.2	\$7.6
Total**	\$34.9	\$2.2	\$7.1	\$1.6	\$6.1	\$7.3	\$48.3

* The "Health/Ecology/Risk" problem area includes all site projects that must remain active from the year 2007 and beyond to manage relatively high risks. This problem area includes costs from the other six problem areas.

** Individual costs may not sum to totals due to rounding.

¹⁰ These "high cost" projects have total estimated costs from the year 2007 and beyond of \$50 million or more in constant 1998 dollars, based on the report *Accelerating Cleanup: Paths to Closure Draft*, U.S. Department of Energy, March 1998. They also have costs or quantities of materials primarily associated with a major work scope category, corresponding to one of the Environmental Management problem areas.

¹¹ Exhibit 3 does not include the following site costs from the year 2007 and beyond: Transuranic Waste at \$10.2B, Other Wastes at \$8.6B, Long Term Surveillance and Monitoring at \$3.8B, and Infrastructure and Support at \$13.0B. The Mixed Waste costs in Exhibit 3 are included under "Other Wastes" in *Accelerating Cleanup: Paths to Closure Draft*.

Portfolio of Research Awards

Addressing the Department's environmental management research needs requires the expertise of several scientific disciplines such as chemistry, geology, and physics. From these disciplines, 13 science categories were used to date for purposes of merit review and selection, because they reflect the way the scientific community is organized and assist the EMSP in identifying application reviewers. To show the relationship of science to Departmental research needs, research awards were grouped within the 13 science categories into 38 subcategories. Exhibit 4 provides a listing of this hierarchy.

Exhibit 4. EMSP Hierarchy of Science Categories*

Actinide Chemistry Actinide (Heavy Element) Chemistry	Geophysics Subsurface Imaging	Materials Science Chemical & Structural Properties Of Storage Materials Radiation Effects On Storage Materials Surface Chemistry Waste Materials
Analytical Chemistry & Instrumentation Biomedical Instrumentation Laser Ablation Techniques Mass Spectrometry Sensors & Techniques	Health Science Biophysics/Dose Health Effects Molecular, Structural & Genomic Science Risk Assessment	Microbial Science Biodegradation & Biotransformation Microbial Genetics & Instrumentation Microbial Transport
Biogeochemistry Biogeochemistry	Hydrogeology Dense Nonaqueous Phase Liquid Dynamics Fluid-flow & Colloidal Dynamics Instrumentation & Modelling	Plant Science Plant Genetics Plant Membrane Transport Plant Metabolism
Engineering Science Bioengineering Bubble Mechanics & Sonification Design, Process & Modelling Diagnostics Robotics	Inorganic Chemistry Hydrothermal Oxidation Multiphase/Gaseous Chemistry Solid/Solution Chemistry	Separations Chemistry Catalyst Chemistry & Waste Treatment Ligand Design and Ion-exchange Technetium Chemistry & Separations
Geochemistry Colloidal Chemistry & Transport Solid/Solution Geochemistry Sorption/Desorption		

* The list of science categories and subcategories is likely to be expanded as new research awards are made.

Size of the Investment

Exhibit 5 provides the breakdown of the number of EMSP awards by the seven Environmental Management problem areas and the 13 science categories along with total commitments for Fiscal Years 1996 and 1997 awards. To date a total of \$143.7 million has been appropriated: Fiscal Year 1996 - \$48.9 million; Fiscal Year 1997 - \$48.7 million; Fiscal Year 1998 - \$46.1 million. However, awards have only been made in Fiscal Years 1996 and 1997; Fiscal Year 1998 awards are planned for Summer 1998. The cost of Fiscal Years 1996 and 1997 awards total over \$160 million, though many of the awards are funded over multiple years, subject to available funds. Therefore, it is important to note that the Department's laboratory

Exhibit 5. EMSP Portfolio of Research Awards (Number of Awards / Total Funding Dollars in Millions)

SCIENCE CATEGORY	ENVIRONMENTAL MANAGEMENT PROBLEM AREA							
	High Level Waste	Spent Nuclear Fuel	Mixed Waste	Nuclear Materials	Remedial Action	Decontamination and Decommissioning	Health / Ecology / Risk	Total
Actinide Chemistry	3 / \$1.9		2 / \$2.2	2 / \$1.7	3 / \$2.4			10 / \$8.2
Analytical Chemistry and Instrumentation	7 / \$4.8	1 / \$0.8	8 / \$6.1	1 / \$0.5	7 / \$5.0		3 / \$1.5	27 / \$18.7
Biogeochemistry					5 / \$3.3		1 / \$0.9	6 / \$4.2
Engineering Science	6 / \$4.9	1 / \$1.1	4 / \$3.0	1 / \$0.6	3 / \$3.1	2 / \$1.3		17 / \$13.9
Geochemistry	2 / \$1.5	2 / \$1.3			13 / \$11.4			17 / \$14.1
Geophysics	1 / \$0.6				11 / \$9.7			12 / \$10.3
Health Science					3 / \$2.7		14 / \$12.1	17 / \$14.8
Hydrogeology					15 / \$11.8			15 / \$11.8
Inorganic Chemistry	7 / \$6.8		6 / \$3.3		3 / \$1.9	1 / \$1.1		17 / \$13.0
Materials Science	11 / \$9.7		2 / \$1.9	4 / \$5.1		4 / \$3.9		21 / \$20.6
Microbial Science			1 / \$0.4		8 / \$10.1			9 / \$10.6
Plant Science					8 / \$4.4			8 / \$4.4
Separations Chemistry	11 / \$8.2	1 / \$0.9	9 / \$5.4		3 / \$1.0	2 / \$1.3		26 / \$16.8
Total Awards / Funding	48 / \$38.3	5 / \$4.0	32 / \$22.2	8 / \$7.9	82 / \$66.9	9 / \$7.6	18 / \$14.5	202 / \$161.4

* Individual costs may not sum to totals due to rounding.

awards from Fiscal 1996 bear costs in Fiscal Years 1997 through 1999. Similarly, the Department's laboratory awards from Fiscal Year 1997 bear costs through Fiscal Year 2000. The Department's laboratory awards are phase-funded over three years and, therefore, carry mortgages. All other awards are fully funded in the year of the award.

The National Research Council committee reviewing the EMSP stated in its final assessment report, "There is no way to forecast the impact of carefully chosen high-quality projects, but the environmental management problems are so large and the predicted costs of cleanup so great, that the modest investment in the EMSP is viewed as worthwhile."¹² Exhibit 6 reinforces this statement by showing the relative size of the EMSP investment to date against the projected life-cycle costs of all projects from the year 2007 and beyond.

Exhibit 6. Relative Size of the EMSP Investment¹³

Environmental Management Problem Area	2007 and Beyond - Life Cycle Costs (\$B)*	Research Awards Commitments (\$B)
High Level Waste	\$34.9	\$0.038
Spent Nuclear Fuel	\$2.2	\$0.004
Mixed Waste	\$7.1	\$0.022
Nuclear Materials	\$1.6	\$0.008
Remedial Action	\$6.1	\$0.067
Decontamination and Decommissioning	\$7.3	\$0.008
Health / Ecology / Risk**	\$48.3	\$0.014

* In constant 1998 dollars.

** The "Health/Ecology/Risk" problem area includes all site projects that must remain active from the year 2007 and beyond to manage relatively high risks. This problem area includes costs from the other six problem areas.

Linkages Between Research Awards and Cleanup Projects

Based on the research needs identification process described in Section II, the EMSP has linked Fiscal Years 1996 and 1997 research awards to the Environmental Management problem areas and to the site-specific cleanup projects. These projects (Project Baseline Summaries) are broadly described in the *Paths to Closure* with each one encompassing numerous activities and operations. Research awards, in general, address cleanup needs, but are not always site specific.

¹² *Building an Effective Environmental Management Science Program*, Final Assessment Report, National Research Council, June 1997, page 26.

¹³ Exhibit 6 does not include the following site costs from the year 2007 and beyond: Transuranic Waste at \$10.2B, Other Wastes at \$8.6B, Long Term Surveillance and Monitoring at \$3.8B, and Infrastructure and Support at \$13.0B. The Mixed Waste costs in Exhibit 6 are included under "Other Wastes" in *Accelerating Cleanup: Paths to Closure Draft*.

In many cases, the research awards have potential to benefit multiple sites and wide ranges of environmental management projects.

The relationship between the research awards and high cost cleanup projects for the year 2007 and beyond, are presented below by Environmental Management problem area. Projects listed in the health/ecology/risk problem area are those projects from across all programmatic categories that are considered both high cost and high risk. This information shows the potential impact of the research and the Department's ability to leverage the relatively small investment in research to address multiple concerns.

Research awards may be relevant to more than one Environmental Management problem area, but awards listed here are only with the primary problem area to which each relates. A given research award is likely to address several of the site-specific projects listed. For each problem area, projected life-cycle costs are provided to show the relationship between research funded and the problems that may be addressed.

Appendix B provides more detailed descriptions for each EMSP research award and their relation to individual projects. Appendix C provides more detailed descriptions of Environmental Management high cost projects and their relation to individual research awards.

High Level Waste

The Department maintains over 300 large storage tanks containing over 90 million gallons of highly radioactive wastes, which include organic and inorganic chemical compounds in solid, colloidal, slurry, and liquid phases. The environment within the tanks is highly radioactive and chemically harsh. Some of the tanks have leaked to the environment, while others are corroding.

Research Needs

Five subcategories of needs were identified in the area of high level waste:

- Characterization of waste, tanks waste, containers, piping systems
- High level waste retrieval
- High level waste treatment and remediation
- Disposition of tank wastes
- Separation processes for tank waste treatment and removal

Research Awards

Of the 202 research awards funded by the EMSP to date, 48 awards are primarily associated with high level waste research. These awards have potential linkages to cleanup work planned or currently being conducted at three Department of Energy sites (see Exhibits 7 and 8). Additional information on each award is available in Appendix B and on the World Wide Web at <http://www.em.doe.gov/science>.

Environmental Management Projects

There are 17 high cost, high level radioactive waste projects planned or currently being conducted. Ten of these projects manage a high potential risk to workers, the public, and/or the environment. The funding required for all high level radioactive waste projects in the Department is \$34.9 billion, in constant 1998 dollars, from the year 2007 and beyond.

Exhibit 7 identifies potential linkages among the research awards, science categories, Environmental Management problem areas, and cleanup activities planned or currently being conducted.

Exhibit 8 lists the research awards related to high level radioactive waste and ongoing high cost high level radioactive waste tank projects planned or currently being conducted at Department of Energy sites.

^o Projects with costs greater than \$50M from the year 2007 and beyond and which have costs or quantities of materials associated with High Level Waste.
 + Projects which must remain active from the year 2007 and beyond to manage high risks.

WGB-97-0257 High Waste
04/02/98

Exhibit 8. High Level Waste Related EMSP Research Awards by Science Category and Associated High Cost Environmental Management Projects by Operations Office

HIGH LEVEL WASTE	
AWARDS	ENVIRONMENTAL MANAGEMENT PROJECTS
<p>Actinide Chemistry Actinide (Heavy Element) Chemistry 54595-NM - f-Element Ion Chelation in Highly Basic Media 54621-WA - Chemical Speciation of Strontium, Americium, and Curium in High Level Waste: Predictive Modeling of Phase Partitioning During Tank Processing 59977-MD - Synthesis and Characterization of Templated Ion Exchange Resins for the Selective Complexation of Actinide Ions</p> <p>Analytical Chemistry and Instrumentation Laser Ablation Techniques 55318-CA - Improved Analytical Characterization of Solid Waste-Forms by Fundamental Development of Laser Ablation Technology 60075-WA - Particle Generation by Laser Ablation in Support of Chemical Analysis of High Level Mixed Waste from Plutonium Production Operations</p> <p>Mass Spectrometry 59978-TN - Thermospray Mass Spectrometry Ionization Processes Fundamental Mechanisms for Speciation, Separation and Characterization of Organic Complexants in DOE Wastes 60424-ID - High Temperature Condensed Phase Mass Spectrometric Analysis</p> <p>Sensors and Techniques 54674-OH - Design and Development of a New Hybrid Spectroelectrochemical Sensor 60217-TN - Optically-Based Array Sensors for Selective In Situ Analysis of Tank Waste 60219-PA - Development of Advanced Electrochemical Emission Spectroscopy for Monitoring Corrosion in Simulated DOE Liquid Waste</p> <p>Engineering Science Bubble Mechanics and Sonification 60143-IL - Foaming in Radioactive Waste Treatment and Immobilization Processes 60451-WA - Mechanics of Bubbles in Sludges and Slurries</p> <p>Design, Process and Modeling 54656-CA - Mixing Processes in High-Level Waste Tanks</p> <p>Diagnostics 54890-CA - On-Line Slurry Viscosity and Concentration Measurement as a Real-Time Waste Stream Characterization Tool 55179-NY - Acoustic Probe for Solid-Gas-Liquid Suspensions 55294-IL - Superconducting Open-Gradient Magnetic Separation for the Pretreatment of Radioactive or Mixed Waste Vitrification Feeds</p> <p>Geochemistry Sorption/Desorption 55042-GA - Quantifying Silica Reactivity in Subsurface Environments: Controls of Reaction Affinity and Solute Matrix on Quartz and SiO₂ Glass Dissolution Kinetics 60403-NM - Phase Chemistry of Tank Sludge Residual Components</p>	<p>Idaho Operations Office Idaho National Engineering and Environmental Laboratory ID-HLW-101 - High-Level Waste Pretreatment ID-HLW-102 - High-Level Waste Immobilization Facility (Privatized) +ID-HLW-103 - High-Level Waste Treatment and Storage</p> <p>Richland Operations Office Hanford Site - Richland Operations Office +RL-TW04 - Retrieval Project +RL-TW05 - Process Waste Support +RL-TW06 - Process Waste Privatization Phase I +RL-TW07 - Process Waste Privatization Phase II +RL-TW08 - Process Waste Privatization Infrastructure RL-TW09 - Immobilized Tank Waste Storage & Disposal Project +RL-WM05 - Liquid Effluents Project</p> <p>Savannah River Operations Office Savannah River Site +SR-HL01 - H-Tank Farm +SR-HL02 - F-Tank Farm SR-HL03 - Waste Removal Operations and Tank Closure +SR-HL04 - In Tank Precipitation/Extended Sludge Processing/Late Wash (ITP/ESP/LW) Operations SR-HL05 - Vitrification SR-HL08 - Saltstone SR-HL12 - High Level Waste System Upgrades</p> <p>+ Projects which must remain active from the year 2007 and beyond to manage high risks.</p>

Exhibit 8. HIGH LEVEL WASTE, Continued

AWARDS	ENVIRONMENTAL MANAGEMENT PROJECTS
<p>Geophysics Subsurface Imaging 55141-MA - Imaging and Characterizing the Waste Materials Inside an Underground Storage Tank Using Seismic Normal Modes</p> <p>Inorganic Chemistry Hydrothermal Oxidation 54765-NM - Enhanced Sludge Processing of HLW: Hydrothermal Oxidation of Chromium, Technetium, and Complexants by Nitrate</p> <p>Multiphase/Gaseous Chemistry 54807-GA - Studies Related to Chemical Mechanisms of Gas Formation in Hanford High-Level Nuclear Wastes 55137-CA - Investigation of Novel Electrode Materials for Electrochemically-Based Remediation of High-and Low-Level Mixed Wastes in the DOE Complex</p> <p>Solid/Solution Chemistry 54628-WA - Colloidal Agglomerates in Tank Sludge: Impact on Waste Processing 54646-WA - Interfacial Radiolysis Effects in Tank Waste Speciation 55229-IL - The NO_x System in Nuclear Waste 60296-CA - Research Program to Investigate the Fundamental Chemistry of Technetium</p> <p>Materials Science Chemical and Structural Properties Of Storage Materials 54982-FL - Analysis of Surface Leaching Processes in Vitrified High-Level Nuclear Wastes Using In-Situ Raman Imaging and Atomistic Modeling 60020-TN - Stability of High-Level Waste Forms 60345-WA - New Silicotitanate Waste Forms: Development and Characterization 60362-WA - Ion-Exchange Processes and Mechanisms in Glasses</p> <p>Radiation Effects On Storage Materials 54672-WA - Radiation Effects in Nuclear Waste Materials 54691-MI - Radiation Effects on Materials in the Near-Field of Nuclear Waste Repository 55188-DC - Chemical Decomposition of High-Level Nuclear Waste Storage/Disposal Glasses Under Irradiation 55367-IL - Investigation of Microscopic Radiation Damage in Waste Forms Using ODNMR and AEM Techniques 59827-AZ - The Influence of Radiation and Multivalent Cation Additions on Phase Separation and Crystallization of Glass</p> <p>Surface Chemistry 60401-SC - Mechanism of Pitting Corrosion Prevention by Nitrite in Carbon Steel Exposed to Dilute Salt Solutions</p> <p>Waste Materials 54773-NM - Microstructural Properties of High Level Waste Concentrates and Gels with Raman And Infrared Spectroscopies</p>	<p>Idaho Operations Office Idaho National Engineering and Environmental Laboratory</p> <p>Richland Operations Office Hanford Site - Richland Operations Office</p> <p>Savannah River Operations Office Savannah River Site</p>

Exhibit 8. HIGH LEVEL WASTE, Continued

AWARDS	ENVIRONMENTAL MANAGEMENT PROJECTS
<p>Separations Chemistry Catalyst Chemistry and Waste Treatment 54996-WA - Ionizing Radiation Induced Catalysis on Metal Oxide Particles 59982-NY - Reactivity of Peroxynitrite: Implications for Hanford Waste Management and Remediation 59993-NM - Dynamic Effects of Tank Waste Aging on Radionuclide-Complexant Interactions 60050-WA - Chemical Speciation of Inorganic Compounds under Hydrothermal Conditions 60313-IL - Radiation Effects on Transport and Bubble Formation in Silicate Glasses Ligand Design and Ion-exchange 54716-DC - Polyoxometalates for Radioactive Waste Treatment 54735-TX - Development of Inorganic Ion Exchangers for Nuclear Waste Remediation 55087-TN - Design and Synthesis of the Next Generation of Crown Ethers for Waste Separations: An Inter-Laboratory Comprehensive Proposal 60123-WA - Potential-Modulated Intercalation of Alkali Cations into Metal Hexacyanoferrate Coated Electrodes Technetium Chemistry and Separations 59990-NM - Fundamental Chemistry, Characterization, and Separation of Technetium Complexes in Hanford Waste 60017-PA - Removal of Technetium, Carbon Tetrachloride, and Metals from DOE Properties</p>	<p>Idaho Operations Office Idaho National Engineering and Environmental Laboratory</p> <p>Richland Operations Office Hanford Site - Richland Operations Office</p> <p>Savannah River Operations Office Savannah River Site</p>

Spent Nuclear Fuel

Spent nuclear fuel is fuel that has been withdrawn from a nuclear reactor following irradiation. The Department of Energy is responsible for safely and efficiently managing Department-owned spent nuclear fuel and spent nuclear fuel returned to the United States from foreign research reactors. The fuel is treated where necessary, packaged suitable for repository disposal where practicable, and placed in interim storage. These actions remove remaining vulnerabilities, make as much spent fuel as possible ready for ultimate disposition, and substantially reduce the cost of continued storage.

Research Needs

Six subcategories of needs were identified in the area of spent nuclear fuel:

- Stabilization of spent nuclear fuel, including mechanisms of pyrophoricity and combustion parameters for various fuel types
- Characterization/nondestructive examination (moisture content, radioisotopic inventory, physical condition, criticality, and synergistic effects) of spent nuclear fuel
- Characterization corrosion, degradation, and radionuclide release mechanisms, kinetics, and rates for the representative fuel matrices; mechanisms which may lead to accelerated degradation of containers; dissolution characteristics of the matrices; and the effects of microbes on fuel packages; long-term storage and deterioration of fuel/canisters of spent nuclear fuel
- Characterization of water clarity of basins
- Development of alternative spent nuclear fuel processes; waste forms; alternative disposal process; mixed oxide fuels
- Development of methods to remove moisture without damage to the fuel elements

Research Awards

Of the 202 research awards funded by the EMSP to date, five awards are primarily associated with spent nuclear fuel research needs. These awards have potential linkages to cleanup work planned or currently being conducted at three Department of Energy site (see Exhibits 9 and 10). Additional information on each award is available in Appendix B and on the World Wide Web at <http://www.em.doe.gov/science>.

Environmental Management Projects

There are five high cost spent nuclear fuel projects planned or currently being conducted. Two of these projects manage a high potential risk to the workers, public and/or environment. The funding required for all spent nuclear fuel projects in the Department is \$2.2 billion, in constant 1998 dollars, from the year 2007 and beyond.

Exhibit 9 identifies potential linkages among the research awards, science categories, Environmental Management problem areas, and cleanup activities planned or currently being conducted.

Exhibit 10 lists the research awards related to spent nuclear fuel and ongoing spent nuclear fuel projects planned or currently being conducted at Department of Energy sites.

Exhibit 9. Potential Linkages of EMSP Research Awards to High Cost Spent Nuclear Fuel Environmental Management Projects by Operations Office

° Projects with costs greater than \$50M from the year 2007 and beyond and which have costs or quantities of materials associated with Spent Nuclear Fuel.

+ Projects which must remain active from the year 2007 and beyond to manage high risks.

WGLR-97-0037 Spent Fuel
04/02/98

Exhibit 10. Spent Nuclear Fuel Related EMSP Research Awards by Science Category and Associated High Cost Environmental Management Projects by Operations Office

SPENT NUCLEAR FUEL	
AWARDS	ENVIRONMENTAL MANAGEMENT PROJECTS
Analytical Chemistry and Instrumentation Sensors and Techniques 60141-DC - Gamma Ray Imaging for Environmental Remediation Engineering Science Design, Process and Modeling 60144-ID - Flow Visualization of Forced and Natural Convection in Internal Cavities Geochemistry Solid/Solution Geochemistry 59849-MI - Radionuclide Immobilization in the Phases Formed by Corrosion of Spent Nuclear Fuel: The Long-Term Assessment 59960-IN - Direct Investigations of the Immobilization of Radionuclides in the Alteration Phases of Spent Nuclear Fuel Separations Chemistry Catalyst Chemistry and Waste Treatment 60392-WA - Radiolytic and Thermal Process Relevant to Dry Storage of Spent Nuclear Fuels	Idaho Operations Office Idaho National Engineering and Environmental Laboratory ID-SNF-102 - Integrated Spent Nuclear Fuel Program Richland Operations Office Hanford Site - Richland Operations Office RL-WM02 - Canister Storage Building Operations Savannah River Operations Office Savannah River Site +SR-SF02 - L-Reactor Spent Nuclear Fuel Project SR-SF03 - Receiving Basin for Off-site Fuels (RBOF) Spent Nuclear Fuel Project +SR-SF09 - Spent Nuclear Fuel Transfer and Storage + Projects which must remain active from the year 2007 and beyond to manage high risks.

Mixed Waste

Waste containing both radioactive and hazardous materials is considered mixed waste. There are currently 167,000 cubic meters of mixed waste estimated to be in storage at Department of Energy sites awaiting treatment and disposal. There are over 1,400 different mixed waste streams in inventory, located at 37 sites in 19 states. This inventory will be increased with newly generated mixed waste resulting from DOE's ongoing activities in environmental restoration, facility decontamination, and transition processes. Existing treatment and disposal capacities are presently too limited to allow the treatment and disposal of this inventory of mixed wastes. Research at a fundamental science level could lead to innovative processes or technologies, or could provide data to permit the advancement of technologies currently under development.

Research Needs

Seven subcategories of needs were identified in the area of mixed waste:

- Non-intrusive, nondestructive characterization, monitoring, and measurement
- Reduction of waste volumes from remediation, decommissioning, and separations processes
- Waste treatments for heavy metal, dioxin, organics, and radionuclide contamination
- Shipping and storage of wastes, including hazardous and radioactive materials
- Materials stabilization, including improved methods for predicting partitioning performance of vitrification techniques
- Development of waste forms having long-term durability
- Long-term behavior of different waste disposal forms and containment media

Research Awards

Of the 202 research awards funded by the EMSP to date, 32 awards are primarily associated with mixed waste research needs. These awards have potential linkages to cleanup work planned or currently being conducted at five Department of Energy sites (see Exhibits 11 and 12). Additional information on each award is available in Appendix B and on the World Wide Web at <http://www.em.doe.gov/science>.

Environmental Management Projects

There are 12 high cost mixed waste projects planned or currently being conducted. Six of these projects manage a high potential risk to workers, the public and/or the environment. The funding required for all mixed waste projects in the Department is \$7.1 billion, in constant 1998 dollars, from the year 2007 and beyond.

Exhibit 11 identifies potential linkages among the research awards, science categories, Environmental Management problem areas, and cleanup activities planned or currently being conducted.

Exhibit 12 lists the research awards related to mixed waste and ongoing high cost mixed waste projects planned or currently being conducted at Department of Energy sites.

Exhibit 11. Potential Linkages of EMSP Research Awards to High Cost Mixed Waste Environmental Management Projects by Operations Office

* Projects with costs greater than \$50M from the year 2007 and beyond and which have costs or quantities of materials associated with Mixed Waste.
 + Projects which must remain active from the year 2007 and beyond to manage high risks.

WCA-97-0217 Mixed Waste
04/02/98

Exhibit 12. Mixed Waste Related EMSP Research Awards by Science Category and Associated High Cost Environmental Management Projects by Operations Office

MIXED WASTE	
AWARDS	ENVIRONMENTAL MANAGEMENT PROJECTS
<p>Actinide Chemistry Actinide (Heavy Element) Chemistry 54679-WA - Architectural Design Criteria for F-Block Metal Ion Sequestering Agents 60370-CA - Rational Design of Metal Ion Sequestering Agents</p> <p>Analytical Chemistry and Instrumentation Mass Spectrometry 59981-NM - Real-Time Broad Spectrum Characterization of Hazardous Waste by Membrane Introduction Mass Spectrometry</p> <p>Sensors and Techniques 54751-NM - High Fluence Neutron Source for Nondestructive Characterization of Nuclear Waste 54864-KS - Supra molecular Chemistry of Selective Anion Recognition for Anions of Environmental Relevance 55146-WA - Adsorption/Membrane Filtration as a Contaminant Concentration and Separation Process for Mixed Wastes and Tank Wastes 55171-PA - Development of Advanced In-Situ Techniques for Chemistry Monitoring and Corrosion Mitigation in SCWO Environments 55247-IL - Sensors Using Molecular Recognition in Luminescent, Conductive Polymers 60070-MS - The Development of Cavity Ringdown Spectroscopy as a Sensitive Continuous Emission Monitor for Metals 60231-MD - Novel Miniature Spectrometer for Remote Chemical Detection</p> <p>Engineering Science Bubble Mechanics and Sonification 54973-TN - A Novel Energy-Efficient Plasma Chemical Process for the Destruction of Volatile Toxic Compounds 55211-IL - Cavitation Hydrothermal Oxidation: A New Remediation Process</p> <p>Design, Process and Modeling 60155-CO - Measurements and Models for Hazardous Chemical and Mixed Wastes 60326-AZ - Isolation of Metals from Liquid Wastes: Reactive Scavenging in Turbulent Thermal Reactors</p> <p>Inorganic Chemistry Hydrothermal Oxidation 54506-TX - Acid-Base Behavior in Hydrothermal Processing of Wastes 54828-SC - Processing of High Level Waste: Spectroscopic Characterization of Redox Reactions in Supercritical Water 55276-TN - Fundamental Chemistry and Thermodynamics of Hydrothermal Oxidation Processes</p>	<p>Idaho Operations Office Idaho National Engineering and Environmental Laboratory ID-WM-105 - Advanced Mixed Waste Treatment Project (AMWTP) Production Operations ID-WM-107 - Long Term Treatment/Storage/Disposal Operations</p> <p>Oak Ridge Operations Office Oak Ridge Reservation +OR-38111 - Mixed Low Level Waste Management</p> <p>Richland Operations Office Hanford Site - Richland Operations Office RL-ER04 - Environmental Restoration Disposal Facility +RL-ST01 - PNNL Waste Management RL-WM03 - Solid Waste Storage and Disposal RL-WM04 - Solid Waste Treatment</p> <p>Rocky Flats Operations Office Rocky Flats Environmental Technology Site RF002 - Waste Management Project</p> <p>Savannah River Operations Office Savannah River Site +SR-SW01 - Consolidated Incinerator Facility +SR-SW02 - Transuranic Waste Project +SR-SW03 - Mixed Low Level Waste Project +SR-SW04 - Low Level Waste Project</p> <p>+ Projects which must remain active from the year 2007 and beyond to manage high risks.</p>

Exhibit 12. MIXED WASTE, continued

AWARDS	ENVIRONMENTAL MANAGEMENT PROJECTS
<p>Inorganic Chemistry, continued</p> <p>Multiphase/Gaseous Chemistry</p> <p>54897-WA - The Sonophysics and Sonochemistry of Liquid Waste Quantification and Remediation</p> <p>59934-IN - Hazardous Gas Production by Alpha Particles in Solid Organic Transuranic Waste Matrices</p> <p>Solid/Solution Chemistry</p> <p>55115-TX - The Adsorption and Reaction of Halogenated Volatile Organic Compounds (VOC's) on Metal Oxides</p> <p>Materials Science</p> <p>Chemical and Structural Properties Of Storage Materials</p> <p>55110-MO - An Alternative Host Matrix Based on Iron Phosphate Glasses for the Vitrification of Specialized Nuclear Waste Forms</p> <p>Surface Chemistry</p> <p>55387-NM - Photooxidation of Organic Wastes Using Semiconductor Nanoclusters</p> <p>Microbial Science</p> <p>Microbial Genetics and Instrumentation</p> <p>60150-WA - Genetic Engineering of a Radiation-Resistant Bacterium for Biodegradation of Mixed Wastes</p> <p>Separations Chemistry</p> <p>Catalyst Chemistry and Waste Treatment</p> <p>54847-CO - Photocatalytic and Chemical Oxidation of Organic Compounds in Supercritical Carbon Dioxide</p> <p>55103-TN - Utilization of Kinetic Isotope Effects for the Concentration of Tritium</p> <p>Ligand Design And Ion-exchange</p> <p>54571-MA - Removal of Heavy Metals and Organic Contaminants from Aqueous Streams by Novel Filtration Methods</p> <p>54770-NM - New Anion-Exchange Resins for Improved Separations of Nuclear Materials</p> <p>54791-KS - Managing Tight-binding Receptors for New Separations Technologies</p> <p>54942-IN - Spectroscopy, Modeling and Computation of Metal Chelate Solubility in Supercritical CO₂</p> <p>55012-CO - Extraction and Recovery of Mercury and Lead from Aqueous Waste Streams Using Redox-active Layered Metal Chalcogenides</p> <p>55223-MO - De Novo Design of Ligands for Metal Separation</p> <p>60096-TN - Rational Synthesis of Imprinted Organofunctional Sol-Gel Materials for Toxic Metal Separation</p>	<p>Idaho Operations Office</p> <p>Idaho National Engineering and Environmental Laboratory</p> <p>Oak Ridge Operations Office</p> <p>Oak Ridge Reservation</p> <p>Richland Operations Office</p> <p>Hanford Site - Richland Operations Office</p> <p>Rocky Flats Operations Office</p> <p>Rocky Flats Environmental Technology Site</p> <p>Savannah River Operations Office</p> <p>Savannah River Site</p>

Nuclear Materials

The Department of Energy is the custodian of large quantities of nuclear materials which were left in the manufacturing and processing facilities after the United States halted its nuclear weapons production activities. After the Department halted weapons production, large quantities of unstable materials were left in the production line or stored in a condition unsuitable for long-term storage. Consequently, residues and other processing intermediates are present in various states at several sites under conditions that cannot assure long-term safety. These materials include plutonium solutions, plutonium metals and oxides, plutonium residues and compounds, highly enriched uranium, and nuclides of other actinide elements.

Research Needs

Five subcategories of needs were identified in the area of nuclear materials:

- Nuclear materials stabilization, including forms for long-term disposal
- Treatment methods for fissile materials
- Characterization of fissile materials behavior; thermodynamics and kinetics; interactions with organometallics, surfaces and organic residues; stabilization and storage
- Development of methods to verify integrity of storage containers, detect and/or prevent hydrogen buildup
- Development and maintenance of robotic technology to minimize personnel exposure and handling of storage containers

Research Awards

Of the 202 research awards funded by the EMSP to date, eight awards are primarily associated with nuclear materials research. These awards have potential linkages to cleanup work planned or currently being conducted at two Department of Energy sites (see Exhibits 13 and 14). Additional information on each award is available in Appendix B and on the World Wide Web at <http://www.em.doe.gov/science>.

Environmental Management Projects

There are three high cost nuclear materials projects planned or currently being conducted. Two of these projects manage a high potential risk to workers, the public, and/or the environment. The funding required for all nuclear materials projects in the Department is \$1.6 billion, in constant 1998 dollars, from the year 2007 and beyond.

Exhibit 13 identifies potential linkages among the research awards, science categories, Environmental Management problem areas, and cleanup activities planned or currently being conducted.

Exhibit 14 lists the research awards related to nuclear materials and ongoing high cost nuclear materials projects planned or currently being conducted at Department of Energy sites.

Exhibit 13. Potential Linkages of EMSP Research Awards to High Cost Nuclear Materials Environmental Management Projects by Operations Office

* Projects with costs greater than \$50M from the year 2007 and beyond and which have costs or quantities of materials associated with Nuclear Materials.
 + Projects which must remain active from the year 2007 and beyond to manage high risks.

WGB-97-0237 Nuclear Materials
04/02/98

Exhibit 14. Nuclear Materials Related EMSP Research Awards by Science Category and Associated High Cost Environmental Management Projects by Operations Office

NUCLEAR MATERIALS	
AWARDS	ENVIRONMENTAL MANAGEMENT PROJECTS
<p>Actinide Chemistry Actinide (Heavy Element) Chemistry 59967-NM - Aqueous Electrochemical Mechanisms in Actinide Residue Processing 60319-CA - Thermodynamics of the Volatilization of Actinide Metals in the High-Temperature Treatment of Radioactive Wastes</p> <p>Analytical Chemistry and Instrumentation Sensors and Techniques 60247-IL - Miniature Nuclear Magnetic Resonance Spectrometer for In-Situ and In-Process Analysis and Monitoring</p> <p>Engineering Science Design, Process and Modeling 60077-TN - Development of Nuclear Analysis Capabilities for DOE Waste Management Activities</p> <p>Materials Science Chemical and Structural Properties Of Storage Materials 55094-CA - Chemical and Ceramic Methods Toward Safe Storage of Actinides Using Monazite 60118-NM - Fundamental Thermodynamics of Actinide-Bearing Mineral Waste Forms 60387-WA - Distribution & Solubility of Radionuclides & Neutron Absorbers in Waste Forms for Disposition of Plutonium Ash & Scraps, Excess Plutonium, and Miscellaneous Spent Nuclear Fuels</p> <p>Radiation Effects On Storage Materials 55382-IL - Determination of Transmutation Effects in Crystalline Waste Forms</p>	<p>Richland Operations Office Hanford Site - Richland Operations Office +RL-TP02 - Waste Encapsulation and Storage Facility (WESF) Sub-Project +RL-TP07 - Plutonium Finishing Plant (PFP) Vault Management</p> <p>Savannah River Operations Office Savannah River Site SR-NM06 - Nuclear Materials Storage</p> <p>+ Projects which must remain active from the year 2007 and beyond to manage high risks.</p>

Remedial Action

Remediation includes environmental problems associated with hazardous and radioactive contaminants in soil and groundwater that exist throughout the Department of Energy complex, including radionuclides, heavy metals, and dense, nonaqueous phase liquids. More than 5,700 known Department of Energy groundwater plumes have contaminated over 600 billion gallons of water and 50 million cubic meters of soil. Migration of these plumes threatens local and regional water sources and in some cases, has already adversely impacted off-site resources. In addition, the Department is responsible for the remediation of numerous landfills at Department facilities. These landfills are estimated to contain over three million cubic meters of radioactive and hazardous buried waste, some of which has migrated to the surrounding soils and groundwater. Currently available cleanup technologies are inadequate or unacceptable due to excessive costs, increased risks, long schedules, or the production of secondary waste streams. A window for opportunity is thus provided for EMSP to inject new innovative research.

Research Needs

Four subcategories of needs were identified in the area of remedial action:

- Characterization and location of contamination in soil and groundwater
- Removal/remediation of contaminants in groundwater and soils
- Separations of radionuclides from hazardous contaminants for treatment and disposal
- Prediction of future contamination and migration of contaminants

Research Awards

Of the 202 research awards funded by the EMSP to date, 82 awards are primarily associated with remedial action research needs. These awards have potential linkages to cleanup work planned or currently being conducted at twelve Department of Energy sites (see Exhibits 15 and 16). Additional information on each award is available in Appendix B and on the World Wide Web at <http://www.em.doe.gov/science>.

Environmental Management Projects

There are 23 high cost remedial action projects planned or currently being conducted. Eleven of these projects manage a high potential risk to workers, the public, and/or the environment. The funding required for all remedial action projects in the Department is \$6.1 billion, in constant 1998 dollars, from the year 2007 and beyond.

Exhibit 15 identifies potential linkages among the research awards, science categories, Environmental Management problem areas, and cleanup activities planned or currently being conducted.

Exhibit 16 lists the research awards related to remedial action and ongoing remedial action projects planned or currently being conducted at Department of Energy sites.

**Exhibit 15. Potential Linkages of EMSP Research Awards to High Cost Remedial Action
Environmental Management Projects by Operations Office**

* Projects with costs greater than \$50M from the year 2007 and beyond and which have costs or quantities of materials associated with Remedial Action.
 + Projects which must remain active from the year 2007 and beyond to manage high risks.

WGB-97-0337 Remedial Action 04/17/98

Exhibit 16. Remedial Action Related EMSP Research Awards by Science Category and Associated High Cost Environmental Management Projects by Operations Office

REMEDIAL ACTION	
AWARDS	ENVIRONMENTAL MANAGEMENT PROJECTS
<p>Actinide Chemistry Actinide (Heavy Element) Chemistry 54683-MA - Speciation and Structural Characterization of Plutonium and Actinide-organic Complexes in Surface and Groundwaters 54893-FL - Research Program to Determine Redox Properties and Their Effects on Speciation and Mobility of Pu in DOE Wastes 59996-NM - Plutonium Speciation, Solubilization, and Migration in Soils</p> <p>Analytical Chemistry and Instrumentation Biomedical Instrumentation 54698-CA - Rapid Mass Spectrometric DNA Diagnostics for Assessing Microbial Community Activity During Bioremediation 55108-TN - Monitoring Genetic & Metabolic Potential for In Situ Bioremediation: Mass Spectrometry</p> <p>Laser Ablation Techniques 55205-SC - A Fundamental Study of Laser-Induced Breakdown Spectroscopy Using Fiber Optics for Remote Measurements of Trace Metals</p> <p>Sensors and Techniques 54639-NM - Development of an In-Situ Microsensor for the Measurements of Chromium and Uranium in Groundwater at DOE Sites 54800-WA - Construction of Bending Magnet Beamline at the APS for Environmental Studies 55328-TN - Novel Analytical Techniques Based on an Enhanced Electron Attachment Process 60197-TN - Microsensors for In-situ Chemical, Physical, and Radiological Characterization of Mixed Waste</p> <p>Biogeochemistry Biogeochemistry 54790-CAN-ON - Microbial Mineral Transformations at the Fe(II)/Fe(III) Redox Boundary for Solid Phase Capture of Strontium and Other Metal/Radionuclide Contaminants 55071-ME - Reduction and Immobilization of Radionuclides and Toxic Metal Ions Using Combined Zero Valent Iron and Anaerobic Bacteria 55164-AL - Advanced Experimental Analysis of Controls on Microbial Fe(III) Oxide Reduction 55267-TN - Containment of Toxic Metals and Radionuclides in Porous and Fractured Media: Optimizing Biogeochemical Reduction versus Geochemical Oxidation 55388-IL - Stable Isotopic Investigations of in situ Bioremediation of Chlorinated Organic Solvents</p> <p>Engineering Science Bioengineering 55013-TN - Biofiltration of Volatile Pollutants: Engineering Mechanisms for Improved Design, Long-term Operation, Prediction and Implementation</p> <p>Bubble Mechanics and Sonification 55374-IL - Use of Sonication for In-Well Softening of Semivolatile Organic Compounds Diagnostics 54857-NM - Surface Nuclear Magnetic Resonance Imaging of Water Content Distribution in the Subsurface</p>	<p>Albuquerque Operations Office Grand Junction Office AL024 - Grand Junction Office (GJO) All Other Projects Kansas City Plant AL007 - Environmental Restoration Los Alamos National Laboratory AL009 - LANL Environmental Restoration</p> <p>Idaho Operations Office Idaho National Engineering and Environmental Laboratory +ID-ER-103 - Idaho Chemical Processing Plant Remediation ID-ER-106 - Radioactive Waste Management Complex Remediation ID-ER-109 - Remediation Operations</p> <p>Nevada Operations Office Nevada Test Site NV212 - Underground Test Area (UGTA) NV214 - Industrial Sites</p> <p>Oak Ridge Operations Office Oak Ridge Reservation OR-42101 - Y-12 East Fork Poplar Creek Remedial Action +OR-43203 - ORNL Bethel Valley Remedial Action +OR-44301 - East Tennessee Technology Park (ETTP) Remedial Action +OR-48101 - Offsite Remedial Action</p> <p>Paducah Gaseous Diffusion Plant +OR-45301 - Paducah Remedial Action</p> <p>Portsmouth Gaseous Diffusion Plant +OR-46301 - Portsmouth Remedial Action</p> <p>Ohio Operations Office Fernald Environmental Management Project +OH-FN-07 - Silos</p> <p>Richland Operations Office Hanford Site - Richland Operations Office +RL-ER01 - 100 Area Remedial Action +RL-ER02 - 200 Area Remedial Action +RL-ER03 - 300 Area Remedial Action RL-ER08 - Groundwater Management</p> <p>Rocky Flats Operations Office Rocky Flats Environmental Technology Site RF013 - Closure Caps Project RF014 - Industrial Zone Closure Project</p> <p>Savannah River Operations Office Savannah River Site SR-ER03 - Lower Three Runs & Operations Project +SR-ER06 - Upper Three Runs Project</p> <p>+ Projects which must remain active from the year 2007 and beyond to manage high risks.</p>

Exhibit 16. REMEDIAL ACTION, continued

AWARDS	ENVIRONMENTAL MANAGEMENT PROJECTS
<p>Geochemistry</p> <p>Colloidal Chemistry and Transport</p> <p>55284-CA - Aquifer Transport of Th, U, Ra, and Rn in Solution and on Colloids</p> <p>55351-CA - Evaluation of Isotopic Diagnostics for Subsurface Characterization and Monitoring: Field Experiments at the TAN and RWMC (SDA) Sites, INEL</p> <p>Sorption/Desorption</p> <p>54548-MI - The Efficacy of Oxidative Coupling for Promoting In-Situ Immobilization of Hydroxylated Aromatics in Contaminated Soil and Sediment Systems</p> <p>54585-OH - Permanganate Treatment of DNAPLs in Reactive Barriers and Source Zone Flooding Schemes</p> <p>54635-WA - Molecular-Level Process Governing the Interaction of Contaminants with Iron and Manganese Oxides</p> <p>54741-NM - Characterization of Contaminant Transport Using Naturally-Occurring U-Series Disequilibria</p> <p>54823-NM - Modeling of Cation Binding in Hydrated 2:1 Clay Minerals</p> <p>54860-CA - Sorption of Heavy Metals and Radionuclides on Mineral Surfaces in the Presence of Organic Co-Contaminants</p> <p>55014-AL - Kinetics and Mechanisms of Metal Retention/Release in Geochemical Processes in Soil</p> <p>55148-CA - Hydrologic and Geochemical Controls on the Transport of Radionuclides in Natural Undisturbed Arid Environments as Determined by Accelerator Mass Spectrometry Measurements</p> <p>55249-CA - Experimental Determination of Contaminant Metal Mobility as a Function of Temperature Time and Solution Chemistry</p> <p>55396-CA - Sorption of Colloids, Organics, and Metals onto Gas-Water Interfaces: Transport Mechanisms and Potential Remediation Technology</p> <p>60355-WA - Mineral Surface Processes Responsible for the Decreased Retardation (or Enhanced Mobilization) of 137Cs from HLW Tank Discharges</p> <p>Geophysics</p> <p>Subsurface Imaging</p> <p>54655-CA - Collaborative Research: Hydrogeological-Geophysical Methods for Subsurface Site Characterization</p> <p>54699-CAN-BC - The Use of Dielectric and NMR Measurements to Determine the Pore-Scale Location of Organic Contaminants</p> <p>55011-CA - Surface and Borehole Electromagnetic Imaging of Conducting Contaminant Plumes</p> <p>55218-GA - Seismic Surface-Wave Tomography of Waste Sites</p> <p>55300-MA - 3-D Spectral IP Imaging: Non-Invasive Characterization of Contaminant Plumes</p> <p>55332-NM - A Hybrid Hydrologic-Geophysical Inverse Technique for the Assessment and Monitoring of Leachates in the Vadose Zone</p> <p>55411-CA - Joint Inversion of Geophysical Data for Site Characterization and Restoration Monitoring</p> <p>60115-TX - Advanced High Resolution Seismic Imaging, Material Properties Estimation and Full Wavefield Inversion for the Shallow Subsurface</p>	<p>Albuquerque Operations Office</p> <p>Grand Junction Office</p> <p>Kansas City Plant</p> <p>Los Alamos National Laboratory</p> <p>Idaho Operations Office</p> <p>Idaho National Engineering and Environmental Laboratory</p> <p>Nevada Operations Office</p> <p>Nevada Test Site</p> <p>Oak Ridge Operations Office</p> <p>Oak Ridge Reservation</p> <p>Paducah Gaseous Diffusion Plant</p> <p>Portsmouth Gaseous Diffusion Plant</p> <p>Ohio Operations Office</p> <p>Fernald Environmental Management Project</p> <p>Richland Operations Office</p> <p>Hanford Site - Richland Operations Office</p> <p>Rocky Flats Operations Office</p> <p>Rocky Flats Environmental Technology Site</p> <p>Savannah River Operations Office</p> <p>Savannah River Site</p>

Exhibit 16. REMEDIAL ACTION, continued

AWARDS	ENVIRONMENTAL MANAGEMENT PROJECTS
<p>Geophysics, continued</p> <p>Subsurface Imaging, continued</p> <p>60162-CO - Enhancements to and Characterization of the Very Early Time Electromagnetic (VETEM) Prototype Instrument and Applications to Shallow Subsurface Imaging at Sites in the DOE Complex</p> <p>60199-KS - Seismic-Reflection and Ground Penetrating Radar for Environmental Site Characterization</p> <p>60328-CA - High Frequency Electromagnetic Impedance Measurements for Characterization, Monitoring and Verification Efforts</p> <p>Health Science</p> <p>Molecular, Structural and Genomic Science</p> <p>55033-TN - Characterization of Chemically Modified Hyperthermophilic Enzymes for Chemical Syntheses and Bioremediation Reactions</p> <p>55185-TX - New Strategies for Designing Inexpensive but Selective Bioadsorbents for Environmental Pollutants: Selection of Specific Ligands & Their Cell Surface Expression</p> <p>55343-CA - Enzyme Engineering for Biodegradation of Chlorinated Organic Pollutants</p> <p>Hydrogeology</p> <p>Dense Non-Aqueous Phase Liquid (DNAPL) Dynamics</p> <p>54680-MI - The Migration and Entrapment of DNAPLs in Physically and Chemically Heterogeneous Porous Media</p> <p>54908-AZ - Partitioning Tracers for In Situ Detection and Quantification of Dense Nonaqueous Phase Liquids in Groundwater Systems</p> <p>55083-TN - Behavior of Dense, Immiscible Solvents in Fractured Clay-Rich Soils</p> <p>55196-OR - In Situ, Field Scale Evaluation of Surfactant Enhanced DNAPL Recovery Using a Single-Well, Push-Pull Test</p> <p>55216-TX - In-Situ Characterization of Dense Non-Aqueous Phase Liquids Using Partitioning Tracers</p> <p>55395-NM - Physics of DNAPL Migration and Remediation in the Presence of Heterogeneities</p> <p>60158-OR - Development of Radon-222 as a Natural Tracer for Monitoring the Remediation of NAPL Contamination in the Subsurface</p> <p>Fluid-flow and Colloidal Dynamics</p> <p>54888-MA - Manipulating Subsurface Colloids to Enhance Cleanups of DOE Waste Sites</p> <p>55036-TN - Colloid Transport and Retention in Fractured Deposits</p> <p>Instrumentation and Modelling</p> <p>54576-IN - On the Inclusion of the Interfacial Area Between Phases in the Physical and Mathematical Description of Subsurface Multiphase Flow</p> <p>54793-NY - Establishing a Quantitative Functional Relationship Between Capillary Pressure Saturation and Interfacial Area</p> <p>54950-CA - Characterization of Contaminant Transport by Gravity, Capillarity and Barometric Pumping in Heterogeneous Vadose Regimes</p> <p>55109-NM - New Permeameters for in situ Characterization of Unsaturated Heterogeneous Permeability</p>	<p>Albuquerque Operations Office</p> <p>Grand Junction Office</p> <p>Kansas City Plant</p> <p>Los Alamos National Laboratory</p> <p>Idaho Operations Office</p> <p>Idaho National Engineering and Environmental Laboratory</p> <p>Nevada Operations Office</p> <p>Nevada Test Site</p> <p>Oak Ridge Operations Office</p> <p>Oak Ridge Reservation</p> <p>Paducah Gaseous Diffusion Plant</p> <p>Portsmouth Gaseous Diffusion Plant</p> <p>Ohio Operations Office</p> <p>Fernald Environmental Management Project</p> <p>Richland Operations Office</p> <p>Hanford Site - Richland Operations Office</p> <p>Rocky Flats Operations Office</p> <p>Rocky Flats Environmental Technology Site</p> <p>Savannah River Operations Office</p> <p>Savannah River Site</p>

Exhibit 16. REMEDIAL ACTION, continued

AWARDS	ENVIRONMENTAL MANAGEMENT PROJECTS
<p>Hydrogeology, continued</p> <p>Instrumentation and Modelling, continued</p> <p>55359-CA - Chaotic-Dynamical Conceptual Model to Inorganic Chemistry Describe Fluid Flow and Contaminant Transport in a Fractured Vadose Zone</p> <p>60069-VT - Least-Cost Groundwater Remediation Design Multiphase/gaseous Chemistry Using Uncertain Hydrogeological Information</p> <p>Inorganic Chemistry</p> <p>Multiphase/Gaseous Chemistry</p> <p>54834-IN - An Investigation of Homogeneous and Heterogeneous Sonochemistry for Destruction of Hazardous Waste</p> <p>55119-TN - Phase Equilibria Modification by Electric Fields</p> <p>Solid/Solution Chemistry</p> <p>55061-CA - Fundamental Studies of the Removal of Contaminants from Ground and Waste Waters via Reduction by Zero-Valent Metals</p> <p>Microbial Science</p> <p>Biodegradation and Biotransformation</p> <p>54666-CA - Mechanisms, Chemistry, and Kinetics of Anaerobic Biodegradation of Cis-Dichloroethylene and Vinyl Chloride</p> <p>55105-MI - Complete Detoxification of Short Chain Chlorinated Aliphatics: Isolation of Halorespiring Organisms and Biochemical Studies of the Dehalogenating Enzyme Systems</p> <p>Microbial Genetics and Instrumentation</p> <p>55031-WA - Genetic Analysis of Stress Responses in Soil Bacteria for Enhanced Bioremediation of Mixed Contaminants</p> <p>55152-MD - Molecular Profiling of Microbial Communities from Contaminated Sources: Use of Subtractive Cloning Methods and rDNA Spacer Sequences</p> <p>59786-MD - Design and Construction of <i>Deinococcus radiodurans</i> for Biodegradation of Organic Toxins at Radioactive DOE Waste Sites</p> <p>Microbial Transport</p> <p>54681-CA - Dynamics of Coupled Contaminant and Microbial Transport in Heterogeneous Porous Media</p> <p>55264-CA - Subsurface High Resolution Definition of Subsurface Heterogeneity for Understanding the Biodynamics of Natural Field Systems: Advancing the Ability for Scaling to Field Conditions</p> <p>55416-ID - Control of Biologically Active Degradation Zones by Vertical Heterogeneity: Applications in Fractured Media</p> <p>Plant Science</p> <p>Plant Genetics</p> <p>54837-GA - Phytoremediation of Ionic and Methyl Mercury Pollution</p> <p>55278-CA - Molecular Genetics of Metal Detoxification: Prospects for Phytoremediation</p> <p>Plant Membrane Transport</p> <p>54898-AZ - Molecular Dissection of the Cellular Mechanisms Involved in Nickel Hyperaccumulation in Plants</p> <p>55041-CA - Molecular Characterization of a Novel Heavy Metal Uptake Transporter from Higher Plants & its Potential for Use in Phytoremediation</p>	<p>Albuquerque Operations Office</p> <p>Grand Junction Office</p> <p>Kansas City Plant</p> <p>Los Alamos National Laboratory</p> <p>Idaho Operations Office</p> <p>Idaho National Engineering and Environmental Laboratory</p> <p>Nevada Operations Office</p> <p>Nevada Test Site</p> <p>Oak Ridge Operations Office</p> <p>Oak Ridge Reservation</p> <p>Paducah Gaseous Diffusion Plant</p> <p>Portsmouth Gaseous Diffusion Plant</p> <p>Ohio Operations Office</p> <p>Fernald Environmental Management Project</p> <p>Richland Operations Office</p> <p>Hanford Site - Richland Operations Office</p> <p>Rocky Flats Operations Office</p> <p>Rocky Flats Environmental Technology Site</p> <p>Savannah River Operations Office</p> <p>Savannah River Site</p>

Exhibit 16. REMEDIAL ACTION, continued

AWARDS	ENVIRONMENTAL MANAGEMENT PROJECTS
<p>Plant Science, continued</p> <p>Plant Membrane Transport, continued</p> <p>55097-CA - Heavy Metal Pumps in Plants</p> <p>60271-NH - Characterization of a New Family of Metal Plant Metabolism Transport Proteins</p> <p>54889-WA - Using Trees to Remediate Groundwaters Contaminated with Chlorinated Hydrocarbons</p> <p>55118-CA - Plant Rhizosphere Effects on Metal Mobilization and Transport</p> <p>Separations Chemistry</p> <p>Catalyst Chemistry and Waste Treatment</p> <p>54122-PA - A Broad Spectrum Catalytic System for Removal of Toxic Organics from Water By Deep Oxidation</p> <p>54661-DE - Electrochemical Processes for In-Situ Treatment of Contaminated Soils</p> <p>Ligand Design And Ion-exchange</p> <p>54926-CA - Novel Ceramic-Polymer Composite Membranes for the Separation of Hazardous Liquid Waste</p>	<p>Albuquerque Operations Office</p> <p>Grand Junction Office</p> <p>Kansas City Plant</p> <p>Los Alamos National Laboratory</p> <p>Idaho Operations Office</p> <p>Idaho National Engineering and Environmental Laboratory</p> <p>Nevada Operations Office</p> <p>Nevada Test Site</p> <p>Oak Ridge Operations Office</p> <p>Oak Ridge Reservation</p> <p>Paducah Gaseous Diffusion Plant</p> <p>Portsmouth Gaseous Diffusion Plant</p> <p>Ohio Operations Office</p> <p>Fernald Environmental Management Project</p> <p>Richland Operations Office</p> <p>Hanford Site - Richland Operations Office</p> <p>Rocky Flats Operations Office</p> <p>Rocky Flats Environmental Technology Site</p> <p>Savannah River Operations Office</p> <p>Savannah River Site</p>

Decontamination and Decommissioning

The Department of Energy must decontaminate and decommission a large number of aging, surplus facilities. The nature and magnitude of the facility decontamination, decommissioning, and material disposition problems require the Department to address these problems quickly and cost-effectively. The Department is attempting to solve the problems of 7,000 buildings that require deactivation and 900 buildings, including their contents, that require decommissioning. The Department is also responsible for decontaminating the metal and concrete within those buildings and disposing of 180,000 metric tons of scrap metal.

Decommissioning is the process of returning equipment and structures to a desired end state for a facility. Desired end states include complete removal and remediation of the facility, release of the facility for unrestricted use, or release of the facility for restricted use. Decontamination is the removal of unwanted radioactive or hazardous contamination by a chemical or mechanical process. Deactivation refers to ceasing facility operations and placing the facility in a safe and stable condition to prevent unacceptable exposure of people or the environment to radioactive or other hazardous materials until the facility can be decommissioned. Typically, deactivation involves removal of stored radioactive and other hazardous materials and the draining of systems.

Research Needs

Nine subcategories of needs were identified in the area of decontamination and decommissioning:

- Reduction of wastes produced by remediation and decontamination
- Characterization, monitoring, and certification of contaminated equipment facilities
- Control of radioactive emissions, especially from waste processing activities
- Improved methods for removing surface contamination, including metals, concrete, and non-porous surfaces
- Containment technologies/techniques to prevent spread of contamination
- Methods for size reduction in equipment
- Technologies for removal of hazardous materials, including asbestos and lead

- Remote handling and operations, including demolition
- Decontamination techniques for process equipment and facilities

Research Awards

Of the 202 research awards funded by the EMSP to date, nine awards are primarily associated with decontamination and decommissioning research needs. These awards have potential linkages to cleanup work planned or currently being conducted at six Department of Energy sites (see Exhibits 17 and 18). Additional information on each award is available in Appendix B and on the World Wide Web at <http://www.em.doe.gov/science>.

Environmental Management Projects

There are 22 high cost decontamination and decommissioning projects planned or currently being conducted. Seven of these projects manage a high potential risk to the workers, public and/or environment. The funding required for all decontamination and decommissioning projects in the Department is \$7.3 billion, in constant 1998 dollars, from the year 2007 and beyond.

Exhibit 17 identifies potential linkages among the research awards, science categories, Environmental Management problem areas, and cleanup activities or currently being conducted.

Exhibit 18 lists the research awards related to decontamination and decommissioning and ongoing decontamination and decommissioning projects planned or currently being conducted at Department of Energy sites.

Exhibit 17. Potential Linkages of EMSP Research Awards to High Cost Decontamination and Decommissioning Environmental Management Projects by Operations Office

* Projects with costs greater than \$50M from the year 2007 and beyond and which have costs or quantities of materials associated with Decontamination & Decommissioning.

+ Projects which must remain active from the year 2007 and beyond to manage high risks.

WOL-97-0237 Decontamination and Decommissioning
04/02/98

Exhibit 18. Decontamination and Decommissioning Related EMSP Research Awards by Science Category and Associated High Cost Environmental Management Projects by Operations Office

DECONTAMINATION AND DECOMMISSIONING	
AWARDS	ENVIRONMENTAL MANAGEMENT PROJECTS
<p>Engineering Science</p> <p>Robotics</p> <p>55052-SC - Advanced Sensing and Control Techniques to Facilitate Semi-Autonomous Decommissioning</p> <p>60040-NY - Development of Monitoring and Diagnostic Methods for Robots Used in Remediation of Waste Sites</p> <p>Inorganic Chemistry</p> <p>Solid/Solution Chemistry</p> <p>54724-NM - Synthesis of New Water-Soluble Metal-Binding Polymers: Combinatorial Chemistry Approach</p> <p>Materials Science</p> <p>Surface Chemistry</p> <p>54914-CA - Atmospheric-Pressure Plasma Cleaning of Contaminated Surfaces</p> <p>55380-IL - In-Situ Spectro-Electrochemical Studies of Radionuclide Contaminated Surface Films on Metals and the Mechanism of their Formation and Dissolution</p> <p>59925-WV - Modeling of Diffusion of Plutonium in Other Metals and of Gaseous Species in Plutonium-Based Systems</p> <p>Waste Materials</p> <p>60363-NM - Optimization of Thermochemical, Kinetic, and Electrochemical Factors Governing Partitioning of Radionuclides during Melt Decontamination of Radioactively Contaminated Stainless Steel</p> <p>Separations Chemistry</p> <p>Ligand Design And Ion-exchange</p> <p>60041-OK - Removal of Radioactive Cations and Anions from Polluted Water Using Ligand-Modified Colloid-Enhanced Ultrafiltration</p> <p>60283-IL - Waste Volume Reduction Using Surface Characterization and Decontamination by Laser Ablation</p>	<p>Albuquerque Operations Office</p> <p>Los Alamos National Laboratory</p> <p>+AL013 - LANL Waste Management - Legacy Waste</p> <p>Idaho Operations Office</p> <p>Idaho National Engineering and Environmental Laboratory</p> <p>ID-ER-110 - Decontamination and Decommissioning</p> <p>ID-OIM-113 - Post-2006 Surveillance, Maintenance, and Monitoring</p> <p>Oak Ridge Operations Office</p> <p>Oak Ridge Reservation</p> <p>+OR-43202 - ORNL Melton Valley Watershed Remedial Action</p> <p>OR-43204 - ORNL Bethel Valley Deactivation and Decommissioning</p> <p>OR-44302 - East Tennessee Technology Park (ETTP) Process Equipment D&D</p> <p>+OR-44303 - East Tennessee Technology Park (ETTP) D&D</p> <p>Oakland Operations Office</p> <p>Separations Process Research Unit</p> <p>SP-SPRU - Separations Process Research Unit (SPRU)</p> <p>Richland Operations Office</p> <p>Hanford Site - Richland Operations Office</p> <p>+RL-ER05 - Facility Surveillance & Maintenance - ADS 3500</p> <p>+RL-ER06 - Decontamination and Decommissioning</p> <p>RL-ER07 - Post Closure Surveillance & Maintenance</p> <p>+RL-TP05 - Plutonium Finishing Plant Deactivation</p> <p>RL-TP10 - Accelerated Deactivation</p> <p>+RL-TP13 - Landlord Project</p> <p>Savannah River Operations Office</p> <p>Savannah River Site</p> <p>SR-FA02 - F Canyon Deactivation Project</p> <p>SR-FA04 - H Canyon Deactivation Project</p> <p>SR-FA06 - 235-F Deactivation Project</p> <p>SR-FA16 - F-Area Monitoring</p> <p>SR-FA17 - H-Area Monitoring and Minor Facility Monitoring</p> <p>SR-FA18 - M Area Monitoring Project</p> <p>SR-FA20 - Reactors Monitoring Project</p> <p>SR-FA22 - Receiving Basin for Off-site Fuels (RBOF) Monitoring Project</p> <p>+ Projects which must remain active from the year 2007 and beyond to manage high risks.</p>

Health, Ecology, or Risk

There is scientific uncertainty about the levels of risk to human health and the environment at the end stages of the Department of Energy cleanup effort. Accurate risk analyses require thorough knowledge of contaminant characteristics, basic ecological processes and principles, rates at which contaminants move through ecosystems, and health and ecological effects. In particular, better knowledge of radionuclide and toxic chemical transport dynamics and the potential effects of long-term exposure to low levels of radionuclides, in combination with other contaminants, is essential. Research is required to improve understanding of threatened and damaged ecosystems and processes to restore the viability and quality of these ecosystems.

Research Needs

Eleven subcategories of needs were identified in the area of health, ecology, or risk:

- Identification of biological pathways and effects of contaminants in order to determine levels of risk
- Methods for determining the human health toxicity of contaminants
- Evaluation of the toxic effects of radioisotope/chemical synergisms on humans and biota
- Improved detection of hazardous conditions and development of protective equipment
- Methods of assessing worker exposure, including safety risks during remediation activities
- Understanding of soil properties and microorganism ecology to determine uptake of contaminants
- Understanding how remediation activities affecting surface water, groundwater, ecological systems, and emissions generated by remediation activities impact the environment
- Development of comprehensive long-term models of ecological systems
- Development of methods for relating cleanup levels to environmental risk
- Development of a credible risk assessment tool to evaluate residual and cumulative risk
- Determining the risk of seismic activity

Research Awards

Of the 202 research awards funded by the EMSP to date, 18 awards are primarily associated with health, ecology or risk research. Because health, ecology, or risk is a cross-cutting problem area, these awards have potential linkages to cleanup work currently being conducted across the Department of Energy complex. Additional information on each award is available in Appendix B and on the World Wide Web at <http://www.em.doe.gov/science>.

Environmental Management Projects

Health, ecology and risk projects are cross-cutting. There are 38 high cost projects which may pose high or urgent risks to workers, the public, or the environment if discontinued from the year 2007 and beyond, based on the March 1998 *Paths to Closure* data. The funding for all high cost/high risk projects in the Department is \$48.3 billion, in constant 1998 dollars, from the year 2007 and beyond.

Exhibit 19 identifies potential linkages among the research awards, science categories, Environmental Management problem areas, and cleanup activity planned or currently being conducted.

Exhibit 20 lists the research awards related to health, ecology, or risk and ongoing high cost/high risk projects planned or currently being conducted at Department of Energy sites.

Exhibit 19. Potential Linkages of EMSP Research Awards to High Cost Health/Ecology/Risk Environmental Management Projects by Operations Office

^o Projects with costs greater than \$50M from the year 2007 and beyond and which have costs or quantities of materials associated with one of the six Environmental Management problem areas.

+ Projects which must remain active from the year 2007 and beyond to manage high risks.

WGB.97-0257 Health / Ecology / Risk
04/02/98

Exhibit 20. Health/Ecology/Risk Related EMSP Research Awards by Science Category and Associated High Cost Environmental Management Projects by Operations Office

HEALTH / ECOLOGY / RISK	
AWARDS	HIGH COST & HIGH RISK ENVIRONMENTAL MANAGEMENT PROJECTS
<p>Analytical Chemistry and Instrumentation</p> <p>Biomedical Instrumentation</p> <p>60218-TN - Novel Mass Spectrometry Mutation Screening for Contaminant Impact Analysis</p> <p>Sensors and Techniques</p> <p>60163-NM - Investigation of Techniques to Improve Continuous Air Monitors Under Conditions of High Dust Loading in Environmental Setting</p> <p>60474-OH - Develop and Demonstrate Novel Ultrahigh Sensitivity Heavy Noble Gas Detectors for Long-Term Monitoring of Spent Fuel and TRU Waste</p> <p>Biogeochemistry</p> <p>Biogeochemistry</p> <p>60015-NM - Long-term Risk from Actinides in the Environment: Modes of Mobility</p> <p>Health Science</p> <p>Biophysics/Dose</p> <p>54584-NJ - Comparison of the Bioavailability of Elemental Waste Laden Soils Using in vivo and in vitro Analytical Methodology, and Refinement of Exposure/Dose Models</p> <p>59882-NY - Measurements of Radon, Thoron, Isotopic Uranium and Thorium to Determine Occupational & Environmental Exposure & Risk at Fernald Feed Materials Production Center</p> <p>59918-NM - Improved Radiation Dosimetry/Risk Estimates to Facilitate Environmental Management of Plutonium Contaminated Sites</p> <p>Health Effects</p> <p>54684-WA - Mechanism Involved in Trichloroethylene-Induced Liver Cancer: Importance to Environmental Cleanup</p> <p>55032-LA - Environmental Analysis of Endocrine Disrupting Effects from Hydrocarbon Contaminants in the Ecosystem</p> <p>55356-CA - Environmentally-induced Malignancies: An In Vivo Model to Evaluate the Health Impact of Chemicals in Mixed Waste</p> <p>Molecular, Structural and Genomic Science</p> <p>54546-CA - Engineered Antibodies for Monitoring of Polynuclear Aromatic Hydrocarbons</p> <p>54856-PA - Structural Biology of the Sequestration & Transport of Heavy Metal Toxins: NMR Structure Determination of Proteins Containing the -Cys-X-Y-Cys-metal Binding Motifs</p> <p>54931-VT - A Novel Biomarker for Beryllium Sensitization in Humans</p> <p>55100-NY - Human Genetic Marker for Resistance to Radiations and Chemicals</p>	<p>Albuquerque Operations Office</p> <p>Los Alamos National Laboratory</p> <p>+AL013 - LANL Waste Management - Legacy Waste</p> <p>Idaho Operations Office</p> <p>Idaho National Engineering and Environmental Laboratory</p> <p>+ID-ER-103 - Idaho Chemical Processing Plant Remediation</p> <p>+ID-HLW-103 - High-Level Waste Treatment and Storage</p> <p>Oak Ridge Operations Office</p> <p>Oak Ridge Reservation</p> <p>+OR-38111 - Mixed Low Level Waste Management</p> <p>+OR-43203 - ORNL Bethel Valley Remedial Action</p> <p>+OR-44301 - East Tennessee Technology Park (ETTP) Remedial Action</p> <p>+OR-48101 - Offsite Remedial Action</p> <p>Paducah Gaseous Diffusion Plant</p> <p>+OR-45301 - Paducah Remedial Action</p> <p>Portsmouth Gaseous Diffusion Plant</p> <p>+OR-46301 - Portsmouth Remedial Action</p> <p>+OR-43202 - ORNL Melton Valley Watershed Remedial Action</p> <p>+OR-44303 - East Tennessee Technology Park (ETTP) D&D</p> <p>Ohio Operations Office</p> <p>Fernald Environmental Management Project</p> <p>+OH-FN-07 - Silos</p> <p>Richland Operations Office</p> <p>Hanford Site - Richland Operations Office</p> <p>+RL-ER01 - 100 Area Remedial Action</p> <p>+RL-ER02 - 200 Area Remedial Action</p> <p>+RL-ER03 - 300 Area Remedial Action</p> <p>+RL-ER05 - Facility Surveillance & Maintenance - ADS 3500</p> <p>+RL-ER06 - Decontamination and Decommissioning</p> <p>+RL-ST01 - PNNL Waste Management</p> <p>+RL-TP02 - Waste Encapsulation and Storage Facility (WESF) Sub-Project</p> <p>+RL-TP05 - Plutonium Finishing Plant Deactivation</p> <p>+RL-TP07 - Plutonium Finishing Plant (PFP) Vault Management</p> <p>+RL-TP13 - Landlord Project</p> <p>+ Projects which must remain active from the year 2007 and beyond to manage high risks.</p>

Exhibit 20. HEALTH / ECOLOGY / RISK, Continued

AWARDS	HIGH COST & HIGH RISK ENVIRONMENTAL MANAGEMENT PROJECTS
Health Science, continued Risk Assessment 54940-NM - Improved Risk Estimates for Carbon Tetrachloride 55410-SC - Determining Significant Endpoints for Ecological Risk Analyses 59828-CA - Bioavailability of Organic Solvents in Soils: Input into Biologically Based Dose-Response Models for Human Risk Assessments 60037-TN - Estimation of Potential Population Level Effects of Contaminants on Wildlife	Richland Operations Office, continued Hanford Site - Richland Operations Office, continued +RL-TW04 - Retrieval Project +RL-TW05 - Process Waste Support +RL-TW06 - Process Waste Privatization Phase I +RL-TW07 - Process Waste Privatization Phase II +RL-TW08 - Process Waste Privatization Infrastructure +RL-WM05 - Liquid Effluents Project Savannah River Operations Office Savannah River Site +SR-ER06 - Upper Three Runs Project +SR-HL01 - H-Tank Farm +SR-HL02 - F-Tank Farm +SR-HL04 - In Tank Precipitation/Extended Sludge Processing/Late Wash (ITP/ESP/LW) Operations +SR-SF02 - L-Reactor Spent Nuclear Fuel Project +SR-SF09 - Spent Nuclear Fuel Transfer and Storage +SR-SW01 - Consolidated Incinerator Facility +SR-SW02 - Transuranic Waste Project +SR-SW03 - Mixed Low Level Waste Project +SR-SW04 - Low Level Waste Project + Projects which must remain active from the year 2007 and beyond to manage high risks.

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IV. Capitalizing on Science Investments

The Environmental Management Science Program (EMSP) shares a number of characteristics with other similar scientific endeavors. By the very nature of basic science, exploring and explaining the unknown, the outcomes are often achieved after years of careful, persistent study. Furthermore, scientific advances are most often incremental improvements in existing knowledge rather than monumental breakthroughs that fundamentally change the way we do things. Moreover, scientific advances are sometimes the result of unexpected outcomes. Implications of these realities about the nature of scientific investigations are two-fold. Outcomes of a scientific investigation cannot be scheduled or predicted. This unpredictability of scientific endeavors—in terms of schedule and outcome—makes it difficult for Environmental Management problem holders to factor scientific results into their program plans. Environmental Management problem holders need technical solutions to meet near-term compliance driven requirements, while scientific advances generally have a long time frame, and will provide benefits that can be factored into Environmental Management's long-term plans. While the EMSP cannot change these scientific realities, it can establish an environment that capitalizes on the Department's past, present, and future scientific investments. This environment can be created through effective collaboration and communication between and among all interested and affected parties.

Collaboration and communication are a cornerstone of the EMSP. The EMSP is a collaborative partnership between the Offices of Environmental Management and Energy Research. This partnership capitalizes on over four decades of the Office of Energy Research's research investments and research management experience and the Office of Environmental Management's understanding of the technical barriers the Environmental Management Program faces. This collaboration has already paid dividends in the form of important research results after only one year. This was possible because the EMSP focused its research efforts and leveraged the other related research investments and experience of the Department. For example, the EMSP benefits from the Environmental Management/Energy Research partnership by leveraging and capitalizing on Office of Energy Research investments such as the Natural and Accelerated Bioremediation Research program, a new program to explore the use of naturally occurring and genetically engineered bacteria for cleanup. Results of this program are factored into the ongoing EMSP research needs analysis process.

Importance of Collaboration and Communication

Because effective collaboration and communications are essential elements of a successful science program, the characteristics of the Environmental Management/Energy Research partnership include all EMSP participants. Collaboration and communication capitalize on the collective wisdom of the scientific community, provide synergy between and among all

participants, facilitate a sharing of perspectives between scientists and problem holders, and serve a continuous review function.

An effective collaboration and communication network is a complex network of relationships among a large universe of interested and affected parties. In the case of the EMSP, this network includes the EMSP, problem holders, scientists, technology developers, regulators, and stakeholders. For example, collaboration may be between scientists in the same institution or different institutions working on the same or similar problems.

The EMSP is working to foster collaboration and communication between and among researchers, problem holders, regulators, and stakeholders. Innovative working relationships or collaborations can ensure that research investments advance an understanding of underlying problems, technology development and ultimately the early, cost-effective achievement of Environmental Management's cleanup objectives. Timely dissemination of the research results to as large an audience as possible will facilitate the application and use of the scientific investment. EMSP has been able to build upon the communication strategies already in place within the Offices of Environmental Management and Energy Research to effectively leverage existing pathways for communicating EMSP scientific information.

Information flow is critical to innovation. Through real-time information dissemination, EMSP can enhance information flow and foster collaborations to develop innovative solutions to cleanup problems. This will enable EMSP to stimulate the communication between the scientific community, the Department of Energy, stakeholders, and regulators. It will also enable the EMSP to define the underlying research needs for Environmental Management's high cost problems.

The transfer of information, including research results, from researchers to problem holders is often a circuitous path. Effective collaboration and communication can facilitate the transfer of information to all interested parties. The principles of transferring new scientific information were stated in the National Research Council's report, *Building an Effective Environmental Management Science Program*: "...the movement of new knowledge and insights from investigators to full scale application is a slow and diffuse process—a process without clear pathways in most cases."¹⁴

¹⁴ *Building an Effective Environmental Management Science Program*, Final Assessment Report, National Research Council, June 1997, page 66.

Collaboration and Communications Strategy

The EMSP will serve as a catalyst for advances in scientific knowledge that lead to the development and deployment of technologies to reduce life cycle costs, and risks associated with the environmental cleanup program. Improving communication can be a formidable challenge and a costly endeavor. There are several barriers to effective communication. Communities involved in the science-to-technology development/deployment process (e.g., scientists, technologists, problem holders, stakeholders, regulators) often use different "languages" to communicate their interests, concerns and accomplishments. Furthermore, there is often a natural inertia that must be overcome to stimulate a productive dialogue among these communities. The cost of effective communications can be high if program-specific communication networks are established and administered.

For the EMSP, serving as a catalyst involves acting as an agent of change, removing "language" barriers, stimulating and using existing infrastructures when possible, bridging infrastructure gaps when necessary, using cutting edge communication tools, making strategic investments, and providing incentives for the use of research results.

The EMSP will fulfill its role as an agent of change by creating an environment to maximize the products of the EMSP and the use of resulting information. This will be accomplished by:

- Establishing an effective information network
- Fostering effective communications
- Encouraging scientific collaboration
- Providing for information analysis, integration and management

Establishing an Effective Information Network. The EMSP already has an infrastructure upon which to build an effective information network. This network includes established communication over the Internet and the World Wide Web. The Office of Energy Research has an established reporting system and a cadre of research managers who serve as points of contact for researchers. In addition, the Department of Energy's Office of Scientific and Technical Information serves as a clearinghouse and distribution point for research publications.

Internet tools such as the World Wide Web and electronic mail are providing real-time access to information about the EMSP. The EMSP home page, at www.em.doe.gov/science ties these resources together and provides links to program information such as the research portfolio, solicitation announcements, news, events, and links to pertinent documents. The research portfolio database is maintained by the Office of Scientific and Technical Information and is the primary resource for linking EMSP research to the broader set of research supported by the Department of Energy and other organizations. It allows researchers and problem holders to see how the full set of past and present Department of Energy research relates to EMSP research and Environmental Management problems. In addition, the database is searchable through many

popular Internet search engines such as Lycos, AltaVista, and Excite, which bring in researchers and users who would otherwise be unaware of the EMSP. Other on-line resources include an EMSP systems engineering database, which allows users to interactively explore the "linkage" information in this report, and the Technology Management System, which shows how the EMSP research fits into the advanced technology research occurring in the Environmental Management Technology Development Program. In addition, all interested participants, including all EMSP researchers, can join the EMSP Discussion Forum, an electronic mail "list server," which is periodically used to distribute program news and information.

For each research award granted, a management point of contact is established to provide researchers with a mechanism for communication. These managers ensure every researcher has the information they need. This information includes funding and reporting requirements and more importantly, information about the environmental management problems for which the research is needed.

Fostering Effective Communications. The EMSP will use cutting edge communication tools such as electronic forums to foster improved communications and collaboration among researchers, technology developers, problem holders and other interested parties. The EMSP will arrange for site visits by researchers to assist them in understanding more fully the nature of the Department's cleanup problems. Meetings, workshops, new solicitations, and annual reports will also be used to communicate success stories, update research needs, and provide mechanisms for sharing lessons learned.

Encouraging Scientific Collaboration. Solicitations for the EMSP encourage collaboration among researchers. EMSP managers encourage award recipients to share information and collaborate as much as possible. Meetings, workshops, and site visits by researchers assist with this process. In addition, EMSP staff is working to identify and coordinate with internal and external programs sponsoring research relevant to the EMSP.

Providing for Information Analysis, Integration and Management. Through its information management tools, the EMSP will coordinate with researchers, provide researchers with information on potential collaboration points, and integrate EMSP research into decision making, technology development, and projects. Effective information management ensures that accurate information is used to communicate and collaborate, as well as to plan and coordinate research results with end users.

Near-Term Activities

Research needs and research results must be disseminated using many information exchange tools. The dialogue among potential researchers, Department officials, cleanup managers, and technology developers began with the early site specific workshops and has continued through topical workshops focused on specific problem areas, information exchange over the World

Wide Web, and an Internet list server. Additional topical workshops are planned for the first EMSP Workshop to be held in the summer of 1998. Arrangements are also being made for individual researchers to visit Department of Energy sites to work with technology developers and problem holders.

Workshops. The EMSP will use workshops to promote information exchange, networking, collaboration, and research integration planning. The workshops are a vehicle to facilitate the transition of research results to cleanup solutions. The value of workshops was recognized by the National Academy of Sciences/National Research Council Committee. It recommended that the EMSP convene annual workshops, seminars, and symposia to facilitate the communications between and among EMSP researchers, program managers from the Offices of Environmental Management and Energy Research, site contractors, other problem holders, public stakeholders, regulators, and individuals from other research programs.¹⁵

Interactions among potential researchers, Department officials, environmental cleanup project managers, technology developers, regulators, and stakeholders were initiated with early site-specific workshops to identify basic research needs. This dialogue will be continued through topical and site-specific workshops focused on specific problem areas and scientific disciplines. These workshops also provide opportunities for the EMSP to foster communications and scientific collaboration. Several activities can be conducted in these workshops. These activities include the identification and validation of Environmental Management research needs, dissemination of research outcomes, development of science advocates at the sites, review and discussion of the latest site-specific cleanup plans, and communication of research activities that may address site EM problems.

Additionally, the EMSP can leverage other information exchange opportunities within the Environmental Management Program. By encouraging EMSP researchers to attend Environmental Management events, the EMSP can champion greater networking and communications among interested parties. Environmental Management events or symposia such as Waste Management '98 and Spectrum '98 provide opportunities for further exchanges of information and research outcomes. Other scientific meetings offer opportunities for EMSP researchers to communicate their results. For example, in the fall of 1997, an American Chemical Society symposium was held to focus on the latest research efforts related to nuclear waste management and remediation problem areas. The topical discussions held at the symposium ranged from macroscopic engineering problems to microscopic research issues such as colloidal chemistry and gas production rates. The EMSP will conduct a session at the national American Chemical Society symposium in Spring 1999.

¹⁵ *Building an Effective Environmental Management Science Program*, Final Assessment Report, National Research Council, June 1997, page 66.

A goal of the summer 1998 EMSP Workshop is to: create an atmosphere of common purpose for the EMSP participants through a better understanding of the cleanup problems; improve the dialogue between the researchers and problem holders; and increase regulator and stakeholder awareness of the EMSP. The workshop is expected to consist of over 200 scientific and technical presentations and attract as many as 400 participants. Participants will include scientists conducting EMSP sponsored research, representatives from the scientific community, and representatives from key DOE organizations involved with cleanup, technology development, basic research, planning, and decision making. Workshop invitations will also be extended to the Environmental Protection Agency, the Department of Defense, the National Science Foundation, National Institute of Standards and Technology, and other Federal agency representatives with programmatic interests in environmental science. Representatives from professional groups such as the American Chemical Society, the American Institute of Chemical Engineers, and the Institute of Energy and Environmental Engineers will also be invited.

Advisory Groups. The EMSP derives a number of benefits from its interactions with advisory organizations which review and evaluate the EMSP research program, and provide valuable insights in the form of advisory recommendations. As a result, the EMSP will maintain its relationships with advisory groups. In 1998, the Environmental Management Advisory Board Science Committee held a series of programmatic review meetings which seek information from site management, laboratory management, university and laboratory principal investigators, site staff, and other stakeholders. The Committee collected perceptions on the quality of the application selection process, the quality of the output of the program, and the impact of the program on existing Environmental Management activities. The EMSP will also seek advice from the National Research Council again at appropriate times in the future. The advice and counsel of other groups such as the Department's Strategic Laboratory Council, the American Chemical Society, and other professional organizations will be sought to provide the EMSP with perspectives from the scientific community that enhance communication between the researchers and cleanup problem holders. These groups not only provide general advice, participate in program planning, and evaluate ongoing EMSP activities, but they provide the EMSP with the collective wisdom of the scientific community.

Potential Benefits

The EMSP is taking the steps necessary to capitalize on the Department's scientific research investments. Its role in support of the Office of Environmental Management mission is to serve as a catalyst for scientific discoveries that lead to cost, schedule, and risk reductions for the Environmental Management Program. It will fulfill this role by creating an environment to maximize the output of the program and the ultimate use of resulting information. This will be accomplished by establishing an effective information network, fostering effective communications, encouraging scientific and technology collaboration, providing for data analysis and integration, and managing information. The EMSP has a number of systems in place to facilitate communications and collaboration including: the Internet, meetings and

workshops with advisory boards and stakeholders, program need updates, reports on the progress and results of research, solicitations for additional research, and lessons learned. These systems, coupled with the time necessary for research to take its natural course, will maximize the science return in the form of new and improved knowledge that can be used to reduce program life-cycle costs and risk.

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Appendix A

Environmental Management Science Program Requests for Applications

April 1998

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Office of Energy Research and Office of Environmental Management; Energy Research
Financial Assistance Program Notice 96-10; Environmental Management Science Program

AGENCY: U.S. Department of Energy (DOE).

ACTION: Notice inviting grant applications.

SUMMARY: The Offices of Energy Research (ER) and Environmental Management (EM), U.S. Department of Energy, hereby announce their interest in receiving grant applications for performance of innovative, fundamental research to support the management and disposal of DOE radioactive, hazardous chemical, and mixed wastes.

This basic research should contribute to environmental management and restoration actions that would decrease risk for the public and workers, provide opportunities for major cost reductions, reduce time required to achieve EM's mission goals, and, in general, should address problems that are considered intractable without new knowledge. This program is designed to inspire "breakthroughs" in areas critical to the EM mission through long-term research and will be managed in partnership with ER. ER's well-established procedures, as set forth in the Energy Research Merit Review System, as published in the Federal Register, March 11, 1991, Vol. 56, No. 47, pages 10244-10246, will be used for merit review of applications submitted in response to this notice.

DATES: Potential applicants are strongly encouraged to submit a brief preapplication. All preapplications, referencing Program Notice 96-10, should be received by DOE by 4:30 P.M. E.S.T., February 28, 1996. A response discussing the potential program relevance of a formal application generally will be communicated to the applicant within 15 days of receipt. The deadline for receipt of formal applications is 4:30 P.M., E.D.T., May 8, 1996, in order to be accepted for merit review and to permit timely consideration for award in fiscal year 1996.

ADDRESSES: All preapplications, referencing Program Notice 96-10, should be sent to Ms. Bobbi Parra, Office of Health and Environmental Research, ER-74, U.S. Department of Energy, 19901 Germantown Road, Germantown, Maryland 20874-1290, 301-903-3316, fax 301-903-8519, or by the internet email address bobbi.parra@oer.doe.gov.

After receiving notification from DOE concerning successful preapplications, applicants may prepare formal applications and send them to: U.S. Department of Energy, Office of Energy Research, Grants and Contracts Division, ER-64, 19901 Germantown Road, Germantown, Maryland 20874-1290, Attn: Program Notice 96-10. The above address for formal applications

must also be used when submitting formal applications by U.S. Postal Service Express Mail, any commercial mail delivery service, or when hand carried by the applicant. Please note that notification of a successful preapplication is not indication that an award will be made in response to the formal application.

It is anticipated that up to \$20,000,000 will be available for grant awards during FY 1996 that will enable innovative fundamental research contingent upon the availability of appropriated funds. Multiple-year funding of grant awards is expected and is also contingent upon the availability of funds. Award sizes are expected to be on the order of \$100,000 - \$300,000 per year for total project costs for a typical three year grant.

FOR FURTHER INFORMATION CONTACT: Dr. Michelle Broido, Office of Health and Environmental Research, ER-74, Office of Energy Research, 19901 Germantown Road, Germantown, Maryland 20874-1290. Telephone: (301) 903-3281, or Dr. Carol Henry, Office of Science and Risk Policy, Office of Environmental Management, 1000 Independence Ave. SW, Washington, D.C. 20585, Telephone: (202) 586-7150.

SUPPLEMENTARY INFORMATION: The Office of Environmental Management, in partnership with the Office of Energy Research, is initiating an Environmental Management Science Program to fulfill DOE's continuing commitment for the cleanup of DOE's environmental legacy. Funding to initiate this program was established in the Conference Report accompanying the FY 1996 Energy and Water Development Appropriation Bill.

Purpose

The need to build a stronger scientific basis for the Environmental Management effort has been established in a number of recent studies and reports. Among the important observations and recommendations made by the Galvin Commission (Alternative Futures for the Department of Energy National Laboratories, February 1995) are the following:

There is a particular need for long term, basic research in disciplines related to environmental cleanup... Adopting a science-based approach that includes supporting development of technologies and expertise... could lead to both reduced cleanup costs and smaller environmental impacts at existing sites and to the development of a scientific foundation for advances in environmental technologies.

The objectives of the basic science program are to:

- Provide scientific knowledge that will revolutionize technologies and clean-up approaches to significantly reduce future costs, schedules, and risks; and
- Bridge the Gap between broad fundamental research that has wide-ranging applicability such as that performed in DOE's Office of Energy Research and needs-driven applied technology development that is conducted in EM's Office of Science and Technology; and

- Focus the Nation's science infrastructure on critical DOE environmental management problems.

Representative Research Areas

Basic research is solicited for areas of concern to the Department's environmental management programs including but not limited to: chemical characterization of wastes and contaminants on an atomic and molecular level; development of knowledge of the physical and chemical behavior of such species; physical and chemical basis for waste separations and treatment; characterization and modeling of multi-phase chemical systems in natural systems, waste tanks and process streams; and monitoring, controlling, and assessing these processes. Understanding the fate of contaminants already in the environment includes the identification of the biological and geochemical reactions that sequester or degrade contaminants; understanding colloids or complexes of associated contaminants; and quantifying the impacts of geologic heterogeneity on the effectiveness of various remediation strategies. Indirect characterization of the geological environment by geophysical techniques provides the basic structural information essential in planning and monitoring remedial actions. Also important are studies to characterize flow and reactive transport through fractured and porous rocks and soils, and to characterize the physiological, biochemical, and genetic mechanisms for the uptake, transport, and sequestering of inorganic ions and organic molecules related to the use of plants and microorganisms for the cleanup of hazardous wastes.

Advances in information and monitoring technologies will also allow evaluation of progress in addressing these problems and devising new solutions. In the future, the focus will be on increasing efficiency in terms of materials and energy use. Better means of monitoring and controlling present system operations will significantly improve process efficiency and reduce waste outputs.

Specific examples illustrating the general subject areas, above, are found in the background section of this document.

Applicants in this program are strongly encouraged to collaborate with researchers in industry and/or the DOE National Laboratories, when appropriate, and to incorporate cost sharing and/or consortia wherever feasible. Grant applications are encouraged from all disciplines.

Merit Review and Evaluation Criteria

Formal applications will be subjected to formal merit review (peer review) and will be evaluated against the following evaluation criteria codified at 10 CFR 605.10(d).

1. Scientific and/or Technical Merit of the Project
2. Appropriateness of the Proposed Method or Approach
3. Competency of Applicant's Personnel and Adequacy of Proposed Resources

4. Reasonableness and Appropriateness of the Proposed Budget

Examples of the considerations associated with determining the scientific and/or technical merit of the project include, but are not limited to:

- Potential for addressing problems identified by DOE, with meaningful progress within the proposed time frame.
- Benefits and merits of an application e.g. public purpose, time savings, extent of applicability, cost and risk reduction.

DOE shall also consider, as part of the evaluation, program policy factors such as an appropriate balance among the program areas.

Note, external peer reviewers are selected with regard to both their scientific expertise and the absence of conflict-of-interest issues. Non-federal reviewers may be used, and submission of an application constitutes agreement that this is acceptable to the investigator(s) and the submitting institution.

Preapplications

The brief preapplication, in accordance with 10 CFR 600.10(d)(2), should consist of two to three pages of narrative describing the research objectives and methods of accomplishment together with a brief summary of the principal investigator's publication and research background. The preapplications will be reviewed relative to the scope and research needs of the DOE's Environmental Management Science Program by qualified DOE program managers from both ER and EM. Telephone and FAX numbers are required parts of the preapplication, and electronic mail addresses are desirable.

Information

Information about the development, submission of applications, eligibility, limitations, evaluation, the selection process, and other policies and procedures may be found in 10 CFR Part 605, and in the Application Guide for the Office of Energy Research Financial Assistance Program. The Application Guide is available from the U.S. Department of Energy, Office of Energy Research, ER-74, 19901 Germantown Road, Germantown, Maryland 20874-1290. Telephone requests may be made by calling (301) 903-3316. Electronic access to ER's Financial Assistance Application Guide is possible via the World Wide Web at:
<http://www.er.doe.gov/production/grants/grants.html>

Background

The justification for such a program is grounded in the long-term costs for the Environmental Management program estimated at \$200-350 billion over 75 years; in 10 years at current budget

projections, \$60 billion will have been spent, with over two thirds of the program yet remaining. This is the largest legacy from the Cold War of any other Federal program, dwarfing the Department of Defense's DOD's legacy by ten-fold. The Office of Environmental Management is responsible for waste management and cleanup of DOE sites. The EM operations have been historically compliance-based and driven to meet established goals in the shortest time possible using either existing technologies or those that could be developed and demonstrated within a few years. The Office of Energy Research addresses fundamental, frequently long-term, research issues related to the many missions of the Department. The Environmental Management Science Program will use ER's experience in managing fundamental research to address the needs of technology breakthroughs in EM's programs.

This research agenda has been initiated for Fiscal Year 1996, along with a development process for a long term program within the Office of Environmental Management, with the objective of providing continuity in scientific knowledge that will revolutionize technologies and clean-up approaches for solving DOE's most complex environmental problems.

Specific examples of areas of interest for research under this solicitation are:

- Advanced characterization methods that accelerate treatment and immobilization of high-level wastes. Pretreatment and separation methods that lead to a significant reduction in the amount of immobilized high-level waste requiring long-term isolation. Innovative separations for solids and for liquids, needed to significantly reduce projected high-level waste volume.
- In-situ characterization of dense non-aqueous phase liquid to allow comparative risk assessments of alternative treatment methods. In situ immobilization of subsurface contaminants to reduce pump and treat costs. Permeable in situ treatment barriers and factors governing in situ treatment processes to replace unsatisfactory, extant alternatives for treatment of large plumes. Degradation and extraction methods for radioactive and hazardous contaminants from soil/water. Dissolution of water-soluble sludge; washing of water soluble sludge, with recovery of cesium, strontium, technetium.
- Characterization of heterogeneous wastes needed to optimize decontamination and decommissioning recycling alternatives. Surface stabilization to reduce the ultimate waste volume and to enhance recycling. Selective and non-selective removal of contaminants from surfaces or bulk materials. Recycling of valuable commodities into general commerce.
- Non-destructive and in situ characterization methods to characterize the hazard of landfills. Innovative immobilization and transformation concepts that significantly reduce the cost of remediation. Ex-situ separation and treatment concepts to rapidly and safely destroy or immobilize landfill constituents.

- Emission-free destruction of organic wastes. Off-gas treatment that eliminates emissions in the environment that exceed Environmental Protection Agency requirements. Non-thermal treatment concepts for mixed waste. Bioremediation, enzymatic reactions, enzyme redesign, genetic engineering, microbial gene sequencing.
- Plutonium behavior in mixed matrices. Long-term monitoring concepts for plutonium.
- New concepts for waste stabilization of spent nuclear fuel. Long-term monitoring and performance assessment of spent nuclear fuel. Physics and chemistry of radionuclides in mixed matrices
- Specialized waste forms. Performance assessment concepts for nuclear waste disposal.
- Ecology. Comprehensive understanding of the flow and use of materials and energy in our environmental system and the implications of those flows with respect to the environment. Ecosystem restoration and management; conduct monitoring, modeling, and process research to improve understanding of threatened and damaged ecosystems, technologies to restore the productivity and quality of these ecosystems.
- Biomarkers and sensors of exposure to contaminated media. Multi-site epidemiology studies. Effort to address current health concerns while continuing to conduct research that will promote a better future understanding of the relationship between exposure and health impacts.

The program will be competitive and offered to investigators in universities or other institutions of higher education, or other non-profit or for-profit organizations, non-Federal agencies or entities, or unaffiliated individuals. Apart from this notice, the program also will be offered to DOE national laboratories and other Federal laboratories, which will compete separately for appropriated funds. To ensure that the program is mission-oriented and that its achievements are recognized and used by EM, the Environmental Management Science Program will be closely integrated with EM's Technology Development Focus Areas and will also be closely coordinated with the Office of Energy Research to ensure use of broad-based fundamental research and development supported by that office.

Details of the programs of the Office of Environmental Management and the technologies currently under development or in use by Environmental Management Program can be found on the World Wide Web at <http://www.em.doe.gov> and at the extensive links contained therein. These programs and technologies should be used as guidance when considering areas of research to be proposed.

The United States involvement in nuclear weapons development for the last 50 years has resulted in the development of a vast research, production, and testing network known as the nuclear weapons complex. The Department has begun the environmental remediation of the complex,

encompassing radiological and nonradiological hazards, vast volumes of contaminated water and soil, and over 7,000 contaminated structures. The Department must characterize, treat, and dispose of hazardous and radioactive wastes that have been accumulating for more than 50 years at 120 sites in 36 states and territories. By 1995, the Department had spent about \$23 billion in identifying and characterizing its waste, managing it, and assessing the remediation necessary for its sites and facilities. The Department estimates that the remedial actions at Department sites (not including groundwater cleanup, currently operating facilities and Naval facilities) could cost a total of \$200-350 billion and take at least 75 years to complete. According to the estimates of the total program cost, 49% would go to waste management and 28% to environmental restoration, 10% to nuclear material and facility stabilization, and 5% to research and technology development with the remaining 8% for activities such as site security, transportation, and other landlord activities. The estimated life cycle costs over 75 years for the seven highest cost problem areas within the programs in descending order are as follows:

- Decommissioning
- High Level Waste
- Remedial Actions
- Low Level Waste
- Transuranic Waste
- Mixed Low Level Waste
- Spent Nuclear Fuel

Environmental Management is also responsible for conducting the program for waste minimization and pollution prevention for the Department. The variety and volume of the Department's current activities make this effort a challenge itself. In some cases, fundamental science questions will have to be addressed before a technology or process can be engineered. For example, improved understanding of the principles of pollutant transport in groundwater is required for important advancement in the development of effective groundwater-remediation technology. There is a need to involve more basic science researchers in the challenges of the Department's remediation effort.

References for Background Information on the Mission Responsibilities of the Office of Environmental Management

Note: World Wide Web locations of these documents are provided where possible. For those without access to the World Wide Web, hard copies of these references may be obtained by writing Dr. Carol Henry at the address listed in the contacts section.

DOE. 1995. Closing the Circle on Splitting of the Atom: The Environmental Legacy of Nuclear Weapons Production in the United States and What the Department of Energy is Doing About It. The U.S. Department of Energy, Office of Environmental Management, Office of Strategic Planning and Analysis, Washington, D.C.
<http://www.em.doe.gov/circle/index.html>

DOE. 1995. Estimating the Cold War Mortgage: The 1995 Baseline Environmental Management Report. Volume I, March 1995. U.S. Department of Energy Office of Environmental Management, Washington, D.C.

[*http://www.em.doe.gov/bemr/index.html*](http://www.em.doe.gov/bemr/index.html)

DOE. 1995. Environmental Management 1995: Progress and Plans of the Environmental Management Program. The U.S. Department of Energy, Office of Environmental Management, Washington, D.C.

[*http://www.em.doe.gov/em95/index.html*](http://www.em.doe.gov/em95/index.html)

DOE. 1995. Risks and the Risk Debate: Searching for Common Ground The First Step. The U.S. Department of Energy, Office of Environmental Management, Washington, D.C.

[*http://raleigh.dis.anl.gov:81/cgi-bin/dispdoc_return.pl?rrd+1*](http://raleigh.dis.anl.gov:81/cgi-bin/dispdoc_return.pl?rrd+1)

DOE. 1995. Technology Summary Reports, June 1995 (Rainbow Books).

[*http://www.em.doe.gov/emnet5.html*](http://www.em.doe.gov/emnet5.html)

DOE. 1995. Office of Science and Technology EM-50.

[*http://www.em.doe.gov/emnet5.html*](http://www.em.doe.gov/emnet5.html)

National Academy of Sciences. Allocating Federal Funds for Science and Technology. 1995. National Academy Press, Washington, D.C.

[*http://www.nas.edu/nap/online/fedfunds/*](http://www.nas.edu/nap/online/fedfunds/)

National Commission on Superfund Members. Final Consensus Report of the National Commission on Superfund. March 1994. Keystone Center and the Environmental Law Center of Vermont Law School.

N/A

National Environmental Technology Strategy. Bridge to a Sustainable Future. April 1995. National Science and Technology Council, Washington, D.C.

[*http://iridium.nttc.edu/env/envstrat.txt*](http://iridium.nttc.edu/env/envstrat.txt)

National Research Council. Improving the Environment: An Evaluation of DOE's Environmental Management Program. 1995. National Academy Press, Washington, D.C.

N/A

Secretary of Energy Advisory Board. Alternative Futures for the Department of Energy National Laboratories. February 1995. Task Force on alternative Futures for the Department of Energy National Laboratories, Washington, D.C.

[*http://www.doe.gov/html/doe/whatsnew/galvin/tf-rpt.html*](http://www.doe.gov/html/doe/whatsnew/galvin/tf-rpt.html)

U.S. Congress, Office of Technology Assessment. Complex Cleanup: The Environmental Legacy of Nuclear Weapons Production, February 1991. U.S. Government Printing Office, Washington, D.C.
N/A

The Catalog of Federal Domestic Assistance Number for this program is 81.049, and the solicitation control number is ERFAP 10 CFR Part 605.

Issued in Washington, DC. January 31, 1996.

John Rodney Clark,

Associate Director for Resource Management Office of Energy Research

[FR Doc. 96-2877 Filed 2-8-96; 8:45 am]

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Office of Energy Research and Office of Environmental Management; Energy Research
Financial Assistance Program Notice 97-03; Environmental Management Science Program

AGENCY: U.S. Department of Energy (DOE).

ACTION: Notice inviting grant applications.

SUMMARY: The Offices of Energy Research (ER) and Environmental Management (EM), U.S. Department of Energy, hereby announce their interest in receiving grant applications for performance of innovative, fundamental research to support the management and disposal of DOE radioactive, hazardous chemical, and mixed wastes; the stabilization of nuclear materials and spent nuclear fuel; remediation of contaminated sites; and the decontamination and decommissioning of facilities.

The DOE Environmental Management program currently has ongoing applied research and engineering efforts under its Technology Development program. These efforts must be supplemented with basic research to address long-term technical issues crucial to the EM mission. Basic research can also provide EM with near-term fundamental data that may be critical to the advancement of technologies that are under development but not yet at full scale nor implemented. Proposed basic research under this notice should contribute to environmental management activities that would decrease risk for the public and workers, provide opportunities for major cost reductions, reduce time required to achieve EM's mission goals, and, in general, should address problems that are considered intractable without new knowledge. This program is designed to inspire "breakthroughs" in areas critical to the EM mission through basic research and will be managed in partnership with ER. ER's well-established procedures, as set forth in the Energy Research Merit Review System, as published in the Federal Register, March 11, 1991, (56 FR 10244), will be used for merit review of applications submitted in response to this notice. This information is also available on the World Wide Web at

<http://www.er.doe.gov/production/grants/merit.html>.

Subsequent to the formal scientific merit review, applications that are judged to be scientifically meritorious will be evaluated by DOE for relevance to the objectives of the Environmental Management Science Program. Additional information can be obtained at

<http://www.em.doe.gov/science>.

DATES: Potential applicants are strongly encouraged to submit a brief preapplication. All preapplications, referencing Program Notice 97-03, should be received by DOE by 4:30 P.M. E.S.T., January 15, 1997. A response encouraging or discouraging a formal application generally

will be communicated to the applicant within three weeks of receipt. The deadline for receipt of formal applications is 4:30 P.M., E.D.T., April 16, 1997, in order to be accepted for merit review and to permit timely consideration for award in Fiscal Year 1997.

ADDRESSES: All preapplications, referencing Program Notice 97-03, should be sent to Dr. Roland F. Hirsch, ER-73, Mail Stop F-240, Office of Health and Environmental Research, U.S. Department of Energy, 19901 Germantown Road, Germantown, Maryland 20874-1290, telephone: (301) 903- 5349. Preapplications will be accepted if submitted by United States Postal Service, including Express Mail, commercial mail delivery service, or hand delivery, but will not be accepted by fax, electronic mail, or other means.

After receiving notification from DOE concerning successful preapplications, applicants may prepare formal applications using the instructions in the Office of Energy Research Application Guide and in the Supplementary Information in this notice. Applications must be sent to: U.S. Department of Energy, Office of Energy Research, Grants and Contracts Division, ER-64, 19901 Germantown Road, Germantown, Maryland 20874-1290, Attn: Program Notice 97-03. The above address for formal applications must also be used when submitting formal applications by U.S. Postal Service Express Mail, any commercial mail delivery service, or when hand carried by the applicant. Please note that notification of a successful preapplication is not an indication that an award will be made in response to the formal application.

Awards

Multiple-year funding of grant awards is anticipated, contingent upon the availability of funds. Award sizes are expected to be on the order of \$100,000-\$300,000 per year for total project costs for a typical three year grant. Applications for collaborative projects involving several research groups or more than one institution may receive larger awards if merited. Investigators considering submitting collaborative projects are encouraged to prepare a single application incorporating the entire research program and a combined budget as well as separate budgets for each collaborating institution. DOE reserves the right to fund in whole or part any or none of the applications received in response to this Notice.

FOR FURTHER INFORMATION CONTACT: Dr. Roland F. Hirsch, ER-73, Mail Stop F-240, Office of Health and Environmental Research, Office of Energy Research, U.S. Department of Energy, 19901 Germantown Road, Germantown, Maryland 20874-1290, telephone: (301) 903-5349, fax: (301) 903-0567, electronic mail: roland.hirsch@oer.doe.gov, or Dr. Carol J. Henry, Office of Science and Technology, Office of Environmental Management, 1000 Independence Ave. SW, Washington, D.C. 20585, telephone: (202) 586-7150, electronic mail: carol.henry@em.doe.gov.

SUPPLEMENTARY INFORMATION: The Office of Environmental Management, in partnership with the Office of Energy Research, sponsors the Environmental Management

Science Program (EMSP) to fulfill DOE's continuing commitment to the cleanup of DOE's environmental legacy. The program was initiated in Fiscal Year 1996.

Purpose

The need to build a stronger scientific basis for the Environmental Management effort has been established in a number of recent studies and reports. Among the important observations and recommendations made by the Galvin Commission ("Alternative Futures for the Department of Energy National Laboratories," February 1995) are the following:

There is a particular need for long term, basic research in disciplines related to environmental cleanup ... Adopting a science-based approach that includes supporting development of technologies and expertise ... could lead to both reduced cleanup costs and smaller environmental impacts at existing sites and to the development of a scientific foundation for advances in environmental technologies.

The objectives of the Environmental Management Science Program are to:

- Provide scientific knowledge that will revolutionize technologies and clean-up approaches to significantly reduce future costs, schedules, and risks; and
- "Bridge the gap" between broad fundamental research that has wide-ranging applicability such as that performed in DOE's Office of Energy Research and needs-driven applied technology development that is conducted in EM's Office of Science and Technology; and
- Focus the Nation's science infrastructure on critical DOE environmental management problems.

Representative Research Areas

Basic research is solicited in all areas of science with the potential for addressing one or more of the areas of concern to the Department's Environmental Management program. The scientific disciplines relevant to the program include, but are not limited to, biology (including cellular and molecular biology, ecology, bioremediation, genetics, biochemistry, and structural biology; plant sciences are listed as a separate category below), chemistry (including analytical chemistry, catalysis, heavy element chemistry, inorganic chemistry, organic chemistry, physical chemistry, and separations chemistry), computational sciences (including research and development of mathematical/ numerical, informatics, and communication procedures and software technology, for example for deterministic simulations and optimization), engineering sciences (including control systems and optimization, diagnostics, transport processes, thermophysical properties and bioengineering), geosciences (including geophysical imaging, physicochemical dynamics and chemical transport in fluid-rock systems, and hydrogeology), health sciences, materials science (including condensed matter physics, metallurgy, ceramics, waste minimization, welding and joining, degradation mechanisms, and remote sensing and monitoring), physics (including

atomic, molecular, optical, and fluid physics) and plant science (including mechanisms of mineral uptake, intercellular transport, and concentration and sequestration).

Projects in bioremediation that fall within the scope of Notices issued by the Natural and Accelerated Bioremediation Research (NABIR) Program of the Office of Energy Research (such as Notice 97-04) should be submitted to that program rather than to the Environmental Management Science Program. Projects outside the scope of NABIR but within the scope of this Notice may be submitted to the EMSP.

Applicants to the EMSP are strongly encouraged to collaborate with researchers in other institutions, such as universities, industry, non-profit organizations, the DOE National Laboratories, and/or other Federal Laboratories, where appropriate, and to incorporate cost sharing and/or consortia wherever feasible. Applicants are encouraged to provide training opportunities, including student involvement, in applications submitted to the program.

Major Environmental Management Challenges

The following is an overview of the major technical challenges facing the Environmental Management program that are the focus of this announcement. More detailed descriptions of the specific technical needs and areas of emphasis associated with these problem areas can be found in the background section of this Notice.

The Department is the guardian of over 300 large storage tanks containing over 100 million gallons of highly radioactive wastes, which include organic and inorganic chemical compounds, in solid, colloidal, slurry, and liquid phases. The environment within the tanks is highly radioactive and chemically harsh. A few of the tanks have leaked to the environment while others are corroding. The contents of these tanks need to be characterized, removed from the tanks, treated, and converted to safe forms for disposal.

The Department is the custodian of several thousand metric tons of spent nuclear reactor fuels, resulting primarily from weapons fabrication activities during the Cold War, but also including fuel from research and naval reactors. The long-term containment performance of the fuel under storage and disposal conditions is uncertain. Such uncertainties affect the ability to license disposal methods.

The Office of Environmental Management is the custodian of large quantities of fissile materials which were left in the manufacturing and processing facilities after the United States halted its nuclear weapons production activities. These materials include plutonium solutions, plutonium metals and oxides, plutonium residues and compounds, highly enriched uranium, and nuclides of other actinides. Additional scientific information is required to choose processes for converting these materials to stable forms.

The Department currently has on its sites over one hundred sixty thousand cubic meters of waste containing both radioactive and hazardous materials. This mixed waste contains a wide variety of materials, as varied as protective clothing, machining products and wastes, packaging materials, and process liquids. Fundamental scientific data are needed to improve processes associated with treatment systems, such as characterization, pre-treatment, and monitoring.

The Department is committed to the safe disposal of all radioactive wastes, including high-level wastes, mixed wastes, and fissile materials. Safe disposal of these materials requires that the wide range of potential waste streams be converted into insoluble materials for long term storage. Some radioactive material-containing forms have been successfully developed and are being produced; however, at present, research challenges still exist in developing suitable forms for each material to be stored.

The Department is currently conducting cleanup activities at many of its sites, and is preparing plans for additional remediation work. There is much scientific uncertainty about the levels of risk to human health at the end stages of the DOE clean-up effort.

The aforementioned areas of emphasis do not preclude, and DOE strongly encourages, any innovative or creative ideas contributing to solving EM challenges mentioned throughout this Notice.

Application Evaluation and Selection

- **Scientific Merit.** The program will support the most scientifically meritorious and relevant work, regardless of the institution. Formal applications will be subjected to scientific merit review (peer review) and will be evaluated against the following evaluation criteria listed in descending order of importance as codified at 10 CFR 605.10(d).
 1. Scientific and/or Technical Merit of the Project
 2. Appropriateness of the Proposed Method or Approach
 3. Competency of Applicant's Personnel and Adequacy of Proposed Resources
 4. Reasonableness and Appropriateness of the Proposed Budget.
- **External peer reviewers** are selected with regard to both their scientific expertise and the absence of conflict-of-interest issues. Non-federal reviewers may be used, and submission of an application constitutes agreement that this is acceptable to the investigator(s) and the submitting institution.
- **Relevance to Mission.** Subsequent to the formal scientific merit review, applications which are judged to be scientifically meritorious will be evaluated by DOE for relevance to the objectives of the Environmental Management Science Program. These objectives were established in the Conference Report for the Fiscal Year 1996 Energy and Water

Development Appropriations Act, and are published in the Congressional Record-House, October 26, 1995, page H10956.

DOE shall also consider, as part of the evaluation, program policy factors such as an appropriate balance among the program areas, including research already in progress. Research funded in the Environmental Management Science Program in Fiscal Year 1996 can be reviewed at <http://www.doe.gov/em52/science-grants.html>.

Application Format

Applicants are expected to use the following format in addition to following instructions in the Office of Energy Research Application Guide. Applications must be written in English, with all budgets in U.S. dollars.

- ER standard face page (DOE F 4650.2 (10-91))
- Application classification sheet (see below for list of categories)
- Table of Contents
- Project Abstract (no more than one page)
- Budgets for each year and a summary budget page for the entire project period (using DOE F 4620.1)
- Budget Explanation
- Budgets and Budget explanation for each collaborative subproject, if any
- Project Narrative (recommended length is no more than 20 pages; multi-investigator collaborative projects may use more pages if necessary up to a total of 40 pages)
 - Goals
 - Significance of Project to the EMSP
 - Background
 - Research Plan
 - Preliminary Studies (if applicable)
 - Research Design and Methodologies
- Literature Cited
- Collaborative Arrangements (if applicable)
- Biographical Sketches (limit 2 pages per senior investigator)
- Description of Facilities and Resources
- Current and Pending Support for each senior investigator

While the original application and seven required copies must be submitted, applicants are encouraged to also provide a 3.5-inch diskette containing the application in electronic format. The label on the diskette must clearly identify the institution, principal investigator, title of application, and the computer system and program used to prepare the document.

Application Categories

In order to properly classify each preapplication and application for evaluation and review, the documents must indicate the applicant's preferred scientific research field and environmental category, selected from the following lists. More than one environmental category may be indicated if desired.

Field of Scientific Research

1. Biology, not including plant science
- Chemical Sciences (2-6):
 2. Analytical Chemistry and Instrumentation
 3. Catalysis
 4. Heavy Element Chemistry
 5. Separations Chemistry
 6. Other Topics in Chemistry
7. Computer and Mathematical Sciences
8. Engineering Sciences
- Geosciences (9-11):
 9. Geophysics
 10. Geochemistry
 11. Hydrogeology: Flow Modeling and Subsurface Science
12. Health Sciences
13. Materials Science
14. Physics
15. Plant Science
16. Other

Environmental Category:

- A. Decontamination/Decommissioning
- B. Health/Ecology/Risk
- C. High-level Radioactive Waste
- D. Waste Disposal Forms
- E. Fissile materials
- F. Spent Nuclear Fuel
- G. Subsurface Characterization
- H. Subsurface Contaminant Treatment
- I. Waste Characterization & Separations
- J. Waste Treatment & Destruction
- K. Other

Program Schedule

Preapplications must be received by DOE on or before January 15, 1997, and full applications on or before April 16, 1997, at the times and addresses noted above. It is anticipated that awards will be made no later than September 30, 1997.

Program Funding

Up to a total of \$20,000,000 of Fiscal Year 1997 Federal funds is expected to be available for new Environmental Management Science Program awards resulting from both this Notice and a parallel announcement to government laboratories and Federally Funded Research and Development Centers, including the DOE national laboratories. All projects will be evaluated using the same criteria, regardless of the submitting institution. The program will be competitive and offered to investigators in universities or other institutions of higher education, other non-profit or for-profit organizations, non-Federal agencies or entities, or unaffiliated individuals. Apart from this notice, the program also will be offered to DOE national laboratories and other Federal laboratories.

Preapplications

A brief preapplication may be submitted. The original and five copies must be received by January 15, 1997, to be considered. The preapplication should identify on the cover sheet the institution, name, address, telephone, fax and electronic mail address for the principal investigator, title of the project, and the field of scientific research and category(ies) of environmental application to which the project is responding (using the list above). The preapplication should consist of up to three pages of narrative describing the research objectives and the plan for accomplishing them, and should also include a paragraph describing the research background of the principal investigator and key collaborators if any. A 3.5 inch diskette containing the preapplication in any common word processing format may also be submitted in addition to the required printed copies.

Preapplications will be evaluated relative to the scope and research needs of the DOE's Environmental Management Science Program by qualified DOE program managers from both ER and EM. Preapplications are strongly encouraged but not required prior to submission of a full application.

Information

Information about the development, submission of applications, eligibility, limitations, evaluation, the selection process, and other policies and procedures may be found in 10 CFR Part 605, and in the Application Guide for the Office of Energy Research Financial Assistance Program. The Application Guide is available from the U.S. Department of Energy, Office of Energy Research, ER-73, 19901 Germantown Road, Germantown, Maryland 20874-1290.

Telephone requests may be made by calling (301) 903-5349. Electronic access to ER's Financial Assistance Application Guide and forms is possible via the World Wide Web at <http://www.er.doe.gov/production/grants/grants.html>.

Background

The United States involvement in nuclear weapons development for the last 50 years has resulted in the development of a vast research, production, and testing network known as the nuclear weapons complex. The Department has begun the environmental remediation of the complex encompassing radiological and nonradiological hazards, vast volumes of contaminated water and soil, and over 7,000 contaminated structures. The Department must characterize, treat, and dispose of hazardous and radioactive wastes that have been accumulating for more than 50 years at 120 sites in 36 states and territories. By 1995, the Department had spent about \$23 billion in identifying and characterizing its waste, managing it, and assessing the remediation necessary for its sites and facilities. Over the next ten years at current budget projections, another \$60 billion will be spent. The DOE cleanup of the Cold War legacy is the largest cleanup program in the Federal Government, even larger than that of the Department of Defense legacy. The Office of Environmental Management (EM) is responsible for waste management and cleanup of DOE sites. The EM operations have been historically compliance-based and driven to meet established goals in the shortest time possible using either existing technologies or those that could be developed and demonstrated within a few years. Environmental Management is also responsible for conducting the program for waste minimization and pollution prevention for the Department.

The variety and volume of the Department's current activities make this effort a challenge itself. In some cases, fundamental science questions will have to be addressed before a technology or process can be engineered. There is a need to involve more basic science researchers in the challenges of the Department's remediation effort. The Office of Energy Research (ER) addresses fundamental, frequently long-term, research issues related to the many missions of the Department. The Environmental Management Science Program will use ER's experience in managing fundamental research to address the needs of technology breakthroughs in EM's programs.

This research agenda has been developed for Fiscal Year 1997, along with a development process for a long term program within EM, with the objective of providing continuity in scientific knowledge that will revolutionize technologies and clean-up approaches for solving DOE's most complex environmental problems. The following are descriptions of the technical challenges in addressing many of these issues, in areas which are of particular interest for this notice.

High-level Radioactive Waste Tanks. The Department is the guardian of over 300 large storage tanks containing over 100 million gallons of highly radioactive wastes, which include organic and inorganic chemical compounds, in solid, colloidal, slurry, and liquid phases. The environment within the tanks is highly radioactive and chemically harsh. A few of the tanks have leaked to the environment while others are corroding.

Specific areas of emphasis in technology needs and research challenges related to high-level waste tank problems include, but are not limited to:

- The characterization and safe removal of the contents of these tanks, with the contents converted into forms suitable for long-term storage. Particular challenges include the need for improved characterization and separation methods of these wastes, including pretreatment, and methods to reduce the total volume of waste requiring long-term storage, which will reduce the large disposal costs associated with these wastes. Problems exist in the plugging of transport lines, mobilizing waste sludge, leak detection, process control, and conversion to final waste forms.
- The separation of complex chemical and radioactive waste to minimize the final volume of high level waste remaining after processing. The removal of liquid from sludges is a difficult challenge. There is not yet sufficient understanding of the factors that control the selectivity and efficacy of chemical and physical interactions, including structure-function relationships, and the effect of particle shapes and kinetics. In pretreatment unit operations there is a need to understand waste behavior and effects at waste processing interfaces, as well as how pretreatment processes affect the ability to transport waste between unit operations. Difficulties also exist in separating radioactive species from high ionic strength, multi-component aqueous solutions of salts dominated by species such as sodium nitrate, nitrite, carbonate, and phosphate. Separation of radionuclides and hazardous substances from solid (e.g. calcined) waste streams is also of interest.
- The physical state of the wastes in storage tanks. Some tanks contain distinct layers of sludge, salt cake and supernatant, and these layers may also not be homogeneous. There is evidence that much of the solid waste exists as colloidal particles that may remain suspended, settle out of solution, or gel and solidify with changes in conditions. Fine solids or colloidal particulates can carry a large fraction of contaminant and can interfere with subsequent processing. Important unknown factors which inhibit the remediation of tank wastes include the effects of temperature, pH, particle chemistry and morphology on agglomeration, sedimentation, viscosity, partitioning, dissolution, and speciation.
- The optimization of waste conversion processes. The presence of radionuclides results in radiation-induced, high-energy chemical reactions and in waste heating, which can accelerate chemical reactions. Some of these reactions may be catalyzed by extreme pH conditions and an array of active surface sites on the solids suspended in the waste. These processes lead to considerable variability in the chemical composition of the waste and therefore to difficulties

in treatment process design. Some wastes or processes include byproducts which are unacceptable for long-term storage (e.g. organics, nitrates, nitrites, ferrocyanides, nitrogen oxides, chlorinated hydrocarbons) and which therefore must be destroyed or eliminated from the system. Treatment of both acidic and alkaline (up to several molar hydroxide) aqueous solutions is required.

Spent Nuclear Fuel. The Department is the custodian of several thousand metric tons of spent nuclear reactor fuels which resulted primarily from weapons fabrication activities during the Cold War, but also include fuel from research and naval reactors. The long-term containment performance of the fuel under storage and disposal conditions is uncertain. Such uncertainties affect the ability to license disposal methods.

Specific areas of emphasis in technology needs and research challenges related to spent nuclear fuel problems include, but are not limited to:

- Mechanisms which may adversely affect the performance of the fuel package during storage must be identified. Deleterious effects which are incompletely characterized include: radiolytic effects of the radiation field on surrounding materials; corrosion, degradation, and radionuclide release mechanisms and rates for the representative fuel matrices; mechanisms which may lead to accelerated degradation of containers; dissolution characteristics of the matrices; and the effects of microbes on fuel packages. Some fuel storage pools have water clarity problems during fuel movement which affect safe operations.
- A technical basis is required for other steps in the spent fuel program, including: mechanisms of pyrophoricity and combustion parameters for various fuel types; gas generation during processing; determination of moisture content of fuel and maximum acceptable amount of moisture; degradation mechanisms and kinetics of spent fuel in a dry storage environment over a period of several decades; fissile and radioisotopic content of some spent fuel types; segregation behavior of elements; control of criticality in the very long term; and synergistic effects. Methods to remove moisture without damage to the structure of fuel elements are required.
- Some spent fuel types require additional characterization, such as fission and/or gamma ray nondestructive assay or evaluation, before disposal activities can be commenced. Current characterization methods are either extremely expensive or may not yield the necessary information for performance criteria for safe interim storage, transportation, and repository deposition. Thermodynamic and kinetic properties of miscellaneous spent fuel types, such as mixed oxide fuels, are not known to the level of detail needed to include them in a general purpose treatment process. Online measurement of fissile content and nuclear poisons during stabilization must be developed.

Fissile Materials. The Office of Environmental Management is the custodian of large quantities of fissile materials which were left in the manufacturing and processing facilities after the United

States halted its nuclear weapons production activities. These materials include plutonium solutions, plutonium metals and oxides, plutonium residues and compounds, highly enriched uranium, and nuclides of other actinides.

Specific areas of emphasis in technology needs and research challenges related to fissile material problems include, but are not limited to:

- Gaps exist in the information base needed for choosing among the alternate processes to be used in safe conversion of various types of fissile materials to optimal forms for safe interim storage, long term storage, and ultimate disposition. Necessary information includes accurate determination of thermodynamic redox potentials and heterogeneous electron transfer kinetics of selected actinides and actinide complexes; characterization of plutonium compound solubility in aqueous phosphate and sulfate media; actinide chemical thermodynamics and kinetics; behavior of mixed oxidation states of plutonium-containing materials; plutonium diffusion and corrosion behavior; the application of acid solution separation processes to neutralized and alkaline residues and wastes; the nature and effect of actinide interactions with organometallics, surfaces, and organic residues; and the performance of various analytical methods, including x-ray tomography, digital radiography, acoustic resonance spectroscopy, and actinide self-fluorescence.

Mixed hazardous and radioactive low-level waste. The term "mixed waste" refers to waste containing both radioactive and hazardous materials. There is currently estimated to be about 167,000 cubic meters of mixed waste in storage awaiting treatment and disposal. There are over 1,400 different mixed waste streams in inventory, located at 38 separate sites in 19 states. This inventory will be increased with newly generated mixed waste resulting from DOE's ongoing activities in environmental restoration, facility decontamination, and transition processes. Existing treatment and disposal capacities are presently too limited to allow the treatment and disposal of this inventory of mixed wastes. Research at a fundamental scientific level could lead to innovative processes or technologies, or could provide data to permit the advancement of technologies currently under development.

Specific areas of emphasis in technology needs and research challenges related to mixed waste problems include, but are not limited to:

- Characterization technologies for non-destructive evaluation of drum and box contents for the presence of materials defined by the Resource Conservation and Recovery Act as hazardous in the waste, and for segregating and routing incoming waste streams to appropriate treatment processes, are lacking. Effluent monitoring must be improved to optimize treatment operations, and to ensure compliance with applicable environmental requirements.
- Sorting of the large volume of wastes is impractical without improved nondestructive, noninvasive measurement techniques. Long-term performance of advanced waste forms still

must be ascertained. To support equipment design and permitting of high- temperature treatment processes, more information is needed on the thermodynamics, transport and generation of regulated hazardous materials and radionuclides in these processes. Real time monitors for heavy metals, dioxins, and volatile organic compounds are also not available. Alternatively, nonthermal treatment processes could be used, but major technical issues remain unresolved. Methods for direct removal of radioactive material are also of interest.

- Monitoring for the presence of mercury and other toxic metals in wastes, and removal of mercury from wastes, are high priorities but large-scale techniques are not yet available. Relative to mercury containing wastes, methods are required for the stabilization of mercury and for the amalgamation of bulk, non-recyclable mercury to meet Universal Treatment Standards and leachability testing standards. Improvements are required in techniques for identifying alpha-emitting radionuclides.
- Removal of radioactive components from waste in solid forms. These wastes include sludges from defense reprocessing activities, metals and concrete from decontamination and decommissioning activities, and calcined wastes. Highly radioactive sludges are typically metal oxides with large amounts of potentially soluble materials such as sodium or aluminum. A method for direct removal of the small radioactive fraction of these materials would greatly reduce disposal costs, but such methods are lacking.

Waste Disposal Forms. Safe disposal of radioactive wastes requires that a wide range of potential waste streams be converted into insoluble materials for long term storage. Some radioactive material-containing forms have been successfully developed and are being produced; however, the forms must be developed and optimized for each material to be stored, including high-level wastes, low-level wastes, mixed wastes, and fissile materials.

Specific examples of technology needs and research challenges relating to waste forms include, but are not limited to:

- Borosilicate glass is a waste form which is currently used for the storage of some high level waste and is considered a candidate for disposal of other high and low level wastes. It is unclear whether all waste types can be dissolved in borosilicate glass. Many common waste components, such as phosphates, sulfates, and chromates, are thought to have low solubilities. Some extractant materials, such as crystalline silicotitanate, may have limited solubilities as well.
- A better understanding of waste form leaching performance is required, including the hydrodynamics of fluids in cracked media, transport phenomena and phase separation at surfaces, and radiation-enhanced dissolution at interfaces. Validated chemical and thermodynamic models are required to predict leaching and gas bubble formation. The structure and bonding of waste components in waste forms, as well as the effect of the waste

and the radiation field on stability, solubility, durability, and processing of the host, must be elucidated.

- Waste forms for mixed waste which have higher waste loading, improved stability and chemical durability than current forms are required to reduce disposal costs and facilitate waste acceptance. Evaluation of the long-term performance is required to ensure that disposal satisfies stakeholder concerns and regulatory requirements.
- Vitrification of certain plutonium-contaminated waste materials may be preferred to cementation due to the lower volume of the final waste form. Vitrification has not been as highly developed for actinide residues or wastes as for fission product wastes. For other actinide wastes, mineral waste forms may be preferred; however, an enhanced technical basis for alternate waste forms for stabilizing plutonium is needed before mineral compositions can be used as intermediate- and long-term storage materials.

Risk, Quantitative Methodologies, Human and Environmental Health Analyses. There is much scientific uncertainty about the levels of risk to human health at the end stages of the DOE clean-up effort. Research challenges in the area of risk, quantitative, and health analyses include, but are not limited to:

- Accurate risk analyses require thorough knowledge of contaminant characteristics, basic ecological processes and principles, rates at which contaminants move through ecosystems, and health and ecological effects. In particular, better knowledge of radionuclide and toxic chemical transport dynamics and the potential effects of long-term exposure to low levels of radionuclides, in combination with other contaminants, is essential.
 - There is a need for health and environmental research to support adoption of performance standards that present quantifiable criteria for the levels to which high level waste tanks must be cleaned prior to closure.
- Research is required to improve understanding of threatened and damaged ecosystems and processes to restore the viability and quality of these ecosystems.

Details of the programs of the Office of Environmental Management and the technologies currently under development or in use by Environmental Management Program can be found on the World Wide Web at <http://www.em.doe.gov> and at the extensive links contained therein. These programs and technologies should be used to obtain a better understanding of the missions and challenges in environmental management in DOE when considering areas of research to be proposed.

References for Background Information

Note: World Wide Web locations of these documents are provided where possible. For those without access to the World Wide Web, hard copies of these references may be obtained by writing Dr. Carol J. Henry at the address listed in the contacts section.

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(The Catalog of Federal Domestic Assistance Number for this program is 81.049, and the solicitation control number is ERFAP 10 CFR Part 605)

Issued in Washington, DC on December 2, 1996.

John Rodney Clark,

Associate Director for Resource Management, Office of Energy Research.

[FR Doc. 96-31071 Filed 12-5-96; 8:45 am]

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Office of Energy Research and Office of Environmental Management; Energy Research Financial Assistance Program Notice 98-04; Environmental Management Science Program: Research Related to Decontamination and Decommissioning of Facilities

AGENCY: U.S. Department of Energy (DOE).

ACTION: Notice inviting grant applications.

SUMMARY: The Offices of Energy Research (ER) and Environmental Management (EM), U.S. Department of Energy, hereby announce their interest in receiving grant applications for performance of innovative, fundamental research to support specifically activities for facility decontamination and decommissioning (D&D); which include, but are not limited to, the characterization, monitoring, and certification of contaminated equipment and facilities; contaminant removal, contaminant control of various treatment processes; the treatment, removal, and stabilization of DOE D&D-derived radioactive, hazardous chemical, and mixed wastes.

DATES: Potential applicants are strongly encouraged to submit a brief preapplication. All preapplications, referencing Program Notice 98-04, should be received by DOE by 4:30 P.M. E.S.T., December 16, 1997. A response encouraging or discouraging a formal application generally will be communicated to the applicant within three weeks of receipt. The deadline for receipt of formal applications is 4:30 P.M., E.S.T., March 17, 1998, in order to be accepted for merit review and to permit timely consideration for award in Fiscal Year 1998.

ADDRESSES: All preapplications, referencing Program Notice 98-04, should be sent to Dr. Roland F. Hirsch, ER-73, Mail Stop F-240, Office of Biological and Environmental Research, U.S. Department of Energy, 19901 Germantown Road, Germantown, MD 20874-1290. Preapplications will be accepted if submitted by U. S. Postal Service, including Express Mail, commercial mail delivery service, or hand delivery, but will not be accepted by fax, electronic mail, or other means.

After receiving notification from DOE concerning successful preapplications, applicants may prepare and submit formal applications. Applications must be sent to: U.S. Department of Energy, Office of Energy Research, Grants and Contracts Division, ER-64, 19901 Germantown Road, Germantown, MD 20874-1290, Attn: Program Notice 98-04. The above address for formal applications must also be used when submitting formal applications by U.S. Postal Service Express Mail, any commercial mail delivery service, or when hand carried by the applicant.

FOR FURTHER INFORMATION CONTACT: Dr. Roland F. Hirsch, ER-73, Mail Stop F-240, Office of Biological and Environmental Research, Office of Energy Research, U.S. Department of Energy, 19901 Germantown Road, Germantown, MD 20874-1290, telephone: (301) 903-5349, fax: (301) 903-0567, E-mail: roland.hirsch@oer.doe.gov, or Mr. Mark Gilbertson, Office of Science and Risk Policy, Office of Science and Technology, Office of Environmental Management, 1000 Independence Avenue, SW, Washington, D.C. 20585, telephone: (202) 586-7150, E-mail: mark.gilbertson@em.doe.gov.

SUPPLEMENTARY INFORMATION: The Office of Environmental Management, in partnership with the Office of Energy Research, sponsors the Environmental Management Science Program (EMSP) to fulfill DOE's continuing commitment to the cleanup of DOE's environmental legacy. The program was initiated in Fiscal Year 1996.

The DOE Environmental Management program currently has ongoing applied research and engineering efforts under its Technology Development Program. These efforts must be supplemented with basic research to address long-term technical issues crucial to the EM mission. Basic research can also provide EM with near-term fundamental data that may be critical to the advancement of technologies that are under development but not yet at full scale nor implemented. Proposed basic research under this notice should contribute to environmental management activities that would decrease risk for the public and workers, provide opportunities for major cost reductions, reduce time required to achieve EM's mission goals, and, in general, should address problems that are considered intractable without new knowledge. This program is designed to inspire "breakthroughs" in areas critical to the EM mission through basic research and will be managed in partnership with ER. ER's well-established procedures, as set forth in the Energy Research Merit Review System, as published in the Federal Register, March 11, 1991, Vol. 56, No. 47, pages 10244-10246, will be used for merit review of applications submitted in response to this notice. This information is also available on the World Wide Web at <http://www.er.doe.gov/production/grants/merit.html>.

Subsequent to the formal scientific merit review, applications that are judged to be scientifically meritorious will be evaluated by DOE for relevance to the objectives of the Environmental Management Science Program. Additional information can be obtained at <http://www.em.doe.gov/science>.

Additional Notices for the Environmental Management Science Program may be issued during Fiscal Year 1998 covering other areas within the scope of the EM program.

Purpose

The need to build a stronger scientific basis for the Environmental Management effort has been established in a number of recent studies and reports. The Galvin Commission report ("Alternative Futures for the Department of Energy National Laboratories," February 1995) also provided the following observations and recommendations:

"There is a particular need for long term, basic research in disciplines related to environmental cleanup " ... "Adopting a science-based approach that includes supporting development of technologies and expertise " ... "could lead to both reduced cleanup costs and smaller environmental impacts at existing sites and to the development of a scientific foundation for advances in environmental technologies."

The Environmental Management Advisory Board Science Committee (Resolution on the Environmental Management Science Program, May 2, 1997) made the following observations:

"EMSP results are likely to be of significant value to EM" ... "Early program benefits, include: improved understanding of EM science needs, linkage with technology needs, and expansion of the cadre of scientific personnel working on EM problems" ... "Science program has the potential to lead to significant improvement in future risk reduction and cost and time savings."

The objectives of the Environmental Management Science Program are to:

- Provide scientific knowledge that will revolutionize technologies and clean-up approaches to significantly reduce future costs, schedules, and risks;
- "Bridge the gap" between broad fundamental research that has wide-ranging applicability such as that performed in DOE's Office of Energy Research and needs-driven applied technology development that is conducted in EM's Office of Science and Technology; and
- Focus the Nation's science infrastructure on critical DOE environmental management problems.

Representative Research Areas

Basic research is solicited in all areas of science with the potential for addressing problems in decontamination and decommissioning of nuclear facilities, an important subject of concern to the Department's Environmental Management Program. The relevant scientific disciplines include, but are not limited to, bioremediation, chemistry (including analytical chemistry and instrumentation, surface chemistry, and separations chemistry), computational sciences (including research and development of digital control algorithms for robotics, communication procedures and software technology for remote control of processing equipment), engineering sciences (including control systems and optimization, diagnostics, transport processes, fracture mechanics, and bioengineering), materials science (including alternate materials processing routes for waste minimization, welding and joining, degradation mechanisms, including corrosion and irradiation damage in radioactive waste forms, and remote sensing and monitoring), and physics (including optical, surface, and fluid physics).

Program Funding

Up to a total of \$4,000,000 of Fiscal Year 1998 Federal funds is expected to be available for new Environmental Management Science Program awards resulting from this Notice. Multiple-year funding of grant awards is anticipated, contingent upon the availability of funds. Award sizes are expected to be on the order of \$100,000-\$300,000 per year for total project costs for a typical three-year grant. Collaborative projects involving several research groups or more than one institution may receive larger awards if merited. The program will be competitive and offered to investigators in universities or other institutions of higher education, other non-profit or for-profit organizations, non-Federal agencies or entities, or unaffiliated individuals. DOE reserves the right to fund in whole or part any or none of the applications received in response to this Notice. A parallel announcement with a similar potential total amount of funds will be issued to DOE Federally Funded Research and Development Centers. All projects will be evaluated using the same criteria, regardless of the submitting institution.

Collaboration and Training

Applicants to the EMSP are strongly encouraged to collaborate with researchers in other institutions, such as universities, industry, non-profit organizations, federal laboratories and Federally Funded Research and Development Centers (FFRDCs), including the DOE National Laboratories, where appropriate, and to incorporate cost sharing and/or consortia wherever feasible.

Applicants are also encouraged to provide training opportunities, including student involvement, in applications submitted to the program.

Collaborative research applications may be submitted in several ways:

- (1) When multiple private sector or academic organizations intend to propose collaborative or joint research projects, the lead organization may submit a single application which includes another organization as a lower-tier participant (subcontract) who will be responsible for a smaller portion of the overall project. If approved for funding, DOE may provide the total project funds to the lead organization who will provide funding to the other participant via a subcontract arrangement. The application should clearly describe the role to be played by each organization, specify the managerial arrangements and explain the advantages of the multi-organizational effort.
- (2) Alternatively, multiple private sector or academic organizations who intend to propose collaborative or joint research projects may each prepare a portion of the application, then combine each portion into a single, integrated scientific application. A separate Face Page and Budget Pages must be included for each organization participating in the collaborative project. The joint application must be submitted to DOE as one package. If approved for funding, DOE will award a separate grant to each collaborating organization.

(3) Private sector or academic applicants who wish to form a collaborative project with a DOE FFRDC may not include the DOE FFRDC in their application as a lower-tier participant (subcontract). Rather each collaborator may prepare a portion of the proposal, then combine each portion into a single, integrated scientific proposal. The private sector or academic organization must include a Face Page and Budget Pages for their portion of the project. The FFRDC must include separate Budget Pages for their portion of the project. The joint proposal must be submitted to DOE as one package. If approved for funding, DOE will award a grant to the private sector or academic organization. The FFRDC will be funded, through existing DOE contracts, from funds specifically designated for new FFRDC projects. DOE FFRDCs will not compete for funding already designated for private sector or academic organizations. Other Federal laboratories who wish to form collaborative projects may also follow guidelines outlined in this section.

Preapplications

A brief preapplication may be submitted. The original and five copies must be received by December 16, 1997, to be considered. The preapplication should identify on the cover sheet the institution, PI name, address, telephone, fax and E-mail address for the principal investigator, title of the project, and the field of scientific research (using the list in the Application Categories section). The preapplication should consist of up to three pages of narrative describing the research objectives and the plan for accomplishing them, and should also include a paragraph describing the research background of the principal investigator and key collaborators if any.

Preapplications will be evaluated relative to the scope and research needs of the DOE's Environmental Management Science Program by qualified DOE program managers from both ER and EM. Preapplications are strongly encouraged but not required prior to submission of a full application. Please note that notification of a successful preapplication is not an indication that an award will be made in response to the formal application.

Application Format

Applicants are expected to use the following format in addition to following instructions in the Office of Energy Research Application Guide. Applications must be written in English, with all budgets in U.S. dollars.

- ER Face Page (DOE F 4650.2 (10-91))
- Application classification sheet (a plain sheet of paper with one selection from the list of scientific fields listed in the Application Categories Section)
- Table of Contents
- Project Abstract (no more than one page)
- Budgets for each year and a summary budget page for the entire project period (using DOE F 4620.1)
- Budget Explanation

- Budgets and Budget explanation for each collaborative subproject, if any
- Project Narrative (recommended length is no more than 20 pages; multi-investigator collaborative projects may use more pages if necessary up to a total of 40 pages)
 - Goals
 - Significance of Project to the EMSP
 - Background
 - Research Plan
 - Preliminary Studies (if applicable)
 - Research Design and Methodologies
- Literature Cited
- Collaborative Arrangements (if applicable)
- Biographical Sketches (limit 2 pages per senior investigator)
- Description of Facilities and Resources
- Current and Pending Support for each senior investigator

Application Categories

In order to properly classify each preapplication and application for evaluation and review, the documents must indicate the applicant's preferred scientific research field, selected from the following list.

Field of Scientific Research:

1. Bioremediation
2. Analytical Chemistry and Instrumentation
3. Separations Chemistry
4. Surface Chemistry
5. Computer and Mathematical Sciences
6. Engineering Sciences
7. Materials Science
8. Physics
9. Other

Application Evaluation and Selection

Scientific Merit.

The program will support the most scientifically meritorious and relevant work, regardless of the institution. Formal applications will be subjected to scientific merit review (peer review) and will be evaluated against the following evaluation criteria listed in descending order of importance as codified at 10 CFR 605.10(d).

1. Scientific and/or Technical Merit of the Project

2. Appropriateness of the Proposed Method or Approach
3. Competency of Applicant's Personnel and Adequacy of Proposed Resources
4. Reasonableness and Appropriateness of the Proposed Budget.

External peer reviewers are selected with regard to both their scientific expertise and the absence of conflict-of-interest issues. Non-federal reviewers may be used, and submission of an application constitutes agreement that this is acceptable to the investigator(s) and the submitting institution.

Relevance to Mission.

Subsequent to the formal scientific merit review, applications which are judged to be scientifically meritorious will be evaluated by DOE for relevance to the objectives of the Environmental Management Science Program. These objectives were established in the Conference Report for the Fiscal Year 1996 Energy and Water Development Appropriations Act, and are published in the Congressional Record--House, October 26, 1995, page H10956.

DOE shall also consider, as part of the evaluation, program policy factors such as an appropriate balance among the program areas, including research already in progress. Research funded in the Environmental Management Science Program in Fiscal Year 1996 and Fiscal Year 1997 can be viewed at <http://www.doe.gov/em52/science-grants.html>.

Application Guide and Forms

Information about the development, submission of applications, eligibility, limitations, evaluation, the selection process, and other policies and procedures may be found in 10 CFR Part 605, and in the Application Guide for the Office of Energy Research Financial Assistance Program. Electronic access to the Guide and required forms is made available via the World Wide Web at <http://www.er.doe.gov/production/grants/grants.html>.

Major Environmental Management Challenges

This research announcement has been developed for Fiscal Year 1998, along with a development process for a long-term program within Environmental Management, with the objective of providing continuity in scientific knowledge that will revolutionize technologies and clean-up approaches for solving DOE's most complex environmental problems. The following is an overview of the technical challenge facing the Environmental Management Program in the area of Decontamination and Decommissioning which is the focus of this announcement. More detailed descriptions of the specific technical needs and areas of emphasis associated with this problem area can be found in the background section of this Notice.

Deactivation refers to ceasing facility operations and placing the facility in a safe and stable condition to prevent unacceptable exposure of people or the environment to radioactive or other

hazardous materials until the facility can be decommissioned. Typically, deactivation involves removal of stored radioactive and other hazardous materials and the draining of systems. Decommissioning is the process of decontaminating or removing contaminated equipment and structures to achieve the desired end state for the facility. Desired end states include complete removal and remediation of the facility, release of the facility for unrestricted use, or release of facility for restricted use. Decontamination is the removal of unwanted radioactive or hazardous contamination by a chemical or mechanical process.

DOE must decontaminate and decommission a large number of aging, surplus facilities. The nature and magnitude of the facility decontamination, decommissioning, and material disposition problems require Environmental Management to address these problems quickly and cost-effectively. In Facility Decontamination and Decommissioning, Environmental Management is attempting to solve the problems of 7,000 contaminated buildings that require deactivation, and 900 contaminated buildings including their contents that require decommissioning. DOE is also responsible for decontaminating the metal and concrete within those buildings and disposing of 180,000 metric tons of scrap metal.

Several themes in the area of Facility Decontamination and Decommissioning were identified from research needs statements. These are summarized below:

- Characterization: Improved characterization and monitoring and certification of contaminated equipment and facilities with emphasis on real time characterization in the field.
- Contaminant removal: Advances in the removal of contamination from equipment and facilities, particularly metallic structures and equipment, and concrete structures. Other gaps in the knowledge base exist in containment technologies to prevent radioactive emissions and spread of contamination during deactivation and decommissioning; improved knowledge for safe removal of hazardous materials, including asbestos and lead; and remote handling and operations and ideas that could increase worker safety and productivity.
- Reduction of waste: Methods for reduction of waste volume produced by decontamination and decommissioning.

The aforementioned areas of emphasis does not preclude, and DOE strongly encourages, any innovative or creative ideas contributing to solving EM D&D challenges mentioned throughout this Notice.

Background

The United States involvement in nuclear weapons development for the last 50 years has resulted in the development of a vast research, production, and testing network known as the nuclear weapons complex. The Department has the challenge of deactivating 7,000 contaminated buildings and decommissioning 900 contaminated buildings that are currently on DOE's list of

surplus facilities. It is also responsible for decontaminating the metal and concrete within those buildings and disposing of 180,000 metric tons of scrap metal. As stated earlier, deactivation refers to ceasing facility operations and placing the facility in a safe and stable condition to prevent unacceptable exposure of people or the environment to radioactive or other hazardous materials until the facility can be decommissioned. Typically, deactivation involves removal of fuel and stored radioactive and other hazardous materials and draining of systems.

Decommissioning is the process of decontaminating or removing contaminated equipment and structures to achieve the desired end state for the facility. Desired end states include complete removal and remediation of the facility, release of facility for unrestricted use, or release of facility for restricted use. Decontamination is the removal of unwanted radioactive or hazardous contamination by a chemical or mechanical process.

Decontamination and Decommissioning (D&D) is centered around four main areas of surplus facilities. These are Reactor Facilities, Processing Facilities, Laboratory Facilities, and Infrastructure and Supporting Activities that pertain to all types of surplus facilities.

Reactor facilities include production, test, and research reactors and their associated buildings. These facilities represent a significant portion of DOE's D&D mortgage. The decontamination and decommissioning of these reactors could expose workers to high levels of radiation and hazardous material using currently-available, labor-intensive technologies.

Processing facilities includes plutonium, uranium, tritium, lithium processing facilities, and gaseous diffusion plants. Decommissioning of these facilities could benefit from innovative science in the areas of in-situ characterization and analysis, less costly waste disposal options, automated systems for containment and dismantlement, and material recycling.

Laboratory facilities include hot cells, gloveboxes, and analytical laboratories. Hot cells and gloveboxes have a high-radiation environment with highly-contaminated equipment. Decommissioning of these facilities could benefit from innovative science in the areas of debris removal, wet and dry decontamination methods, waste segregation and volume reduction, and remote and robotic dismantlement techniques.

Infrastructure and Supporting Activities includes innovative science in the areas of worker safety and protection; concrete and metal recycle; pollution prevention; and final waste forms.

This research agenda has been developed for Fiscal Year 1998, along with a development process for a long term program within EM, with the objective of providing continuity in scientific knowledge that will revolutionize technologies and clean-up approaches for solving DOE's most complex environmental problems. The following are descriptions of the Facility Decontamination and Decommissioning challenges which are intended to help align research and researchers in these efforts. Also included in bullet form are the specific science research challenges.

Characterization

Improvement of characterization, monitoring, and certification of contaminated equipment and facilities. Improvements are needed in the area of remote characterization and remote surveying, including improved means to obtain samples remotely from difficult-to-access places such as underground tanks and piping systems and in areas having high radiation fields or other hazardous situations. Rapid automated characterization and certification of levels of surface radioactive contamination on scrap metal is needed; that is, systems which can differentiate between contaminated and non-contaminated equipment and methods to aid in material segregation. Also, advances in engineering sciences associated with development of miniaturized and micro-equipment, robotics, and control theories are needed to support remote inspection needs. A method is needed to trace and plot the exact spatial location of underground piping and unknown buried or embedded objects. Improved remote and non-intrusive methods are needed to verify the existence or absence of contamination in drains, pipes, and associated equipment. Non-destructive characterization mapping methods are needed. Improved radiological characterization and certification of contaminated equipment and facilities are also needed. Improved methods and techniques are needed to detect the presence of asbestos-containing materials in the field in real-time or near real-time. Improved methods and ideas are needed to detect and quantify contaminants that have penetrated below the surface of porous materials such as concrete and transite.

Some examples of specific science research challenges include but are not limited to:

- Research to advance the state-of-the art for radiation-hardened microelectronics, sensors, sample-collection systems, and controls in robotics for remote characterizations in difficult-to-access places and in areas having high radiation fields or other hazardous situations.
- Applications of new principles and innovations to support the development of sensors, detectors, or monitors for rapid automated characterization and certification of levels of radionuclides, asbestos, lead, dioxin, or other toxic substances that may exist on the surface of scrap metal, equipment, and facilities, or be introduced into the atmosphere during cleanup operations.
- Research to expand knowledge of the principles of energy beam-material interactions, including energy coupling, mass removal by vaporization and ablation, particle generation, gas dynamics, solid vapor entrainment, and transport processes, for characterizing and removing contamination from surfaces.

Deactivation

Improved methods and ideas to reduce the cost to survey and maintain facilities awaiting deactivation or decommissioning, including automated, non-intrusive monitoring of facilities for

structural integrity and contaminant migration. Improved methods and ideas should minimize labor and cost to survey and maintain facilities.

Some examples of specific science research challenges include but are not limited to:

- Exploration of computational and artificial intelligence approaches for robotics technology to enhance material packing, disposition, or recycling and thereby help reduce the health risks to workers, as well as the costs and time associated with decontamination and decommissioning.

Contaminant Removal

Improved methods for removing contamination from surfaces, including metals, concrete, and non-porous surfaces. In contaminated facilities, much of the concrete, paint, or similar materials are contaminated only on the surface or to a relatively shallow depth (for concrete, typically less than one inch). Fundamental studies associated with diffusion of species into and out of porous materials are needed to design innovative approaches to cleaning of porous materials. Historically, such materials have been handled by mechanically removing the paint by sanding/blasting or the surface layers of concrete through a scrubbing operation. These processes are slow and costly and directly expose the workers to radiation fields. Dust control is also a problem. In addition to surface contamination, concrete often contains expansion joints or cracks where contamination may have penetrated deeper. Jackhammers are typically used to remove concrete from these cracks or seams in an attempt to remove the contamination. This is a labor intensive operation. It is desired that new or significantly improved ideas be developed to decontaminate these concrete structures and painted areas, and reduce the amount of secondary waste. In addition, improved methods and ideas are needed to remove greater than one-inch depth of concrete surface.

Improved understanding of radionuclide and heavy metal adhesion and adsorption to material surfaces is needed. Fundamental studies associated with structure bonding of materials is advantageous to develop new or improved removal methods. Steel or other metals are often encountered in a variety of shapes and sizes in contaminated nuclear facilities. Since the decontamination of metal often results in the generation of large volumes of secondary waste, the metal is disposed of as radioactive waste rather than expend funds on decontaminating and surveying the metal. New or significantly improved decontamination techniques are needed for stainless steel, copper, nickel, iron, carbon steel structural members, and galvanized siding that could lead to recycling the metal into products for use within DOE, or free releasing the metal to the commercial scrap metal market. The decontamination process should be cost effective and safe and should not generate large volumes of a secondary waste, which would be difficult or expensive to dispose of. Improved methods and ideas are needed for in-situ decontamination of contaminated pipes.

Some examples of specific science research challenges include but are not limited to:

- Research to develop understanding of the formation and dissolution of surface films, including structure, speciation, composition and energetics.
- Elucidation of the mechanisms of radionuclide and metal adhesion, adsorption, and structural bonding to material surfaces, including work specific to Pu and other actinides.
- Exploration of principles of ultrasonic irradiation and cavitation to evaluate potential for destroying organic contaminants, accelerating reaction rates, enhancing catalysis, and cleaning surfaces.
- Research on the nature and design of ligands that can photo-release radionuclides, metals, and contaminants from surfaces.
- Elucidation of the principles of biological approaches to surface cleaning and diagnostics.

Containment methods/techniques to prevent spread of contamination.

Cleanup, decommissioning, dismantling, and construction activities will require containment methods to prevent the spread of contamination offsite or to uncontaminated areas on-site. Containment of the airborne contamination during disassembly and demolition activities is also a problem. Fundamental chemical research is desired for development of fixatives and auto-forming barriers to support development of cost effective containment technology. Fundamental chemical research is needed in the development of cost effective reactant or binding agents. Improved and easily portable containment systems are also needed. Research is needed to improve personal protective equipment to improve the level of worker protection, productivity, and comfort with emphasis on reducing heat stress to workers and ability to safely and comfortably work at heights and in confined or restricted spaces.

Some examples of specific science research challenges include but are not limited to:

- Research to support the development of fixatives, binding agents, and auto-forming barriers for effective containment on surfaces.
- Scientific and engineering research to support development of easily portable systems for containing environmental contaminants.

Remote Decontamination and Decommissioning Handling and Operations, including Demolition.

Improved methods of remote demolition are needed: fast, cost-effective ways of dismantling metal structures, piping, machinery, and concrete structures. The goal is to reduce the

requirement of hands-on dismantlement by D&D workers while reducing the cost of such operations. Basic science is needed to improve the ability of robotic devices to function in harsh environments such as high radiation, high temperature, and/or abrasive environments.

Some examples of specific science research challenges include but are not limited to:

- Work to improve the ability of robotic devices to function in harsh environments such as high radiation, high temperature, and/or abrasive environments.

Improvement of Decontamination Techniques for Process Equipment and Facilities Dismantlement.

Research into ways to decontaminate complex process equipment and techniques to recycle materials or reduce waste are needed. Improved methods and ideas are needed to dismantle or cut metallic and other materials in the form of metallic equipment and piping, concrete structures, asbestos-containing materials, and other construction materials.

Some examples of specific science research challenges include but are not limited to:

- Research to remove limitations on achievable power levels in, and ease of control of, remotely operable focused heat sources, such as electron and laser beams.
- Research to establish criteria and methods for the identification and isolation of components which require further treatment.

Reduction of Waste.

Reduction of Wastes Produced by Decontamination and Decommissioning.

Many wastes are generated in the process of decommissioning a contaminated nuclear facility. Typically, large amounts of concrete, metal, and construction materials (e.g., roofing, asphalt, asbestos, lumber, tile, siding, and sometimes electronic equipment) are encountered as waste. Improved methods are needed for volume reduction of decommissioning waste such as metallic equipment, piping, conduit, concrete structures, metallic support structures, and asbestos-containing materials. Recycling or reuse of these materials would result in significant reductions in the volume of waste. Improved techniques or ideas are needed that could dismantle or decontaminate equipment and structures while minimizing the generation of secondary waste.

Some examples of specific science research challenges include but are not limited to:

- Research on fracture mechanisms in various types of materials.

- Elucidation of the principles of the diffusive and advective transport of chemical species in porous or fractured material.
- Engineering research to couple existing surface decontamination methods with diagnostic and control technologies to discriminate between contaminated and non-contaminated areas on heterogeneous surfaces.
- Research to support development of computational and artificial intelligence approaches for robotics technology to enhance material packing, disposition, or recycling and reduce the risks, costs and time associated with decontamination and decommissioning.

Details of the programs of the Office of Environmental Management and the technologies currently under development or in use by Environmental Management Program can be found on the World Wide Web at <http://www.em.doe.gov> and at the extensive links contained therein. These programs and technologies should be used to obtain a better understanding of the missions and challenges in environmental management in DOE when considering areas of research to be proposed.

References for Background Information

Note: World Wide Web locations of these documents are provided where possible. For those without access to the World Wide Web, hard copies of these references may be obtained by writing Mark A. Gilbertson at the address listed in the FOR FURTHER INFORMATION CONTACT section.

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<http://www.doe.gov/policy/doeplan.htm>

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<http://www.em.doe.gov/circle/index.html>

National Research Council. 1997. Building an Environmental Management Science Program: Final Assessment. National Academy Press, Washington, DC.
<http://www.nap.edu/readingroom/books/envmanage/>

National Research Council. 1995. Improving the Environment: An Evaluation of DOE's Environmental Management Program. National Academy Press, Washington, D.C.
<http://www.nap.edu/readingroom/books/doemp/>

Secretary of Energy Advisory Board. Alternative Futures for the Department of Energy National Laboratories. February 1995. Task Force on alternative Futures for the Department of Energy National Laboratories, Washington, D.C.
<http://www.doe.gov/html/doe/whatsnew/galvin/tf-rpt.html>

U.S. Congress, Office of Technology Assessment. Complex Cleanup: The Environmental Legacy of Nuclear Weapons Production, February 1991. U.S. Government Printing Office, Washington, D.C. NTIS Order number: PB91143743. To order, call the NTIS sales desk at (703) 487-4650.
http://www.wws.princeton.edu:80/~ota/disk1/1991/9113_n.html

National Science and Technology Council. 1996. Assessing Fundamental Science, Council on Fundamental Science.
<http://www.nsf.gov/sbe/srs/ostp/assess/>

The Catalog of Federal Domestic Assistance Number for this program is 81.049, and the solicitation control number is ERFAP 10 CFR Part 605.

Issued in Washington, DC November 12, 1997.

John Rodney Clark,

Associate Director for Resource Management Office of Energy Research

[FR Doc. 97-30121 Filed 11-14-97; 8:45am]

BILLING CODE 6450-01-P

Office of Energy Research and Office of Environmental Management; Energy Research Financial Assistance Program Notice 98-08; Environmental Management Science Program: Research Related to High Level Radioactive Waste

AGENCY: Office of Energy Research and Office of Environmental Management. U.S. Department of Energy (DOE).

ACTION: Notice inviting grant applications.

SUMMARY: The Offices of Energy Research (ER) and Environmental Management (EM), U.S. Department of Energy, hereby announce their interest in receiving grant applications for performance of innovative, fundamental research to support specific activities for high level radioactive waste; which include, but are not limited to, characterization and safety, retrieval of tank waste and tank closure, pretreatment, and waste immobilization and disposal.

DATES: Potential applicants are strongly encouraged to submit a brief preapplication. All preapplications, referencing Program Notice 98-08, should be received by DOE by 4:30 P.M. E.S.T., January 27, 1998. A response encouraging or discouraging a formal application generally will be communicated to the applicant within three weeks of receipt. The deadline for receipt of formal applications is 4:30 P.M., E.D.T., April 16, 1998, in order to be accepted for merit review and to permit timely consideration for award in Fiscal Year 1998.

ADDRESSES: All preapplications, referencing Program Notice 98-08, should be sent to Dr. Roland F. Hirsch, ER-73, Mail Stop F-240, Office of Biological and Environmental Research, U.S. Department of Energy, 19901 Germantown Road, Germantown, MD 20874-1290. Preapplications will be accepted if submitted by U. S. Postal Service, including Express Mail, commercial mail delivery service, or hand delivery, but will not be accepted by fax, electronic mail, or other means.

After receiving notification from DOE concerning successful preapplications, applicants may prepare and submit formal applications. Applications must be sent to: U.S. Department of Energy, Office of Energy Research, Grants and Contracts Division, ER-64, 19901 Germantown Road, Germantown, MD 20874-1290, Attn: Program Notice 98-08. The above address for formal applications must also be used when submitting formal applications by U.S. Postal Service Express Mail, any commercial mail delivery service, or when hand carried by the applicant. **FOR FURTHER INFORMATION CONTACT:** Dr. Roland F. Hirsch, ER-73, Mail Stop F-240, Office of Biological and Environmental Research, Office of Energy Research, U.S. Department of Energy, 19901 Germantown Road, Germantown, MD 20874-1290, telephone:

(301) 903-5349, fax: (301) 903-0567, E-mail: roland.hirsch@oer.doe.gov, or Mr. Mark Gilbertson, Office of Science and Risk Policy, Office of Science and Technology, Office of Environmental Management, 1000 Independence Avenue, SW, Washington, D.C. 20585, telephone: (202) 586-7150, E-mail: mark.gilbertson@em.doe.gov. This Notice is also available on the World Wide Web at http://www.er.doe.gov/production/grants/fr98__08.html.

SUPPLEMENTARY INFORMATION: The Office of Environmental Management, in partnership with the Office of Energy Research, sponsors the Environmental Management Science Program (EMSP) to fulfill DOE's continuing commitment to the cleanup of DOE's environmental legacy. The program was initiated in Fiscal Year 1996. We are soliciting ideas for basic scientific research which promotes the broad national interest of a better understanding of the fundamental characteristics of highly radioactive chemical wastes and their effects on the environment. The DOE Environmental Management program currently has ongoing applied research and engineering efforts under its Technology Development Program. These efforts must be supplemented with basic research to address long-term technical issues crucial to the EM mission. Basic research can also provide EM with near-term fundamental data that may be critical to the advancement of technologies that are under development but not yet at full scale nor implemented. Proposed basic research under this Notice should contribute to environmental management activities that would decrease risk for the public and workers, provide opportunities for major cost reductions, reduce time required to achieve EM's mission goals, and, in general, should address problems that are considered intractable without new knowledge. This program is designed to inspire "breakthroughs" in areas critical to the EM mission through basic research and will be managed in partnership with ER. ER's well-established procedures, as set forth in the Energy Research Merit Review System, as published in the Federal Register, March 11, 1991, Vol. 56, No. 47, pages 10244-10246, will be used for merit review of applications submitted in response to this Notice. This information is also available on the World Wide Web at <http://www.er.doe.gov/production/grants/merit.html>. Subsequent to the formal scientific merit review, applications that are judged to be scientifically meritorious will be evaluated by DOE for relevance to the objectives of the Environmental Management Science Program. Additional information can be obtained at <http://www.em.doe.gov/science>.

Additional Notices for the Environmental Management Science Program may be issued during Fiscal Year 1998 covering other areas within the scope of the EM program.

Purpose

The need to build a stronger scientific basis for the Environmental Management effort has been established in a number of recent studies and reports. The FY 1998 Conference Report for Appropriations for Energy and Water Development, Report 105-271, dated September 26, 1997, on page 92 states the following:

"The conferees are pleased with the progress to date in implementing the environmental science program..."

The Environmental Management Advisory Board Science Committee (Resolution on the Environmental Management Science Program, May 2, 1997) made the following observations:

“EMSP results are likely to be of significant value to EM” ... “Early program benefits include: improved understanding of EM science needs, linkage with technology needs, and expansion of the cadre of scientific personnel working on EM problems” ... “Science program has the potential to lead to significant improvement in future risk reduction and cost and time savings.”

The objectives of the Environmental Management Science Program are to:

- Provide scientific knowledge that will revolutionize technologies and clean-up approaches to significantly reduce future costs, schedules, and risks;
- “Bridge the gap” between broad fundamental research that has wide-ranging applicability such as that performed in DOE's Office of Energy Research and needs-driven applied technology development that is conducted in EM's Office of Science and Technology; and
- Focus the Nation's science infrastructure on critical DOE environmental management problems.

Representative Research Areas

Basic research is solicited in areas of science with the potential for addressing problems in the cleanup of high level radioactive waste. Relevant scientific disciplines include, but are not limited to, chemistry (including actinide chemistry, analytical chemistry and instrumentation, interfacial chemistry, and separation science), computer and mathematical sciences, engineering science (chemical and process engineering), materials science (degradation mechanisms, modeling, corrosion, non-destructive evaluation, sensing of waste hosts, canisters), and physics (fluid flow, aqueous-ionic solid interfacial properties underlying rheological processes).

Program Funding

Up to a total of \$4,000,000 of Fiscal Year 1998 Federal funds is expected to be available for new Environmental Management Science Program awards resulting from this Notice. Multiple-year funding of grant awards is anticipated, contingent upon the availability of funds. Award sizes are expected to be on the order of \$100,000-\$300,000 per year for total project costs for a typical three-year grant. Collaborative projects involving several research groups or more than one institution may receive larger awards if merited. The program will be competitive and offered to investigators in universities or other institutions of higher education, other non-profit or for-profit organizations, non-Federal agencies or entities, or unaffiliated individuals. DOE reserves the right to fund in whole or part any or none of the applications received in response to this Notice. DOE is under no obligation to pay for any costs associated with the preparation or submission of applications. A parallel announcement with a similar potential total amount of funds will be

issued to DOE Federally Funded Research and Development Centers (FFRDCs). All projects will be evaluated using the same criteria, regardless of the submitting institution.

Collaboration and Training

Applicants to the EMSP are strongly encouraged to collaborate with researchers in other institutions, such as universities, industry, non-profit organizations, federal laboratories and FFRDCs, including the DOE National Laboratories, where appropriate, and to incorporate cost sharing and/or consortia wherever feasible.

Applicants are also encouraged to provide training opportunities, including student involvement, in applications submitted to the program.

Collaborative research applications may be submitted in several ways:

- (1) When multiple private sector or academic organizations intend to propose collaborative or joint research projects, the lead organization may submit a single application which includes another organization as a lower-tier participant (subaward) who will be responsible for a smaller portion of the overall project. If approved for funding, DOE may provide the total project funds to the lead organization who will provide funding to the other participant via a subcontract arrangement. The application should clearly describe the role to be played by each organization, specify the managerial arrangements and explain the advantages of the multi-organizational effort.
- (2) Alternatively, multiple private sector or academic organizations who intend to propose collaborative or joint research projects may each prepare a portion of the application, then combine each portion into a single, integrated scientific application. A separate Face Page and Budget Pages must be included for each organization participating in the collaborative project. The joint application must be submitted to DOE as one package. If approved for funding, DOE will award a separate grant to each collaborating organization.
- (3) Private sector or academic applicants who wish to form a collaborative project with a DOE FFRDC may not include the DOE FFRDC in their application as a lower-tier participant (subcontract). Rather, each collaborator may prepare a portion of the proposal, then combine each portion into a single, integrated scientific proposal. The private sector or academic organization must include a Face Page and Budget Pages for its portion of the project. The FFRDC must include separate Budget Pages for its portion of the project. The joint proposal must be submitted to DOE as one package. If approved for funding, DOE will award a grant to the private sector or academic organization. The FFRDC will be funded, through existing DOE contracts, from funds specifically designated for new FFRDC projects. DOE FFRDCs will not compete for funding already designated for private sector or academic organizations. Other Federal laboratories who wish to form collaborative projects may also follow guidelines outlined in this section.

Preapplications

A brief preapplication may be submitted. The original and five copies must be received by January 27, 1998, to be considered. The preapplication should identify on the cover sheet the institution, Principal Investigator name, address, telephone, fax and E-mail address, title of the project, and the field of scientific research (using the list in the Application Categories section). The preapplication should consist of up to three pages of narrative describing the research objectives and the plan for accomplishing them, and should also include a paragraph describing the research background of the principal investigator and key collaborators if any.

Preapplications will be evaluated relative to the scope and research needs of the DOE's Environmental Management Science Program by qualified DOE program managers from both ER and EM. Preapplications are strongly encouraged but not required prior to submission of a full application. Please note that notification of a successful preapplication is not an indication that an award will be made in response to the formal application.

Application Format

Applicants are expected to use the following format in addition to following instructions in the Office of Energy Research Application Guide. Applications must be written in English, with all budgets in U.S. dollars.

- ER Face Page (DOE F 4650.2 (10-91))
- Application classification sheet (a plain sheet of paper with one selection from the list of scientific fields listed in the Application Categories Section)
- Table of Contents
- Project Abstract (no more than one page)
- Budgets for each year and a summary budget page for the entire project period (using DOE F 4620.1)
- Budget Explanation
- Budgets and Budget explanation for each collaborative subproject, if any
- Project Narrative (recommended length is no more than 20 pages; multi-investigator collaborative projects may use more pages if necessary up to a total of 40 pages):
 - Goals
 - Significance of Project to the EMSP
 - Background
 - Research Plan
 - Preliminary Studies (if applicable)
 - Research Design and Methodologies
- Literature Cited
- Collaborative Arrangements (if applicable)
- Biographical Sketches (limit 2 pages per senior investigator)
- Description of Facilities and Resources
- Current and Pending Support for each senior investigator

Application Categories

In order to properly classify each preapplication and application for evaluation and review, the documents must indicate the applicant's preferred scientific research field, (please use only the designation on this list and please select only one field of scientific research) from the following list of Field of Scientific Research:

1. Actinide Chemistry
2. Analytical Chemistry and Instrumentation
3. Interfacial Chemistry
4. Separations Science
5. Computer and Mathematical Sciences
6. Engineering Sciences
7. Materials Science
8. Physics
9. Other

Application Evaluation and Selection

Scientific Merit. The program will support the most scientifically meritorious and relevant work, regardless of the institution. Formal applications will be subjected to scientific merit review (peer review) and will be evaluated against the following evaluation criteria listed in descending order of importance as codified at 10 CFR 605.10(d):

1. Scientific and/or Technical Merit of the Project
2. Appropriateness of the Proposed Method or Approach
3. Competency of Applicant's Personnel and Adequacy of Proposed Resources
4. Reasonableness and Appropriateness of the Proposed Budget.

External peer reviewers are selected with regard to both their scientific expertise and the absence of conflict-of-interest issues. Non-federal reviewers may be used, and submission of an application constitutes agreement that this is acceptable to the investigator(s) and the submitting institution.

Relevance to Mission. Subsequent to the formal scientific merit review, applications which are judged to be scientifically meritorious will be evaluated by DOE for relevance to the objectives of the Environmental Management Science Program. These objectives were established in the Conference Report for the Fiscal Year 1996 Energy and Water Development Appropriations Act, and are published in the Congressional Record--House, October 26, 1995, page H10956.

DOE shall also consider, as part of the evaluation, program policy factors such as an appropriate balance among the program areas, including research already in progress. Research funded in the

Environmental Management Science Program in Fiscal Year 1996 and Fiscal Year 1997 can be viewed at <http://www.doe.gov/em52/science-grants.html>.

Application Guide and Forms

Information about the development, submission of applications, eligibility, limitations, evaluation, the selection process, and other policies and procedures may be found in 10 CFR Part 605, and in the Application Guide for the Office of Energy Research Financial Assistance

Program. Electronic access to the Guide and required forms is made available via the World Wide Web at <http://www.er.doe.gov/production/grants/grants.html>.

Major Environmental Management Challenges

This research announcement has been developed for Fiscal Year 1998, along with a development process for a long-term program within Environmental Management, with the objective of providing continuity in scientific knowledge that will revolutionize technologies and clean-up approaches for solving DOE's most complex environmental problems. The following is an overview of the technical challenge facing the Environmental Management Program in the area of High Level Radioactive Waste which is the focus of this announcement. More detailed descriptions of the specific technical needs and areas of emphasis associated with this problem area can be found in the Background section of this Notice.

High-level Radioactive Waste Tanks. The Department is the guardian of over 300 large storage tanks containing over 90 million gallons of highly radioactive wastes, which include organic and inorganic chemical compounds, in solid, colloidal, slurry, and liquid phases. The environment within the tanks is highly radioactive and chemically harsh. A few of the tanks have leaked to the environment while others are corroding.

Specific areas of emphasis in technology needs and research challenges related to high level waste (HLW) tank problems include, but are not limited to:

- Characterization and Safety
- Retrieval of Tank Waste and Tank Closure
- Pretreatment and Separation Processes for Tank Waste
- Waste Immobilization and Disposal

Historically, characterization of tank waste has been very expensive, has failed to obtain representative data for many tanks, and has generated safety concerns from worker exposure to radioactive waste. Within the Characterization and Safety area there is the need to develop systems to identify chemical and physical characteristics of the waste in situ, improve data quality and timeliness, and reduce safety concerns.

In the Retrieval of Tank Waste and Tank Closure area, there is the need to develop cost-efficient methods to remove saltcake, sludge, and waste heels and close a high-level waste tank that may contain a flammable gas environment. Some sites have numerous tanks that contain saltcake so that the potential cost savings of less expensive saltcake retrieval methods is very large.

Pretreatment and Separation Processes for Tank Waste will separate tank wastes into low-and high-level fractions, thereby significantly reducing the volumes of high-level waste requiring disposal. These separations include not only chemical separations, but also physical separations.

Low level waste (LLW) immobilization will reduce waste volumes and produce waste forms that are chemically and physically durable. EM is applying two technologies (grout and glass) to the same waste stream to allow an unbiased appraisal of the true costs and risks associated with implementing each technology for full-scale tank waste remediation. Both technologies must be robust enough to handle the range of constituents found in the tank wastes.

The aforementioned areas of emphasis do not preclude, and DOE strongly encourages, any innovative or creative ideas contributing to solving EM HLW challenges mentioned throughout this Notice.

Background

Environmental Management (EM) is responsible for the development, testing, evaluation, and deployment of remediation technologies within a system architecture to characterize, retrieve, treat, concentrate, and dispose of radioactive waste stored in the underground storage tanks at DOE facilities and ultimately stabilize and close the tanks. The goal is to provide safe and cost-effective solutions that are acceptable to both the public and regulators.

Within the DOE complex, 335 underground storage tanks have been used to process and store radioactive and chemical mixed waste generated from weapon materials production and manufacturing. Collectively, these tanks hold over 90 million gallons of high-level and low-level radioactive liquid waste in sludge, saltcake, and as supernate and vapor. Very little has been treated and/or disposed of in final form.

Tanks vary in design from carbon or stainless steel to concrete, and concrete with carbon steel liners. Two types of storage tanks are most prevalent: the single-shell and double-shell concrete tanks with carbon steel liners. Capacities vary from 5,000 gallons (19m^3) to 1,300,000 gallons (4920m^3). The tanks are covered with a layer of soil ranging from a few feet to tens of feet thick.

Most of the waste is alkaline and contains a diverse portfolio of chemical constituents including nitrate and nitrite salts (approximately half of the total waste), hydrated metal oxides, phosphate precipitates, and ferrocyanides. The 784 MCi of radionuclides are distributed primarily among the transuranic (TRU) elements and fission products, specifically strontium-90, cesium-137, and their decay products yttrium-90 and barium-137. In-tank atmospheric conditions vary in severity

from near ambient to temperatures over 93°C. Tank void-space radiation fields can be as high as 10,000 rad/h.

EM is focusing attention on four DOE locations:

- Hanford Site near Richland, Washington.
- Idaho National Engineering and Environmental Laboratory near Idaho Falls, Idaho.
- Oak Ridge Reservation near Oak Ridge, Tennessee.
- Savannah River Site near Aiken, South Carolina.

Hanford has 177 tanks that contain approximately 55 million gallons of hazardous and radioactive waste. There are 149 single-shell tanks that have exceeded their life expectancy. Sixty-seven of these tanks have known or suspected leaks. Due to several changes in the production processes since the early 1940s, some of the tanks contain incompatible waste components, generating hydrogen gas and excess heat that further compromise tank integrity.

The 11 stainless steel tanks at Idaho store approximately 2 million gallons of acidic radioactive liquids. Additionally, approximately 4000 m³ of calcined waste solids are stored in seven stainless steel bins enclosed in massive underground concrete vaults.

Dilute low-level waste (LLW) supernatants and associated sludge at Oak Ridge are stored in the inactive Gunite and associated tanks, the old hydrofracture tanks, and other tanks. The wastes from underground collection systems are currently being retrieved and consolidated in the stainless steel central treatment/storage tanks, including eight Melton Valley Storage Tanks.

Tank waste at Savannah River consists of 33 million gallons of salt, salt solution, and sludge containing waste stored in 51 underground storage tanks, two of which have been closed (emptied of all waste and filled with grout). Twenty-three tanks are being retired, because they do not have full secondary containment. Nine tanks have leaked detectable quantities of waste from the primary tank to secondary containment.

Most of the participant sites share four problem areas. These areas are:

- Characterization and Safety.
- Retrieval of Tank Waste and Tank Closure.
- Pretreatment and Separation Processes for Tank Waste.
- Waste Immobilization and Disposal.

Characterization and Safety

DOE, contractors, and stakeholders have committed to a safe and efficient remediation of HLW, mixed waste, and hazardous waste stored in underground tanks across the DOE complex.

Currently, there are only limited fully developed or deployed in situ techniques to characterize tank waste. In situ characterization can eliminate the time delay between sample removal and

sample analysis and aid in guiding the sampling process while decreasing the cost (approximately \$1 million is spent for one tank core extrusion) of waste analysis. Most importantly, remote analysis eliminates sample handling and safety concerns due to worker exposure. However, analysis of extruded tank samples allows a more complete chemical and physical characterization of the waste when needed. Knowledge of the chemical and radioactive composition and physical parameters of the waste is essential to safe and effective tank remediation.

There are three primary drivers for the development of new chemical analysis methods to support tank waste remediation: (1) provide analyses for which there are currently no reliable existing methods, (2) replace current methods that require too much time and/or are too costly, and (3) provide methods that evolve into on-line process analysis tools for use in waste processing facilities.

Characterization of the elemental and isotopic chemical constituents in DOE tank waste is an important function in support of DOE tank waste operation and remediation functions. Proper waste characterization enables: safe operation of the tank farms; resolution of tank safety questions; and development of processes and equipment for retrieval, pretreatment, and immobilization of tank waste. All of these operations are dependent on the chemical analysis of tank waste.

Moisture is one of the key elements influencing the safety status of some of Hanford's HLW tanks. Ferrocyanides were added to tank wastes to increase the available storage space when production outstripped the ability to provide adequate storage space. Organics from some of the extraction processes used at Hanford ended up in tanks because of inefficient reagent recovery processes. Moisture provides a thermal buffer for the prevention of ignition and propagation of thermal reactions in waste containing ferrocyanides or organics. Insufficient moisture level raises the possibility of explosion. The conditions for a thermal event are reduced by the presence of water in the wastes. A method is needed to measure and quantify tank waste water concentrations in situ.

The need for chemical characterization of the tank wastes is driven by both safety and operational considerations. Safety drivers include the monitoring of organic chemicals and oxidizers to address flammability and energetics, nitrate and nitrite levels to address corrosion concerns, plutonium levels to address criticality prevention considerations, and detection of organic and inorganic species to identify chemical incompatibility hazards associated with ferrocyanides, nitrates, sulfates, carbonates, phosphates, and other oxyanions. Operational concerns include the monitoring of phosphate levels driven by the potential formation of sodium phosphate crystals, thereby increasing the viscosity of the waste by formation of a gelatinous matrix which will reduce the ability of pumps to transfer and retrieve waste.

Current techniques of tank waste analysis involve the removal of core samples from tanks, followed by costly and time consuming wet analytical laboratory testing. Savings in both cost

and time could be realized in techniques that involve in situ probes for direct analysis of tank materials.

Single-shell and double-shell waste tank construction is common across the DOE complex. The single-shell tanks present potential environmental hazards because only a single barrier contains the liquids and any breach in the barrier will cause contaminant spillage. A sluicing method being considered to retrieve the waste requires thousands of gallons of water, raising the possibility of HLW leakage into the surrounding environment. In other tanks, water is added to prevent the waste matrix from drying and provides a deterrent from possible ignition due to flammable gases. There is a need to develop instrumentation to determine the location of a leak, the amounts of materials that were exposed, and the quantity of the contaminant material.

Assessments of the long-term performance of waste forms is rare; performance assessments of radionuclide containment rely primarily on the geologic barriers (e.g., long travel times in hydrologic systems or sorption on mineral surfaces). The physical and chemical durability of the waste form, however, can contribute greatly to the successful isolation of radionuclides; thus the effects of radiation on physical properties and chemical durability of waste forms are of great importance. The changes in chemical and physical properties occur over relatively long periods of storage, up to a million years, and at temperatures that range from 100 to 300 degrees Celsius, depending on waste loading, age of the waste, depth of burial, and the repository-specific geothermal agent. Thus, a major challenge is to effectively simulate high-dose radiation effects that will occur over relatively low-dose rates over long periods of time at elevated temperatures. Thus there is a paramount need for improved understanding and modeling of the degradation mechanisms and behavior of primary radioactive waste hosts and/or their containment canisters, corrosion mechanisms and prevention in aqueous and/or alkali halide containing environments, and remote sensing and non-destructive evaluation.

Examples of specific science research challenges include but are not limited to: basic measurement science and sensor development required for remote detection of low concentrations of hydrogen inside tanks and in containers; basic analytical studies needed to develop new methods for chemical and physical characterization of solid and liquids in slurries and for development of advanced processing methodologies; basic instrument development needed to perform in situ radiological measurements and collect spatially resolved species and concentration data; basic materials and engineering science needed to develop radiation hardened instrumentation.

Retrieval of Tank Waste and Tank Closure

Underground tanks throughout the DOE in Hanford, Savannah River, Oak Ridge, and Idaho have stored a diverse accumulation of wastes during the past fifty years of weapons and fuel production. If these tanks were entrapped in a manner that would preclude the escape into the environment for hundreds of years, there would be no reason to disturb them. However, a number

of the storage tanks are approaching the end of their design life. At the four sites, 90 tanks have either leaked or are assumed to have leaked waste into the soil and sediments near the tanks.

Recently, dewatering processes have removed much of the free liquid from the alkaline waste tanks. The tanks now contain wastes ranging in consistency from remaining supernate and soft sludge to concrete-like saltcake. Tanks also contain miscellaneous foreign objects such as Portland cement, measuring tapes, samarium balls, and in-tank hardware such as cooling coils and piping. Unlimited sluicing, adding large quantities of water to suspend solids, is the baseline method for sludge removal from tanks. This process is not capable of retrieving all of the material from tanks. Besides dealing with aging tanks and difficult wastes, retrieval also faces the problem of the tank design itself. Retrieval tools must be able to enter the tanks, which are under an average of 10 feet of soil, through small openings called risers in the tops of the tanks.

Retrieval of tank waste and tank closure requires tooling and process alternative enhancements to mixing and mobilizing bulk waste as well as dislodging and conveying heels. Heel removal is linked to tank closure. The working tools and removal devices being developed include suction devices, rubblizing devices, water and air jets, waste conditioning devices, grit blasting devices, transport and conveyance devices, cutting and extraction tools, monitoring devices, and various mechanical devices for recovery or repair of waste dislodging and conveyance tools.

The areas directly below the access risers are often disturbed or contain a significant amount of discarded debris. Therefore, evaluation of tank waste characteristics by measurements taken at these locations may not be representative of the properties of the waste in other areas of the tanks.

To monitor current conditions and plan for tank remediation, more information on the tank conditions and their contents is required. Current methods used at DOE tank sites are limited to positioning sensors, instruments, and devices to locations directly below access penetrations or attached to a robotic arm for off-riser positioning. These systems can only deploy one type of sensor, requiring multiple systems to perform more than one function in the tank.

Currently, decisions regarding necessary retrieval technologies, retrieval efficiencies, retrieval durations, and costs are highly uncertain. Although tank closure has been completed on only two HLW tanks (at Savannah River), the tank contents proved amenable to waste retrieval using current technology. DOE has just begun to address the issue of how clean a tank must become before it is closed. Continued demonstration that tank closure criteria can be developed and implemented will provide substantial benefit to DOE.

A related problem that retrieval process development is examining, is the current lack of a retrieval decision support tool for the end users. As development activities move forward toward collection of retrieval performance and cost data, it has become very evident that the various sites across the complex need to have a decision tool to assist end users with respect to waste retrieval

and tank closure. Tank closure is intimately tied to retrieval, and the sensitivity of closure criteria to waste retrieval is expected to be very large.

All the existing processes and technologies that could be used as a baseline for tank remediation have not yet been identified. Identifying these processes is one of EM's major issues in addressing the tank problems. The overall purpose of retrieval enhancements is to continue to lead the efforts in the basic understanding and development of retrieval processes in which waste is mobilized sufficiently to be transferred out of tanks in a cost-effective and safe manner. From that basic understanding, data are provided to end users to assist them in the retrieval decisionmaking process. The overall purpose of retrieval enhancements is to identify processes that can be used to reduce cost, improve efficiency, and reduce programmatic risk.

The hermetic sealing and closure of containment vessels and the long term resistance to corrosion and stress corrosion cracking and failure of such seals and closures warrants attention. Routine or conventional welding and joining procedures, while adequate to form hermetic seals in a non-hostile environment, may result in local composition gradients across weld or join interfaces and heat-affected-zones that create local electrochemical cells that are vulnerable to galvanic degradation and/or corrosion related cracking. Research is needed to establish reliable welding or joining procedures that will not result in either the establishment of local gradients in chemical composition or in grain-boundary depletion of passivating chemical elements at welding or joining closures.

Basic engineering and separation science studies are needed to support tank remediation of liquids which contain high concentrations of solids.

Pretreatment and Separation Processes for Tank Waste

DOE has about 90 million gallons of HLW and LLW stored in tanks at four primary sites within the DOE complex. It is neither cost-effective nor practical to treat and dispose of all of the tank waste to meet the requirements of the HLW repository program and the Nuclear Waste Policy Act.

The current baseline technology systems for waste pretreatment at DOE's tank waste sites are expensive. Technology gaps exist. Large volumes of HLW will be generated, while there is limited space in the planned Nuclear Waste Repository for HLW from DOE. Even if adequate space were made available, treatment and disposal of HLW is still very expensive, estimated to be about \$1 million for each canister of vitrified HLW.

Only a small fraction of the waste, by weight, is made up of radionuclides. The bulk of the waste is chemical constituents intermingled with, and sometimes chemically bonded to, the radionuclides. However, the chemicals and radionuclides can be separated into HLW and LLW fractions for easier treatment and disposal.

Most of the waste stored in tanks was put there as a result of nuclear fuel processing for weapons production. In that process, irradiated fuel and its cladding were first dissolved, uranium and plutonium were recovered as products, and the highly radioactive fission product wastes were concentrated and sent to tanks for long-term storage.

Fuel processing at Savannah River did not change substantially from the beginning of operations in about 1955 to the present. While these wastes are fairly uniform, they still require pretreatment to separate the LLW from HLW prior to immobilization. Waste at Idaho is stored at acidic pH in stainless steel tanks. Much of it has already been calcined at high temperature to a dry powder. Tank wastes at Oak Ridge are small in volume (less than 1 million gallons) and radionuclide inventory (0.16 MCi) compared to other sites (33 million gallons and 534 MCi at Savannah River and 55 million gallons and 198 MCi at Hanford).

At Hanford, several processes were used over the years (beginning in 1944), each with a different chemical process. This resulted in different waste volumes and compositions. Wastes at Hanford and Savannah River are stored as highly alkaline material so as not to corrode the carbon steel tanks. The process of converting the waste from acid to alkaline resulted in the formation of different physical forms within the waste.

The primary forms of waste in tanks are sludge, saltcake, and liquid. The bulk of the radioactivity is known to be in the sludge which makes it the largest source of HLW. Saltcake is characteristic of the liquid waste with most of the water removed. Saltcake is found primarily in older single-shell tanks at Hanford.

Saltcake and liquid waste contain mostly sodium nitrate and sodium hydroxide salts. They also contain soluble radionuclides such as cesium. Strontium, technetium, and transuranics are also present in varying concentrations. The radionuclides must be removed, leaving a large portion of waste to be treated and disposed of as LLW and a very small portion that is combined with HLW from sludge for subsequent treatment and disposition.

Waste in tanks has been blended and evaporated to conserve space. Although sludge contains most of the radionuclides, the amount of HLW glass produced (vitrification is the preferred treatment of HLW) could be very high without pretreatment of the sludge. Pretreatment of the sludge by washing with alkaline solution can remove certain nonradioactive constituents and reduce the volume of HLW. Pretreatment can also remove constituents that could degrade the stability of HLW glass. If the alkaline sludge washing is not effective, some sludge may need to be dissolved in acid and treated by extraction techniques to make a suitable feed to HLW vitrification. This option is currently outside the sites baseline.

The pretreatment functional area seeks to address multiple needs across the DOE complex. The primary objectives are to reduce the volume of HLW, reduce hazards associated with treating LLW, and minimize the generation of secondary waste.

The concentration of certain chemical constituents such as phosphorus, sulfur, and chromium in sludge can greatly increase the volume of HLW glass produced upon vitrification of the sludge. These components have limited solubility in the molten glass at very low concentrations. Some sludge has high concentrations of aluminum compounds which can also be a controlling factor in determining the volume of HLW glass produced. Aluminum above a threshold concentration in the glass must be balanced with proportional amounts of other glass-forming constituents such as silica. There are estimated to be 25 different types of sludge at Hanford distributed among more than 100 tanks. Samples from 49 tanks would represent approximately 93 percent sludge in Hanford tanks. Testing of enhanced sludge washing, the combination of caustic leaching and water washing of sludge, on all of these samples is needed to determine whether enhanced sludge washing will result in an acceptable volume of HLW glass destined for the repository and will allow processing in existing carbon steel tanks at Hanford and Savannah River.

The efficiency of enhanced sludge washing is not completely understood. Inadequate removal of key sludge components could result in production of an unacceptably large volume of HLW glass. Improvements are needed to increase the separation of key sludge constituents from the HLW.

Enhanced sludge washing is planned to be performed batchwise in large double-shell tanks of nominal one million gallon capacity. This will generate substantial volumes of waste solutions which require treatment and disposal as LLW. Settling times for suspended solids may be excessive and the possibility of colloid or gel formation could prohibit large-scale processing. Alternatives are needed that will reduce the amount of chemical addition required and prevent the possibility of colloid formation. Sludge at Savannah River, Hanford, and Oak Ridge will be washed to remove soluble components prior to HLW vitrification. Removing suspended solids from the wash solutions is inherently inefficient due to long intervals required for the solids to settle out. The baseline process for sludge washing at Savannah River and Hanford is done batchwise in large, one-million gallon underground storage tanks. This requires large volumes of wash solution, powerful mixing pumps, and long settling times. Retrieval of waste using large volumes of dilution water is planned at Hanford. To consider the benefits of flocculent addition and the possibility of using countercurrent decantation to help optimize sludge washing, the settling characteristics of the solids need to be determined.

Baseline sludge washing processes at both Hanford and Savannah River call for large volumes of caustic (sodium hydroxide) solution. The supernatant from sludge washing then becomes feed to LLW treatment. The added caustic can be recovered after washing and recycled to subsequent sludge washing steps. In addition, the HLW sludge at Hanford and Savannah River contains large quantities of sodium salts that can, in principle, be recovered as sodium hydroxide and also be recycled.

Approximately 1.8 million gallons of acidic liquid waste are stored in single-shell, stainless steel, underground storage tanks at Idaho. In 1992 a Notice of Noncompliance was filed stating that the tanks did not meet secondary containment requirements of the Resource Conservation and

Recovery Act. Subsequently, an agreement was reached between DOE, the Environmental Protection Agency, and the Idaho Department of Health and Welfare that commits DOE to remove the liquid waste from all underground tanks by the year 2015. Recent discussions with the state of Idaho have accelerated this date to 2012.

The baseline treatment for Idaho liquid wastes produced after 2012 is the full treatment option, wherein actinides and fission products will be removed from the liquid waste and HLW calcine.

The depleted stream will be processed to Class A LLW standards and the radionuclides will be immobilized in an HLW fraction.

The transuranic extraction process for removal of actinides, or transuranics, from acidic wastes has been tested on actual Idaho waste in continuous countercurrent process equipment. The strontium extraction process shows promise for co-extraction of strontium and technetium and also has been demonstrated on Idaho waste in continuous countercurrent operation.

DOE's underground storage tanks contain liquid wastes with high concentrations of radioactive cesium. The various processes for retrieving and redissolution of HLW calcine for pretreatment are not fully demonstrated.

DOE's underground storage tanks at Hanford, Savannah River, Oak Ridge, and Idaho contain liquid wastes with high concentrations of radioactive cesium. Cesium is the primary radioactive constituent found in alkaline supernatant wastes. Since the primary chemical components of alkaline supernatants are sodium nitrate and sodium hydroxide, the majority of the waste could be disposed of as LLW if the radioactivity could be reduced below Nuclear Regulatory Commission limits. Processes have been demonstrated that removed cesium from alkaline supernatants and concentrate it for eventual treatment and disposal as HLW.

At Hanford, cesium must be removed to a very low level (3 Ci/m^3) to allow supernatant waste to be treated as LLW and disposed of in a near-surface disposal facility. The revised Hanford Federal Facility Agreement and Consent Order, or Tri-Party Agreement (between DOE, Environmental Protection Agency and the Washington State Department of Ecology) also recommends treatment of LLW in a contact-maintained or minimally shielded vitrification facility to speed remediation and reduce costs. Cesium removal performance data are needed to estimate dose rates for this process and provide input to the design of an LLW pretreatment facility for Hanford supernatants.

At Savannah River, cesium removal by ion exchange may be needed as an alternative to the current in-tank precipitation process. Cesium ion exchange may also be needed to separate cesium from Defense Waste Processing Facility recycle, or offgas condensate, to greatly reduce the amount of cesium that is routed back to the waste storage tanks.

Technetium (Tc)-99 has a long half-life (210,000 years) and is very mobile in the environment when in the form of the pertechnetate ion. Removal of Tc from alkaline supernatants and sludge washing liquids is expected to be required at Hanford to permit treatment and disposal of these wastes as LLW. The disposal requirements are being determined by the long-term performance assessment of the LLW waste form in the disposal site environment. It is also expected that Tc removal will be required for at least some wastes to meet Nuclear Regulatory Commission LLW criteria for radioactive content. To meet these expected requirements, there is a need to develop technology that will separate this extremely long-lived radionuclide from the LLW stream and concentrate it for feed to HLW vitrification.

A number of liquid streams encountered in tank waste pretreatment contain fine particulate suspended solids. These streams may include tank waste supernatant, waste retrieval sluicing water, and sludge wash solutions. Other process streams with potential for suspended solids include evaporator products and ion exchange feed and product streams. Suspended solids will foul process equipment such as ion exchangers. Radioactive solids will carry over into liquid streams destined for LLW treatment, increasing waste volume for disposal and increasing the need for shielding of process equipment. Streams with solid/liquid separation needs exist at all of the DOE tank waste sites.

Some examples of specific science research challenges include but are not limited to: fundamental analytical chemical studies needed for improvement of separation processes; materials science of waste forms germane to their performance; elucidation of technetium chemistry; basic engineering and separation science studies required to support pretreatment activities and the development of solid/liquid separations; fundamental separations chemistry of precipitating agent and ion exchange media needed to support the development of improved methods for decontamination of HLW; fundamental physical chemistry studies of sodium nitrate/nitrite needed for HLW processing; basic materials science studies concerned with the dissolution of mixed oxide materials characteristic of calcine waste needed to design improved pretreatment processes; basic chemistry of sodium when mixed with rare earth oxides needed for the development of alternative HLW forms; fundamental chemical studies associated with high temperature (500°C) calcination of nitrate solutions using agents others than sugar needed for advanced HLW calcination processing.

Waste Immobilization and Disposal

Waste immobilization technology converts radioactive waste into solid waste forms which will last in natural environments for thousands of years. Wastes requiring immobilization at DOE sites include LLW such as the pretreated liquid waste from waste tanks and HLW such as the tank sludge. There are also a number of secondary wastes requiring immobilization that result from tank waste remediation operations, such as resins from cesium and technetium removal operations.

The baseline technologies to immobilize radioactive wastes from underground storage tanks at DOE sites include converting LLW to either grout or glass and converting HLW to borosilicate glass. Grout is a cement-based waste form that is produced in a mixer tank and then poured into canisters or pumped into vaults. Glass waste forms are created in a ceramic-lined metal furnace called a melter. Tank waste and dry materials used to form glass are mixed and heated in the melter to temperatures ranging from 1,800°F to 2,700°F. The molten mixture is then poured into log-shaped canisters for storage and disposal. The working assumption is that the LLW will be disposed of on site, or at the Waste Isolation Pilot Plant if transuranic elements are present. The HLW will be shipped for off-site disposal in a licensed HLW repository, such as the one proposed at Yucca Mountain, Nevada.

Methods are needed to immobilize the LLW fraction resulting from the separation of radionuclides from the liquid and high-level calcine wastes at Idaho. LLW is to be mixed with grout, poured into steel drums, and transferred to an interim storage facility, but alternatives are being considered. Tests must be conducted with surrogate and actual wastes to support selection of a final waste form. Savannah River has selected saltstone grout (pumped to above ground concrete vaults and solidified) as the final waste form. Savannah River would like to evaluate LLW glass as an alternative to saltstone disposal.

DOE sites at Hanford, Savannah River, Idaho and Oak Ridge will remove cesium from the hazardous radioactive liquid waste in the underground storage tanks. If cesium is removed, it costs less to treat the rest of the waste. However, cesium removal from tank waste, while cost-effective, creates a significant volume of solid waste that must be turned into a final waste form for ultimate disposal. The plan is to separate cesium from the liquid waste using ion exchange or other separations media, treat the cesium-loaded separations media to prepare it for vitrification, and convert the cesium product into a glass waste form suitable for final disposal. Personnel exposures during processing and the amount of hazardous species in the offgases must be kept within safe limits at all times.

The effectiveness of advanced oxidation technology for treating organic cesium-loaded separations media prior to vitrification is not proven. After a suitable melter feed is obtained, vitrification of the cesium-loaded media must be demonstrated. Technology development is needed because: (1) Compounds are in the separation media that must be destroyed or they will cause flammability problems in the melter and decrease the durability and waste loading of the final waste form, (2) high beta/gamma dose rates are associated with handling cesium-containing waste, and (3) cesium volatilizes in the melter and becomes a highly radioactive offgas problem.

Confidence and assurance that long-term immobilization will be successful in borosilicate glass warrants research and improved understanding of the structural and thermodynamic properties of glass (including the structure and energetics of stable and metastable phases), systematic irradiation studies that will simulate long-term self-irradiation doses and spectra (including archived glasses containing Pu or Cm, and over the widest range of dose, dose rate and

temperature) and predictive theory and modeling based on computer simulations (including ab initio, Monte Carlo, and other methods).

Some examples of specific science research challenges include but are not limited to: fundamental chemical studies needed to determine species concentrations above molten glass solutions containing heavy metals, cesium, strontium, lanthanides, actinides, with and without a cold cap composed of unmelted material; materials science studies of molten materials that simulate conditions anticipated during vitrification and storage in vitrified form of HLW needed to develop improved processes and formulations; fundamental physical chemistry studies of sodium nitrate/nitrite mixtures needed for HLW stabilization.

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