Office of Energy Research

Notice 97-04
Natural and Accelerated Bioremediation Research Program

Department of Energy
Office of Energy Research

Energy Research Financial Assistance Program Notice 97-04;
Natural and Accelerated Bioremediation Research Program

Agency: Office of Energy Research, Department of Energy

Action: Notice inviting research grant applications.

SUMMARY: The Office of Health and Environmental Research (OHER) of the Office of Energy Research (ER), U.S. Department of Energy (DOE), hereby announces its interest in receiving applications for research grants in the Natural and Accelerated Bioremediation Research (NABIR) Program. The NABIR Program is made up of the following scientific research elements: Acceleration; Assessment; Biogeochemical Dynamics; Biomolecular Science and Engineering; Biotransformation and Biodegradation; Community Dynamics and Microbial Ecology; and System Engineering, Integration, Prediction, and Optimization. The NABIR program also includes a social-legal element called Bioremediation and its Social Implications and Concerns (BASIC). Grant applications are being solicited in each of the first six scientific research elements, as well as in the BASIC element, but not in the System Engineering, Integration, Prediction, and Optimization element.

DATES: Applicants are encouraged (but not required) to submit a preliminary application for programmatic review. Early submission of preliminary applications is encouraged, to allow time for meaningful dialogue. A brief preliminary application 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; only one copy is required. The deadline for receipt of formal applications is 4:30 p.m., E.S.T., January 30, 1997, to be accepted for merit review and to permit timely consideration for award in fiscal year 1997. An original and seven copies of the application must be submitted; however, applicants are requested not to submit multiple applications using more than one delivery or mail service.

ADDRESSES: If submitting a preliminary application, referencing Program Notice 97-04, it should be sent e-mail to john.houghton@oer.doe.gov. Formal applications referencing Program Notice 97-04 on the cover page must be forwarded 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 97-04. This address must also be used when submitting applications by U.S. Postal Service Express Mail or any other commercial overnight delivery service, or when hand-carried by the applicant.

FOR FURTHER INFORMATION CONTACT: Dr. John Houghton, Environmental Sciences Division, ER-74, Office of Health and Environmental Research, Office of Energy Research, U.S. Department of Energy, 19901 Germantown Road, Germantown, MD 20874-1290, telephone (301) 903-8288, e-mail john.houghton@oer.doe.gov, fax (301) 903-8519.

SUPPLEMENTARY INFORMATION: The mission of the NABIR Program is to provide the scientific understanding needed to use natural processes and to develop new methods to accelerate those processes for the bioremediation of contaminated soils, sediments, and groundwater at DOE facilities. The program will be implemented through seven interrelated scientific research elements (Acceleration, Assessment, Biogeochemical Dynamics, Biomolecular Science and Engineering, Biotransformation and Biodegradation, Community Dynamics and Microbial Ecology, and System Engineering, Integration, Prediction, and Optimization); and a social and legal element called Bioremediation and its Social Implications and Concerns (BASIC). A document entitled Natural and Accelerated Bioremediation Research Program Plan (DOE/ER-0659T) contains an initial planning description of the NABIR Program and each of the science elements. It is available via the Internet using the following web site address: http://www.er.doe.gov/production/oher/nabir/cover.html. The NABIR Program Plan is also available from the Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831 (DOE and DOE grantees only) and the U.S. Department of Commerce, Technology Administration, National Technical Information Service, Springfield, VA 22161, (703) 487-4650 (public source). Additional information about NABIR, such as references to infrastructure that could be available to the research community, can be accessed from the NABIR Homepage: http://www.lbl.gov/NABIR/. Each scientific research element is directed by a program manager from OHER, who is responsible for providing support and overall direction for the element, including determining the relevance of the proposed research to the goals and objectives of the program element to the NABIR and other DOE programs. The NABIR program also has Science Team Leaders, selected through a previous peer review process, who will provide scientific leadership and coordination to the community of NABIR investigators.

Program Focus

The NABIR Program supports long-term, hypothesis-driven research directed at specific topics that will provide the understanding necessary to develop effective new technologies for DOE site cleanup. This research will help determine the future viability of bioremediation technologies at the DOE sites. The NABIR Program will not support research to evaluate the risk to humans or to the environment. Although the program is directed at specific goals, it supports research that is more fundamental in nature than demonstration projects.

The initial theme for the NABIR Program will be an emphasis on field-scale research and metal and radionuclide contamination, specifically on the metals and radionuclides associated with weapons production. However, the research program will support laboratory, theoretical, modeling, and other non-field research projects, if they fill important gaps that would be necessary to complete understanding for field-scale applications. The study of real problems might iterate between, for example, the laboratory and the field. Investigators without access to laboratories licensed to work with radionuclides may propose research with non-radioactive surrogates of radionuclides, or collaboration with a licensed laboratory. The NABIR program

will initially emphasize the bioremediation of metals and radionuclides in the subsurface below the root zone, including both thick vadose and saturated zones. Typically, the bioremediation of metals and radionuclides involves, but is not limited to, mobilization and immobilization scenarios. Consideration of organic contaminants, such as solvents and complexing agents that would be important substrates, facilitators, inhibitors, or carbon or electron donors or acceptors, can be included in the proposed research to the extent that they influence the primary goal of understanding the remediation of metals and radionuclides. Applicants are encouraged to review Chemical Contaminants on DOE Lands, DOE/ER-0547T, available at the OHER Homepage: http://www.er.doe.gov/production/oher/EPR/pub_epr.html, for a compilation of wastes and waste mixtures at the DOE sites.

NABIR is a research program designed to serve as a foundation for microbial in situ bioremediation techniques. Although "spillover" benefits of the research to other cleanup needs such as the use of bioreactors to process waste streams are anticipated, NABIR supports investigations into bioremediation of subsurface waste sites. This emphasis includes research that will assist the application of in situ bioremediation in conjunction with other cleanup methods, for example, using bioremediation to mobilize radionuclides so that pump-and-treat techniques could be more effective. Problems characterized by large areas with low-concentration contamination are emphasized over problems of localized, high concentrations. Research on phytoremediation will not be supported during this initial funding period.

In research plans that involve the potential release of chemicals, enzymes, and/or microorganisms to the field (both at contaminated and non-contaminated control sites), applicants should discuss how they will involve the public or stakeholders in their research, beginning with experimental design through completion of the project. All applicants should discuss other relevant societal issues, where appropriate, which may include intellectual property protection, communication with and outreach to affected communities (including members of affected minority communities where appropriate) to explain the proposed research.

NABIR Infrastructure

The NABIR program anticipates selecting at least one Field Research Center (FRC) located on a DOE site. The FRC will serve as a central facility for researchers to use at their option. However, FRCs will not be available (or even identified) for at least a year, because of a current National Environmental Policy Act (NEPA) review of the NABIR Program. Therefore, applicants are encouraged to use any site that is presently available to them, including but not limited to DOE sites. Investigators should describe how their research will interface with or transfer to field scale research at their site. Applicants should access the NABIR Homepage: http://www.lbl.gov/NABIR/ for a listing of available sites and facilities.

A centrally-maintained database will be developed to provide limited data, such as site characterization and kinetics data, needed by a broad segment of investigators. Applications shall include a short discussion of the Quality Assurance and Quality Control (QA/QC) measures that will be applied in data gathering and analysis activities. Successful grantees will be expected to coordinate their QA/QC measures with NABIR program personnel.

Scientific Research Elements

The following sections describe each of the six NABIR scientific research elements and the emphasis that is given preference in this solicitation. Applicants may propose research that transcends more than one research element; it is also anticipated that many applications could be placed in more than one element. However, each application should state the one science element most closely aligned with the proposed research, to facilitate scientific review.

Biotransformation and Biodegradation: The goal of all bioremediation efforts is to reduce the potential toxicity of chemical contaminants in the field by using living organisms or their products to mineralize, degrade, transform, mobilize, or immobilize contaminants. There is already a significant base of knowledge about many pathways for organic chemical degradation, and several important contaminant degradation mechanisms are presently under detailed investigation. Despite the successful contributions of existing knowledge about biodegradation and biotransformation mechanisms, there is still need for additional research. At present, the understanding of biotransformation and biodegradation pathways and mechanisms in the field is incomplete. Although the degradation of many organic compounds and the biotransformation of some inorganic compounds in laboratory cultures have been well described, it is unclear how this information relates to bioremediation processes under field conditions. The biotransformation of metals and radionuclides in thick vadose zones is poorly understood. Successful laboratory studies have not allowed for predictions about the fate of complex chemical mixtures that include metals and radionuclides in the field. It would be useful to know the metabolic pathways taken by mixtures of chemicals in the presence of complex microbial communities in vadose zones and their interfaces with saturated zones and the waste plume. It would be equally useful to understand the kinetics of desirable metal and radionuclide biotransformations and the physicochemical factors affecting those kinetics. Research is needed to address questions such as:

- o How can laboratory studies be used to accurately represent field situations and allow for predictions of chemical fate?
- o How important are microbial species interactions in the biotransformation of metals and radionuclides?
- o How do organic co-contaminants affect the biotransformation of metals and radionuclides?
- o What factors control the kinetics of desirable metal and radionuclide biotransformations in vadose and saturated zones?
- o Can biological processes be harnessed to permanently sequester metals and/or radionuclides in the subsurface?
- o What are the metal- and radionuclide-transforming capabilities of indigenous microorganisms in deep vadose or saturated zones representative of DOE sites?

Community Dynamics and Microbial Ecology: Fundamental research in Community Dynamics and Microbial Ecology at both the molecular and the organismal level is needed to understand better the natural intrinsic processes of bioremediation in mixed contaminant sites. A more complete understanding of energetics and biogeochemical transformation at the community level may ultimately provide the ability to control or stimulate communities capable of transformation and to channel carbon flow (particularly of polluting organic compounds) through these communities or populations. It is essential to understand the roles and interactions of diverse

communities in order to understand how and to what extent the structure of the biological community influences the course of bioremediation and to what extent the environmental factors influence community dynamics in sites containing metals and radionuclides. This need is especially critical to successful bioremediation of diffuse metals and radionuclides in thick vadose and deep saturated zones. Research should be directed toward the identification and characterization of microbial communities at contaminated sites, and toward understanding the dynamics of extant microbial communities under the influence of metals and radionuclides. Research is needed to address questions such as:

o Is there sufficient biological activity and diversity in thick vadose zones to support natural and/or accelerated bioremediation of metals and radionuclides?

o What are the effects of metals and radionuclides on microbial community activity and diversity, including both metabolic and genetic activity and diversity?

o Do microbial (population) interactions occur within communities present in vadose zones contaminated with metals and radionuclides?

o What kind of measurement (assessment) technology must be developed to interrogate microbial communities for their activity and diversity before, during, and after bioremediation?

Biomolecular Science and Engineering: The overall goal of research in the Biomolecular Science and Engineering element is to use molecular and structural biology to enhance understanding of bioremediation and to genetically modify macro-molecules and organisms to improve their bioremedial activities. Using information and data gained from other program elements, the molecules, enzymes, and enzyme pathways that are most effective for bioremediation of metals and radionuclides will be identified. Initial DOE objectives and priorities for research in Biomolecular Science and Engineering are to: (i) identify, clone, and sequence novel genes and promoters important to the bioremediation of metals and radionuclides; and (ii) construct or enhance bioremedial enzymatic pathways by identifying active genes from different procaryotic, eukaryotic and archaeal organisms and inserting those genes into one or more organisms that can survive and compete effectively in a contaminated subsurface environment. Research in these areas is encouraged that includes:

o How can we identify and characterize important genes and proteins that detoxify mixed contaminants or that affect the ability of organisms to live and survive under contaminated conditions?

o How can we identify and characterize genes from different organisms that can work together to improve bioremediation?

o How can we identify critical promoter elements that induce or regulate bioremedial genes or gene clusters?

o How can we develop expression systems for genes with an emphasis on the use of organisms that will survive in contaminated environments?

o How can we develop organisms with improved enzymatic pathways for bioremediation by combining genes from different organisms into a single organism with an emphasis on the use of soil organisms or organisms that will survive in other types of contaminated environments?

Biogeochemical Dynamics: Successful bioremediation of metals and radionuclides at DOE sites is closely linked to understanding the complex and dynamic interplay of hydrological, geochemical, and biological processes within geological media that are themselves spatially and temporally heterogeneous. Understanding the natural biogeochemical processes that control the

mobility and form of radionuclides is one of the most challenging problems affecting the future viability of bioremediation at DOE sites, particularly within the thick vadose zones and saturated zones below the root zone where much of the contamination resides.

DOE cleanup problems are at the field scale, and the immediate priority in biogeochemical dynamics is to scale up the existing scientific knowledge base on underlying mechanisms and processes governing metal and radionuclide behavior to the field. Focus will be on (i) understanding how natural biogeochemical processes control the mobility and stability of contaminants in waste mixtures, including the biogeochemical processes that modify the form and behavior of contaminants in mixtures; and (ii) the influence of spatial heterogeneity in chemical, microbiological, and physical processes on the transport and transformation of contaminant mixtures.

Research within biogeochemical dynamics seeks to quantify the intrinsic biogeochemical processes that influence the form and behavior of contaminants and which can lead to development of new concepts for in situ bioremediation. New and creative scientific approaches are sought that address the following fundamental research questions:
o What are the principal biogeochemical reactions that govern mixed contaminant concentration, chemical speciation, and distribution between the aqueous and solid phases in the vadose and saturated zones?
o What are the thermodynamic and kinetic controls on these reactions?
o What are the major factors controlling the rate and extent of oxidation and reduction of multivalent radionuclides and naturally-occurring metals in various mineral phases? How can these factors be manipulated to enhance or limit the mobility of contaminants?
o What are the geochemical, microbiological, and transport processes and their interactions that control biological availability, transformation, and movement of contaminant mixtures?
o What are the interdependent distributions of microbiological, chemical, and physical properties and processes that have scale-dependent effects on biogeochemical phenomena and contaminant behavior? How can this information be scaled to the field?
o How can fundamental understanding of biogeochemical dynamics be used to develop innovative in situ remediation concepts for application to DOE sites?

Assessment: Current methods for measuring and evaluating the effectiveness of bioremediation are inadequate and, in most cases, undeveloped. Demonstrating the effectiveness of bioremediation will require documentation for direct impacts, such as loss of contaminants from the site, or indirect impacts, such as product accumulation and detoxification. The two primary objectives of research in the Assessment program element are to develop innovative and effective methods for assessing (i) bioremediation rate and activity, including microbial community structure and dynamics, biotransformation processes and rates, and electron flow; and (ii) bioremediation end points, including not only the concentrations of the contaminants and byproducts but also the stability, bioavailability, and toxicity of residual end-products. NABIR will not, however, fund projects that examine human health risks of end points.

This element will focus on developing techniques for assessing the bioremedial activities of individual strains and functional groups within a community, as well as validate existing and emerging laboratory and field techniques. Priority will be given to research applications that

could result in techniques and/or instrumentation that: (i) operate in real time; (ii) operate in field-scale heterogeneous environments; (iii) are cost-effective; and (iv) determine endpoints which more closely approximate limited or non-bioavailability. Research is sought to answer questions such as:

o Can quantitative techniques be adapted or developed for measurement of microbial community structure, movement, activity, and effectiveness during bioremediation?
o How can geophysical, geochemical, and hydrologic properties critical to bioremediation effectiveness be determined?
o What new methods might be developed to interpret complex data sets, including temporal and spatial variability in support of bioremediation management?
o Can bioremediation endpoints that accurately measure bioavailability be quantitatively established?

Acceleration: This program element will address effective delivery of microorganisms to contaminated zones, where bacteria and/or archaea can transform, mobilize, or immobilize toxicants, particularly metals and radionuclides in thick vadose and deep saturated zones. Highest priority will be on research that defines issues of microbial transport, such as chemical and physical heterogeneity and geochemistry. The fundamental processes that affect microbial survival are included in the Community Dynamics and Microbial Ecology Program Element.

Building on new knowledge being developed in other program elements on microbial community dynamics, biogeochemical processes governing the form and behavior of inorganic solutes and the effects of heterogeneity on these processes, research is needed to address questions such as:

o What factors control the delivery and transport of microorganisms and genetic elements in heterogeneous subsurface systems?
o What are the coupled effects of chemical, biological, and hydrologic processes on transport, such as attachment/detachment of microbial cells (including viruses and genetic elements) to mineral grains in concert with advection and dispersion of cells and chemicals during flow through porous media?
o How can key controlling factors and coupled processes be evaluated and scaled to the field for acceleration of natural processes?

BASIC

The introduction of non-native or genetically engineered microorganisms or the manipulation of the environment to change its microbial composition or chemical characteristics has the potential to raise concerns among those who may live or work nearby. Great care is required to involve the affected communities and stakeholders in any plans to use novel agents and/or processes to remediate a contaminated site; for example, a deliberate release of a non-indigenous microorganism, the purposeful manipulation of a microbial community, or the mobilization of a hazardous chemical. Although it may be many years before work under the auspices of this program gets to that point, it is wise to begin to consider some of the issues involved now.

The Bioremediation and its Societal Implications and Concerns (BASIC) component of the NABIR program is directed at these larger societal implications of bioremediation. DOE seeks to

encourage applications that address effective ways to articulate the risks and benefits attendant to in situ bioremediation to stakeholders, and effective ways to involve affected communities in bioremediation research and decision making. The DOE also solicits applications for the preparation and dissemination of educational materials in any appropriate medium that will enhance understanding of the scientific as well as the societal aspects of NABIR among the public or specified groups. If an educational effort for a specific group is proposed, the value to NABIR of that group or community should be explained in detail. In addition, the DOE encourages applications for the support of conferences focusing on the legal and societal implications of NABIR. Applications should demonstrate knowledge of any relevant literature and should include detailed plans for the gathering and analysis of factual information and the associated societal implications. All proposed research applications should address the issue of efficient dissemination of results to the widest appropriate audience.

ADMINISTRATIVE INFORMATION: To provide a consistent format for the submission, review and solicitation of grant applications submitted under this notice, the preparation and submission of grant applications must follow the guidelines given in the Application Guide for the Office of Energy Research Financial Assistance Program 10 CFR Part 605.

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, MD 20874-1290. Telephone requests may be made by calling (301) 903-3338. 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. The Office of Energy Research (ER), as part of its grant regulations, requires at 10 CFR 605.11(b) that a grantee funded by ER and performing research involving recombinant DNA molecules shall comply with the National Institutes of Health "Guidelines for Research Involving Recombinant DNA Molecules" (51 FR 16958, May 7, 1986), or such later guidelines as may be published in the Federal Register. Grantees must also comply with other federal and state laws and regulations as appropriate, for example, the Toxic Substances Control Act (TSCA) as it applies to genetically modified organisms. Although compliance with NEPA is the responsibility of DOE, grantees proposing to conduct field research are expected to provide information necessary for the DOE to complete the NEPA review and documentation. The research description must be 15 pages or less, exclusive of attachments, and must contain an abstract or summary of the proposed research (to include the hypotheses being tested, the proposed experimental design, and the names of all investigators and their affiliations). Attachments include curriculum vitae, QA/QC plan, a listing of all current and pending federal support, and letters of intent when collaborations are part of the proposed research.

Applications will be subjected to formal merit review (peer review) and will be evaluated against the following evaluation criteria which are listed in descending order of importance 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.

Also, as part of the evaluation, program policy factors become a selection priority. Note, external peer reviewers are selected with regard to both their scientific expertise and the absence of conflict-of-interest issues. Non-federal reviewers will often be used, and submission of an application constitutes agreement that this is acceptable to the investigator(s) and the submitting institution.

It is anticipated that up to $10 million will be available for multiple awards to be made in FY 1997 and early FY 1998 in the categories described above, contingent on availability of appropriated funds. Applications may request project support up to three years, with out-year support contingent on availability of funds, progress of the research, and programmatic needs. Annual budgets for most of the six scientific research element projects are expected to range from $200,000 to $500,000 total costs. Annual budgets for most of the BASIC projects are expected not to exceed $100,000. Researchers are encouraged to team with investigators in other disciplines where appropriate. DOE may encourage collaboration among prospective investigators, to promote joint applications or joint research projects, by using information obtained through the preliminary applications or through other forms of communication.

Although the required original and seven copies of the application must be submitted, researchers are asked to submit an electronic version of their abstract of the proposed research in ASCII format and their e-mail address to Karen Carlson by e-mail at karen.carlson@oer.doe.gov. Additional information on the NABIR Program is available at the following web site: http://www.lbl.gov/NABIR/. For researchers who do not have access to the world wide web, please contact Karen Carlson; Environmental Sciences Division, ER-74; U.S. Department of Energy; 19901 Germantown Road; Germantown, MD 20874-1290; (301) 903-3338 phone; (301) 903-8519 fax; karen.carlson@oer.doe.gov; for hard copies of background material mentioned in this solicitation. Curriculum vitae should be submitted in a form similar to that of NIH or NSF (two to three pages), see for example: http://www.nsf.gov:80/bfa/cpo/gpg/fkit.htm#forms-9.

RELATED FUNDING OPPORTUNITIES: Investigators may wish to obtain information about the following related funding opportunities:

Department of Energy, Office of Environmental Management: The Environmental Management Science Program (EMSP). Contact: Carol Henry, Science and Policy Director, Office of Integrated Risk Management, EM-52, U.S. Department of Energy, 1000 Independence Avenue, S.W., Washington, DC 20585, e-mail carol.henry@em.doe.gov. Phone 202-586-7150. The EMSP home page is available at web site: www.em.doe.gov.science.

DOE/EPA/NSF/ONR Joint Program on Bioremediation, Dr. Robert E. Menzer, U.S. Environmental Protection Agency, National Center for Environmental Research and Quality Assurance, 401 M Street, SW, Washington, DC 20460, menzer.robert@epamail.epa.gov., phone (202) 260-5779

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

John Rodney Clark
Associate Director
for Resource Management
Office of Energy Research

Published in the Federal Register November 25, 1996, Vol. 61, No. 228,
pages 59868-59872.