Report of NABIR Subcommittee of BERAC
June 21, 22, 2001 meeting at AGU, Washington D.C.

Review of the Draft of the NABIR Strategic Plan

Preface

The DOE program staff is to be complemented on a (draft) strategic plan that shapes information from various constituencies into clearly defined scope and goals. The plan is presented in a logical and effective manner. The proposed focus on biostabilization of chromium, mercury, uranium, technetium and plutonium, is appropriate and should be a priority basic research goal for DOE, given the direction of the agency in waste management. . The committee did conclude, however that the scientific impact of NABIR research is broader and more impactful than implied in the draft plan. To address this issue, suggested changes in goals, deliverables and research focus are offered below.

I. Introduction: revamp and strengthen.

Existing text in the introduction is clear and important to present. However, subcommittee members recommend that the introduction include text that: (a) presents NABIR in a stronger light; and (b) states explicitly why the program direction is shifting.

(a) Stronger presentation of NABIR Program. The strategic plan should further capitalize on the major scientific opportunites and value offered by the NABIR Program. For example, NABIR is the only federal program that funds fundamental research on the target metals and radionuclides. It is exemplary in focusing talents and expertise from many disciplines on these challenging research questions. The products from NABIR research will influence the development of effective bioremediation technologies *as well as* contribute new knowledge about how subsurface ecological systems function at the microbiological and geochemical levels. These advances can contribute to more effective stewardship of our natural resources as well as to remediation of DOE wastes.

(b) Explicitly stating why the program direction is changing. The strategic plan should include text (perhaps a paragraph) to explain explicitly *why* this strategic plan was developed and *why* its goals differ from the original NABIR plan. Subcommittee members think this explanation is necessary to maintain and promote DOE's openness with regard to this program, and to avoid unintentionally raising questions and concerns. The explanation seems straightforward—DOE's cleanup policy has shifted toward long-term stewardship; the budget for the program is significantly less than originally projected; and research directions can be sharpened as a result of NABIR findings to date.

© Plan should distance NABIR from policy decisions. NABIR is a fundamental science program conducting research that supports—through the provision of sound scientific information—the DOE mission. However, NABIR science has much broader

implications than development of remediation technologies and will markedly advance our understanding of the fundamental processes that control the effectiveness of containment, information essential to critical decisions on long-term stewardship. However, the strategic plan, in its introduction and throughout, should not imply support for long-term stewardship or link too casually the research with the policy. The document should state explicitly that DOE or DOE-EM is moving toward (or has adopted) a policy of long-term stewardship. NABIR research aims to provide the fundamental knowledge that will allow DOE to learn if, or how, that policy might be implemented using bioremediation strategies. As one example, the state of science currently is unable to answer the questions of if, or how, long-term immobilization can be achieved.

II. NABIR Program goals.

(a) There is an under recognition of the importance of co-contaminants in the plan. Chromium, uranium, and technetium can be especially mobile in the subsurface under certain conditions; they are risk-driving contaminants at some DOE sites. Co-contaminants such as nitrate, complexing agents and chlorinated solvents (TCE, CCl_4) sometimes are found with these primary contaminants in the DOE subsurface, and their effects on and behavior during bioremediation must be explicitly considered.

(b) Defining long-term stewardship. The goal section should define long-term stewardship. The following two paragraphs can be considered for the ending of the goal section.

Long-term stewardship is the post-closure responsibility of DOE at its contaminated sites. It entails long-term monitoring and other maintenance activities to assure that residual in-ground contaminants do not spread further.

Immobilization is focused on contaminant capture from both vadose zone and groundwater contaminant plumes. As such, it may be a strategy applied to prevent the discharge of deep or widely distributed contaminants from the vadose zone to groundwater, or from groundwater to a receiving water body (e.g., the Columbia River at Hanford). Immobilized metals and radionuclides are not removed from the subsurface as may occur with excavation, pump and treat, or biodegradation. Therefore, an important aspect of NABIR research is to assess factors controlling the long-term stability of the immobilized contaminants and to devise approaches (biological/chemical) to maintain their immobilization through the stewardship phase. In the future, engineering approaches may be designed to extract the immobilized contaminants that are captured in highly localized, biostimulated zones.

© *An improved multidisciplinary understanding of the biological and biogeochemical functioning of terrestrial subsurface systems*. Sophisticated new findings related to the molecular/microscopic workings of mineral-microbe-associations and their regulation by hydrologic, physical, and other field scale processes and features will have broad applicability. The science base will enable the remediation program's objectives while

providing fundamental new insights on the biogeochemical cycling of nutrients, trace elements, and trace gases.

III. NABIR Deliverables

This section of the Plan appropriately identifies the DOE Office of Environmental Management/Office of Science and Technology, the Department of Defense, and the site contractors/industries engaged in cleanup as customers for the concepts, tools, and fundamental knowledge developed by the NABIR program. In this context, deliverables focus on the development of bioremediation strategies, predictive models, long-term stewardship, and innovative tools for determining bioremediation potential.

Although important, these deliverables under-represent the potential contributions of the NABIR Program. It also is important to emphasize NABIR's strong scientific contributions. These contributions derive from interdisciplinary studies of microbial processes occurring at mineral surfaces and the broad implications of resulting new knowledge. Potential contributions range from new understandings about bioremediation and immobilization of contaminants in the subsurface to advances in our understanding of interfacial phenomena and geochemical processes, such as mineral formation and elemental cycling in the environment. A recommended new deliverable (in the Plan format) describing these scientific contributions is given below:

"An integration of the disciplines of microbiology, geosciences and environmental engineering in a manner not previously accomplished. This fundamental understanding of the functioning of microbial communities will provide the scientific underpinnings required to address a myriad of existing subsurface science problems as well as providing new insights on the biogeochemical cycling of elements on the planet."

It is also critically important to show that fundamental science advances will markedly advance the state-of-the-art in remediation of contaminated subsurface environments. To emphasize this issue, a suggested revision of the second Plan deliverable ("Science based predictive models….") is provided below:

"Defining the state-of-the-art in bioremediation applications. Fundamental knowledge will help delineate the limits of the technology--what can and cannot be achieved relative to other technologies within the context of disposal site conditions; aid in determining the system attributes and features critical for process optimization and success; and provide the basis for criteria to assess bioremediation effectiveness and regulatory compliance."

IV. General Comments

(a) Greater role for genomics in NABIR. DOE leadership has realized that advances in microbial genomics can lead to more reliable management and predictability of microbial processes, including those affecting the fate of contaminants. The plan is noticeably silent on the involvement of genomics and its daughter "omics" in the research strategy. Synergies with the Genome to Life program need to be recognized and links to that

program should be made explicitly. Genomics complements and enhances the basic science character of NABIR.

(b) How much emphasis on the FRC? The FRC has served an effective mechanism to focus interest on rapidly moving NABIR supported technologies for direct experimentation to a DOE relevant field site. Further, it serves as an effective integrating element of multidisciplinary research activity and provides important experience in dealing with regulatory hurdles. Additional experiences in developing technologies for cataloguing, collecting, preserving, and shipping a wide variety of materials from contaminated sites has been developed and implemented. The FRC has just begun to serve its role as a major focus for the research activities of the program at this stage in the NABIR life cycle.

The committee is concerned, however, that too much focus on the FRC may limit the science potential of the program since the FRC has a limited contaminant set and geological conditions. Despite the statement in the 3rd year projections (page 5, NABIR Strategic Plan Draft) that additional sites can be considered, budget projections strongly suggest that funding will not be available for an additional FRC. The current FRC is serving its purpose well but the small, shallow vadose zone, low pH, high nitrate co-contamination and the restriction on ever using GEMs at the FRC create significant limitations in meeting DOE needs if the strategic plan is overbalanced toward the FRC. The committee recommends that DOE consider actions that will broaden the applicability of the research to other DOE sites.

On suggestion is to ensure flexibility in sample acquisition and (limited) field investigations elsewhere so that the results of the NABIR program are applicable to DOE sites other than those represented by the Oak Ridge FRC. A major fraction of the national inventory of DOE waste resides in unconsolidated porous media in relatively thick vadose zones and in groundwaters that are low in soluble organic carbon and not subject to diurnal and seasonal variations in recharge.

© *Research needs in fluid flux.* The strategic plan should recognize that immobilization/remobilization cannot be studied exclusively in static systems if new knowledge of microbial-mineral interfacial phenomena is to be extrapolated to the field. It is critical to address, at some point in the research program, the hydrodynamics of the system at the pore scale and the role of fluid flux on mobilization and transport (for example, the effective removal of aqueous reaction products from the mineral surface and the corresponding changes in chemical equilibria). Neither of the current field efforts at the FRC addresses this issue.

(d) Overemphasis on iron reduction. The focus of the NABIR program on immobilization is appropriate. However, investigation of the mechanisms of immobilization should not be limited to iron reduction processes, as implied. Other microbial processes directly and indirectly influence mobility, including, for example, alteration of pH and redox conditions, complexation (ligand synthesis and degradation) and promotion of changes in partial pressure of gases, such as carbon dioxide, that

influence mineral formation and stability. It is important that immobilization processes other than iron reduction are recognized in the plan and that innovative ideas for their use in remediation be encouraged.

Additional recommendations beyond the strategic plan

***Regulatory issues*.** It is not clear how regulatory issues, which may impact the basic science conducted within the various NABIR elements, have been utilized to formulate the NABIR program. The committee suggests an early sensitivity to such issues as the strategic plan is being finalized, perhaps involving discussions with informed and enlightened regulators. We make this recommendation because the maze of regulatory issues that attends immobilization efforts may help focus the research by defining knowledge gaps that could be addressed in components of the research program. A proactive NABIR approach to assist investigators in addressing relevant issues, perhaps through the BASIC program, would seem appropriate and help ensure that the research is fully utilized in developing and improving the regulatory process.

V. Summary comments. The DOE program staff did an excellent job in prioritizing and focusing on key issues, and on developing an interdisciplinary and phased plan to address these issues. We have the following summary points.

- Interdisciplinary NABIR research among microbiology, geosciences, environmental engineering, and other disciplines is a unique strength that should be captured in the document. The NABIR program has been, and continues to be, exemplary in demonstrating the rewards of interdisciplinary research.

- The plan should highlight the point that the NABIR program is unique in the federal government in conducting fundamental bioremediation research on metal and radionuclide contamination in the subsurface environment.

- The potential for non-remediation-related program contributions should be stated in the strategic plan. Because of the fundamental research character of this program, results will have impact beyond DOE site cleanup. For example, a better understanding of microbial processes at mineral surfaces will inform questions on mineral formation and geochemical cycling of elements.

- Fundamental science research in the NABIR program has been strong; the strategic plan should better emphasize this theme, particularly with regard to future research.

- The FRC appears to be overemphasized in the plan, at some risk to overall scientific needs and opportunities within the program scope. The FRC addresses an important, but limited set of conditions and additional flexibility in research on samples from other sites would broaden the applicability of NABIR research

- The committee strongly supports NABIR efforts to focus the research program on critical issues, however, the nature of problems in remediation being faced at DOE sites suggests that consideration be given in the strategic plan to selective expansion of research scope to include the effects of co-contaminants and processes other than iron reduction.

- The strategic plan should include future goals relative to genomics (and other omics), a DOE strength. In addition, the NABIR program should continue to collaborate with the Microbial Genome program. NABIR has the potential to play a leadership role in implementing Genome to Life program objectives for DOE missions.

- The plan should better define the deliverables in the context of the broad advances in science and in the state-of-the art of bioremediation. Such deliverables should include both potentials and limits, features critical to process optimization, long-term stability and criteria to assess effectiveness.

Signed for the Committee

James M. Tiedje, Chair August 2, 2001

Members present:

Linda Chrisey
Derek Lovley
Joe Suflita
Catherine Vogel
David White
Ray Wildung
Ken Williamson
Amy Wolfe
John Zachara
Lew Semprini was not present but sent the committee his written comments