National Institute of Environmental Health Sciences | **Superfund Basic Research Program**

A LEGACY IN MULTIDISCIPLINARY RESEARCH

Charting a Course for Advancing Basic Research to Practice

Report of the 2003 External Advisory Group
September 2003

U.S. Department of Health and Human Services | National Institutes of Health | National Institute of Environmental Health Sciences

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Executive Summary

The National Institute of Environmental Health Sciences' (NIEHS) Superfund Basic Research Program (SBRP) was created under the 1986 Superfund Amendments and Reauthorization Act (SARA) to establish a university-based research program to help address the wide array of scientific uncertainties facing the Environmental Protection Agency's (EPA) Superfund program. Until 2001, when Congress chose to provide Program funds directly to the NIEHS, the SBRP received its funds as pass through dollars from the EPA. This change in funding strategy expands the research opportunities for the Program as it strives to address its mandates and allows for the use of additional funding mechanisms as well as changes to the grant award cycle.

The SBRP is preparing to release annual Requests for Applications (RFAs), beginning in Fall 2003. As the Program plans for the future, NIEHS considered an external review of the SBRP essential. In February of 2003, the NIEHS established an ad hoc External Advisory Group (EAG) as a working group of the National Advisory Environmental Health Sciences Council. The EAG, which consisted of sixteen individuals representing academia, industry, and federal and state agencies, served to identify the strengths and areas of productivity of the Program and assess the efforts undertaken to communicate the science emanating from the Program. In addition, the group provided insights on potential future directions for the Program. The EAG did not evaluate specific SBRP programs or individual projects within the programs, this having been conducted via competitive application and independent peer review processes.

Research and Programmatic Issues

The EAG review of the current status of the Program focused on the scope of the science funded, internal and external communication efforts, and programmatic management. The EAG believes that the SBRP is an active, vibrant, and significant program, citing the overall historical quality and relevance of SBRP-funded research and results. The EAG determined that SBRP-funded research remains highly relevant to the EPA Superfund goals, noting that the SBRP has been successful at enhancing investigations and remediation work at many hazardous waste sites across the country.

Research: The SBRP is the only NIEHS or NIH program to fund both biomedical and nonbiomedical research within the structure of a multi-project grant. The SBRP strives to assemble researchers from diverse disciplines to focus on a unifying theme. This cross-cutting focus and multidisciplinary nature enable the SBRP to address the range of environmental problems that exist at hazardous waste sites. The resultant synergy between biomedical and nonbiomedical projects research projects is crucial to the development of holistic evaluations of hazardous waste sites.

The SBRP has always emphasized the importance of a firm public health foundation and is well positioned to meet the challenge of translating research findings into public health practice. The multidisciplinary structure of the Program places it in a in a strong position to address complex public health issues that cannot be adequately resolved through the contributions of a single scientific discipline. The programmatic goal that basic research should lead to application is an important feature of the SBRP and supporting an effective integrated research approach maximizes the likelihood of achieving this goal.

The EAG recommended that the SBRP continue the integrated science approach in its funded research programs while working to develop additional mechanisms to identify and address unmet needs and emerging issues.

Communication: Without question, technology transfer, in the broadest sense, is the SBRP's raison d'etre. Because of the ultimate goals of the SBRP — that is, enhancing decision making — the research results must be freely communicated at several levels, from the scientific community, to other agencies and to those affected. The Program views information and technology transfer activities to be a shared responsibility with efforts required by both the Program staff and the grantees. The grantees address this responsibility through technology and information transfer, community outreach, and training.

Clearly, technology and information transfer must be concerned with converting research results into practical applications. Grantees have selected several approaches to foster this exchange:

- SBRP grantees have an impressive record of peer-reviewed publications, with over 6,500 publications in the scientific literature. The existing SBRP web-accessible database containing all publications resulting from SBRP sponsorship is excellent. Suggested further refinements to the web search features will enhance the ability to access this rich data set.
- SBRP researchers communicate their findings at local, national and international scientific meetings, resulting in a successful transfer of science and technology both within and external to the scientific community. The EAG considered this activity to be laudable.
- A significant amount of SBRP-funded science has been converted to patents, suggesting current and future commercialization to field or other laboratory applications; however, the EAG recognized that it is difficult to assess other areas that have not progressed to the same extent.
- SBRP grantees have conducted research at more than 100 hazardous waste sites, which demonstrates the successful reduction of SBRP research to practice.
- In 2002, the Program established Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Initiatives designed to foster development of field applications of science and technology in the private sector. This mechanism appears to be a potentially valuable one to promote the movement of science into commercial or other field use.

The EAG recognized that Outreach has become a natural extension and an integral part of the Program; however, the EAG recommended that Outreach should be more effectively presented in future RFAs by more explicitly identifying overall outreach goals, priorities and audiences.

The concept of a multidisciplinary approach is also an integral aspect of SBRP-funded training and has a major impact on graduate and post-graduate students. The SBRP provides an environment that fosters the development of multi-faceted investigators within the interdisciplinary framework required to meet complex human and environmental health challenges. The EAG recommendations to enhance the SBRP's training efforts included increased involvement of students in Outreach activities and formal post-graduation tracking of students for documentation and evaluation purposes.

Management: There is a clear sense of commitment to the mission of the SBRP by the Program staff who actively work to promote the Program and continually seek ways to assist individual SBRP-funded programs in getting their message out. SBRP staff have reached out to EPA, the Agency for Toxic Substances and Disease Registry (ATSDR), and state agencies with the intent of promoting the use of the Program's research results and identifying potential future research needs. The EAG recommended that SBRP staff should continue to build upon their communication with EPA regions when SBRP-funded research involves investigations and applied technology at specific Superfund sites.

The SBRP staff have established several programmatic tools and information transfer mechanisms that serve as important common resources to the SBRP. These resources, which include the SBRP website, the monthly Research Briefs, web-based seminars, and support for scientific meetings and lectures, provide an important foundation for facilitating and tracking the efficacy of technology transfer within, across, and outside of institutional SBRP grantees. With respect to the existing resources, the EAG recommended 1) restructuring of the website to emphasize the overall science and technology output and value of the SBRP; 2) increasing the distribution of the Research Briefs to additional industry sectors; and 3) using the Research Briefs to illustrate science/technology transfers between investigators within, across, or external to their funded institution.

To ensure the growth and continued relevance of the SBRP, clearly defined program assessment plans such as metrics need to be incorporated into planning activities. The Program currently uses a variety of data to evaluate program successes; these include numbers of publications, patents, and students trained. The EAG recommended that additional qualitative metrics be incorporated to evaluate synergy, publication impact, graduate student success or career relevance, and success of technology transfer. The EAG noted that approaches to collecting and evaluating these, or other, measures are not yet developed.

Future Directions

Since its inception, the SBRP has been on the forefront of health and environmental research — the SBRP's proactive, interdisciplinary approach is clearly exemplified by its early recognition of and involvement in research related to arsenic contamination, children's environmental health, and the value of the use of wildlife as indicators of public health. The SBRP continues to look to the future and strives to maintain the cutting-edge nature of the Program. The EAG attempted to provide guidance in future directions for SBRP, placing particular emphasis on two aspects: utilization of existing and emerging cutting-edge science tools and approaches; and encouraging innovative, cross-cutting, systems-level interdisciplinary approaches. EAG discussion led to observations on particular research areas where members see the opportunity for innovative research that will be relevant to the SBRP mission. Many of these concepts build upon current Program elements and activities.

The EAG was encouraged to note that several current research projects utilize new tools and methods that are being developed through basic research in biomolecular sciences, especially those that relate to gene-environment relationships. To remain relevant and cutting-edge, the EAG recommended that the SBRP consider new research avenues, including:

- development and application of scientific approaches and methods that will advance the integration of human and ecological risk assessment;
- utilization of a dynamic systems-level approach to site characterization;
- development and application of methods to examine the theoretical and empirical connectivity between human health and ecological condition;
- design and implementation of studies to examine strategies for information transfer to communities and the resulting impacts on community attitudes and actions; and
- inclusion of researchers from a wider breadth of academic disciplines such as sociology, economics, ethnology, anthropology, psychology/behavioral medicine, and bioethics and philosophy to add additional insight to research design, interpretation, and communication.

In addition, the EAG recommended that the SBRP increase its emphasis on:

- development and application of advanced sensor systems to enhance site characterization;
- development and application of scientific approaches and methods that will advance the integration of biological systems and chemical-physical processes in mechanistic studies of environmental processes;
- development and application of new analysis and visualization methods to interpret environmental information;
- development and application of more vigorous mathematical methods to model environmental data;
- application of "omics" technologies to investigate the human and ecosystem health impacts of exposure-dose levels representative of real-world conditions at hazardous waste sites;
- development and application of increasingly sophisticated and innovative remediation approaches that rely on cooperative efforts of researchers from multiple disciplines;
- development and application of creative approaches to examine remediation and risk management such as those that involve theoretical approaches based on computational and statistically-based biological models;
- design and implementation of studies related to specific community groups who may be especially affected, such as the aged, children, and minorities or low-income populations; and
- development of interdisciplinary approaches to the study of Superfund events, sites, and chemicals to serve as a mechanism to further the synergistic goals of the SBRP.

To be positioned to most effectively address interdisciplinary research, the EAG felt that the SBRP should encourage the sharing of expertise among the SBRP community. Accordingly, mechanisms should be developed and applied that decrease impediments to inter-program collaboration. The goal would be to foster the sharing of resources, expertise, and to include increased scientific and logistical interchange amongst program directors. The working group also recommended the broadening of SBRP grant mechanisms beyond the "P" series to include a variety of types of "R" series grants to fulfill the Program mandates.

The EAG acknowledges several limitations to its evaluation and recommendations for future direction of the SBRP:

- The list of observations and opportunities for the future is by no means comprehensive nor can it be, given the pace of innovation in contemporary science;
- The EAG recognizes that the NIEHS does not direct the research envisioned and that the Program will consist of funded grant applications, approved on the basis of scientific quality; and
- While acknowledging resource restrictions faced by the Program, the EAG did not consider the resource issues generated by its observations and recommendations.

The EAG's view of the overall quality of SBRP-funded research and results is very favorable. The EAG believes that over the past 16 years the SBRP has established a remarkable record of research and outreach through its support of over 60 programs. The EAG found the Program to be strong, relevant, and well-focused to address its mandates. With respect to the future direction of the Program, the EAG believes that the SBRP has built a firm foundation to increase opportunities to merge cutting-edge technologies with hypothesis-driven research. The EAG supports the SBRP's aim to apply systems approaches using innovative technologies to address environmental health issues. The EAG regards the SBRP strategy of annual competition as a valuable opportunity for the Program to become increasingly responsive to emerging issues.

The EAG believes that this review of the SBRP accurately reflects its perceptions and study of the present status of the Program. Recommendations for future directions or improvement of the Program represent its best efforts, based on the information supplied and acquired. The EAG would like to acknowledge the assistance received during this process. The SBRP staff provided extensive background materials and was available to provide additional information as needed. Mr. Larry Reed, EPA, served as Executive Secretary, functioning as liaison between the EAG and SBRP staff. Mr. Reed provided invaluable support to Dr. Daniel Baden and the entire EAG. We are also appreciative of the editorial support provided by Ms. Kerry Murray and Ms. Maureen Avakian of MDB, Inc.

Introduction

Purpose of this Review

The National Institute of Environmental Health Sciences' (NIEHS) Superfund Basic Research Program (SBRP) was created under the Superfund Amendments and Reauthorization Act (SARA) of 1986. It was established as a multidisciplinary research program to address the broad, complex health and environmental issues that arise from the multimedia (air, land, water) nature of hazardous waste sites. The intent was that the research conducted by the SBRP would assist in the identification, characterization and cleanup of the unknown number of abandoned or uncontrolled hazardous waste sites around the country. Historically, the SBRP has considered appropriate areas of study to include ecology, epidemiology, toxicology, molecular biology, hydrogeology, engineering and soil science, and has required its grantees to include both biomedical and non-biomedical studies in their programs.

The Program[1] has witnessed significant growth in its first 16 years. In 1987, the newly created Program was a $3 million program with four participating universities. Today, the SBRP budget is over $45 million a year with 19 grant programs that include 70 participating universities and institutions and involve nearly 1000 investigators and students.

An important component of the SBRP is the ongoing internal review of science direction and accomplishments of each of the funded programs, and of the Program as a whole. Review is conducted at multiple levels. Each grantee has constituted its own external advisory board that convenes at least annually. On another level, the National Advisory Environmental Health Sciences (NAEHS) Council provides oversight to NIEHS staff responsible for the SBRP. In addition, the SBRP considers it a sound policy to periodically request an external working group to review the Program with a fresh perspective.

Because the Program is embarking on a new competitive cycle that will offer the opportunity for change and the ability to define new directions, SBRP staff felt that it was an appropriate time to form an external advisory working group. Accordingly, the SBRP External Advisory Group (EAG) was convened in February 2003 as a working group of the NAEHS Council. The goal of establishing the working group was to review the performance and needs of the SBRP, and to provide input into potential future directions for the Program. The working group concluded its efforts in July 2003. This document contains the results of this activity.

Charge to the External Advisory Group

The purpose of the EAG was to provide SBRP staff with an independent and constructive assessment of the Program. Specifically, members of the EAG were asked to:

1) Identify areas where the Program has demonstrated strengths and greatest productivity;
2) Address efforts the Program has undertaken to communicate the science to the variety of academic, government and other stakeholder communities; and
3) Identify opportunities for the future direction of the Program.

Consequently, this document is divided into two distinct parts. Part One provides the EAG's assessment of the quality, relevance, and performance of several aspects of the Program to date, while Part Two looks toward the future, offering some observations on possible future directions for the Program.

It is important to note that the EAG assessment was based largely on documents and other information provided by NIEHS to the EAG in support of this activity, including:

- *Superfund Basic Research Program: A Legacy in Multidisciplinary Research*
  Volumes 1-3; these documents are available at: http://www-apps.niehs.nih.gov/sbrp/eag
- Request For Application (RFA) ES-99-001: http://www-apps.niehs.nih.gov/sbrp/descrip/rfa.cfm
- Superfund Basic Research Program Research Needs Evaluation Workgroup (ReNEW), 1998
- SBRP website: http://www-apps.niehs.nih.gov/sbrp/Index.cfm

[1] Note: Throughout this document, the use of the word Program with a capital "P" indicates the SBRP, whereas the use of the word program with a lower case "p" indicates the individual, SBRP-funded grantee program.

In addition, EAG members relied on their personal experiences, knowledge of the Program, and personal interviews with research investigators supported by the SBRP in order to gain further programmatic overviews of SBRP-funded research. The material provided to the EAG offered a comprehensive overview of the activities and accomplishments of the SBRP since its inception in 1987. This information was extremely useful not only for preparation of this review; it also serves as a valuable resource for any individual, group, institution or agency that is interested in the research agenda and work products of the SBRP.

EAG Membership

Sixteen individuals agreed to participate in the 2003 SBRP External Advisory Group, representing academia, industry, federal and state agencies, and the community. The Group represented a cross-section of professional disciplines that encompass the full spectrum of the SBRP.

Dr. Daniel G. Baden from the University of North Carolina – Wilmington (UNCW) served as Chair of the EAG. Dr. Baden is the director of the UNCW Center for Marine Science and a member of the NAEHS Council. Drs. James Bus, Katherine Banks, Ernest Hodgson, William Glaze and Michael Gallo provided expert subcommittee leadership on various aspects of the report.

A full list of EAG Members is included on the following page. Members provided written and oral comments on numerous drafts of this document, met twice in Research Triangle Park for in-depth committee meetings, and participated in several subcommittee conference calls.

Members of the External Advisory Group

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PART ONE
RESEARCH AND PROGRAMMATIC ISSUES

1. EAG Review Process

For the first set of review discussions, the EAG divided into two Subcommittees, Research Issues and Programmatic Issues, to discuss specific aspects of past and present SBRP emphasis and progress. The Research Issues Subcommittee focused on the multidisciplinary nature of the SBRP, SBRP-funded scientific advances, and translation of the basic science to applications that impact public health. The Programmatic Issues Subcommittee addressed issues relevant to the management and emphases of the SBRP. Subcommittee membership was as follows:

Research Subcommittee

Co-Chairs:	Katherine Banks Ernest Hodgson
Members:	Mike Gallo William Glaze Carol Henry Cornell Long Betsy Southerland

Programmatic Subcommittee

Chair:	James Bus
Members:	Henry Anderson Catherine Burroughs Yolanda Banks-Anderson Darrin Curtis Christopher DeRosa Joan Flocks

2. SBRP Science

SBRP science is evaluated in this section in terms of the scientific quality of the research, the synergy within the SBRP-funded program projects – reflected, for example, by the interaction between projects and people from different disciplines – and the contributions of the Program to furthering public health.

2A. Research

Quality

The most important function of the SBRP is to generate interdisciplinary scientific information to address the broad, complex human and environmental health issues that surround hazardous waste sites. The EAG was not charged with a specific review of the quality of the research currently funded by the SBRP, but rather, to accept the analysis of the NIEHS Scientific Review Panels responsible for competitive, peer-review evaluation of programs to be funded. The programs funded by the SBRP are selected following a competition in response to a NIEHS-generated Request for Application (RFA). Two-thirds of the approximately 145 individual program projects were placed in the outstanding to excellent categories by the NIEHS SBRP peer-review Scientific Review Panels and probably few, if any, below the very good category. Although the individual program projects vary in quality, the overall quality of each of the existing programs is considered to be exceptional. The EAG's view of the overall/historical quality of SBRP-funded research and results is very favorable.

Relevance

SBRP-funded research remains highly relevant to the U.S. Environmental Protection Agency (EPA) Superfund goals in two ways: by providing 1) basic research to further all environmental science and engineering research; and 2) applied research that is directly targeted at Superfund issues. The NIEHS consults with EPA national and regional offices to identify EPA Superfund research needs as it develops the SBRP RFA, thereby integrating the needs of the EPA Superfund Program into the broad scope of basic research.

The cross-cutting focus and multidisciplinary nature of the Program reflects the wide range of environmental problems that exist at hazardous waste sites. The SBRP is successful in integrating research on critical areas that must be understood in order to remove or mitigate contamination and protect human health. These areas include the study of human health effects, fate and transport in the environment and biological systems, analytical methods, and remediation technologies. For example, the SBRP has generated research in these areas for a number of chemicals that are most prevalent at Superfund sites, including polychlorinated biphenyls (PCBs), heavy metals, and trichloroethylene.

Performance

The EAG was not responsible for reviewing the performance of specific SBRP-funded programs or of individual projects within the programs. However, based on the EAG's evaluation of publication records of SBRP-funded principal investigators, the overall performance of the Program appears to be exceptional.

In addition, the EAG concluded that SBRP staff have an excellent feel for which of the lower-rated individual projects improve over the life of the program funding cycle, which disappear at the next renewal, and which outstanding projects end up as less than outstanding, etc. Each SBRP-funded program has an external advisory board that meets annually to evaluate progress and to make recommendations, which may result in termination or redirection of individual projects deemed to be unsuccessful.

Performance of the SBRP can be evaluated based on the value added to the EPA Superfund Program's mission to cleanup sites efficiently and effectively for the protection of public health and the environment. The SBRP has been successful at enhancing Superfund site investigations and remediation work at many sites across the country.

Examples of SBRP-funded remediation advances include:

- thermally enhanced soil and groundwater remediation;
- bioremediation of chlorinated hydrocarbons, PCBs, and polycyclic aromatic hydrocarbons (PAHs) in contaminated soil;
- bioavailability of soil lead and arsenic to humans;
- wildlife as sentinel species; and
- fate and transport, remediation of volatile organic compounds (VOCs) and perchlorate.

Examples of SBRP-funded biomedical advances include:

- increased understanding of the mechanisms of arsenic-induced cancer and vascular disease;
- assessment of levels of persistent pollutants in urban anglers living near the Hudson River;
- development of biomarkers to enable scientists to show that prenatal exposures could be critical in producing childhood leukemia; and
- application of a non-invasive and rapid method for measuring lead in bones (K-x-ray fluorescence).

It is encouraging that several recent SBRP-funded research projects utilize new tools and methods that are being developed through basic research in biomolecular sciences, especially those that relate to gene-environment relationships, although these projects are still a distinct minority. These developments hold extraordinary promise for understanding how organisms - including humans - respond to environmental stressors such as chemicals, and explaining individual variability in these responses. At the same time, the biomolecular approach is providing new sensors for detecting responses as well as developing new biomarkers of exposure, dose and effect.

Performance may be enhanced by the proposed movement of the SBRP review cycle from an "all programs competing" schedule that occurs every five years to an annual, staggered five-year schedule of review. The competition by a subpopulation of all SBRP-funded programs on this staggered schedule should allow the SBRP to rapidly grasp new technologies and entrain them into the peer-reviewed cycle for Program implementation. What remains to be seen is how well the logistics of transition from the current five-year competitive renewal cycle to an annual cycle will work. Performance may suffer unless the transition is handled very carefully.

EAG Recommendations on SBRP Science

- New flexibility associated with annual competitions should be used not only to address unmet needs and emerging issues, but also to improve performance and quality in areas that have not yet been adequately addressed.
- A mechanism to identify emerging areas of need is not clearly defined. Stakeholder meetings may only highlight the application, rather than identify basic research questions. Such a mechanism should be established to receive stakeholder input on data needs on relevant, emerging issues.
- SBRP staff should consider placing the summary information contained in the EAG review volumes on the SBRP website. Doing so would make a visible statement about the overall quality of the science being generated, and serve as a reminder to current and future grantees of the competitive standards sought and supported by the SBRP.
- The Program has grown through its continued partnership with the EPA, both in Washington, DC, and at the regional level. SBRP-funded program directors should become aware of the areas of ongoing EPA research that are relevant and could potentially overlap with SBRP research (i.e., within the office of Research and Development [ORD]) and the extension and application of science within the EPA Regions.

2B. Contributions to Public Health

Each iteration of the SBRP RFA has clearly identified the importance of public health and has required a public health justification. Successful applicants have been required to demonstrate an understanding of public health and preventive approaches. For many basic research institutions, the intercalation of basic science and public health was an unfamiliar concept. The requirement for public health justification necessitated them to develop innovative new programmatic linkages in order to be successful. The resulting research Program, while consisting primarily of basic rather than applied approaches, clearly has a firm public health foundation.

Quality and Relevance

As stated in the previous section, a critical feature of the SBRP is its multidisciplinary programmatic structure. Using such a structure places the SBRP in a strong position to address complex public health issues that cannot be adequately resolved through the contributions of a single scientific discipline. Further, the interaction of several complementary disciplines encourages both increased communication amongst research communities and a better understanding of the importance of the research discoveries and their potential applications by stakeholder groups. The SBRP programmatic requirement that research leads to application sets it apart and maximizes the likelihood of achieving the goal of an effective integrated research approach to improving public health.

Performance

For each SBRP-funded program, there are clear linkages between the research findings and their contributions to achieving identified public health goals. In some instances, the translation of the basic research results into public health practice can be expected to be rapid and achievable within the time frame of individual five-year grant program cycles. Examples of programs with this kind of success are provided in the programmatic summaries. In other programs, because of the basic nature of the research and the complexity of the problem being addressed, success can only be achieved after several consecutive five-year grant periods. In most instances, the public health objectives are long-term goals and are only now reaching fruition.

Evidence of basic science to public health translation is documented in Volume 3 of *Superfund Basic Research Program: A Legacy in Multidisciplinary Research*. The Program is positioned to meet the challenge of translating those results into public health practice. Communication successes are less developed, and in many cases the progression to implementation is only beginning to be realized. The maturity of the SBRP program is exemplified by activities that precisely communicate research results to stakeholder communities.

EAG Recommendations on SBRP Programmatic Contributions to Public Health

- Each SBRP-funded program has an external advisory board; currently, three of the programs have representatives of state health departments on their external advisory boards. Ensuring that public health practitioners, especially non-academic state and local public health officials, have a strong role in the strategic planning activities of these boards is important and recommended. Such members can assist in providing a link between the community and the research strategy and priorities of the programs. They can also help in placing students and providing them experiences outside of the laboratory. It is important for programs, as they mature, to maintain flexibility to adjust their programs and their advisory structures to complement their research.
- NIEHS should develop a system to track how the education and training functions of SBRP-funded programs are building public health capacity; particularly, subsequent employment of the trainees should be monitored. Formal tracking of students for documentation and evaluation purposes is essential and should be implemented. Elements of such documentation should include contact data, field of employment, and post-SBRP training.

2C. Synergies

Quality and Relevance

SBRP is the only National Institutes of Health (NIH) program to fund both biomedical and non-biomedical research. Clearly, without the specified synergy required between biomedical and non-biomedical projects within SBRP-funded programs, none of the non-biomedical projects would have been appropriate to NIEHS or NIH. Although synergy within and across individual grant programs seems to be high, it is difficult to assess.

Synergy between research projects is a very important aspect of the SBRP, and is relevant to the development of holistic evaluations of Superfund sites. The SBRP encourages the implementation of programs that assemble researchers from diverse disciplines to focus on a unifying theme. This provides the opportunity to advance the science in a more effective manner than could be accomplished by single, unrelated projects. The full incorporation of a systematic approach to the study of Superfund sites is possible, and has been fostered by the synergy element incorporated into the pioneering legislation that mandated collaborative studies involving multiple disciplines.

Performance

While it would appear to be almost axiomatic that including biomedical and non-biomedical projects within the framework of an integrated research program would be more productive than supporting individual research projects, no SBRP-funded program provides a complete set of quantitative measures for synergy.

Thus, synergy within individual grant programs is an important objective, but a precise definition is elusive. However, a preliminary analysis by SBRP staff covering the years 2000, 2001 and 2002 identified a relatively small number of multidisciplinary and interdisciplinary publications. The numbers show a consistent increase during this time period, which is essential for documentation of integrated approaches to SBRP-related science.

EAG Recommendations on SBRP Synergy

- Continue development of the SBRP publications database until it is complete and fully searchable. This could (and should) be used to explore synergy among multidisciplinary projects by searching for inter-project and inter-program publications. Citation indices could be examined for those deemed synergistic as compared to those deemed to be non-synergistic.
- Continue the integrated science approach in SBRP research programs.
- Consider additional types of discipline synergy, e.g., sociology, economics, psychology (Refer to Part Two, Section 3I, Subsection c of this report for further EAG observations and recommendations on Encouraging the Integration of Additional Academic Disciplines).
- Continue hosting the SBRP Annual Meeting, as it provides for valuable interaction among SBRP researchers.

3. SBRP Communication Efforts

A primary programmatic goal of the SBRP is "establishing multidisciplinary programs … to provide a more comprehensive understanding of the complex environmental issues in order to support state, local, and federal agencies and private organizations and industry in making decisions related to the management of hazardous substances … particularly from uncontrolled, leaking waste disposal sites." (RFA ES-99-001). Proactive, successful communication of SBRP-funded research outcomes from individual programs and Program staff to its stakeholders is essential to achieving this goal. SBRP staff and SBRP-funded programs currently support this need by providing technology and information transfer, conducting outreach activities to diverse audiences, and offering relevant education and training opportunities.

3A. Technology and Information Transfer

A key element in achieving SBRP's programmatic goals is effective transfer of both basic and applied science and technology across several research and institutional sectors. This transfer should include:

- intra-institutional, i.e., achieving synergy through technology transfer within a SBRP grantee institution;
- inter-institutional, i.e., achieving synergy through technology transfer between SBRP grantee institutions; and
- extra-institutional, i.e., technology transfer from SBRP grantees to external users (academia, regulators, consultants, private technology development firms, public).

In preparation for the development of the 1999 SBRP RFA (RFA ES-99-001), NIEHS sponsored the ReNEW evaluation in the fall of 1998. The purpose of this meeting was to allow scientific experts and policy makers to assess the "feasibility, timeliness, and relevance of research recommendations identified by professionals working in the areas of hazardous waste management, remediation and assessment." Many of these recommendations appear to have been incorporated into the 1999 RFA, e.g., requirement for establishment of "Technology Transfer Planning" in the Administrative Core of SBRP programs. See Appendix 2 for a list of ReNEW recommendations.

Quality

This is a complex area because "technology transfer" means different things to different people and in different contexts. Many institutions have technology transfer offices that focus entirely on patent applications, patent licensing, etc. Clearly, for the SBRP, technology transfer must be much more than this and must be concerned with converting research results into practical applications and outreach activities. Specific examples of such applications are found in Volume 3 of *Superfund Basic Research Program: A Legacy in Multidisciplinary Research*.

Communication of research results at the level of individual program investigators and projects is excellent, with some 6,500 publications in the scientific literature. However, the quality and efficiency of information transfer through publications in the scientific literature is not easily quantifiable and therefore not immediately apparent. The existing SBRP database containing all publications resulting from SBRP sponsorship is excellent and with suggested further refinement of search capabilities will be an invaluable tool. Not only will this information be available to the scientific community via peer-reviewed papers, but it will also permit several types of program analyses that must currently be carried out by hand.

Relevance

Without question, the relevance of technology transfer in the broadest sense is the SBRP's raison d'être. Technology and information are very important. In an interdisciplinary program of this type with applied goals, the results must be freely available at several levels, from the scientific community to other agencies, and to the affected public.

Performance

In addition to the impressive publications record, SBRP researchers also communicate their findings at local, national and international scientific meetings, and this is laudable.

There are excellent examples of the reduction of SBRP research to practice. SBRP grantees have conducted research on more than 100 Superfund sites. Overall, the information contained in Volumes 1 and 3 of *Superfund Basic Research Program: A Legacy in Multidisciplinary Research* confirms a successful transfer of science and technology both within and external to the scientific community. A significant amount of the science has been converted to patents, suggesting

current and future commercialization to field or other laboratory applications. It is more difficult to assess areas that have not yet progressed to the same extent.

Following the FY2001 change in funding mechanism for the SBRP (see Section 5B), the Program established Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Initiatives designed to foster development of field applications of science and technology in the private sector. In 2002, 12 SBIR/STTR grants were funded to actively transfer laboratory science to field applications; of the 12, four represent partnerships with SBRP grantees. The SBIR funding mechanism appears to be a potentially valuable mechanism to promote the movement of SBRP science into commercial or other field use.

EAG Recommendations on Technology and Information Transfer

- The SBRP should develop a definition of the term "technology transfer" for the benefit of those who conduct and those who use SBRP research. The term has many meanings to different individuals and organizations.
- SBRP-funded programs should not rely solely on technology transfer offices in host institutions. Each program should designate an individual whose responsibility is optimizing technology transfer. Evaluation of technology transfer results should be formally included in annual reviews.
- Given the maturity of the SBRP, SBRP staff are encouraged to keep the technology transfer theme as an essential element of the SBRP Annual Meeting, and to continue to use the website to publicize the agendas and Annual Meeting summaries.
- The existing publications database should be further developed to be fully searchable by author, keywords, research areas and project of origin as soon as possible.
- The list of peer-reviewed journals in which SBRP researchers publish should include a comparison of impact and citation indices.

3B. Grant Program (University-Based) Outreach Activities

Quality and Relevance

Superfund Outreach is included on the NIEHS website as a Translational Research Program. According to NIEHS, the purpose of translational research is to convert environmental health research into resources that can be used by health professionals and by the public, including vulnerable populations, to improve quality of life. Judging by its inclusion within this family of NIEHS research programs and the definition of this research, it appears that outreach, including community outreach, is an integral part of the SBRP.

Performance

The SBRP was designed to fulfill SARA mandates, which do not specifically include outreach activities. However, outreach has become a natural extension of the Program's goal of transferring research findings to appropriate audiences.

In the last RFA, ES-99-001, the inclusion of an Outreach Core was strongly recommended. For the first time, RFA ES-99-001 permitted applicants to include a Community-Based Prevention/Intervention Research Project, which, by its very nature, would address many outreach concerns at the community level. This type of project was only an optional component and the resulting response rate was low. The same RFA required that "information dissemination and transfer" occur within the mandatory Administrative Core, which may have compromised efficiency. The responsibility of outreach to more public stakeholders therefore continues to be at the discretion of, and take the form developed by, the individual SBRP-funded programs.

As a specific example, at least eight Outreach Cores include strategies to develop secondary educational products or programs to increase awareness and interest in environmental science and health. There is some question as to the extent to which these types of efforts build from the research efforts of the SBRP-funded program. In addition, these educational activities seem to duplicate or overlap with other educational activities of NIEHS-funded programs, such as the Community Outreach Education Program (COEP) component of Core Centers.

Appendix 1 of this document, SBRP-Funded Outreach Projects Chart, details the goals and ongoing activities of each SBRP-funded program.

EAG Recommendations on Grant Program Outreach Activities

- What is expected by the outreach efforts of SBRP-funded programs should be further refined and more effectively presented in future RFAs. To be clear about what is expected, SBRP staff need to identify overall outreach goals, priorities and audiences, perhaps through a more formalized coordination at the Program level.
- Efforts to refine communication and collaboration should be explored within outreach programs or processes underway within other parts of the NIEHS and the EPA. SBRP should consider increasing the level of formal relationships/collaborations/coordination efforts between outreach efforts at the individual SBRP-funded program level and the NIEHS COEP Resource Center (http://www-apps.niehs.nih.gov/coeprc/), the Community-Based Participatory Research and Environmental Justice projects, the EPA's Superfund Community Involvement and Outreach Center, or the outreach programs of the EPA's Hazardous Substance Research Center's Technical Outreach Services for Communities (TOSC) program and Technical Assistance for Brownfield communities (TAB).
- SBRP staff should also consider re-categorizing and re-defining the overlapping non-research goals of SBRP-funded programs, adding goals that are not currently specified (e.g. See Appendix 1, Outreach Goal IV, "Data Integration," and Outreach Goal III, "Collaboration Building") under a more inclusive umbrella Communications Core.

Appendix 2 contains a list of recommendations regarding outreach from previous evaluations of the SBRP. Some, but not all, of these recommendations have been implemented. The list as presented is a set of objectives that, if implemented, would make the outreach efforts of SBRP more comprehensive, useful, and uniform.

3C. SBRP Education and Training

For Program purposes, SBRP staff view training as its investment in undergraduate, graduate and post-graduate students and view education as the continuing education of stakeholders. Training Cores exist at 18 of the 19 currently funded programs. In most cases, trainees are linked to specific SBRP-funded program research projects. The majority of Training Cores provide training to a combination of graduate students and postdoctoral fellows; many focus on graduate students, and one targets pre-college students.

The 1999 RFA strongly recommended the inclusion of a Training Core to support graduate and advanced training, stressing the importance of interdisciplinary training and encouraging cross-training in biomedical and non-biomedical research disciplines.

Quality and Performance

The evidence provided in Volume 3, Section 4j of *Superfund Basic Research Program: A Legacy in Multidisciplinary Research*, suggests that SBRP-funded programs are having a major impact on graduate and post-graduate students. Statements like "[students] have seen first-hand that collaborative research yields value-added results on individual SBRP projects," and "The interdisciplinary nature […] was critical to my training and development" reinforce the concept that both faculty mentor and student alike recognize the value of the interdisciplinary approach. The approach – and not necessarily the actual subject of the research – is the important point here. The compilation of trainees who have moved on to successful careers in environmental agencies, private firms, and universities is impressive and indicates an ad hoc "tracking" of students, essential for documentation and program evaluation purposes.

There is inconsistency in the structure of the Training Cores, however. Some include a requirement for completion of courses from multiple disciplines in addition to participation on a research project. Others focus on a series of training activities such as seminars, colloquia and participation in professional meetings. This inconsistency makes it difficult to determine if some Cores are stronger than others or have a greater impact on the overall research program.

Relevance

Training is a principal mechanism by which scientific knowledge and the culture of disciplines is passed from generation to generation. Ways of looking at research problems, especially within the SBRP, are an acquired skill. Working within an interdisciplinary framework is an approach to science that is not immediately rewarding for the trainee, but with time becomes a mantra, a valued way of viewing the world and potential implications of actions. As the concept of a systematic approach to SBRP science matures, environments which foster the development of multi-faceted investigators

will become the norm. SBRP has an excellent background in promoting such environments.

EAG Recommendations on SBRP Education and Training

- NIEHS should develop a system to track how the education and training functions of individual SBRP-funded programs are building environmental protection and public health capacity; particularly, subsequent employment of the trainees and the impact they appear to be making relative to their colleagues from other training programs should be monitored. Formal tracking of students for documentation and evaluation purposes is essential and should be implemented. Elements of such documentation should include contact data, field of employment, evidence of impact in the field, and post-SBRP training.
- It is recommended that all trainees be required to have experience with the Outreach Core.
- Provision of training for health care providers and environmental managers, as recommended in the 1998 ReNEW report, could be conducted as an educational activity of the Outreach Cores.

4. SBRP Program Management

This section of the report examines SBRP management, by evaluating mechanisms through which Program staff work to ensure the continual growth of the Program and the quality and relevance of its research; tools used to measure the performance and impact of individual projects as well as the Program as a whole; and vehicles promoted and utilized by Program staff to ensure maximum information transfer to and from stakeholder groups.

4A. Transition to Annual Competition and Flexibility in Funding Mechanisms

In 2001, the SBRP began to receive its funds directly rather than as pass through dollars from the EPA. This has provided new flexibility, allowing Program staff to make management changes to address issues resulting from the re-competition of the entire Program every five years. Plans are now underway to compete a fraction of the Program each year.

Quality

Because this is a new activity, its quality in action has not yet been tested. However, the plans are well advanced and SBRP staff are handling the issues well.

Relevance

Annual competition and flexibility in funding mechanisms are of critical importance to several aspects of the Program, particularly in that they will permit defined and organized mechanisms to address unmet needs and emerging issues. Multiple funding mechanisms will provide opportunities to explore exciting research areas or high risk/high impact studies outside of the current large-program format.

Performance

Performance has been in the area of planning and the consideration of various models that might be used to enhance performance and scope. Both are being handled in a thoroughly professional manner.

EAG Recommendations on the SBRP's Transition to Annual Competition and Flexibility in Funding Mechanisms

- In order to ensure a smooth and orderly transition, it is important to communicate the re-competition plan to all potential applicants as soon as possible with specific information as to how the preparation of proposals will be affected.
- If flexibility will permit, RFAs should be published as soon as possible.
- SBRP staff should investigate whether non-biomedical R01-type projects, not traditionally in the scope of NIH programs, might be funded by some innovative grant mechanism within the SBRP.
- If other NIH grant mechanisms are used, it should be made clear to applicants and peer reviewers that, because of the special and specific needs of the Superfund Program, relevance must be addressed. The NIH peer-review mechanism may provide for these special needs.

4B. SBRP Staff – Communication and Partnership Activities

Primary stakeholders that the SBRP staff attempt to reach through ongoing outreach activities are federal agency personnel (especially those that SBRP staff consider primary stakeholders at the EPA and ATSDR), as well as regional and state level health and environment officials, SBRP-funded program investigators, and industry groups.

Quality

SBRP staff are very knowledgeable in the subject area of the SBRP, as evidenced by the three volumes of SBRP summary information provided to the EAG and their responses to direct questions posed by the EAG. They also are very familiar with the requirements and rules for funding under the NIH grant programs. The staff were very helpful in providing information on partnering, ample information on the SBRP Annual Meetings, and in general was very introspective about their roles and how to increase their effectiveness. That several of the SBRP staff have written published articles on a variety of facets of the SBRP is a testament to their thoughtfulness in accompanying this Program's development over the years. There is a clear sense of commitment to the mission of the SBRP by the Program staff.

Relevance

Scientists and individual SBRP-funded program directors drive their own individual science, and are quite adept at all of the scientific marketing skills and laboratory protocol. SBRP staff integrate these individual elements into the whole Program. A collaborative sense has developed within SBRP that indicates clearly that the Program staff understand the science of individual programs, promote it at every opportunity, and continually seek ways to assist individual SBRP-funded programs in getting their message out. That SBRP staff work annually to assist in interactions amongst individual programs is a further indication of their fervor in this area.

Performance

In 1998, the SBRP sought feedback on the upcoming RFA by broadening its sphere of stakeholders to include community members and public interest groups in a series of meetings. SBRP staff encourage SBRP grantees to conduct outreach activities on a local level as critical stakeholders in their individual, ongoing outreach activities. SBRP staff consider other federal agencies, academia, and industry as their target stakeholders.

SBRP staff recognize that in order for the SBRP to achieve a full measure of success, they must actively engage with colleagues in other government organizations. Ongoing communication with such counterparts has many advantages, particularly improving the SBRP's ability to address societal needs and leveraging resources. With these ends in mind, the SBRP staff have reached out to EPA, the Agency for Toxic Substances and Disease Registry (ATSDR), and state agencies with the intent of promoting the use of the Program's research results and identifying potential future research needs. Examples of partnership efforts include regular meetings with the Deputy Director of EPA's Office of Emergency and Remedial Response (OERR), establishment of the Risk-e-Learning web-based seminar series with OERR and the EPA Office of Solid Waste and Emergency Response's (OSWER) Technology Innovation Office (TIO), regular meetings with representatives of EPA's Office of Research and Development (ORD), and interaction with EPA Hazardous Substance Research Centers (HSRCs). (The EPA has recently undergone restructuring. Accordingly, OERR's name has changed to the Office of Superfund Remediation and Technology Innovation. TIO is now the Technology Innovation Program.)

In order to facilitate individual, SBRP-funded program technology transfer efforts, SBRP staff have established several programmatic tools and information transfer mechanisms that serve as important and valuable common resources to the SBRP. These resources include:

1. SBRP website
   The website is well-visited, recording approximately 10,000-20,000 hits per month. Further, it appears to attract interest from a wide variety of audiences, including evidence of visits from commercial sites (i.e., .com) that may indicate interest from this sector in the science and technology generated by SBRP. The website allows easy and intuitive access to many elements of the funded programs, and permits the visitor to rapidly gain information on the content of individual grantee research programs. The SBRP website also provides a complete listing of conferences supported by the SBRP, including the NIEHS-sponsored Annual Meeting of the SBRP grantees.
2. Electronic distribution of Research Briefs
   The Research Briefs activity of the SBRP is a very useful tool to communicate the ongoing activities of the SBRP-funded programs. In addition to being reported and archived on the SBRP website, the Research Briefs are widely distributed electronically to over 2,600 individuals in 15 countries, including subscribers from academia, federal and state governments, non-governmental organizations (NGOs), consultants, and the public. The Research Briefs have been lauded by the EPA Superfund Program for years and are widely distributed throughout the Agency. It appears that private industry beyond environmental remediation and consulting firms are not a major outreach target for the Research Briefs. However, one concern is that the examples of Research Briefs provided to the EAG (Volume 1, Section 2c, Attachment B of *Superfund Basic Research Program: A Legacy in Multidisciplinary Research*), and a cursory sampling of other Research Briefs on the SBRP website, do not appear to offer clear evidence of multidisciplinary intra-, inter- and external technology transfer activities. Most of the sampled Research Briefs describe specific research outputs of individual investigators or research teams localized to a single laboratory. Thus, although they highlight important science, the sampled Research Briefs leave an impression that multidisciplinary coordination/collaboration between research teams is not being effectively addressed or accomplished. Another concern is that the NIEHS does not provide any centralized peer-review oversight of the Research Briefs'

content. Although all of the science presented in the Research Briefs has been published in the peer-reviewed literature, individual Research Briefs are prepared by SBRP staff in concert with the investigators and are widely distributed to diverse audiences. Given the approach to preparation of the Research Briefs, NIEHS may wish to be cautious about inferring their endorsement of the content of any Research Brief.

3. SBRP-sponsored meetings
   The SBRP Annual Meetings are designed to stimulate interactions among the grantee institutions and external stakeholders. Annual meetings appear to create valuable opportunities for information sharing among SBRP investigators and external stakeholders. Importantly, the theme of the 2002 Annual Meeting focused on technology transfer, and contained presentations illustrating useful SBRP examples of translating fundamental research into practical applications addressing issues associated with Superfund sites. Between 1995 and 2000, SBRP grantees and the SBRP sponsored or co-sponsored 68 meetings and workshops focusing on areas of programmatic interests. Participants in these meetings generally have been SBRP investigators, EPA and ATSDR colleagues, students, the academic community, and interested parties from co-sponsoring agencies.
4. Risk-e-Learning web seminar series
   Live, two-hour events hosted on the Hazardous Waste Clean-Up Information (CLU-IN) website (http://clu-in.org) are conducted in collaboration with the EPA Technology Innovation Program. The target audiences for this interactive seminar format are EPA risk assessors and regional project managers, state and local regulatory agencies, environmental engineering/consulting firms, and academia.
5. Distinguished Lecturer seminar series
   This series was developed primarily as an enrichment program for NIEHS staff. The SBRP encourages students and scientists of all disciplines within NIEHS to attend the seminars and meet with the lecturers; however, members of the local scientific community are also invited.
6. SBRP partnership efforts
   Activities are aimed at 1) increasing information transfer to federal and state agencies with mandated responsibilities for Superfund site oversight, and 2) addressing the recommendations put forward by the 1998 ReNEW Workgroup. SBRP administrators state that their outreach projects include "collaborative partnerships between environmental researchers and a number of other parties actively involved with hazardous waste issues including government agencies, community groups, journalists, and industry."

Overall, these NIEHS-centralized resources appear to provide an important foundation from which to identify and implement opportunities for facilitating and tracking the efficacy of technology transfer within, across, and outside of institutional SBRP grantees.

EAG Recommendations on SBRP Communication and Partnership Activities

- Additional analyses of publication authorship, as available through the SBRP website, might be used to provide further tracking evidence of the effectiveness of intra-, inter- and external collaborations and technology transfer among SBRP researchers. Thus, multidisciplinary research should be evidenced in part by publication authorship and acknowledgements that reflect participation of multiple laboratories, and/or by evidence of SBRP publication citation of other SBRP- generated technology.
- For the purpose of encouraging effectiveness and ease of technology transfer, additional elements or restructuring to the SBRP website should be considered. Because the current website is constructed to visualize and focus on the activities of the individual SBRP-funded programs, it does not provide a particularly useful centralized resource to visualize and capture the overall science and technology output and value of the SBRP. Some additional options that should be considered for the website are best represented by how the materials were organized in the three-volume set of review materials provided by NIEHS for the EAG (Volumes 1-3, *Superfund Basic Research Program: A Legacy in Multidisciplinary Research*).
- The current website does not readily allow for integrated analyses of program-wide information in that it is mostly focused on individual programs. For the purpose of encouraging and facilitating technology transfer, a website record of SBRP-funded program projects, publications and other science products could also be organized by patents issued or pending, non-patented applications, small business startups and SBIR grants (e.g., as outlined in Volume 1, Section 1b, Attachment C of *Superfund Basic Research Program: A Legacy in Multidisciplinary Research*).

- The current SBRP website is grantee-oriented. To further visualize both the breadth and focus of science of being produced by the SBRP, a re-organization of the site by major topic areas, as outlined in the information in Volume 2 of *Superfund Basic Research Program: A Legacy in Multidisciplinary Research*, could be extremely valuable.
- Because some industry sectors or businesses may have a large stake in the science used to address health and environmental issues associated with Superfund sites, efforts to increase the distribution of the Research Briefs to these audiences should be considered.
- NIEHS should consider using the Research Briefs to effectively illustrate science/technology transfers between investigators within, across or external to their funded institution.
- Consider making the Distinguished Lecturer series available more broadly through electronic communication technology.
- SBRP staff should continue to improve upon communication with EPA regions when the research involves investigations and applied technology at specific Superfund sites. A directory of research scientists and their areas of expertise, including those beyond the SBRP, will help the EPA and the NIEHS to improve the cross-cutting, interdisciplinary nature of this research Program.

4C. Use of Metrics

Quality

Present SBRP-funded programs use a variety of metrics to evaluate success. Most often, these metrics are basic numbers that calculate total publications, patents, and student graduates. This is a traditional approach. However, few programs provide a detailed accounting of qualitative information such as publication impact, graduate student success or career relevance, and technology transfer. It is noteworthy that approaches to collecting these, or other, measures are not yet developed.

Relevance

Metrics are also needed to provide credibility of the SBRP to those in government who are responsible for its continued funding; to academics, especially to those outside of the environmental and public health arenas so as to encourage them to enter this important field of research; and to the general public, who must eventually provide the last word for the evaluation of the Program.

To ensure the growth of high-quality programs, clearly defined program assessment plans including metrics need to be incorporated into SBRP planning activities. A key purpose of the SBRP is to build understanding of potential risks associated with chemical exposures from Superfund sites. Since many of these exposures may be at low-levels, it would be useful if metric tools were developed to assess and track laboratory experimental dosages conducted by SBRP-funded investigators and compare them to known or anticipated exposures associated with actual sites.

Performance

SBRP staff have done an excellent job of compiling large quantities of information for review purposes, given that the collection and reporting of all relevant metrics have not been required from SBRP-funded programs. Publications to date have been enumerated, as well as a number of graduate students and relevant field projects. These are appropriate metrics being applied to evaluate program impact.

EAG Recommendations on the SBRP's Use of Metrics

- Quality of SBRP-funded programs should be more clearly defined through additional benchmarking, using a variety of metrics. Numbers of publications should be used, but other criteria should also be considered (quality of publications, citation indices, technology transfer success, etc.). Although information about project success has been collected, a more integrated strategy and clear plan for metrics identification, collection and evaluation should be documented for future use.
- One metric of impact on public health is the documentation of altered behavior. SBRP staff should examine ways to do this at the risk assessor, remediation manager, public health official and general public levels.
- Further metric(s) reflecting synergy, education and training, and outreach should be developed.

PART TWO
FUTURE DIRECTIONS

1. EAG Review Process

Part Two of the EAG report focuses on the future of the SBRP, offering observations on future directions for the Program.

For the second set of review discussions, the EAG divided into two Subcommittees, Science at the Interfaces and Science Tools and Approaches. The Science Tools and Approaches Subcommittee focused on identifying those cutting-edge science tools and approaches that offer the most potential for public health protection, as well as new scientific developments and environmental issues dawning on the horizon. The Science at the Interfaces Subcommittee focused on the inclusion of essential academic disciplines and expertise as new collaborators in SBRP-funded research. Subcommittee membership was as follows:

Science at the Interfaces Subcommittee

Chair Members: Michael Gallo
Yolanda Banks Anderson
Katherine Banks
Catherine Burroughs
Jim Bus
Ernest Hodgson
Carol Henry

Science Tools and Approaches Subcommittee

Chair Members: William Glaze
Henry Anderson
Darrin Curtis
Chris DeRosa
Joan Flocks
Cornell Long
Jayne Michaud

2. Introduction and Overview

Over the past 16 years, the NIEHS Superfund Basic Research Program has established a remarkable record of research and outreach through its support of over 60 programs (encompassing over 420 individual research projects). The Program review in Part One of this report is extremely positive, recognizing the many accomplishments of the individual program projects and their combined impact. Part Two offers observations on how the Program can benefit by 1) reviewing new and competing proposals based on their promise and/or demonstrated capability to better utilize existing and emerging cutting-edge science tools and approaches; and 2) encouraging innovative, cross-cutting, systems-level research that goes beyond the approaches used by most of the programs in the past. The EAG did not consider the resource issues generated by observations and recommendations within this section.

As a result of this review process, the EAG believes that the SBRP is an active, vibrant and relevant program. However, the EAG has identified specific, significant changes that could be made that would lead to a stronger Program with enhanced potential to improve risk assessment strategies and decision-making processes. There are several new or impending tools and approaches that could reduce uncertainty and enhance remediation cost-effectiveness.

In the following sections, the External Advisory Group makes some observations on particular research areas where its members see the opportunity for innovative research that will be relevant to the SBRP mission. Many of these recommendations are natural extensions of current efforts; however, other recommendations suggest new directions for the Program. The list of observations and opportunities for the future is by no means comprehensive nor can it be, given the pace of innovation in contemporary science.

The EAG recognizes that the NIEHS does not direct the research envisioned and that the Program will consist of funded grant applications, approved on the basis of scientific quality. That being the case, guidance into needed directions can only be achieved by very carefully crafted RFAs that both peer-review panels and applicants need to take seriously.

3. Science Tools, Disciplines and Approaches

3A. Risk Analysis

Observations

Human health risk assessments and ecological risk assessments result from different processes and frequently produce quite different results that give rise to diametrically opposed recommendations. For example, a human health risk assessment could give rise to the conclusion that chemical X represented no serious threat to human health and therefore no stringent control measures are necessary. At the same time, an ecological risk assessment might conclude that chemical X represented a serious threat to the ecosystem and that stringent and immediate control measures are essential. In part, this is because human health risk assessment deals with individuals or human populations, while environmental risk assessment deals with entire ecosystems. In each case, there are difficult extrapolations to be made and recourse is made to "uncertainty factors" given ill-defined values. Recently, there has been a movement toward integration of the two types of risk assessment and an increase in confidence in the results, although much remains to be done.

Opportunities for the Future

- Since the study of Superfund sites and their remediation always requires both types of risk assessments, the trend toward integration must be encouraged. In the past, the SBRP has supported some crossover research in which human biomarkers are used to detect exposure in wildlife. This approach should be enhanced and built upon in the future. Accordingly, RFAs should be written to encourage the development of scientific approaches and methods that will advance the integration of human and ecological risk assessment.

3B. Site Characterization

Observations

The scientific methods for characterization of environmental systems are rapidly developing, taking advantage of new developments in analytical chemistry, micro- and even nano-scale sensors, applications of genomics and other new biological information, and new informatics methods that allow data to be accumulated in larger and larger amounts on shorter time scales and from the molecular to regional system level. Attention is focused especially on the development of sensors with greater specificity, including those that may be small enough to be non-invasive, are able to rove through a large geographical area, and are able to collect large amounts of information that can be transmitted to receivers where it may be analyzed on a real-time basis.

Opportunities for the Future

- It is appropriate for more SBRP-funded programs to utilize these advanced methods and for some to lead in their development. Sensor development and deployment within the SBRP could expand the capability for site characterization – broadly defined – and provide more information that relates to function and potential dysfunction of an organism or system, e.g. response to specific toxicants.[2]
- Site characterizations should be improved to obtain more detailed information on the total environment of a contaminated site, utilizing a dynamic systems approach. The purpose should be to understand as much as possible about the site in its present condition, and if possible before the effects of the contamination, and to be able to predict the status of the site in the future. While specific parts of the system – soils and groundwater, air emissions, biota, humans, etc. – must be dealt with individually, more emphasis needs to be directed toward the integration of this information and toward a better understanding of the total system at scales ranging from the molecular to that of the total site and its environs.
- Particular attention needs to be given to characterization of the effects of the contamination on biological communities, including humans, focusing not only on the chemical contaminants that may have entered these systems but also on the changes in community structure that may have occurred as a result of contamination or habitat changes. For humans, this should include information on apparent exposure groups and improved quantitative estimates of exposures over time, effects on health broadly defined, as well as mental, social and behavioral patterns.

[2] Websites of academic research programs in sensor development include: University of Wisconsin Center for Limnology www.mscmc.org/Docs/Slides/020114/Krantz.pdf ; LTER Network / San Diego Supercomputer Center http://lternet.edu/technology/sensors/ ; Microbial Oceanography at MBARIC http://www.mbari.org/microbial/ESP/ ; Cornell Nanobiotechnology Center http://www.nbtc.cornell.edu/researchareas1.htm.

3C. Environmental Informatics

Observations

The development of methods such as those described above has the potential to generate large amounts of data. While this is precisely what an investigator likes to see, it can be a challenge to make the data useful to investigators, especially in a multidisciplinary project. It is true that "High-throughput technologies have placed new demands on data storage, data management and the scale of simulation modeling required to develop computational models."[3] Concerns over systematic and random errors, and sensor malfunction are important, but no less so than conquering the problem involved in the mining of the all of the information in a large data set.

Opportunities for the Future

- The SBRP has historically supported the use of innovative approaches and advanced technologies. The Program should expand its support of research that proposes to utilize new analysis and visualization methods to interpret environmental information, and provide insight into the processes that influence the observed patterns. This can apply to molecular scale information obtained from gene microarrays to regional scale information obtained from consortia of sensors, including satellite and smaller-scale observation platforms. However, these tools will make communication with the public, increasingly important within the Superfund program, more difficult when databases are complex. This will require new approaches to abstract massive amounts of data into a form more understandable to the affected public.[4]
- All of these approaches are appropriate for SBRP-funded programs and offer the opportunity for some program proposals to include mathematicians and modelers to a great advantage. These approaches are justified because of the new information and tools that are now emerging and becoming available to environmental health investigators, brought on by dramatic advances in the biosciences and informatics, to name only two of the rapidly changing fields of science. In addition, there is growing consensus that it is time for environmental research to deal with the complexity of biological systems, rather than taking a more reductionist approach.

3D. Environmental Processes

Observations

Environmental science has increasingly progressed from a descriptive to a mechanistically-based science. For SBRP-funded programs, which address complex biogeochemical systems including human populations, the challenge of understanding the systems at this level is daunting but, nonetheless, necessary. As in the areas already discussed, the accumulated body of knowledge and the new scientific tools available make it possible for more to be accomplished at the mechanistic level than ever before. SBRP-funded research should focus on mechanistically-based science in its support of environmental studies, to the same extent as it has in health studies.

Opportunities for the Future

- Mechanistic studies of environmental processes in the past have too often focused only on either biological systems to the exclusion of chemical-physical processes, or vice versa. SBRP-funded programs should lead in the integration of these studies[5], especially in the study of complex systems where human health issues are linked to occurrence, transport, and transformations of chemical substances. As noted in more detail below, these studies must increasingly deal with variations and interconnectivities within the system, and to issues such as the complex mixtures of substances in heterogeneous environments and how their physical-chemical properties determine human exposures. Thus, multi-dimensional models are needed that describe these substances from source to receptors, and within receptors through complex pathways to the incipience of dysfunction or disease.
- Additional, integrated studies imply more detailed data sets and more sophisticated methods for their interpretation, and more elegant mathematical methods for their modeling. Indeed, the entire area of computational biology and computational toxicology are important potential growth areas for the SBRP. A common interest in relational databases as a result of such sophisticated treatment should foster future symposia, workshops, and study groups across programs within SBRP, across NIEHS, and, in fact, across the sciences.

3 CIIT, Center for Health Research, Jan-March 2003.

4 For a program of interest, see the website for The Social and Ethical Reporting Clearingho"se of the Center for Environmental Informatics, The University of Sund"rland: http://cei.sunderland.ac.uk/core.htm.

5 As an example, Morel, F. and N. Price, Science, 300, 94"-947 (2003).

3E. Human Health Effects

Observations

It is generally conceded that the investigation of the effects of environmental stressors on humans and other organisms is in the process of a remarkable revolution, based on the availability of information from the expanding field of functional genomics. Omics (i.e. genomics, proteomics and metabonomics) are sure to have a dramatic effect on the power of epidemiological studies of human disease, including diseases relevant to Superfund sites.

New methods are evolving to better determine the genetic diversity in populations of humans and other species and their individual responses to stressors such as environmental toxicants and other changes in their environments. For example, the understanding of the structure and function of microbial communities is now being pushed forward by new techniques referred to as metagenomics: the analysis of the collective genomes of the microorganisms, e.g. in a soil or water community. Analysis of genetic variants of individuals and communities of humans and other species is also proceeding rapidly and promises to provide important information on the individual differences to toxic threats and susceptibility to disease or dysfunction.[6]

The use of this information to design new population studies that will yield a better understanding of these stressors is an important emerging area that is appropriate for SBRP funded-programs. Indeed, biomarkers of susceptibility is illustrative of a larger set of methods based on functional genomics that are evolving that will have a large impact on environmental science and public health assessments. Linking mechanistic and genetic profile studies with epidemiological studies should continue as a priority for the SBRP, provided there is demonstrated cooperation of the research groups that are necessary for this task.

It is important to note here that many have pointed out that the study of human susceptibility to disease utilizing an individual's genetic information is fraught with significant ethical issues, and care must be taken to carefully consider these issues in advance of the studies. This certainly has relevance to SBRP-funded programs, and may also represent an opportunity for some creative programs to conduct useful research or demonstrations of how to avoid these problems.

While most of the new research needed for the study of the human health effects of chemicals found in Superfund sites is an extension of earlier studies, new techniques and new knowledge present new and exciting opportunities. Furthermore, these advances will allow studies directly on human material rather than experimental animals, although the latter will still be essential.

Some of the aspects of human health studies that will utilize the new techniques of genomics, proteomics and metabonomics, combined with the information available from the human genome project and the availability of human recombinant enzymes, human cell fractions and human cell lines include the following:

a. Polymorphisms

The presence of genetic polymorphisms in human populations may be an important determinant of adverse health outcomes. Important research aspects for humans are the identification of individuals or sub-groups at increased risk and evaluation of variation with the population under study. The polymorphisms under study can be in xenobiotic-metabolizing enzymes, in enzymes involved in modes of toxic action, etc. High throughput techniques will be essential. In addition, the potential implications of polymorphisms on health outcomes can be further explored through the use of genetically modified animal and other test systems (e.g., transgenics, gene knockouts, etc.) created as equivalent models of specific human polymorphisms.

b. Human Metabolism of Superfund Chemicals

Knowledge of the human metabolism of actual Superfund chemicals is essential for the study of polymorphisms since the base sequences of the gene coding for the enzymes are needed to design primers for the study of the polymorphisms in question.

c. Effect of Superfund Chemicals and Mixtures on Gene Expression

The new micro-array techniques will be invaluable in this regard and the effect on hundreds, if not thousands, of genes can be estimated in single experiments. It should be emphasized that this is still a relatively blunt tool; knowing that

6 Metagenomics: University of Wisconsin Plant Pathology, http://www.plantpath.wisc.edu/fac/joh-m2.htm.

100 genes are over-expressed and a different 100 are under-expressed as a result of a particular chemical treatment does not help with identification of their specific roles in the mode of toxic action. Specialized micro-arrays could be used in different areas such as metabolism, various modes of toxic action, etc., to help solve this problem or at least better focus the research. Given the levels of chemicals exposures originating from Superfund sites, emphasis must be directed at understanding how such array experiments can identify adverse, as compared to homeostatic, responses.

d. Organ-based Approaches to Toxic Effects

Out of necessity, whole animal and organ-based toxicity testing will continue to be done with experimental animals, although continuing refinements in epidemiologic methods will be essential to addressing these critical health endpoints. However, both animal and epidemiological studies will be accelerated and improved by the use of the molecular tools outlined above.

e. Epidemiology Studies

The experience to date with epidemiology studies conducted by SBRP-funded programs demonstrates significant scientific contributions; however, they have mostly used traditional designs and methodologies of exposure assessment and disease outcomes. Future SBRP programs should be uniquely organized to integrate cutting-edge omics and bioinformatics into rigorous human epidemiology.

Omics findings from experimental animal studies provide valuable opportunities to be incorporated into new and improved methods that further refine health assessments developed from traditional epidemiology studies. Given the availability of critical expertise within SBRP-funded programs, they should also be able to address the social and ethical issues inherent in the application of the *omics* in their studies and incorporate evaluations into their designs.

Opportunities for the Future

While the promise of these new methods and techniques has direct relevance to the future of the SBRP and the EPA Superfund Program, it also raises some important questions about the balance of human health effects research within the SBRP versus the other aspects of the Program. Because the study of each compound for a single endpoint (such as cancer) can be a complex, lengthy process, a significant amount of SBRP resources could be spent on such studies. Still, the payoff for studies in this area could be huge compared to other aspects of the SBRP portfolio of research, and these studies must be encouraged.

- More studies are needed that use the omics to inform the mode of action, pharmacokinetic models for tissue dosimetry, and pharmacodynamic dose-response models of chemicals that are important at Superfund sites. Perhaps one criterion for funding of these studies should be the promise of new information that is likely to provide a breakthrough in the assessment of the effects of a particular compound. In particular, the advent of omics technologies allows such assessments to be explored at exposure-dose levels representative of real-world conditions found at Superfund sites.
- It is very important that the SBRP be focused on the prime objectives of the Program and that encouragement be given to studies of Superfund chemicals rather than "model" compounds and to studies of humans rather than experimental animals when such studies are equivalent and ethical. As a complement to human research, animal studies should be designed to emphasize the types and levels of exposures representative of Superfund sites.
- The assessment of the implications of genomic variability on susceptibility of individuals and populations to potential environmental toxicants can and should be linked to laboratory-based whole animal and in vitro approaches. For example, the advent of transgenic and other genetically altered animal and cell models affords opportunities to explore the toxicological sensitivity to low-dose exposures in genetically-modified test systems created to parallel known human susceptibility elements.

3F. Ecological Effects

Observations

In principle, almost everything said in the previous section on Human Health Effects is relevant to the study of ecological effects. The study of the effects of stressors such as chemicals or radiation on species other than humans, or on ecosystems as a whole, is also undergoing a remarkable change as the tools of the *omics*, new sensor technologies, and informatics are

turned toward this purpose. On the other hand, the number of species involved and their interdependencies increases the level of the research challenge, complexity and resources needed.

Opportunities for the Future

- Creative approaches that will integrate these new methods with traditional ecological assessment methods should be encouraged in future SBRP solicitations, particularly to demonstrate the combined human and ecological effects of chemicals. Ideally, these studies should yield a better understanding of the effects of these stressors as they actually occur in the environment and specifically at Superfund sites, not just as isolated compounds in cell cultures with individual organisms, although such studies are important. Again, creative approaches are needed that use new methods to obtain multidimensional models of these systems that approach reality.
- Given the broad public health and environmental mandate of the SBRP, it seems particularly appropriate for some SBRP-funded programs to address the connectivity between human health and ecological condition.[7] At both the theoretical and empirical levels, these studies could provide a more informed understanding of this relationship, and in the process provide practical guidelines for Superfund managers who must often attempt to balance human health and ecological risks.

3G. Remediation and Risk Management

Observations

Breakthroughs are needed in the approach used to cleanup Superfund sites. Present approaches continue to use methods that either work well only for a few substances at a time, brute force techniques such as incineration or land-filling, or default methods such as capping. Few new methods have been developed that remove the source of the problem economically without potential environmental impacts. Among the methods that have been suggested recently, bioremediation and phytoremediation processes seem to hold great promise.

Related to remediation is the question of "How clean is clean?" Given what was stated above regarding the potential benefit of the new omics, it is possible that we are now approaching a time when decisions about "How clean is clean?" can be made in a more informed way.

Opportunities for the Future

- Future SBRP-sponsored studies should continue to investigate innovative remediation approaches, but the requirements for the sophistication of the science need to be increased. Thus, areas such as microbiological remediation should be advanced through cooperative efforts with basic scientists in molecular and cell biology and others in the fields of transport, bioavailability and multidimensional modeling.
- Studies within SBRP-funded programs that would use new approaches to examine remediation and risk management would be welcomed; for example, through creative theoretical approaches based on computational and statistically-based biological models.

3H. Community-Based Participatory Research

Observations

It is well known that the Superfund cleanup Program must involve communities located near to the sites if the program is to be successful. Further research is needed to examine how this process can be more effective, especially in view of the emerging information that is being generated from the research community.[8] This information is important to communities to show how science is informing the process, particularly if it has direct relevance to the interests and needs of the community or parts of it.

Exposed and affected communities often have different agendas than academic researchers, and researchers are often hesitant to involve communities for fear of conflict. However, social and behavioral scientists – including some funded by the NIEHS – have been successful in developing participatory research methods consistent with the Community-Based

7 Kitano, H. *Nature* 420, 206-10 (2000).

8 Linkages of the SBRP Centers to established community-based research programs such as those sponsored by the NIEHS Community-Based Participatory Research in Environmental Health would seem to be advisable. See *Environmental Health Perspectives Supplements*, 110, Number 2, 139-140 (2002).

Participatory Research Model developed by the NIEHS. These methods reduce the potential for academic/community conflict, while maximizing the benefits of environmental health research for all stakeholders.[9] Current environmental health projects involving human populations are already studying ethical issues that arise from this type of research and some have included bioethicists in their research agenda. Some of these issues include re-examining informed consent, confidentiality, data ownership, data access, and the potential use (or misuse) of information.

Opportunities for the Future

- Exposure studies – including their spatial and time variability – should be related to specific community groups who may be especially affected, such as the aged, children, and minorities or low-income populations.
- Research is needed to show how this information is best transmitted to and interpreted for the community, and how it affects their attitudes and actions. Research can also inform how the community might be restructured after remediation is complete, i.e. how it can be made more healthy and sustainable through community empowerment or land use adjustments. Additional links with the EPA's HSRC Technical Services to Communities (TOSC) program may be useful for SBRP-funded programs and affected communities.

3I. Approaches to Achieve Synergy

Observations and Opportunities for the Future

a. Achieving Greater Integration

While an assortment of themes and foci for individual SBRP-funded programs have been presented, they vary in their degree of integration. One suggested mechanism to further the synergistic goals of the SBRP could be to more fully develop interdisciplinary approaches to the study of Superfund events, sites, and chemicals. This concept, as compared to multidisciplinary approaches to the same studies, requires a closer relationship between the parties, including joint research discussions, training exercises, and enrichment experiences.

Participants in interdisciplinary programs are versed in the studies "of the whole," and seek to further their work by understanding and implementing the results of others in their revised research agendas. Biomedical and non-biomedical alike should be operating in a mode of a consolidated whole. Multidisciplinary work, on the other hand, may be a group of investigators who each collect and analyze their own data, give little credence to results of others, and do not develop a sense of the systemic whole of the program. Especially with respect to training aspects, graduate students and postdoctoral associates should interface with investigators in different disciplines to provide them with opportunities to expand their critical evaluation and appreciation of interdisciplinary research and outreach.

Scientists working in the complex, interdisciplinary, and still-developing field of environmental program evaluation would seem to have relevant contributions to SBRP goals. Evaluators require knowledge and skills drawn from a range of disciplines, including computer science, statistics, measurement theory, psychology, sociology and anthropology. There are many ways to apply evaluation principles and methodologies, ranging from the identification of collaborative research goals and outcomes, to making environmental research policy decisions, or identifying and communicating the multiplicity of possible issues and questions within and between SBRP programs. Thus, incorporating an evaluation framework within the multidisciplinary approach of the SBRP will contribute tools for management and policy decisions; help to identify the research questions and data that are important to intended outcomes; and build a body of knowledge that can be applied to other Superfund sites and communities.

b. Enhancing Inter-program Collaboration

A further aspect of interdisciplinary research involves the shared expertise with the entire SBRP community. Mechanisms should be developed to foster the sharing of resources, expertise, and training and research programs. Impediments to inter-program collaboration include:

- funding and allocation of Facilities and Administrative (F&A) costs;
- lack of unique funding mechanisms that promote inter-program collaborations; and
- lack of information exchange to present opportunities for collaboration.

9 O'Fallon L.R. and A. Dearry. Community-Based Participatory Research as a Tool to Advance Environmental Health Sciences. *Environmental Health Perspectives Supplements*, 110, Number 2, 155-159 (2002).

The F&A cost discussion is a purely logistical one, and impediments could be eliminated through a number of mechanisms. On an institutional administrative level, the F&A costs support the research administration and there is a hesitancy, rightly so, to allocate those resources elsewhere. While this may be fiscally sound, it impedes collaboration between programs.

One useful alternative that benefits all parties is to establish an "inter-program" project line item, administered by the Administrative Core of each SBRP-funded program. A fixed amount – the EAG suggests $50,000 plus the associated F&A – would be allocated annually for inter-program studies, along with a described mechanism for allocation and administration. Each SBRP program would fund their respective investigator(s) to carry out research in collaboration with an investigator from another SBRP program. Review and allocation of resources could be done as part of a pilot project program, and require funding at both SBRP programs to be successful. A second, but less likely, scenario would be for the two SBRP programs to waive the F&A and proceed to fund only direct costs outside of the SBRP program funding the collaboration.

Regardless of the funding mechanism, the ideas would come from the SBRP-funded program scientists who meet on an annual basis to discuss their work. This very useful interchange should be continued and its prominence highlighted to foster inter-SBRP interactions.

At the SBRP level, a scientific and logistical interchange amongst directors would foster approaches that are inter-SBRP programmatic. Some mechanism outside of the SBRP Annual Meeting needs to be developed whereby brainstorming amongst program directors can take place, agendas can be developed which provide the intellectual future of the Program, and where the directors can seek ways to optimize limited resources. An annual two-day retreat might suffice, given that the directors would come prepared with cutting-edge ideas, compelling arguments for specific research agendas, and an idea on how their expertise might be used synergistically with their colleagues' expertise to take the Program to the next level of sophistication.

Mechanisms for funding special initiatives or collaborations outside of the traditional SBRP must be developed. As an example in addition to those already given, one could use the SBRP-funded program directors as a group to review and advise on funding special requests for inter-SBRP initiatives using monies held by SBRP staff. This would require an altruistic attitude on the part of the program directors, but with time could build a consensus of operation, themes, mechanism, and community.

c. Encouraging Integration of Additional Academic Disciplines

The special initiatives approach could also be used to begin to develop synergistic relationships between current SBRP-funded investigators/programs and, to date, non-traditional participants. Examples of relevant disciplines might be sociology, economics, ethnology, anthropology, psychology/behavioral medicine, and bioethics and philosophy. A useful mechanism for initiating such interactions could be at the request of SBRP staff or as a result of SBRP-funded program director deliberations.

For example, the inclusion of sociologists could allow SBRP-funded programs to define the risk assessment so that the affected public can better understand the scientific issue and participate in the site decision-making. Inclusion of economists might provide insight into the most cost-effective method of site cleanup. Finally, collaboration between psychologists/behavioral medicine experts and SBRP program experts could result in the development of mechanisms and methods by which Superfund health effects could be reduced; these health effects are of two types: the direct contribution of altered behavior on exposure and the emotional issues associated with proximity to a contaminated site.

4. Conclusion

The SBRP has a unique opportunity to greatly enhance the research enterprise. A structure is already in place within the SBRP to allow for multi- and inter-disciplinary research. By taking advantage of the new *omics* technologies and advanced sensor and visualization tools, in combination with advanced computational and bioinformatic approaches within this structural framework, a new generation of research questions can be addressed that integrates the spectrum of scientific disciplines and scientific enquiry needed to improve public health and the environment.

Appendix 1:

SBRP-Funded Outreach Projects Chart

Note from the EAG: The SBRP does not seem to offer explicit outreach goals or criteria that define what is expected by Outreach Cores. The below chart categorizes the "Specific Outreach Activities" listed by each project (in Volume 2 of the EAG briefing materials) under what seem to be the implied outreach goals. Each goal is more specifically defined by "Desired Results" which are implied from Outreach Core focus statements (since, again, "Desired Results" are not explicitly stated in the EAG briefing materials).

Outreach Goal

I. Research Dissemination

Desired Results

To exchange information, facilitate coordination of research and to foster future research collaborations

Strategies & Scope of Reach	Audience	Significant Publications	Grantee	Total FTE Outreach	Years of Effort	Other Support
1. Conference (international) 2. Seminar series (university & local) 3. Luncheon talks (university & local) 4. Training class on GIS (university) 5. Training class on Risk Assessment (university)	Educators, students, research scientists, government staff and officials, international agencies, private companies, public non-profit organizations, and community groups		Columbia University	60%		
1. Visiting Scholars: • New degree programs • Work with World Bank • Create environmental health curricula for nursing programs • Establish lead abatement training center at college 2. Seminars with Dartmouth and Boston University SBRP sites	Academia, corporations, non-profit organizations, state and federal government agencies	Visiting Scholars Annual Report	Harvard	145%	8	
Collaboration of SBRP research between the University of Cincinnati and Central State University	Krisnakumar Nedumuri's laboratory at Central State University		University of Cincinnati	50%	12	
International conference	Researchers, scientists, educators	Book on PCBs	University of Kentucky	10%		
Disseminate the results of SBRP research to the professional community	Other SBRP grantees and researchers	Newsletter, articles	University of North Carolina – Chapel Hill	90%		
Scientific meeting –2.5 day conference on arsenic	Scientists, students, resource managers, policymakers, health professionals		Dartmouth	165%		

Outreach Goal

II. Research Translation – Translate research for practical use and application

Desired Results

Increased awareness and understanding regarding environmental health issues by professional and public stakeholders

Strategies & Scope of Reach	Audience	Significant Publications	Grantee	Total FTE Outreach	Years of Effort	Other Support
Interactive website with comprehensive information on metal toxicology	Teachers, the public, journalists, and students	Brochure, poster	Dartmouth	165%	2	
Seminars at EPA Region Offices	Risk assessors, project managers, and the State Department of Health		Harvard Dartmouth Boston University			
Website linking: 1. Fact sheets 2. Presentations 3. Glossaries	Community assistance leaders, outreach assistance leaders, and citizen leaders	Envirotools website	Michigan State University	100%	8	Looks like the website draws from the EPA's HSRC, TOSC, and TAB programs
1. "Direct Outreach Materials" 2. On-site presence at fishing locations, community events 3. Environmental health training lab 4. In-class presentations	Urban fisherman/women, students, teachers, and urban community members	Journal article, brochure, website, informational flyers, press releases, and questionnaires geared toward educating Hudson River communities about health effects related to their environment	Mount Sinai School of Medicine	105%	1	

II. Research Translation – continued on next page

II. Research Translation – continued from previous page

Strategies & Scope of Reach	Audience	Significant Publications	Grantee	Total FTE Outreach	Years of Effort	Other Support
1. Write and translate undergraduate-level instructional materials on basic environmental toxicology, risk assessment, and remediation on the Internet in Spanish 2. Write a workbook on environmental toxicology in Spanish 3. Co-sponsor binational scientific meetings with Mexican Toxicologists 4. Establish a combined instruction and research program in Toxicology and Environmental Engineering for Mexican university faculty who teach in the environmental sciences	1. U.S. and Mexican graduate students 2. Local interest groups 3. State environmental agencies 4. Professional engineers, public health workers, and governmental officials	Toxicologica Ambiental (Spanish textbook on toxicology)	University of Arizona	50%	10	
To disseminate information and facilitate interaction with regional environmental professionals by the maintenance and expansion of the University of Cincinnati SBRP homepage, and by the use of an advisory board of regional professionals	Local and regional environmental health officials		University of Cincinnati	50%	12	
1. Increase the awareness of school children on how their everyday actions affect the environment via interactive exhibits 2. Increase public understanding of human health concerns related to waste sites via public forums, newspaper, flyers, and postcards	1. School children & teachers 2. Community members	Newspaper	University of Kentucky			
1. Provide technical assistance and education to communities facing problems with hazardous wastes 2. Increase public awareness of SBRP research and outreach	1. North Carolina community and environmental organizations 2. General public	Fact sheet, newsletter, website, brochure	University of North Carolina – Chapel Hill	90%	3	

Strategies & Scope of Reach	Audience	Significant Publications	Grantee	Total FTE Outreach	Years of Effort	Other Support
1. Increase public awareness of health disparity issues via participation in the Health Justice Network 2. Assess environmental health needs of refugee and immigrant communities 3. Raise awareness of environmental health issues in youth via videoconferences, web-based modules and on-line chats and in-class presenters 4. Increase public understanding of environmental health concerns at contaminated sites via educational presentations and language-appropriate publications	1. Community members 2. Refugee and immigrant communities in King County 3. K-12 students 4. Residents near the Everett Smelter and the Lower Duwamish Waterway		University of Washington	60%	3	Environmental Health and Safety (EHS) COEP EHS ATSDR/Association of Occupational and Environmental Clinics (AOEC)
Professional photos of workplace and the environment	Public	Photographic exhibit	Harvard	145%	7	NIEHS Centers Program

Outreach Goal

III. Build collaborative network of university and community-based partners

Desired Results

Understanding how problems of environment and development interrelate across local, regional and global scales via multidisciplinary research and service learning

Strategies & Scope of Reach	Audience	Significant Publications	Grantee	Total FTE Outreach	Years of Effort	Other Support
Regional Workbench Consortium, a web-based portal and site with planning and decision support tools	Researchers, planners, policymakers and decision-makers, and the general public	Brochure, report, conference paper	University of California – San Diego	65%	3	Totally funded by SBRP?
Consortium Development (state, university)	Resource managers, policy-makers, scientists, and public health workers	Brochure, bi-monthly meetings, scientific conference	Dartmouth	165%	2	

Outreach Goal

IV. Data integration and sharing using information technology/ data management

Desired Results

Increased knowledge of public health workforce and Community-Based Organizations (CBOs) regarding toxicological data of Superfund and Toxic Release Inventory (TRI) sites

Strategies & Scope of Reach	Audience	Significant Publications	Grantee	Total FTE Outreach	Years of Effort	Other Support
GIS spatial analysis	State, county health departments, and CBOs		Duke University	80%	1	
Creation of a web-based Geographic Information System (GIS) useful for linking Superfund-related science to water quality and public health issues in the larger San Diego-Tijuana bi-national border region; also, Quality of Life Indicators, and on-line interactive mapping	Researchers, planners, policy-makers and decision-makers, general public		University of California – San Diego	65%	3	Regional Workbench Consortium—university and community-based partners

Outreach Goal

V. Classroom-based curriculum enrichment in environmental health

Desired Results

Increase science literacy and interest in environmental health careers

Strategies & Scope of Reach	Audience	Significant Publications	Grantee	Total FTE Outreach	Years of Effort	Other Support
GIS spatial analysis	High school students and teachers	Lead Mapping Program for high schools	Harvard	145%	7	NIEHS Centers Program
1. Museum displays (to tour the U.S.) 2. Classroom presentations	Teachers and grades 7-12	Website	Texas A&M University	30%	3	National Science Foundation (NSF)
1. Provide mentoring and training to students in experimental research design and methods via SBRP Internships; science fairs 2. Develop environmental science curriculum via teacher training in series of workshop meetings	Disadvantaged high school students, teachers		University of California – San Diego	65%	3	
Work with educators to provide environmental health sciences- based training programs and create supporting materials	Educators		University of Cincinnati	50%	12	
Collaborating with teachers and science museum educators to develop effective methods for teaching middle school environmental science via curriculum modules, summer workshop and lab camp and classroom participation of Dartmouth scientists	Teachers	Poster	Dartmouth	165%	2	

Outreach Goal

VI. Education for nurses and allied health

Desired Results

Increase skill in treatment and prevention of environmentally related health conditions

Strategies & Scope of Reach	Audience	Significant Publications	Grantee	Total FTE Outreach	Years of Effort	Other Support
Environmental health curricula for nurses, social workers	Nurses, social workers		Harvard	145%	7	NIEHS Centers Program

Outreach Goal

VII. Increased development, dissemination and use of research on children's environmental health risk

Desired Results

- To promote the development of sound public health and child-focused national policy
- To stimulate prevention-oriented research
- To educate health professionals, policy makers and community members in preventive strategies
- To elevate public awareness of environmental hazards to children

Strategies & Scope of Reach	Audience	Significant Publications	Grantee	Total FTE Outreach	Years of Effort	Other Support
1. Seminar with web 2. Develop research agenda for children's environmental health concerns in CA with group and individual meetings 3. Articles in popular media, radio PSAs, and a web page 4. Development of web resources targeting concerns of African-American communities 5. Maintain 2 listservs (for science and community leaders) on children's environmental health concerns 6. Increase "environmental health literacy" of faith community leaders and the populations they serve via seminars and conferences; web-based resources	1. Health care professionals (doctors, nurses, and public health officials) 2. Researchers in many fields, policy-makers 3. General public 4. Parents and community leaders 5. 1) Researchers and clinicians 2) community leaders and policy-makers 6. Faith community leaders and congregations	Organizations directory (for community leaders) Anthology (for clinicians)	University of California – Berkeley	42%	8	Outreach to environmental justice communities (various foundations) Outreach coordination for NIEHS pediatric centers (NIEHS) Briefings on state of the science for policy-makers (various foundations) Partner: BET.com

Appendix 2:

Past Recommendations Regarding Outreach

Past recommendations regarding outreach. Many of the stakeholder recommendations documented from the 1998 pre-RFA meetings and the ReNEW workshop pertained to outreach activities and community concerns. The following summary list includes these specific recommendations from all of the 1998 meetings (some recommendations have been combined in summary for clarity):

1. Implement more aggressive communications of new basic research findings from the SBRP to EPA Headquarters and Regional Risk Assessors and Regional Toxicologists.
2. Link scientists participating in the SBRP with EPA Regional Program Managers for consultation and collaboration where indicated.
3. Develop more effective distribution of research findings to: state and local public health officials, environmental risk managers, state Superfund program officials, communities and the media.
4. Notify local health care providers serving communities near Superfund sites on the contents of these sites, the possible exposures and outcomes of exposures and availability of diagnostic and therapeutic methods.
5. Engage health care providers and local health authorities in exposure and effects surveillance.
6. Identify means to work with the media to interpret new scientific data and methodologies that are produced by the SBRP.
7. Establish working guidelines for basic research scientists who intend to collect human tissues or ecological samples at National Priority List (NPL) sites.
8. Include NPL communities in all levels of decision-making from the beginning of a process.
9. Collect, interpret, organize and make available all emerging relevant hazardous substance basic research conducted or funded by federal agencies.
10. Understand what citizens affected by NPL sites want to know about potential and actual adverse effects on health, environment and ecology. Create methods to offer complete, current, holistic, understandable information to these citizens.
11. Create mechanisms to answer citizen questions on an ongoing basis.
12. Consider creating community advisory committees or councils to reduce tension between government and industry officials and impacted communities.
13. Consider developing criteria for "Outreach Requirements" for NIEHS/EPA SBRP grantees to clarify the relationships and roles of ATSDR, EPA and grantees at NPL sites.
14. Review the extent of coordination of the EPA/NIEHS SBRP with similar research programs sponsored by the Department of Defense and the Department of Energy.