United States Environmental Protection Agency
EPA Science Advisory Board (1400A) Washington DC
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THE SCIENCE TO ACHIEVE RESULTS (STAR) WATER AND WATERSHEDS GRANTS PROGRAM: AN EPA SCIENCE ADVISORY BOARD REVIEW

A REVIEW BY THE ECOLOGICAL PROCESSES AND EFFECTS COMMITTEE (EPEC) OF THE EPA SCIENCE ADVISORY BOARD

November 26, 2001

EPA-SAB-EPEC-02-001

Honorable Christine Todd Whitman
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW
Washington, DC 20460

Re: Review of the Science to Achieve Results (STAR) Water and Watersheds Extramural Grants Program

Dear Governor Whitman:

A panel of the EPA Science Advisory Board recently reviewed the Water and Watersheds component of the Agency's extramural grants program, Science to Achieve Results (STAR). The overall STAR program, currently funded at over $100 million per year, represents a significant investment by the Agency in extramural research to support EPA's mission. For this reason, STAR was the focus of recent reviews by the U.S. General Accounting Office and a joint panel of the Agency's SAB and Board of Scientific Counselors. The Agency requested the current SAB review of the STAR Water and Watersheds program because it is one of the longest running components of STAR, having funded grants for approximately five years.

The SAB panel found that the Water and Watersheds program has provided relevant and useful information. We have provided recommendations for mid-course corrections to the program help ensure that the results will be used more effectively. The remainder of this letter highlights our findings and recommendations. We look forward to your consideration of and response to the enclosed report.

Background

The Science to Achieve Results (STAR) program provides a mechanism for the Agency to engage academic researchers in work that supports the Agency's mission. Run by the Office of Research and Development (ORD), the objectives of the STAR program are, in part, to involve the best academic scientists in research efforts targeted at Agency priorities and to train a cadre of environmental scientists for the future.

Within the STAR program, the Water and Watersheds component is designed to complement the Agency's work on ecosystem assessment and restoration. The specific objectives of the Water and Watersheds component are to:

a) Develop an improved understanding of the natural and anthropogenic processes that govern the quantity, quality, and availability of water resources in natural and human-dominated systems;

b) Develop an understanding of the structure, function, and dynamics of the terrestrial and aquatic systems that comprise watersheds; and

c) Promote integration across the biological, physical, and social sciences in the area of watershed management.

Since 1996, approximately $36 million in Water and Watershed grants has been awarded to academic researchers. These grants have required that the researchers use interdisciplinary teams (representing biological, physical, and social sciences) to address watershed research questions.

Results from many of the multi-year grants are not yet available to the Agency, and many of the research teams have not had time to publish their results for the use of other scientists. In order to review the program, therefore, the SAB panel attended a three-day meeting at which the STAR Water and Watershed scientist teams were required to present their interim results to the Agency. Our assessment of the research program and our recommendations for mid-course corrections are based on information gathered at that meeting, as well as on written materials provided by the Agency.

Conclusions

The Panel agreed that the Water and Watersheds program is an important component of STAR and covers subject areas critical to the Agency's goals of protecting water quality and participating in collaborative management of watershed resources. The scientific quality of the research is high, and the program is producing a crop of younger researchers with experience in practical applications of sophisticated academic research. An additional long-term benefit of the program is to further legitimize within universities the pursuit of research on questions that cut across traditional academic boundaries yet are relevant to the Agency's mission. The Panel strongly recommends that STAR WW be retained as a major, focused program within EPA.

To date, much of the research has been focused on a subset of the Water and Watersheds program objectives. The research predominantly has targeted water quality in human-dominated systems. Within this subject area, many of the projects have generated models and other "decision tools" that can be used to analyze the effects of watershed management schemes on nature and the people who live in the watershed. These tools have broken new ground by more rigorously linking knowledge about natural processes on the one hand and the social and political drivers of human activities on the other hand.

The Panel feels, however, that the current focus of the grant program may be forcing too much homogeneity among projects while precluding some important areas of watershed research. The requirement that each project incorporate social science, ecological, and physical science research components has become a barrier to research on pressing questions that involve a different mix of disciplines. Accordingly, the program should be refocused around fundamental issues in watershed science, rather than on funding integrated research per se. Interdisciplinary research will probably still be common under this scenario, although the mixture of disciplines may shift over time as progress is made in addressing important problems.

The charge questions presented to the SAB also asked whether the results of the Water and Watersheds program are likely to be useful. The Panel found that most of the research grants appear directly relevant to on-the-ground watershed management decisions. The primary client base for most of the grants is local, and the information that is generated should be both useful and understandable to the local groups. Little evidence was presented to the Panel, however, to demonstrate that regional or national agencies will apply the information and tools generated by the grants. Moreover, the collective results of the research grants have not yet been used effectively. Now that a number of the projects have been completed, valuable insights can be gained by analyzing the results of groups of projects.

Mid-Course Corrections

We suggest the Agency consider the following mid-course corrections for the STAR Water and Watersheds program:

a) In conjunction with the Agency's program and regional offices, ORD should identify known information gaps that limit effective watershed management and target these for research. The Panel has provided examples of gaps that could be targeted, such as developing a classification system for aquatic ecosystems that comprise watersheds and establishing baseline (or "reference") conditions against which watershed management success can be measured. These targeted information gaps must be defined far less globally than the broad annual themes currently used in the STAR WW Requests for Applications.

b) ORD should continue to promote research that is policy-relevant, but judge relevance directly rather than using integration across academic disciplines as an indirect measure. Projects that represent only one discipline, yet address critical questions should be funded. The Panel has provided suggestions, including a proposed template of questions for grant recipients, which may help accomplish this purpose.

c) ORD also should continue to reserve some of the Water and Watersheds funding for research that involves several academic disciplines, because it is one of the few sources of such research funds, and because Agency funding will continue to develop needed capacity for multi-disciplinary research within the academic community. For example, the inclusion of social sciences in STAR research

projects has produced insights that would not have arisen from an ecological research focus alone. Because truly integrated research is complex and organizationally cumbersome, however, these grants should be longer-term and for larger amounts than those presently provided. Planning grants would be an effective means of enhancing the integration of research questions in grant proposals.

d) ORD should far more aggressively pursue its plans to produce "State of the Science" reports that review and analyze the collective findings of STAR-funded research. We recommend that ORD commission groups of researchers to synthesize cross-project findings on a variety of issues. Typical questions might include the following: What ecological endpoints were used most often and how can these be improved to better represent changes in ecological condition? Did multiple researchers make the same adaptations to common watershed models and can more useful versions of the models now be published? Did the individual projects independently arrive at the same study elements and similar sequence for their execution, and can this experience now streamline management of interdisciplinary research?

e) The Agency should develop a process systematically to distill and communicate STAR research findings to its program and regional offices and to state agencies. This recommendation was made earlier by the joint SAB/BOSC review of the overall STAR program and remains relevant. The Panel provides several specific suggestions that may be used by the Agency to accomplish this task. Although we are well aware of the benefits of maintaining a free marketplace of research ideas in the academic sector, we also concur with the earlier recommendation by the SAB/BOSC that STAR scientists should work more directly with Agency scientists and managers.

f) Should the Agency wish to measure more quantitatively the utility of the STAR Water and Watersheds program, the Panel has provided a number of metrics that might be used.

In sum, the Committee's relatively detailed review of the Water and Watersheds component of the STAR program yielded conclusions strikingly similar to those of the SAB/BOSC panel that reviewed the entire STAR program a year ago. While we have made numerous specific suggestions to sharpen the focus of the program and derive more value-added from its results, we agree with the previous SAB/BOSC panel's conclusions that, overall, "the

STAR program is structured and managed so as to generate high-quality science, conducted by well-qualified scientists, on topics that are relevant to the environmental problems identified in the EPA Strategic Plan." We look forward to your response.

Sincerely,

/ Signed /

Dr. William Glaze, Chair
EPA Science Advisory Board

/ Signed /

Dr. Terry F. Young, Chair
Ecological Processes & Effects Committee
EPA Science Advisory Board

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U.S. Environmental Protection Agency
EPA Science Advisory Board
Ecological Processes and Effects Committee
STAR Water and Watersheds Review Panel

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1. EXECUTIVE SUMMARY

The Science to Achieve Results (STAR) Program is an EPA extramural grants program begun in 1995 as a means to "include this country's universities and non-profit centers in EPA's research program and to ensure the best possible quality of science in areas of highest risk and greatest importance to the Agency"(EPA, 1999). Since its beginning, the STAR Program has grown to approximately $100 million/year in research grants over 32 topic areas (see Table 1). STAR Requests for Applications (RFA) are developed by the Office of Research and Development in consultation with representatives of EPA program and regional offices. The Water and Watersheds (STAR WW) portion of the STAR Program issues joint RFAs with the National Science Foundation and (since 1998) the U.S. Department of Agriculture. Since 1996, STAR Water and Watersheds has funded over 50 watershed research grants totaling approximately $36 million (Table 2). Of these grants, 35 have been funded by EPA for a total of approximately $28 million. The overall STAR Program has been reviewed with respect to its management structure and alignment with the Agency's research priorities (e.g., U.S. GAO, 2000; SAB-BOSC, 2000). The present review, however, is the first external evaluation to examine the scientific quality and likely utility of the STAR Water and Watersheds research findings.

In a 1999 report, *Evaluating Federal Research Programs*, the Committee on Science, Engineering, and Public Policy (COSEPUP) (a joint committee of the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine) recommended that expert peer reviewers evaluating a research program look at scientific quality, relevance, and benchmarking (i.e., the stature and influence of the research as compared to other research programs, including those in other countries) (NRC, 1999). For the SAB panel's review of the STAR WW program, the Agency's charge focused on relevance (Questions 1-3), and benchmarking (Question 4). Although there was not a specific question on the scientific quality of the STAR WW research, the Panel commends the program on the quality of the researchers and the research. Research on the processes–both human and natural–that shape watersheds is important to EPA's mission to protect human health and the environment, and the STAR program should retain Water and Watersheds as a focus area. The STAR WW grants are supporting research that likely would not be done by academic researchers absent the STAR program.

The NRC (1999) also recommended that both research and mission agencies should have as one of their goals "the goal of developing and maintaining adequate human resources in fields critical to their missions." The Panel applauds the STAR WW program for its focus on developing capacity in the extramural research community for interdisciplinary thinking and problem-solving. The STAR WW program will have long-lasting effects because of its role in facilitating and strengthening interdisciplinary research within the academic community.

The Charge Questions posed by the Agency, and the Panel's summary responses, are given below:

> ***Charge Question 1****: Are the STAR Water and Watersheds grants, taken collectively, likely to produce a body of research that will improve our practical understanding of: a) natural and anthropogenic processes that govern the quantity, quality, and availability of water resources in natural and human-dominated systems, and b) the structure, function, and dynamics of the terrestrial and aquatic ecosystems that comprise watersheds?*

Summary Response: Yes, the STAR WW grants have increased our practical knowledge of watershed sciences. The inclusion of social sciences in the STAR WW program has produced insights into decision-making on watershed management that would not have arisen from an ecological research focus alone. On the other hand, the advancements have been limited to particular subject areas in the watershed sciences. The STAR WW projects have focused primarily on linking the effects of anthropogenic processes on water quality and biotic integrity measures. Within this focus, there is a preponderance of work on models that link some aspect of social science with aspects of physical and ecological components.

Many of the STAR WW projects are local case studies that currently have limited applicability elsewhere. In order to enhance scientific understanding from the STAR WW research, the Panel recommends that the Agency analyze and synthesize the results of groups of like projects. Future STAR WW research could then focus on critical information gaps.

> ***Charge Question 2****: Are the research findings likely to make a difference in environmental protection (i.e., are research results influencing Agency programs, directions, or regulations? influencing other organizations and other researchers?)*

Summary Response: Individually, most of the STAR WW grants appear directly relevant to on-the-ground watershed management decisions. The primary client base for most of the grants is local, and the information that is generated should be both useful and understandable to the local groups. Little evidence was presented to the Panel, however, to indicate that the knowledge developed in the grants is being applied by Agency staff or other local constituencies outside of the watershed where the research was conducted. The Agency does not have a systematic process to collect information on the application of` STAR WW research results, and is just beginning to consider ways of distilling and communicating STAR WW research findings. Improvements in this arena are timely because many more of the multi-year grants are now nearing completion. Interdisciplinary integration and stakeholder involvement—while important emphases of the STAR WW program—are not sufficient to ensure that funded research will have utility to decision-makers. The Panel suggests additional steps that could enhance the policy relevance, applicability, and ecological protection afforded by STAR WW projects. The Panel also suggests some possible metrics for which data could be collected to support future evaluations of program success.

Charge Question 3*: Is the requirement that grant proposals integrate ecological, physical and social sciences producing a unique body of research? Would funding each of the "circles" [in the Venn diagram] individually have the same outcome? Is the integrated approach so important that it is giving us new insights into decision making at the watershed scale?*

Summary Response: Yes, the requirement to include ecological, physical and social sciences in most of the STAR Water and Watersheds projects to date has produced a unique body of research. The STAR WW program, both in its focus and its interdisciplinary nature, provides a source of research funding that is rare within federal research programs. Funding projects within the individual discipline groups (or "circles") would not have produced the same results. Most of the progress made by STAR WW projects occurred at the interface between disciplines and/or at the interface between scientists and stakeholders. In particular, the integration of socioeconomics and management issues into watershed research is a very encouraging, unique and beneficial aspect of the STAR WW program.

The requirement to integrate social, physical, and biological sciences in every project appears, however, to be forcing too much homogeneity among projects while precluding some important areas of watershed research. The Panel recommends that future STAR WW Requests for Applications retain some, but not exclusive, emphasis on interdisciplinary projects, and that they allow the mix of disciplines to be determined primarily by the important science questions that need to be answered. A portion of program funding could be set aside to ensure support for projects that include social science research and one other of the discipline areas. Similarly, a portion of program funding might be reserved for a few large, multidisciplinary projects. For these projects, the Agency should consider providing planning grants, an increased level of funding, and longer grant periods, commensurate with the additional complexity of the proposed research.

Charge Question 4*: As a result of the Water and Watersheds program, do we see any major advancements or breakthroughs in watershed science or interdisciplinary integration across the relevant disciplines?*

Summary Response: The Panel did not see evidence of major breakthroughs in watershed science but did conclude that STAR WW was producing valuable opportunities to link the natural and social sciences relevant to watershed assessment and management. Given the emphasis on interdisciplinary research, which requires additional time and effort by researchers, it may be too early to expect major advances in interdisciplinary integration. Advances from the currently funded projects are likely to take the form of integrated application of existing models and more refined decision tools for watershed management.

Charge Question 5*: How is the STAR WW program perceived within and outside the research community?*

Summary Response: In general the Panelists felt that the data provided in the pre-meeting materials plus their experience at the STAR Progress Review did not provide a factual basis to assess how the STAR WW program is viewed by the rest of the research community. The Panel agreed, however, that a positive answer to this question would be a significant indication that the STAR WW funding was achieving its goal of expanding the appreciation of integrated research on watershed management. Measures of awareness and acceptance of STAR WW research could be developed as part of a more comprehensive evaluation of program success.

Charge Question 6: *What changes would [the Panel] recommend to the [STAR WW] program managers?*

Summary Response: Based on the materials provided by the Agency, and the STAR WW researcher presentations in San Francisco, the Panel suggests a number of mid-course corrections to enhance the impact of the STAR WW program. The recommended changes include cross-study evaluation of existing STAR WW projects to distill and synthesize program results; improved dissemination of STAR WW research findings to the larger research community and to potential users; and redirection of future RFAs. The Panel's summary recommendations are as follows:

Recommendation 1: The Panel strongly recommends that STAR WW be retained as a major, focused program within EPA.

Recommendation 2: In order to meet the Program's stated objectives, the Panel recommends that STAR WW Requests for Applications focus more on fundamental issues in watershed science, rather than on funding integrated research *per se*. Interdisciplinary research will probably still be common under this scenario. Specifically, the Agency should:

a) Pursue a more balanced approach to addressing the program's objectives. The Panel notes that STAR WW projects have focused primarily on anthropogenic processes, water quality issues, biotic integrity measures, and human-dominated systems. The Panel recommends placing additional emphasis on natural systems and reference conditions, on the understanding of water quantity issues, and on ecosystem processes and dynamics related to the maintenance of native communities and species.

b) Retain some, but not exclusive, emphasis on interdisciplinary projects, and allow the mix of disciplines to be determined by important and relevant science questions that need to be answered. In particular, replace the Venn diagram with a broader definition of interdisciplinary research, and fund projects that only include one or two disciplines when needed to address gaps in our understanding of watersheds. Continue to emphasize the integration of social sciences with ecological research.

c) For a small number of particularly complex, truly integrated, multi-disciplinary projects, consider providing planning grants, an increased level of funding, and longer grant

periods.

Recommendation 3: The Panel believes that benefits from the existing STAR WW research grants and practical application of research results could be significantly enhanced. Steps to do this include:

a) Cross-study evaluations to analyze and synthesize the results of groups of projects (e.g., through convened panels of internal and external scientists);

b) Disseminate research results in useful forms (e.g., peer-reviewed literature, web-based products, simplified glossy products) to business, government, and science sectors;

c) Improve delivery of extramural research results to Agency scientists and program managers;

d) Continue to build capacity for trans-disciplinary work related to the Agency's mission by, for example, enhancing inter-disciplinary and inter-project thinking and communications; and

e) Provide support for fuller engagement of EPA STAR program managers in relevant scientific and management communities, and for increased interaction with funded scientists.

Recommendation 4: If the Agency desires a more methodical measure of STAR WW benefits in the future, the Panel suggests that the Agency identify sets of measures that correspond to the specific program objectives to be achieved, then determine means of gathering information on the measures. The Panel provides examples of such measures in this report.

2. INTRODUCTION

2.1 Background

The Science to Achieve Results (STAR) Program is an EPA extramural grants program begun in 1995 as a means to "include this country's universities and non-profit centers in EPA's research program and to ensure the best possible quality of science in areas of highest risk and greatest importance to the Agency"(EPA, 1999). Since its beginning, the STAR Program has grown to approximately $100 million/year in research grants over 32 topic areas (see Table 1). STAR Requests for Applications (RFA) are developed by the Office of Research and Development in consultation with representatives of EPA program and regional offices. All STAR research proposals undergo external scientific peer review and, for those that receive a "very good" or "excellent" score on scientific merit, an internal relevancy review. The relevancy review, conducted by representatives of EPA program and regional offices, identifies "which proposals are most relevant, responsive, timely and complementary to the intramural research program" (EPA, 1999).

The Water and Watersheds portion of the STAR Program issues joint RFAs with the National Science Foundation and (since 1998) the U.S. Department of Agriculture. Since 1996, STAR WW has funded over 50 watershed research grants totaling approximately $36 million (Table 2). Of these grants, 35 have been funded by EPA at a total of approximately $28 million. The goals of the STAR Water and Watersheds program are to:

a) develop an improved understanding of the natural and anthropogenic processes that govern the quantity, quality, and availability of water resources in natural and human-dominated systems;

b) develop an understanding of the structure, function, and dynamics of the terrestrial and aquatic ecosystems that comprise watersheds; and

c) promote integration across the biological, physical, and social sciences in the area of watershed management.

Beginning in 1996, the Water and Watersheds RFA shifted toward requiring greater integration of ecological, physical, and social sciences relevant to watersheds. The program's conceptual approach to integrated watershed research was embodied in a Venn diagram showing areas of intersection among ecological, physical, and social science research (Figure 1). In 1996, projects were required to demonstrate incorporation of at least two of the research categories (i.e., Areas 2, 3 and 4 of Figure 1), with most desirable proposals including all 3 categories (i.e., Area 1 of Figure 1). In subsequent RFAs, only projects falling within Area 1 were considered for funding. In addition, the RFAs have emphasized different focus areas each year (e.g., watershed restoration, Total Maximum Daily Load development).

Table 1. STAR RESEARCH AREAS (1995 - 2000)

AIR
Indoor Air Quality
Health Effects of Particulate Matter & PM Centers
Air Pollution Chemistry and Physics
Air Toxics
Mercury Fate and Transport

WATER
Drinking Water
Risk-based Decisions for Contaminated Sediments
Water and Watersheds
Health Effects of Arsenic

HUMAN HEALTH
Exposure of Children to Pesticides
Endocrine Disruptors
Children's Environmental Health & Disease Prevention Research Centers
Human Health Risk Assessment
Role of Interindividual Variability in Human Susceptibility
Children's Vulnerability to Toxic Substances in the Environment
Exposure to Waste Combustion Products
Chemical Mixtures in Environmental Health

ECOLOGY
Ecological Assessment and Indicators
Global Climate Change
Regional Scale Assessment and Analysis
Ecology & Oceanography of Harmful Algal Blooms
Ecosystem Restoration

OTHER
Analytical and Monitoring Methods
Environmental Fate & Treatment of Toxics & Hazardous Wastes
Environmental Statistics
High Performance Computing
Technology for Sustainable Environment
Decision-making & Valuation for Envir. Policy
General Solicitation: Exploratory Research
Socioeconomic Projects Related to Pollution Prevention
Program on Bioremediation
Futures: Detecting the Early Signals

The overall STAR Program has been reviewed with respect to its management structure and alignment with the Agency's research priorities (e.g., GAO, 2000; SAB-BOSC, 2000). The present review, however, is the first external evaluation to examine the scientific quality and likely utility of the STAR Water and Watersheds research findings.

Table 2. STAR Water and Watersheds Funding and Focus Areas for 1996-2000

Year	Integration Requirements	Focus Areas	# New Grants	Total EPA ($1000's)	Total All Partners ($1000's)
1996	2 discipline categories		8 EPA 4 NSF	6,872	8,572
1997	3 discipline categories	urban/ suburban; public/stakeholder involvement	10EPA 4 NSF	8,131	10,475
1998	3 discipline categories	watershed restoration; public/stakeholder involvement	9 EPA 2 NSF 2 USDA	6,535	8,260
1999	3 discipline categories	TMDL; public/stakeholder involvement; education & outreach	8 EPA 2 NSF 2 USDA	6,556	9,077
TOTALS			35 EPA 12 NSF 4USDA	28,093	36,384

Source: NSF-EPA Partnership for Environmental Research web site (www.nsf.gov/home/crssprgm/). For summary tables of STAR WW projects, see Appendix A.

2.2 Statement of the Charge

The EPA's Office of Research and Development, which administers the STAR Program, requested that the Science Advisory Board evaluate several aspects of the STAR Water and Watersheds (STAR WW) program. After discussions between the Agency and members of the SAB's STAR WW Review Panel, the following charge questions were adopted to focus the review:

> Question 1: Are the STAR Water and Watershed grants, taken collectively, likely to produce a body of research that will improve our practical understanding of: a) natural and anthropogenic processes that govern the quantity, quality, and availability of water resources in natural and human-dominated systems, and b) the structure, function, and dynamics of the terrestrial and aquatic ecosystems that comprise watersheds?

Question 2: Are the research findings likely to make a difference in environmental protection (i.e., are research results influencing Agency programs, directions, or regulations? influencing other organizations and other researchers?)

Question 3: Is the requirement that grant proposals integrate ecological, physical and social sciences producing a unique body of research? Would funding each of the "circles" individually have the same outcome? Is the integrated approach so important that it is giving us new insights into decision making at the watershed scale?

Question 4: As a result of the Water and Watersheds program, do we see any major advancements or breakthroughs in watershed science or interdisciplinary integration across the relevant disciplines?

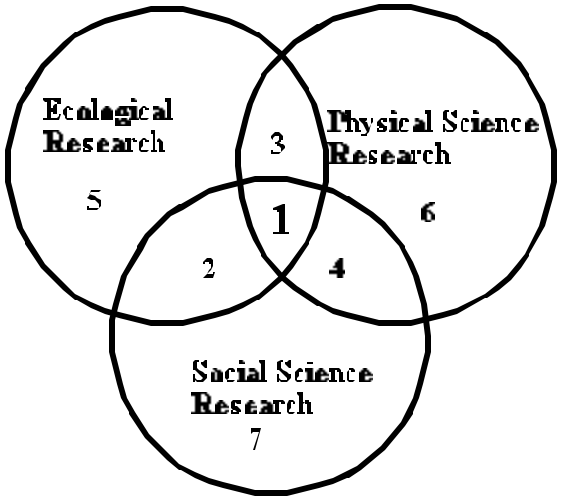

Figure 2. STAR Water and Watersheds Diagram Used to Show Interdisciplinary Integration.

Question 5: How is the program perceived within and outside the research community?

Question 6: What changes would you recommend to the program managers?

2.3 SAB Review Procedures

The STAR WW Review Panel (the Panel) was composed of 9 members of the SAB's Ecological Processes and Effects Committee, augmented by 3 panelists (an invited expert from Canada and 2 SAB consultants) with expertise in geography, sociology, public participation, economics, and decision-making. The panel held a public teleconference meeting on April 3, 2001 and a public face-to-face meeting in San Francisco on April 20, 2001. Prior to the meetings, the panel reviewed a package of written materials prepared by the Agency, which included abstracts of all STAR WW projects, a sample STAR WW Request for Applications, summary information on STAR WW products and likely clients, and previous evaluations of the overall STAR Program. During the April 3 meeting, the panel was briefed on the STAR WW program by Agency officials, discussed the charge questions, and requested additional information from the Agency. Based upon the written materials provided and the Agency briefing on April 3, pre-meeting comments were submitted by individual panelists prior to the April 20 meeting and these comments were shared among the panel members and with the Agency and interested members of the public. In addition, the panelists attended an Agency-sponsored meeting of STAR WW researchers on April 18-19, 2001 in order to hear first hand about

the research funded by the STAR WW program. A public teleconference call of the Panel was held on June 1, 2001 to continue discussion of Panel responses to the charge questions. Although opportunity was provided for public comment, no comments were received for any meeting of the panel.

3. RESPONSE TO THE CHARGE QUESTIONS

3.1 General Comments

In a 1999 report, *Evaluating Federal Research Programs*, the Committee on Science, Engineering, and Public Policy (a joint committee of the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine) recommended that expert peer reviewers evaluating a research program look at scientific quality, relevance, and benchmarking (i.e., the stature and influence of the research as compared to other research programs, including those in other countries) (NRC, 1999). For the SAB panel's review of the STAR WW program, the Agency's charge focused on relevance (Questions 1-3), and benchmarking (Question 4). Although there was not a specific question on the scientific quality of the STAR WW research, the Panel commends the program on the quality of the researchers and the research. Research on the processes–both human and natural–that shape watersheds is important to EPA's mission to protect human health and the environment, and the STAR program should retain Water and Watersheds as a focus area. The STAR WW grants are supporting research that likely would not be done by academic researchers absent the STAR program. The Panel strongly recommends that STAR WW be retained as a major, focused program within EPA

The NRC (1999) also recommended that both research and mission agencies should have as one of their goals "the goal of developing and maintaining adequate human resources in fields critical to their missions." The Panel applauds the STAR WW program for its focus on developing capacity in the extramural research community for interdisciplinary thinking and problem-solving. The STAR WW program will have long-lasting effects because of its role in facilitating and strengthening interdisciplinary research within the academic community.

The Panel notes also that the value of integrated, multi-disciplinary research is not unique to watershed assessment and management. Thus, the Agency should consider ways to bring the same sort of integrated thinking, including social and natural sciences and stakeholder involvement, to other decision-making arenas. Other arenas that would be enhanced by such research include, for example, new product development and selection of control strategies for environmental releases to manage air quality. In this example, future STAR funding might include airshed/watershed interactions and how their management could be integrated on a local and regional scale.

And finally, the charge to the Panel included questions about the STAR WW program's potential to improve practical understanding of watershed processes, to provide research findings that will make a difference in environmental protection, to integrate ecological, physical, and social sciences, and to produce breakthroughs in watershed science or interdisciplinary integration. The Panel concluded, however, that program "success" did not require that all of the program objectives be met equally. Realistic expectations for a scientific research program might include progress on some, but not all, of the objectives implicit in the charge questions.

The Panel's responses to the charge questions posed by the Agency are based on review of STAR WW project abstracts and some final project reports, and researcher presentations. The Panel did not conduct a detailed review of all program outputs, and indeed the majority of the funded projects are still ongoing.

3.2 A Practical Understanding of Watersheds

Charge Question 1*: Are the STAR Water and Watershed grants, taken collectively, likely to produce a body of research that will improve our practical understanding of: a) natural and anthropogenic processes that govern the quantity, quality, and availability of water resources in natural and human-dominated systems, and b) the structure, function, and dynamics of the terrestrial and aquatic ecosystems that comprise watersheds?*

Summary Response*: Yes, the STAR WW grants, taken collectively, have increased our practical knowledge of watershed sciences. The inclusion of social sciences in the STAR WW program has produced insights into decision-making on watershed management that would not have arisen from an ecological research focus alone. On the other hand, the advancements have been limited to particular subject areas in the watershed sciences. The STAR WW projects have focused primarily on linking the effects of anthropogenic processes on water quality and biotic integrity measures. Within this focus, there is a preponderance of work on models that link some aspect of social science with aspects of physical and ecological components.*

Many of the STAR WW projects are local case studies that currently have limited applicability elsewhere. In order to enhance scientific understanding from the STAR WW research, the Panel recommends that the Agency analyze and synthesize the results of groups of like projects. Future STAR WW research could then focus on critical information gaps.

According to the materials provided to the Panel, the goals of the Water and Watersheds program are to: a) develop an improved understanding of the natural and anthropogenic processes that govern the quantity, quality, and availability of water resources in natural and human-dominated systems; b) develop an understanding of the structure, function, and dynamics of the terrestrial and aquatic ecosystems that comprise watersheds; and c) promote integration across the biological, physical, and social sciences in the area of watershed management. Charge Question 1 asks whether the body of research being funded by STAR WW is likely to meet the first two program goals. (Comments on the third goal–integration across disciplines–are contained in Section 3.4.)

The Panel interprets the phrase "practical understanding" in Charge Question 1 as meaning that the research findings would be relevant to decisions facing managers of watershed landscapes and regional water supplies. Although we discuss the relevance of STAR WW research in Section 3.3, our general conclusion was that the results of most of the STAR WW projects appear to be relevant to management decisions in the watersheds where the work is being conducted. Moreover, since stakeholders are involved in almost all STAR WW projects, the products of the research likely will be incorporated into the public decision process. The STAR WW portfolio, therefore, meets the "relevance" test in the targeted watersheds.

3.2.1 Watershed Ecosystems

It seems likely that the STAR WW research ultimately will improve our general understanding of watershed ecosystems, but the advancements to date have been limited to particular subject areas. The current STAR WW program goals encompass a great deal of scientific territory: natural AND anthropogenic processes; water quantity AND quality; natural AND human-dominated systems. Given the broad scope of the STAR WW program, it is not surprising that the portfolio of funded projects does not adequately treat all of these research areas. That said, the Panel has the following observations about the balance of research funded to date under the STAR WW program:

a) **Natural vs. human-dominated ecosystems**

There is a strong emphasis on human-dominated ecosystems in the STAR WW projects funded to date. This focus may be appropriate in light of the emphasis of other funding programs on more natural (less heavily modified) ecological systems. However, in order to manage or restore watershed functions, managers need data on reference conditions against which to compare the human-dominated watersheds. This argues for more research on natural (i.e., less human-dominated) systems. At the individual project level, researchers should give greater attention to the issue of reference condition when designing watershed studies and interpreting research findings. In this regard, a classification of aquatic ecosystems to match that in use for terrestrial ecosystems (Federal Geographic Data Committee--FGDC--standard) would be an important step in allowing comparisons between watersheds. That is, the transferability of information between systems requires a common basis for defining the systems.

b) **Water quality vs. water quantity**

The STAR WW program seems to be supporting more work on water quality than on water quantity issues. More emphasis on quantity would be helpful, since the amount of water and its apportionment among user groups (e.g., agriculture, municipalities, and environment) is arguably the paramount issue in many areas of the country.

c) **Ecosystem structure vs. function and dynamics**

The STAR WW projects supported to date are strong on structural description but functional (or process) measurements are not as widely embraced and little has been done to investigate dynamics. However, it should be noted that the intended distinction between dynamics and function or process is not made clear. In addition to water quality and biotic integrity measures, projects should address landscape structure, maintenance of an array of native communities and habitats, hydrology and geomorphology, ecological processes (such as carbon and nutrient cycling), and disturbance regimes.

d) **Freshwater vs. estuarine systems**

The current STAR WW portfolio contains relatively few projects that focus on estuarine systems and the interactions between upland watersheds and estuarine or coastal watersheds or, more

importantly, on the interactions between upland watersheds and the coastal ecosystems downstream. The U.S. population increasingly is concentrated in coastal areas, with associated stress on coastal ecosystems. Further, large coastal ecosystems have an important influence on global cycles and on the oceans. Coastal watersheds are historically under-represented in funding by federal agencies because of perceived "jurisdictions" in research funding. However, management of many large drainage basins in the U.S. is being driven by effects in coastal systems downstream. Examples include management of the enormous Mississippi River basin in relation to the "dead zone" in the Gulf of Mexico, management of Mid-Atlantic watershed of the Chesapeake Bay to respond to Bay degradation, and the links between water management in southern Florida and coral reef loss in the Florida Keys.

3.2.2 Human Dimensions of Watersheds

While the human dimensions influencing water quality and watershed conditions were evident in most of the STAR WW research projects, there was little evidence of real integration of findings about human systems and non-human components of watershed ecosystems. In sum, human dimensions research efforts paralleled the research on biological, physical and chemical elements. But human dimensions were not treated as critical parts of a synthetic analysis with other components to achieve a more integrated and system-wide approach to research for understanding changes in watersheds. The Panel had the following observations about the STAR WW research projects' contributions to our understanding of the influence of anthropogenic processes on watersheds and stakeholder involvement in watershed assessment and management:

a) **Anthropogenic Processes in Watersheds**

Much of the STAR WW research made concrete contributions towards describing how human behavioral factors determine land use patterns, residential and farm management practices, and general urban and suburban landscape sprawl and economic growth. These human activities in turn affect environmental conditions in STAR WW project areas. Research findings were most effective at explaining causal relationships among particular land use types and watershed impacts when researchers focused on smaller study areas where human settlement and activity patterns corresponded with hydrological boundaries of watersheds. This research examined such problems as linking growth of recreational land use in a lake watershed with controlling problems of lake sedimentation and phosphorus loading; studying farm agrochemical and crop tillage practices to determine best rural watershed strategies; and using GIS programs to relate coastal town expansion with ensuing problems of *E. coli* water pollution. Smaller watershed and human area research also was effective in developing community participation schemes and models for decision-support systems based on the local context. There is a need for the STAR WW program to collect and distill the results and disseminate the lessons from smaller watersheds and particular forms of human settlements in order to increase understanding and reach a wider range of social, economic and watershed contexts.

Few STAR WW studies focused on larger river basin systems and fewer examined a wide range of human factors and their influence on watersheds. Yet, those that did provided valuable results. The framework applied in the Baltimore Ecosystem Study, for example, integrated information on long periods of historic urban and human settlement processes with relatively large-scale modeling of

ecological river basin changes. Such integration efforts will provide important lessons for long range management of waters and watersheds.

b) **Stakeholder Involvement**

Several STAR WW research projects addressed stakeholder involvement by investigating why some watershed projects are more successful than others in organizing social capital for making decisions and implementing solutions to social and environmental problems. Many of the projects incorporated human values, beliefs and perceptions by promoting feedback among researchers and the public, and sharing information and gathering watershed data along side community-based organizations and watershed citizen groups. A subset of the STAR WW projects took a more complex approach to involvement using applied social science research, where researchers surveyed community members of watersheds and analyzed attributes for citizen role models and leadership through community-based organizations, examining the formal arrangement for citizen participation within a process of local watershed management and planning. Here, research focused on understanding the characteristics of effective planning and citizen inputs involving questions of trust, legitimization, interpreting scientific data, differences in manager and public perspectives about water and watershed protection, and the overall qualities needed to build more effective community problem-solving organizations. Research about the workings of stakeholder involvement should be encouraged and can point to desirable collaborative citizen-manager-scientist- cooperation and management systems.

3.2.3 Building A Body of Knowledge

The Agency should continue to encourage STAR WW researchers to publish their results in the peer reviewed literature so that the STAR WW program will make lasting and significant contributions to our understanding of watershed ecosystems. In addition, the improvement in understanding of watershed ecosystems from the STAR WW work could be greatly enhanced by targeted efforts to analyze the results of groups of STAR WW projects (e.g., to synthesize modifications made to existing watershed models). The Agency should increase its efforts to distill and synthesize transferrable lessons from STAR WW projects to create a body of knowledge from the many individual projects. Likely outcomes of such cross-project evaluations are discussed in Section 3.7. Efforts to "mine" the project results would greatly increase the benefits from the STAR WW program at relatively low additional cost. Program synthesis efforts would benefit from increased support from EPA for STAR program managers engagement in WW-related scientific communities.

3.3 Making a Difference: Evaluating STAR WW Research Findings

Charge Question 2*: Are the research findings likely to make a difference in environmental protection (i.e., are research results influencing Agency programs, directions, or regulations? influencing other organizations and other researchers?)*

Summary Response*: Individually, most of the STAR WW grants appear directly relevant to on-the-ground watershed management decisions. The primary client base for most of the grants is local, and the information that is generated should be both useful and understandable to the local groups. Little evidence was presented to the Panel, however, to indicate that the knowledge developed in the grants is being applied by Agency staff or other local constituencies outside of the watershed where the research was conducted. The Agency does not have a systematic process to collect information on the application of` STAR WW research results, and is just beginning to consider ways of distilling and communicating STAR WW research findings. Improvements in this arena are timely because many more of the multi-year grants are now nearing completion. Interdisciplinary integration and stakeholder involvement—while important emphases of the STAR WW program—are not sufficient to ensure that funded research will have utility to decision-makers. The Panel suggests additional steps that could enhance the policy relevance, applicability, and ecological protection afforded by STAR WW projects. The Panel also suggests some possible metrics for which data could be collected to support future evaluations of program success.*

Although it is too early to gauge the ultimate value of this program, it is easy to speculate that the STAR WW research results will promote more effective and efficient environmental protection. For example, a number of models have been adapted by STAR WW researchers to integrate ecological and social (including economic) attributes. The body of research on these decision tools should produce transferable lessons. Even more important, a number of prominent research groups now have learned how to focus research on questions of interest to watershed stakeholders, and citizen groups evidently have learned a great deal about the relevance and functioning of various ecological attributes. STAR WW research projects seem to be having important impacts on watershed management at local and regional levels. These are important and valuable outcomes.

3.3.1 Evidence of Program Impact

The Panel was provided summary information from STAR WW researchers on likely clients for their research (EPA, 2001--"Examples of STAR Water/Watersheds Grantees and Their Clients"). In some areas, anecdotal evidence of research impact was provided: e.g., fecal contamination detection methods developed and evaluated in a 1995 STAR WW grant apparently have been incorporated in

an EPA standard, and Kahl et al. (EPA, 2001, pp. 52-53) mentioned that their study results will be used by the Agency, in response to a Congressional mandate, to help determine the effectiveness of the Clean Air Act. The examples of STAR WW clients provided prior to the review indicated that several state agencies, local governments, and stakeholder groups were at least interested in the information being developed by these selected projects. Many of the examples of potential clients, however, were not specific enough to allow the Panel to determine whether novel methodologies were developed or whether the results of the grant work truly are being used.

One approach to evaluating the impact of STAR WW research projects is to assess the likelihood that results of the type being generated by these grants are needed and applicable. Potential indicators of applicability could be the number of peer-reviewed publications that deal with an application of the research and the quality of web material generated by the grants. This type of analysis was done by the Panel for a sample of STAR WW grants and the partial data indicate that the fraction of publications dealing with the application of the results was very low for 1995, and shifting to application-oriented publications after 1995. The existence of web material, which is one mechanism to promote application of research findings, was very low in the grants sampled by the Panel. (In an informal check of 15 STAR WW grants from 1995-1998, the Panel found that, other than brief progress reports to EPA, only three had results available on web sites.) STAR WW should emphasize the use of more web-based material to facilitate dissemination of results and models, but EPA should include adequate support for these efforts in WW grants. In Section 3.3.3, the Panel suggests an expanded set of metrics that might be used to evaluate the impact of the STAR WW program.

Based on the STAR WW researchers' presentations, materials provided to the Panel, and the partial analysis described above, the Panel concluded that some of the broader benefits seen from the STAR WW program include:

a) Developing a cadre of skilled, interdisciplinary scientists and managers capable of tackling watershed issues and problems;

b) Building a wider and potentially more adaptable "toolbox" of resources for use in watershed assessment and management;

c) Collaboration among multiple levels of government, including municipalities (which can be both regulator and regulated), and the private sector (e.g., watershed associations); and

d) Facilitating and strengthening interdisciplinary research within universities.

3.3.2 Enhancing Policy Relevance and Stakeholder Participation

Since 1996, the STAR WW program has emphasized interdisciplinary research. Being interdisciplinary, however, is not sufficient on its own to ensure that research is policy relevant. What is needed is that the research be oriented to address questions that bear directly on specific policy decisions. It was clear from the STAR WW research presentations that the research questions, focus,

and relevance could be sharpened in many cases by input from stakeholders. It is also possible (though not proven) that more immediate and direct impacts could be made at lower cost to address particular issues. Elsewhere in this report, the Panel recommends that the STAR WW program begin to target known information gaps. As part of this shift, for example, researchers might query local planners (e.g., county commissioners, sanitation engineers, urban planners) regarding the pressing issues, decisions, and challenges they face that could benefit from better understanding of the ecological, social, and economic consequences of various management options under consideration. It also would be helpful to increase emphasis in grant application reviews and in project plans and reports on transferability and application of a project's results to other watersheds.

To demonstrate a potential method for focusing STAR WW research on explicit questions relevant to watershed management, the Panel suggests a series of questions that could be answered by grant recipients (see Figure 2). The basis for these questions is policy analysis structured in terms of multiple objectives. Alternatively, if analysts are interested in policy analysis in terms of economists' approaches to benefit/cost analysis, then those approaches can be built onto the series of questions posed to STAR WW researchers. In asking the researchers to respond to these questions, we are in effect asking them to think through and create a summary of the policy objectives, alternatives, and their consequences for the policy decision(s) relevant to their project. Benefits of this type of analysis include a) creating an explicit decision framework for the policy questions addressed in the project, in order to focus attention of the researchers and interested parties on the key issues, and b) fostering communication among interested parties about the policy decision and the contribution of the research project. There are a variety of guide books for policy analysis that may be consulted for discussion of the various approaches. More broadly, we suggest that investigators consider the writings of Morgan and Henrion (1994) on the "Ten Commandments for Good Quantitative Policy Analysis."

Research Questions

1. Summarize the basic research questions your project is attempting to answer.

2. Outline the fundamental, integrative questions of science that are addressed by these research questions.

3. Explain how the research questions relate to Agency science priorities as given in the Office of Research and Development's Strategic Plan.

Decision Framework

4. What are the specific environmental management decisions regarding water and watersheds that your research questions are intended to help inform?

5. In what watershed(s) is your work being conducted? Will the research be generalizable to other watersheds or other policy decisions? If yes, please explain how.

6. What are the fundamental ecological system attributes that affect, or will be affected by, the decisions?

7. What are the fundamental societal values that matter to stakeholders, agencies and other interested parties in making these policy decisions? For guidance on how to clarify public values as a basis for defining objectives for ecological risk management decisions, see, for example, the appendices to the recent EPA guidelines for ecological risk assessment. Some examples of objectives that could be relevant for the most of the policy decisions associated with water and watersheds research projects could include:

-Promoting ecological health or ecological integrity within the watershed;
-Avoiding adverse effects on private property rights of landowners;
-Minimizing direct costs to governments, organizations and individuals
-Promoting beneficial uses of water
-And others, depending on the context, and what matters to interested parties.

8. What are some of the broad alternatives that could be considered for this environmental management or policy decision?

9. What are the major uncertainties that arise in considering the impacts of these alternatives, in terms of the objectives?

10. In a few sentences, what are the key value tradeoffs that arise in comparing and selecting among the broad alternatives?

Figure 2. Example Questions to Sharpen Policy Relevance of STAR WW Projects

3.3.3 A More Systematic Approach to Evaluating Program Success

Although expert review may be the most effective means of evaluating a research program's quality and relevance, an additional method for evaluating the results of a research program is bibliometric analysis. (For a discussion of the strengths and weaknesses of this approach in the context of the Government Performance and Results Act, see NRC, 1999). If the Agency wishes to augment expert review with a measurement approach in the future, the Panel suggests that the Agency identify sets of metrics that are relatively easy to measure and that correspond to the specific program objectives to be achieved (e.g., see Table 3). This might be done in a variety of ways: for example, by asking grantees to explicitly address the question in their reports, or through questionnaires to stakeholders and Agency staff. Serious deliberation will be required to define measures that reflect STAR WW program objectives without themselves leading to unintended consequences.

The selection of program performance measures requires definition of "environmental protection" in terms of process (e.g., conforming with regulations, stakeholder groups developed, institutional developments); effective planning (e.g., preventing adverse impacts, ensuring sustainable natural resources); or environmental outcomes (e.g., restoration or remediation of perturbed systems). The types of metrics will differ depending on the goal, e.g., the audience to be influenced.

Table 3. Potential Evaluation Measures for the STAR WW Program

POTENTIAL STAR WW GOALS	POTENTIAL EVALUATION MEASURES			
INFLUENCE ON SCIENTIFIC COMMUNITY				
Scientific Productivity & Communication of Results	# of peer-reviewed publications	# of presentations	# of theses	availability and quality of results at URL sites
Utility to Other Researchers	# of times cited			
Creating a Body of Knowledge	# of publications that synthesize findings from multiple projects	# of STAR WW projects that address identified knowledge gaps		
Building Interdisciplinary Research Capacity	# of teams that undertake additional activities	# of researchers that participate in other interdisc. activities	# of STAR WW research teams doing research together 2 yrs after grant completion	
INFLUENCE ON DECISION-MAKERS				
Policy Relevance	# of publications that deal with applications	identification of national, regional, and/or local clients	citation of STAR results in guidance or regulatory documents	
Transferability	results used to support decisions in other watersheds			
Communication of Findings to Potential Users	quality and availability of web-based results			
INFLUENCE ON STAKEHOLDERS				
Stakeholder Acceptance and Use of STAR WW Tools	knowledge and use of STAR results by potential users (e.g., local watershed groups, county planners, NGOs within and outside of research watersheds	# of stakeholder web sites that reference STAR results	# of citations of STAR projects in stakeholder publications	# of communities served
RELEVANCE TO WATERSHED ASSESSMENT				
Enhanced Understanding of Ecological System Condition	landscape diversity	% non-native species	magnitude and variability of surface water flows	nutrient mass balance
Enhanced Understanding of Ecological System Stressors	habitat conversion	frequency and distribution of disease/pest outbreaks	turbidity/ sedimentation	acid deposition to terrestrial and aquatic systems

3.4 Integration of Ecological, Physical, and Social Sciences

Charge Question 3*: Is the requirement that grant proposals integrate ecological, physical and social sciences producing a unique body of research? Would funding each of the "circles" [in the Venn diagram] individually have the same outcome? Is the integrated approach so important that it is giving us new insights into decision making at the watershed scale?*

Summary Response*: Yes, the requirement to include ecological, physical and social sciences in most of the STAR Water and Watersheds projects to date has produced a unique body of research. The STAR WW program, both in its focus and its interdisciplinary nature, provides a source of research funding that is rare within federal research programs. Funding projects within the individual discipline groups (or "circles") would not have produced the same results. Most of the progress made by STAR WW projects occurred at the interface between disciplines and/or at the interface between scientists and stakeholders. In particular, the integration of socioeconomics and management issues into watershed research is a very encouraging, unique and beneficial aspect of the STAR WW program.*

The requirement to integrate social, physical, and biological sciences in each project appears, however, to be forcing too much homogeneity among projects while precluding some important areas of watershed research. The Panel recommends that future STAR WW Requests for Applications retain some, but not exclusive, emphasis on interdisciplinary projects, and that they allow the mix of disciplines to be determined primarily by the important science questions that need to be answered. A portion of program funding could be set aside to ensure support for projects that include social science research and one other of the discipline areas. Similarly, a portion of program funding might be reserved for a few large, multidisciplinary projects. For these projects, the Agency should consider providing planning grants, an increased level of funding, and longer grant periods, commensurate with the additional complexity of the proposed research.

3.4.1 Defining Integrated Research

An integrative approach to the study of watersheds is essential to progress in understanding how watersheds function and to developing management tools that will allow both humans and ecosystems to prosper. Further, an integrated understanding of both the complex sources of stressors and the multi-dimensional nature of how stresses are initiated and ultimately controlled, could only come from a strongly interdisciplinary research program. The Panel recommends that the STAR WW program continue, and that the interdisciplinary nature of the projects and the emphasis on projects with stakeholder involvement both be retained.

The Panel has some concern, however, that the STAR WW program's definition of "integration" in its recent RFAs, i.e., the intersection of three circles of a Venn diagram (Figure 1), may be too restrictive a definition of integrated watershed science. Interesting and important watershed science questions may be proposed within the intersection of two, rather than three, of the research categories. For example, the most productive areas of integration appear to be those at the interface of the ecological and social sciences, and the STAR WW may wish to fund such work even in the absence of physical research questions.

While the Panel feels that it is critically important to retain an integrative approach to watershed research within EPA, the current STAR WW definition of integrated research forces too much homogeneity among projects. As investigators struggle to fit their research programs within the intersection of the three designated discipline groups, the types of studies being done actually may be narrowed. While a number of the STAR WW researchers discussed how to conduct interdisciplinary projects and how to work with stakeholders, the Panel heard little discussion of the fundamental questions in watershed science or state-of-the-art hypotheses in any of the three designated disciplines. Absent a conceptual framework for integrating the required disciplines, most investigators apparently developed hypotheses within their discipline areas and combined them later. This resulted in projects with a clumping of disciplinary groups, but often without significant work at the intersection of the "circles." It appears that research excellence is being sacrificed somewhat to accommodate formation of large interdisciplinary teams.

The Panel applauds the STAR WW program for its efforts to bring together historically separate disciplines that generally act independently. However, the absence of an existing conceptual framework other than the Venn diagram to drive this research was a limitation. If an acceptable conceptual framework for these types of studies can be extracted from the existing project results (see Section 3.7.1), then it can be used to drive the next generation of funding. Until that time, the Panel recommends the following:

a) **Eliminate the requirement that every future project include all elements of the Venn diagram.**

The use of the Venn diagram to drive integration was a worthwhile aspect of previous funding efforts. It seems fair to say that this requirement drove innovation, even though the challenge of truly operating at the intersection of the three circles was not well met by the researchers. As the STAR WW program moves forward, however, the research program should be refocused around fundamental issues in watershed science, rather than on funding integrated research *per se*. Interdisciplinary research will probably still be common under this scenario.

Future RFAs should seek proposals that target specific technical needs identified by analyzing the existing STAR WW portfolio, and request project proposals that target known gaps in knowledge in ecological, physical, or social sciences. The option to address any subject area where researchers can show that end results will be utilizable both in a particular location and across watersheds should be open. The criteria for whether a study is eligible for funding also should include its potential to advance the overall practice of integrated research on watersheds.

b) **For the most complex interdisciplinary projects (e.g., Area 1 of the Venn diagram), consider the use of planning grants, an increased level of funding, and longer grant periods.**

Ambitious, innovative efforts such as the STAR Water and Watersheds program that seek to integrate research activities bring with them some risk that good science will be done, but not in a truly integrated fashion. Projects that focus on integration across the entire Venn diagram could benefit from a step in which they compete for small planning grants. These grants would be used to build a solid integrative proposal. This step would reduce the risks of failed approval of submissions for the researchers, and reduce the Agency's overall risk that supported research will not deliver on the promised integration.

In addition, interdisciplinary research requires more time and resources than more traditional disciplinary research because of the need to develop research teams and relationships, develop hypotheses that are informed by the perspectives of multiple disciplines, and conduct integrated analyses of research results. The Panel is concerned that the current STAR WW program may not provide either the time or funding necessary for such research. Projects of the complexity required by the recent STAR WW RFA have high overhead costs associated with project management that are not fully supported at the current level of funding and the quality of research appears to have suffered as a result. The most successful efforts are the ones where interdisciplinary groups were already in existence and STAR WW funding built on past and existing funding. This suggests that the funding level for STAR WW projects (approximately $1 million) is not high enough to fund integrated efforts by a large number of investigators, and/or that three years is not enough time to meet the program objectives when multi-disciplinary groups arise *de novo.*

If, as recommended above, the Agency relaxes the requirements on the extent of interdisciplinarity required, it may be possible to enhance the success of the more complex interdisciplinary projects by offering small planning grants, providing additional funding, allowing longer time frames for project completion, or by other means. The Panel supports the current Agency policy of providing no-cost extensions automatically at the first request, and potentially for a second year if there is progress with a possibility of renewal.

c) **Continue to encourage integration of social and natural science research by setting aside some portion of STAR WW funds for projects that integrate aspects of human systems with non-human components of watershed ecosystems.**

Physical and ecological scientists historically have worked together to do research on watersheds, and so the inclusion of social sciences in the STAR WW program in particular has added a valuable new perspective. In some cases, the social sciences requirement of the program has produced insights into decision-making on watershed management that would not have arisen from an ecological research focus alone. In other cases, however, the social science aspects of the projects seemed to be conducted in parallel, rather than being truly integrated, with the ecological research. Future projects

that include a social sciences component should both better integrate social and natural sciences and improve the quality of the social science component.

3.4.2 A Need for Integrated, Basic Research

The Panel believes that a primary motivator behind the current requirement for the inclusion of social science research in all STAR WW projects is the recognition of the influence of humans on watersheds and the desire to understand the linkages among human and natural systems. This understanding should lead to both policy relevant and integrated science insights. While it will usually be the case that integrated research will be more applicable to decision-making, integrated research is not synonymous with applied research. Even in the STAR WW scheme, there is a role for integrated, basic research on, for example, ecological system processes. While basic, integrated watershed science may not yield decision support tools or other applications in the near term, such research is critical in the longer term for improving our understanding of how ecological systems function.

The relationship between interdisciplinary research (including social, economics, ecological, and hydrological research) and applicability of research (including utility for stakeholders) can be used to define different categories of research (Figure 3). Populating different sectors of this integration-applicability space with STAR WW projects has been accomplished by the design of the RFA over the life of the program. In 1995, the STAR WW competition produced several disciplinary-basic research projects; whereas in 1996 interdisciplinary work was encouraged, moving the research effort towards integrated, basic (IB) projects and some integrated, applied (IA) projects. After 1997, RFA emphasis on both interdisciplinary and relevancy has driven the proposals in both directions towards the integrated, applied (IA) research quadrant (Figure 3) with slight variation in focus (e.g., restoration, TMDL).

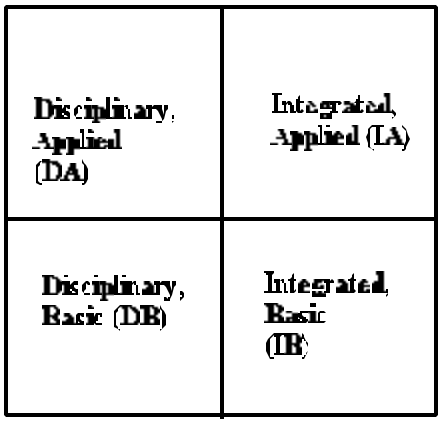

Figure 3. Interdisciplinary and Policy-Relevant Research

The current STAR WW program emphasis has resulted in interdisciplinary, applied research topics, but fewer IB projects are currently being conducted in STAR WW. It is important to recognize that science of types IB and disciplinary-applied (DA) should still attract the interest of the STAR WW program. Two examples come to mind: type IB projects to improve our basic understanding of the human or ecological processes being modeled are crucial to the success of the applicability and integration; and type IB projects that attempt to construct unified theoretical underpinnings of integrated watershed science are important, even though their applicability may occur at a later time.

3.5 Major Advancements or Breakthroughs

Charge Question 4*: As a result of the Water and Watersheds program, do we see any major advancements or breakthroughs in watershed science or interdisciplinary integration across the relevant disciplines?*

Summary Response*: The Panel did not see evidence of major breakthroughs in watershed science, but did conclude that STAR WW was producing valuable opportunities to link the natural and social sciences relevant to watershed assessment and management. Given the emphasis on interdisciplinary research, which requires additional time and effort by researchers, it may be too early to expect major advances in interdisciplinary integration. Advances from the currently funded projects are likely to take the form of integrated application of existing models and more refined decision tools for watershed management.*

3.5.1 Watershed Science

Based on the information provided by the Agency and the STAR WW researchers, it appears that the major advancements stimulated by the STAR Water and Watersheds Program have been largely in the form of new integration of traditional approaches to studying watersheds. Many of the projects combined watershed ecological or hydrological models with spatial information summarized using geographic information system (GIS) technologies. Often, the results of social assessments (e.g., surveys, stakeholder groups) were incorporated into this framework with the objective of developing decision support capabilities. Such integration likely will provide valuable support to decision-making and watershed management. However, examination of the individual project components (e.g., physical, ecological, or hydrological) failed to identify any significant breakthroughs or compelling intellectual advancements in the underlying science. The measures of water quality (e.g., nutrients, PCBs, *E. coli*), ecological integrity (e.g., biodiversity, Index of Biotic Integrity), and watershed processes, for example, appear to be fairly standard in concept and practice. The described modeling approaches either modify existing watershed models (e.g., HSPF), or develop traditional compartmental models (with their corresponding strengths and limitations). The spatial modeling approaches reported in several abstracted project descriptions have been used for about 10-15 years.

Given the emphasis on interdisciplinary integration, the ability of STAR WW to produce major advances in watershed science may not be the right measure of program success. The adaptation and application of models to different analysis scenarios and data sets, while a more incremental approach to science, is valuable nonetheless. For this approach to add up to a contribution to watershed science, however, there would have to be a conscious effort to bring the different models and results together and see what could be learned in the aggregate.

While acknowledging that it is likely too early to assess the extent to which the STAR WW program will produce breakthroughs in watershed science, it is timely to consider whether the program is configured so as to lead to this result in the longer term. In general, the STAR WW projects did not seem to have identified either gaps in watershed science or unanswered questions, which the project then targeted for study. Rather, teams of researchers seemed to have formed for the express purpose of seeking STAR WW funding. Thus, the capacity of the STAR WW program to produce advances in watershed science sometimes seemed limited by the way in which the teams were formed.

One important research issue highlighted by several of the STAR WW projects was the apparent mismatch between the scale of the hydrology models and the scale of the land use decisions, social institutions, and other aspects of the watershed. This showed up in the reliance on stream segment approaches, for example, in contrast to the more integrative concept of the "catchment." Having hydrological models focused on stream segments greatly reduces the capacity of these projects to contribute to advancing watershed science in a more interdisciplinary context, partly because of the mismatch in scales of analysis. This issue could be addressed in both the requirements stated in future RFAs and the evaluation criteria for proposal review.

3.5.2 Interdisciplinary Integration

As noted above, the development of interdisciplinary research teams takes time, and thus advancement in interdisciplinary work was most evident in cases where the research team and the project had been initiated prior to STAR funding. Sometimes the project, like the Baltimore Long Term Ecological Research (LTER) project, had been initiated several years before receiving STAR WW funding, but the STAR funding fit perfectly the kind of integrated, interdisciplinary work intended within an LTER site. Not surprisingly, teams put together specifically for STAR WW grants achieved less integration in their research. In presentations where individual researchers seemed to have conceptualized and worked on "their piece of the problem," then little integration was evident. In projects where the team pre-dated the STAR WW grant or specifically worked to focus on integrated results, then there was more evidence of integrated outcomes. Of course, while the Panel members listened to the presentations given at the STAR WW researchers' meeting in San Francisco and reviewed the written materials provided, what we could not know was the extent to which new relationships among interdisciplinary scientists were initiated or strengthened through STAR WW funding. The panel did see evidence that collaborations begun due to STAR WW funding requirements had been continued because they were interesting and useful to the researchers. On the whole, it seems that the STAR WW program is having a positive impact in moving toward more interdisciplinary approaches in watershed science, policy, and practice.

The Panel acknowledges the scarcity of publication outlets for interdisciplinary research. Yet, after reviewing the articles attributed to the STAR WW grants to date, it appeared that most of the publications were fairly traditional in scope and content. It is difficult to know if this is the result of the constraints of publication requirements or the result of scientists writing that which is most familiar to them. Either way there needs to be greater emphasis on developing publishable papers that are based on interdisciplinary contributions - not simply disciplinary pieces of the larger project - and attempts to

publish in the journals available to interdisciplinary work. This means that researchers have to figure out how to write together, a process that will greatly enhance their ability to work across disciplines.

An opportunity is also available in the form of a significant comparative "data base" of STAR WW projects for analysis. Whatever the suggestions for improved integration, these STAR WW projects represent a significant investment of research funding and researcher time and commitment. There is much to be learned by looking across the STAR WW projects in systematic ways. For example, the San Francisco researchers' meeting offered the opportunity to both engage researchers in dialogue across projects as well as to include the large number of watershed scientists, policy makers, and practitioners across all groups in a dynamic discussion. It was unfortunate that neither occurred given the time and cost of the meetings. The opportunity to take what has been learned from STAR WW projects to date and use it to refine or critique models or proposed policy interventions should not be lost.

3.6 Perception of STAR WW Within and Outside the Research Community

Charge Question 5*: How is the STAR WW program perceived within and outside the research community?*

Summary Response*: In general the Panelists felt that the data provided in the pre-meeting materials plus their experience at the STAR Progress Review did not provide a factual basis to assess how the STAR WW program is viewed by the rest of the research community. The Panel agreed, however, that a positive answer to this question would be a significant indication that the STAR WW funding was achieving its goal of expanding the appreciation of integrated research on watershed management. Measures of awareness and acceptance of STAR WW research could be developed as part of a more comprehensive evaluation of program success.*

In general the Panelists felt that the data provided in the pre-meeting materials plus their experience at the STAR WW Progress Review did not provide a factual basis to assess how the STAR WW program is viewed by the rest of the research community or by those outside the research community most likely to use the research findings. Based on its own experience, however, the Panel concluded that the STAR WW program likely is viewed as a valuable, and largely unique, source of funding to address key questions that need to be answered to manage and conserve watershed values. Some panelists also felt, from anecdotal data, that some members of the research community are struggling with the value of developing funding requests on such complex projects with low probability of success. That said, STAR WW publication lists and web citations described earlier demonstrate that respectable within-discipline research is being done. The dearth of "integrated" interdisciplinary publications may be a reflection of the relative scarcity of journals devoted to such papers, although there are journals, such as *Environmental Science and Technology*, that actively seek such papers.

With regard to the appreciation of the STAR WW work outside of the researchers involved, the Water and Watersheds research is more useful to local and state agencies, elected officials, and community stakeholders than to federal program managers. The appreciation of this work and its value, therefore, likely would be greatest among local stakeholders in the watershed and the regional authorities responsible for its management. This may well be appropriate, however, since many of the decisions that directly affect a watershed's ecological condition are made at the local and regional governmental levels. As with the research community, however, there was little reported on the measurement of awareness and satisfaction of stakeholders with the technical approaches employed by STAR WW researchers.

If the Agency wishes to understand the level of recognition and appreciation of STAR WW research, a systematic effort might be made to gain feedback from both the research and non-research communities. Over time, as STAR WW results are published in the peer reviewed literature and other researchers begin to cite them, it will be possible to assess the reaction of the general research community to the program. With regard to non-research communities, funded researchers could be

asked to collect this information as an assessment of their research at the local and regional level. For example, periodic questionnaires to community participants in the project, and potential users of the information and other researchers could provide a basis for evaluating a project's strengths and weaknesses. By compiling this information for all (or a subset of) projects, the value of the STAR WW program to the non-research community could be assessed.

3.7 Enhancing the Value of Current STAR WW Projects

The Panel concluded that the Agency could and should do more to extract value from the set of existing STAR WW projects. Suggested activities include supporting cross-project synthesis of findings on a variety of issues and enhancing communication of research findings to the larger research community and to potential users.

3.7.1 Cross-Study Evaluation of Projects

To its credit, the STAR program staff have already recognized the value of extracting knowledge from the STAR WW researchers as a group. The workshop and subsequent report on *lessons-learned*, for example, yielded some good generalizable information that can be used by future researchers. The STAR program should continue to extract knowledge from the entire set of WW projects by a more expanded cross-study evaluation. The Panel encourages periodic repetition of the "lessons learned" workshops as a means of distilling common themes and findings from STAR WW projects. It would be useful to have periodic workshops to critique and synthesize particular sets of tools (e.g., DSS, modeling approaches) so as to consolidate and make widely available (through publication and web dissemination) the collective wisdom of different approaches to problems that are being addressed by the research teams. An alternative approach would be to ask an organization such as the National Center for Ecological Analysis and Synthesis (a Center funded by NSF and the University of California) to have a working group target specific cross-cutting questions, compare the results of different research projects, and summarize and disseminate any conclusions that can be drawn. Contracting one person to do a peer reviewed synopsis or state-of-the-science report on a topic likely will not be adequate to the need.

Cross-project evaluations and synthesis of STAR WW findings should:

a) Identify major gaps in understanding or information (e.g., the need for a standard classification system for the aquatic ecosystems that comprise watersheds; the need for tools for comparative analysis of the Net Environmental Consequences of various watershed management options) that can be targeted in future grants.

b) Identify future watershed research priorities. The STAR WW research should not only create innovation at the margins of the integration between disciplines but should also highlight the principal scientific weaknesses in the elements of the experimental design and supporting models. Looking broadly across the STAR WW research projects and focusing on where there were barriers or limitations to successful integration would lead to identification of areas for future research funding. The researchers themselves are best able to identify those barriers and to provide a prioritized list of recommended basic research to improve the ability to integrate with confidence in the future.

c) Identify improvements in data collection, analysis and modeling in association with watershed science so that integration with social and economic disciplines can be optimized.

In addition, cross-project evaluations could be used to:

a) Develop a database that links STAR WW projects and associated public policy choices or decisions that the research findings will help to inform. (Input could be derived in part from researchers' responses to questions such as those included in Figure 2.) The database might be made accessible from a web site, and could provide links to the specific projects for those seeking more information.

b) Deduce the common elements of a framework for integrated watershed research that might provide the basis for defining and addressing fundamental interdisciplinary science questions important to the Agency. A trans-disciplinary conceptual model could be extracted by overlaying the designs of the various projects to identify the common elements and the sequence of their execution. This extracted framework could then be the backbone for further analysis of the work to identify gaps in knowledge.

c) Develop a best practices design manual for integrated assessments of watersheds that brings together lessons learned from STAR WW projects. Such a guide might include suggestions for project design and management, integrated analysis, stakeholder involvement, and so forth.

3.7.2 Building Capacity for Integrated Approaches

An important result of the STAR WW funding of integrated studies on watersheds should be that it builds capacity for design and execution of integrated studies and use of results to make decisions. In its current form, the program takes a very critical step towards advancing society's ability to manage watersheds in an integrated fashion. Additional, more aggressive efforts to communicate the results of the programs and formalize research networks would go a long way towards assuring that such integrated work is supported during the early stages of development.

The STAR WW program efforts to date have been useful in bringing together the principal investigators and some of their team members to share their research and experiences on the difficulties in working across disciplines. Yet, STAR WW managers and researchers could and should do more to ensure that results of the research are expeditiously disseminated in useful form to communities, and to business, government, and science sectors. Proposals should be encouraged to include a plan to disseminate results and tools in a useful form (e.g., in a web-compatible format for posting by the EPA or a research center with a durable web site, with documentation, and with training). While the Panel agrees that researchers have an obligation to publish in scientific journals, this should not be the sole means of communicating research results. The Agency also has a responsibility to further disseminate research findings and possible applications to watershed managers and decision-makers by, for example, organizing regional workshops, training, disseminating STAR WW materials on web sites, and developing state-of-the-science reports derived through multi-expert synthesis and peer review.

The Panel also urges the Agency and the STAR WW researchers to give attention to the application of results and external communication of results to decision-makers and practitioners in

agencies, organizations, etc. Grant reports should explicitly address how the results may be applied to watershed management problems. The potential for a grant to enhance watershed management not only in the geographic study area of the grant but elsewhere should be a significant factor considered in the evaluation of grant proposals, and transferability should be reassessed as results become available.

To improve dissemination of STAR WW results and build capacity for integrated approaches, the Panel suggests the following:

a) **Require Communication Plans**

The STAR program should require investigators to develop communication plans that include publication in the peer-reviewed literature, web-based products and summary documents for other scientists, EPA program managers, and the public, and production of working decision tools when that is a goal of the project. Project budgets should include the cost of an effective communication plan and therefore funding for these projects may need to be increased accordingly.

b) **Document DSS and Other Tools**

Many of the STAR WW researchers are developing decision support systems and other tools. Many researchers are also developing improvements to existing modeling techniques, or even in some cases new modeling techniques. If these grants are to have impacts to other watersheds outside the study area, it is essential that any tools and models developed be fully documented with adequate metadata so that they could be used elsewhere by a technically competent person not involved in the original project. The tools and models should be made freely available on the web by EPA, or at least be linked to EPA's web site if housed on a relatively permanent site elsewhere.

c) **Create Fora for Presentations of Integrated Research**

Professional societies or journals that are dedicated to the individual disciplines usually are not effective venues for individual submissions of highly integrated studies. Thus, the Agency might consider supporting special sessions dedicated to STAR WW integrated research at meetings of professional societies (e.g., Society of Environmental Toxicology and Chemistry, Ecological Society of America, or Society for Risk Analysis), or holding an annual STAR WW researchers' review in conjunction with an existing scientific meeting as a means of expanding the awareness of STAR research in the scientific community. The Agency also should support supplemental issues devoted to STAR WW research in journals dedicated to integrated studies.

d) **Integrate Intramural and Extramural Research**

EPA's mandate to strengthen the quality of internal science could be aided by finding ways to have EPA scientists and managers become more aware of WW projects and by strengthening interactions between Agency scientists and STAR WW researchers. One means of enhancing the integration of the Agency's intramural and extramural research programs relating to watersheds would be to use more effectively the annual STAR WW researcher meetings. There were few EPA

researchers present at the STAR WW meeting attended by the Panel. The Agency should consider a different format for the meetings that focuses researchers on lessons learned, innovations, and breakthroughs (even minor) in thinking and research. The target audience for the meetings should be broadened to include EPA researchers, regional program offices, and state and local regulators, as well as interested researchers from watershed programs in other agencies (e.g., U.S. Geological Survey's National Water-Quality Assessment Program–NAWQA). Another means of enhancing awareness of STAR WW research within the Agency would be to bring "best practice" STAR WW researchers into the EPA regional and program offices to present research applicable to the particular offices (e.g., research conducted in specific regions could be presented to that EPA regional office).

To increase engagement in scientific communities, the Agency should support greater interaction between STAR program managers, funded STAR researchers, and others in the research communities, including greater participation by STAR program managers in national and international scientific meetings. Greater interaction with the scientific community will enhance the value of STAR managers to synthesize program results and to disseminate that information to management and regulatory communities.

e) **Consider Establishing Formalized Research Networks**

At this point there does not appear to be a formal mechanism to regularly bring researchers interested in the integrated assessments together in a trans-disciplinary meeting. Creating a standing research network and a web-based clearinghouse could stimulate such regular and formal interaction, both physically and virtually. The STAR WW program, either on its own or in partnership with NSF or others, could fund the development of formal networks. NSF, for example, has funded a network called *ecological circuitry*. The NSF network is designed to bring together both the thought leaders in an area and their graduate students to work on common projects. Although there is a lead organization that coordinates the network, the staff of the organizations physically spend time at other network member facilities. The NSF network may not be as interdisciplinary as the integrated watershed research might demand, but it should serve as a worthwhile model to consider. Given the fact that many of the STAR projects have a local to regional flavor, STAR WW also might organize networks on a regional (e.g., Northwest) or on an ecotype (e.g., arid lands, forested watershed) basis.

f) **Support Web-based Distribution of Information Related to STAR WW Studies**

The STAR program should facilitate the communication of both the results of individual projects as well as the results of lessons learned via the Internet. This facilitation could occur either by setting the expectation as part of the individually funded projects or such web-based systems could be established as part of the scope of any research networks. The web-based system can act as a clearinghouse of information on best practices, tools, and other lessons learned.

4. SUMMARY RECOMMENDATIONS

Charge Question 6: *What changes would [the Panel] recommend to the [STAR WW] program managers?*

Based on the materials provided by the Agency, and the STAR WW researcher presentations in San Francisco, the Panel suggests a number of mid-course correction to the STAR WW program. These recommendations are discussed in the previous sections in response to the charge questions and summarized below:

Recommendation 1: The Panel strongly recommends that STAR WW be retained as a major, focused program within EPA (see Section 3.1).

Recommendation 2: In order to meet the Program's stated objectives, the Panel recommends that STAR WW Requests for Applications focus more on fundamental issues in watershed science, rather than on funding integrated research *per se*. Interdisciplinary research will probably still be common under this scenario. Specifically, the Agency should:

a) Pursue a more balanced approach to addressing the program's objectives. The Panel notes that STAR WW projects have focused primarily on anthropogenic processes, water quality issues, biotic integrity measures, and human-dominated systems. The Panel recommends placing additional emphasis on natural systems and reference conditions, on the understanding of water quantity issues, and on ecosystem processes and dynamics related to the maintenance of native communities and species. (See Section 3.2)

b) Retain some, but not exclusive, emphasis on interdisciplinary projects, and allow the mix of disciplines to be determined by important and relevant science questions that need to be answered. In particular, replace the Venn diagram with a broader definition of interdisciplinary research, and fund projects that only include one or two disciplines if the projects address important gaps in our understanding of watersheds. Within these guidelines, continue to emphasize the integration of social sciences with ecological research. (See Section 3.4)

c) For a small number of particularly complex, truly integrated, multi-disciplinary projects, consider the use of planning grants, an increased level of funding, and longer grant periods. (See Section 3.4)

Recommendation 3: The Panel believes that benefits from the existing STAR WW research grants and practical application of research results could be significantly enhanced (see Section 3.7). Steps to do this include:

a) Cross-study evaluations to analyze and synthesize the results of groups of projects (e.g., through convened panels of internal and external scientists);

b) Disseminate research results in useful forms (e.g., peer-reviewed literature, web-based products, simplified glossy products) to business, government, and science sectors;

c) Improve delivery of extramural research results to Agency scientists and program managers;

d) Continue to build capacity for trans-disciplinary work related to the Agency's mission by, for example, enhancing inter-disciplinary and inter-project thinking and communications; and

e) Provide support for fuller engagement of EPA STAR program managers in relevant scientific and management communities, and for increased interaction with funded scientists.

Recommendation 4: If the Agency desires a more methodical measure of STAR WW benefits in the future, the Panel suggests that the Agency identify sets of measures that correspond to the specific program objectives to be achieved, then determine means of gathering information on the measures. The Panel provides examples of such measures in this report. (See Section 3.3.3)

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APPENDIX A: SUMMARY OF PROJECTS FUNDED BY THE STAR WATER AND WATERSHEDS PROGRAM

(Source: NSF-EPA Partnership for Environmental Research web site at www.nsf.gov/home/crssprgm/ unless otherwise noted. *Source: EPA/ORD)

1995 STAR Water and Watersheds

PROJECT TITLE	Principal Investigator(s), Institution	State	NSF Number	EPA/ USDA Number	Funding ($)
A Comparative Institutional Analysis of Conjunctive Management Practices Among Three Southwestern States	Edella C. Schlager University of Arizona School of Public Administration and Policy	AZ	9524483	EPA R824781	198,000
A Comparison of Agricultural vs Forested Basins: Carbon and Nutrien Cycling within the Hyproheic Ecotone of Streams	David S. White Murray State University Hancock Biological Station	KY	9524721	EPA R824786	300,000
Alternate States and Ecosystem Metabolism in Lakes: Interactions of Nutrients and DOC	James F. Kitchell University of Wisconsin, Madison	WI	9509595		763,403
An Ecoregion-Specific Comparison of Stream Community Responses to Nutrient Gradients Using Both Survey and Experimental Approaches	Robert Jan Stevenson University of Louisville Department of Biology	KY	9524759	EPA R824783	376,200*
Carbon Exchange Dynamics in a Temperate Forested Watershed: A Laboratory and Field Multidisciplinary Study	Lynn Walter University of Michigan Department of Geological Sciences	MI	9524454	EPA R824978	800,000*
Characterization of Metal Ion Complexation and Aggregation of Humic Substances	W. Robert Carper Wichita State University Chemistry Department	KS	9524865		143,001
Characterization of Metal Ion Complexation and Aggregation of Humic Substances	Cynthia K. Larive University of Kansas, Lawrence Chemistry Department	KS	9524514		221,401
Contemporary Water and Constituent Balances for the Pan-Arctic Drainage System: Continent to Coastal Ocean Fluxes	Bruce J. Peterson Marine Biological Laboratory	MA	9524740		959,987

Detecting Fecal Contamination and Its Sources in Water and Watersheds	Mark D. Sobsey University of North Carolina, Chapel Hill Department of Environmental Sciences and Engineering	NC	9524535	EPA R824782	400,000
Development and Application of Spectroscopic Probes for Measurement of Microbial Activity in Aquatic Ecosystems	Carol Arnosti University of North Carolina, Chapel Hill Curriculum in Marine Sciences	NC	9524268	EPA R825159	405,811*
Development of Geomorphological Artificial Neural Networks (GANNs) for Modeling Watershed Runoff	Rao S. Govindaraju Kansas State University	KS	9524758		
Diffusion Rate Limitations in Heterogeneous Porous Media: Model Structure, Scale and Geologic Characterization	David L. Freyberg Stanford University Department of Civil Engineering	CA	9524430	EPA R824768	198,000
Environmental Change and Adaptive Resource Markets: Computer-Assisted Markets for Water Allocation	Vernon L. Smith University of Arizona	AZ	9409525		
Fluvial Responses to Climate Change and Human Activities in Burgundy, France	Michael D. Blum Southen Illinois University	IL	9506643		9,960
Formation and Propagation of Large-Scale Sediment Waves in Periodically Disturbed Mountain Watersheds	Gary Parker University of Minnesota St. Anthony Falls Hydraulic Lab	MN	9524358	EPA R824779	280,000
Geomorphic, Hydrologic and Ecological Connectivity in Columbia River Watersheds: Implications for Endangered Salmonids	Hiram W. Li Oregon State University Department of Fisheries and Wildlife Patricia F. McDowell University of Oregon Department of Geography	OR	9524854	EPA R824773 + R824774	891,052*
Influences of Watershed Land Use on Stream Ecosystem Structure and Function	Judy L. Meyer University of Georgia Institute of Ecology	GA	9524819	EPA R824777	500,000

In-Situ Assessment of the Transport and Microbial Consumption of Oxygen in Groundwater	Tadashi Yoshinari New York State Department of Health Wadsworth Center Research Laboratories	NY	9524305	EPA R824787	346,500*
Integrated Ecological Economic Modeling and Valuation of Watersheds	Robert Costanza University of Maryland - Center for Environmental Science Chesapeake Biological Lab	MD	9525573	EPA R824766	997,000*
Integrating Planning, Forecasting, and Watershed Level Ecological Risk Assessment Techniques: A Test in the Eastern Cornbelt Plains Ecoregion of Ohio	Steven I. Gordon Ohio State University Department of City and Regional Planning	OH	9524398	EPA R824769	445,000
Modeling Temporal Rainfall via a Fractal Geometric Approach	Carolos E. Puente University of California, Davis Land, Air & Water Resources Hydrologic Science Program	CA	9524755	EPA R824780	198,000
Norwalk Virus-Like-Particles (VLPs) for Studying Natural Groundwater Disinfection	Mary C. K. Estes Baylor College of Medicine Division of Molecular Biology Stanley B. Grant University of California, Irvine Department of Civil and Environmental Engineering	TX CA	9524481	EPA R824775 + R824770	700,000*
Resistance of Communities to Chronic Haloaromatic Contamination from Biogenic and Anthropogenic Sources	David E. Lincoln University of South Carolina Department of Biological Sciences	SC	9524703	EPA R824776	465,300*
Response and Compensation to a Bivalve Invasion by an Aquatic Ecosystem	David L. Strayer Institute of Ecosystems Studies	NY	9508981		900,000

Scaling Up Spatially Distributed Hydraulic Models of Semi-Arid Watersheds	David G. Tarboton Utah State University Department of Civil and Environmental Engineering	UT	9524405	EPA R824784	330,000
The Role of Colloidal Particles in the Transport of Chemicals through an Agricultural Watershed	George M. Hornberger University of Virginia Department of Environmental Sciences	VA	9524352	EPA R824772	500,000
The Role of Hg(II) Reduction and Chemical Speciation in Controlling the Concentration of Mercury and its Methylation in Natural Waters	Francois M. M. Morel Princeton University Department of Geological and Geophysical Sciences	NJ	9524644	EPA R824778	349,950
The Role of Ling-Lived Zooplankton Diapausing Eggs Response and Recovery of Impacted Lakes	Nelson G. Hairston, Jr. Cornell University Ecology and Systemics	NY	9524583	EPA R824771	350,000
The Role of Oyster Reefs in the Structure and Function of Tidal Creeks	Eric T. Koepfler Coastal Carolina University	SC	9509057		405,000
Towards a Model of the Biogeochemistry of Large-Scale River Basins: An Application to the Pacific Rim	Jeffrey E. Richey University of Washington, Seattle	WA	9524524		93,260
Tracing the Fate of Nitrogen Inputs from Watersheds to Estuaries	Linda A. Deegan Marine Biology Laboratory Ecosystems Center	MA	9524297	EPA R824767	230,000*
Traveling Wave Behavior During Subsurface Transport of Biologically Reactive Contaminants: Implications for In-Situ Bioremediation	Albert J. Valocchi University of Illinois, Urbana-Champaign Department of Civil Engineering	IL	9524432	EPA R824785	200,000
Variability of Dissolved Trace Elements in Rivers and Streams: Seasonal Redox Effects	Alan Shiller University of Southern Mississippi	MS	9508199		50,000
Water and Sustainable Development in the Binational Lower Rio Grande/Bravo Basin	Jurgen Schmandt Houston Advanced Research Center for Global Studies	TX	9524748	EPA R824799	785,539*

Watersheds and Wetlands: Large Scale Disturbances and Small Scale Responses	Charles Cole Pennsylvania State University Environmental Resources Research Institute	PA	9524350	EPA R824905	742,079*

1996 STAR Water and Watersheds

PROJECT TITLE	Principal Investigator(s), Institution	State	NSF Number	EPA/ USDA Number	Funding ($)
An Integrated Approach to Assessing Water Management Options in Major Watersheds: Extending a Hydrodynamic, Water Quality Model to Include Biological and Politico-Economic Components	Paul A. Sabatier University of California, Davis Division of Environmental Studies	CA		EPA R825285	1,292,627
Effectiveness of Regulatory Incentives for Sediment Pollution Prevention: Evaluation Through Policy Analysis and Biomonitoring	Seth Reice University of North Carolina, Chapel Hill Department of Biology	NC		EPA R825286	556,981
Geochemical, Biological, and Economical Effects of Arsenic and Other Oxyanions on a Mining Impacted Watershed	Glenn C. Miller University of Nevada, Reno Department of Environmental and Resource Sciences	NV	9613472	EPA R825289	767,805
Influence of Forest Fragmentation on Watershed Functions in Northern Vietnam	A. Terry Rambo East-West Center Program on Environment	HI	9613613		418,749
Integrated Urban Watershed Analysis: The Los Angeles Basin and Coastal Environment	Richard Turco University of California, Los Angeles Institute of the Environment	CA		EPA R825381	1,200,000
Integrating Modeling and Management of Agriculturally-Impacted Watersheds: Issues of Spacial and Temporal Scale	Patrick Brezonik University of Minnesota Water Resources Research Center and Department of Civil Engineering	MN		EPA R825290	813,085
Modeling Effects of Alternative Landscape Design and Management on Water Quality and Biodiversity in Midwest Agricultural Watersheds	Mary Santelmann Oregon State University Department of Geosciences	OR		EPA R825335	1,228,521
Strategic Renewal of Large Floodplain Rivers	John B. Braden University of Illinois, Urbana-Champaign	IL	9613562		291,511

Streamside Reforestation: An Analysis of Ecological Benefits and Societal Perceptions	Bernard W. Sweeney Academy of Natural Sciences Stroud Water Research Center	PA	9613588		940,000
Toward and Integrated Regional Model of River Basins of the Pacific Rim	Jeffrey E. Richey University of Washington School of Oceanography	WA	9613370		50,000
Urban Stream Rehabilitation in the Pacific Northwest - Physical, Biological, and Social Considerations	Stephen Burges University of Washington, Seattle Department of Civil Engineering	WA		EPA R825284	663,020
Watershed Protection in Agricultural Environments: Integrated Social, Geomorphological, and Ecological Research to Support Ecosystem-Based Stream Management	Bruce L. Rhoads University of Illinois, Urbana-Champaign Department of Geography	IL	9612958	EPA R825306	350,000

1997 STAR Water and Watersheds

PROJECT TITLE	Principal Investigator(s), Institution	State	NSF Number	EPA/ USDA Number	Funding ($)
A Study of Effects of Natural and Anthropogenic Processes on Tillamook Bay and its Watershed: An Integrated Process Study and Land-Use Perspective	James McManus Oregon State University College of Oceanic and Atmospheric Sciences	OR		EPA R825751	749,995
An Integrated Ecological and Socio-Economic Approach to Evaluating and Reducing Agricultural Impacts on Upper Mississippi River Watersheds	Prasanna H. Gowda University of Wisconsin, La Crosse Biology/Microbiology	WI		EPA R825761	650,921*
An Integrated Watershed Approach to Evaluate and Model Ecosystem Effects of Erosion and Pollutant Transport in Urbanized Subalpine Landscapes	Charles R. Goldman University of California, Davis Environmental Studies	CA		EPA R826282	879,376
Community Values and the Long-Term Ecological Integrity of Rapidly Urbanizing Watersheds	M. Bruce Beck University of Georgia; Warnell School of Forest Resources	GA		EPA R825758	849,999
Comprehensive Watershed Management: A Spacial Water Quality Assessment System (SWQAS)	C. Gregory Knight Pennsylvania State University	PA	9726863		475,106
Connecting Ecological and Social Systems: Watershed Research Relating Ecosystem Structure and Function to Human Values and Socioeconomic Behaviors	Gaboury Benoit Yale University	CT	9726861		795,000
Development and Implementation of Decision Support Systems for Predicting Economic and Ecological Impacts of Alternative Land and Water Management Policies in Urbanized Regions	Daniel P. Loucks Cornell University	NY	9726860		258,292
Ecological Risks, Stakeholder Values and River Basins: Testing Management Alternatives for the Illinois River	Mark Meo University of Oklahoma Science and Public Policy Program	OK		EPA R825791	849,996
Impact of Social Systems on Ecology and Hydrology in Urban-Rural Watersheds: Integration for Restoration	Steward T. A. Pickett Institute of Ecosystem Studies	NY		EPA R825792	999,932

Integrated, Ecological-Economic Modeling of Watersheds and Estuaries at Multiple Scales	Charles S. Hopkinson Marine Biological Laboratory Woods Hole	MA	9726862		815,000
Landscapes and Waterscapes: An Integrating Framework for Urbanizing Watersheds	Panos Diplas Virginia Polytechnic Institute and State University Department of Civil Engineering	VA		EPA R825760	849,266
Linking Watershed-Scale Indicators of Changes in Atmospheric Deposition to Regional Response Patterns	Jeffrey S. Kahl University of Maine Water Research Institute	ME		EPA R825762	623,395
Risk Based Urban Watershed Management - Integration of Water Quality and Flood Control Objectives	Vladimir Novotny Marquette University Department of Civil Engineering	WI		EPA R825759	827,745*
Social and Ecological Transferability of Integrated Ecological Assessment Models	Linda A. Deegan Marine Biological Laboratory Ecosystems Center	MA		EPA R825757	850,575

1998 STAR Water and Watersheds

PROJECT TITLE	Principal Investigator(s), Institution	State	NSF Number	EPA/ USDA Number	Funding ($)
An Integrated Systems Approach to Watershed Restoration with Community Involvement Applied to a Small Rural Watershed	J. Boll University of Idaho	ID		USDA 9801	362,300*
Combining Economics and Ecological Indicators to Prioritize Wetlands Restoration Projects within a Spatial GIS Framework	James J. Opaluch University of Rhode Island	RI	9900678		475,000
Developing Methods and Tools for Watershed Restoration: Design, Implementation, and Assessment in the Willamette Basin, Oregon	John Bolte Oregon State University	OR		EPA R827146	809,993
Development and Testing of a Decision Support System for River Restoration	J. David Allan University of Michigan	MI	9900679		9,645
Development of an Integrated Scientific and Technological Framework for Stream Naturalization	Bruce L. Rhoads University of Illinois	IL		EPA R827148	881,913
Development of an Urban Watershed Rehabilitation Method Using Stakeholder Feedback to Direct Investigation and Restoration Planning	Marty Matlock Texas A & M University	TX		EPA R827147	838,767
Integrating Models of Citizens Perceptions, Metal Contaminants and Wetlands Restoration in an Urbanizing Watershed	Robert K. Tucker Stony Brook-Millstone Watershed Association	NJ		EPA R827288	749,954
Integrating Salmon Habitat Restoration and Flood Hazard Initiatives: Societal/Biophysical Estimators for the Cedar River and Implications for Regional Rivers	Robert C. Wissmar University of Washington, Seattle	WA		EPA R827149	749,991
Restoring and Maintaining Riparian Ecosystem Integrity in Arid Watersheds: Meeting the Challenge through Science and Policy Analysis	Thomas Maddock University of Arizona	AZ		EPA R827150	849,638
Social Impact Assessment of Human Exposure to Mercury Related to Land Use and Physical Chemical Settings in the Mobile-Alabama River Basin	Jean-Claude Bonzongo University of Alabama	AL		EPA R827168	804,534

Understanding the Social Context of Ecological Restoration in Multiple Watersheds	Steve Kraft University of Southern Illinois	IL		USDA 9802	878,360*
When Do Stakeholder Negotiations Work?	Paul Sabatier University of California, Davis	CA		EPA R827145	149,935
Whole Watershed Health and Restoration: Applying the Patuxent and Gwynns Falls Landscape Models to Designing a Sustainable Balance Between Humans and the Rest of Nature	Robert Costanza University of Maryland	MD		EPA R827169	699,916

1999-2000 STAR Water and Watersheds

PROJECT TITLE	Principal Investigator(s), Institution	State	NSF Number	EPA/ USDA Number	Funding ($)
Alternative Urbanization Scenarios for an Agricultural Watershed: Design Criteria, Social Constraints, and Effects on Groundwater and Surface Water Systems	Richard C. Lathrop Wisconsin Department of Natural Resources	WI		EPA R828010	886,105
An Acre an Hour: Documenting the Effects of Urban Sprawl on a Model Watershed in Philadelphia, Pennsylvania	Claire Welty Drexel University	PA	0001884		464,012
Identification and Control of Non-Point Sources of Microbial Pollution in a Coastal Watershed	Synnove F. Knutsen University of California	CA		EPA R828011	895,234
Integrating Coral Reef Ecosystem Integrity and Restoration Options with Watershed-based Activities in the Tropical Pacific Islands and the Societal Costs of Poor Land-use Practices	Robert H. Richmond University of Guam Marine Laboratory	GU		EPA R828008	795,249
Linking Environmental and Social Performance Measurement for Management at National and Watershed Levels: Modeling and Statistical Approaches	Scott Farrow Carnegie Mellon University	PA		EPA R828021	649,864
Strategic Renewal of Large Floodplain Rivers: Integrated Analysis	Richard Sparks University of Illinois, Champaign-Urbana	IL	0003208		1,090,000
Targeting Decisions to Reduce Risk in Agricultural Watersheds: Effective Nutrient Management Through Local Implementation	D. J. Mulla University of Minnesota, St. Paul	MN		USDA 9901	75,377*
The Impact of Lawn Care Practices on Aquatic Ecosystems in Suburban Watersheds	Kevin Armbrust University of Georgia, Griffin	GA		EPA R828007	893,849
Watershed Scale Assessments of E. coli Contamination: Implications of Source Identification for Public Policy Debate	Ronald F. Turco Purdue University	IN		USDA 0001	892,270*
Pulses - The Importance of Pulsed Physical Events for Watershed Sustainability in Coastal Louisiana	John W. Day Louisiana State University	LA		EPA R82-8009	899,995*

The Spatial Patterning of Land Use Conversion: Linking Economics, Hydrology, and Ecology to Evaluate the Effects of Alternative Future Growth Scenarios on Stream Ecosystems	Margaret A. Palmer University of Maryland/College Park	MD		EPA R82-8012	1,125,212*
An Integrated GIS Framework for Water Reallocation and Decision Making in the Upper Rio Grande Valley.	Paul Olen Mattews University of New Mexico	NM		EPA R82-8070	410,000*