B·O·S·C

BOARD OF SCIENTIFIC COUNSELORS

REVIEW OF THE OFFICE OF RESEARCH AND DEVELOPMENT'S WATER QUALITY RESEARCH PROGRAM AT THE U.S. ENVIRONMENTAL PROTECTION AGENCY

Final Report

BOSC SUBCOMMITTEE ON WATER QUALITY RESEARCH

Dr. Herbert Windom (Chair), Skidaway Institute of Oceanography
Dr. Gary Sayler (Co-Chair), Center for Environmental Biotechnology, U. of Tennessee
Dr. Christian Chauret, Indiana University Kokomo
Dr. Laura Ehlers, National Academy of Science
Dr. Kevin Kleinow, Louisiana State University
Dr. Judith Meyer, Institute of Ecology University of Georgia
Dr. Stephen Weisberg, Southern California Coastal Water Research Project Authority

EPA Contact
Dr. Bernice Smith, Designated Federal Officer
U.S. Environmental Protection Agency

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I. SUMMARY

The Executive Committee of the Board of Scientific Counselors (BOSC) of the Office of Research and Development (ORD) within the U.S. Environmental Protection Agency (EPA) has agreed to undertake a series of reviews of major EPA research programs. It accomplishes this by forming Subcommittees having appropriate expertise for the specific program. This report is a BOSC review of ORD's Water Quality Research Program (WQRP). The members of the Water Quality Subcommittee are listed in Appendix A.

This program review was structured to address a number of charge questions that relate to Program relevance, quality, performance, leadership, and coordination/communication. To facilitate this review, the Subcommittee was provided a number of presentations on the goals, management, and research of the Program. The Subcommittee members also heard a number of presentations and reviewed a number of posters prepared by Program staff related to research activities, accomplishments, and user application. Presentations also were provided by major clients of the Program.

The overall impression of the Subcommittee is that the WQRP is addressing its goals in an efficient and effective manner and that this research contributes significantly to the strategic goals of the EPA. Based on the testimonials of its major clients, the Program is providing them with needed technical support and products for environmental management. The Program is providing leadership in the area of water quality research focused on management and it has a diverse and competent staff, which is commended for its work.

The Subcommittee has high regard for this Program but provides, as an outcome of this review, 25 specific recommendations (summarized in Table 1) for consideration by EPA to maintain and enhance Program performance. Although the Subcommittee members believe that all of the recommendations, if adopted, will lead to improvements, the following recommendations rise to a more important level:

- **A more transparent approach to prioritizing research is recommended. This should be provided in the next update to the Multi-Year Plan (MYP). The prioritization should consider the following questions:**
  - Does the research have national versus regional or local significance?
  - Does the research provide the best return in terms of products and outcomes for the investment?
  - Is the research logically related to prior research endeavors and, when applicable, will its performance result in a "finished" usable product?
  - Will implementation result in a high impact improvement in the environment?

This explicit list of questions (some of which already are addressed in the MYP) could serve a purpose both for incorporating new research into the Program as well as removing research projects if resources diminish.

- **An annual accounting of Program outcomes is needed that includes the following six metrics:**

  - Research activities completed by a specified date.
  - Research results published in papers, reports, or otherwise made available.
  - Transfer and communication of report results.
  - Institutional outcomes.
  - Management outcomes.
  - Environmental outcomes.

- **The exploratory part of the Science To Achieve Results (STAR) Program should be reinstated and made sustainable. This is necessary to keep the WQRP "fresh" and flexible to confront emerging issues.**

- **The Program should continue to improve partnering and collaboration, particularly with the states.**

- **The MYP needs considerable improvement if it is to better communicate the goals of the Program as it is intended. It needs to communicate where the Program has been, where it is now, and where it is going.**

- **Biosolids should not be elevated to a Long-Term Goal (LTG). This research should be subsumed either in LTG 3 or under the same structure as other pollutant sources in the frameworks for LTGs 1, 2, and 3.**

Comments on various aspects of the Program along with the 25 specific recommendations are summarized in Table 1. These are organized according to the major topics of the review. Comments are numbered to correspond with the charge questions (see Appendix B) under each topic and provide a context for the corresponding recommendations. Because there are elements of redundancy in the charge questions there also is some redundancy in the comments in the table and in the body of the report. For detailed comments and background for the recommendations, the reader is referred to the body of the report.

The Subcommittee appreciates the great amount of effort that ORD's WQRP staff put into preparing for this review and their helpful interaction during the process. The Subcommittee also acknowledges, with great gratitude, the logistical/organizational assistance of our Designated Federal Officer for this review, Dr. Bernice Smith.

Table 2 summarizes the meetings in which the Subcommittee participated.

Table 1. Summary of Subcommittee Comments and Recommendations

RELEVANCE	
Comments: **1.** The WQRP appropriately addresses EPA's Goal 2 (Clean and Safe Water) by creating the tools necessary for the Office of Water (OW) to establish water quality criteria and respond when those criteria are not being met. The Program is responsive to OW, which the Program has identified correctly as its primary client, in developing its research priorities. This is reflected in the MYP, which is organized along the lines of the Total Maximum Daily Load (TMDL) paradigm.	**Recommendations:**
2. Much of the Program's research is being implemented regionally rather than nationally. The Program has an ecosystem classification research Program to define critical boundaries for developing indicators and criteria, but results from that effort have not been incorporated into its research planning.	The MYP should include a strategy for evaluating each of the criteria and tools it develops in multiple ecoregions, based on findings from the ecosystem classification research.
There is a reasonable, though imperfect, relationship between the MYP and the specific research projects presented to the Subcommittee. The multi-year planning process appears to be in the early part of a learning curve about how to prepare these plans.	The MYP should develop a better system for tracking progress on LTGs by developing a clearer linkage between Annual Performance Measures (APMs), Annual Performance Goals (APGs), and LTGs.
The ability of the Program to respond to emerging issues generally depends on its ability to maintain a core research competency and to continue to diversify its workforce as staff members retire. Exploratory research competency also is achieved through extramural funding, fellowships, and collaboration.	
3. The Program has maintained a core competency while diversifying the expertise of its work force over the last decade, but collaboration with external researchers needs to remain a key component in implementing emerging issue research. The STAR Program is an appropriate means for ORD to address areas of emerging concern, but the Program has become too proscriptive.	The Program should strive to maintain its core competency in water quality research. Exploratory research should be encouraged more and made to be a sustainable part of the STAR Program.

QUALITY	
Comments: **1.** The Program ensures quality through competitive and merit-based funding by selection and review of topics for Requests for Applications (RFAs) using Research Coordination Teams (RCTs) from across ORD. These RFAs are advertised through a number of appropriate mechanisms.	**Recommendations:** The Program should establish a more systematic use of external reviews for RFAs. A better link to the grant program Web pages from EPA's main page is recommended.
2. The Program follows procedures laid out in EPA's *Peer Review Handbook* to ensure the quality of its work products. Examples demonstrate the use of an appropriate mix of external and internal reviewers in the process.	A combination of external and internal peer review of Program products should continue to be used. Collaboration with other agencies in the review of Program products should be encouraged whenever appropriate to ensure their quality.
PERFORMANCE	
A. Program Design **Comments:** **1.** The Program design is based logically on EPA's mission, the mission of the WQRP, informational needs of clients, including states, regions, other EPA programs and offices, federal research partners, municipalities, and the private sector. The MYP and LTGs 1, 2, and 3 are a logical approach to providing research activities and products in support of the mission and parallel the sequence of events found in the TMDL framework. LTG 4 originated from external National Research Council (NRC) recommendations and although it provides research products of importance, it does not follow the logic of the previous goals nor does it rise to their scope.	**Recommendations:** Biosolids should not be elevated to an LTG. This research should be subsumed under the same structure as other pollutant sources as in the frameworks for LTG 1, 2, and 3 or included in LTG 3.
The Program design articulates activities that address environmental protection and restoration but does not articulate well the significant proactive protective research activities that are evident in the WQRP.	Program design should articulate more clearly the proactive aspects of the WQRP.
2. Program priorities as well as goals are based on impact, sensitivity (environmental response), and scientific uncertainty related to a stressor and are in response to a variety of external (to ORD) inputs and are refined by RCTs across ORD.	Prioritization based on impact, sensitivity, and uncertainty should be continued, but national versus regional significance, scaling according to anticipated completion of projects, and the relationship between existing and emerging topics also should be taken into account.

	Specific questions addressed in the prioritization process should be stated more clearly. A more transparent history of research progression should be provided in planning documents to allow for ongoing management overview and prioritization.
3. The Program fills a number of intellectual gaps and supplies a variety of tools necessary for implementation of the Clean Water Act (CWA) as related to the various uses of the nation's waters. The rationale for such an approach is developed and articulated clearly on the Program scale. Individual research projects have been organized around specific goals to which they apply, but the linkage between them (i.e., their place in specific lines of inquiry) is articulated inconsistently.	Clearly articulate the linkage between research from the Program (i.e., LTG) level down to and among individual projects.
4. Research performed, underway, and planned is sequenced clearly within the timeframe of the MYP LTGs as defined by the APGs and APMs. The existing MYP, however, does not provide timelines for the accomplishment of specific research (i.e., an APM) that links it to past or planned research.	Program plans should indicate where a line of inquiry has been, where it is now, and where it is going to better determine if the research is sequenced appropriately and relevant to current and future needs.
5. The Program's client needs are anticipated by several mechanisms and subsequently are reflected in the research planning process. Research needs are anticipated primarily by direct communication between the Program and its clients.	Mechanisms of communication and input at multiple levels are applauded. The Subcommittee encourages this and recommends that the Program institutionalize a more systematic approach to communicating with clients.
6. Criteria already in place for prioritization, such as stressor impact, environmental sensitivity, and scientific uncertainties, are well founded. Other items, such as political and budgetary inputs, are a given. Program improvement, however, might be realized by consideration of additional criteria in prioritizing research.	Additional prioritization criteria that are recommended include: national versus regional or local significance, return in terms of products and outcomes versus investment, relation to prior research, and anticipated impact.
B. Program Progress **Comments:** **1.** Although it is difficult to make a one-to-one correspondence between accomplishments and the APMs described in the documents provided, the Subcommittee concludes that	**Recommendations:** The WQRP should do a more thorough annual accounting of APMs to track progress under each LTG.

the APGs have been met, as measured by an accounting of completed research activities.	
2 and 3. Client testimonials indicate that Program research results and products are used and lead to positive institutional, management, and/or environmental outcomes.	
SCIENTIFIC LEADERSHIP	
Comments: **1 and 2.** The Program has played and continues to play a leadership role in a number of areas of water quality research, such as probabilistic monitoring, biological criteria, and stressor identification, and is taking a leading position in emerging issues such as pharmaceuticals and personal care products (PPCPs) in the environment. Leadership also is evident in the publication record of Program researchers and the frequency of citation of their papers.	**Recommendations:** The Program should continue to diversify its research competence to address emerging regulatory issues while maintaining research in support of regulatory mandates.
COORDINATION AND COMMUNICATION	
Comments: **1.** Research planning is coordinated well with major clients of the Program. The Program receives regional and state input through the regional offices, which are asked to help the WQRP in prioritizing which of the state and local government requests have the broadest applicability to the Agency.	**Recommendations:**
2. The Program's collaborative research efforts have been successful, yet there is much room for expanding the number of partnership projects. Only about 5 percent of ORD publications during the last 5 years were collaborative with state/local agencies, and only about 10 percent were collaborative with other federal agencies.	Implementation of incentives that inspire a culture motivated toward collaboration is recommended. In particular, an increase in partnership projects is encouraged with state/local government, as these agencies typically are the ultimate users of ORD products.
3. There are many opportunities for collaboration with other agencies (detailed in the Report) that would allow better leveraging of Program resources and opportunities.	The Program should institute mechanisms for achieving better technology and information transfer between the STAR Program and the ORD laboratories.
4. The MYP provides the best mechanism to communicate the goals of the Program, its activities, and its accomplishments. The	The MYP should describe a sense of Program continuity: where the Program has been, where it is, and where it is going.

present version, however, does not do this well.	
5. The publication rate is reasonable for researchers in the Program considering they have multiple roles, which include technology transfer, technical assistance to clients, and preparation of reports to Congress and others. Papers that are published are highly cited.	The Program should encourage its scientists to aim for the higher-tier journals, as excessive publication in lower-tier journals creates a poor perception about the research quality.
6. The emphasis on technology transfer to potential users/clients of Program products varies widely among projects.	The Program should develop a systematic set of activities or incentives and metrics of success that encourages and tracks the establishment of relationships with users that lead to better technology transfer.
7. The immediate clients within the OW clearly understand and appreciate the benefits of ORD's water quality research.	The Program should use the new procedure it has instituted for meeting with organizations, such as the Association of State and Interstate Water Pollution Control Administrators (ASIWPCA), for enhancing interaction with other stakeholder groups.

II. INTRODUCTION

The U.S. Environmental Protection Agency (EPA) relies on expert external review to assess the scientific quality and performance of its research programs. Here we report the findings of a review of the Water Quality Research Program (WQRP) within the Office of Research and Development (ORD) of EPA. The WQRP is one of nine research programs within ORD designed to coordinate its efforts across its laboratories and centers.

The Clean Water Act (CWA) provides the legislative mandate to restore and maintain the chemical, physical, and biological integrity of the nation's waters. Therefore, a common management goal for all aquatic ecosystems is to maintain ecological integrity by protecting aquatic systems against degradation of habitat, loss of ecosystem functions and services, and reduced biodiversity. To this end, environmental managers must be able to: (1) assess the condition of an aquatic resource and determine the degree of impairment; (2) diagnose the causes of impairment; (3) forecast the effects of changes in stressor levels; and (4) develop and implement remediation and maintenance strategies. ORD's WQRP aims at addressing these needs. The Long-Term Goals (LTGs) for the program are presented in the adjacent text box. Each of the LTGs focus on aspects of the management needs summarized above by addressing specific scientific questions, which form the basis for Annual Performance Goals (APGs), from which Annual Performance Measures (APMs) are proposed.

LTG 1: Provide the approaches and methods to develop and apply criteria for habitat alteration, nutrients, suspended and bedded solids, pathogens, and toxic chemicals that will support designated uses for aquatic systems.

LTG 2: Provide the tools to assess and diagnose the causes and pollutant sources of impairment in aquatic systems.

LTG 3: Provide the tools to restore and protect impaired aquatic systems and to forecast the ecological, economic, and human benefits of alternative approaches to attain water quality standards.

LTG 4: Provide the approaches, methods, and tools to assess the exposure and reduce the human health risks from biosolids contaminants for use by the Office of Water, states, and others in updating biosolids guidance and regulations.

The focus of LTG 1 is to provide the approaches and methods to develop and apply criteria for habitat alteration, nutrients, suspended and bedded sediments, pathogens, and toxic chemicals that will support designated uses for aquatic systems. These are the major, pervasive stressors with potentially adverse effects on aquatic systems. For LTG 1, the science questions are:

1. What are the quantitative and causal relationships between varying levels of stressors, alone and in combination, and the biological response of aquatic ecosystems and the resulting services such systems provide? For habitat alteration? For nutrients? For pathogens? For toxic chemicals?

2. What are the best ways to classify ecosystems, landscapes, and watersheds to enable efficient and scientifically sound development and application of indicators, biocriteria, listing criteria, and water quality criteria?

3. How can stressor levels, biological-response relationships, classification schemes, bioassessment

methods, ecological risk assessments, and indicators be applied across U.S. surface waters to set criteria for identifying/restoring impaired waters and maintaining designated uses?

Once a water body is monitored and the condition is assessed (LTG 1), the water body may be identified and listed as "impaired" under CWA Section 305b. For some stressors (e.g., toxics, pesticides), the causes and sources of the impairment may be relatively easy to identify (with the exception of major water bodies with numerous stressor sources). For the majority of stressors (e.g., nutrients, suspended sediments, pathogens, and toxics in major water bodies with multiple sources) the cause of the impairment is known (because of the direct relationship to the stressor-specific criteria), but the relative contributions from different sources are uncertain. EPA is encouraging states and tribes to adopt biological criteria and assessments as a more effective measure of water body condition (compared to physical/chemical measurements and criteria). In this case, unlike stressor-specific criteria, both the causes and the sources of biological impairment are difficult to identify. LTG 2 addresses all of these "diagnostic" needs. For LTG 2, the science questions are:

1. How can multiple and possibly related causes of biological impairment be inferred from indicator and other observations, and cause/effect modeling? For habitat alteration? For nutrients? For suspended and bedded sediments? For pathogens? For toxic chemicals?

2. How can the sources and source strengths of stressors be inferred from *in situ* measurements? From stressor measurements? From biological indicators? From remotely-sensed observations and watershed properties?

3. How does one determine the most appropriate and efficient scale for application of diagnostic methods within the Total Maximum Daily Load (TMDL) and CWA 303(d) process?

Ultimately, to meet the goals of the CWA, states and tribes need to restore impaired waters and have measures in place that will protect these resources from unwanted degradation in the future. EPA requires them to develop TMDLs for impaired waters, and promotes a watershed management approach to achieve water quality objectives. Under the TMDL approach, significant pollutant loading of point and nonpoint sources are identified and quantified. Estimates then are made of loading rates that will bring the surface water quality to acceptable levels for the desired designated uses. Similarly, when new activities occur in a watershed, increases in pollutant loads must be restricted so that water quality goals are maintained. LTG 3 aims at developing the tools for this process. For LTG 3, the science questions are:

1. What additions to models are most needed for the TMDL process? For habitat alteration? For nutrients? For suspended and bedded sediments? For pathogens? For toxic chemicals?

2. What best management practices (BMP) treatment systems and restoration technologies remain as uncertain options for watershed management? For mixed land use watersheds? For habitat alteration? For priority stressors?

3. How can classification schemes, modeling scenario analyses, landscape classification, and economic projections be applied to provide alternatives for meeting water quality goals efficiently at multiple scales? What are the economic benefits of watershed management?

ORD has been conducting research on biosolids since the late 1960s, and supported the Office of Water (OW) in the development of the 1979 and later 1993 regulations and in Agency actions that followed, some of which were required by Congress or litigation. The level of research in the late 1990s through 2002 was modest, but important activities, such as the chairing of the Pathogen Equivalency Committee (PEC) continued. LTG 4 focuses on assessing and controlling exposure to stressors associated with biosolids land application. Four science questions are addressed by LTG 4:

1. Do contaminants in biosolids pose a significant health risk to the public when applied in compliance with current regulations?

2. What additional models, tools, and methods are needed to identify, measure, and assess aggregate exposure pathways and risks?

3. What improved analytical techniques can be developed to determine adequately pathogen and priority toxic chemicals in or released from biosolids?

4. What is the current state of management practices for biosolids production and application, and how can those be made more effective?

For the present review, a seven-member Subcommittee was formed, the members of which are listed in Appendix A. The charge to the Subcommittee is provided in Appendix B and includes questions that originate/relate to the Office of Management and Budget (OMB) Program Assessment Rating Tool (PART). The Subcommittee was provided with a number of documents related to the Program as well as several presentations made during public teleconferences and during one face-to-face meeting (see Table 2 for the dates of these events). The following responses of the Subcommittee are organized according to the major topics of Program relevance, quality, performance, scientific leadership, and communication and coordination.

Table 2. Summary of Water Quality Subcommittee Meetings

DATE	TYPE OF MEETING
December 21, 2005	Conference Call
January 12, 2006	Conference Call
January 25-27, 2006	Face-to-Face Meeting
March 6, 2006	Conference Call

III. RELEVANCE

Question 1: How is the focus of ORD's WQRP, as reflected in the Multi-Year Plan (MYP), relevant to the Agency's Goal 2 and Strategic Goals, and to recommendations for water quality research priorities developed by the National Research Council (NRC), Science Advisory Board (SAB), EPA's OW, states, and regions?

The WQRP appropriately addresses EPA's Goal 2 (Clean and Safe Water) by creating the tools necessary for the OW to establish water quality criteria and respond when those criteria are not being met. The Subcommittee was particularly impressed by the Program's responsiveness to OW, which has been identified correctly as its primary client, in developing its research priorities. The presentations made by the Office Directors from the Office of Wetlands, Oceans, and Watersheds (OWOW); the Office of Science and Technology (OST); and the Office of Water Management (OWM) were overwhelming in their commendation of the Program for meeting OW's needs.

The MYP is organized quite appropriately along the lines of the TMDL paradigm. Thus, the MYP and associated budget first emphasize development of water quality standards (LTG 1), through which regulation will be accomplished. LTG 2 follows logically from the first goal by providing managers with the investigative tools that will point them toward what needs to be fixed when water quality standards are not being met. LTG 3 follows logically by developing options for mitigating or ameliorating the effects of pollutants on water quality.

It is less clear why LTG 4 is broken out as a separate objective. Although LTG 4 is responsive to both program office needs and the 2002 NRC biosolids report, it would be included more appropriately in the MYP as a subset of the concentrated animal feeding operations (CAFO) research associated with LTG 3. The Subcommittee was concerned that the LTGs should reflect long-term needs in a risk assessment or TMDL framework, rather than what appears to be catering to the "issue of the month" pressures.

The Subcommittee identified four recent NRC reports that should affect the WQRP:

- *Biosolids Applied to Land: Advancing Standards and Practices* (2002)
- *Assessing the TMDL Approach to Water Quality Management* (2001)
- *Confronting the Nation's Water Problems: The Role of Research* (2004)
- *Indicators for Waterborne Pathogens* (2004).

For some of these reports, the Program has taken the relevant recommendations into account and developed comprehensive responses that are reflected in the MYP. The most apparent of these is the biosolids report. Although the Subcommittee was concerned about this research being elevated to the level of an LTG, the members thought that the research was appropriate to address the NRC recommendations. Another example of responsiveness to NRC is with respect to the TMDL report, which appears to have been a motivating force in the structuring of the MYP. It is less clear how the Program has incorporated recommendations from the other two

NRC reports, although this may be a reflection of these documents having been published only recently.

The Subcommittee was not provided with documents describing recommendations from the SAB, but the impression of the members from the description of ORD's planning process is that SAB recommendations are being incorporated adequately into the research planning process.

Recommendations: See Recommendation under **Chapter V, Section A,** Question 1.

Question 2: How does the Program use the MYP to help guide and manage its research?

The Subcommittee members thought that there was a reasonable, though imperfect, relationship between the MYP and the specific research projects contained within the plan. Discussions with Program staff led the Subcommittee to believe that the Program is in the early part of a learning curve about how to prepare these plans. The Program appears to be headed in the proper direction and the Subcommittee believes that the connection between the research activities and the MYP will continue to improve in the future.

The Subcommittee identified two ways that this process can be improved to better guide the Program's research direction. The first is to develop a clearer linkage among and between the APGs and the LTGs. The second is to develop a better system for tracking progress on each LTG (i.e., the APMs), which is critical to logical development of its next set of research activities.

There also is concern that the plan is, in many cases, being implemented regionally rather than nationally. ORD has a research element for ecosystem classification in which it is defining critical boundaries for developing indicators and criteria. The outcomes of those analyses, however, do not appear to have been incorporated into the research planning. Rather, the geographical allocation of the research efforts appears to be driven by the location of the laboratory that is leading the effort for that particular Program element, and collaboration across laboratories to implement the research elements at a national level is inconsistent. Even the partnerships that the Program has developed with states seem focused on proximity to the laboratories that are leading a particular research effort, rather than seeking out state partners that would allow assessment of applicability of the Program's research projects to other ecoregions. There are several examples in which this regionalization has impeded acceptance of Program research. For instance, the State of Hawaii has resisted adopting EPA's desired bacterial criteria because it is concerned that the selected indicators grow naturally in tropical soils.

Recommendations:

- ✧ The MYP should provide clearer linkage between the APGs and the LTGs and identify a better system for tracking progress on LTGs by developing a clearer linkage between APM, APGs, and LTGs.

- ✧ The MYP should include a strategy for evaluating each of the criteria and tools it develops in multiple ecoregions, based on findings from the ecosystem classification research.

Question 3: How does the WQRP address and respond to key and emerging scientific questions?

The MYP is a flexible framework that allows program restructuring on an annual basis. It has been used successfully to keep the overall programs highly relevant to client needs. Emerging regulatory issues are addressed explicitly in the present research plan, and they seem to have resulted from productive dialog between ORD and the OW program offices. In particular, the plan includes several projects to assess the effects of endocrine disruptor compounds (EDCs). That seems appropriate as EDCs are among the most prominent emerging issues. Another example in the present MYP is ORD's participation in the Ecology of Harmful Algal Blooms (EcoHAB) partnership to develop tools for assessing harmful algal blooms.

The ability of the Program to respond to emerging issues generally depends on its ability to maintain a core research competency and to continue to diversify its workforce as staff members retire. Exploratory research competency also is achieved through extramural funding, fellowships, and collaboration. In particular, the academic sector offers a greater diversity of research expertise than found at the ORD laboratories and centers, which positions the Program more advantageously to address new and exploratory issues. EPA is not well positioned for hiring specialists to address exploratory issues that may or may not develop into regulatory issues. The Science To Achieve Results (STAR) Program is potentially well-suited to address this need and was an important contributor to defining the need for further research in areas such as endocrine disruption and personal care products. The Subcommittee is concerned, however, that the STAR Program has become more proscriptive, reducing the flexibility of external researchers to address exploratory issues.

The WQRP has diversified the expertise of its work force over the last decade, but collaboration with external researchers needs to remain a key component in implementing emerging issue research. The Program is encouraged to develop mechanisms, such as onsite sabbatical and postdoctoral programs, which will encourage transition of exploratory research from the academic laboratories into Program facilities when these topics become of regulatory interest. The Subcommittee was pleased to hear that the STAR Fellowship Program had been resurrected. This may provide a good mechanism for accomplishing exploratory research and certainly attracts new talent to the Agency in those areas where exploratory research may have regulatory relevance.

The Subcommittee also was concerned that it is difficult for EPA to expand its list of topic areas in the context of a stagnant budget. There naturally will be an increasing number of areas of water quality concerns in a growing society. Unless budgets can be increased to address these new issues, the Program must develop a strategy for phasing out certain research areas as new concerns become more active.

Recommendations:

- ✧ The Program should strive to maintain its core competency in water quality research.

- ✧ Exploratory research should be encouraged more and be made a sustainable part of the STAR Program. This is necessary to keep the research program "fresh" and flexible to confront emerging issues.

IV. QUALITY

Question 1: How does the Program ensure quality through competitive and merit-based funding?

Peer review processes can ensure quality when distributing competitive and merit-based funding. To be effective, however, this must include internal and external reviews. The review process for both research proposals and Requests for Applications (RFAs) are determinants in the ultimate quality of funded research. The response to this question revolves around the adequacy of this review process at ORD, and is considered separately for extramural and intramural research funding. ORD funds various extramural research activities, which include grants and cooperative agreements (MYP 2003). The National Center for Environmental Research (NCER) is the main component through which ORD supports extramural research, most of which is accomplished through the STAR Program. Although the use of external peer review and merit-based analysis for intramural research programs and cooperative agreements is somewhat obscure, the extent to which external peer review is used to ensure the quality of STAR grants is well documented. In water quality, STAR funding has varied from $0.5 to $4.4 million since 1996 and has fallen from $2.5 million in 2001 to $0.9 million in 2005 and 2006.

Review of EPA's STAR Program by Others

EPA's STAR Program has been reviewed by two BOSC subcommittees, by the SAB, by the Government Accounting Office, and by the Agency's Inspector General. In addition, the scientific merit of the STAR Program was assessed extensively by the NRC in 2002. More specifically, the NRC was charged to examine STAR's research priorities, research solicitations, peer-review process, and current research projects, as well as dissemination of research findings and results. One of the goals was to compare research conducted or funded by EPA with those of other research grant programs. The focus of the review was on three research programs: Particulate Matter, Ecologic Indicators, and Endocrine Disruptors. In May 2003, the NRC issued the report entitled *The Measure of STAR: Review of the U.S. Environmental Protection Agency's Science To Achieve Results (STAR) Research Grants Program* (http://www.nap.edu/books/0309089387/html/). The NRC review concluded that:

- ✧ The STAR Program has tended to focus more on the quality of its process than on the quality of its products. That is understandable and appropriate. It is understandable because, being a relatively young program, STAR has had to focus on trying to get the process right and only now is beginning to accumulate a sufficient number of products to support a quality evaluation, and because most of the external reviews of the Program have tended to focus on process issues.

- ✧ The processes established by the STAR Program compare favorably with and, in many cases substantially exceed, those established by other research-supporting organizations.

- ✧ The STAR Program has established a rigorous peer-review process to evaluate the quality of proposals.

The Subcommittee generally agrees with this assessment.

Selection of Topics

Established Research Coordination Teams (RCTs), which include ORD staff and staff from EPA's program and regional offices, work together to identify appropriate research topics for STAR solicitations and intramural research in ORD laboratories/centers. This research plan is based on both the EPA and ORD strategic plans. The RCTs also consider specific regional needs in this process. The RCTs then use a series of criteria to decide whether a certain research topic should be addressed internally or externally through grants, cooperative agreements, or contracts. These criteria address the following questions:

- ✧ Which organization has the most appropriate expertise?

- ✧ How urgently is the research needed?

- ✧ What is our available in-house capacity?

- ✧ Does the proposed RFA-driven extramural research complement the intramural research program?

- ✧ Is this an area of research where scientists from academic institutions can make a contribution?

This process appears to be very thorough. Its criteria are formulated clearly and would ensure the selection of topics of quality. Once this preliminary process has been completed, the RCTs work with NCER staff to write the RFAs.

RFAs

It appears that the Program conducts an extensive internal review (within EPA) of RFAs to ensure that they meet Program goals. No significant external review of RFAs seems to take place on a systematic basis, however, but nothing precludes this, and external review sometimes is used. The Subcommittee believes that more systematic use of external reviews of RFAs would improve the Program in that they would bring different perspectives and ideas and enhance the quality of the RFAs. Without external reviews, it is possible that the scope of the RFAs may be limited by the expertise of the internal reviewers.

Dissemination of RFAs

The dissemination of RFAs for the STAR Program is done in many different ways, including through the NCER Website, the *Federal Register*, announcements at professional meetings, and e-mail lists. Although this seems adequate, the NCER Web page, where the RFAs are provided,

can be difficult to find (http://epa.gov/ncer/rfa/#2006star). It is suggested that more direct links between the Program and this page should be created from EPA's main page (http://www.epa.gov).

Cooperative Agreements and Contracts

Cooperative agreements in excess of $10,000 are required to undergo competition as a measure to ensure quality. Cooperative agreements are peer reviewed internally and also may be subjected to some external peer review. It is not clear, however, that external peer review is a mandatory requirement or that all agreements necessarily are subjected to external review. The Program would benefit from a more systematic use of external reviews of cooperative agreements and contracts to improve the quality of these agreements.

Intramural Program Funding

Intramural research programs are not subject to external peer review. They are reviewed internally. There is no current merit-based evaluation of project researchers in determining research funding. The National Program Director (NPD) indicated, however, that a new Agency-wide, goals-based merit system was being instituted and that such a system could be used to assist in determining funding. Currently, the NPD has no role in determining personnel funding decisions; this is determined by Laboratory and Center Directors. Individual merit for high-quality science is acknowledged through the Agency "medal" system, and gold medal awards are high recognition of quality and significant research accomplishment.

The process described above, if followed, should ensure the quality of products produced by the WQRP. Evidence presented to the Subcommittee during its Program Review, indicates that the Program uses an appropriate peer-review mechanism in the STAR Program selection process, which should ensure the quality of products resulting from that research.

Recommendations:

- ✧ A more systematic use of external reviews of RFAs is recommended. This would improve the originality and overall quality of RFAs, grants, contracts, and other agreements.

- ✧ A direct link between the Program and the NCER Web pages that advertise RFAs should be created from EPA's main page to facilitate better dissemination of information about grant programs.

Question 2: What procedures (e.g., use of peer review) does the Program have to ensure the quality of its products?

Peer Review

For any scientific product, regardless of its origin, high quality depends to a large extent on whether or not the research product was subjected to an objective peer-review process. High quality and objective peer review is one of the fundamental principles of scientific research. At

EPA, whether a product is internally or externally reviewed depends on the type of product. Accordingly, EPA has an extensive peer-review process in place for its various products. Peer review is used to ensure quality of the products of ORD's WQRP. To be efficient and ensure quality, peer review must be done systemically and highly standardized. According to the EPA *Peer Review Handbook* (p. 10), the peer-review protocol can be described as follows:

> Peer review is a documented critical review of a specific Agency major scientific and/or technical work product. The peer review is conducted by qualified individuals (or organizations) who are independent of those who performed the work, but who are collectively equivalent in technical expertise (i.e., peers) to those who performed the original work. The peer review is conducted to ensure that activities are technically adequate, competently performed, properly documented, and satisfy established quality requirements. The peer review is an in-depth assessment of the assumptions, calculations, extrapolations, alternate interpretations, methodology, acceptance criteria, and conclusions pertaining to the specific major scientific and/or technical work product and of the documentation that supports them. Peer review may provide an evaluation of a subject where quantitative methods of analysis or measures of success are unavailable or undefined; such as research and development. Peer review is usually characterized by a one-time interaction or a limited number of interactions by independent peer reviewers. Peer review can occur during the early stages of the project or methods selection, or as typically used, as part of the culmination of the work product, ensuring that the final product is technically sound.

EPA work products that require peer review must meet the following criteria:

- ✧ It must be a major scientific or technical work product (some non-major work products also may need to be peer reviewed). The guidelines to follow to classify a work product as "major" are detailed on pp. 26-27 of the *Peer Review Handbook.*

- ✧ If the scientific aspect of the major work product was not previously peer reviewed, then it must be peer reviewed.

Once these criteria have been met and the work product is deemed subject to peer review, the next steps are to identify the terms of reference for a review, identify key staff members who will be involved in the process, create a peer review record, ensure funding, and determine the timeframe for the peer-review process to be conducted.

The WQRP appears to use the appropriate peer-review mechanism, as described above, in the STAR Program selection process and in the development of products resulting from the research. An example of how the peer-review process has been used for the "Aquatic Stressor" document is described below.

In 2002, EPA published a document entitled *Aquatic Stressors – Framework and Implementation Plan for Effects Research*. This document and the underlying research are examples of an EPA product that was peer reviewed both internally and externally. This document aimed to identify the problems and the research that needs to be conducted regarding aquatic stressors. Eventually, it was anticipated that the research would lead to the development of "scientifically valid approaches for protecting the ecological integrity of aquatic ecosystems from multiple

aquatic stressors…." A preliminary review of this document was performed by ORD staff. A final review of the document was completed in February 2002 by a diverse group of 10 external scientific reviewers. The reviewers were from U.S. and Canadian universities and institutes, the U.S. Geological Survey (USGS), one private company, one nonprofit environmental organization, and one water utility. This was an excellent mix of reviewers for such a document.

In addition, the framework section of this document was developed by a steering committee composed of scientists from ORD's National Health and Environmental Effects Research Laboratory (NHEERL), other ORD laboratories and centers, OW, and various EPA regional offices. Finally, as part of this project, a "State-of-the-Science Review" was proposed. This extensive review was to be conducted by various EPA scientists primarily from NHEERL, but also from other ORD laboratories/centers, in collaboration with OW, USGS, and the U.S. Army Corps of Engineers.

This example demonstrates a robust and thorough peer-review process. Because of the scope of its products, the Program seeks reviewers from a variety of different organizations and sectors. In addition, the process is improved further by collaboration with various federal agencies.

Recommendations:

- ✧ A combination of external and internal peer review of Program products should continue to be used.

- ✧ Collaboration with other agencies in the review of Program products should be encouraged whenever appropriate to ensure their quality.

V. PERFORMANCE

A. PROGRAM DESIGN

Question 1: What is the logic underlying the Program design (based on the MYP and LTGs)?

The Program design is based on national priorities, EPA's mission, the mission of the WQRP, and the informational needs of clients, including states, regions, other EPA programs and offices, federal research partners, municipalities, and the private sector. The framework supports the goals described by EPA's *Strategic Plan* and the CWA. The goals of the WQRP are to provide research products that support Agency and national efforts toward clean safe water for the various designated water uses and to support maintenance of healthy aquatic communities.

The MYP and LTGs 1, 2, and 3 are a logical approach to providing research activities and products that support Agency and national objectives regarding water quality. These goals are focused on: (1) developing criteria that define healthy or impacted waters; (2) identifying the causes and sources of pollutant impairments in aquatic systems; and (3) developing approaches to the restoration and/or treatment of impacted aquatic systems. The logic supporting the design of the WQRP in regard to the first three LTGs is sound in that it parallels the sequence of events found in the TMDL framework. The fourth LTG deals with biosolids—identifying approaches, methods, and tools to assess exposure and risks to humans from biosolids and to evaluate the effectiveness of current practices aimed at identifying management options. This fourth goal originated from external NRC recommendations. Although this topic area falls under the CWA and provides research products of importance, it does not follow the logic of the previous goals, nor does it rise to the scope of the previous goals. Its presentation as an LTG gives the topic visibility; however, the available resources suggest that this LTG and program are a small component of the WQRP's research effort.

As part of the Program design and logic, research results are disseminated via a number of means including publications, briefings and consultations, workshops, conferences, the Internet, and public meetings. The recipients include the EPA offices, regions, states, local agencies, and other interested parties. This approach provides an effective means to furnish diverse groups access to available research products.

Although environmental protection along with human health provides the overall direction for the WQRP, as it does for all EPA ORD programs, and the WQRP design addresses well its environmental assessment and restoration goals and accomplishments, it inadequately articulates its significant proactive, protective research activities. Examples of these kinds of proactive activities can be found in research on low-impact development, stormwater management, point source control, and landscape management and sludge management.

Recommendations:

- ✧ Biosolids should not be elevated to an LTG. This research should be subsumed under the same structure as other pollutant sources in the framework for LTGs 1, 2, and 3 or into LTG 3.

- ✧ Proactive aspects of the WQRP should be articulated more clearly in the Program design.

Question 2: How are Program goals and priorities identified?

Program goals and priorities are a function of varied inputs from the EPA Administration, Congress, the Executive Branch, regions, EPA offices, the National Academy of Sciences (NAS), NRC, and Program reviews. These priorities are refined annually through the budget process and an evaluation of human resource needs. RCTs consisting of Program, laboratory, and regional representatives may fine-tune the conditions necessary for implementation of the priorities.

Priorities as well as goals are based on impact, sensitivity (environmental response), and scientific uncertainty related to a stressor. Those with greater impacts and increasing levels of uncertainty are given a higher priority. This approach is appropriate and sound, although it would be understood more clearly if a list of questions to be answered for each potential topic were used and the rationale for the choice of particular research areas were stated more clearly (e.g., responses to questions used for prioritization). In conjunction with the foregoing format, the Program also would benefit from prioritization based on the scope of the problem (e.g., regional versus national) and the effort required to complete a particular research product. Research focusing on more universal issues has the potential for greater impact than do those solely addressing localized problems. Likewise, it makes sense to bring near finished research products to completion and application. Clearly, the means for prioritization of emerging versus existing needs requires development. How does the WQRP prioritize emerging uncertainties relative to existing programs? In the same line of thought, how does the WQRP provide for program flexibility to address these immediate needs?

It is unclear how the current priorities fit into the WQRP's greater research history and specific goals. A "line of inquiry" or pert chart would provide Agency memory of what has been done, communicate relevance of a given current research endeavor, track progress, and identify additional science needs. This would allow more transparent communication of the research process and allow for succinct management overview and prioritization.

Recommendations:

- ✧ Retain prioritization according to impact, sensitivity, and uncertainty, but also incorporate national versus regional significance, scaling according to project completion, and the relationship between existing and emerging topics (see Question 6).

- ✧ Provide a better indication of the questions used in the prioritization process.

- ✧ Provide a more transparent research progression to allow for succinct management overview and prioritization.

Question 3: How well is the rationale for the research articulated?

The need for the information and products produced by the WQRP is clear as evidenced by the number of articulated environmental issues at hand and the diversity of uncertainties. The research program fills a number of intellectual gaps and supplies a variety of tools necessary for implementation of the CWA as related to the various uses of the nation's waters. The stepwise approach and rationale for such an approach is developed and articulated clearly at the program or LTG scale. Assessment tools and means to diagnose causes and sources of stressors and restoration are developed clearly. The individual research projects have been organized around specific goals to which they apply; however, the linkage between them (i.e., their place in specific lines of inquiry) is articulated inconsistently.

Recommendation:

- ✧ Clearly articulate the linkage between research from the program (i.e., LTG) level down to and among individual projects.

Question 4: Is research sequenced appropriately?

The studies performed, underway, and to be performed are sequenced clearly within the timeframe of the MYP. LTGs as defined by the APGs and the APMs; however, for an ongoing investigative effort that has started before and/or ends after the existing MYP, it is difficult to place MYP projects contextually along a timeline for any particular research effort. The MYP often is just a slice of the WQRP's research history. In addition, science questions are not related clearly to APGs and APMs, so research sequencing cannot be discerned for individual projects from these measures. Additional sources of information, such as from the poster sessions, were needed to appreciate how science questions were sequenced. The posters suggest that research flow follows a logical order, sequentially addressing uncertainties for science questions. For example, without aid from the poster (LTG 1 #8) it was difficult to ascertain that evaluating the importance of dietary routes of exposures to aquatic risk assessments for metals (APM), combined exposure to polycyclic aromatic hydrocarbon mixtures and ultraviolet radiation (APM), and a framework for water quality criteria for nonbioaccumulative chemicals (APM) are methods being used for development of the next generation of aquatic life criteria.

Recommendation:

- ✧ Some indication of where the Program has been, where it is now, and where it is going is necessary to better determine if the research is sequenced appropriately and is relevant to current and future needs.

Question 5: How have client needs been anticipated?

ORD's WQRP client needs are anticipated by several mechanisms and subsequently are reflected in the research planning process. Research needs are anticipated primarily by direct communication between WQRP and its clients. The Program's primary research client is OW, which includes the Office of Ground Water and Drinking Water, OST, OWM, OWOW, and the Office of American Indian Environment. ORD maintains personnel in EPA regional offices, who act as liaisons and provide a direct communication link from the regional offices. Less defined inputs come from states and components of the private sector. ORD's Executive Council and the NPD of the WQRP also attempt to anticipate future client needs. Mandated directives, routes put forth by the EPA *Strategic Plan*, as well as input from advisory bodies form the basis for top-down assessment of these needs. ORD and the WQRP NPD make administrative decisions regarding what specific research will be performed as related to these needs. Mechanisms of communication and input at multiple levels are applauded, and further development in this area should be encouraged.

Recommendation:

- ✧ Mechanisms of communication and input at multiple levels are applauded. The Subcommittee encourages this and recommends that the Program institutionalize a more systematic approach to communicating with clients.

6. How can the Program be improved?

Although it is understood that many factors come into play regarding prioritization, it is the conclusion of the Subcommittee that the Program can benefit from a more formalized and transparent mechanism for prioritizing research activities. Criteria already in place for prioritization, such as stressor impact, environmental sensitivity, and scientific uncertainties are well founded. Other items, such as political and budgetary inputs, are a given. Additional criteria should be considered, however, when prioritizing research topics in a crowded field with limited resources.

Recommendation:

- ✧ Consideration of the following questions could serve as additional criteria for incorporating new research areas into the MYP as well as to remove research topics if retraction of the Program becomes necessary:

    - ✦ Does the research have national versus regional or local significance?

    - ✦ Does the research provide the best return in terms of products and outcomes for the investment?

- ✦ Is the research related logically to prior research endeavors and, when applicable, will its performance result in a "finished" usable product?

- ✦ Will implementation result in a high impact improvement in the environment?

B. PROGRAM PROGRESS

Question 1: What evidence has been presented to demonstrate that significant progress has been made toward each of the LTGs?

Demonstrating significant progress toward meeting the LTGs is paramount to understanding how ORD's efforts are contributing to the Agency's mission. Furthermore, it is necessary to help guide future research efforts and to justify the worth of the WQRP to outside groups. Because the WQRP MYP is relatively new and the research described within takes place over a time scale of years, there is not yet an abundance of evidence with respect to achieving the LTGs. Several mechanisms, however, are or should be in place that will facilitate such an accounting as the Program matures.

Within the MYP description (EPA, 2003), each of the four LTGs are described and associated with a variety of APGs. The APGs tend to correspond to specific lines of inquiry, such as development of models for how wildlife responds to environmental stressors (APG Example 1) or the provision of monitoring strategies for BMPs (APG Example 2). The APGs are slated to be reached at different times, ranging from 2003 to 2008. In addition, each APG is the sum of several APMs. Almost all of the APMs consist of producing reports or models by a specific date on a research topic related to the theme of the APG. For example, the APMs that correspond to APG Example 2 include such documents as reports to the states, regions, and EPA program offices on methods to evaluate wetlands for their ability to control nutrients and sediments in stormwater. Deadlines for meeting the APMs also are indicated in the MYP, such that all APMs under a given APG should be finished by the deadline proposed for that APG. Finally, there is an attempt within the MYP to illustrate a logical sequence for completion of the APGs using flow diagrams, with the notion that the results of certain projects can be used as input into later projects.

Ideally, the most efficient way to assess progress toward each LTG would be to assess the Program's efforts to meet the APGs and APMs. Several levels of assessment are possible that correspond to increasingly informative evidence for progress. As articulated by the NPD of the WQRP, six measurements of progress are possible. At the most basic level is an accounting of *research activities completed*. This should be relatively easy to produce and should be framed according to the APGs to facilitate understanding of progress toward meeting the LTGs. A similarly easy assessment is to determine *research outputs* as measured by the number of peer-reviewed publications, other published technical information, and Web-based decision support materials developed. A more in-depth assessment would consider *the extent to which the research results are transferred and communicated*. This can happen actively or passively through publications, briefings, technical consultations, scientific workshops, conferences, and public meetings. All of these assessment methods are amenable to quantification.

Three additional measurements of progress are more difficult to evaluate quantitatively but convey considerably more information about program progress. First, *institutional outcomes* would describe how OW, regions, states, tribes, and local agencies use Program products and support to develop water quality criteria, water quality standards in general, and watershed management tools. *Management outcomes* relate to how the regions, states, tribes, and local agencies have used EPA research results to make scientifically sound decisions and implement effective management actions, for example, as they comply with the CWA. The highest level of assessment would be to determine *environmental outcomes*, such as whether water quality conditions have improved and whether designated uses have been attained for waters previously in violation of the standards.

At the present time, the information supplied to the Subcommittee has not been compiled in a manner that relates to the six measurements of progress defined above. EPA managers have not released a list of APMs that have been met (although the Subcommittee was informed that if deadlines are 2005 or earlier, those documents have been completed), nor have the documents that comprise the APMs been compiled in a manner that would facilitate understanding whether the APMs have been met. Rather, the program managers have constructed their own accounting of accomplishments that is broken down by LTG and by certain subheadings, as shown in Appendix C of this report. It should be noted that there is no one-to-one correspondence between accomplishments described in Appendix C and the APMs. Nonetheless, the Subcommittee's evaluation of Appendix C leads it to believe that the APMs have been met, as measured by an accounting of completed research activities (Metric 1).

Appendix C also provides information with respect to the other five metrics, although not in a systematic fashion that makes it easy to assess program progress. For example, it is clear that efforts are being made to transfer and communicate research results as evidenced by the fact that ORD organized a scientific session on Habitat Alteration in the Gulf of Mexico with the Gulf Estuarine Research Society and the Society for Wetland Scientists in Pensacola, Florida. A separate bibliometric analysis presented to the Subcommittee reveals that 506 papers were published by EPA scientists in the WQRP between 2000 and 2005.

Whether an entry in Appendix C discusses one of the three more qualitative metrics of progress (i.e., institutional, management, and environmental outcomes) is highly variable, although many examples are provided. To verify the information given in Appendix C, the Subcommittee reviewed 36 posters describing research results, all of which provided details on their outcomes and potential impacts. For example, the Stormwater Management Model (SWMM) is described in Appendix C as being one of the most successful models produced for the water environment and widely used throughout the world to analyze quantity and quality problems related to stormwater runoff, combined sewers, sanitary sewers, and other drainage systems in urban and nonurban areas. The Subcommittee's review of the poster "The Storm Water Management Model and Related Watershed Tools Development" confirmed that SWMM continues to be used by many local and state governments. The model has been updated to be applicable to sites as small as one acre, to encompass additional hydrologic, hydraulic, and water quality parameters, and to provide more user-friendly Web-based interfaces for viewing results. This exercise of relating the information in Appendix C to the results given on the posters as well as in-depth

conversations with EPA scientists during the poster session solidified the Subcommittee's confidence in the validity of the qualitative statements found in Appendix C.

Recommendation:

- ✧ The WQRP should do a more thorough annual accounting of how it has met the LTGs according to the framework provided in the MYP, which breaks research activities down by APGs and APMs. For each APM, this accounting should include information on the following six metrics of progress:

    - ✦ Research activities completed by a specified date.
    - ✦ Research results published or reports otherwise made available.
    - ✦ Transfer and communication of report results.
    - ✦ Institutional outcomes.
    - ✦ Management outcomes.
    - ✦ Environmental outcomes.

(The gathering of information on the last three metrics likely will require the cooperation of the program offices, from which this information might be more readily available. Although such an assessment may be beyond the commonly accepted responsibilities of ORD, its importance in ensuring the continued operation of the WQRP cannot be understated.)

Question 2: How have clients applied the Program's research in environmental decisions and regulations?

The client base for the WQRP, mentioned earlier in this report, is charged with implementing the CWA. Input was received from representatives of client groups both as presentations to the Subcommittee and in written testimonials. The clients related the various ways in which ORD's water quality research has been instrumental in furthering their own objectives. This ranged across such issues as: (1) using research results to set more accurate water quality criteria (by OST); (2) using research results to comply with regulations, e.g., to determine violations of water quality standards more accurately (by states); and (3) using research results to advance fundamental understanding, e.g., to facilitate the restoration of degraded habitats (by nonprofit organizations). Three presenters from OST, OWOW, and OWM were consistent in their praise of the quality and timeliness of research results provided by ORD. For example, to support the OST mission of setting water quality criteria, ORD has expanded its research on the effects of toxic chemicals on target organisms to take into account more complicated processes such as biomagnification. As part of the Oceans and Coastal Protection Program spearheaded by OWOW, the WQRP is participating directly on the task force that is addressing hypoxia in the Gulf of Mexico. Their relevant research is investigating the ecological impacts of hypoxia on coastal ecosystems, particularly benthic communities. Program research is used for many purposes by OWM, including providing information to the Stormwater Program. Indeed, the major modeling tool used by OWM to determine compliance with stormwater permits was developed and is maintained by ORD scientists. These examples are just a few of the many items discussed by managers from OW.

Appendix D summarizes the testimonials received by 38 clients, focusing on how the water quality research results that were used by the clients led to particular institutional, management, or environmental outcomes.

Question 3: What suggests that the Program has met client needs in a timely and useful way?

Appendix D summarizes whether clients needs were met in a timely way (if that information was provided in a testimonial). Usefulness is dependent on whether the research results had important institutional, management, or environmental outcomes, and this also is mentioned in Appendix D. Although it is not possible to extrapolate these findings to the entire WQRP, the submitted testimonials suggest that EPA research results are broadly useful for a wide variety of purposes.

VI. SCIENTIFIC LEADERSHIP

Question 1: How has the Program played a leadership role in advancing the state-of-the-science of water quality research and in solving important research problems?

There are several areas in which the Program has played a leadership role in water quality research. One area in which the Program has a long record of leadership is the use of biological indicators of water quality. Program researchers have been instrumental in the development of probabilistic monitoring schemes, which have been adopted widely by states, thereby improving their ability to identify impaired waters more efficiently. Coupled with this has been the development of biological criteria, for which the program also has been a leader. Current research efforts presented during this review demonstrate a continuing leadership role in this field. One criticism of biological monitoring approaches has been that, although they are able to detect impairment, it is difficult to identify the causes of that impairment. The Program is conducting cutting-edge research that meets this need. The *Stressor Identification Guidance Document* and the Web-based Causal Analysis/Diagnosis Decision Information System (CADDIS) represent the cutting edge of research directed toward identifying stressors leading to the observed impairment. The logical structure of the analysis, the use of multiple lines of evidence, emphasis on identification of underlying mechanisms, and using a weight-of-evidence approach are strengths of this tool. Continued refinement of these tools offers promise for realizing the potential of biological indicators. The letter from the Connecticut Department of Environmental Protection (see Appendix D) provides two examples of the successful application of this stressor identification approach. In one case, it provided a scientifically defensible basis for a TMDL decision that withstood scrutiny and challenge; in another case, the approach was used to develop a defensible restoration plan that was implemented and resulted in water quality improvement. The next advance in this field may come from better integration of biological assessment results in the development of aquatic life criteria. The Program is in a unique position to take the lead in this area; it has both the expertise and the recognized leadership in the field to do so.

Additional examples of leadership include the development of models that have been adopted widely; downloads of individual models in 2005 range from 243 for an advanced version of a Hydrological Simulation Program-FORTRAN (HSPF) runoff module to more than 11,000 for a multi-pollutant, multidimensional water quality model (WASP). Importantly, the Program not only has developed the models, but continues to invest in maintaining, improving, and updating them.

There also is evidence of leadership in the use of molecular methods for monitoring sources of fecal pollution, such as the use of microarrays. EPA has taken a leadership role in microbial source tracking and is collaborating with other agencies in North America on this issue.

The Program also has evidenced leadership in research that supports the development of nutrient trading programs and has the potential to advance the field by providing the scientific basis for policies that better incorporate wetlands and wetland mitigation practices into nutrient trading

programs. Evaluating economic benefits of ecological goods and services is an emerging discipline in which the Program could be a leader. To do that, the Agency will need to expand its pool of expertise to include socioeconomic disciplines. This could be accomplished through postdoctoral positions and/or enhanced collaborations with academic researchers.

To explore additional areas where the Program is taking a leadership role, the Subcommittee considered the *Aquatic Stressors – Framework and Implementation Plan for Effects Research.* Most documents that address stressors and biological responses acknowledge the ubiquity of multiple stressors, but few offer approaches for addressing them. This plan focuses on four main stressors: habitat alteration, nutrients, suspended and bedded sediments, and toxic chemicals. Some of the research presented in the posters showed evidence of trying to tackle the problem of multiple stressors. For example, the work with loons considers the effects of both mercury and habitat on this aquatic-dependent species; recognition of multiple stressors is apparent in research on the development of nutrient criteria, which is investigating the usefulness of classification schemes to resolve responses of aquatic ecosystems to multiple landscape stressors. The freshwater component of this research is focused in the Great Lakes and Pacific Northwest. Being a leader requires having a vision of how research in these areas can be applied in other parts of the country; this was not evident in this document. Furthermore, the nutrient processing that occurs in flowing waters does not seem to be considered. Landscape loading models are being used, but processes occurring within aquatic systems seem to be overlooked.

To determine whether the Program is showing leadership in areas of emerging science and regulatory concern, the Subcommittee read *Pharmaceuticals and Personal Care Products (PPCPs) in the Environment.* This is a draft report of a workshop held in August 2005 that consisted of papers presented before a diverse audience of regulators, stakeholders, and researchers (both Agency scientists and academics). STAR grantees also presented their research progress. Presentations addressed issues such as the existing statutory authority for regulation of PPCPs, PPCP research being done by and needed by regions, persistence of PPCPs in the environment, and potential treatments for removal of PPCPs from drinking water. The limited studies that have been done on nontarget organisms suggest potential for considerable impact. An analysis of expected introductory concentrations (EIC) of 800 pharmaceuticals showed that 80 percent of compounds that are likely to be present at detectable concentrations have not been targeted by researchers, and as many as 10 percent are likely to be of environmental concern. The need to develop a list of priority pharmaceuticals was expressed clearly. The Program played a leadership role by funding much of the research presented in the workshop and by sponsoring this workshop. Furthermore, it is co-chairing a Committee on Environment and Natural Resources (CENR) Interagency PPCP Task Group with the U.S. Food and Drug Administration (FDA) and USGS with tasks that include developing a research blueprint to address priority data gaps and areas of uncertainty. This is clear evidence of leadership in an area of emerging importance.

Question 2: How have water quality researchers demonstrated leadership in their respective disciplines?

To address this question, the Subcommittee was provided with 197 *curriculum vitae* of ORD scientists and 27 STAR grant recipients, a listing of awards received by these individuals, and a

bibliometric assessment. These documents show a community of well-trained and engaged researchers with diverse expertise. Several of them are leaders in their fields, and the following list provides considerable evidence of leadership:

- ✧ 17 listings as chairs of committees or working groups, and 54 listings as members of advisory panels or committees addressing important water quality issues.

- ✧ 10 listings for offices in scientific societies and 2 fellows of scientific societies.

- ✧ Additional listings for patents, invited lectures, and service on review panels.

- ✧ 53 listings as editors, co-editors, or members of editorial review boards and 2 recognitions for being an outstanding reviewer.

- ✧ 75 listings of extramural awards, which cover a wide range of activities (from best student paper to awards from scientific societies) over many years. A particularly relevant one was given by an engineering society for leadership in improvement of stormwater management.

- ✧ EPA awards included: 7 gold medals for exceptional service, 5 silver medals for superior service, and 93 Scientific and Technical Achievement Awards, which are awarded by the SAB for outstanding publications. Fifteen additional EPA awards were listed, many of them science achievement awards in chemistry.

The bibliometric analysis covered 506 papers published from 2000 to 2005 on water quality research. Journals can be ranked by their impact factor, which reflects the frequency of citation of published papers. Thirteen percent (67) of the water quality papers have been published in journals ranked in the top 10 percent of impact factors. The average number of citations of water quality papers in 12 fields of research ranges from 3 to 24, with an average of 5 citations of each paper. The self-citation rate is 7.8 percent, which is below the accepted range of 10 to 30 percent self citation. The number of times a paper has been cited can be compared to the expected number of citations, which is the average frequency of citation of papers in a particular journal. In 10 of the 12 fields identified, the ratio of observed to expected citations is greater than one (1.04 – 5.94), indicating that most Program papers are cited more widely than the average paper in a particular journal. This analysis reveals that Program researchers are publishing peer-reviewed papers in relevant disciplines and that these researchers and theirs papers are being cited by their colleagues.

Recommendation:

- ✧ The Program should continue to diversify its research competence to address emerging regulatory issues while maintaining research in support of regulatory mandates.

VII. COORDINATION AND COMMUNICATION

Question 1: How are key stakeholders (e.g., program and regional offices, state and local governments) involved in research planning and prioritization?

ORD's WQRP has identified OW as its primary client and has geared its research planning toward meeting OW's needs. The Subcommittee agrees that this is the correct starting place for research planning because the largest portion of the Program's research is intended to support OW in implementing water quality criteria and developing approaches to water quality management when those criteria are not met. Program staff described several mechanisms that are used for obtaining input from OW in planning, and it is apparent from the presentations to the Subcommittee that the program offices within OW are quite satisfied with their involvement in the research planning process.

The WQRP also has demonstrated reasonable coordination with the regional offices. The Program maintains a Regional Scientist program, in which WQRP personnel are detailed as liaisons to each regional office. This provides communication from the Program about its latest research findings and to the Program about the next set of regional needs. In addition, the WQRP has one regional office each year on a rotating basis serve on its research planning review team to represent regional needs.

There is less direct opportunity for input from states and local government, but this is appropriate, as the WQRP cannot be asked to interact with all potential parties. The Program, however, receives this input through the regional offices, which are asked to help the WQRP determine which requests from the states, local governments, and tribes have the broadest applicability to the Agency. This is a logical approach.

The WQRP also described a new procedure it has instituted that involves meeting with other organizations, such as the Association of State and Interstate Water Pollution Control Administrators (ASIWPCA), to ensure that critical input from local agencies has not been lost in translation through the regional offices. The Program should be commended for adding this level of coordination to its planning process and encouraged to expand coordination with other interested stakeholder groups. In particular, the Subcommittee suggests that the WQRP look toward using this mechanism for enhancing interaction with environmental nongovernmental organizations (NGOs) in its planning process, as NGOs often affect OW's ability to implement the tools being developed by the Program. NGOs have consolidating organizations, such as the Clean Water Network, that could facilitate the interaction in a manner similar to what ASIWPCA has been asked to do for local government agencies.

Question 2: How has the program demonstrated collaboration with other agencies (inside and outside the government, nationally and internationally) in advancing EPA's research agenda?

There are many positive examples in which the WQRP has partnered effectively with other institutions although, as noted in the response to the next question, there is room for improvement in this area.

The Subcommittee was provided several good examples of partnership at the federal level in the poster presentations. For instance, Poster LTG 2 #4 described EPA's participation in an interagency effort to develop the tools, data, and models that will lead to better methods for detecting, predicting, and controlling harmful algal blooms. Other notable examples included the WQRP's interaction with the U.S. Department of Agriculture in assessing impacts of CAFOs on water quality (Poster LTG 2 #7) and ORD's partnership with USGS toward developing a classification scheme for streams (Poster LTG 2 #10).

There also are good examples in which EPA has worked jointly with states toward the development of criteria and assessment tools. One such example is the partnership between the WQRP and the State of California toward the development of new approaches for assessing beach water quality. The Program leveraged several million dollars of state money for a source tracking workshop and method evaluation study, which was instrumental in the Program's preparation of its recent source tracking guidance document (Poster LTG 2 #5). The WQRP also is working with California toward the development of more rapid measurement techniques (Poster LTG 1 #9) and in implementation of epidemiology studies that will allow the establishment of new microbiological bathing water criteria. This partnership not only leverages the cost of such studies, but it also builds consensus about the most appropriate directions to take in establishing these new microbiological criteria.

The WQRP has had success in partnering with the private sector, such as in development of the Biotic Ligand Model. This new approach to setting site-specific water quality objectives was conducted in cooperation with the Water Environment Research Foundation and the Copper Development Association. These organizations were helpful in co-funding the studies that established the methodology, but more importantly have assisted in training industry and local government about the availability and use of these new methods. These partners have communication networks to their member organizations that typically would not be available to disseminate findings when the research is conducted by ORD alone.

Recommendation:

- ✧ Implementation of incentives that inspire a culture motivated toward collaboration is recommended. In particular, an increase in partnership projects with state and local government is encouraged, as these agencies typically are the ultimate users of ORD products.

Question 3: What important interagency collaborations should and can be improved to advance the Agency's research agenda?

The WQRP's collaborative research efforts have been among its most successful, and the Subcommittee encourages increased emphasis on partnership. At the moment, though, collaboration appears to be investigator-driven, and there does not appear to be a reward system that encourages collaboration with other organizations. Implementation of incentives to motivate collaboration would be helpful. In particular, the Subcommittee encourages an increase in partnership projects with states and local governments and other federal agencies. Only about 5 percent of Program publications over the last 5 years were prepared in collaboration with state and/or local agencies, and only about 10 percent were collaborative with other federal agencies. These numbers are low, and the Subcommittee encourages the WQRP to develop quantitative goals for this activity, such as increasing its collaborative publication rates by three-fold over the next 5 years. The Subcommittee also encourages the WQRP to detail collaborative relationships (or lack thereof) on the posters it presents to future BOSC subcommittees as a further means of encouraging its scientists toward partnership with other organizations.

Collaborative projects offer many advantages to the WQRP, including: (1) expanding the Program's knowledge base by leveraging expertise of others from outside the organization; (2) providing a larger funding base for its projects by sharing costs across organizations; (3) promoting consensus positions across organizations, which is critically important in assisting OW with its ultimate goal of incorporating WQRP products in criteria or guidance documents; and (4) disseminating more broadly the Program's findings through independent communication networks provided by the project collaborators.

Collaboration with states and local governments can be the most difficult to achieve because many of these agencies do not have appropriate expertise or adequate staffing given their other responsibilities. Nonetheless, collaboration with states and local governments particularly is encouraged because it offers the additional advantage of technology transfer to the ultimate clients of WQRP products.

Federal collaboration opportunities will be easier to identify than state relationships. For instance, the National Oceanographic Partnership Program (NOPP) was formed by Congress to enhance partnerships among federal agencies with respect to ocean research issues. EPA is one of 15 named participants in the NOPP, but the WQRP has not participated yet in any of the cooperative projects. Another such interagency mechanism for developing partnerships is through the Subcommittee on Water Availability and Quality (SWAQ). This is an interagency group run by the White House Office of Science and Technology Policy that meets on a regular basis.

Among the individual agencies, the National Oceanographic and Atmospheric Administration (NOAA) is an obvious federal partner with which EPA should seek to expand its interactions. NOAA has a congressionally-mandated Oceans and Human Health Initiative, which contains research elements for recreational contact microbiological indicators, harmful algal blooms (with which there is some interaction, but mostly through the STAR Program rather than through EPA researchers), and hypoxia, all of which should be of interest to the WQRP. One mechanism for

enhancing those interactions might be through the Joint Subcommittee on Ocean Science and Technology, which presently is preparing position papers on these topics in response to the President's Ocean Action Plan.

The WQRP also could leverage the research accomplished through its STAR Program more effectively. Most of that research is conducted independently of the ORD laboratories by academic institutions and does not lead to capacity building within ORD. There are numerous possible mechanisms for achieving better technology transfer between STAR and the laboratories/centers, including promoting sabbaticals for faculty and internships for their students at ORD laboratories and centers.

Recommendation:

- ✧ The Program should institute mechanisms for achieving better technology transfer between the STAR Program and the laboratories/centers, such as promoting sabbaticals for faculty and internships for their students at ORD laboratories and centers.

Question 4: How does the Program use effective mechanisms for communicating research activities and results, both internally and externally?

The WQRP relies primarily on the standard approaches of preparing scientific papers in peer-reviewed publications and presenting its findings at scientific conferences. These are appropriate mechanisms for communicating findings from individual research projects, but are not necessarily the best means for communicating ORD's overall long-term research strategy.

The Program also effectively uses the World Wide Web to communicate many of its findings. The Subcommittee was impressed particularly with its use in the CADDIS project (Poster LTG 2 #2). The Web, however, is being used primarily to communicate the findings of individual research projects, rather than the Program's overall research direction and strategy.

The MYP is the best mechanism for communicating the scope and direction of the WQRP's research activities. Although the MYP is on the Web, it is not written in a way that is understood easily by an external audience. The MYP needs a much clearer logic model that relates goals, research, and outcomes. The logic should articulate more clearly the scientific uncertainties and programmatic/client needs that drive the research agenda. It should communicate where the program is going and why, and the sequence of activities (particularly when they are interdependent).

Recommendation:

- ✧ The MYP should describe a sense of program continuity: where the program has been, where it is now, and where it is going. One aspect of this should be to develop a clearer linkage in the progression of efforts directed at individual APGs that lead toward accomplishing the LTGs. The second aspect is to develop a better system for tracking progress on each LTG, which is critical to logical development of the Program's next set of research activities.

Question 5: To what extent have research results been published and cited in peer-reviewed literature?

The WQRP's publication record is reasonable. Their publication rate is not as high as expected at a typical academic setting (i.e., two or more publications per investigator per year), but ORD scientists have multiple roles and, appropriately, are expected to engage in other activities that will reduce their publication rate. These other roles include technology transfer to the states and regions, assistance to OW in the preparation of guidance documents, and preparation of reports to Congress, such as the *National Coastal Condition Report*. A large fraction of WQRP's written materials appropriately appears in these kinds of documents.

The quality of the WQRP's publications, as judged by the stature of the journals in which they are published, also is reasonable. Journals can be ranked by their impact factor, which reflects the frequency of citation of published papers. As previously stated, the bibliometric analysis indicated that 13 percent of the WQRP's water quality papers were published in journals ranked in the top 10 percent by impact factor. There also were numerous publications, however, that appeared in relatively obscure journals.

As mentioned above, in 10 of the 12 fields identified, the ratio of observed to expected citations was greater than one, indicating that the WQRP papers generally are cited more widely than the average paper in the journals in which they are published. Moreover, the self-citation rate was only 7.8 percent, which is low and indicates that the high citation results from recognition of WQRP's work by other scientists.

Recommendation:

- ✧ The Program should encourage its scientists to aim for the higher tier journals, as excessive publication in lower tier journals creates poor perception about the research quality.

Question 6: How has the Program provided expertise to clients applying research products?

The primary implementers of methodologies developed by the WQRP operate at the state and local levels. The Program's greatest success in technology transfer to these groups has been through its partnership projects, and the Subcommittee encourages the Program to continue looking for these opportunities. One of the best examples in which the WQRP has influenced the behavior of states and local governments has been in establishing monitoring networks in both fresh and marine waters within the states. The states have adopted the probabilistic and biologically based strategies advocated by the Program, representing a substantial change from the way they were conducting monitoring a decade ago. The WQRP accomplished this through a series of partnership activities, such as the Regional Environmental Monitoring and Assessment Program (R-EMAP), and technical services, such as statistical support and assistance in biocriteria development. This work is being continued with the development of stressor identification tools, as described in Poster LTG 2 #1.

Another mechanism for providing expertise is through the Regional Scientist position, in which a WQRP scientist is detailed to each regional office to enhance communication. In addition, the OST Director described a recently implemented program in which a WQRP scientist was detailed to OST to assist in the establishment of a wetlands program. The Subcommittee members agree with his assessment about the effectiveness of that effort in transferring Program research through OST to the states, and more interactions of that type are encouraged.

Although the Subcommittee noted good examples of success in technology transfer (see Appendix D), the members also observed that technology transfer to states and local governments varied widely among projects. Outside of the Regional Scientist positions, there does not seem to be a systematic set of activities or incentives to encourage WQRP scientists to establish relationships that would lead to technology transfer.

The Subcommittee recommends that the WQRP build upon the successes at the individual project level and incorporate metrics of success for technology transfer into a larger percentage of their projects.

Recommendation:

- ✧ The Program should develop a systematic set of activities or incentives and metrics of success that encourages and tracks the establishment of relationships with users that lead to better technology transfer.

Question 7: How well are program benefits articulated?

The effectiveness to which Program benefits are communicated depends on the audience. The immediate clients within OW clearly understand and appreciate the benefits of ORD's water quality research. Their understanding is so strong that it has become the foundation on which OW builds many of its programs and policies.

It is less clear that state, regional, and tribal resource managers are aware of the benefits of the WQRP's research. The Subcommittee was provided with numerous testimonial letters from state and regional programs, but these letters mostly reflect the success of collaboration on individual projects. There was less evidence that these clients had a more holistic view of the Program and its benefits.

The larger concern is about communication of Program benefits to outside groups, such as public interest organizations and the larger research community (e.g., scientific societies). These groups are particularly important because they are the ones who promote scientific research with Congress and other public officials. A mechanism for articulating program benefits to these groups would facilitate more widespread use and appreciation of program outputs.

Recommendation:

- ✧ The Program should use the new procedure it has instituted for meeting with organizations, such as ASIWPCA, for enhancing interaction with other stakeholder groups.

VIII. CONCLUSIONS

ORD's WQRP overall is in very good shape. It is conducting high quality research focused on well-articulated goals. It has strong leadership and a well-trained, diverse, motivated, and productive staff. Based on responses from clients, the Program appears to be serving them well. The Program has accomplished much with the resources available to it. Although the Subcommittee clearly was impressed with this Program, this report provides a number of comments that the Subcommittee hopes are constructive and a number recommendations which may help to ensure the Program's continued success and communicate its accomplishments more effectively.

APPENDIX A: WATER QUALITY SUBCOMMITTEE MEMBERS

Herb Windom, Ph.D.
Subcommittee Chair
Professor Emeritus
Skidaway Institute of Oceanography
10 Ocean Science Circle
Savannah, Georgia 31411
Office: 912-598-2490
E-mail: herb@skio.peachnet.edu

Gary Sayler, Ph.D.
Subcommittee Vice Chair
Professor/Director
Center for Environmental Biotechnology
The University of Tennessee
676 Dabney Hall
Knoxville, Tennessee 37996
Office: 865-974-8080
E-mail: sayler@utk.edu

Christian Chauret, Ph.D.
Department of Natural, Information, and Mathematical Sciences
Indiana University Kokomo
Kokomo, Indiana 46904
Office: 765-455-9290
E-mail: cchauret@iuk.edu

Laura Ehlers, Ph.D.
Senior Scientist
National Academy of Sciences
National Research Council
500 5th Street, N.W.
Washington, DC 20001
Office: 919-530-1074
E-mail: LEhlers@nas.edu

Kevin Kleinow, D.V.M., Ph.D.
Professor of Toxicology
Louisiana State University
School of Veterinary Medicine
Department of Comparative Biomedical Sciences
Baton Rouge, Louisiana 70803
Office: 225-578-9757
E-mail: kleinow@vetmed.lsu.edu

Judith Meyer, Ph.D.
Distinguished Research Professor
Institute of Ecology
University of Georgia
517 Biological Sciences Building
Athens, Georgia 30602-2602
Office: 706-542-3363
E-mail: jlmeyer@uga.edu

Stephen Weisberg, Ph.D.
Executive Director
Southern California Coastal Water Research Project Authority
7171 Fenwick Lane
Westminster, California 92683
Office: 714-372-9203
E-mail: stevew@sccwrp.org

APPENDIX B: BOSC WATER QUALITY SUBCOMMITTEE DRAFT CHARGE

1.0 Objective. The objective of this review is to evaluate the relevance, quality, performance, and scientific leadership of the Office of Research and Development's (ORD's) Water Quality Research Program (WQRP).

The independent external peer panel's evaluation and recommendations then will provide guidance for ORD to:

- strengthen, plan, and implement the program and its research investment decisions;
- prepare the Agency's performance and accountability reports to Congress under the Government Performance and Results Act; and
- improve coordination with other programs designed to achieve similar outcomes in other parts of the Environmental Protection Agency (the Agency) and in other federal agencies.

The independent review also will provide the most pertinent information for evaluations of federal research conducted by the Office of Management and Budget (OMB). OMB highlights the value of recommendations from independent expert panels in its guidance to federal agencies regarding improvement and reaching articulated goals.[1,2]

2.0 Background Information. Independent expert review is used extensively in industry, federal agencies, Congressional committees, and academia. The National Academy of Sciences has recommended this approach for evaluating federal research programs.[3]

Because of the nature of research, it is not easy to measure the creation of new knowledge as it develops, nor the pace at which research progresses or scientific breakthroughs occur. Demonstrating research contributions to outcomes is very challenging[4] when federal agencies conduct research to provide input for regulatory decisions, and then rely on third parties[5] (e.g., state environmental agencies) to enforce the regulations and demonstrate environmental improvements.

Typically, many years may be required for practical research applications to be developed, and decades may be required for some research public benefit outcomes to be achieved and quantified.

Most of the Agency's environmental research programs investigate complex environmental problems and processes, combining use-inspired basic research[6,7] with applied research and integrating several scientific disciplines across a conceptual framework[8] that links research to environmental decisions or outcomes. In multidisciplinary research programs such as these, progress toward outcomes usually cannot be measured by outputs created in a single year. Rather, research progress occurs over several years, as research teams explore

hypotheses with individual studies, interpret research findings, and then develop hypotheses for future investigations.

In designing and managing its research programs, ORD emphasizes the importance of identifying priority research questions or topics to guide the research directions. Similarly, ORD recommends that its programs develop a small number of performance goals, which serve as indicators of progress to answer the priority questions and to accomplish outcomes. Short-term outcomes are accomplished when research is applied by specific clients to strengthen environmental decisions or regulations. These decisions and resulting actions (e.g., reducing or preventing exposure of humans to environmental stressors posing a high risk) ultimately contribute to the improved health of the American public or to the protection of ecosystems.

In a comprehensive evaluation of EPA's science and research, the National Research Council recommended[9] that the Agency substantially increase its efforts to explain the significance of its research products and to assist internal and external Agency clients in applying them. In response to this recommendation, ORD has engaged science advisors from client organizations to serve as members of its research program teams. These teams help identify research contributions with significant decision-making value and help plan for their transfer and application.

For the Agency's environmental research programs, periodic retrospective analysis is conducted at intervals of 4 or 5 years. Conducting program evaluation at this interval enables assessment of research inputs, progress, its scientific quality and decision-making value, whether research has been applied by specific clients, and whether health and environmental outcomes are quantifiable in the short term.

A description of the Office of Science and Technology Policy (OSTP)/OMB *Research and Development Investment Criteria* is included in Appendix I (not included in this report appendix). These investment criteria of relevance, quality, performance, and leadership of the WQRP are pertinent to the draft charge questions, as are the coordination and communication of research activities.

3.0 Draft Charge Questions for ORD's WQRP

The following charge questions should be used to facilitate the peer evaluation of the relevance, quality, performance, and scientific leadership of ORD's water quality research, and the coordination and communication of that research:

Relevance

1. How is the focus of ORD's WQRP, as reflected in the Multi-Year Plan (MYP), relevant to the Agency's Goal 2 and Strategic Goals, and to recommendations for water quality research priorities developed by the National Research Council, Science Advisory Board, EPA Office of Water (OW), states, and regions?

2. How does the research program use the MYP to help guide and manage its research?

3. How does the WQRP address and respond to key and emerging scientific questions?

Quality

1. How does the program ensure quality through competitive and merit-based funding?

2. What procedures (e.g., use of peer review) does the program have to ensure the quality of its products?

Performance

A. Program Design

1. What is the logic underlying the program design (based on MYP Long-Term Goals)?

2. How well are the program goals and priorities identified?

3. How well is the rationale for the research articulated?

4. Is research sequenced appropriately?

5. How have client needs been anticipated?

6. How can the program be improved?

B. Program Progress

1. What evidence has been presented to demonstrate that significant progress has been demonstrated toward each of the Long-Term Goals?

2. How have clients applied the program's research in environmental decisions and regulations?

3. What suggests that the program has met client needs in a timely and useful way?

Scientific Leadership

1. How has the Program played a leadership role in advancing the state-of-the-science of water quality research and in solving important research problems?

2. How have water quality researchers demonstrated leadership in their respective disciplines?

Coordination and Communication

1. How are key stakeholders (e.g., program and regional offices, and state and local governments) involved in research planning and prioritization?

2. How has the program demonstrated collaboration with other agencies (inside and outside the government, nationally and internationally) in advancing EPA's research agenda?

3. What important interagency collaborations should and can be improved to advance the Agency's research agenda?

4. How does the program use effective mechanisms for communicating research activities and results, both internally and externally?

5. To what extent have research results been published and cited in peer reviewed literature?

6. How has the program provided expertise to clients applying research products?

7. How well are program benefits articulated?

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[3] Evaluating Federal Research under the Government Performance and Results Act. National Research Council, 1999.

[4] The House Science Subcommittee. Letter to Dr. Bruce Alberts, President of the National Academy of Sciences, from F. James Sensenbrenner, Jr. and George E. Brown. October 23, 1997.

[5] The Government Performance and Results Act: 1997 Governmentwide Implementation Will Be Uneven. U.S. General Accounting Office (GAO/GGD), 1997.

[6] Building a Foundation for Sound Environmental Decisions. National Research Council, 1997.

[7] Renewing the Compact between Science and Government, Stokes, D.E., in *1995 Forum Proceedings, Vannevar Bush IICScience for the 21st Century*. Sigma Xi, 1995, pp. 15-32.

[8] Risk Assessment in the Federal Government: Managing the Process. National Research Council, 1983.

[9] Strengthening Science at the U.S. Environmental Protection Agency. National Research Council, 2000, p. 141.

APPENDIX C: KEY ACCOMPLISHMENTS IN WATER QUALITY RESEARCH FROM 1995 TO 2010

LTG 1	ANALYZING STRESSOR EFFECTS FOR CRITERIA DEVELOPMENT
LTG 1	**Guidelines for Multiple Stressors (note: other research below also addresses multiple stressors)**
2001	*Evaluation Guidelines for Ecological Indicators*. These guidelines address conceptual relevance, feasibility of implementation, response variability, interpretation and utility, and include examples of three very different types of indicators: a direct chemical measurement (dissolved oxygen concentration) and two multimetric indices, an estuarine benthic community index, and a stream fish community index of biotic integrity.
2002	Landscape disturbance gradient design developed to provide sampling strategy for the Great Lakes. An EPA/Great Lakes Environmental Indicators Project (GLEI) study established a framework for field study site selection to establish stressor-response models.
2002	*Aquatic Stressors – Framework and Implementation Plan for Effects Research*. This peer-reviewed document was instrumental in providing the framework, context, and approach for National Health and Environmental Effects Research Laboratory (NHEERL) research addressing risks posed by toxic chemicals, nutrients, habitat alteration, and suspended and embedded sediments. Primary focus on the effects of those stressors on coastal ecosystems. Produced in response to high priority research needs of EPA program offices and other clients.
2002-2005	Many published studies and reports on hydrologic, biogeographic, and other ecosystem classification factors that may influence biological responses in Great Lakes coastal wetlands. Evaluation of the response classification factors needed to develop disturbance-response trends, including linking landscape character to coastal condition.
2003	Risk-Based Wildlife Criteria. Conducted a 1-day symposium at The Wildlife Society Annual Meeting entitled Assessing Risks To Wildlife Populations From Multiple Stressors. This session brought together 15 scientists in wildlife ecology, environmental protection, and conservation who are working to develop, test, and apply methods that quantify and predict risks to a variety of wildlife species subject to multiple stressors.
2004	Aquatic Stressors: Review of the Research. ORD organized a meeting with key EPA program offices and regions to review all aquatic stressor research conducted under the 2002 *Aquatic Stressors Framework.*
2005	*Wildlife Research Strategy*. This peer-reviewed document is instrumental in shaping the research needed to establish the technical basis for risk-based wildlife criteria.
LTG 1	**Methods for Assessing Risks of Toxic Chemicals**
1995	Amphipod sediment toxicity test. This method has become the standard for the dredging program and for conducting marine/estuarine risk assessments (American Society for Testing and Materials [ASTM] document).
1995-2000	Sediment Quality Criteria. Developed and validated the Sum-PAH model, which provides a means for developing sediment quality guidelines based on the probability that a polycyclic aromatic hydrocarbon (PAH)-contaminated sediment will be toxic to marine and estuarine amphipods.
1999	Developed methods for testing the chronic toxicity of contaminated sediments to freshwater organisms; published EPA guidance manual.
2000	Toxics. In cooperation with the Office of Water (OW), developed and published OW's *Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health.* Often used by states to set water quality standards that determine allowable discharge of pollutants into U.S. waters.
2002	Toxics. Developed inter-species correlation estimation (ICE) method for predicting toxicological sensitivity of infrequently tested species, including a user-friendly computer interface.
2002	Toxics. In cooperation with OW, prepared Analysis Document-Copper Prototype for use in conducting Biological Evaluations for Water Quality Criteria chemicals.

2002	Toxics. In cooperation with OW, the U.S. Fish and Wildlife Service (FWS), and the National Marine Fisheries Service (NMFS), prepared a methods manual for conducting Biological Evaluations for Water Quality Criteria chemicals. Initial work in this area demonstrated an interagency coordination under the Clean Water Act and the Endangered Species Act that resulted in a memorandum of understanding between EPA, FWS, and NMFS.
2002	Toxics. Developed Version 1.00 of Toxicity Response Analysis Program—software for analysis of toxicity test data for use in developing new aquatic life criteria for copper by OW.
2002	*Draft Action Plan for the Development of a Framework for Metals Assessment and Guidance for Characterizing and Ranking Metals*. First of two documents representing the Agency's strategy and recommendations on the incorporation of the latest science in Agency risk assessments of inorganic metal compounds.
2002	Acute to Chronic Toxicity Estimation (ACE). Developed time-concentration-effect models for use in predicting chronic toxicity to aquatic organisms from acute toxicity data.
2003	Toxics. Published Equilibrium-Partitioning Sediment Benchmarks (ESBs) for endrin and dieldrin.
2003	Toxics. In cooperation with OW, published the *Methodology for Deriving Ambient Water Quality for the Protection of Human Health* (2000). Technical Support Document Volume 2: Development of National Bioaccumulation Factors.
2003	Toxics. Provided an evaluation of methodology for predicting response to fluctuating exposure for incorporation into water quality criteria.
2003	Toxics. Published ESBs for PAH mixtures.
2003	Toxics. Published *Effects of Aryl Hydrocarbon Receptor-Mediated Early Life Stage Toxicity on Lake Trout Populations in Lake Ontario During the 20th Century*.
2003	Toxics. Developed a draft framework for the application of the toxicity equivalence methodology for polychlorinated dioxins, furans, and biphenyls in ecological risk assessment.
2003	Risk-based Wildlife Criteria. Created the Wildlife Mercury Database to support development of risk-based wildlife criteria.
2004	Toxics. Published ICE for acute toxicity to aquatic organisms and wildlife. II. User manual and software.
2004	Toxics. Published acute-to-chronic estimation (ACE v 2.0) with time-concentration-effect models. User manual and software.
2004	Toxics. Developed a framework for assessing risks from photo-activated toxicity of PAHs to aquatic organisms.
2004	*Framework for Inorganic Metals Risk Assessment* (Peer Review Draft). Second of two documents representing the Agency's strategy and recommendations on the incorporation of the latest science in Agency risk assessments of inorganic metal compounds.
2004-2006	Pharmaceuticals and Personal Care Products (PPCPs): Polar Organic Chemical Integrative Sampling (POCIS) and LC-ES/ITMS for Assessing Selected Prescription and Illicit Drugs in Treated Sewage Effluents. Levels of synthetic musks in municipal wastewater for estimating biota exposure in receiving waters; Closed-loop stripping of synthetic musk compounds from fish tissues and analysis by GC/MS/SIM. Virtual Symposium: *State of the Science — PPCPs as Environmental Pollutants*; Review article on environmental forensic techniques (e.g., high resolution MS and ICE software) over the last decade. Determination of a bound musk xylene metabolite in carp hemoglobin as a biomarker of exposure by gas chromatography-mass spectrometry using selected ion monitoring.
2005	Toxics. Published ESBs for metal mixtures.
2005	Toxics. In cooperation with OW, prepared a new framework for developing water quality criteria for the protection of aquatic life and presented it to the EPA Science Advisory Board. Provides approaches for developing risk-based Water Quality Criteria for protecting aquatic life and aquatic-dependent wildlife.
2005	Toxics. In cooperation with OW, drafting the document: *Methodology for Deriving Ambient Water Quality for the Protection of Human Health* (2000). *Technical Support Document Volume 3: Development of Site-Specific Bioaccumulation Factors.*

2005	*Predicting Toxicity to Amphipods from Sediment Chemistry*. This report describes the development of logistic regression models that quantify relationships between the concentration of contaminants in field-collected sediments and the likelihood that those sediments will cause toxicity to marine amphipods. These models are being used to evaluate the ecological risks associated with chemicals in marine and estuarine sediments and inform sampling designs; and were used by OW to evaluate the quality of the nation's sediments in the report to Congress (*National Inventory of Sediment Quality*).
LTG 1	**Tools To Assess Response to Nutrients**
2000	*Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Saltwater): Cape Cod to Cape Hatteras.* Ambient water quality criteria often are used by states to set water quality standards that determine the allowable discharge of pollutants in the nation's waters. Although this document was aimed initially at coastal regions within the Virginian Province, it has been used to help develop state standards for dissolved oxygen in estuaries throughout the coastal United States.
2001	Workshop on classification of ecological responses in coastal systems (EMAP symposium). Helped establish attributes to test in empirical NHEERL field studies across loading gradients.
2002	Estuarine Nutrient Criteria and Management. Applied long-term monitoring information to determine the processes regulating nutrient dynamics, chlorophyll distributions, and hypoxia in a Gulf of Mexico estuary. Results demonstrate that phosphorus pollution, in addition to nitrogen, must be considered in comprehensive nutrient management plans.
2002	*Comparative Systems Empirical Modeling Approach: The Empirical Regression Method To Determine Nutrient Load-Ecological Response Relationships for Estuarine and Coastal Waters*. This is part of EPA's Nutrient Criteria Technical Guidance for Estuaries and Coastal Waters. It outlines the use of comparative ecology along a nutrient gradient as a method to derive load-response models.
2003	*Development of Nitrogen Loading—Response Relationships for Estuarine Waters Using an Empirical Comparative Systems Approach*. This is the first national presentation of the Atlantic Ecology Division's approach to development of nitrogen load-response models supportive of OW's Nutrient Criteria Development for estuaries.
2003	*Development of Nitrogen Loading-Response Models for Northeast U.S. Estuaries.* This is an OW/ORD jointly produced summary of the method for development of load-response models.
2003	*Proposed Classification Scheme for Predicting Sensitivity of Coastal Receiving Waters to Effects of Nutrients*. This report outlined a methodology for development of a function classification of nutrient load-response models for U.S. estuaries and Great Lakes waters.
2003	*National Saltwater Criteria for Dissolved Oxygen: Potential Addenda to Virginia Province Saltwater Criteria for Warmer and Colder Waters*. The document was created to address the growing demand for using the Virginian Province dissolved oxygen criteria approach to regions outside this Province. Specifically, there was a need to evaluate potential alterations to the criteria when standards were developed for states that have surface waters that are warmer or colder than those within the Virginian Province.
2003	Estuarine Nutrient Criteria and Management. Demonstrated the critical role of microbial communities in seagrass bed sediments to seagrass growth and condition and developed a model of microbial community interactions and seagrass condition.
2004	Nutrients. Produced seagrass, nutrient stress-response model capable of dealing with multiple stressors.
2004	Estuarine Nutrient Criteria and Management. Applied comprehensive historical water quality information in the Chesapeake Bay to determine the long-term change in hypoxia in relation to nutrient loading and river flow. The results are being used by the Chesapeake Bay Program and its partners to refine nutrient management and restoration goals.
2005	Estuarine Nutrient Criteria and Management. Participated in development of a technical document comparing and contrasting the causes and consequences of nutrient enrichment and the prospects for management of eutrophication in two estuaries, Choptank River (primarily affected by agricultural activities) and Patuxent River (primarily affected by sewage inputs).
2005	Convened symposium entitled Response of Aquatic Food Webs to Nutrient Enrichment: Assessing the State of the Science, which included invited academic experts and EPA. A synthesis report from the symposium is in preparation.

2005	Nutrients. Produced summary report of state-of-the-science in relation to setting nutrient criteria protective of Submerged Aquatic Vegetation (SAV).
2005	Nutrients. Produced new food web model using stable isotopes as flux constraints to describe effects of freshwater input, nutrient loading, and other stressors on estuarine ecosystem.
2005	Produced sediment diagenetic model for Gulf of Mexico hypoxia zone.
2005	Nutrients. Landscape disturbance gradient design for the Great Lakes. GLEI-EPA study establishes framework for stressor-response studies of coastal systems and enables evaluation of integrated biological indicators for coastal monitoring.
2005	Implementation Spreadsheet for Interpreting Ambient Dissolve Oxygen Concentrations. This is an Excel-based spreadsheet that allows states and regions to estimate the percent of impairment to larval recruitment using measured or estimated concentrations of dissolved oxygen from the field. The spreadsheet was developed specifically for Region 4.
LTG 1	**Responses to Habitat Alteration**
2003	Habitat Alteration. Developed prototype stream network modeling approach for Coho salmon and native fish.
2003-2004	Habitat Alteration. Technical review of Region 10 water temperature standards for ORD, Region 10, and recently OW.
2003	Estuarine Habitat Criteria and Management. ORD organized a regional workshop on monitoring tidal wetlands to assess their ecological condition for EPA Region 1, the New England Interstate Water Pollution Control Commission, Massachusetts Bays Program, Massachusetts Coastal Zone Management, Massachusetts Office of Ecosystem Restoration, and Wells National Estuarine Research Reserve, Maine.
2003	Estuarine Habitat Criteria and Management. ORD co-organized a 1-day symposium at the Annual Meeting of the National Shellfish Association (New Orleans, Louisiana) entitled Effect of Habitat Alteration of Shellfish Populations. This meeting brought together scientists from across the country to discuss the relations between habitat alterations and shellfish populations.
2004	Provided support to OW on the ecology of isolated wetlands in response to a 2001 U.S. Supreme Court decision.
2004	Estuarine Habitat Criteria and Management. ORD organized a scientific session on Habitat Alteration in the Gulf of Mexico with the Gulf Estuarine Research Society and the Society for Wetland Scientists in Pensacola, Florida.
2004	Estuarine Habitat Criteria and Management. Conducted a 2-day symposium at the Northeast Aquaculture Conference and Exposition (Manchester, New Hampshire) entitled International Bay Scallop Restoration Aquaculture Symposium. This session brought together scientists from the Atlantic states to discuss research needs to support restoration of Bay Scallop populations.
2004	Estuarine Habitat Criteria and Management. ORD co-organized a meeting with OW to consolidate research directions and programs in habitat alteration in Washington, DC. Every part of OW that works with habitat was represented, as were NHEERL, National Center for Environmental Assessment (NCEA), National Risk Management Research Laboratory (NRMRL), National Exposure Research Laboratory (NERL), National Center for Environmental Research (NCER), and Office of Science Policy (OSP).
2005	Estuarine Habitat Criteria and Management. ORD organized a national workshop to enhance coordination of wetland projects, with the goal of promoting transfer of ORD's wetland science to EPA Regions, states, tribes, and local officials. The workshop was sponsored jointly by OW's Office of Wetlands, OW's Oceans and Watersheds, and ORD's OSP.
2005	Estuarine Habitat Criteria and Management. ORD and Region 1 organized a framework for Tiered Aquatic Life Uses and Habitat Alteration at the Association of National Estuary Programs conference in Newport, Rhode Island.
2005	Estuarine Habitat Criteria and Management. ORD organized a national working group and national synthesis meeting on Headwater Streams and Isolated Wetlands in response to OW needs.
LTG 1	**Methods for Monitoring Pathogens**
1995	PLUMES Model. Provides methods to design and analyze aquatic outfall systems that form plumes in the environment, having the ability to predict dilution, plume rise, bacterial decay, and other plume properties.

2002	*Method 1604: Total Coliforms and* Escherichia coli *in Water by Membrane Filtration Using a Simultaneous Detection Technique (MI Medium).* Reduced culture method to 24 hours and is being used extensively for water quality monitoring.
2004	*EMPACT Beaches Project: Results from a study on microbiological monitoring in recreational waters*. A scientifically sound measurement protocol for collecting samples to monitor and assess the safety of beach waters more effectively.
2004	Rapid (~ 2-hour) fecal indicator method developed (Q-PCR; flow cytometry) for measuring fecal contamination at public beaches (currently being used in recreational water epidemiology study to obtain associations with adverse health effects for OW to use to develop new recreational water criteria).
LTG 1	**Methods for Bioassessment**
2002	*Report on the Biological Condition of Mid-Atlantic Shallow Streams and Deep Rivers Based on Macroinvertebrates as a Basis for Management Action*. This report demonstrated that a macroinvertebrate biotic integrity index responded well to the presence of stressors in shallow streams, and it identified the percentage of streams in the Mid-Atlantic highlands region that were in good, fair, and poor condition. By contrast, the study showed that the index responded differently in deep rivers.
2004	Bioassessment. *A Review of Biological Assessment Tools and Biocriteria in New England States* was provided to state and regional biologists, as well as to OW and the Office of Environmental Information. This report helps improve the quality and consistency in bioassessment and biocriteria programs to provide for more scientifically sound water body protection and restoration decisions.
2004	*Statistical Guidance for Developing Indicators for Rivers and Streams: A Guide for Constructing Multimetric and Multivariate Predictive Bioassessment Models*. This document was incorporated in the EPA Office of Science and Technology's document *Methods for the Use of Statistics in Bioassessments and Biocriteria Development.*
2004	*Association Among Invertebrates and Habitat Indicators for Large Rivers in the Midwest - How Sampling Distance, Point-Sampling of Habitat, and Subsample Size Affect Measures of Large River Macroinvertebrate Assemblages*. With development of this standardized method, regulatory agencies that are responsible for protecting and restoring water quality have a new tool for determining the condition of large rivers. The method already is in use as the standardized approach for a project in Region 5.
2004	*Prototype Indicators of Condition for Deep River Fish Assemblages Developed—Electrofishing in Boatable Rivers: Does Sampling Design Affect Bioassessment Metrics?* This research detected significant differences in many common measures of fish assemblage condition as a result of field design. The method is beginning to be adopted as the standard method for conducting state-wide assessments (currently used by U.S. Army Corps of Engineers and Kentucky).
2004	*A Review of Biological Assessment Tools and Biocriteria in New England States*. This report provides a central resource to compare stream and river bioassessment programs across six New England states.
2004	*Statistical Guidance for Developing Indicators for Rivers and Streams: A Guide for Constructing Multimetric and Multivariate Predictive Bioassessment Model*. This guidance document provides step-by-step approaches for the developing bioindicators for use in water quality monitoring and promotes the use of biocriteria to protect and restore ecosystems and water quality more effectively.
2004	*Association Among Invertebrates and Habitat Indicators for Large Rivers in the Midwest* and *Prototype Indicators of Condition for Deep River Fish Assemblages*. These reports identify new large-river sampling methods for macroinvertebrate and fish communities, respectively, now in use in several Midwestern states.
2005	*Report on the Field and Laboratory Performance Characteristics of a New Sampling Method for Riverine Macroinvertebrate Assemblages.* Quantifies the precision, sensitivity, performance range, bias, and interferences of a large-river macroinvertebrate sampling method so that managers can interpret biomonitoring program results accurately.
2005	*A Comparison of Random and Modified Random Site Selection for Assessment of Wadeable Streams in Wisconsin*. Quantifies the bias that results from using nearest bridge crossing rather than fully random site selection, so that state water quality assessment programs understand the trade-offs between sampling cost and data quality.

LTG 1	**Suspended and Bedded Sediments (SABS)**
1996	Sediment Bioaccumulation Test. Developed standard (ASTM) methods for bedded sediment bioaccumulation test for marine/estuarine waters in support of the dredging program and marine/estuarine risk assessments.
1998	Sediment Quality Criteria. Multi-laboratory effort on development of Agency sediment quality criteria based on equilibrium partitioning theory.
2003	In cooperation with OW, presented approaches for the development of water quality criteria for Suspended and Bedded Sediments (SABS) to the Science Advisory Board
2005	In cooperation with OW, prepared a draft national strategy for the development of water quality criteria for SABS. Provides a synthesis of procedures (tool box) to the states for developing SABS criteria.
LTG 2	**DIAGNOSING CAUSES OF IMPAIRMENT**
1996	*Marine TIE Guidance*. EPA 1996. *Marine Toxicity Identification Evaluation (TIE) Phase I Guidance Document.* September 1996, EPA/600/R-96/054. Guidance provides water quality managers tools to identify toxic chemicals causing toxicity in effluents discharged to the marine receiving waters. The guidance also is useful for TIEs performed on receiving waters and sediment interstitial waters.
1999	*TIE Guidance*. EPA 1999. *Toxicity Reduction Evaluation Guidance for Municipal Wastewater Treatment Plants*. August 1999, EPA/833/B-99/002.
1999	*Sediment Toxicant Identification*. Development of methods to characterize and identify metal toxicants in contaminated sediments (freshwater and marine).
1999-2001	*Watershed Classification Pilot*. This NHEERL pilot project demonstrated the utility of the watershed classification approach through application of a probability-based design to tributaries of the western arm of Lake Superior. The watershed classification allowed researchers to predict biotic, chemical, and habitat quality of different watershed classes. Watershed classification maps were provided to the Lake Superior Basin planning teams in Minnesota and Wisconsin.
2000	In collaboration with OW, developed the *Stressor Identification Guidance Document* (EPA/822/B-00/025) in 2000 to assist water resource managers in identifying the causes of biological impairment. This report provides a systematic, scientifically sound method for diagnosing the causes of adverse biological changes in aquatic systems. It has been used by the scientists in the regions and states to direct management activities, including TMDL development, toward the chemical, physical, or biological factors that will most improve biological condition. Case studies to supplement the guidance were published in 2001.
2000	*Sediment Toxicant Identification*. Development of methods to characterize and identify ammonia as a toxicant in contaminated sediments (freshwater and marine).
2001	ORD provided EPA Region 6 with extensive data at the Canton field site, some of which were used as the information base for EPA Region 6 to exercise rarely used emergency powers to compel swine farms to give families in the area safe drinking water and change land management practices.
2001	*Ecological Risk Assessment for the Middle Snake River, Idaho*. EPA/600/R-01/017. Mathematical simulations and field observations were used to better understand how stressors such as altered river flow or sediment input impact macrophyte biomass or fish populations. This enables managers to explore alternative management options and make more informed decisions.
2002	*Clinch and Powell Valley Watershed Ecological Risk Assessment*. EPA/600/R-01/050. This assessment makes clearer the connection between coal mining, agriculture, and urbanization with declines in fish and mussel species richness. These findings help the FWS and The Nature Conservancy encourage farmers and others to take management actions to minimize impacts on fish and mussels.
2002	Wetlands Classification Module. This Web-based module was incorporated into an EPA series on methods for assessing wetlands condition. The module compares and contrasts different applications for classification based on both reference condition and sensitivity to nutrients.
2002	*Waquoit Bay's Watershed Ecological Risk Assessment*: *The effect of land derived nitrogen loads on estuarine eutrophication*. EPA/600/R-02/079. The models provided in this report provide the opportunity for managers to assess a variety of options to reduce nitrogen loads to their estuaries and to achieve the loads that could allow the return of eelgrass to the area.

2002-2004	Series of Microbial Source Tracking Workshops/Factsheets for EPA regional offices and states on the state-of-the-science and the use of molecular biological tools in water quality evaluation: Regions 3, 9, and 10 and the Association of State and Interstate Water Pollution Control Administrators (ASIWPCA). Microbial Source Tracking Guide Fact Sheet for the board members of ASIWPCA.
2003	*Watershed Classification Survey Design.* A watershed-scale sampling framework was developed in cooperation with West Virginia state agencies, applied to a survey of fish communities in wadeable streams, and presented in an EPA Report. The project demonstrated that it is possible to assess stream condition as well as produce information on probability of impairment for different watershed classes.
2003	*ORD Method for Analysis of Estrogens Associated with CAFOs* published in *Journal of Chromatography*. ORD used this method to detect estrogens in groundwater at the Cimarron Pork field site and will be assessing other types of concentrated animal feeding operations (CAFOs) in the future.
2003	Rapid PCR-based diagnostic techniques were developed to identify *Pfiesteria* complex organisms and better delineate their distribution. These techniques are used by both Maryland and Delaware departments of natural resources for water quality monitoring and assessment, NCER R827084 (Oldach).
2003	Obtained data needed to produce models of the biophysical interactions of *Karenia brevis* (red tide) with its chemical and physical habitat. This program, along with the larger ECOHAB program, provides data to conduct large- and small-scale modeling of blooms, NCER R827085 (Stiedinger) and R826792 (Vargo).
2003	A successful preliminary evaluation of the use of clays to mitigate harmful algal blooms was completed in a joint effort with scientists at NHEERL. This research led to a subsequent pilot study (funded by the National Oceanic and Atmospheric Administration [NOAA]) to address the "real-world issues" of clay dispersal and its effects in the field, NCER CR827091 (Anderson).
2004	EPA Region 6, U.S. Department of Agriculture (USDA)-Natural Resources Conservation Service (NRCS), and USDA-Agricultural Research Service (ARS) formed an ad hoc workgroup to focus research efforts on Comprehensive Nutrient Management Plans (CNMPs) associated with land application of CAFO waste. This marked the first extensive research collaboration between EPA and USDA and thus far has led to two collaborative research projects.
2004	*Causal Analysis Database of Literature (CADLit): Suspended and Settled Particle Module*. This effort will help risk managers determine if an impairment is caused by excess sediment and will help them establish TMDL goals. This work also supports the development of guidance for states and tribes to set standards for bedded and suspended sediments, a joint ORD/OW effort. The CADLit database is available as a compact disc by request for EPA personnel and scientific collaborators.
2004	Several publications and a final report discussing the mechanisms of lesion initiation and the contributory environmental and biological conditions required for the progression of such lesions in fish following exposure to *Pfiesteria* complex organisms. This research furthered the understanding of lesion formation in menhaden and its relationship to *Pfiesteria*, NCER R828225 (Shields).
2004	*Sediment Toxicant Identification*. Development of methods to characterize, fractionate, and identify organic toxicants in contaminated sediments (freshwater and marine).
2005	*Microbial Source Tracking Guide Document* (EPA/600-R-05-064). This report provides scientists, engineers, and environmental managers with a comprehensive, interpretive analysis of current microbial source tracking (MST) information.
2005	*Watershed Classification*. Tested and applied three approaches for classifying all HUC12 watersheds in EPA Region 5 in support of nutrient criteria development for streams, including comparison of nutrient-response relationships across watershed classes. Results will provide support for effects-based classification, as well as stratified nutrient-response relationships that can be used for criteria development. Provided input to watershed ranking for Upper Mississippi River hydrologic unit codes (HUCs) for EPA Region 5 as part of a nationwide exercise to prioritize watersheds for load reductions.

2005	*Classification*. Developed a coastal classification scheme to group estuarine watersheds by similarities in physical and hydrological characteristics. To comply with CWA 303(d) and TMDL regulations, states are required to diagnose the causes of biological impairment.
2005 - 2006	EPA, along with other federal agencies co-sponsored the first Interagency International Symposium on Cyanobacterial Harmful Algal Blooms (IISOC-HAB) in 2005. The final IISOC product produced in 2006 will be a monograph containing: (1) a synthesis paper describing a potential National Research Plan on cyanobacteria; (2) six workgroup reports; (3) about 28 papers authored by the invited speakers; and (4) multiple poster abstracts. The monograph will be presented to the Task Force that HABHRCA requires to be established through the Committee on Environment and Natural Resources for its use in meeting the mandates of HABHRCA.
Tech support	Provided Region 4 with a report on the application and comparison of DNA-based methodologies to be used in the development of MST technology by the Region's laboratory support. Supported Fish and Wildlife Initiative in protecting a coastal critical habitat by assessing the exposure level of fecal contaminants.
LTG 3	**RESTORATION**
LTG 3	**Concentrated Animal Feeding Operations (CAFOs) – Releases Control**
2002	Report to OW concerning the risk presented by CAFO related pathogens. This internal report (in the form of a memo) was submitted to OW in support of its development of the 2002 National Pollutant Discharge Elimination System (NPDES) "CAFO Rule."
2004	*Risk Management Evaluation for Concentrated Animal Feeding Operations*. This document assessed the current state-of-the-art in managing environmental pollution from CAFO operations. It informs ORD's CAFO research and is expected to be used as a resource for Agency decision makers.
2004	*A Strategy to Evaluate Best Management Practice (BMP) Performance via Molecular Biology Methods in Watersheds Impaired by Fecal Contamination*. This document discusses a method for evaluating the effectiveness of riparian buffers for attenuating non-point source pathogen contamination from manure-applied fields.
LTG 3	**Controlling Non-Point Source Releases of Major Pollutants**
2002	Workshop on the State of the Art of Suspended and Bedded Sediments Management (proceedings will be published as an EPA report). This workshop brought together experts in the various disciplines associated with sediment management and mitigating the effects of excess sedimentation in watersheds. This workshop informed ORD sediments research planning.
2004	*Stormwater Best Management Design Guide*. This three-volume design manual addresses factors that should be considered in the BMP design, with a focus on specific design guidance for the three most commonly used structural treatment BMPs.
2004	Development of a method for evaluating BMP effectiveness based on the use of flow duration curves. This method allows for the determination of stressor loadings based on commonly available data and allows for the prediction of the conditions under which established limits (e.g., TMDLs) may be exceeded. Being used by the State of Kansas.
2005	*The Use of Best Management Practices (BMPs) in Urban Watersheds.* Summary description of the current state-of-the-art of BMP application in urban watersheds. The reference is used by many municipal stormwater management programs as a guide. Kansas City, Missouri is designing its entire stormwater management program based upon the recommended strategies and protocols.
2005	Experimental Stream Facility (ESF). Initiated lease at a unique research facility that is set up to balance the controlled conditions of the laboratory with the variability of the natural environment required to develop scalable models of the linkage between chemical-based water quality standards and small stream biotic assemblages.
2005	Modeling framework to optimize the placement of BMPs within a watershed. Through the use of Monte-Carlo analysis, it is possible to obtain reliable analyses with minimal data and with data of unknown quality. This accomplishment is essential for the success of TMDLs, trading programs, and other strategies for reducing stressor loadings because it accounts for the importance of location in determining the overall effect that use of a BMP has on water quality.

LTG 3	**Ecological Assessment and Benefit Analysis**
2003	*Integrating Ecological Risk Assessment and Economic Analysis in Watersheds*. Presents three watershed-level ecological risk assessments, followed by economic analyses, to improve environmental management in watersheds.
2004	*Ecological Benefits Assessment Strategic Plan*. SAB Review Draft. The Plan describes the ecological and economic evaluation approaches currently used at the Agency and proposes a more integrated process for assessing ecological benefits. A number of actions are presented that could help the Agency improve its ability to identify, quantify, and value the ecological benefits of its activities.
2005	*Economics and Ecological Risk Assessment: Applications to Watershed Management*. Focusing on real-world decisions, this book makes several contributions to environmental management, including placing economic analysis into a context familiar to risk assessors, using the risk assessment perspective to challenge economists to translate risk statements into terms amenable for economic analysis, and introducing a conceptual approach for integrating economics and ecological risk assessment in the context of watershed management.
LTG 3	**Forecasting Effectiveness of Management Alternatives**
2002	A new hydrodynamic and sediment transport model was developed for the HSPF model, which makes HSPF more versatile and comprehensive for evaluating sediment transport within stream/river networks.
2002-2004	Landscape characterization tools and models Analytical Tools Interface for Landscape Assessments (ATtILA) and Automated Geospatial Watershed Assessment (AGWA) incorporated into OW's Better Assessment Science Integrating Point and Non-point Sources (BASINS) modeling framework for more targeted, efficient condition assessment and forecasting. ATtILA is a geographic information system (GIS) extension that calculates many commonly used landscape metrics. AGWA incorporates spatial data sets into the Kinematic Runoff and Erosion (KINEROS) and Soil and Water Assessment Tool (SWAT) models.
2003	New sediment transport model Generalized Sediment Transport for Alluvial Rivers (GSTAR-1D) and modified sediment transport model Environmental Fluid Dynamics Code (EFDC) for more accurate state/region TMDL sediment load allocations. GSTAR-1D is a one-dimensional hydraulic and sediment transport model for use in natural rivers and manmade canals. EFDC is a three-dimensional hydrodynamic model that is capable of simulating the transport of both cohesive and noncohesive sediments in estuaries, rivers, reservoirs, and coastal seas, and also is a mobile boundary model.
2004	Landscape Indicators for Pesticides Study – Mid-Atlantic Coastal Streams (LIPS-MACS). Developed landscape indicator models for pesticides, nutrients, and toxic chemicals in stream water and sediments within the coastal plain. Used to evaluate existing sampling programs and/or to plan future programs that are specific to the areas predicted to have higher concentrations.
2005	"Automated GIS Watershed Analysis Tools of RUSLE/SEDMOD Soil Erosion and Sedimentation Modeling" – new soil and landform metrics for landscape modeling. Significant improvement in computing erosion and sedimentation estimates for large regions, leading to improved estimates for soil loss and sedimentation, important to water quality assessments such as the TMDL process.
Ongoing	Watershed & Water Quality Modeling Technical Support Center to support water resource managers with TMDL allocations and water quality assessments, diagnoses, and forecasting.
LTG 3	**Urban Wet Weather Flow (WWF)—Problem Characterization and Research Vision**
1996	*Risk Management Research Plan for Wet Weather Flows (WWF)*. This has been an important influence on ORD's research direction on developing better risk management decision-support tools and WWF control measures.
2003 & 2004	Peer-reviewed state-of-the-science documents on water quality management of five key stressors – nutrients, sediments, toxics, flow, and pathogens.
LTG 3	**Urban Wet Weather Flow—Control Technologies**
1996	Swirl Technology. The research developed design, evaluation, and application practice enhancements for the use of swirl/vortex technologies, which are used widely as part of combined sewer overflow (CSO) and stormwater pollution control systems.

1999	*Stormwater Treatment at Critical Areas: The Multi-Chambered Treatment Train (MCTT).* The MCTT is a treatment system that provides pollution control at isolated, critical ("hot-spots") locations. It has been used for stormwater pollution control by Milwaukee and Minaqua, Wisconsin and by CALTRANS in California.
2000	*Evaluation of Street Storage System for Control of Combined Sewer Surcharge*
2000	*Evaluation of Retrofitting Control Facilities for Wet-weather Flow*. Feasibility and cost effectiveness of 13 separate retrofit approaches, which demonstrated that, in most cases, retrofitting existing facilities can be technically feasible and cost effective.
2002	Critical reviews of five disinfection technologies applicable to CSO. Based on ORD pilot studies, the results were used to plan multi-million dollar improvements to the New York City's CSO facilities.
2003	Patent: "System and Method for Vacuum Flushing Sewer Solids" for sewer sediment control**.**
2003-2005	WWF Environmental Technology Verifications. The ORD Water Quality Protection Center conducted verification assessments on WWF innovative monitoring and control technologies by collecting effectiveness data.
2004	*Sewer Sediment and Control: A Management Practices Reference Guide.* This guide helps municipalities in their efforts to protect receiving waters and maintain the structural integrity of their sewers.
LTG 3	**Urban Wet Weather Flow—Stormwater Runoff Modeling**
1999	Stormwater Management Model (SWMM). One of the most successful models produced for the water environment, SWMM is used widely throughout the world to analyze quantity and quality problems related to stormwater runoff, combined sewers, sanitary sewers, and other drainage systems in urban and non-urban areas.
2004	SWMM5. New version of SWMM that is compatible with current computational technology and a system that is more accessible for updating by the current generation of modelers.
LTG 3	**Urban Wet Weather Flow—Outreach and Technology Transfer**
1997 to Present	Website. The Website provides rapid, free access to the user community to ORD WWF-related research.
2000	*Innovative Urban Wet-Weather Flow Management Systems*. A book co-edited by ORD that outlines the principles of sustainable urban water management and describes innovative methods to improve these systems.
2002	*Stormwater Effects Handbook: A Toolbox for Watershed Managers, Scientists, and Engineers.* A book that provides a logical approach for an experimental design to determine if stormwater runoff is causing adverse effects and beneficial-use impairments in local receiving water.
2003	*Management of Combined Sewer Overflows.* The book is a reference for the user community faced with the challenges and mandates to combat urban wet-weather induced water pollution.
LTG 4	**METHODS TO REDUCE RISK FROM BIOSOLIDS**
1995	*Process Design Manual for Land Application of Sewage Sludge and Domestic Septage* and *Process Design Manual for Surface Disposal of Sewage Sludge and Domestic Septage*. These documents provided background information for development of EPA's sewage sludge regulations.
1996	*Technology Transfer Handbook: Management of Water Treatment Plant Residuals*. A comprehensive guidance document on how to treat properly the solid residuals that are a byproduct of drinking water treatment. This document is used by water treatment plant professionals to determine the proper way to manage the solid wastes that result from their operations.
2003	*Environmental Regulations and Technology: Control of Pathogens and Vector Attraction in Sewage Sludge*. The authoritative guidance document on the treatment of sewage sludge to assure environmentally benign disposal on land. This document is used by those who are responsible for the disposal of treated sewage sludge (biosolids) on land in compliance with federal regulation.
2003	Development of the response to the National Research Council (NRC) Review of the EPA's Biosolids Program in *Federal Register* Notice (12/31/03). ORD provided major support to OW to develop response. This document identified how EPA planned to respond to the recommendations of the National Academy of Sciences regarding needed improvements to the Agency's biosolids program.

2004	*Results of the Inter-laboratory Validation of EPA Methods 1680 (LTB/EC) and 1681 (A-1) for Fecal Coliforms in Biosolid* and *Results of the Inter-laboratory Validation of EPA Method 1682 for Salmonella in Biosolids*. These reports present the results of EPA's inter-laboratory validation study of procedures for the analysis of selected indicators in biosolids material. These results will be used by OW to develop standardized methods to analyze of the effectiveness of sewage sludge treatment techniques.

APPENDIX D: TABLE OF CLIENT TESTIMONIALS

Client	Topic	Is Timeliness Mentioned?	Institutional, Management, or Environmental Outcome? Explain
LTG 1			
1. Wisconsin Department of Natural Resources (WDNR)	Wildlife mercury risk assessment		**Management.** Close collaboration between ORD and WDNR to develop wildlife risk assessment models, especially for mercury.
2. Environment Canada	Wildlife population risks from chemicals		**Management/Institutional.** ORD developing new approach to wildlife risk assessment that should lead to regulatory criteria for mercury emissions.
3. Tampa Bay Estuary Program	Estuarine nutrient criteria and management; other specific projects	Yes, EPA provided timely information on pharmaceuticals	**Management/Institutional.** EPA developed the Tampa Bay Benthic Index; using EPA documents to develop tiered uses and criteria.
4. EPA Chesapeake Bay Program Office	Dissolved oxygen criteria		**Institutional.** ORD developed dissolved oxygen and chlorophyll a criteria for the program. Since been adopted by MD, DC, VA, and DE.
5. Narragansett Bay Estuary Program	Nutrient criteria and estuarine diagnostics case study		**Management.** Using EPA's estuary categorization techniques, getting help on nutrient TMDLs
6. Connecticut Department of Environmental Protection (DEP)	Coastal stressors/effects of nitrogen on eelgrass beds		**Institutional.** ORD is expected to be instrumental is setting nitrogen criteria and loading limits.
7. U.S. Army Corps of Engineers	Seagrass-sediment modeling	Strongly implied	**Management.** ORD model was used to determine how, when, and where to dredge.
8. Washington Department of Natural Resources (DNR)	Seagrass stress response modeling	Strongly implied	**Management.** Using EPA model to further eelgrass restoration efforts.
9. University of Minnesota	Collaboration with EPA's Mid-Continent Ecology Division		**Institutional.** Used ORD research to develop an indicator of polycyclic aromatic hydrocarbons (PAHs) and other indicators relevant to the Great Lakes.
10. EPA Region 8: Ecological Risk	Assessments on Superfund Sites		**Management.** ORD research used to refine site-specific risk assessments by incorporating bioavailability factors.
11. University of Minnesota	Collaboration with EPA's Mid-Continent Ecology Division; View from the Lake Education Program		**Information Transfer** to further educational goals of university sea grant program.

Client	Topic	Is Timeliness Mentioned?	Institutional, Management, or Environmental Outcome? Explain
12. Florida DEP	Estuary classification and causes of impairment		**Management.** ORD has supplied monitoring methods, classification tools, and stressor identification methods to DEP.
13. The Nature Conservancy (TNC)	Development of biological indicators, methods, and assessment techniques for use in headwater streams		**Management/Institutional.** ORD is developing bioassessment techniques that eventually can be used to establish biocriteria for headwater streams, enabling better stream management by TNC.
14. EPA Region 3	Headwater streams/ large rivers/novel indicators	Implied	**Management/Institutional.** ORD is developing bioassessment techniques for multiple purposes.
15. Mississippi Department of Environmental Quality (MDEQ)	Sampling methodology for large rivers		**Management/Information Transfer.** EPA developed bioassessment methods customized to MDEQ's needs.
LTG 2			
16. Maryland DNR	Ecology and Oceanography of Harmful Algal Bloom Program	Measurement technique provides very timely results.	**Management.** DNR uses a sampling technique for algae to better manage algal blooms. Development and deployment of the technique is funded by ORD's ECOHAB Program.
17. EPA Region 5	Development of Diagnostic Indicators of Stream Impairment Caused by Nutrients	Project not yet completed.	**Institutional.** ORD researchers are collecting and analyzing data to determine nutrient criteria.
18. Connecticut DEP	Stressor Identification Guidance Document (not on letterhead)		**Management/Environmental/Information Transfer.** ORD developed a restoration plan for the Willamantic River that led to attainment of water quality standards.
19. Delaware Department of Natural Resources and Environmental Control (DNREC)	Ecology and Oceanography of Harmful Algal Bloom Program	Measurement technique provides very timely results.	**Management.** DNREC uses a sampling technique for algae to better manage algal blooms. Development and deployment of the technique is funded ORD's ECOHAB Program.
20. Coastal America	Water quality analyses and biological correlations		**Management.** ORD sampled water quality and made biological correlations to aid in restoration of the Westport River watershed.
21. Iowa DNR	Stressor Identification Guidance and the Development of CADDIS		**Management.** DNR used the Stressor guidance and CADDIS to develop TMDLs for biologically impaired waters where the stressor is unknown.
22. EPA Region 6: Kerr Laboratory Ada, OK	Concentrated animal feeding operations (CAFOs)		**Management/Institutional.** ORD modeled nitrate in groundwater and is determining the effectiveness of permeable reactive barriers (PRBs). Results may lead to limits on how nutrients are applied to land.
23. ASIWPCA	Liaison with the Cincinnati office	Timeliness mentioned	**Information Transfer.** ORD Cincinnati has shared information on MST, CADDIS, and sediment criteria with state programs.

LTG 3			
24. EPA Region 5	Constructed Wetlands Manual		**Management/Information Transfer**. ORD's manual has been used repeatedly in Region 5 to design and build wetlands.
25. Clermont County (OH) Board of Commissioners	Integrated watershed planning and implementation		**Management.** County is using (1) an ORD monitoring system to augment its own efforts; (2) ORD models that link water chemistry to biotic health; and (3) ORD guidance on stormwater BMPs.
26. Maryland Department of the Environment (MDE)	TMDL water quality models		**Management/Information Transfer**. MDE has long used ORD watershed and water quality models for TMDLs and sends employees to EPA training workshops.
27. Canaan Valley Institute	Emergy and economic valuation analysis		**Management.** ORD research is trying to better determine the economic value of restoration. Useful for local watershed groups.
28. Delaware River Basin Commission	Models for PCB homologs for the Delaware River Estuary	Input from ORD was received in a timely manner	**Management**. An ORD researcher was involved in developing, reviewing, and calibrating a model developed by the commission.
29. Philadelphia Water Department (PWD)	Storm Water Management Model (SWMM)		**Management.** The model is used by PWD for stormwater management, CSO control, stream restoration, and other local projects.
30. Environment and Water Resources Institute of the American Society of Civil Engineers	Wet Weather Research Program products		**Management/Information Transfer**. The extensive utility of two ORD products—a manual on BMPs and a manual on CSOs—is commended.
31. EPA Region 5	Evaluation of wetlands for stressor control		**Management.** ORD has helped Region 5 understand the water quality benefits of wetlands restoration. No specifics given.
32. Maryland Department of the Environment	Monitoring prioritization tool		**Management**. ORD developed a tool for MDE to allow them to prioritize bacterial monitoring efforts more effectively.
33. EPA Region 3	BMP research products and support		**Management/Information Transfer**. Collaborative efforts between ORD and EPA Region 3 have led to significant advances in our understanding of several BMPs important to stormwater management.
LTG 4			
34. Schwing Bioset Technologies	Pathogen Equivalency Committee	Mentioned as slow to respond due to lack of staff	**Management**. ORD has assisted Schwing by testing its protocols for converting biosolids. ORD also has suggested good indicators.

35. Wisconsin DNR	Pathogen Equivalency Committee		**Institutional/Management/Information Transfer**. ORD research provides the foundation for the 503 regulations. Methods development, creation of reference manuals, Website for regulators also praised.
36. EPA Region 8	Biosolids research and guidance documents		**Management/Institutional.** Region 8 uses ORD analytical methods and reference manuals.
37. EPA Region 2	Biosolids guidance documents		**Information Transfer.** ORD has reviewed monitoring results, equivalency determinations, etc.
38. Water Environment Research Foundation (WERF)	Biosolids research		**Institutional/Information Transfer**. ORD reviewed and helped establish criteria for equivalency for several WERF projects. ORD holds workshops and meetings.

APPENDIX E: LIST OF ACRONYMS

ACE	Acute to Chronic Toxicity Estimation
AGWA	Automated Geospatial Watershed Assessment
APG	Annual Performance Goal
APM	Annual Performance Measure
ARS	Agricultural Research Service (ARS)
ASIWPCA	Association of State and Interstate Water Pollution Control Administrators
ASTM	American Society for Testing and Materials
ATtILA	Analytical Tools Interface for Landscape Assessments
BASINS	Better Assessment Science Integrating Point and Non-point Sources
BMP	Best Management Practice
BOSC	Board of Scientific Counselors
CADDIS	Causal Analysis/Diagnosis Decision Information System
CADLit	Causal Analysis Database of Literature
CAFO	Concentrated Animal Feeding Operation
CENR	Committee on Environment and Natural Resources
CNMPs	Comprehensive Nutrient Management Plans
CSO	Combined Sewer Overflow
CWA	Clean Water Act
DEP	Department of Environmental Protection
DNR	Department of Natural Resources
DNREC	Delaware Department of Natural Resources and Environmental Control
EcoHAB	Ecology of Harmful Algal Blooms
EDC	Endocrine Disruptor Compound
EFDC	Environmental Fluid Dynamics Code Model
EIC	Expected Introductory Concentrations
EMAP	Environmental Monitoring and Assessment
EPA	Environmental Protection Agency
ESB	Equilibrium-Partitioning Sediment Benchmark
ESF	Experimental Stream Facility
FACA	Federal Advisory Committee Act
FDA	Food and Drug Administration
FWS	Fish and Wildlife Service
GAO	General Accounting Office
GGD	General Government Division
GIS	Geographic Information System
GLEI	Great Lakes Environmental Indicators
GSTAR	Generalized Sediment Transport for Alluvial Rivers Model
HABHRCA	Harmful Algal Bloom and Hypoxia Research and Control Act
HSPF	Hydrological Simulation Program-FORTRAN
HUC	Hydrologic Unit Code
ICE	Inter-species Correlation Estimation

IISOC-HAB	Interagency International Symposium on Cyanobacterial Harmful Algal Blooms
KINEROS	Kinematic Runoff and Erosion Model
LIPS-MACS	Landscape Indicators for Pesticides Study – Mid-Atlantic Coastal Streams
LTG	Long-Term Goal
MDE	Maryland Department of the Environment
MDEQ	Mississippi Department of Environmental Quality
MST	Microbial Source Tracking
MYP	Multi-Year Plan
NAS	National Academy of Sciences
NCEA	National Center for Environmental Assessment
NCER	National Center for Environmental Research
NERL	National Exposure Research Laboratory
NGO	Nongovernmental Organization
NHEERL	National Health and Environmental Effects Research Laboratory
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NOPP	National Oceanographic Partnership Program
NPD	National Program Director
NPDES	National Pollutant Discharge Elimination System
NRC	National Research Council
NRCS	Natural Resources Conservation Service
NRMRL	National Risk Management Research Laboratory
OMB	Office of Management and Budget
ORD	Office of Research and Development
OSP	Office of Science Policy
OST	Office of Science and Technology
OSTP	Office of Science and Technology Policy
OW	Office of Water
OWM	Office of Water Management
OWOW	Office of Wetlands, Oceans, and Watersheds
PAH	Polycyclic Aromatic Hydrocarbon
PART	Program Assessment Rating Tool
PEC	Pathogen Equivalency Committee
POCIS	Polar Organic Chemical Integrative Sampling
PPCPs	Pharmaceuticals and Personal Care Products
PWD	Philadelphia Water Department
Q-PCR	Quantitative-Polymerase Chain Reaction
RCT	Research Coordination Team
R-EMAP	Regional Environmental Monitoring and Assessment Program
RFA	Request for Applications
RUSLE	Revised Universal Soil Loss Equation
SAB	Science Advisory Board
SABS	Suspended and Bedded Sediments
SAV	Submerged Aquatic Vegetation
SEDMOD	Spatially Explicit Delivery Model
STAR	Science To Achieve Results

SWAQ	Subcommittee on Water Availability and Quality
SWAT	Soil and Water Assessment Tool
SWMM	Stormwater Management Model
TIE	Toxicity Identification Evaluation
TMDL	Total Maximum Daily Load
TNC	The Nature Conservancy
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
WASP	Water Quality Analysis Simulation Program
WDNR	Wisconsin Department of Natural Resources
WERF	Water Environment Research Foundation
WQRP	Water Quality Research Program
WWF	Wet Weather Flow