An Overview of the Strategic Content of EPA's Watershed Research Program

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Abstract

Introduction

The Environmental Protection Agency (EPA) has appropriately directed much attention to watersheds during its tenure as the Federal Agency charged with protection of human health and the environment. Watershed research as a vehicle to understand the interaction of the hydrologic cycle and human activities has also enjoyed a vital and active role in EPA's tenure. Specifically, EPA's Office of Research and Development (ORD) is pleased to share in a conference that highlights the role that experimental watersheds and related interagency research has played in our collective interests in informing public policy, increasing knowledge about watershed processes, and promoting stewardship of land, water, and biota – in a phrase, protecting, improving, and sustaining watersheds. The purpose of this paper is to briefly review an EPA-ORD perspective on our progress to date, to describe the EPA research agenda in this arena, and to challenge the watershed research community to address four fundamental hypotheses both as individual ideas and in an interdisciplinary manner. A list of references is provided for those interested in more detailed descriptions and the data upon which this paper is based.

EPA's interest in watersheds and water resources is manifold and flows from requirements of the Clean Water Act (CWA), the Safe Drinking Water Act (SDWA), the Resource Conservation and Recovery Act (RCRA), the Food Quality Protection Act (FQPA), the Federal Insecticide, Rodenticide, and Fungicide Act (FIFRA), the Superfund, the Clean Air Act (CAA), the National Environmental Policy Act (NEPA), and a number of other federal laws and Executive Orders that influence development of EPA regulations, policy directives, and guidance documents (e.g., Threatened and Endangered Species Act, Coastal Zone Management Act, E.O. on Invasive Species). While a detailed analysis of the cross connections between each of these directives and watershed research is no doubt useful if not enlightening to many, this paper will concentrate on the context provided by the Clean Water Act. This is convenient and useful because the goals and requirements of the Clean Water Act integrate the outcomes of many of the other individual interests and legislative requirements; watershed hydrology and water quality integrate atmospheric deposition, land-based activities, ground and surface water dynamics, and terrestrial and aquatic ecology.

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Context and Conceptual Basis for Watershed Research Goals

In the interest of brevity and strategic perspective, it is useful to consolidate the context of EPA's watershed research into a few foundational concepts and program goals. Virtually all EPA programs can be characterized as having components that should: 1) assess the condition of the environment; 2) diagnose apparent problems and forecast alternative solutions; 3) assess current and future risks; and 4) develop remedies and strategies to protect and restore. ORD's watershed research programs are now organized around these components as illustrated in Figure 1. The programmatic goals for

this research, expressed as desirable outcomes are as follows:

- Condition Research – The states and tribes assess the condition of all their waters in a scientifically-defensible and representative fashion that allows aggregation and assessment of trends at multiple scales.

- Diagnosis and Forecasting Research – Federal, State and Local managers can diagnose cause and forecast future condition in a scientifically defensible fashion to more effectively protect and restore valued ecosystems.

- Protection and Restoration Research – Federal, State and Local managers can protect and restore aquatic ecosystems using scientifically defensible methods.

- Assessment Research – Federal, State and Local managers can conduct scientifically defensible assessments of current and future condition, causes of impairments, and management alternatives.

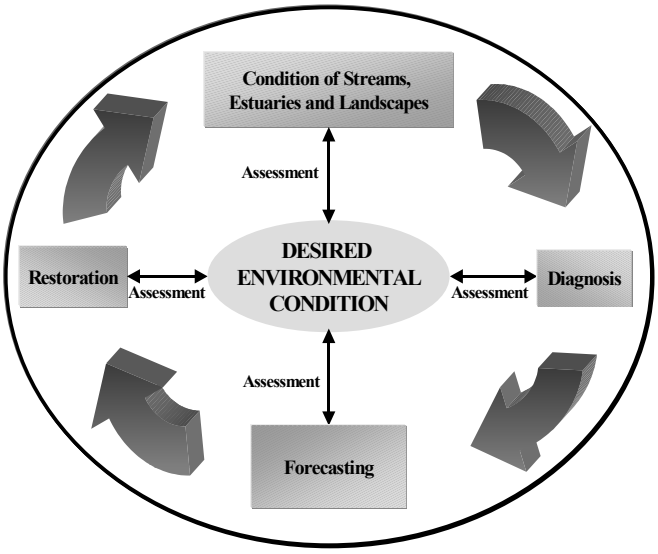

Figure 1. Conceptual approach to ORD research on watersheds.

The programmatic goals outlined above are driven by a series of research questions that must be evaluated. Again, in the interest of brevity and conciseness, these research questions are aggregated to the same level as the programmatic goals and are given below:

- Condition Research - What is the current ecosystem condition, what are the trends in condition, and what stressors appear to have been responsible for harm or deterioration?
- Diagnosis and Forecasting Research - How do biological, chemical, and physical processes affect the condition of ecosystems, and how can we most accurately diagnosis problems facing ecosystems and forecast future effects?

- Assessment Research - What are the relative risks posed to ecosystems by stressors, alone and in combination, now and in the future?

- Protection and Restoration Research - How can we most effectively reduce risks to protect ecosystems and restore them once they have become degraded?

What Have We Learned to Date and What Remains as Challenges?

The data, experiences, models, and analyses presented during this Conference will serve in part to summarize our progress to date in watershed research with particular emphasis on the role that experimental watersheds have played in those endeavors. Part of understanding the current and potential future role of such science is to survey the policy-relevant findings that should inform research planning and experimental designs. Consider the following apparent policy-relevant situation:

- over 20,000 waters identified by States as impaired due to one or more pollutants.

- a shift from point source discharges as the major source of pollutants to nonpoint sources.

- an increasing use of biological indicators and metrics as the preferred method for determining the current condition and desired water quality criteria for aquatic ecosystems.

- an increasing awareness of the importance of landscape- and watershed- scale processes

and activities as determinants of water quality.

- an increasing awareness of the role of atmospheric deposition and multimedia sources as determinants of water quality.
- an increasing awareness of the role of habitat alteration as a cause of aquatic ecosystem impairment.
- an increase in human-health risks from apparent ecosystem responses to stressors, particularly pathogens.

- pressures to increase the efficiency and cost-effectiveness of watershed management implementation.

- an increase in the role of citizen stakeholders in setting watershed management goals and in implementing action programs at the local and watershed levels.

- increasing calls for more efficient, more nearly accurate models and methods, and more explicit representation of uncertainties in decision-making processes used by EPA and State Agencies.

- lack of systematic and statistically-robust evidence that best management practices (BMPs) for non-point source controls are working.

- increasing calls for outcome-based implementation and accountability.

- increasing calls for documentation of the economic benefits derived from government -funded approaches to meet Water Quality Standards and Goals.

- an increasing awareness of the role of invasive species as a cause of aquatic ecosystem impairment.

- integrated assessments for allocation of restoration resources to support water quality standards attainment within the context of socioeconomic factors.

The trends and challenges cited above drive the strategic content of the current EPA watershed research agenda. Many of these trends have been generally acknowledged by others and have shaped ongoing and previous research programs. That said, previously developed and current science and technologies are apparently not yet able to meet all the challenges for the following reasons:

- BMPs and other nonpoint source control measures have rarely been evaluated for their effectiveness in achieving improved water quality (particularly biological condition), rather only for pollutant load or concentration reduction.

- previous focus on chemical and pollutant-specific determinants of water quality does not fully address biological condition.

- the data, analysis tools, and assessment methodologies for landscape and regional scale processes are leading edge research areas not yet exploited to solve problems.

- atmospheric deposition of nutrients (e.g., nitrogen) and toxic substances (e.g., mercury) have not been integrated into watershed management science.

- biological indicators and measurements of habitat alterations, particularly related to flow and sediment, have only recently emerged as issues.

- the causes and control of increasing hazardous algal blooms (HABs), *Pfiesteria,* and pathogens are not fully known.

- ecological risk assessment guidelines, public awareness tools, and risk communication programs are largely new and rarely applied.

- free market based and economically robust risk management systems and frameworks are limited in scope and application.

- many models and decision-support tools are often cumbersome to apply, require data all too often unavailable, and fail to explicitly address uncertainty.

- guidance for setting action and management priorities to achieve outcome-based goals remains problematic.

- water quality management solutions that also lead to sustainable ecosystems and related economies are desirable; the ability to design and implement such solutions is lacking, in large part because of scientific limitations.

- economic valuation of water quality benefits cannot yet be applied to action programs and regulatory activities.

Proposed Hypotheses for Watershed Researchers

Public and natural resource managers' expectations for watershed research and operational watershed management programs are appropriately high and are increasingly interpreted and expressed via multiple disciplinary perspectives. While some perspectives are longstanding, new ones are emerging that give rise to the need for more collaborative and interdisciplinary research. Much remains to be done across the board to be sure; much can be gained by consideration of the interdisciplinary nature of some new questions. From EPA's perspective it is useful to relate all such views to the reality that water quality and water availability remain as national problems deserving continued high priority and investments. This perspective also recognizes that our collective progress in research and in progress toward improving both water quality and availability are substantial. It is also understood, and desirable, that operational watershed management programs provide adaptive learning platforms over time. Here is a set of perspectives or general hypotheses that now face watershed scientists.

Watershed management and restoration to meet local, regional, and national goals for water supply, water quality, and ecological integrity on a sustained basis are not yet achieved because:

- Monitoring hypothesis – Robust and unbiased national, regional, and watershed estimates of the condition and trends are not available to set priorities, efficiently allocate resources, and measure program effectiveness. This hypothesis calls for developing appropriate indicators for the goals, developing improved and cost-effective statistical sampling designs, and conducting assessments that provide robust statements of the magnitude and distribution of conditions.

- Biogeochemical hypothesis – Multiple processes that interact at multiple scales are not sufficiently understood and not sufficiently predictable. This hypothesis calls for continued process and experimental research that both elaborates complexities and that yields more robust and reliable models. Process and systems ecology must be included here. Controlled experiments are needed over appropriate time periods and across a wide array of site-specific conditions and scales.

- Engineering and hydrology hypothesis – Watershed management practices, structures, and technologies can be designed and implemented if the design goals and requirements are known, resources are available, and if the desired hydrologic conditions are known. This hypothesis anticipates a shift from a technology-based design approach (that is, an approach driven by the availability of technology, much like the prevailing Best Management Practice approach) to a performance-based approach (that is, designing to meet a water quality goal or standard). Implementation of this approach will also provide useful economic cost information that further drives innovative technology development.

- Economics and social science hypothesis – The benefits of achieving goals are less than the costs of meeting the goals. This hypothesis derives from the perspective that current outcomes flow from the conscious tradeoffs people make when faced with limited resources or perceptions about the choices. Economic valuation of benefits must be developed and a full array of market mechanisms and incentives must be elaborated and implemented to provide additional tradeoff options. Among such approaches include trading schemes for nonpoint and point sources.

References

The following list of references, as interpreted by the authors, provide the basis for the strategic content of the EPA's Office of Research and Development (ORD) research program on watersheds and watershed-related issues. This research is conducted by intramural scientists and engineers within ORD and with academic partners via ORD's competitive grants program. ORD also partners with other federal agencies engaged in watershed research.

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