Towards More Integrated Management of Watersheds: Some Past Efforts, Present Attempts, and Future Possibilities

Daniel R.G. Farrow and **Blair T. Bower**
National Oceanic and Atmospheric Administration

Introduction

Watershed management has become a major topic in recent years in the context of water quality management. It has been the focus of many conferences, workshops, journal articles, government reports and programs, and even legislative resolutions. However, as many individuals have pointed out, managing water quality from a watershed perspective has a long conceptual, legislative, and institutional history in both the U.S. and other countries.

There is value in examining previous efforts at watershed management to gain a better understanding of: the development of concepts and analytical tools; the strategies and approaches for implementation; what approaches did and did not work, and why; and those aspects that have not been adequately addressed in analysis, planning and implementation.

Learning about past efforts also provides a greater appreciation of the intellectual heritage underlying current efforts, and exposes individuals currently involved to still-relevant, but sometimes forgotten or overlooked, concepts and procedures. This is important because, while some current programs and initiatives reflect continuity with past efforts, others may lack knowledge of earlier efforts, and are therefore doomed to 'reinvent the wheel.'

It is important to emphasize that, from the mid-1930's to mid-1960's, the focus of planning and implementation efforts in watershed management was multiple-purpose management of river basins, with primary emphasis on water quantity, i.e., municipal and industrial water supply, hydroelectric energy generation, irrigation, and flood damage reduction. There was little explicit concern for water quality management, except in relation to providing releases from reservoirs to improve dissolved oxygen concentrations during low flow periods. Interest in, and efforts with respect to, water quality management in river basins increased significantly beginning in the 1960's. An important factor contributing to this evolution involved the research and studies undertaken between 1965-1980 in the Quality of the Environment Program at Resources for the Future (RfF).

This article first presents a brief overview of the RfF work on regional water quality management. It then describes how the work of NOAA's Strategic Environmental Assessments (SEA) Program has built on the work of RfF and others in developing capabilities to provide basic information and technical and analytical support to improve water quality management in the nation's coastal watersheds and coastal waters. Finally, it presents some facts of life of watershed management, with some suggestions to improve future efforts.

RfF's Research on Water Quality Management

The RfF research on regional water quality management was stimulated by the assessment that most of the work in water resources management prior to the 1960's was inadequate in three respects. First, there was little attention given to water quality and water quality management in much of the previous work on river basins. For example, the seminal work of the Harvard Water Resources Program, *Design of Water Resource Systems* (Harvard University Press, Cambridge, 1962) did not address water quality management. Second, minimal attention was devoted to economic factors, particularly economic incentives in relation to behavior of various dischargers into water bodies. Third, there was inadequate consideration of the institutional arrangements/mechanisms for regional water quality management over time. RfF's work explicitly recognized that water quality management is a continuous activity, which must respond to changing conditions over time, and therefore requires a continuous management activity.

The research on regional water quality management at RfF covered four areas: (1) studies of regional water quality management; (2) studies of individual plants in various industries, to understand the factors influencing decisions at the plant level with respect to choices of inputs and types and quantities of discharges; (3) studies of incentive systems, such as effluent charges, i.e., how to induce activities to change their behavior with respect to use of the environment for disposal of the "leftovers;" and (4) studies of "governance," i.e., how one might organize a region for continuous water quality management. One of RfF's major contributions was the attempt to integrate economics, technology, natural systems, and institutions, recognizing that analyzing and understanding the first three represented necessary but not sufficient conditions for achieving effective water quality management.

RfF's work on regional water quality management began with Allen Kneese's early research on the economics of water pollution. This study, and the 1968 book *Managing Water Quality*, by Kneese and Bower, set forth the concepts of regional water quality management and the *basin-wide* *firm*, where the region was defined as the river basin (watershed). The first river basin (watershed) study by RfF was of the Great Miami River Basin in Ohio, done in 1966-67. While the emphasis in Kneese's early work was on economics, *Managing Water Quality* linked economics, technology, and relatively simple concepts of the environment, and provided some discussion of the importance of institutions in water quality management. These early efforts did not address explicitly the problems of how to organize water quality management. Later research attempted to tackle some of these institutional problems.

The next stage in the RfF work was to expand the purview from a focus on water quality and liquid residuals to a multi-media focus on water, air, and land and, hence, on liquid, gaseous, and solid residuals. This focus began with the multi-media study of New York City region encompassing 31 counties in New York, Connecticut, and New Jersey, in 1967-68. The next step, involving a much more sophisticated analysis, was the multi-media study of the Delaware River estuary. This study also broke new ground because it incorporated a non-linear model of the ecosystem of the estuary as an integral part of the optimization analysis. At the same time these regional studies were being conducted, industry-specific studies were undertaken to provide inputs into the regional analysis.

The purpose of the regional studies was to look at the interactions among the three media, and to note the effects that reducing discharges into one medium had on the disposal of residuals in the other two media. The results showed clearly that, for example, limiting gaseous emissions without changing limitations on liquid and solid residuals would result in increases in liquid and solid residuals management costs, as well as those relating to the increased regulation on gaseous discharges. These results showed clearly technologic and economic inter-connections among the three types of residuals.

Three of the most important principles that evolved from the RfF research were that:

(1) Water quality management is related to overall water resources management, and overlaps with management of other natural resources such as forest and fisheries. The major problem is establishing linkages among the sectors.

(2) Water quality management and water resources management are multi-disciplinary, involving economics, technology, geomorphology, law, political science, ecology, etc. One of the most difficult parts is finding individuals skilled in "integrating" the analysis.

(3) Regardless of the areal extent, there will be many agencies involved with a splintering of responsibilities. The problem is how to develop formal linkages among these agencies so that a reasonable degree of management integration will be achieved.

For a more detailed discussion of the Quality of the Environmental Program, see the retrospective volume entitled *Environmental Quality and Residuals Management.*

NOAA's Strategic Environmental Assessments Program

The work of the SEA Program is an example of an ongoing effort to develop capabilities needed for improved water quality management in coastal watersheds. As noted, much of the program's work reflects an attempt to refine and/or make operational, on a national scale, the concepts and principles previously developed at RfF and elsewhere. Throughout, the hydrologic unit, i.e., watershed, has been used as a basic unit for data collection and synthesis.

The SEA Program has evolved through three stages, or foci, to date. The first stage, covering the initial decade of the SEA Program, was the compilation and synthesis of some of the fundamental structural data needed to assess the nation's coastal resources. The second stage involved the development of tools to aid management decisions. The most recent phase involves direct participation with scientists, analysts, planners, managers, and legislators in the evolving process of natural resources and environmental management. A short description of each stage follows.

Data Synthesis in a Consistent Framework

As noted, for the first ten years of the SEA Program, the primary focus was compiling, synthesizing, and summarizing in atlases and reports the fundamental structural data needed to assess the status of the nation's coastal resources. The framework around which much of this data synthesis has been organized is a watershed-based system called the National Estuarine Inventory (NEI). The NEI currently includes national data sets describing the physical, hydrologic, natural resource and human use characteristics for 106 estuaries and estuarine watersheds of the contiguous United States.

Among the data sets that have been compiled for the NEI framework are physical and hydrologic features of the estuaries, land use in the estuarine watersheds, the distribution, relative abundance and life history of the major estuarine living marine resources (over 130 fish and invertebrates), the areal extent and distribution of coastal wetlands, changes in the harvest classification in shellfish producing waters (encompassing over 18.7 million acres of classified waters), population growth in coastal areas from 1960 through 1990, publicly owned or managed coastal recreation facilities, and agricultural use of 35 commonly applied pesticides.

Projects in progress include the characterization of estuarine salinity patterns in five part per thousand zones, the distribution and extent of estuarine surficial bottom sediments, historic and current conditions of nutrient enrichment (eutrophication), and seasonal and annual discharge estimates for 15 pollutants for land-based sources of pollution (point and nonpoint) in coastal watersheds.

Tools for Management Decisions

Although developing and disseminating hard copy summaries and assessments of fundamental structural data fulfilled the needs of some users, convincing state and local analysts and managers to use SEA Program and their own information effectively was still a problem. A major barrier was the lack of tools to determine and analyze what is known about a problem or management decision in a timely fashion. Many state and local institutions lack the resources, time, and experience to develop these tools.

To address this problem of delivering information and analysis capabilities to the point of attack, in 1988 the SEA Program decided to develop decision support tools directly with state and local managers and decisionmakers. The Coastal Ocean Management, Planning, and Assessment System (COMPAS) is perhaps the best illustration of how the approach to developing decision support tools has evolved. The COMPAS program attempts to provide an information tool kit to coastal resource managers that integrates many different data themes into a single desktop system. It is currently configured to run on an Apple Macintosh computer using HyperCard software and Oracle, a relational database management system. With COMPAS, the user can look for and store a wide range of information (e.g., data, charts, text, pictures, and maps) on coastal resources of interest. By simply clicking a mouse or cursor at specified locations on the computer screen, the user can connect pieces of information within COMPAS or activate powerful information-management functions, including customized mapping, analysis, or even modeling.

However, COMPAS is more than software. It is first and foremost a process in which the SEA staff work closely with state and local resource managers and analysts to engineer the mountains of available data into a form that more directly supports the information requirements of management. In the first application of COMPAS in Texas, this process resulted in the development of 14 thematic modules, including pollutant sources, stream flow, water quality monitoring, water rights permits, and coastal tract management. Texas coastal resource managers have gained a new perspective on engineering information that has given them the knowledge to evolve further both the information content, and capabilities, of COMPAS - Texas.

COMPAS projects are now underway in Florida and Oregon. The process is currently being documented, and will be available when COMPAS - Florida is completed. The goal is to make a generic version of COMPAS available to all coastal states in the near future, and to evolve a hands-on technical support capability to enable interested states to develop their own operational COMPAS system in 4 to 6 weeks rather than the 18 to 24 month effort needed to develop COMPAS - Texas.

Direct Participation in Decisionmaking

The compilation of nationally-consistent fundamental data sets, and the development of desktop decision support systems, are two important tools needed to improve coastal watershed management. However, SEA Program's experiences to date have shown that the process of integrating knowledge, technology, interests, and institutions for decisionmaking remains the fundamental obstacle to better watershed management. Making data, information, and analysis tools available has little effect if the decisionmaking process does not use them effectively.

To address this problem, the SEA Program In 1990 began to participate directly in state and even local decisionmaking and planning processes. The goal was, and is, to foster improved ways to integrate information, expertise, and participants into an effective planning and management process that can ultimately be used in many decisionmaking contexts.

By far, the major focus of the work to date has been assisting in the development the management plan for the Florida Keys National Marine Sanctuary (FKNMS). Working closely with a core group of federal, state and local specialists, staff from the SEA Program and the Sanctuaries and Reserve Division (SRD) of NOAA's Office of Ocean and Coastal Resources Management, have been applying knowledge-engineering techniques to acquire and encode the experience of scientists, resource managers, and the public.

The process has maintained a problem-driven and management-focused orientation. From the beginning, this process has clearly recognized management as a continuous activity and has made the maximum use of existing knowledge and experience to identify, characterize, and assess alternative management actions. Sixteen engineered work sessions have been conducted to date. About 80 participants have served as the principle working knowledge base, although about 350 individuals have been involved to some degree. This process is now nearing completion, and a management plan for the Sanctuary is scheduled for distribution in early 1994. The plan will present 97 management strategies or actions, an evaluation of their likely consequences, an assessment of priorities, and an outline for an integrated and continuous management process that involves Federal, state and local participation.

The FKNMS process may point towards new and improved ways of conducting such efforts. Three factors made the evolution of this process possible. First and most important was the willingness of the community (i.e., scientists, managers, and interested individuals) to participate in a highly interactive but structured process. Second was the detailed planning, design, and preparation for each step in the process. Third was the investment of skilled staff to support the process, which required a significant commitment of SEA Division and SRD resources.

The type of direct participation by the SEA Program in the FKNMS effort is a starting point for further development of methods for integration. However, most of these methods are not new. In fact, the SEA Program simply has been applying proven planning, systems analysis, and management principles in a manner that recognizes the constraints of time, resources, data, and knowledge of the FKNMS management context. Involvement in additional direct participation efforts will also be context-specific, but the goal remains to help evolve an improved generic approach from these efforts.

Facts of Life in Watershed Management and Ways to Improve the Process

Decision-making in watershed management has long had to struggle with twin problems of integration: (1) integration of economics, technology, science, and institutions; and (2) integration in the planning and continuous management process of all parties at interest. When problems were smaller in scale and localized, and changes occurred more slowly, business as usual may have worked well enough. However, as government budgets shrink, environmental conditions in some watersheds continue to decline, and competing interests demand conflicting uses for the watershed resources, the need for a more integrated management process becomes more compelling. Overcoming decades of institutional behavior will be a difficult and time-consuming process. No one has all the answers. However, the following facts of life suggest ways to improve the management process.

Facts of Life Regarding Decision Processes

✦ **Seek no quick fixes.** Above all, institutional patience is required. There are no cookbook methods when it comes to improving decisions, i.e., making them more efficient and effective in achieving stated goals. Improvements will take time; continuing effort is mandatory. Institutions, managers, and elected officials must learn how to lead themselves, and others, through integrated processes so that individuals can work together for the common purpose.

✦ **Recognize that consensus-building processes are not referenda.** It is important to clarify the term consensus in discussions of decisionmaking. Consensus can mean many things; all too often it refers to an informal process in which the questions are asked and votes registered. Consensus-building processes must involve a more rigorous balancing of expertise, interaction, and synthesis activities in a carefully structured and iterative process. This type of process is significantly more involved than most recognize.

✦ **Resources for implementation will always be limited.** Analyses for watershed management decisions must explicitly show the costs and consequences of alternative strategies to give decision-makers adequate information for their choices.

✦ **Data relating to demands for water and water-related products and services are developed and compiled primarily on a county and census tract basis.** These data must be translated into demands for products and effects on supply within watersheds. The use of geographic information systems (GIS) shows promise in making this translation more efficient and more representative of true spatial distributions.

✦ **The authority to manage and act resides in governments of general jurisdiction (GGJs).** The boundaries of GGJs rarely coincide with watershed boundaries, nor do they coincide with "external" areas from which demands come. Yet, it is the GGJs which implement management decisions, regardless of how the analyses are made. One solution is to establish special districts which have boundaries along GGJ boundaries, but which approximate river basins (watersheds), as is the case for the water management districts in Florida.

✦ **All management contexts involve a multiplicity of agencies with a splintering of responsibilities.** Linking these agencies to achieve integrated management is a difficult but necessary task.

Suggestions to Improve Management Decisions

✦ **Apply a Continuous Management Framework.** There is a need to have an explicit framework within which analysis, planning, and management activities are orchestrated. The framework must clearly define how these elements relate to each other, and provide operational guidance as to the sequence of activities and the iterative and continuous nature therein. To paraphrase Winston Churchill, it is the planning, not the plan, that is important.

✦ **Adopt Improved Planning and Integration Methods.** Improved approaches are needed to apply fully the Nation's information and knowledge base to watershed management and environmental quality problems. A relatively small portion of what is actually known by experts, both within the science community and at large, is often brought to bear on problems. This means improved techniques (i.e., knowledge engineering principles) should be developed and applied that involve organizing and structuring the process of directing, acquiring, and encoding what is known about a subject or problem. In many cases, this may simply mean applying aspects of already existing planning methods.

✦ **Alter Aspects of the Scientific Approach to Cement a Partnership with Management.** If the best information and knowledge available are to be used at the time of decision, scientists must provide their best judgments based on the data available at that time. Doing so will require scientists to share the risks with managers and other decisionmakers, who often are required to make choices based on imperfect information. Scientists must also understand the need for developing predictive relationships, specifying levels of uncertainty, and ensuring continuity in their inputs to the management process. Some scientists may be required to spend more time synthesizing existing data and information than on traditional research. Synthesis must be recognized as a legitimate scientific activity.

✦ **Involve Decisionmakers in Analysis and Planning.** A continuing problem, especially in complex problem-solving and management contexts, is the lack of participation of key decisionmakers or their surrogates in the analysis and planning process. Key decisionmakers often participate in the process only at the very beginning, to help initiate the process, and at the end, to weigh the alternatives and render a decision. Given the uncertainties in resource and environmental quality assessment (for example, in cause and effect relationships, socioeconomic impacts, the effects of management actions, etc.), it has become extraordinarily difficult, if not impossible, for decisionmakers to take into account the inherent tradeoffs and compromises made to develop and assess management alternatives. The result in many cases is that decisions are either further delayed, or based on some other basis. Although managers should not necessarily try to become experts, they must become more direct, not just periodic, participants in the continuous process.

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Daniel R.G. Farrow is in the Strategic Environmental Assessments Division, NOAA ; Blair T. Bower is a Consultant in the Office of Coastal Resources Conservation and Assessment, NOAA.