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THE WATERSHED ACADEMY

• Information Transfer Series, No. 3 •

Monitoring Consortiums

A cost-effective means to enhancing watershed data collection and analysis

Assessment and Watershed Protection Division
Office of Wetlands, Oceans and Watersheds
U.S. Environmental Protection Agency (4503F)
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Cover - The beneficial result of a monitoring consortium: more than double the buying power of monitoring dollars for the Triangle Area Water Supply Monitoring Project in the Triangle J region of North Carolina.

FOREWORD

The watershed approach has changed the way that the U.S. Environmental Protection Agency (EPA) and other federal, tribal and state agencies formerly managed water resources programs. We now generally recognize that the critical environmental issues facing society are so intertwined that a comprehensive, ecosystem-based and community-based approach is needed. We also recognize that solving environmental problems depends increasingly on local governments and local citizens. Thus, the need to integrate across traditional water program areas (e.g., flood control, wastewater treatment, nonpoint source pollution control) and to cooperate across levels of government (federal, state, tribal, local) and across public and private sectors is leading toward a watershed approach.

Public and private organizations, academic institutions, and citizens and their governments in thousands of communities across the nation are forming partnerships and learning new ways to manage their watersheds together. These groups seek guidance and examples of watershed approach success stories after which to model their own activities. The EPA Office of Water established the Watershed Academy to help address these needs by providing training for watershed managers based on local, state, tribal, and federal experiences in implementing watershed approaches throughout the past decade.

The Watershed Academy provides technical watershed information and outreach through live training courses, the Internet, and published documents. The Academy offers live training courses on the basics of watershed man-agement and maintains a training catalogue concerning where to obtain more advanced training. An Internet distance learning program called Academy 2000 is being developed to help serve the training needs of those who cannot attend the live courses. The Watershed Academy also provides watershed approach reference materials, such as this document, through the Watershed Academy Information Transfer Series.

This document, number 3 in the Series, addresses coordination in watershed monitoring. Monitoring is absolutely essential to track overall watershed health and detect changes in any valued features or functions, but monitoring costs are often a limiting factor. As demonstrated in the document's four case studies, consortiums can stretch the monitoring dollar, improve cooperation among partners, and increase sharing of expertise as well as expenses of data collection and management.

The Information Transfer Series titles include:

no. 1: ***Watershed protection: a project focus*** *(EPA841-R-95-003)*

no. 2: ***Watershed protection: a statewide approach*** *(EPA841-R-95-004)*

no. 3: ***Monitoring consortiums: A cost-effective means to enhancing watershed data collection and analysis*** *(EPA841-R-97-006)*

no. 4: ***Land cover digital data directory for the United States*** *(EPA841-B-97-005)*

no. 5: ***Designing an information management system for watersheds****(EPA841-R-97-005)*

no. 6: ***Information management and communications support for the watershed approach in the Pacific Northwest*** *(EPA841-R-97-004)*

no. 7: ***Watershed Academy catalogue of watershed training opportunities*** *(EPA841-D-97-001)*

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EXECUTIVE SUMMARY

Recently, many watershed and ecosystem management approaches have placed renewed emphasis on strategic, coordinated monit-oring. Coordinated monitoring is essential to assessing the overall condition of our water resources and evaluating how well we are maintaining the quality needed for its intended use; developing goals and priorities for restoring and protecting environmental sys-tems; and developing integrated management strategies.

Numerous monitoring partnerships, or consor-tiums, have been formed in the last decade to meet the need for coordinated monitoring. This document presents four different case studies to demonstrate how consortiums can be tailored to fit available resources, geographic areas of concern, diverse par-ticipants, and goals. Each case study details where and how each partnership was formed; organization structure and responsibilities; monitoring goals and objectives; benefits to consortium participants; data management procedures; cost of the monitoring program; obstacles overcome, with advice for avoiding pitfalls; and methods of program evaluation.

Although the purposes and structures of the monitoring consortiums varied, key to each consortium was the pooling of funds, exp-ertise, and capital to meet the needs of its members. The success of this leveraging of resources shows that monitoring consortiums can be a cost-effective means to enhancing watershed data collection and analysis.

INTRODUCTION

Many environmental resource managers are turning to an ecosystem-based approach to restore and protect our natural resources. Integrating a wide range of technical expertise, regulatory and nonregulatory authorities, and strategic implementation is critical to the success of an ecosystem approach to management, including statewide watershed management frameworks and watershed protection projects. Increasingly limited program resources have intensified the need for coordinated management and for decision-making focused on priority environmental concerns. Well defined priorities depend on solid assessment of good information, which, in turn, depends on well designed monitoring programs. Therefore, many watershed management approaches have placed renewed emphasis on strategic, coordinated monitoring.

In recent years, numerous monitoring partnerships, or consortiums, have been formed. Their purposes vary from water supply protection to coordinated, whole-basin wastewater discharge management to ecosystem assessment. Pooling funds, expertise, and capital is essential for each consortium to monitor a watershed or ecosystem in a way that meets the needs of all partners within the group.

Monitoring consortiums are flexible tools. We present four case studies to demonstrate how consortiums can be tailored to fit available resources, geographic area of concern, diverse participants, and goals. We document why each consortium was formed and the "nuts and bolts" of organizing and maintaining them.

- **The San Francisco Estuary Project:** Regulatory incentive for coordinated NPDES-permit compliance that monitors and supports strategic basin planning through comprehensive water-column and sediment monitoring over a large geographic area.
- **The Triangle Area Water Supply Monitoring Project:** Supplemental, voluntary monitoring of water supply intake areas and their tributaries over a small geographic area with the overall goal of protecting public health.
- **The Lower Neuse Association:** Regulatory incentive for coordinated NPDES-permit compliance that monitors and supports strategic planning as a component of North Carolina's basinwide management approach over a mid-sized geographic area.
- **The Mid-Atlantic Highlands Assessment:** Comprehensive, integrated monitoring to support federal, state, and local strategic planning for ecosystem management over a very large geographic area.

The four case studies detail where and how each partnership was formed; organizational structure and responsibilities; monitoring goals and objectives; benefits to consortium participants; data procedures; cost of the monitoring program;

WHAT DOES THE COORDINATION OF STRATEGIC MONITORING ALLOW FOR?

- Identifying water quality/ecosystem stressors
- Quantifying problems
- Identifying key resources in need of protection
- Estimating risk to waterbodies
- Evaluating attainment of designated uses
- Developing environmental goals and objectives, including site-specific standards
- Assigning priorities
- Developing management strategies
- Evaluating the success of implementation
- Identifying trends toward improvement or degradation
- Knowing the condition of the waterbody or ecosystem

obstacles overcome, with advice for avoiding pitfalls; and method of program evaluation.

In the early 1990s, the Intergovernmental Task Force for Monitoring (ITFM), comprising representatives from multiple state and federal agencies, recognized the importance of effectively coordinating efforts and developed ten recommendations for collaborative, integrated monitoring. Using recommendations from ITFM and the monitoring consortiums, the final section provides a step-by-step list for forming and maintaining strong monitoring partnerships.

CASE STUDY 1

REGIONAL MONITORING PROGRAM FOR THE SAN FRANCISCO ESTUARY

BACKGROUND

Before a monitoring consortium was formed for the San Francisco Estuary, users and dischargers in the watershed did not coordinate monitoring efforts. A vast amount of water quality information was collected in the bay at an estimated annual cost of $16 million, but each party had its own focus and reporting format, and data were of limited use to decision-makers (Mumley 1995). The Regional Monitoring Program (RMP) was implemented in 1993 to coordinate NPDES-permit compliance monitoring and comprehensive water-column, sediment, and biota (tissue) monitoring in support of strategic basinwide planning. The state required that permittees participate in the strategic regional monitoring program and strongly encouraged the consortium approach. Consortium participants, including permitted dischargers and dredgers, have found that the cooperative effort is more cost effective than operating individually and has generated greater quality and quantity of data.

CONSORTIUM DESCRIPTION

HOW WAS THE CONSORTIUM FORMED?

The San Francisco Regional Water Quality Control Board initiated a regional monitoring program in 1989 primarily to provide "cost effective, coordinated regional monitoring and surveillance to evaluate the effectiveness of its water quality control program" (RMP 1993b). The board began conducting pilot studies the same year to develop a long-term multimedia monitoring program for the Bay Protection and Toxic Cleanup Program, EPA-funded Bay-Delta Project and Basin Planning Program. A conceptual monitoring plan was developed based on input from numerous policy makers, resource managers, scientists, and representatives of public and private interest groups. When initiating the program, the Board took advantage of existing studies and organizations to demonstrate the need for and benefits of a more coordinated, strategic

GEOGRAPHIC SETTING

The San Francisco Bay-Delta on the Pacific Coast of central California includes the South Bay, Central Bay, San Pablo Bay, Carquinez Strait, Suisun Bay, and lower portions of the Sacramento and San Joaquin Rivers in the area known as the Delta. Figure 1 shows RMP sampling station locations. The bays and delta combine to form the West Coast's largest estuary, containing about 5 million acre-feet of water at mean tide and encompassing roughly 1600 mi^2. The estuary drains more than 40 percent of California (60,000 mi^2) and contains 34 subwatersheds. The drainage area crosses multiple political jurisdictions, including 12 counties.

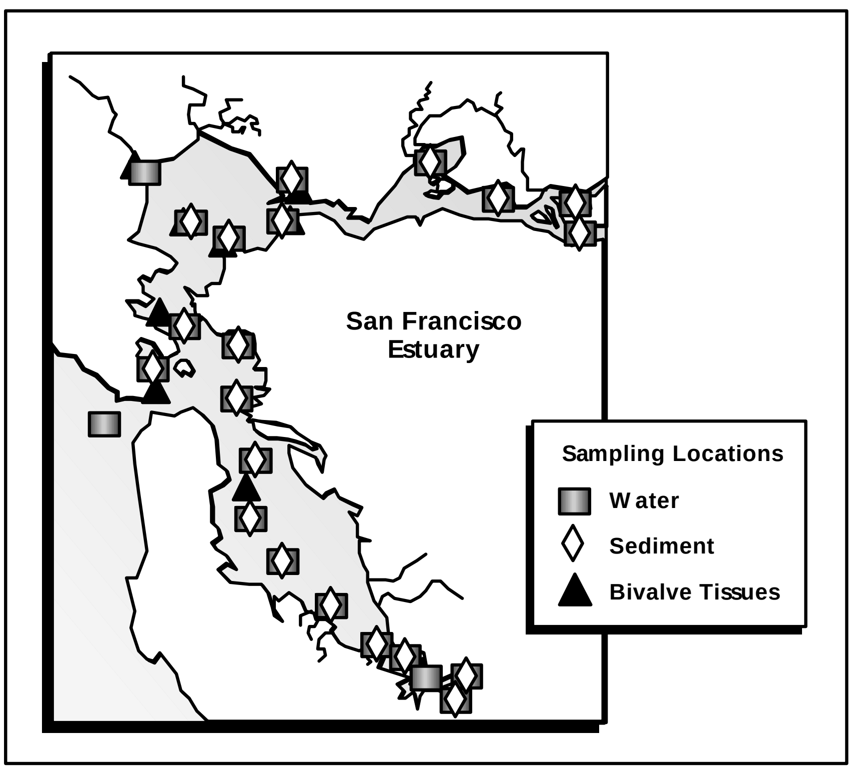

FIGURE 1. RMP STUDY AREA WITHIN THE SAN FRANCISCO ESTUARY.

approach, including the San Francisco Estuary Project (SFEP), Bay Area Dischargers' Authority, and San Francisco Estuarine Institute (SFEI).

In October 1991, SFEI hosted a Regional Monitoring Workshop where participants reached consensus on the need for a coordinated, regional monitoring program. The board then obtained grants for pilot studies in 1991–1992 that demonstrated the ability to generate high-quality, useful data for decision-makers. Based on workshop consensus and pilot studies, the board adopted a resolution in April 1992 that endorsed the Regional Monitoring Program (RMP) in concept and instructed the board's Executive Officer to begin implementation.

The Executive Officer wrote letters to each NPDES permittee and dredger requesting technical reports and listing parameters that would have to be monitored. Letters stated that strategic monitoring and reporting could be conducted either individually or collectively, but encouraged the group to design a collective approach. The Executive Officer discussed the concept of a strategic, coordinated monitoring program with key dischargers to obtain their buy-in (Mumley 1995).

The Board offered monitoring easements on current permits, where feasible, to minimize the overall monitoring cost. At the end of negotiations, some financial sponsors of the project were allowed to use strategic monitoring data in lieu of some conventional ambient monitoring requirements. For instance, reviewing historic pH, dissolved oxygen (DO), and nutrient data indicated that these parameters were no longer a concern and could be waived for certain permittees. (These dischargers still collect some ambient monitoring data as required by their permits.)

Permittees and dredgers also presented the following additional concerns and program design requirements during negotiations. Facilities had been spending a lot of money on monitoring, yet data were of limited value. They wanted better data for decision-making. Publicly owned treatment works (POTWs) believed that better data would show that they were not the big problem generally perceived by others. Sufficient higher-quality data would allow more timely decisions on the need for dredging. Generally, private dischargers anticipated less benefit from the program than did POTWs but were cooperative. The Bay Area Dischargers' Authority, however, did identify concrete potential benefits *for each permit group*. In summary, the board required strategic monitoring/reporting, encouraged a cooperative monitoring approach, provided flexibility in permitting, and involved the whole group early in the program design and decision-making process (Mumley 1995).

HOW IS THE CONSORTIUM ORGANIZED?

After negotiations, the first formal step in the formation of the consortium was the creation of a strategic monitoring plan that specified responsibilities of involved parties. The organizational chart provides an overview of the structure and mechanisms for accountability (Figure 2). The board is ultimately responsible for the regulatory structure, for selecting permittees that must participate in the regional monitoring program, notifying them of their responsibilities, and organizing the financial structure of the project. RMP is currently managed and administered by SFEI through a Memorandum of Understanding (MOU) with the San Francisco Regional Water Quality Control Board. The board's basin plan and NPDES permits govern the water quality of and dischargers to the estuary. RMP monitors compliance with objectives set forth in the basin plan. The institute is an objective party that ensures fair treatment of participants by the board and that the monitoring plan is implemented in a technically sound manner (Carlin 1994/1995).

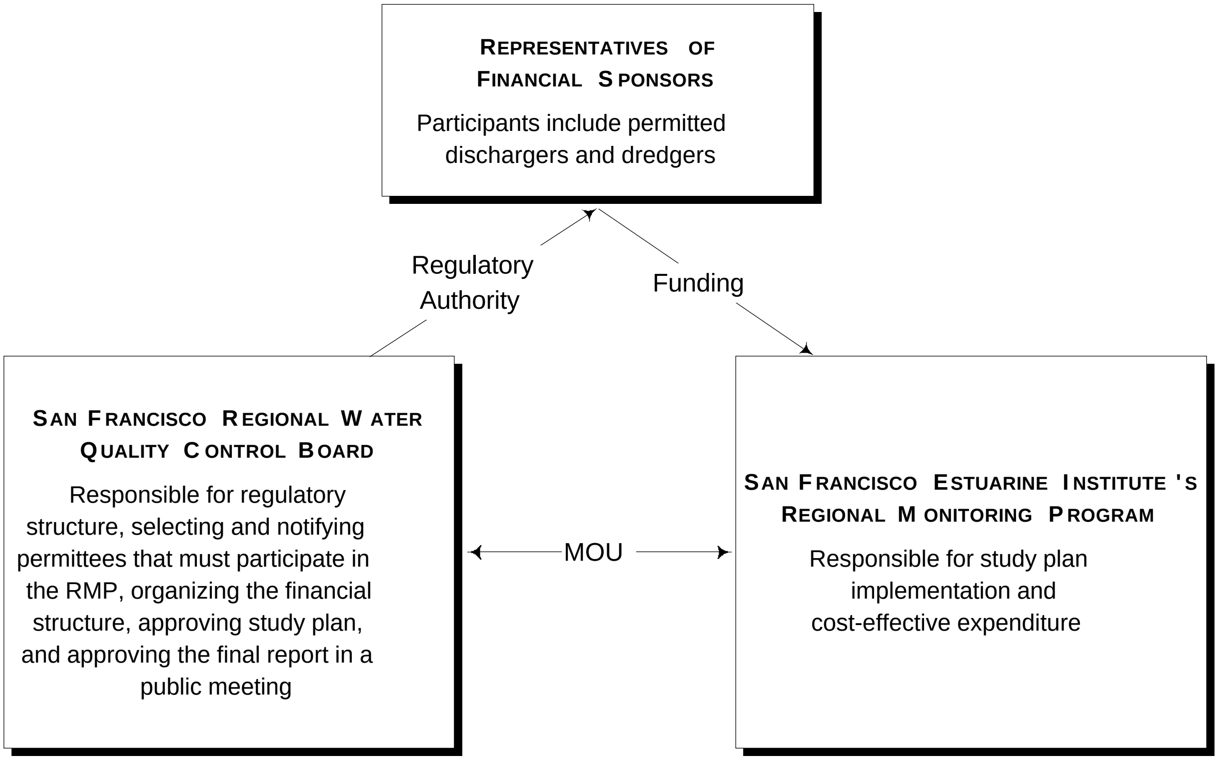

FIGURE 2. ORGANIZATIONAL STRUCTURE OF THE SAN FRANCISCO ESTUARY REGIONAL MONITORING PROGRAM.

The institute staffs two committees to oversee implementation of the RMP: The Steering Committee and the Technical Program Review Committee. Both committees are composed of representatives from sponsoring dischargers; the board, and SFEI. In addition to these working advisory committees, the institute consults with its Board of Directors regarding monitoring goals and objectives and program evaluation.

WHAT ARE THE OBJECTIVES OF THE CONSORTIUM?

RMP was designed to help implement the strategic monitoring objectives of the Board's Basin Planning Program, the San Francisco Estuary Project, and the Bay Protection and Toxic Cleanup Program, including the following (RMP 1993b):

1. Obtain high-quality, baseline data on concentrations of toxic, and potentially toxic trace elements and organic contaminants in the water and sediments of the estuary.
2. Determine seasonal and annual trends in water chemistry in the estuary.
3. Determine whether water-column chemical quality and sediment quality in the estuary complies with objectives set forth in the Board's basin plan.
4. Provide a data base on water-column chemical quality and sediment quality in the estuary that is compatible with data

STEERING COMMITTEE

- Ensure communication among sponsors, the board, and SFEI
- Plan and provide input into RMP implementation
- Provide feedback on effective use of the information that is gathered

TECHNICAL PROGRAM REVIEW COMMITTEE

- Develop annual work plans and special studies based on guidance from the Steering Committee and Regional Board
- Review data and reports produced by RMP

collected in ongoing studies, including, but not limited to, the following areas: waste-load allocation studies and models, sediment quality, in-bay dredged material disposal, enhancement of the Interagency Ecological Study Program's (IESP's) water quality and species productivity studies, local biomonitoring programs, and state and federal mussel watch programs.

HOW IS THE CONSORTIUM IMPLEMENTED?

Representatives from financial sponsors, along with the board, formally oversee RMP implementation. In 1993, the first year of program implementation, RMP was financially sponsored by 46 federal agencies, local special districts, and private companies that held permits for discharge to the estuary. The list grew to 62 financial sponsors in 1994: 34 municipal dischargers, 11 industrial dischargers, 9 stormwater dischargers, 7 dredgers, and 1 cooling-water discharger.

Representatives coordinate with a larger group of public resource agencies. A key monitoring partner is IESP, a consortium that conducts research on fisheries, water quality, and fish facilities as well as manages a special project called the Delta Outflow/SF Bay Study, which conducts compliance monitoring for their water rights permit in the Central Valley. Their annual project budget is approximately $10 million. IESP's focus on issues pertaining to the Delta of the San Joaquin and Sacramento Rivers complements SFEI's efforts well.

RESOURCE AGENCIES INVOLVED IN THE SAN FRANCISCO ESTUARY PROJECT

- U.S. Fish and Wildlife Service (FWS)
- California State Water Resources Control Board
- San Francisco Regional Water Quality Control Board
- Central Valley Regional Water Quality Control Board
- U.S. Environmental Protection Agency (EPA)
- U.S. Army Corps of Engineers (COE)
- Natural Resources Conservation Service (NRCS)
- U.S. Geological Survey (USGS)
- U.S. Bureau of Land Reclamation (BLR)
- Parks and preserves (including East Bay Regional Park District, San Francisco and San Pablo Bay Wildlife Refuges, and the Golden Gate National Recreation Area)
- Cit[illegible] county governments
- Re[illegible] conservation districts
- Po[illegible]rities
- Ac[illegible] research facilities (including the Uni[illegible] of California at Berkeley, Santa Cru[illegible] Davis)
- Nu[illegible] interest groups (ranging from ind[illegible]l to conservationist)

BENEFITS

After two years of implementation, members identified the following benefits of strategic, coordinated monitoring:

- Better understanding of the areas and pollutants of greatest concern
- Higher quality and consistency of data
- Consistent data format across the estuary
- Greater cooperation among stakeholders
- Discovery of problems not previously identified (such as PCBs)
- Cost savings for small operations
- Permittee leveraging[1]

DATA PROCEDURES

INFORMATION MANAGEMENT

RMP data are transferred electronically to the SFEI data base in various spreadsheet forms. All project participants, including laboratories, have standard operating procedures (SOPs) and maintain quality assurance/quality control (QA/QC) records. The QA Program Plan details

[1] In 1995, for example, through COE annual cost-sharing funds of $250,000 and a USGS cooperative agreement of $40,000 per year, permittees paid $1,710,000 for a project valued at $2 million. This calculation excludes university research funds and data contributed by other organizations, so the estimate is conservative. Generally, the leveraging factor has declined as the annual program budget has increased.

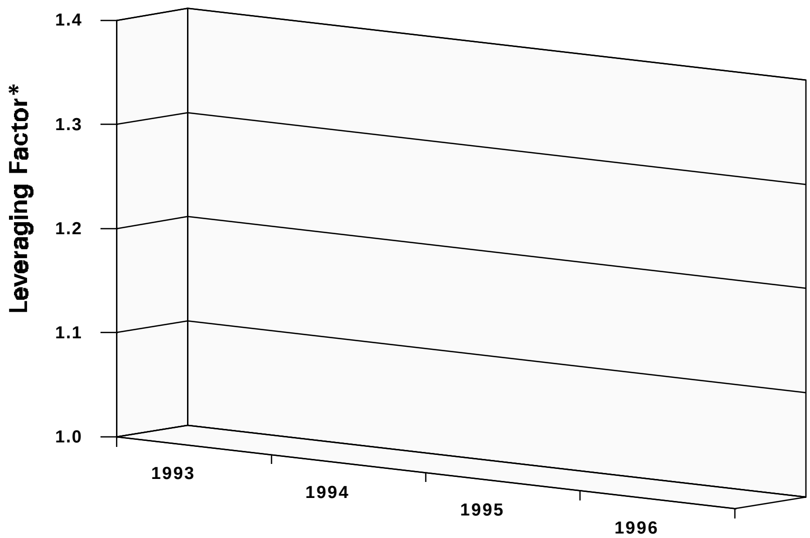

FIGURE 3. ANNUAL LEVERAGING FACTORS
FOR THE SAN FRANCISCO RMP.
[*=RMP ANNUAL BUDGET DIVIDED BY PERMITTEE COST]

procedures for sampling and analysis. RMP subcontractors who collect data generate data sets in a standardized format. Data sets are first sent to Applied Marine Sciences (AMS), the contractor in charge of coordinating the sampling program and assuring data quality. After QA/QC, AMS sends data sets to SFEI where they will be uploaded to the Oracle Relational Data Base Management System for the Sun operating system. Oracle is the primary platform for the project's data management system.

SFEI performs statistical analyses using the PC version of SAS, a computerized statistical analysis system. Spatial and geographic analyses will be performed using GIS ARC/INFO and Geographic Resources Analysis Support System (GRASS) on the Sun workstation. Toxicity data will be analyzed using the program Toxics.

According to project staff, creating a user-friendly data management system was a high priority. The data base will be available to RMP members, educators, researchers, policy makers, and the general public. The vision for the data management system is a menu-driven interface that enables key word searches by general topic, parameter measured or analyzed, region, and time frame. The estuary data base will be searchable by specific geographic reference (e.g., latitude-longitude) or general location. Because different users will require different levels of information, the system will ultimately generate three levels of information: (1) unprocessed data, (2) general program summary, and (3) data summaries.

DATA COLLECTION

Monitoring activities are coordinated with other monitoring programs on the bay, including USGS's bay modeling and primary productivity studies; mussel watch studies sponsored by NOAA and the state; Bay Protection and Toxic Cleanup Program; and many other private, municipal, state, and federal programs. After considering historical data and results of pilot projects, the Board selected 16 stations to be monitored, all of which will be analyzed for chemical constituents and sediments. Fewer stations will be targeted for biological and toxicity data; to the greatest extent possible, stations designated for biological and toxicity evaluation will overlap with stations monitored for chemicals and sediment.

Months for seasonal sampling were selected based on an idealized hydrograph for the estuary. The RMP has four general types of monitoring programs: biological, chemical, physical/conventional, and sediment, all of which are highlighted below.

- *Biological:* Bioaccumulation studies of trace elements and organic contaminants in bivalve tissues are conducted at 11 pre-determined stations.
- *Chemical:* Trace elements and organic contaminants in the water column will be monitored at 16 stations three times a year. Organic contaminants will be analyzed based on the particulate fraction of the filtered sample of water. Trace elements monitored include As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, and Zn. The program also measures five petroleum compounds, fourteen polynuclear aromatic hydrocarbons (PAHs), nine SOCs, PCBs, DDT, and chlordane. Water-column toxicity will be measured at 8 stations three times a year, and in-depth chronic toxicity tests are conducted on a fish, invertebrate, and algal species.
- *Physical and Conventional Parameters:* Whenever chemical and trace metal samples are taken, physical and conventional parameters are also measured: salinity, temperature, conductivity, DO, chlorophyll-*a*, TSS, dissolved organic carbon, pH, and nutrients.
- *Sediment:* Sediment is sampled at all 16 stations during the wet and dry periods. Parameters tested include sediment quality, trace elements, and organic contaminants. To enhance interpretation of metal concentrations in sediments, the program will examine the relationships of four trace elements (Cu, Hg, Ni, and Se), three trace organics (PAHs, PCBs, and pesticides), and different contaminants. Frozen duplicate samples will be kept for possible future analysis.

DATA ANALYSIS

Before establishing RMP procedures, the San Francisco Estuary Project inventoried and evaluated existing monitoring efforts and data sets to identify and remedy data gaps, redundancies, and incompatible procedures. The QA Program Plan details procedures for RMP sampling and analysis. The Regional Monitoring Strategy recommends a performance-based monitoring system, where different methods for measuring the same constituents are allowed provided that results are comparable. To resolve questions about compatibility of methods, field samples are collected, split, and then sent to laboratories for analysis to determine whether differences in data are due to sampling procedures. Methods used to date yield comparable data.

In 1993, SFEI contracted with AMS in Livermore, CA, for field collection and data analysis. Subcontractors include Marine Research Specialists in Soquel, CA; University of California-Santa Cruz's Institute of Marine Sciences in Santa Cruz, CA; University of California-Berkeley's Trace Organics Laboratory in Richmond, CA; Brooks-Rand, Ltd., in Seattle, WA; and S.R. Hansen and Associates in Concord, CA.

USE OF DATA

Participants have identified numerous uses for data gathered by the consortium, including:

- Determining use support status
- Offsetting ambient monitoring requirements
- Analyzing trends
- Calibrating models
- Establishing priorities
- Educating/conducting outreach[2]

COST

To pay for collective monitoring and analysis, the state divided dischargers into five categories and allocated costs to each category based on

[2] Data are currently incorporated into technical reports. The centerpiece of the institute's outreach effort will be an annual State of the Estuary Report, including an assessment of the estuary's condition, trends in water quality, the status of aquatic populations, and description of human activities that affect the ecosystem. The report will draw attention to resources at risk and identify immediate and long-term monitoring and research needs. In addition, the institute will use newsletters, periodic seminars and conferences, and research reports to communicate with a wide audience, ranging from scientists and educators to policy-makers and the general public.

the proportion of pollutants it discharges into the bay (Figure 5). The state allowed each category to determine how to fund its share. RMP's budget has steadily increased since the first year of implementation in 1993 (Figure 4). (Note that dischargers are still required to monitor some parameters individually, so costs shown in tables do not reflect total costs of all monitoring activities conducted in the estuary.)

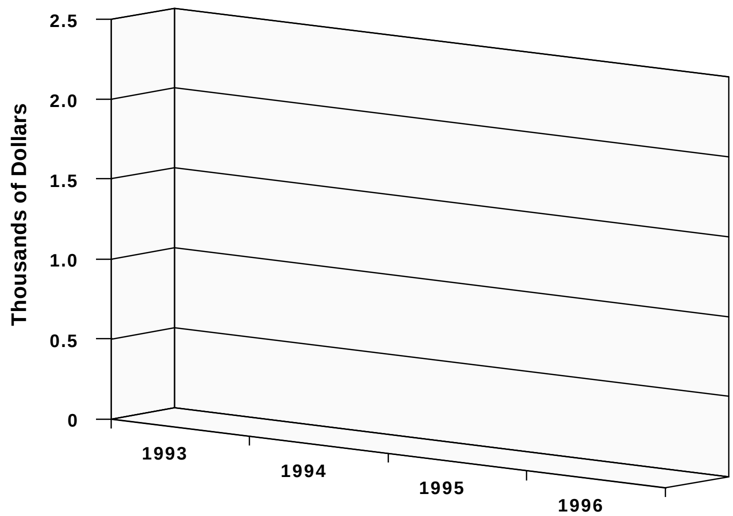

FIGURE 4. ANNUAL BUDGET FOR THE SAN FRANCISCO RMP.

Board staff indicate that the budget for baseline data collection (i.e., field work and laboratory analysis) has remained stable, but costs have increased for data management, particularly QA, data interpretation, pilot projects, and special studies (Carlin 1994/1995). Budget allocations for 1995 are shown in the sidebar. Initially, QA and data interpretation were the most underestimated costs (Carlin 1994/1995). Staff indicated that increasing cost is a challenge to maintaining the consortium.

Program Area	1995 Budget Allocation
Data collection	1,100,000
Data interpretation/data management*	400,000
Pilot projects	200,000
Special studies	300,000
Total	2,000,000

* Includes overall project management

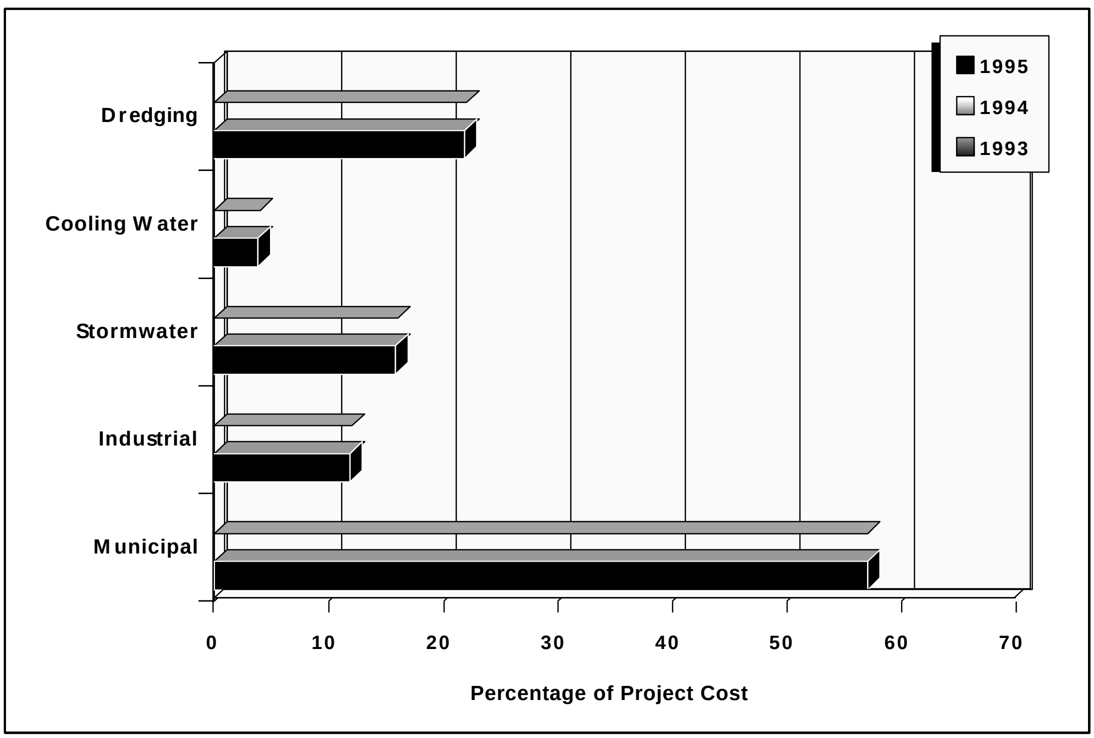

FIGURE 5. COST ALLOCATION BY DISCHARGER CATEGORY.

CHALLENGES

Staff identified key challenges to forming the consortium. First, because monitoring data have been of little use in the past for assessing problems and making decisions, many potential partners did not value monitoring. The Board addressed this skepticism during negotiations by working with key representatives from each group to identify concrete potential benefits of a strategic, coordinated monitoring program and ways to offset program costs. The Board also designed and conducted pilot studies to demonstrate the ability to produce high-quality, useful data for decision-makers. Through meetings, workshops, and conferences, the Board and Institute used this information to achieve buy-in early in the process. Second, the Board demonstrated that permittees could meet many regulatory objectives within the RMP (e.g., determining use support status). Finally, equitable distribution of program cost across different groups was (and continues to be) a challenge to the board. For instance, POTW permittees have a collective annual O&M budget of $500 million, whereas stormwater permittees have an annual O&M budget of $5 million. If each group were to contribute $1 million, budget impacts would be unequitable. The Board assesses each group a percentage of program cost, and the group itself (e.g., all POTWs) determines a fair way to allocate cost among individual permittees within the group.

Staff also identified four ways to address the challenges to maintaining a strong consortium: effectively communicate the value of the project, be cost effective, ensure data collection and interpretation are technically sound, and use findings of the program in making decisions (Mumley 1995; Carlin 1994/1995).

PROGRAM EVALUATION

The RMP was designed as a long-term monitoring program, and will be comprehensively evaluated and updated after 5 years of monitoring. The RMP has short- and long-term evaluation processes: annual program assessments and a five-year comprehensive assessment. Monitoring goals and objectives are evaluated annually by SFEI, based on decisions from its seven-member Board of Directors and input from its working advisory panels. The Scientific Advisory Panel includes researchers from universities, agencies, and other private or public research organizations and is responsible for reviewing the Institute's annual workplan and assisting in the production of the Institute's annual report. A Policy Panel was formed to advise the Scientific Advisory Panel and Board of Directors on research and monitoring needs, resource management questions, and policy implications of scientific findings. This panel is composed of representatives from local, state, and federal governmental agencies that have stake in regulating uses of the estuary.

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CASE STUDY 2
TRIANGLE AREA WATER SUPPLY MONITORING PROJECT

BACKGROUND

The Triangle Area Water Supply Monitoring Project (TAWSMP) began in 1988 as a supplemental, voluntary monitoring program for drinking water source protection. The project conducts chemical, physical, and sediment sampling at 34 stations, both at water supply intake areas and their tributaries throughout the Triangle J Region. Primary objectives of the project are to conduct spatial and temporal water quality trend analyses and pollutant loading studies, better understand the role of sediments in trapping and transporting SOCs, and evaluate the condition of the source water.

GEOGRAPHIC SETTING

The Triangle J Region encompasses 3320 mi^2 and includes six counties of North Carolina within the upper Neuse and Cape Fear Basins in the Piedmont Province: Chatham, Durham, Johnston, Lee, Orange, and Wake (Figure 6). Nearly 80 percent of the households in this region depend on public drinking water supplies, and most of the 13 supplies for the Triangle Area are drawn from the region's streams and reservoirs.

CONSORTIUM DESCRIPTION

HOW WAS THE CONSORTIUM FORMED?

Two major federal, multipurpose reservoirs were built in the early 1980s, Jordan Lake and Falls Lake, with a combined estimated drinking water safe-yield of 160 million gallons per day (MGD). Because these lakes were built in the midst of an urbanized area, potential users raised questions about the types and quantities of SOCs discharged upstream and how potential contaminants might impact the quality of these drinking water supplies (Brewer and Childress 1994). At the same time, with rapid urbanization across the region in the early and mid-1980s and the associated increase in nonpoint source runoff and point source industrial and municipal wastewater discharges, interest grew in protecting the region's surface water supplies (Brewer and Childress 1994).

The Triangle J Council of Governments (TJCOG) sponsored the 1987 World Class Region Conference, which was attended by approximately 500 local elected officials, business leaders, environmentalists, and other citizens of the region. Participants' request for a Triangle Area Water Supply Monitoring Project added legitimacy and impetus to a project idea that had been discussed for several years. Potential cost savings of such a project provided even greater impetus. Heightened interest in the quality of drinking water supply sources led several local governments to begin their own supplementary monitoring programs at a combined annual cost of hundreds of thousands of dollars.

TJCOG formed a task force comprised of key city managers and public utility directors to design the project. This group relies heavily on advisors from universities, North Carolina's Division of Environmental Management (DEM), and the U.S. Geological Survey (USGS). During project design, task force members focused on seven questions (Brewer and Childress 1994):

1. Who is interested in designing and participating in a monitoring program?
2. What are the objectives of the monitoring program?
3. Which parameters should be monitored?
4. Where should the project monitor?
5. How often do we need to monitor to detect trends?
6. Who will conduct field work, laboratory analysis, and data interpretation?
7. What are the costs, and how will we finance the project?

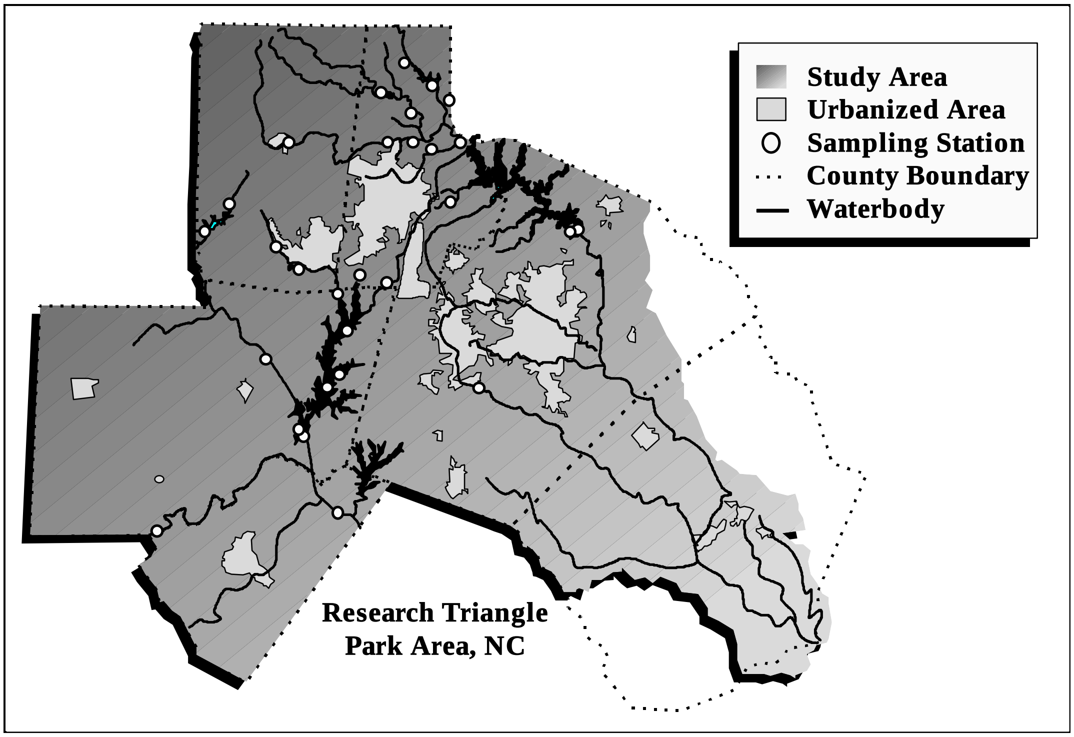

FIGURE 6. MONITORING SITES FOR TRIANGLE AREA WATER SUPPLY MONITORING PROJECT.

HOW IS THE CONSORTIUM ORGANIZED?

Local governments in the region signed letters of interest in forming a monitoring project through interlocal agreement. Then, a task force designed the project, drafted by-laws for project governance, and negotiated a draft interlocal agreement. Local governments entered into a Phase I monitoring project contract/agreement for three years, with the understanding that meeting project objectives would require many additional years of monitoring, and 3- to 4-year phases were appropriate for major data interpretation studies and for monitoring program evaluation (Brewer 1989–1995).

Participating local governments appointed staff representatives to the project Steering Committee, which makes technical, financial, and administrative recommendations to participating local entities (Figure 7). Non-voting resource advisors from DEM, USGS, and local universities also participate on the Steering Committee. Officially, committee chair persons are elected annually; generally, every 2 years the Steering Committee selects a new Chair and Vice Chair and appoints a new Technical Subcommittee Chair to expand and renew opportunities for leadership among all representatives (Brewer 1989–1995).

Through interlocal agreement, the project is co-sponsored by 11 city and county governments. The USGS and local governments share the cost of the monitoring program through cooperative agreement. USGS operates 18 sites in the water quality monitoring network and all 13 stream discharge gages, conducts laboratory analysis and quality assurance/quality control (QA/QC), and interprets data from all water quality and stream discharge sites. To complete the network, DEM supplies data from 12 sites in its ambient monitoring program and collects additional samples for USGS laboratory analysis.

Participating local governments contract with TJCOG as the project manager to (1) coordinate sample collection, analysis, and data-reporting among technical contractors and DEM; (2) provide day-to-day oversight of technical contracts; (3) maintain financial records, including collecting funds and paying contractors; (4) maintain records to ensure compliance with state statutes; (5) provide staff support to the project Steering Committee; and (6) conduct project outreach, including annual reports, press releases, and public

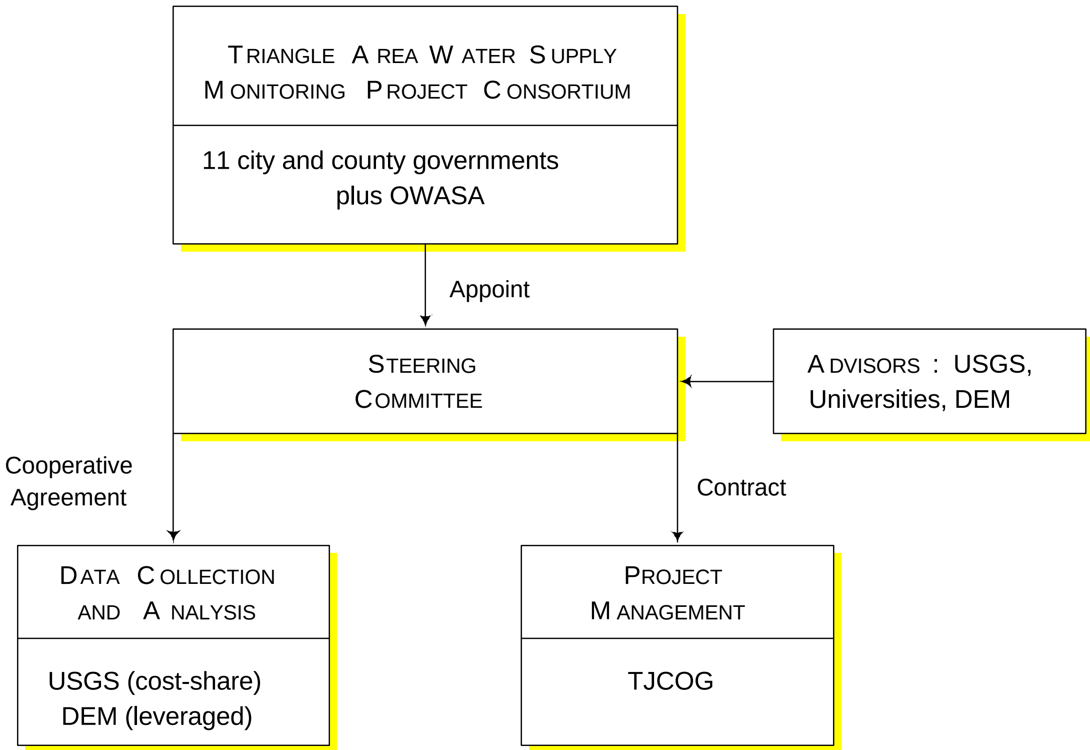

FIGURE 7. ORGANIZATIONAL CHART FOR THE TRIANGLE AREA WATER SUPPLY MONITORING PROJECT.

presentations. Additionally and importantly, participants view TJCOG as a neutral manager providing a neutral meeting place (Brewer 1989–1995).

WHAT ARE THE OBJECTIVES OF THE CONSORTIUM?

TAWSMP has two overall goals: (1) improve understanding and awareness about the quality of the region's drinking water supplies (including intake areas and tributaries) and (2) minimize monitoring costs (TAWSMP 1989, 1991, and 1995). The primary and secondary objectives developed in support of these goals are listed in the side bar (TAWSMP 1989, 1991, and 1995).

HOW IS THE PROJECT IMPLEMENTED?

Monitoring began in October 1988. Initially, the project focused on EPA's priority pollutant list and conventional parameters (TAWSMP 1989, 1991, and 1995). Prior to the start of sampling, a statistical review of existing data collected in the study area indicated that many additional years of monitoring may be required to be confident of project conclusions concerning changes in water quality (Reckhow et al. 1989). Local participants view the project as long-term, with monitoring frequency varying from 3–12 times per year, depending on the sampling location and parameters. The state's ambient monitoring stations and parameters are incorporated into program design to avoid duplicating efforts.

BENEFITS

The Steering Committee reports the following benefits (Kalb 1995, Brewer 1989–1995):

- *Pinpointing Problems More Quickly*: The project has not yet detected a major problem, but problems can develop quickly in rapidly developing urbanized areas. The annual monitoring program allows local governments to pinpoint and address problems in the Triangle more quickly. Also, one of the project's primary objectives has been to determine the concentration of contaminants in the region's water supplies.

- *Preventing Water Treatment Problems*: Federal regulations generally do not require monitoring untreated water. Though a local utility may identify contaminants in treated water, it will not detect contaminants until they have already become a problem. By tracking the quality of the water supply source, the project helps prevent treatment problems.
- *Establishing Long-Term Trends*: Through annual monitoring, the project has begun to gather enough data to conduct trend analyses. Building on this data base through continued monitoring will allow frequent assessment of trends.
- *Responding Flexibly to Emerging Issues*: Annual monitoring has allowed the project to deal with emerging concerns in a flexible and timely manner. Monitoring includes special pesticide studies and *Cryptosporidium* and *Giardia* monitoring.
- *Sharing Costs, Expertise, and Analysis with USGS*: Through the cooperative agreement described above, USGS equally matches the project's monitoring costs and conducts field sampling, laboratory analysis, and data interpretation. The Steering Committee believes USGS's QA/QC as well as its independent, unbiased analysis is key to the credibility of the project.
- *Helping to Protect Major Resources at a Low Cost*: Although this supplementary monitoring program has been operational during a time of very limited program resources, the Steering Committee stresses, and most local governing boards concur, that the project cost is small relative to the value of the water resources being monitored.
- *Leveraging Resources*: Through USGS cooperative agreement and DEM ambient monitoring contributions, the local governments pay $231,733 for a project valued at $543,094—a local government leveraging factor of 2.34 (Figure 8). Also, because multiple governments share interest in individual sites, the consortium cost to each local government is lower than each would pay to maintain its own monitoring program. The resource leveraging factor varies for each jurisdiction depending on its size and the number of monitoring stations associated with a jurisdiction's intake and other in-lake and tributary sites.

PRIMARY PROJECT OBJECTIVES

- Develop and maintain a data base for SOCs to determine their concentration in Triangle Area water supplies
- Supplement existing data on nutrients, major ions, and trace elements as a basis for measuring long-term water quality trends

SECONDARY PROJECT OBJECTIVES

Phases I and II

- Provide a basis for measuring shorter-term, but long-lasting, changes due to large-scale management practices in the watershed, such as the phosphate detergent ban and treatment plant upgrades
- Document overall spatial differences among water supplies within the region, especially differences between smaller upland sources, large multipurpose reservoirs, and run-of-the-river supplies
- Provide additional tributary loading and in-lake data that can be used for predictive models
- Help determine the role of stream sediments in transporting or removing SOCs in the water column

Phase III

- Develop a coordinated data base for state, local, and USGS data
- Report results of the monitoring program to citizens

For instance, OWASA is a mid-sized water supplier, with a direct interest in 9 of the 30 water quality monitoring sites and 4 of the 13 stream gaging sites. Most sites of direct interest to OWASA are also of direct interest to other local governments and USGS. The monitoring, analysis, and management costs of these sites is about $164,000 per year, and OWASA is only assessed about $23,000—a leveraging factor of 7 (Figure 9). Another example is the region's largest water supplier, the City of Raleigh. There are 13 water quality monitoring sites and 7 stream gaging stations in Falls Lake and its tributaries, with a total estimated value of $247,639. The City of Raleigh pays $96,394—a leveraging factor of 2.5.

Agency	Example Leveraging Factors (1995)
Local governments	2.34
City of Raleigh	2.50
USGS	2.57
OWASA	7.00

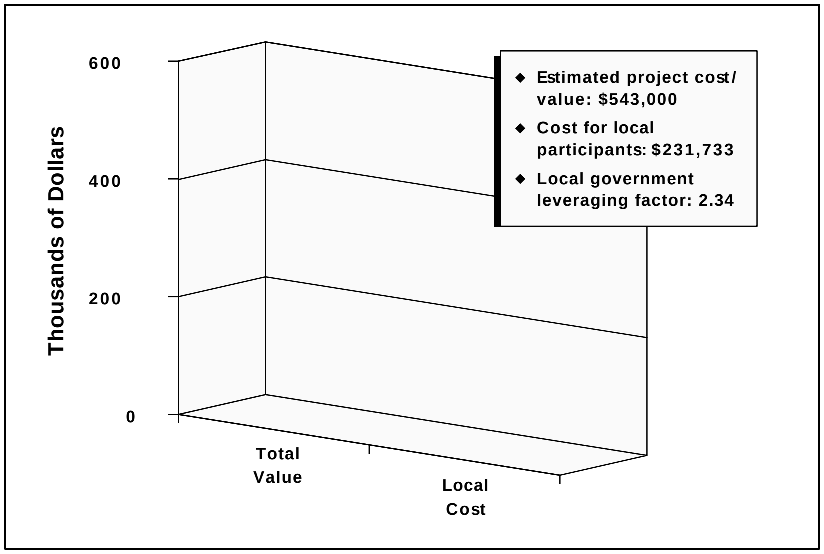

FIGURE 8. TAWSMP ANNUAL RESOURCE LEVERAGING.

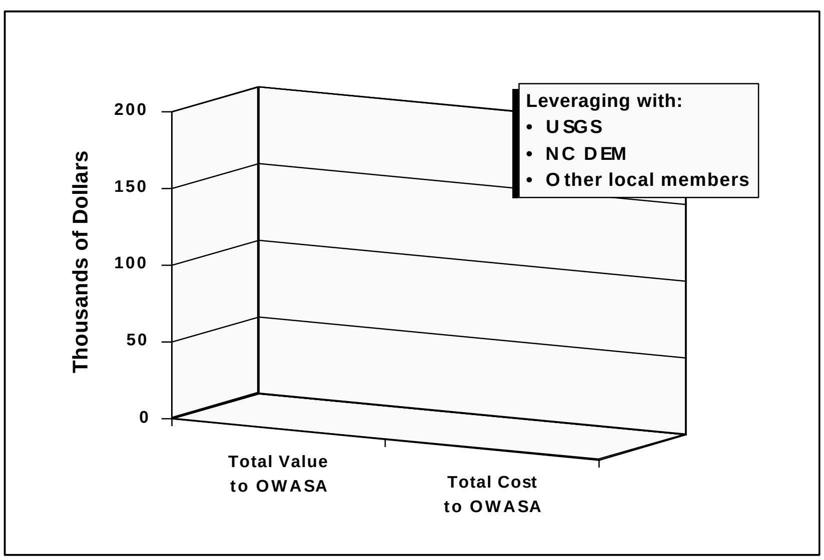

FIGURE 9. OWASA RESOURCE LEVERAGING IN TAWSMP.

The USGS benefits from the program's joint water resource investigation and cost sharing; the comprehensive, long-term nature of the study that allows for trend analysis and interpretive work; and the focus on emerging issues such as *Cryptosporidium* and *Giardia*. USGS's cooperative cost share is $211,361—a federal leveraging factor of 2.57.

These leveraging factors include only the monitoring cost associated with a jurisdiction's intake and its other in-lake and tributary sites (i.e., related drainage area). These factors could be seen as conservative estimates, because there are indirect benefits from monitoring in other basins, such as being able to compare data from similar run-of-the-river intakes or similar small lake intakes. The structure of allocating cost by percent of water produced generally yields larger leveraging factors for smaller jurisdictions than for larger jurisdictions.

DEM is also able to leverage resources through the program. Before the monitoring project began, the state conducted intensive monitoring of Falls and Jordan Lakes. The division is now able to refocus its program resources and mainly contributes tributary ambient monitoring data to the project. DEM also uses project data in its basinwide management planning for the Neuse and Cape Fear River basins.

DATA PROCEDURES

INFORMATION MANAGEMENT

TJCOG, as project manager, coordinates and helps design data base management, maintains all project records, distributes information, and is the central contact. USGS built and maintains a project data base for its sites and retrieves data from STORET for DEM's 12 project sites. USGS also has a combined data base for all sites. In response to the Steering Committee request for easy, user-friendly access to project data, USGS recently developed an Excel spreadsheet format for each site that holds all observations for each site as well as generates summary statistics of most interest to local participants. Data will be loaded, then updated annually. During Phase III of the project, local compliance monitoring data will be incorporated into this spreadsheet format. USGS works with the Project Steering Committee to develop annual reports to local governments, data reports, interpretive reports, and summary updates of special studies.

DATA COLLECTION

The project monitors sites near water supply in-takes, other port

ions of lakes, lake tributaries, and near river intake areas. Several upland tributaries are relatively unimpacted and serve as control sites. There are about 30 water quality sites (the number of sites slightly varies from phase to phase) and 13 stream gaging sites. The project's regional, long-term design enables data to be interpreted for detection of spatial trends in water (e.g., how the water quality changes as it moves downstream or down lake). Areas below wastewater treatment plants and urban areas can be compared, water quality of the intake areas in small reservoirs can be compared to large reservoirs, and loading from different tributaries can be measured. In addition to this routine monitoring, the project also conducts special studies, such as analysis of pesticides, storm events, pollutant loading, and *Cryptosporidium* and *Giardia*.

The monitoring program has been amended based on findings to rotate monitoring parameters (such as dropping VOCs in Phase II and cycling them back in Phase III), to drop sites that are so close to each other that they yield nearly identical data, and to reduce frequencies of monitoring. These amendments allow the project to add other constituents of concern, conduct special studies, and minimize project cost (Brewer 1989–1995).

Two agencies, USGS and DEM, collect samples and conduct laboratory analysis. They conduct tests, as needed, to determine whether different sampling and analytical techniques caused differences in data, and, if so, how to reconcile protocols. For instance, USGS and DEM have basic differences in field sampling methods: DEM grabs samples from mid-stream, and USGS does depth-integrated samples from multiple points in the cross-section. DEM generally samples during base flow, whereas USGS samples during base-flow and high-flow events. Both agencies collected samples at the same sites (using their respective methods), split the samples, and traded. Each sent its split sample to its own laboratory. Analyses revealed no significant differences in base-flow data. There would likely be more variability in the data using the two methods during high-flow events; because only USGS targets high-flow samples, however, this difference in field sampling methods has thus far not posed a problem (Childress 1995).

Also, for some parameters, USGS and DEM have different detection limits. USGS, which maintains and interprets the project data base, notes the different detection limits in its data reports. Differences have not posed a problem for the project to date since both agencies generally measured no detects for these parameters. While USGS, DEM, and the Steering Committee informally agreed to performance-based protocols in 1988, only in the second phase did USGS formally document and report DEM's and USGS's respective protocols for the project. This delay, along with changes in key personnel, led to unnecessary errors in sample collection and analysis (Brewer 1989–1995).

Agency and Cost Category	1995 Cost
USGS: Technical Services	$211, 361
Local Governments: Technical Services Project Management	 $211,361 $20,372
DEM: Technical Services	$100,000
TOTAL PROJECT COST	$543,094

DATA ANALYSIS

Currently, water samples are quantitatively analyzed for 8 major ions, 11 nutrients, 10 physical properties (including chlorophyll-*a* and *b*), 15 metals and trace elements, 133 volatile and semi-volatile organic compounds, and 15 inorganic constituents. In addition, a qualitative analysis of organic compounds is conducted at about half of the sites by scanning with a gas chromatography/flame ionization detector. When significant organic compounds are detected, samples are re-analyzed by gas chromatography/mass spectrometry and a library search of more then 40,000 SOCs to identify the compound. Qualitative analysis does not measure the amount or concentration of the compounds, but does provide a snapshot of "molecular litter" present in the water column.

USE OF DATA

Data are used by the Steering Committee to meet project objectives, particularly evaluating the condition of drinking water supply source waters and analyzing spatial and temporal trends. The Steering Committee has focused and reported on technical, factual issues to date rather than on land-use management and policy issues. Local governments, however, use project data to evaluate wastewater and water treatment plant operational policies and procedures, identify nonpoint source problems, and research the need for watershed protection measures (Brewer 1989–1995).

COST

Through cooperative agreement with the Project Steering Committee, USGS conducts field work, laboratory analysis, and data interpretation. Generally, USGS's technical cost are about $422,722 per year; USGS pays one-half of the technical service cost. Through interlocal agreement, participating local governments pay the remaining one-half of the technical service cost, plus TJCOG's project management cost of $20,372 per year. Overall project costs have been held constant or reduced since 1988. During Phases I and II, project costs were allocated to local governments based on each member's percentage of the total membership's water production. In Phase III, costs will be held constant for all members, except for the largest member whose cost and sites were reduced. The project estimates that the value of the DEM ambient monitoring data is about $100,000. The total estimated cost of the monitoring project is therefore $543,094 per year.

CHALLENGES

TAWSMP encountered the following obstacles in implementing and maintaining the consortium:

1. Revised Safe Drinking Water Act requirements increased monitoring costs, thereby reducing funds available for supplemental monitoring.
2. Raw water monitoring data could not be used in lieu of additional requirements for treated monitoring data.
3. Because no major drinking water problems have yet been detected, some ask, "Why continue monitoring?" Two small local participants have withdrawn from the project for this reason.
4. Individual costs not commensurate with individual benefits or with one-member one-vote governance structure.

Two smaller participants decided not to participate in Phase III for reasons 1, 2, and 3. The City of Raleigh, the largest participant, decided not to participate in Phase III for all four reasons. Nine participants have signed the Phase III interlocal agreement for an additional 5 years of monitoring (Brewer 1989–1995).

PROGRAM EVALUATION

Since its inception in 1988, the monitoring project has periodically evaluated alternative sampling plans for achieving project objectives while minimizing project cost. The monitoring program is evaluated on annual and triennial cycles. The interlocal agreement expires and is renegotiated every 3 to 4 years. Each year the project reports findings and, at the end of each phase, produces a major data interpretive report. Resource advisors review and comment on these reports.

During the last year of each phase, the Project Steering Committee comprehensively evaluates the program in light of project findings, comments from resource advisors regarding program needs, and resources available. Essentially, everything is put on the table for evaluation, including the project's goals and objectives, design of the routine monitoring program, special studies needed, technical contracts, and the local share formulae. The Steering Committee then negotiates a 3- to 4-year project proposal, outlines amendments to the existing program, and forwards the proposed interlocal agreements to local governing boards for their consideration.

Each year, the program also annually evaluates emerging issues or concerns; new special studies or constituents are added as funding becomes available or as current monitoring can be reconfigured to redirect resources. The underlying goal of program evaluation is to maintain a project design that allows the Steering Committee to evaluate conditions and detect long-term water quality trends.

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CASE STUDY 3
THE LOWER NEUSE BASIN ASSOCIATION

BACKGROUND

In 1992, the state targeted the Neuse Basin as its first basinwide water quality management study area. During the basin planning and assessment stages, DEM reviewed the NPDES compliance monitoring data and the state's ambient monitoring data, and concluded that the state and permittees could generate more useful, cost-effective, higher quality data. In 1994, major NPDES dischargers in the Basin formed a monitoring corporation, the Lower Neuse Basin Association. The association signed a related Memorandum of Agreement with the state's Division of Environmental Management. Monitoring began in July 1994 with the primary objectives of determining the effectiveness of state-established TMDLs and better understanding the CBOD/DO relationship in the river and the relative contributions and impact of nutrient loading.

GEOGRAPHIC SETTING

The Lower Neuse Basin is the area draining into the Neuse River below Falls Lake Dam in the Piedmont Province to the tidal waters in the Coastal Province of North Carolina (Figure 10). Comprising 4807 mi^2, the basin is predominantly forested and agricultural along its 185-mi course. The Lower Neuse, which includes 15 counties, is important for the state’s economy from its headwaters in the commercial, industrial, institutional center in Raleigh, through its ubiquitous farms, to its recreational boating, fishing, commercial fishing, and shellfish harvesting waters at the coast (NCDEHNR 1992).

CONSORTIUM DESCRIPTION

HOW WAS THE CONSORTIUM FORMED?

In 1992, the state targeted the Neuse Basin as its first basin-wide water quality management study area.[3] During the basin planning and assessment stages, North Carolina's Division of Environmental Management (DEM) reviewed NPDES-compliance monitoring data and state ambient monitoring data and concluded that through a more flexible, basin-oriented monitoring design, all parties could generate more useful, cost-effective, higher-quality information. Through two of its regional offices, DEM staff initiated talks with some of the larger wastewater dischargers about a coordinated, strategic monitoring program that would replace the routine NPDES compliance monitoring (Crisp 1995).

HOW IS THE CONSORTIUM ORGANIZED?

The largest discharger, the City of Raleigh, assumed the lead role in recruiting and organizing others. In 1994, the largest dischargers in the Lower Neuse River Basin formed a monitoring corporation, the Lower Neuse Basin Association, and opened membership to local governments holding NPDES wastewater discharge permits and public and private entities holding NPDES wastewater discharge permits for 1 MGD or greater. Twenty-three dischargers joined. DEM designed the association’s monitoring program, then both signed a Memorandum of Agreement (MOA) (LNBA 1995).

WHAT ARE THE OBJECTIVES OF THE CONSORTIUM?

The governing mission of the Lower Neuse Basin Association is to preserve the waters of the Lower Neuse River through innovative and cost-effective pollution reduction strategies by:

1. Forming a coalition of local governments, public and private agencies, and other interested and affected communities, organizations, businesses, and individuals

[3] In 1988, DEM classified the Lower Neuse Basin as a nutrient sensitive water and tightened phosphorus limits for permitted wastewater dischargers as well as sharing the cost of imple menting agricultural BMPs. In addition to nutrients, the basin also regularly exceeds DO standards, primarily due to biologi cal oxygen-demanding waste from point source discharges. There are 256 permitted discharge facilities in the Lower Neuse Basin, 24 major discharges (i.e., permitted flow greater than 1 MGD) and 232 minor (permitted flow less than 1 MGD). Major dischargers constitute about 85% of the total permitted flow, though less than 10% of the number of facilities (NCDEHNR 1992).

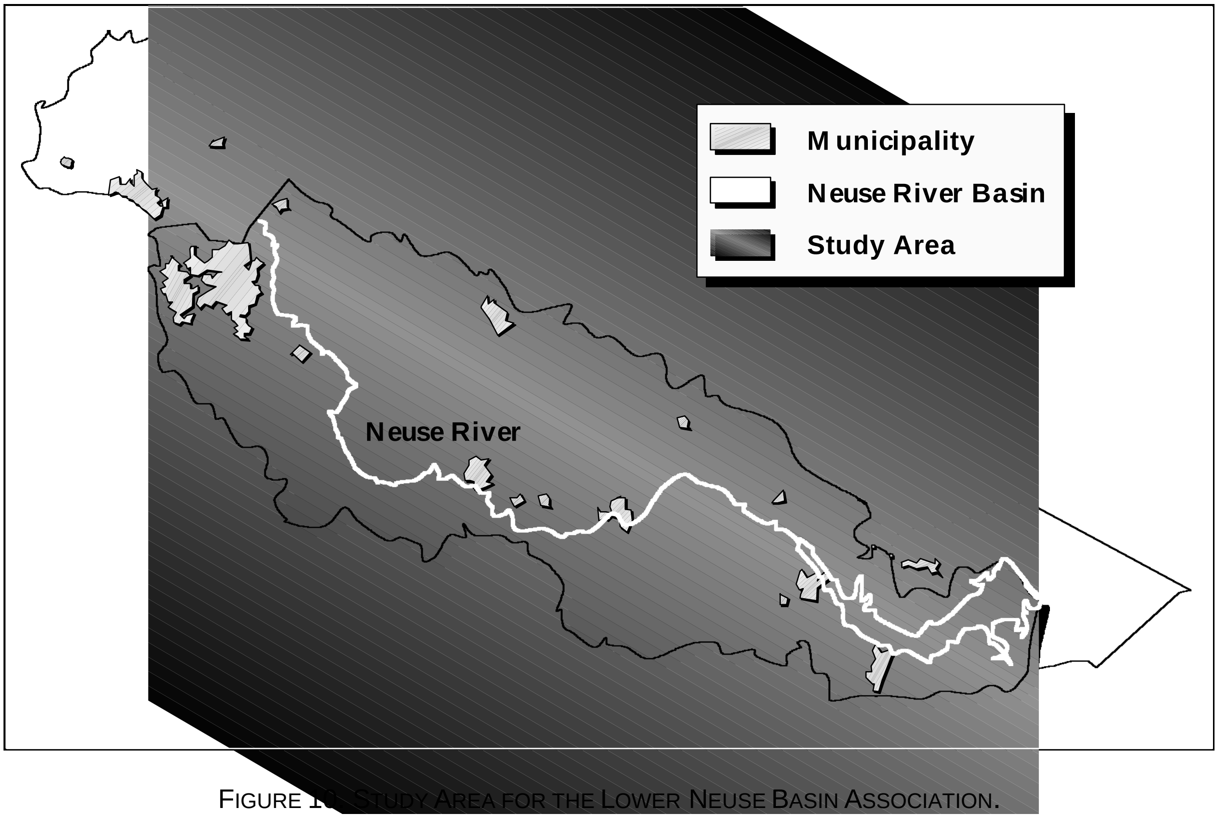

FIGURE 10. STUDY AREA FOR THE LOWER NEUSE BASIN ASSOCIATION.

to secure and pool financial resources and expertise;

2. Collecting and analyzing information and data; and developing, evaluating, and implementing strategies to reduce, control, and manage pollutant discharge;
3. Providing accurate technical, management, regulatory, and legal recommendations regarding the implementation of strategies and appropriate effluent limitations on discharges into the lower portion of the Neuse River.

HOW IS THE CONSORTIUM IMPLEMENTED?

DEM established the monitoring sites, parameters, and sampling frequencies. The Association implements the monitoring program through its annual workplan and MOA with the states. Monitoring began July 1994. The program integrates in-stream monitoring requirements in NPDES permits with the basinwide water quality management strategy that was being implemented in North Carolina (LNBA 1995).

BENEFITS

The Lower Neuse Basin Association and DEM have identified the following benefits of the coordinated monitoring program:

- The state and Association can now conduct special studies that otherwise would not have been possible, including evaluating TMDLs, the relative contributions and impacts of nutrient loading, the impacts of point versus nonpoint sources, and model verification.
- Establishing uniform standard operating procedures and contracting with one certified environmental firm yields higher-quality, more reliable data.
- The state designed a monitoring program that was flexible and basin-oriented and that provides useful information for evaluating point and nonpoint source contributions, for describing tributary and mainstem water quality relationships, and for verifying wasteload allocation models.

Seasonal sampling for the Lower Neuse Basin

Parameter	Site	Summer (May–September)	Winter (October–April)
Field parameters	All sites	Biweekly	Monthly
Nutrients	All sites	Monthly	Monthly
Chlorophyll-*a*	Selected sites	Monthly	Monthly
Turbidity	Selected sites	Monthly	Monthly
Metals	Selected sites	Monthly	Monthly
Fecal coliform	All sites	Monthly	Monthly
Long-term BOD	Selected sites	June, July and August	

Cost Comparison for 1993 and 1995

Range of Permitted Flow (MGD)	Average Net Annual Savings	Number of Reporting Members
0.1–1	$11,707	3
>1–4	$4,600	8
>4–6	$77	2
10–20	$17,021	2
>20–30	$19,133	1
>60	$5,000	1

- The monitoring consortium yields substantial annual cost savings for its members.
- One of the greatest benefits is that dischargers are building and maintaining strong working relationships among themselves and with DEM to better understand and protect the water quality of the Neuse River.

DATA PROCEDURES

INFORMATION MANAGEMENT

All monitoring data are compiled and stored in a consistent format in STORET. The MOA stipulates that the Lower Neuse Basin Association is responsible for coordinating the collection of water quality data, entering data into STORET within 3 months of its collection, and archiving data sheets for 10 years.

DATA COLLECTION

Monitoring is conducted at 42 sites, generally below the wastewater discharges of association members. Water samples are analyzed for

- Field parameters: temperature, DO, conductivity
- Nutrients: total phosphorus, total nitrogen, ammonia, total Kjedahl nitrogen, and NO_x
- Chlorophyll-*a*
- Turbidity and TSS
- pH
- Metals: Al, As, Cd, Cr, Cn, Fe, Fb, Hg, Ni, Zn
- Long-term BOD
- Fecal coliform
- Flow

DATA ANALYSIS

The Association contracts with a certified laboratory to conduct field work and analysis. The MOA requires the association to retain a firm competent to perform the monitoring activities and use a laboratory appropriately certified for required analyses (i.e., certified by the state using EPA-approved procedures).

USE OF DATA

The MOA reflects joint interests of dischargers and the state in strategic monitoring data, including the following uses:

- Evaluate the effectiveness of established total maximum daily loads (TMDLs) throughout the Neuse River Basin
- Evaluate the impacts of point and nonpoint sources
- Quantify relative contributions and impacts of nutrient loading to the Neuse
- Further describe the relationship between carbonaceous biochemical oxygen demand (CBOD) and dissolved oxygen (DO) in the Neuse River and its larger tributaries, including verification of the QUAL2E model.

COST

The annual Association budget is $132,000: $82,000 for in-stream monitoring, $6,000 for administration, and $44,000 for consultation. Through association by-laws, costs are allocated to each member based on its percentage of the association's total permitted flow. A 1995 survey of association members revealed that the strategic monitoring program yields a substantial annual cost savings. Based on information submitted by 19 of the 23 members that responded to the survey, *annual net savings* was $130,319 (i.e., total annual monitoring cost before strategic monitoring minus total annual cost of the association's monitoring program equals net annual savings) [4].

The pattern of cost savings from survey responses suggest a net savings for all 23 members of more than $165,000 and an overall monitoring cost savings factor greater than 2 (i.e., an estimated pre-association annual monitoring cost of $297,000 compared to annual association cost of $132,000) (Figure 11).

Although all participants save, dischargers with a permitted flow of 10 to 30 MGD save the most (Figure 12). Absolute savings for smaller dischargers have very different budgetary impacts than for the larger. For instance, the smallest dischargers have a current average annual monitoring budget of $246 and an average annual savings of $11,707—a cost savings factor of almost 50. While mid-sized dischargers have a greater net annual savings than smaller dischargers ($17,021 per year compared to $11,707), their current average annual monitoring budget is $51,064—a cost savings factor of 1.33.

CHALLENGES

When state and local officials began discussing the consortium, there were no neutral parties at the table, and there were questions about the advisability of the state or a single discharger leading the effort (NCDEHNR 1992). Although Raleigh, the largest discharger in the basin, began organizing the association, the city made concerted efforts to have different members assume future leadership positions. For instance, as working committees were formed, chair people were selected from representatives of different dischargers to strengthen commitment early in the process and ensure that no single organization dominated the process.

The second significant issue was determining who should be responsible for designing the association's monitoring program. The state initially wanted the association to draft monitoring goals and objectives and send them to DEM for

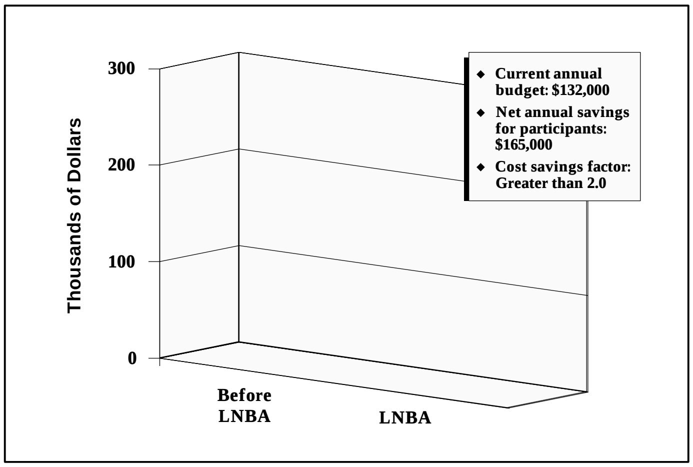

FIGURE 11. LNBA ANNUAL COST SAVINGS.

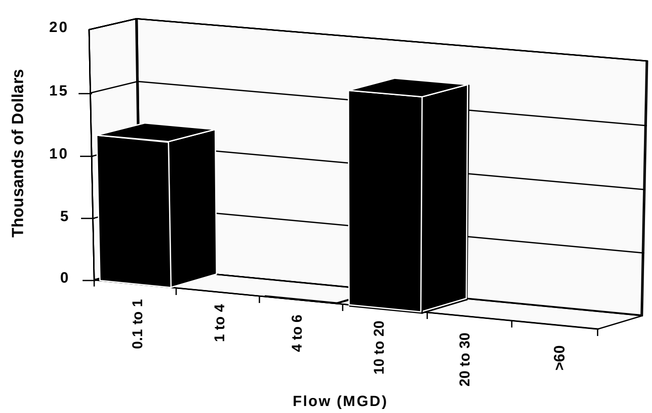

FIGURE 12. LNBA ANNUAL SAVINGS IN DOLLARS BY PERMITTED FLOW.

4 Calculated by subtracting the total annual cost of the association's monitoring program in 1995 from the total annual monitoring cost in 1993 (before strategic monitoring). Cost comparisons from 1993 to 1995 were not adjusted for inflation. Association staff also indicated that estimates of cost savings were conservative.

comment and approval. The association wanted DEM to design the program. After a prolonged impasse, the state did design the program, which became part of the state-association MOA (LNBA 1995; NCDEHNR 1992).

PROGRAM EVALUATION

The MOA is effective from 1994-1999, the same period of the initial Neuse Basin Water Quality Plan. The association must submit to the state an annual notice of compliance or non-compliance with MOA requirements. Additionally, the association meets once annually to review notices, reports, proposed workplans, and budgets. When the state completes its second basin management cycle, monitoring design and requirements in the MOA will be reassessed. The current agreement may be modified to simply substitute parameters or change sampling frequencies at any time by consent of both parties.

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CASE STUDY 4
MID-ATLANTIC HIGHLANDS ASSESSMENT

BACKGROUND

EPA's Region III led the design of the Mid-Atlantic Highlands Assessment as part of the agency's shift to geographic-based environmental planning. Stakeholders participating in the program include four federal agencies, water resource agencies in four states, and numerous local and regional agencies. The assessment evaluates changes in four diagnostic categories: chemistry, hydrology, physical habitat, and biology. Information will be for strategic planning and also to assess ecological conditions, locate sensitive areas, and prioritize needs for additional research.

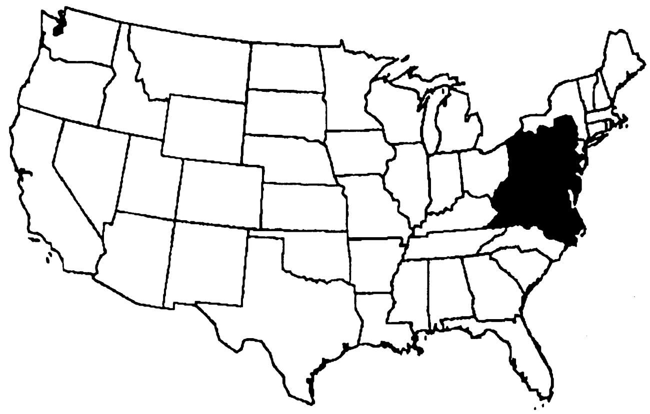

FIGURE 13. STUDY AREA FOR THE MID-ATLANTIC HIGHLANDS ASSESSMENT.

GEOGRAPHIC SETTING

The Mid-Atlantic Highlands are composed of 65,000 mi^2 of oak-hickory forests and upland areas and contain six major watersheds in Pennsylvania, Maryland, Virginia, and West Virginia. The Highlands comprise 55 percent of EPA Region III and include six ecoregions: the Western Allegheny Plateau, the Northern Appalachian Plateau and Uplands, the Central Appalachian Ridges and Valleys, and the Blue Ridge Mountains (Figure 13). All these areas are of rich environmental and aesthetic value and are also stressed by internal and external forces (EPA). For instance, the Highlands receive the highest rates of acidic deposition in the United States, with 8 percent of its streams becoming chronically acidic. The Highlands are also impacted by erosion, siltation, and acid mine drainage attributable to coal mining. Construction of new resort communities and general population growth are also taxing these natural systems (EPA).

CONSORTIUM DESCRIPTION

HOW WAS THE CONSORTIUM FORMED?

In the late 1970s and early 1980s, EPA began developing geographic-based plans, such as the Chesapeake Bay's comprehensive monitoring projects, to address problems. The impetus for the Mid-Atlantic Highlands Assessment (MAHA) project was EPA Region III's belief that a shift from technology- and media-based regulations to strategic monitoring, planning, and management of large ecosystems would make environmental protection and restoration more effective (EPA). MAHA provides support to EPA Region III and states for strategic planning. The monitoring program, which is based on EMAP's probability-based sampling design, targets point sources and both overland and atmospheric nonpoint sources of pollution.

HOW IS THE CONSORTIUM ORGANIZED?

EPA led the design of the Mid-Atlantic Highlands Assessment and, by 1993, was working with state environmental protection and water quality agencies in four states plus dozens of local and regional agencies to implement the monitoring program. The U.S. Geological Survey (USGS) and U.S. Fish and Wildlife Service (FWS)are working with EPA to evaluate how their monitoring activities could be integrated into the assessment (EPA). Integral to the MAHA approach is extensive internal and interagency cooperation and data sharing (Figure 14). The EPA Region III Environmental Services Division administers the project, including coordinating with cooperators on

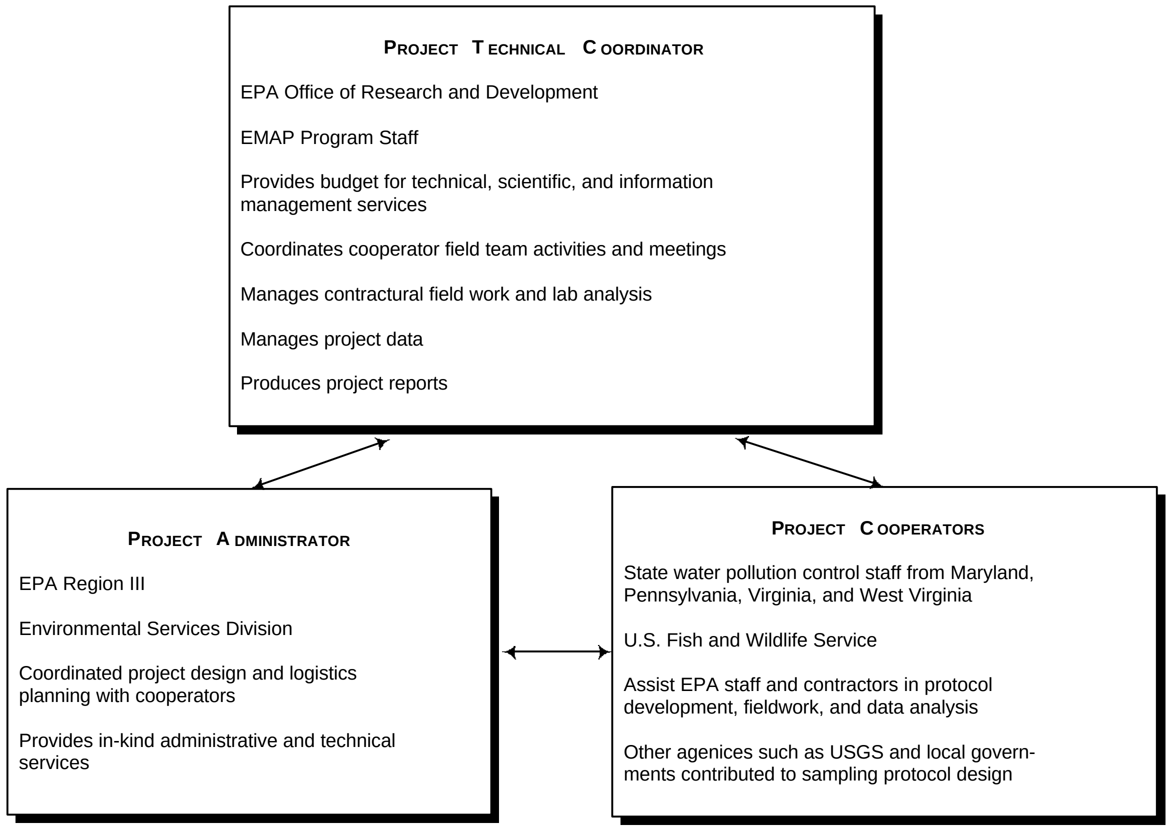

FIGURE 14. EXTENSIVE COOPERATION AND DATA SHARING ARE CRITICAL TO MAHA'S SUCCESS.

the project design and logistics planning. The Division provides in-kind administrative and technical services. The EPA Office of Research and Development's EMAP staff fund, contract, and coordinate the scientific, technical, and information services as well as coordinate the activities/meetings of the field teams. Project cooperation in field sampling teams include state water pollution control staff from Maryland, Pennsylvania, Virginia, and West Virginia, as well as the U.S. Fish and Wildlife Service. These cooperators as well as other local and federal government agencies, and universities, assisted in protocol design and data analysis.

WHAT ARE THE OBJECTIVES OF THE CONSORTIUM?

MAHA's overall program goal is to provide support for EPA Region III and state strategic planning. MAHA was not originally designed as part of a state strategic monitoring program, but EPA staff indicate that one long-term objective of the program is to use assessment results in the design of future state monitoring programs (Preston 1995). Participants identified three additional program objectives: (1) assess the current ecological condition of the mid-Atlantic Highlands and its component ecoregions and states, (2) locate sensitive areas in need of special protection or restoration, and (3) prioritize needs for additional investigation into causes and consequences of pollution (DeMoss).

HOW IS MAHA IMPLEMENTED?

MAHA participants developed five basic steps to their approach (Figure15) (MAHA 1994):

Step 1: Define major regional environmental management questions.

Step 2: Establish biological criteria (i.e., indicators) for unpolluted reference (or control) conditions within streams of specific subecoregions to provide a baseline of what expectations should be. Carefully define ecoregions that share biological criteria.

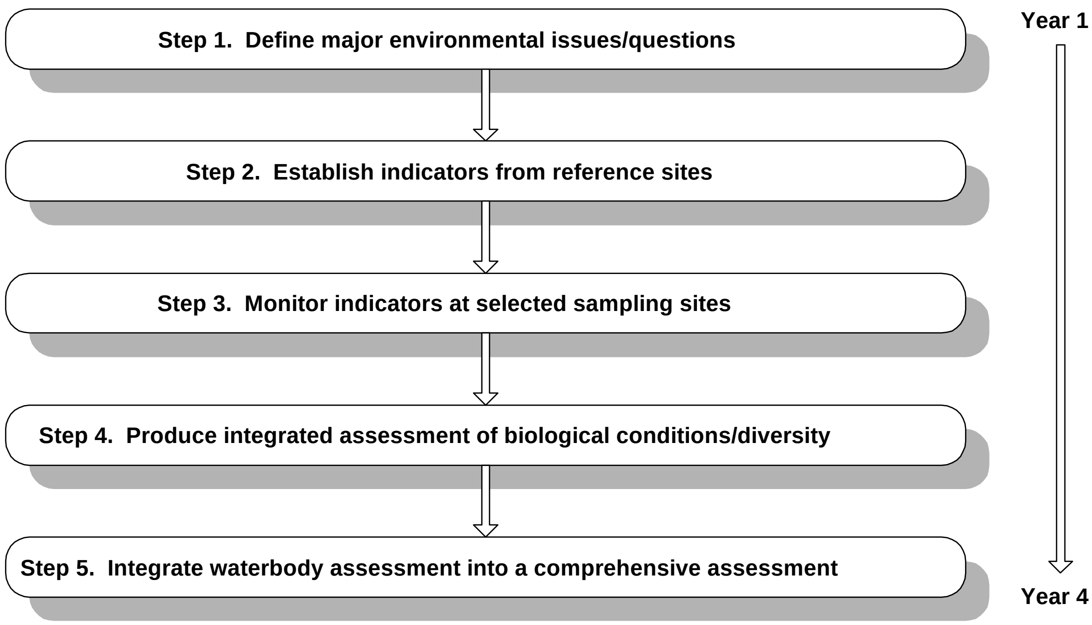

FIGURE 15. MAHA'S FIVE-STEP APPROACH.

Step 3: Monitor indicators derived in Step 2 at approximately 215 probability-based sites across the Highlands. Sites are selected using EMAP's fixed sampling grid to provide unbiased results with known confidence for given geographic areas. Each year, over a four-year period, MAHA randomly selects new sites and a subset of previously sampled monitoring sites to increase the accuracy of temporal and geographical statistical analysis (DeMoss).

Step 4: Produce an integrated assessment of biological conditions and diversity for streams and rivers in the mid-Atlantic Highlands.

Step 5: Combine the assessment of streams and rivers with similar assessments of major forest types and agricultural systems and with analyses of land-use patterns and other landscape and human impact measures; develop a comprehensive, integrated report on environmental conditions for the large ecosystem and major subcategories (such as specific states, forest types, ecoregions, or other designations). Region III is working with EMAP–Landscape Characterization to develop data on regional land cover.

BENEFITS

MAHA participants have identified the following benefits of coordinating and integrating monitoring activities:

- Conducting special studies that otherwise would not have been possible if not for the probability based sampling design,
- Leveraging resources for monitoring sites that are important to multiple agencies to allow broader and more intensive monitoring, and
- Building and maintaining strong working relationships.

DATA PROCEDURES

INFORMATION MANAGEMENT

The field teams enter data into field computers then ship data and samples to lab contractors. All datasets are sent to the EMAP staff at EPA for storage and analysis using a SAS database. Data QA/QC is completed by the EMAP staff. Datasets structures were designed by each indicator team but the datasets had to be compatible with the centralized SAS database.

DATA COLLECTION

In 1993, MAHA monitored a total of 246 wadable stream sites (EPA):

- 65 surface water demonstration sites selected using EMAP's probability-based sampling sites,
- 31 reference sites (unimpacted areas),
- 46 regional sites, and
- 104 acidic deposition sites.

Monitoring parameters included benthic organisms, macroinvertebrates, fish samples, physical habitat condition, and physical and chemical water quality components. The monitoring period was from mid-April to late June (EPA). MAHA also coordinated monitoring at 45 sites for forest conditions. In 1994, monitoring included 296 wadable stream sites, forest health monitoring at 120 sites, and 1200 National Agricultural Statistical Survey sites (EPA). The monitoring frequency and duration was designed to support an assessment of current conditions, rather than trend analysis (Preston 1995). The staff hopes that possible future monitoring cycles will generate sufficient data for trend analysis.

MAHA also includes landscape ecology—the study of the influence of landscape patterns on the flow of water, energy, nutrients, and biota (EPA). To generate an accurate picture of land use/land cover of the Highlands, EPA, FWS, USGS, and the National Oceanic and Atmospheric Administration (NOAA) formed a partnership with the National Data Center at USGS to develop comprehensive land-characteristic data from satellite imagery for the entire United States. Land-cover mapping for the MAHA region is estimated to be complete in 1996 (EPA). At that time, stream biological conditions and landscape conditions can be compared at different watershed scales and overlaid with numerous coverages such as point source discharges. Therefore EPA will have georeferenced formats for both a representative sample of stream segments and the watersheds that influence them. This model can be used by others as they move toward watershed-based management.

The field crews include a team of four investigators (including staff from EPA Region III state water pollution control agencies, FWS, and contractors) which conducts 6- to 8-hour site visits. Project investigators also attend an annual training session on SOP documentation.

MAHA adopted EMAP's sampling protocols for benthic surveys, chemical analysis, fish community sampling, and physical habitat assessment. An EMAP team of representatives from EPA, USGS, state water pollution control agencies, and FWS jointly reviewed each agency’s protocols and negotiated uniform procedures for each of the above areas. The review team selected EPA’s procedures for benthic macroinvertebrate surveys and chemical analysis and USGS's NAQWA procedures for fish community sampling. Because physical habitat assessment was not standardized, the team contracted with a consultant to develop assessment procedures that were incorporated into the sampling SOPs. The manual adopted by MAHA also includes standardized procedures for sample preservation.

DATA ANALYSIS

EMAP contracted with laboratories for the MAHA project previously used by EMAP for other projects, including a university contract for chemical analysis, a private laboratory for macroinvertebrate sampling and analysis, and the Smithsonian for fish community. EMAP used an interagency team, the same procedure used to negotiate field sampling protocols, to establish and document SOPs and QA/QC for laboratory analysis.

Laboratories send MAHA data to EMAP staff for second-level QA/QC. Data are currently being interpreted jointly by EMAP and EPA Region III staff. The strategy is to develop strawman assessments to be sent out for interagency peer review and comment. MAHA staff indicated that additional time and planning are needed for the data analysis/interpretation stage.

USE OF DATA

MAHA uses data to develop stressor indicators. Stressors are characteristics of the environment that are suspected to worsen the condition of the ecological resource; they can be natural or human induced (EPA). MAHA uses reference conditions to evaluate alterations in four diagnostic categories that comprise the full range of impacts to aquatic systems (EPA):

- ♦ Chemical alterations, including pollution by nutrients, metals, and organic compounds. They can be classified by contaminant source categories: point source, overland non-point source, and atmospheric point and nonpoint sources.
- ♦ Hydrologic alterations, including the timing, amount, and path of flow.
- ♦ Physical habitat alterations, including changes in habitat complexity, substrate size, bank stability, and riparian vegetation.
- ♦ Biological alterations, including the introduction of exotic species (both plant and animal), overstocking and overharvesting of fish, and loss of plant and animal species.

Assessments are intended to support strategic planning efforts; also, some states have committed to using assessments to (EPA):

- ♦ Rank problems according to severity and focus future field assessment work on areas with the worst problems to measure the effectiveness of remediation efforts.
- ♦ Identify problems with toxics for special control programs.
- ♦ Select waters to be protected from any further degradation.
- ♦ Establish instream goals for clean-up activities and calculate appropriate permit limits.
- ♦ Evaluate the effectiveness of water quality criteria or best management practices.

COST

Scientific and information management services are funded through EPA ORD's EMAP budget at a cost of $1.4 million per year. EPA Region III provides in-kind administrative services at an estimated cost of $300,000 per year, bringing the total annual project cost to $1.7 million currently. This is an in-house EPA leverage factor of 1.2 and does not include the in-kind contributions from other agencies.

CHALLENGES

MAHA staff identified obstacles EPA faced in forming the consortium. First, each state and federal agency had its own procedures. To obtain buy-in for adopting EMAP's uniform procedures for field sampling and laboratory analysis for the data collection period, EPA Region III demonstrated that:

- ♦ Existing monitoring objectives could be met using the new, uniform protocols
- ♦ New protocols would not automatically be mandated in the future by EPA (Due to the experimental nature of the project in which EMAP protocols were essentially being implemented for the first time, protocols would be evaluated and refined, as needed, after project completion.)
- ♦ The monitoring design could save the states money in the future

Second, an ongoing challenge to the MAHA project is communicating the value of the project to multiple agencies and how it might help meet their diverse objectives. Staff sees this as not only a challenge in effective communication, but also to a sustained leadership. From the earliest discussions, EPA Region III assumed the leadership, or champion, role. Staff indicated that other partners had previously viewed EPA as a narrowly focused regulator (Preston 1995). MAHA partners accepted and appreciated EPA's new role of neutral organizer of holistic resource assessment, but some individuals and landowners believed EPA would turn MAHA into an enforcement action.

MAHA also identified major obstacles to implementing or continuing the project. First, the logistical challenge was significantly underestimated, including obtaining landowner permission for sampling, a narrow window for sampling requiring 6 crews in the field at a time, and all equipment and supplies assembled and conveniently dropped for the teams. Running the project smoothly required detailed advanced planning. For highest efficiency, similar projects should (Preston 1995):

- ♦ Identify all sampling sites 9 months in advance
- ♦ Identify all landowners of sampling sites and requested access permission 6 months in advance
- ♦ Have all logistical information in hand, including equipment and supplies needed, 3 months in advance

Getting landowner approval to enter property required a great deal of research, mailing, follow-up, and local site visits. After increased media attention about the Endangered Species Act, a number of land owners refused site access. Dropping these sites has the potential to bias results. MAHA staff advised overcoming this limitation by identifying a local, part-time cooperator who can go to the courthouse to identify the landowners and make initial contact with landowners.

Thorough planning is needed for the data interpretation and analysis phase (Preston 1995). In retrospect, the staff believes each phase needs equal attention upfront. MAHA staff believes that planning for the data collection phase and, in retrospect, that MAHA would have benefited from more upfront planning for data interpretation. One way that MAHA/ORD-EMAP staff are dealing with the quandry of a tremendous amount of data and limited assessment/evaluation resources is to distribute strawman assessment documents for wide peer review to state and regional experts.

PROGRAM EVALUATION

MAHA staff indicate the program will be evaluated in 1996–1997 upon completion of field sampling and an interpretation of the 1993–1994 data (Preston 1995).

SOURCES

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MAHA. 1994. Mid-Atlantic Highlands Assessment—Monitoring and Assessment Conference. February.

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Preston, R. August 6, 1995. Personal communication with EPA Region III Biological Sciences Coordinator.

RECOMMENDATIONS FOR BUILDING AND MAINTAINING STRONG MONITORING CONSORTIUMS

In the early 1990s, the Intergovernmental Task Force for Monitoring, comprising representatives from multiple state and federal agencies, recognized the importance of effectively coordinating efforts and developed recommendations for collaborative, integrated monitoring (Appendix A). Additionally, staff from the four consortium case studies were asked, "What would you advise other groups that would like to set up a consortium, particularly insights on obstacles they may face, how to overcome them, and keys to success?" Several common themes on pitfalls and successes emerged from our study. Recommendations from ITFM and the consortium suggest a ten-step process for building a strong monitoring consortium (Figure 16). Below are suggested milestones and guiding principles for each of the ten steps. Generally, the list conveys a progression of actions; many steps, however, will be conducted concurrently, and all actions are interrelated.

FIGURE 16. STEPS TO BUILDING A STRONG MONITORING CONSORTIUM.

SUGGESTED MILESTONES AND GUIDING PRINCIPLES

STEP 1: EXPLORE NEED FOR AND BENEFITS OF STRATEGIC, COORDINATED MONITORING

- Identify key managers and permit holders in the study area (e.g., estuary drainage area, water supply watershed, and whole river basin) and determine whether sense of need is shared.
- Identify at least one expected benefit for each partner (e.g., the state, local governments, and industrial dischargers).
- Host discussions in a neutral meeting place using a neutral facilitator (if possible).

STEP 2: ESTABLISH LEADERSHIP (WHO WILL CHAMPION THE CAUSE?)

- If initial discussions with key players indicate an interest in coordinated monitoring, identify which agency or organization will assume the primary leadership role.

- Identify an objective, neutral organization to lead recruiting, organizing, and educating potential partners and facilitating the process (if possible).
- Establish a plan for contacting partners in the watershed and exploring monitoring strategies.
- To the extent possible, tap leadership in existing organizations, associations, and forums.
- Spread leadership mantle over potential partners (for example, by speaking at existing forums in the watershed, working on task forces, and chairing task forces.
- Engage a representative of each potential partner in the design and decision-making process.

STEP 3: ESTABLISH CONSENSUS ON NEED FOR CO-ORDINATED MONITORING

- After laying initial groundwork, establish a broad-based consensus through a neutral forum on the need for and general purposes of the monitoring program. Use an existing forum for consensus building, if possible.
- For NPDES permit holders ensure that the coordinated monitoring program helps meet, or offsets, regulatory requirements (to the extent possible).
- Communicate specific expected benefits to each partner group, including potential cost savings and resource leveraging.
- Obtain buy-in or authority to develop recommendations on specific monitoring goals and objectives, monitoring design, project budget and cost allocations, project governance and management, and project evaluation.
- Establish a timeline and a task force for developing and reporting recommendations.
- The Task Force completes Step 4-10.

STEP 4: DESIGN THE MONITORING PROGRAM

- Draft specific monitoring goals and objectives to guide program design. If the monitoring program is a component of a watershed management framework, monitoring goals should reflect needs and priorities for long-term, baseline assessment as well as shorter-term, strategic assessment.
- Design the monitoring program for the flexibility and continuity to measure long-term trends; regularly evaluate the monitoring program to ensure that the project meets goals and objectives cost effectively and adequately addresses emerging issues and priority concerns.
- Review and evaluate historical monitoring data and protocols for the study area.
- Identify others who may participate in coordinated monitoring and assessment, including representatives from all levels of government, the private sector, universities, and regulatory and voluntary monitoring programs.
- Design program to take advantage of historical and existing monitoring programs of other agencies and overall capabilities and resources of consortium members; avoid duplicating efforts.
- Select monitoring parameters, sites, and frequencies consistent with monitoring goals and objectives.
- Establish flow measurement sites as well as reference sites to aid in water quality data interpretation and assessment.
- Using a performance-based monitoring approach, establish field sampling, laboratory, and QA/QC protocols that are compatible and yield comparable data.
- Where there are uncertainties about compatibility of protocols, incorporate tests into first year workplan (and subsequent years as needed) to determine compatibility, and institute changes in protocols in a timely way.
- Jointly choose/design data interpretation methods and indicators to measure progress in meeting monitoring goals (related to Step 5 - Interpreting and Reporting Data). Make sure monitoring design supports index measurement and other assessment tools.
- Conduct pilot studies as needed.

- Document monitoring design, protocols, and participants' responsibilities in a manual of standard operating procedures.
- Determine who will do field work, and lab analysis.
- Develop annual cost estimates for the monitoring program, including field work, lab analysis, and QA/QC.

STEP 5: PLAN HOW TO INTERPRET DATA AND REPORT FINDINGS

- Outline methods and types of data interpretation (e.g., water quality trend analysis, pollutant loading, and general conditions) consistent with project goals and objectives. Because the monitoring design must support index measurement and other assessment tools, the planning process for monitoring design and data interpretation should be integrated and concurrent.
- Determine audience for project reporting and develop effective and appropriate formats for each audience.
- Jointly select environmental indicators to measure progress in meeting monitoring goals. Make sure monitoring design supports index measurement and other assessment tools.
- Develop communication plan for regularly scheduled data interpretation and report on project findings.
- Develop mechanism for tracking benefits, including documenting cost savings, for the consortium collectively and for members individually. Report benefits with other project findings.
- Determine who will interpret data and produce reports.
- Estimate annual cost for interpreting data and reporting results to consortium members and the general public.[5]

[5] Data interpretation and reporting constitute 20-30% of the entire annual project budget. MAHA is currently interpreting data, but project staff did not develop a detailed workplan and budget for this component; in hindsight staff believe they should have devoted equal resources to data collection and data interpretation phases.

STEP 6: DESIGN THE DATA MANAGEMENT SYSTEM

- Implement a performance-based monitoring system to obtain comparable data and achieve more flexible use of monitoring and laboratory analysis methods.
- Jointly develop standard names, definitions, and formats for each data element. Produce a cross-referencing code list and data dictionary, as needed.
- Jointly establish QA/QC procedures for data review, entry, verification, etc.
- Document methods, protocols, and QA/QC procedures in a standard operating procedures manual.
- Record metadata (e.g., data sources and quality).
- Using standard programs, make data available to project participants and other interested groups.
- Have central, automated library for all updated files and reports.
- Determine who will manage project data.
- Develop annual cost estimates for managing data, including retrieving data from cooperating agencies and conducting QA/QC of overall database.

STEP 7: ESTIMATE COST AND ACQUIRE FUNDING

- Add cost estimates from Steps 4-6.
- Estimate project administration/management cost (at a minimum of 5% of total technical budget).
- Identify funding sources for project monitoring and administration, including likely cost-share cooperative agreements; grants; and federal, state, and local governments.
- Propose annual project budget detailing cost and major revenue sources for the first phase of the project, which is generally 3-5 years.

STEP 8: DRAFT CONTRACTS/AGREEMENTS

- Draft contracts, memoranda of agreement, cooperative agreements, a manual of standard operating procedures, and other mechanisms for formalizing technical and administrative roles and responsibilities of consortium participants.

STEP 9: DEVELOP GOVERNANCE AGREEMENTS AND STRUCTURES

- Include representatives of potential partners early in the project design.
- Convene a subcommittee with policy and technical representatives to draft proposed project by-laws establishing roles, functions, and membership as well as methods of appointment and voting rules for the project's steering committee.
- Develop criteria for allocating project costs among and within member groups.
- Develop a subcommittee with policy and technical representatives to draft proposed project incorporation agreement, interlocal agreement, memoranda of agreement, or other instrument to formalize the purpose, goals, and objectives of the monitoring consortium; responsibilities of members; duration of the project; and project budget, method of allocating costs, and member dues. Send draft agreement to potential partners for ratification. (They should receive it 4-6 months before new fiscal year to include project dues early in budget process.)
- Retain a project manager considered by all task force members to be neutral and objective (if possible).

STEP 10: DEVELOP A TIMELINE AND METHOD FOR EVALUATING THE PROJECT

- The measures for project evaluation are its stated goals and objectives.
- Generally, the project should be comprehensively evaluated every 3 to 5 years. This should also be the duration for memoranda of agreements and other contracts.
- The project should be adjusted annually, as needed, to meet emerging issues or concerns.
- Project evaluation should include benefits to consortium members.
- After evaluation, proposed changes in the project workplan, goals and objectives for the next phase, as well as cost should be clearly explained and defended.
- New contracts agreements should be drafted and forwarded to consortium members to reflect results of project evaluation.
- Experience indicates that this process—from early explorations to initial field sampling—will take at least 1 year, but more often 2 years, to fully implement.

CONCLUSION

Many environmental resource managers are turning to a watershed-based approach to restore and protect our natural resources. Key to this approach is management that integrates a wide range of technical expertise, regulatory and non-regulatory authorities, and strategic implementation. Increasingly limited program resources intensify the need for strategic, coordinated management and for decision-making that remains focused on priority environmental concerns.

In the last decade, groups have successfully used monitoring partnerships to address many different problems and monitoring objectives as well as waterbodies and ecosystems of varying geographic scales. Moreover, they have saved money in the process. Purposes of monitoring programs vary from water supply protection to coordinated, whole-basin wastewater discharge management to ecosystem assessment. Although the case studies highlighted some differences in the approach to setting up and maintaining a consortium, several common themes on program pitfalls and successes, and a ten-step process for building and maintaining a strong monitoring consortium emerged.

TOP TEN LESSONS LEARNED

- Establish watershed-wide consensus on the need for a coordinated monitoring program.
- Take advantage of existing organizations (particularly key leaders), current and historical monitoring programs to establish a strong foundation.
- Design a coordinated monitoring program that meets the collective and individual needs of the participants. For example, to the extent possible, ensure that the monitoring helps the regulated partners help meet or offset permit monitoring requirements.
- Bring potential partners into the design and decision-making process early and spread the leadership mantle.
- Design the monitoring program for continuity (so you can measure long-term trends) and flexibility (so you are adequately addressing emerging issues and priority concerns).
- Using a performance-based approach, design field sampling, lab analysis, or data management with flexibility and compatibility as your guiding principles.
- Adequately plan and budget for data collection, management, and interpretation. Quality assurance and quality control is essential for long-term program credibility.
- Clearly and regularly communicate the program's benefits for each partner and for the region.
- Regularly evaluate the monitoring program to make sure you are meeting the project's goals and objectives cost effectively and that you are adequately addressing emerging issues.
- Value the project's unquantifiable asset: the good working relationship you are building with consortium partners.

Watershed management is a continuing cycle of identifying, prioritizing, and mitigating key watershed issues. Well-defined watershed priorities depend on solid assessment of good information; good information depends on well-designed monitoring. Public and private agencies should design a strategic, coordinated monitoring program as a cycle within the larger cycle of watershed activities.

APPENDIX A

MAJOR ITFM RECOMMENDATIONS

A. MONITORING AND ASSESSMENT PROGRAM DESIGN

- Design water-quality monitoring programs to measure progress in meeting clearly stated goals for aquatic resources.
- Public and private organizations should develop and/or evaluate their monitoring programs using the framework fro monitoring recommended in this report.
- Gather and evaluate existing information using geographic information systems to portray water resources conditions and the River Reach File 3 codes to georeference water bodies.
- Adopt flexible monitoring program designs tailored to the conditions, uses, and goals for water resources in specific areas.

B. ENVIRONMENTAL INDICATORS

- Jointly choose specific environmental indicators to measure progress toward water quality goals, including State standards for designated uses.
- Use the multimetric approach to characterize biological integrity.
- Agree on a core set of widely physical, chemical, and biological indicators that support interstate and national aggregations of comparable information for assessments.

C. COMPARABLE METHODS AND DATA

- Jointly develop and adopt standard data-element names, definitions, and formats.
- Implement a performance-based monitoring methods system (PMBS) to achieve both comparable data and more flexible use of monitoring methods.
- Jointly establish reference conditions as a key tool for shared use in biological and ecological assessments.

D. DATA STORAGE AND RETRIEVAL

- Automate useful information .
- Use metadata standards to help secondary users judge whether data are useful for their applications.
- Use standard data sets, communications, and access systems when they are available.

E. INTERPRETATION, ASSESSMENT, AND REPORTING

- Regularly interpret, assess, and report measurements and raw data for use by the public and decision-makers. Do not simply collect data.
- Develop more effective reporting formats that are tailored for specific audiences.
- Seek a change in the Clean Water Act to alter the reporting period identified in section 305(b) from every 2 years to every 5 years.

F. TRAINING

- Promote training at all levels of government to transfer technology and to facilitate comparable and scientifically sound methods and data.

G. VOLUNTEER MONITORING

- Establish formal links between volunteer monitoring programs and agencies at all levels of government.
- Develop guidance to assist volunteer groups in documenting their methods and conducting their programs.

H. EVALUATION

- Organizations should regularly evaluate the monitoring programs and resulting information to ensure that they are meeting management goals and to adjust the programs as requirements change.
- Nationwide evaluations of water-quality monitoring activities similar to the ITFM effort should be conducted every 5 years.

I. INSTITUTIONAL COLLABORATION

- Work with representatives from all levels of government and the private sector to improve water-quality monitoring at national, interstate, State and Tribal, and watershed levels.
- Establish a National Water Quality Monitoring Council with broad representation to develop guidelines for use nationwide, to foster technology transfer, and to coordinate planning and resource sharing.
- Building on existing collaborative mechanisms, establish and maintain teams comprised of monitoring organizations to implement the strategy within State and Tribal jurisdictions and at the interstate level, as necessary.
- Link national ambient water-quality assessment programs.

J. PILOT STUDIES AND PLANNING

- Conduct additional pilot studies before widespread implementation of the ITFM proposals.

- Carefully plan and coordinate efforts to implement the ITFM recommendations. In particular, special care must be taken to ensure that attempts to implement aspects of the strategy using available monitoring resources do not adversely impact existing monitoring that now supports critical objectives.