EPA United States Environmental Protection Agency

Delivering Timely Water Quality Information to Your Community

The River Index Project: Lower Great Miami River Watershed

E M P A C T

Environmental Monitoring for Public Access & Community Tracking

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Delivering Timely Water Quality Information to Your Community

The River Index Project:
Lower Great Miami River Watershed

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Contributors

Dr. Dan Petersen (U.S. Environmental Protection Agency, National Risk Management Research Laboratory) served as principal author of this handbook and managed its development with the support of ERG, Inc., an EPA contractor. Contributing authors include the following:

Dr. Allen Burton, Wright State University Institute for Environmental Quality

Scott A. Hammond, Miami Valley Regional Planning Commission

Michele Jones, City of Dayton

Bill Littleton, YSI, Inc.

Mike Lucas, Miami Valley Regional Planning Commission

Beth Moore, City of Miamisburg

Ned Pennock, CH2M HILL, Inc.

Donna Winchester, City of Dayton

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1. Introduction

People who spend time in, on, or close to rivers can benefit from timely information about water quality. This information can help people make day-to-day decisions about when and how to use the river. For example, swimmers can find out about fecal coliform levels to protect their health when bacteria levels in a river are too high, and anglers can use the information to help decide when and where to go fishing. If the information is not communicated in a timely manner, the value of the information can be reduced and, in some cases, lost.

In 2000, a team of academic and government organizations launched a project to gather and communicate timely environmental information to the public in the southwest Ohio and southeast Indiana region of the Great Miami River watershed. This project, known as the River Index Project, was funded with a grant from the U.S. Environmental Protection Agency's (EPA's) EMPACT Program. The goal of disseminating timely information to the was achieved by:

- Designing and operating a system of water quality monitoring stations to gather real-time water quality data.
- Designing and operating a system to retrieve, manage, and analyze real-time water quality data.
- Using the real-time water quality data to develop a water quality index and a river index for each water quality monitoring station.
- Developing a plan to communicate timely water quality information to the public.

This technology transfer handbook presents a case study of the River Index Project. It describes how the River Index Project started, how real-time water quality data are collected in the Lower Great Miami River Watershed, and how those data are processed and then communicated to the public. The handbook also presents lessons learned during the project and provides readers with information on how to develop similar water quality monitoring, data processing, and outreach programs for their community. The handbook is written primarily for community organizers, non-profit groups, local government officials, tribal officials, and other decision-makers who implement or are considering implementing environmental monitoring and outreach programs.

1.1 About the EMPACT Program

This handbook was developed by EPA through its EMPACT Program. EPA created EMPACT (Environmental Monitoring for Public Access and Community Tracking) to promote new and innovative approaches to collecting and managing environmental information and for communicating the information to the public.

1 For this handbook, real-time data are data collected and communicated to the public in a time frame that allows the public to use the data to make day-to-day decisions.

1.2 About the River Index Project

The Great Miami River watershed includes approximately 10,680 square kilometers of land in southwest Ohio and southeast Indiana (see Figure 1). The Great Miami River flows from northeast to southwest through southwest Ohio and eventually drains into the Ohio River near Cincinnati, Ohio. Major tributaries on the Great Miami River include the Stillwater River and the Mad River, both of which join the Great Miami River in Dayton, Ohio.

Figure 1. The Great Miami River Watershed

The Lower Great Miami River Watershed is the local name for the drainage area covering most of Montgomery County, the southeast portion of Miami County, and the northwest portion of Greene County in Ohio (see Figure 2). It covers 1,204 square kilometers (465 square miles) and includes 18 townships and 24 villages and cities. In addition to the Stillwater and Mad Rivers, tributaries to the Great Miami River in the Lower Great Miami River Watershed include Bear Creek, Wolf Creek, Twin Creek, and Holes Creek.

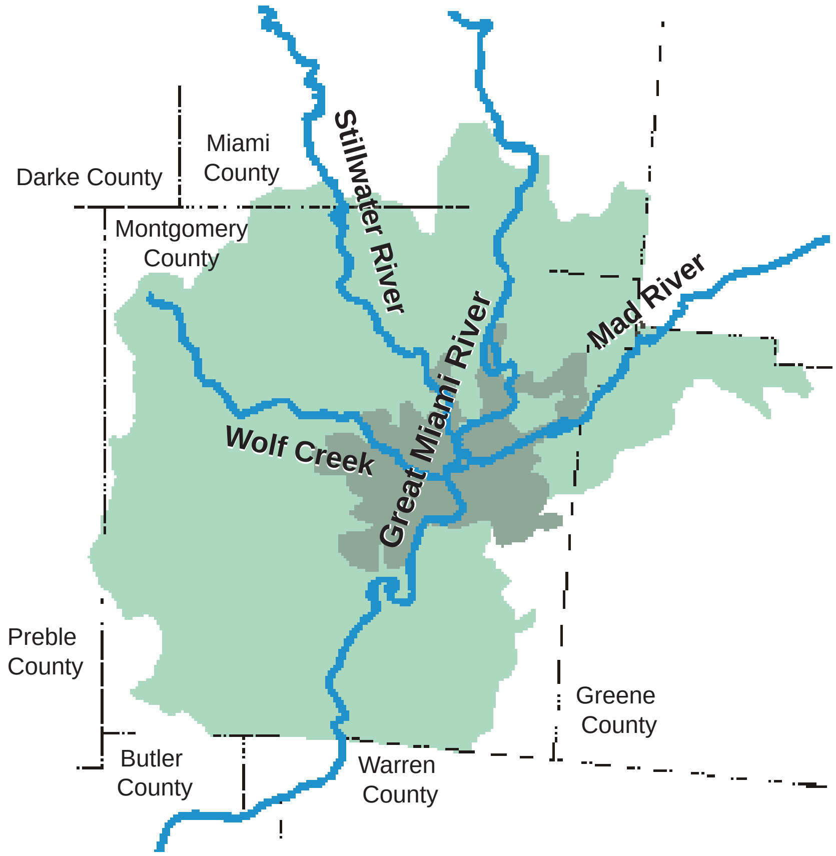


Figure 2. The Lower Great Miami River Watershed

Much of the greater Dayton area, which comprises the largest urbanized area in the Miami Valley Region, is in the Lower Great Miami River Watershed. With a 1990 census population of 613,000, the Dayton urbanized area makes a significant contribution to the complex mixture of urban, suburban, and rural land uses in the Lower Great Miami River Watershed. This land use mixture and the associated pollution sources (e.g., urban and suburban stormwater runoff, nutrients and pesticides from lawns and crop land, and eroded soil from agricultural and construction sites) have resulted in increased reliance and stress on the precious, dynamic water resources in the watershed.

In 1986, the Miami Valley Regional Planning Commission (MVRPC), the agency responsible for areawide water quality planning in the Lower Great Miami River Basin, initiated the Lower Great Miami Watershed Enhancement Program (WEP). The goal of the WEP was to coordinate the efforts of the area's many public agencies and private organizations in the development and implementation of cost-effective and non-duplicative watershed protection activities. One aspect of the WEP was the initiation of educational programs to make the public more aware of the quality of the region's surface water resources. The idea of developing a "river index" that would translate complex water quality data into user friendly information was an "action item" identified early by the WEP stakeholders. When the EMPACT Program grants were initiated, a group of WEP partners joined together to write the grant proposal and subsequently carry out the River Index Project.

The River Index Project helps water quality management organizations and other interested parties learn more about the characteristics of the rivers in the Lower Great Miami River Watershed through remote real-time monitoring of river water quality. Data gathered are used to calculate an index that portrays the quality of the river at each of the monitoring stations in the River Index Project. Indexes often are used to combine several measures of a complicated process into a single number. A good example is the Dow Jones Industrial Index: a single number designed to reflect the trend of the entire U.S. stock market.

The MVRPC is the lead agency for the River Index Project. Original partners with the MVRPC on this project are listed below:

- Miami Conservancy District (MCD)
- City of Dayton, Ohio
- Wright State University
- CH2M HILL, Inc.
- YSI, Inc.
- Unites States Geological Survey (USGS)

In addition, the City of Miamisburg assisted with the operation of a monitoring station during 2001 and 2002.

MCD left the project in the fall of 2000.

The River Index Project leverages several existing programs. For example, MCD's experience and expertise were used during the collection of river stage and water quality data. MCD, a regional agency formed in 1915, worked with the USGS and YSI, Inc. to retrofit existing gauge houses for use as water quality monitoring stations. Wright State University's Institute for Environmental Quality (IEQ), in conjunction with MCD, USGS, and YSI, Inc., oversaw the field activities for the project.

In addition, the City of Dayton used its experience and expertise in developing the communication materials for the project, and Wright State University's Center for Urban and Public Affairs (CUPA) designed and implemented pre- and post- random telephone surveys to assess the effectiveness of the communications component of the project. Finally, approximately 32 percent of the costs of the River Index Project was obtained through in-kind services.

1.3 Other Local Monitoring Efforts

The Miami Valley has always been on the cutting edge of managing valuable water resources. Management projects include the early formation of the Miami Conservancy District for flood control, the development of the City of Dayton's world-renowned Wellfield Protection Program, and the federal designation of the Great Miami/Little Miami Sole Source Aquifer. Today, the region is host to a number of programs aimed at evaluating, protecting, and managing the water resources of the basin. Some examples are:

The Lower Great Miami Watershed Enhancement Program (WEP)

As previously mentioned, this program, coordinated by the MVRPC, seeks to bring together stakeholders in the Lower Great Miami River Watershed to identify and prioritize needs and to take actions to protect and improve water quality. For more information on the WEP, go to <www.mvrpc.org/wq/wep.htm>.

Wolf Creek Watershed Project

This is a WEP program that focuses on raising local awareness about water quality threats and protection strategies in the mixed urban and rural Wolf Creek watershed.

The Honey Creek/Great Miami River Watershed Protection Program

The objective of this program is to protect the water resources of the Honey Creek watershed and the Great Miami River watershed in Montgomery, Miami, Champaign, and Clark Counties north of Dayton.

The Stillwater River Watershed Protection Project

This is a program that facilitates the identification of water quality problems and the implementation of protective measures for the state-designated scenic Stillwater River in Darke and Miami Counties. It focuses primarily on rural areas.

The National Water Quality Assessment Program

This is a USGS program that assesses the status of and trends in the quality of the Nation's water resources. A long-term study is underway that focuses on the Great and Lower Great Miami River Watersheds. For more information on this study, go to <www-oh.er.usgs.gov/miam.html>.

Numerous Locally-Based Well Field Protection Programs

More than 95 percent of the Miami Valley's population depend on groundwater for their drinking water supply. Many County, City, and Village water suppliers have implemented strategies to protect their wellfields from possible contamination.

1.4 About this Handbook

Several communities throughout the United States have expressed interest in projects similar to the River Index Project. The purpose of this handbook is to help interested communities and organizations learn more about the River Index Project and to provide them with the technical information they can use to develop their own programs. The Technology Transfer and Support Division of the EPA Office of Research and Development's (ORD) National Risk Management Research Laboratory initiated the development of this handbook in collaboration with EPA's Office of Environmental Information. ORD, working with the River Index Project partners, produced the handbook to leverage EMPACT's investment in the project and minimize the resources needed to implement similar projects in other areas.

Both the print and CD-ROM versions of the handbook are available for direct online ordering from ORD's Technology Transfer Web site at <www.epa.gov/ttbnrmrl>. A PDF version of the handbook also can be downloaded from that site. In addition, you can order the handbook (print or CD-ROM version) by contacting ORD Publications by telephone or mail at:

EPA ORD Publications
26 W. Martin Luther King Dr.
Cincinnati, Ohio 45268-001
EPA NSCEP Toll Free: 1-800-490-9198
EPA NSCEP Local: 513-489-8190

Please make sure that you include the title of the handbook and the EPA document number in your request. We hope you find the handbook worthwhile, informative, and easy to use.

1.5 For More Information

Try the following resources for more information on the issues and programs this handbook addresses:

- **The EMPACT Program**

  www.epa.gov/empact

- **The River Index Project**

  www.riverindex.org

- **Water Quality Monitoring**

  www.epa.gov/owow/monitoring

2. How To Use This Handbook

This handbook provides you with step-by-step information in an easy-to-understand format on developing a program that provides timely water quality information to your community. Using the River Index Project for the Lower Great Miami River Watershed in southwest Ohio as a model, the handbook contains information on how to:

Design, site, operate, and maintain a system to gather real-time water quality data. → Design, operate, and maintain a system to retrieve, manage, and analyze your real-time water quality data. → Develop a water quality index and a river index using those data. → Develop a plan to communicate information about water quality to residents in your community.

- ***Chapter 3*** provides detailed information on water quality monitoring. The chapter begins with an overview of water quality monitoring in freshwater systems and then focuses on the manual and automated water quality monitoring done in the River Index Project. It provides step-by-step instructions on how to install, calibrate, and maintain the automated equipment used in the River Index Project to gather real-time water quality data.

- ***Chapter 4*** provides information on how to operate and maintain an automated system to transmit, store, retrieve, and analyze water quality data collected using automated equipment. The chapter focuses on the software used by the River Index Project Team.

- ***Chapter 5*** provides information on how to present the water quality data in an understandable format. It focuses on the water quality and river indexes developed in the River Index Project, including the weighting factors and measures used to rate the water quality parameters. You might want to use these measures and weighting factors in developing indexes to communicate your real-time water quality data to the public.

- ***Chapter 6*** outlines the steps involved in developing an outreach plan to communicate information about the quality of your community's rivers. It also provides information about the outreach efforts for the River Index Project. The chapter includes a list of resources to help you develop easily understandable materials to communicate information about your real-time water quality monitoring program to a variety of audiences.

- ***Chapter 7*** addresses how water quality monitoring can be sustained over time. It discusses building on existing programs, housing of a database and Web server, obtaining public support for water quality monitoring, and determining the information that can be collected with respect to fund availability.

This handbook is designed for decision-makers considering whether to implement a real-time water quality monitoring program in their community and for technicians responsible for implementing these programs. Managers and decision-makers likely will find the initial sections of Chapters 3, 4, 5, and 6 most helpful. The latter sections of these chapters are targeted primarily at professionals and technicians and provide detailed “how to” information. Chapter 7 is designed for managers.

The handbook also refers you to supplementary sources of information, such as Web sites and guidance documents, where you can find additional guidance with a greater level of technical detail. Interspersed throughout the handbook are discussions of some of the lessons learned by the River Index Project Team in developing and implementing its real-time water quality monitoring, data management, and outreach programs.

3. Water Quality Monitoring

This chapter provides information about water quality monitoring—the first step in the process of generating timely information about water quality and making it available to the public. Each section's contents are as follows:

- Section 3.1 provides a broad overview of water quality monitoring. The chapter then focuses on the remote real-time water quality monitoring conducted as part of the River Index Project.
- Section 3.2 discusses factors to consider when designing a remote real-time water quality monitoring project.
- Sections 3.3 and 3.4 explain how to select remote real-time monitoring frequencies and parameters, respectively.
- Sections 3.5 and 3.6 discuss selecting monitoring equipment and the location of your remote real-time water quality monitoring stations, respectively.
- Sections 3.7, 3.8, and 3.9 explain how to install, calibrate, and maintain the remote real-time water quality monitoring equipment used in the River Index Project.

Readers primarily interested in an overview of water quality monitoring might want to focus on the introductory information in Sections 3.1 and 3.2. If you are responsible for the actual design and implementation of a monitoring project, you also should review Sections 3.3 through 3.9. They provide an introduction to the specific steps involved in developing and operating a remote real-time water quality monitoring project and information on where to find additional guidance.

3.1 Water Quality Monitoring: An Overview

Water quality monitoring provides information about the condition of streams, lakes, ponds, estuaries, and coastal waters. The information reveals whether these waters are safe for swimming, fishing, or as a source for drinking water. The Web site of EPA's Office of Water (www.epa.gov/owow/monitoring) provides essential background information on water quality monitoring. Another good source of information on water quality monitoring is the Web site for the River Index Project (www.riverindex.org). Information presented in the following paragraphs is summarized from these Web sites.

The following parameters often are measured to evaluate the quality of surface waters:

1. **Chemicals.** These include both inorganic and organic chemicals. Inorganic chemicals include metals such as iron, calcium, and magnesium, and nutrients such as nitrogen and phosphorus. Organic chemicals include a wide range of carbon-containing compounds. Some organic chemicals originate from natural sources, while others, such as pesticides and solvents, are synthetic.

2. **Physical parameters.** These include general conditions such as water temperature, clarity, and flow rate. Water temperature has a direct effect on biological activity and growth of aquatic organisms, while clarity is related to the concentration of total suspended solids in the water. Flow rate is a measure of the volume of water that flows past a location over a period of time.

3. **Biological populations.** Typically, insects living on the bottom of a water body (benthic macro invertebrates) and fish are the two biological populations monitored to evaluate water quality. To address human health, the density of either fecal coliform or *E. coli* bacteria is measured. These bacteria are indicators of the presence of human and animal wastes in surface waters that might cause human disease.

4. **Habitats.** Aquatic organisms need good habitats in which to hide, feed, and reproduce. A good habitat consists of many features including:

    - Coarse stream bottoms that contain sand, gravel, and cobbles with smaller amounts of clay and silt.
    - Combinations of deep pool and shallow riffle areas that allow for either slow or fast water conditions.
    - Tree limbs, boulders and debris piles that provide places for creatures to hide, spawn, and forage for food.
    - Stream banks covered with vegetation to prevent erosion and provide food.
    - Overhanging trees and fringing plants to provide shade and a source of leaves and other organic matter that serve as a food source for aquatic species.

You can conduct several kinds of water quality monitoring projects, such as those:

- On a continuous basis at fixed locations.
- On an as-needed basis or to answer specific questions at selected locations.
- On a temporary or seasonal basis (such as during the summer at swimming beaches).
- On an emergency basis (such as after a spill).

Many agencies and organizations conduct water quality monitoring, including state pollution control agencies, Indian tribes, city and county environmental offices, EPA and other federal agencies, and private entities, such as universities, watershed organizations, environmental groups, and industries. Volunteer monitors—private citizens who voluntarily collect and analyze water quality samples, conduct visual assessments of physical conditions, and measure the biological health of waters—also provide important water quality information. EPA provides specific information about volunteer monitoring at <www.epa.gov/owow/monitoring/vol.html>.

Water quality monitoring primarily is conducted to:

- Characterize waters and identify trends or changes in water quality over time.
- Identify existing or emerging water quality problems.

- Gather information for the design of pollution prevention or restoration projects.
- Determine if the goals of specific programs (such as the implementation of pollution prevention strategies) are being met.
- Respond to emergencies such as spills or floods.

EPA helps administer grants for water quality monitoring projects and provides technical guidance on how to monitor and report monitoring results. You can find a number of EPA's water quality monitoring technical guidance documents on the Internet at <www.epa.gov/owow/monitoring/techmon.html>. EPA's "Surf Your Watershed" Web site (www.epa.gov/surf3) also contains information on water quality monitoring.

In some cases, special types of water quality data (e.g., real-time data) or special water quality monitoring methods (e.g., remote monitoring) are needed to meet a water quality monitoring program's objectives. *Real-time* environmental data are data collected and communicated to the public in a time frame that makes them useful for making day-to-day decisions about public health and the environment. They may be displayed immediately after the data are collected or after a time delay depending on the equipment used to process the data. Monitoring is considered "remote" when the operator collects and analyzes data from a location different from the monitoring site itself.

Remote Real-Time Water Quality Monitoring: The River Index Project

The River Index Project Team uses state-of-the-art automated monitoring equipment to collect daily data for flow and key water quality parameters, while data for other water quality parameters such as *E. coli* bacteria are collected manually. Remote monitoring is conducted at six locations—the Englewood Dam station on the Stillwater River, the Huffman Dam station on the Mad River, the Wolf Creek station in west Dayton, the Taylorsville Dam Station on the Great Miami River, and the Miamisburg Station on the Great Miami River (see Figure 3).

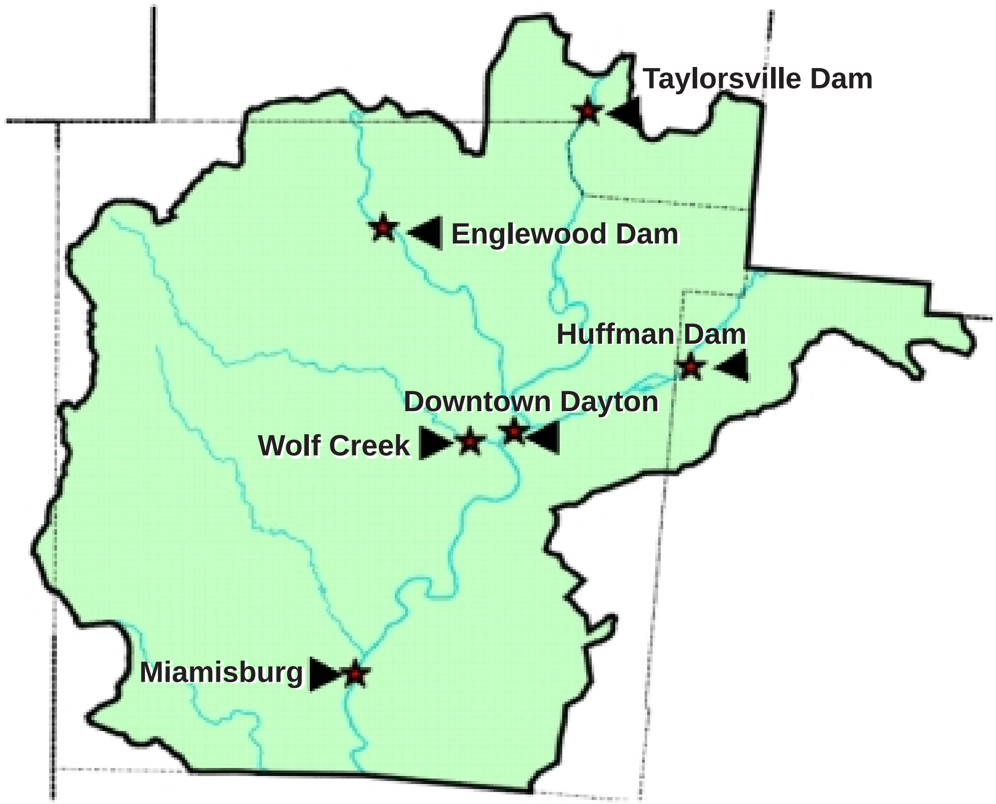


Figure 3. Location of Water Quality Monitoring Stations for the River Index Project

Existing MCD and USGS gauge houses are used to house the monitoring instrumentation at the Englewood Dam, Miamisburg, Huffman Dam, and Taylorsville Dam sites. A phone line and an electric line were installed at the Englewood Dam, Miamisburg, and Huffman Dam sites. A cell phone powered by a solar panel is used at the Taylorsville Dam site. In addition, river intake pipes were installed at each site, and tanks, pumps, and monitoring sondes were installed in each of the existing gauge houses at the Englewood Dam, Miamisburg, and Huffman Dam monitoring stations. Because there is no electrical service at the Taylorsville Dam station, the monitoring sonde was placed directly into the river intake pipe, and batteries are used to power the sonde.

At the Downtown Dayton site, a monitoring station was established in a City of Dayton storm sewer pump station. For the Wolf Creek monitoring station, MCD relocated an out-of-use concrete gauge house from a site south of Dayton and modified it so that it could be used in the River Index Project (see Figure 4).

Figure 4. Water Quality Monitoring Station at Wolf Creek

The diagram in Figure 5 illustrates the water quality monitoring set-up at the Englewood Dam, Miamisburg, Huffman Dam, Downtown Dayton, and Wolf Creek monitoring stations. As shown in the diagram, water flows continuously from the river to a flow-through (see Figure 6) tank in the monitoring station. Water is pumped through a 3-foot long pump screen using a 3/4-hp Prosser Model 9-01011-28FK submersible pump. This pump has two advantages: it can be used when the suspended solids concentration in the water is high, and it is reliable when installed in the horizontal position.

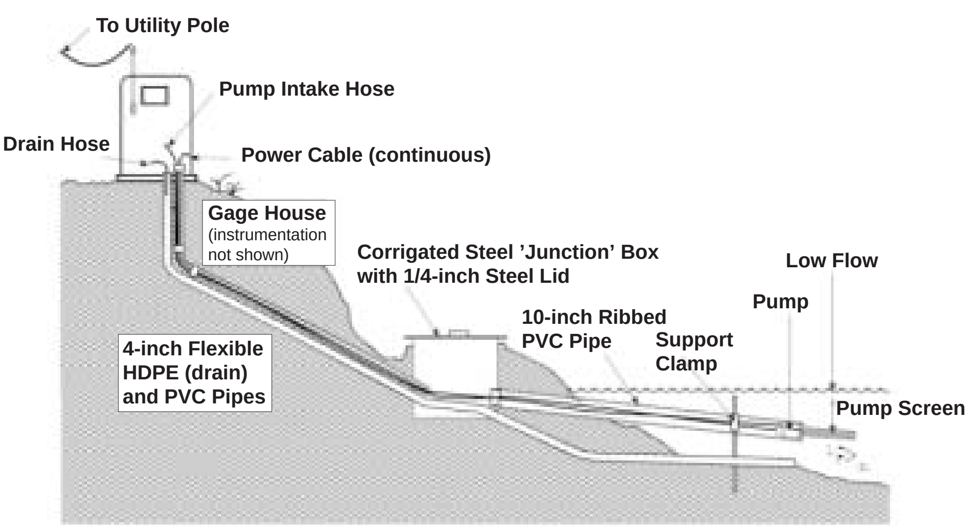


Figure 5. Diagram Illustrating the Water Quality Monitoring Set-up

To ensure that the water quality monitoring probes are completely submerged, water fills the flow-through tank to a depth of 10 inches. The water drains by gravity through an overflow pipe and is discharged back to the river several feet downstream of the pump intake. If operated during winter, heaters can be placed in the monitoring stations to keep the equipment warm.

The set-up illustrated in Figure 5 offers the following advantages:

- It reduces the probability of vandalism because monitoring equipment is kept in a secure building.
- It reduces the probability of losing equipment during high flow events.
- It facilitates field calibration of equipment during bad weather conditions.

Figure 6. Flow-through Tank at the Wolf Creek Monitoring Station

Data for several parameters were collected at each monitoring station and used to calculate river indexes during the first monitoring season in 2000. The parameters included:

- Ammonia-Nitrogen
- Atrazine
- Chlorpyrifos
- Dissolved Oxygen
- *E. coli* Bacteria
- Fish Toxicity
- Flow (River Discharge)
- Nitrate - Nitrogen
- Polycyclic hydrocarbons
- pH
- Specific Conductance
- Turbidity
- Water Temperature
- Fish and Benthic Communities
- Habitat

Real-time data for ammonia-nitrogen, dissolved oxygen, flow rate, nitrate-nitrogen, pH, specific conductance, turbidity, and water temperature were collected hourly, and retrieved automatically three times per day. The data were then uploaded automatically to a central database. In addition, concentration data for pesticides (i.e., atrazine and chlorpyrifos), *E. coli* bacteria, and polycylic aromatic hydrocarbons (PAH) were collected weekly, and fish toxicity data were collected monthly; those data also were entered into the central database. Data for all of these parameters were used to calculate the river indexes for each monitoring station. Fish and benthic communities and habitat data also were collected seasonally, but were not used to calculate the indexes.

During and following the first monitoring season, the monitoring parameters were evaluated with respect to importance in characterizing overall water quality and cost-effectiveness. Based on the results of those evaluations, the number of monitoring parameters was reduced during the second and third monitoring seasons.

Parameters that were deleted include: ammonia-nitrogen, atrazine, chlorpyrifos, fish toxicity, nitrate-nitrogen, PAH, fish and benthic communities, and habitat. Data for these parameters were not cost-effective with respect to providing sustainable and timely information to characterize water quality and river conditions. Parameters for which data currently are collected in the River Index Project include:

- Dissolved Oxygen
- *E. coli* Bacteria
- Flow (River Discharge)
- pH
- Specific Conductance
- Turbidity
- Water Temperature

3.2 Designing a Real-Time Water Quality Monitoring Project

The first step in developing any water quality monitoring project is to define your objectives. Keep in mind that remote monitoring might not be the best method for your organization or community. For example, you would not likely require a remote real-time monitoring capability when conducting monthly monitoring to comply with a state or federal regulation.

Here are some questions to help determine if remote monitoring is appropriate for your monitoring objectives:

- What types of questions about water quality do you want to answer? Do you need real-time data to answer these questions? For example, do you want to know more about how rapid events, such as urban or agricultural runoff from storms, might affect water quality in your area by stimulating algal blooms?

- If you already have other water quality monitoring projects in place, how does the addition of real-time data enhance them? For example, does the frequent review of real-time data allow you to tailor your other monitoring projects to yield more representative water quality data or conserve your organization's labor and analytical resources?
- How does your community or organization benefit from a real-time monitoring project? For example, do real-time data provide you with a better opportunity to communicate water quality issues to your community?

Making the Most of Your Real-Time Water Quality Data

Currently, your organization will find a limited number of cost-effective real-time monitoring technologies available. Also keep in mind that real-time data might not be as accurate, precise, or consistent as "conventional" laboratory data. You should carefully consider how your project uses real-time data and make the most of data for the real-time monitoring parameters you select.

In designing your program, think about how you could use real-time measurements of certain parameters as indicators of the phenomena you wish to document. For example, depending on your water body's characteristics and the location of your monitoring equipment, you could use turbidity and dissolved oxygen measurements as indicators of an algae bloom. Then you could learn more about the bloom by conducting manual monitoring of parameters that might not currently be available to you on a cost-effective, real-time basis (e.g., atrazine and chlorpyrifos). Another example might involve using real-time measurements of turbidity and conductivity to estimate the impact of a storm event on the concentration of particulate matter (as indicated by turbidity) and dissolved solids (as indicated by conductivity) in a stream or river.

Designing the River Index Project

The River Index Project Team's decision to collect near real-time water quality data grew out of an interest to make the public better informed about water quality in the Lower Great Miami River Watershed. The objectives of the River Index Project are presented in the box on page 17.

After you define the objectives of a water quality monitoring project, the frequency of monitoring, parameters for which data are collected, and the equipment used to monitor water quality have to be selected. The sites where monitoring occurs also have to be selected.

The River Index Project Objectives

The economic vitality and public health of the Miami Valley are tied closely to the quality of the region's water resources. The success of efforts to stimulate economic growth and activity along the rivers also relies on the condition of the rivers and the public's perception of the river condition.

Although the quality of the rivers in the Lower Great Miami River Watershed has improved greatly over the last 25 years, public perception is that the rivers are not clean and are not safe places on which to recreate. For the public to be better informed, they need to have access to understandable timely information regarding river water quality. For this reason, the objectives of the River Index Project are to:

1. Provide the public access to clear and understandable information regarding the quality of the area's rivers.
2. Enhance initiatives by other groups and agencies that seek to heighten access to and awareness of the region's waterways.
3. Support efforts to stimulate economic growth and activity along the rivers.
4. Increase the use of the river corridors (e.g., for canoeing and fishing) and areas adjacent to the river corridors (e.g., parks and bikeways).
5. Foster a sense of public ownership of the rivers.
6. Generate long-term data that can be used to evaluate changes in water quality because of water quality improvement initiatives.
7. Sustain the River Index Project beyond the life of the EMPACT grant by incorporating it into existing programs and activities.

As you will read in this chapter, information obtained through remote real-time monitoring helps the River Index Project Team achieve these objectives.

3.3 Selecting Your Monitoring Frequency

The frequency of monitoring you select for your remote real-time water quality monitoring project depends on your project's objectives. For example, if you want to determine the effects of storm-related nonpoint sources on water quality in your area, you could tailor your monitoring frequency to collect data during storm events. If you want to study a water body affected by tidal flow, you could tailor your monitoring frequency to collect data during tidal events. It is appropriate to experiment with different monitoring frequencies to optimize your ability to fulfill your project's objectives.

River Index Project Monitoring Frequency

Data for several of the water quality parameters monitored in the River Index Project are collected hourly and are retrieved three times per day. This monitoring frequency allows the river index for each monitoring station to be updated every eight hours. To insure the quality of the data collected, the data's accuracy and precision have to be certified. See the discussion on Data Quality Assurance and Quality Control (QA/QC) in the box below.

Data Quality Assurance and Quality Control (QA/QC)

QA/QC procedures ensure that collected data are accurate, precise, and consistent. QA/QC involves following established rules in the field and in the laboratory to ensure that samples are representative of the water you are monitoring, free from contamination as a result of the sampling activity, and analyzed using standard procedures.

Two types of water quality data were collected in the River Index Project:

1. Real-time data collected using YSI, Inc. water quality sensors.
2. Data obtained from the collection and analyses of weekly and monthly water samples by trained staff. In addition, fish and benthic community samples and habitat samples were collected and analyzed seasonally.

To ensure the QA/QC of data collected using YSI sensors, the River Index Project Team follows the manufacturer's instructions for sensor calibration and maintenance (See Sections 3.8 and 3.9 for more information on the calibration and maintenance procedures). To ensure QA/QC of the other data collected, the River Index Project Team follows guidelines set forth by EPA and the American Public Health Association.

The team also has several years of experience identifying systematic errors associated with sensor deterioration, or biofouling, that occurs when algae, bacteria, and fungi grow on the sensor when it is submerged continually in water.

EPA's publication *The Volunteer Monitor's Guide to Quality Assurance Project Plans* provides more information on QA/QC plans for monitoring projects. For information on this guide, visit <www.epa.gov/volunteer/qappexec.htm>.

3.4 Selecting Water Quality Parameters for Monitoring

Your selection of real-time water quality monitoring parameters depends on your project's objectives and on the remote real-time technologies available to you. To satisfy the objectives of the River Index Project, the project team chose to monitor parameters important to aquatic life. In selecting those parameters, the project team considered information such as EPA's water quality criteria, Ohio Environmental Protection Agency water quality and biocriteria standards, existing water quality in the Lower Great Miami River Watershed, the cost-effectiveness of data for each parameter, and the expense and availability of the monitoring equipment.

Six parameters were chosen to be monitored on a real-time basis: dissolved oxygen, flow rate, pH, conductivity, turbidity, and water temperature (ammonia-nitrogen and nitrate-nitrogen also were monitored at the Taylorsville and Miamisburg stations during the first year of the project). A brief description of these parameters is presented in the box below.

River Index Project Real-Time Water Quality Parameters

Dissolved Oxygen. The concentration of dissolved oxygen (DO) in water affects the number and type of aquatic organisms that live in the water. Dissolved oxygen must be present at a concentration high enough to sustain these organisms. It is important to measure DO frequently. For example, some streams impacted by wastewater discharges have a fluctuating DO. An average DO of eight is not acceptable if there are episodes where the DO is zero, even for short periods.

Flow Rate. The volume of water that flows past a monitoring station over a period of time (e.g., cubic feet per second). River stage data were collected during the River Index Project and then converted to flow rate data.

pH. pH is a measure of the acidity of the water. A pH of seven is neutral. Values lower than seven are acidic and higher than seven are basic. Many important chemical and biological reactions are strongly affected by pH. In turn, chemical reactions and biological processes (e.g., photosynthesis and respiration) affect pH. Low pH values increase the concentration of some dissolved metals in the water, increasing the toxicity of these metals.

Conductivity. Conductivity is an estimator of the amount of total dissolved salts or total dissolved ions in water. Many factors influence the conductivity of water, including the watershed's geology, wastewater from point sources, runoff from nonpoint sources, atmospheric inputs, evaporation rates, and some types of bacterial metabolism. Conductivity also is a function of temperature; therefore, the data have to be standardized to 25° C. Conductivity corrected to 25° C is specific conductance.

Turbidity. Turbidity describes the clarity of water. Turbidity increases as the concentration of total suspended solids in the water increases.

Water Temperature. Water temperature has a direct effect on biological activity and the growth of aquatic organisms because most aquatic organisms are “cold-blooded” (i.e., they cannot regulate their core body temperature). Temperature also affects biological activity by influencing water chemistry. For example, because warm water holds less oxygen than does cold water, warm water might not contain enough oxygen to support some types of aquatic life.

In addition to the real-time parameters, measurements were taken for atrazine, chlorpyrifos, *E. coli* bacteria, and PAH on a weekly basis during the first monitoring season. Also, fish toxicity was measured monthly, and habitat and benthic community analyses were conducted seasonally during the first monitoring season. Results of the habitat and fish and benthic community analyses were not included in the calculation of the river indexes.

3.5 Selecting Monitoring Equipment

Your selection of remote real-time water quality monitoring equipment also depends on your project's objectives. When selecting monitoring equipment, you should consider equipment lifetime, reliability, and maintenance requirements.

River Index Project Monitoring Equipment

The automatic water quality monitoring equipment selected by the River Index Project Team includes a data acquisition system, water quality sondes, and water quality probes manufactured by YSI, Inc. The table below contains the model numbers for the equipment.

Description	Model Number
Data Acquisition System (DAS) and Data Collection Platform (DCP)	YSI 6200 DAS with Ecowatch™ DCP
Water Quality Sonde	YSI 6820 YSI 6920 (Taylorsville station only)
Temperature Probe	YSI 6560 (all stations)
pH Probe	YSI 6561 (all stations)
Conductivity Probe	YSI 6560 (all stations)
Dissolved Oxygen Probe	YSI 6562 (all stations)
Turbidity Probe	YSI 6026 (all stations)
Ammonium-Nitrogen Probe	YSI 6883 (Taylorsville and Miamisburg stations only)
Nitrate-Nitrogen Probe	YSI 6884 (Taylorsville and Miamisburg stations only)

A water quality sonde is a device that houses program software and the electronics used to calibrate sensors and communicate data collected by the sensors. A probe is a device that contains one or more water quality sensors (the device that actually collects the data). For example, YSI Model 6560 is a probe that contains both a water temperature sensor and a conductivity sensor.

The ammonium-nitrogen and nitrate-nitrogen probes require additional calibration steps that are cumbersome to do in the field. For this reason, extra sondes were purchased at the beginning of the River Index Project. This allowed sondes to be calibrated in the laboratory and then switched with the sondes in the field.

3.6 Siting Monitors

You should select monitoring locations that best fulfill the objectives of your remote real-time water quality monitoring project. You should consider several factors when making your final siting decisions. See the checklist of questions below when choosing your location.

Monitoring Site-Selection Checklist

- ❑ Are the real-time data you collect at these locations likely to fulfill your project's objectives? Specifically, what questions can you answer with your data, and how do the answers help you to meet those objectives?
- ❑ Do people in your community support equipment installation and remote real-time monitoring at your locations?
- ❑ Does the monitoring equipment pose a potential danger to the people in your community? For example, are your monitoring locations near a heavy traffic area?
- ❑ Is monitoring equipment safe at your locations? For example, is the equipment susceptible to vandalism or tampering?
- ❑ What local, state, or federal regulations do you need to consider when choosing your locations?
- ❑ Is flexibility important to your project? Do you want the option to move your monitoring equipment to different locations, or do you want to monitor at several locations concurrently?
- ❑ Do you foresee any site-specific problems with installing, operating, and maintaining your monitoring equipment at these locations? Do these locations pose any safety hazards to your personnel?
- ❑ Can you adequately survey and access your locations? What equipment-specific considerations do you need to make?

The River Index Project Monitoring Locations

Six monitoring stations are used in the River Index Project to collect water quality data in the Lower Great Miami River Watershed (see Figure 3). The selected locations are near recreational areas, key habitat areas, and population centers. Several of these locations allow the water quality monitoring station to be located in an existing MCD river gauge station.

One station is located at each of the three flood control dams in the Dayton area. The dams, which are the location of popular nature reserves, are on the Stillwater River (Englewood Dam), the Great Miami River (Taylorsville Dam), and the Mad River (Huffman Dam). Another monitoring station is located in the downtown Dayton area, immediately downstream of the confluence of the Stillwater, Great Miami, and Mad Rivers in the middle section of a popular downtown bikeway. A fifth monitoring station is located on Wolf Creek, which runs through a highly populated portion of West Dayton. Another monitoring station is located on the Great Miami River in Miamisburg, several miles south of the Downtown Dayton area.

3.7 Installing Monitoring Equipment

This section summarizes the basic procedures for installing the water quality monitoring equipment used in the River Index Project. These procedures were taken from the YSI Environmental Operations Manual available from YSI, Inc., 1725 Brannum Lane, Yellow Springs, OH 45387. Consult the YSI, Inc. manual for detailed step-by-step installation, calibration, and maintenance guidance. You also may contact YSI, Inc. at <www.ysi.com>.

The monitoring equipment used at each monitoring station in the River Index Project includes a water quality sonde, a temperature probe, a pH probe, a conductivity probe, a dissolved oxygen (DO) probe, and a turbidity probe. In addition, ammonium-nitrogen and nitrate-nitrogen probes were used during the first year of the River Index Project at the Taylorsville Dam and Miamisburg monitoring stations.

Connecting the Water Quality Sonde

A water quality sonde is a torpedo-shaped monitoring device that is placed into the water to gather water quality data (see Figure 7). Sondes support multiple probes. Each probe may have one or more sensors that collect water quality data.

Figure 7. Water Quality Sonde

A sonde may be connected to a computer, data collection device, or to a display/logger. In the River Index Project, a field cable connects a sonde to a Data Collection Platform (see Figure 8).

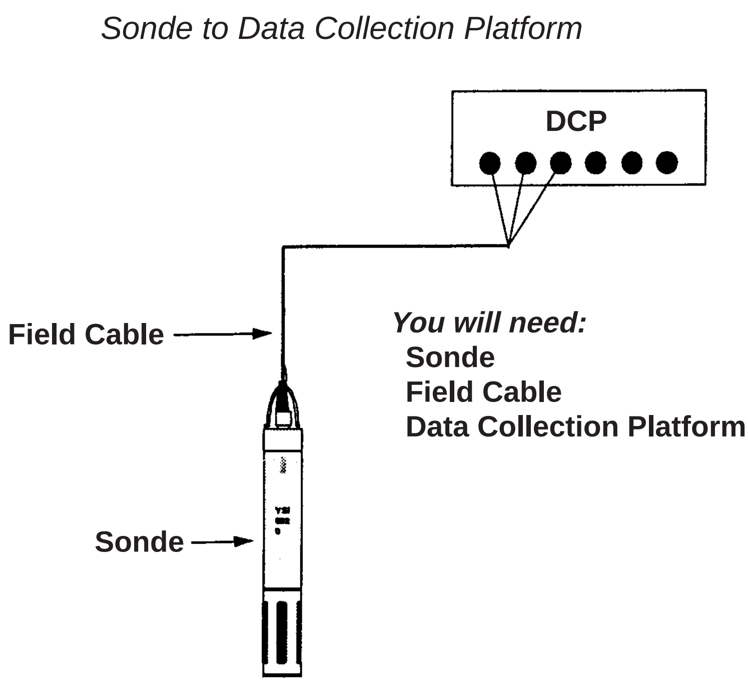


Figure 8. Connecting sonde to data collection platform (DCP)

Preparing the Sonde for Use

To prepare the sonde for calibration and operation, you first need to install a new membrane on the DO probe and then install the probes with the sensors into the connectors on the sonde bulkhead. It is recommended that you install the DO membrane before placing the DO probe into the sonde bulkhead. For subsequent membrane changes, you might be able to install the membrane without removing the probe. This depends on whether the other installed probes interfere with your ability to install a membrane. The four steps for getting your sonde ready for use are:

- Install the membrane on the DO probe
- Place the probes in the sonde bulkhead
- Connect the power
- Connect the field cable

Step 1: Install the DO probe membrane (see Figure 9)

1. Unpack the YSI 6562 DO Probe Kit.
2. Open the membrane kit and prepare the electrolyte solution. Dissolve the potassium chloride (KCl) in the dropper bottle by filling it to the neck with

deionized or distilled water and shaking until the solids are fully dissolved. After the KCl is dissolved, wait a few minutes until the solution is free of bubbles.

3. Remove the protective cap from the DO probe and the dry membrane from the DO sensor. Be careful not to scratch or contaminate the sensor tip.
4. Hold the probe in the vertical position and apply a few drops of KCl solution to the tip. The fluid should completely fill the small moat around the electrodes and form a meniscus on the tip of the sensor. Be sure no air bubbles are stuck to the face of the sensor. If necessary, shake off the electrolyte and start over.
5. Secure a membrane between your left thumb and the probe body. Always handle the membrane with care, touching it only at the ends.
6. With the thumb and forefinger of your right hand, grasp the free end of the membrane. With one continuous motion, gently stretch it up, over, and down the other side of the sensor. The membrane should conform to the face of the sensor.
7. Using the thumb and forefinger of your left hand, secure the end of the membrane.
8. Roll the O-ring over the end of the sensor, being careful not to touch the membrane surface with your fingers. No wrinkles or trapped air bubbles should be in the membrane. Small wrinkles can be removed by lightly tugging on the edges of the membrane. If bubbles are present, remove the membrane and install again using Steps 4 through 9.
9. Trim off any excess membrane with a sharp knife or scissors. Rinse off an excess KCl solution, but be careful not to get any water in the connector.

TIP: You may find it more convenient to mount the probe vertically in a vise with rubber jaws while applying the electrolyte and membrane to the sensor tip.

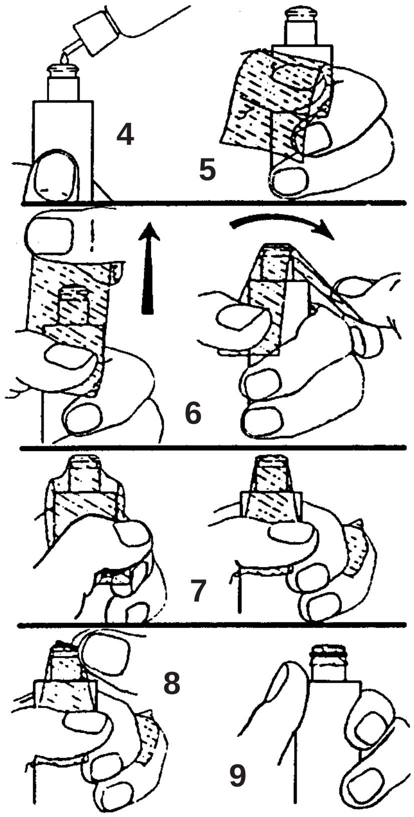


Figure 9. Installing the DO probe membrane

Step 2: Place the probes in the sonde bulkhead

1. Remove the transport clip from the sonde by hand to expose the bulkhead (see Figure 10).

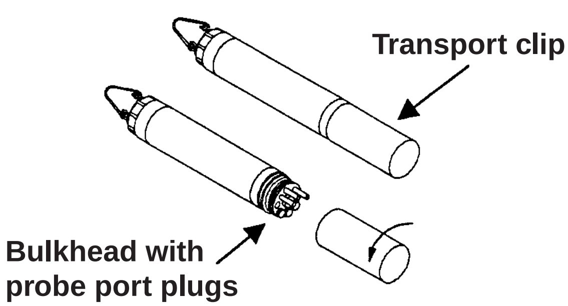


Figure 10. Probe with transport clip

2. Using the probe installation tools provided, remove the port plugs. Save all port plugs for possible future use. In place of the tool provided for port removal, you may use a 7/64" hex key.

3. Apply a thin coat of O-ring lubricant to the O-rings on the connector side of each probe that is installed. Make sure there are no contaminants between the O-ring and the probe. Contaminates under the O-ring may cause the O-ring to leak when the sonde is placed in use.

4. Before installing a probe, be sure the probe port is free of moisture. If moisture is present, you may use a can of compressed air to blow out the moisture.
5. Place a probe into the correct port and gently rotate the probe until the two connectors align. With the connectors aligned, tighten the probe slip nut with the probe installation tool provided. Do not cross thread the probe nut and do not over tighten the slip nut.
6. A turbidity probe should be installed first due to its center position in the sonde bulkhead.
7. Ammonium-nitrogen and nitrate-nitrogen probes do not have slip nuts and should be installed without tools. Use only your fingers to tighten.
8. After the probes are placed in the bulkhead, install the probe guard by aligning it with the threads on the bulkhead and turn the guard clockwise until it is secure. The probe guard protects the probes during calibration and measurement procedures (see Figure 11).

Caution: Be careful not to damage the DO membrane during installation of the probe guard.

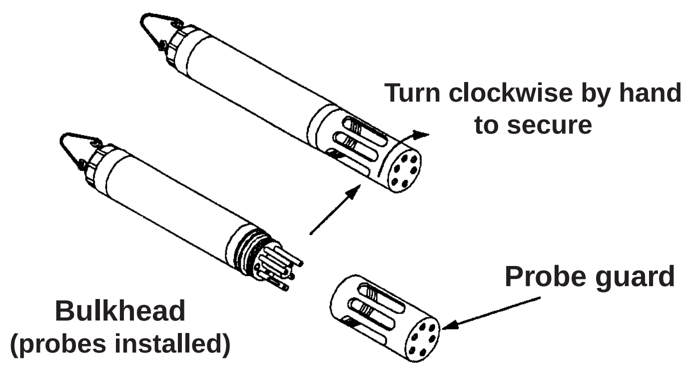


Figure 11. Sonde with probe guard

Step 3: Connect the power

1. Connect the sonde to an external power source.
2. For the YSI 6920 sonde, place the batteries into the sonde using the following procedure (see Figure 12):
   - Position the bail so that it is perpendicular to the sonde and use it as a lever to unscrew the battery cap by hand. Then slide the battery lid up and over the bulkhead connector.
   - Insert eight AA-size alkaline batteries into the sonde, paying special attention to polarity. Labeling on the sonde body describes the proper orientation of the batteries with respect to polarity.

- Check the O-ring and sealing surfaces for any contaminants that could interfere with the O-ring seal of the battery chamber. Contaminants under the O-ring may cause the O-ring to leak when the sonde is placed in use.
- Lightly lubricate the O-ring on the outside of the battery cover. DO NOT lubricate the internal O-ring.
- Replace the battery lid and tighten by hand. DO NOT OVER TIGHTEN.

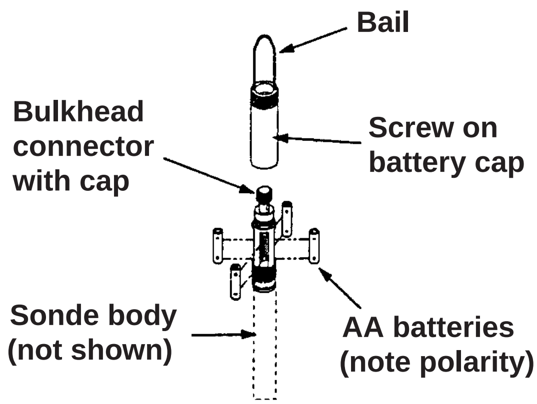


Figure 12. Location of sonde batteries

Step 4: Connect the field cable (see Figure 13)

1. Remove the waterproof cap from the sonde connector and set it aside for later reassembly during storage.
2. Connect the field cable to the sonde connector. A built-in "key" ensures proper pin alignment. Rotate the cable gently until the "key" engages and then tighten the connectors together by rotating them clockwise.
3. Attach the strain relief connector to the sonde bail. Rotate the strain relief connector nut to close the connector's opening.
4. The other end of the field cable for all sondes is a military-style 8-pin connector (MS-8). Through the use of a YSI 6095B MS-8 to DB-9 adapter, the sonde can be connected to a computer for setup, calibration, measurement, and uploading files.
5. For laboratory use, a YSI 6067B calibration cable can be used instead of a field cable. This cable is not waterproof and should not be submersed in water. To use, plug the proper end of the cable into the sonde connector and attach the DB-9 connector of the cable to the COM port of your computer.

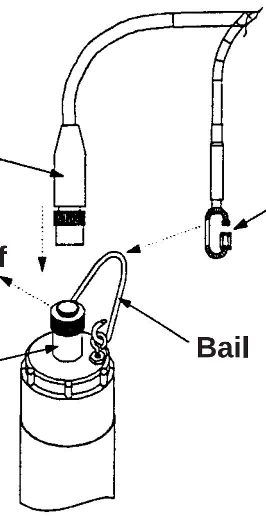


Figure 13. Connecting field cable

3.8 Calibrating the Monitoring Equipment

The following general calibration procedure is used for the most commonly used sensors. Consult the YSI, Inc. manual to determine whether a different procedure is used for a specific sensor. Calibration can be done using either the calibration cup that comes with the sonde or laboratory glassware. Follow the instructions in the text box on page 29 when the calibration cup is used in the general calibration procedure. If you do not use the calibration cup, you are cautioned to do the following:

- Perform all calibrations with the probe guard installed. This protects the probe from possible physical damage.
- Use a ring stand and clamp to secure the sonde body to prevent the sonde from falling over. Some laboratory glassware has convex bottoms.
- Insurer that all sensors are immersed in calibrations solutions. Many of the calibrations factor in readings from other probes (e.g., temperature probe). The top vent hole of the conductivity sensor also must be immersed during calibrations.

The following are the steps in the general calibration procedure:

Using the Calibration Cup to Calibrate Sensors in YSI 6820/6920 Sondes

- ✓ Ensure that a gasket is installed in the gasket groove of the calibration cup bottom cap and that the bottom cap is tightened.
- ✓ Remove the probe guard from the sonde, if installed.
- ✓ Remove the sonde O-ring, if installed.
- ✓ Inspect the installed gasket on the sonde for obvious defects and, if necessary, replace it with the extra gasket (supplied).
- ✓ Screw calibration cup assembly into place on the threaded end of the sonde and securely tighten, but do not over tighten.
- ✓ Sonde calibration can be accomplished with the sonde upright or upside down. A separate clamp and stand, such as a ring stand, is required to support the sonde in the inverted position.
- ✓ To calibrate the DO sensor, loosen the bottom cap or cup assemble to allow pressure equilibration before calibration. The DO calibration is a water-saturated air calibration.
- ✓ Follow the general calibration procedure to calibrate a sensor unless a different procedure is used for a specific sensor.
- ✓ To ensure more accurate results, you can rinse the calibration cup with water, and then rinse with a small volume of calibration solution for the sensor that you are calibrating. Discard the rinse solution and add fresh calibration solution. Consult the YSI, Inc. manual for the correct volume of calibration solution for a sensor.

Step 1:

Carefully immerse the probes in the calibration solution. It is recommended that the sonde be supported with a ring stand and clamp to prevent the sonde from falling over.

Step 2:

With a field cable connecting the sonde to a personal computer (PC), access EcoWatch for Windows and proceed to the Main menu. From the Main menu, select number 2-Calibrate.

Step 3:

From the Calibrate menu, select the number of the sensor that you are calibrating. A number in parenthesis appears next to the selected parameter. This is a default value that is used during calibration unless you input a different value. For parameters for which no default value is shown, you must type in a value. After you are satisfied with the default value, press “enter.”

Step 4:

After you press “enter,” a real-time display appears on the screen. Carefully observe the stabilization of the readings for the parameter that is being calibrated. When the readings are stable for approximately 30 seconds, press “enter” to accept the calibration.

Step 5:

Press “enter” to return to the Calibrate menu, and proceed with the calibration for the other sensors.

Calibration Tips

- Temperature sensors do not require calibration.
- The key to successful calibration is to insure that the sensors are completely submersed when calibration values are entered.
- For maximum accuracy, use a small volume of previously used calibration solution to pre-rinse the sonde. You may wish to save old calibration standards for this purpose.
- Fill a bucket with water at ambient temperature to rinse the sonde between calibrations using different solutions.
- Have several clean, absorbent paper towels or cotton cloths available to dry the sonde between rinses and calibration solutions. Shake the excess rinse water off the sonde, especially when the probe guard is installed. Dry off the outside of the sonde and probe guard to reduce carry-over contamination of calibration solutions.
- If you use laboratory glassware instead of a calibration cup, you do not need to remove the probe guard to rinse and dry the probe between calibrations using different solutions. The inaccuracy resulting from just rinsing the probe compartment and drying the outside of the sonde is minimal.
- Make certain that port plugs are installed in all ports where probes are not installed. CAUTION: It is extremely important to keep these electrical connectors dry.

River Index Project

For the River Index Project, the probes were calibrated initially on a weekly basis. After several weeks of testing the equipment, the calibration frequency was decreased to biweekly.

The ammonium-nitrogen and nitrate-nitrogen probes require additional calibration steps that are cumbersome to do at a monitoring site. For this reason, extra sondes were purchased at the beginning of the River Index Project. This allowed sondes to be calibrated in the laboratory and then switched with the sondes at the monitoring site.

3.9 Maintaining Monitoring Equipment

Most of the maintenance activities for the monitoring equipment focus on cleaning the sondes and the probes. The activities vary by the type of probe used.

The YSI 6570 Maintenance Kit is available for a sonde. The kit includes two types of O-rings (for probes and cable connector), probe installation and replacement tools, two cleaning brushes for the conductivity sensor, O-ring lubricant, and a syringe for cleaning the depth sensor port. These items are helpful in performing routine maintenance on your sondes.

To prevent water from entering a sonde port, it is extremely important that the entire sonde and all probes be thoroughly dried prior to the removal of a probe or probe plug. If moisture is present inside a probe port when either a probe or plug is removed, use compressed air to completely dry the connector inside the port. Remember, you will never a need to gain access to the interior circuitry of a sonde during cleaning, because the sonde is sealed at the factory.

Maintenance activities for the cable connector port and the different sensors are discussed below.

Cable Connector Port

The cable connector port at the top of the sonde should be covered at all times, and the cable should be tightened at all times. This assures that a proper connection is made and prevents moisture and contaminants from entering the sonde. If moisture enters a connector, dry the connector completely using compressed air, a clean cloth, or a paper towel.

When a communications cable is not connected to the cable connector port, the pressure cap supplied with the instrument should be tightened. Apply a thin coat of the lubricant that comes in the maintenance kit to the O-ring inside the cable connector cap prior to each use.

DO Probe

For best results, the KCl solution and the membrane on the tip of the DO probe should be changed prior to each time the sonde is used and at least every 30 days during use. The KCl solution and membrane also should be changed if 1) bubbles are visible under the membrane, 2) if significant deposits of dried electrolyte are visible on the membrane or O-ring, or 3) if the probe provides unstable readings.

- Dry the probe tip completely with lens cleaning tissue.
- Hold the probe in a vertical position and place one of the sanding disks supplied by manufacturer under your thumb.
- Stroke the probe face in a direction parallel to the gold electrode (located between the two silver electrodes). The motion is similar to that used to strike a match.
- Usually, 10 to 15 strokes of the sanding disk are sufficient to remove the black deposits on the silver electrodes. In extreme cases, more sanding may be required to regenerate the original silver surface.
- After completing the sanding procedure, rinse the probe face with clean water and wipe with lens cleaning tissue to remove any grit from the sanding disk.
- Rinse the entire tip of the probe with distilled or deionized water and install a new membrane.
- Be sure only to use the fine sanding disk provided by the manufacturer and sand in the direction of the gold electrode. Not adhering to both of these instructions can damage the electrodes.

Conductivity/Temperature Probe

The openings that allow liquid access to the conductivity electrodes must be cleaned regularly. Dip a small cleaning brush (provided in the maintenance kit) in clean water and insert it into each hole 15 to 20 times. In the event that deposits are on the electrodes, adding a mild detergent in the cleaning water might be necessary. After cleaning, check the response and accuracy of the conductivity cell with a calibration solution.

The temperature portion of the probe requires no maintenance.

pH Probe

Cleaning of the pH probe is required whenever deposits or contaminants are on the glass surfaces of the probe, or whenever there is a slow response. Several procedures are used to clean the pH probe after it is removed from the sonde.

The initial procedure is to use clean water and either a saturated soft clean cloth, lens cleaning tissue, or cotton swab to remove all foreign material from the glass bulb. Then, use a moistened cotton swab to carefully remove material that may block the reference electrode junction of the sensor. Be careful not to wedge the swab tip between the guard and the glass sensor. If necessary, remove the cotton from the swab tip so that the cotton can reach all parts of the sensor tip without stress.

If good pH response is not restored using the initial procedure, perform the following procedure:

1. Soak the probe for 10 to 15 minutes in clean water containing a few drops of commercial dishwashing liquid.

2. Gently clean the glass bulb by rubbing with a cotton swab soaked in cleaning solution.

3. Rinse the probe in clean water, wipe with a cotton swab saturated with clean water, and then rinse again with clean water.

If good pH response still is not restored, perform the following additional procedures:

1. Soak the probe for 30 to 60 minutes in one molar hydrochloric acid solution. Be sure to follow the safety instructions that come with the acid solution.

2. Gently clean the glass bulb by rubbing with a cotton swab soaked in the acid solution.

3. Rinse the probe in clean water, wipe with a cotton swab saturated with clean water, and then rinse again with clean water. To be certain that all of the acid solution is removed from the probe crevices, soak the probe in clean water for about an hour with occasional stirring.

If good pH response is not restored through the above procedures or if biological contamination of the reference junction is suspected, perform the following additional cleaning step.

1. Soak the probe for approximately one hour in a one-to-one dilution of commercially available chlorine bleach.

2. Rinse the probe with clean water and then soak for at least one hour in clean water with occasional stirring to remove residual bleach from the junction. If possible, soak the probe for longer than one hour to be certain that all traces of chlorine beach are removed. Then rinse the probe with clean water and retest.

If good pH response is achieved at the end of any of the above procedures, dry the sonde port and probe connector with compressed air and apply a thin coat of lubricant to all O-rings. Then place the pH probe in the sonde. If good pH response is still not achieved, consult the manufacturer.

Turbidity Probe

The turbidity probe requires minimal maintenance. After each use, the optical surface of the tip of the turbidity probe should be inspected for fouling. If necessary, clean the surface by gently wiping the probe face with moist lens-cleaning paper. The wiper assembly might have to be replaced periodically depending on the quality of water that is monitored.

River Index Project

Initially, maintenance activities were performed weekly in the River Index Project. After several weeks of testing, the maintenance frequency was reduced to biweekly.

As mentioned previously, extra sondes were purchased at the beginning of the River Index Project so that sondes could be maintained in the laboratory and then switched with sondes at the monitoring sites. Approximately one hour is needed to clean, service, maintain, and calibrate a sonde in the laboratory. The time required for maintenance of each sonde and any problems encountered with the sonde are recorded in a log book.

Field maintenance includes cleaning of the flow-through tank wall, back flushing of the monitoring system by turning off the pump, cleaning pipes, and confirming the pump is in good working condition by recording the time it takes to refill the flow-through tank. All field activities are recorded on a sheet that remains at the monitoring station.

4. Collecting, Transferring, and Managing Real-Time Water Quality Data

To effectively assess the water quality of a river, it is necessary to collect representative field samples over a time span that takes into account as many influences on the water body as possible. Conducting a comprehensive manual sampling program that covers different times of the day and different seasons and seasonal events presents distinct challenges. As a result, many agencies responsible for water quality monitoring rely on automated systems in which remote water sampling units collect data at programmed intervals and then transmit the collected data to a project headquarters for storage, retrieval, and analysis. Automated systems measure a variety of water quality parameters that are laborious to monitor manually on a daily basis (e.g., pH, temperature, conductivity, and flow rate). A commitment to automation gives an agency the freedom to focus their resources on collecting samples for measurements that usually are not made using automated systems: bacteria counts, chemical analyses, and broad ecological assessments, for example.

Using the River Index Project as a model, this chapter provides you and your community with information on how to operate and maintain automated data collection systems:

- Section 4.1 provides introductory information as an overview of the system.
- Sections 4.2, 4.3, 4.4, and 4.5 explain technical information on implementing this system, such as processing information, calculating a river index, and lessons learned in the River Index Project.

4.1 System Overview

An automated data collection, transfer, and management system benefits your community in two ways: it enables you to automate the collection of water quality data and it allows you to control the resulting data easily. By using the system's software, you can program your remote data acquisition system (DAS) to collect water quality data at specified intervals and store them. Then you can program a computer in your headquarters to call the DAS at specified times and download recent data. With little or no need for human intervention, the information can be exported to a database, set in a standard format, and merged with manually collected data. After the data are available in a database, they can be used in a wide variety of applications. They can be:

- Manually inspected for quality control purposes
- Plotted using graphing software
- Mapped using a geographical information system (GIS)
- Processed and combined with other data
- Made available to the public via a connected Web server

River Index Project

Various components make up the automated data collection, transfer, and management system for the River Index Project. They are:

- **Data Acquisition System (DAS).** This is a small, rugged computer located at each of the monitoring stations in the Lower Great Miami River Watershed (see Figure 14). It receives data directly from the water quality and flow sensors, provides short-term storage for the data, and periodically transmits the data to computers that call in. The DAS is set up for either cellular or land-line telephone service. Each DAS is controlled by proprietary software developed by the manufacturer:
  - **Data Collection Platform (DCP).** DCP is software designed specifically by the DAS manufacturer. It controls the operation of the DAS instruments, causes data to be stored, and uploads data to computers that dial the DAS.

Figure 14. Data acquisition system at Downtown Dayton monitoring station

- **The project headquarters Station,** located in Dayton, Ohio, contains a computer that runs different software programs:
  - **Procomm Plus software.** This is a general purpose telecommunications program that can be set to automatically dial the DAS and download recent river stage data. This program also is used to upload river stage and water quality data to the database server at the distribution station. For more information on Procomm Plus software, go to <www.symantec.com/procomm>.

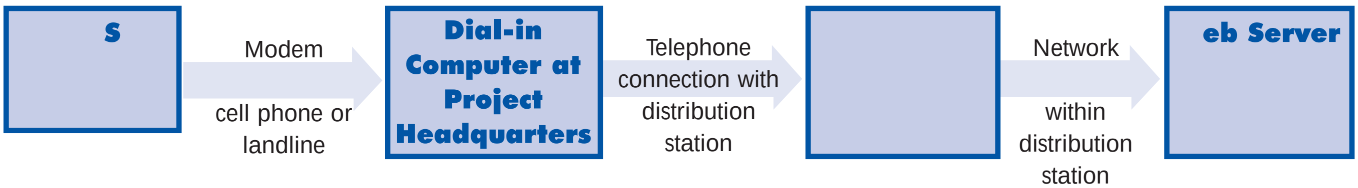
  - **EcoWatch for Windows.** This software, which was developed by YSI, Inc., calls and downloads data collected using the dissolved oxygen, pH, conductivity, turbidity, temperature, and nitrogen sensors.

- **The Distribution Station,** located at CH2M HILL's office in San Francisco, California, receives data, stores them in a database, and distributes data to the public over the Internet. Most of the computer hardware and software needed for the River Index Project is used to provide information to the public through the project's Web site. The distribution station runs the following software:

  - **Microsoft SQL Database Server.** This software formats, quality checks, and stores the collected data. The server responds to queries (either directly from users or from other software programs) by providing appropriate records from its database.

  - **Microsoft IIS Web Server** provides Internet users with a graphical user interface (i.e., a "Web site"). When the server needs real-time data to send to an Internet user, it obtains the data from the database server.

The Distribution Station in California collects data from the project headquarters Station to save money on long distance calls. It cost less to make one long distance call to the project headquarters Station than to make six long distance calls to the monitoring stations.



- Runs DCP Software to collect data

- Runs Procomm Plus and EcoWatch for Windows to gather data collected at monitoring stations
- Runs Procomm Plus to upload data to database server at distribution station

- Runs Microsoft SQL to format and store data, and to do quality checks on data

- Runs Microsoft IIS to retrieve data from database server and display data on Web site

To learn more about how to use the software products, consult the manufacturers' documentation.

How often should you collect data?

Given the system's flexibility, communities are able to establish sampling and data transmission protocols based on their specific monitoring needs. For example, one community might program its DAS to sample every hour, seven days a week to monitor general trends over time. Another community might collect only event-specific samples relevant to the period of a nonpoint source event. This might involve continuous monitoring at a single depth before, during, and after a storm.

The River Index Project Team programmed their computers to collect water quality and flow data every eight hours. Each eight-hour reading is itself an average of eight hourly readings collected by the DAS. Manually collected water quality data, such as *E. coli* bacteria density measurements, were collected less frequently (either once a week or once a month) during the first year of the River Index Project. When a river index is calculated, the most recent data, both automated and manual, are used in the calculation. Graphs of the dissolved oxygen, pH, temperature, turbidity, and specific conductance data collected in the River Index Project during 2000 are presented in Appendix B.

4.2 Processing the Information

In the River Index Project, data processing includes quality control and formatting. For quality control, checks are performed to determine the accuracy of the data. For formatting, data are modified so that they can be stored together in a database.

Quality Control Checks

One of the most important data processing functions is to perform quality control checks of data collected automatically. The primary quality control check used by the River Index Project Team is to validate data by comparing them to data collected using a hand-held probe. During the biweekly maintenance operations, the River Index Project Team collects data manually and compares them to data collected automatically.

A judgement was made that if the values of the data collected automatically are within 10 percent of the values of the data collected manually, they are considered valid. If the values for the automated data are different from the data collected manually by more than 10 percent, the automated data are considered suspect.

A Web-based tool allows field personnel to qualify data uploaded to the master database as valid, suspect, or invalid. The "invalid" flag is used in cases where there is an obvious problem with the data (e.g., low pH data at a monitoring station). Periodically, the River Index Project Team also compares the data collected from the same probe (e.g., pH) at the different monitoring stations. If the data at one monitoring station vary significantly from the data at another monitoring station, further reviews are conducted to determine why those data vary.

Data Formatting

Three types of data are transmitted to the database at the distribution station:

- Real-time water quality data collected by the DAS at the monitoring stations.
- Water quality data collected manually by field staff and keyed into a data collection program.
- River flow data collected automatically.

A computer procedure at the distribution station formats these three data sets so that they "fit together" in the same database.

4.3 Calculating a River Index

An innovative risk communication tool of the River Index Project is its indexing system. The indexing system converts measurements into a single, easy-to-understand index that is disseminated to the public on the River Index Project Web site (www.riverindex.org).

A key concern for the River Index Project Team as they developed the index and other risk communication tools was that the tools meet, and be perceived as meeting, the highest professional and scientific standards. Yet generating a river index involves making judgement calls about where to set cutoffs between different categories of environmental quality (i.e., between "excellent" and "good" river quality). It involves similar judgement calls about how to weight and combine an array of dissimilar measurements into a single measurement of water quality. To this end, the River Index Project Team recruited eight internationally-recognized water quality experts to serve on a peer review panel for the project.

Drawing on their own expertise and that of the members of the peer review panel, the River Index Project Team developed the following indexes:

- A **Water Quality** index that synthesizes and summarizes data for these water quality parameters:
  - Ammonia-nitrogen
  - Atrazine
  - Chlorpyrifos
  - Dissolved oxygen
  - *E. coli* bacteria
  - Fish toxicity
  - Nitrate-nitrogen
  - pH
  - Conductivity
  - Water temperature
- A **River** index that synthesizes and summarizes data for the parameters in the water quality index, plus data for two additional parameters:
  - Flow rate
  - Turbidity

While the water quality index focuses on those issues pertaining to the health of the river, the river index provides a broader sense of whether river conditions are right for recreation. Flow rate (river stage) is a particularly important parameter for determining river safety. A very high flow rate not only indicates strong, potentially dangerous currents, but it warns of possible flooding. For the sake of safety, the river index is set up to automatically take the "poor" rating (regardless of how good the other parameters are) if flow rate approaches a level characteristic of flood activity. Under these circumstances, the River Index Project Web site also displays a special flood warning.

Index Definitions

General vs. specific ratings. The river index is a mathematical procedure for "rating" a stretch of water in terms of its current suitability for recreational pursuits. The index system does not specify which particular recreational activities are likely to be safe or advisable—it is simply a statement about whether the river conditions are favorable for recreation in general. The River Index Project Team originally considered issuing use-based advisories (e.g., the river is safe for boating, swimming, and fishing) but ultimately decided against this strategy because they felt it called for overly subjective judgements and exposed the Project to potential legal liability. It remains the responsibility of individual users to make their own judgments about whether a particular river activity is wise. The Web site for the River Index Project also provides the raw data on which the river index is based to assist the user in making such decisions.

What the ratings mean. The rating used to describe the river index at each monitoring station varies from "excellent" to "poor." The point range assigned to each rating and the meaning of the rating are presented in the table below.

Ratings Used to Describe River Index

Rating	Point Range	Meaning
Excellent	32-40	Overall measurements indicate good water quality. Conditions highly favorable for recreation.
Good	25-31	Most measurements meet or exceed water quality standards. Conditions favorable for recreation.
Fair	18-24	Some measurements meet or exceed water quality standards. Conditions marginally favorable for recreation.
Poor	11-17	Measurements indicate some water quality problems. Conditions generally not favorable for most recreation.

Averaging parameter values. Because the value for some of the parameters in the river index change frequently, the river index also changes frequently. It is updated every eight hours using an average of the previous eight hourly automated readings and the most recent manual readings. Web site visitors can "drill down" to the most recent automated readings from the monitoring stations if they wish. One reason for updating the index every eight hours (rather than hourly) is to prevent it from fluctuating in a seemingly random and confusing manner.

It is conceivable that, depending on the values for particular water quality parameters, the river index might be on the borderline between two different ratings—for example, "good" and "fair." If the index is updated every hour, insignificant variation (i.e., "noise") in the values for the water quality parameters might cause the rating to flip-flop between good and fair. This phenomenon might undermine public confidence in the index's reliability. This potential pitfall is averted by reliance on averaged data, which are more likely to reflect significant changes in water quality.

Calculating the River Index

Except in the special case of flood danger, the procedure for calculating a River Index is described below.

Step 1: Rate individual water quality parameters. Each of the water quality parameters that contribute to the River Index has a different value. The River Index rates these values as either poor (1 point), fair (2 points), good (3 points), or excellent (4 points). The advantage of this system is that it places values in a standardized form—there are only four possible ratings for each parameter.

Take the case of dissolved oxygen as an example. Based on Ohio EPA regulations and the judgement of several water quality experts, dissolved oxygen concentrations greater than 9 mg/l are considered "excellent," and those between 5 and 9 mg/l are considered "good." The range from 2 to 5 mg/l is "fair" and any value below 2 mg/l is "poor." Therefore, a value of 5.6 mg/l for dissolved oxygen translates into a good rating, which receives three points as shown below. The ratings for the other water quality parameters are presented in Appendix C.

Ratings Used to Describe River Index

Dissolved Oxygen Concentration (mg/l)	Rating/Points
>9	Excellent / 4
5-9	Good / 3
2-5	Fair / 2
<2	Poor / 1

Step 2: Weight and score the points from Step 1 and add the scores for each parameter to obtain the total score for a monitoring station.

Not all of the parameters measured are equally important in describing water quality. To address this issue, the River Index Project Team developed the weighting factors presented below for each of the parameters. Those factors and the points for a parameter from Step 1 are used to calculate a score for the parameter. The total score for a monitoring station is obtained by adding the scores for all of the parameters:

- Points for a parameter from Step 1 x weighting factor for the parameter = score for the parameter.
- Total score = sum of the scores for all of the parameters.

Weighting Factors for Parameters

Parameter	Weighting Factor
Dissolved oxygen	3
E. coli bacteria	1
pH	1
Conductivity	1
Water temperature	1
Flow rate	2
Turbidity	1

Step 3: Assign a final rating based on the total score for the parameters.

The final step in developing a river index for a monitoring station is to assign a rating to the total score from Step 2. As mentioned previously, the River Index Project Team used the following ratings and point ranges for the ratings.

Ratings for Total Score and Corresponding Point Ranges

Rating for	Point Range
Excellent	32-40
Good	25-31
Fair	18-24
Poor	11-17

One important caveat for the river index rating system is that it has a limited ability to convey information about extreme deviations from the norm for any particular parameter. For example, if the rating for pH is poor (e.g., pH = 1), the score for pH would be 1 (point value of 1 for poor rating times weighting factor of 1 for pH). Thus, out of a possible total score of 40, only one point would be lost because of low pH. If the total score for all other parameters is between 32 and 39, the rating for a river with a poor rating for pH would still be excellent.

This, of course, is a highly unlikely scenario because there is no practical reason why the pH of a river in the greater Dayton area would suddenly drop in such an extreme fashion. The scenario merely demonstrates the logical limitations inherent in an empirically weighted, linear indexing system. The River Index Project Team addressed this issue for flow rate by instituting a safety override to prevent extremely high flow rates from getting "hidden" in the index's scoring system.

4.4 Lessons Learned

Over the course of the first year, the River Index Project Team encountered a variety of minor obstacles that it had to work around to provide uninterrupted access to real-time water quality data:

- **Lightening strikes.** The computers at the project headquarters occasionally lost communication with the DAS at the monitoring stations because of lightening strikes. Power surges resulting from the lightening strikes traveled along the telephone lines, damaging the modem at the monitoring station. This problem can be solved by equipping the monitoring stations with effective surge protectors.

- **Clock synchronization problems.** The Taylorsville Dam monitoring station is powered by solar energy due to its remote location. To conserve this highly limited energy, the station only turns on its cell phone for a few brief periods each day. The dial-in computer at the project headquarters is scheduled to call the DAS at precisely the moments when the DAS is "awake" and ready to be called. However, from time to time the clock on the DAS and the clock on the dial-in computer get out of synchronization. When this happens, the two computers do not communicate—the dial-in computer calls during times when the DAS is not answering the phone. This problem was addressed by using a newer version of EcoWatch that synchronizes the dial-in computer and DAS clocks every time the project headquarters computer connects with the DAS.

- **Interpreting unreliable data.** Some of the instruments used in the River Index Project reported values that deviated—inexplicably—from normal ranges without a corresponding change in values for other parameters. For example, the pH sensor at the Downtown Dayton monitoring station reported values that were highly erratic and generally much lower than those at the other stations. In one year, for example, this station reported values ranging from pH 2 to pH 8 while the other stations reported values ranging from 6.5 to 8.5. Certain dissolved oxygen sensors experienced similar problems. These problems can be addressed initially by replacing the sensors. If this does not solve the problem, the underlying causes should be investigated further.

5. Depicting Real-Time Water Quality Data

Now that your water quality monitoring network is in place and you have collected the resulting data, you can turn to the next step in providing your community with timely water quality information: using data visualization tools to graphically depict this information. By using the types of data visualization tools described in this chapter, you can create graphic representations of water quality data that can be used on Web sites, in reports and educational materials, and in other outreach and communication initiatives.

- Section 5.1 provides an overview of data visualization.
- Section 5.2 contains an introduction to the data visualization tools used by the River Index Project Team.

If you are interested in a basic introduction to data visualization, you might only want to read the initial section. If you are responsible for choosing and using data visualization software to model and analyze data, you also should consult Section 5.2

5.1 What Are Data Visualization Tools?

In this handbook, data visualization tools are any graphic representations that communicate environmental information. Presenting data in a visual format enhances your audience's understanding of and interest in the data. Data visualization tools discussed below include maps, color coding, icons, graphs, and Geographic Information Systems (GIS).

- **Maps.** Maps are one of the most basic and familiar data visualization tools used to communicate timely environmental information. If kept simple (e.g., clutter-free) and a good key explaining the different map symbols is provided, maps are one of the easiest data interpretation and visualization tools to develop and use.
- **Color coding.** Like maps, color coding is a data visualization tool that is already familiar to many people, and thus its message can be easily understood. The use of color coding to indicate “good” or “poor” environmental conditions (and ranges between those extremes) has been combined successfully with maps, graphs, indexes, icons, and other tools for risk communication. Appropriate choices of colors (and ranges of colors) enhance a viewer's understanding. For example, using well-known color coding schemes, such as green to represent “go” (i.e., it is safe to swim in a particular beach based on water quality conditions) and red to represent “stop” (i.e., do not swim in this beach today because of poor water quality conditions) is recommended.
- **Icons.** The term “icon” is used here in a very general sense to describe any visual cue or image used to communicate information—anything from a physical placard (e.g., a beach closure symbol or sign) to a symbol on a computer screen. Although words may be added, an icon ideally should be able to convey at least its basic meaning without relying on language.

- **Graphs.** Graphs are another commonly used and relatively easy-to-understand data visualization tool. They are often used to convey information about how several variables are related or compare. Some projects allow users to generate graphs as needed by specifying which variables they want plotted and how they would like them plotted.
- **Geographic Information Systems (GIS).** GIS are effective data visualization tools for displaying, analyzing, and modeling spatial or geographic information. GIS maps, animations, and two-and three-dimensional models can be generated after the detailed data are input into the system by skilled staff, which can be labor-intensive and fairly expensive. Two key advantages of GIS are the ability to quickly overlay and view several different data layers simultaneously, such as open space lands, water resources, and population, and to view and compare different future scenarios (e.g., future land uses) and their possible impacts (e.g., on environmental resources).

By applying these tools to water quality data, you can help your community's residents gain a better understanding of factors affecting water quality in area rivers and streams. Once you begin using data visualization tools, you will immediately be impressed with their ability to model and analyze your data for a variety of purposes, from making resource management decisions to supporting public outreach and education efforts.

5.2 Data Visualization Tools Employed In the River Index Project

On the home page of its Web site (see Figure 15), the River Index Project displays a schematic map of the Miami River Valley, centered on the city of Dayton, Ohio. The purpose of this map is to provide an "at-a-glance" summary of water quality for all the rivers covered by the project. The most prominent features of the map are the area's rivers and streams, colored in light blue. The name of each river is written on the map. The background color of each river's label changes to match the river's current index—a key on the map reminds the viewer of what each color means. The map also displays the boundaries of the Lower Great Miami River Watershed and of local counties. In addition, the home page has an image of the River Index's "happy fish" that the River Index Project Team created to provide the public with an easily recognizable mascot for the River Index.

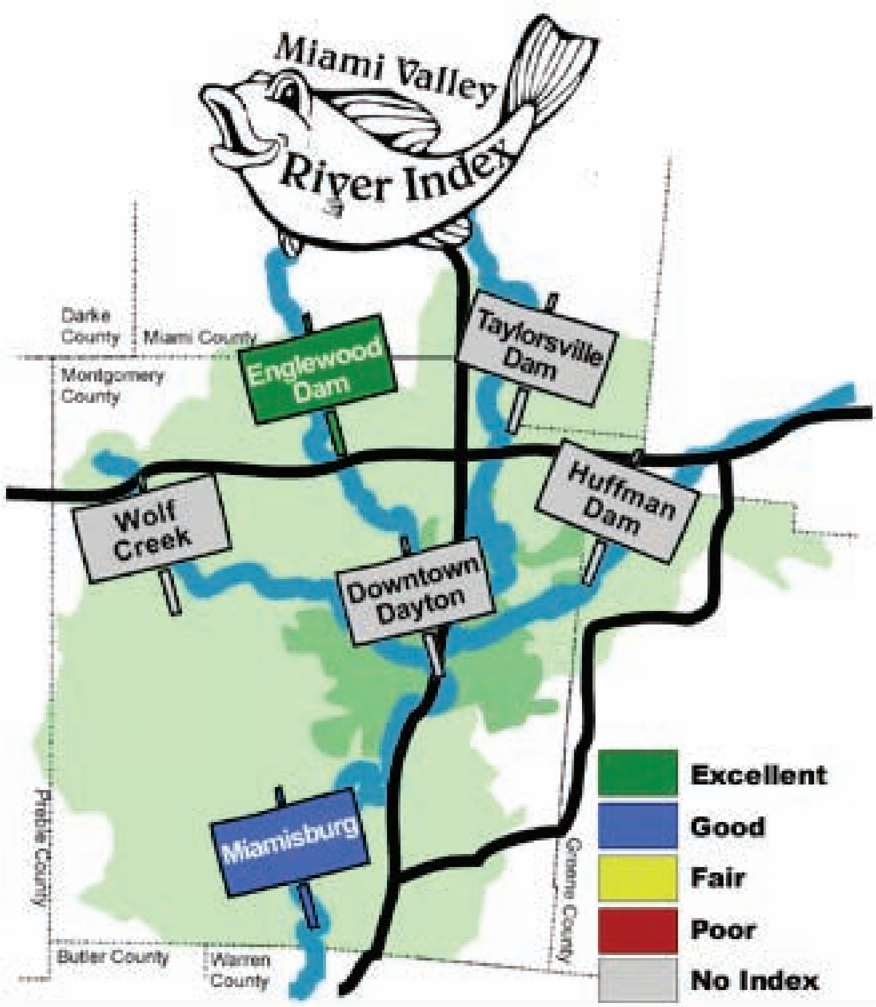


Figure 15. Home page for the River Index Project Web site

Color-Coded Index Ratings

Each of the river index ratings is paired with a color. The color scheme chosen by the River Index Project Team and the cultural significance of each color are presented below. The color scheme amplifies and coincides with the explanatory text for each rating. This is particularly important because some people might not bother reading or thinking about the carefully-crafted text that explains each rating. They may simply note the color of the rating and make their conclusions about the river based on their intuitive understanding of that color. Other people might actually read the explanatory language but be confused about its practical significance (e.g., the difference between “favorable” and “highly favorable conditions”). Colors with a known cultural significance help to communicate the level of risk reflected by the different ratings.

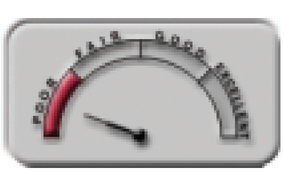
Color-Coding System Used in the River Index Project

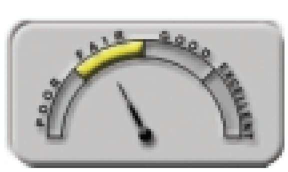
Rating	Color	Cultural Significance of Color
Excellent	Green	In traffic signals, the green light says “go ahead.” Similarly, this rating actively entices the index user to “go ahead” and use the river for recreation. Green also connotes environmental well-being. It suggests that not only is the river good for recreation, but it is ecologically healthy.
Good	Blue	Unlike the other three colors, blue is not used in traffic signals. “Good” lacks, therefore, the direct impact of the other ratings possess. In aesthetic terms, however, it is widely accepted as the normal color of water. Even though “good” is not the best possible rating, the color blue reassures the user that the water is still clean and safe.
Fair	Yellow	Yellow is the caution light in traffic signals. Without forbidding passage, it exhorts the viewer to exercise discretion and maintain a heightened state of awareness. Similarly, a yellow rating encourages the user to think twice about his or her plans for using the river. The color encourages the user to learn more about the specific nature of the river's problems
Poor	Red	In traffic, the color red commands the viewer to stop. In an environmental context, it also conveys an impression of danger, emergency, and authority. The color red anchors “poor” at the bottom of the ranking system, and indicates that there is, at present, a serious problem with the river. The color encourages users to avoid the river until the situation improves.

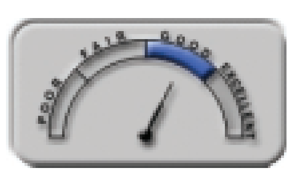
“Dial” Displays of River Index

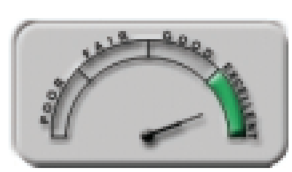
Before the widespread use of digital readouts, scientific instruments typically presented their readings by means of analog dials. In automobiles, these dials remain the principal technology for communicating real-time information (e.g., speed, RPMs, oil pressure) to the driver. Thus, for many people the idea of reading a value off a dial is quite intuitive.

In the River Index Project, each dial has four sections, one for each of the four ratings. The needle of the dial always points squarely in the middle section of the dial. The sections of the dial are labeled (poor, fair, good, excellent) but only the one that the needle is pointing to is illuminated. These dials do not represent continuous variation in index values. Because the needle simply “jumps” from one state to the next, the dial does not distinguish between a “good” rating that is very close to “fair” and one that is very close to “excellent.” An interested user can make this distinction by looking at the total numerical score for the index.









6. Communicating Real-Time Water Quality Data

As your community develops its real-time water quality monitoring and reporting systems, you need to think about the best ways to communicate the information these systems yield. This chapter discusses how to communicate that information.

- Section 6.1 outlines the steps in creating an outreach plan for real-time water quality data.
- Section 6.2 discusses the elements of the River Index Project outreach plan.
- Section 6.3 provides guidance for communicating information effectively, including resources for water quality monitoring and promoting awareness that you can incorporate into your own communication and outreach materials.

6.1 Creating an Outreach Plan for Real-Time Water Quality Data

Outreach is most effective if you plan it carefully, considering such issues as: Whom do you want to reach? What information do you want to disseminate? What are the most effective mechanisms to reach people? Developing a plan ensures that you consider important elements of an outreach project before you begin. The plan itself provides a blueprint for action.

An outreach plan is most effective if you involve a variety of people in its development. Where possible, consider involving:

- A communications specialist or someone who has experience developing and implementing an outreach plan.
- Technical experts in the subject matter (both scientific and policy).
- Someone who represents the target audience (i.e., the people or groups you want to reach).
- Key individuals involved in implementing the outreach plan.

As you develop your outreach plan, consider whether you would like to invite any organizations to partner with you in planning or implementing the outreach effort. Potential partners might include local businesses, environmental organizations, schools, boating associations, local health departments, local planning and zoning authorities, and other local or state agencies. Partners can participate in planning, product development and review, and distribution. Partnerships can be valuable mechanisms for leveraging resources while enhancing the quality, credibility, and success of outreach efforts.

An outreach plan does not have to be lengthy or complicated. You can develop a plan simply by documenting your answers to each of the questions discussed below. As you answer the questions, you might want to revisit and refine the decisions you made based on answers to earlier questions until you have an integrated, comprehensive, and achievable outreach plan.

Whom Are You Trying To Reach?

Identifying Your Audience(s)

The first step in developing an outreach plan is to clearly identify the target audience or audiences for your outreach effort. Outreach goals often define the target audience. You might want to refine and add to your goals after you have specifically considered which audiences you want to reach.

Target audiences for a water quality outreach program might include, for example, the general public, local decision-makers, land management agencies, educators and students (high school and college), and special interest groups (e.g., homeowner associations, fishing and boating organizations, gardening clubs, and lawn maintenance/landscape professionals). Some audiences, such as educators and special interest groups, might serve as conduits to help disseminate information to other audiences you have identified, such as the general public.

Consider whether you should divide the public into two or more audience categories. For example: Are you providing different information to certain groups, such as citizens and businesses? Does a significant portion of the public you are trying to reach have a different cultural or linguistic background from other members? If so, it is appropriate to consider these groups as separate audience categories.

Profiling Your Audience(s)

Outreach is most effective if the type, content, and distribution of outreach products are tailored specifically to the characteristics of target audiences. After you identify your audiences, the next step is to develop a profile of their situations, interests, and concerns. This profile helps you identify the most effective ways of reaching the audience. For each target audience, consider:

- What is their current level of knowledge about water quality?
- What do you want them to know about water quality?
- What information is likely to be of interest to the audience? What information will they want to know once they develop some awareness of water quality issues?
- How much time are they likely to give to receiving and assimilating the information?
- How does this group generally receive information?
- What professional, recreational, and domestic activities does this group typically engage in that might provide avenues for distributing outreach products? Are there any organizations or centers that represent or serve the audience and might be avenues for disseminating your outreach products?

Profiling an audience essentially involves putting yourself "in your audience's shoes." Ways to do this include consulting with individuals or organizations who represent or are members of the audience, consulting with colleges who have successfully developed other outreach products for the audience, and using your imagination.

What Are Your Outreach Goals?

Defining your outreach goals is the next step in developing an outreach plan. Outreach goals should be clear, simple, action-oriented statements about what you hope to accomplish through outreach. Once you have established your goals, every other element of the plan should relate to those goals.

What Do You Want To Communicate?

The next step in planning is to think about what you want to communicate. In particular, think about the key points or "messages" you want to communicate. Messages are the "bottom line" information you want your audience to walk away with, even if they forget the details.

A message usually is phrased as a brief (often one-sentence) statement. For example:

- The River Index allows you to track daily changes in river water quality.
- The River Index helps you plan river-related recreational activities.

Outreach products often have multiple related messages. Consider what messages you want to send to each target audience group. You might have different messages for different audiences.

What Kinds of Outreach Products Will You Develop?

The next step in developing an outreach plan is to consider what types of outreach products are the most effective for reaching each target audience. There are many different types of outreach products: print, audiovisual, electronic, events, and novelty items. The table below provides some examples:

Outreach Products

Print	■ Brochures ■ Educational curricula ■ Newsletters ■ Posters ■ Question-and-answer	■ Editorials ■ Fact sheets ■ Newspaper and magazine articles ■ Press releases ■ Utility bill inserts sheets
Audiovisual	■ Cable television ■ Exhibits and kiosks ■ Videos	■ Public service programs announcements(radio)
Electronic	■ E-mail messages ■ Web pages	■ Subscriber list servers
Events	■ Briefings ■ Fairs and festivals ■ One-on-one meetings ■ Public meetings	■ Community days ■ Media interviews ■ Press conferences ■ Speeches
Novelty Items	■ Banners ■ Buttons ■ Floating key chains ■ Magnets	■ Bumper stickers ■ Coloring books ■ Frisbee discs ■ Mouse pads

The audience profile information you assembled earlier is helpful in selecting appropriate products. A communications professional can provide valuable guidance in choosing the most appropriate products to meet your goals within your resource and time constraints. Questions to consider when selecting products include:

- How much information does your audience really need to have? How much does your audience know now? The simplest, most straightforward product generally is most effective.
- Is the product likely to appeal to the target audience? How much time does it take to interact with the product? Is the audience likely to make that time?
- How easy and cost-effective is the product to distribute or, in the case of an event, organize?
- How many people is this product likely to reach? For an event, how many people are likely to attend?
- What time frame is needed to develop and distribute the product?
- How much does it cost to develop the product? Do you have access to the talent and resources needed for development?

- What other related products are already available? Can you build on existing products?
- When will the material be out of date? (You probably want to spend fewer resources on products with short lifetimes.)
- Is it effective to have distinct phases of products over time? For example, a first phase of products designed to raise awareness, followed at a later date by a second phase of products to encourage changes in behavior.
- How newsworthy is the information? Information with inherent news value is more likely to be rapidly and widely disseminated by the media.

How Will Your Product Reach Your Audience?

Effective distribution is essential to the success of an outreach strategy. There are many avenues for distribution. Some examples are:

- Your mailing list
- Partner's mailing list
- Phone/Fax
- E-mail
- Internet
- Journals or newsletters
- TV
- Radio
- Print media
- Hotline that distributes products on request
- Meetings, events or locations (e.g., libraries) where products are made available

You should consider how each product is distributed and determine who is responsible for distribution. For some products, your organization might manage distribution. For others, you might rely on intermediaries (such as the media or educators) or organizational partners who are willing to participate in the outreach effort. Consult with an experienced communications professional to obtain information about the resources and time required for the various distribution options. Some points to consider in selecting distribution channels include:

- How does the audience typically receive information?
- What distribution mechanisms has your organization used in the past for this audience? Were these mechanisms effective?
- Can you identify any partner organizations that might be willing to assist in the distribution?
- Can the media play a role in distribution?
- Does the mechanism you are considering really reach the intended audience? For example, the Internet can be an effective distribution mechanism, but certain groups might have limited access to it.
- How many people is the product likely to reach through the distribution mechanism you are considering?

What Follow-up Mechanisms Will You Establish?

Successful outreach might generate requests for further information or concern about issues you introduced to the audience. Consider whether and how you will handle this interest. The following questions can help you develop this part of your strategy:

- What types of reactions or concerns are audience members likely to have in response to the outreach information?
- Who will handle requests for additional information?
- Do you want to indicate on the outreach product where people can go for further information (e.g., provide a contact name, number, or address, or establish a hotline)?

What is the Schedule for Implementation?

Once you have decided on your goals, audiences, messages, products, and distribution channels, you need to develop an implementation schedule. For each product, consider how much time is needed for development and distribution. Be sure to factor in sufficient time for product review. Wherever possible, build in time for testing and evaluation by members or representatives of the target audience in focus groups or individual sessions so that you can get feedback on whether you have effectively targeted your material for your audience. Section 6.3 contains suggestions for presenting technical information to the public. It also provides information about online resources that provide easy to understand background information that you can use in developing your own outreach projects.

6.2 Elements of the River Index Project Outreach Program

With the assistance of the other project team members, the City of Dayton took the lead in developing and implementing mechanisms to communicate timely water quality information—as well as information about the project itself —to the public in the Lower Great Miami River Watershed area. Elements of the project's communication program are highlighted below.

Random telephone surveys. Wright State University's Center for Urban and Public Affairs designed and conducted a random telephone survey to assess citizens' attitudes and behaviors toward the Great Miami River and other waterways in Montgomery County. A core set of questions on the survey was administered as a pre-and post-test that included a set of questions to evaluate citizens' awareness of the River Index Project communication strategy. By asking the same set of attitude and behavioral questions in the pre- and post-test, it was possible to determine whether the River Index Project communicated timely information about water quality in a user-friendly manner. Computer Aided Telephone Interview equipment was used to minimize human data entry error and to manage the telephone interviewing process. The telephone survey form is presented is Appendix D.

Newspapers. During the 17-week high-use period beginning in mid-May and ending in late-September, the river index for each monitoring station is presented daily on the weather page of the area's largest newspaper. Indexes are not reported during the remainder of the year.

The newspaper published the river index information in color, which meant that a different scale did not have to be developed to portray the river index in the newspaper. Weather staff at the newspaper simply obtained the river index information from the Web site and used it in the newspaper.

Television. The goal of the River Index Project Team was to have the river index for each monitoring station presented during weekend weather forecasts on major television stations during the 17-week high-use period. However, because of the time required to obtain the information, only one station presented the river index during the weather cast, and this was done infrequently.

Web site. The River Index Project Web site, designed and maintained by CH2M HILL, Inc., is the primary vehicle for communicating timely information to the public. For this reason, the River Index Project Team concluded that the site should:

- Be nonmechanical looking.
- Be easy to navigate.
- Contain the most important and easy to understand information up front.
- Contain detailed information for the technical user at deeper levels within the site.

The Web site was developed on a Microsoft IIS server running Windows NT using Fireworks, Cold Fusion, Cold Fusion Studio, Chart FX, ASP, and Microsoft SQL 7. It contains a summary sheet with the current index for each of the water quality monitoring stations and explains how an index is calculated. The site also contains information on the River Index Project and the Lower Great Miami River Watershed as well as general information on water quality monitoring. In addition, the site contains a page with a "Search The Index" graphing feature.

Automated sampling data are uploaded three times per day into a master Microsoft SQL database, which resides on the Web server. After the data are loaded, a stored procedure is automatically initiated within SQL that runs the most current data through the river index calculation. The updated river indexes are available immediately for viewing through the River Index Project Web site (www.riverindex.org).

Because not all of the River Index Project data are collected daily, a Web-based data entry application was developed to facilitate data entry. All data collected manually are entered into the database using the entry application. After they are entered into the database, the most recent data are used to calculate the river indexes.

Brochures and flyers. Several brochures and flyers were created with varying degrees of technical information, and distributed to the public.

Signs and banners. A River Index advertisement sign was developed and installed on several Regional Transit Authority buses that serve downtown Dayton. A large River Index banner also was developed and used at a booth during local and regional events.

Free promotion items. Pens, can koozies, and refrigerator magnets with the "happy fish" logo, River Index name, and Web site address were developed and distributed at various local and regional events.

6.3 Resources for Presenting Water Quality Information to the Public

As you begin to implement your outreach plan and develop the products selected in the plan, you want to make sure that these products present your messages and information as clearly and accurately as possible. You might want to review available resources on the Internet to help you develop your outreach products or serve as additional resource materials (e.g., fact sheet).

How Do You Present Technical Information to the Public?

Environmental topics are often technical in nature, and water quality is no exception. Nevertheless, this information can be conveyed in simple, clear terms to nonspecialists, such as the public. Principles of effective writing for the public include avoiding jargon, translating technical terms into everyday language the public can easily understand, using the active voice, keeping sentences short, and using headings and other format devices to provide a very clear, well-organized structure. You may refer to the following Web sites for more ideas about how to write clearly and effectively for a general audience:

- The National Partnership for Reinventing Government has developed a guidance document, *Writing User-Friendly Documents*, that can be found on the Internet at <www.plainlanguage.gov>.
- The Web site of the American Bar Association (www.abanet.org) has links to important online style manuals, dictionaries, and grammar primers.

As you develop communication materials for a specific audience, remember to consider what the audience members are already likely to know, what you want them to know, and what they are likely to understand. Then tailor your information accordingly. Provide only information that is valuable and interesting to the target audience. For example, environmentalists in your community might be interested in why turbidity is important to aquatic life. However, it's not likely that school children are interested in this level of detail.

When developing outreach products, be sure to consider any special needs of the target audience. For example, if your community has a substantial number of people who speak little or no English, you should prepare communication materials in their native language.

The rest of this section contains information about online resources that provide easy to understand background information that you can use in developing your own outreach projects. Some of the Web sites listed contain products, such as downloadable fact sheets, that you can use to support your education and outreach efforts.

Federal Resources

EPA's Surf Your Watershed

www.epa.gov/surf3

EPA provides this service to locate, use, and share environmental information on watersheds. One section of this site, "Locate Your Watershed," allows the user to enter the names of rivers, schools, or their zip code to learn more about the water resources in their local watershed. Users also can access the Index of Watershed Indicators (IWI) from this site. The IWI is a compilation of information on the "health" of aquatic resources in the United States. The index uses a variety of indicators that point to whether rivers, lakes, streams, wetlands, and coastal areas are "well" or "ailing."

EPA's Nonpoint Source Pointers

www.epa.gov/owow/nps/facts

This Web site features a series of fact sheets on nonpoint source pollution. Topics covered by the fact sheets include: programs and opportunities for public involvement in nonpoint source control, managing urban runoff, and managing nonpoint pollution from various sources (e.g., agriculture, boating, and households).

U.S. Department of Agriculture Natural Resources Conservation Service

www.wcc.nrcs.usda.gov/water/quality/frame/wqam

Go to this site and click on "Guidance Documents." The resources there include a simple tool to estimate water body sensitivity to nutrients, a procedure to evaluate the conditions of a stream based on visual characteristics, and information on how to design a monitoring system to observe changes in water quality associated with agricultural nonpoint source controls.

Education Resources

Project WET (Water Education for Teachers)

www.montana.edu/wwwwet

The goal of Project WET is to facilitate and promote awareness, appreciation, knowledge, and stewardship of water resources by developing and disseminating classroom-ready teaching aids and establishing state and internationally sponsored Project WET programs. This site includes a list of all the State Project WET Program Coordinators to help you locate a contact in your area.

Global Rivers Environmental Education Network (GREEN)

www.earthforce.org/green

The Global Rivers Environmental Education Network (GREEN) helps people protect the rivers, streams, and other vital water resources in their communities. This program merges hands-on, scientific learning with civic action. It contains extensive information on water quality monitoring.

Adopt-A-Watershed

www.adopt-a-watershed.org/about.htm

Adopt-A-Watershed is a K-12 school-community learning experience. Adopt-A-Watershed uses a local watershed as a living laboratory in which students engage in hands-on activities. The goal is to make science applicable and relevant to students' lives.

National Institutes for Water Resources

http://wrri.nmsu.edu/niwr/niwr.html

The National Institutes for Water Resources (NIWR) is a network of 54 research institutes throughout the United States. They conduct basic and applied research to solve water quality problems unique to their area and establish cooperative programs with local governments, state agencies, and industry.

Other Organizations

The Watershed Management Council

www.watershed.org

The Watershed Management Council is a nonprofit organization whose members represent a broad range of watershed management interests and disciplines. Membership includes professionals, students, teachers, and individuals whose interest is in promoting proper watershed management.

7. Sustaining Timely Water Quality Information

This chapter discusses how real-time water quality monitoring can be sustained over time. This is necessary to insure that the public and interested groups continue to have information on which to base decisions on how and when to use an area's water resources.

- Section 7.1 discusses using existing programs to collect real-time water quality data.
- Section 7.2 discusses where to house the database and Web server for a water quality monitoring project.
- Section 7.3 addresses public support for water quality monitoring.
- Section 7.4 discusses the water quality data that can be collected given a certain level of funding.

7.1 Building on Existing Programs

A key aspect of a water quality monitoring program is the ability to sustain the program over the long term. This can be done by building on existing programs, whenever possible, by using existing infrastructure, and by using low maintenance automated equipment to collect data. This approach reduces the funding needed to continue a water quality monitoring program and at the same time helps ensure full use of existing facilities.

River Index Project

One of the existing programs that was leveraged in the River Index Project is the program for collecting and analyzing river stage data. MCD currently maintains the existing river gauge houses throughout the Great Miami River Basin, and collects river stage data at those locations. MCD's experience and expertise were used to collect river stage data and water quality data at the six water quality monitoring stations for the River Index Project.

MCD also worked with the USGS and YSI, Inc. to retrofit existing gauge houses so that they could be used in the River Index Project. In addition, Wright State University's Institute for Environmental Quality (IEQ) in conjunction with MCD, USGS, and YSI, Inc. oversaw the field activities for this project as well as the laboratory analyses that were conducted. IEQ has extensive experience in the assessment of contamination of freshwater ecosystems.

The communication component of the River Index Project also relies on an existing program. The City of Dayton, the River Index Project partner responsible for this component, used its expertise and experience in developing the communication materials for this project and in implementing the communications component. In addition, Wright State University's Center for Urban and Public Affairs (CUPA) designed and implemented pre- and post- random telephone surveys to assess the effectiveness of the communications component for this project.

Another example of leveraging existing programs is in-kind services. Approximately 32 percent of the costs for the River Index Project was obtained through in-kind services. In-kind services also are expected to be approximately 30 percent of the annual budget to sustain the River Index Project in the future.

7.2 Housing of Database and Web Server

The database and Web server for a water quality monitoring project can be located at several locations or at one location. When deciding where to house your database and Web server, consider the advantages of one location. The benefits of one location include better administrative control, easier management, and less expense. In addition, less software and licensing agreements are needed when the database and Web server are housed at one location. One disadvantage is that redundancy has to be included at the single location. Housing the database and Web server at multiple locations provides this redundancy.

River Index Project

The River Index Project Team concluded that the database and Web server for the River Index Project should be housed physically at one location. The selected location is CH2M HILL's office in San Francisco, California. Even though the server is outside of CH2M HILL's network at that location, it is still under their direct control, connected to the Internet through a dedicated telephone line and DSL.

7.3 Public Support

Public support is critical to sustaining a water quality monitoring program. It keeps decision-makers informed of the public's level of interest in the quality of an area's rivers and streams. This knowledge is important when decisions are made on project funding. Without public support, there is little to no impetus to either initiate or continue a water quality monitoring program.

River Index Project

Several new initiatives in the greater Dayton area are aimed at reviving economic development along the river corridors. Along with the new economic focus, citizens and local organizations are demonstrating increasing interest in environmental issues, which rallies great public support for the River Index Project. Because of this, several organizations expressed an interest in supporting the River Index Project. The presence of partnering agencies such as the City of Dayton along with letters of support received from a wide variety of organizations in the area are evidence of this interest.

Sustainable Support for the River Index Project

Letters of support, including pledges of in-kind services in some cases, were received from the following:

- Five Rivers MetroParks
- League of Women Voters
- Dayton Power & Light
- General Motors Corporation
- Miami Valley Project GREEN
- Dayton Daily News
- WKEF-TV NBC 22
- Rhine McLin, Ohio State Senator
- Dixie J. Allen, Ohio State Representative
- Ohio Environmental Protection Agency
- Wright-Patterson Air Force Base
- Downtown Dayton Partnership
- Dayton Area Chamber of Commerce

Interest in the River Index Project was greatest when projects funds were obtained through the EMPACT grant. The project's strength has waned since funds have been provided by local agencies. One approach that might secure continued collection of river stage and water quality data is to incorporate the River Index Project monitoring stations into MCD's surface water monitoring program. MCD would maintain the monitoring equipment and monitoring stations and would make the data collected available to the River Index Project partners. The project partners then would communicate the data to the public through the project Web site. If this approach is not accepted, the River Index Project may not be able to continue until after another source of funding is obtained. Other water quality monitoring projects may experience similar problems in obtaining the long-term funding needed to sustain the projects.

7.4 Determining Data To Collect

Data that can be collected in a real-time water quality monitoring program depend on the available funding. When funds are limited, the critical water quality parameters for a water body should be determined, and the monitoring effort should focus on collecting data for those parameters. Any seasonal variation in the critical parameter should be considered when designing the monitoring program.

River Index Project

The parameters monitored in the River Index Project represent important aspects of water quality. While developing the list of parameters, the project team considered information such as EPA's water quality criteria, Ohio EPA's water quality criteria and biocriteria standards, peer-reviewed scientific literature, natural background conditions of the rivers and creeks, and the expense and availability of manual and automatic data collection methods.

During the first year of the River Index Project, daily real-time data were collected for ammonia-nitrogen, dissolved oxygen, flow rate, nitrate-nitrogen, pH, specific conductance, and water temperature. Data for atrazine, chlorpyrifos, *E. coli* bacteria, and PAH were collected weekly, and fish toxicity data were collected monthly. These were the initial parameters that the project team selected to describe water quality in Lower Great Miami River Watershed.

Based on the experience obtained during the first monitoring season, several changes were made in the monitoring program for the River Index Project. These changes, which were made to reduce the monitoring costs, include eliminating:

- Monitoring at the Taylorsville Station because of problems associated with the cell phone modem.
- Automated monitoring of ammonium-nitrogen and nitrate-nitrogen because of the high cost and maintenance of the probes.
- Sampling and analysis for atrazine, chlorpyrifos, and PAH because the low concentrations for these pollutants during the 2000 monitoring program did not affect the rating for the river indexes.
- Sampling and analysis for fish toxicity.

As a result of the above changes, the parameters used to calculate the river indexes in 2001 and 2002 included: dissolved oxygen, *E. coli* bacteria, flow rate, pH, specific conductance, turbidity, and water temperature. The project team concluded that the monitoring data for these parameters are adequate to describe water quality conditions at the River Index Project monitoring stations.

Appendix A: Glossary of Terms

A

Algae: Small plants that lack roots, stems, flowers, and leaves; living mainly in water and using the sun as an energy source.

Algal bloom: Rapid growth of algae on the surface of lakes, streams, or ponds; stimulated by nutrient enrichment.

Alkalinity: A measurement of water's ability to neutralize acid.

Ammonium: A nitrogen compound, NH_4, having the chemical relations of a strongly basic element like the alkali metals.

Aquifer: A soil or rock formation saturated with water.

Atrazine: An herbicide used extensively for weed control for corn, sorghum, and sugarcane, and found frequently in streams and rivers, particularly following floods and periods of heavy rain; designated a "possible human carcinogen" by EPA.

B

Basin: The geographic area drained by a stream; also referred to as Drainage Basin or Watershed.

Benthic: The environmental setting and organisms associated with the bottom of a water body.

C

Chlorpyrifos: A broad-spectrum, organophosphate insecticide used to control foliage- and soil-borne insect pests on lawns and a variety of food, feed and ornamental crops; in residential settings it is used for lawn care, termite and mosquito control, indoor foggers and pet collars.

Conductivity: A measure of the ability of water to conduct an electrical current as measured using a 1-cm cell and expressed in units of electrical conductance (i.e., Siemens - S or ohms) at 25° C. Conductivity is related to the type and concentration of ions in solution and can be used to approximate the total dissolved solids (TDS) content of water by testing its capacity to carry an electrical current; conductivity corrected to 25° C is specific conductance.

D

Dissolved Oxygen (DO): The amount of oxygen dissolved in water. Adequate concentrations of dissolved oxygen are necessary for the life of fish and other aquatic organisms and the prevention of offensive odors. Dissolved oxygen levels are considered the most important and commonly employed measurement of water quality and indicator of a water body's ability to support desirable aquatic life. Generally, proportionately higher amounts of oxygen can be dissolved in colder waters than in warmer waters.

Drainage basin: The total land area drained by a stream. A drainage basin may be composed of many small watersheds; see also Basin and Watershed.

E

E. coli **(Escherichia coli):** A bacterium of the intestines of warm-blooded organisms, including humans, that is used as an indicator of the presence of disease causing organisms.

Erosion: The wearing away of the land surface by physical and chemical processes.

Eutrophication: The process by which water bodies are enriched with nutrients (usually phosphorus and nitrogen) that generally result in excessive aquatic plant growth. Eutrophication can lead to low levels of dissolved oxygen. Natural eutrophication is the process of water body aging. Cultural eutrophication occurs when nutrients are added from agricultural runoff, sewage, or other sources.

F

Fecal coliform bacteria: The portion of the coliform group that is present in the gut or feces of warm-blooded animals. The presence of fecal coliform bacteria in water is an indication of pollution and potential human health problems.

G

Groundwater: Water in the pores and cracks in soil and rock below the land surface.

H

Habitat: The environmental setting in which an organism lives.

I-L

Inorganic compound: Any compound not containing carbon.

M

MCL (Maximum Contaminant Level): The allowable concentration of a compound in drinking water; EPA considers the properties of the compound, the known human health effects of the compound, the likely occurrence in drinking water, and the detection limit for the analytical method used to analyze a sample of drinking water when developing a MCL for a compound.

N

Nitrogen: An often limiting nutrient for plant growth in the aquatic environment. When nitrogen is present in a water body in high concentrations, algae can grow quickly, resulting in a depletion of dissolved oxygen.

NTU - Nephelometric Turbidity Units: a unit of measurement that indicates the depth that light can penetrate a water sample.

Nutrient: Any substance necessary for growth of living things.

O

Organic material: Any compound containing carbon.

P

Pesticide: A chemical agent used for the control of specific organisms, such as weeds and insects.

pH: The measurement of acidity or alkalinity on a scale of 0 - 14. A pH of 7 is neutral while a pH lower than 7 is acid and a pH higher than 7 is alkaline (basic).

Phosphorus: An essential plant nutrient that in excessive quantities can contribute to the eutrophication of water bodies.

Photosynthesis: Process by which green plants use sunlight to produce food or energy.

Point source pollution: Pollutants originating from an identifiable "point" source, such as a pipe, vent, or culvert.

Probe: A device that contains one or more sensors that collect water quality data; a probe usually is placed in a sonde.

Q

QA/QC (Quality Assurance/Quality Control): The process by which data accuracy and precision are evaluated in a scientific inquiry. In laboratory water analyses, the process often includes performing duplicate tests and testing samples that contain a known concentration of a compound.

R

Real-time data: Data that depict conditions in the present. These data may be displayed immediately after they are collected or after a short time-delay depending on the equipment used to process the data.

River corridor: Land areas with physical characteristics, such as vegetation, that show the direct influence of a body of water. Steam sides, lake borders, and marshes are typical river corridor areas.

Runoff: Water from rain, snowmelt, or irrigation that flows over the ground surface and runs into a water body.

S

Sediment: Soil, sand, and minerals deposited in a water body.

Sonde: A torpedo-shaped device placed in water to gather water quality data. Sensors that collect water quality data are placed in probes that are then placed in a sonde.

Stormwater: The water and associated material draining into streams, lakes, or sewers as the result of a storm.

Storage: The volume of water detained in a drainage basin in groundwater, channel storage, and depression storage. The terms “drainage basin storage” and “basin storage” sometimes are used to describe the volume of water in natural storage in a drainage basin.

Surface water: Waters that are exposed naturally to the atmosphere. Examples include rivers, lakes, reservoirs, ponds, streams, impoundments, seas, and estuaries.

T

Total dissolved solids (TDS): A measure of the concentration of material (mostly inorganic salts) dissolved in water. High concentrations of TDS can lead to discolored water with unpleasant tastes or odors and can sometimes affect the quality of drinking water. TDS cannot be removed by filtering.

Total suspended solids (TSS): Whole particles, such as silt, sand, or small algae or animals that are carried or suspended in the water and cause discoloration of the water. These substances can be removed from the water by a filter.

Toxicity: A measurement of how harmful a substance is to plants and animals.

Turbidity: Dissolved or suspended solids in water that make the water unclear, murky, or opaque.

U-V

Urban runoff: Water that drains from the surfaces such as roofs, paved roads, and parking lots in subdivisions.

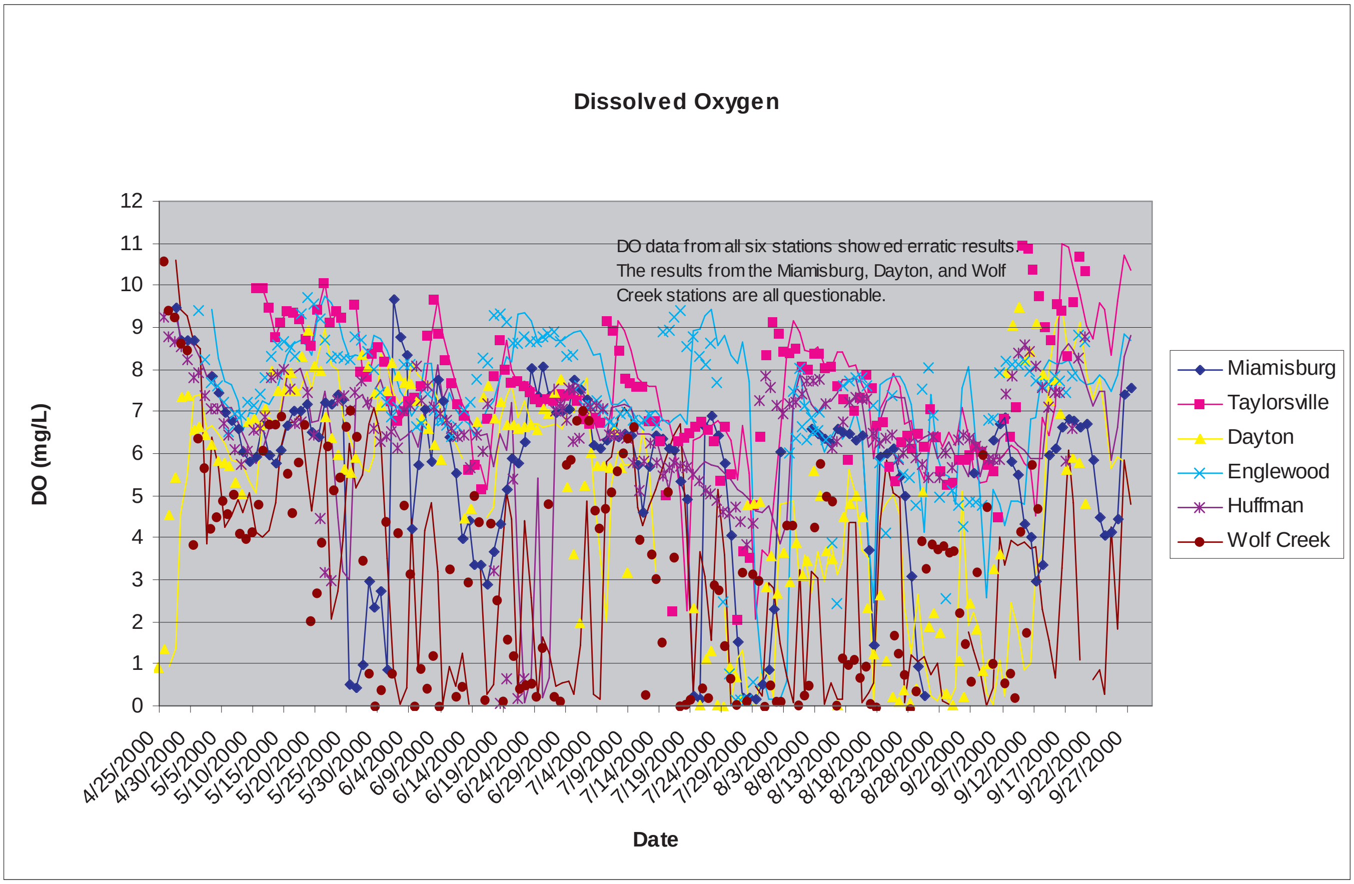
W-Z

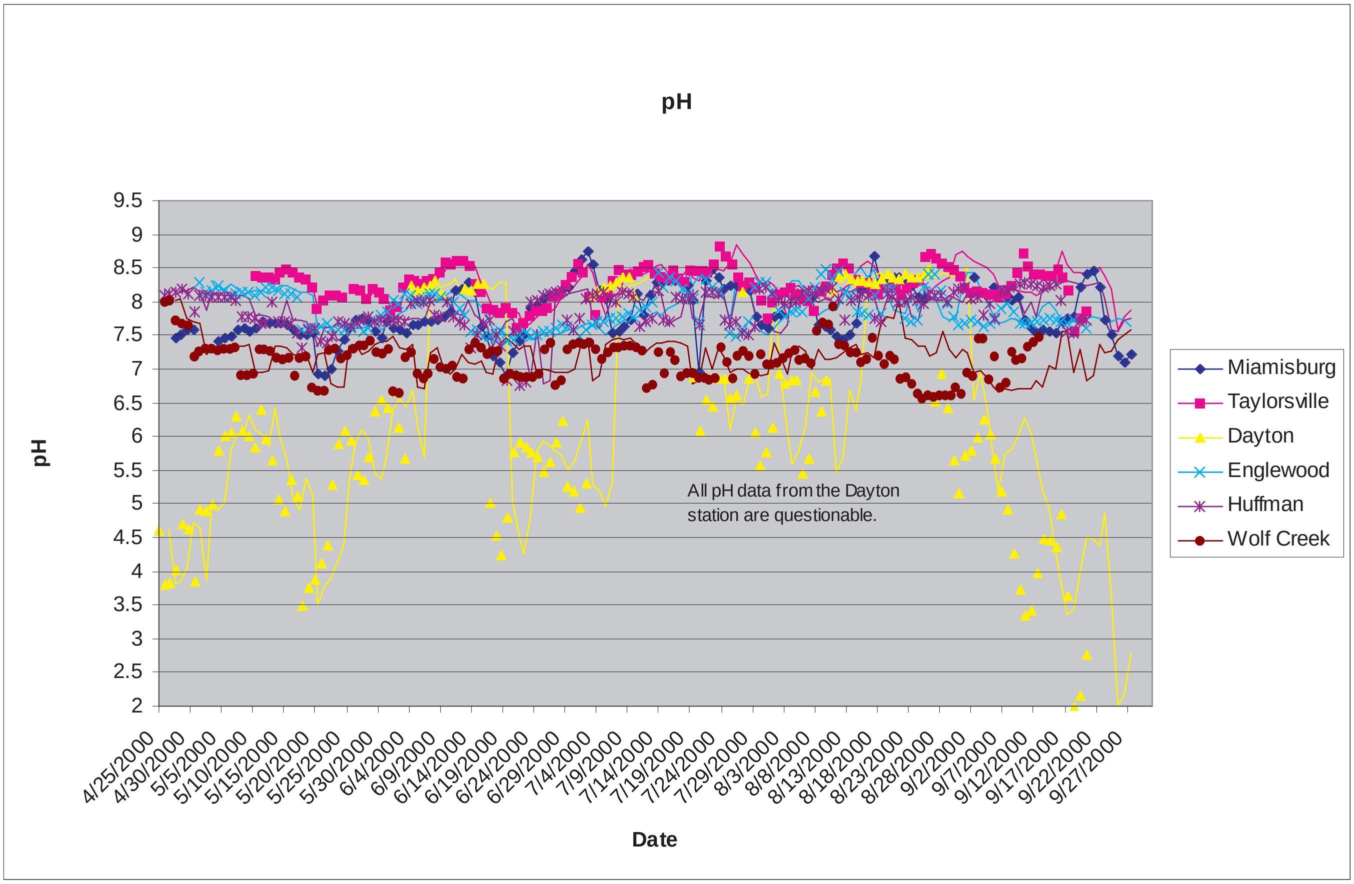
Water chemistry: The study of the chemical reactions in surface water and groundwater. The study of microbial activity and its effect on surface water and groundwater often is included in water chemistry studies.

Water quality: The condition of the water with regard to the presence or absence of pollution.

Watershed: The surface drainage area that contributes water in a stream or river at a specific location. Also see “basin” and “drainage basin.”

Appendix B: Graphs of Water Quality Data Collected in 2000




pH
9.5
9
8.5
8
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
pH
All pH data from the Dayton station are questionable.
4/25/2000
4/30/2000
5/5/2000
5/10/2000
5/15/2000
5/20/2000
5/25/2000
5/30/2000
6/4/2000
6/9/2000
6/14/2000
6/19/2000
6/24/2000
6/29/2000
7/4/2000
7/9/2000
7/14/2000
7/19/2000
7/24/2000
7/29/2000
8/3/2000
8/8/2000
8/13/2000
8/18/2000
8/23/2000
8/28/2000
9/2/2000
9/7/2000
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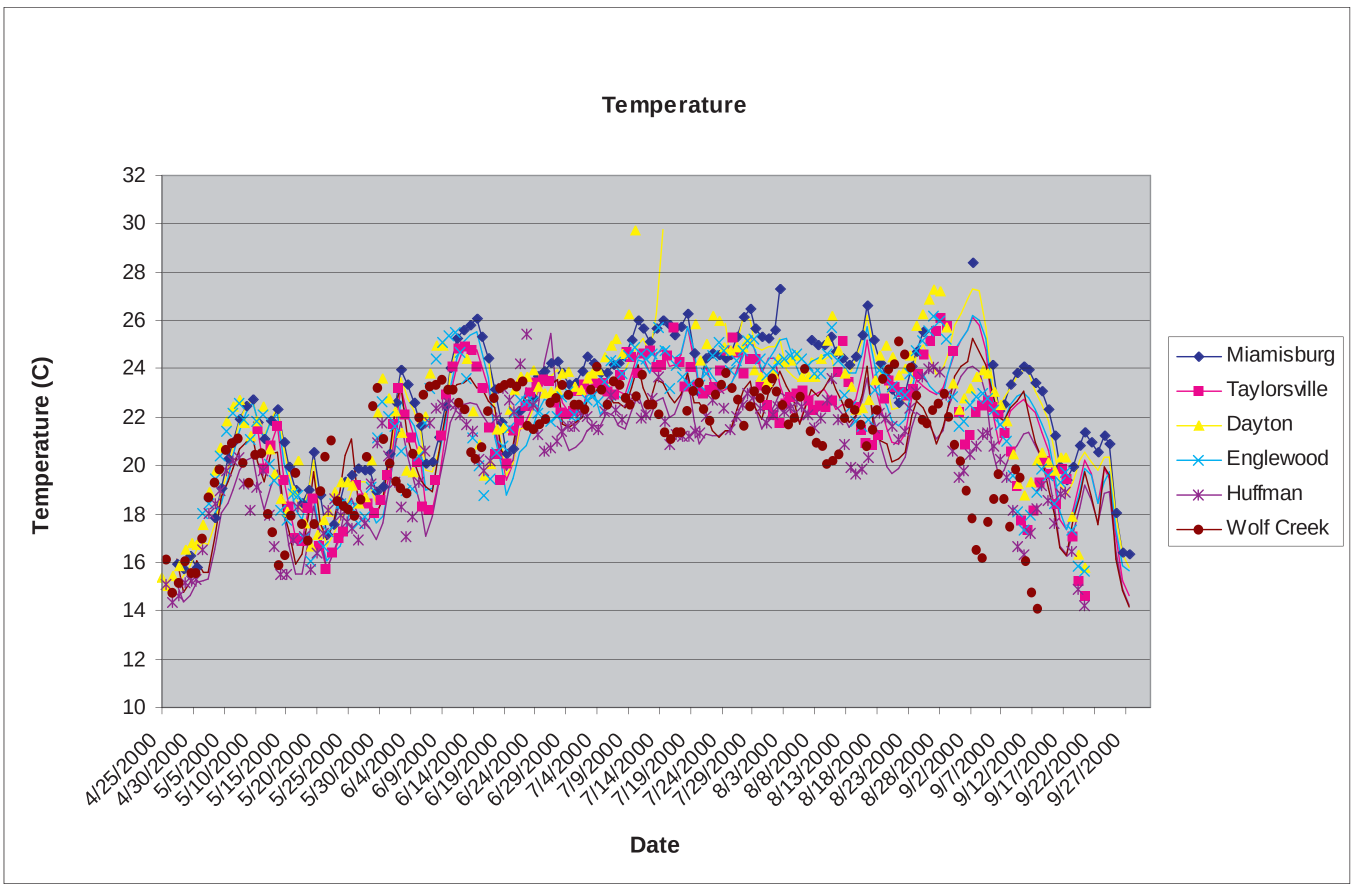
Date
Miamisburg
Taylorsville
Dayton
Englewood
Huffman
Wolf Creek


Temperature
32
30
28
26
24
22
20
18
16
14
12
10
Temperature (C)
4/25/2000
4/30/2000
5/5/2000
5/10/2000
5/15/2000
5/20/2000
5/25/2000
5/30/2000
6/4/2000
6/9/2000
6/14/2000
6/19/2000
6/24/2000
6/29/2000
7/4/2000
7/9/2000
7/14/2000
7/19/2000
7/24/2000
7/29/2000
8/3/2000
8/8/2000
8/13/2000
8/18/2000
8/23/2000
8/28/2000
9/2/2000
9/7/2000
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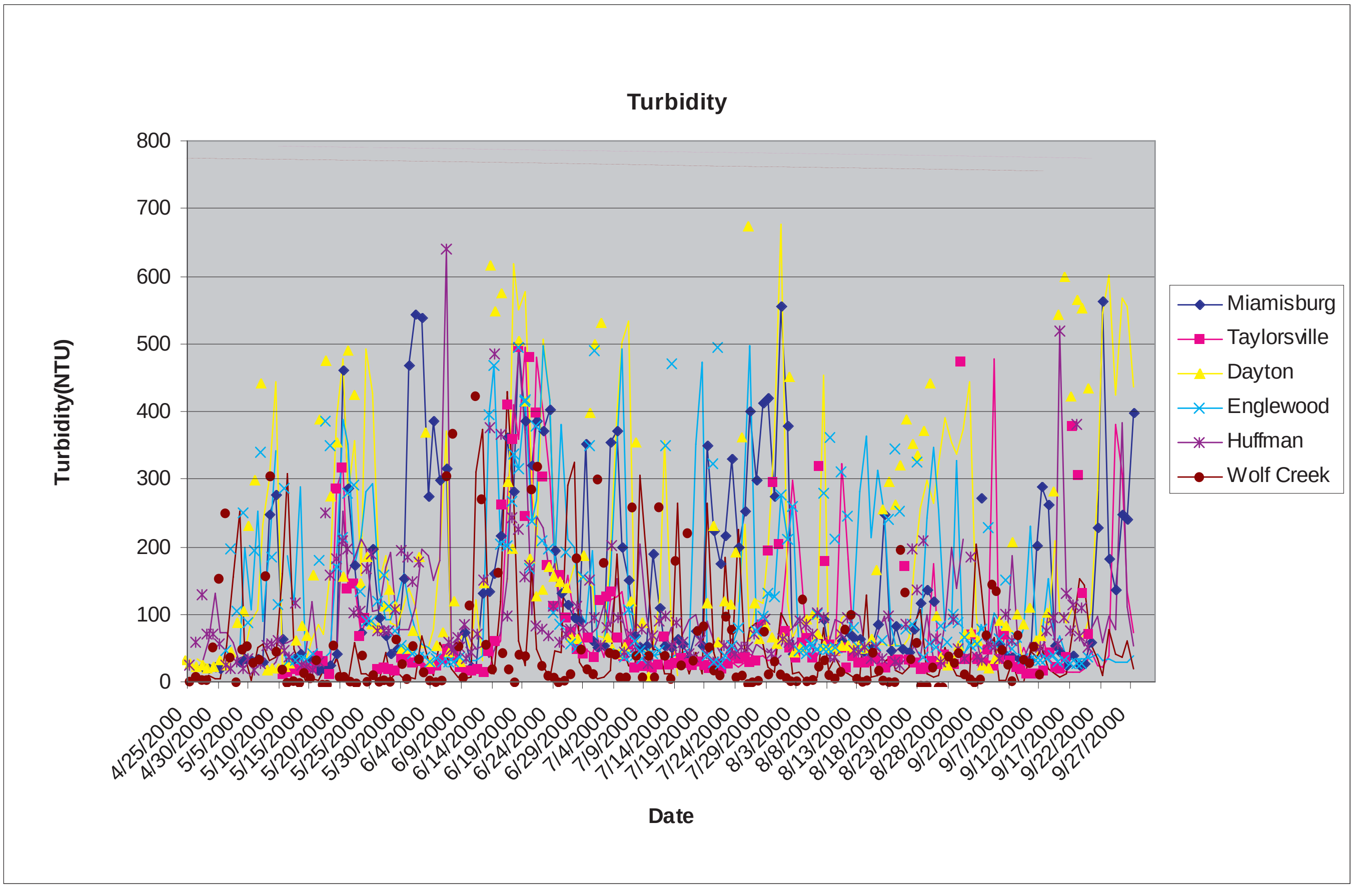
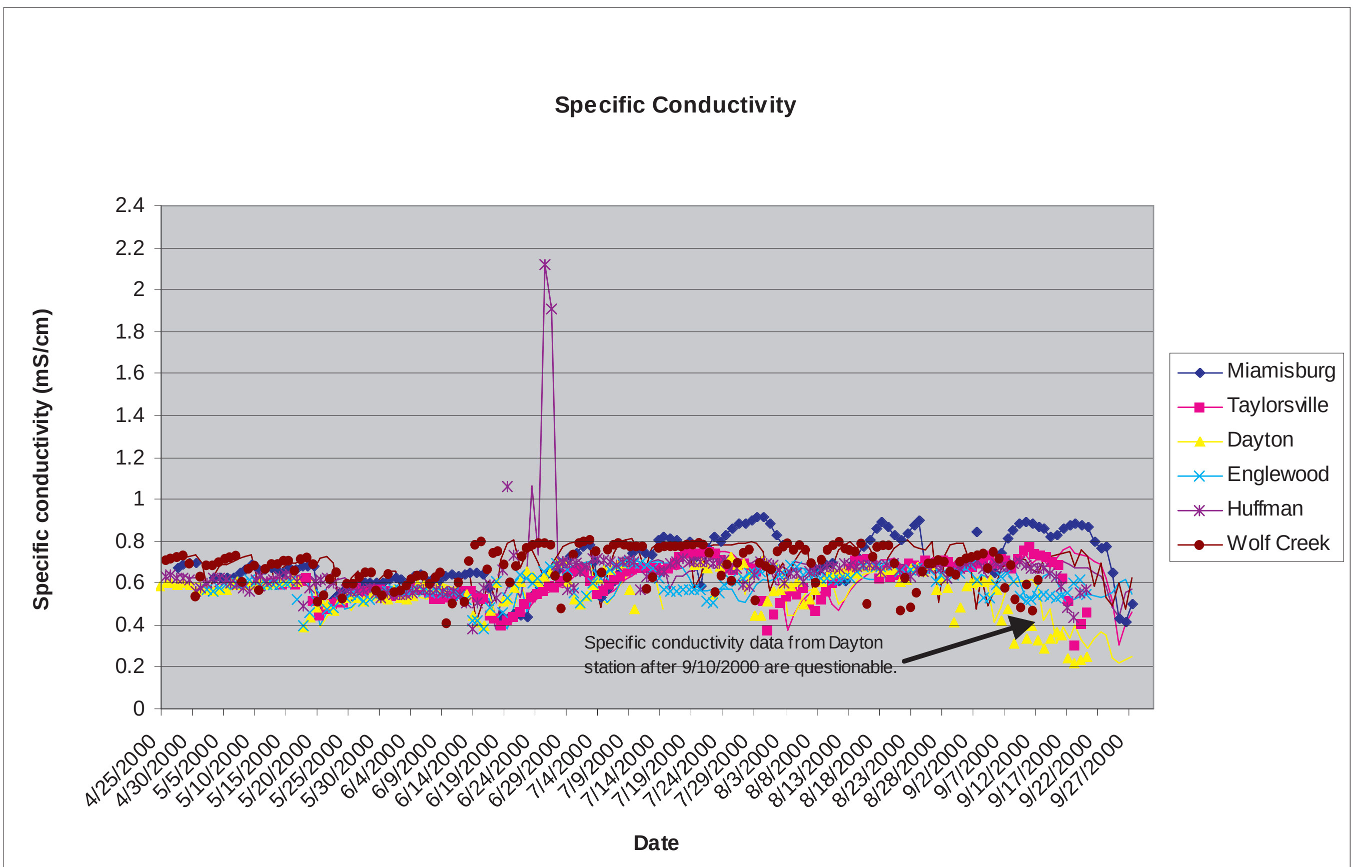
Dayton
Englewood
Huffman
Wolf Creek


Turbidity
800
700
600
500
400
300
200
100
0
Turbidity(NTU)
4/25/2000
4/30/2000
5/5/2000
5/10/2000
5/15/2000
5/20/2000
5/25/2000
5/30/2000
6/4/2000
6/9/2000
6/14/2000
6/19/2000
6/24/2000
6/29/2000
7/4/2000
7/9/2000
7/14/2000
7/19/2000
7/24/2000
7/29/2000
8/3/2000
8/8/2000
8/13/2000
8/18/2000
8/23/2000
8/28/2000
9/2/2000
9/7/2000
9/12/2000
9/17/2000
9/22/2000
9/27/2000
Date
Miamisburg
Taylorsville
Dayton
Englewood
Huffman
Wolf Creek


Specific Conductivity
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Specific conductivity (mS/cm)
Specific conductivity data from Dayton
station after 9/10/2000 are questionable.
4/25/2000
4/30/2000
5/5/2000
5/10/2000
5/15/2000
5/20/2000
5/25/2000
5/30/2000
6/4/2000
6/9/2000
6/14/2000
6/19/2000
6/24/2000
6/29/2000
7/4/2000
7/9/2000
7/14/2000
7/19/2000
7/24/2000
7/29/2000
8/3/2000
8/8/2000
8/13/2000
8/18/2000
8/23/2000
8/28/2000
9/2/2000
9/7/2000
9/12/2000
9/17/2000
9/22/2000
9/27/2000
Date
Miamisburg
Taylorsville
Dayton
Englewood
Huffman
Wolf Creek

Appendix C: Ratings for Water Quality Parameters

Parameter	Units	Range for "Excellent"	Range for "Good"	Range for "Fair"	Range for "Poor"
Ammonia- N[a]	mg/l	<0.2	0.2 - 0.6	0.6 - 0.8	>0.8
Atrazine[a]	ppb	<5[b]	5 -20[b]	20 -50b	>50[b]
Chlorpyrifos[a]					
Dissolved oxygen	mg/l	>9	5 - 9	2 - 5	<2
E. coli	#/100ml	<126	126 - 576	576 - 850	>850
Fish Toxicity[a]	% survival	>80	70 - 80	60 - 70	<60
Flow Rate	cfs	Dependent	On	Specific	Station
Nitrate - N[a]	mg/l	<0.2	0.2 - 0.6	0.6 - 0.8	<0.8
PAH[a]	ppb	<1	1 - 50	50 - 100	>100
pH (upper)	standard units	7 - 8	8 - 8.4	8.5 - 8.9	>9
pH (lower)	standard units	7 - 8	8 - 8.4	8.5 - 8.9	>9
Conductivity	MS/cm	<0.2	0.2 - 0.6	0.6 - 1	>1
Turbidity	NTU	Dependent	On	Specific	Station
Temperature (upper)	Celsius	21.11 - 31.11	31.12 - 32.78	32.79 - 34.43	>34.44
Temperature (lower)	Celsius	21.11 - 31.11	15.57 - 21.10	10.01 - 15.56	<10.00

[a] Parameter only monitored during the first monitoring season.

[b] Combined rating for atrazine and chlorpyrifos.

Appendix D: Telephone Survey Form

MIAMI VALLEY RIVER INDEX

QUESTIONNAIRE

Hello, this is ________ calling from Wright State University. I'm calling to find out what citizens from the Miami Valley region, like yourself, think about our rivers. May I speak to a person who is 18 or older and who most recently celebrated his or her birthday?

1. Yes
2. No ***(set up a time to call back)***

I know your time is valuable, so I won't keep you long. Do you have five to ten minutes to answer a few brief, but important questions for me?

1. Yes
2. No ***(thank you for your time; exit the interview)***

Do you live in Montgomery County?

1. Yes
2. No ***(thank you for your time; exit the interview)***

1. Do you know the name of the nearest river, stream, or creek to your home?

1. Yes
2. No ***(skip to Q4)***
7. Don't know
9. Refused

2. What is the name of it?

*******Do not read list******

1. Great Miami Valley River
2. Still Water River
3. Mad River
4. Wolf Creek
5. Other _______________
7. Don't know
9. Refused

3. Approximately, how far is your home from the river, stream, or creek you just named?

1. Within 1 mile
2. 1-5 miles
3. 6-10 miles
4. More than 10 miles
7. Don't know
9. Refused

1

Now, I'm going to ask you about some aspects of river water quality of the four major rivers in this area. The four rivers are the Great Miami River, Still Water River, Mad River, and Wolf Creek.

4. How concerned are you about the water quality of these four rivers? Are you:

1. Very concerned
2. Somewhat concerned
3. Somewhat not concerned, or
4. Not at all concerned
7. Don't know/No opinion
9. Refused

5. How satisfied are you with the overall quality of the rivers? Are you:

1. Very satisfied
2. Somewhat satisfied
3. Somewhat dissatisfied, or
4. Very dissatisfied
7. Don't Know/No Opinion
9. Refused

6. How would you rate the quality of the rivers? Would you say they are:

1. Excellent
2. Good
3. Fair, or
4. Poor
7. Don't Know/No Opinion
9. Refused

7. How concerned are you about how clear the water is for these four rivers? Are you:

1. Very concerned
2. Somewhat concerned
3. Somewhat not concerned, or
4. Not at all concerned
7. Don't know/No opinion
9. Refused

2

8. How satisfied are you with how clear the rivers are? Are you:

1. Very satisfied
2. Somewhat satisfied
3. Somewhat dissatisfied, or
4. Very dissatisfied
7. Don't Know/No Opinion
9. Refused

9. How would you rate the clearness of the rivers? Would you say they are:

1. Excellent
2. Good
3. Fair, or
4. Poor
7. Don't Know/No Opinion
9. Refused

10. Do you feel that fish caught from the rivers are safe for people to eat?

1. Yes
2. No (Why?______________________)
7. Don't know/No opinion
9. Refused

11. Do you have storm drains/catch basins in your neighborhood?

1. Yes
2. No ***(skip to Q12)***
7. Don't know
9. Refused

12. Where do you think the contents of these storm drains go?

1. Sewage plants
2. Rivers without treatment
3. Rivers with treatment
7. Don't know
9. Refused

I'm going to ask you some questions about the environment. Although Montgomery County has a wastewater treatment plant, not all water is treated. Rain water and other substances that enter storm drains and sewers are carried back to the rivers without treatment.

3

13. Do you think most people are aware of the fact that not all water is treated?

1. Yes
2. No
7. Don't know/No opinion
9. Refused

14. Did you know that lawn fertilizer is washed into the rivers by rain?

1. Yes
2. No
7. Don't know/No opinion
9. Refused

15. Now that you know that rain washes pollutants into the river, what do you feel are the worst pollutants affecting our four rivers?

____

____

16. Do you feel that local officials should spend money to better educate citizens, like your friends and neighbors about how our rivers become polluted?

1. Yes
2. No
7. Don't know/No opinion
9. Refused

Now, I am going to ask you about recreation opportunities involving the use of rivers and river corridors in the Miami Valley.

17. Which river do you most often visit?

1. Great Miami Valley River ***(skip to Q19)***
2. Still Water River ***(skip to Q19)***
3. Mad River ***(skip to Q19)***
4. Wolf Creek ***(skip to Q19)***
5. Other _______________ ***(skip to Q19)***
6. None
7. Don't know
9. Refused

4

18. What keeps you from going to the rivers?

1. Safety
2. Its unattractiveness
3. Nothing to do there
4. I'm Too busy
5. It is too far and/or out of the way
6. Other _______________
7. Don't know/No opinion
9. Refused

19. Have you been to a Five Rivers Metro Park or City of Dayton park in the last 12 months?

1. Yes
2. No *(skip to Q22)*
7. Don't know/No opinion
9. Refused

20. Were any of the parks you visited located along a river?

1. Yes
2. No *(skip to Q22)*
7. Don't know/No opinion
9. Refused

21. Was the river an additional feature of why you visited the park?

1. Yes
2. No
7. Don't know/No opinion
9. Refused

22. Thinking back over the last twelve months, how often have you or your family members used the river recreation opportunities offered at the rivers?

1. Never have used
2. 1 time a year or less
3. 2 – 3 times/year *(skip to Q24)*
4. 4 – 11 times/year *(skip to Q24)*
5. 1 time/month *(skip to Q24)*
6. 2 – 3 times/month *(skip to Q24)*
8. Weekly *(skip to Q24)*
10. More than once a week *(skip to Q24)*
11. Daily *(skip to Q24)*
7. Don't know/no opinion
9. Refused

5

23. What is the key reason why you use river recreation less than once a year?

____

Now I'm going to read a list of activities most people enjoy. Please tell me whether you do any of them.

24. Do you fish in the rivers?

1. Yes
2. No
7. Don't Know/No Opinion
9. Refused

25. Do you canoe on the rivers?

1. Yes
2. No
7. Don't Know/No Opinion
9. Refused

26. Do you picnic along the rivers?

1. Yes
2. No
7. Don't Know/No Opinion
9. Refused

27. Do you bike, jog, rollerblade, or walk along the rivers?

1. Yes
2. No
7. Don't Know/No Opinion
9. Refused

28. Is there anything else you enjoy in or along the rivers?

____

6

29. Overall, how would you rate the recreational opportunities available on the river corridors in the Miami Valley region?

1. Excellent
2. Good
3. Fair
4. Poor
7. Don't Know/No Opinion
9. Refused

30. How do you receive most of your information about the quality of rivers in the Miami Valley Region? Select all that apply

****Do not read list****

11. Dayton Daily News
12. Other newspaper
13. T.V. ads
14. T.V. news
15. Radio ads
16. Radio news
17. Direct mailings
18. Flyers
19. Other
20. Don't know/No opinion
21. Refused

31. Have you received information about the River Quality Index from the newspaper?

1. Yes
2. No
7. Don't know/No opinion
9. Refused

32. Have you received information about the River Quality Index from the television news?

1. Yes
2. No
7. Don't know/No opinion
9. Refused

33. Have you received information about the River Quality Index from the Internet?

1. Yes
2. No
7. Don't know/No opinion
9. Refused

34. Do you use the River Quality Index when deciding to use the river(s) for recreational activities?

1. Yes
2. No
7. Don't know/No opinion
9. Refused

35. On a scale of 1 to 10, with 1 meaning I don't enjoy at all and 10 meaning I enjoy very much, how much do you enjoy river water activities?

1	10	77	99
I don't enjoy at all ***(skip to Q33)***	I enjoy very much	Don't know	Refused

36. Most of the time, where do you go for river water activities? Do you go to:

1. Local rivers, or
2. Elsewhere other than local rivers
7. Don't know/No opinion
9. Refused

Now I have some final questions to classify this interview

37. What is your home zip code? ________________

38. What year were you born? ______________

77. Don't know
99. Refused

39. What is your marital status?

1. Married
2. Single
3. Divorced
4. Widowed
5. Other
7. Don't Know/No Opinion
9. Refused

8

40. Do you rent or own your home?

1. Rent
2. Own
7. Don't know/No opinion
9. Refused

41. If any, how many children do you have? ____________________

42. Do you consider yourself to be White, African-American, Asian or another race?

1. White
2. African-American
3. Asian, or
4. Another race
7. Don't Know/No Opinion
9. Refused

43. What is your total household income before taxes, including all members of your household and all sources of income? Is it:

1. Under $10,000
2. $10,001 - $20,000
3. $20,001 - $30,000
4. $30,001 - $40,000
5. $40,001 - $50,000
6. $50,001 - $75,000
8. Over $75,000
7. Don't Know/No Opinion
9. Refused

44. What was the last grade of school you completed?

1. Less than High School
2. High School Grad
3. Some College/Tech School
4. College Graduate
5. Post Graduate Work or Degree
7. Don't know
9. Refused

9

45. How long have you lived at your present address?

1. Less than 1 year
2. 1 year, but less than 2
3. 2 to 3 years
4. 4 to 6 years
5. 7 to 10 years
6. 11 to 15 years
8. 16 years plus
7. Don't know
9. Refused

46. Are you:

1. Male
2. Female

47. Can I confirm that I reached you at:

1. Confirmed
2. Not confirmed

48. Can I ask your phone number? _____________

Those are all of the questions I have for you today I really appreciate your taking the time to talk with me. Do you have any additional comments or questions?

Thank you, good bye

10

United States
Environmenta Protection
Agency

National Risk Management
Research Laboratory
Office of Research and Development
Cincinnati, OH 45268

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