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NATIONAL WATER-QUALITY ASSESSMENT PROGRAM

Great and Little Miami River Basins

MAJOR WATER-QUALITY ISSUES IN THE Great and Little Miami River Basins

Implementation of a National Water Quality Assessment (NAWQA) Program study in the The Great and Little Miami River Basins area will increase scientific understanding of natural processes and human activities that affect the quality of water in streams and aquifers. This information will benefit water-resource managers that need, but often lack, the data required to implement effective water-quality management actions and evaluate long-term changes in water quality.

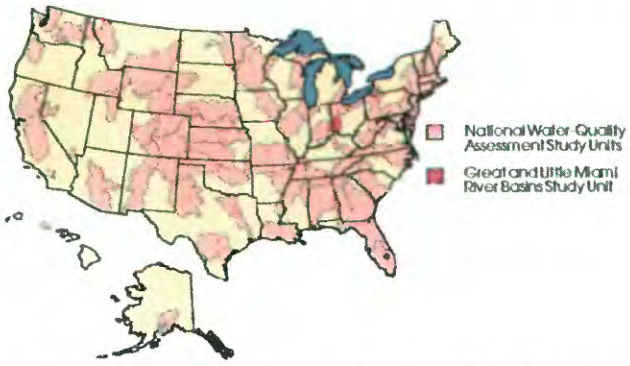
Figure Caption: Blue sucker, one of Ohio's rarest and most endangered fish species, has recently been identified in both the Little Miami and Great Miami Rivers. The occurrence of this pollution-sensitive species indicates improving stream quality in both watersheds. (Photo courtesy of Ohio Environmental Protection Agency)

Water quality has improved significantly in the Great and Little Miami River Basins over the past few decades because of improvements in the treatment of municipal and industrial wastes. However, the effects of industrialization and urbanization on the quality of rivers and ground-water resources remain a priority concern of water-resource managers and planners, state and local governments, and citizen groups. Some of these effects relate to nonpoint sources of contaminants and are the subject of ongoing research and watershed management projects such as the Lower Great Miami Watershed Enhancement Program, the Little Miami Partnership, the Stillwater Watershed Project, Indian Lake Watershed Project, and the Miami Conservancy District's Groundwater 2000 Program. Water resource managers in the Great and Little Miami River Basins area are currently addressing the following water-quality issues:

- *Contamination of the sole-source Miami Valley aquifer by synthetic organic chemicals, trace elements, and radionuclides.*
- *Degradation of surface- and ground-water quality by urban and agricultural sources of fertilizers and pesticides.*
- *Assessing the relative importance of point and nonpoint sources to contaminant loads in the Great and Little Miami Rivers.*
- *Habitat degradation and decreases in stream biodiversity as a result of urbanization.*
- *Occurrence of water-borne pathogens in streams and shallow ground water in rural and urban land-use settings.*
- *Effect of septic systems and combined sewer overflows on surface- and shallow ground-water quality.*
- *Disruption and fragmentation of stream habitats by low dams and impoundments and their effects on fish and benthic invertebrate communities.*

WHAT IS THE NAWQA PROGRAM?

During the past 25 years, government and industry have made large financial investments aimed at improving water quality across the Nation. Although major progress has been made, many water-quality issues remain. To address the need for consistent and scientifically sound information for managing the Nation's water resources, the U.S. Geological Survey began a full-scale National Water Quality Assessment (NAWQA) Program in 1991. The overall goals of the NAWQA Program are to (1) describe current water-quality conditions for a large part of the Nation's freshwater streams and aquifers (water-bearing sediments and rocks), (2) describe how water quality is changing over time, and (3) improve our understanding of the principal natural and human factors affecting water quality.



Assessing the quality of water in every location of the Nation would not be practical; therefore, NAWQA Program studies are planned within a set of areas called study units. These study units are composed of 59 important river and aquifer systems that represent the diverse geography, water resources, and land and water uses of the Nation. The Great and Little Miami River Basins constitute one such study unit. The study unit includes (1) three important tributaries of the Ohio River, (2) largely agricultural watersheds affected by two major metropolitan areas and rapid urbanization, and, (3) a Nationally important sole-source aquifer that is heavily used for public water supply. Study-unit activities in the Great and Little Miami River Basins began in 1997.

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STUDY UNIT DESCRIPTION

Surface Water. The Great and Little Miami River Basins drain approximately 7,350 mi^2 (square miles) of southwestern Ohio (80 percent) and southeastern Indiana (20 percent). Principal streams include the Great Miami River (4,124 mi^2), and Little Miami River (1,756 mi^2) in Ohio and the Whitewater River (1,474 mi^2) in Indiana. Drainage is toward the south-southwest; all streams in the watershed ultimately drain into the Ohio River. Major tributaries of the Great Miami River include the Stillwater River (676 mi^2) and the Mad River (657 mi^2), both of which join the Great Miami River at Dayton, Ohio.

Rivers originate in the upper reaches of the basins in agricultural areas consisting of rolling hills and steep-walled but shallow valleys. Large streams are usually underlain by buried valleys filled with sand and gravel deposited by glacial meltwaters. A significant component of baseflow in some streams is provided by ground-water discharge from glacial and shallow bedrock aquifers. The area contains many lakes and small reservoirs that are used for flood control, water supply, and recreation. The largest water bodies in the study unit are Brookville Lake (8.2 mi^2) near Brookville, Indiana and Indian Lake (8.0 mi^2) near Russells Point, Ohio; Indian Lake was constructed in 1851 to supply water to the Miami-Erie Canal System.

East Fork Little Miami River near Batavia, Ohio. Physical habitat of many reaches of major streams in the study area is of good to exceptional quality, consisting of riffle/run/pool sequences associated with forested riparian corridors (Photo courtesy of Ohio Environmental Protection Agency)

Population and Land Use. An estimated 2.8 million people lived in the study unit in 1995. Major cities (population greater than 100,000) in the study unit are Cincinnati and Dayton, Ohio. Approximately 79 percent of the total land area is used for agricultural activities, primarily row-crop production of corn, soybeans, and alfalfa. Residential, commercial, and industrial land uses comprise 13 percent of the area whereas the remaining area consists of forests (7 percent) and water bodies or wetlands (1 percent). Major industries, which are concentrated along the Dayton- Cincinnati corridor, produce automobile parts, business and computer equipment, chemicals, household goods, paper products, and processed foods and beverages. Streams and lakes in the study unit are heavily used by residents for boating, fishing, and other outdoor recreation.

Largemouth bass from Great Miami River near downtown Dayton. High-quality streams contribute to a diverse sports fishery used by many residents (Photo courtesy of Ohio Environmental Protection Agency)

Physiography and Climate. The Great and Little Miami River Basins are in the Till Plains section of the Central Lowlands Physiographic Province. Glaciation and subsequent erosion produced a flat to gently rolling land surface that is cut by steep-walled river valleys of low to moderate relief. In the southernmost areas, glacial cover is thin and erosion of the less resistant shales has produced a more dissected, hilly terrain of higher stream density. The regional topographic gradient is from north to south; altitudes in the study unit range from 1,550 feet above sea level near the headwaters of the Mad River to 450 feet along the Ohio River at Cincinnati. Average annual precipitation in the study unit ranges from 35 to 43 inches and increases towards the south; about one-third of the precipitation becomes surface runoff. Average annual air temperature ranges from 51^0 Fahrenheit in the north to 54^0 in the south. Average snowfall in the study unit is 20 to 30 inches per year.

Ground Water. The principal aquifer in the study unit is a complex, buried-valley system that underlies the Great and Little Miami River valleys. This aquifer has been designated a sole-source aquifer by the U.S. Environmental Protection Agency and is the principal source of drinking water for 1.6 million people. The aquifer is found in bedrock valleys incised into uplifted Silurian and Ordovician bedrock by a tributary of the Teays preglacial drainage system. These valleys were buried by sediments deposited by advancing glaciers (tills) or filled in by coarse-grained sediments deposited by glacial meltwaters (outwash). Depth to water in most parts of the aquifer is less than 20 ft; supply wells completed in the sand and gravel deposits commonly yield more than 1,000 gallons per minute. At several locations, high pumping rates are maintained by induced infiltration of river water or by artificial recharge lagoons. In the northern part of the study unit, Silurian limestones and dolomites form a carbonate bedrock aquifer that is used for domestic and small industrial supply. Wells completed in the carbonate aquifer typically yield between 10 and 100 gallons per minute. In the southern part of the study unit, the shale-rich Ordovician bedrock is poorly permeable and is used for domestic-water supply only where other sources of water are not available.

Confluence of Mad and Great Miami Rivers at Dayton, Ohio. Despite being at the confluence of three major streams, Dayton relies almost entirely on ground water from a sole-source aquifer for municipal and industrial water supply (Photo courtesy of Joel Kane Aerial Photography, Dayton, Ohio).

Water Supply. In 1995, an estimated 745 million gallons per day was withdrawn from streams and aquifers in the Great and Little Miami River Basins. Of this, approximately 48 percent was withdrawn from surface-water bodies whereas the remaining

Activity	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Plan and review														
Intensive data collection														
Reports														
Low-intensity monitoring														

52 percent was derived from ground-water sources. Excluding withdrawals from the Ohio River, almost 92 percent of the water used for public, domestic, commercial, and industrial supply was derived from ground-water sources. Most of this ground water is pumped from the buried-valley aquifer underlying stream valleys associated with the Great and Little Miami Rivers.

Although rivers in the Great and Little Miami River Basins greatly influenced the early development of the region's economy, it has been the availability of abundant ground-water supplies that has spurred rapid growth and development in the region since the beginning of this century. Another important factor affecting growth and development is the relatively unspoiled nature of the streams and rivers. The Little Miami River (a State and National Scenic River), the upper Great Miami River and its tributaries, and the Whitewater River in Indiana largely contain high-quality warmwater habitats with biologically diverse fish and wildlife populations.

Study-area map.

SCHEDULE OF STUDY ACTIVITIES

The Great and Little Miami Basins study is one of a set of NAWQA Program studies that will start in 1996 and 1997. Planning, study design, and analysis of existing data will occur in the first two years of the study. After the 2-year planning period, ground-water, surface-water, and biological data are collected intensively for 3 years (termed the high-intensity phase). A low-intensity phase follows for 6 years, where water quality is monitored at a selected number of sites and areas assessed during the high-intensity phase. The second cycle of the study begins in 2007. This combination of high- and low-intensity monitoring phases allows the NAWQA Program to examine trends in water quality over time.

During the planning period, existing data and results from previous studies are reviewed to help understand the primary physical, chemical, and biological factors that affect water quality in the study unit and to identify gaps in the current data. Descriptions of how land use and land cover, soils, geology, physiography, climate, and drainage characteristics may influence water quality are to be included in technical and non-technical reports. These reviews, along with field checks of existing monitoring stations and candidate sampling sites, and field reconnaissance data are used to design a sampling program for the study unit.

During the high-intensity phase, new water-quality and biological data collections are done for selected areas at both local and regional scales to describe water-quality conditions across the study unit. Measurements are made to determine water chemistry in streams and aquifers; the quantity of suspended sediment and quality of bottom sediments in streams; the variety and number of fish, benthic invertebrates, and algae in streams; and contaminants in fish tissues. Individual streams and aquifers, particular chemical constituents, and biological species are selected for sampling to represent the primary water resources and water-quality concerns for both the study unit and the Nation. The low-intensity phase will continue monitoring at selected sites so that long-term trends can be identified. A series of technical and non-technical reports describing results of high and low-intensity phase are planned.

ASSESSING WATER QUALITY IN THE GREAT AND LITTLE MIAMI RIVER BASINS STUDY UNIT

The NAWQA Program is designed to assess the status of and trends in the quality of the Nation's ground- and surface-water resources and to link the status and trends with an understanding of the natural and human factors that affect the quality of water. The design of the Program balances the unique assessment requirements of individual study units with a nationally consistent design and data-collection structure that incorporates a multiscale, interdisciplinary approach. Surface- and ground-water studies are done at local scales (a few square miles to hundreds of square miles) and regional scales (thousands of square miles) to aid in the understanding of water-quality conditions and issues within a study unit.

An Occurrence and Distribution Assessment is the largest and most important component of the first intensive study phase in each study unit. The goal of the Occurrence and Distribution Assessment is to characterize, in a nationally consistent manner, the broad-scale geographic and seasonal distributions of water quality in relation to major contaminant sources and background conditions. The following discussions describe the typical surface- and ground-water monitoring components of the Occurrence and Distribution Assessment. The Great and Little Miami River Basins NAWQA study will have a similar design.

Surface Water. The national study design for surface water focuses on water-quality conditions in streams using three interrelated components—water-column studies, bed-sediment and fish-tissue studies, and ecological studies. Water-column studies monitor physical and chemical characteristics, which include suspended sediment, major ions, nutrients, organic carbon, and dissolved pesticides, and their relation to hydrologic conditions, sources, and transport. Most surface water is monitored at sites termed either basic fixed sites or intensive fixed sites, according to the frequency of the sampling. The sampling sites are selected to determine the quality of water in relation to important environmental settings in the study unit. Most NAWQA study units have 8–10 basic fixed and 2–3 intensive fixed sites. Basic fixed sites are sampled monthly and at high-flows for 2 years of the 3-year high-intensity phase. The intensive fixed sites are monitored more frequently (as often as weekly during key periods) for at least 1 year, to characterize seasonal variations of water quality. Basic or intensive fixed sites can be either indicator or integrator sites. Indicator sites represent relatively homogeneous, small basins (typically less than 100 mi^2) associated with specific environmental settings, such as a particular land use that substantially affects water quality in the study unit. Integrator sites are established at downstream points in large, relatively heterogeneous drainage basins (thousands of square miles) having multiple land-use settings. Indicator sites are typically placed within the drainage basins of integrator sites. Water samples also are collected as part of synoptic (short-term) investigations of specific water-quality conditions or issues during a specific hydrologic period (for example during low streamflow) to provide greater spatial coverage and to allow investigators to assess whether the basic fixed or intensive fixed sites are representative of streams throughout the study unit. Bed-sediment and fish-tissue studies assess trace elements and hydrophobic organic contaminants at 15–30 sites to determine their occurrence and distribution in the study unit.

Ecological studies evaluate the relations among physical, chemical, and biological characteristics of streams. Aquatic biological communities at the basic and intensive fixed sites are surveyed during the 3 years of the high-intensity-sampling phase. These surveys are made along a delineated stream reach and include a habitat assessment of the site and annual surveys of the fish, algal, and benthic invertebrate communities. Additionally, ecological sampling may be integrated with surface-water synoptic studies to provide greater spatial coverage and to assess whether the biological communities at basic and intensive fixed sites are representative of streams throughout the study unit.

Ground Water. The national study design for ground water focuses on water-quality conditions in major aquifers, with emphasis on recently recharged ground water associated with present and recent human activities, by using study-unit surveys, land-use studies, and flowpath studies. Ground-water samples are analyzed for major ions, nutrients, pesticides, volatile organic compounds, and trace elements. Study-unit surveys are used to assess the water quality of the major aquifer systems of each study unit. About 20–30 existing wells are randomly selected to be sampled in each of 2–3 aquifer subunits. Land-use studies focus on recently recharged shallow aquifer systems so that the influences of land-use practices and natural conditions can be assessed. Typically, about 20–30 new observation wells are randomly located within each land use and aquifer type. Results from the 2–3 land-use studies typically performed can be compared with results from the general study-unit survey to determine the effect of particular land uses on ground-water quality. Flowpath studies use transects and groups of clustered, multilevel observation wells to examine specific relations among land-use practices; ground-water flow; contaminant occurrence and transport; and interactions between ground water and surface water.

COMMUNICATION AND COORDINATION

Communication and coordination between the U.S. Geological Survey and other scientific and land- and water-management organizations are critical components of the NAWQA Program. Each study-unit investigation maintains a liaison committee consisting of representatives from Federal, State, and local agencies, universities, the private sector, watershed organizations, and those who have water-resource responsibilities and interests. Activities include the exchange of information about regional and local water-quality issues, identification of sources of data and information, assistance in the design and scope of study products, and the review of study planning documents and reports. The Great and Little Miami River Basins liaison committee will be formed in 1997.

SUGGESTIONS FOR FURTHER READING

Gilliom, R.J., Alley, W.M., and Gurtz, M.E.,1995, Design of the National Water-Quality Assessment Program: Occurrence and distribution of water-quality conditions: U.S. Geological Survey Circular 1112, 33 p.

Leahy, P.P., Rosenshein, J.S., and Knopman, D.S., 1990, Implementation plan for the Nation Water-Quality Assessment Program: U. S. Geological Survey Open-File Report 90-174, 10 p.

FOR MORE INFORMATION

Information on technical reports and hydrologic data related to the NAWQA Program can be obtained from:

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