

Current Water-Resources Activities in Ohio, 1993-94

Compiled by S.M. Hindall and R.P. Frehs

United States Geological Survey
Open-File Report 93-458



Columbus, Ohio
1993

U.S. DEPARTMENT OF THE INTERIOR
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U.S. GEOLOGICAL SURVEY
ROBERT M. HIRSCH, Acting, Director



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FOREWORD

The U.S. Geological Survey, Water Resources Division, has been active in water-resources investigations in Ohio for more than 70 years. During that time, volumes of data have been collected, numerous investigations have been completed, and more than 150 reports have been published on various aspects of Ohio's water resources. Many changes have taken place in the Geological Survey and the Water Resources Division since its formation in 1879, but our mission remains firm—*"to provide the hydrologic information and understanding needed for the optimum utilization and management of the Nation's water resources for the overall benefit of the people of the United States."* As the water resources of Ohio become increasingly important to its economy and quality of life, the Ohio District's role as an unbiased water-resources investigation and data-collection agency also becomes increasingly important.

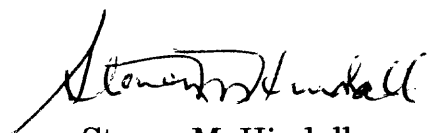
Over the years, the District's programs have reflected the needs of the people and the priority issues of the times. We have evolved from the early days of hydrologic data collection and ground-water and surface-water reconnaissance studies into flood and low-flow studies, projects associated with energy production, and, finally, into studies relating to hazardous-waste disposal and ground-water contamination. The District continues to move into new areas of water resources previously not studied by our scientists. Those areas are: (1) agricultural contamination of ground water and surface water, (2) bridge scour, and (3) microbiological and bacterial research and assessments. Through all of this, the District has continued to expend a considerable amount of its resources in collecting and disseminating basic data on surface water, ground water, and sediment.

Our present program centers on five areas: basic hydrologic data collection and geohydrological, environmental, hydrological, water-quality, and ecological studies. Of the five, the basic hydrologic data-collection effort is the largest in terms of employees involved, whereas the environmental studies is the largest in terms of funds expended. In all of the above areas, chemical quality of the resources is an important factor. This is evidenced by the rapid growth of new projects in the area of water quality and aquatic biology and microbiology as it relates to ground-water and surface-water systems. In fact, water quality will most likely become the overriding concern in all water-resources investigations well into the 1990's and beyond. The use of computers and digital modeling will continue to be an integral part of all investigations.

The Ohio District has become involved with the U.S. Department of Defense at Wright-Patterson Air Force Base in water-resources data-collection assessments and applied research. We are also in the process of expanding our programs with the U.S. Environmental Protection Agency with regard to their Superfund site activities. We look forward to the U.S. Geological Survey's active role in these activities and to a continuing relationship with state, county, local, and other Federal agencies in studying and addressing water-resources concerns and issues in Ohio.

Nationally, the Water Resources Division has recently embarked on a far-reaching activity—the implementation of a full-scale National Water-Quality Assessment program (NAWQA). The goals of the NAWQA program are to provide a nationally consistent description of current water-quality conditions for a large part of the Nation's water resources; to define long-term trends (or lack of trends) in water quality; and to identify, describe, and explain the major factors that affect observed water-quality conditions and trends. Of the 60 proposed study units, 20 began in Federal fiscal year 1991, and an additional 20 will follow in fiscal year 1994. In Ohio the Lake St. Clair drainage has been selected to begin in 1994 and the Great Miami/Little Miami drainage for 1997.

The Water Resources Division completed a divisionwide reorganization designed to increase Districts' abilities to meet the needs of cooperating agencies and respond to changing water-resources issues. A major component of the reorganization was the formation of 19 program areas within the four existing regions. The Ohio District was joined by the Kentucky and Indiana Districts to form the Ohio Program Area. Slight modifications of the boundaries of the existing four regions were made. The Northeastern Region (Ohio's region) was divided into five areas. The individual district structure or the way in which the districts deal with cooperating agencies has not and will not change. It is hoped that the subregional reorganization will result in increased efficiency of operation and improvement of the quality of technical programs.



Steven M. Hindall,
District Chief

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CURRENT WATER-RESOURCES ACTIVITIES IN OHIO, 1993-94

Compiled by S. M. Hindall and R. P. Frehs

ABSTRACT

The mission of the U.S. Geological Survey's Water Resources Division is to provide the hydrologic information and understanding needed for the optimum utilization and management of the Nation's water resources for the overall benefit of the United States. This report summarizes the Division's program in Ohio in 1993-94.

The work of the Ohio District is carried out through the district office in Columbus and a field office in New Philadelphia. Collection of the basic data needed for continuing determination and evaluation of the quantity, quality, and use of Ohio's water resources is the responsibility of the district's Hydrologic Surveillance and Information Management Section. The Hydrologic Investigation and Program Development Section conducts analytical and interpretive water-resources appraisals describing the occurrence, availability, physical, chemical, and biological characteristics of surface water and precipitation. The Geohydrologic and Environmental Investigation Section conducts similar appraisals associated with ground water. In addition, the U.S. Department Of Defense and U.S. Environmental Protection Agency programs are the responsibility of this section.

In addition to introductory material describing the structure of the Ohio District, information is presented on current projects, sites at which basic surface-water and ground-water data are collected, and reports on Ohio's water resources published by the U.S. Geological Survey and cooperating agencies.

INTRODUCTION

The U.S. Geological Survey was established by an act of Congress on March 3, 1879, to provide a permanent Federal agency to conduct the systematic and scientific *"classification of the public lands, and examination of the geological structure, mineral resources, and products of national domain."* An integral part of that original mission includes publishing and disseminating the earth-science information needed to understand, to plan the use of, and to manage the Nation's energy, land, mineral, and water resources.

Since 1879, the research and fact-finding role of the Survey has evolved to meet the changing needs of the Nation it serves. As part of that evolution, the Survey has become the Federal government's largest earth-science research agency, the Nation's largest civilian map-making agency, the primary source of data on the Nation's surface-water and ground-water resources, and the employer of the largest number of professional earth scientists.

Today's programs serve a diversity of needs and users. Programs include:

- **Conducting detailed assessments of energy and mineral potential of the Nation's land and offshore areas.**
- **Investigating and issuing warnings of earthquakes, volcanic eruptions, landslides, and other geologic and hydrologic hazards.**
- **Conducting research on the geologic structure of the Nation.**
- **Studying the geologic features, structure, processes, and history of the other planets of our solar system.**
- **Conducting topographic surveys of the Nation and preparing topographic and thematic maps and related cartographic products.**
- **Developing and producing digital cartographic data bases and products.**
- **Collecting data on a routine basis to determine the quantity, quality, and use of surface water and ground water.**
- **Conducting water-resources appraisals to describe the consequences of alternative plans for developing land and water resources.**
- **Conducting research in hydraulics and hydrology, and coordinating all Federal water-data acquisition.**
- **Using remotely sensed data to develop new cartographic, geologic, and hydrologic research techniques for natural-resources planning and management.**
- **Providing earth-science information through an extensive publications program and a network of public-access points.**

Along with its continuing commitment to meet the growing and changing earth-science needs of the Nation, the Survey remains dedicated to its original mission to collect, analyze, interpret, publish, and disseminate information about the natural resources of the Nation—providing *“Earth Science in the Public Service.”*

Basic Mission and Program of the Water Resources Division

The mission of the Water Resources Division is to provide the hydrologic information and understanding needed for the optimum utilization and management of the Nation's water resources for the overall benefit of the people of the United States.

This is accomplished, in large part, through cooperation with other Federal and non-Federal agencies by:

- **Collecting on a systematic basis data needed for the continuing determination and evaluation of the quantity, quality, and use of the Nation's water resources.**
- **Conducting analytical and interpretive water-resources appraisals describing the occurrence, availability, and the physical, chemical, and biological characteristics of surface water and ground water.**
- **Conducting supportive basic and problem-oriented research in hydraulics, hydrology, and related fields of science to improve the scientific basis for investigations and measurement techniques and to understand hydrologic systems sufficiently well to quantitatively predict their response to stress, either natural or man made.**
- **Disseminating the water data and the results of these investigations and research through reports, maps, computerized information services, and other forms of public releases.**
- **Coordinating the activities of Federal agencies in the acquisition of water data for streams, lakes, reservoirs, estuaries, and ground waters.**
- **Providing scientific and technical assistance in hydrologic fields to other Federal, State, and local agencies, to licensees of the Federal Power Commission, and to international agencies on behalf of the Department of State.**
- **Acquiring, developing, and disseminating information on water-related natural hazards such as droughts, floods, landslides, land subsidence, mudflows, and volcanoes.**
- **Administering the provisions of the Water Resources Research Act of 1984, which include the State Water Resources Research Institutes and the Research Grants and Contracts Programs.**
- **Supporting the provisions of the National Environmental Policy Act of 1969 and managing the Geological Survey conduct of natural-resources surveys in response to the Comprehensive Environmental Response, Compensation, and Liability Act (Superfund Act) of 1980.**

Operation of the Ohio District

The Ohio District is part of the U.S. Department of the Interior, Geological Survey, Water Resources Division. There are a total of 47 districts: each State is a district except for four States (Delaware, Rhode Island, New Hampshire, and Vermont), which are parts of other districts. Recent Water Resources Division reorganization further grouped the 47 districts into 13 areas within 4 major regions. Ohio, Indiana, and Kentucky constitute the Ohio Valley Program Area.

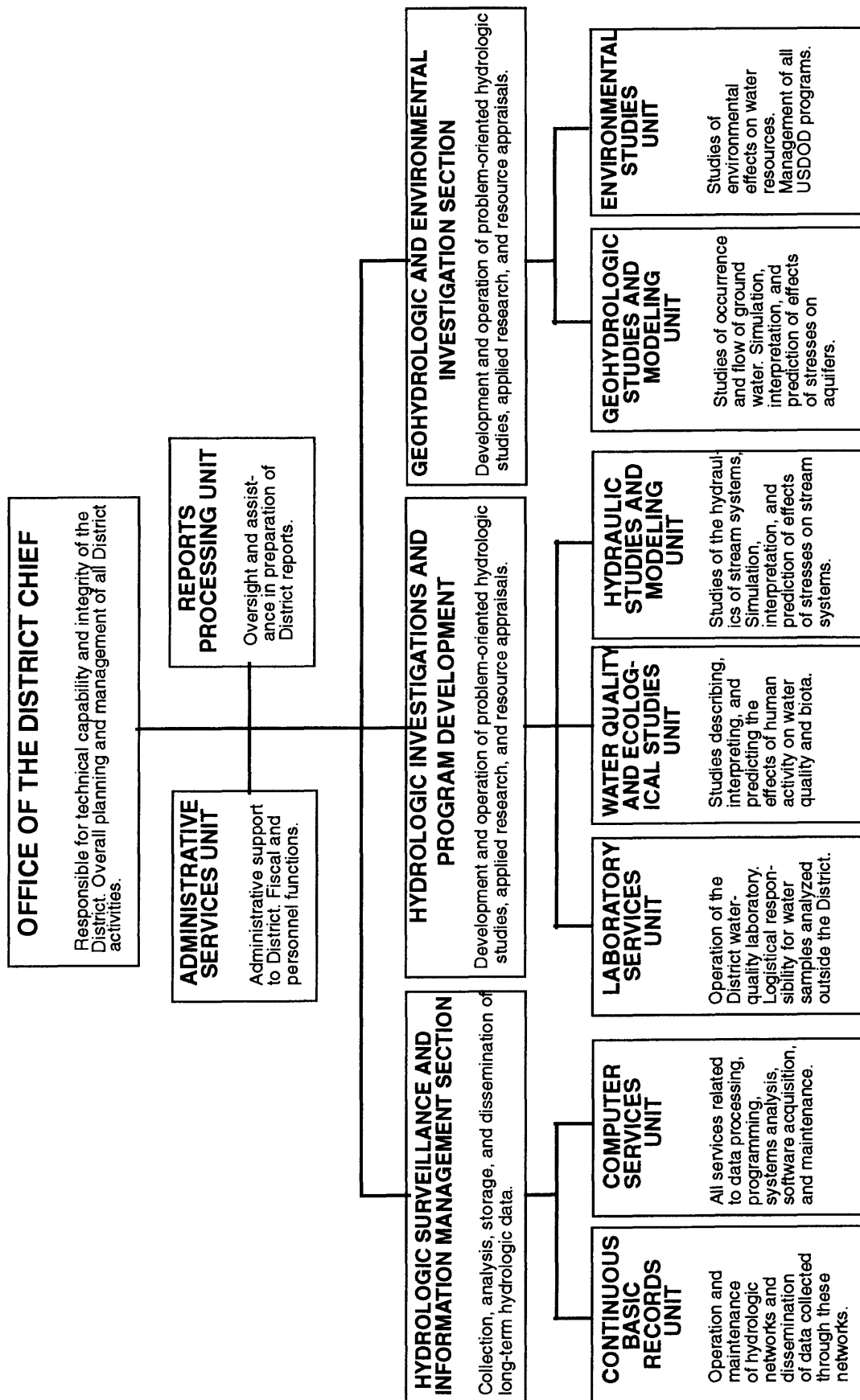
The Ohio District consists of the district office in Columbus and a field office in New Philadelphia. There are three major sections in the district office—Hydrologic Investigation and Program Development, Hydrologic Surveillance and Information Management, and Geohydrologic and Environmental Investigation Sections. The New Philadelphia field office is part of the Hydrologic Surveillance and Information Management Section.

Steven M. Hindall, District Chief, is responsible for the overall operation and management of the district and is assisted by the Assistant District Chief, Richard V. Swisshelm, Jr., and Section Chiefs, Harold L. Shindel and Jeffrey T. de Roche. To carry out the diversity of tasks in support of its varied program, the Ohio District's 66-member staff consists of administrative, clerical, and support personnel.

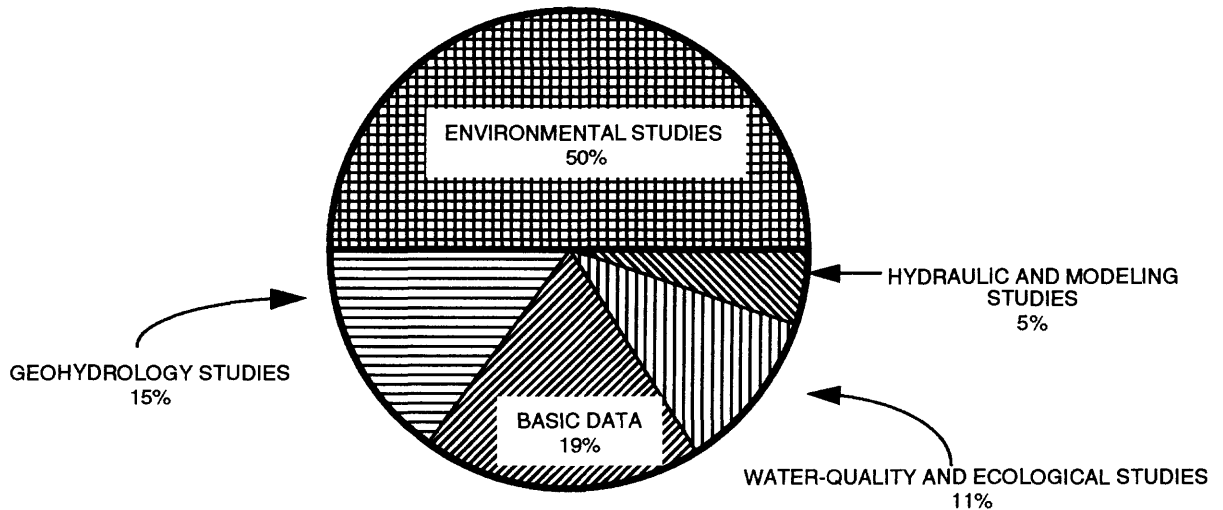
The chart on the following page depicts the organization of the Ohio District and explains the functions of the individual sections and units within those sections.

Funds to support the work performed by the Ohio District, Water Resources Division, are derived from three principal sources:

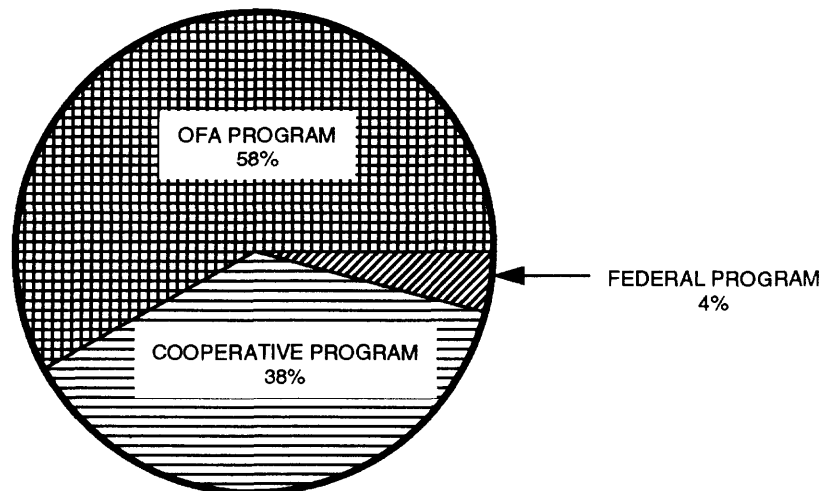
- **Federal Program**—Funds for the Federal Program are appropriated by Congress, and are specifically identified in the annual Geological Survey budget. These funds are used to support research, data collection, high-priority topical programs including Regional Aquifer Systems Analysis (RASA), National Water Quality Assessment program (NAWQA), climate research, coordination of all Federal programs related to collection of water data, and internal support services.
- **Federal-State Cooperative Program**—Federal funds are appropriated by Congress and used to match those furnished by State and other tax-supported agencies. These funds are used for a variety of hydrologic data-collection activities and water-resources investigations in which the Water Resources Division represents the national responsibilities and the cooperating agencies represent State and local interests.
- **Other Federal Agencies (OFA) Program**—In this program, the funds are transferred to the Geological Survey as reimbursement for work performed at the request of another Federal agency.



The diagram below shows the percentage of the district's projects for fiscal 1993 in each of the broad program categories of hydrologic data collection, water quality and ecological studies, hydraulic and modeling studies, geohydrologic studies, and environmental studies.



The programs are supported by funds provided by State and local units of government and Federal funds from the U.S. Geological Survey and other Federal agencies (OFA program). About 65 percent of the funds contributed by the Geological Survey are matched funds contributed by State and other local units of government. In fiscal year 1993, the total financial support for all programs in Ohio is about \$6.1 million and is distributed as follows:



Summary of Water Conditions in Ohio

The availability of water has been an important factor in Ohio's development. Ohio's principal streams (fig. 1) were the settlers' first avenues of transportation and their first sources of power for manufacturing. Shallow, hand-dug wells provided water to a growing farm population. The construction of canals beginning in 1825 continued to encourage the growth of cities and industries and to stimulate agricultural production. Today, Ohio is still characterized by a diverse economy in which water resources play a vital part.

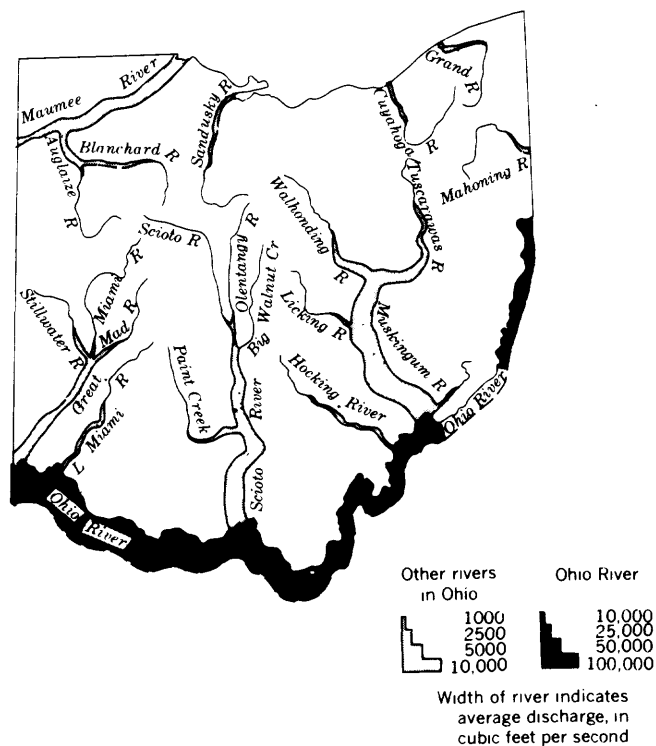


Figure 1.-Average discharge of principle streams in Ohio.

Ohio receives about 38 inches of precipitation annually. About 10 inches runs off immediately, 2 inches is retained at or near the surface and evaporates or transpires, and 26 inches enters the ground. Of the 26 inches that enters the ground, 20 inches is retained in the unsaturated zone and is later lost by evapotranspiration. The remaining 6 inches reaches the water table. Of this 6 inches, 2 inches is eventually discharged to streams, and the rest is lost by evapotranspiration or consumptive use.

Ohio's water problems tend to be localized. Generally, these problems involve excess water (flooding or poor drainage) or water quality. Nonpoint source (NPS) contamination of surface water and ground water is becoming a significant problem in Ohio as more is being learned of the effects of NPS on water-resource systems.

Serious local flooding occurs in Ohio nearly every year. Most Ohio floods are either flash floods resulting from intense summer thunderstorms or large-stream floods resulting from a combination of rain and snowmelt. Accelerated erosion of bare ground and stream banks and deposition of sediment in stream channels, culverts, and drainage ditches are negative side effects of flooding. Eight projects are active in the Ohio District, in fiscal year 1993, that directly or indirectly contribute to our knowledge of flooding and (or) related sedimentation problems in the State.

The focus of concern about Ohio's water quality in recent years has been on waste disposal and its effects on ground-water quality. Despite the predominance of surface water in terms of total withdrawal, the importance of ground water to Ohio cannot be overlooked. Nearly 80 percent of the public water-supply systems in the State depends to some extent on ground water as a source, and 42 percent of the Ohio population uses ground water as their primary supply. The principle aquifers in Ohio are the unconsolidated deposits of coarse- or fine-grained sediments and sedimentary rocks of shaley sandstone and (or) limestone (carbonate). Geographic distribution of the principle aquifers in Ohio is shown in figure 2.

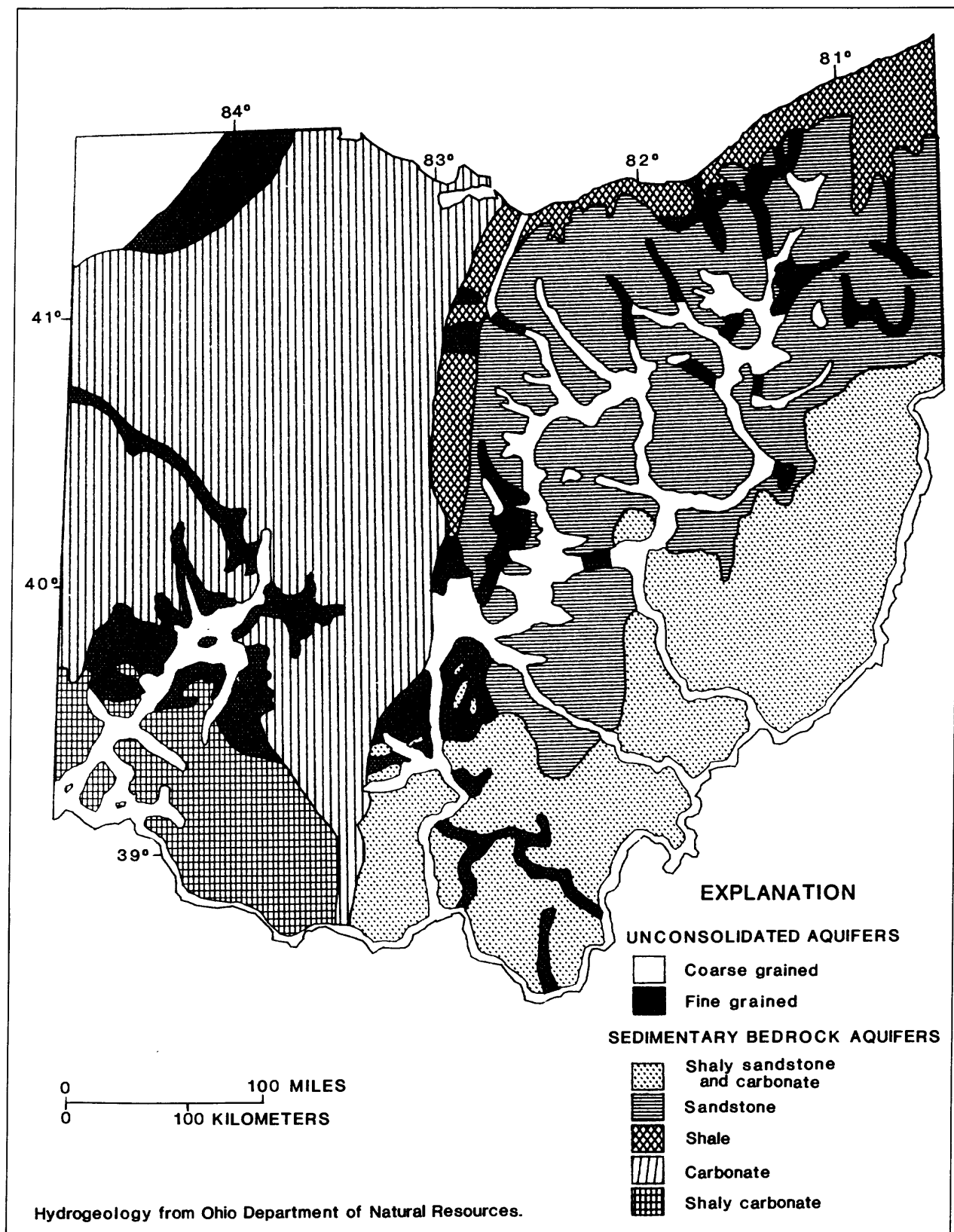


Figure 2.--Geographic distribution of principal aquifers in Ohio.

INFORMATION CONTAINED IN THIS REPORT

Information is presented in the remainder of this report in four parts: (1) A listing and brief description of current projects, (2) a listing of surface-water hydrologic data stations, (3) a listing of ground-water hydrologic-data stations, and (4) selected references on Ohio hydrology. The first part contains information on the status of all projects in which there has been activity during 1993. Further information concerning project activities is available from the project leader or from Richard V. Swisshelm, Jr. The second and third parts contain tables showing station numbers, station names, and types of data collected. Further information on statewide station activities, unpublished records, or provisional data prior to publication is available from Harold L. Shindel. The fourth part is a selected list of reports issued by the U.S. Geological Survey and its cooperating agencies concerning hydrologic investigations in Ohio. Further information on these reports is available from the Information Officer for the Ohio District.

These contact people can be reached at

Water Resources Division
U.S. Geological Survey
975 W. Third Avenue
Columbus, OH 43212
(614) 469-5553

Additional Information about data-collection activities in northeastern Ohio can be obtained by contacting

Lowell Trimble
New Philadelphia Field Office
Water Resources Division
U.S. Geological Survey
551 Wabash Avenue, P.O. Box 272
New Philadelphia, OH 44663
(216) 343-2343

OTHER INFORMATION AVAILABLE

The U.S. Geological Survey publishes an annual series of reports titled "*Water Resources Data—Ohio, volume 1 and 2*" in which the hydrologic data collected during each water year are presented. Information about these reports and how to obtain them is available from the district office at the address and phone number given on the previous page.

Flood-prone area maps for selected parts of Ohio also are available from the district office. These maps were prepared in cooperation with the U.S. Department of Housing and Urban Development, Federal Insurance Administration, to serve as guides for public agencies and private citizens concerned with present and future land development. The maps were prepared on standard 7-1/2 minute topographic quadrangles and show the approximate area subject to inundation by a 100-year flood.

The Ohio District does not sell the standard 7-1/2 minute topographic maps of Ohio. These maps may be purchased from:

Ohio Department of Natural Resources
Division of Geological Survey
Fountain Square, Building B
Columbus, OH 43224
(614) 265-6605

To order topographic, hydrologic, geologic, land-use, and land-cover maps, and map indexes for other states published by the USGS, contact:

USGS Map Distribution
Box 25286, Building 810
Denver Federal Center
Denver, CO 80225
(303) 236-7477

CURRENT PROJECTS

The project descriptions that follow show project title and number, period of project, project leader, cooperating agencies, purpose of project, and progress and significant results.

SURFACE-WATER STATIONS (OH001)

Period of Project:

Continuous since October 1915

Project Leader:

Harold L. Shindel

Cooperators:

Ohio Department of Natural
Resources
City of Columbus
Miami Conservancy District
Ohio Environmental Protection
Agency
City of Canton
U.S. Army Corps of Engineers
Seneca Soil and Water District
Ross County
City of Fremont
Toledo Metropolitan Area Council of
Governments
University of Cincinnati
Eastgate Development
City of Lima
City of Akron
U.S. Department of Energy

Purpose: Provides a surface-water data base through collection, analysis, and publication of records for streamflow-gaging stations and selected sites along streams, lakes, and reservoirs throughout Ohio. The gaging-station network is operated in cooperation with other Federal, State, and local agencies. The surface-water data base provides information for research purposes of surveillance, planning, design, hazards warning, accounting systems, operation, and management in various water-related fields.



Progress and significant results: Field data were collected on schedule and prepared for publication (water year 1992) as "*U.S. Geological Survey, Water Resources Data—Ohio, 1992, volumes 1 and 2.*" Network maintenance was continued, including modernization of equipment at selected sites to improve record quality. Modifications to the network, such as additions or deletions of stations or data-collection activity, were made in response to program needs.

GROUND-WATER STATIONS (OH002)

Period of Project:

Continuous since January 1938

Project Leader:

Stephen A. Vivian

Cooperator:

Ohio Department of Natural
Resources



Purpose: Observe the effects on ground-water quantity and quality exerted by such factors as climate variations and withdrawal patterns. Water-level data are collected to provide a data base against which scientists and water-resources managers can compare short and long-term fluctuations.

Progress and significant results: Field data were collected and processed on schedule for annual report publication. The network currently consists of 102 State-operated sites instrumented with continuous recorders and 11 sites at which periodic measurements are made.

WATER-QUALITY STATIONS (OH003)

Period of Project:

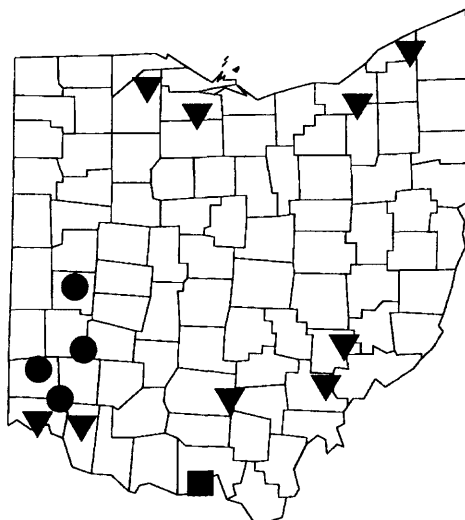
Continuous since January 1946

Project Leader:

Charles N. Owens

Cooperators:

Miami Conservancy District
Ohio Environmental Protection
Agency



Purpose: Collect, analyze, and publish water-quality records for selected sites in Ohio in cooperation with State and local agencies. The records contribute to a national water-quality data base requisite to national and regional planning and action programs.

- ▼ NASQAN station
- Benchmark station
- Ground-water site

Progress and significant results: Surface-water stations operated by the U.S. Geological Survey consist of eight NASQAN stations and one Benchmark station in the water-quality network in water year 1993. Four Miami Conservancy District ground-water sites also were sampled. The Geological Survey collects a water sample at the NASQAN sites for the Ohio Environmental Protection Agency for the determination of chemical oxygen demand. Data for water year 1992 were published in the annual report.

SEDIMENT STATIONS (OH004)

Period of Project:

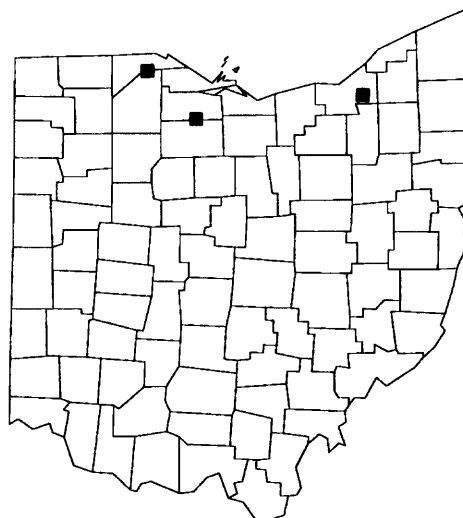
Continuous since July 1970

Project leader:

John W. Roberts

Cooperator:

Ohio Department of Natural
Resources



Purpose: Provide a data base needed to assess sedimentation characteristics of drainage areas required for planning and management of State and Federal programs. The data also are needed to evaluate effectiveness of Ohio House Bill 513, which concerns the abatement of sediment loading in agricultural and urban situations.

Progress and significant results: A network of three daily sediment stations is being operated to provide spatial and temporal averages of concentration, discharge, and particle-size distribution of suspended sediment carried by a major stream tributary to Lake Erie. All 1992 data were collected and processed on schedule for publication in the annual report.

FLOOD INVESTIGATIONS (OH006)

Period of Project:

March 1984 (reestablished) through
February 1993

Project leader:

K. Scott Jackson

Cooperator:

Federal Emergency Management
Agency (FEMA)



Purpose: Conduct the necessary hydrologic and hydraulic evaluations and studies of areas assigned by the Federal Emergency Management Agency (FEMA) and to present the results in an appropriate format. The National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973 provide for the operation of a flood-insurance program. Flood studies in selected areas are needed by FEMA to determine applicable flood-insurance premium rates.

Progress and significant results: Work has been completed on FEMA-Flood Insurance Agency Type 15 flood-insurance studies at Crooksville, Perry County, and London, Madison County, Ohio. Nineteen Limited-Detail Studies have been completed: St. Marys, Auglaize County; Darbyville, Pickway County; Jewett, Harrison County; Amesville, Athens County; Middlefield, Geauga County; Jeffersonville, Fayette County; Belle Valley, Noble County;

Sabina, Clinton County; Lynchburg, Highland County; Hamden, Vinton County; Salineville, Columbiana County; Coalton, Jackson County; Rutland, Meigs County; Roseville, Perry County; Westerville, Franklin County; Pickerington, Fairfield County; Montgomery, Hamilton County; Louisville, Stark County; and Powell, Delaware County. One Limited-Map Maintenance Program restudy, for the community of Reynoldsburg, Franklin, Licking, and Fairfield Counties, has been completed. A restudy of Paulding County is in progress.

WATER USE IN OHIO (OH007)

Period of Project:

Continuous since October 1977

Project Leader:

Vance E. Nichols

Cooperator:

Ohio Department of Natural
Resources



Purpose: Establish an effective and coordinated program for collecting, storing, accessing, and disseminating water-use data. The data are organized to be compatible with a National data base for water use. In Ohio, there is a demonstrated need for local and statewide water-use information that is consistent with regard to definitions, standards, and methods of presentation.

Progress and significant results: U.S. Geological Survey Circular 1081, *1990 Estimated Water-Use Data for the United States*; Open-File Report 92-63, *Preliminary Estimates of Water Use in the United States, 1990*; and a Fact Sheet titled *Estimated Water Use in Ohio, 1990 — Public-Supply Data* were published recently. A microcomputer data base, developed in cooperation with the Ohio Department of Natural Resources, Division of Water, is installed at the Division of Water to store and organize data on water users who use

100,000 gallons per day or more (reporting of water use of 100,000 gallons per day or more is now required by State law).

Public-water-supply, commercial, and industrial data continue to be entered into the National Water Inventory

System's Site Specific Water Use Data System data base on the District's computer system. Quality-assurance and quality-control evaluation of the entered data also continues.

HYDRAULICS OF RIVER VALLEYS AND BRIDGE SITES (OH010)

Period of Project:

Continuous since June 1963

Project Leader:

G.F. Koltun

Cooperator:

Ohio Department of Transportation



Purpose: Evaluate the hydraulic effects of proposed or existing bridges and highway fills at selected locations. Such structures can decrease the capacity of river valleys for conveying floodwaters and, in turn, could cause backwater and excessive upstream flooding. This project also provides information to highway engineers on miscellaneous hydrologic topics related to the design or maintenance of highway properties.

Progress and significant results: Monitoring of discharge from conventional sand-and-gravel-fill and geotextile longitudinal highway drains continues. The conventional drain generally exhibits the quicker, more peaked response after a storm; however, a greater volume of water discharges from the geotextile drain over time.

AUTOMATIC MEASUREMENT OF TEMPERATURE, SPECIFIC CONDUCTANCE, DISSOLVED OXYGEN, AND pH IN SELECTED STREAMS IN OHIO (OH042)

Period of Project:

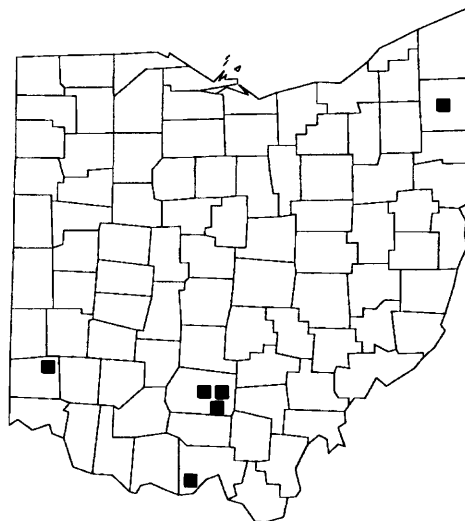
Continuous (reestablished
October 1985)

Project Leader:

Max S. Katzenbach

Cooperators:

Miami Conservancy District
U.S. Army Corp of Engineers
Ross County Engineers



Purpose: (1) Continuously collect stream-temperature, dissolved-oxygen, specific-conductance, and pH data, which will serve as either direct or surrogate indicators of water-quality conditions in analyses conducted by the U.S. Geological Survey and State agencies to determine the effect of human activity on surface waters, and (2) provide relevant standardized data collected continuously for comprehensive study by the U.S. Geological Survey and other agencies for planning purposes and pollution control.

Progress and significant

results: Data collection and processing continued at all five water-quality monitor stations. Five stations have been added to the real-time data network. Modifications to the network, such as additions or deletions of stations, were made in response to program's needs. Data for 1992 were published in the annual hydrologic data report.

EFFECTS OF HIGHWAY DEICING CHEMICALS ON SHALLOW UNCONSOLIDATED AQUIFERS IN OHIO (OH092)

Period of Project:

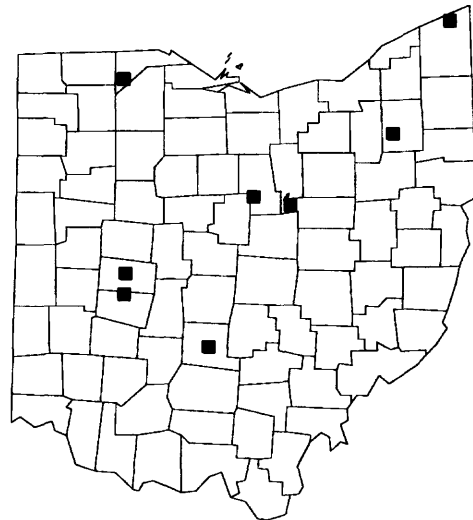
January 1988 through
December 1997

Project Leader:

Allison L. Jones

Cooperator:

Ohio Department of Transportation



Purpose: (1) Determine the effects of highway-deicing chemicals, predominantly chloride, on the ground-water quality of shallow unconfined aquifers that underlie highways in Ohio, (2) determine those effects in different soil-type and climate areas of Ohio, (3) track the movement of chlorides away from the highway to observe seasonal variations in chloride migration, (4) determine yearly changes in chloride concentrations caused by variation in snowfall, and (5) determine the concentrations of selected ions in the soil and unsaturated zone. In Ohio, there is a lack of detailed knowledge concerning the movement of deicing salts after they have been applied to roads. The use of road salts has been increasing continuously since about 1940. There is growing indication that all applied salts do not leave the area of application, but that some, in fact, accumulate. The Ohio Department of Transportation (ODOT) needs long-term data on the effects of salts on soil and ground water in Ohio.

Progress and significant results: Eight sites were selected from a group of 55 potential sites through the use of maps of geology, glacial features, snowfall, and soil types. Records of county salt-application rates, water-well logs, and other literature also were consulted. Each site was investigated by use of a ground-conductivity electromagnetic geophysical system. Test drilling was done at each potential site to determine formation type and content, water levels, and direction and velocity of ground-water flow. The eight study sites were selected in the following counties: Lucas, Pickaway, Champaign, Clark, Richland, Ashland, Portage, and Ashtabula. Seven to nine wells were drilled at each site and developed. Background water-quality samples were collected at all wells. Results of slug tests and a solute-transport model were used to predict ground-water velocity and determine placement of permanent wells.

**EFFECTS OF HIGHWAY DEICING CHEMICALS ON SHALLOW
UNCONSOLIDATED AQUIFERS IN OHIO
(OH092)—*Continued***

Detailed programs for electronic data logging and storage devices were prepared. Instrumentation assembly and installation were completed. Detailed geophysical surveys were done at each site.

Ground-water samples are collected every 4 to 6 weeks at each site by use of a multilevel dialysis membrane ground-water sampler. Other information collected on an hourly basis includes: air temperature, ground temperature, specific conductance, water temperature, rainfall, and water level. A solute-transport model is being tested at the Lucas County site where the geology is fairly homogeneous. An interim report is planned for publication in 1994.

HYDROGEOLOGY AND GROUND-WATER QUALITY OF WRIGHT-PATTERSON AIR FORCE BASE, SOUTHWESTERN OHIO (OH093)

Period of Project

June 1987 through February 1993

Project Leader:

Denise H. Dumouchelle

Cooperator:

U.S. Air Force,
Air Force Logistics command,
645th Air Base Wing,
Office of Environmental Management



Purpose: The purpose of this project was to describe the hydrogeology, simulated flow, and quality of ground water at Wright-Patterson Air Force Base and the surrounding region.

Progress and significant results: Project is finished; results are published in the report, "Hydrogeology, simulated ground-water flow and ground-water quality, Wright-Patterson Air Force Base, Ohio," (U.S. Geological Survey Water-Resources Investigations Report 93-4047). Three other reports have also been published: "Lithologic, natural-gamma, grain-size and well-construction data for Wright-Patterson Air Force Base, Ohio" (U.S. Geological Survey Open-File Report-91-181); "Ground-water levels and flow in the vicinity of Wright-Patterson Air Force Base, Ohio, October- December 1987" (U.S. Geological Survey Water-Resources Investigations Report 92- 4022); and "Altitude of top of bed-rock in the vicinity of Wright-Patterson

Air Force Base, Ohio" (U.S. Geological Survey, Water Resources Investigat 92-4072).

The model simulates steady-state conditions based on water levels and hydraulic gradients measured from October to December 1987, and river discharges measured in 1991.

Ground water enters the modeled area primarily by river leakage (52 percent), boundary flux (29 percent), and precipitation (19 percent) and exits the modeled area primarily by boundary flux (45 percent), production wells (35 percent), and river leakage (20 percent). An analysis of the model output indicates that the contribution of water to the buried-valley glacial aquifer from the bedrock that forms the valley walls is about 2 to 4 percent of the total ground-water flow in the modeled area.

Shallow ground water of the glacial aquifer is characterized by elevated

**HYDROGEOLOGY AND GROUND-WATER QUALITY OF WRIGHT-
PATTERSON AIR FORCE BASE, SOUTHWESTERN OHIO
(OH093)—Continued**

concentrations of sodium, chloride, sulfate, and nitrate that are related to human activities that alter the composition of precipitation-derived recharge and shallow ground water. All shallow ground-water samples contained detectable concentrations of tritium, indicating that recharge to these parts of the aquifer had occurred in the last few decades. Deeper parts of the glacial aquifer had significantly lower median concentrations of sodium and chloride indicating suggesting that recharge to these parts of the aquifer occurs slowly. Ground water collected from the deepest parts of the glacial aquifer (>180 ft.) did not contain measurable tritium concentrations, indicating that water in these zones entered the aquifer before 1953. Stable isotope data for deuterium and ^{18}O indicate a meteoric origin for all ground water beneath WPAFB, but were inconclusive with respect to identifying distinct isotopic differences between ground water collected from the glacial drift or bedrock aquifers. Tritium concentrations, which were used to distinguish waters having a pre- and post-1953 recharge component, indicate that most water entered the glacial aquifer after 1953. This finding indicates that recharge from shallow to deep parts of the aquifer occurs over time intervals of a few years or decades. However, some deep parts of the glacial aquifer did not contain measurable tritium, indicating that ground-water flow from recharge zones to these parts of the aquifer takes decades (or longer). Ground water collected from wells screened in the Brassfield Formation did contain tritium,

indicating that recharge to the Brassfield strata occurred on a time scale of a few years to a few decades. However, ground water collected from wells completed in Richmondian strata did not contain tritium, indicating very slow recharge rates, an observation consistent with the inferred low permeability of the shale bedrock.

LAKE ERIE TRIBUTARY LOADING—OHIO, INDIANA, AND MICHIGAN (OH096)

Period of Project:

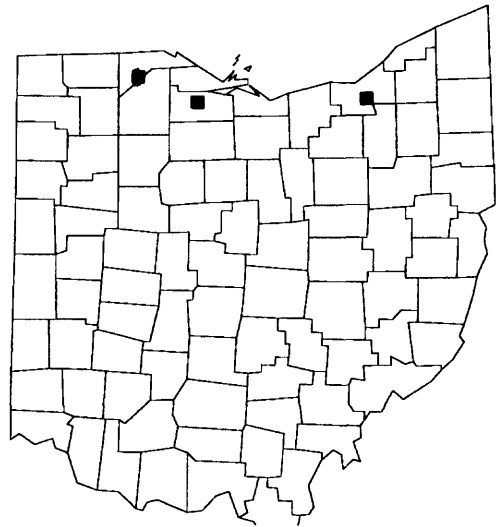
Continuous since August 1987

Project leader:

John W. Roberts

Cooperator:

Ohio Department of Natural
Resources



Purpose: Determine phosphorus, sediment, and selected chemical loads in several major streams tributary to Lake Erie. Agriculture is the primary land use in the Ohio part of the Lake Erie basin and is considered responsible for much of the water-quality degradation of Lake Erie and its tributaries. In June 1983, the United States and Canada agreed to reduce phosphorus loading to Lake Erie by an additional 2,000 metric tons per year. A network of data-collection stations is needed on Lake Erie tributaries to determine (1) if this goal is being met, (2) the amounts of other chemicals entering the lake, and (3) other effects of agricultural land use.

Progress and significant results: A network of data-collection stations has been established in Ohio on the Huron, Maumee, Sandusky, Cuyahoga, and Grand Rivers and Honey Creek. Suspended-sediment and water-quality samples and continuous data have been collected at all five sites.

Sampling was discontinued at the end of the 1989 water year on Honey Creek and at the end of the 1991 water year for Grand and Huron Rivers. Annual loads have been computed for suspended sediment, total phosphorus, total Kjeldahl-nitrogen, total and dissolved nitrite plus nitrate, and dissolved chloride.

EVALUATION OF BRIDGE-SCOUR DATA AT SELECTED SITES IN OHIO (OH099)

Period of Project

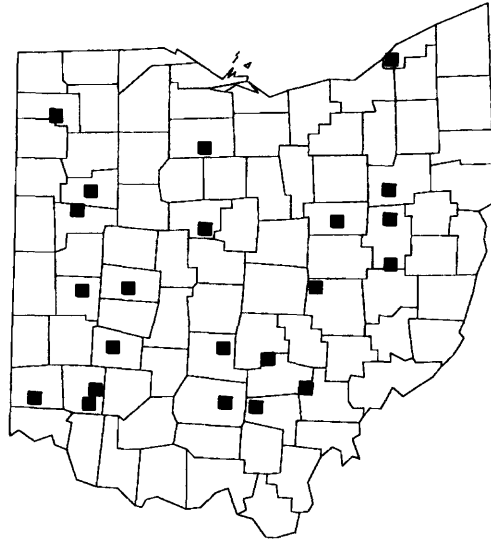
January 1989 through October 1996

Project Leader:

K. Scott Jackson

Cooperator:

Ohio Department of Transportation



Purpose: (1) Collect reliable and sufficient data during flood events to determine whether local scour, contraction scour, and general channel scour are taking place at 20 selected sites in Ohio, (2) compare and evaluate published local scour-prediction equations with observed data, and (3) compare local scour data collected by means of geophysical techniques with local scour data defined by physical measurements. Adequate definition of the potential scour (erosion of bed materials) at bridge sites is essential to proper design, construction, and maintenance of hydraulic structures in Ohio. Data will be collected during a 5-year period. And if hydrologic conditions permit, 50 total measurements will be obtained with at least 2 measurements made at each site.

Progress and significant

results: Currently 34 high-flow scour measurements have been obtained during the first 3 years of data collection at various bridge-scour measurement

sites throughout the State. Modification to the scour-site network, such as additions or deletions of sites, have been made to respond to cooperator program needs. Limited use of fathometers (depth finders) has initially proved to be successful in the collection of scour data. Instantaneous discharge measurement data for 1992 were published in the annual hydrologic data report.

THE REGIONAL HYDROGEOLOGY OF THE BURIED TEAYS RIVER VALLEY SYSTEM (OH100)

Period of Project:

May 1989 to September 1993

Project Leader:

Rodney A. Sheets

Cooperator:

Midwestern Basin and Arches
Regional Aquifer Systems
Analysis



Purpose: To investigate the role of a major buried-valley system on the ground-water flow and chemistry of the carbonate and glacial aquifers of western Ohio and Indiana.

Progress and significant results: Ground-water and surface-water flow and chemistry have been examined at one site in southwestern Ohio near the boundary of the regional carbonate aquifer system. Major buried valleys that dissect the boundary between the Silurian carbonates and Ordovician shales act as ground-water drains to those sections of the regional ground-water-flow system. At a second site in northwestern Indiana, ground-water-flow and chemical data have been collected. The buried glacial-drift valleys in this area may act as local recharge areas, where not associated with major rivers. Where glacial-drift-filled valleys are overlain by rivers and dissect the eastern boundary of the carbonates, they also act as drains to the regional ground-water flow.

CALIBRATION OF A DYNAMIC STREAMFLOW MODEL FOR SUMMIT COUNTY, OHIO (OH101)

Period of Project:

August 1989 through July 1999

Project Leader:

James M. Sherwood

Cooperator:

Summit County Engineer



Purpose: Provide Summit County engineers with a means of accurately testing the effects of proposed development and runoff-controlling mechanisms on the flood characteristics of two drainage basins and numerous subbasins in west-central Summit County. The analytical tool to be developed will be based on onsite streamflow and rainfall data and will provide detailed information on peak discharge frequency, flood profiles, flood hydrographs, flood volumes, and flow velocities. The HSPF (Hydrologic Simulated Program—Fortran) model will be calibrated for each of the two basins. Data from 10 stream gages and 10 rain gages will be used to calibrate the models.

rain gages. Rainfall-runoff modeling will begin in 1994.

Progress and significant

results: All 10 rain gages and 9 of the 10 of the ten stream gages have been installed. Stage-discharge relations have been established for all nine stream-gage sites. One year of data has been collected at all 9 stream gages and all 10

**CAPTURE-ZONE ANALYSIS OF THE SOUTH WELL FIELD,
COLUMBUS, OHIO, BY USE OF A TRANSIENT GROUND-WATER-FLOW
MODEL AND PARTICLE TRACKING
(OH102)**

Period of Project:

November 1989 through
January 1994

Project Leader:

Charles W. Schalk

Cooperator:

City of Columbus, Ohio



Purpose: (1) Present estimates of ground-water traveltimes and flow paths under transient flow to determine the zones of contribution to the City of Columbus' South Well Field, (2) monitor water levels quarterly at selected wells in the vicinity of the South Well Field, and (3) monitor water quality semi-annually at two surface-water and five ground-water sites in the vicinity of the South Well Field.

Progress and significant results: The report of the transient ground-water flow-model is in review. Transient particle tracking is a relatively new technology; a transient particle-tracking algorithm is being tested with data sets from this project. The program will be used to evaluate zones of contribution to wells at the South Well Field. Data collected in 1991-92 were published in respective annual hydrologic reports.

**GROUND-WATER FLOW AND GEOCHEMISTRY BENEATH ABANDONED
SURFACE-MINED WATERSHEDS RECLAIMED WITH FLUE-GAS
DESULFURIZATION BYPRODUCTS AS SPOIL AND SOIL AMENDMENTS,
SOUTHEASTERN OHIO
(OH103)**

Period of Project:
Through 1994

Project Leader:
Ralph J. Haefner

Cooperator:
The Ohio State University
Research Foundation



Purpose: (1) Determine short-term changes and develop the capability to detect long-term changes in ground-water quality beneath an abandoned surface coal-mine site reclaimed with flue-gas desulfurization (FGD) byproduct, and (2) describe the occurrence and mobility in ground water of elements derived from the FGD byproduct.

Progress and significant results:
An extensive literature search has been done and resulted in the compilation of over 300 references regarding hydrology, geology, coal, and FGD technology. Work has centered on finding a suitable site for abandoned mine reclamation. Socio-political concerns regarding land application of FGD materials have caused delays in the site-selection process because landowners are cautious about possible environmental effects.

DAYTON REGIONAL GROUND-WATER-FLOW MODEL (OH104-01)

Period of Project:

June 1991 through September 1996

Project leader:

Denise H. Dumouchelle

Cooperator:

U.S. Environmental Protection
Agency—Region V



Purpose: To improve the understanding of the regional ground-water-flow system of the buried-valley aquifer system by use of a numerical ground-water-flow model.

Progress and significant

results: The initial phase of the project, the compilation of existing regional and site-specific data, has begun. Draft maps, in digital format, of the surficial geology, waste-site locations, and bed-rock topography are complete. These maps are based on publications or data collected from U.S. Environmental Protection Agency or Ohio Department of Natural Resources files.

Industrial Excess Landfill (OH104-02)

Period of Project:

Continuous from 1992

Project leader:

Denise H. Dumouchelle

Cooperator:

U.S. Environmental Protection
Agency—Region V



Purpose: To assist U.S. Environmental Protection Agency as needed in the collection and interpretation of hydrogeologic data at the Industrial Excess Landfill (IEL) site in Uniontown, Ohio.

Progress and significant findings: In the summer of 1992, the USGS drilled a well at the IEL site to collect additional water-quality data. In the spring of 1993, USEPA requested that the USGS review new data on water levels and ground-water flow from the site. In particular, to compare the recent data with the 1989 report "Ground-water levels and flow near the Industrial Excess Landfill, Uniontown, Ohio" (U.S. Geological Survey Open-File Report 89-272).

EVALUATION OF THE EFFECTS OF PHYSICAL, CHEMICAL, AND BIOLOGICAL FACTORS ON PESTICIDE SORPTION, BIOTRANSFORMATION, AND TRANSPORT IN A BURIED-VALLEY AQUIFER (OH105)

Period of Project:

March 1990 through September 1993

Project Leader:

Martha Jagucki

Cooperators:

The Toxic Substances Hydrology Program



Purpose: (1) Characterize spatial variations in the physical properties of the aquifer beneath the Management Systems Evaluation Area (MSEA), (2) characterize spatial and temporal variations in the aqueous chemistry of the aquifer, (3) develop a conceptual flow model and water budget for the aquifer beneath the MSEA, (4) determine whether a correlation exists between aquifer physical properties of the aquifer and the sorptive capacity of aquifer sediments, (5) characterize spatial variations in microbial numbers and diversity in the aquifer, (6) determine whether a correlation exists between microbial numbers and physical aquifer properties and (or) aqueous constituent concentrations, (7) determine whether the geomicrobial population in the aquifer can degrade atrazine, and (8) determine whether atrazine in ground water causes toxic inhibition of denitrification.

Progress and significant results: Numerous subsurface sediment samples were collected during the installation of 37 wells. Analyses of the samples for grain-size distribution, mineralogy, and organic carbon content have been completed. Water samples collected from 32 ground-water locations and 2 surface-water locations three times during 1991, were analyzed for field parameters, major ions, selected trace metals, nutrients, and triazine herbicides. From August 1991 to July 1993, 15 wells were instrumented with continuous specific-conductance and temperature recorders to collect data

Twenty-four sediment samples collected during well installation were analyzed for microbial numbers and diversity. Microbial numbers varied between $<10^3$ colonies and 143×10^3 colonies per gram of dry sediment. Although no correlation existed between microbial numbers and depth below ground surface, some samples showed a marked differ-

ence in colony color and morphology

EVALUATION OF THE EFFECTS OF PHYSICAL, CHEMICAL, AND BIOLOGICAL FACTORS ON PESTICIDE SORPTION, BIOTRANSFORMATION, AND TRANSPORT IN A BURIED-VALLEY AQUIFER

(OH105)—*Continued*

with depth. Only a slight correlation was found between microbial numbers and percent silt and clay in the sediment samples.

In laboratory experiments covering a 23-day incubation period, native subsurface microbes were able to mineralize <0.1 percent of the ring-labeled atrazine and <0.1 to 1.5 percent of the chain-labeled atrazine added to aquifer sediment samples. This indicates that the atrazine ring structure is resistant to degradation in ground water. The measured rate of atrazine chain degradation was slow but still may be significant in field studies, given the typically long residence time of ground water.

In laboratory experiments where microcosms of native subsurface sediments, no evidence of inhibition of denitrification by atrazine was found at atrazine concentrations as high as 500 µg/l. Apparently the correlation between the presence of atrazine and nitrates in ground water is not due to toxic inhibition of denitrification by atrazine.

Raw data from sediment, microbial numbers, and water-quality analyses and continuous water-level and specific-conductance records have been published in Water Resources Data—Ohio, Volume 2 for water years 1991 and 1992. "Atrazine Mineralization Potential of Alluvial-Aquifer Sediments under Aerobic Conditions" was published in Environmental Science and Technology, 1992, volume 26, p. 1556-1559. Two

additional interpretive reports are being written: "Hydrogeology and Water Quality at the Management Systems Evaluation Area near Piketon, Ohio," and "Toxic Inhibition of Denitrification by Atrazine."

DISCHARGE CHARACTERISTICS OF SELECTED LONGITUDINAL DRAIN MATERIALS

(OH106)

Period of Project:

August 1990 to October 1994

Project Leader:

David E. Straub

Cooperator:

Ohio Department of Transportation



Purpose: The purpose of this study is to document the relative performance of four longitudinal drain-material products under nearly equal geological and environmental field settings. Damp highway subbases are known to hasten pavement deterioration. As a consequence, current recommended design standards generally include permeable base courses with longitudinal drains underlying the shoulder to mainline joints.

Progress and Significant

Results: Data collection continued at all four sites on State Route 16, just east of Granville, Ohio. Rainfall and discharge from the four edge-drain materials were measured for the past two data-collection periods from April to December. Lag times between the centroid of the rainfall and discharge hydrographs were computed for selected events throughout both periods of time.

**HYDROLOGIC AND BIOLOGIC FACTORS AFFECTING FECAL-
INDICATOR BACTERIA DISCHARGE AND IMPLICATIONS FOR
WATER-CONTACT RECREATION IN THE CUYAHOGA RIVER, SUMMIT
AND CUYAHOGA COUNTIES, OHIO
(OH107)**

Period of Project:

April 1991 through September 1994

Project Leader:

Donna N. Myers

Cooperators:

Ohio Water Development Authority
County of Summit
City of Akron
Northeast Ohio Regional Sewer
District
Cuyahoga River Community
Planning Organization



Purpose: Water-contact recreation in many Ohio rivers must be restricted after rainfall and runoff to protect the public from potentially unhealthful water-quality conditions associated with the occurrence of pathogenic microorganisms and the fecal-coliform bacteria that indicate their presence.

The objectives of this project are to quantify processes including transport, die-off, deposition and resuspension of *Escherichia coli* (*E. coli*) and fecal-coliform bacteria in a segment of the Cuyahoga River. Measurements of these processes will be applied in model simulations of the river to predict when levels of *E. coli* and fecal-coliform bacteria will exceed established safe levels during wet-weather periods.

Progress and significant results: Four bacterial die-off studies and two time-of-travel and fecal-indicator bacteria transport studies

have been completed. Field studies and model calibration and verification are being completed in 1993. An initial report comparing *E. coli* to fecal-coliform bacteria as predictors of recreational water quality was completed.

ZONES OF CONTRIBUTION TO WATER SUPPLY WELLS AT WRIGHT-PATTERSON AIR FORCE BASE, OHIO (OH108)

Period of Project:

October 91 to September 1994

Project Leader:

Rodney A. Sheets

Cooperator:

Wright-Patterson Air Force Base,
Office of Environmental
Management



Purpose: (1) To delineate, using a numerical ground-water-flow model, zones of contribution to well fields at Wright-Patterson Air Force Base, and (2) to geographically reference potential contamination sources to the water-supply wells. The zones of contribution and source data will be used by Base officials to aid in the design of a well-head-protection strategy that conforms to the Ohio Environmental Protection Agency's wellhead protection program.

geographic features have been entered into a geographic information system to facilitate comparison with zones of contribution.

Progress and Significant

Results: A regional ground-water-flow model of the Base area has been used to identify contributing recharge areas to two active and one inactive water-supply well fields on the Base. Construction and pumping information for the wells has been compiled. Additional geophysical data have been collected in order to refine the regional model to a set of subregional models including the well fields. Roads, buildings, and other

WRIGHT-PATTERSON AIR FORCE BASE BASEWIDE MONITORING PROGRAM

(OH109)

Period of Project:

October 1991 through 1996

Project Leader:

William L. Cunningham

Cooperator:

U.S. Air Force,
645th Air Base Wing,
Office of Environmental
Management



Purpose: The purpose of the Base Wide Monitor Program is to assess the impacts of contamination sources at Wright-Patterson Air Force Base (WPAFB) on regional ground water and surface water by monitoring water quality at the Base. This is a multi-year, flexible program to identify trends in regional water quality. The investigative approach of the program is designed to implement a long-term Basewide ground-water and surface-water sampling network to:

- (a) characterize current ground-water and surface-water quality,
- (b) describe water-quality changes as water enters, flows through, and exits base boundaries,
- (c) conduct statistical analyses of water quality, and
- (d) estimate the effect of WPAFB on regional water quality.

A synthesis of the statistical, hydraulic, and geochemical investigations will provide a more complete characterization of the ground

water as it enters, traverses, and exits WPAFB. Upgradient, interior, and downgradient water-quality data along ground-water-flow paths will result in a more complete understanding of the fate and transport of chemical constituents at WPAFB. The resultant information will be useful in planning for the design of future remediation strategies on the Base.

Progress and significant results: An INGRES data base has been designed to store and manipulate the large amount of data to be generated by the program. A project workplan was developed which describes in detail the plan of study, including specific field methods to be used. Twenty-nine surface-water sites have been located. A ground-water-monitoring network consisting of 79 existing and 51 planned wells has been designed. The drilling program began in March 1993. Ground- and surface-water sampling will begin in July 1993.

WASHOUT AND RECOLONIZATION OF AQUATIC BIOTA (OH110)

Period of Project:

October 1992 through
September 1995

Project Leader:

Kevin D. Metzker

Cooperator:

Franklin and Madison Counties
City of Columbus



Purpose: Investigate the relations of the macroinvertebrate and algal communities to hydrology, water chemistry, and physical disturbance associated with runoff events. Floods are known to cause significant and sometimes frequent disruptions of aquatic community by washing out macroinvertebrates and algae. Resilient macroinvertebrates and algae recolonize within days, weeks, or a month, depending on the extent of wash-out. Although the phenomena of wash-out and recolonization have been documented, the relation between wash-out and recolonization and the physical stream environment is not well understood.

tributaries. Initial samplings of macroinvertebrates and algae were completed at all three sites.

Progress and significant

results: In 1992, 30 synoptic sites were sampled throughout the Big Darby Basin to identify three sites for continued data collection. Three gaging stations were constructed to monitor discharge, sediment, and water quality of Big Darby Creek and two major

**USE OF CHLOROFLUOROCARBONS TO CALIBRATE A REGIONAL
GROUND-WATER-FLOW MODEL OF A BURIED-VALLEY AQUIFER
NEAR DAYTON, OHIO
(OH-112)**

Period of Project:

April 1992 through September 1996

Project Leader:

Gary L. Rowe

Cooperator:

Miami Conservancy District



Purpose: To develop a three-dimensional ground-water-flow model and associated hydrogeologic data base of the Great Miami buried-valley aquifer in the vicinity of Dayton, Ohio. To assist in calibration of the ground-water-flow model, an environmental tracer study based on the newly developed chloro-fluorocarbon and tritium-³He age-dating techniques of the aquifer will also be done. Results of age-dating studies along regional flow paths will be compared with particle-tracking simulations done with the calibrated flow-model.

Progress and significant results: Organization and project planning activities are underway. Data-collection activities for fiscal year 1993 will consist of collection of basic hydrogeologic data needed for calibration of the ground-water-flow model, including: 1) synoptic water-level data, 2) a gain-loss study of major streams and rivers of the study area, 3) measurement of stream profiles and channel

cross-sections, and 4) measurements of streambed conductance. Approximately 30 to 40 water-quality samples will be collected from wells throughout the buried-valley aquifer for analysis of chloro-fluorocarbons compounds and tritium-³He to assess the viability of these age-dating techniques in the study area.

SURFACE-WATER STATIONS FOR WHICH RECORDS ARE PUBLISHED

This section contains a list of hydrologic data stations for which daily records have been published by the U.S. Geological Survey in 1993-94. Surface-water stations are numbered and listed in downstream order along the main stem. A station on a tributary entering between two main-stem stations is listed between them. A similar order is followed in listing stations on first rank, second rank, and other ranks of tributaries. This downstream-order numbering system is a permanent system of numerical designations adopted by the Survey in 1950.

Surface-water stations for which daily data are collected are classified as: discharge, stage only, sediment, continuous-record water quality, and reservoir or lake contents and (or) elevation. Daily discharge and stage-only stations are sites instrumented to provide a continuous stage record. For daily discharge stations, calculations of mean daily discharge, peak flows during floods, and total monthly and yearly runoff are made by applying stage data to a stage-discharge rating curve derived from actual discharge measurements.

Pool-elevation data collected at reservoir or lake stations are used to determine periodic changes in the amount of water held in storage. Continuous-record water-quality stations are sites equipped to record one or more physical or chemical characteristics. The record is used to determine maximum and minimum daily values. For daily sediment stations, samples collected daily are analyzed for their suspended-sediment concentrations to develop a curve from which daily mean concentrations are determined. Suspended-sediment discharges are computed by multiplying water discharge times sediment concentration times a conversion factor.

In addition to the daily stations listed, data are collected at many sites where daily stations are not feasible. At these partial-record stations, data are collected at regular intervals ranging from one to several times annually. Types of data collected include peak discharge, low-flow discharge, chemical quality, sediment, and biologic. Information about locations of partial-record stations and types of data collected is available upon request.

Standard abbreviations used in station names:

ab	above	E	east	nr	near
B	branch	F	fork	R	river
bk	brook	G	great	re	reservoir
bl	below	L	little	rn	run
C	creek	lk	lake	s	south
ca	canal	M	middle	tr	tributary
d	ditch	n	north	W	west

The letters after the station names designate type of data: (B) biological, (C) chemical, (D) discharge, (E) contents and (or) elevation, (M) water-quality monitor, (NASQAN) National stream-quality accounting network, (R) radiochemical, (S) sediment, (T) temperature, and (CSG) crest-stage gage

Station number	Station	Type of data
	OHIO RIVER BASIN	
	Ohio River:	
	BEAVER RIVER BASIN	
03086500	Mahoning R (head of Beaver R) at Alliance	D
03091500	Mahoning R at Pricetown	D
03092000	Kale C nr Pricetown	D
03092090	W B Mahoning R nr Ravenna	D
03093000	Eagle C at Phalanx	D
03094000	Mahoning R at Leavittsburg	D

SURFACE-WATER STATIONS—*Continued*

Station number	Station	Type of data
03097550	Mahoning R at Ohio Edison Power Plant at Niles	D
03098600	Mahoning R bl West Avenue Bridge at Youngstown	DM
	Shenango R:	
03102950	Pymatuning C at Kinsman	D
	LITTLE BEAVER CREEK BASIN	
03109500	L Beaver C nr East Liverpool	D
	YELLOW CREEK BASIN	
03110000	Yellow C nr Hammondsville	D
	SHORT CREEK BASIN	
03111500	Short C nr Dillonvale	D
	WHEELING CREEK BASIN	
03111548	Wheeling C bl Blaine	DS
	CAPTINA CREEK BASIN	
03114000	Captina C at Armstrongs Mills	D
	MUSKINGUM RIVER BASIN	
	Tuscarawas R (head of Muskingum R):	
03117000	Tuscarawas R at Massillon	D
03117500	Sandy C at Waynesburg	D
03118000	M B Nimishillen C (head of Nimishillen C) at Canton	D
03118500	Nimishillen C at North Industry	D
03120500	McGuire C bl Leesville Dam, nr Leesville	CSG
03122500	Tuscarawas R bl Dover Dam, nr Dover	CSG
03124000	Sugar Creek bl Beach City Dam, nr Beach City	CSG

SURFACE-WATER STATIONS—*Continued*

Station number	Station	Type of data
03124500	Sugar C at Strasburg	D
	Stillwater C	
03126000	Stillwater C at Piedmont	CSG
03127000	Stillwater C at Tippecanoe	CSG
03127500	Stillwater C at Uhrichsville	CSG
	Clear F (head of L Stillwater C):	
03128500	L Stillwater C bl Tappan Dam, at Tappan	CGS
03129000	Tuscarawas R at Newcomerstown	D
03130000	Black F (head of Walhonding R) bl Charles Mill Dam, nr Mifflin	CSG
03131500	Black F at Loudonville	CSG
03133500	Clear F bl Pleasant Hill Dam nr Perrysville	CSG
	Mohican R (continuation of Black F):	
	Lake F:	
03135000	L F bl Mohicanville Dam, nr Mohicanville	D
03136500	Kokosing R nr Mount Vernon	D
03138500	Walhonding R (continuation of Mohican R) bl Mohawk Dam, at Nellie	CSG
03139000	Killbuck C at Killbuck	D
03140000	Mill C nr Coshocton	D
03040500	Muskingum R (continuation of Tuscarawas R) nr Coshocton	D
	Wills C:	
	Seneca F:	
03141500	Seneca F bl Seneca Dam, nr Senecaville	CSG
03142000	Wills C at Cambridge	D

SURFACE-WATER STATIONS—*Continued*

Station number	Station	Type of data
03143500	Wills C bl Wills C Dam, at Wills Creek	CSG
03144000	Wakatomika C nr Frazeyburg	D
	Licking R:	
03145000	S F Licking R (head of Licking R) nr Hebron	D
03146500	Licking R nr Newark	D
03147500	Licking R bl Dillon dam, nr Dillon Falls	CSG
03150300	Muskingum R nr Beverly	D
	HOCKING RIVER BASIN	
	Hocking R:	
03157000	Clear C nr Rockbridge	D
03157500	Hocking River at Enterprise	D
03159510	Hocking River bl Athens (NASQAN)	DCS
	SHADE RIVER BASIN	
03159540	Shade R nr Chester	D
	RACCON RIVER BASIN	
03202000	Racoon Cr at Adamsville	D
	SCIOTO RIVER BASIN	
03219500	Scioto R nr Prospect:	D
03219590	Bokes C nr Warrensburg	D
03220000	Mill C nr Bellepoint	D
03221000	Scioto R bl O' Shaughnessy Dam nr Dublin	D
	Olentangy River:	
03223000	Olentangy R at Claridon	D
03225500	Olentangy R nr Delaware	D

SURFACE-WATER STATIONS—*Continued*

Station number	Station	Type of data
03227500	Scioto R at Columbus	D
03228300	Big Walnut C at Sunbury	D
03228500	Big Walnut C at Central College	D
03228805	Alum C at Africa	D
03229000	Alum C at Columbus	D
03229500	Big Walnut C at Rees	DS
03230310	L Darby Cr at West Jefferson	DS
03230450	Hellbranch Run nr Harrisburg	DS
03230500	Big Darby C at Darbyville	D
03230900	Dear C nr Pancoastburg	D
03231000	Dear C at Williamsport	CSG
03231500	Scioto R at Chillicothe	DM
	Paint C:	
03232470	Paint C bl Paint C Dam nr Bainbridge	CSG
	Rocky F:	
03232500	Rocky F nr Barretts Mills	D
03234000	Paint C nr Bourneville	D
03234300	Paint C at Chillicothe	DM
03234500	Scioto R at Higby (NASQAN)	DCBMTS
	Reservoirs in Scioto R Basin	E
	UPPER TWIN CREEK BASIN	
03237280	Upper Twin C at McGraw (HBM)	DCBMSR
	OHIO BRUSH CREEK BASIN	
03237500	Ohio Brush C nr West Union	D

SURFACE-WATER STATIONS—*Continued*

Station number	Station	Type of data
	WHITEOAK CREEK BASIN	
03238500	Whiteoak C nr Georgetown	D
	LITTLE MIAMI RIVER BASIN	D
03240000	L Miami R nr Oldtown	D
03241500	Massies C at Wilberforce	D
03245500	L Miami R at Milford (NASQAN)	DCBTS
03247050	E F L Miami R nr Batavia	D
03247500	E F L Miami R at Perintown	D
	MIAMI CREEK BASIN	
03259000	Mill C at Carthage	D
	GREAT MIAMI RIVER BASIN	
	G Miami R:	
03260700	Bokengehalas C nr De Graff	D
03261500	G Miami R at Sidney	D
03261950	Loramie C nr Newport	D
03262000	Loramie C at Lockington	D
03262700	G Miami R at Troy	D
03263000	G Miami R at Taylorsville	D
	Stillwater R:	
03264000	Greenville C nr Bradford	D
03265000	Stillwater R at Pleasant Hill	D
03266000	Stillwater R at Englewood	D
03267000	Mad R at Urbana	D
03267900	Mad R (at St. Paris Pike) at Eagle City	D
03269500	Mad R nr Springfield	D

SURFACE-WATER STATIONS—*Continued*

Station number	Station	Type of data
03270000	Mad R nr Dayton	D
03270500	G Miami R at Dayton	D
03271000	Wolf C at Dayton	D
03271500	G Miami R at Miamisburg	D
03271510	G Miami R nr Linden Ave at Miamisburg	M
03271601	G Miami R nr bl Miamisburg	D
03271800	Twin C nr Ingomar	D
03272000	Twin C nr Germantown	D
	Sevenmile C:	
03272700	Sevenmile C at Camden	D
03274000	G Miami R at Hamilton	D
03274600	G Miami R at New Baltimore (NASQAN)	CBTS
ST. LAWRENCE RIVER BASIN (STREAMS TRIBUTARY TO LAKE ERIE)		
04177000	Ottawa R at Toledo University	D
04185000	Tiffin R at Stryker	D
04185440	Lost C nr Farmer	D
04186500	Auglaize R nr Ft Jennings	D
04187100	Ottawa R at Lima	D
04189000	Blanchard R nr Findlay	D
04191500	Auglaize R nr Defiance	D
04192500	Maumee R nr Defiance	D

SURFACE-WATER STATIONS—*Continued*

Station number	Station	Type of data
04193500	Maumee R at Waterville (NASQAN)	DCBTS
04195500	Portage R at Woodville	D
	SANDUSKY RIVER BASIN	
04196800	Tymochtee C at Crawford	D
04197100	Honey C at Melmore	D
04197170	Rock C at Tiffin	D
04198000	Sandusky R nr Fremont (NASQAN)	DCMBTS
04199000	Huron R at Milan	DSC
04199155	Old Woman's C at Berlin Road	D
04199165	Old Woman's C at U.S. 6 nr Huron	E
04199175	Lake Erie at Ruggles Beach	E
04199287	Vermilion R nr Fitchville	D
04200500	Black R at Elyria	D
04201500	Rocky R nr Berea	D
04202000	Cuyahoga R at Hiram Rapids	D
04206000	Cuyahoga R at Old Portage	D
04207200	Tinkers C at Bedford	D
04208000	Cuyahoga R at Independence (NASQAN)	DCMTS
04208504	Cuyahoga R at LTV Steel, Cleveland	D
04209000	Chagrin R at Willoughby	D
04212100	Grand R nr Painesville	DSC
04212200	Grand R at Painesville (NASQAN)	CT
04213000	Conneaut C at Conneaut	D

GROUND-WATER STATIONS FOR WHICH RECORDS ARE PUBLISHED

The following table is a list of ground-water stations in Ohio for which the U.S. Geological Survey is publishing data in 1993. The first digits of the well numbers denote degrees, minutes, and seconds of latitude, and the next seven digits denote degrees, minutes, and seconds of longitude. The last two digits are used, if needed, for sequential numbering within a 1-second grid.

In addition to the sites listed, data on water levels, yield, and chemical quality of ground water have been collected at many other locations in Ohio. Information about these miscellaneous measurements is available upon request.

GROUND-WATER STATIONS—*Continued*

(Letter after station location designates type of data:
c = chemical; l = water level)

Well number	Local number	Location
		ASHLAND COUNTY
405303082170700	AS-2	Ashland (l)
405425082173000	AS-3	Jerome Fork (l)
		ATHENS COUNTY
392004082071600	AT-2A	Athens (l)
392009082072200	AT-5	Athens (l)
		AUGLAIZE COUNTY
403233083574500	AU-3	Southwest of New Hampshire (l)
		BELMONT COUNTY
400118081082200	B-3	Mount Oliver (l)
		BROWN COUNTY
385932083412400	BR-2	Fincastle (l)
		BUTLER COUNTY
391805084261800	BU-9	Northwest of Sharonville (l)
391904084371800	BU-12	East of Rose
392017084345200	BU-7	Fairfield (l)
392048084311400	BU-8	East of Hamilton (l)
392445084333000	BU-36	Hamilton (c)
393202084241500	BU-15	Middletown (l)
392737084291300	BU-16	Southwest of Trenton (l)
392743084295500	BU-17	Near Trenton (l)
392939084231700	BU-3	Middletown (l)

GROUND-WATER STATIONS—Continued

Well number	Local number	Location
		BUTLER COUNTY
393103084240900	BU-2	Middletown (1)
		CARROL COUNTY
403709081052800	C-1	North of Carrollton (1)
		CHAMPAIGN COUNTY
400638083453900	CH-3	Urbana (1)
		CLARK COUNTY
39563908401220	CL-9	New Carlisle (1)
395840083495200	CL-7	Northwest of Springfield (1)
		COSHOCTON COUNTY
401256081525100	CS-3	North of Conesville (1)
401735081523800	CS-2	Coshocton
		CRAWFORD COUNTY
404838082563100	CR-1	Bucyrus (1)
		DARKE COUNTY
400514084345700	D-2	East of Greenville (1)
		DELAWARE COUNTY
402126083040400	DL-3	Delaware (1)
		FAIRFIELD COUNTY
393450082403600	F-7	Southeast of Amanda (1)
394257082362900	F-6	Lancaster (1)
394544082271000	F-1	West Rushville (1)
395053082361900	F-5	Baltimore (1)
		FAYETTE COUNTY
393153083322000	FA-1	West of Washington Court House (1)

GROUND-WATER STATIONS—*Continued*

Well number	Local number	Location
		FRANKLIN COUNTY
394956083002700	FR-18	Shadeville (l)
395118082573300	FR-3	Southwest of Rees (l)
400101083021800	FR-10	Columbus (l)
		GALLIA COUNTY
383638082103300	G-2	East of Crown City (l)
		GREENE COUNTY
394330083531400	GR-11	Near Wilberforce (l)
394411083561300	GR-1	North of Xenia (l)
394425083551100	GR-10	North of Xenia (l)
		HAMILTON COUNTY
391039084291500	H-11	Cincinnati (l)
391101084172100	H-3	Southeast of Miami
391201084281600	H-10	Cincinnati (l)
391214084470100	H-1	Southeast of Harrison (l)
391324084272500	H-9	Cincinnati (l)
391341084275300	H-8	Wyoming (l)
391442084262900	H-7	Evendale (l)
391608084254400	H-6	Glendale (l)
391733084392400	H-2	South of Ross (l)
391748084393800	H-19	Southwest of Venice (c)
391817084393300	H-4	Southwest of Ross (l)
		HANCOCK COUNTY
405940083275500	HA-3	South of Vanlue (l)
		HARDIN COUNTY
404218083503700	HN-1	Alger (l)

GROUND-WATER STATIONS—*Continued*

Well number	Local number	Location
		HARDIN COUNTY
4046480834012600	HN-2A	Southeast of Dola (1)
		HENRY COUNTY
412123083574000	HY-2	Southwest of McClure (1)
		HOCKING COUNTY
393200082235300	HK-1	Logan (1)
		KNOX COUNTY
402344082300700	K-1	Mt. Vernon (1)
		LICKING COUNTY
400848082251100	LI-4	Near St. Louisville (1)
		LUCAS COUNTY
413704083362200	LU -1	Toledo (1)
		MADISON COUNTY
395301083272200	M-2	London (1)
395352083292100	M-5	Near London (1)
395357083304400	M-4	Northwest of London (1)
395740083255700	M-3	North of London (1)
		MAHONING COUNTY
410042080453800	MA-1	Canfield (1)
		MARION COUNTY
403413083170500	MN-4	Southeast of New Bloomington (1)
403443083230400	MN-1	LaRue (1)
403601083110400	MN-2	West of Marion (1)
		MEDINA COUNTY
410120081431800	MD-3	Wadsworth (1)

GROUND-WATER STATIONS—*Continued*

Well number	Local number	Location
		MEDINA COUNTY
410142082005900	MD-1	Lodi (l)
		MERCER COUNTY
402833084375200	MR-2	Coldwater (l)
		MIAMI COUNTY
395848084085500	MI-3	Northeast of Tipp City (l)
400208084112900	MI-44	Troy (c)
		MONTGOMERY COUNTY
393757084173600	MT-928	Miamisburg (c)
394012084151700	MT-55	West Carrollton (l)
394025084162800	MT-49	West Carrollton (l)
394425084113200	MT-3	Dayton (lc)
394533084113800	MT-6	Dayton (l)
394811084095000	MT-74	Dayton (l)
		MUSKINGUM COUNTY
395804081593200	MU-1A	Zanesville (l)
		OTTAWA COUNTY
413434082494000	O-2	Catawba Island (l)
		PICKAWAY COUNTY
393327082571600	PK-7	South of Circleville (l)
393402082572500	PK-4	South of Circleville (l)
393638082572300	PK-6	Northwest of Circleville (l)
393438083072200	PK-8	Williamsport (l)
394742083094800	PK-9	Near Orient (l)
		PIKE COUNTY
390359083015100	PI-2	West of Piketon (l)

GROUND-WATER STATIONS—*Continued*

Well number	Local number	Location
		PORTAGE COUNTY
411401081025000	PO-1	Windam (1)
		PREBLE COUNTY
394438084335900	PR-2	East of Eaton (1)
		PUTNAM COUNTY
405505084032900	PU-1	Columbus Grove (1)
		RICHLAND COUNTY
404625082305100	R-4	Mansfield (1)
405753082360800	R-3	Shiloh (1)
		ROSS COUNTY
391341083172200	RO-7	West of Bainbridge (1)
391913082580500	RO-8	Chillicothe (1)
		SANDUSKY COUNTY
411914083045300	S-3	Fremont (1)
41270383213600	S-2	Woodville (1)
		SENECA COUNTY
410802083093900	SE-2	Tiffin (1)
		SHELBY COUNTY
401712084103500	SH-4	Sidney (1)
		STARK COUNTY
404939081203800	ST-5A	Canton (1)
405211081253500	ST-27	North Canton (1)
		SUMMIT COUNTY
410330081282000	SU-6	Akron (1)
410846081271600	SU-7	Cuyahoga Falls (1)

GROUND-WATER STATIONS—*Continued*

Well number	Local number	Location
		TRUMBULL COUNTY
411604080505600	T-3	Near Warren (1)
		TUSCARAWAS COUNTY
403207081293800	TU-3	Dover (1)
403557081313600	TU-4	Strasburg (1)
403653081321800	TU-1	North of Strasburg (1)
403823081324200	TU-5	Near Strasburg (1)
		UNION COUNTY
401826083255200	U-4	Southeast of Raymond (1)
402010083321900	U-5	East of Liberty (1)
		VAN WERT COUNTY
405215084335400	VW-1	Van Wert (1)
		VINTON
391452082282900	V-1	McArthur (1)
		WARREN COUNTY
392712084191700	W-5	East of Monroe (1)
		WASHINGTON COUNTY
392553081281600	WA-2	Marietta (1)
393241081353500	WA-3	Near Beverly (1)
		WAYNE COUNTY
404655081553200	WN-3	Near Wooster (1)
404802081583100	WN-2A	Near Wooster (1)
405745081510200	WN-7	Near Sterling (1)
405805081462300	WN-6	Rittman (1)

GROUND-WATER STATIONS—Continued

Well number	Local number	Location
		WILLIAMS COUNTY
412821084313600	WM-1	Near Bryan (1)
412930084320900	WM-3	Bryan (1)
413108084415300	WM-12	East of Blakeslee (1)
		WYANDOT COUNTY
405009083172600	WY-1	Upper Sandusky (1)

SELECTED REFERENCES ON OHIO HYDROLOGY

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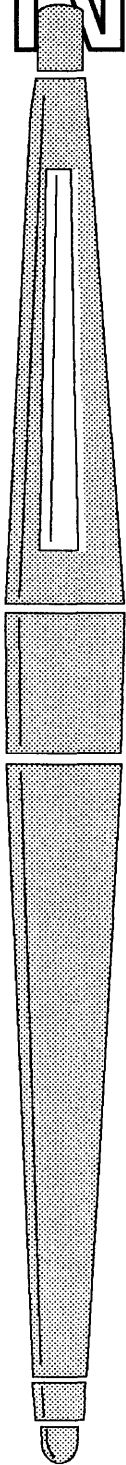
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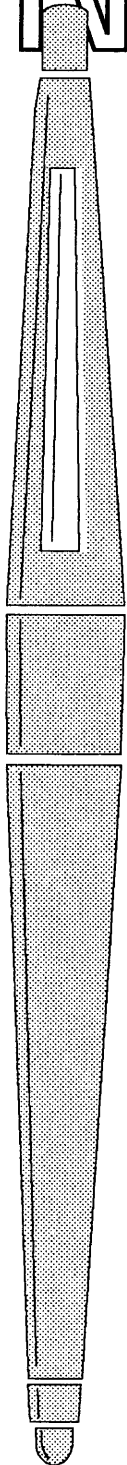
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