WISCONSIN

Water-Resources Investigations

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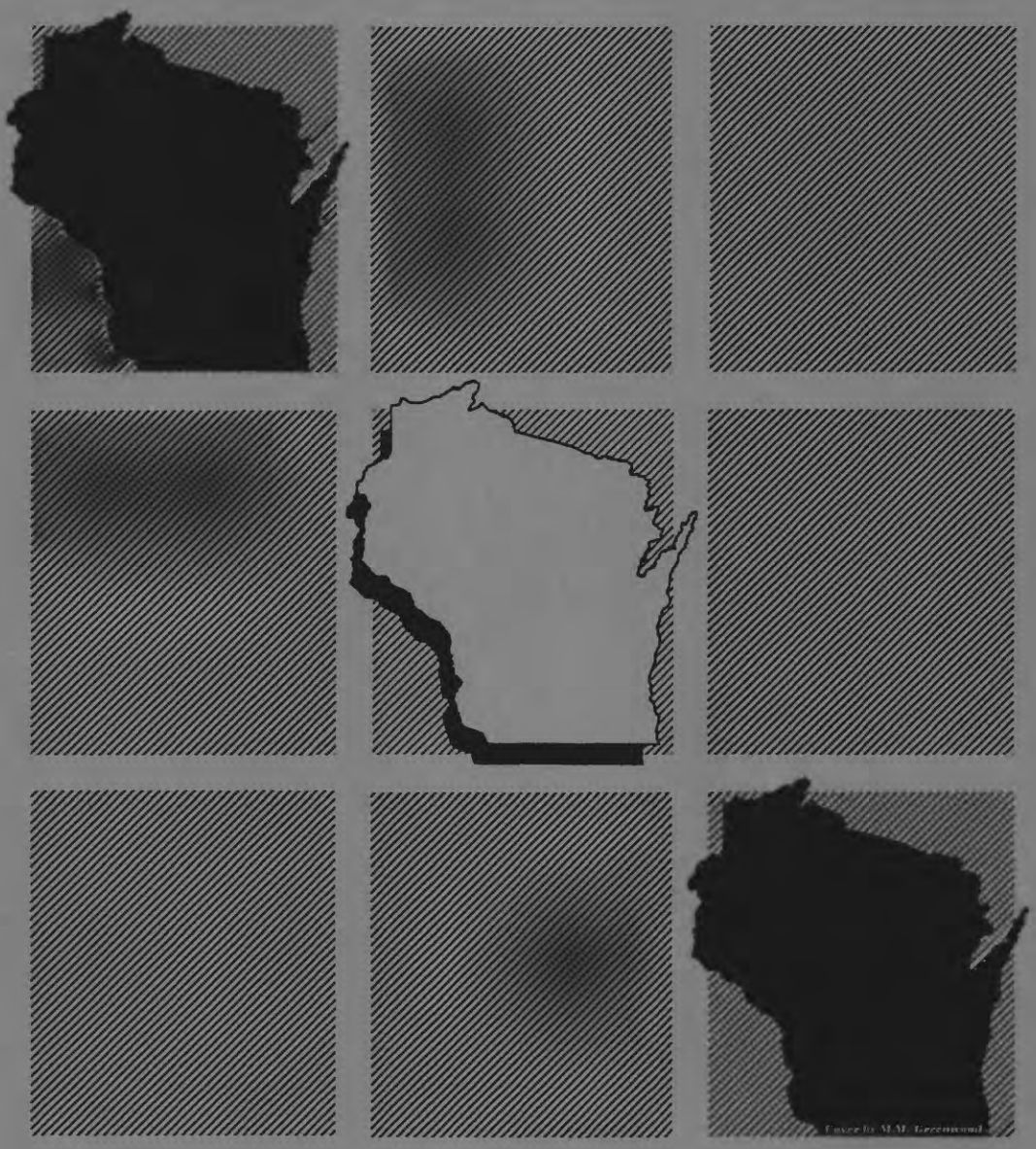
U.S. GEOLOGICAL SURVEY
Open-File Report 94-321



1994

WATER-RESOURCES INVESTIGATIONS IN WISCONSIN

by D.E. Maertz

U.S. GEOLOGICAL SURVEY
Open-File Report 94-321

Madison, Wisconsin
1994

U.S. DEPARTMENT OF THE INTERIOR

BRUCE BABBITT, *Secretary*

U.S. GEOLOGICAL SURVEY

Gordon Eaton, *Director*

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CONTENTS

ILLUSTRATIONS

BASIC MISSION AND PROGRAMS

U.S. Geological Survey

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 U.S. Geological Survey (USGS) has grown and has been modified to meet the changing needs of the Nation it serves. As part of the evolution, the USGS 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 in the Nation. Today's programs serve a diversity of needs and users. Programs include:

- Conducting detailed assessments of the energy and mineral potential of 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 land and offshore areas.
- Studying the geologic features, structure, processes, and history of the other planets of our solar system.
- Conducting topographic surveys 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-resource 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 USGS 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."

Water Resources Division

The mission of the Water Resources Division (WRD) 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 mission 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-resource appraisals describing the occurrence, availability, and 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.

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 water.

Providing scientific and technical assistance in hydrologic fields to other Federal, State, and local agencies, to licensees of the Federal Energy Regulatory Commission, and to international agencies on behalf of the U.S. Department of State.

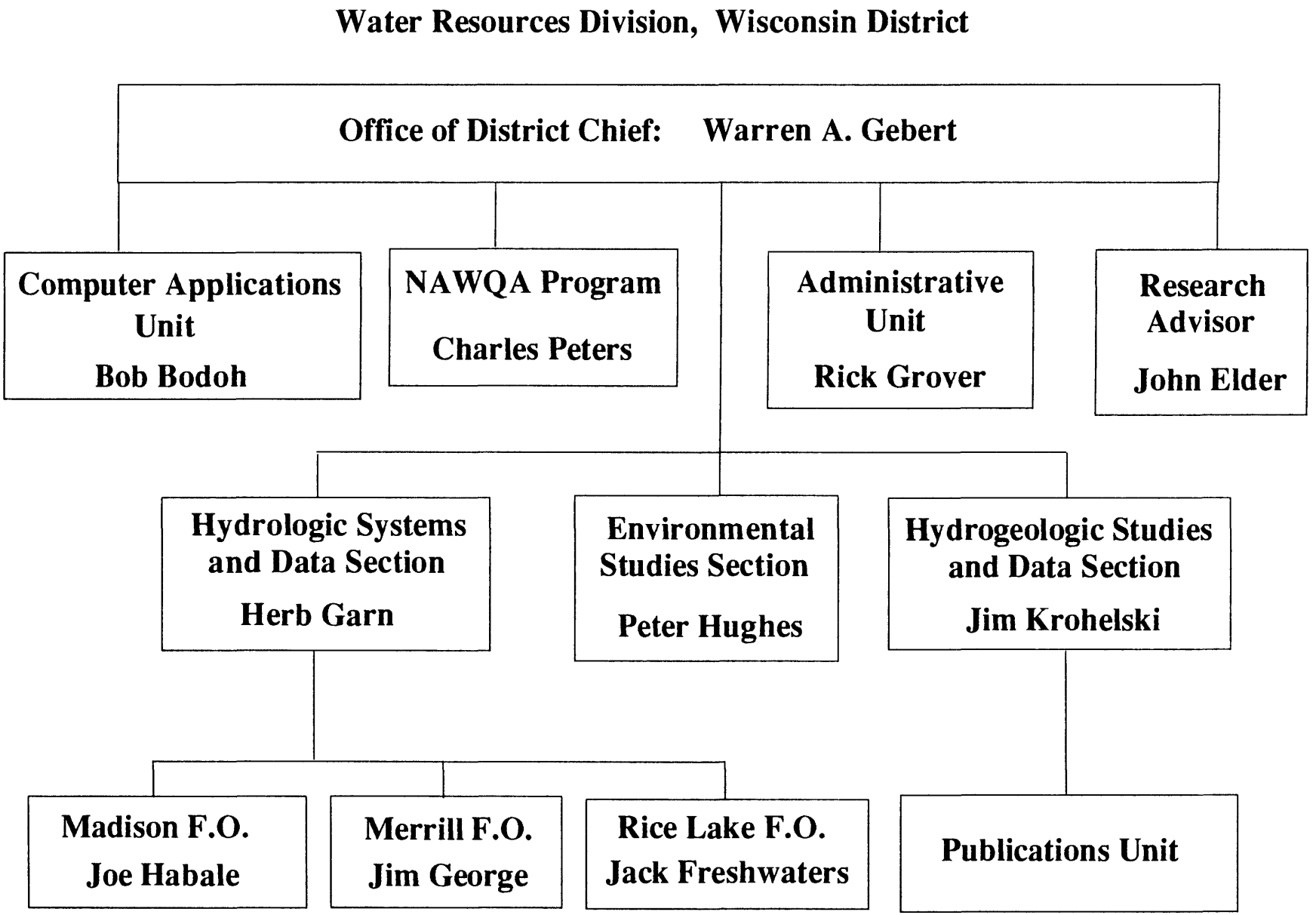


Figure 1. Organization chart of the U.S. Geological Survey, Water Resources Division, Wisconsin District.

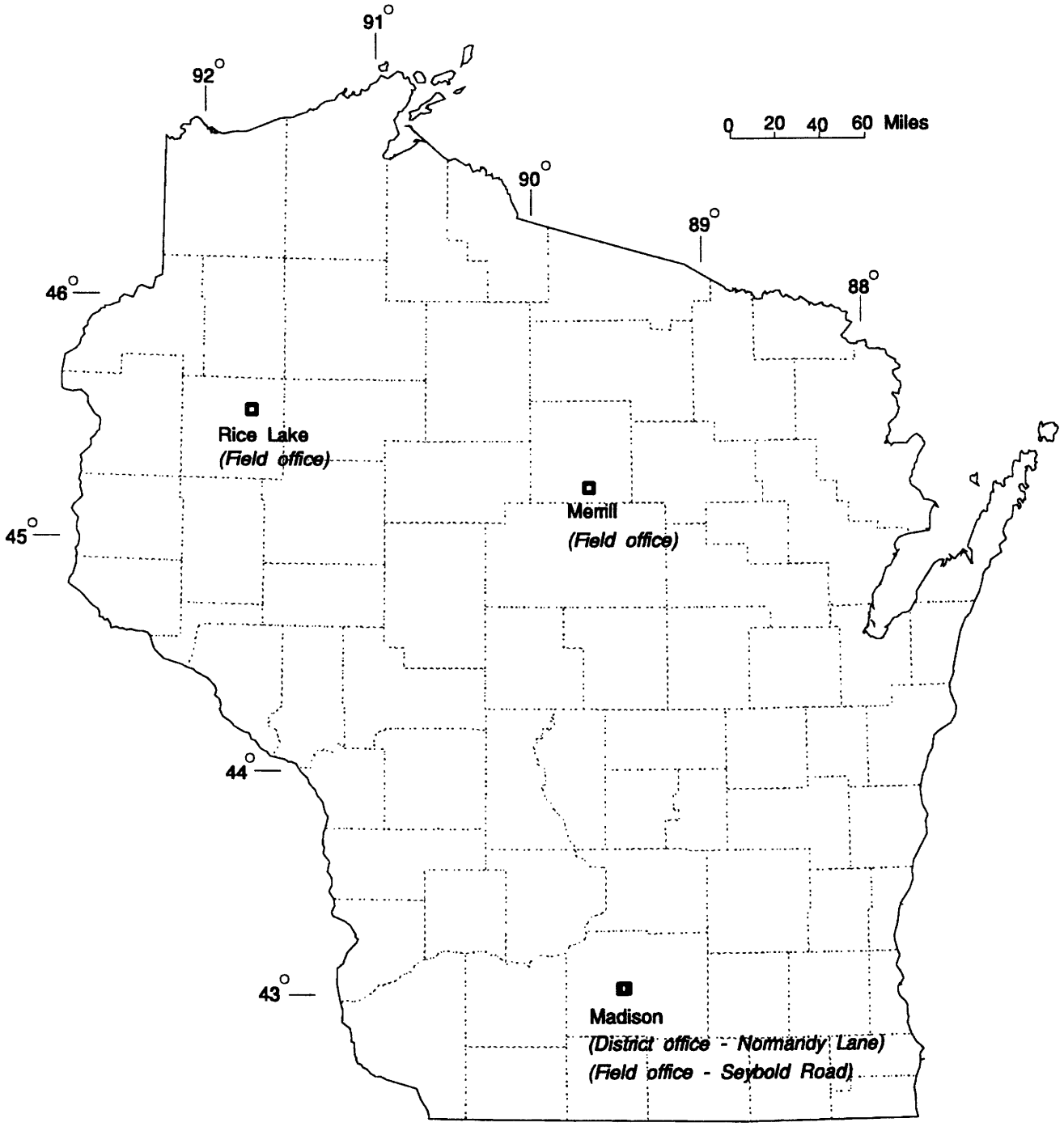


Figure 2. Location of offices in the Wisconsin District.

FUNDING SOURCES

State Agencies

Illinois Department of Transportation
Wisconsin Department of Natural Resources
Wisconsin Department of Transportation
Wisconsin Geological and Natural History Survey
Wisconsin Department of Justice

Local Agencies

Brown County Planning Commission
City of Barron
City of Beaver Dam
City of Brookfield
City of Fond du Lac
City of Hillsboro
City of Madison
City of Middleton
City of Peshtigo
City of Sparta
City of Thorp
City of Waupun
Dane County Regional Planning Commission
Dane County Department of Public Works
Darboy Sanitary District #1
Fontana/Walworth Water Pollution Control Commission
Green Bay Metropolitan Sewerage District
Greenville Sanitary District
Kaukauna Electric and Water Utilities
Kimberly Water Works Department
Madison Metropolitan Sewerage District
Rock County Public Works Department
Southeastern Wisconsin Regional Planning Commission
Town of Baraboo
Town of Menasha Sanitary District #4
Village of Little Chute
Village of Wittenberg

Other Federal Agencies

U.S. Army Corps of Engineers,
Detroit District
Rock Island District
St. Paul District
Vicksburg, MS
Federal Emergency Management Agency
Federal Energy Regulatory Commission licensees
U.S. Environmental Protection Agency

Indian Tribes

Lac du Flambeau Band of Lake Superior Chippewa
Menominee Indian Tribe of Wisconsin
Oneida Tribe of Indians of Wisconsin
Stockbridge-Munsee Band of Mohican Indians

Lake Districts

Alma/Moon Lake District
Balsam Lake Protection and Rehabilitation District
Big Muskego Lake District
City of Muskego
Dane County Lakes and Watershed Commission
Druid Lake Protection and Rehabilitation District
Eagle Spring Lake Management District
Elkhart Lake Improvement Association
Fowler Lake Management District
Green Lake Sanitary District
Lake Keesus Management District
Lauderdale Lakes Management District
Little Arbor Vitae Lake District
Little Green Lake Protection and Rehabilitation District
Little Muskego Lake District
Little St. Germain Lake District
Marinette County Land Conservation Department
Okauchee Lake District
Park Lake Management District
Potters Lake Rehabilitation and Protection District
Powers Lake Management District
Pretty Lake Protection and Rehabilitation District
Upper Nemahbin Lake Management District
Wolf Lake Management District
Town of Auburn
Town of Cedar Lake
Town of Delavan
Town of Kansasville
Town of Mead
Town of Norway
Town of St. Germain
Town of Summit
Town of Troy
Town of Waterford
Village of Lake Nebagamon
Village of Oconomowoc Lake
Wind Lake Management District

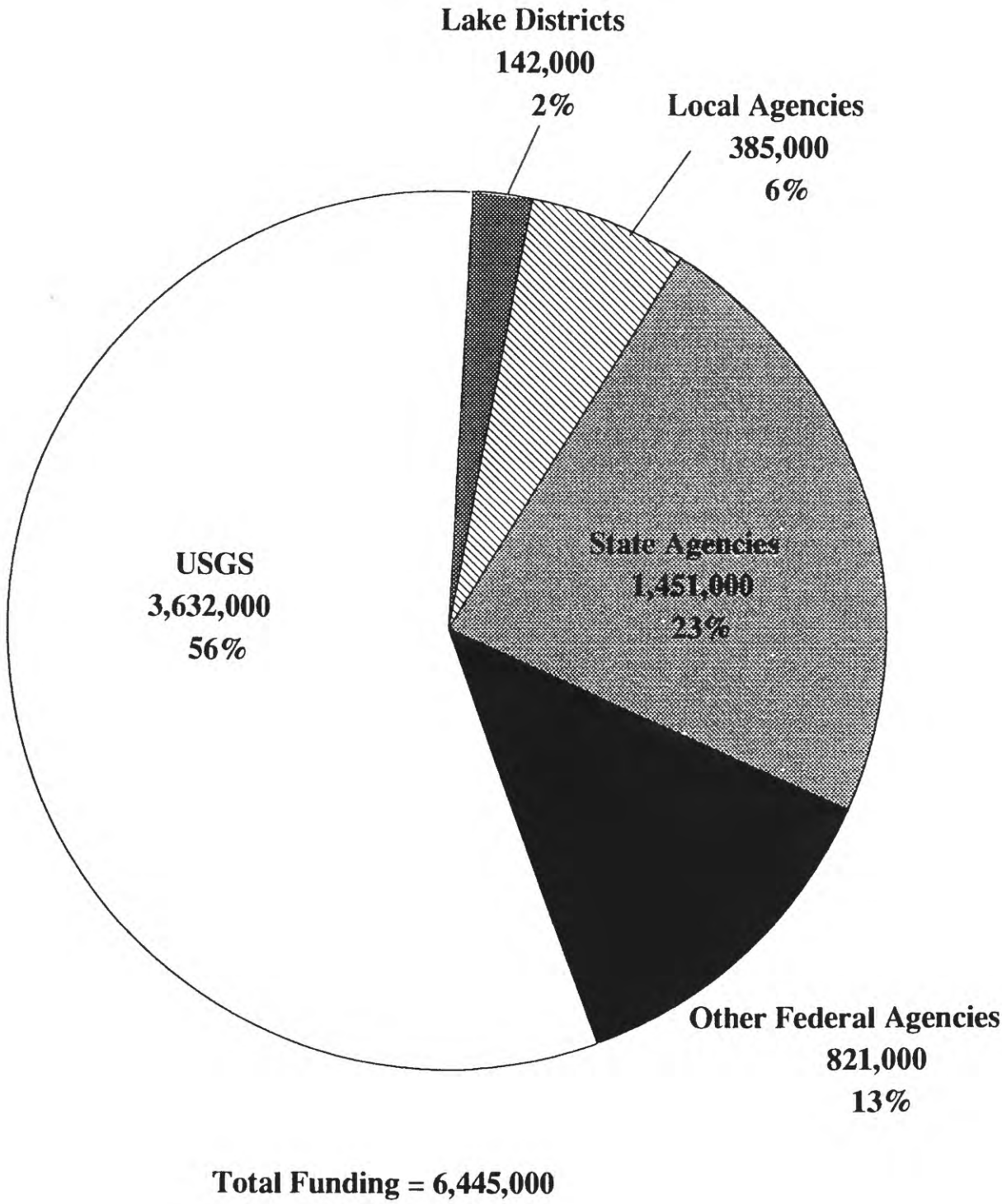


Figure 3. Funding sources for the water-resources program in Wisconsin for the 1994 fiscal year.

SUMMARY OF 1993 HYDROLOGIC CONDITIONS

Streamflow

The statewide average precipitation of 38.79 inches for the 1993 water year was 122 percent of the normal annual precipitation of 31.77 inches for water years 1961-90. Average precipitation values ranged from 103 percent of normal in northwestern Wisconsin to 150 percent of normal in southwestern Wisconsin (Pamela Naber Knox, UW-Extension, Geological and Natural History Survey, written commun., 1993).

Runoff was variable for rivers throughout the State ranging from 99 percent in north-central Wisconsin to 278 percent in southwestern Wisconsin. Departure of runoff in the 1993 water year from long-term average runoff is shown in figure 4, along with long-term average runoff for the period 1951-80. Runoff was lowest (99 percent of the average annual runoff from 1936-93) for the Wisconsin River at Rainbow Lake near Lake Tomahawk. Runoff was highest (278 percent of the average annual runoff from 1939-93) for the Pecatonica River at Darlington. The average annual runoff for the 1993 water year was the maximum for the period of record at 33 long-term stations (more than 10 years of record) in the southern half of Wisconsin.

A comparison of the annual discharge for the individual water years (1916-93) at the Oconto River near Gillett, Jump River at Sheldon, and Sugar River near Brodhead is shown in figure 5. The comparisons of monthly and annual discharges for the 1993 water year to discharge for a 78-year base period at the same three gaging stations are shown in figure 6.

Spring runoff from snowmelt and major storms, in the period March through September 1993, caused floods with discharges that equalled or exceeded those with a recurrence interval of 10 years (Krug and others, 1991) at a number of crest-stage gage and gaging stations.

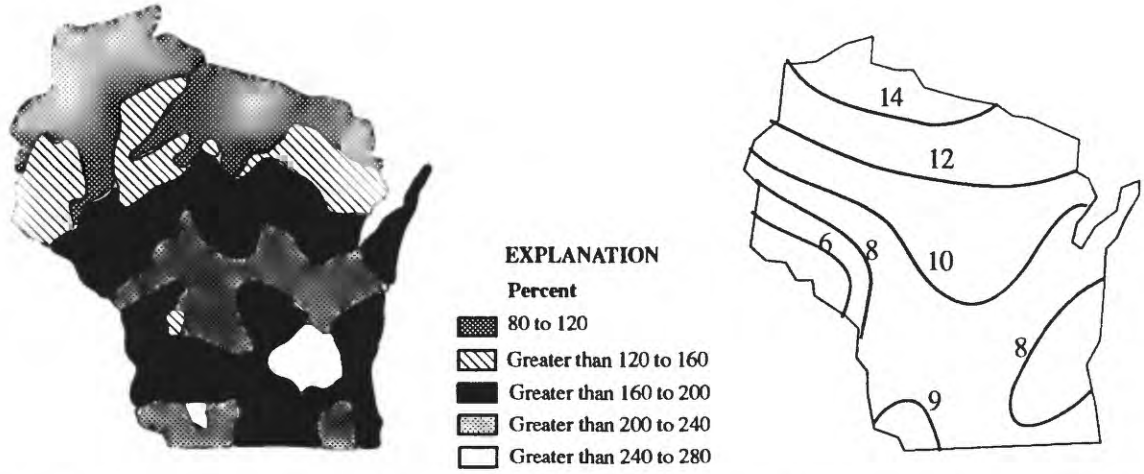


Figure 4. Departure of runoff from long-term average runoff, 1993 water year (left) and long-term average runoff, 1951-80 (right)

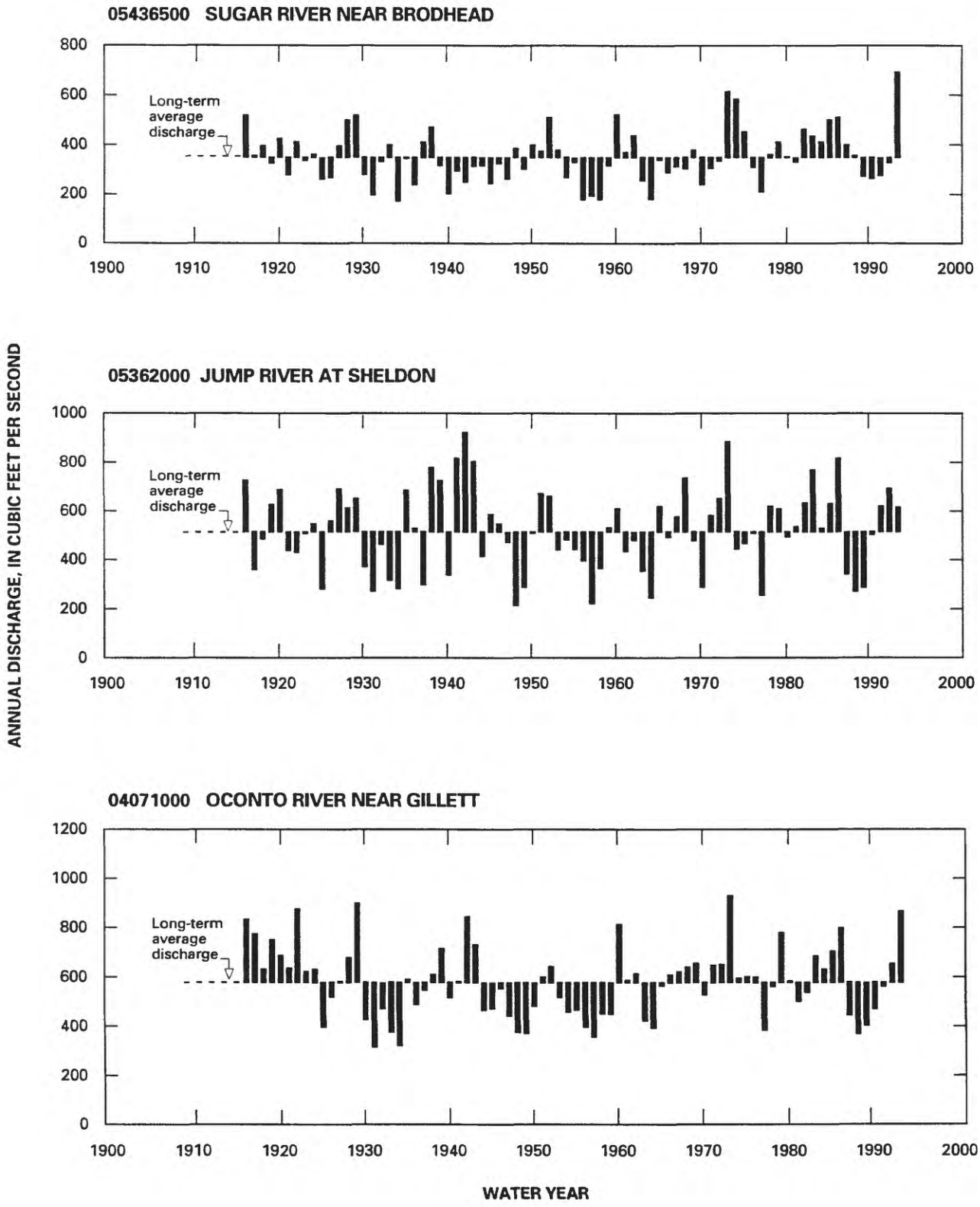


Figure 5. Comparison of annual discharge at representative gaging stations to their long-term average discharge for water years 1916-93.

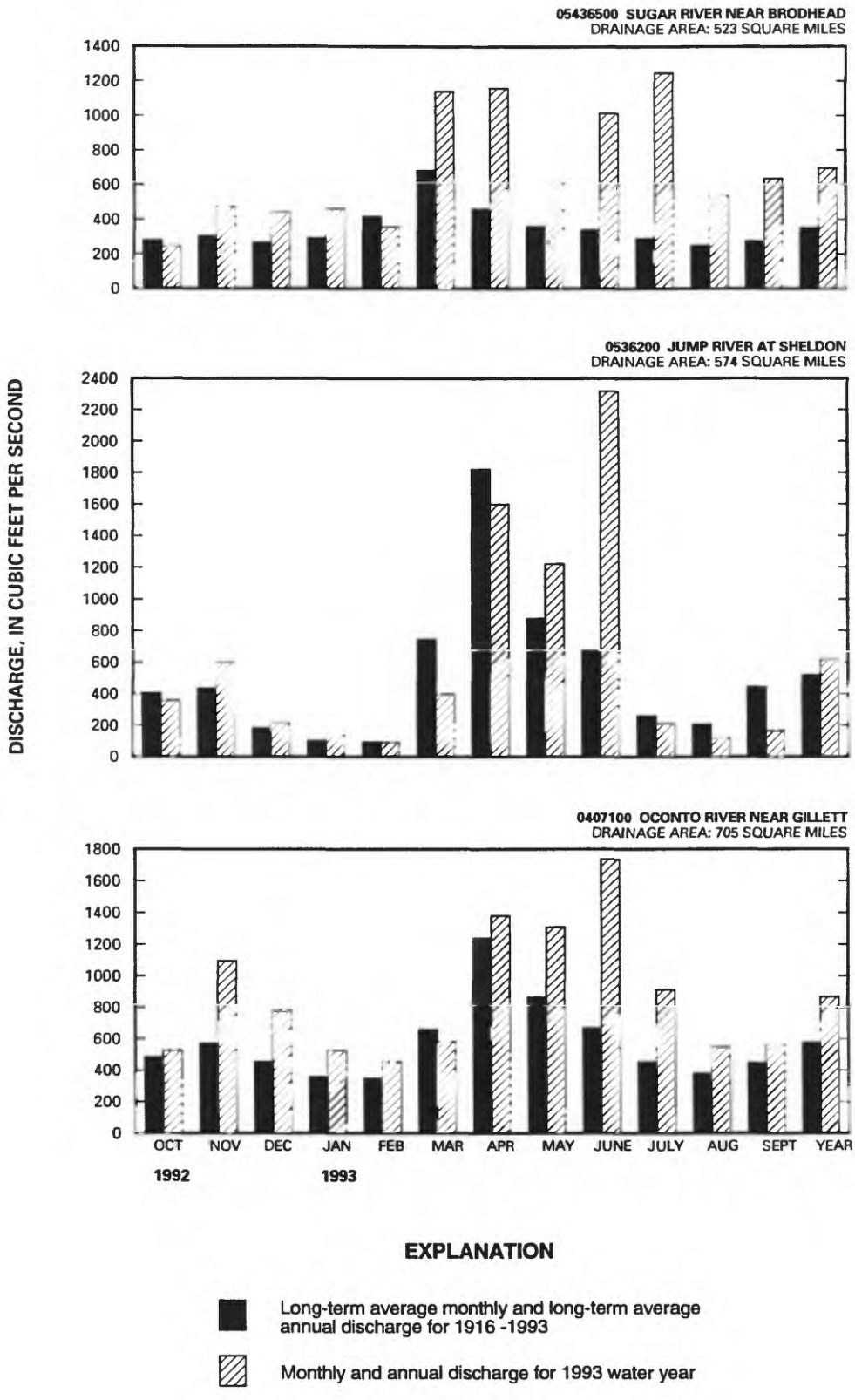


Figure 6. Comparison of discharge at representative gaging stations during water year 1993 with discharge for 1916-93.

The unprecedented floods during June and July of 1993 began with wet antecedent conditions and above-normal runoff in south-central Wisconsin in May. Periods of flooding that stand out occurred on June 20-25, July 5-6, and July 18, although the two months were unusually wet in general and had frequent passes of thunderstorms from frontal systems. The worst flooding generally occurred in drainage basins of south-central and southwestern Wisconsin.

The unusual conditions were caused by a high-pressure center anchored on the East Coast, which drew up moist, unstable air into the Midwest. This high pressure kept other systems in the Midwest from moving east, reported meteorologists from the National Meteorological Center at Camp Spring, MD (Wisconsin State Journal, August 8, 1993). At the same time, a trough over the Rocky Mountains spawned rainstorms hitting the Midwest. The jet stream, normally farther north, stalled over southern Wisconsin, trapping warm, unstable air to the south (Wisconsin State Journal, July 7, 1993). The stalled low-pressure system was locked over the Midwest, ushering storms into Wisconsin, which first began in June. Storms recurred, sometimes affecting the same areas. Over the next two months there were over a dozen storm systems passing over the region. According to the Midwest Climate Center, the June-July period was the wettest since 1895 in parts of Wisconsin, Iowa, and Illinois (Wisconsin State Journal, August 8, 1993).

Rain totals for June in west-central Wisconsin at Hatfield and LaCrosse were 12.14 inches and 10.79 inches, respectively. Neillsville in north-central Wisconsin also had a total of 10.57 inches for June (Pamela Naber Knox, UW-Extension, Geological and Natural History Survey, written commun., 1993). The precipitation total for June at LaCrosse made it the wettest month in 93 years. A total of 8.35 inches of the 10.57 inch amount fell in the week ending June 20th (Interagency Hazard Mitigation Team Report Wisconsin, 1993). The heavy rains during the week ending June 20 caused flooding which destroyed a levee on the Black River on June 20 and caused significant flooding in Black River Falls. Over 700 people were evacuated in Jackson and Clark Counties. Interstate 94 near the Black River was closed for 7 hours on June 20. The Lake Arbutus Dam on the Black River near Hatfield experienced erosion around the left abutment and was in danger of failing (Wisconsin State Journal, June 21, 1993). The first flooding along the Mississippi River and evacuation of homes near Trempealeau and Prairie du Chien occurred from this storm. On June 22, the State Journal reported the majority of farm fields were saturated, and that 71-100 percent of farmers in counties throughout the State reported surplus soil moisture hurting the corn crop. Since April 1, southern Wisconsin received 16-17+ inches of rain; the normal amount is about 9 inches.

Rainfall totals for June also exceeded 10 inches at a number of precipitation stations in southwest and south-central Wisconsin. Rainfall amounts at Monroe, Beloit, Brodhead, Cuba City, Darlington, Blanchardville, Clinton, Platteville, and Lancaster were 14.53 inches, 14.39 inches, 13.11 inches, 13.03 inches, 12.68 inches, 11.84 inches, 11.04 inches, 10.75 inches, and 10.39 inches, respectively (Pamela Naber Knox, UW-Extension, Geological and Natural History Survey, written commun., 1993). New maximum monthly mean flows were set for June for the period of record at many of the gaging stations in the southern half of the State.

A second round of significant flooding occurred from heavy rains on July 5 in south-central Wisconsin, causing significant flood damage in the Madison area and on the Pecatonica River at Darlington and East Branch Pecatonica River near Blanchardville. Madison received a record rainfall of 3.75 inches the evening of July 5, more than the normal total for the month (Wisconsin State Journal, July 6 1993).

Tributaries of the Baraboo River near Baraboo were hit hard by an extremely intense rainstorm that dumped 7 inches of rain in one hour and 12 to 13 inches of rain in four hours near Devil's Lake on the night of July 17; Baraboo received 7.78 inches (Brian Hahn, National Weather Service, written commun., July 19, 1993). Resulting flash floods in small streams were responsible for the death of a 12-year-old boy (Wisconsin State Journal, July 19, 1993).

For July, Madison received 9.34 inches of rain, 5.95 inches above normal, which is the third wettest July on record (Brian Hahn, National Weather Service, written commun., August 1993); Baraboo received 14.79 inches, 10.99 inches above normal. Most of southern Wisconsin had rainfalls for July totalling more than 6 inches, and many areas had year-to-date totals equal to or greater than that for the entire year. New maximum monthly mean flows were also set for July for the period of record at many gaging stations in southern Wisconsin.

Preliminary flood damage estimates from the initial flooding on the Black River and other streams in southwestern Wisconsin totalled $50 million on June 25 (Wisconsin State Journal, June 25, 1993). The Governor declared a state of emergency for 24 counties in the flood-stricken area. By the end of June, the Governor asked the President to declare 30 counties federal disaster areas. Damage estimates now totalled $175 million, including $125 million in damage to agriculture and $50 million in damage to structures (Wisconsin State Journal, June 30, 1993). By this time commercial traffic on the Mississippi from St. Paul to St. Louis was halted because of the high water.

Additional flooding from the July storms raised the flood damage estimates up to a total of $256 million, including $131 million in damage to roads, bridges, homes, and businesses (Wisconsin State Journal, July 12, 1993). High water levels in Madison area lakes alone caused $12 million in damage. As of August, 46 of the 72 Wisconsin counties had been declared federal disaster areas (Diane Kleiboer, Wisconsin Division of Emergency Government, oral commun., August 24, 1993). Forty of these counties were eligible for both individual and public disaster assistance. Final estimated damages in Wisconsin totalled $800 million.

Peak discharges which had recurrence intervals that equalled or exceeded 10 years are summarized in the following table:

Station number	Station name	Date	Peak discharge (cubic feet per second)	Recurrence interval (years)
04073400	Bird Creek at Wautoma	June 18	160	25
04074700	Hunting Creek near Elcho	Sept. 13	150	20
04077400	Wolf River near Shawano	June 21	3,820	17
04081900	Sawyer Creek near Oshkosh	July 5	1,700	20
04085030	Apple Creek near Kaukauna	July 5	1,900	50
04085200	Kewaunee River near Kewaunee	July 6	6,010	14
04085400	Killsnake River near Chilton	June 8	1,470	15
04087050	Little Menomonee River nr Freistadt	Apr. 20	340	13
04087200	Oak Creek near South Milwaukee	Apr. 19	660	14
04087204	Oak Creek at South Milwaukee	Apr. 19	887	10
04087233	Root River Canal near Franklin	Apr. 20	1,260	17

Station number	Station name	Date	Peak discharge (cubic feet per second)	Recurrence interval (years)
05341900	Kinnickinnic River Tributary near River Falls	Mar. 28	2,700	10
05360500	Flambeau River near Bruce	June 21	16,500	10
05362000	Jump River at Sheldon	June 21	16,400	13
05364100	Seth Creek near Cadott	June 20	532	20
05366500	Eau Claire River near Fall Creek	June 20	24,500	45
05367030	Willow Creek near Eau Claire	June 19	260	10
05369500	Chippewa River at Durand	June 23	90,100	21
05371800	Buffalo River Tributary near Osseo	June 19	154	25
05371920	Buffalo River near Mondovi	June 20	4,000	25
05380900	Poplar River near Owen	June 20	10,800	20
05380970	Cawley Creek near Neillsville	June 20	7,000	25
05381000	Black River at Neillsville	June 20	30,400	24
05382000	Black River near Galesville	June 21	64,000	>100
05386300	Mormon Creek near LaCrosse	June 17	3,770	15
05393500	Spirit River at Spirit Falls	June 20	2,730	10
05397600	Big Sandy Creek near Wausau	June 17	1,300	22
05398000	Wisconsin River at Rothschild	June 21	44,400	10
05400760	Wisconsin River at Wisconsin Rapids	June 21	64,600	34
05401800	Yellow River Tributary nr Pittsville	June 9	715	12
05404000	Wisconsin River nr Wisconsin Dells	June 24	59,100	23
05405000	Baraboo River near Baraboo	July 18	6,340	19
05406500	Black Earth Creek at Black Earth	July 6	1,320	31
05407000	Wisconsin River at Muscoda	June 26	59,600	12
05414900	Pats Creek near Elk Grove	July 9	7,000	>100
05425500	Rock River at Watertown	Apr. 20	4,620	25
05425700	Robbins Creek near Columbus	July 5	344	15
05426000	Crawfish River at Milford	Apr. 23	4,140	12
05427948	Pheasant Branch at Middleton	July 6	746	18
05427965	Spring Harbor Storm Sewer at Madison	July 5	754	21
05429500	Yahara River near McFarland	Apr. 21	681	26
05430403	Fisher Creek Tributary at Janesville	June 30	680	18
05430500	Rock River at Afton	Apr. 23	10,700	10
05431486	Turtle Creek near Clinton	June 30	5,580	14
05432300	Rock Branch near Mineral Point	July 5	3,100	>100
05432500	Pecatonica River at Darlington	July 6	12,400	24
05433500	Yellowstone River nr Blanchardville	July 6	4,700	13
05435900	Sugar River Tributary nr Pine Bluff	July 5	800	>100
05436200	Gill Creek near Brooklyn	Mar. 23	285	45
05437200	East Fork Racoon Creek Tributary near Beloit	June 30	2,300	>100
05546500	Fox River at Wilmot	Apr. 22	5,060	14
05548150	North Branch Nippersink Creek near Genoa City	June 30	350	30

References cited

Interagency hazard mitigation team report Wisconsin, FEMA 994 DR-WI, July 23, 1993, 49 p.

Krug, W. R., Conger, D. H., and Gebert, W. A., 1991, Flood-frequency characteristics of Wisconsin streams: U.S. Geological Survey Water-Resources Investigations Report 91-4128, 185 p.

Wisconsin State Journal, 800 evacuated as 2 towns flood: Madison, Wis., June 21, 1993.

____, Relentless rain hits corn hardest: Madison, Wis., June 22, 1993.

____, Rain adds to flood woes: Madison, Wis., June 25, 1993.

____, Thompson to seek federal aid for 30 counties hit by floods: Madison, Wis., June 30, 1993.

____, Record rainfall in Madison: Madison, Wis., July 6, 1993.

____, Why so much rain? Jet stream stalled: Madison, Wis., July 7, 1993.

____, Flood damage $256 million: Madison, Wis., July 12, 1993.

____, Baraboo hit hard: Madison, Wis., July 19, 1993.

____, When rivers overflow with rage: Madison, Wis., August 8, 1993.

Water Quality

Suspended-sediment and total phosphorus yields in southern Wisconsin for the 1993 water year were well above long-term average yields. The suspended-sediment yield at the Grant River at Burton in southwestern Wisconsin was 794 tons/mi^2 (tons per square mile), which is about three times the average yield for 1978-93. The total-phosphorus yield for Delavan Lake Inlet in southeastern Wisconsin for the 1993 water year was 725 lbs/mi^2 (pounds per square mile), which is about twice the average yield for the period 1984-93. Suspended-sediment and total-phosphorus yields at Silver Creek near Ripon were about 75 percent higher in the 1993 water year than the average annual yield for the period 1988-93.

Data collection began at ten sites operated by the National Water-Quality Assessment Program (NAWQA). Samples were collected at approximately monthly intervals and during storms from March through September. Data for these sites for the 1993 water year are included in this report; data collection will continue in the 1994 water year.

Ground-Water Levels

Maps showing the seasonal ground-water trends for the year (fig. 7) are based on water-level data from 26 shallow-aquifer wells, each having at least 15 years of record. Water-level measurements from each well are grouped so that fall consists of measurements from October through December 1992; winter consists of measurements from January through March 1993; spring consists of measurements from April through June 1993; and summer consists of measurements from July through September 1993. Mean seasonal water levels were compared to the long-term mean seasonal water levels. The 1993 water level was considered normal if it was within one-half of the standard deviation on the long-term mean.

In general, shallow ground-water levels during the 1993 water year were normal to above normal for most of the wells in the State. The only counties having below normal ground-water levels were Door and Milwaukee in the fall, Forest in the winter, and Chippewa in the spring, with no counties having ground-water levels below normal in the summer. Most ground-water levels were above normal in the summer, with only a narrow section in northern part of the State having normal ground-water levels. The large extent of the above normal ground-water levels can be attributed to the above normal rainfall during the 1993 water year.

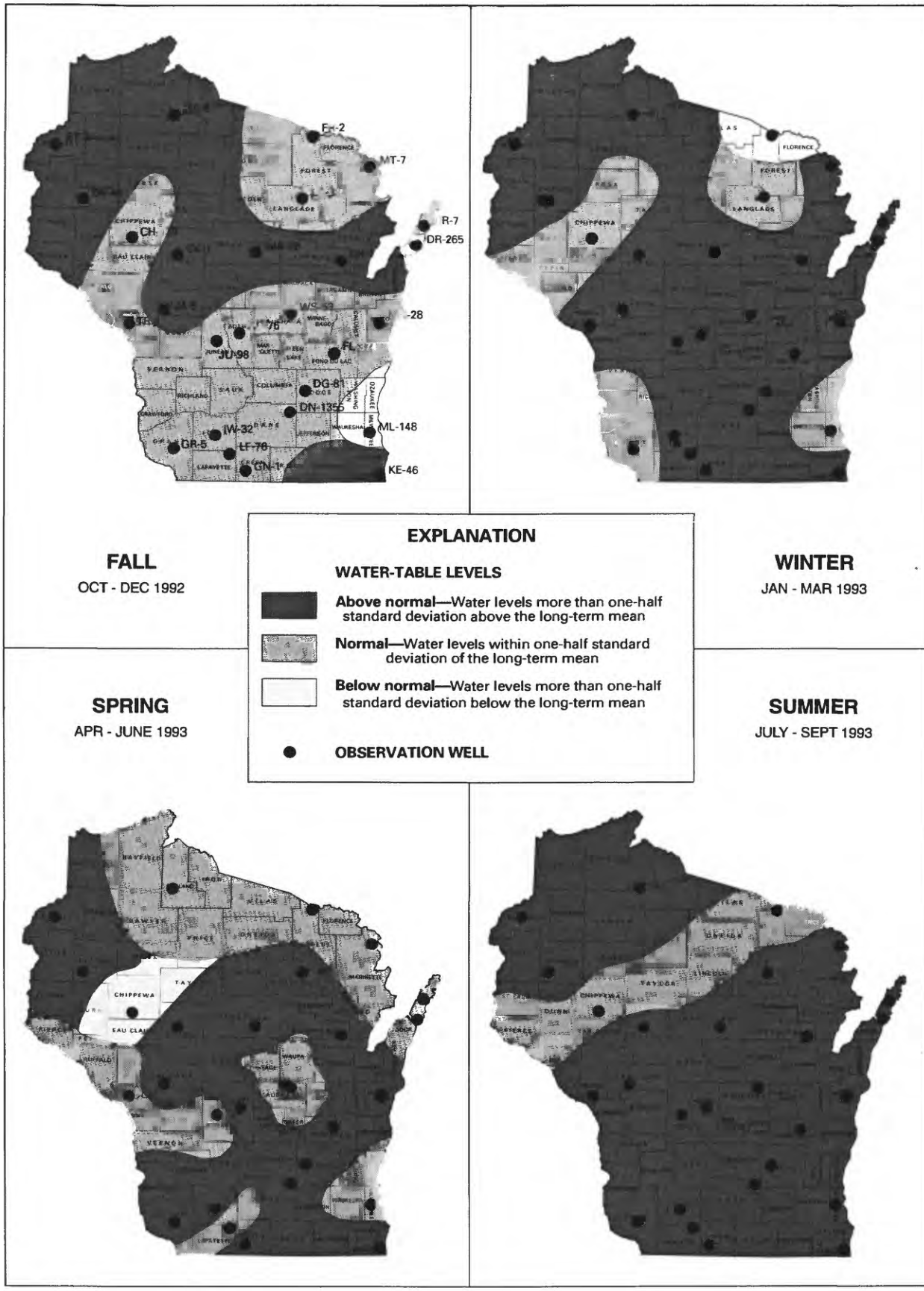


Figure 7. Relation of seasonal water-table levels to long-term means.

COLLECTION OF BASIC RECORDS—SURFACE WATER, WI 001

COOPERATORS:
Wisconsin Department of Natural Resources
U.S. Army Corps of Engineers
Southeastern Wisconsin Regional Planning Commission
Federal (Regular)
Madison Metropolitan Sewerage District
Dane County Department of Public Works
Federal Energy Regulatory Commission Licensees
Lac du Flambeau Band of Lake Superior Chippewa
Illinois Department of Transportation
City of Barron
City of Beaver Dam
City of Brookfield
City of Hillsboro
City of Peshtigo
City of Sparta
City of Thorp
City of Waupun
Village of Wittenberg
Fontana/Walworth Water Pollution Control Commission
Rock County Public Works Department

LOCATION:
Statewide

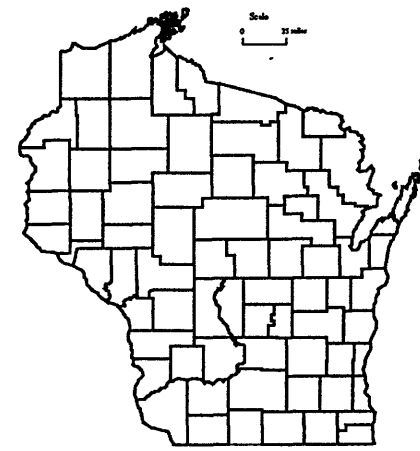
PROJECT CHIEF:
Barry K. Holmstrom

PERIOD OF PROJECT:
July 1913-Continuing

PROBLEM: Surface-water information is needed for surveillance, planning, design, hazard warning, operation, and management in water-related fields such as water supply, hydroelectric power, flood control, irrigation, bridge and culvert design, wildlife management, pollution abatement, flood-plain management, and water-resources development. An appropriate data base is necessary to provide this information.

OBJECTIVE: The objectives of this study are to provide continuous discharge records for selected rivers at specific sites to supply the needs for: regulation, analytical studies, definition of statistical properties, trends analysis, determination of the occurrence, and distribution of water in streams for planning. The project is also designed to determine lake levels and to provide discharge for floods, low-flow conditions, and for water-quality investigations. Requests for streamflow data and information relating to streamflow in Wisconsin are answered. Basic data are published annually in "Water Resources Data-Wisconsin, water year 1994."

APPROACH: A network of streamflow stations and lake-level stations will be maintained throughout Wisconsin. This includes: operating the equipment at the gaging station to record river or lake stage, making periodic discharge measurements at each streamflow station to establish or verify a stage-discharge rating curve, reducing the stage records to instantaneous and daily discharges, compilation



of monthly and annual discharges, and preparing data for publication in the annual "Water Resources Data-Wisconsin, water year 1994" report.

Requests for streamflow data from other government agencies, consultants, and private parties will be processed.

PROGRESS (July 1993 to June 1994): During the current fiscal year, streamflow data were collected at a total of 96 sites: 39 sites for the Wisconsin Department of Natural Resources, 8 sites for the Corps of Engineers, 14 sites for the Southeastern Wisconsin Regional Planning Commission, 8 sites for the Federal program, 2 sites for Federal Energy Commission Licensees, 2 sites for the Madison Metropolitan Sewerage District, and 1 site each for the Lac du Flambeau Band of Lake Superior Chippewa, Illinois Department of Transportation, cities of Barron, Beaver Dam, Brookfield, Hillsboro, Peshtigo, Sparta, Thorp, Waupun, village of Wittenberg, and Fontana/Walworth Water Pollution Control Commission. Streamflow data were also collected at 11 sites for agencies working jointly with the USGS. Lake-level data were collected at two sites for the Dane County Department of Public Works, at two sites for the Corps of Engineers, and at one site for Rock County Public Works Department.

Computation of streamflow and lake-level records for all the network stations for the 1993 water year was completed, stored in our WATSTORE computer data base, and published in the annual "Water Resources Data-Wisconsin, water year 1993" report.

More than 100 requests for streamflow information were answered.

PLANS (July 1994 to June 1995): Data will be collected at 98 continuous-streamflow stations (see the following list) and lake levels at 5 stations. Streamflow records will be computed and data published for the 1994 water year. Requests for streamflow information will be answered.

SURFACE-WATER GAGING STATIONS EXPECTED TO BE OPERATED IN 1995 FY

Station number	Name and location	Period of record (water year)	Cooperator
04024430	Nemadji River - South Superior	1974-	DNR
04025500	Bois Brule River - Brule	1943-81, 1984-	Fed.
04027000	Bad River - Odanah	1914-23, 1948	C of E, Detroit
04027500	White River - Ashland	1948-	DNR
04029990	Montreal River - Saxon Falls	1987	DNR
04063700	Popple River - Fence	1964-	Fed.
04065106	Menominee River - Niagara	1993-	FERC
04066003	Menominee River - Pembine	1950-	DNR
04069500	Peshtigo River - Peshtigo	1953-	City of Peshtigo
04071000	Oconto River - Gillett	1906-09, 1914-	Fed.
04071858	Pensaukee River - Pensaukee	1973-	DNR
04073500	Fox River - Berlin	1898-	C of E, Detroit
04077400	Wolf River - Shawano	1907-09, 1911-	FERC
0407809265	Middle Branch Embarrass River -Wittenberg	1990	Village of Wittenberg
04078500	Embarrass River - Embarrass	1919-85, 1994-	Fed.
04079000	Wolf River - New London	1896-	C of E, Detroit
04082400	Fox River - Oshkosh	1991	DNR
04084445	Fox River - Appleton	1986-	C of E, Detroit
04084500	Fox River - Wrightstown	1896-	DNR
04085200	Kewaunee River - Kewaunee	1964-	DNR
04085281	East Twin River - Mishicot	1972-	DNR
04085427	Manitowoc River - Manitowoc	1972-	DNR
04086000	Sheboygan River - Sheboygan	1916-24, 1951-	DNR
04086360	Milwaukee River - Waubeka	1968-81, 1994 -	Fed.
04086500	Cedar Creek - Cedarburg	1930-70, 73-81, 1983-87, 1991 -	DNR
04086600	Milwaukee River - Pioneer Road	1982-	SEWRPC
04087000	Milwaukee River - Milwaukee	1914-	SEWRPC
04087030	Menomonee River - Menomonee Falls	1975-77, 1979-	SEWRPC
04087088	Underwood Creek - Wauwatosa	1975-	SEWRPC
04087120	Menomonee River - Wauwatosa	1962-	SEWRPC
04087160	Kinnickinnic River - Milwaukee	1976-	SEWRPC
04087204	Oak Creek - South Milwaukee	1964-	SEWRPC
04087220	Root River - Franklin	1964-	SEWRPC
04087233	Root River Canal - Franklin	1964-	SEWRPC
04087240	Root River - Racine	1963-	SEWRPC
04087257	Pike River - Racine	1972-	SEWRPC
05332500	Namekagon River - Trego	1928-70, 1988	DNR
05333500	St. Croix River - Danbury	1914-81, 1985-	DNR
05340500	St. Croix River - St. Croix Falls	1902-	DNR
05341500	Apple River - Somerset	1901-70, 1987	DNR
05356000	Chippewa River - Winter	1912-	DNR
05356500	Chippewa River - Bruce	1914-	DNR
05357335	Bear River - Manitowish Waters	1991	Lac du Flambeau Band of Lake Superior Chippewa
05360500	Flambeau River - Bruce	1951-	DNR, FERC
05362000	Jump River - Sheldon	1915-	DNR
05365500	Chippewa River - Chippewa Falls	1888-1983, 1987	DNR
05365707	North Fork Eau Claire River - Thorp	1986	City of Thorp
053674464	Yellow River - Barron	1991	City of Barron
05368000	Hay River - Wheeler	1951-	Fed.
05369000	Red Cedar River - Menomonie	1907-08, 1913-	DNR
05369500	Chippewa River - Durand	1928-	C of E, St. Paul, DNR
05369945	Eau Galle River - low water bridge	1982-83, 1986-	C of E, Vicksburg
05370000	Eau Galle River - Spring Valley	1944-	C of E, St. Paul

SURFACE-WATER GAGING STATIONS EXPECTED TO BE OPERATED IN 1995 FY

Station number	Name and location	Period of record (water year)	Cooperator
05379500	Trempealeau River - Dodge	1914-19, 1934	C of E, St. Paul, DNR
05381000	Black River - Neillsville	1905-09, 1914-	DNR
05382000	Black River - Galesville	1932-	C of E, St. Paul, DNR
05382325	La Crosse River - Sparta	1992-	City of Sparta
05391000	Wisconsin River - Lake Tomahawk	1936-	DNR
05393500	Spirit River - Spirit Falls	1942-	DNR
05394500	Prairie River - Merrill	1914-31, 1939-	DNR
05395000	Wisconsin River - Merrill	1903-	DNR
05397500	Eau Claire River - Kelly	1914-27, 1939-	DNR
05398000	Wisconsin River - Rothschild	1945-	DNR
05399500	Big Eau Pleine River - Stratford	1914-26, 1937-	DNR
05400760	Wisconsin River - Wisconsin Rapids	1914-50, 1958-	DNR
05401050	Tenmile Creek - Nekoosa	1963-79, 1987	DNR
05402000	Yellow River - Babcock	1944-	DNR
05403500	Lemonweir River - New Lisbon	1944-87, 1994-	Fed.
05404000	Wisconsin River - Wisconsin Dells	1935-	DNR
05404116	S. Br. Baraboo River - Hillsboro	1988-	City of Hillsboro
05405000	Baraboo River - Baraboo	1914-22, 1943-	Fed.
05406500	Black Earth Creek - Black Earth	1954-	DNR
05407000	Wisconsin River - Muscoda	1903-04, 1914-	C of E, St. Paul, DNR
05408000	Kickapoo River - LaFarge	1939-	DNR
05410490	Kickapoo River - Steuben	1933-	C of E, St. Paul, DNR
05413500	Grant River - Burton	1935-	C of E, R. Island, DNR
05414000	Platte River - Rockville	1935-	C of E, R. Island, DNR
05423500	S. Br. Rock River - Waupun	1948-69, 1987	City of Waupun
05425500	Rock River - Watertown	1931-70, 1977-	C of E, R. Island, DNR
05425912	Beaverdam River - Beaver Dam	1984-	City of Beaver Dam
05426000	Crawfish River - Milford	1931-	C of E, R. Island, DNR
05426031	Rock River - Jefferson	1978-	C of E, R. Island, DNR
05426250	Bark River - Rome	1980-	SEWRPC
05427570	Rock River - Indianford	1975-	DNR
05429500	Yahara River - McFarland	1930-	DNR
05430150	Badfish Creek - Cooksville	1977-	MMSD
05430175	Yahara River - Fulton	1977	MMSD
05430500	Rock River - Afton	1914-	DNR
05431486	Turtle Creek - Clinton	1939-	DNR
05432500	Pecatonica River - Darlington	1939-	C of E, R. Island
05433000	E. Br. Pecatonica River - Blanchardville	1939-1986, 1988	C of E, R. Island
05434500	Pecatonica River - Martintown	1940-	C of E, R. Island
05436500	Sugar River - Brodhead	1914-	DNR
05438283	Piscasaw Creek - Walworth	1992-	Fontana/Walworth WPCC
05543800	Fox River -Watertown Road - Waukesha	1993-	City of Brookfield
05543830	Fox River - Waukesha	1963-	SEWRPC
05544200	Mukwonago River - Mukwonago	1973-	SEWRPC
05546500	Fox River - Wilmot	1940-	IL. DOT
	LAKES		
04082500	Lake Winnebago - Oshkosh	1882-	C of E, Detroit
04084255	Lake Winnebago - Stockbridge	1983-	C of E, Detroit
05427235	Lake Koshkonong - Newville	1987	Rock County
05428000	Lake Mendota - Madison	1903, 1916-	DCDPW
05429000	Lake Monona - Madison	1915-	DCDPW

DNR — Department of Natural Resources
C of E, Detroit — Corps of Engineers, Detroit, Michigan
C of E, R. Island — Corps of Engineers, Rock Island, Illinois
C of E, St. Paul — Corps of Engineers, St. Paul, Minnesota
SEWRPC — Southeastern Wisconsin Regional Planning Commission
Fed. — USGS Federal Program
FERC — Federal Energy Regulatory Commission Licensees
MMSD — Madison Metropolitan Sewerage District
DCDPW — Dane County Department of Public Works
IL. DOT — Illinois Department of Transportation
Fontana/Walworth WPCC - - Fontana/Walworth Water Pollution Control Commission

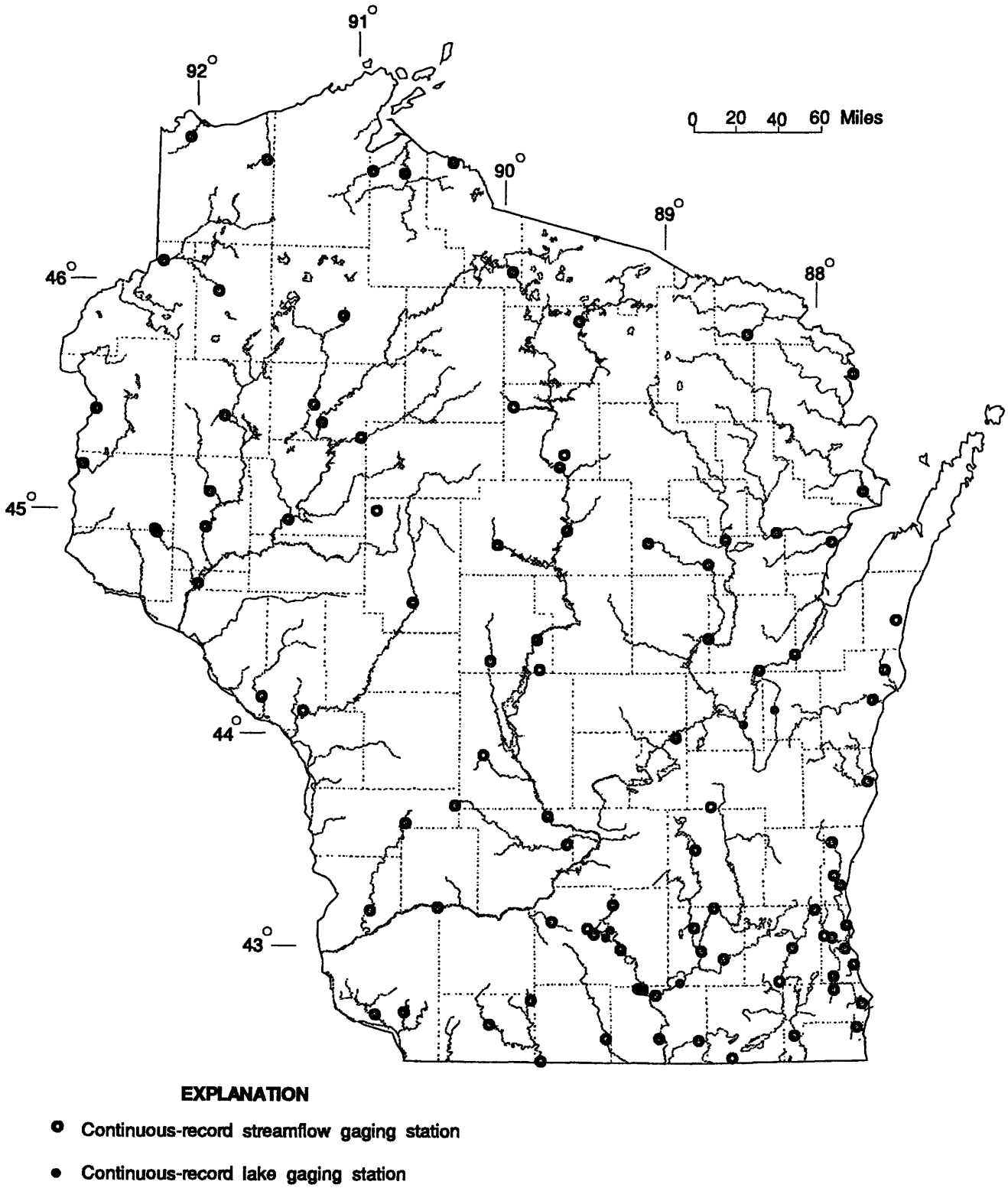


Figure 8. Location of continuous-record data-collection stations.

DISCONTINUED SURFACE-WATER DISCHARGE STATIONS

The following continuous-record surface-water discharge stations in Wisconsin have been discontinued. Daily streamflow records were collected and published for the period of record, expressed in water years, shown for each station. Those stations with an asterisk (*) after the station number are currently operated as crest-stage partial-record stations. Some of the discontinued project stations with less than three years of record have not been included. Information regarding these stations may be obtained from the District Office at the address given on the back side of the title page of this report.

Discontinued surface-water discharge stations

Station name	Station number	Drainage area (square miles)	Period of record
STREAMS TRIBUTARY TO LAKE SUPERIOR			
Little Balsam Creek at Patzau, WI	04024314	4.89	1976-78
Little Balsam Creek near Patzau, WI	04024315	5.05	1976-78
Little Balsam Creek Tributary near Patzau, WI	04024318	0.60	1976-78
Little Balsam Creek near Foxboro, WI	04024320	3.27	1977-78
Amnicon River near Poplar (Amnicon Falls), WI	04025000	110	1914-16
Bois Brule (Brule) River near Brule, WI	04026000	160	1914-17
Sioux River near Washburn, WI	04026300*	33.9	1965-66
Pine Creek at Moquah, WI	04026347	6.20	1976-78
Pine Creek Tributary at Moquah, WI	04026348	0.48	1976-78
Pine Creek near Moquah, WI	04026349	19.9	1976-78
North Fish Creek near Moquah, WI	040263491	65.4	1990-91
Bad River near Mellen, WI	04026450*	82.0	1971-75
Bad River at Mellen, WI	04026500	98.3	1948-55
Alder Creek near Upson, WI	04026870	22.2	1972-77
Montreal River near Kimball, WI	04028500	100	1924-26
West Fork Montreal River at Gile, WI	04029000	75.0	1918-26, 1943-47
West Fork Montreal River near Kimball, WI	04029500	86.2	1924-26
STREAMS TRIBUTARY TO LAKE MICHIGAN			
North Branch Pine River at Windsor Dam nr Alvin, WI	04063640*	27.8	1967-68
Pine River near Florence, WI	04064000	510	1914-23
Pine River below Pine River Power Plant near Florence, WI	04064500	533	1924-76
Pike River at Amberg, WI	04066500	255	1914-70
Menominee River near McAllister, WI	04067500	3,930	1945-61, 1979-86, 1988-90
Peshtigo River at High Falls near Crivitz, WI	04068000	537	1912-57
Suamico River at Suamico, WI	04072000	60.7	1951-52
Lawrence Creek near Westfield, WI	04072750	13.4	1968-73
Grand River near Kingston, WI	04073050	73.5	1968-75
West Branch White River near Wautoma, WI	04073405	38.9	1964-75
White Creek at Forest Glen Beach near Green Lake, WI	04073462	3.05	1982-88
Swamp Creek above Rice Lake at Mole Lake, WI	04074538	46.3	1977-83, 1985-87
Swamp Creek below Rice Lake at Mole Lake, WI	04074548	56.8	1977-79, 1982-85
Wolf River near White Lake, WI	04075000	485	1935-38
Evergreen Creek near Langlade, WI	04075200*	8.09	1964-73
Wolf River above West Branch Wolf River, WI	04075500	616	1928-62
West Branch Wolf River at Neopit, WI	04076000	93.2	1911-17
West Branch Wolf River near Keshena, WI	04076500	163	1928-32
Little Wolf River near Galloway, WI	04079602	22.6	1974-79
Spaulding Creek near Big Falls, WI	04079700*	5.57	1964-66
Little Wolf River at Royalton, WI	04080000	507	1914-70, 1983-85
Emmons Creek near Rural, WI	04080950	25.1	1977
Storm Sewer to Mirror Lake at Waupaca, WI	04080976	0.04	1971-74
Waupaca River near Waupaca, WI	04081000	265	1916-66, 1983-85
Daggets Creek at Butte Des Morts, WI	04081800	10.6	1977
West Branch Fond du Lac River at Fond du Lac, WI	04083000	83.1	1939-54
East Branch Fond du Lac River near Fond du Lac, WI	04083500	78.4	1939-54
Brothertown Creek at Brothertown, WI	04084200	5.10	1976-77
Onion River at Hingham, WI	04085813	37.2	1979-80
Onion River near Sheboygan Falls, WI	04085845	94.1	1979-82
Milwaukee River at Kewaskum, WI	04086150	138	1968-81
East Branch Milwaukee River near New Fane, WI	04086200	54.1	1968-81

Discontinued surface-water discharge stations

Station name	Station number	Drainage area (square miles)	Period of record
North Branch Milwaukee River near Fillmore, WI	04086340	148	1968-81
Mud Lake Outlet near Decker Corner, WI	04086488	7.36	1983-84
Milwaukee River above North Ave Dam at Milwaukee, WI	04087010	702	1982-84
Menomonee River at Germantown, WI	04087018	19.0	1975-77
Jefferson Park Drainageway at Germantown, WI	04087019	1.82	1976-78
Menomonee River at Butler, WI	04087040	60.6	1975-79
Little Menomonee River near Freistadt, WI	04087050*	8.0	1975-79
Noyes Creek at Milwaukee, WI	04087060	1.94	1975-80, 1990
Little Menomonee River at Milwaukee, WI	04087070	19.7	1975-77
Honey Creek at Wauwatosa, WI	04087119	10.3	1975-81
Schoonmaker Creek at Wauwatosa, WI	04087125	1.94	1975-79
Hawley Road Storm Sewer at Milwaukee, WI	04087130	1.83	1975-77
Menomonee River at Milwaukee, WI	04087138	134	1982-84
Kinnickinnic River at Milwaukee, WI	04087160	20.4	1976-83
ST. CROIX RIVER BASIN			
Namekagon River at Trego, WI	05332000	433	1914-27
Loon Creek near Danbury, WI	05335010	17.6	1970-71
Bashaw Brook near Shell Lake, WI	05335380*	26.6	1964-66
Clam River near Webster, WI	05335500	361	1941-42
St. Croix River near Grantsburg, WI	05336000	2,980	1923-70
Wood River near Grantsburg, WI	05339000	185	1939-40
Rice Creek near Balsam Lake, WI	05341375	12.5	1988-89
Balsam Branch at Balsam Lake, WI	05341402	52.8	1988-90
Kinnickinnic River near River Falls, WI	05342000	165	1917-21
CHIPPEWA RIVER BASIN			
West Fork Chippewa River at Lessards, nr Winter, WI	05355500	474	1912-16
Couderay River near Couderay, WI	05356121	169	1981-83
Flambeau River at Flambeau Flowage (Flambeau Reservoir), WI	05357500	622	1927-61
Flambeau River near Butternut, WI	05358000	688	1914-39
Pine Creek near Oxbo, WI	05358300	38.9	1971-75
Flambeau River at Babbs Island near Winter, WI	05358500	967	1929-75
South Fork Flambeau River near Phillips, WI	05359500	609	1929-75
Price Creek near Phillips, WI	05359600*	16.9	1964-66
Flambeau River near (at) Ladysmith, WI	05360000	1,790	1903-06, 1914-61
Chippewa River near Holcombe, WI	05361000	3,720	1944-49
South Fork Jump River near Ogema, WI	05361500	327	1944-54
Chippewa River at Holcombe, WI	05362500	4,680	1943-49
Fisher River at (near) Holcombe, WI	05363000	81.5	1944-45
O'Neil Creek near Chippewa Falls, WI	05363500	78.1	1944-45
Yellow River near Hannibal, WI	05363700	86.7	1962-63
Yellow River at Cadott, WI	05364000*	364	1943-61
Duncan Creek at Bloomer, WI	05364500*	50.3	1944-52
Duncan Creek Tributary near Tilden, WI	05364850	4.17	1987-89
Duncan Creek at Chippewa Falls, WI	05365000	117	1943-55
Eau Claire River near Augusta, WI	05366000	509	1914-26
Bridge Creek at Augusta, WI	05366300	35.0	1980
Eau Claire River near Fall Creek, WI	05366500*	760	1943-55
Chippewa River at (near) Eau Claire, WI	05367000	6,620	1903-09, 1944-54
Red Cedar River near Cameron, WI	05367425	442	1966-70
Red Cedar River near Cameron, WI	05367426	443	1971-73
Red Cedar River near Colfax, WI	05367500	1,100	1914-80, 1989-90
Eau Galle River near Woodville, WI	05369900	39.4	1978-83
French Creek near Spring Valley, WI	05369955	6.03	1981-83
Lousy Creek near Spring Valley, WI	05369970	5.97	1981-83
Lohn Creek near Spring Valley, WI	05369985	2.53	1981-83
Eau Galle River at Elmwood, WI	05370500	91.6	1943-54
BUFFALO RIVER BASIN			
Buffalo River near Tell, WI	05372000	406	1933-51

Discontinued surface-water discharge stations

Station name	Station number	Drainage area (square miles)	Period of record
TREMPEALEAU RIVER BASIN			
Bruce Valley Creek near Pleasantville, WI	05379288	10.1	1980
Elk Creek near Independence, WI	05379305	108	1980
Trempealeau River at Arcadia, WI	05379400	553	1960-77
Trempealeau River near Trempealeau, WI	05380000	719	1932-34
BLACK RIVER BASIN			
Black River at Medford, WI	05380806	48.1	1984-87
Poplar River near Owen, WI	05380900*	155	1964-66
LA CROSSE RIVER BASIN			
Little LaCrosse River near Leon, WI	05382500	76.9	1934-61, 1979-81
LaCrosse River near West Salem, WI	05383000	396	1914-70
COON CREEK BASIN			
Spring Coulee Creek near Coon Valley, WI	05386490	9.01	1979-81
Coon Creek at Coon Valley, WI	05386500	77.2	1934-40, 1978-81
Coon Creek near Stoddard, WI	05386999	120	1934-40, 1979-81
BAD AXE RIVER BASIN			
North Fork Bad Axe River near Genoa, WI	05387100*	80.8	1964-66
WISCONSIN RIVER BASIN			
Wisconsin River at Conover, WI	05390180	177	1967-71
Pelican River near Rhinelander, WI	05391226	101	1976-79
Wisconsin River at Whirlpool Rapids, near Rhinelander, WI	05392000	1,220	1906-61
Bearskin Creek near Harshaw, WI	05392350*	31.1	1964-66
Tomahawk River near Bradley, WI	05392400	422	1915-27, 1929
Tomahawk River at Bradley, WI	05393000	544	1930-73
New Wood River near Merrill, WI	05394000	82.2	1953-61
Rib River at Rib Falls, WI	05396000	303	1925-57
Little Rib River near Wausau, WI	05396500	79.1	1914-16
East Branch Eau Claire River near Antigo, WI	05397000	81.5	1949-55
Eau Claire River near Antigo, WI	05397110	185	1975-81
Bull Junior Creek (Bull Creek Junior) near Rothschild, WI	05398500	27.4	1944-52
Big Eau Pleine River near Colby, WI	05399000	78.1	1941-54
Hamann Creek near Stratford, WI	05399431	11.3	1977-79
Wisconsin River at Knowlton, WI	05400000	4,530	1921-42
Plover River near Stevens Point, WI	05400500	145	1914-20, 1944-52
Little Plover River near Arnott, WI	05400600	2.24	1959-75
Little Plover River at Plover, WI	05400650	19.0	1959-87
Fourmile Creek near Kellner, WI	05400840	75.0	1964-67
Buena Vista Creek near Kellner, WI	05400853	53.1	1964-67
Tenmile Creek Ditch 5 near Bancroft, WI	05401020	9.73	1964-73
Fourteenmile Creek near New Rome, WI	05401100	91.1	1964-79
Wisconsin River near Necedah, WI	05401500	5,990	1903-14, 1944-50
Big Roche a Cri Creek near Hancock, WI	05401510	9.61	1964-67
Big Roche a Cri Creek near Adams, WI	05401535	52.8	1964-78
Yellow River at Sprague, WI	05402500	392	1927-40
Yellow River at Necedah, WI	05403000	491	1941-57
Hulbert Creek near Wisconsin Dells, WI	05403630*	11.2	1971-77
Dell Creek near Lake Delton, WI	05403700*	44.9	1957-65, 1971-80
Narrows Creek at Loganville, WI	05404200*	40.1	1964-66
Wisconsin River at Prairie du Sac, WI	05406000	9,180	1946-54
Trout Creek at Confluence with Ameson Crk nr Barneveld, WI	05406573	8.37	1976-78
Trout Creek at Twin Parks Dam 8 nr Barneveld, WI	05406574	9.02	1976-79
Trout Creek at County Highway T nr Barneveld, WI	05406575	12.1	1976-78
Trout Creek near Ridgeway, WI	05406577	13.5	1976-79
Knight Hollow Creek near Arena, WI	05406590	7.57	1976-78
Otter Creek near Highland, WI	05406640	16.8	1968-69, 1970-75
Kickapoo River at Ontario, WI	05407500	151	1939, 1973-77
Knapp Creek near Bloomingdale, WI	05408500	8.44	1955-69
West Fork Kickapoo River near Readstown, WI	05409000	106	1939

Discontinued surface-water discharge stations

Station name	Station number	Drainage area (square miles)	Period of record
WISCONSIN RIVER BASIN--CONTINUED			
Kickapoo River at Soldiers Grove, WI	05409500	530	1939
North Fork Nederlo Creek near Gays Mills, WI	05409830	2.21	1968-79
Nederlo Creek near Gays Mills, WI	05409890	9.46	1968-80
Kickapoo River at Gays Mills, WI	05410000	617	1914-34, 1964-77
GRANT RIVER BASIN			
Pigeon Creek near Lancaster, WI	05413400*	6.93	1964-66
Rattlesnake Creek near Beetown, WI	05413451	45.2	1990-91
GALENA RIVER BASIN			
Little Platte River near Platteville, WI	05414213	79.7	1987-90
Sinsinawa River near Hazel Green, WI	05414800	24.9	1987-90
Pats Creek near Belmont, WI	05414894	5.42	1981-82
Madden Branch Tributary near Belmont, WI	05414915*	2.83	1981-82
Madden Branch near Meekers Grove, WI	05414920	15.04	1981-82
Galena River at Buncombe, WI	05415000	125	1939-92
APPLE RIVER BASIN			
Apple River near Shullsburg, WI	05418731	9.34	1981-82
ROCK RIVER BASIN			
West Branch Rock River near Waupun, WI	05423000	40.7	1949-70, 1978-81
West Branch Rock River at County Trunk Highway D near Waupun, WI	05423100	43.9	1978-81
East Branch Rock River near Mayville, WI	05424000	179	1949-70
Rock River at Hustisford, WI	05424082	511	1978-85
Johnson Creek near Johnson Creek, WI	05425537	1.13	1978-80
Johnson Creek near Johnson Creek, WI	05425539	13.3	1978-80
Pratt Creek near Juneau, WI	05425928	3.54	1978-80
Whitewater Creek near Whitewater, WI	05426500	11.8	1926-28, 1946-54
Whitewater Creek at Millis Road near Whitewater, WI	05426900	20.6	1978-81
Whitewater Creek at Whitewater, WI	05427000	22.8	1926-28, 1946-54
Koshkonong Creek near Rockdale, WI	05427507	150	1977-82
Token Creek near Madison, WI	05427800*	24.3	1964-66, 1976-81
Sixmile Creek near Waunakee, WI	05427900	41.1	1976-82
Pheasant Branch at Airport Road near Middleton, WI	05427943	9.61	1977-81
South Fork Pheasant Branch at Highway 14 near Middleton, WI	05427945	5.74	1978-81
Pheasant Branch at Century Avenue at Middleton, WI	05427950	20.8	1977-81
Pheasant Branch at mouth at Middleton, WI	05427952	24.5	1978-81
Willow Creek at Madison, WI	05427970	3.15	1974-83
Olbrich Park Storm Ditch at Madison, WI	05428665	2.57	1976-80
Manitou Way Storm Sewer at Madison, WI	05429040	0.23	1971-77
Nakoma Storm Sewer at Madison, WI	05429050	2.30	1972-77
Lake Wingra Outlet at Madison, WI	05429120	6.00	1971-77
Door Creek near Cottage Grove, WI	05429580	15.3	1976-79
Yahara River near Edgerton, WI	05430000	430	1917-18
Oregon Branch at Oregon, WI	05430030	9.93	1979-81
Badfish Creek at County Highway A near Stoughton, WI	05430095	41.9	1956-66, 1986-88
Badfish Creek near Stoughton, WI	05430100	41.3	1956-66
Livingston Branch, Pecatonica River near Livingston, WI	05432055	16.4	1987-91
Yellowstone River near Blanchardville, WI	05433500*	28.5	1954-65, 1978-79
Pecatonica River at Dill, WI	05434000	944	1914-19
Steiner Branch near Waldwick, WI	05433510	5.9	1978-79
Skinner Creek at Skinner Hollow Road near Monroe, WI	05434235	32.6	1978-81
Skinner Creek at Klondyke Road near Monroe, WI	05434240	35.0	1978-81
West Branch Sugar River near Mount Vernon, WI	05435980	32.7	1979-80
Mount Vernon Creek near Mount Vernon, WI	05436000	16.4	1954-65, 1976-80
ILLINOIS RIVER BASIN			
White River near Burlington, WI	05545300	110	1964-66, 1973-82

DISCHARGE RATINGS FOR TAINTER AND ROLLER GATES AT LOCK AND DAM NO. 7 ON THE MISSISSIPPI RIVER AT LA CROSSE, WISCONSIN, WI 00101

COOPERATOR:
U.S. Army Corps of Engineers

LOCATION:
Lock and Dam No. 7 on the Mississippi River at LaCrosse, Wisconsin

PROJECT CHIEF:
Steven R. Corsi

PERIOD OF PROJECT:
June 1992 to September 1994

PROBLEM: The operation of the Mississippi River navigation system requires an accurate system to determine discharge on a real-time basis. The current discharge ratings at Lock and Dam No. 7 are based on theoretical equations for roller and tainter gates and have not been verified with field measurements.

OBJECTIVE: The objective of this study is to develop accurate discharge ratings for the roller and tainter gates at Lock and Dam No. 7 on the Mississippi River at LaCrosse, Wisconsin.

APPROACH: Field measurements using a current meter will be made to develop coefficients and equations for calculating discharge at roller and tainter gates. Discharge rating tables will be constructed for numerous different combinations of the decrease in head through the dam and gate openings. The rating tables in this study will be compared to the theoretical ratings currently being used.

PROGRESS (July 1993 to June 1994): All of the needed discharge measurements have been taken. Coefficients and equations were developed for the roller and tainter gates, and discharge rating tables were constructed.

PLANS (July 1994 to June 1995): The final report will be written and published in the USGS Water-Resources Investigations Report series.

COLLECTION OF BASIC RECORDS—GROUND WATER, WI 002

PROBLEM: Ground-water data are needed to better determine short-term changes and long-term trends in ground-water levels in the State. It is important to know if these changes are natural or man-induced and how these changes are effecting storage in the ground-water reservoirs.

OBJECTIVE: The objective is to maintain records of ground-water-level fluctuations from a network of observation wells representative of Wisconsin's principal aquifers.

APPROACH: A basic network of about 203 wells is being maintained. The network will be constantly modified and improved to provide the best possible coverage of our ground-water resource. A subnetwork of key wells is included in this network. Key wells have long periods of record and are measured weekly or are equipped with continuous recorders.

PROGRESS (July 1993 to June 1994): Additional computer programs were written and are being used to make data entry of water levels more efficient. Local observers were visited and hired to collect water-level data. Several wells were destroyed or discontinued from the network and were replaced with new ones. Data for the annual report, "Water Resources Data-Wisconsin, water year 1993", was completed. Several digital recorders were replaced with state-of-the-art data loggers.

PLANS (July 1994 to June 1995): Continue measurements on observation-well network. Replace and hire new observers and make quality assurance checks when possible. Have water-level information available on computer disk for individuals requesting these types of data. Plan to drill replacement wells in several counties in locations where no other observation wells could be located. Replace additional digital recorders with state-of-the-art data loggers on selected wells.

REPORTS:

Patterson, G.L., and Zaporozec, A., 1988, Analysis of water-level fluctuations in Wisconsin wells: Wisconsin Geological and Natural History Survey Information Circular 63.

Erickson, R.M., and Cotter, R.D., 1983, Trends in ground-water levels in Wisconsin through 1981: Wisconsin Geological and Natural History Survey Information Circular No. 43.

Erickson, R.M., 1972, Trends in ground-water levels in Wisconsin, 1967-71: Wisconsin Geological and Natural History Survey Information Circular No. 21.

Devaul, R.W., 1967, Trends in ground-water levels in Wisconsin through 1966: Wisconsin Geological and Natural History Survey Information Circular No. 9.

COOPERATOR:
Wisconsin Geological and Natural History Survey

LOCATION:
Statewide

PROJECT CHIEF:
Bernie R. Ellefson

PERIOD OF PROJECT:
July 1946-Continuing

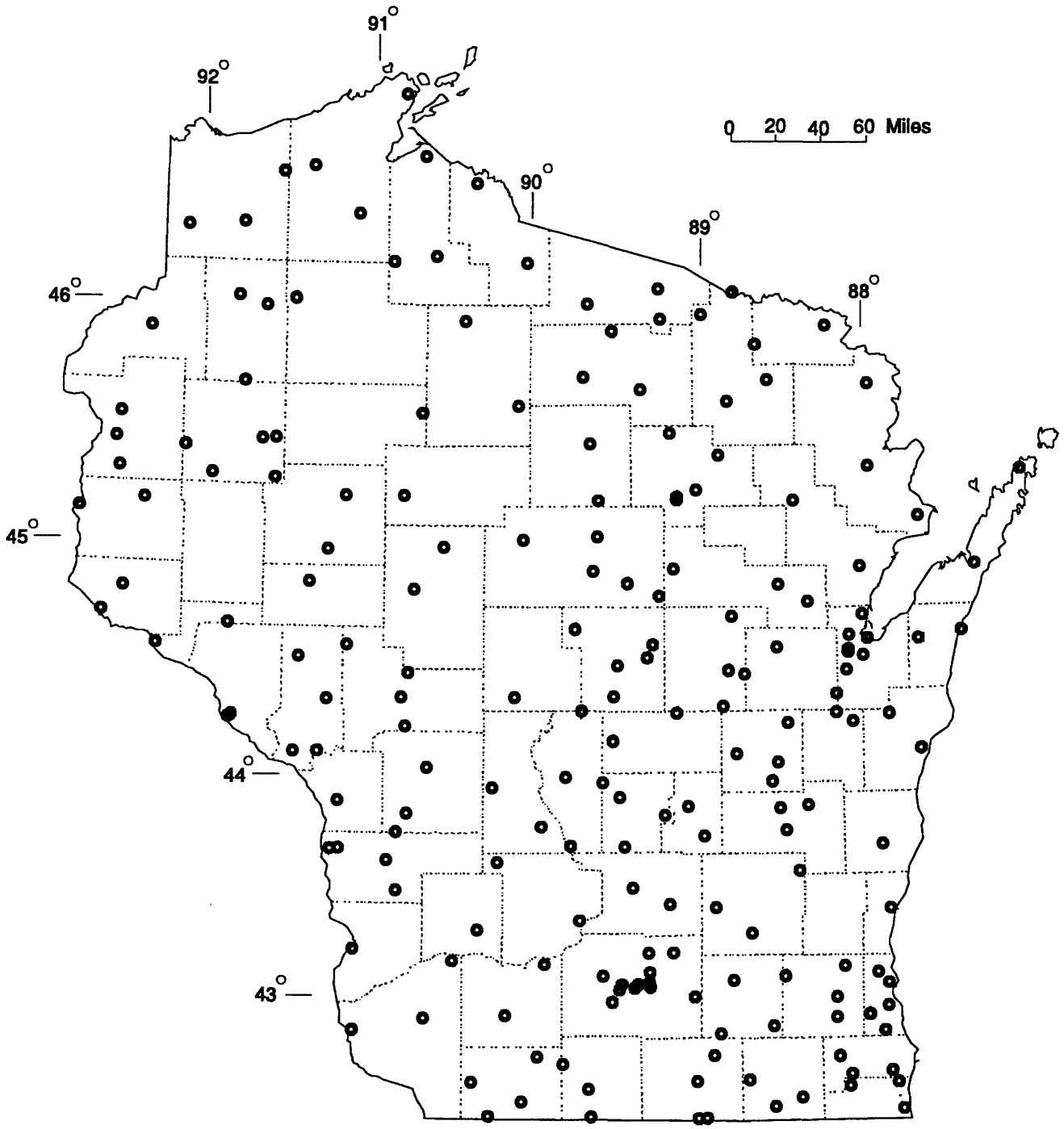


Figure 9. Location of network observation wells.

COLLECTION OF BASIC RECORDS—WATER QUALITY, WI 003

PROBLEM: A long-term base of water-quality data is needed for regional water-quality assessments and water-resource planning.

OBJECTIVE: The Federal program consists of the National Stream Quality Accounting Network (NASQAN) and the Hydrologic Benchmark Network (HBMN). The objectives of the NASQAN program are to (1) account for the quantity and quality of water moving within and from the United States; (2) depict areal water-quality variability; and (3) detect changes in stream quality with time. The objective of the HBMN program is to monitor hydrologic characteristics at sites where they are relatively unaffected by man's activities and will remain unaffected for the foreseeable future.

APPROACH: Chemical, bacteriological, and physical water-quality data are systematically collected at fixed-time intervals and stations for NASQAN and HBMN. Data collected is the same for both programs and includes measurements of water temperature, specific conductance, pH, and concentrations of dissolved oxygen, plant nutrients, common mineral constituents, trace constituents, fecal bacteria, and suspended sediment.

PROGRESS (July 1993 to June 1994): Data were collected bimonthly at NASQAN stations on Tenmile Creek and the Bad, Chippewa, Black, Wisconsin and Grant Rivers, and quarterly at NASQAN stations on the Fox (Green Bay), Manitowoc, and Milwaukee Rivers and a HBMN station on the Popple River. Radiochemical data were collected semiannually at the Chippewa and Popple River stations.

Data collected during the 1993 water year were processed for publication in the annual data release "Water Resources Data-Wisconsin, water year 1993."

NASQAN stations on Tenmile Creek and the Bad River were discontinued October 1, 1993.

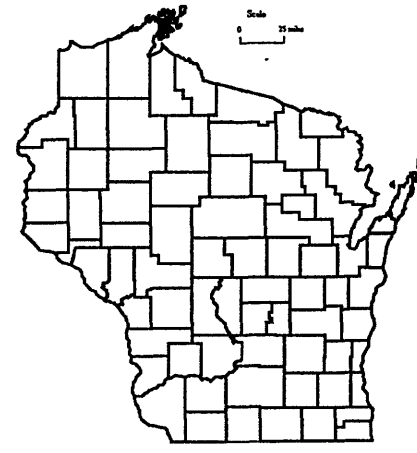
PLANS (July 1994 to June 1995): Data collection and processing will be continued.

COOPERATOR:
Federal Program

LOCATION:
Statewide

PROJECT CHIEF:
Phil A. Kammerer

PERIOD OF PROJECT:
July 1964-Continuing



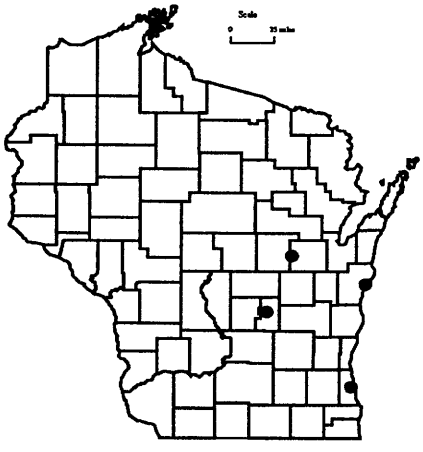
INTERGOVERNMENTAL TASK FORCE ON MONITORING--WISCONSIN WATER RESOURCES COORDINATION PILOT PROJECT, WI 00301

COOPERATOR:
Federal Program
(Interagency Personnel Agreement with the Wisconsin Department of Natural Resources)

LOCATION:
Statewide

PROJECT CHIEF:
Phil A. Kammerer

PERIOD OF PROJECT:
August 1993 to March 1996



PROBLEM: Protocols for water-sample collection and processing for USGS and the Wisconsin Department of Natural Resources (DNR) water-quality monitoring programs in Wisconsin differ, and samples from each agency are analyzed by different laboratories. There are no data available to show whether or not the differences in sample collection and processing protocols cause differences in monitoring results.

OBJECTIVE: The objective of this study is to identify interagency differences in monitoring results caused by differences in sample collection and processing protocols.

APPROACH: Concurrent samples are collected by both agencies at visits to three stream sites and one lake site, split between labs, and analyzed in triplicate for concentrations of a suite of constituents common to their respective monitoring programs. The purpose of the splits and replication is to measure or eliminate variables other than sample collection and processing that could contribute to differences in monitoring results. The constituents chosen for analysis are total phosphorus, dissolved orthophosphate, dissolved chloride and suspended sediment/suspended solids for streams and total phosphorus, dissolved orthophosphate and chlorophyll a for the lake. These constituents were chosen as surrogates to represent the general behavior of constituents in dissolved and suspended phases and to test interagency differences in laboratory methods and sample processing.

Sampling sites were selected to provide a range of detectable concentrations for the suite of constituents and, in the case of streams, for their potential to transport substantial amounts of suspended material during high flows. Samples will be collected over a range of seasons and flow conditions.

PROGRESS (July 1993 to June 1994): Samples were collected at each stream site in August and October 1993 during baseflow conditions. Preliminary analysis of the data indicates little, if any, significant difference in results due to differences in sample collection and processing protocols. Similar conclusions can be drawn from lake samples collected to date. Two rounds of stream samples are to be collected at each stream site during the period March-September 1994 during periods when surface runoff to the streams is causing transport of substantial quantities of suspended material.

PLANS (July 1994 to June 1995): Any remaining stream sampling will be completed. An interpretive report summarizing the results of the comparison of sampling and processing protocols will be prepared.

COLLECTION OF BASIC RECORDS—DANE COUNTY PROGRAM, WI 00302

PROBLEM: A long-term base of water-quality data is needed for water-resource planning and assessment of water quality in the lakes and streams of Dane County.

OBJECTIVE: The objectives of this program are to determine suspended-sediment and phosphorus loads on selected tributaries to Lake Mendota and to collect data to identify long-term changes in base-flow water quality in selected streams in Dane County.

APPROACH: Streamflow-monitoring stations with automatic water-quality samplers are operated on three tributaries to Lake Mendota. Samples for analysis of suspended-sediment and phosphorus concentrations are collected at low flow and during periods when surface runoff is entering the streams. The concentration and streamflow data are used to compute annual suspended-sediment and total-phosphorus loads for each station.

PROGRESS (July 1993 to June 1994): Suspended-sediment loads for Spring Harbor Storm Sewer at Madison and suspended-sediment and total-phosphorus loads for Pheasant Branch at Middleton and the Yahara River at Windsor were computed for the 1993 water year.

Load and concentration data were published in the annual data report "Water Resources Data-Wisconsin, water year 1993."

Collection of total phosphorus concentration data at Pheasant Branch was discontinued January 1, 1994.

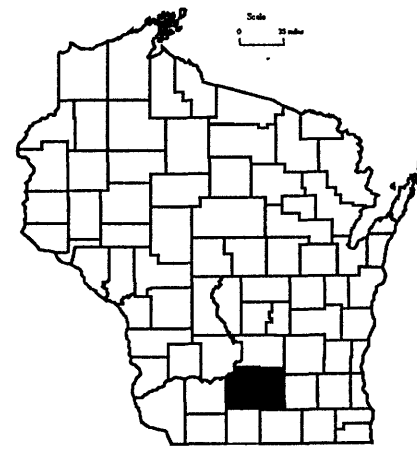
PLANS (July 1994 to June 1995): Continue data collection and processing for the three stations on tributaries to Lake Mendota.

COOPERATOR:
Dane County Regional Planning Commission

LOCATION:
Dane County, Wisconsin

PROJECT CHIEF:
Phil A. Kammerer

PERIOD OF PROJECT:
Continuing



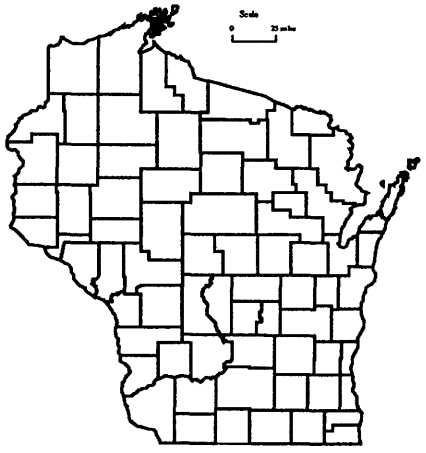
COLLECTION OF BASIC RECORDS—SEDIMENT, WI 004

COOPERATORS:
Wisconsin Department of Natural Resources
U.S. Army Corps of Engineers
Dane County Regional Planning Commission

LOCATION:
Statewide

PROJECT CHIEF:
William J. Rose

PERIOD OF PROJECT:
March 1968-Continuing



PROBLEM: Water-resources planning and water-quality assessment require a knowledge of the quantity and quality of sediment being transported in rivers and streams in Wisconsin.

OBJECTIVE: This project will provide sediment data for use in specific planning and action programs and will develop a data base for determining trends in sediment discharge and yield. Streams will be characterized according to range of concentration and particle size of suspended sediment.

APPROACH: Sediment-monitoring stations will be operated at selected stream sites throughout the State, including sites of specific interest to cooperating agencies.

The extent of monitoring at a given site will depend on the characteristics of the basin and the needs of the cooperating agency. Some sites will be sampled manually at infrequent intervals; other sites, where flow responds rapidly to precipitation, will be sampled by automatic samplers.

At sites where bedload or unmeasured sediment discharge may be a significant part of the total sediment discharge, suspended- and bed-sediment particle size will be determined from samples collected concurrently with hydraulic data. These data will be used to estimate total sediment discharge using one of several techniques such as the modified Einstein procedure.

PROGRESS (before July 1993): Sediment data have been collected at more than 200 stream sites in Wisconsin since 1968. The sampling intensity and length of sampling period varies considerably from site to site. At some sites, only a few samples a year were collected at irregular intervals for concentration analysis; at other sites, hundreds of samples per year were collected with stage-activated automatic samplers. Suspended and bed material particle-size data are available for many of the sites. Except for data collected as part of the National Stream Quality Accounting Network program, data collection at most sites has been of relatively short (less than 4 years) duration. Most sediment data collection has been in the southern one-third of the State and associated with local special problem studies except for about a five-year period in the early 1970's when there was a Statewide network of sediment monitoring stations. All data have been published annually in the data report, "Water Resources Data-Wisconsin."

PROGRESS (July 1993 to June 1994): The 1993 monitoring program is as follows:

CORPS OF ENGINEERS--Suspended sediment was sampled at the Grant River at Burton. Daily loads were determined from these data.

WISCONSIN DEPARTMENT OF NATURAL RESOURCES (WDNR)--A study whose objective was to estimate the coarse-material sediment load at three sites on North Fork Fish Creek near Ashland, Wisconsin, began on July 1, 1989. Monitoring for this study was completed in October 1991. Preliminary load estimates have been provided to the WDNR. The report summarizing the study is in the review stage.

PLANS (July 1994 to June 1995):

CORPS OF ENGINEERS--Operation of the Grant River monitoring station will continue.

WISCONSIN DEPARTMENT OF NATURAL RESOURCES--The brief report summarizing the results of the North Fork Fish Creek study will be completed.

Efforts will continue to establish a long-term sediment-monitoring network. About 10 sites areally distributed to sample runoff from the major geographic provinces would provide an adequate network.

REPORTS:

Rose, William J., 1992, Sediment transport, particle sizes, and loads in the lower reaches of the Chippewa, Black, and Wisconsin Rivers in western Wisconsin, U.S. Geological Survey Water-Resources Investigations Report 90-4124, 38 p.

Rose, William J., and Graczyk, David J., Sediment transport, particle size, and loads in North Fish Creek in Bayfield County, Wisconsin, 1989-91 (in review).

FEMA FLOOD-INSURANCE STUDY, WI 006

COOPERATOR:
Federal Emergency Management Agency

LOCATION:
Statewide

PROJECT CHIEF:
Todd D. Stuntebeck

PERIOD OF PROJECT:
March 1984-Continuing

PROBLEM: The National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973 provide for the operation of a flood-insurance program. The Federal Emergency Management Agency (FEMA) needs flood studies in selected areas to determine applicable flood insurance premium rates.

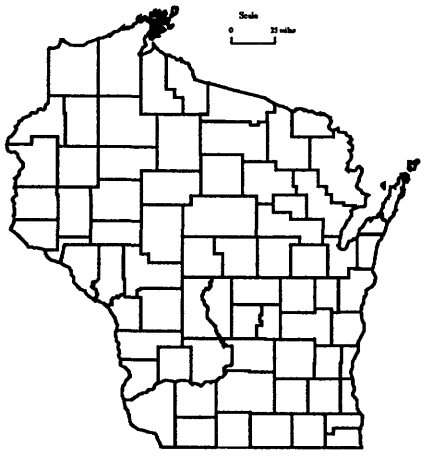
OBJECTIVE: Hydrologic and hydraulic analyses will be performed in order to complete flood-insurance studies at communities selected by FEMA.

APPROACH: Flood-discharge frequency relationships will be determined from local historical information, gaging station records, or other applicable information. Water-surface profiles will be produced by using step-backwater models or by other acceptable methods and the results will be published in reports prepared according to FEMA specifications.

PROGRESS (July 1993 to June 1994): Limited map maintenance (LMM) restudies were completed for the cities of Verona and Merrill, Wisconsin. Hydrologic analysis was completed for LMM restudies for city of LaCrosse and Fond du Lac County, Wisconsin.

PLANS (July 1994 to June 1995): Respond to review comments on completed studies and answer data requests as needed. Work will be continued on LMM studies for city of LaCrosse and Fond du Lac County.

REPORTS: Work was completed for the LMM restudies for cities of Verona and Merrill and results were sent to FEMA.



WISCONSIN WATER-USE DATA FILE, WI 007

PROBLEM: The need for reliable water-use data by State and Federal planning agencies is increasing as the competition for use of the State's water resources increases. Water-use data in a standardized format needs to be available to assist in making decisions on future water use.

OBJECTIVE: The purpose of this project is to collect accurate and complete data on Wisconsin's water use, to store data in the State Water-Use Data System (SWUDS), and to prepare periodic reports on water use in the State.

APPROACH: Sources of water-use information will be evaluated. The best available data will be entered into the SWUDS. Efforts will be made to upgrade the accuracy of the water-use data.

PROGRESS (July 1993 to June 1994): The SWUDS was updated with current water-use information as it became available. These data included high-capacity well data and information on discharge from sewage-treatment plants in the State. Reformatting programs were written or updated as needed for entering data from other agencies into SWUDS.

PLANS (July 1994 to June 1995): Continue to update and maintain the SWUDS data base with current water-use data as it becomes available. Explore the possibility of a cooperative project with Wisconsin Department of Natural Resources to meter selected industrial users to better estimate consumptive water use. Supply water-use data for water-resources studies currently being conducted in the State.

REPORTS:

Ellefson, B.R., Sabin, T.J., Krohelski, J.T., 1993, Water use in Wisconsin, 1990: U.S. Geological Survey Open-File Report 93-118, 1 sheet, scale 1:5,000,000.

Ellefson, B.R., Rury, K.S., and Krohelski, J.T., 1988, Water-use in Wisconsin, 1985: U.S. Geological Survey Open-File Report 87-699, 1 sheet, scale 1:5,000,000.

U.S. Geological Survey, 1990, National Water Summary, 1987--Hydrologic events and water supply and use: U.S. Geological Survey Water-Supply Paper 2350, 553 p.

Krohelski, J.T., Ellefson, B.R., and Storlie, C.A., 1987, Estimated use of ground water for irrigation in Wisconsin, 1984: U.S. Geological Survey Water-Resources Investigations Report 86-4079, 12 p., 1 pl.

Lawrence, C.L., and Ellefson, B.R., 1984, Public-supply pumpage in Wisconsin, by aquifer: U.S. Geological Survey Open-File Report 83-931, 40 p.

— 1982, Water use in Wisconsin, 1979: U.S. Geological Survey Open-File Report 82-444, 98 p.

COOPERATOR:

Wisconsin Department of Natural Resources

LOCATION:

Statewide

PROJECT CHIEF:

Bernie R. Ellefson

PERIOD OF PROJECT:

March 1978-Continuing

LOW FLOW AT OUTFALL SITES, WI 035

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Selected sites throughout Wisconsin

PROJECT CHIEF:
Barry K. Holmstrom

PERIOD OF PROJECT:
April 1972-Continuing

PROBLEM: Water-quality standards have been adopted for all surface waters of the State. To implement these standards, the Department of Natural Resources (DNR) has to evaluate the sewage effluent from all waste sources in relation to the low-flow characteristics of the receiving stream. Water-quality standards in Wisconsin are based on a number of streamflow characteristics. These include the annual minimum 7-day consecutive mean flow that occurs on the average of once every 2 years ($Q_{7,2}$) and once every 10 years ($Q_{7,10}$), the annual minimum 30-day consecutive mean flow that occurs on the average of once every 5 years ($Q_{30,5}$), $Q_{7,10}$ values for selected months ($Q_{7,10}$-month), 10-year low mean monthly flows for October, November, April, and May, and the mean annual discharge.

OBJECTIVE: The purpose of this study is to determine the following streamflow characteristics:

1. $Q_{7,10}$ for receiving streams at sewage-treatment plants and industrial plants discharging wastes.
2. $Q_{7,2}$ for selected streams.
3. The 10-year low mean monthly flows for October (Oct. MMQ_{10}), November (Nov. MMQ_{10}), April (Apr. MMQ_{10}), and May (May MMQ_{10}) for sites at fill-and-draw wastewater-treatment lagoons or waste-stabilization ponds.
4. $Q_{30,5}$ for selected streams.
5. The mean annual discharge (MAQ) for selected streams.
6. $Q_{7,10}$ for selected months for selected streams.

APPROACH: Low-flow characteristics of selected streams will be determined by: drainage-area/discharge relationships, graphical-regression methods, regression equations, Log-Pearson Type III frequency analysis, and other statistical and graphical methods.

PROGRESS (July 1993 to June 1994): Low-flow estimates were determined at approximately 54 sites in response to requests for information from the Surface Waters and Monitoring Section of the DNR.

PLANS (July 1994 to June 1995): Low-flow characteristics at approximately 50 sites will be determined in response to DNR requests for information. The low-flow characteristics, in most instances, will be determined by drainage-area/discharge relationships or by regression equations. Biological design flows and other flow characteristics may also be determined.

GROUND-WATER-QUALITY APPRAISAL OF WISCONSIN'S AQUIFERS, WI 093

PROBLEM: Ground-water-quality problems in Wisconsin have not been summarized and evaluated in a published report. Summary and evaluation of the problems are needed to develop strategies for ground-water protection. Many chemical analyses of Wisconsin's ground water are available, but little attempt has been made to relate water quality to hydrogeology on a regional scale.

OBJECTIVE: The objectives of this project are to delineate and evaluate areas with known ground-water-quality problems and to define the quality of Wisconsin's ground water by aquifer and relate the quality to the hydrogeologic environment.

APPROACH: The objectives of the project will be met through two complimentary and concurrent studies:

STUDY 1 (conducted by DNR)--DNR will describe the water resources of the State, summarize water-quality problems, and recommend a ground-water-management policy.

STUDY 2 (conducted by USGS)--USGS will provide a study of the quality of water from Wisconsin's principal aquifers and present it in two reports.

PROGRESS (July 1993 to June 1994): Preparation of the first report listed below for publication was completed. The second report listed below was submitted for preparation for publication.

PLANS (July 1994 to June 1995): Begin preparation of the Hydrologic Investigations Atlas listed below.

REPORTS:

Kammerer, P.A., Jr., 1993, Ground-water flow and quality in Wisconsin's shallow aquifer system: U.S. Geological Survey Water-Resources Investigations Report 90-4171 (in preparation).

Kammerer, P.A., Jr., Trotta, L.C., Krabbenhoft, D.P., and Lidwin, R.A., 1994, Geology, ground-water flow, and dissolved-solids concentrations along hydrogeologic sections through Wisconsin's aquifers: U.S. Geological Survey Hydrologic Investigations Atlas (in preparation).

COOPERATOR:

Wisconsin Department of Natural Resources

LOCATION:

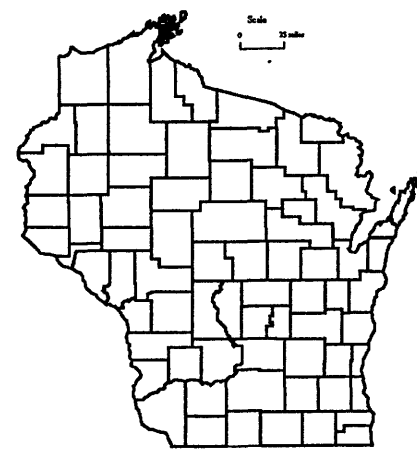
Statewide

PROJECT CHIEF:

Phil A. Kammerer

PERIOD OF PROJECT:

June 1978 to September 1985



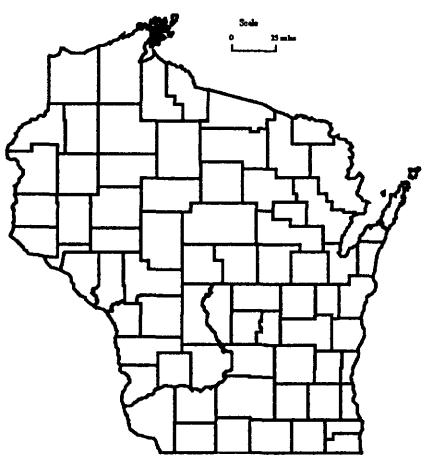
REGIONAL FLOOD-FREQUENCY STUDY FOR URBAN AND RURAL STREAMS IN WISCONSIN, WI 109

COOPERATOR:
Wisconsin Department of Transportation-Highways

LOCATION:
Statewide

PROJECT CHIEF:
William R. Krug

PERIOD OF PROJECT:
July 1985-Continuing



PROBLEM: Flood-frequency estimates are required at many sites for bridge and culvert design, as well as for flood-plain management and flood-insurance studies. Most sites at which such estimates are required do not have records of flood peaks.

OBJECTIVES:
1. Develop improved regression equations for the State of Wisconsin.

2. Analyze and improve the network of crest-stage gages to obtain better data for developing improved regression equations.

APPROACH: The GLSNET program will be used to analyze the crest-stage-gage network. The goal of this analysis will be to determine how to get the most regional flood information from a network of about 100 crest-stage gages. Some stations have been dropped from the network and new stations will be added as a result of this analysis and discussions with the cooperators about areas where the information is most needed.

PROGRESS (July 1993 to June 1994): A journal article was approved giving the results of the model study on the Coon Creek basin. Annual flood peaks were computed and published in the annual data report at 104 crest-stage stations. The network of crest-stage gages was analyzed to determine which stations provided the least information for regional frequency analysis and should be replaced by new stations. Thirty stations were discontinued as a result of this analysis. New stations have been installed in areas where the cooperator indicated the greatest need for more information on flooding.

PLANS (July 1994 to June 1995): The crest-stage-gage network will be monitored with changes starting this year. New gages will have ratings developed for them as measurements and surveys are available. Significant effort will be made to improve ratings at all of the gages.

REPORTS:

Krug, W.R., 1992, Simulation of temporal changes in rainfall-runoff characteristics, Coon Creek Basin, Wisconsin.

Krug, W.R., Conger, D.H., and Gebert, W.A., 1992, Flood-frequency characteristics of Wisconsin streams: U.S. Geological Survey Water-Resources Investigations Report 91-4128, 185 p., 2 pls.

Conger, D.H., 1986, Estimating magnitude and frequency of floods for Wisconsin urban streams: U.S. Geological Survey Water-Resources Investigations Report 86-4005, 18 p.

Conger, D.H., 1981, Techniques for estimating magnitude and frequency of floods for Wisconsin streams: U.S. Geological Survey Water-Resources Investigations Open-File Report 80-1214, 116 p., 2 pls.

Conger, D.H., 1971, Estimating magnitude and frequency of floods in Wisconsin: U.S. Geological Survey Open-File Report, 200 p.

LIST OF CREST-STAGE GAGES

CHIPPEWA RIVER BASIN

05357360 Bear River near Powell, WI
05359600 Price Creek near Phillips, WI
05361400 Hay Creek near Prentice, WI
05361420 Douglas Creek near Prentice, WI
05364000 Yellow River at Cadott, WI
05364100 Seth Creek near Cadott, WI
05364500 Duncan Creek at Bloomer, WI
05366500 Eau Claire River near Fall Creek, WI
05367030 Willow Creek near Eau Claire, WI
05367700 Lightning Creek at Almena, WI
05370900 Spring Creek near Durand, WI

CENTRAL WISCONSIN RIVER BASIN

05395020 Lloyd Creek near Doering, WI
05395100 Trappe River Tributary near Merrill, WI
05396300 Wisconsin River Tributary at Wausau, WI
05397600 Big Sandy Creek near Wausau, WI
05400025 Johnson Creek near Knowlton, WI
05401800 Yellow River Tributary near Pittsville, WI
05403700 Dell Creek near Lake Delton, WI

FOX-WOLF RIVER BASIN

04073400 Bird Creek at Wautoma, WI
04074850 Lily River near Lily, WI
04075200 Evergreen Creek near Langlade, WI
04079700 Spaulding Creek near Big Falls, WI
04081900 Sawyer Creek at Oshkosh, WI

LAKE MICHIGAN BASIN

04085400 Killsnake River near Chilton, WI
04087100 Honey Creek at Milwaukee, WI
04087200 Oak Creek near South Milwaukee, WI
04087230 West Branch Root River Canal Tributary near North Cape, WI
04087250 Pike Creek near Kenosha, WI

LAKE SUPERIOR BASIN

04024400 Stony Brook near Superior, WI
04025200 Pearson Creek near Maple, WI
04026200 Sand River Tributary near Red Cliff, WI
04026300 Sioux River near Washburn, WI
04026450 Bad River near Mellen, WI
04027200 Pearl Creek at Grandview, WI

LOWER WISCONSIN RIVER BASIN

05405600 Rowan Creek at Poynette, WI
05407200 Crooked Creek near Boscobel, WI

MENOMINEE-OCONTO-PESHTIGO RIVER BASIN

04059900 Allen Creek Tributary near Alvin, WI
04063640 North Branch Pine River at Windsor Dam near Alvin, WI
04067760 Peshtigo River near Cavour, WI
04069700 North Branch Oconto River near Wabeno, WI
04071700 North Branch Little River near Coleman, WI
04071800 Pensaukee River near Pulaski, WI

PECATONICA-SUGAR RIVER BASIN

05413400 Pigeon Creek near Lancaster, WI
05414213 Little Platte River near Platteville, WI
05414900 Pats Creek near Elk Grove, WI
05432300 Rock Branch near Mineral Point, WI
05433500 Yellowstone River near Blanchardville, WI
05436200 Gill Creek near Brooklyn, WI

ROCK-FOX RIVER BASIN

05430403 Fisher Creek Tributary at Janesville, WI
05431400 Little Turtle Creek at Allens Grove, WI
05545100 Sugar Creek at Elkhorn, WI
05545200 White River Tributary near Burlington, WI
05548150 North Branch Nippersink Creek Tributary near Genoa City, WI

ST. CROIX RIVER BASIN

05340300 Trade River near Frederic, WI
05341900 Kinnickinnic River Tributary at River Falls, WI

TREMPEALEAU-BLACK RIVER BASIN

05371800 Buffalo River Tributary near Osseo, WI
05371920 Buffalo River near Mondovi, WI
05380900 Poplar River near Owen, WI
05380970 Cawley Creek near Neillsville, WI
05382200 French Creek near Ettrick, WI
05386300 Mormon Creek near La Crosse, WI
05387100 North Fork Bad Axe River near Genoa, WI

UPPER WISCONSIN RIVER BASIN

05391260 Gudegast Creek near Starks, WI
05391950 Squaw Creek near Harrison, WI
05392150 Mishonagon Creek near Woodruff, WI
05392350 Bearskin Creek near Harshaw, WI
05393640 Little Pine Creek near Irma, WI
05394200 Devil Creek near Merrill, WI

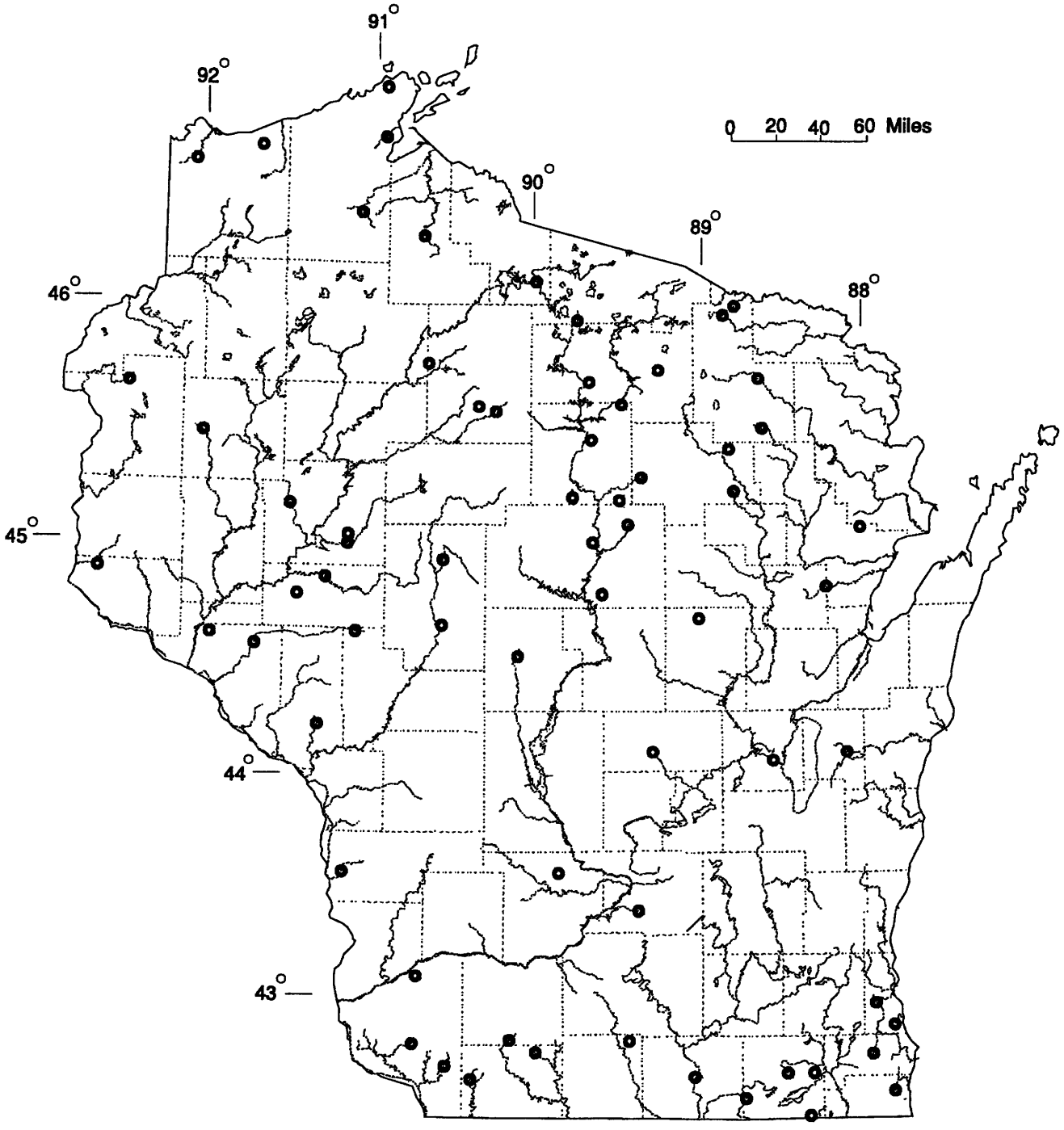


Figure 10. Location of crest-stage-gage data-collection stations.

EFFECTS OF ACID PRECIPITATION ON LAKES IN NORTHERN WISCONSIN, WI 110
LONG-TERM EFFECTS OF ACID PRECIPITATION ON LAKES IN NORTHERN WISCONSIN, WI 129

PROBLEM: Acid precipitation has damaged lakes in Canada and the northeastern United States. Wisconsin has more susceptible and potentially susceptible lakes than any State east of the Mississippi River. Studies have shown that acid precipitation in northern Wisconsin, where pH's average 4.0 to 4.5, may affect as many as 8,000 lakes. This could seriously affect the tourist-based economy of this area. Long-term hydrologic and chemical budgets of a representative susceptible lake will increase the understanding of the effect of acid precipitation on aquatic systems and will provide information to evaluate and possibly predict these effects so that future damage can be minimized.

OBJECTIVE: Determine hydrologic and chemical budgets for Vandercook Lake and Lake Clara in northern Wisconsin to provide information regarding mechanisms and long-term changes of acid loadings to these lakes.

APPROACH: Lake inflows from precipitation, overland flow, and ground-water discharge, and lake outflows from evaporation, streamflow, and ground-water recharge will be quantified. Alkalinity, pH, major cations and anions, nutrients, and trace elements in selected flow paths will be quantified. The lakes will be evaluated for their potential for acidification.

PROGRESS (July 1993 to June 1994): The report "Long-term hydrologic and geochemical responses of a soft-water seepage lake in north-central Wisconsin" was submitted to Water Resources Research (WRR), was reviewed, revised, and resubmitted to WRR.

PLANS (July 1994 to June 1995): The report "Long-term hydrologic and geochemical responses of a soft-water seepage lake in north-central Wisconsin" will be published.

REPORTS:

Wentz, D.A., Rose, W.J., and Webster, K.E., 1992, Long-term hydrologic and geochemical responses of a soft-water seepage lake in north-central Wisconsin (approved, has been submitted to Water Resources Research for publication).

Wentz, D.A., and Rose, W. J., 1991, Hydrology of Lakes Clara and Vandercook in north-central Wisconsin, U.S. Geological Survey Water-Resources Investigations Report 89-4204, 24 p.

Wentz, D.A., and Rose, W.J., 1989, Interrelationships among hydrologic-budget components of a northern Wisconsin seepage lake and implications for acid-deposition modeling: Archives of Environmental Contamination and Toxicology, v. 18, p. 147-155

COOPERATORS:

Wisconsin Department of Natural Resources (WI 110)
U.S. Geological Survey (WI 129)

LOCATION:

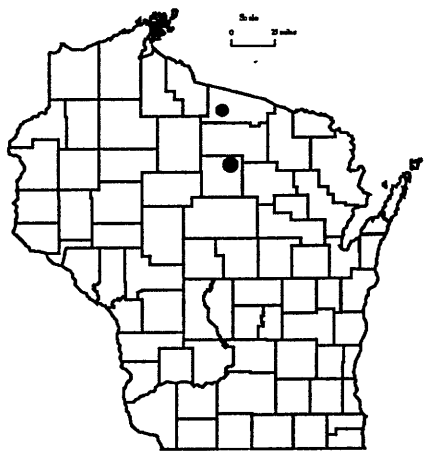
Lincoln and Vilas Counties, north-central Wisconsin

PROJECT CHIEF:

Dennis A. Wentz

PERIOD OF PROJECT:

August 1980 to September 1990



Chen, C.W., Gomez, L.E., Gherini, Steve, Wentz, D.A., and Whipple, J.J., 1986, Seepage lake and acid rain model-Hydrologic processes (abs.): Transactions American Geophysical Union, v. 67, no. 16, p. 282.

Wentz, D.A., Rose, W.J., and Krohelski, J.T., 1986, Hydrology and geochemistry of seepage-lake systems in areas of Wisconsin receiving acid deposition (abs.): Transactions American Geophysical Union, v. 67, no. 16, p. 282.

Wentz, D. A., 1982, Hydrology of Wisconsin lakes potentially affected by acid deposition (abs.): Stevens Point, Wisconsin, American Water Resources Association, Wisconsin Section, Abstracts (March 1982), p. 18-19.

EFFECTS OF ACID PRECIPITATION ON LAKES IN NORTHWESTERN WISCONSIN, WI 116

PROBLEM: Acid precipitation has damaged lakes in Canada and the northeastern United States. Wisconsin has more potentially susceptible lakes than any State east of the Mississippi River. Studies have shown that acid precipitation in northern Wisconsin, where pH's average 4.0 to 4.5, may affect as many as 8,000 lakes. This could seriously affect the tourist-based economy of this area. Hydrologic and chemical budgets of representative potentially susceptible lakes will increase the understanding of the effect of acid precipitation on aquatic systems and will provide information to evaluate and possibly predict these effects so that future damage can be minimized.

OBJECTIVE: Determine hydrologic and chemical budgets for Round and East Eightmile Lakes in northwestern Wisconsin to provide information regarding mechanisms of acid loadings to these lakes and to assist modification and calibration of the Integrated Lake Watershed Acidification Study (ILWAS) ecosystem model to this area.

APPROACH: Lake inflows from precipitation and ground-water discharge, and lake outflows from evaporation and ground-water recharge will be quantified. Alkalinity, pH, major cations and anions, nutrients, and trace elements in selected flowpaths will be measured. The lakes will be evaluated for their potential for acidification.

PROGRESS (July 1993 to June 1994): Final approved reports on "Hydrology," "Chemistry of Snowpack and Ground Water," and "Chemical Budgets" on the entire 5-year study awaited publication by Electric Power Research Institute (EPRI). EPRI decided not to publish the reports.

PLANS (July 1994 to June 1995): The final report will be reformatted and published as a WDNR report.

REPORTS:

Greb, S.R., and Wentz, D.A., 1989, Section 7--Chemical budgets, in Knauer, D.R., and Brouwer, S.A., eds., The Wisconsin Regional Integrated Lake-Watershed Acidification Study (RILWAS)--Wisconsin application, final report: Palo Alto, California, Electric Power Research Institute publication (in preparation).

Wentz, D.A., 1989, Section 6--Chemistry of snowpack and ground water, in Knauer, D.R., and Brouwer, S.A., eds., RILWAS--Wisconsin application, final report: Palo Alto, California, Electric Power Research Institute publication (in preparation).

Wentz, D.A., Krohelski, J.T., and Rose, W.J., 1989, Section 5--Hydrology, in Knauer, D.R., and Brouwer, S.A., eds., RILWAS--Wisconsin application, final report: Palo Alto, California, Electric Power Research Institute Publication (in preparation).

COOPERATOR:

Wisconsin Department of Natural Resources

LOCATION:

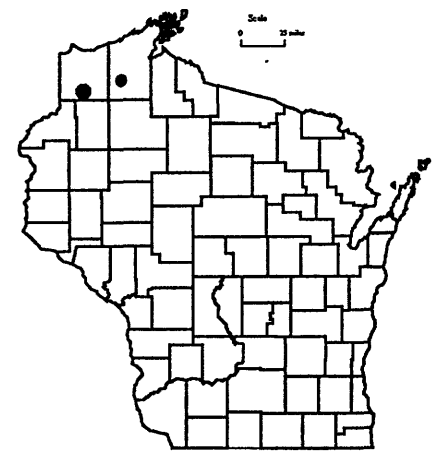
Douglas and Bayfield Counties, northwest Wisconsin

PROJECT CHIEF:

Dennis A. Wentz

PERIOD OF PROJECT:

July 1981 to June 1988



Wentz, D.A., Garrison, P.J., and Bockheim, J.G., 1989, Section 7--Chemical in Knauer, D.R., and Brouwer, S.A., eds., The Wisconsin Regional Integrated Lake-Watershed Acidification Study (RILWAS): 1981-1983, Palo Alto, California, Electric Power Research Institute Report EA-6214, p. 7-1 to 7-30.

Wentz, D.A., Rose, W.J., and Krohelski, J.T., 1989, Section 5--Hydrologic component, in Knauer, D., and Brouwer, S.A., eds., The Wisconsin Regional Integrated Lake-Watershed Acidification Study (RILWAS): 1981-1983, Palo Alto, California, Electric Power Research Institute Report EA-6214, p. 5-1 to 5-77.

Li, C.S., Bockheim, J.G., Leide, J.E., and Wentz, D.A., 1988, Potential for buffering of acidic precipitation by mineral weathering in a forested entisol: Soil Science of America Journal, v. 52, p. 1148-1154.

Garrison, P.J., Greb, S.R., Knauer, D.R., Wentz, D.A., Krohelski, J.T., Bockheim, J.G., Gherini, S.A., and Chen, C.W., 1987, Application of the ILWAS model to the northern Great Lakes States: Lake and Reservoir Management, v. 3, p. 356-364.

Krohelski, J.T., Wentz, D.A., Rose, W.J., and Elder, J.F., 1987, Ground-water flow in the vicinity of East Eightmile Lake, Wisconsin (abs.): Madison, Wisconsin, American Society of Limnology and Oceanography, Abstracts of Papers for the 1987 Annual Meeting (June 1987), p. 43.

Wentz, D.A., Krohelski, J.T., Rose, W.J., Bockheim, J.G., Garrison, P.J., Knauer, D.R., and Goldstein, R.A., 1987, Hydrologic and chemical budgets of Wisconsin seepage lakes receiving acid deposition, in Perry, R., and others, eds., Acid rain: Scientific and technical advances: London, UK, Selper Ltd., p. 309-316.

Krohelski, J.T., Wentz, D.A., and Rose, W.J., 1986, Ground-water flow in the vicinity of East Eightmile Lake (abs.): Wisconsin Dells, American Water Resources Association, Wisconsin Section, Abstracts (April 1986), p. 7.

WATER RESOURCES OF WISCONSIN INDIAN RESERVATIONS, WI 123

PROBLEM: For most tribes, there is a need to characterize and define the hydrology and water quality of reservation areas to establish baselines for use by tribal planners and others in future site-specific investigations and studies concerned with long-term water-quality trends. For some tribes, site-specific problems related to ground- and surface-water contamination and water supply need to be defined and assessed.

OBJECTIVE: The objectives are to define water resources and address site-specific problems related to water resources on Wisconsin tribal lands.

APPROACH: Approaches vary because of the variability of types of water resources and problems.

PROGRESS (July 1993 to June 1994):

Oneida Tribe of Indians of Wisconsin

Stage-discharge and water quality for Duck Creek at the gaging station at County Highway FF and water levels in the three shallow observation wells adjacent to the gaging station were monitored. Ground-water capture zones for 3-4 high-capacity wells were determined.

Menominee Indian Tribe of Wisconsin

Stage-discharge measurements at the Wolf River at Langlade and water-quality sampling of the Wolf River at County M and at the southern boundary of the Menominee Reservation were continued.

Stockbridge-Munsee Band of Mohican Indians

A gaging station to monitor stage-discharge was continued on the Red River near Morgan.

PLANS (July 1994 to June 1995):

Oneida Tribe of Indians of Wisconsin

Stage-discharge for Duck Creek at the gaging station at County Highway FF and water levels in the three shallow observation wells adjacent to the gaging station will be monitored.

Menominee Indian Tribe of Wisconsin

Stage-discharge measurements at the Wolf River at Langlade will be continued.

Stockbridge-Munsee Band of Mohican Indians

Stage-discharge measurements at the Red River near Morgan will be continued.

REPORTS:

Krabbenhoft, D.P., and Krohelski, J.T., 1992, Data on water quality, lake sediment, and lake-level fluctuation, St. Croix Indian Reservation, Wisconsin, 1981-87: U.S. Geological Survey Open-File Report 92-26, 53 p.

COOPERATORS:

The Menominee and Oneida Tribes of Wisconsin
The Stockbridge-Munsee Band of Mohican Indians of Wisconsin

LOCATION:

Statewide

PROJECT CHIEFS:

Jim Krohelski, John DeWild

PERIOD OF PROJECT:

August 1977-Continuing

Lidwin, R.A., and Krohelski, J.T., 1992, Hydrology and water quality of the Forest County Potawatomi Indian Reservation, Wisconsin: U.S. Geological Survey Water-Resources Investigations Report 91-4136, 30 p.

Batten, W.G., and Lidwin, R.A., A summary of hydrologic data for the Lac Du Flambeau Indian Reservation, Wisconsin: U.S. Geological Survey Water- Resources Investigations Report (in press).

Krohelski, J.T., and Kammerer, P.A., Water resources of the Menominee Indian Reservation of Wisconsin: U.S. Geological Survey Water-Resources Investigations Report (in press).

Batten, W.G., Water resources of the Bad River Indian Reservation of Wisconsin: U.S. Geological Survey Water-Resources Investigations Report (through editorial review).

Krohelski, J.T., Krabbenhoft, D.P., and Hoaglund, J., Hydrology and Water Quality of the Stockbridge-Munsee Indian Reservation, Wisconsin: U.S. Geological Survey Water-Resources Investigations Report (first draft written).

Krabbenhoft, D.P., and Hurley, J., Distribution of PCB and mercury in sediments of the Apostle Islands/Chequamegon Bay area of Lake Superior, Wisconsin, journal article, 5 p. (planned).

LAKE WATER-QUALITY MONITORING, CHEMICAL AND BIOLOGICAL MONITORING OF SELECTED LAKES, WI 133

COOPERATORS:

In the 1993 water year:
Big Muskego, Little Muskego, Fowler, Hills, Wind, Okauchee, Alma/Moon, Hooker, Balsam, Druid, Eagle, Potter, Wolf, Pretty, Little Arbor Vitae, Little Green, Little St. Germain, Loon and Powers Lake Districts; town of Cedar Lake (Balsam, Red Cedar and Hemlock Lakes), village of Oconomowoc Lake (Oconomowoc Lake); Wisconsin Department of Justice (Big Sissabagama Lake); town of Norway (Kee-Nong-Go-Mong and Waubeesee Lakes); Eagle Springs Sanitary District, city of Muskego (Denoon Lake); township of Hubbard (Sinissippi Lake); township of Mead (Mead Lake); township of Merton (Keesus Lake); Marinette County Soil and Water Conservation District (Lake Noquebay); village of Lake Nebagamon (Lake Nebagamon); Summit Township (Silver Lake); town of Bear Lake (Bear Lake); town of Troy (Booth Lake); and town of St. Germain (Big St. Germain Lake)

In the 1994 water year:
Big Muskego, Little Muskego, Fowler, Wind, Okauchee, Alma/Moon, Upper Nemahbin, Balsam, Druid, Eagle, Potter, Wolf, Pretty, Little Arbor Vitae, Little Green, Little St. Germain and Powers Lake Districts; town of Cedar Lake (Balsam, Red Cedar and Hemlock Lakes), village of Oconomowoc Lake (Oconomowoc Lake); Wisconsin Department of Justice (Big Sissabagama Lake); town of Norway (Kee-Nong-Go-Mong and Waubeesee Lakes); Eagle Springs Sanitary District, city of Muskego (Denoon Lake); township of Mead (Mead Lake); township of Merton (Keesus Lake); Marinette County Soil and Water Conservation District (Lake Noquebay); village of Lake Nebagamon (Lake Nebagamon); Summit Township (Silver Lake); town of Troy (Booth Lake); town of St. Germain (Big St. Germain Lake); town of Auburn (Forest Lake); and town of Waterford (Tichigan Lake)

PROBLEM: Lakes are a valuable resource in the State of Wisconsin and their water quality needs documentation.

OBJECTIVE: The objective of this project is to determine lake stage and water quality at selected lakes throughout Wisconsin and, through a continuous monitoring program, provide data to detect chemical or biological changes that may take place.

LOCATION:

Selected lakes in Wisconsin

PROJECT CHIEF:

Stephen J. Field

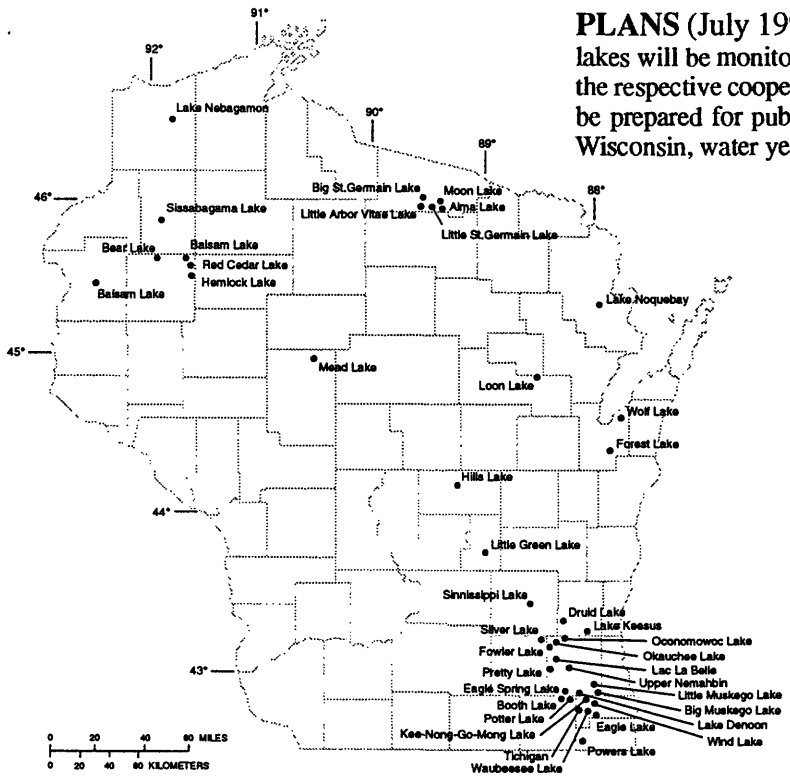
PERIOD OF PROJECT:

June 1983-Continuing

APPROACH: Water quality at each lake will be monitored in February, April, June, July, and August. Depth profiles of dissolved-oxygen concentration, temperature, pH, and specific conductance will be determined. In April, the lakes will be sampled at the top and bottom for analysis of the major anions and cations, nitrogen, and dissolved phosphorus. Secchi-disc readings will be made for all months (except February), and total phosphorus and chlorophyll a samples will be collected and analyzed. Weekly stage readings of the lake level will be obtained by a local observer.

PROGRESS (July 1993 to June 1994): In the 1993 water year, total phosphorus, chlorophyll a, dissolved oxygen, temperature, pH, specific conductance, and Secchi-depth data were collected and analyzed at Big Muskego, Little Muskego, Fowler, Hills, Wind, Okauchee, Powers, Oconomowoc, Big Sissabagama, Kee-Nong-Go-Mong, Waubeesee, Balsam, Eagle Springs, Denoon, Druid, Keesus, Lac La Belle, Little Arbor Vitae, Little Green, Little St. Germain, Loon, Mead, Noquebay, Nebagamon, Moon, Alma, Silver, Bear, Booth, Big St. Germain, Hooker, Sinissippi, Hills, Eagle, Potter, Wolf, Pretty, Red Cedar, Balsam, and Hemlock Lakes. A letter evaluating the water quality of each lake was sent to the respective cooperator. In the 1994 water year, Forest, Upper Nemahbin and Tichigan Lakes were added to the program. Hills, Sinnissippi, Hooker, Bear and Loon Lakes discontinued the program. The locations of lakes included in the monitoring program for water years 1993-94 are shown on the following map.

PLANS (July 1994 to June 1995): In the 1994 water year, 36 lakes will be monitored. We will compile the data and transmit it to the respective cooperator after the August monitoring. The data will be prepared for publication in the annual "Water Resources Data-Wisconsin, water year 1994."



OCCURRENCE, TRANSPORT, AND SIMULATION OF PCB'S IN THE LOWER FOX RIVER, WI 145

PROBLEM: Polychlorinated biphenyls (PCB's) in the Lower Fox River have been identified and classified as "in-place pollutants" by the Wisconsin Department of Natural Resources (WDNR) due to the high concentrations found in the bottom sediments (up to 250 milligrams per kilogram). These PCB deposits are believed to be a significant source of continuing PCB loading to Green Bay and Lake Michigan. The WDNR is developing a remedial action plan to reduce the PCB presence in the Fox River and Green Bay. Information is needed regarding the location of PCB deposits and transport rate of PCB's within the Fox River to support this remedial action effort.

OBJECTIVE: The objectives of this study are to estimate the total mass of PCB's present in the study reach bottom sediments, compute the total PCB load carried by the river, and simulate present and future PCB transport in the river. The study is being coordinated with and will compliment the U.S. Environmental Protection Agency's mass-balance study of PCB's in Green Bay.

APPROACH: Streamflow-monitoring and automated-suspended-sediment sampling equipment is installed on the Fox River between Neenah/Menasha and DePere. Fox River discharge and suspended-sediment data were collected through September 1990.

Acoustical velocity meter (AVM) systems were used to determine discharge in the Fox River at Appleton and DePere. Automated sediment samplers were operated at Appleton, Little Rapid, and DePere, and samples were collected on a daily basis.

Water samples were analyzed to obtain PCB concentrations with congener resolution of hundreths of a nano-gram/liter. Dissolved and particulate PCB concentrations were determined separately so the PCB partition coefficients could be computed. Water samples were also analyzed to determine total and dissolved organic carbon and other parameters. Samples were collected every two weeks, except in winter. Winter sampling was done about once per month.

The total mass of PCB's present in the study reach was estimated by use of an unconsolidated sediment thickness contour map and sediment-core analysis. The sediment cores were divided into several sections by visual inspection and analyzed for PCB concentration. Sediment cores were also analyzed to determine density of the bottom deposits.

The Water Analysis Simulation Program (WASP) model has been used to simulate PCB kinetics and transport. This modeling effort is done by a USGS employee on loan to the WDNR. Water-column data collected during the summer and fall of 1992, along with high-flow data collected during the summer of 1993, has been used to validate the transport model.

COOPERATOR:

Wisconsin Department of Natural Resources (WDNR)

LOCATION:

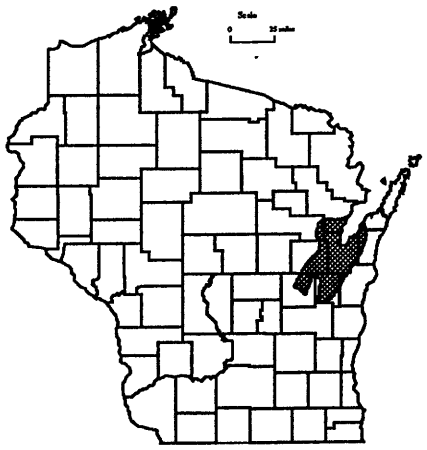
Lower Fox River, East Central Wisconsin

PROJECT CHIEF:

Jeffrey J. Steuer

PERIOD OF PROJECT:

July 1985 to June 1995



PROGRESS (July 1993 to June 1994): The report on the Little Lake Butte des Morts phase of the study has been approved for publication. The WASP4 modeling effort by USGS/WDNR has been completed. Model documentation and transference to WDNR personnel is 75 percent complete. WDNR continues to use the calibrated WASP model to evaluate various remedial actions.

PLANS (July 1994 to June 1995): The report for the Little Lake Butte des Morts study will be published. Complete model documentation and transference to WDNR personnel.

REPORTS:

House, Leo B., 1993, Distribution, concentration, and transport of polychlorinated biphenyls in Little Lake Butte des Morts, Fox River, Wisconsin 1987-88, U.S. Geological Survey Open-File Report 93-31 (pending water-supply paper).

NAWQA NATIONAL-RELATIONS BETWEEN LAND- AND WATER-MANAGEMENT PRACTICES AND CONTAMINANT EFFECTS ON AQUATIC ORGANISMS, WI 151

PROBLEM: The U.S. Geological Survey initiated the National Water-Quality Assessment (NAWQA) program in 1986 to provide information on the condition of the nation's water resources and identify long-term effects of changes in land- and water-management practices on those resources. Contaminants introduced as a result of land- and water-management practices may have direct and indirect effects on populations and communities of aquatic organisms. The often complex nature of these effects presents challenges for their identification and interpretation.

OBJECTIVE: The objectives of the National Water-Quality Assessment (NAWQA) program include (1) describing current surface water-quality conditions; (2) defining long-term trends in water quality; and (3) improving our understanding of factors affecting observed water-quality conditions and trends. The objectives of the Wisconsin project are to investigate the relations between land- and water-management practices and bioavailability of contaminants to aquatic organisms. The effects of these contaminants on aquatic communities in surface-water ecosystems will be evaluated.

APPROACH: Assistance will be given to the Illinois District and national NAWQA personnel in habitat assessment, biological tissue sampling, site selection, and field logistics for biological sampling in the UIRB. A literature review will be conducted. Data analysis and interpretation will be performed to determine spatial trends in element concentrations of biological tissues collected in the UIRB during 1989 and 1990. Relations between element concentrations in tissues, water, and sediment will also be examined. As a coauthor, portions of a water-supply paper will be written evaluating trace elements in water, sediment, and biota in the UIRB.

PROGRESS (July 1993 to June 1994): A water-supply paper entitled "Surface-water-quality assessment of the upper Illinois River basin in Illinois, Indiana, and Wisconsin: major and trace elements in water, sediment, and biota" was colleague reviewed and is being revised according to reviewers' comments.

PLANS (June 1994 to July 1995): The final report will be submitted to NR for approval and published.

REPORTS:

Fitzpatrick, F.A., Scudder, B.C., Crawford, K.J., and Kupperman, J.B., Surface-water-quality assessment of the upper Illinois River basin in Illinois, Indiana, and Wisconsin: major and trace elements in water, sediment, and biota, 1978 through 1990: U.S. Geological Survey Water-Supply Paper (in review).

COOPERATORS:

USGS Headquarters,
Office of Water Quality
USGS Illinois District

LOCATION:

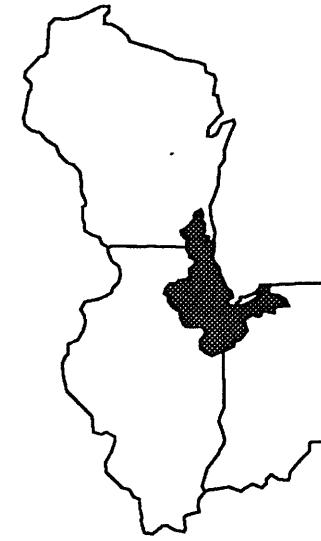
Upper Illinois River Basin (UIRB) in Illinois, Wisconsin, and Indiana

PROJECT CHIEF:

Barbara C. Scudder

PERIOD OF PROJECT:

June 1986 to September 1992



GROUND-WATER CONTROL OF THE CHEMICAL EVOLUTION OF NEVINS LAKE, MICHIGAN, WI 15401

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
North-central Upper Peninsula, Michigan

PROJECT CHIEF:
David P. Krabbenhoft

PERIOD OF PROJECT:
March 1989 to September 1992

PROBLEM: Many lakes are poorly buffered and are thus potentially sensitive to the effects of acid precipitation. Seepage lakes in the Upper Midwest rely on ground water as their principal source of alkalinity. Seasonal reversals in ground-water flow, or for more extended periods during drought, can result in rapid loss of lake-water alkalinity and consequent acidification. To investigate this problem, an acid-sensitive lake must be studied to determine how lakes respond to periods of no ground-water inflow.

OBJECTIVE: Determine what role ground water plays in the episodic and rapidly responding chemical character of Nevins Lake, Michigan. It is hypothesized that ground-water inflow to Nevins Lake is periodically discontinued, resulting in a mounded lake system that is particularly sensitive to rapid acidification.

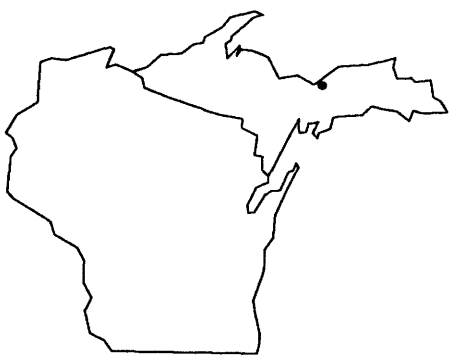
APPROACH: Lake chemistry will be closely monitored and correlated with observed changes in the mounded/flow-through nature of the ground-water-flow system. Mass-balance calculations on conservative solutes (calcium) in the lake, in combination with precipitation loading rates, will be used to estimate ground-water-inflow and outflow rates. A new sampling strategy is being employed whereby water samples are taken from the lakebed rather than wells.

PROGRESS (July 1993 to June 1994): Report is in colleague review.

PLANS (July 1994 to June 1995): Report will be sent for approval when reviews are completed and published.

REPORTS:
Krabbenhoft, D.P., and Webster, K.E., 1992, Ground-water role in the episodic acidification of Nevins Lake, Michigan (journal article in preparation).

Krabbenhoft, D.P., and Webster, K.E., 1990, Use of episodic changes in lake water chemistry to estimate ground-water flow rates at Nevins Lake, Michigan. Abstract, American Water Resources Association, Wisconsin Chapter, March 1990.



SUPERFUND REMEDIAL RESPONSE SUPPORT, EPA REGION V, WI 164

PROBLEM: The U.S. Environmental Protection Agency, Region V, has requested the Wisconsin District to provide technical assistance in the hydrogeological characterization of Superfund sites.

OBJECTIVE: The objectives are to provide the requested assistance to broaden the knowledge of ground-water hydrology in the vicinity of Superfund sites.

APPROACH: The Wisconsin District will provide hydrogeological and geophysical expertise and support to Region V-Superfund. Services, such as drilling and monitor well installation and selective formation packer tests will be conducted upon request by EPA-Superfund throughout Region V.

PROGRESS (July 1993 to June 1994): Support work was conducted at the following Superfund sites: Parsons Casket, Belvidere, Illinois; Byron Salvage Yard, Byron, Illinois; Tomah Armory, Tomah, Wisconsin; Tomah Fairgrounds, Tomah, Wisconsin; Better Brite, De Pere, Wisconsin.

PLANS (July 1994 to June 1995): Assistance will be provided throughout Region V upon request.

COOPERATOR:
U.S. Environmental Protection Agency, Office of Superfund

LOCATION:
EPA-Region V (Wisconsin, Illinois, Michigan, Minnesota, Indiana and Ohio)

PROJECT CHIEF:
Bart Manion

PERIOD OF PROJECT:
November 1988-Continuing

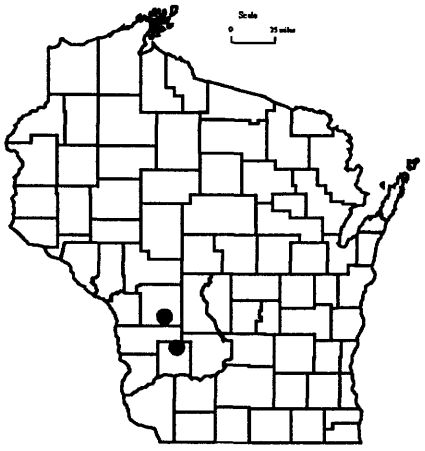
HYDROLOGIC INVESTIGATIONS OF WETLAND RESTORATION AND CREATION PROJECTS, WI 170

COOPERATOR:
Wisconsin Department of Transportation

LOCATION:
One mile south of Wilton, Wisconsin; one mile north of Hub City, Wisconsin

PROJECT CHIEF:
Randy J. Hunt

PERIOD OF PROJECT:
November 1989 to September 1996



PROBLEM: Agencies charged with mitigating wetland acreage losses due to construction projects are increasingly turning to wetland restoration and creation as a means of meeting requirements of Section 404 of the Clean Water Act. However, the hydrology and hydrogeology of wetlands is complex and not well understood. This lack of understanding has resulted in a low and unpredictable success rate for wetland mitigation projects.

OBJECTIVE: The overall objective of this study is to gain a better understanding of the hydrology of natural, restored, and created wetlands in order to promote a higher degree of success in wetland restoration and creation projects.

APPROACH: Detailed hydrologic investigations of restoration and creation sites will be coupled with contemporaneous study of adjoining natural wetlands. This study plan will allow us to evaluate how experimental wetlands behave relative to their natural counterparts. Test plots employed in the experimental sites will elucidate the importance of several key parameters in restoration and creation sites, and will aid in the development of guidelines for future wetland mitigation design.

PROGRESS (July 1993 to June 1994): Additional stable isotope sampling has indicated that solute chemistry in both the natural and constructed wetland is complex. The results indicate vegetative pathways control cation movement in the natural wetland, and chemical processes in the microenvironment (e.g., cation exchange, mineral dissolution) control the distribution of cations in the constructed wetland. Innovative ways of measuring ground-water inflow into the wetlands (stable isotope mass balances, temperature profile modeling, numerical water-balance modeling) estimated fluxes on the order of millimeters per day. Modeling results demonstrate that discharge strength is variable over both the natural and constructed wetlands. In addition, net ground-water recharge is calculated for some areas in the constructed wetland (agreeing with the stable isotope results) in what is considered a strong hydrogeologic discharge area.

PLANS (July 1994 to June 1995): The results of the project to date will be submitted as journal articles. The verification site in southeastern Wisconsin will be instrumented to test the transferability of the methods developed to date. In addition, monitoring will continue at the initial wetland sites.

DETERMINATION OF SEDIMENT-REDUCTION GOALS IN PRIORITY WATERSHED PROJECTS, WI 171

PROBLEM: The Nonpoint-Source Program of the Wisconsin Department of Natural Resources (WDNR) wants to develop more quantitative methods for estimating pollutant reduction goals and be able to predict the effectiveness of management activities with regard to fisheries. Modeling the physical, chemical, and biological factors affecting the fishery is necessary to determine the sensitivity of the fisheries to different factors, including pollutant loads. Increased sediment and sediment-related factors resulting from agricultural practices are a concern in the three river basins.

OBJECTIVE: Using Habitat Suitability Index (HSI) models recently developed by the U.S. Fish and Wildlife Service: (1) determine whether sediment or sediment-related factors may be significantly affecting the fish populations in selected streams of three river basins in western Wisconsin; (2) estimate the reduction in these factors necessary to effect a significant increase in the fish populations; and (3) assess the suitability of the models for estimating sediment-reduction goals for the Nonpoint-Source Program of the Wisconsin Department of Natural Resources.

APPROACH: Fish and fish habitat data will be collected by the WDNR in two river basins. WDNR fish crews will be interviewed and selected streams will be visited. The data will be compiled and the models applied. The significance of sediment or sediment-related factors on fish populations in these river basins will be determined using the models. After interpretation of results from the two river basins, methods for collecting habitat data will be revised and habitat data will be collected by the USGS in a third river basin. Models will be applied to this data to determine the importance of sediment or sediment-related factors to fish populations. Literature research on the models and their use will be conducted, and WDNR staff will be consulted regarding previous use of the models. The utility of the models to the DNR's Nonpoint-Source Program will be assessed.

PROGRESS (July 1993 to June 1994): Report was approved for publication as a journal article.

PLANS (July 1994 to June 1995): Report will be published.

REPORTS:

Scudder, Barbara, Application of habitat-suitability index models to assess effects of fine-grained sediment on brook trout and brown trout habitat (approved for publication as a journal article).

COOPERATOR:

Wisconsin Department of Natural Resources

LOCATION:

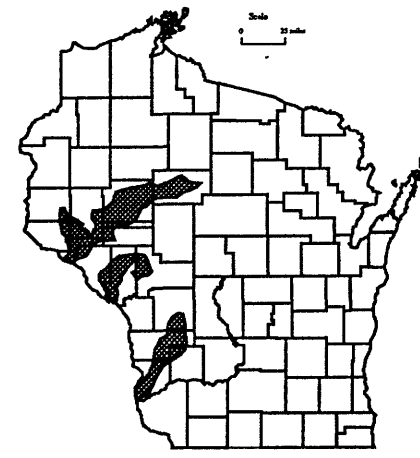
Chippewa, Kickapoo, Trempealeau River basins in western Wisconsin

PROJECT CHIEF:

Barbara C. Scudder

PERIOD OF PROJECT:

July 1990 to July 1992



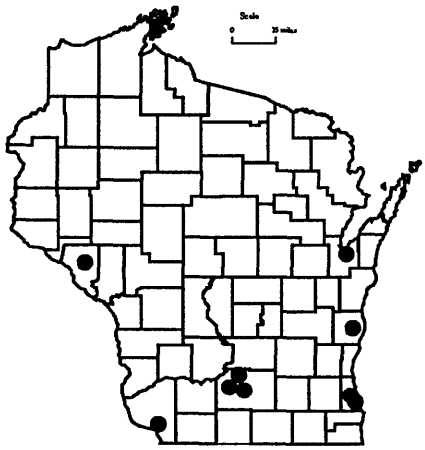
TRENDS IN WATER QUALITY AND STREAM HABITAT FOR PRIORITY WATERSHEDS, WI 17201-17205, 17208-17210, 17213, 17214

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Priority watersheds in Brown, Buffalo, Dane, Grant, Milwaukee and Sheboygan Counties

PROJECT CHIEF:
David J. Graczyk,
Steven R. Corsi, and
David W. Owens

PERIOD OF PROJECT:
October 1990 to September 1997



PROBLEM: An evaluation strategy is needed to assess the effectiveness of nonpoint-source pollution control measures in priority watersheds. Several important processes require research including the role of ground water in nonpoint-source contamination, factors leading to dissolved-oxygen reduction in a stream during runoff events, and the impact of management practices on bedload transport. Several techniques need to be developed and/or refined, such as detecting trends in stream-water chemistry, sampling of fish and fish habitat, relationship between fish/fish habitat and changes resulting from watershed management practices, and use of habitat models for determining impact of watershed management on fish populations.

OBJECTIVE: The overall objective of this project is to determine the trends in water quality for 10 sites during and after implementation of improved land-management practices in 7 priority watersheds.

APPROACH: Ten streams were selected in seven different priority watersheds. Continuous-record streamflow, water temperature, and dissolved-oxygen gaging stations were installed at each stream site. Water-quality samples will be collected during events and low flows and analyzed for selected constituents. Land-use inventories will be taken each year to help determine the cause of any changes in water quality.

PROGRESS (July 1993 to June 1994): Continued streamflow and water-quality monitoring at 10 sites in the priority watersheds. Dissolved oxygen was monitored at 7 sites in the priority watersheds. All data was summarized and will be published in the "Water Resources Data-Wisconsin" report for water year 1994. Water-quality loads were calculated for selected parameters and storm periods for the 10 sites. Land-use inventories were done for each basin.

PLANS (July 1994 to June 1995): Continue streamflow, water-quality (for the 10 sites), and dissolved-oxygen (at 7 sites) monitoring. Water-quality loads for selected parameters and storm periods will be calculated and compared to data collected in 1993. The data will be analyzed to determine if there are any apparent trends in water quality during implementation of the best management plans. Land-use inventories will be updated for each basin.

REPORTS:
Graczyk, D.J.; Walker, J.F., Greb, S.R., Corsi, S.R., Owens, D.W., 1993, Evaluation of nonpoint-source contamination, Wisconsin: Selected data for 1992 water year: U.S. Geological Survey Open-File Report 93-630, 48 p.

Walker, John F., and Graczyk, David J., 1993, Preliminary evaluation of effects of best management practices in the Black Earth Creek, Wisconsin, priority watershed: Water Science Technology, v. 28, no. 3-5, p. 539-548.

Bannerman, R.T., Owens, D.W., Dodds, R.B., and Hornewer, N.J., 1993, Sources of pollutants in Wisconsin stormwater: Water Science Technology, v. 28, no. 3-5, p. 241-259.

BEST MANAGEMENT PRACTICE EVALUATION, WI 17206

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
State of Wisconsin

PROJECT CHIEF:
John F. Walker

PERIOD OF PROJECT:
October 1989 to September 1997

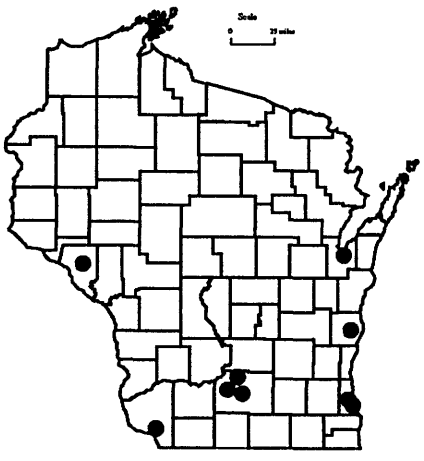
PROBLEM: To date, the effectiveness of best management practices (BMP's) in Wisconsin has not been determined. The natural variability of water-quality data complicates the detection of changes due to BMP implementation. Research is needed to identify techniques for detecting changes due to BMP implementation and applying the techniques to before and after data.

OBJECTIVE: Investigate statistical analysis techniques for assessing trends in water quality due to Best Management Practice (BMP) implementation using data from other States. The effectiveness of BMP's in two urban basins and seven rural basins in Wisconsin will be determined using the identified statistical techniques.

APPROACH: A comprehensive literature search will be conducted to identify viable statistical analysis techniques and identify needs for method modification or development. Data for several rural and urban basins in other States will be compiled and used to test the selected techniques. Storm loads of total-suspended solids and total phosphorus will be computed and used along with rainfall data and land-use information to assess the effectiveness of the BMP's in several basins in Wisconsin.

PROGRESS (July 1993 to June 1994): Open-File Report was printed and distributed. Journal article was completed, accepted by journal, and is in press.

PLANS (July 1994 to June 1995): The statistical techniques developed and described in the two reports below will be applied to data collected at all of the master monitoring sites (see description under projects 17201, et al.), data-collection efforts and statistical techniques will be modified if deemed necessary, and current research will focus on incorporation of snowmelt events into the analysis and a more direct link between BMP implementation and observed trends in water quality.



REPORTS:

Walker, J.F., 1994, Statistical techniques for assessing water-quality effects of BMPs, ASCE J. of Irrigation and Drainage Engineering (in press).

Walker, J.F., 1993, Techniques for detecting effects of urban and rural land-use practices on stream-water chemistry in selected watersheds in Texas, Minnesota, and Illinois: U.S. Geological Survey Open-File Report 93-130, 16 p.

A METHOD FOR ANALYZING THE EFFECTS OF STORM-WATER DISCHARGE ON POLLUTANT CONCENTRATIONS IN URBAN STREAMS, WI 17211

PROBLEM: An effective method is needed for determining a probable distribution of pollutant concentrations in urban streams, pollutant reduction goals, and an optimal way of defining these goals. Given the financial constraint that not all urban streams and storm sewers can be monitored for water quality, a less expensive modeling procedure will need to be developed for this purpose. A statistical technique is desired by the Wisconsin Department of Natural Resources (WDNR) to replace the need for intensive monitoring to assess urban runoff and water quality. This technique will need the capability to predict storm-sewer discharges, concentrations of pollutants from these sewers, their effect on a receiving water, and the reductions needed to achieve water-quality goals.

OBJECTIVE: The purpose of this project is to develop a method for determining the effect of storm-water discharges on the levels of pollutants in urban streams.

APPROACH: Existing water-quality models and combinations of models will be explored. The selected modeling method will be applied to Lincoln Creek, a 9.5-square-mile urban stream in Milwaukee County, Wisconsin. Extensive water-quality modeling will be done at two storm sewers discharging into Lincoln Creek and at the outlet of the basin for verification of the models. A probability-dilution method will be used to combine multiple storm-water discharges with a receiving stream resulting in estimated probability distributions of various water-quality constituents at the basin outlet.

PROGRESS (July 1993 to June 1994): Modeling has been done in 16 subbasins within the Lincoln Creek Basin using the Source Loading and Management Model. Results from these subbasins were combined using the "Probabilistic Dilution Model." Final runoff volumes and suspended-sediment concentrations were calibrated with values from the stream gage at the outlet. Several different contaminant-reduction scenarios were run through the models to evaluate the effect on stream concentrations.

PLANS (July 1994 to June 1995): A final report will be prepared that will discuss the modeling techniques, their effectiveness, and their usefulness to WDNR as a water-quality evaluation tool.

COOPERATOR:

Wisconsin Department of Natural Resources

LOCATION:

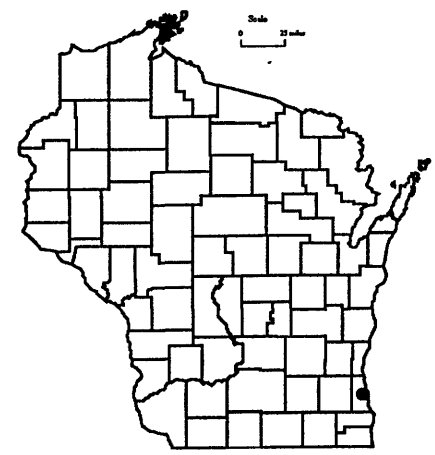
Lincoln Creek in Milwaukee, Wisconsin

PROJECT CHIEF:

Steven R. Corsi

PERIOD OF PROJECT:

October 1992 to September 1993



LAKE SUPERIOR URBAN STORM-WATER DEMONSTRATION PROJECT, WI 17212

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Eleven cities in Lake Superior Basin (Minnesota, Wisconsin, Michigan)

PROJECT CHIEF:
Jeffrey J. Steuer

PERIOD OF PROJECT:
April 1993 to December 1995

PROBLEM: The Lake Superior Binational Program requires an understanding of the importance of urban storm-water pollution in the Lake Superior Basin.

OBJECTIVE: The objective is to provide water-quality data needed to construct storm-water management plans as required under the Binational Program. In addition to discharge, these data will include nutrients, metals, poly-aromatic hydrocarbons (PAHs) and eight organic bioaccumulative substances identified by the Binational Program.

APPROACH: One storm sewer in each of two cities (Marquette, Michigan and Superior, Wisconsin) will be intensively monitored (15 events) for runoff flow and constituent concentrations. Within the Marquette basin, runoff from nine source areas (streets, parking lots, roof tops, driveways and lawns) will be sampled. These data will be used to calibrate an urban model for the Marquette flume site.

One storm sewer in each of eight smaller municipalities will be monitored over four events for constituent concentrations. Constituent concentrations will be monitored (6 events) at two bulk storage piles in the Duluth/Superior area.

PROGRESS (April 1993 to June 1994): Sites have been selected and field equipment installed. Fifty percent (50%) of the field data have been collected.

PLANS (July 1994 to June 1995): Complete data-collection effort at the two flume sites, nine source-area sites, eight municipalities, and two storage piles. Commence report writing.

WISCONSIN LAKES, ASSESSMENT OF THE HYDROLOGY AND PHOSPHORUS LOADING TO FISH AND MUD LAKES, DANE COUNTY, WISCONSIN, WI 17301

PROBLEM: Fish and Mud Lakes are seepage lakes separated by about a 200-foot-wide isthmus, but connected by a 5-foot-diameter culvert. Fish Lake is mesotrophic and Mud Lake is eutrophic. Eurasian water milfoil has become a nuisance macrophyte in much of the lake's littoral zone in recent years. A study of Fish Lake in the late 1970's showed significant internal phosphorus loading from the littoral sediment during summer stratification. Extensive row crop farming and large animal feed lots in the western part of the watershed may generate most external loading to both Fish and Mud Lakes. The Wisconsin Department of Natural Resources will be evaluating the lakes' water chemistry and trophic status and testing various means of controlling macrophytes. Identification of the amounts and sources of phosphorus entering the lakes is needed to evaluate phosphorus loading in relation to the lakes' trophic status. This information is needed for developing and assessing lake- and land-management alternatives for maintaining or improving water quality of the lakes.

OBJECTIVE: The objectives of this study are to define the hydrology of Fish and Mud Lakes and to identify and quantify major sources of phosphorus entering the lakes.

APPROACH: The study will be done in two phases. The first phase is data collection and providing the data to the cooperator. The second phase is to interpret the data and publish a summary report. The study will have a one-year (November 1, 1990 to October 31, 1991) data-collection period. Hydrology and phosphorus loading will be evaluated using the following techniques:

Water Budget: The equation describing the water budget for Fish and Mud Lakes is as follows:

$$DS = P - E + S + GI + LE - GO$$

where

DS is change in lake storage volume,
P is precipitation,
E is evaporation,
S is surface runoff into the lake,
GI is ground-water discharge to the lake,
LE is lake exchange or net flow through the culvert separating the lakes,
and GO is ground-water recharge from the lake.

The study emphasis will be on only the most significant (with regard to phosphorus loading) water-budget components owing to funding constraints. These are DS, P, and S. The remaining components (GI, E, LE, and GO) will be evaluated and, if possible, estimated on the basis of minimal data.

Phosphorus loading: An automatic water sampler at a tributary gaging station will collect storm-runoff samples for total-phosphorus

COOPERATOR:

Dane County Lakes and Watershed Commission

LOCATION:

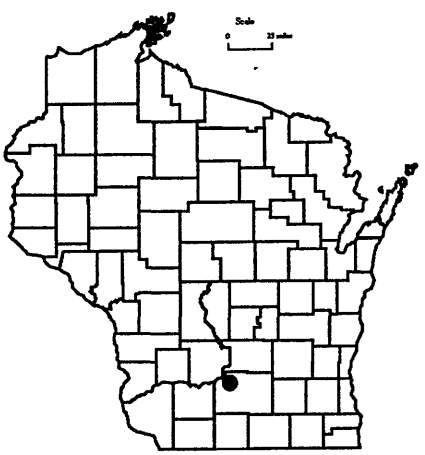
Northwest Dane County near Roxbury, Wisconsin

PROJECT CHIEF:

William J. Rose

PERIOD OF PROJECT:

October 1990 to March 1993



analysis. Forty to sixty samples will be collected--the number of samples will depend on the number of storms. Phosphorus load will be calculated by the streamflow and phosphorus-integration techniques described by Porterfield (1972).

Surface runoff in many small gullies and drainageways will be sampled with siphon samplers for phosphorus-concentration analysis. These data will be the basis for estimating the phosphorus concentration of ungaged storm runoff entering the lake.

PROGRESS (July 1993 to June 1994): Interpretation of data for final report is completed. Preparation of final report is partially completed.

PLANS (July 1994 to June 1995): The final report will be completed.

REPORTS:

Rose, W. J., Hydrology of, and phosphorus loading to, Fish Lake in south-central Wisconsin, 1990-91: U.S. Geological Survey Water-Resources Investigations Report (in preparation).

WISCONSIN LAKES, WHITEWATER LAKE, WISCONSIN, WI 17302

PROBLEM: Whitewater/Rice Lakes are mesotrophic lakes with moderate water-quality problems. Water and phosphorus loadings and in-lake chemistry need to be documented to develop a comprehensive management plan for the lakes.

OBJECTIVE: The objectives of this study are to (1) determine the hydrologic budget for Whitewater and Rice Lakes; (2) determine the phosphorus budget for the lakes; (3) describe and quantify the lakes' water chemistry; and (4) evaluate the trophic status of the lakes.

APPROACH: Data collection will be from November 15, 1990 to November 14, 1991, with emphasis on the open-water period.

Hydrology: Evaporation and precipitation data will be collected at the study site using an evaporation pan and continuous-rainfall recorders. Precipitation data from the nearby Whitewater weather observation station will be used during freezing periods (from about November through March).

Lake stage and storage will be monitored by use of a continuous recorder. A bathymetric map will be used to compute changes in lake storage. Seepage from the lake outlets will be measured monthly. The drainage area to Whitewater Lake is small; therefore, tributary and rivulet flow will be estimated using a rainfall-runoff model. Ground-water flow will be estimated using Darcy's Law and minipiezometer data.

Phosphorus loading: Tributary and rivulet phosphorus loadings will be calculated using the rainfall-runoff model and concentration data from samplers and local observers. Septic-system and groundwater inputs of phosphorus will be estimated using literature values and results of previous investigations on the lake. Atmospheric phosphorus inputs will be estimated by use of data from a USGS study in 1984-85 of Lake Delavan, located about 10 miles southeast. Grab samples of precipitation will also be collected for phosphorus analysis during this study.

In-lake water-quality monitoring: Phosphorus outflow in surface water will be sampled when there is flow. Flow is not anticipated from the outlet. The in-lake water quality will be monitored at four sites. Water samples will be collected from the epilimnion and hypolimnion in spring (April) and fall (October or November). Water samples will be collected twice monthly from May through September. The in-lake phosphorus mass will be calculated from this information. Internal phosphorus load from bottom sediments will be estimated as the difference between the changes in observed in-lake mass and external phosphorus inputs. Considerable diurnal fluctuation of dissolved oxygen is expected during the warm summer months because of the dense aquatic macrophytes. A set of 24-hour dissolved-oxygen profiles will be

COOPERATOR:
Whitewater Lake Management District

LOCATION:
Whitewater Lake, Walworth County

PROJECT CHIEFS:
Stephen J. Field and
Jerry Goddard

PERIOD OF PROJECT:
October 1990 to September 1992

collected in late July at 3-hour intervals at each of the four lake-monitoring sites.

Trophic status: The trophic status of the lake will be evaluated according to Carlson's Trophic-State Index (1977) and by use of other empirical models.

PROGRESS (July 1993 to June 1994): The report has been written and submitted to the Director's Office for approval.

PLANS (July 1994 to June 1995): The report will be published as a Water Resources Investigations Report.

REPORTS:

Field, Stephen J., and Goddard, Gerald L., Hydrology and Water Quality of Whitewater and Rice Lakes in southeastern Wisconsin (submitted for approval).

WISCONSIN LAKES, SILVER CREEK, WI 17303

PROBLEM: Silver Creek has been documented as the primary phosphorus source to Green Lake. Continued documentation of these loads helps to explain the lake's water quality. The station also serves as an indicator of annual phosphorus loading variability to help explain regional lake-water-quality problems.

OBJECTIVE: The objective of this project is to define the water quality in relation to streamflow in stream basins where nonpoint-source pollution exists.

APPROACH: Streamflow will be monitored continuously at two sites. Water-sediment samples will be collected manually on a monthly basis and by automatic samplers during storm runoff. Suspended-sediment and nutrient concentrations will be determined. Daily, monthly, and annual mean suspended-sediment and nutrient loads will be computed.

PROGRESS (July 1993 to June 1994): Streamflow and water quality were monitored at Silver Creek near Ripon, and Green Lake inlet near Green Lake.

Loads for the 1993 water year were computed for suspended sediment and total phosphorus for Silver Creek near Ripon. Annual yields were: total phosphorus, 666 pounds per square mile; and suspended sediment, 47.8 tons per square mile. At Green Lake inlet near Green Lake, annual yields were: total phosphorus, 527 pounds per square mile; and suspended sediment, 66.8 tons per square mile.

PLANS (July 1994 to June 1995): Continue monitoring streamflow and water quality at Silver Creek near Ripon and Green Lake inlet near Green Lake. All data will be published in the annual "Water Resources Data-Wisconsin" report.

COOPERATOR:
Green Lake Sanitary District

LOCATION:
Green Lake County,
south-central Wisconsin

PROJECT CHIEF:
Stephen J. Field

PERIOD OF PROJECT:
October 1977-Continuing

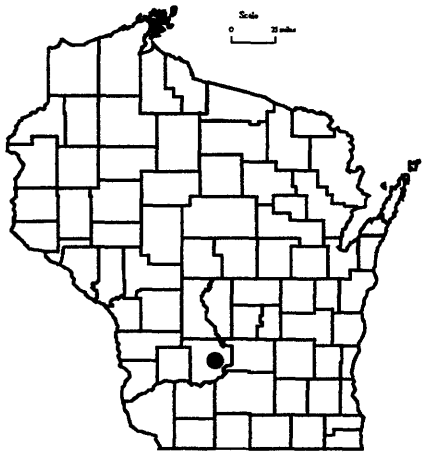
WISCONSIN LAKES, DEVIL'S LAKE WATER-BUDGET MODEL, WI 17304

COOPERATORS:
Town of Baraboo
Wisconsin Department of Natural Resources

LOCATION:
Southeastern Sauk County near Baraboo, Wisconsin

PROJECT CHIEF:
William G. Batten

PERIOD OF PROJECT:
July 1991 to September 1993



PROBLEM: Phosphorus released from bottom sediment in Devil's Lake during anoxic periods has accelerated algae growth, particularly during late summer months, reducing water clarity. The Wisconsin Department of Natural Resources (WDNR) is researching methods to reduce the phosphorus available for algal growth. It is essential to understand the hydrology of Devil's Lake before any remedial action is taken to improve water quality in the lake.

OBJECTIVE: The objectives are to determine the hydraulic parameters and water-budget components of Devil's Lake and to simulate historical lake-stage changes using a FORTRAN computer program.

APPROACH: The hydrologic budget can be described as follows:

$$S = P + RO \pm GW - E$$

where

S = change in lake storage,
P = precipitation falling directly on the lake,
RO = RUNOFF into the lake
GW = ground-water seepage into or out of the lake
E = water evaporated from the lake surface

The following water-budget components will be measured for the period from July 1, 1991 to December 1992:

Change in lake storage (S) will be calculated by relating lake stage to lake volume. An in-lake gage will be used to measure lake stage. The relationship between lake stage and lake volume will be described from an existing bathymetric map.

Precipitation (P) will be measured using commercially available measuring devices at two locations near the lake.

Surface-water inflow (SW) will be determined from intermittent discharge measurements of the small spring creek entering the southwest edge of the lake. Estimates of overland flow (RO) along the steep east and west edges of the lake may be necessary to further quantify the surface-water-inflow component with runoff from snowmelt and rainstorms.

Ground-water seepage into and out of the lake (GW) will be determined using Darcy's Law calculations. Data for these calculations will be obtained by determining the relationship between change in lake stage and evaporation rates during periods of no precipitation.

Evaporation (E) data from the Arlington climatological station located about 15 miles east of Devil's Lake will be used to calculate the lake water lost to evaporation.

Historical precipitation and evaporation data and measured hydraulic parameters will be used to calibrate a water-budget model designed to simulate lake stage. Reasonable adjustments of individual parameters will be made as necessary to make simulated stage hydrographs agree with historical stage data for Devil's Lake.

PROGRESS (July 1993 to June 1994): Lake stage and precipitation continued to be monitored. Lake stage reached a historical high for the period of record on July 18, 1993, following an intense rainstorm. Lake stages, simulated with a FORTRAN computer program, correlated well with measured lake stages for the period 1980-92. Simulated lake stage is sensitive to small changes in runoff and evaporation coefficients and ground-water-flow rates used in the computer model. A report of the results of the study has been written.

PLANS (July 1994 to June 1995): A report and journal article describing the computer model and results will be published.

WISCONSIN LAKES, ASSESSMENT OF THE WATER QUALITY AND TROPHIC STATUS OF PARK LAKE, COLUMBIA COUNTY, WISCONSIN, WI 17306

COOPERATOR:
Park Lake Management District

LOCATION:
Pardeeville, Columbia County

PROJECT CHIEF:
Phil A. Kammerer

PERIOD OF PROJECT:
October 1992 to November 1994

PROBLEM: Local residents on Park Lake perceive deteriorating water quality in the lake due to excessive algae and aquatic plants. No measurements have been made of factors affecting the lake's quality, and measurement of the lake's condition are limited to two years of in-lake data collection in 1986-87.

The Park Lake Management District plans to prepare a lake management plan to limit input of phosphorus, which contributes to excessive algae and plant growth, to the lake. An understanding of the hydrology of the lake and determination of the sources and amounts of phosphorus entering and leaving the lake are needed to develop a management plan. The trophic status of the lake needs to be determined to evaluate the effectiveness of the management plan.

OBJECTIVE: The objectives of this study are to describe the hydrology of the lake, determine a phosphorus budget for the lake, describe present in-lake water quality, and determine the trophic status of the lake.

APPROACH: The study will consist of a year of data collection followed by data analysis and report preparation. Hydrologic and water-quality data will be collected to describe the hydrology of the lake, compute an annual phosphorus budget to determine the sources and amounts of phosphorus that are available for algae and plant growth, and describe the lake's trophic status and seasonal changes in its water quality. Components of the hydrologic budget for the lake that will be measured directly include precipitation, lake stage, and surface inflow. Surface outflow, evaporation from the lake surface, and net ground-water flow will be estimated from other budget components or taken from the literature. The Fox River is assumed to be the major source of phosphorus entering the lake. Phosphorus input and surface-water inflow to the lake will be measured at a monitoring station on the Fox River upstream from the lake.

In-lake water quality will be measured at four locations in the lake to describe seasonal water-quality characteristics of the lake and to provide data needed to evaluate the lake's trophic status. The trophic status of the lake will be evaluated using empirical models.

PROGRESS (July 1993 to June 1994): Streamflow and lake- and stream-quality monitoring were completed in November 1993. Streamflow was monitored for slightly more than a year and 95 water samples were collected for analysis for total phosphorus concentration during that time. Measurements of lake water quality were made at four sites in the lake between May and November 1993. Measurements included depth profiles of dissolved-oxygen concentration, pH, water temperature and specific conductance. Sufficient water samples were collected at each site to define differences in total phosphorus concentration with depth.

Data collected during the monitoring phase of the project were published in the annual data report "Water Resources Data-Wisconsin, water year 1993."

Data analysis and preparation of an interpretive report was begun.

PLANS (July 1994 to June 1995): The interpretive report will be completed.

ELKHART LAKE HYDROLOGY, WI 17307

COOPERATOR:
Elkhart Lake Improvement Association (Center for Great Lakes Studies is collaborating on project).

LOCATION:
Elkhart Lake, Wisconsin

PROJECT CHIEF:
Jim Krohelski

PERIOD OF PROJECT:
April 1993 to September 1994

PROBLEM: Maintaining the excellent water quality in Elkhart Lake is important to both residents and visitors using the lake. Increased use from daily visitors and residents from new developments on the lake point to the need for studies to understand the lake hydrology and chemical processes. This study will provide some of the necessary technical background for the development of effective lake management strategies.

OBJECTIVE: The objective is to understand the hydrology and chemical processes of Elkhart Lake. The Center for Great Lakes Studies is responsible for determining chemical processes. The USGS will monitor discharge at the outlet and determine ground-water inflow and outflow areas of the lake.

APPROACH: Establish a stage-discharge relationship and maintain a continuous-recording gaging station at the outlet. Conduct a piezometer survey along the shoreline to determine the direction of ground-water flow and a marine-reflection survey to determine the distribution of fine-grained lake sediment (to define areas where ground-water-flow rates are insignificant).

PROGRESS (July 1993 to June 1994): A gaging station, consisting of a pressure-transducer system to monitor lake stage, a tipping-bucket rain gage and a shallow piezometer, was installed in late June 1993. The gaging station is located in the northwest corner of the lake close to the outflow structure.

For the period July 1, 1993 to January 10, 1994, the maximum lake stage was 17.44 on July 9 and the minimum was 16.92 on September 11. Six discharge measurements, made during the period of record, range from 2.40 to 6.31 cubic feet per second. These measurements were used to develop a stage-discharge rating so that daily discharge can be estimated. The maximum precipitation event was 3.03 inches and occurred on July 5. Increases in lake stage and discharge correlate very well to precipitation events.

Piezometer surveys of the lake bed near shore were conducted on August 8 and October 19, 1993 and March 15, 1994. Results from the first two surveys indicate ground-water entering the lake except in the vicinity of the gaging station. Ground-water gradients were generally greater on the north side of the lake than on the south side of the lake and did not vary significantly between these two surveys. Sediment underlying the piezometer sites were coarse (sand and gravel) except near the gaging station where the sediment was much finer. The piezometer survey conducted on March 15, 1994 was greater in scope than the other piezometer surveys and indicates the possibility of lake water discharging on the east side of the lake. Approximately 30 piezometers were installed during the March survey.

PLANS (July 1994 to September 1994): Data will continue to be collected at the gaging station. These additional data will help quantify the hydrologic budget of Elkhart Lake.

ASSESSMENT OF HYDROLOGY, TROPHIC STATUS, AND LAKE-BED SEDIMENT OF STEWART LAKE NEAR MT. HOREB, WI 17308

PROBLEM: Stewart Lake is a man-made, 8-acre lake just north of the Village of Mt. Horeb. About one third of the lake's 450-acre watershed is in Mt. Horeb. The lake's earthen dam was built in 1940. Local residents believe lake water quality has deteriorated in recent years, and that sediment and nutrient loading to the lake may have increased as a result of the development of two subdivisions in the last 20 years. However, no measurements have been made to quantify or document the lake's condition. Accumulation of sediment in the lake is believed to have significantly reduced the lake's volume. Construction of detention ponds to trap sediment and nutrients and dredging sediment from the lake have been suggested. More information is needed to evaluate the merits of various corrective measures. Sources and quantity of water, sediment, and phosphorus entering the lake need to be determined. Information is needed to evaluate the trophic status of the lake and the chemical character, quantity, and areal distribution of sediment in the lake.

OBJECTIVE: The objectives of the study will be to determine water, sediment, and total-phosphorus budgets for the lake, evaluate the trophic status of the lake, and determine the volume, areal distribution, and chemical character of sediment in the lake.

APPROACH: Data collection will be done between April 1, 1992 through November 30, 1993. Study emphasis will be on only the most significant (with regard to sediment and phosphorus loading) water-budget components owing to funding constraints. These are lake storage, precipitation (P), surface runoff (R), and lake outflow (O). Ground-water inflow and outflow and evaporation will be estimated based on minimal data. P, change in lake storage (DS), and O will be measured continuously. R will be estimated by mass balance ($R = DS - P + O$). Runoff in many small channels and gullies and the lake outlet will be sampled and analyzed for suspended-sediment and total-phosphorus concentrations. The lake's trophic status will be monitored by measuring secchi depth, total-phosphorus concentration, and chlorophyll a concentration. The thickness of sediment accumulated since 1940 will be determined by mapping the present lake bottom and comparing it with the bottom in 1940. Lake sediment will be analyzed for particle size, density, and concentrations of lead and pesticides.

PROGRESS (July 1993 to June 1994): In-lake water-quality and watershed monitoring were completed October 31, 1993. Lake-bed sediment and bathymetric maps were constructed. Tributary streamflow and sediment and phosphorus concentration data were compiled and published in the annual data report, "Water Resources Data-Wisconsin, water year 1994."

PLANS (July 1994 to June 1995): The final study report will be prepared.

COOPERATOR:

Dane County Lakes and Watershed Commission

LOCATION:

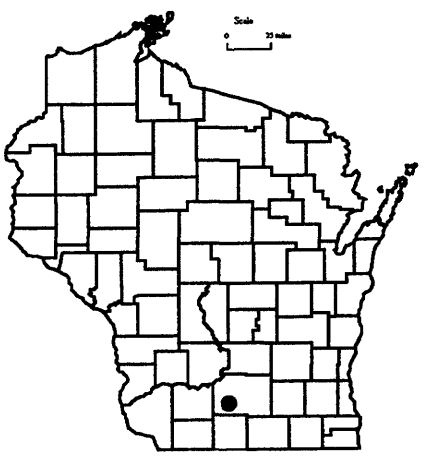
Near Mt. Horeb in Dane County, Wisconsin

PROJECT CHIEF:

William J. Rose

PERIOD OF PROJECT:

May 1992 to September 1994



ASSESSMENT OF THE HYDROLOGY AND WATER QUALITY OF LAUDERDALE LAKES,WALWORTH COUNTY, WISCONSIN, WI 17310

COOPERATOR:
Lauderdale Lakes Lake Management District

LOCATION:
La Grange, Walworth County, Wisconsin

PROJECT CHIEF:
Herbert S. Garn

PERIOD OF PROJECT:
October 1993 to September 1996

PROBLEM: Lauderdale Lakes are a chain of three interconnected lakes with a surface area of about 824 acres that are located in the more populated southeastern part of Wisconsin north of Elkhorn. The area is experiencing much population growth and development. Members of the lake district have expressed concern over the deteriorating water quality of the lakes. The lakes also have had problems with increasing macrophyte growth in the past 5 years, and the district has had to harvest macrophytes, which it has not had to do previously. The lake management district plans to prepare a waste-management plan to limit the input of phosphorus, which contributes to excessive algae and aquatic plant growth. An understanding of the hydrology of the lakes and determination of the sources and amounts of phosphorus entering and leaving the lakes is needed to develop a management plan. The present trophic condition of the lakes needs to be determined to evaluate the effectiveness of the management plan.

OBJECTIVE: The objectives of the study are to determine the hydrologic and phosphorus budgets for the Lauderdale chain of lakes, to describe and quantify present in-lake water quality, and to evaluate the trophic status of the lakes.

APPROACH: The study will consist of a year of data collection followed by data analysis and report preparation. Data collection will begin in October 1993 and go through October 1994 with emphasis on the open-water period. Hydrologic and water-quality data will be collected to describe the hydrology of the lake, to calculate an annual phosphorus budget for the lakes to determine major sources, and to describe the lakes' trophic status and seasonal changes in water quality. Major components of the hydrologic budget that will be measured directly include precipitation and evaporation, lake outflow (continuously), and lake stage (continuously). No perennial streams flow into the lake. Groundwater inflow and outflow will be estimated from head-difference values measured in piezometers installed around the lakes. Water samples for phosphorus analysis will be collected from ephemeral drainages entering the lake, from the piezometers, from lake outflow, and from within the lakes to define the phosphorus budget. In-lake water quality will be measured at three locations to describe the seasonal water-quality characteristics of the lakes and to evaluate the lakes' trophic status. The trophic status of the lakes will be evaluated using various indices and empirical models.

PROGRESS (July 1993 to June 1994): A recording lake gage was installed at Lauderdale Marina and a recording streamflow gage was installed at the lake outlet in October 1993. About 10-15 small-diameter piezometers were installed around the shoreline of the lakes in November; these will be monitored monthly for water level and P concentration. The lakes were also sampled at the three deep holes in November for general water chemistry and profiles measured. The outlet will be sampled monthly. No lake sampling

was done over the winter. A rain gage and evaporation pan was installed in the spring to be read by a local observer. Lake sampling was begun again with spring overturn and continued twice monthly to define lake water-quality characteristics and depth profiles.

PLANS (July 1994 to June 1995): Collection of hydrologic data and water-quality sampling will continue through October 1994. Data compilation, summarization, and analysis will be started. Data will be prepared for publication in the annual data report "Water Resources Data-Wisconsin, water year 1994". Work on the first draft of the interpretive report describing the results of the study will begin.

HYDROLOGIC INVESTIGATION OF THE PRETTY LAKE WATERSHED, WI 17311

COOPERATOR:
Pretty Lake Protection and Rehabilitation Lake District

LOCATION:
Near Ottawa, Wisconsin

PROJECT CHIEF:
Randy J. Hunt

PERIOD OF PROJECT:
April 1994 to September 1995

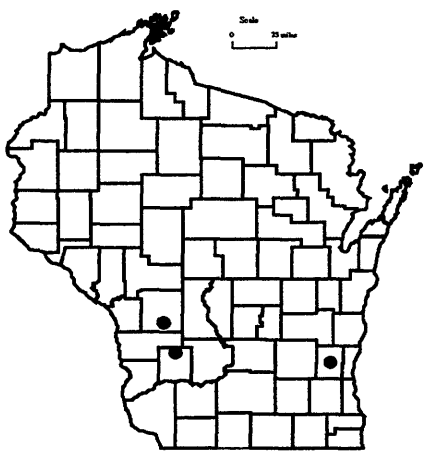
PROBLEM: Since 1977, the citizens in the vicinity of Pretty Lake have attempted to evaluate, protect and enhance the lake's water quality. However, a better understanding of the ground-water system, and the surrounding watershed, is required to attain the project objectives.

OBJECTIVE: The objectives of this study are to delineate ground-water recharge areas and ground-water divides, and to quantify water and solute loading rates as a means to assess the effects of surrounding land-use and lake-management plans.

APPROACH: A ground-water-flow model of the area will be constructed. The model will encompass hydrologic features in the lake vicinity (e.g., ditches, wells) and features important to the regional system. Particle-tracking will be used to assess the capture zone of the lake. The model will also quantify ground-water flux into the lake given model parameters and will allow prediction of hydrologic response to future system stresses and to possible management alternatives.

PROGRESS (April 1994 to June 1994): Water-level data, hydraulic conductivity estimation, and flux measurements from the site vicinity made during previous studies have been reviewed.

PLANS (July 1994 to June 1995): An analytic element model of the site will be constructed from previously collected data.



WESTERN LAKE MICHIGAN DRAINAGES NATIONAL WATER-QUALITY ASSESSMENT (NAWQA), WI 174

PROBLEM: Growing populations throughout the United States have resulted in increased development and use of our water resources. As our water resources become stressed, decisions on how to effectively utilize and manage these resources will need to be made. These decisions must be based on accurate assessments of the quality of the water resource and the factors affecting its use.

OBJECTIVE: The long-term goals of the NAWQA project are to determine the water quality of the streams and aquifers in the Western Lake Michigan Drainages, determine the presence or absence of any trends in the water quality, and provide an understanding of the link between natural and anthropogenic factors and observed water quality. Specific goals are (1) to determine the occurrence and spatial distribution of a broad array of water-quality constituents in water and stream-bed sediments; (2) determine the occurrence of contaminants in selected target taxa; (3) evaluate the aquatic habitat and community structure of streams in the study unit; (4) assess the surface- to ground-water interaction and the effects of land use on base-flow water quality in selected stream reaches; (5) evaluate the sources and transport of selected hydrophilic compounds in agricultural settings; and (6) assess the influence of land use on shallow ground-water quality in selected land-use settings.

APPROACH: The foundation of the study approach is based upon identifying relatively homogenous areas of specific land-use and environmental characteristics. Identification of these areas is accomplished by overlaying digital coverages of land use and various environmental variables using a geographical information system. Sampling sites completely contained in these relatively homogeneous areas (indicator sites) will be incorporated into a nested design of surface-water, streambed sediment, and biological sampling. The sampling strategy consists of a retrospective analysis of available water-quality data, followed by extensive data collection. Monitoring of basic fixed sites in selected areas (indicator sites), as well as downstream sites draining heterogeneous land uses and environmental characteristics (integrator sites), will be conducted for two years beginning in March 1993. These sites will be sampled monthly and augmented with event-related samples. Three of these sites will be extensively sampled for pesticides for a 15-month period. Pesticide samples will be collected approximately weekly during the early to mid-summer period and less frequently during the rest of the year. Synoptic studies will be conducted during high- and low-flow conditions (spring and summer of 1994) to better delineate the sources of nutrients throughout the basins and describe the seasonal variability of these sources. Other program components include an ecological survey (spring 1993) at approximately 40 sites to evaluate the relationship between community (fish and invertebrates), habitat structure, land-use practices, and environmental factors. Selected ground-water studies also will occur including a flow-path study and two land-use studies. The flow-path study will examine transformations in various constituents through time and space. Surface-water/ground-water interactions will be examined using shallow wells and lysimeters

COOPERATOR:

U.S. Geological Survey
Reston, Virginia

LOCATIONS:

Upper peninsula of Michigan from the Menominee River basin in the west to the Fishdam River basin in the east; and the eastern portion of Wisconsin to include the Menominee, Oconto, Peshtigo, Fox-Wolf River basins discharging to Green Bay, and in Wisconsin that directly drain into Lake Michigan from the west which include the Manitowoc, Sheboygan, Milwaukee, Root, and Pike River basins.

PROJECT CHIEF:

Charles A. Peters

PERIOD OF PROJECT:

December 1990-Continuing

installed adjacent to the nearby stream. Effects of land use on ground-water quality will be assessed through sampling in specific relatively homogenous areas (1994 and 1995).

PROGRESS (July 1993 to June 1994): Ten basic fixed sites were instrumented with gaging equipment and sampled approximately monthly (plus during events) for nutrients, major ions, organic carbon, and total suspended sediment. Three of these sites were sampled for hydrophilic pesticides during this period (approximately 40 samples at each site). In 1993, an ecological survey was performed at 27 sites for which habitats were assessed and invertebrate samples were collected. Fish community analyses were performed at 20 of these sites. In 1994, a nutrient, major ions, and total suspended-sediment synoptic study was done during high flow (spring) near seven of the basic-fixed sites. A post-pesticide-application synoptic was also done in spring of 1994 at or upstream of five of the basic fixed sites.

In the ground-water land-use surveys, 27 wells were drilled, of which 13 were sampled for nutrients, pesticides, major ions, organic carbon, stable and radioactive isotopes, chlorofluorocarbons (CFCs) and volatile organic compounds (VOCs). The location for the flow path was selected and 8 wells were drilled.

A ground-water/surface-water survey was conducted near the basic fixed site on the North Branch of the Milwaukee River. As part of this survey, 3 ground-water transects (5 sites in each transect) and 10 surface-water sites were sampled for nutrients, pesticides, major ions, and organic carbon.

Two retrospective reports (Nutrients and Suspended Sediments Retrospective and Environmental Retrospective) and a fact sheet describing the distribution of nitrate in ground water were written and submitted for colleague review.

PLANS (July 1994 to June 1995): The 10 basic fixed sites will continue to be sampled approximately monthly plus during storm events until May 1995. In August 1994, a nutrient, major ions, and total suspended-sediment synoptic study will be conducted during low flow near seven of the basic-fixed sites, similar to the high-flow synoptic. Three reaches at five of the basic fixed sites will be sampled for habitat characteristics, and invertebrate and fish community structure.

The remaining 33 wells of the land-use surveys will be drilled and 47 will be sampled for nutrients, pesticides, major ions, organic carbon, stable and radioactive isotopes, CFCs, and VOCs. All of the wells in the flow-path will be sampled for nutrients, pesticides, major ions, and isotopes.

The two retrospective reports (Nutrient and Suspended Sediment, and Environmental) and the ground-water fact sheet will be completed.

HYDROLOGIC AND BIOGEOCHEMICAL BUDGETS IN TEMPERATE LAKES AND THEIR WATERSHEDS, NORTHERN WISCONSIN, WI 175

PROBLEM: There has been expanding evidence that rates of global changes are increasing. There is a need for research to identify, describe, and quantify the processes that control the Water, Energy, and Biogeochemical Budgets (WEBB) of aquatic ecosystems in order to understand and predict their responses to global changes. Promotion of such research is the function of the Water Resources Division's WEBB program. In the northern highlands lakes district of north-central Wisconsin, five lakes and two bog lakes have been the site of long-term ecological research conducted by University of Wisconsin scientists for the past decade. These studies have provided extensive information about biological and chemical features of the lake systems, but understanding of interactions among the lakes, streams, ground-water system, and wetlands is still limited. Research is urgently needed to describe these interactions and basin-wide processes that influence the character of the lakes.

OBJECTIVE: (1) Describe processes controlling water and solute fluxes in northern Wisconsin lake watersheds; (2) examine interactions among those processes and their relations to climatic variables; and (3) improve the capability to predict changes in water and solute fluxes for a range of spatial and temporal scales. Fulfillment of these objectives in Wisconsin will contribute to meeting the overall objective of the federal global change program: to understand processes underlying the responses of hydrological, biological, and chemical systems to climate variations and human activities.

APPROACH: Selected streamflow/recharge sites on tributaries of Trout Lake are the sites for detailed research of hydrologic processes. Most of the current research effort is concentrated at Allequash Creek, one of four inflowing tributaries of Trout Lake. Analyses of hydrologic connections among precipitation, streamflow, and ground water are conducted at three cross sections of the Allequash Creek basin. Monitoring and sampling equipment installed at these sites include piezometer nests, lysimeters, tensiometers, precipitation collectors, and thermocouple nests. Analyses of stable isotopes (C-13, O-18, Sr-86, and deuterium) are also used to determine water exchange pathways and sources of stream water. The site-specific hydrologic research is supported by data from several rain gages throughout the study area, and a complete climatological station in the vicinity.

Stream-water and ground-water samples, collected at each of the Trout Lake tributaries and at different points in the Allequash system, undergo analysis for nitrogen species, phosphorus, silica, organic carbon, major ions, and metals. Tributary sampling is done on a monthly basis, supplemented with more intense sampling of particular storms. Coupled with hydrologic data, the water sampling provides a basis for describing chemical budgets.

COOPERATOR:

Global Change Hydrology Program, WRD, U.S. Geological Survey

LOCATION:

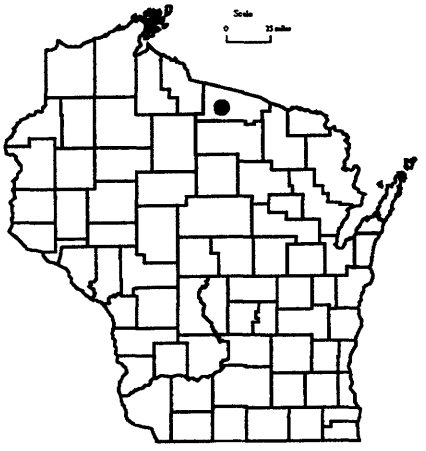
North-central Wisconsin

PROJECT CHIEFS:

John F. Elder,
David P. Krabbenhoft and
John F. Walker

PERIOD OF PROJECT:

October 1990-Continuing



Investigation of geochemical processes that control transport of important chemical species across stream and lake sediments involves fine-scale sampling at the sediment/water interface. This is done by a variety of techniques, including membrane equilibrators, core squeezing, microprobes, and seepage meters.

PROGRESS (July 1993 to June 1994): Three Allequash Creek monitoring sites, previously established and equipped for intensive hydrologic and geochemical data collection, were further developed and data collection and analysis proceeded at those sites. Precipitation, ground-water and stream samples were analyzed for stable isotope composition providing results that have been used to characterize the hydrology of the system in considerable detail. Sampling of Trout Lake tributaries and various sites along Allequash Creek also continued, with collections approximately monthly. Chemical analyses of these samples were mostly completed and nutrient and carbon loads have been computed. A set of near-stream to near-upland monitoring and water-level wells was established in the Allequash peatland for assessment of water and carbon flux through the peatland. Other procedures to provide more information about carbon pools and fluxes in the system were initiated, including measurement of greenhouse gases in ground water and stream samples, and increased sampling and characterization of dissolved organic carbon. Data collection for calculation of the Trout Lake heat budget included continuous temperature profile measurements from a raft anchored at one site on the lake and monthly profile measurements from 10 sites throughout the lake.

PLANS (July 1994 to June 1995): Data collection at hillslope monitoring sites will decrease and more effort will be directed toward analyses, interpretation, and write-up of existing data. Stream-water and ground-water monitoring will continue for further examination of seasonal and spatial variability. Measurements of gas-phase and aquatic-phase transport of carbon and nutrients through the system will continue. Additional sites for gas sampling in the unsaturated zone will be installed in forest sites. Additional field work will emphasize investigation of carbon budget.

REPORTS:

Elder, John F., Krabbenhoft, David P., and Walker, John F., 1992, Water, Energy, and Biogeochemical Budgets (WEBB) program: data availability and research at the Northern Temperate Lakes site, Wisconsin: U.S. Geological Survey Open-File Report 92-48.

Krabbenhoft, D.P., Walker, J.F., and Kendall, Carol, and Bullen, T.D., 1992, Definition of water flow paths by stable isotope analysis of ground water, rainfall, and stream water in temperate lake watersheds, northern Wisconsin (journal article, planned).

GROUND-WATER RESOURCES AT THE KETTLE MORAINE SPRINGS FISH HATCHERY, SHEBOYGAN COUNTY, WISCONSIN, WI 178

PROBLEM: The Kettle Moraine Springs Fish Hatchery supplies salmon to Lake Michigan. The fish hatchery's present water supply consists of springs and two wells. The hatchery is planning to expand its salmon-rearing operations and add rearing facilities for walleye. Additional water supplies will be obtained by drilling at least one new well. The effect of additional ground-water withdrawals on hatchery springs and wells and on nearby private wells is unknown.

OBJECTIVE: The study will assess the ground-water resources available to the fish hatchery and evaluate the effect on hatchery springs and wells and private wells of developing a ground-water supply.

APPROACH: The fish hatchery may obtain water from the bedrock dolomite aquifer, or sand and gravel deposits if present. Seismic-refraction data will be collected to determine the thickness of glacial deposits and the depth to the bedrock aquifer. Test holes will be drilled to determine if sand and gravel deposits are present and confirm the depth to bedrock obtained from seismic data. Large diameter production wells and observation wells will be installed and monitored during two pumping tests. Results from the aquifer tests will be interpreted using analytical solutions.

PROGRESS (July 1993 to June 1994): Drilling and refraction data indicate that the thickness of glacial deposits ranges from 60 to more than 150 feet. The glacial deposits are fine-grained and confine the underlying Silurian dolomite aquifer in the lowlands near the raceways. Tiled springs located on surrounding hillsides provide water to the hatchery. Pumping from wells open to the dolomite aquifer in the lowlands causes water levels in shallow wells near the springs to decline, which suggests pumping from the dolomite aquifer will reduce flow from springs. Results from aquifer tests indicate that wells interfere with each other, and the transmissivity of a hatchery well is 1,200 ft^2/day. By drilling a well open to a greater interval of the dolomite, it is possible to increase the transmissivity and yield of the well. Using the conservative value for transmissivity of 1,200 ft^2/day, distance drawdown curves were developed which allow water-supply managers to estimate the drawdown in any one well resulting from pumping from one or more wells.

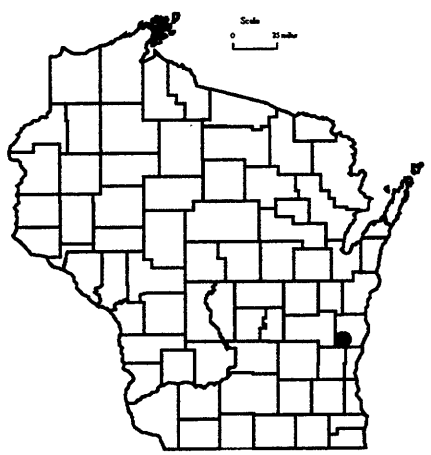
PLANS (July 1994 to June 1995): The report, "Ground-water resources at the Kettle Moraine Springs Fish Hatchery, Sheboygan County, Wisconsin," is in review and is expected to be approved by June 1994.

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Sheboygan County, Wisconsin

PROJECT CHIEF:
Terrence Conlon

PERIOD OF PROJECT:
June 1991 to September 1993



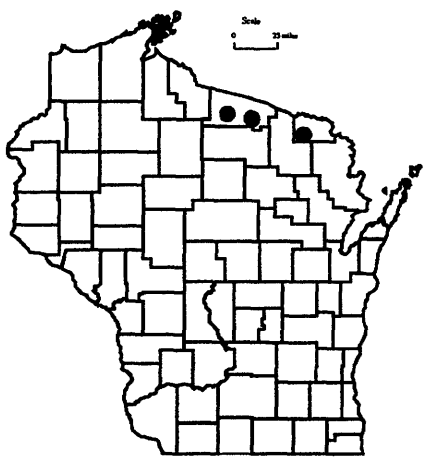
MERCURY CYCLING IN LAKES, WI 18001

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Florence and Vilas Counties, northern Wisconsin

PROJECT CHIEF:
William J. Rose

PERIOD OF PROJECT:
March 1987 to September 1991



ACIDIC LAKES

PROBLEM: Acid deposition has damaged lakes in Canada and in the northeastern United States. The pH of precipitation in northern Wisconsin averages 4.6 to 4.7, and Wisconsin has more susceptible lakes than any state east of the Mississippi. Many of these lakes are seepage lakes, whose chemistry is closely associated with precipitation chemistry. Previous studies addressing hydrologic and chemical budgets in northern Wisconsin have concentrated on lakes with alkalinities greater than 20 ueq/L; however, to truly address the potential effects of acid deposition on sensitive lake ecosystems, it is necessary to study lakes with alkalinities less than 20 ueq/L.

OBJECTIVE: Determine the hydrologic and chemical budgets for Honeysuckle, Max, and Morgan Lakes in northern Wisconsin to provide information about mechanisms of acid loadings to these lakes. Investigate differences between bog lakes and clear-water lakes. Evaluate the feasibility of, and develop an approach for, pumping ground water in an acid lake to raise its pH and alkalinity. Continue limited hydrologic monitoring at Vandercook Lake, which has a data base going back to October 1980.

APPROACH: Lake inflows from precipitation and ground-water discharge, and lake outflows from evaporation and ground-water recharge will be quantified. Alkalinity, pH, major cations and anions, nutrients, and mercury plus other trace elements in selected flowpaths will be quantified. The lakes will be evaluated for their potential for acidification.

The ground-water-pumping study will be done at Max Lake where a well will be installed to draw water from the lower part of the sand and gravel aquifer adjacent to the lake. The chemical quality and quantity of pumped water will be monitored as well as the effects of the pumping on the lake.

PROGRESS (July 1993 to June 1994): Most monitoring emphasis was at Max Lake; lake stage and a single recorder-equipped well were monitored at Morgan Lake; and lake stage, precipitation, and the ground-water well network were monitored at Vandercook Lake.

Ground-water pumping was increased during the summer of 1993 in an attempt to raise pH to 7.0. In mid-August, after it was evident that the 16 gallons-per-minute (gpm) pumping rate was raising the lake's pH slower than desired, a larger pump was installed. The pumping rate with the larger pump was about 25 gpm. The lake's pH was 6.8 when the pump was stopped for the season in mid-November.

PLANS (July 1994 to June 1995): Routine data collection will continue at approximately the same level as last year. Max Lake's pH will be raised to, and maintained at, 7.0 by intermittent ground-water pumping. Preliminary water budgets will be computed for Max Lake.

HYDROLOGIC CONSIDERATIONS ASSOCIATED WITH THE ARTIFICIAL ACIDIFICATION OF LITTLE ROCK LAKE IN VILAS COUNTY, WI

PROBLEM: A multi-agency group will study biological chemical responses to artificial acidification of one basin of two-basin Little Rock Lake by artificially lowering the pH incrementally over an 8-year period. The basins will be separated by a barrier; one basin will be acidified, the other will function as a control. A detailed understanding of the lake hydrology is needed by the group to (1) determine which of the basins to acidify; (2) estimate the amount of acid required to achieve a given pH level; (3) characterize the lake hydrologically to increase the transfer value of the study's results to other lakes; (4) monitor the effects of the acidification on the local ground water; and (5) provide basic hydrologic information on lake hydrology that would be input to any acidification models that may be tested.

OBJECTIVE: The goal of this project is to determine monthly water budgets for each basin (the control and acidified basins) of Little Rock Lake, define ground-water-flow paths, and monitor ground-water quality.

APPROACH: Inflow to the lake from precipitation, overland flow, and ground-water discharge, and outflow from the lake from evaporation and ground-water recharge will be determined. Ground-water gradients determined from a piezometer network will be evaluated to define flow paths of ground water discharging to and recharging from the lake. Ground water discharging to and recharging from the lake will be sampled from piezometers situated in the appropriate flow paths. Concentrations of major chemical constituents, including hydrogen ion and alkalinity, nutrients, and trace elements, including aluminum and lead, will be determined. Monthly water budgets will be calculated.

PROGRESS (July 1993 to June 1994): Routine hydrologic monitoring continued. Analysis of the ground-water-flow components of the lake's water budget for the 1984-1990 water years was completed, and the report covering this period was published.

PLANS (July 1994 to June 1995): A skeleton hydrologic monitoring network will be maintained to track the exchange of lake and ground water. This network consists of continuous measurement of lake stage and precipitation and intermittent measurement of about six piezometers.

REPORTS:

Rose, William J., 1993, Hydrology of Little Rock Lake in Vilas County, north-central Wisconsin: U.S. Geological Survey Water-Resources Investigations Report 93-4139, 22 p.

COOPERATOR:

Wisconsin Department of Natural Resources

LOCATION:

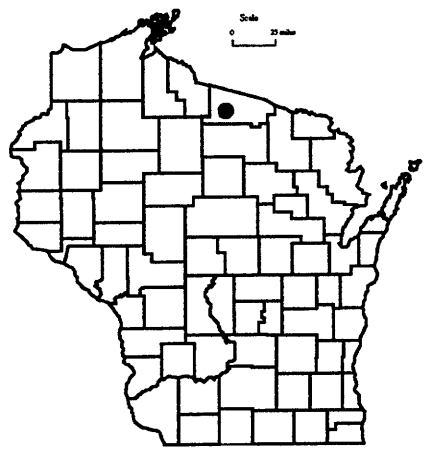
Florence and Vilas Counties, northern Wisconsin

PROJECT CHIEF:

William J. Rose

PERIOD OF PROJECT:

March 1987 to September 1991



MERCURY ACCUMULATION, PATHWAYS, AND PROCESSES, WI 18003

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
North-central Wisconsin

PROJECT CHIEF:
David P. Krabbenhoft

PERIOD OF PROJECT:
January 1992 to December 1994

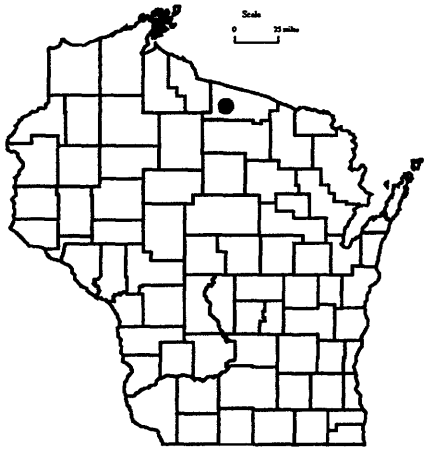
PROBLEM: Analytical data from the waters and biota of many Wisconsin lakes has indicated that there is a Statewide problem of mercury contamination in natural water systems. Elevated concentrations of mercury, coupled with the high toxicity of the element, has led to issuance of fish consumption advisories for many Wisconsin lakes. The causes of mercury contamination and processes affecting mercury cycling within the lake systems are not well understood. An intensive study of mercury biogeochemistry in the lakes is needed to provide information that can be applied to develop appropriate management practices.

OBJECTIVE: The project will be one part of a team research program whose overall objective is to understand the processes responsible for aquatic transport and transformation of mercury. Goals of this subproject are to determine net accumulation rates of mercury in lake sediments, qualify advective and diffusive fluxes of mercury from sediments, determine spatial and temporal variations in mercury accumulation and remineralization below the sediment-water interface, and assess the role of complexation and precipitation in controlling the fate of mercury.

APPROACH: The approaches used in this study will be novel, as no previous methods can yield samples without contamination. Methods developed will focus on various near-sediment, sediment, pore-water, and ground-water-sampling techniques.

PROGRESS (July 1993 to June 1994): Sampling of porewaters at small scale (centimeter) and small volume (about 50 ml) were carried out on about a monthly basis for the ice-free season (May-October) and once during ice cover. Samples were analyzed for total mercury and methylmercury content as well as other important ancillary parameters. Results show that the littoral-zone porewaters have some of the highest concentrations of methylmercury anywhere at the study site, and that the sediment/water interface is a primary site for methylmercury production in lake systems.

PLANS (July 1994 to June 1995): Results from the first two years of this study will be presented at the Third International Conference on Mercury, Vancouver, B.C., in July 1994. Field sampling during the next ice-free season will concentrate on a more spatially and geochemically complete description at longer intervals between samplings. A journal article describing the results of this study will be prepared and is expected to be completed in the fall.



ASSESSMENT OF THE HYDROLOGY, WATER QUALITY, AND BIOLOGY OF DELAVAN LAKE, WI 18101

PROBLEM: Delavan Lake was a hypereutrophic lake where severe blue-green algae blooms occurred. Nutrient sources and loads were identified and a comprehensive management plan was developed and implemented to improve the water quality of the lake. Monitoring is continuing to determine the effectiveness of the plan.

OBJECTIVE:

1. Determine nutrient and suspended-sediment discharge at Jackson Creek near Elkhorn, Jackson Creek tributary near Elkhorn, Jackson Creek at Mounds Road (wetland outlet), and Delavan Lake inlet. Determine phosphorus discharge from the lake at Delavan Lake outlet. Continuous streamflow will be determined at all sites.
2. Determine lake stage.
3. Determine phosphorus characteristics of the lake water and other physiochemical characteristics.
4. Determine the phytoplankton and zooplankton populations, May through September.

APPROACH: Nutrients and suspended sediments will be monitored at Jackson Creek, Jackson Creek tributary, Jackson Creek wetland outlet, and Delavan Lake inlet. Phosphorus will be monitored at Delavan Lake outlet. Streamflow will be monitored at all sites. Lake stage will be monitored continuously. Phosphorus concentration of the lake water and dissolved oxygen, water temperature, pH, and specific conductance will be monitored. Phytoplankton and zooplankton will be monitored.

PROGRESS (July 1993 to June 1994): Streamflow was monitored continuously at four inflow sites and at one outflow site from Delavan Lake. Water-phosphorus samples were collected monthly at all stream sites. During storm runoff, samples were collected by an automatic sampler or by an observer. Water samples were analyzed for nutrients and suspended sediment. Three sites within the lake were monitored to determine the physiochemical characteristics of the water. The 1993 water-year data was compiled for publication in "Water Resources Data-Wisconsin, water year 1993." The final phase of the lake rehabilitation plan was completed in the 1993 water year with the construction of the wetland to filter nutrients and sediments to the lake.

PLANS (July 1994 to June 1995): Continue monitoring program as scheduled. Abnormally high phosphorus loading appears to be generated from the sediments from within Delavan Lake Inlet that drain to Delavan Lake. This was documented the first year following the refilling of the lake. A special project to address the mechanisms for the phosphorus release will be conducted from May through September 1994. Compile data for publication.

REPORTS:

Field, Stephen J., and Duerk, Marvin D., 1988, Hydrology and water quality of Delavan Lake in southeastern Wisconsin: U.S. Geological Survey Water-Resources Investigations Report 87-4168, 61 p.

COOPERATOR:

Delavan Lake Town Board

LOCATION:

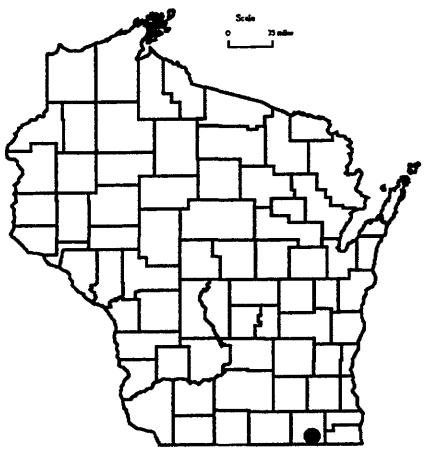
Walworth County, southeast Wisconsin

PROJECT CHIEF:

Stephen J. Field

PERIOD OF PROJECT:

August 1983-Continuing



WETLAND RETENTION OF SURFACE-WATER NUTRIENT AND SUSPENDED-SEDIMENT LOADS INFLOWING TO A EUTHOPHIC LAKE IN SOUTHEASTERN WISCONSIN, WI 18102

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Delavan Lake and Jackson Creek, southeast Wisconsin

PROJECT CHIEF:
John F. Elder

PERIOD OF PROJECT:
October 1991 to September 1996

PROBLEM: Jackson Creek is the major inflowing tributary to Delavan Lake in southeastern Wisconsin. An artificial wetland has been constructed on the creek as a means of trapping nutrients and sediments that would otherwise flow to the lake and contribute to its eutrophication. Other studies have shown that the trapping function of wetlands is not consistent and depends on little-known processes and particular conditions of the system. More information about the wetland functions is needed to assess and predict the effectiveness of the Jackson Creek wetland construction as a management strategy.

OBJECTIVE: Assess the effectiveness of the Jackson Creek wetland as a nutrient and sediment-retention system, with emphasis on retention of phosphorus. Quantify nutrient and suspended-sediment loads in surface-water inflows and outflows of the wetland. Characterize effects of water flow through the wetland on variability of these loads. Describe phosphorus cycling processes and dominant phosphorus partitioning reservoirs in the wetland.

APPROACH: Phosphorus partitioning and transformation will be investigated in microcosms that simulate the wetland. Phosphorus retention in the microcosms as a function of presence and types of sediments and plants will be determined. Additional samples from selected points within the wetland will be analyzed for phosphorus, nitrogen, and other constituents to allow for comparisons between observations in the natural system and in the microcosms.

PROGRESS (July 1993 to June 1994): The mesocosm chamber that was deployed in spring of 1993 was used for four experiments of phosphorus mobility and retention in sediments and water from the Jackson Creek wetland. Different factors that might affect retention, including presence/absence of sediments, organic-carbon content of sediments, presence/absence of vegetation, and presence/absence of microbial activity were examined in the experiments. Results were analyzed to determine changes in phosphorus concentrations and chemical speciation. Analyses and interpretation of results is in progress.

PLANS (July 1994 to June 1995): Final data interpretation will be completed and report written.

REPORTS (planned; subject to change):

Elder, J.F., and Manion, B.J., Mesocosm analysis of phosphorus retention by an artificial wetland on a tributary of Delavan Lake southeastern Wisconsin.

HYDROGEOLOGY AND GROUND-WATER USE AND QUALITY, FOX CITIES AREA, WISCONSIN, WI 182

PROBLEM: Declining water levels and degraded water quality have been documented in wells open to the sandstone aquifer serving the Fox Cities, a group of cities along the Fox River between Neenah and Green Bay, Wisconsin. Studies indicate that the cone of depression due to pumping in the vicinity of Green Bay has merged with the cone of depression due to pumping in the Fox Cities area. Ground-water development is recognized as a regional problem and requires developing data bases and models to help in managing the ground-water resources in the area.

OBJECTIVE: The study will (1) characterize the hydraulic properties and boundaries of the aquifer and confining units; (2) map the past and present potentiometric surfaces of the study area; (3) compile a history of aquifer development; (4) estimate recharge rates; (5) define areal distribution of ground-water quality; and (6) calibrate a ground-water-flow model that can be used to evaluate aquifer response to future pumping.

APPROACH: Information to evaluate aquifer properties and past potentiometric surface maps will be compiled from a literature review. Geophysical logging of municipal water supply wells will be performed to better define the hydrostratigraphy. The rate that water infiltrates to the sandstone aquifer beneath the Fox Cities area will be evaluated by performing formation tests in wells open to the uppermost rock unit. Water samples will be collected and analyzed for isotopes to help in interpreting the recharge area of water captured by deep wells. The USGS modular finite-difference ground-water-flow model will simulate the ground-water-flow system and will be calibrated to past and present water levels. Predictive simulations will be used to evaluate aquifer response to future pumping and land-use changes.

PROGRESS (July 1993 to June 1994): Drilling and formation tests in the Sinnipee Group, the uppermost bedrock layer beneath the Fox Cities, indicate that the Sinnipee Group has low permeability and probably does not allow much surface recharge to reach the underlying aquifers. With this assumption, a screening model was developed to simulate ground-water flow in the underlying aquifers. Preliminary results suggest that recharge infiltrating west of the Fox Cities is sufficient to maintain water levels in the area. Sampling for hydrogen, oxygen and strontium isotopes has been completed. The isotope data will help to estimate the recharge areas and flowpath for water captured by deep municipal wells. Thickness and elevation maps have been compiled based on well data. This data has been used in developing a finite-difference ground-water-flow model to simulate flow in aquifers beneath the Fox Cities.

PLANS (July 1994 to June 1995): Data used in the finite-difference ground-water-flow model will be compiled in a geographic information system (GIS). The GIS will format and output the

COOPERATORS:

East Central Wisconsin Regional Planning Commission
Darboy Sanitary District #4
Greenville Sanitary District
Kaukauna Electrical and Water Utilities
Town of Menasha Sanitary District #4
Kimberly Water Works Department
Wisconsin Geological and Natural History Survey

LOCATION:

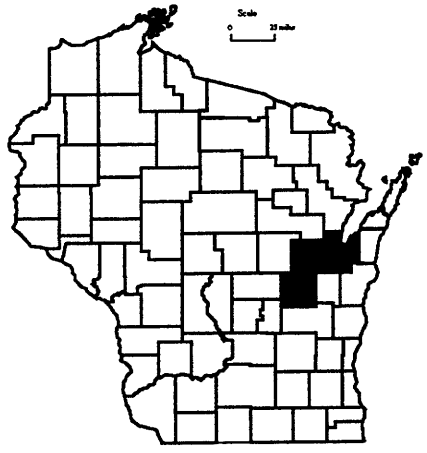
East-central Wisconsin

PROJECT CHIEF:

Terrence Conlon

PERIOD OF PROJECT:

January 1992 to September 1995



data for use in the ground-water-flow model. The ground-water-flow model will be calibrated by attempting to match simulated ground-water levels to historic and present water levels. Once calibrated, the model will be used to predict the effects on water levels of future pumping in the area.

LAKE MICHIGAN TRIBUTARY LOADING, WI 183

PROBLEM: Concern about the potential negative health and biologic effects of toxic chemicals and heavy metals being transported into Lake Michigan has increased with growing evidence of links between the presence of these contaminants and carcinogens in fish, genetic defects in fish-eating birds, and reproductive disorders in biota. Adequate management of chemical loads requires that the total contribution of contaminants from atmospheric, ground water, and tributary rivers be quantified.

OBJECTIVE: Objectives of this project are to build a streamflow and water-quality data base for 11 Lake Michigan tributaries to act as a baseline for evaluation of future remediation activities; estimate loads of PCB's, atrazine, trace metals, nutrients, and suspended solids to Lake Michigan; compare loads between tributaries to target basins of major concern; identify contaminants of greatest concern; and describe the mobility of contaminants.

APPROACH: The Wisconsin District will install acoustic velocity metering (AVM) stations at the mouths of the Milwaukee, Sheboygan, Fox, and Menominee Rivers to provide real-time flow and water-quality data. Field sampling will be scheduled to obtain approximately 75 percent of the samples during non-baseflow periods. Composited samples for analyses of congener-specific PCB's and pesticides will be field filtered and processed through XAD-2 resin columns. Composited samples for analyses of particulate and dissolved trace metals will be obtained using clean sampling protocols. Data will be entered into the WATSTORE and ADAPS data bases.

PROGRESS (July 1993 to June 1994): Shakedown sampling of four tributaries was conducted in October 1993 to refine the field operations procedures and to determine acceptable laboratory detection limits for different sample volumes. The Quality Assurance Project Plan has been granted conditional approval by EPA Region V and field sampling was started in March 1994. Calibration of OBS-3 suspended-solids monitors is continuing. Doppler discharge measurements have been made at all sites for calibration of the AVMs.

PLANS (July 1994 to June 1995): Sampling is scheduled to be completed at the end of May 1995. Data will be summarized as it becomes available from the laboratories and preliminary loads will be calculated for the monitored tributaries. A final report outline will be prepared and sent out for review.

COOPERATORS:

Environmental Protection Agency
Wisconsin Department of Natural Resources

LOCATION:

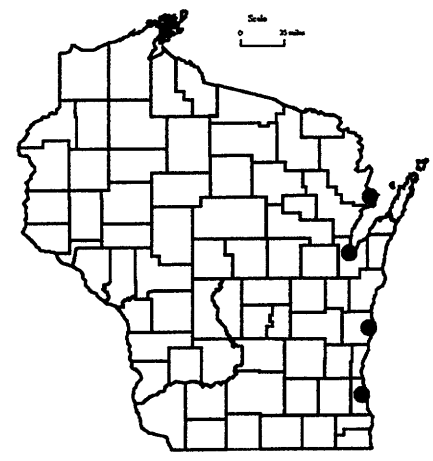
Cities of Marinette, Green Bay, Milwaukee and Sheboygan

PROJECT CHIEF:

Peter E. Hughes

PERIOD OF PROJECT:

July 1992 to October 1996



TRACE-METAL TRANSPORT TO STREAMS, WI 18301

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
North Branch of the Milwaukee River at Cascade, Wisconsin

PROJECT CHIEF:
David Krabbenhoft

PERIOD OF PROJECT:
October 1992 to September 1995

PROBLEM: Recent investigations on trace-metal concentrations in surface waters have revolutionized scientists' view of the trace-metal cycle in aquatic ecosystems. Ultra-clean methodologies must be employed at all steps of this research, and even then it is difficult to acquire contamination-free samples. Although we now have a better understanding of trace-metal concentrations in the environment, very little is known about how the metals are delivered to the stream and the processes that affect the transport of trace metals once in the stream.

OBJECTIVE: The principal objective of this project is to gain a better understanding of the processes that control trace-metal transport to streams. Under this broad objective, we propose to (1) develop ultra-clean sampling methods for ground water, pore water at the near sediment/water interface, springs, and stream water; and (2) to examine the temporal variability of trace-metal concentrations in stream/ground-water ecosystems.

APPROACH: A variety of sampling methods will be employed, all of which adhere to the strict protocols for trace-metal sampling. A site along North Branch of the Milwaukee River has been chosen as the location for intensive investigations of stream-, ground-, pore- and spring-water concentrations of trace metals (Hg, Pb, Zn, Cu, Cd) as well as other chemical ancillary measurements. Stream discharge and ground-water levels will be monitored to relate hydrologic conditions to trace-metal concentrations in each part of the hydrologic system. Sampling will be conducted on about a bimonthly basis.

PROGRESS (July 1993 to June 1994): The site was chosen and instrumented with piezometers, a recording rain gage, and staff gage in April. Sampling was initiated in May and has been continued on a bimonthly basis.

PLANS (July 1994 to June 1995): Continue the bimonthly sampling schedule, and initiate efforts to better describe the influence of dissolved and particulate sulfides on trace-metal cycling.

LAKE SUPERIOR TRIBUTARY LOADING, WI 18302

PROBLEM: Concern about the potential negative health and biologic effects of toxic chemicals and heavy metals being transported into Lake Superior has increased with growing evidence of links between the presence of these contaminants and carcinogens in fish, genetic defects in fish-eating birds and reproductive disorders in biota. Adequate management of chemical loads requires that the total contribution of contaminants from atmospheric, ground water, and tributary rivers be quantified.

OBJECTIVE: Objectives of this project are to build a streamflow and water-quality data base for two Lake Superior tributaries to act as a baseline for evaluation of future remediation activities; estimate loads of targeted contaminants to Lake Superior; compare loads between tributaries to target basins of major concern; identify contaminants of greatest concern; and describe the mobility of contaminants.

APPROACH: The Wisconsin and Minnesota Districts will install acoustic velocity metering (AVM) stations at the two St. Louis River harbor exits to Lake Superior, instrument the Nemadji River for water-quality sampling, and install an automatic suspended-solids sampler downstream of the Fond du Lac Dam on the St. Louis River. The AVM sites will be calibrated using aDoppler discharge measurements. Infiltrex automated organic samplers will be installed to obtain flow-composited samples for organic analyses. Data will be entered into the WATSTORE and ADAPS data bases.

PROGRESS (July 1993 to June 1994): Equipment has been obtained and plans established to get the monitoring stations operational by the end of May 1994. Calibration of the AVM's will be started and automated ISCO suspended-solids samplers will be activated.

PLANS (July 1994 to June 1995): Calibration of the AVM's will be completed and a plan for the long-term operation of the sampling sites will be developed.

COOPERATORS:

U.S. Environmental Protection Agency
Wisconsin Department of Natural Resources
Minnesota Pollution Control Agency

LOCATION:

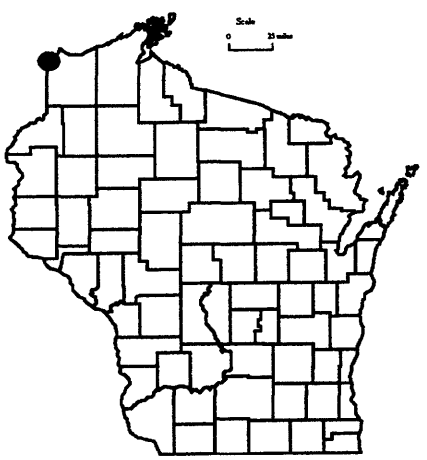
Cities of Duluth, Minnesota and Superior, Wisconsin

PROJECT CHIEF:

Peter E. Hughes

PERIOD OF PROJECT:

July 1993 to October 1996



REGIONALIZED ESTIMATES OF LOADS TO THE UPPER GREAT LAKES, WI 18303

COOPERATOR:
U.S. Environmental Protection Agency

LOCATION:
Drainages to Lake Michigan and Lake Superior

PROJECT CHIEF:
Dale M. Robertson

PERIOD OF PROJECT:
January to September 1994

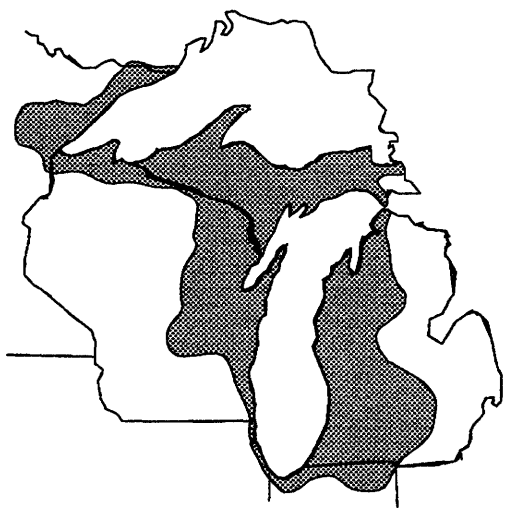
PROBLEM: In establishing a prioritization of sites for mass-balance studies and remediation, it is desirable to rank the tributaries based upon their relative contributions of sediment-derived contaminants. Prioritization studies have been conducted within small geographic areas; however, a prioritization for the entire area near the Upper Great Lakes has not been performed.

OBJECTIVES: The objectives of this project are to: (1) develop methods to estimate frequency-volume relations for streams draining to the Upper Great Lakes; (2) develop methods to compute the suspended-sediment loads for specific flood frequencies (i.e., 10- and 50-year storms); (3) rank the tributaries on the basis of sediment loads; and (4) use sediment chemistry to calculate the loads for selected constituents for each tributary.

APPROACH: The approach for this project is as follows: (1) conduct a regionalized frequency-volume analysis, for 1-, 3-, and 7-day storms with return frequencies of 10 and 50 years; (2) estimate storm loads for suspended sediment using constituent-transport models for locations with extensive historical data--the constituent-transport models which are being used are based on multiple-regression analyses between constituent load and several variables including discharge and time (seasonal and annual); (3) after calibrating the models (deriving equations to estimate loads), the storm loads will be estimated using the storm discharges from part 1 for two different seasonal periods (spring and summer); (4) the storm loads will then be extrapolated to sites with limited data using sites of similar land use and soil type and the ratio of drainage sizes; and (5) the basins will then be ranked based on the total storm loads of suspended sediment for the design floods and available sediment-chemistry information.

PROGRESS (January 1994 to June 1994): The statistical and analytical parts of this project were completed.

PLANS (July 1994 to June 1995): The report summarizing the project results will be published.



DELINEATION OF THE POTENTIOMETRIC DIVIDE IN THE SANDSTONE AQUIFER BETWEEN THE WOLF RIVER AND LOWER FOX RIVER BASINS, WISCONSIN, WI 184

PROBLEM: The existence of a regional ground-water divide between the Wolf and Lower Fox Rivers has been postulated but never proven. The location of this divide, if it exists, determines the extent of the ground-water recharge area of the deep Sandstone Aquifer that provides water for much of the Green Bay metropolitan area. Data from this project could be used to refine an existing ground-water-flow model used to estimate drawdowns caused by projected increases in water use in the Green Bay metropolitan area.

APPROACH: Three test wells that fully penetrate the Sandstone Aquifer were drilled in northern Outagamie County. Geologic and hydraulic-head data collected from drilling and packer testing each well were correlated with existing geologic and water-level data to provide evidence of a ground-water divide between the Wolf and Lower Fox Rivers. Water-quality data collected from discrete intervals in each well were used to determine the general water quality and age of water at various depths in the Sandstone Aquifer system.

PROGRESS (July 1993 to June 1994): All test-well data were analyzed and combined with existing data. Results indicate that a ground-water divide exists. Oxygen- and tritium-isotope data from water samples collected in the test wells also suggest that a divide exists. Data collected in this study support the assumption and location of a regional ground-water divide used in a ground-water-flow model to estimate drawdowns from future pumpage in the Green Bay area. A final report has been finished and will be approved for publication.

PLANS (July 1994 to June 1995): A final report will be published as a Wisconsin Geological and Natural History Survey Information Circular.

COOPERATORS:

Brown County Regional Planning Commission
Wisconsin Geological and Natural History Survey

LOCATION:

Brown and Outagamie Counties

PROJECT CHIEF:

William G. Batten

PERIOD OF PROJECT:

July 1992 to September 1993

WATER-QUALITY MONITORING OF INDUSTRIAL STORM-WATER RUNOFF, WI 185

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Madison and Milwaukee, Wisconsin

PROJECT CHIEF:
David W. Owens

PERIOD OF PROJECT:
June 1992 to April 1994

PROBLEM: The United State Environmental Protection Agency (USEPA) is requiring industries to monitor storm-water runoff for given chemical constituents. Sampling techniques need to be developed for industries with and without well-defined drainage networks.

OBJECTIVE: (1) Compare and evaluate different storm-water sampling schemes; (2) estimate storm-event mean concentrations and annual chemical constituent loads from selected industries using appropriate modeling techniques; and (3) design and operate a monitoring program to collect representative storm-water-quality samples.

APPROACH: Paired sampling techniques will be used to determine whether time-composite samples can be substituted for flow-composite samples. Furthermore, source-area sheet-flow sample results will be used to calculate a loading value which will be compared to the flow-composite loading value.

PROGRESS (July 1993 to June 1994): Storm-water sampling at all five industrial sites has been completed. Storm loads have been calculated using the time-composite, flow-composite, discrete and source-area sample data from the 1993 field season.

PLANS (July 1994 to June 1995): The remaining data from the 1994 field season will be analyzed and a data report will be written to summarize the results.

WATER QUALITY OF URBAN STORM-WATER RUNOFF IN MADISON, WISCONSIN, WI 187

PROBLEM: Section 402 (P) of the Water Quality Act of 1987 requires that municipalities with a population of 100,000 or more obtain permits to control the quality of storm-water runoff. Final results published by the U.S. Environmental Protection Agency require that municipalities prepare permit applications to include, among other information, the following technical data:

1. Characterization of the quantity and quality of discharge from storm conveyance channels/outfalls during periods of dry weather.

2. Characterization of the wet-weather quantity and quality of discharge from representative storm conveyance channels/outfalls during three or more representative storm events.

3. Determination of storm and annual pollutant loadings from each storm conveyance channel/outfall as characterized in item 1 in the permitted municipality.

4. Characterization of rainfall and runoff conditions.

5. Characterization of the quality of water in the receiving stream (waters of the United States) impacted by storm-water runoff outfalls using existing data.

OBJECTIVES: The objectives of the investigation are to:

1. Characterize storm-water quantity and quality for representative urban land uses.

2. Estimate city-wide storm-event mean concentrations and annual pollutant loads of the cumulative discharges.

3. Assist in design of a monitoring program for the life of the permit (5 years) that will provide representative storm-water-quality data for the city.

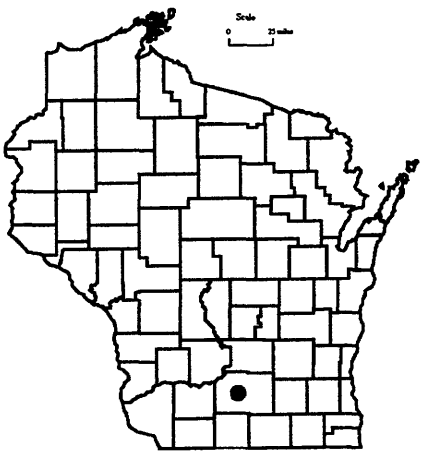
APPROACH: Seven sites have been selected in Madison for collection of storm-water-quality data. Contributing drainage areas to the sampling sites range from 17 to 115 acres in size and are of a predominantly single land-use type. Land-use types as specified by EPA regulations are residential, commercial, and industrial. Additional land-use types specific to the city of Madison are university and highway. A minimum of 3 event samples per site (total of about 21 samples) have been collected and analyzed for water-quality constituents specified by the Wisconsin Department of Natural Resources (WDNR). Attempts were made to sample an additional three storms at each site, so that more complete characterization is possible.

COOPERATOR:
City of Madison

LOCATION:
Dane County, south-central Wisconsin

PROJECT CHIEF:
Robert J. Waschbusch

PERIOD OF PROJECT:
August 1992 to September 1994



Discharge was determined from continuous water-level measurements and theoretical discharge ratings. Event-mean concentrations (EMC) were determined by flow-composite sampling methods. Constituent loads for pollutants at the seven data-collection sites will be estimated using the WDNR SLAMM model. This model will be used to compute seasonal loads and EMC of certain constituents for a representative storm event.

PROGRESS (July 1993 to June 1994): Samples have been collected from the seven sampling sites for three representative storms. Preliminary estimates of constituent loads and EMC for storm-water runoff at conveyance channels/outfalls have been computed.

PLANS (July 1994 to June 1995): Final computations will be made and a data report will be published.

CONCENTRATION OF RADON-222 IN GROUND WATER AND SOIL GAS IN THE VICINITY OF WISCONSIN INDIAN RESERVATIONS, WI 188

PROBLEM: The Indian Health Service and Great Lakes Intertribal Council have measured indoor air for concentration of radon-222 in homes on Wisconsin Indian Reservations over the last several years. Results from these surveys indicate that the U.S. Environmental Protection Agency's (USEPA) standard of 4 picocuries per liter (pCi/l) of radon-222 in air is frequently exceeded. According to USEPA, radon in ground water generally accounts for 5 percent of the total indoor air concentrations for homes with ground water as the primary source of drinking water. In view of the high concentrations of radon in indoor air for homes on the Wisconsin Indian Reservations and the fact that ground water is the source of all domestic water supply for the reservations, it is possible that the ground water used on these reservations contains radon-222 concentrations in excess of the USEPA proposed standard of 300 pCi/l for municipal supply.

OBJECTIVE: Define the distribution and occurrence of radon-222 in domestic ground-water supplies for Wisconsin Indian Reservations.

APPROACH: Ground water from 30 wells distributed among the 11 Wisconsin Indian Reservations will be sampled and analyzed for radon-222. The number of wells sampled on each reservation will be selected as a percentage of total acreage held by each tribe. After the number of wells to be sampled on each reservation has been determined, specific wells will be chosen by USGS personnel according to following criteria: (1) previous air monitoring of the residence supplied by a well has shown a radon-222 concentration equal to or exceeding 4 pCi/l, (2) a driller's construction report is available and (3) the well is finished in the aquifer most representative of the area. In addition to sampling the ground water, soil gases in the unsaturated zone near the well head will also be sampled and analyzed for radon-222. The concentration of radon in the soil gas samples will be compared to the concentration of radon in corresponding ground-water samples to determine if there is a correlation.

PROGRESS (July 1993 to June 1994): The Quality Assurance Plan required by USEPA was approved. A report outline was approved by the Regional Reports Specialist. All ground-water and soil-gas samples were collected and analyzed for radon.

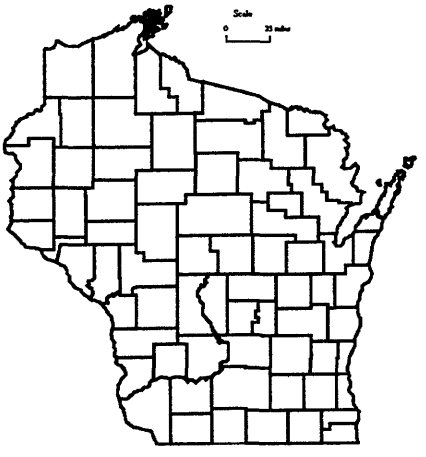
PLANS (July 1994 to June 1995): The final report, in the form of a U.S. Geological Techniques of Water Resources Investigations Report, will be published.

COOPERATOR:
U.S. Environmental Protection Agency

LOCATION:
Wisconsin Indian Reservations

PROJECT CHIEF:
John F. De Wild

PERIOD OF PROJECT:
October 1992 to September 1994



DANE COUNTY REGIONAL HYDROLOGIC STUDY, WI 189

COOPERATORS:

City of Middleton
Dane County Regional Planning Commission
Madison Metropolitan Sewerage District
Wisconsin Department of Natural Resources
Wisconsin Geological and Natural History Survey

LOCATION:

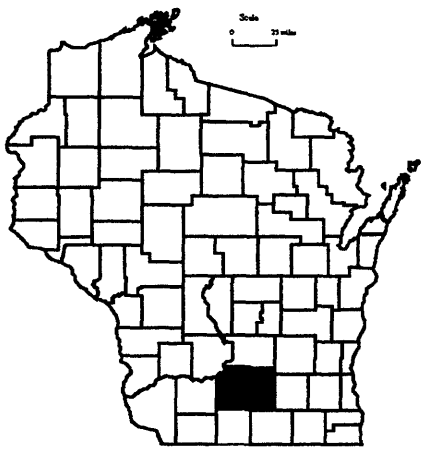
Dane County and parts of surrounding counties

PROJECT CHIEF:

William G. Batten

PERIOD OF PROJECT:

October 1992 to December 1995



PROBLEM: Officials at all levels of government are concerned about the effects of increasing urban growth and development on the surface- and ground-water resources in Dane County. The relationship between surface water and ground water must be understood to allow for increased ground-water withdrawals while protecting the quality and quantity of surface-water resources in the county. A comprehensive study that combines existing water data with new data is needed to provide government and planning agencies with a tool to aid in managing the water resources of the Dane County area.

APPROACH: Existing and new data will be compiled to update potentiometric and water-table surfaces, subsurface geology, and aquifer parameters. New data will be collected in areas critical to understanding ground-water flow and direction. A regional ground-water-flow model will be developed to simulate changes in ground-water levels caused by increased pumpage, to identify critical recharge and discharge areas and to show the direction and rate of ground-water flow. The model will then be used as a management tool to simulate and evaluate the effects of management strategies designed to mitigate adverse effects of increased ground-water withdrawals on the surface- and ground-water system in the Dane County area.

PROGRESS (July 1993 to June 1994): All available data useful in describing the ground-water flow system were collected and compiled. This includes water-level and geologic data from a test well completed as part of this study. A "screening" ground-water-flow model was completed to test the conceptual model of the flow system and to identify areas where additional data are needed to better understand the flow system. Development of a regional ground-water-flow model to simulate the ground-water-flow system in the County using data collected in the early part of this study.

PLANS (July 1994 to June 1995): The regional ground-water-flow model will be completed and calibrated to historical water-level data. This calibrated model will be used with estimated changes in ground-water pumpage and land use in the County to simulate the effects that these changes may have on the aquifer and surface-water resources in Dane County. A draft report of the results of this study will be completed.

REPORTS: A report that includes water-table and potentiometric-surface maps, hydrogeologic cross sections, values of aquifer parameters, and a conceptual description of the ground-water-flow system will be published. A second report describing the regional ground-water-flow model design, calibration, and results of model simulations of the flow system will also be published.

EFFECTS OF MICROBIAL ACTIVITY ON SEDIMENT/WATER EXCHANGE OF POLYCHLORINATED BIPHENYL CONGENERS IN THE LOWER FOX RIVER, WISCONSIN, WI 190

PROBLEM: The lower Fox River, the principal tributary of Green Bay and Lake Michigan, flows through a heavily industrialized area. More than 100 contaminants have been identified in the system; among the most significant of these are PCB's. To predict possible toxicological effects and downstream transport of these contaminants, it is important to take into account not only their source concentrations, but also the factors that can affect their partitioning, especially their transfer from bottom sediments (the principal repository) to water (the principal medium of transport). There is a scarcity of this kind of information at present.

OBJECTIVE: Describe the role of microbial activity in controlling sediment/water exchange of PCB congeners and determine the extent to which microbially-mediated exchange is dependent on total PCB concentration and congener composition.

APPROACH: Sediment and water samples from the lower Fox River are used in controlled microcosm experiments in elution columns, applying an experimental design similar to that used in previous work. A specific PCB congener, labeled with carbon-14, is mixed uniformly into a measured quantity of sediment which is used to fill a vertical column that is connected to a precision metering pump. Ambient river water is pumped through the system, and carbon-14 activity is monitored over time in the outflow water. The results include data that can be used to calculate observed distribution coefficient—a measure of partitioning of the PCB congener between sediments and water mobility. The elution column experiments will be tested under different conditions to assess effects of microbial activity and presence or absence of oxygen.

PROGRESS (July 1993 to June 1994): Sediment core samples were collected from bottom sediment deposits in the lower Fox River to use in column elution experiments. Sediments were maintained in an anaerobic environment. Experiments were conducted to determine sediment-water transfer of 2,2'5,5'-tetrachlorobiphenyl and how such transfer is affected by presence or absence of oxygen and presence or absence of bacterial action.

PLANS (July 1994 to June 1995): Experimentation will continue, using sediments from different sites and depths, and using different PCB congeners. The data produced will be closely examined to test hypotheses about PCB congener flux and microbial effects on this process. Experiments are expected to be completed in late 1994. Analyses and interpretation of results will serve as the basis for planned reports.

REPORTS (planned; subject to change):

Elder, J.F., James, R.V., Godsy, E.M., and Steuer, J.J., Microbial enhancement of PCB congener mobility at the sediment/water interface in the lower Fox River, Wisconsin.

COOPERATOR:

Wisconsin Department of Natural Resources

LOCATION:

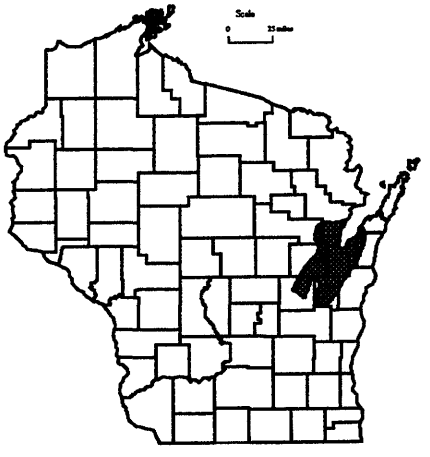
Northeastern Wisconsin

PROJECT CHIEF:

John F. Elder

PERIOD OF PROJECT:

October 1992 to September 1995



TRANSPORT AND BIOGEOCHEMICAL CYCLING OF PCB'S IN THE MILWAUKEE RIVER - THE IMPORTANCE OF ALGAL DYNAMICS, WI 191

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Milwaukee County, eastern Wisconsin

PROJECT CHIEF:
Jeffrey J. Steuer

PERIOD OF PROJECT:
February 1993 to December 1996

PROBLEM: The Milwaukee Harbor is identified as an area of concern by the International Joint Commission because it is highly contaminated by toxic synthetic organic chemicals and trace metals. A plan is being developed to restore and revive the surface waters of this area, but little is known about the upstream transport of contaminated in-place sediments. Knowledge of the processes that control cycling and transport of polychlorinated biphenyls (PCB's) is essential to the remediation effort. Algal incorporation of PCB's may be a quantitatively important process in this transport.

OBJECTIVE: The objective is to determine the link between algal dynamics and PCB transport by: characterizing total suspended solids (TSS) in the river as biogenic (algal) and detrital components, and determine PCB, organic carbon and lipid concentrations of each fraction; evaluating the link between algal uptake of PCB's and concentration of PCB's in TSS and resuspendable surficial bottom sediments. Milwaukee River PCB loading will be determined at Estabrook Park and at two upstream sites (Pioneer Road and Thiensville) which bracket known soft-sediment deposits. Due to high bottom sediment and fish PCB concentrations, a fourth site has been selected on the South Branch of the Manitowoc River at Hayton.

APPROACH: Monitor the three Milwaukee River sites and one Manitowoc River site for one year during event and base-flow conditions. Automated water-quality samples will be used to obtain daily total and volatile suspended solids (TSS/VSS) samples; more intensive samples will be obtained on the rising hydrograph limb. Between June 1993 and June 1994, 16 manual organic samples (80 liters) will be collected at the Milwaukee sites and 9 samples will be collected at the Hayton site. Measured water-column characteristics include PCB (dissolved and particulate), TSS, VSS, particulate and dissolved organic carbon, chlorophyll a, sand/silt split and chloride.

Water column and bed algae will be seasonally collected and a biomass determined. Dominant algal species will be laboratory cultured and PCB uptake subsequently measured. These data will be used to calculate the algal and detrital PCB fractions.

Seasonal samples will also be collected from the surficial sediment layer at each of the four sites. Total organic carbon, congener-specific PCB, porosity, particle density, bulk density, and chlorophyll a will be determined during each of the four seasons.

PROGRESS (June 1993 to July 1994): Field data have been collected and data analysis commenced.

PLANS (July 1994 to June 1995): PCB loading report for the four sites will be completed. Algal identification effort will be continued; laboratory algal PCB experimentation will commence; and the algal dynamics report will be started.

WATER RESOURCES AT WILD ROSE FISH HATCHERY, WAUSHARA COUNTY, WISCONSIN, WI 192

PROBLEM: The Wild Rose State Fish Hatchery is one of the oldest and largest cold-water hatcheries in the State. The water supply for the hatchery consists of scattered springs, seeps, and many small-diameter flowing wells screened in sand and gravel. Combined flow from springs and wells is approximately 3 million gallons per day. Water from these sources requires treatment to remove nitrate. Water is treated at each raceway because of the diffuse nature of the water supply. Water from this supply system is expensive to treat and may be contaminated.

OBJECTIVE: The study will evaluate the ground-water system at the hatchery, provide estimates of the hydraulic properties of the sand and gravel aquifer, and recharge area for water captured by hatchery wells, and predictions of the effects of pumping from several large-diameter wells on spring flow and ground-water levels.

APPROACH: Using wells at the hatchery, slug and aquifer tests will be performed to estimate the hydraulic conductivity of the sand and gravel aquifer. Environmental isotopes will be used to estimate the recharge area for the aquifer. Seismic-refraction data will be collected to determine the thickness of the aquifer. A ground-water-flow model, calibrated to ground-water levels and streamflow measured at the hatchery, will predict the effect of pumping from wells on water levels in the sand and gravel aquifer and the effect on spring flow.

PROGRESS (July 1993 to June 1994): A well and rain gage were installed and instrumented to measure the variation in the water-table altitude and the effect of precipitation on the water table. A correlation between precipitation and changes in water level has not been observed. Discharge from the hatchery, measured at Highway 22, is approximately 5.2 cubic feet per second (3 million gallons per day). Slug tests have been performed and seismic data collected.

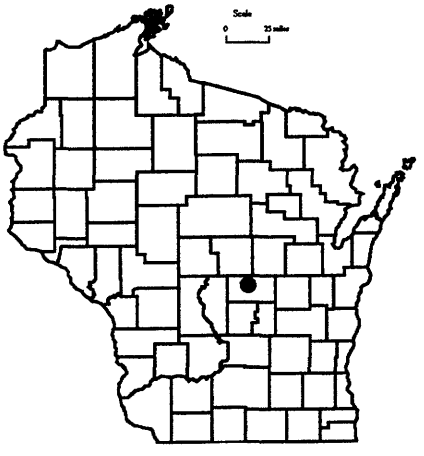
PLANS (July 1994 to June 1995): A ground-water-flow model will be developed using aquifer properties determined from slug test, seismic-refraction data, water-level measurements and data from literature. The model will simulate an aquifer test. An aquifer test will be performed at the hatchery to check the simulation of the model and refine the model. Environmental isotope data will be collected to estimate the recharge area of the sand and gravel aquifer. The model will be refined and used to evaluate the effect of pumping from several wells open to the sand and gravel aquifer on water levels and spring flow.

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
2 miles north of Wild Rose, Waushara County, Wisconsin

PROJECT CHIEF:
Terrence Conlon

PERIOD OF PROJECT:
June 1993 to September 1996



OSW RESEARCH, WI 986

COOPERATOR:
Office of Surface Water, WRD,
U.S. Geological Survey

LOCATION:
Nationwide

PROJECT CHIEF:
John F. Walker

PERIOD OF PROJECT:
January 1987-Continuing

VELOCITY PROFILES UNDER AN ICE COVER

PROBLEM: The practice of using a single coefficient to adjust measured velocity at a single point in the vertical under an ice cover is suspect in light of recent evidence in the literature. An evaluation of the present technique and development of alternative techniques for measuring discharge under an ice cover is needed.

OBJECTIVE: The objectives of this project are to determine the variation of coefficients for adjusting point velocity to mean velocity at various locations under an ice cover and to develop recommendations for measuring discharge under an ice cover.

APPROACH: Weekly velocity profiles will be made at 13 sites across the United States. Complete vertical velocity profiles will be made at the usual 20-30 points across the cross section. For each profile, coefficients to adjust point velocity to mean velocity will be computed using an integrated estimate of the mean velocity in the vertical. The coefficients will be analyzed at each site to determine spatial and temporal variations, and for variation across sites. Various computational procedures will be compared to discharge computed using the full profile information.

PROGRESS (July 1993 to June 1994): Two journal articles were completed. The first describes results from the field data collected by the USGS, and was accepted by ASCE journal of Hydraulic Engineering for publication later in 1994. The second describes results from theoretical and laboratory study conducted by Iowa Institute of Hydraulic Research, and has been submitted to the journal for review.

PLANS (July 1994 to June 1995): Complete publication of the two journal articles. Complete a joint report with the Water Survey of Canada (WSC) describing the field data collected by USGS and WSC; the report will be a USGS Open-File Report.

REPORTS:

Walker, J.F., 1994, Methods for measuring discharge under an ice cover, ASCE J. of Hydraulic Engineering (in press).

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The reports listed below are a partial list of reports prepared by the Wisconsin District in cooperation with other agencies since 1948. The list contains reports that are relevant and contribute significantly to understanding the hydrology of Wisconsin's water resources.

The reports published in a U.S. Geological Survey series are for sale by the U.S. Geological Survey, Box 25425, Federal Center, Denver, CO 80225. Prepayment is required. Remittance should be sent by check or money order payable to the U.S. Geological Survey. Prices can be obtained by writing to the above address or by calling (303) 236-7476. Copies of reports published by the University of Wisconsin, Geological and Natural History Survey, can be obtained from their office at 3817 Mineral Point Road, Madison, WI 53705.

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Oakes, Edward, Field, S.J., and Seeger, L.P., 1973, The Pine-Popple River basins—hydrology of a wild river area, northeastern Wisconsin: U.S. Geological Survey Water-Supply Paper 2006, 57 p.

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Hurtgen, D.C., 1972, Floods of March 27-April 4, 1967, in northwestern and west-central Wisconsin, in Summary of floods in the United States during 1967: U.S. Geological Survey Water-Supply Paper 1880-C, p. 7-10.

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