WATER-RESOURCES INVESTIGATIONS IN WISCONSIN

Programs and Activities of the U.S. Geological Survey, 1991-92

By
D.E. Maertz

U.S. GEOLOGICAL SURVEY

Open-File Report 92-125

Madison, Wisconsin
1992

U.S. DEPARTMENT OF THE INTERIOR

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U.S. GEOLOGICAL SURVEY

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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.

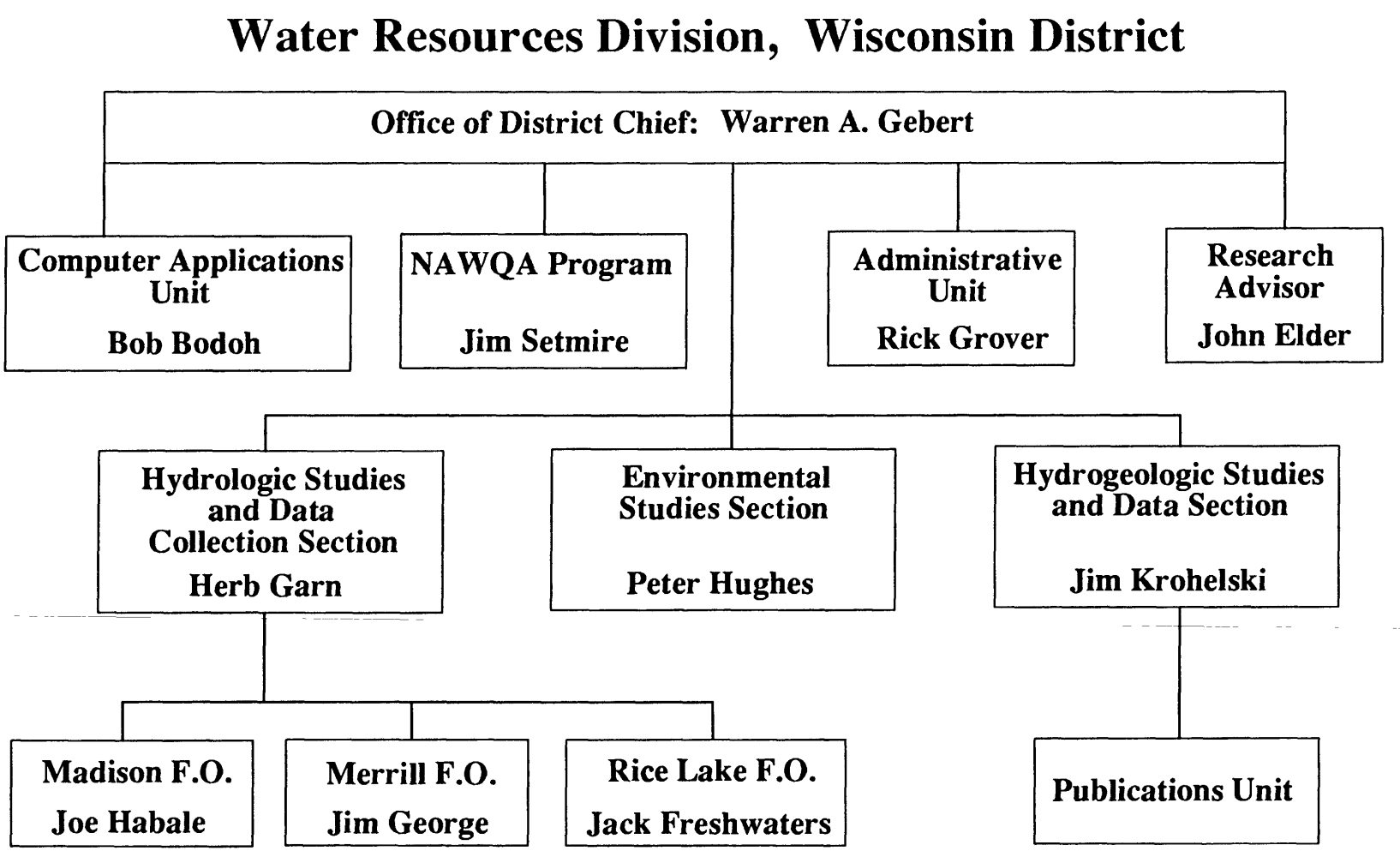


Figure 1 -- Organization chart of the U.S. Geological Survey, Water Resources Division, Wisconsin District.

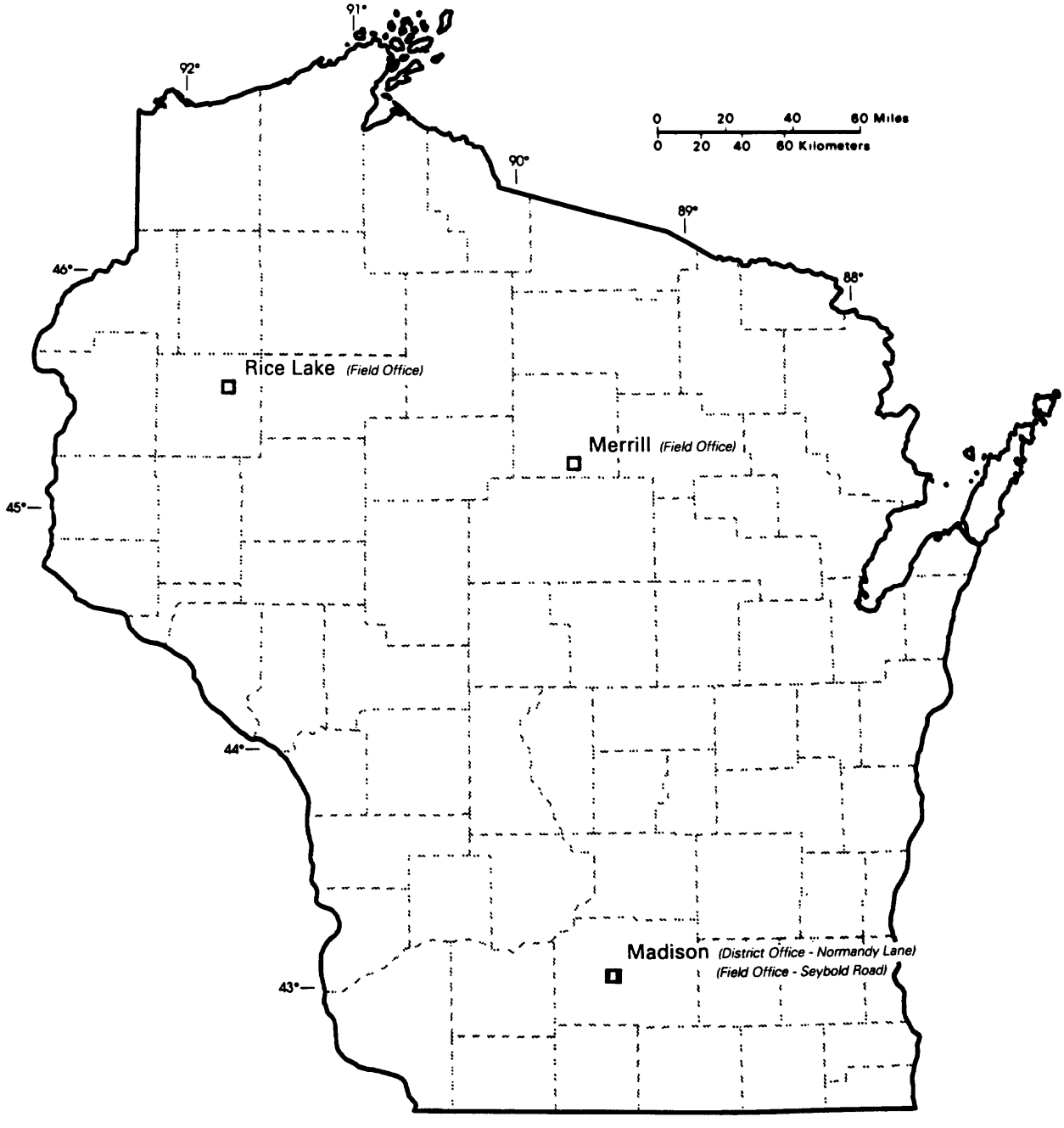


Figure 2. Location of offices in the Wisconsin District.

FUNDING SOURCES

State Agencies

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

Local Agencies

Brown County Planning Commission
Chippewa County
City of Barron
City of Beaver Dam
City of Fond du Lac
City of Galena, Illinois
City of Hillsboro
City of Madison
City of Middleton
City of Oshkosh
City of Peshtigo
City of Thorp
City of Waupun
City of Waukesha Water Utility Commission
Dane County Regional Planning Commission
Dane County Department of Public Works
Darboy Sanitary District #1
East Central Wisconsin Regional Planning 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 Menasha Sanitary District #4
Village of Little Chute
Village of Wittenberg
Walworth County Land Conservation Commission

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

Bad River Band of Lake Superior Chippewa
Forest County Potawatomi
Lac Courte Oreilles Governing Board
Lac du Flambeau Band of Lake Superior Chippewa
Menominee Indian Tribe of Wisconsin
Oneida Tribe of Indians of Wisconsin
Red Cliff Band of Lake Superior Chippewa
St. Croix Tribes of Wisconsin
Stockbridge-Munsee Band of Mohican Indians
Winnebago Tribe of Wisconsin

Lake Districts

Alma/Moon Lake District
Balsam Lake Protection and Rehabilitation District
Big Muskego Lake District
City of Muskego
Dane County Lakes and Watershed Management
Delavan Lake Sanitary District
Druid Lake Protection and Rehabilitation District
Eagle Springs Lake Sanitary District
Fowler Lake Management District
Green Lake Sanitary District
Hooker Lake District
Little Arbor Vitae Lake District
Little Green Lake Protection and Rehabilitation District
Little Muskego Lake District
Little St. Germain Lake District
Loon Lake/Wescot Management District
Marinette County Soil and Water Conservation Department
Okauchee Lake District
Powers Lake Management District
Town of Baraboo
Town of Bear Lake
Town of Delavan
Town of Hubbard
Town of Mead
Town of Merton
Town of Norway
Town of St. Germain
Town of Summit
Town of Troy
Village of Lake Nebagamon
Village of Oconomowoc Lake
Whitewater/Rice Lakes Management District
Wind Lake Management District
Wisconsin Department of Justice

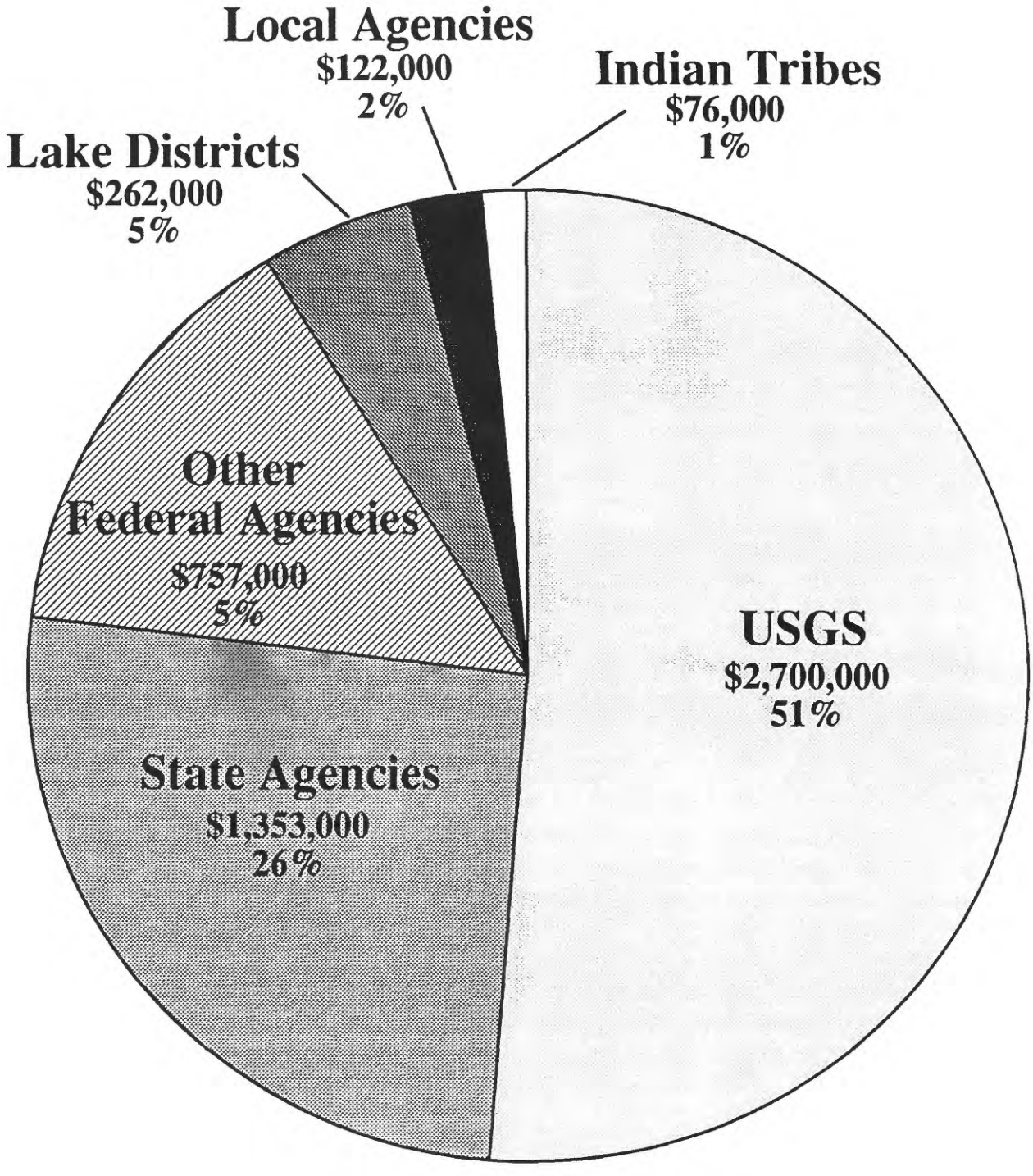


Figure 3. Funding sources for the water-resources program in Wisconsin for the 1992 fiscal year.

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
Dane County Regional Planning Commission
Federal Energy Regulatory Commission Licensees
Lac Courte Oreilles Governing Board
Lac du Flambeau Band of Lake Superior Chippewa
Illinois Department of Transportation
City of Barron
City of Beaver Dam
City of Galena, Ill.
City of Hillsboro
City of Peshtigo
City of Thorp
City of Waupun
Village of Wittenberg
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."

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" report.

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

PROGRESS (July 1991 to June 1992): During the current fiscal year, streamflow data were collected at a total of 94 sites: 35 sites for the Wisconsin Department of Natural Resources, 8 sites for the Corps of Engineers, 14 sites for the Southeastern Wisconsin Regional Planning Commission, 6 sites for the Federal program, 3 sites for the Dane County Regional Planning Commission, 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, cities of Barron, Beaver Dam, Galena, Hillsboro, Peshtigo, Thorp, Waupun, and village of Wittenberg. Streamflow data were also collected at 15 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.

Computation of streamflow and lake-level records for all the network stations for the 1991 water year was completed, stored in our WATSTORE computer data base, and published in the annual "Water Resources Data—Wisconsin, Water Year 1991" report.

More than 100 requests for streamflow information were answered.

PLANS (July 1992 to June 1993): Data collection will continue at 94 continuous-streamflow stations (see the following list) and lake levels at 5 stations. Streamflow records will be computed and data published for the 1992 water year. Requests for streamflow information will be answered.

SURFACE-WATER GAGING STATIONS EXPECTED TO BE OPERATED IN 1993 FY

Station no.	Name and location	Period of record (water year)	Cooperator
04024430	Nemadji River - South Superior	1974-	Fed.
04025500	Bois Brule River - Brule	1943-81, 1984-	Fed.
04027000	Bad River - Odanah	1914-23, 1948	Fed., C of E, Detroit
04027500	White River - Ashland	1948-	DNR
04029990	Montreal River - Saxon Falls	1987	DNR
04063700	Popple River - Fence	1964-	Fed.
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
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
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
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
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

SURFACE-WATER GAGING STATIONS EXPECTED TO BE OPERATED IN 1993 FY

Station no.	Name and location	Period of record (water year)	Cooperator
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
05400800	Wisconsin River - Wisconsin Rapids	1914-50, 1958-	FERC
05401050	Tenmile Creek - Nekoosa	1963-79, 1987	DNR
05402000	Yellow River - Babcock	1944-	DNR
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
05415000	Galena River - Buncombe	1939-	City of Galena
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
05427718	Yahara River - Windsor	1990	DCRPC
05427948	Pheasant Branch - Middleton	1974-	DCRPC
05427965	Spring Harbor Storm Sewer - Madison	1976-	DCRPC
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-	C of E, R. Island
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
05543830	Fox River - Waukesha	1963-	SEWRPC
05544200	Mukwonago River - Mukwonago	1973-	SEWRPC
05546500	Fox River - Wilmot	1940-	C of E, Chicago, and 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, Chicago — Corps of Engineers, Chicago, Illinois
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
DCRPC — Dane County Regional Planning Commission
DCDPW — Dane County Department of Public Works
IL. DOT — Illinois Department of Transportation

Figure 4. 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 3 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 (sq mi)	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
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
Embarrass River near Embarrass, WI	04078500	384	1919-85
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 (sq mi)	Period of record
North Branch Milwaukee River near Fillmore, WI	04086340	148	1968-81
Milwaukee River at Waubeka, WI	04086360	432	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 (sq mi)	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
Lemonweir River at New Lisbon, WI	05403500	507	1944-87
Hulbert Creek near Wisconsin Dells, WI	05403630*	11.2	1971-77
Dell Creek near Lake Delton, WI	05403700*	44.9	1957-1965, 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 (sq mi)	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
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
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
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

COLLECTION OF BASIC RECORDS—GROUND WATER, WI 002

COOPERATOR:
Wisconsin Geological and Natural History Survey

LOCATION: Statewide

PROJECT CHIEF:
Bernie R. Ellefson

PERIOD OF PROJECT:
July 1946-Continuing

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 levels from a network of observation wells representative of Wisconsin's principal aquifers.

APPROACH: A basic network of about 213 wells is being maintained. When possible, the network will be 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 1991 to June 1992): A computer program was developed and used to make data entry of water levels more efficient. Local observers were visited and hired to measure water levels. All strip chart recorders were replaced with digital recorders so data can be stored directly on the USGS computer. Several wells were destroyed or discontinued from the network and were replaced with new ones.

PLANS (July 1992 to June 1993): Measurements of observation wells will be continued. Observers will be visited and quality-assurance checks will be made when possible. Water-level information will be made available on computer disk for individuals requesting these data.

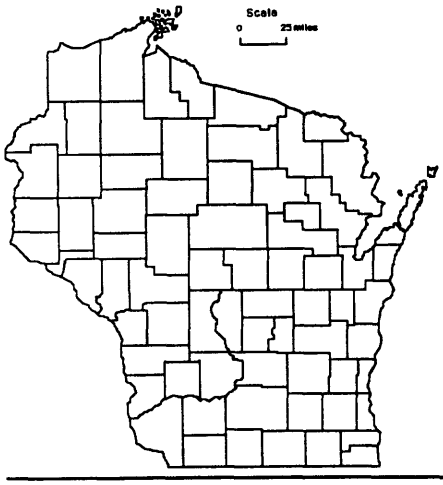
REPORTS:

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.



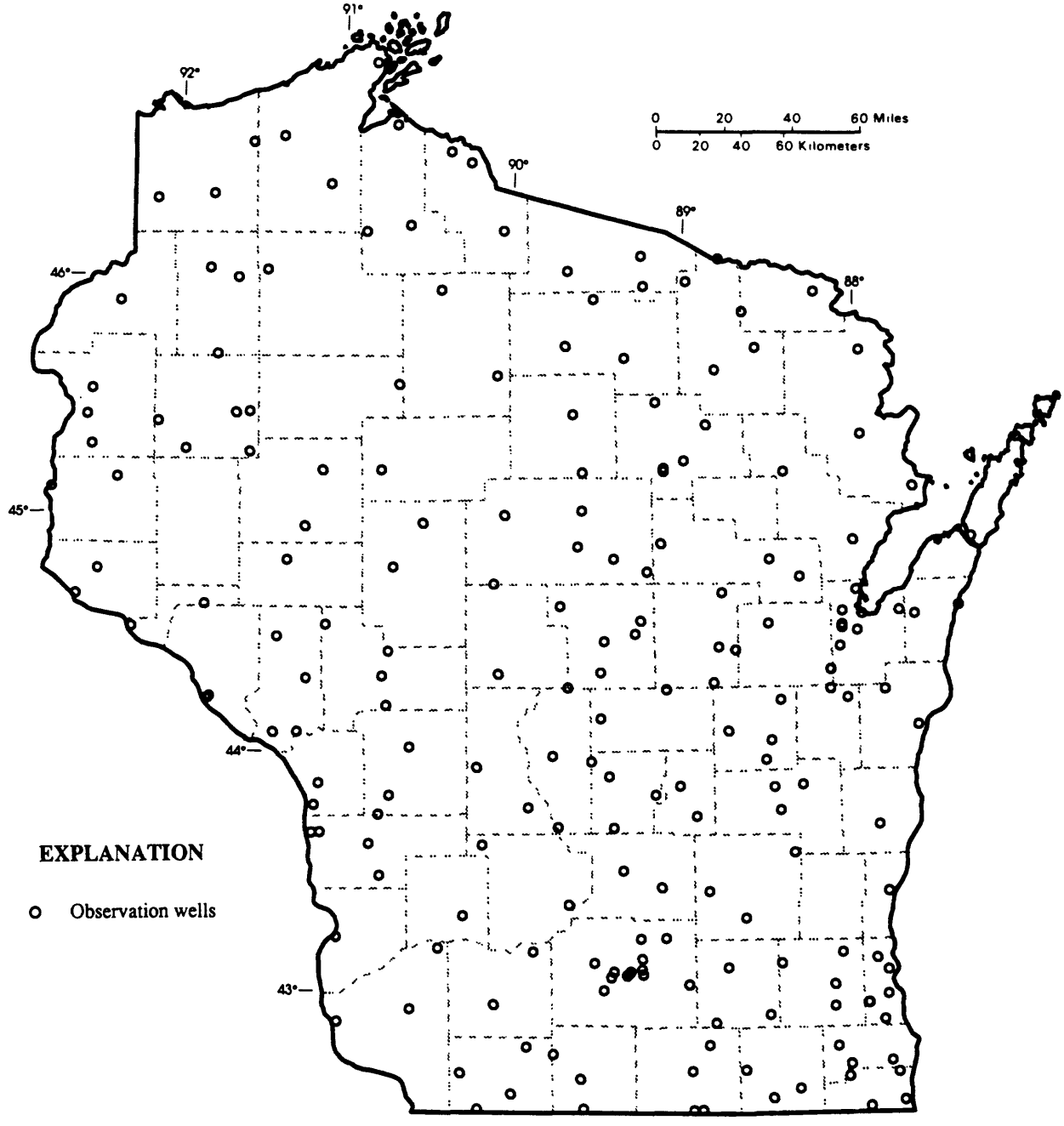


Figure 5. Location of network observation wells.

DETECTION OF FAULTS AND FRACTURED BEDROCK USING ELECTRO-MAGNETIC AND SEISMIC GEOPHYSICAL TECHNIQUES, COPPER FALLS STATE PARK, MELLEN, WISCONSIN, WI 00201

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Copper Falls State Park
Mellen, Wisconsin

PROJECT CHIEF:
Terrence Conlon

PERIOD OF PROJECT:
September 1991 to June 1992

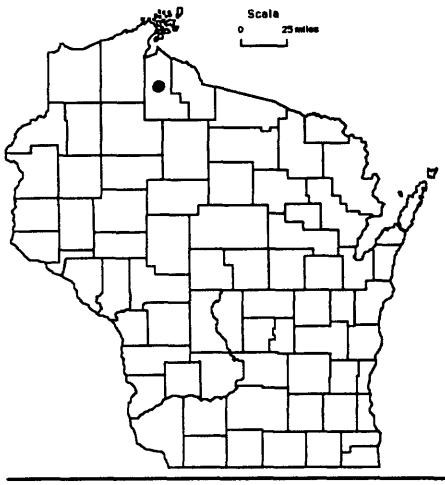
PROBLEM: The Wisconsin Department of Natural Resources staff -- Copper Falls State Park -- is interested in switching from spring water to ground water for water supply. Well drilling in the past has encountered till and basalt, neither of which yielded adequate amounts of water. Maps dating back to the 1920's suggest the park overlies three areas of faulted bedrock. Fractured bedrock near the faults may yield significant amounts of water if wells intersect fractures. The exact location of the faults and the degree of fracturing is unknown.

OBJECTIVE: The study will attempt to locate faults and areas of fractured bedrock using geophysical methods.

APPROACH: The park is underlain by low permeability igneous rock including gabbro, basalt, and granite. Some sedimentary rocks are present north and east of the Bad River, but are not located close to the areas where water is needed. Faults, where igneous rocks may be fractured and yield adequate amounts of water, have been mapped within the park. The study will attempt to locate these areas using the following methods: (1) fracture trace analysis of air photos, (2) analysis of outcrop data, (3) very low frequency (VLF) electromagnetic geophysics, (4) ground terrain conductivity electromagnetic geophysics, and (5) seismic-refraction geophysics.

The location of faults may be identified by looking for lineations on air photos or for faults in bedrock exposed on the land surface. Assuming the faulted zones have a higher conductivity due to the increase in water content in fractured zones, electromagnetic geophysical surveying should show an anomaly above the fractured area. Where the faults result in a significant change in bedrock topography, the change in bedrock elevation may be identified using the seismic-refraction technique. Fault locations will be identified based on all data collected, and the degree of fracturing will be estimated based on the electromagnetic response.

PROGRESS (September 1991 to June 1992): Electromagnetic data were collected along several transects and seismic data were collected along one transect. Data interpretation has revealed one possible fractured location. Information will be sent to the cooperator; project will be completed by June 30.



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. The objective of the Dane County Regional Planning Commission (DCRPC)-U.S. Geological Survey cooperative program is to monitor water quality in selected streams in Dane County.

APPROACH: Chemical, bacteriological, and physical water-quality data will be systematically collected at fixed time intervals and stations for NASQAN. Data collected for the HBMN program is similar to that for the NASQAN program. For the DCRPC-USGS program, data collected will be used to evaluate sediment and nutrient input to Lake Mendota.

PROGRESS (July 1991 to June 1992): Under the NASQAN program, concentration data for fecal bacteria, dissolved oxygen, nutrients, common ions, trace elements, suspended sediment, measurements of water temperature, specific conductance, and pH were collected bimonthly at stations on the Bad, Chippewa, Black, Wisconsin, and Grant Rivers and Tenmile Creek. These data were collected quarterly at stations on the Fox, Manitowoc, and Milwaukee Rivers and at the HBMN station on the Popple River. Radiochemical data were collected semiannually at the Chippewa and Popple River stations.

Water samples for laboratory analysis were collected during periods of runoff from precipitation and snowmelt at two stations for the DCRPC-USGS program. Automatic stage-activated samplers were used to collect water-sediment samples for analyses of nutrient and suspended-sediment concentration from Pheasant Branch and suspended-sediment concentrations from the Spring Harbor storm sewer.

Data collected during the 1991 water year were processed for publication in the annual data release "Water Resources Data—Wisconsin, Water Year 1991."

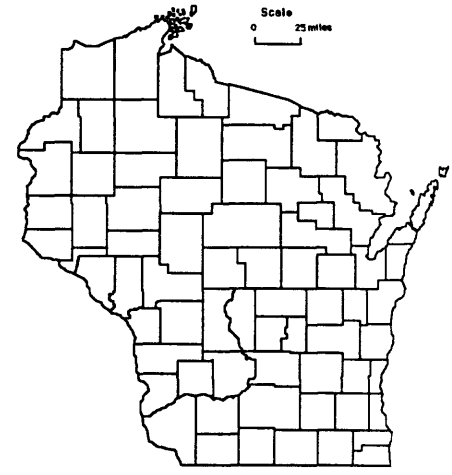
PLANS (July 1992 to June 1993): Data collection and processing will be continued.

COOPERATOR:
Federal Program
Dane County Regional Planning Commission

LOCATION: Statewide

PROJECT CHIEF:
Phil A. Kammerer

PERIOD OF PROJECT:
July 1964-Continuing



RECONNAISSANCE FOR HERBICIDES IN GROUND WATER IN THE MIDWESTERN UNITED STATES, WI 00351

COOPERATOR:
Federal Program

LOCATION:
Statewide

PROJECT CHIEF:
William G. Batten

PERIOD OF PROJECT:
January 1991 to September 1991

PROBLEM: The use of agricultural chemicals to improve crop yields has increased over the past two decades. Application of these chemical pesticides has created concern for nonpoint-source contamination of surface- and ground-water supplies.

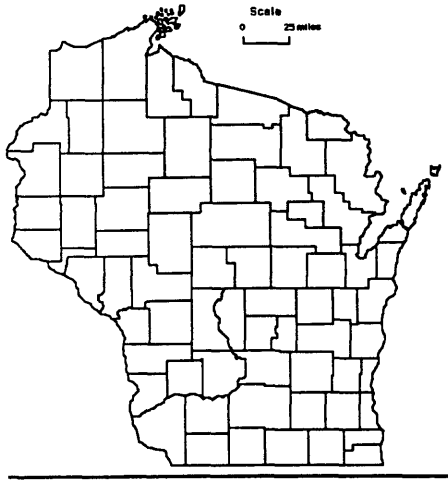
OBJECTIVE: The overall objectives of this study are to (1) determine the spatial and seasonal distribution of selected herbicides and nitrate in near-surface aquifers in the Midwest, and (2) examine regional relationships between the occurrence of herbicides and selected land-use and hydrologic factors.

APPROACH: Reconnaissance samples will be collected in an 11-state area that includes Wisconsin based on areally consistent site-selection criteria, sampling and analytical protocols, and supporting information. The Wisconsin District is responsible for site selection and sample collection in Wisconsin. The 18 sampling sites in Wisconsin include 12 wells in near-surface bedrock (6 in the upper half and 6 in the lower half of the aquifer) and 6 wells in unconsolidated deposits (3 in the upper half and 3 in the lower half of the aquifer). Two rounds of samples will be collected—one in March and April prior to herbicide application, and one in June and July following herbicide application. Herbicide analyses will include triazine herbicides, two atrazine metabolites, alachlor, and metolachlor.

PROGRESS (July 1991 to June 1992): The second of two rounds of samples was collected in August 1991. Samples were collected at the same sites where samples were collected in March 1991.

PLANS (July 1992 to June 1993): Project is complete.

REPORTS:
Kolpin, Dana W., and Burkart, Michael R., 1991, Work plan for regional reconnaissance for selected herbicides and nitrate in ground water of the mid-continent United States, 1991: U.S. Geological Survey Open-File Report 91-59.



COLLECTION OF BASIC RECORDS—SEDIMENT, WI 004

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 1991): 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 1991 to June 1992): The 1991 monitoring program is as follows:

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

DANE COUNTY—Intermittent storm-runoff samples were collected at the Spring Harbor storm sewer at Madison and at Pheasant Branch Creek at Middleton. Daily loads were computed for Pheasant Branch Creek.

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

WISCONSIN DEPARTMENT OF NATURAL RESOURCES—A study whose objective is 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. Sample sets consisting of suspended- and bed-material sediment and Helley-Smith bedload sediment were collected covering the range from low to high streamflow.

PLANS (July 1992 to June 1993):

CORPS OF ENGINEERS—Operation of the Grant River monitoring station will continue. An approved report on sediment transport at the Black River near Galesville; Chippewa River near Caryville, at Durand and near Pepin; and the Wisconsin River at Muscoda will be published.

DANE COUNTY—The collection of suspended-sediment concentration data will continue as scheduled at Spring Harbor storm sewer at Madison and at Pheasant Branch Creek at Middleton.

WISCONSIN DEPARTMENT OF NATURAL RESOURCES—A brief report summarizing the results of the North Fork Fish Creek study will be prepared.

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.

FEMA FLOOD-INSURANCE STUDY, WI 006

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 1991 to June 1992): Time and cost meetings were held to determine the study limits for the cities of Merrill, Watertown, and Verona, Wisconsin. Restudies of Sawyer Creek at Oshkosh and Winnebago County and the Pigeon River at Clintonville were finished.

PLANS (July 1992 to June 1993): Respond to review comments on completed studies and answer data requests as needed. Complete limited map maintenance (LMM) studies for Merrill, Verona, and Watertown.

REPORTS: Work was completed for the restudy of Sawyer Creek at Oshkosh and Winnebago County and results were sent to FEMA.

COOPERATOR:
Federal Emergency Management Agency

LOCATION: Statewide

PROJECT CHIEF:
Peter E. Hughes

PERIOD OF PROJECT:
March 1984-Continuing

WISCONSIN WATER-USE DATA FILE, WI 007

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION: Statewide

PROJECT CHIEF:
Bernie R. Ellefson

PERIOD OF PROJECT:
March 1978-Continuing

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 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 State Water-Use Data System (SWUDS). Efforts will be made to upgrade the accuracy of the water-use data.

PROGRESS (July 1991 to June 1992): 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. Data was compiled for a 5-year national report on water use in Wisconsin.

PLANS (July 1992 to June 1993): The SWUDS data base will be updated and maintained with current water-use data as it becomes available. The possibility of a cooperative project with Wisconsin Department of Natural Resources to meter selected industrial users to better estimate consumptive water use will be explored. An atlas-type report using 1990 data from the 5-year summary will be prepared.

REPORTS:

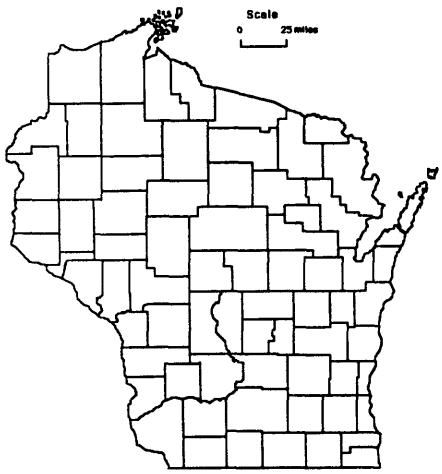
Ellefson, B.R., Rury, K.S., and Krohelski, J.T., 1988, Water-use in Wisconsin, 1985: U.S. Geological Survey Open-File Report 87-699, 1 sheet, scale 1:500,000,000.

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.



LOW FLOW AT OUTFALL SITES, WI 035

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 ($Q_{30,5}$), 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.

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 1991 to June 1992): Low-flow estimates were determined at approximately 60 sites in response to requests for information from the Surface Waters and Monitoring Section of the DNR. Low-flow characteristics at additional sites were made for other DNR personnel.

Low-flow characteristics, $Q_{7,2}$ and $Q_{7,10}$ values, for sites published in the Low-flow Characteristics of Wisconsin Streams at Sewage-Treatment Plants and Industrial Plants report and at low-flow partial-record stations were redetermined. Low-flow characteristics for sites in the Chippewa River basin were determined. These data were transmitted to the DNR by letter in tabular format.

PLANS (July 1992 to June 1993): 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.

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Selected sites throughout Wisconsin

PROJECT CHIEF:
Barry K. Holmstrom

PERIOD OF PROJECT:
April 1972-Continuing

EFFECTS OF LAND-USE CHANGES ON AN URBAN LAKE, WI 084

COOPERATORS:
City of Middleton
Dane County Regional Planning Commission

LOCATION:
Near Madison, Wisconsin

PROJECT CHIEF:
William R. Krug

PERIOD OF PROJECT:
December 1976 to June 1982
January 1984 to September 1992

PROBLEM: Changes in land use and industrial development around Graber Pond have resulted in increases in water levels in the pond. The pond's watershed is urbanizing. Further increases in water levels could inundate more areas, and could cause outflow from the pond, which currently has no outlet.

OBJECTIVE: The objectives of this project are to:

1. Develop a water budget for Graber Pond for existing conditions.
2. Evaluate the effects of changing land use on pond water levels.
3. Collect data at selected sites on base-flow water quality six times per year.

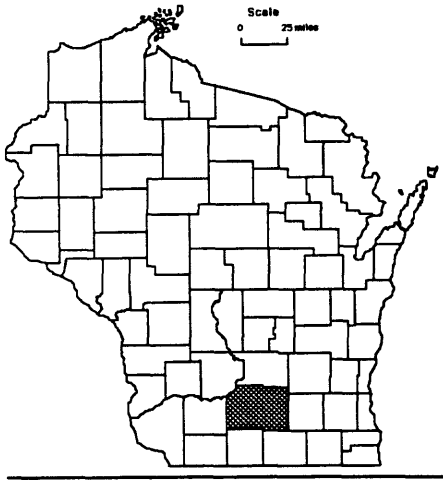
APPROACH:

1. Water Budget—Existing water levels in Graber Pond will be monitored and recorded from spring thaw in early 1988 until freeze up the following winter, and again starting with spring thaw in 1989 until sufficient data is collected to calibrate a simple rainfall-runoff model.

   Rainfall will be recorded at the site. Other meteorological data needed to estimate evaporation will be obtained from the Weather Service Station at the Dane County Regional Airport.

   Ground-water infiltration rates and relations will be estimated as the residual of changes in pond storage after accounting for rainfall and evaporation.

2. Evaluating the effects of changing land use—A custom designed rainfall-runoff model will be developed for the Graber Pond watershed using accepted hydrologic methods, similar to the previous study model. This model will be calibrated to existing land use and observed meteorologic conditions. Runoff volumes and pond levels for proposed development conditions will then be estimated for the observed rainfall record, hypothetical seasonal record and for selected high-intensity rainfall events, such as the 100-year, 24-hour storm.



PROGRESS (July 1991 to June 1992): A report was prepared describing the model and presenting the changes in long-term water levels of Graber Pond for present and full development in the basin. The report has been approved for publication.

Base-flow water-quality data were collected at sites designated by the Dane County Regional Planning Commission during July, August, October, December, April, and June.

Sediment-discharge loads were determined for Pheasant Branch at Highway 12 at Middleton.

PLANS (July 1992 to September 1992): The report of the Graber Pond simulation will be published.

Base-flow water-quality data will be collected at sites designated by the Dane County Regional Planning Commission during July and August.

The project is ending; any further data-collection activity will be in a basic data-collection project.

REPORTS:

House, L. B., 1992, Simulation of the effects of hypothetical residential development on water levels in Graber Pond, Middleton, Wisconsin: U.S. Geological Survey Water-Resources Investigations Report 92-4029 (in preparation).

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

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION: Statewide

PROJECT CHIEF:
Phil A. Kammerer

PERIOD OF PROJECT:
June 1978 to September 1985

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.

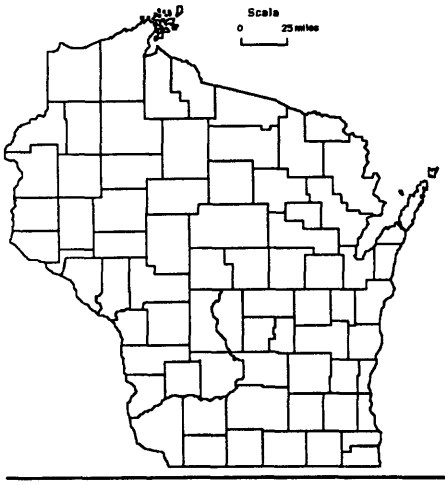
PROGRESS (July 1991 to June 1992): Preparation of approved report for publication has begun. The second report will be revised and resubmitted for approval for publication.

PLANS (July 1992 to June 1993): Publish approved report. Publish second report after approval is received.

REPORTS:

Kammerer, P.A., Jr., 1992, Ground-water movement 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., Generalized geology, water movement, and dissolved solids concentrations along cross sections through Wisconsin's aquifers: U.S. Geological Survey Hydrologic Investigations Atlas (to be resubmitted for approval for publication following revisions).



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

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. Determine why flood characteristics are different for the Driftless Area.
3. Analyze the network of crest-stage gages to determine which station can be dropped from the network and what type of sites should be added.

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 will be dropped from the network and new stations added as a result of this analysis.

PROGRESS (July 1991 to June 1992): The flood-frequency report was published. A journal article was published 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 gages. The network of crest-stage gages was analyzed to determine which stations provided the least information for regional frequency analysis and could be replaced by new stations.

PLANS (July 1992 to June 1993): The crest-stage gage network will be monitored with no change for another year. Meanwhile, a network analysis feature of the generalized-least-squares procedure will be used to determine if more information could be obtained by making changes in the gage network. This analysis should show which gages could be discontinued with little loss to the accuracy of future regression equations and what sort of gages should be added to the network to contribute the most to the accuracy of the equations.

REPORTS:

Krug, W.R., 1992, Changes in the rainfall-runoff characteristics in the Coon Creek Basin, Wisconsin (in preparation).

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.

COOPERATOR:

Wisconsin Department of Transportation - Highways

LOCATION: Statewide

PROJECT CHIEF:

William R. Krug

PERIOD OF PROJECT:

July 1985-Continuing

LIST OF CREST-STAGE GAGES

CHIPPEWA RIVER BASIN
05357360 Bear River near Powell, WI
05357390 Weber Creek near Mercer, WI
05358100 Smith Creek near Park Falls, WI
05359600 Price Creek near Phillips, WI
05361400 Hay Creek near Prentice, WI
05361420 Douglas Creek near Prentice, WI
05361600 North Fork Jump River near Phillips, WI
05364000 Yellow River at Cadott, WI
05364100 Seth Creek near Cadott, WI
05364500 Duncan Creek at Bloomer, WI
05365700 Goggle-Eye Creek near Thorp, WI
05366500 Eau Claire River near Fall Creek, WI
05367030 Willow Creek near Eau Claire, WI
05367480 East Branch Pine Creek Tributary near Dallas, WI
05367700 Lightning Creek at Almena, WI
05370600 Arkansaw Creek Tributary near Arkansaw, WI
05370900 Spring Creek near Durand, WI

CENTRAL WISCONSIN RIVER BASIN
05395020 Lloyd Creek near Doering, WI
05395100 Trappe River Tributary near Merrill, WI
05396100 Pet Brook Tributary near Edgar, 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
05403520 Webster Creek at New Lisbon, WI
05403550 Onemile Creek near Mauston, WI
05403630 Hulbert Creek near Wisconsin Dells, WI
05403700 Dell Creek near Lake Delton, WI

FOX-WOLF RIVER BASIN
04073400 Bird Creek at Wautoma, WI
04074300 Mud Creek near Nashville, WI
04074700 Hunting River near Elcho, 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
04085030 Apple Creek near Kaukauna, WI

LAKE MICHIGAN BASIN
04085300 Neshota River Tributary near Denmark, WI
04085400 Killsnake River near Chilton, WI
04087050 Little Menomonee River near Freistadt, 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
05404200 Narrows Creek at Loganville, WI
05405600 Rowan Creek at Poynette, WI
05406800 Rocky Branch near Richland Center, WI
05407100 Richland Creek near Plugtown, 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
04063688 South Branch Popple River near Newald, WI
04063800 Woods Creek near Fence, WI
04064800 Little Popple River near Aurora, WI
04067760 Peshtigo River near Cavour, WI
04067800 Armstrong Creek near Armstrong Creek, 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
05414200 Bear Branch near Platteville, WI
05414213 Little Platte River near Platteville, WI
05414900 Pats Creek near Elk Grove, WI
05414915 Madden Branch Tributary near Belmont, WI
05432300 Rock Branch near Mineral Point, WI
05433500 Yellowstone River near Blanchardville, WI
05435900 Sugar River Tributary near Pine Bluff, WI
05436200 Gill Creek near Brooklyn, WI
05437200 East Fork Raccoon Creek Tributary near Beloit, WI

ROCK-FOX RIVER BASIN
05423800 East Branch Rock River Tributary near Slinger, WI
05425700 Robbins Creek at Columbus, WI
05427200 Allen Creek near Fort Atkinson, WI
05427800 Token Creek near Madison, WI
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
05333100 Little Frog Creek near Minong, WI
05335380 Bashaw Brook near Shell Lake, WI
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
05378200 Eagle Creek near Fountain City, WI
05380800 Black River Tributary near Whittlesey, 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
05390140 Muskrat Creek at Conover, WI
05390240 Fourmile Creek near Three Lakes, WI
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

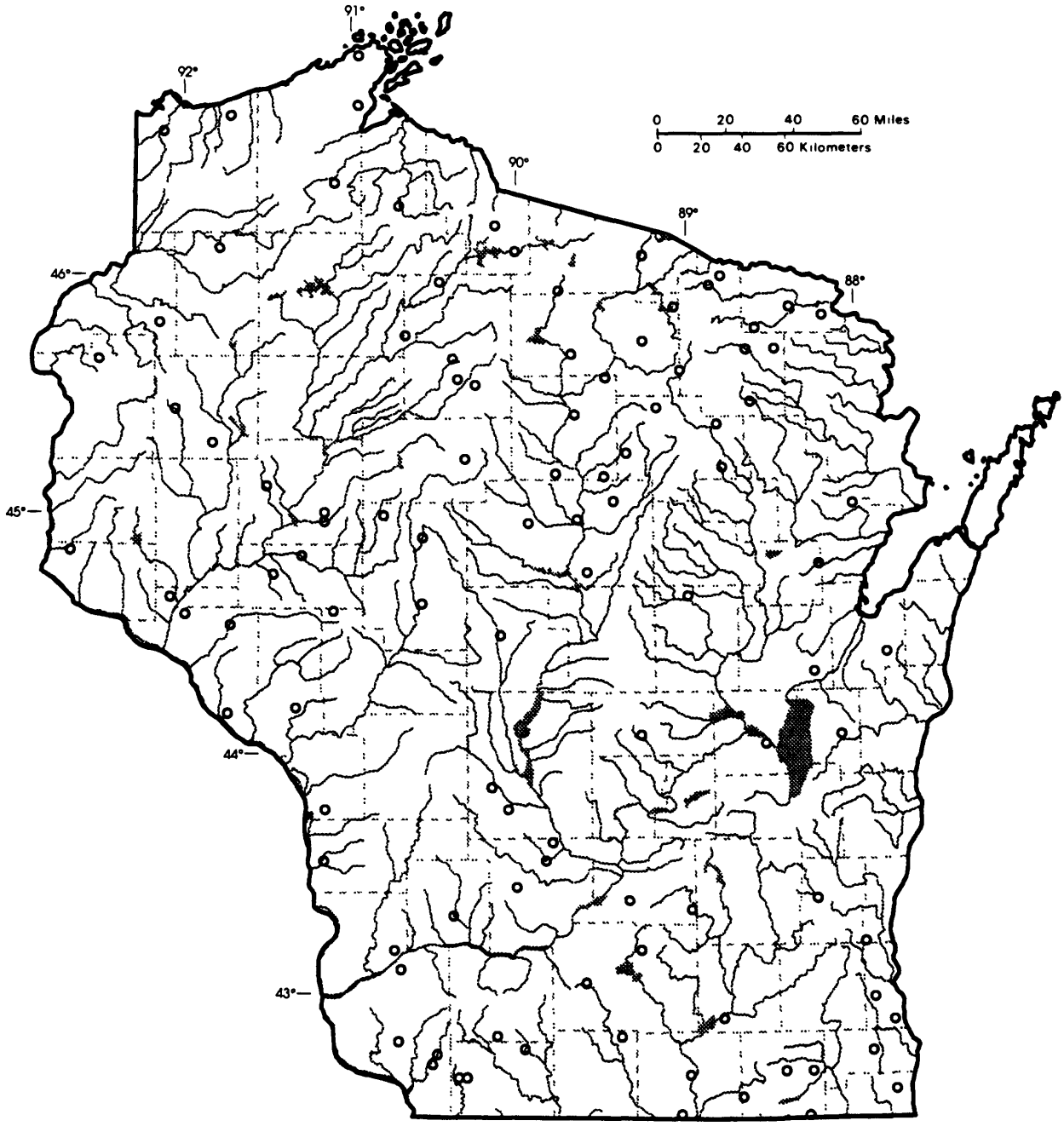


Figure 6. Location of crest-stage-gage data collection stations.

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

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

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 1991 to June 1992): The report "Hydrology of Lakes Clara and Vandercook" was published. The report "Long-term hydrologic and geochemical responses of a soft-water seepage lake in north-central Wisconsin" was approved for publication by USGS headquarters.

PLANS (July 1992 to June 1993): The report "Long-term hydrologic and geochemical responses of a soft-water seepage lake in north-central Wisconsin" will be submitted to Water Resources Research for publication.

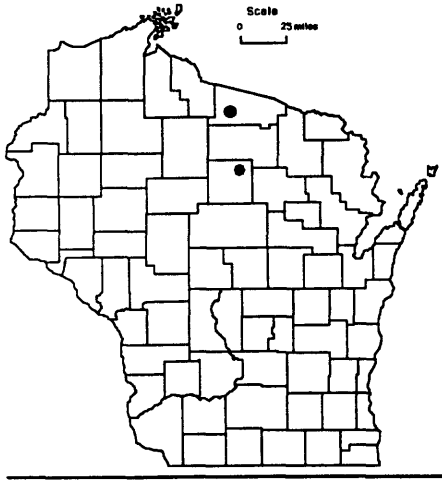
REPORTS:

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, will be 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.

Chen, C.W., Gomez, L.E., Gherini, Steve, Wentz, D.A., and Whipple, J.J., 1986, Seepage lake 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

COOPERATORS:
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

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 1991 to June 1992): 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).

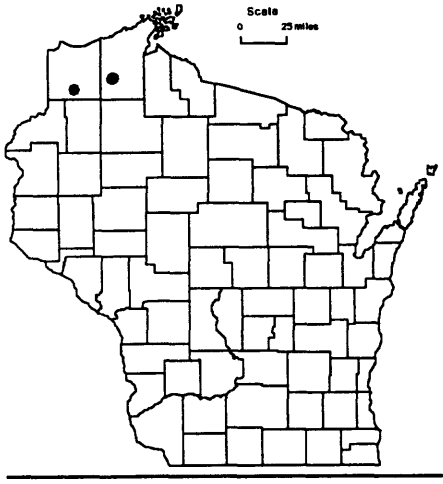
PLANS (July 1992 to June 1993): The final report will be published by EPRI as previously planned or the sections will be published as separate reports in the USGS Water-Resources Investigations Report series.

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).



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

COOPERATORS:

Current cooperators include the Bad River, Lac Du Flambeau, and Red Cliff Bands of Lake Superior Chippewa, the Menominee, Oneida, Winnebago, Forest County Potawatomi, and St. Croix Tribes of Wisconsin, and the Stockbridge-Munsee Band of Mohican Indians of Wisconsin.

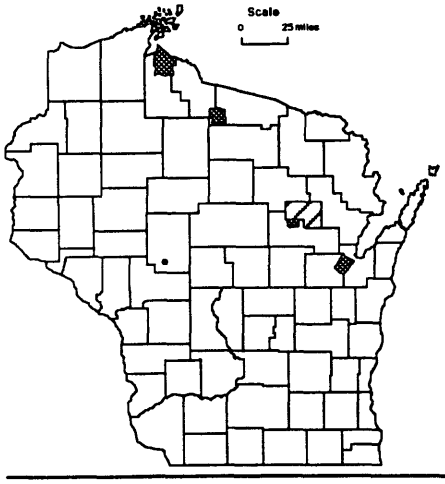
LOCATION: Statewide

PERIOD OF PROJECT:

August 1977-Continuing

PROJECT CHIEFS:

Jim Krohelski, Bill Batten, John DeWild



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 1991 to June 1992):

Bad River Band of Lake Superior Chippewa

The water quality, direction of ground-water flow and hydraulic characteristics of an area near an abandoned recycled-paper sludge dump on the Bad River Reservation were determined. Six sites (four wells and two surface water) were sampled for priority pollutants at the sludge dump. Organic contaminants were present in water from three wells and one surface-water site.

The study was expanded to include an area northwest of the dump where recycled-paper sludge was stockpiled and spread in a pit because water from a domestic well near the pit was found to be contaminated with organics. Soil borings to define the extent of the stockpiled sludge were made. Six sites (three wells and three surface water) were sampled for priority pollutants. Organic contaminants were present in water from one well.

All data collected on the sludge dump and stockpiled sludge area were submitted to James Q. Brown, Hydrologist, Bureau of Indian Affairs. He will summarize data into a report to the tribe.

A draft report using data collected during previous years and describing the water resources of the Bad River Reservation was written.

Oneida Tribe of Indians of Wisconsin

Present ground- and surface-water quality on a large portion of the Oneida Indian Reservation was described by collecting a variety of data within the Duck Creek watershed. Streamflow data, collected for the past three years, indicates that no-flow conditions often occur in Duck Creek during the summer months and peak flows diminish rapidly. Possible causes of stream-water depletion within the Duck Creek watershed were investigated. These possible causes include drought, capture of ground water from nearby pumping centers, and land-use changes. Of these causes, the most probable is land-use changes in channels tributary to Duck Creek. Surface- and ground-water data for the Duck Creek watershed were summarized and presented to the Oneida Business Committee.

Red Cliff Band of Lake Superior Chippewa

A study to describe the occurrence, distribution, and sources of mercury and PCB's in the Apostle Islands/Chequamegon Bay area of Lake Superior was initiated. The approach was outlined in a proposal submitted to the tribe and Bureau of Indian Affairs last year.

Sediment cores collected in August are being analyzed for 91 PCB congeners, organic carbon, and anthropogenic metals. Water-column samples were also collected and analyzed for mercury; pH, dissolved oxygen, temperature, and specific-conductance measurements were made in the field.

Water column mercury concentrations of the Bayfield County and Apostle Islands seepage lakes were found to be similar to lakes studied in Vilas County. Water column mercury concentrations of inter-island areas of Lake Superior sites were about 50 percent less than the seepage lakes. Presently, no analyses of the sediment cores are available.

Menominee Indian Tribe of Wisconsin

Stage-discharge measurements at the Wolf River at Langlade and water-quality sampling of the Wolf River at County Trunk M and at the southern boundary of the Menominee Reservation were continued. Monitoring of five lakes in the southeastern portion of the Menominee Reservation for various physical and chemical parameters to determine water-quality trends was continued.

A comparison of the discharges at Langlade and at the gaging station below the dam near Shawano (southern boundary of reservation) indicates that approximately 35 percent of the downstream discharge enters the stream as it passes through the reservation. This indicates that land use on tribal lands is very important to the water quality of the Wolf River. Although the objective for collecting water-quality data is to establish a baseline, a comparison of the two sites does not indicate that tribal lands are detrimentally affecting the water quality of the Wolf River. However, no extensive trend analysis has been done on the water-quality data as yet because the duration of sampling has not been long enough for a valid statistical analysis. Trend analysis may be possible after sampling has been completed for the 1992 water year.

As in the previous two years, the five lakes classified (based on Carlson's Trophic-State Index) as oligotrophic to slightly mesotrophic for chlorophyll a and total phosphorus.

Eight domestic wells were sampled for Radon-222 and analyzed using liquid scintillation counting at the USGS National Water-Quality Laboratory. The wells sampled represent the range of Radon-222 concentrations in air found at selected tribal residences during 1988. Three wells are finished in the Precambrian aquifer and five are finished in the sand and gravel aquifer. The U.S. Environmental Protection

Agency currently has no standards for radon in water but is proposing a primary drinking-water standard of 300 picocuries per liter (pCi/l) for Radon-222 in municipal-water systems. Six of the eight wells sampled exceed this level.

A report using data collected during previous years and describing the water resources of the Menominee Reservation is through colleague review.

Winnebago Tribe of Wisconsin

A literature review and summary describing the possible effects of cranberry operations on the water resources of Winnebago tribal lands was completed and submitted to the tribe last year. Based on the summary, ground water was sampled for one well and analyzed for pesticides commonly used in cranberry agriculture. The analysis indicated no detectable concentrations of these pesticides.

Stockbridge-Munsee Band of Mohican Indians

A synoptic survey of the Red River and its tributaries to determine the water quality of the Red River watershed within the reservation was conducted.

A draft report using data collected during previous years and describing the water resources of the Stockbridge-Munsee Reservation is being revised.

PLANS (July 1992 to June 1993):

Oneida Tribe of Indians of Wisconsin

Continue to monitor streamflow and water quality for Duck Creek at the gaging station at County Highway FF and continue to monitor water levels in the three shallow observation wells adjacent to the gaging station. Continue to measure observation well BN-1265 (near Bingo Hall) monthly.

Red Cliff Band of Lake Superior Chippewa

A journal article describing the occurrence, distribution, and sources of mercury and PCB's in the Apostle Islands/Chequamegon Bay area of Lake Superior will be written.

Menominee Indian Tribe of Wisconsin

Stage discharge at the Wolf River at Langlade and water-quality sampling of the Wolf River at CTY M and at the southern boundary of the Menominee Reservation will continue. Monitoring of five lakes in the southeastern portion of the Menominee Reservation for various physical and chemical parameters will continue. The draft report describing the water resources of the Menominee Reservation will be published.

Stockbridge-Munsee Band of Mohican Indians

A continuous-record gaging station will be installed and operated on the Red River where it enters the Reservation. The draft report describing the water resources of the Stockbridge-Munsee Reservation will be published.

REPORTS:

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. (in press).

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. (in press).

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 (through colleague review).

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

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

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

LOCATION:
Selected lakes in Wisconsin

PROJECT CHIEF:
Stephen J. Field

PERIOD OF PROJECT:
June 1983-Continuing

COOPERATORS:
In the 1991 water year:
Big Muskego, Little Muskego, Fowler, Hills, Wind, Okauchee, Balsam, Druid, Lac La Belle, Little Arbor Vitae, Little Green, Little St. Germain, Loon, and Powers Lake Districts; 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); and Marinette County Soil and Water Conservation District (Lake Noquebay)

In the 1992 water year:
Big Muskego, Little Muskego, Fowler, Hills, Wind, Okauchee, Alma/Moon, Hooker, Balsam, Druid, Little Arbor Vitae, Little Green, Little St. Germain, Loon and Powers Lake Districts; 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)

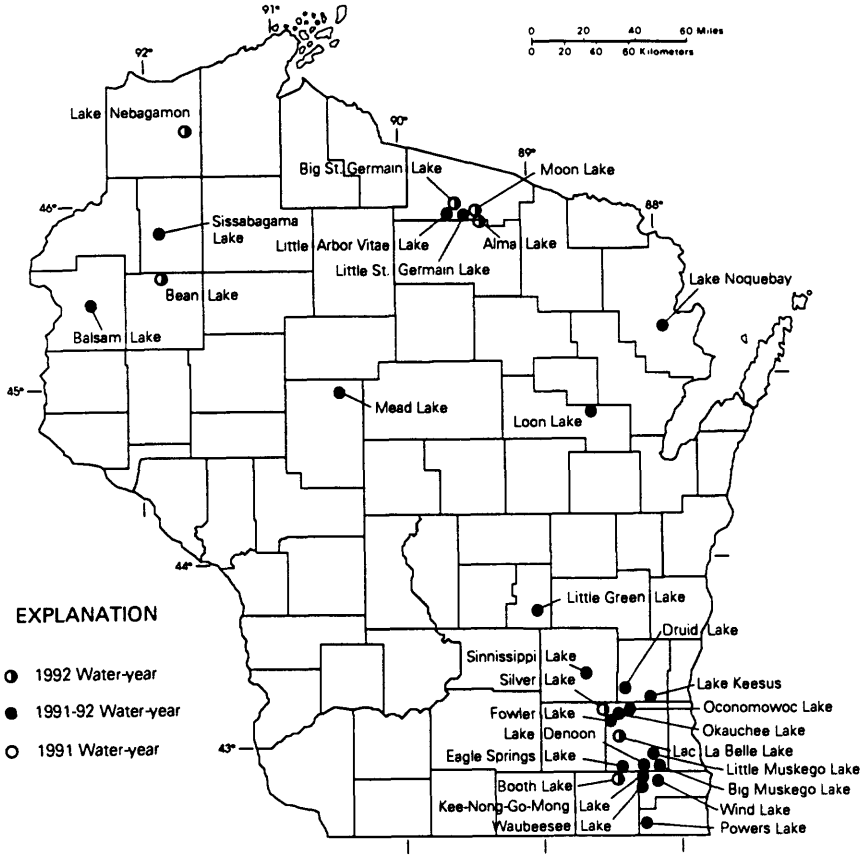
PROBLEM: Lakes are a valuable resource in the State of Wisconsin and their water quality needs documentation.

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.

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 1991 to June 1992): In the 1991 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, 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, and Sinissippi Lakes. In the 1991 water year, a letter evaluating the water quality of each lake was sent to the respective cooperator. In the 1992 water year, Nebagamon, Moon, Alma, Silver, Bear, Booth, Big St. Germain, and Hooker Lakes were added to the program. The locations of lakes included in the monitoring program for water years 1991-92 are shown on the following map.

PLANS (July 1992 to June 1993): In the 1992 water year, 30 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 1991."



LAKE WATER-QUALITY MONITORING, STATEWIDE LAKE-STAGE AND SECCHI-DISC MONITORING, WI 13301

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION: Statewide

PROJECT CHIEF:
Stephen J. Field

PERIOD OF PROJECT:
October 1984-Continuing

PROBLEM: Lakes are a valuable resource in the State of Wisconsin. Secchi-discs are an inexpensive method for collecting valuable data to determine lake water-quality trends. Lake stage data provides valuable information throughout the State to help explain the high or low lake stages other lakes experience.

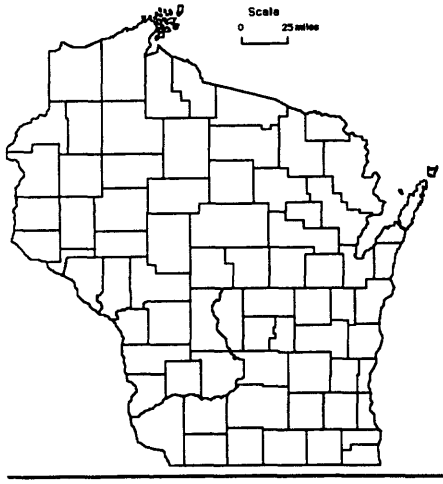
OBJECTIVE: The objectives are to determine lake stage and water transparency at selected lakes throughout Wisconsin and, through a continuous monitoring program, provide the data that will document lake-stage fluctuations and detect water-quality changes that may take place.

APPROACH: Staff gages will be installed at each selected lake to monitor stage fluctuations. Reference marks will be established and levels run at each lake. Stage readings will be made weekly during the open-water period, and monthly during the winter by lake district personnel. Stage data will be entered into the USGS computer data-base storage file. They will be retained as part of the permanent data record of the water resources of Wisconsin.

Secchi-disc readings will be made by lake-district personnel weekly during ice-free periods in the deepest part of the lake. Secchi-disc readings will be entered into the USGS computer data-base storage file.

PROGRESS (July 1991 to June 1992): Lake-stage and/or Secchi-disc data were compiled for six lakes: Amnicon, Anvil, Devils, Fish, McKensie, and Wheeler. Data have been formatted for publication in "Water Resources Data—Wisconsin, Water Year 1991."

PLANS (July 1992 to June 1993): In the 1992 water year, only six lakes will be monitored: Amnicon, Anvil, Devils, Fish, McKensie and Wheeler. Data will be published in "Water Resources Data—Wisconsin, Water Year 1992."



LAKE ASSESSMENT—FOWLER LAKE, WI 138

PROBLEM: Fowler Lake is a small drainage lake on the Oconomowoc River. The lake is experiencing nuisance weed and algae growth which have necessitated control programs including mechanical harvesting and chemical application. Identification of the nutrient sources is required to develop management alternatives to control the problem.

OBJECTIVE: The objectives of this project are to identify the sources of nutrient enrichment to Fowler Lake; compare the nutrient and suspended- sediment discharge to the Oconomowoc River from the contributing urban area and from the lake; monitor chemical and physical characteristics of the lake water; and estimate internal recycling of nutrients.

APPROACH: Monitor inflow to Fowler Lake and collect monthly water-quality samples from the lake from January 1984 through November 1984. Calculate a mass balance for nitrogen and phosphorus loads for 1984.

PROGRESS (July 1991 to June 1992): The report has been approved for publication.

PLANS (July 1992 to June 1993): Publish the report.

REPORTS:

Hughes, P.E., Hydrology, water quality, trophic status, and aquatic plants of Fowler Lake, Wisconsin: U.S. Geological Survey Water-Resources Investigations Report 91-4076 (in preparation for printing).

COOPERATOR:

Fowler Lake Management District

LOCATION:

City of Oconomowoc, Waukesha County, southeast Wisconsin

PROJECT CHIEF:

Peter E. Hughes

PERIOD OF PROJECT:

January 1984 to March 1985

EAST RIVER WATER-QUALITY ASSESSMENT STUDY, WI 144

COOPERATOR:
Fox Valley Water Quality Planning Agency

LOCATION:
City of Green Bay and Brown County, northeast Wisconsin

PROJECT CHIEF:
Peter E. Hughes

PERIOD OF PROJECT:
January 1985 to September 1987

PROBLEM: Agricultural and urban nonpoint-source discharges were suspected of contributing significantly to degraded water quality.

OBJECTIVE: The streamflow characteristics of the East River near its mouth and of a small tributary watershed will be determined. The baseline- and storm-water quality for the same sites will be monitored. The baseline-water quality for the East River upstream of the estuary influence will be determined. Dissolved oxygen and temperature at the gaging stations will be monitored. The application of an acoustic velocity meter (AVM) for determining streamflow in an estuary-affected river reach and the utility of telecommunications data retrieval will be demonstrated.

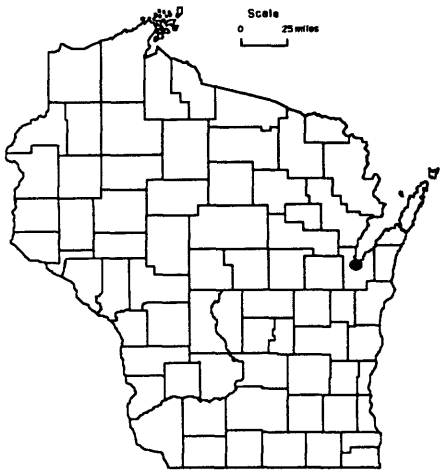
APPROACH: An AVM gaging station will be established near the mouth of the East River. A gaging station will be established on a 5-square-mile drainage area tributary to the East River to provide data for a model that will be used to extrapolate information to other tributary source areas. Dissolved oxygen and temperature monitoring and storm event water-quality sampling will be supplemented by bimonthly baseline sampling. The transport of phosphorus and sediment both upstream and downstream in the East River estuary reach will be evaluated.

PROGRESS (July 1991 to June 1992): The report has been approved for publication.

PLANS (July 1992 to June 1993): Publish the report.

REPORTS:

Hughes, P.E., Hydrologic and water-quality data for the East River basin in northeastern Wisconsin: U.S. Geological Survey Open-File Report 89-245 (in preparation for printing).



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 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 resolution of one nano-gram/liter, and a detection limit of three nano-grams/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 will be used to simulate PCB kinetics and transport. This modeling effort is done by a USGS employee on loan to the WDNR.

COOPERATOR:
Wisconsin Department of Natural Resources (WDNR)

LOCATION:
Lower Fox River, East Central Wisconsin

PROJECT CHIEF:
Leo B. House and Jeffrey Steuer

PERIOD OF PROJECT:
July 1985 to June 1993

PROGRESS (July 1991 to June 1992): All discharge and suspended-sediment data collected for the study was published in the "Water Resources Data—Wisconsin" report for 1991. The report on the Little Lake Butte des Morts phase of the study was submitted to headquarters for review and approval for publication. The WASP4 modeling effort by WDNR is continuing. The WASP4 model is being used to simulate advective transport of selected representative PCB congeners. WDNR will use the calibrated WASP model to evaluate various remedial actions.

PLANS (July 1992 to June 1993): The report for the Little Lake Butte des Morts study will be published. The WASP modeling effort will continue. A report of the WASP4 modeling study will be prepared for publication as a USGS Water-Resources Investigations Report or as a peer-reviewed journal article.

REPORTS:

House, Leo B., Distribution, concentration, and transport of polychlorinated biphenyls in Little Lake Butte des Morts, Fox River, Wisconsin 1987-88, U.S. Geological Survey Water-Supply Paper (in review).

DETENTION POND EVALUATION, WI 149

PROBLEM: Urban storm-water runoff quality has adversely impacted local lakes and streams. Best management practices (BMP) used to control selected pollutants in several urban watersheds will be implemented in the next several years. The effectiveness of given BMP's will be evaluated before full implementation of the BMP's is undertaken.

OBJECTIVE: Evaluate the effects of BMP's on the water quality of urban storm-water runoff.

APPROACH: Two urban basins located in the Madison area will be instrumented to measure storm-water-runoff volume and precipitation. Automatic water-quality samplers will be installed to take flow proportional samples. Nutrients, dissolved and total metals, and suspended and total solids will be sampled. Data will be recorded on the site with a Campbell Scientific CR10 datalogger and transmitted to the USGS office via telecommunications equipment.

PROGRESS (July 1991 to June 1992): Both the Syene Road and Monroe Street gaging stations were used to determine pollutant loads from their respective basins during the pollutant source project. The Syene Road gaging station performed very well with over 57 percent of the total annual runoff sampled. The Monroe Street gaging station had over 20 storms sampled for the period.

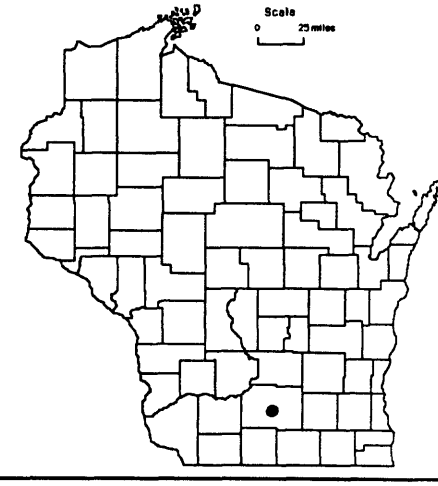
PLANS (July 1992 to June 1993): Results of the detention pond evaluations will be published as a journal article. Continue monitoring storm-water runoff events at Syene Road and Monroe Street gaging stations.

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
City of Madison, University of Wisconsin Arboretum

PROJECT CHIEF:
David Owens

PERIOD OF PROJECT:
July 1986 to June 1998



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

COOPERATORS:

USGS Headquarters,
Office of Water Quality
USGS Illinois District

LOCATION:

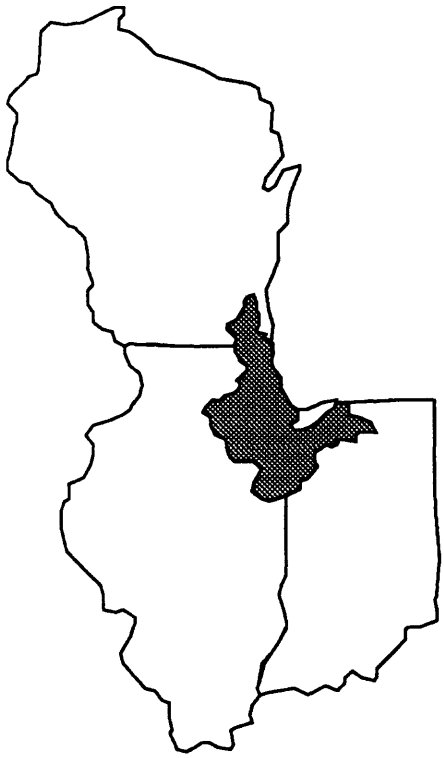
Upper Illinois River Basin (UIRB) in Illinois, Wisconsin, and Indiana

PROJECT CHIEF:

Barbara C. Scudder

PERIOD OF PROJECT:

June 1986 to September 1992



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 1991 to June 1992): Literature compilation and review has been completed. Analysis and interpretation of the data sets have been completed. As a coauthor, progress has been made toward completion of the first draft of 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." A review by personnel from the USGS Illinois District and USGS Headquarters has been conducted for the partial draft of the manuscript.

PLANS (June 1992 to July 1993): The final report will be completed.

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 preparation).

ASSESSMENT OF THE HYDROLOGY AND WATER QUALITY OF POWERS LAKE, WI 153

PROBLEM: Powers Lake is a mesotrophic lake with good water quality. Phosphorus sources and loads need to be documented to develop a comprehensive management plan to protect the lake's water quality.

OBJECTIVE: To determine for the 1987 water year (1) a hydrologic budget, (2) a phosphorus budget defining the inputs from surface water, ground water, and precipitation, and the losses, (3) physiochemical depth profiles of the lake water column, and (4) the phytoplankton and zooplankton summer population.

APPROACH:

1. Monitor streamflow and phosphorus load at inlet and outlet.
2. Monitor lake stage.
3. Monitor seven minipiezometers to determine ground-water discharge and recharge areas.
4. Determine physiochemical characteristics of lake-water column.
5. Record precipitation at three sites in the basin.
6. Identify and enumerate summer phytoplankton and zooplankton populations.
7. Prepare an annual hydrologic and phosphorus budget.

PROGRESS (July 1991 to June 1992): The report describing the water quality and hydrology of Powers Lake was approved for publication on July 26, 1990.

PLANS (July 1992 to June 1993): Publish report.

REPORTS:

Field, Stephen J., Hydrology and water quality of Powers Lake in southeastern Wisconsin, U.S. Geological Survey Water-Resources Investigations Report 90-4126 (in preparation).

COOPERATOR:

Powers Lake District

LOCATION:

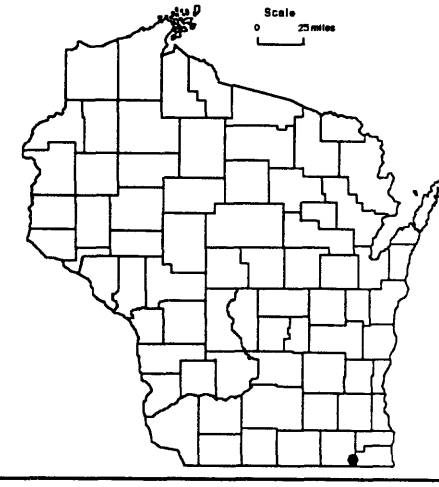
Kenosha and Walworth Counties, southeast Wisconsin

PROJECT CHIEF:

Stephen J. Field

PERIOD OF PROJECT:

October 1986 to September 1988



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

COOPERATORS:
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 1991 to June 1992): Two years of coordinated lake chemistry and ground-water data have been collected and evaluated. Calculations of ground-water inflow and outflow were made using solute/mass-balance relationships. Samples were collected in the spring and early summer of 1991 to test a new sampling strategy that will give better estimates of ground-water-discharge chemistry.

PLANS (July 1992 to June 1993): Data collection will be continued at the site until August 1992. The results will be written in the form of a journal paper for publication in 1992.

REPORTS:

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.

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

HYDROLOGY AND WATER QUALITY AT SMALLMOUTH BASS STREAMS IN SOUTHWEST WISCONSIN, WI 155

PROBLEM: Smallmouth bass streams in southwestern Wisconsin were a renowned smallmouth bass fishery in the 1950's and 1960's. There has been a considerable concern that the smallmouth bass populations have decreased dramatically. A survey of 10 southwest Wisconsin streams found smallmouth bass populations were low, even though habitat was good. Previous studies have indicated that the population declines may be attributed to declining water quality.

OBJECTIVE: Determine streamflow and water-quality characteristics and examine their relation to bass populations.

APPROACH: Four streams were selected in southwestern Wisconsin: three that have declining smallmouth bass populations and one where populations appear to have remained stable. Continuous streamflow, water temperature, and dissolved-oxygen gaging stations were installed at each site. Water-quality samples were collected and analyzed for selected constituents.

PROGRESS (July 1991 to June 1992): Installed a continuous-streamflow and water-quality sampling station on Kuenster Creek. Discontinued data collection at the Livingston Branch of the Pecatonica River. An interpretive report was prepared jointly by the USGS and Wisconsin Department of Natural Resources. This report summarized the streamflow and water-quality conditions during the study period and their effects on macroinvertebrates and smallmouth bass populations.

It was determined that the dissolved-oxygen concentration was the most detrimental water-quality constituent that is affecting smallmouth bass populations. Dissolved-oxygen concentration was reduced to below or near the lethal concentration of 1.0 milligram per liter at all four study streams on some occasions. Two fish kills were documented as the result of low dissolved-oxygen concentrations. These episodes of low dissolved-oxygen concentrations all occurred during or just after rising streamflows.

Streamflow also was determined to be important in determining smallmouth bass reproductive success. In years when overland runoff was greater than 0.10 inch from mid-May to mid-July, smallmouth bass reproductive success was severely restricted. In those years where runoff exceeded 0.10 inch, only zero to three age 0 smallmouth bass per acre were caught in late summer to fall sampling swings. Conversely when overland runoff was less than 0.10 inch, 32 to 279 age 0 smallmouth bass per acre were found in late summer or fall.

PLANS (July 1992 to June 1993): Continue streamflow water-quality and dissolved-oxygen monitoring at Rattlesnake Creek and Kuenster Creek. These stations will be used to evaluate best management practices in the Lower Grant River Priority Watershed Project. Publish report as a U.S. Geological Survey Water-Resources Investigations Report.

COOPERATOR:

Wisconsin Department of Natural Resources

LOCATION:

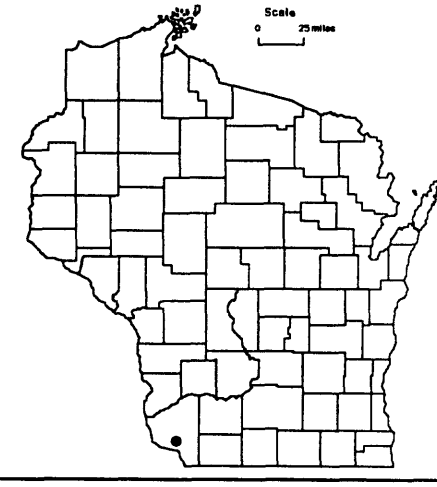
Four streams in southwestern Wisconsin: Little Platte River near Platteville, Rattlesnake Creek near North Andover, Sinsinawa River near Hazel Green, and the Livingston Branch of the Pecatonica River near Livingston.

PROJECT CHIEF:

David J. Graczyk

PERIOD OF PROJECT:

July 1987 to September 1992



REPORTS:

Graczyk, D.J., Surface-water hydrology and quality and macroinvertebrate and smallmouth bass populations in four stream basins in southwestern Wisconsin, 1987-90: U.S. Geological Survey Water-Resources Investigations Report (in review).

Mason, John W., Graczyk, David J., and Kerr, Roger A., 1991, Effects of runoff on smallmouth bass populations in four southwestern Wisconsin streams: in D. Jackson (ed), First International Smallmouth Bass Symposium, Nashville, Tennessee, August 24-26, 1989, Mississippi State University, Mississippi, p. 28-38.

Graczyk, D.J., and Sonzogni, W.C., 1991, Reduction of dissolved oxygen concentration in Wisconsin streams during summer runoff: Journal of Environmental Quality, v. 20, no. 2, p. 445-451.

EVALUATION OF THE SAND AND GRAVEL AQUIFER IN THE PREGLACIAL BEDROCK VALLEY OF SOUTHERN WAUKESHA COUNTY, WISCONSIN, WI 158

PROBLEM: An alternative water source, such as a shallow ground-water aquifer, is needed because increasing municipal pumpage from the deep sandstone aquifer in southern Waukesha County, is accelerating the present rate of water-level decline in this aquifer. Concentrations of naturally occurring radium in water from the sandstone aquifer also have exceeded drinking-water standards.

OBJECTIVE: The objective of this study is to better understand the shallow ground-water system and aquifer characteristics of glacial deposits in a preglacial bedrock valley in southern Waukesha County.

APPROACH: Data from five test holes, geophysical surveys, and existing drillers' well construction reports were compiled to map the bedrock surface. A map of the saturated thickness of glacial deposits was compiled from this map and a previously published water-table map. The texture and thickness of glacial deposits were described at the five test-hole locations. An aquifer test and a slug test were conducted to determine the hydraulic properties of glacial deposits at two test-hole locations.

PROGRESS (July 1991 to June 1992): All data collected during this study were compiled and a U.S. Geological Survey Water-Resources Investigations Report was written to present the results. It was determined that glacial deposits found at all test-hole sites were not suitable for providing the high pumpage rates needed for a large-scale aquifer test to determine aquifer properties and boundary conditions in the shallow aquifer system. As a result, five additional geophysical surveys were conducted to identify one or two sites for additional test-hole drilling.

PLANS: No further plans or funding presently exist for this project.

REPORTS:

Batten, W.G., and Conlon, T.D., Hydrogeology of glacial deposits in a preglacial bedrock valley, Waukesha County, Wisconsin (in review).

COOPERATOR:

Waukesha Water Utility

LOCATION:

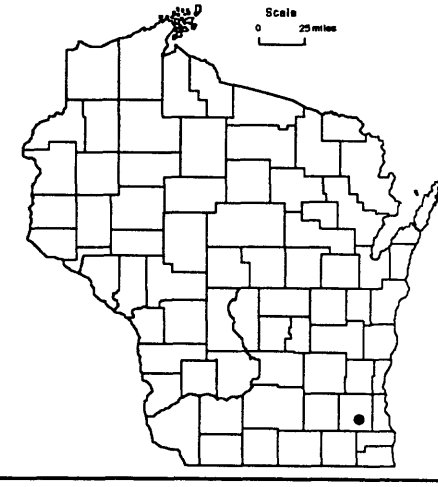
Southern Waukesha County

PROJECT CHIEF:

William G. Batten

PERIOD OF PROJECT:

October 1987 to September 1991



ASSESSMENT OF THE HYDROLOGY AND WATER QUALITY OF WIND LAKE, WI 159

COOPERATOR:
Wind Lake Management District

LOCATION:
Racine County,
southeast Wisconsin

PROJECT CHIEF:
Stephen J. Field

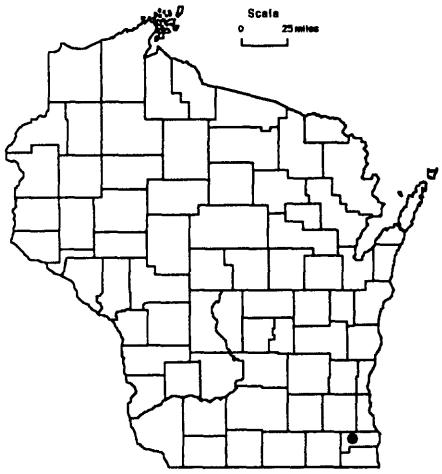
PERIOD OF PROJECT:
October 1987 to September 1989

PROBLEM: Wind Lake is a eutrophic lake where severe algal blooms occur. Phosphorus sources and loads need to be identified in order to develop a comprehensive management plan to improve the water quality of the lake.

OBJECTIVE: To determine for the 1988 water year (1) phosphorus loads into the lake from surface water, ground water, and precipitation, (2) phosphorus loads from internal recycling, (3) characteristics of the bottom lake sediments, (4) physiochemical characteristics of the water column, (5) phytoplankton and zooplankton present, and (6) phosphorus discharges from the lake in surface water and ground water. In the 1989 water year, determine (1) phosphorus loads into the lake from surface water, ground water, and precipitation, (2) physiochemical characteristics of the water column, and (3) phosphorus discharges from the lake in surface water.

APPROACH:

1. Monitor streamflow and phosphorus loads at the inlet and outlet.
2. Monitor lake stage.
3. Sample bottom lake sediments during winter to determine percent moisture, total phosphorus, iron, and manganese.
4. Monitor five minipiezometers to determine the ground-water discharge and recharge areas.
5. Determine physiochemical characteristics of lake-water column.
6. During ice-free periods, record precipitation at three sites and evaporation at one site.
7. Identify and quantify phytoplankton and zooplankton populations.
8. Prepare an annual hydrologic and phosphorus budget.



PROGRESS (July 1991 to June 1992): A report describing the results of the study was approved for publication. Recommended changes have been made.

PLANS (July 1992 to June 1993): The report will be published.

REPORTS:

Field, Stephen J., Hydrology and water quality of Wind Lake in southeastern Wisconsin: U.S. Geological Survey Water-Resources Investigations Report 91-4107 (in preparation).

BALSAM LAKE WATER AND PHOSPHORUS BUDGETS, WI 160

PROBLEM: Local residents and property owners along Balsam Lake have perceived a degradation in lake-water quality in recent (last five) years. Rice Creek, the only significant stream discharging to Little Balsam Lake, is considered to be a likely source of phosphorus input to the lake. Rice Lake, a shallow lake through which Rice Creek flows, is also believed by local residents to have experienced deteriorating water quality in recent years. There is speculation that sewage-treatment plant effluent is enriching the waters of Rice Creek and ultimately Balsam Lake. Ground water may be a significant source of phosphorus to the lake. There are limited data that suggest that concentration of phosphorus in ground water in the Polk County area is greater than in the rest of the State. A preliminary assessment indicates that more than half of the water entering Balsam Lake is ground-water discharge.

OBJECTIVE: Determine monthly and annual water and phosphorus budgets for Balsam Lake and identify the sources of phosphorus in the Rice Creek watershed.

APPROACH: Water and phosphorus budget components to be quantified are (1) change in lake storage, (2) precipitation, (3) surface inflow, (4) ground-water inflow, (5) evaporation, (6) surface outflow, and (7) ground-water outflow. Change in lake storage will be determined by monitoring lake stage. Surface inflows and outflows will be determined by operating two continuous and one intermittent gaging stations. Evaporation will be estimated by applying lake/pan coefficients to class A pan-evaporation values. Ground-water inflows and outflows will be estimated by Darcy equation calculations. Hydraulic-gradient data will be determined from a network of in- and near-lake piezometers. Phosphorus-budget components will be quantified for all of the water-budget components except evaporation. Water associated with each of the components will be sampled and analyzed for total-phosphorus concentration. Sources of phosphorus in the Rice Creek watershed will be identified by streamflow and phosphorus-concentration monitoring at four stream sites in the Rice Creek watershed.

PROGRESS (July 1991 to June 1992): The final report was approved for publication.

PLANS (July 1992 to June 1993): The final report will be published.

REPORTS:

Rose, William J., Water and phosphorus budgets and trophic state, Balsam Lake, northwestern Wisconsin, 1987-89, U.S. Geological Survey Water-Resources Investigations Report 91-4125 (in preparation).

COOPERATOR:

Balsam Lake Protection and Rehabilitation District

LOCATION:

Polk County, northwestern Wisconsin

PROJECT CHIEF:

William J. Rose

PERIOD OF PROJECT:

November 1987 to September 1990

PCB AND OTHER CONTAMINANT LOADS TO GREEN BAY, LAKE MICHIGAN, WI 161

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Green Bay watershed tributaries, Northeast Wisconsin and Upper Peninsula Michigan.

PROJECT CHIEFS:
Peter E. Hughes and
Leo B. House

PERIOD OF PROJECT:
July 1987 to September 1992

PROBLEM: Green Bay is an arm of Lake Michigan. There is a significant polychlorinated biphenyls (PCB's) presence in the fish biomass and bottom sediments of the Bay. The Fox, Menominee, Oconto, Peshtigo, and Escanaba Rivers have been identified as sources of PCB's to the Bay. The U.S. Environmental Protection Agency (EPA) is conducting a mass-balance evaluation of the PCB's entering and cycling through the ecosystem of the Bay.

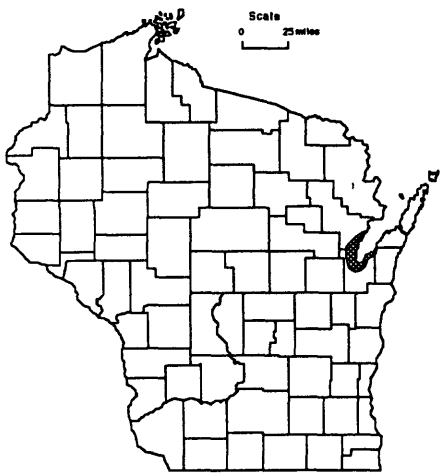
OBJECTIVE: The objective of this study is to determine the load of PCB's and other selected contaminants into Green Bay from its major tributaries. This information will be used as input to the EPA's comprehensive mass-balance study of Green Bay. An additional objective is to evaluate methods used to compute the contaminant loads at the Fox River mouth site.

APPROACH: Water samples will be collected and analyzed for PCB's and lead concentrations from five major tributaries to Green Bay. These are the Fox River at DePere and at the mouth, the Menominee River at Marinette, the Escanaba River at Escanaba, the Oconto River at Oconto, and the Peshtigo River at Peshtigo. Samples will be collected weekly on the Fox and Menominee Rivers during non-winter periods, and approximately once per month during the winter. Samples will be collected once per month at the other sites. Streamflow-monitoring and suspended-sediment (or suspended solids) sampling stations will be installed on each river. Contaminant loads will be determined by a USGS regression method, using the contaminant concentration results and corresponding discharge data. The data-collection period is anticipated to run from April 1989 through April 1990.

PROGRESS (July 1991 to June 1992): Discharge records were published in the annual report, "Water Resources Data—Wisconsin, Water Year 1991," for all sites except the Fox River mouth. Water-quality data for all inorganic substances were also published for these sites. All data collected and analyzed by the USGS has been provided to the EPA.

PLANS (July 1992 to June 1993): PCB loads will be computed after all sample result data has been received and all discharge records are finalized. The contaminant loads computed for the Fox River mouth will be compared to those estimated by the use of urban-runoff models (and added to the computed loads for the Fox River at DePere site). The PCB concentration data will be published in the annual report, "Water Resources Data—Wisconsin, Water Year 1992."

A summary report will be prepared to describe the field methods used to collect PCB samples and to present the PCB load computed for each tributary. A separate report or journal article will be prepared to present the evaluation of alternative methods to determine PCB load at the Fox River mouth.



CEDAR CREEK MASS BALANCE STUDY, WI 16101

PROBLEM: Cedar Creek is a tributary to the Milwaukee River. It's waters are exposed to sediments contaminated with varying concentrations of polychlorinated biphenyls (PCB's). Conditions in the system have led to fish and waterfowl consumption advisories due to elevated limits of PCB's in the tissue. The Wisconsin Department of Natural Resources (WDNR) is conducting a mass-balance evaluation of the PCB transport through the lower Cedar Creek system in the Cedarburg area.

OBJECTIVE: The objective of this study is to collect PCB samples downstream from each of the impoundments and determine the total PCB load from Cedar Creek into the Milwaukee River. This information will be used as input to the WDNR's mass-balance study.

APPROACH: Water samples will be collected and analyzed at five sites on Cedar Creek. The most upstream site at Highway 60 will be used to monitor streamflow, water temperature, rainfall, and total suspended solids on a continuous basis. PCB and suspended solids will be collected downstream of four of the impoundments on an event basis. The Green Bay road site will also have an automatic sampler for continuous suspended-solid samples. The data-collection period will be from October 1990 through September 1991.

PROGRESS (October 1990 to June 1992): Discharge records were published in the annual report, "Water Resources Data—Wisconsin, water year 1991". Water-quality data for all inorganic substances were also published for these sites. All data collected and analyzed by the USGS has been provided to WDNR.

PLANS (July 1992 to June 1993): Discharge-data collection at the Highway 60 site will be continued through the 1992 water year, PCB sample concentration data collected from October 1990 to September 1991 will be published in the annual report, "Water Resources Data—Wisconsin, water year 1992."

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Cedar Creek at Cedarburg, southeast Wisconsin

PROJECT CHIEF:
Peter E. Hughes

PERIOD OF PROJECT:
October 1990-September 1991

ROLES OF GROUND-WATER TRANSPORT AND LAKE-SEDIMENT SORPTION PROCESSES IN MERCURY CYCLING IN NORTHERN WISCONSIN LAKES, WI 163

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Vilas County, Wisconsin

PROJECT CHIEF:
John F. Elder

PERIOD OF PROJECT:
July 1988 to December 1991

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.

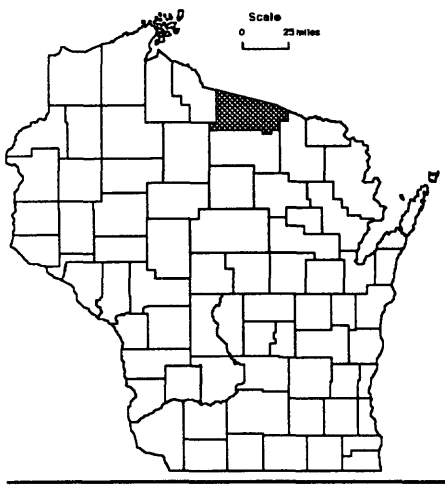
OBJECTIVE: (1) Determine ground-water contributions to the hydrologic budget in each of five study lakes in Vilas County, (2) determine ground-water contributions to the inputs and losses of mercury in each lake, (3) describe the speciation of mercury and the distribution of methyl mercury in the bottom sediments of the study lakes, particularly as influenced by the presence of other trace elements.

APPROACH: Five lakes in north-central Wisconsin were selected for this study of sources, distribution, transport and speciation of mercury. The lakes have different pH levels and dissolved organic carbon concentrations. All are seepage lakes; hence, the ground-water inflows and outflows constitute important parts of the hydrologic budgets of the lakes. Piezometers and well nests were installed to establish a data base sufficient to describe the ground-water-flow system in the watershed of each lake. Special noncontaminating wells were installed for collecting samples for mercury analysis.

Bottom-sediment cores are collected from established sites in the study lakes, and analyzed for total and methyl mercury and other trace elements. Organic carbon content and grain-size distribution of the sediments are also analyzed to determine the importance of these factors in affecting the distribution and speciation of elements.

PROGRESS (July 1991 to June 1992): Data compilation and analysis from field sampling and experimentation were completed. Report manuscripts were written, colleague and editorial reviews done, and manuscripts were revised to incorporate review suggestions.

PLANS (July 1992 to June 1993): Reports to be submitted for publication in journals.



REPORTS:

Elder, John F., Distribution, seasonal variation, and grain-size partitioning of major and trace elements in bottom sediments of two northern Wisconsin lakes and their potential effects of mercury cycling. Journal article in preparation.

Krabbenhoft, David P., Use of oxygen-18 and deuterium to assess the hydrology of ground-water/lake systems. Chapter for ACS book, Environmental Chemistry of Lakes and Reservoirs, L.A. Baker, editor, to be published in 1992.

Krabbenhoft, David P., and Babiarz, Christopher L., The role of ground-water transport in aquatic mercury cycling. Journal article submitted to Water Resources Research (in review).

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 and 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 1991 to June 1992):

Byron Salvage Yard

The following work was conducted at the Byron Salvage Yard, Byron, Illinois:

1. Five holes were drilled into unconsolidated deposits. Water-table wells were installed in four of these holes.

2. Four boreholes were drilled into unconsolidated deposits and surface casings were installed.

3. Three bedrock wells were installed.

4. Two double-nested bedrock wells were installed.

5. Two selective formation packer tests were conducted.

6. Well completion forms and construction schematics were completed for all wells drilled and constructed.

Parson's Casket

The following work was conducted at Parson's Casket, Belvedere, Illinois:

1. Two selective formation tests were conducted and water samples were collected during each test.

2. Two bedrock wells were constructed.

3. Well completion forms and construction schematics were completed for all wells constructed.

PLANS (July 1992 to June 1993): A study to characterize the Galena-Platteville Dolomite will be initiated. The drilling and installation of monitor wells at the site in Medford, Wisconsin, will be initiated.

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

BEST MANAGEMENT PRACTICE EVALUATION, WI 166

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
State of Wisconsin

PROJECT CHIEF:
John F. Walker

PERIOD OF PROJECT:
July 1989 to September 1994

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.

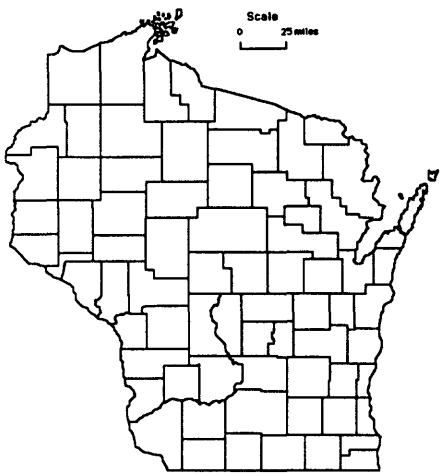
OBJECTIVE: Investigate statistical analysis techniques for assessing trends in water quality due to Best Management Practice (BMP) implementation using data from other States. The effectiveness of BMP's in two urban basins and seven rural basins in Wisconsin will be determined using the identified statistical 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 1991 to June 1992): A draft report describing the statistical techniques was revised and sent out for review. An annual progress report was prepared describing the data-collection activities in all of the nonpoint projects. Data-collection activities for an urban site in Madison were transferred to project WI 169.

PLANS (July 1992 to June 1993): Complete review process for report and submit to an appropriate journal for publication. Prepare annual progress report for all nonpoint projects.

REPORTS:
Walker, J.F., Techniques for detecting trends in stream-water quality caused by changes in land management (in review).



MOBILITY OF POLYCHLORINATED BIPHENYLS (PCB's) FROM BOTTOM SEDIMENTS TO WATER IN AN INDUSTRIALIZED RIVER BASIN, WI 167

PROBLEM: An extensive investigation is being made of PCB's and other toxic materials in Green Bay, an arm of Lake Michigan. A goal of the study is to develop and test a model that can identify sources, describe relative significance of sources, and predict the response of the ecosystem to proposed regulatory actions. To achieve this goal, it will be necessary to obtain quantitative information about loadings of contaminants from the numerous tributaries of the Bay.

OBJECTIVE: Describe the capacity for flux of PCB's between bottom sediments and the water column of the Lower Fox River. Determine distribution coefficients for sediment-associated PCB congeners in Fox River sediment-water systems. Determine the importance of factors that may influence PCB distributions, including ground-water inflow, biological activity, and physical characteristics of the sediments.

APPROACH: Sediments and water are collected from the Lower Fox River system for use in laboratory experiments. The experiments consist of measurement of phase transfers and transport of 2,2',5,5'-tetrachlorobiphenyl (TCB), labeled with carbon-14. Two types of experiments are used—elution and advection. In the elution experiments, native water is pumped at controlled flow rates through columns containing sediments amended with a known activity of labelled TCB. Based on the distribution of TCB and the fraction of organic carbon in the sediments, distribution coefficients (K_d) and soil sorption coefficients (K_{oc}) can be determined. In the advection experiments, labelled TCB is placed as a point source at the base of an undisturbed sediment column. Movement of the labelled compound is measured after a long-term (many weeks) incubation period.

PROGRESS (July 1991 to June 1992): Data compilation and analysis from experimental work were completed. Report manuscript was written, colleague and editorial reviews were completed, and manuscript was revised to incorporate reviewer suggestions.

PLANS (July 1992 to June 1993): Report to be submitted for publication in journal. All data produced by the study will be made available to the cooperator.

REPORTS:

Elder, John F., James, Ronald V., and Steuer, Jeffrey J., Mobility of 2,2',5,5'-tetrachlorobiphenyl in model systems containing bottom sediments and water from an industrialized river basin in northeastern Wisconsin.

COOPERATOR:

Wisconsin Department of Natural Resources

LOCATION:

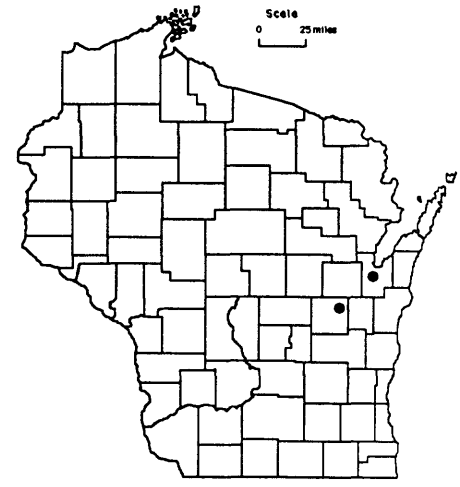
Fox River and Little Lake Butte des Morts, northeast Wisconsin

PROJECT CHIEF:

John F. Elder

PERIOD OF PROJECT:

May 1989 to September 1991



EVALUATING BEST MANAGEMENT PRACTICES IN THE BLACK EARTH CREEK BASIN, WI 168

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Three streams near Cross Plains, Wisconsin: Garfoot Creek, Brewery Creek and Black Earth Creek

PROJECT CHIEF:
David J. Graczyk

PERIOD OF PROJECT:
July 1989 to September 1996

PROBLEM: In many basins, nonpoint-source pollution accounts for a substantial portion of the water-quality problems. The nonpoint program in Wisconsin provides matching money for voluntary implementation of various best management practices (BMP's). In most instances, the effectiveness of the best management practices is not known with certainty. Thus, an evaluation of the effectiveness is an important part of the management process.

OBJECTIVE: To determine if dissolved-oxygen characteristics and concentrations of suspended sediment, nitrogen and phosphorus in the streams change after best management practices (BMP's) are implemented.

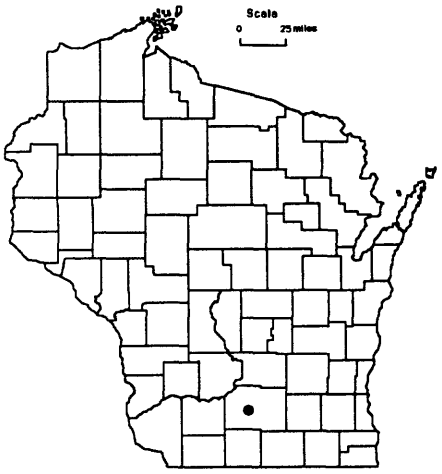
APPROACH: Continuous-recording streamflow-gaging stations will be installed at five sites. Two of these sites will be equipped with automatic refrigerated samplers. These two sites were monitored in a previous USGS study. Ten to fifteen storms will be sampled and loads calculated for individual storm events. One analysis technique will use regressions to remove the natural variability; changes are detected by applying the Wilcoxon rank-sum test to the regression residuals.

Dissolved oxygen will be monitored at five sites. This data will be used to investigate trends in dissolved-oxygen concentrations.

PROGRESS (July 1991 to June 1992): Continued streamflow, water-quality and dissolved-oxygen monitoring at five sites in the Black Earth Creek basin. All data was summarized and will be published in the "Water Resources Data—Wisconsin" reports for water years 1990 and 1991. Water-quality loads were calculated for selected parameters and storm periods at Garfoot and Brewery Creek.

PLANS (July 1992 to June 1993): Continue streamflow, water-quality and dissolved-oxygen monitoring at the five sites. Water-quality loads for selected parameters and storm periods will be compared to data collected in water years 1985 and 1986.

A journal article will be prepared that will compare the regression residuals from the data before the BMP's were installed to the regression residuals during BMP installation.



REPORTS:
Walker, J.F., and Graczyk, D.J., Evaluation of changes in water quality after best management practice implementation in the Black Earth Creek watershed (in preparation).

EVALUATING THE TOXICITY OF URBAN RUNOFF, WI 169

PROBLEM: An evaluation of the toxic nature of urban runoff is needed to effectively manage nonpoint-source pollution and determine if urban runoff exceeds Wisconsin toxic water-quality standards. The nonpoint program operated by the Wisconsin Department of Natural Resources (WDNR) provides matching money to individuals and municipalities for implementation of management practices designed to reduce pollution from nonpoint sources. Because the program is voluntary, the need for such measures must be identified. Currently, many municipalities feel that the quality of urban runoff is within toxic standards set by the State of Wisconsin. An evaluation of the toxic nature of urban runoff will provide needed information to the municipalities and WDNR.

OBJECTIVE: The main objective of this project is to determine if urban storm-water runoff violates Wisconsin's water-quality standards for toxic substances. A second objective is to determine the concentration of priority pollutants in the bottom sediments of three urban streams.

APPROACH: To accomplish the first objective, four gaging stations will be established in the city of Milwaukee. Two sites will be located on storm sewers to monitor a residential and a commercial basin. The other two sites will be on Underwood Creek and Noyes Creek. Flow composite samples will be obtained for 10 runoff events using automatic samplers. Each sample will be analyzed for priority pollutants, bacteria, solids, and acute toxicity. Analytical data will be compared to water-quality standards for toxic substances. An attempt will be made to relate instances when water-quality standards are exceeded to characteristics of storms (recurrence interval, duration).

Samples of bottom sediments from the Milwaukee River, Menomonee River, and Lilly Creek will be analyzed for priority pollutants.

PROGRESS (July 1991 to June 1992): A report describing the results of the study has been written.

PLANS (July 1992 to June 1993): Publish the results of the study as a journal article.

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
City of Milwaukee, Wisconsin

PROJECT CHIEF:
Peter E. Hughes

PERIOD OF PROJECT:
October 1989 to June 1991

HYDROLOGIC INVESTIGATIONS OF WETLAND RESTORATION AND CREATION PROJECTS, WI 170

COOPERATORS:
Wisconsin Department of Transportation

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

PROJECT CHIEF:
David P. Krabbenhoft

PERIOD OF PROJECT:
November 1989 to September 1996

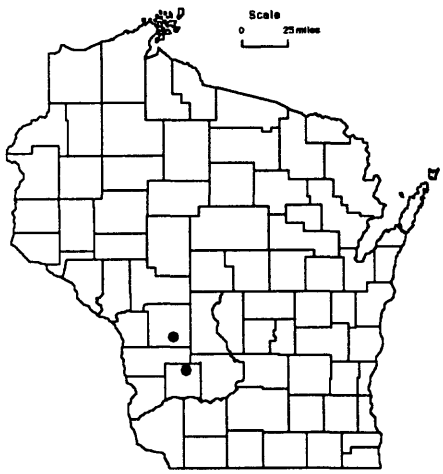
PROBLEM: Agencies charged with mitigating wetland acreage losses due to construction projects are increasingly turning to wetland restoration and creation as a means of meeting requirements of Section 404 of the Clean Water Act. However, the hydrology and hydrogeology of wetlands is complex and not well 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 1991 to June 1992): The first phase of this project was to conduct an in-depth literature review, and status of the science assessment for wetland hydrology and wetland restoration and creation. Sites were selected in the summer of 1990 and initial instrumentation networks were established at both sites. The creation site was constructed by using earth-moving equipment in the summer and fall of 1991.

PLANS (July 1992 to June 1993): Additional instrumentation will be employed in the spring of 1992 to initiate the comparative hydrologic and geochemical research. Deep wells into the bedrock underlying the site will be drilled in late winter 1992.



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 1991 to June 1992): Results of the models indicated that sediment-related factors were of importance to brown and brook trout in several streams in the Kickapoo and Trempealeau river basins. Habitat data-collection methods were then revised to allow for collection of more accurate and suitable data for model input. Using the revised methods, the USGS collected habitat data in two streams in the Chippewa River basin. HSI models, including sensitivity analyses, have been applied for four fish species known to occur in the river basin. Results are being interpreted and the utility of the models for estimating sediment-reduction goals evaluated for the Nonpoint-Source Program.

PLANS: Project will be completed as of June 30, 1992.

REPORTS:

Scudder, Barbara, Utility of U.S. Fish and Wildlife Service habitat suitability index models for establishing sediment-reduction goals.

COOPERATOR:

Wisconsin Department of Natural Resources

LOCATION:

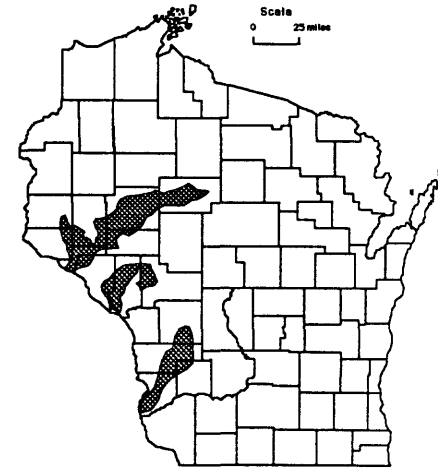
Chippewa, Kickapoo, Trempealeau River basins in western Wisconsin

PROJECT CHIEF:

Barbara C. Scudder

PERIOD OF PROJECT:

July 1990 to July 1992



TRENDS IN WATER QUALITY AND STREAM HABITAT FOR PRIORITY WATERSHEDS, WI 172

COOPERATOR:
Wisconsin Department of Natural Resources

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

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

PERIOD OF PROJECT:
October 1990 to September 1997

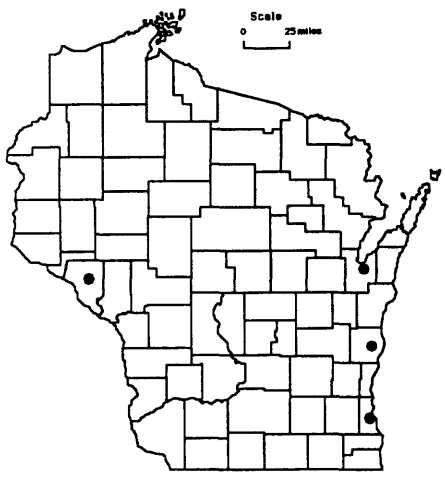
PROBLEM: An evaluation strategy is needed to assess the effectiveness of nonpoint-source pollution control measures in priority watersheds. Several important processes require research including the role of ground water in nonpoint-source contamination, factors leading to dissolved-oxygen reduction in 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 streamwater 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 five sites during and after implementation of improved land-management practices in four priority watersheds.

APPROACH: Five streams were selected in four 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.

PROGRESS (July 1991 to June 1992): Continued streamflow, water-quality and dissolved-oxygen monitoring at five sites in the priority watersheds. All data was summarized and will be published in the "Water Resources Data—Wisconsin" report for water year 1991. Water-quality loads were calculated for selected parameters and storm periods for the five sites.

PLANS (July 1992 to June 1993): Continue streamflow, water-quality (for the five sites), and dissolved-oxygen (at four sites) monitoring. Water-quality loads for selected parameters and storm periods will be calculated and compared to data collected in 1991. The data will be analyzed to determine if there are any apparent trends in water quality during implementation of the best management plans.



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 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).

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

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 1991 to June 1992): The one-year data-collection phase of the study was completed October 31, 1991. Precipitation, streamflow, lake-stage and phosphorus-concentration data were published in the report "Water Resources Data—Wisconsin, Water Year 1991." Interpretation of data and preparation of a final report is partially completed.

PLANS (July 1992 to June 1993): 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 ground-water 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 collected in late July at 3-hour intervals at each of the four lake-monitoring sites.

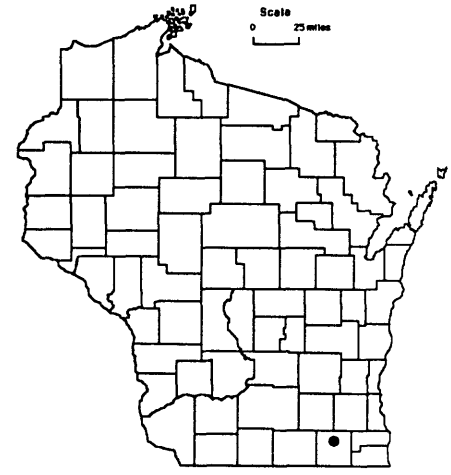
Trophic status: The trophic status of the lake will be evaluated according to Carlson's Trophic-State Index (1977) and by use of other empirical models.

COOPERATOR:
Whitewater Lake Management District

LOCATION:
Whitewater Lake, Walworth County

PROJECT CHIEF:
Stephen J. Field, Jerry Goddard

PERIOD OF PROJECT:
October 1990 to September 1992



PROGRESS (July 1991 to June 1992): All monitoring done as scheduled. All data except ground water has been compiled.

PLANS (July 1992 to June 1993): All data will be published in the annual report "Water Resources Data—Wisconsin." A final report will be published as a U.S. Geological Survey Open-File Report.

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 1991 to June 1992): Streamflow and water quality were monitored at Silver Creek near Ripon, and Green Lake inlet near Green Lake.

Loads were computed for suspended sediment and total phosphorus for Silver Creek near Ripon. Annual yields were: total phosphorus, 218 pounds per square mile; and suspended sediment, 17.7 tons per square mile. At Green Lake inlet near Green Lake, annual yields were: total phosphorus, 156 pounds per square mile; and suspended sediment, 11.3 tons per square mile.

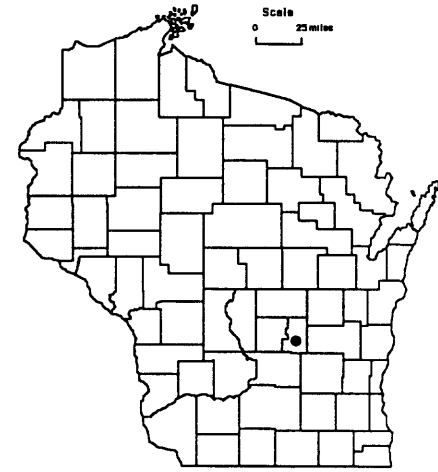
PLANS (July 1992 to June 1993): Continue monitoring streamflow and water quality at Silver Creek near Ripon and Green Lake inlet near Green Lake. All data will be published in the annual "Water Resources Data—Wisconsin" report.

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) has suggested pumping phosphorus-rich water from near the lake bottom during late summer as a "passive" way of reducing the phosphorus available for algal growth. It is proposed that phosphorus-rich water be pumped out of the lake for a four- to six-week period each fall for several years. It is essential to understand the hydrology of Devil's Lake and assess the effects of pumping on lake stage before pumping is initiated.

OBJECTIVE: The objectives are to determine the hydraulic parameters and budget components of Devil's Lake and to simulate the rate of lake-stage recovery from pumping during extreme wet and dry years. The simulated recovery rates will be used by WDNR to determine if the Devil's Lake system can satisfactorily recover from the effects of pumping water from the lake.

APPROACH: The hydrologic budget can be described as follows:

$$S = P + SWI + GWI - E - SWO - GWO - Pump$$

where

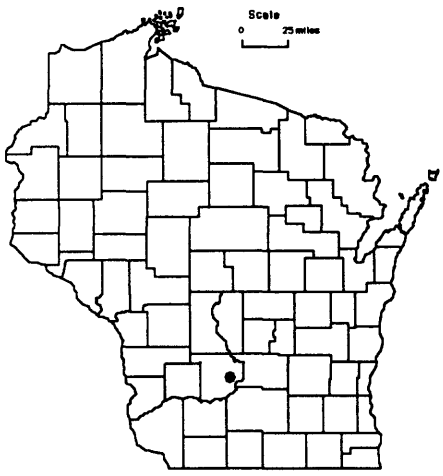
S = change in lake storage,
P = precipitation falling directly on the lake,
SWI = surface-water flow into the lake
GWI = ground-water seepage into the lake
E = water evaporated from the lake surface
SWO = surface-water flow out of the lake
GWO = ground-water seepage out of the lake
Pump = water pumped during four- to six-week period in late summer

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. Two in-lake staff gages 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 (SWI) will be determined from intermittent discharge measurements of the small spring creek entering the southwest edge of the lake. Estimates of overland flow 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 the lake (GWI) will be determined using Darcy's Law calculations. Data for these calculations will be obtained from head-difference values measured in piezometers installed adjacent to the lake and from infiltometer tests of lake-bottom materials along the edge of the lake.

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

Surface-water outflow (SWO) does not appear to be a significant water budget component. However, there may be some measurable lake outflow at the northeast end of the lake when lake stage is high or a storm event occurs. This component will be measured only as necessary.

Ground-water seepage out of the lake (GWO) will be determined using the same methods as ground-water inflow.

Ground-water seepage through the crystalline quartzite on the east and west sides of the lake is probably insignificant. However, where possible, piezometers will be installed along these two sides of the lake.

The amount of pumpage from the lake (Pump) will be provided by DNR for the pumpage period.

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, such as hydraulic conductivity, will be made as necessary to make simulated stage hydrographs agree with historical stage data for Devil's Lake.

Pumpage will be added to the calibrated water-budget model to simulate lake-stage recovery from pumping under two climatic scenarios. The first will simulate recovery over an 11-month period following a month of pumping with, for example, 40 percent lower than average precipitation, and the second for a similar period with 20 percent above average precipitation. The change in lake stage will be determined during each of these two 11-month periods.

PROGRESS (July 1991 to June 1992): A monitoring station was installed in July 1991 to monitor changes in lake stage, ground-water levels in a shallow observation well, and precipitation every 15 minutes. All historical climate data from nearby weather stations and Devil's Lake stage data were collected. These data were used in a simple spread-sheet model to test the utility of a simple model for predicting lake stage. It was determined that a more refined model will be needed. A FORTRAN program was written to include more budget variables.

Nine shallow piezometers were installed in February 1992 along the perimeter of the lake to measure and compare lake stage to ground-water levels at these sites. These measurements will be used to determine areas and amounts of ground-water inflow and outflow to the lake for the winter period prior to spring recharge.

PLANS (July 1992 to June 1993): Lake stage, ground-water levels, and precipitation will continue to be monitored on a continuous basis through December 1992. Data will be compiled and values for each of the water-budget terms will be determined. The FORTRAN program will be used with this data to simulate lake-stage fluctuations and calibrated with historical and lake-stage data collected during this study. After calibration, the model will be run to predict lake-stage recovery under two climatic scenarios. One scenario will simulate recovery during a period of below-average precipitation and the other will simulate recovery during a period of above-normal precipitation.

Results of the study will be written as a U.S. Geological Survey Water-Resources Investigations Report with approval for publication by October 1993.

NATIONAL WATER-QUALITY ASSESSMENT (NAWQA) OF WESTERN LAKE MICHIGAN DRAINAGES, 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 homogenous subareas of specific land use and environmental characteristics. Identification of these subareas is accomplished by stratifying the study unit into subcategories. Stratification relies on geographical information system technology using digital coverages of environmental variables and land use. The homogenous areas identified with this process (indicator sites) will be incorporated into a complex nested study design of surface-water, streambed sediment, and biological sampling. The sampling strategy consists of a reconnaissance of water quality within the study unit, and a sampling to determine the occurrence and distribution of organic and inorganic constituents in streambed sediments and tissues. Basic fixed-site monitoring of indicator sites, as well as monitoring of drainage basins having heterogeneous land use and environmental variables (integrator sites), will be instituted for two years beginning in FY 1993. Monthly surface-water sampling will be augmented with five to eight event-related samples at both indicator and integrator sites. A subset of these sites (intensive fixed sites) will be sampled seasonally. This component will be accomplished with weekly and/or daily sample collection during a 3- to 9-month period. Other program components include determining the spatial distribution in water and streambed sediments of constituents identified during occurrence survey. This synoptic sampling will focus on sources and transport of selected constituents. Ecological surveys at 50 to 80 sites will evaluate community structure and habitat in relation to land use and other environmental factors. This evaluation likely will occur during FY 1995. Selected ground-water studies also will occur with the evaluation of surface-water/ground-water interaction using shallow wells and lysimeters installed adjacent to selected stream reaches. Effects of land use on ground-water quality will be assessed through sampling of targeted ground water in specific environmental settings.

COOPERATOR:

U.S. Geological Survey
Reston, Virginia

LOCATIONS:

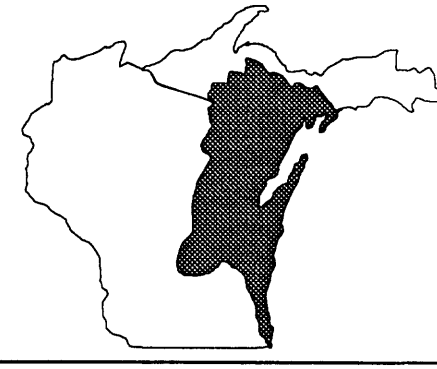
Upper peninsula of Michigan from the Menominee River basin in the west to the Fishdam River basin in the east; and the eastern portion of Wisconsin to include the Menominee, Oconto, Peshtigo, Fox-Wolf River basins discharging to Green Bay, and in Wisconsin that directly drain into Lake Michigan from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

PROJECT CHIEF:

James G. Setmire

PERIOD OF PROJECT:

December 1990-Continuing



PROGRESS (July 1991 to June 1992): There were major revisions in the approach to the NAWQA study-unit investigations in December 1991. As a result of these revisions, a new work plan detailing the plans for FY 1992 was completed in February 1992. Development of a geographic information system data base has been proceeding and available data from QWDATA has been accessed. The second liaison committee meeting for the project was held on March 17, 1992.

PLANS (July 1992 to June 1993): A drive-by assessment of 100 sites is scheduled for May and June 1992, followed during the summer of 1992 by the on-site assessment. Plans to complete the occurrence survey in bed sediments and tissues also have been formulated and are awaiting funding approval. Implementation of other selected study components described in the approach will also commence during FY 1993.

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.

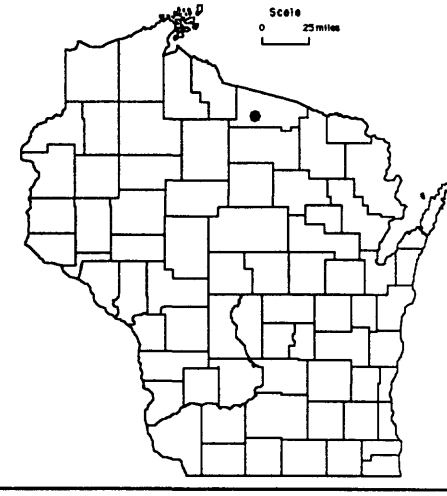
Investigation of geochemical processes that control transport of important chemical species across stream and lake sediments involves fine-scale sampling at the sediment/water interface. This is done by a variety of techniques, including membrane equilibrators, core squeezing, microprobes, and seepage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

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 to September 1993



PROGRESS (July 1991 to June 1992): A U.S. Geological Survey Open-File Report that describes the purpose, scope, design and approach of the study was written and printed. Water sampling at tributaries of Trout Lake was initiated in July, and continued monthly, with additional sampling during certain storms. The research plan for the Allequash Creek basin was developed, equipment was installed, and data collection began. Several sites along a longitudinal transect of Allequash Creek were sampled in autumn and spring to assess chemical changes from headwaters to mouth. A technician was hired, trained, and stationed at Trout Lake to oversee data-collection activities.

PLANS (July 1992 to June 1993): Hydrologic data collection and water sampling will continue as described above; the summer and autumn of 1992 will be an intense data-collection phase of the project. Reconnaissance of peatland characteristics and hydrology, aided by participation of personnel from the WRD National Research Program (NRP), is planned for summer 1992. Other work to be conducted by NRP personnel includes measurement of greenhouse gas flux between the unsaturated zone and the atmosphere, and isolation and characterization of organic matter involved in hydrologic transport of solutes.

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 (in press).

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).

Walker, J.F., Krabbenhoft, D.P., and Elder, J.F , 1992. Partitioning of precipitation into quick-response streamflow and recharge in temperate lake watersheds, northern Wisconsin (journal article, planned).

SOURCES OF POLLUTANTS IN URBAN RUNOFF, WI 176

PROBLEM: Urban storm-water-runoff quality has adversely impacted local lakes and streams. Identifying the pollutant sources that contribute the majority of pollutant load may offer a cost effective way of controlling the selected pollutant.

OBJECTIVE: Determine the concentration of selected contaminants in sheet flow from urban surfaces and evaluate the relative contributions of the contaminants from different types of surfaces.

APPROACH: Two small urban basins on the southwest side of Madison will be used for evaluation. Fifty-three source areas will be sampled for 10 runoff events between April 15 and June 30, 1991. Samples from streets, rooftops, parking lots, driveways, and lawns will be analyzed for solids, metals, bacteria, and phosphorus concentrations.

PROGRESS (July 1991 to June 1992): All samples were analyzed for the selected pollutants. Data analysis and final summary was completed.

PLANS (July 1992 to June 1993): Results of the study will be published as a journal article.

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
City of Madison, Wisconsin

PROJECT CHIEF:
David Owens

PERIOD OF PROJECT:
March 1991 to June 1992

THE RELATIONSHIP BETWEEN LAKE STAGE, GROUND-WATER LEVELS, AND AGRICULTURAL DRAINAGE DITCHES IN THE VICINITY OF PRETTY LAKE, WISCONSIN, WI 177

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Waukesha County, Wisconsin

PROJECT CHIEF:
Terrence Conlon

PERIOD OF PROJECT:
January 1991 to September 1995

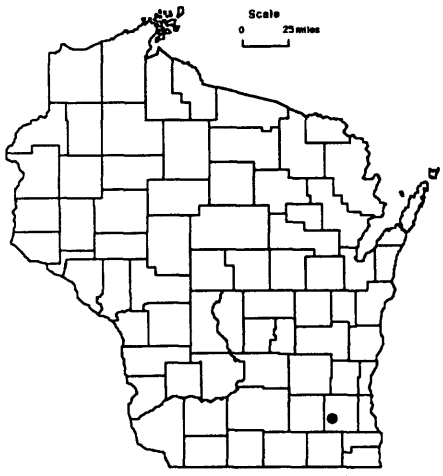
PROBLEM: Lake stage at Pretty Lake has declined despite above normal precipitation and baseflow in nearby streams. Agricultural ditches close to the lake are maintained to facilitate drainage and reduce water levels in wetland areas. The effect of these ditches on lake stage is not known but may be a factor in the decline of the lake stage.

OBJECTIVE: The study will determine the relation between the shallow ground-water system, Pretty Lake and agricultural drainage ditches. Field measurements will be used to verify an analytical solution or calibrate a digital model that may be used to predict the response of the water table and lake stage to changes in the water level of the ditch.

APPROACH: Precipitation rates, and water levels in the ditch, lake and a line of water-table wells between the ditch and lake will be measured before, during, and after the water level in the ditch is changed. The effect of the water level maintained in the ditch on the lake and water table will be evaluated by analysis of hydrographs. Water-level measurements will be used to verify an analytical solution or calibrate a digital model. The analytical solution or model will be used to predict response of the water table and lake stage to changes in the water level of the ditch.

PROGRESS: No work has been performed because of site-access problems.

PLANS (July 1992 to June 1993): After permission to access the study area is obtained, water-table wells and a lake gage will be installed and water levels will be regularly measured. A structure to regulate the water level in the ditch will be constructed.



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 1991 to June 1992): Refraction data along six lines were collected and interpreted. Contour maps of thickness of glacial deposits and bedrock topography were prepared. Observation wells at one location were installed and instrumented.

PLANS (July 1992 to June 1993): Observation wells and a large diameter pumping well will be installed and instrumented. Aquifer tests will be conducted at two locations while monitoring flow rates from springs. Results of aquifer tests will be analyzed and summarized in report.

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Sheboygan County, Wisconsin

PROJECT CHIEF:
Terrence Conlon

PERIOD OF PROJECT:
June 1991 to September 1993

TRANSPORT OF TRACE ORGANICS FROM THE SHEBOYGAN RIVER INTO LAKE MICHIGAN, WI 179

COOPERATOR:
Environmental Protection Agency

LOCATION:
City of Sheboygan

PROJECT CHIEF:
Peter E. Hughes

PERIOD OF PROJECT:
August 1991 to September 1993

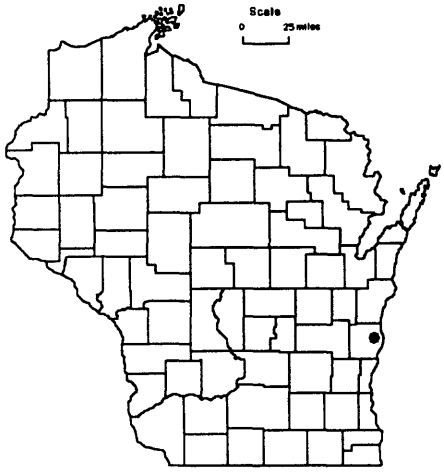
PROBLEM: The Sheboygan Harbor and River was designated as a Superfund site in 1986. Data collected as part of the remedial investigations program shows that PCB's, heavy metals, and pesticides are being transported via the river into Lake Michigan.

OBJECTIVE: Determine the load of selected contaminants entering Lake Michigan from the Sheboygan River from October 1991 through September 1992. The selected contaminants of the study are PCB's, heavy metals, polynuclear aromatic hydrocarbons (PAH's), and suspended solids.

APPROACH: An acoustic velocity monitoring station will be established at the mouth of the Sheboygan River. Storm-event samples using an automatic pump sampler will be collected for one year. Large volume samples for PCB analyses will be collected manually for eight events during this period. Samples will be analyzed for congener-specific PCB's, PAH's, heavy metals, and suspended solids.

PROGRESS (August 1991 to June 1992): All field equipment was installed and water-quality samples have been collected starting on April 30.

PLANS (July 1992 to June 1993): Continue with data collection and enter data into ADAPS and QW data systems.



MERCURY CYCLING IN LAKES — EFFECTS OF ACID PRECIPITATION ON ACIDIC LAKES IN NORTHERN WISCONSIN, WI 18001

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.

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 1991 to June 1992): Most monitoring emphasis was at Max Lake; lake stage and a single recorder-equipped well were monitored at Morgan Lake; and there was no monitoring at Honeysuckle Lake.

Ground water has intermittently discharged to Max Lake from a small region near the northeast side of the lake since June 1990. It is believed that this is "short-flow-path" ground water that may be chemically different than main-aquifer ground water. Water from selected piezometers in this region was analyzed to assess the significance of this ground-water discharge on lake chemistry.

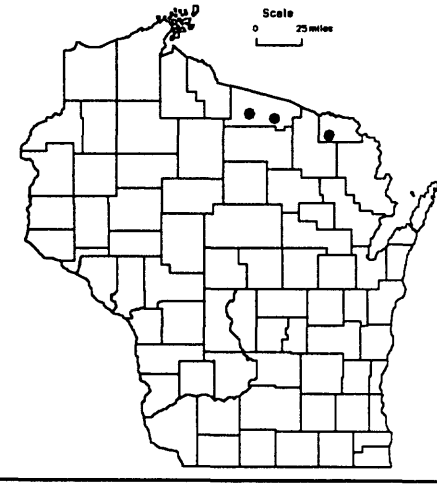
Ground water was pumped into Max Lake from May 8-29 and July 11 to August 3, 1991, at a 16 gallons-per-minute rate to maintain the lake's pH at 5.6. This was 46 percent as much pumping as was required the previous year to raise the lake's pH from 5.1 to 5.6 and maintain pH at 5.6.

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



Preliminary water budgets were prepared for Max Lake for water years 1989-91. During water years 1990 and 1991, precipitation accounted for 93 percent of the water entering the lake and ground-water pumping accounted for most of the remaining 7 percent. Ground-water discharge from the small transient flow region was not quantified, but is believed to be small compared to precipitation and pumped ground water.

PLANS (July 1992 to June 1993): Routine data collection will continue at approximately the same level as last year. Max Lake's pH will be raised from 5.6 to 6.1 and maintained at 6.1 by intermittent ground-water pumping. Preliminary water budgets will be computed for all three lakes.

MERCURY CYCLING IN LAKES — HYDROLOGIC CONSIDERATIONS ASSOCIATED WITH THE ARTIFICIAL ACIDIFICATION OF LITTLE ROCK LAKE IN VILAS COUNTY, WI 18002

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 1991 to June 1992): Routine hydrologic monitoring continued but, starting October 1, 1991, hydrologic studies at Little Rock Lake became a part of the "Mercury accumulation, pathways, and processes" (WI 180) project. Analysis of precipitation, evaporation, and lake-storage components of the lake's water budget for the 1984-1991 water years was completed. Analysis of the ground-water-flow components was partially completed.

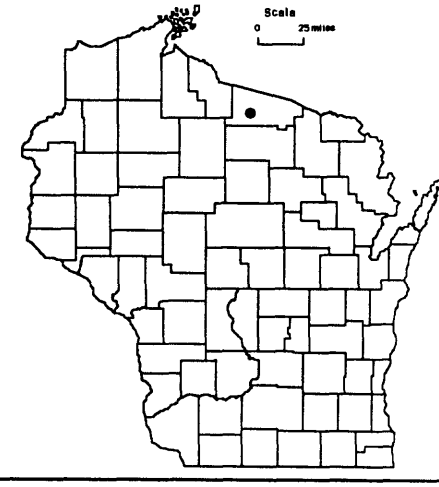
PLANS (July 1992 to June 1993): Analysis of the ground-water-flow components of the lake's water budget will be completed. A report summarizing the lake's general hydrology and water budgets will be completed.

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Vilas County, north-central Wisconsin

PROJECT CHIEF:
William J. Rose

PERIOD OF PROJECT:
August 1983 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

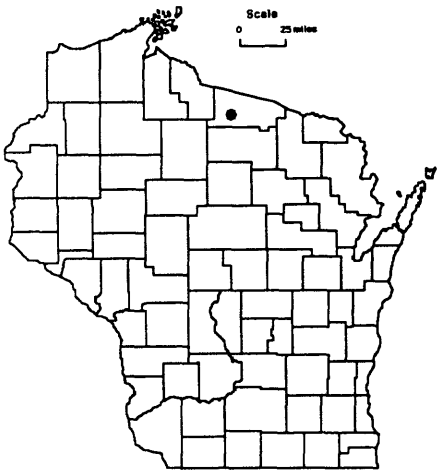
PROBLEM: Analytical data from the waters and biota of many Wisconsin lakes has indicated that there is a Statewide problem of mercury contamination in natural water systems. Elevated concentrations of mercury, coupled with the high toxicity of the element, has led to issuance of fish consumption advisories 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 (January 1992 to June 1992): Construction of new sampling gear has been initiated, as well as upgrading analytical capabilities to include methyl-mercury. Field sampling of water and sediment will begin in May.

PLANS (July 1992 to June 1993): Sediment and water sampling using ultra-clean methods will be continued. Initial results will be drafted into a journal paper for publication. Overall project progress will be reported at the International Mercury Meeting in June 1993.



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, 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 1991 to June 1992): 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 except Jackson Creek. During storm runoff, samples were collected by an automatic sampler or by an observer. Water samples were analyzed for total phosphorus and suspended sediment. Three sites within the lake were monitored to determine the physiochemical characteristics of the water. The 1991 water year data was compiled for publication in "Water Resources Data—Wisconsin, Water Year 1991." The lake rehabilitation plan continued in the 1991 water year.

In the 1991 water year, in-lake total phosphorus concentrations increased as a result of phosphorus mass from dead fish and filling the lake with high phosphorus-laden water, to a volume-weighted mean concentration of 255 µg/L on January 24, 1991. An alum application in April-May reduced the in-lake total-phosphorus concentrations to 21 µg/L by September 23, 1991.

PLANS (July 1992 to June 1993): Continue monitoring program as scheduled. Install monitoring stations on created wetland. 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 EUTROPHIC LAKE IN SOUTHEASTERN WISCONSIN, WI 18102

COOPERATOR:
Wisconsin Department of Natural Resources

LOCATION:
Delavan Lake and Jackson Creek, southeast Wisconsin
Town of Delavan; Walworth County Land Conservation Committee

PROJECT CHIEF:
John F. Elder

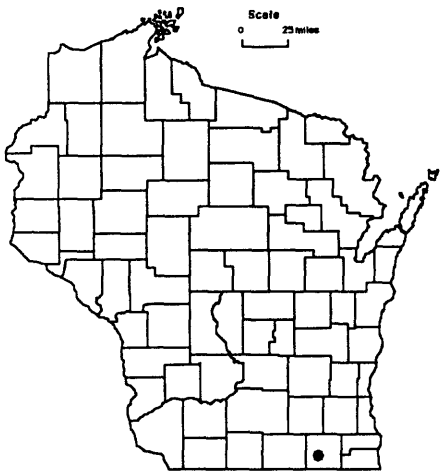
PERIOD OF PROJECT:
October 1991 to September 1996

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: Continuous-streamflow measurement and automated water-sample collection will be conducted on the wetland outlet stream and two inflowing streams. Monthly sampling will be supplemented by more frequent sampling during storms. Daily, monthly, and annual loads of nitrogen species and total phosphorus will be determined from the flow data combined with water-quality data. Sediment trapping efficiency will be assessed by observation of sediment accumulation in sedimentation ponds that are to be constructed within the wetland. 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 (October 1991 to June 1992): Plans were developed for stream measurement and water sampling. Equipment was purchased as needed for this work. Plans were developed for phosphorus partitioning experiments, taking into account current knowledge and methodology. Literature was collected on nutrient flow through wetlands by computerized search through scientific journals and proceedings.



PLANS (July 1992 to June 1993): We will initiate monitoring and experimental work once the wetland construction is complete. We will prepare draft outlines of reports as field work is implemented.

REPORTS: (planned; subject to change)

Field, S.J., Goddard, G. L., and Elder, J.F., Nutrient and sediment transport through a constructed wetland in the drainage area of Delavan Lake, Wisconsin.

Elder, J.F., and Manion, B.J., Partitioning processes and principal retention reservoirs of phosphorus in an artificial wetland bordering a eutrophic lake in 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. Water levels will be collected to map present potentiometric surfaces. Aquifer recharge rates will be estimated by collecting precipitation and water-level data in selected areas. Water samples will be analyzed to evaluate the quality of ground water. 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 (January 1992 to June 1992): A literature review was completed. Several wells were geophysically logged. Well logs, drillers' construction reports and water levels were compiled for the area around the Fox Cities. Model boundaries were selected. Wells in which water levels will be measured were chosen.

PLANS (July 1992 to June 1993): Geophysical logging of wells will be continued. Hydraulic properties of surficial deposits based on past studies will be characterized. Recharge sites where wells and precipitation gages will be installed will be chosen. Water-level and water-use data will be collected. Collection of water-quality samples will be initiated.

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:

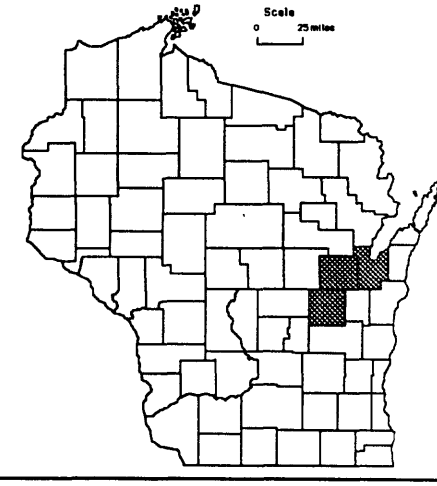
East-central Wisconsin

PROJECT CHIEF:

Terrence Conlon

PERIOD OF PROJECT:

January 1992 to September 1995



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

OBJECTIVE: Perform basic research for the Office of Surface Water in Reston, Virginia. Two projects are in progress: discharge determination during ice cover and velocity profiles under an ice cover. The individual objective, approach, progress, and plans for each project follow.

DISCHARGE DETERMINATION DURING ICE COVER

PROBLEM: Present techniques for determining streamflow records during periods of ice cover require a great deal of judgment and are very difficult to adapt to automated data processing. A systematic evaluation of present and proposed techniques for computing ice-affected streamflow records is needed.

OBJECTIVE: The objective of this project is to evaluate current and proposed methods for the determination of discharge during periods of ice cover. This work is being performed with the Iowa District.

APPROACH: Methods currently used by the U.S. Geological Survey and agencies in other countries will be identified through questionnaires. An extensive literature search will be conducted to determine appropriate methods proposed in the scientific literature. Data will be collected at three sites in Iowa for the winter of 1988. All of the methods will be compared to the data set with the frequent winter discharge measurements and an error analysis will be performed.

PROGRESS (July 1991 to June 1992): A second printing of the U.S. Geological Survey Open-File Report was prepared and distributed. A paper summarizing the project results was published in ASCE Journal of Hydraulic Engineering. The galley proofs for the U.S. Geological Survey Water-Supply Paper were reviewed and returned to the editor. The Water-Supply Paper was printed and distributed.

PLANS (July 1992 to June 1993): Printing of the U.S. Geological Survey Water-Supply Paper constitutes completion of this project; hence there are no plans for this period.

REPORTS:

Melcher, N.B., and Walker, J. F., 1992, Evaluation of selected methods for determining streamflow during periods of ice effect: U.S. Geological Survey Water-Supply Paper 2378, in press.

Walker, J.F., 1991, Accuracy of selected techniques for estimating ice-affected streamflow, ASCE Journal of Hydraulic Engineering, v. 117, no. 6, p. 697-712.

Melcher, N.B., and Walker, J.F., 1990, Evaluation of selected methods for determining streamflow during periods of ice effect: U.S. Geological Survey Open-File Report 90-554, 51 p.

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 1991 to June 1992): Analyzed non-polymer profiles from United States (U.S.) data base and partial results for Canadian data base; concluded complete U.S. data base can be used for further analysis. Secured USGS funding for Ph.D. graduate student at Iowa Institute of Hydraulic Research (IIHR). Met twice with graduate student to discuss progress and plans. Continued to work on paper presenting results of study. Met twice with staff from Water Survey of Canada to discuss mutual research interests and insure data-base compatibility.

PLANS (July 1992 to June 1993): Complete analysis of U.S. data base and complete draft of a journal article describing results. Begin review process for journal article. Continue directing IIHR graduate student research.

REPORTS:

Walker, J.F., and Wagner, C.R., Analysis of adjustment coefficients for measuring discharge under an ice cover (in preparation).

WISCONSIN DISTRICT PUBLICATIONS

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.

WATER-SUPPLY PAPERS

U.S. Geological Survey, 1991, National water summary 1988-89—Hydrologic Events and Floods and Droughts: U.S. Geological Survey Water-Supply Paper 2375, 591 p.

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.

_____,1988, National water summary 1986—Hydrologic events, selected water-quality trends, and ground-water quality: U.S. Geological Survey Water-Supply Paper 2325, 569 p.

_____1986, National water summary 1985—Hydrologic events and surface-water resources: U.S. Geological Survey Water-Supply Paper 2300, 506 p.

_____1985, National water summary 1984—Hydrologic events, selected water-quality trends, and ground-water resources: U.S. Geological Survey Water-Supply Paper 2275, 467 p.

_____1984, National water summary 1983—Hydrologic events and issues: U.S. Geological Survey Water-Supply Paper 2250, 243 p.

Batten, W.G., and Hindall, S.M., 1980, Sediment deposition in the White River Reservoir, northwestern Wisconsin: U.S. Geological Survey Water-Supply Paper 2069, 30 p.

Sherrill, M.G., 1978, Geology and ground water in Door County, Wisconsin, with emphasis on contamination potential in the Silurian dolomite: U.S. Geological Survey Water-Supply Paper 2047, 38 p.

Hurtgen, D.C., 1975, Summary of floods, June 29-30 in southwestern Wisconsin, in Summary of floods in the United States during 1969: U.S. Geological Survey Water-Supply Paper 2030, p. 116-119.

Bell, E.A., and Sherrill, M.G., 1974, Water availability in central Wisconsin—an area of near-surface crystalline rock: U.S. Geological Survey Water-Supply Paper 2022, 32 p.

Novitzki, R.P., 1973, Improvement of trout streams in Wisconsin by augmenting low flows with ground water: U.S. Geological Survey Water-Supply Paper 2017, 52 p.

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.

Hamilton, L.J., 1971, Water for cranberry culture in the Cranmoor area of central Wisconsin: U.S. Geological Survey Water-Supply Paper 1999-I, 20 p.

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.

Hutchinson, R.D., 1970, Ground-water resources of Racine and Kenosha Counties, Wisconsin: U.S. Geological Survey Water-Supply Paper 1878, 63 p.

Olcott, P.G., 1966, Geology and water resources of Winnebago County, Wisconsin: U.S. Geological Survey Water-Supply Paper 1814, 61 p.

Weeks, E.P., Erickson, D.W., and Holt, C.L.R., Jr., 1965, Hydrology of the Little Plover River basin, Portage County, Wisconsin, and the effects of water-resources development: U.S. Geological Survey Water-Supply Paper 1811, 78 p.

Green, J.H., and Hutchinson, R.D., 1965, Ground-water pumpage and water-level changes in the Milwaukee-Waukesha area, Wisconsin, 1950-61: U.S. Geological Survey Water-Supply Paper 1809-I, 19 p.

Summers, W.K., 1965, Geology and ground-water resources of Waushara County, Wisconsin: U.S. Geological Survey Water-Supply Paper 1809-B, 32 p.

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