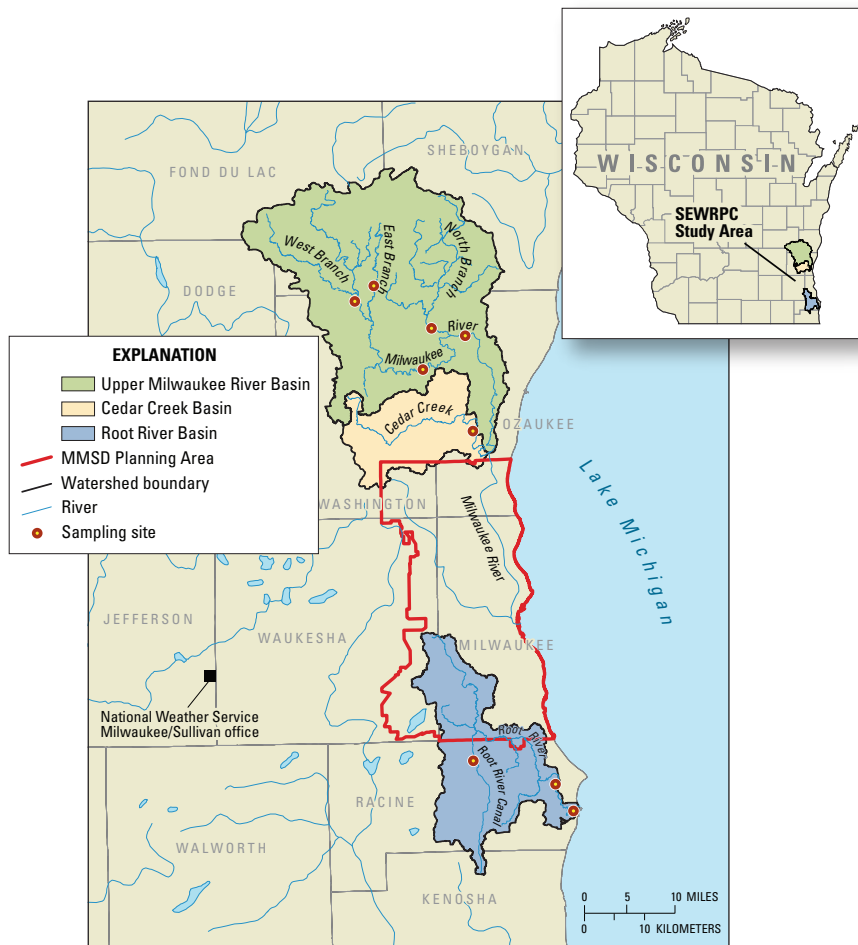


In cooperation with the Southeastern Wisconsin Regional Planning Commission

Surface-Water Quantity and Quality of the Upper Milwaukee River, Cedar Creek, and Root River Basins, Wisconsin, 2004



Open-File Report 2006–1121

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By David W. Hall

In cooperation with the Southeastern Wisconsin Regional
Planning Commission

Open File Report 2006–1121

**U.S. Department of the Interior
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Contents

Abstract.....	1
Introduction.....	2
Purpose and Scope	2
Previous Studies	2
Description of the Study Areas	4
Factors Affecting Surface-Water Quality	5
Geologic Setting.....	5
Land Use.....	5
Population Density.....	8
Methods and Quality Assurance.....	8
Site Selection.....	8
Data-Collection Equipment	8
Data-Collection Schedule	8
Collection of Manual Samples.....	11
Collection of Mercury Samples.....	11
Analytical Methods.....	11
Quality Assurance.....	11
Surface-Water Quantity and Quality	13
Surface-Water Quantity.....	13
Surface-Water Quality	18
Water Quality During Baseflow Conditions.....	20
Water Quality During Storm Conditions	20
Specific Conductance, Temperature, and Dissolved Oxygen	31
Biological Oxygen Demand, Fecal Coliform Bacteria, and <i>Escherichia coli</i>	31
Chloride.....	38
Suspended Solids	38
Nutrients.....	38
Metals	44
Chlorophyll <i>a</i>	44
Summary and Conclusions.....	50
References Cited.....	51

Figures

1–4.	Maps showing:	
	1.	Location of monitored watersheds, the Milwaukee Metropolitan Sewerage District (MMSD) Planning Area, and sampling sites, southeastern Wis. 3
	2.	Quaternary surficial deposits in the Southeastern Wisconsin Regional Planning Commission (SEWRPC) study area and the Milwaukee Metropolitan Sewerage District (MMSD) Planning Area..... 6
	3.	Land use in the Southeastern Wisconsin Regional Planning Commission (SEWRPC) study area and the Milwaukee Metropolitan Sewerage District Planning Area..... 7
	4.	Population density of southeastern Wisconsin including the Southeastern Wisconsin Regional Planning Commission study area, and the Milwaukee Metropolitan Sewerage District Planning Area 9
	5.	Photo showing a temporary shelter with sampling instrumentation and equipment at New Fane, Wis..... 10
6–10.	Graphs showing:	
	6.	Daily precipitation recorded at the National Weather Service Milwaukee/Sullivan site, Wis., May 1 through Nov. 15, 2004 10
	7.	Hydrographs of discharge with sample-collection dates at six sites in the upper Milwaukee River and Cedar Creek Basins, Wis., from May 1 through November 15, 2004 14
	8.	Hydrographs of discharge with sample-collection dates at three sites in the Root River Basin, Wis., from May 1 through November 15, 2004 15
	9.	Hydrographs of discharge with sample-collection dates at six sites in the upper Milwaukee River and Cedar Creek Basins, Wis., in the post-flood period starting on July 15, 2004..... 16
	10.	Hydrographs of discharge with sample-collection dates at three sites in the Root River Basin, Wis., in the post-flood period starting on July 15, 2004..... 17
	11.	Photos showing extensive flooding occurred in the study area during June of 2004..... 18
12–20.	Graphs showing:	
	12.	Changes in chloride, suspended solids, and total phosphorus concentrations during storm events, July 29 through August 15, 2004, at the Newburg, Wis. site..... 23
	13.	Discharge data and sample dates at the five upper Milwaukee River Basin sites, southeastern Wis., from October 22 through October 29, 2004..... 28
	14.	Discharge data and sample dates at the Cedar Creek site, southeastern Wis., from October 22 through October 29, 2004..... 29
	15.	Discharge data and sample dates at the Root River Canal, Root River Racine, and Root River Mouth sites, southeastern Wis. from October 22 through October 29, 2004..... 30
	16.	Daily specific conductance recorded at the six upper Milwaukee River and Cedar Creek Basin sites, southeastern Wis..... 32
	17.	Daily specific conductance recorded at the three Root River Basin sites, southeastern Wis. 33

Figures (cont.)

18–20.	Graphs showing:	
18.	Daily temperature recorded at the nine sampling sites in southeastern Wis.	34
19.	Daily dissolved oxygen concentration recorded at the upper Milwaukee River Basin and Cedar Creek Basin sites, southeastern Wis.	35
20.	Daily dissolved oxygen concentration recorded at the three Root River Basin sites, southeastern Wis.	36
21–28.	Graphs showing statistical distributions of:	
21.	Chloride concentrations in samples collected at the nine sampling sites in southeastern Wis.	39
22.	Suspended solids concentrations in samples collected at the nine sampling sites in southeastern Wis.	40
23.	Nitrate plus nitrite-nitrogen concentrations in samples collected at the nine sampling sites in southeastern Wis.	41
24.	Distributions of ammonia-nitrogen concentrations in samples collected at the nine sampling sites in southeastern Wis.	42
25.	Distributions of organic plus ammonia Kjeldahl nitrogen concentrations in samples collected at the nine sampling sites in southeastern Wis.	43
26.	Distributions of total phosphorus concentrations in samples collected at the nine sampling sites in southeastern Wis.	45
27.	Distributions of orthophosphorus concentrations in samples collected at the nine sampling sites in southeastern Wis.	46
28.	Chlorophyll <i>a</i> concentrations in samples collected at the nine sampling sites in southeastern Wis.	47

Tables

1. Latitude, longitude, and period of historic record for the nine sampling sites in the study area	4
2. Land-use inventory for the upper Milwaukee, Cedar Creek, lower Milwaukee, and Root River Basins, southeastern Wisconsin	5
3. Number and type of quality-assurance analyses performed at each site in southeastern Wisconsin.....	12
4. Largest historic mean daily discharges, in cubic feet per second, recorded at Cedar Creek, Wis.....	13
5. Largest historic mean daily discharges, in cubic feet per second, recorded at Root River Canal, near Franklin, Wis.....	13
6. Numbers and types of water-quality samples from the nine sites in southeastern Wisconsin.....	19
7. Sampling dates and types of water-quality analysis for sites in the upper Milwaukee River, Cedar Creek and Root River Basins, Wis.....	19
8. Results of water-quality analysis of samples collected during base flow June 30–July 1, 2004, in Wisconsin	21
9. Water quality in samples collected during base-flow sampling Sept. 8–9, 2004.....	22
10. Selected water-quality parameters in the upper Milwaukee River Basin, Wis., during base flow on September 9, 2004, and during the storm that began on October 23, 2004	24
11. Selected water-quality parameters at Cedar Creek Basin, Wis. during base flow on September 9, 2004, and during a storm event that began on October 23, 2004.....	26
12. Selected water-quality parameters in the Root River Basin, Wis. at base flow on September 9, 2004, and during a storm event that began on October 23, 2004.....	27
13. Biological oxygen demand, fecal coliforms, and <i>Escherichia coli</i> in samples collected at nine sampling sites in Wisconsin.	37
14. Maximum and minimum concentrations of total copper, particulate mercury, dissolved mercury, particulate methylmercury, dissolved methylmercury, and total zinc for nine sites in Wisconsin.....	48

Conversion Factors, Vertical Datum, and Abbreviated Units of Measurement

Multiply	By	To obtain
Length		
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
Area		
acre	0.004047	square kilometer (km ²)
square mile (mi ²)	2.590	square kilometer (km ²)
Volume		
gallon (gal)	3.785	liter (L)
gallon (gal)	0.003785	cubic meter (m ³)
cubic foot (ft ³)	0.02832	cubic meter (m ³)
Flow rate		
cubic foot per second (ft ³ /s)	0.02832	cubic meter per second (m ³ /s)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$^{\circ}\text{F}=(1.8\times^{\circ}\text{C})+32$$

Vertical coordinate information for geospatial coverages are referenced to the North American Datum of 1983 (NAD 83) and the North American Vertical Datum of 1988 (NAVD 88).

Altitude, as used in this report, refers to distance above the vertical datum.

Abbreviated water- and suspended solids-quality units: Chemical concentrations and water temperature are given in metric units. Chemical concentrations are given in milligrams per liter (mg/L), micrograms per liter (µg/L), and nanograms per liter (ng/L). Milligrams per liter, micrograms per liter, and nanograms per liter are units expressing the concentration of chemical constituents in solution as weight of solute per volume of water. For concentrations less than 7,000 mg/L, the numerical value of the mg/L concentration is the same as for concentrations in parts per million. The numerical value of concentrations expressed as one microgram per liter is equivalent to one milligram per liter cubed. Concentrations expressed as micrograms per liter are equivalent to parts per billion. Concentrations expressed as nanograms per liter are equivalent to parts per trillion.

Specific conductance is given in microSiemens per centimeter at 25 degrees Celsius (µS/cm at 25°C).

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Surface-Water Quantity and Quality of the Upper Milwaukee River, Cedar Creek, and Root River Basins, Wisconsin, 2004

By David W. Hall

Abstract

The U.S. Geological Survey, in cooperation with the Southeastern Wisconsin Regional Planning Commission (SEWRPC), collected discharge and water-quality data at nine sites in previously monitored areas of the upper Milwaukee River, Cedar Creek, and Root River Basins, in Wisconsin from May 1 through November 15, 2004. The data were collected for calibration of hydrological models that will be used to simulate how various management strategies will affect the water quality of streams. The data also will support SEWRPC and Milwaukee Metropolitan Sewerage District (MMSD) managers in development of the SEWRPC Regional Water Quality Management Plan and the MMSD 2020 Facilities Plan. These management plans will provide a scientific basis for future management decisions regarding development and maintenance of public and private waste-disposal systems.

In May 2004, parts of the study area received over 13 inches of precipitation (3.06 inches is normal). In June 2004, most of the study area received between 7 and 11 inches of rainfall (3.56 inches is normal). This excessive rainfall caused flooding throughout the study area and resultant high discharges were measured at all nine monitoring sites. For example, the mean daily discharge recorded at the Cedar Creek site on May 27, 2004, was 2,120 cubic feet per second. This discharge ranked ninth of the largest 10 mean daily discharges in the 75-year record, and was the highest discharge recorded since March 30, 1960. Discharge records from continuous monitoring on the Root River Canal near Franklin since October 1, 1963, indicated that the discharge recorded on May 23, 2004, ranked second highest on record, and was the highest discharge recorded since March 4, 1974.

Water-quality samples were taken during two base-flow events and six storm events at each of the nine sites.

Analysis of water-quality data indicated that most concentrations of dissolved oxygen, biological oxygen demand, fecal coliform bacteria, chloride, suspended solids, nitrate plus nitrite nitrogen, ammonia nitrogen, Kjeldahl nitrogen, total phosphorus, dissolved orthophosphorus, total copper, particulate mercury, dissolved mercury, particulate methylmercury, dissolved methylmercury, and total zinc were below U.S. Environmental Protection Agency (USEPA) and State of Wisconsin water-quality standards at all sites, with the exception of dissolved oxygen at the Kewaskum, Farmington, Root River Canal, Root River Racine, and Root River Mouth sites. Each of these sites had from several days to several weeks of daily average dissolved oxygen concentrations below the 5 milligrams per liter State of Wisconsin standard for aquatic life. The lowest dissolved oxygen concentrations were measured at the heavily urbanized Root River Mouth site in downtown Racine, Wisconsin, where elevated concentrations of ammonia may have contributed to oxygen consumption during oxidation of ammonia to nitrate. Additionally, the maximum concentrations of copper in several Root River samples exceeded draft USEPA Ambient Water-Quality Criteria (U.S. Environmental Protection Agency, 2003) for acute toxicity to several species of aquatic organisms.

Substantial water-quality changes were not correlated with hydrologic changes at any of the nine sites. Base-flow water-quality was generally indistinguishable from that sampled during storm events. The sparsely developed upper Milwaukee River and Cedar Creek Basins had relatively low ranges of contamination for all laboratory-reported parameters. For all nine sites, the highest reported concentrations of chloride (216 mg/L), total phosphorus (0.627 mg/L), ortho-phosphorus (0.136 mg/L), nitrate plus nitrite (9.32 mg/L), and copper (38 µg/L) were reported for samples collected at the Root River Canal site. The highest concentrations of fecal coliforms (3,600 colonies

per 100 mL) and *Escherichia coli* (2,300 colonies per 100 mL) were reported in samples collected at Kewaskum. The highest concentrations of suspended solids (162 mg/L) and chlorophyll *a* (137 µg/L) were in samples collected at the Root River Racine site.

Introduction

The Southeastern Wisconsin Regional Planning Commission (SEWRPC) and the Milwaukee Metropolitan Sewerage District (MMSD) are responsible for managing the water quality of streams and rivers within the MMSD Planning Area (fig. 1). The SEWRPC Regional Water Quality Management Plan and the MMSD 2020 Facilities Plan are currently (2005) being developed by water-resources managers to present strategies for control of point- and nonpoint-pollution sources, and to provide a scientific basis for managers to make future decisions regarding development and maintenance of public and private waste-disposal systems. Hydrologic Simulation Program Fortran (HSPF) models are being used to assist the planning efforts by providing simulations of future water quality in response to various management and land-use scenarios.

A comprehensive database containing historic and recent water-quality data collected within the MMSD Planning Area was previously constructed (Schneider and others, 2004) to provide calibration and validation data for the HSPF model through a cooperative effort of the MMSD, U.S. Geological Survey (USGS), and the Wisconsin Department of Natural Resources (WDNR). The database contains water-quality data for the MMSD Planning area but is lacking water-quality data in areas to the north and south of the Planning Area. Data from these areas are needed to provide accurate source terms for the boundaries of the HSPF models.

An important part of the mission of the USGS is to collect, evaluate, and disseminate water resources information for the protection of human and aquatic health, and to ensure the enhancement of environmental quality for future generations. The USGS Water Resources Discipline (WRD) conducts assessments of water quality and quantity at a variety of scales. Hydrologic information is disseminated to the public in reports, presentations, and the World Wide Web. Results of USGS investigations are frequently used by other government agencies (federal, state, local, tribal) to understand and manage their water resources.

SEWRPC will use the data generated by this project to determine how various management strategies will

affect water quality in the Milwaukee and Root River drainage basins in southeastern Wisconsin. Data collected as part of this project may be also used by other local, regional and state agencies to evaluate existing hydrologic and water-quality conditions in southeastern Wisconsin.

Additionally, the USGS is uniquely positioned to provide a leadership role in aquatic mercury investigations such as those being conducted as part of this SEWRPC project. The USGS was a prominent participant in the series of studies conducted in northern Wisconsin that largely form the basis of current knowledge about mercury in aquatic ecosystems. The ongoing National Water-Quality Assessment (NAWQA) program in the Lake Michigan drainages of Wisconsin provides additional infrastructure and expertise to gain a local perspective on mercury contamination. A recently established mercury research laboratory in Madison, Wisconsin gives USGS scientists the necessary analytical capabilities to conduct state-of-the-art contamination studies. Thus, the USGS is well situated to advance the understanding of mercury cycling in aquatic ecosystems and to assist resource-management agencies in developing strategies for reducing the effects of mercury contamination.

Purpose and Scope

This report presents discharge and water-quality data that were collected in southeastern Wisconsin from May 1 through November 15, 2004, by the USGS in cooperation with SEWRPC to facilitate development of the HSPF model. The data provide calibration datasets for areas outside of the MMSD Planning Area boundaries (fig. 1), including the upper Milwaukee River, Cedar Creek, and Root River Basins.

Previous Studies

The upper Milwaukee River and Root River Basins have been researched in recent decades by the MMSD, SEWRPC, Wisconsin Department of Natural Resources, the University of Wisconsin Cooperative Extension Service, the USGS, and many others. Specific reports of interest for the upper Milwaukee River and Root River Basins include Burzynski, Beaumier, Benninghoff, and others (2001), and Burzynski, Helker, Cooper and others (2002). A comprehensive list of relevant publications describing the soils, geography, environmental quality, and land use and planning was recently published in Schneider and others (2004).

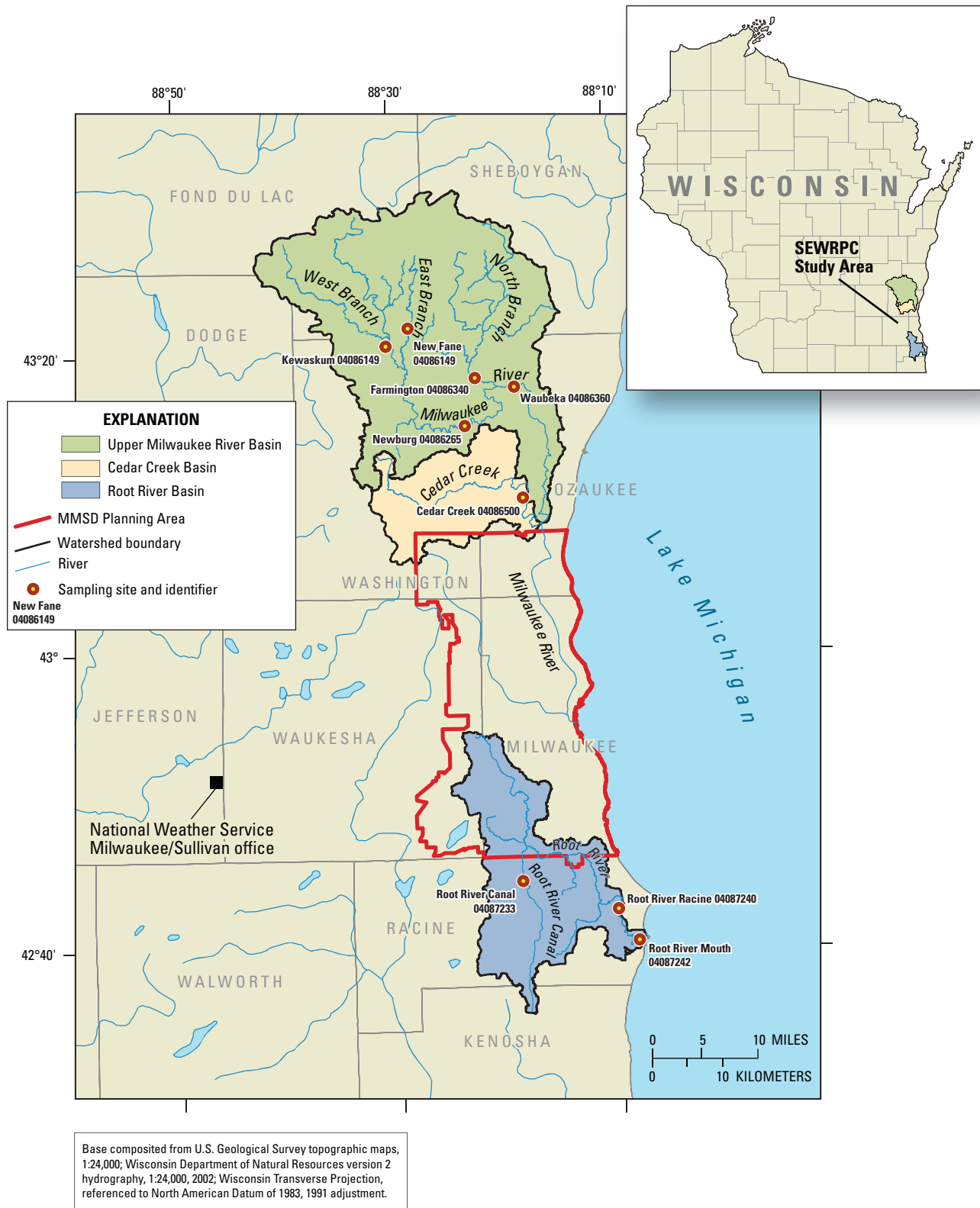


Figure 1. Location of monitored watersheds, the Milwaukee Metropolitan Sewerage District (MMSD) Planning Area, and sampling sites, southeastern Wis.

Many environmental resources, including fisheries in the upper Milwaukee River, Cedar Creek, and Root River Basins, have been well researched. However, a recent and representative data set describing ambient hydrologic and water-quality conditions in the upper Milwaukee River and lower Root River basins outside the boundary of the MMSD Planning Area did not exist prior to the current study.

Description of the Study Areas

The study areas included the North Branch, East Branch, and West Branch Basins of the upper Milwaukee River to the north of the MMSD Planning Area, and Cedar Creek and Root River Basins to the south (fig. 1). Nine water-quality monitoring sites (fig. 1; table 1) were established to provide representative discharge and water-quality data for calibration of the SEWRPC and MMSD Planning Area HSPF models.

Six of the nine sites were in the upper Milwaukee River and Cedar Creek Basins to the north of the MMSD Planning Area. The upper Milwaukee River Basin SEWRPC project sites were on or near the North, East, and West Branches in the upper Milwaukee River Basin as well as on the main stem of the Milwaukee River (fig. 1). The Kewaskum site (fig. 1; table 1) was in the headwaters of the Milwaukee River downstream of the West Branch confluence with the Milwaukee River. The New

Fane site was also in the headwaters of the Milwaukee River Basin but was on the East Branch. The East Branch forms a confluence with the Milwaukee River in the Kettle Moraine State Forest south of the city of Kewaskum and south of the Kewaskum sampling site. The Milwaukee River then flows southward through the city of West Bend before turning east towards the Village of Newburg and the former Newburg site. Downstream of Newburg, the Milwaukee River forms a confluence with the North Branch (downstream of the Farmington North Branch site). The river then flows to the unincorporated community of Waubeka and the former Waubeka site.

No sampling sites were upstream of the Kewaskum (on Milwaukee near the West Branch), New Fane (East Branch), and Farmington (North Branch) sampling sites; however, Kewaskum and New Fane were upstream of the Newburg site. The Newburg and Farmington sites were upstream of the Waubeka site. Cedar Creek forms a confluence with the Milwaukee River downstream of the former Waubeka site. The Cedar Creek site was upstream of the confluence and, therefore, only provided data representative of water-quality in the Cedar Creek Basin.

The remaining three SEWRPC sampling sites were within the Root River Basin, to the south of the MMSD Planning Area (fig. 1). The Root River main stem headwaters area is in the heavily urbanized southernmost parts of the MMSD Planning Area near the city of West Allis; however, the Root River flows to the southeast out of the

Table 1. Latitude, longitude, and period of historic record for the nine sampling sites in the study area.

[USGS, U.S. Geological Survey; ddmms, degrees, minutes, seconds; °, degrees; ', minutes; ", seconds; --, no data available; location of sites shown in figure 1]

Site (USGS site number)	River name and location	Latitude (ddmms)	Longitude (ddmms)	Historic record
04086200	East Branch Milwaukee River at New Fane, Wisconsin	43°33'01"	88°11'18"	1968–1981
04086149	Milwaukee River Upstream of Kewaskum Dam, Wisconsin	43°31'37"	88°13'45"	--
04086340	North Branch Milwaukee River at Farmington, Wisconsin	43°28'58"	88°03'39"	1968–1981
04086265	Milwaukee River at Highway M near Newburg, Wisconsin	43°25'30"	88°04'51"	--
04086360	Milwaukee River at Waubeka, Wisconsin	43°28'22"	87°59'23"	1968–1981, 1994
04086500	Cedar Creek at Cedarburg, Wisconsin	43°19'23"	87°58'43"	1930–1970, 1973–1981, 1983–1987, 1990–present
04087233	Root River Canal near Franklin, Wisconsin	42°48'55"	87°59'40"	1963–present
04087240	Root River at Racine, Wisconsin	42°45'05"	87°49'25"	1963–present
04087242	Root River near the Mouth, Racine, Wisconsin	42°44'03"	87°47'06"	--

MMSD Planning Area toward the city of Racine and ultimately to Lake Michigan. Most of the Root River Basin is south of the MMSD Planning Area.

The water quality of the Root River Canal tributary is more affected by agricultural sources of contamination than the intensively urbanized Root River main-stem headwaters areas within the densely populated MMSD Planning Area. The confluence of the urban Root River headwaters with the more rural Root River Canal tributary is upstream of the former Root River Racine and Root River Mouth sites (fig. 1).

There are no large tributaries entering the Root River downstream of the Root River Racine site that would affect water quality of the downstream Root River Mouth site. Water quality at the Root River Mouth site, however, could have been affected by urban and marina discharges in the downtown area of the city of Racine and by intermittent mixing with Lake Michigan. Streamflow reversals caused by wind- or seiche-induced variations in lake stage frequently cause Lake Michigan to flow upstream into the Root River channel near the Root River Mouth site.

Factors Affecting Surface-Water Quality

Water quality in the upper Milwaukee River, Cedar Creek, and Root River Basins is affected by the geologic setting, land uses, and population density of each basin. The following sections provide a brief description of each factor.

Geologic Setting

The surficial deposits of southeastern Wisconsin are primarily sands, silts, clays, and regolith, with some irregularly distributed carbonaceous materials, that have been highly altered by glaciation (fig. 2). Common glacial features include lateral and end moraines, outwash plains, and drumlins that are interspersed with riverine, lake, regolith, and aeolian deposits (Martin, 1965).

The surface altitude of the Milwaukee River Basin ranges from 580 ft to 1,360 ft above sea level (Burzynski, Beaumier, Benninghoff, and others, 2001). The land area of the entire Milwaukee River Basin is approximately 700 mi². The surface altitude of the Root River Basin ranges from 580 ft to 840 ft above sea level. The land area of the Root River Basin is approximately 197 mi² and includes 117 miles of streams.

Land Use

The rural and sparsely developed character of the upper Milwaukee River and Cedar Creek Basins is shown in table 2 and in figure 3. Approximately half of the land area in both basins is agricultural, relative to only 14.6 percent of the area in the lower Milwaukee River Basin in the more intensely urban MMSD Planning Area downstream (fig. 3). The upper Milwaukee and Cedar Creek Basins contain extensive and undeveloped wetlands.

Land use in the Root River Basin (fig. 3) is also approximately half agricultural (49.2 percent)(table 2),

Table 2. Land-use inventory for the upper Milwaukee, Cedar Creek, lower Milwaukee, and Root River Basins, southeastern Wisconsin.

[Land-use types are illustrated on figure 3; all numbers represent percentages of land use]

	Upper Milwaukee River Basin (percent)	Cedar Creek Basin (percent)	Lower Milwaukee River Basin* (percent)	Root River Basin (percent)
High urban	1.3	2.0	32.5	7.6
Low urban	1.0	1.6	13.8	6.4
Agriculture	50.5	50.1	14.6	49.2
Grassland	15.1	15.3	20.1	16.3
Forest	11.9	10.0	10.9	10.7
Open water	1.6	1.3	2.1	0.9
Wetland	16.5	16.9	3.2	4.8
Barren	1.2	1.6	0.8	2.5
Shrubland	0.8	1.3	1.9	1.6

* No study sites were in the lower Milwaukee River Basin; however, six of the nine study sites were upstream of the lower Milwaukee River Basin.

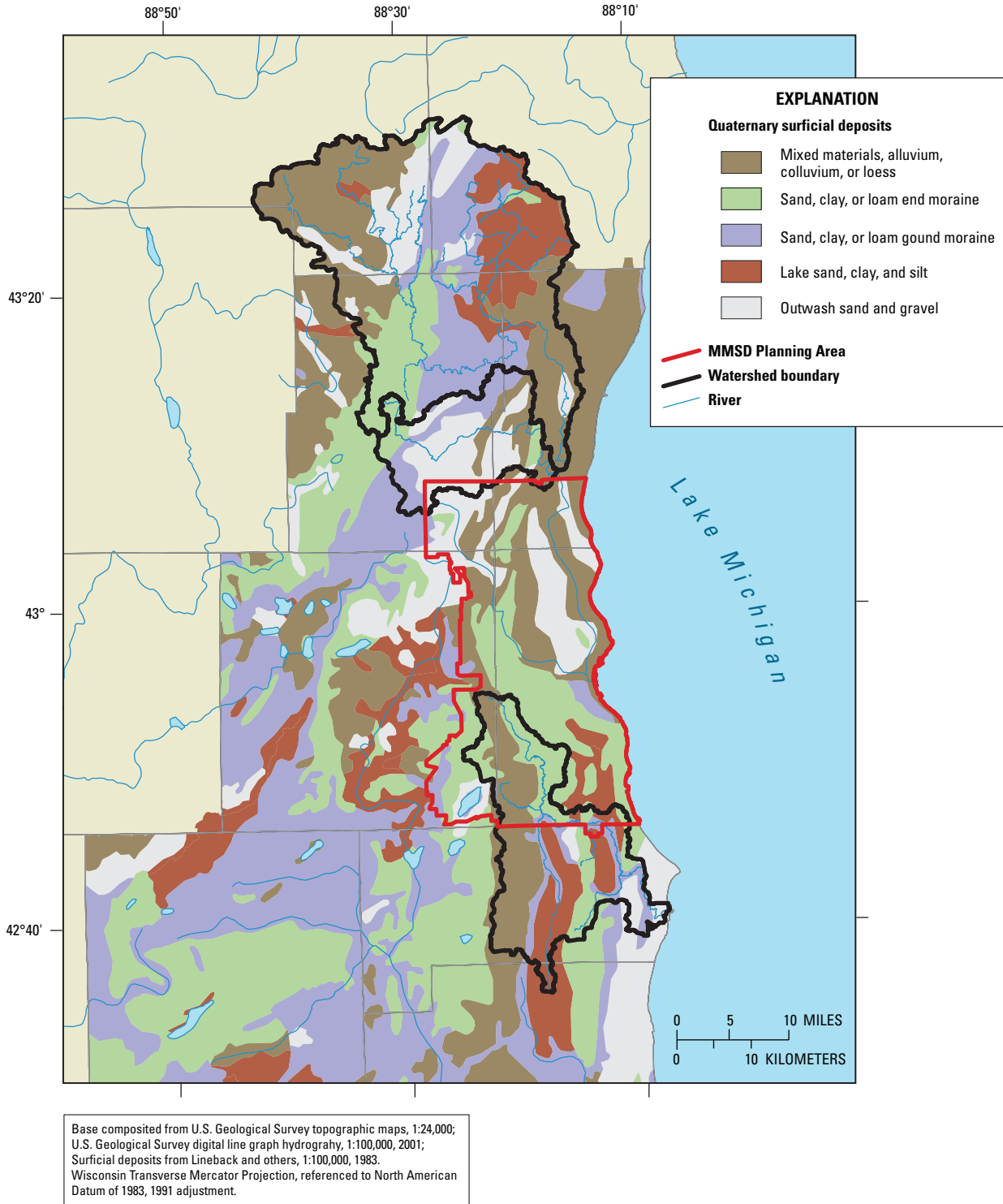


Figure 2. Quaternary surficial deposits in the Southeastern Wisconsin Regional Planning Commission (SEWRPC) study area and the Milwaukee Metropolitan Sewerage District (MMSD) Planning Area.

