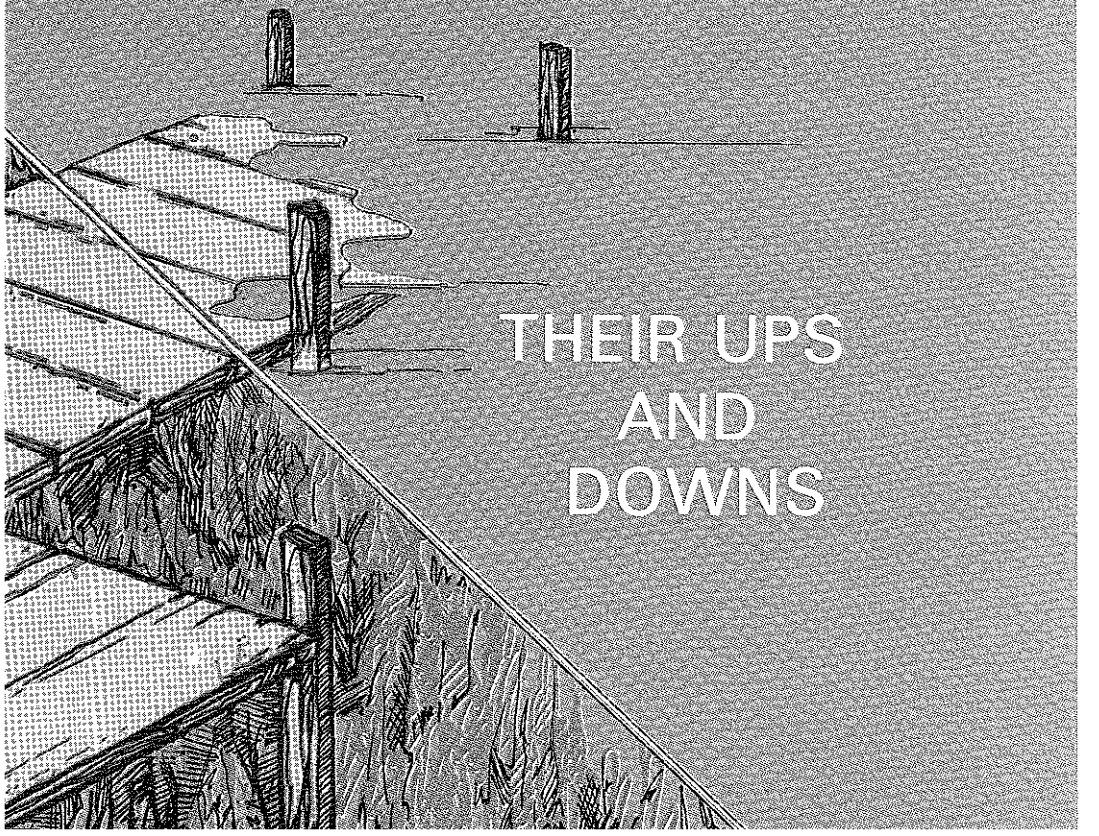
WISCONSIN LAKE LEVELS



THEIR UPS AND DOWNS

This report is a product of the Geological and Natural History Survey Water Resources Program which includes: systematic collection, analysis, and cataloguing of basic water data; impartial research and investigation of Wisconsin's water resources and water problems; publication of technical and popular reports and maps; and public service and information. Most of the work of the Survey's Water Resources Program is accomplished through state-federal cooperative cost sharing with the U.S. Geological Survey, Water Resources Division.

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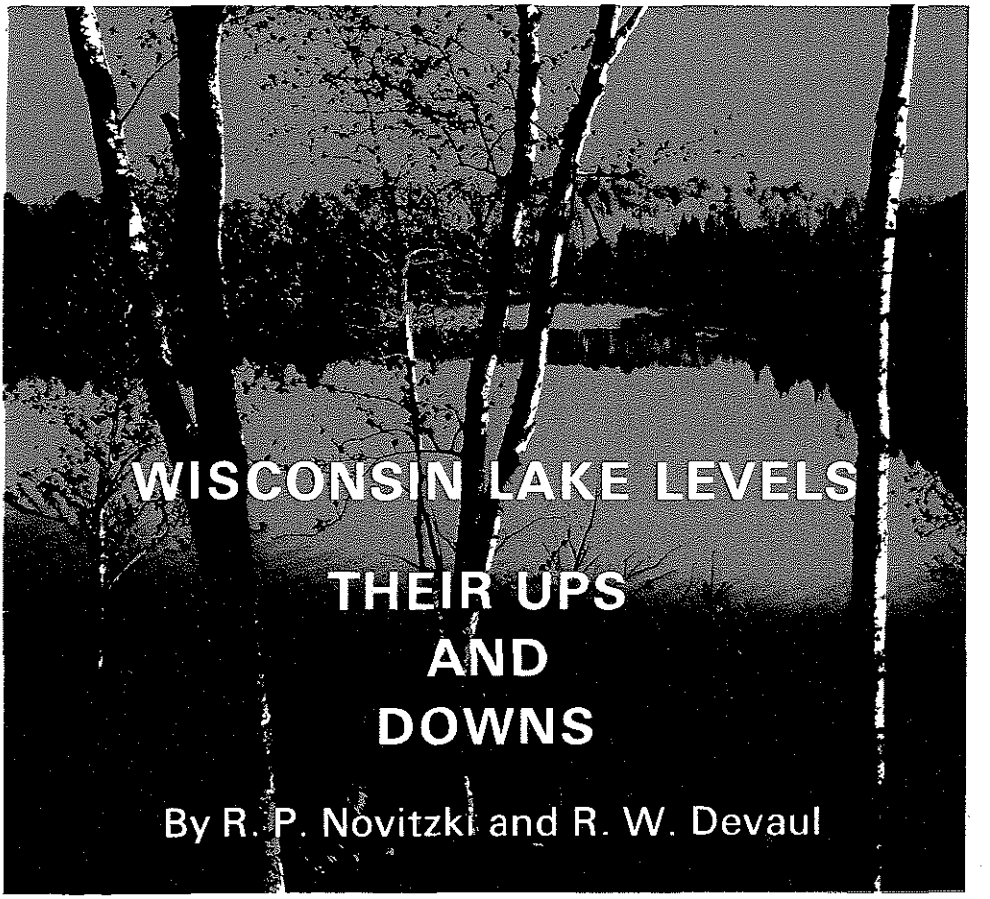


WISCONSIN LAKE LEVELS

THEIR UPS AND DOWNS

By R. P. Novitzki and R. W. Devaul

Lakes are an important resource in Wisconsin (fig. 1), but few people realize how much they fluctuate from season to season and from year to year. However, when lake levels fall (fig. 2), docks may be left high and dry and weeds may spring up on the exposed lake bottom, causing considerable inconvenience to lake users. High lake levels (fig. 3), particularly those that flood lakeshore property and persist for months—or even years, damage shorelines and structures and further inconvenience lake users. We can use and enjoy our lakes more fully when we are prepared to accept and accommodate the ups and downs of Wisconsin lake levels. This report relates lake-level fluctuations to lake type, as determined by the presence or absence of inflow and outflow streams. We hope this information is helpful to the private citizen who enjoys Wisconsin's lakes, as well as to the realtor, developer, or lake manager, whose decisions must be based on sound

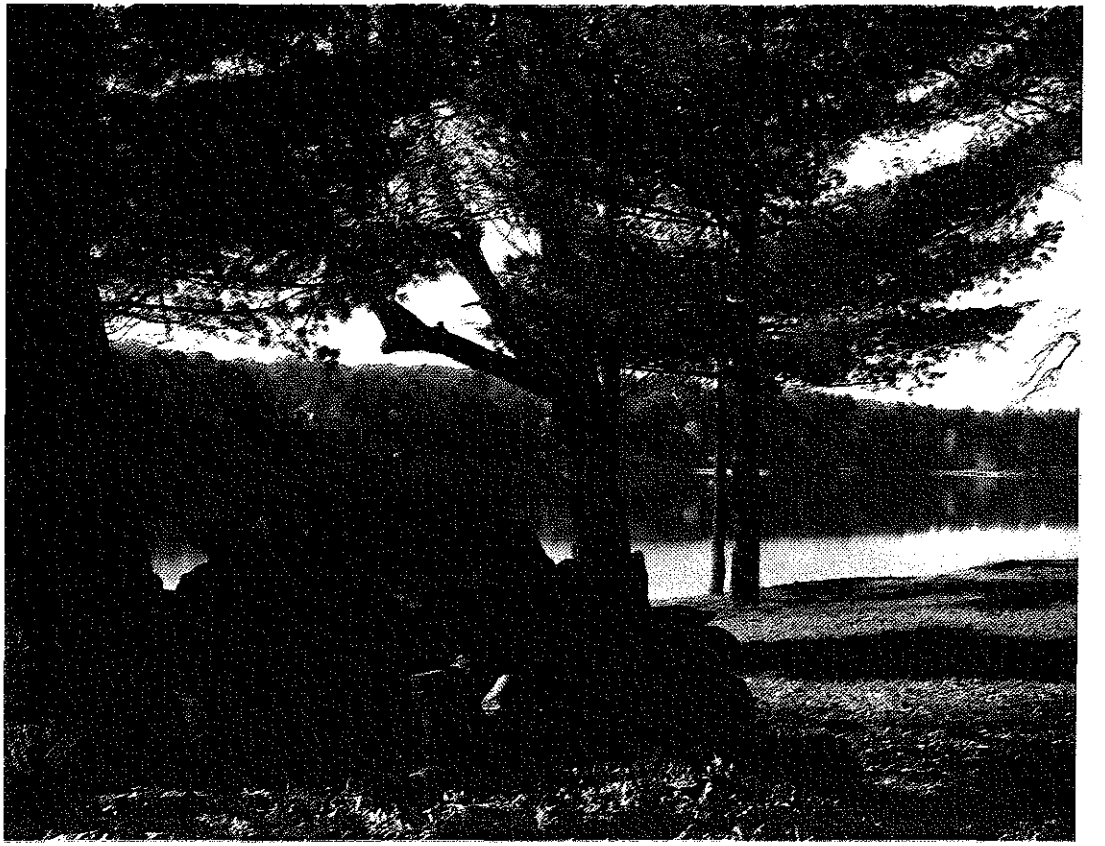


Figure 1. A pleasant Wisconsin lake scene.
(Fish Lake near Hancock)

understanding of lake-level fluctuations.

Lake-level records from 28 lakes throughout Wisconsin (fig. 4), obtained during a period of 20 years or longer, indicate a relationship between lake-level fluctuations and lake type. The range of lake-level fluctuation differs among lakes that are supported by ground water or by surface water and those that have inflow and outflow streams and those that do not (fig. 5).

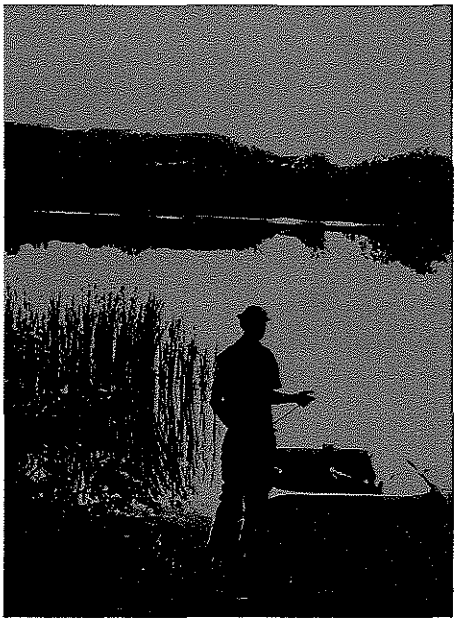
We classified landlocked lakes, with neither inflow nor outflow streams, as ground-water flow-through lakes. We classified lakes that have a perennial outflow stream, but no inflow stream, as ground-water discharge lakes. Lakes with substantial inflow and outflow streams are classed as surface-water flow-through lakes.

GROUND-WATER FLOW-THROUGH LAKES fluctuated most widely, from 2.5 to 10.9 feet during the period of record

(table 1). These lakes usually are in closed basins, and the lake occupies the part of the basin below the water table. Water moves freely between the ground-water system and the lake. The range between high and low levels is great because there is no outlet to release excess water. Lake levels are typically high in spring (ground-water recharge is mostly from snowmelt and precipitation before the growing season) and decline through the rest of the year. Late season recharge can raise lake levels in fall or early winter. Overland flow may raise lake levels when snowmelt or intense storms occur on frozen ground.

GROUND-WATER DISCHARGE LAKES fluctuated least (table 1), from 1.4 to 3.5 feet. These lakes have no significant inflow stream, but do have an outflow stream discharging continuously. Continuous ground-water inflow stabilizes low levels. Streamflow out of the lake in-

Figure 2. Low lake levels expose beaches and allow weeds to encroach. (Long Lake near Plainfield)



creases when lake levels rise, preventing extreme high levels and narrowing the range of lake-level fluctuations. Lake levels are typically high in spring or early summer and low in fall or winter. Recharge to the ground-water system after the growing season may result in fall or winter highs.

SURFACE-WATER FLOW-THROUGH LAKES had long-term fluctuations intermediate between the two ground-water types (table 1), ranging from 2.9 to 7.3 feet. Annually, however, they typically fluctuate somewhat more than the ground-water lakes. Streamflow into the lake is both surface runoff and ground-water runoff: high flow in the spring may be mostly snowmelt (surface runoff), but late summer flow may be entirely ground-water runoff. Ground-water contributions prevent extreme low lake levels, and continuous outflow prevents extreme high levels. High levels typically occur in spring and low levels in fall or winter.

Lake-level fluctuations in these three lake types may be used to estimate fluctuations in lakes where water-level information is not available. The estimates will be reasonable if the 28 lakes we have studied represent all Wisconsin lakes and if the period of record represents future climatic conditions. A statistical analysis of data in table 1 indicates that 9 out of 10 natural lakes in the State will fluctuate within the following approximate ranges during periods of 20 years or longer.

	Period of record (ft)	Average annual (ft)	Maximum annual (ft)	Minimum annual (ft)
Ground-water flow-through	2.5-10.5	0.8-2.7	1.2-5.5	0.3-1.4
Surface-water flow-through	2.6-7.8	1.0-2.6	2.1-4.7	0.5-1.2
Ground-water discharge	1.4-3.8	0.6-1.4	0.9-2.9	0.2-0.6

These estimated ranges will be better defined by ongoing studies.

We did not define the effect of dams on water-level fluctuations in this study. Fixed-crest dams on ground-water discharge lakes may increase water-level fluctuations, causing the lake to function as a flow-through type. The effect of

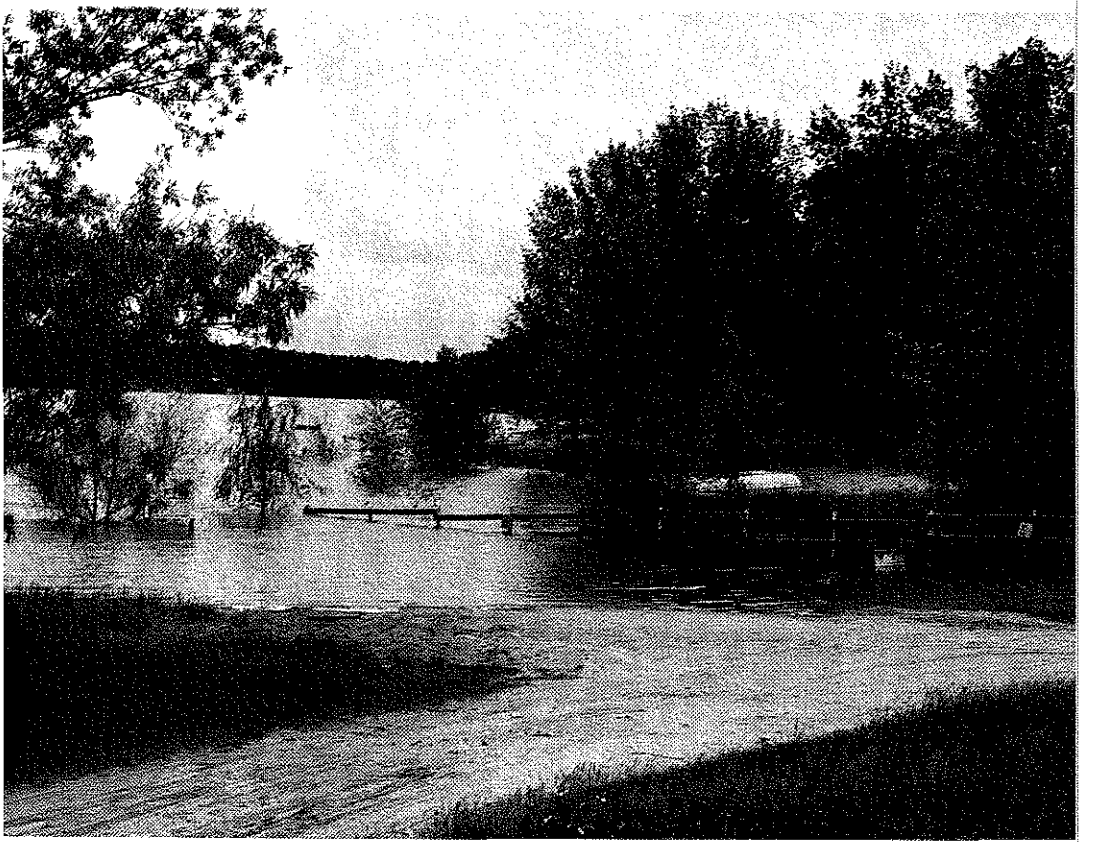


Figure 3. High lake levels flood beaches, and occasionally, buildings. (Fish Lake near Hancock)

other types of dams or control structures depends on their manner of operation. Additional data are needed to understand the influence of dams on long-term water-level fluctuations.

We could not consider other items that influence lake-level fluctuations because data were scant. In our ongoing studies we consider the physical and geologic characteristics of the lake site that affect water-level fluctuations in the different lake types (table 1). Lake classification will be refined as relationships between these characteristics and lake-level fluctuations become apparent. Attempts are being made to develop other techniques for determining lake types quickly and correctly.

Additional geologic, hydrologic, climatic, and water-quality data for the lakes reported are available from the U.S. Geological Survey, Madison, Wisconsin.

Figure 4. Location of lakes included in this study.

Table 1.—Range of lake-level fluctuations by lake type

Lake type	Fluctuation during period of record (ft)	Average annual fluctuation (ft)	Maximum annual fluctuation (ft)	Minimum annual fluctuation (ft)	Period of record
GROUND-WATER FLOW-THROUGH					
Devils	10.91	3.28	6.31	1.83	1937-74
North (Holden)	10.14	1.56	3.70	.49	1937-75
Shell	6.05	1.43	2.74	.61	1936-74
Cedar	5.81	1.18	1.98	.34	1936-74
Anvil	5.10	1.00	1.84	.50	1936-74
Rib	4.77	1.78	3.93	.78	1936-64
Boot	4.43	.90	1.60	.38	1936-64
Pine	4.24	1.30	2.75	.53	1936-75
Silver	4.01	1.03	2.12	.27	1936-64
Wheeler	3.86	.85	1.35	.38	1936-74
Pine	3.48	1.17	1.90	.58	1936-64
Beaver	2.50	.96	1.57	.42	1933-67
SURFACE-WATER FLOW-THROUGH					
Winnebago	7.33	2.41	4.50	.76	1882-1974
Monona	4.05	1.96	3.47	.65	1915-74
Mendota	3.99	1.51	3.44	0.56	1916-74
Yellow	3.41	1.91	3.02	1.15	1941-74
Connor	2.90	1.20	2.28	0.66	1936-64
GROUND-WATER DISCHARGE					
Amnicon	3.50	1.29	3.02	.60	1936-64
Eagle	3.49	1.13	2.05	.54	1936-64
Little Green	3.40	1.25	2.02	.30	1936-64
Mud	3.32	1.02	1.85	.40	1940-60
Turtle	2.77	.94	1.70	.40	1938-64
Ripley	2.64	.78	1.21	.40	1936-64
Browns	2.63	1.20	2.32	.42	1936-64

Table 1.—Range of lake-level fluctuations by lake type—Continued

Lake type	Fluctuation during period of record (ft)	Average annual fluctuation (ft)	Maximum annual fluctuation (ft)	Minimum annual fluctuation (ft)	Period of record
Silver	2.52	1.11	1.76	.48	1936-64
Big McKenzie	1.94	.66	.98	.36	1936-68
Bone	1.70	.68	1.15	.25	1936-64
De Neveu	1.42	.64	1.12	.30	1936-64

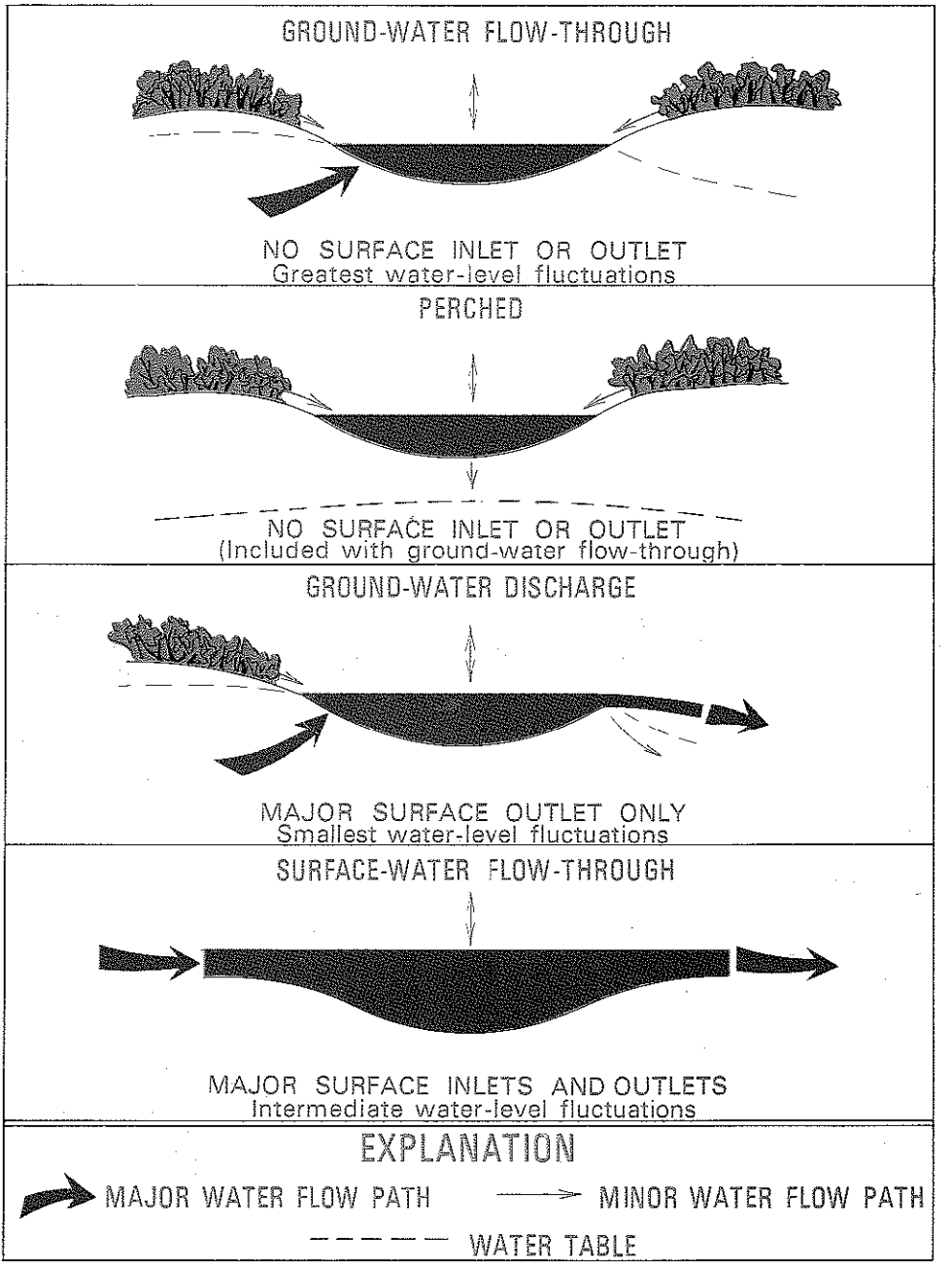


Figure 5. Relation of lake type to the hydrologic system.

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Additional lake information is contained in a series of publications, "Surface-Water Resources of _____ County," available through the Wisconsin Department of Natural Resources, Madison, Wisconsin 53705.

Additional information on the water resources of Wisconsin is contained in a map series, "Water resources of Wisconsin—_____ River basin," available through the University of Wisconsin—Extension, Geological and Natural History Survey, Madison, Wisconsin 53706.

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