eration and irrigation.

Surface water in the basin is used in numerous ways. The

major uses are for power generation, recreation, fish and wild-

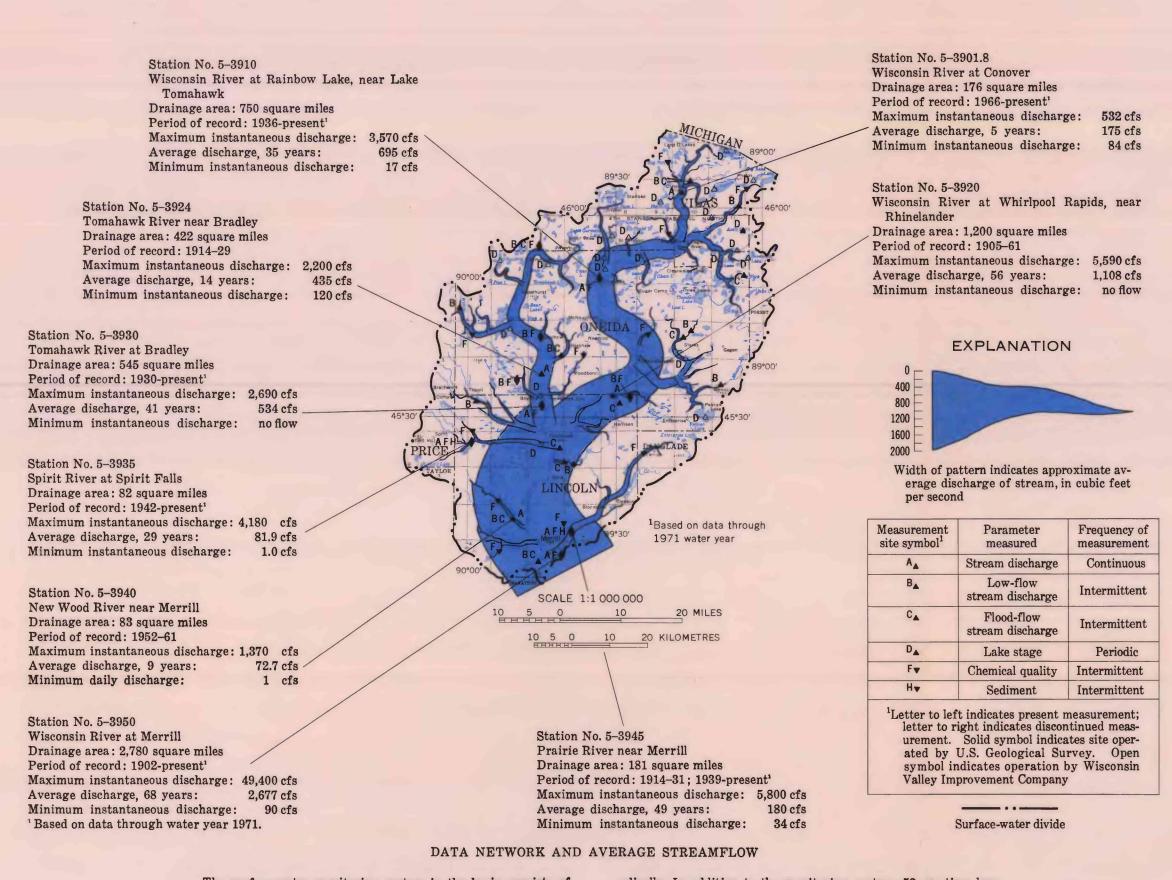
life habitat, industrial processing, and transportation of indus-

trial and municipal wastes. Minor uses include fish-hatchery op-

SURFACE WATER

Streams and lakes in the upper Wisconsin River basin contain

abundant water of generally good quality. However, man's use



The surface-water monitoring system in the basin consists of 58 sites. Of these, 38 are U.S. Geological Survey sites, and the remainder are sites of the Wisconsin Valley Improvement Company.

Street Geological Survey sites, and the consists of flow measurements in the basin are presented in the "Low section.

Chemical quality of streams is monitored intermittent sites Schimpter and the constant of the constant

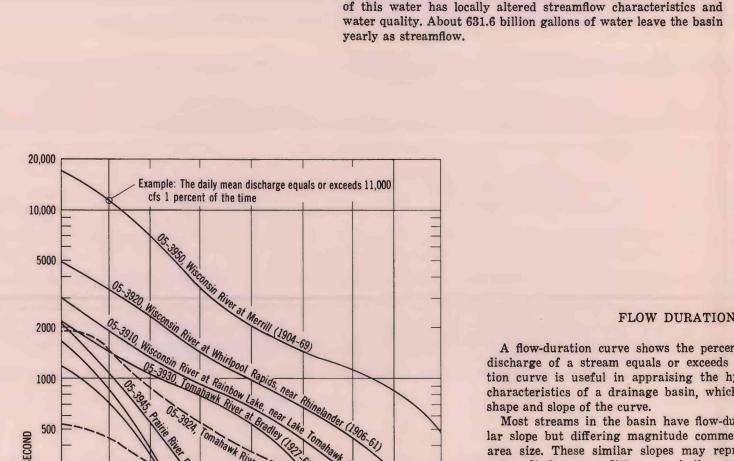
period of record.

Streamflow (including flood and low flows) and reservoir and lake-stage fluctuations are or have been monitored at 47 sites. Streamflow is continuously monitored at six sites. Continuous records also are available for three sites where streamflow measurements have been discontinued. Intermittent low-flow and flood-flow measurements are made at 14 and nine sites, respectively. The stages of 21 lakes and reservoirs are measured peri-

odically. In addition to the monitoring system, 52 one-time low-flow measurements in the basin are presented in the "Low Flow" section.

Chemical quality of streams is monitored intermittently at 20 sites. Sediment concentrations in streamflow are monitored intermittently at two sites. These data and chemical-quality data on lakes are presented in the "Water Quality" section.

The average discharge pattern represents amounts that hypothetically would yield continuous, unvarying flow through the



PERCENTAGE OF TIME INDICATED DISCHARGE WAS EQUALED OR EXCEEDED

(micromhos at 25° C)

SEEPAGE LAKES

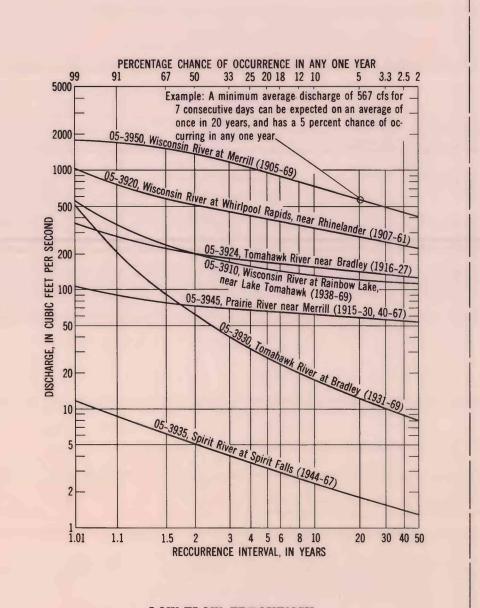
SPRING LAKES

DRAINAGE LAKES

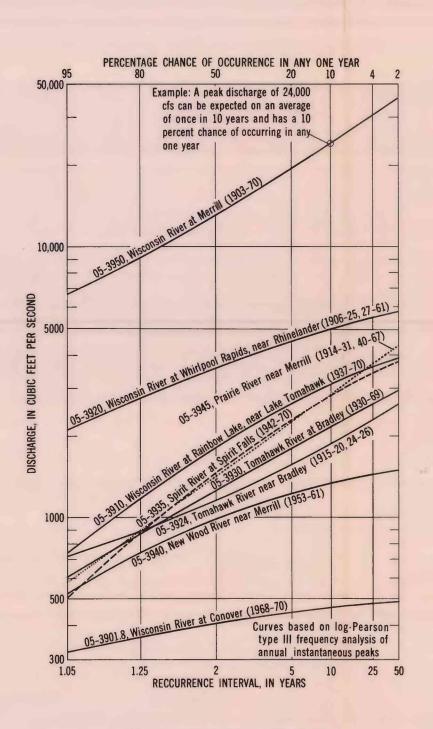
FLOW DURATION A flow-duration curve shows the percentage of time that the discharge of a stream equals or exceeds a given rate. A duration curve is useful in appraising the hydrologic and geologic characteristics of a drainage basin, which are indicated by the shape and slope of the curve. Most streams in the basin have flow-duration curves of similar slope but differing magnitude commensurate with drainage area size. These similar slopes may represent similar groundwater discharge conditions or similar regulation of streamflow by release from impoundments. Each has an effect on the shape and slope of the flow-duration curves. Steep curves, especially the lower ends, for the Spirit River at Spirit Falls and the New Wood River near Merrill (both unregulated streams) indicate little ground-water runoff from the till moraine that covers most of their basins above the gages. The curve for the Prairie River near Merrill, an unregulated stream, is flat at the lower end, indicating substantial ground-water runoff from end moraine and outwash. The other curves represent regulated streams. The difference in the curves for the Tomahawk River at Bradley and the Tomahawk River near Bradley results from the streamflow regulation at the outlet of Lake Nokomis and the relocation of the gage from above to below the lake. The flattened curve for the Wisconsin River near Conover reflects controlled release from impound-

ments and sustained ground-water discharge from outwash.

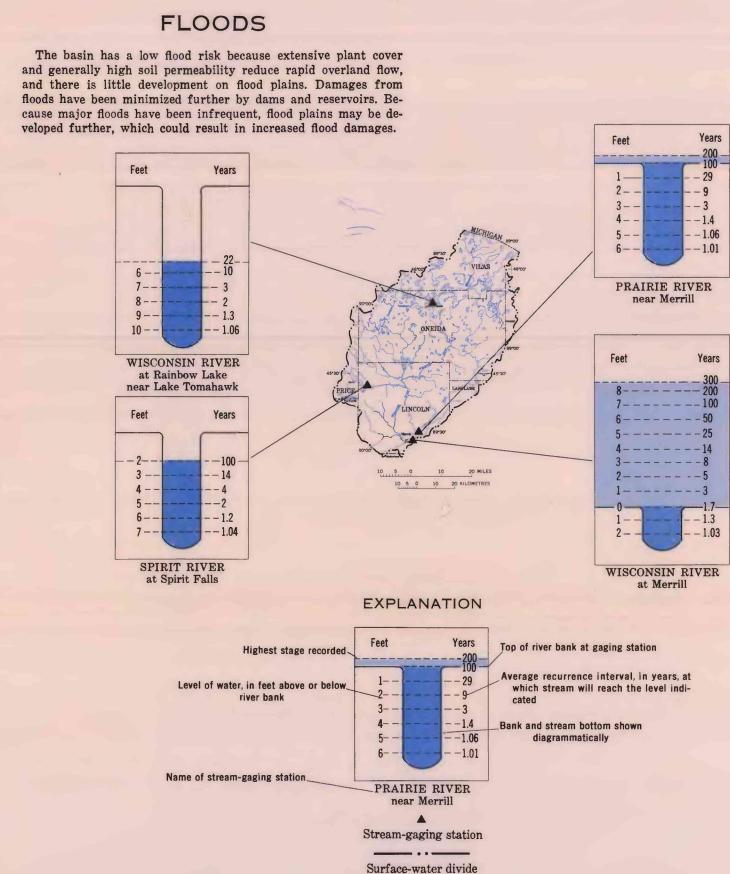
SURFACE-WATER QUALITY



LOW-FLOW FREQUENCY A knowledge of low-flow characteristics of a stream is useful to determine adequacy to supply minimum needs; to design and manipulate reservoirs; to estimate ground-water discharge; and to assess the stream's capacity to assimilate, dilute, and transport waste. Streamflow during the low-flow period is the amount of water released from underground and surface storage. The 7-day low-flow frequency of streams in the basin ranges from 5 cfs (cubic feet per second) every 2 years for the Spirit River at Spirit Falls to 1,380 cfs for the same interval for the Wisconsin River at Merrill. The curves for streams in the basin are generally parallel and plot in descending order related to drainage area. The Spirit River at Spirit Falls and the Tomahawk River at Bradley are exceptions to this general relationship. The Spirit River at Spirit Falls drains 82 square miles, mainly till moraine, which supplies little ground water to streamflow. Low flow at this site is relatively small at all recurrence intervals. The flow of the Tomahawk River at Bradley has been influenced by the

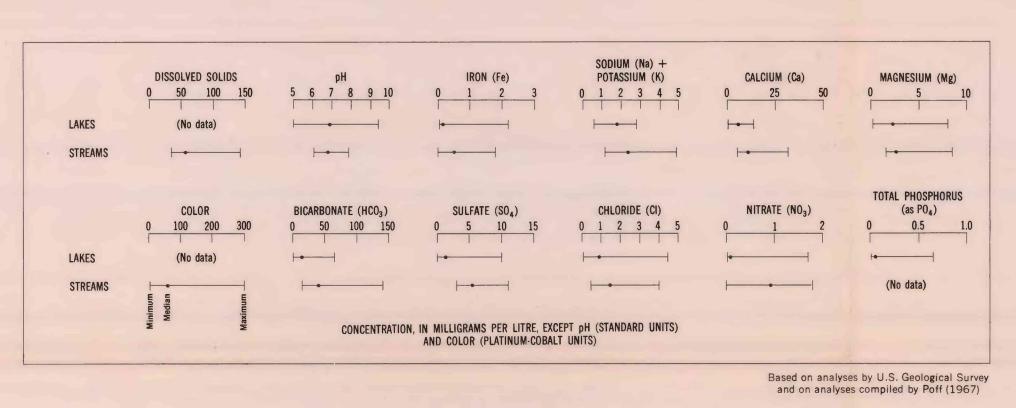


FLOOD-DISCHARGE FREQUENCY The magnitude of flood flows depends mainly upon the size of the drainage area—the largest area receives the most rainfall or snowmelt and has the most runoff. However, intensity and duration of rainfall, rate of snowmelt, land slope, soil permeability, plant cover, and frost effects also influence the magnitude of flood flows. In general, curves on the graph above are in descending order with decreasing drainage area. An exception is the transposed curves for the New Wood River near Merrill and the Wisconsin River at Conover, which is attributed to the dissimilar periods of record for these sites. Similar curves indicate similar stream conditions. The relatively low slopes of most of the curves reflect the temporary storage of flood waters by lakes, wetlands, and reservoirs. The curves for the Spirit River at Spirit Falls and the Prairie River near Merrill are steeper, representing flows of unregulated



The diagrams above illustrate the recurrence frequency of several high-water stages at long-term stream-gaging sites in the basin. The zero point on the diagram represents bank-full stage at the site and is not a staff-gage reading. The diagrams are schematic and do not represent the stream cross section at the gaging station. They can be used to estimate high-water risks

ency of sevsites in the ak-full stage lagrams are ction at the lagrants are ction at the lagrants are large lagrams are ction at the lagrants are large larg



RANGE IN QUALITY OF STREAM AND LAKE WATER

The illustration above compares the quality of water in lakes and streams. Lake analyses represent a cross section of all lake types. Stream analyses include the mainstems of major rivers and 0.03 mg/l inorganic phosphorus, as PO<sub>4</sub>.

Surface water in the basin generally is of good quality and is suitable for most purposes. The water is commonly soft, containing 0-60 mg/1 (milligrams per liter) hardness as CaCO<sub>3</sub>.

Chemical constitutents and sediment do not restrict the use of surface water for recreation or most industries.

Pollution of surf Wisconsin River at degraded (Wisconsin Surface water for recreation or most industries.

Chemical constitutents and sediment do not restrict the use of surface water for recreation or most industries.

Water color of lakes and streams in the basin ranges from clear to dark brown. The colored water is due to organic materials derived from wetland vegetation. As a result, streams draining wetlands and the lakes into which they flow are commonly colored. Statistically, the smaller lakes are more commonly colored and the large lakes clear (Black and others, 1963, p. 184).

(standard units)

5 6 7 8 9 10

-

-

Based on analyses compiled by

Andrews and Threinen (1966), Black,

Andrews, and Threinen (1963), and

Pollution of surface water is minor, although the quality of the Wisconsin River at Rhinelander, Tomahawk, and Merrill has been degraded (Wisconsin Department of Natural Resources, 1970, p. 6-9, 27-29). Ninety-four percent of the suspended solids discharged into streams is from pulp and paper mills; 94 percent of the biological oxygen demand (BOD) is caused by this discharge (Wisconsin Department of Natural Resources, 1970, p. 42). Because the area is comparatively undeveloped, there is little pollution of streams from municipal or other industrial wastes. Fertilization of lakes because of shoreline development of homes is a condition of increasing seriousness.

## RANGE IN QUALITY OF LAKE WATER

regulation of Lake Nokomis.

This diagram shows the range and median values of some chemical constituents in lake water in the basin. The lakes are considered in three categories, spring, seepage, and drainage, used by the Wisconsin Department of Natural Resources. Andrews and Threinen (1966) define them as follows: A spring lake seldom has an inlet but has an outlet of substantial flow. It is fed by ground water rather than surface drainage. A seepage lake has no inlet or outlet, although it may have an intermittent outlet. Lake level is maintained by the water table or by a well-sealed lake bottom. A drainage lake has an outlet and at least one inlet. Its main water source is from stream drainage.

or by a well-sealed lake bottom. A drainage lake has an outlet and at least one inlet. Its main water source is from stream drainage.

Specific conductance values were determined for 160 seepage lakes, 82 drainage lakes, and 28 spring lakes. Conductance is related to mineralization by the general relationship for the area: specific conductance × 0.7 = dissolved solids. The highest conductance and, therefore, the highest mineralization is in

spring lakes, which receive the greatest amount of ground water. Drainage lakes are less mineralized than spring lakes. In this basin many seepage lakes are bog lakes and have only slightly mineralized water.

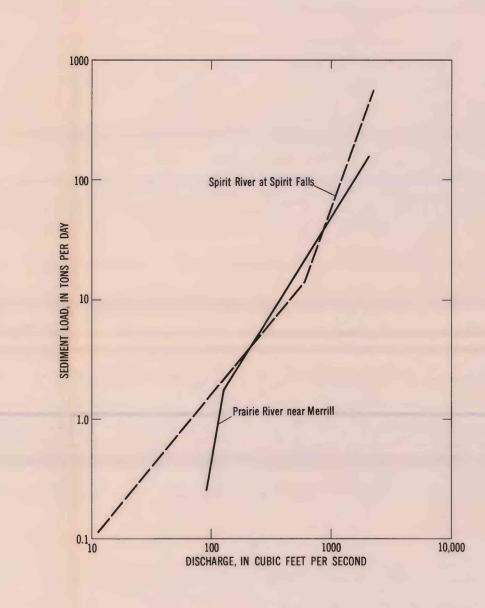
Bicarbonate is related to alkalinity, which is sometimes used as an index of fish productivity (Andrews and Threinen, 1966, p. 160). The median values of bicarbonate for spring and drainage lakes are similar. Both lake types are excellent for fish. Seepage lakes generally are not considered good fish habitat, probably due in part to low bicarbonate content.

The pH of water is a measure of its acidity (low pH) or basicity (high pH). Drainage lakes show the greatest range in pH values, although the median value is nearly neutral (pH 7).

Water in spring lakes is similar to ground water. The range

within seepage lakes is wide, but the low median value of 6.3

probably results from the low pH in shallow bog ponds.



STREAM DISCHARGE-SEDIMENT RELATION

The capacity of a stream to carry sediment depends upon

stream velocity and discharge, but the actual sediment load de-

pends also upon the availability of sediment. Concentrations of

sediment usually peak during storm runoff, shortly before the stream reaches peak discharge.

The graph at left shows the suspended-sediment load, in tons per day, related to discharge based on samples from two stream sites. The relationship is only approximate; for example, at a discharge of about 130 cfs, the sediment load in the Spirit River at Spirit Falls has been measured to be 0.7 ton per day at one time and 10 tons per day at another. This variation occurs because less sediment is available at one time than another, possibly due to seasonal changes in vegetation or agricultural prac-

tices, land clearing and excavations, or road and other construction.

Streams in the upper Wisconsin River basin have low sediment loads ranging from less than 10 to 25 tons of suspended sediment per square mile of drainage area per year (Hindall and Flint, 1970). These streams are in a relatively undeveloped, forested region, where outwash soils have high infiltration rates. Lakes and reservoirs act as stilling ponds where sediment is trapped and retained.

Stream sediment is not a major problem in the basin. However, it diminishes the trout habitat in some tributary streams because of streambank clearing by beavers and subsequent siltation behind their dams (Andrews and Threinen, 1966, p. 185).

## SUMMARY

Large amounts of good quality water are available in the upper Wisconsin River basin. Most areas have adequate supplies of water for future growth. The amount of surface water withdrawn in the basin is three times that of ground water, although the total withdrawal use is only about 2 percent of the streamflow leaving the basin. Ninety-one percent of the surface water used in the basin is for pulp and paper processing.

and tributaries. The number of samples for each parameter

ranges from 11 to 170 for lakes and from 19 to 24 for streams.

water, but excessive concentrations may accelerate weed and

Nitrogen and phosphorus are important nutrients in surface

Nonwithdrawal uses of surface water are power generation, recreation, fish and wildlife habitat, cranberry culture, and fish hatcheries. Ground water is used for all community and most rural supplies and for some irrigation.

Ground water, which is more widespread than surface water, is available principally from glacial sand and gravel deposits, although a few wells tap crystalline bedrock. Domestic and

In general, streams in the basin are slightly more mineralized

than lakes. Concentrations of all chemical constituents in lakes

and streams are low, and the water is suitable for most uses.

stock supplies are available everywhere in the basin. The sand and gravel commonly yields several hundred gallons per minute to wells in many places.

Controlled release from a network of 20 reservoirs regulates streamflow for power generation on the Wisconsin and Tomahawk Rivers. Supplemental benefits of the network are flood control and the development of recreational areas.

The northern part of the basin is a favorite recreation area. Forests cover more than 80 percent of Vilas and Oneida Counties, and the basin contains more than 2,000 lakes and 1,500 miles of streams. The lakes and streams contain trout and many species of game and pan fish.

Water quality in the basin is good. Most surface water is soft, and ground water is soft to moderately hard. There is little

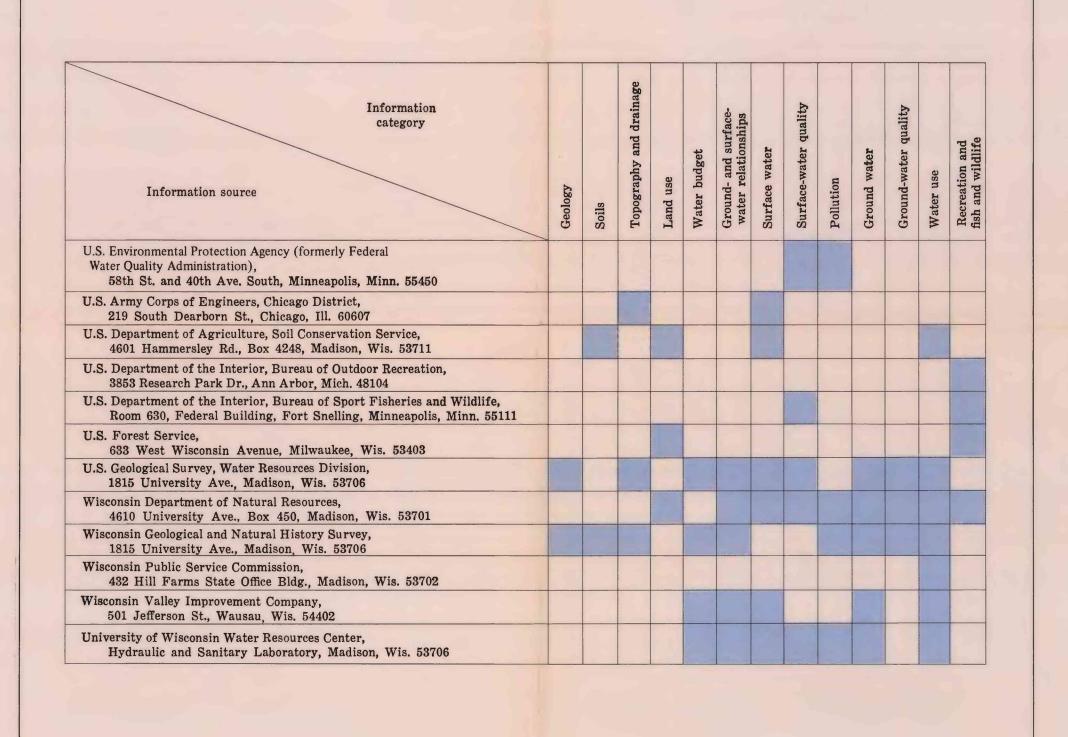
(milligrams per litre)

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pollution, and stream sediment loads are low.

Water problems are minor and are related primarily to water quality. High iron content is a local problem in ground water. Reaches of the Wisconsin River are polluted by industrial wastes. Some small lakes may have an algae problem because of overfertilization, which may contribute to winterkill of fish.

## AGENCIES HAVING ADDITIONAL INFORMATION



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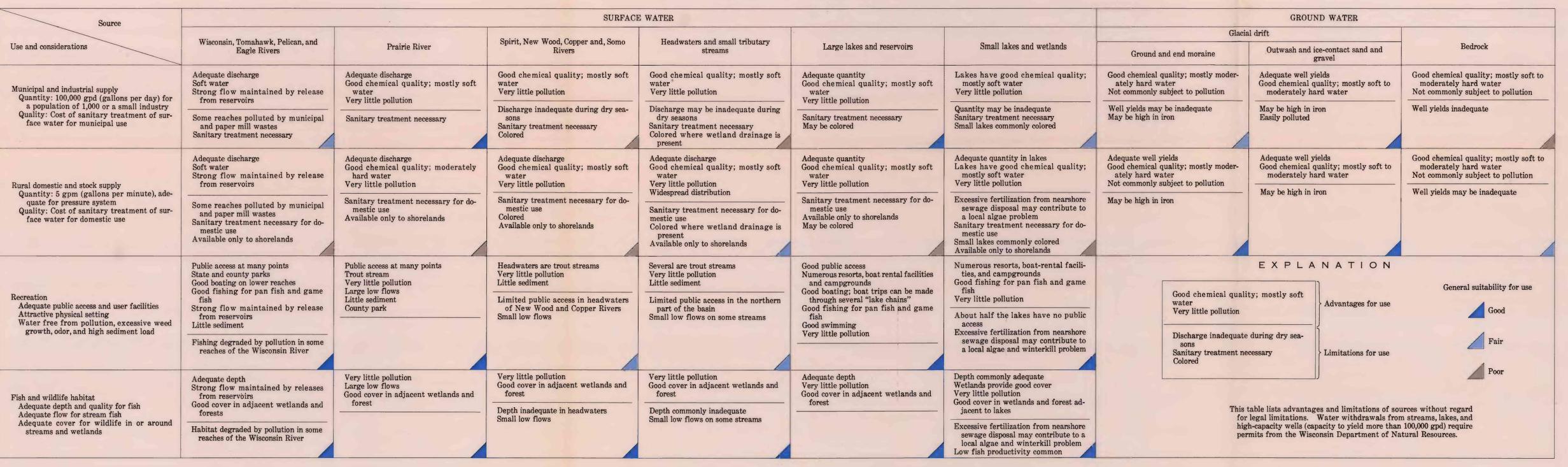
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SUMMARY OF WATER AVAILABILITY AND SUITABILITY FOR VARIOUS USES



Base from U.S. Geological Survey 1:500,000 1968