SURFACE WATER

LOW FLOW

Station No. 4-0852
Kewaunee River near Kewaunee
Drainage area: 129 square miles
Period of record: 1964 to present
Maximum instantaneous discharge: 6,500 cfs
Average discharge: 47.2 cfs
Minimum instantaneous discharge: 4.5 cfs

Station No. 4-0863.4
North Branch Milwaukee River near Fillmore
Drainage area: 110 square miles (est.)
Period of record: 1968 to present
Maximum instantaneous discharge: no data
Average discharge: no data
Minimum discharge: no data

Station No. 4-0862
East Branch Milwaukee River at New Fane
Drainage area: 45 square miles (est.)
Period of record: 1968 to present
Maximum instantaneous discharge: no data
Average discharge: no data
Minimum discharge: no data

Station No. 4-0861.5
Milwaukee River at Kewaskum
Drainage area: 120 square miles (est.)
Period of record: 1968 to present
Maximum instantaneous discharge: no data
Average discharge: no data
Minimum discharge: no data

Station No. 4-0870
Milwaukee River at Milwaukee
Drainage area: 686 square miles
Period of record: 1914 to present
Maximum instantaneous discharge: 15,100 cfs
Average discharge: 384 cfs
Minimum instantaneous discharge: 0

Station No. 4-0871.2
Menomonee River at Wauwatosa
Drainage area: 123 square miles
Period of record: 1961 to present
Maximum instantaneous discharge: 6,010 cfs
Average discharge: 64.6 cfs
Minimum instantaneous discharge: 2.8 cfs

Station No. 4-0872.04
Oak Creek at South Milwaukee
Drainage area: 25.0 square miles
Period of record: 1962 to present
Maximum instantaneous discharge: 612 cfs
Average discharge: 17.1 cfs
Minimum instantaneous discharge: 0.4 cfs

Station No. 4-0872.2
Root River near Franklin
Drainage area: 49.3 square miles
Period of record: 1963 to present
Maximum instantaneous discharge: 5,130 cfs (est.)
Average discharge: 32.3 cfs
Minimum instantaneous discharge: 0.8 cfs

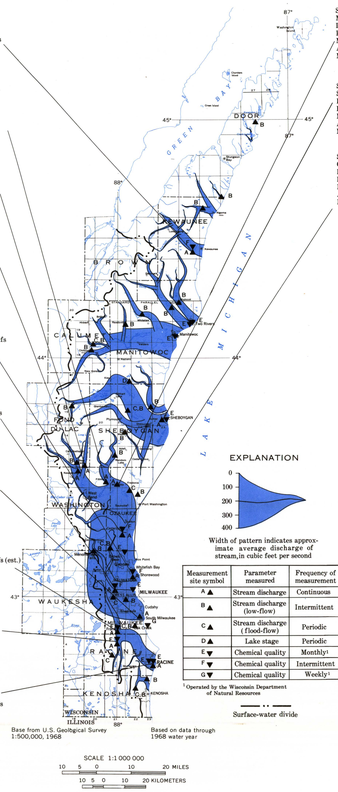
Station No. 4-0872.33
Root River Canal near Franklin
Drainage area: 57.2 square miles
Period of record: 1963 to present
Maximum instantaneous discharge: 774 cfs
Average discharge: 33.7 cfs
Minimum instantaneous discharge: 0.4 cfs

Station No. 4-0872.4
Root River at Racine
Drainage area: 187 square miles
Period of record: 1963 to present
Maximum instantaneous discharge: 2,500 cfs
Average discharge: 104.4 cfs
Minimum instantaneous discharge: 1.3 cfs

Station No. 4-0863.6
Milwaukee River at Waubeka
Drainage area: 390 square miles (est.)
Period of record: 1968 to present
Maximum instantaneous discharge: no data
Average discharge: no data
Minimum discharge: no data

Station No. 4-0860
Sheboygan River at Sheboygan
Drainage area: 432 square miles
Period of record: 1916–24, 1950 to present
Maximum instantaneous discharge: 7,140 cfs
Average discharge: 232 cfs
Minimum instantaneous discharge: about 1 cfs

Station No. 4-0865
Cedar Creek near Cedarburg
Drainage area: 121 square miles
Period of record: 1930 to present
Maximum instantaneous discharge: 3,600 cfs
Average discharge: 62.7 cfs
Minimum instantaneous discharge: 0.2 cfs



Measurement site symbol	Parameter measured	Frequency of measurement
A ▲	Stream discharge	Continuous
B ▲	Stream discharge (low-flow)	Intermittent
C ▲	Stream discharge (flood-flow)	Periodic
D ▲	Lake stage	Periodic
E ▼	Chemical quality	Monthly[1]
F ▼	Chemical quality	Intermittent
G ▼	Chemical quality	Weekly[1]

[1] Operated by the Wisconsin Department of Natural Resources

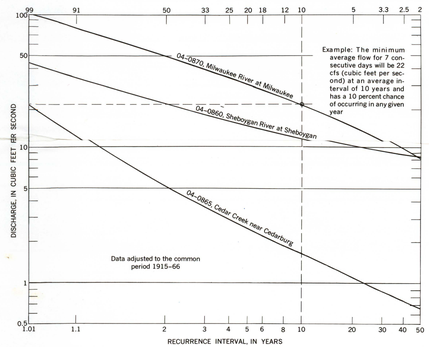
Base from U.S. Geological Survey 1:500,000, 1968

Based on data through 1968 water year

SCALE 1:1 000 000

DATA NETWORK AND AVERAGE STREAMFLOW

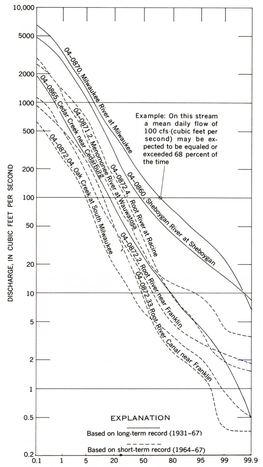
Streamflow is continuously monitored at 13 sites (gaging stations). Frequency and duration curve were prepared, and average flow determined from these records. Average streamflow of major streams and some tributaries, flow and low-flow measuring sites, lake stage sites, and chemical quality measuring sites are shown on the map above. Sites where miscellaneous flow measurements are made are not indicated.



7-DAY LOW FLOW FREQUENCY

A knowledge of low flow of a stream is necessary to determine adequacy of streamflow for minimum supply needs, to maintain reservoir storage, to estimate ground-water discharge, and to estimate a stream's capacity to accommodate and transport waste.

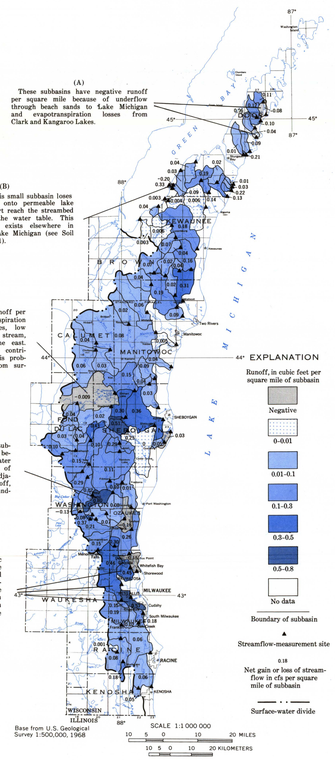
Seven-day low flow curves can be used to determine recurrence intervals of low flow and the percent chance that interval has of occurring in any given year, as indicated in the example above.



FLOW DURATION

Flow duration is generally similar for these eight streams. The moderately steep, fairly uniform slope of the curves indicates that base flow is not sustained at a high level by release from ground or surface storage. Low flows on the Menomonee River, Root River, and Root River Canal are sustained in part by additions of waste water from municipal and industrial sources.

High flows result partly from rapid runoff of snowmelt and rainfall. Contributing factors to rapid runoff are abundant clay till, moderately steep stream gradients, land-use practices, and frozen ground.



RUNOFF DURING LOW FLOW

The map presents streamflow in the study areas as runoff per square mile by subbasin, based on streamflow measurements at 100 sites during October 2–4, 1968. This period represents high base-flow conditions (about 65 percent on the flow-duration curve), when there was no overland runoff and streamflow was maintained by the slow release of water from ground-water storage.

Low flows differ in numerous subbasins because of differences in geology and soil cover, evapotranspiration, the number and size of lakes and marshes, the amount and type of vegetative cover, artificial impoundments, and diversions within the ground-water systems. Some of these differences are discussed in the explanations for subbasins that have unusual runoff per square mile. Many high-unit discharges are related to the two major areas of glacial outwash (see Glacial Geology, sheet 1), where the flows are probably sustained by water released from these deposits.

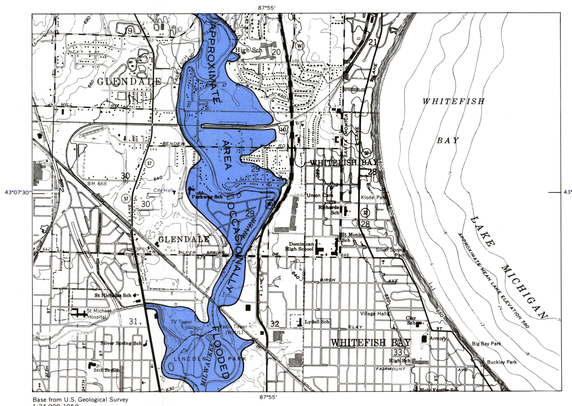
All areas within a subbasin may not be typical of the subbasin. The measured flow is an integration of runoff from the area upstream from the measuring site. The so-called "negative" runoff shown for the eight subbasins results from a downstream loss in streamflow between two measuring sites.

Surface water in the basin is generally abundant and of good quality. Lake Michigan is used for water supply, transportation, waste disposal, recreation, and habitat for fish and wildlife. Streams and the few inland lakes are used for recreation, wildlife, and waste transport. About 480 billion gallons of water leave the basin each year as streamflow.

The activities of man, especially the discharging of wastes and impounding of water, have locally altered water quality and flow characteristics of streams. Some conflicts of water use are evident and may become acute as the population and demand for water increase.

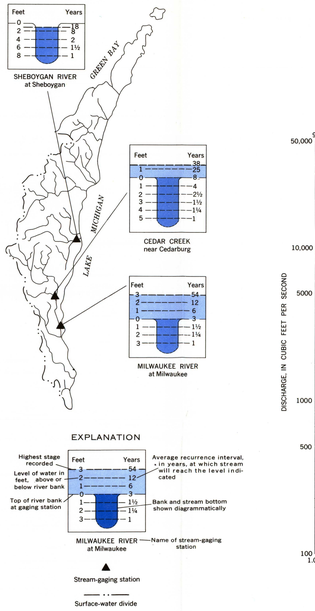
FLOODS

Flooding is a local problem in the Lake Michigan basin. A significant threat of flood and flood damage exists in the heavily urbanized parts of the lower Milwaukee and Root River basins. Moderate relief, flood plain and wetland storage, and practical land use have reduced flood threats in the rest of the basin. However, increased urbanization and improper use of flood plains may result in increased problems associated with storm runoff.



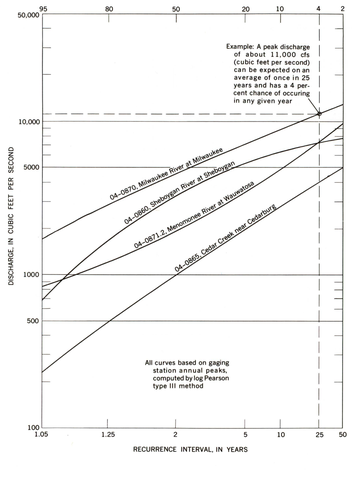
FLOOD-PRONE AREA

The magnitude of floods depends largely upon the size of the drainage area, but the effects of floods depend upon many physical and economic factors. The map above shows a flooded urban area of about 630 acres in the city of Glendale.



FLOOD-STAGE FREQUENCY

Flood stage or height depends upon numerous factors including width, depth, and velocity of flow within the stream channel and on the flood plain; and channel controls such as bridges, dams, ice jams, or natural constrictions. The diagrams shown above illustrate the frequency of various high-water stages at long-term stream-gaging stations in the basin. Because the controlling factors are different at each site on the stream, these stage diagrams can be used to estimate flood risks only in the vicinity of the gaging stations.



FLOOD DISCHARGE FREQUENCY

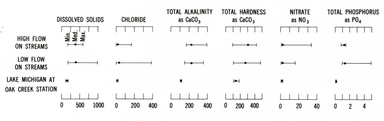
These flood-frequency curves show the probable recurrence of a discharge of given magnitude and the percent chance that discharge has of occurring in any one year. The example indicates how to use the curves to determine these values.

Flood discharge generally reflects the size of the drainage basin. However, as shown in the curves above, the Menomonee River has higher flood discharges than Cedar Creek, although they have similar size drainage areas. The higher flood discharges on the Menomonee River are likely caused by urbanization in the basin. Direct runoff is high, and sewer systems rapidly collect and transport large quantities of water directly to the stream.

WATER QUALITY

Surface water in the Lake Michigan basin is generally of good quality, although hardness is a persistent problem. Stream water is very hard throughout much of the basin (181 mg/l or greater hardness). Lake Michigan water is softer but is hard (about 125 mg/l hardness), and is the only surface water used for public supplies. Commercial softeners might make this water more desirable for some uses.

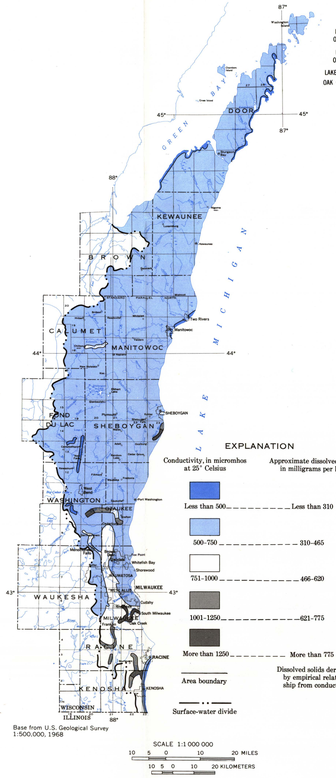
The quality of water in some streams, especially in reaches flowing through urbanized areas in the lower one-half of the basin, has been degraded locally. Nutrients and biological and chemical contaminants have caused much of this degradation.



QUALITY OF WATER IN MAJOR STREAMS AND LAKE MICHIGAN

This diagram shows the range of water-quality parameters in Lake Michigan and major streams within the basin (based on data from multiple samples taken at 15 stream sites and one Lake Michigan site). Dissolved solids represent total mineralization; it is partly natural in origin and partly a result of man's activities. Alkalinity represents mainly bicarbonate and is largely natural in origin. Nutrients (nitrate and total phosphorus) are partly introduced through sewage and fertilizers. Both total and natural mineralization are generally higher in streams than in Lake Michigan and are highest at low streamflow.

Nitrogen and phosphorus are important nutrients in surface water, but excessive concentrations may cause weed-choked channels in streams and obnoxious algal blooms and weedy areas along lakeshores. The critical concentrations given by Sawyer (1947) are 1.3 mg/l inorganic nitrogen as NO_3 and 0.03 mg/l inorganic phosphorus as PO_4. The median value of all streams and the average values of many streams exceed these concentrations.



SURFACE-WATER QUALITY DURING LOW FLOW OCTOBER 2-4, 1968

Specific conductance of water is related to the amount and kind of minerals dissolved in the water. In the Lake Michigan basin this relationship can generally be expressed by the formula:

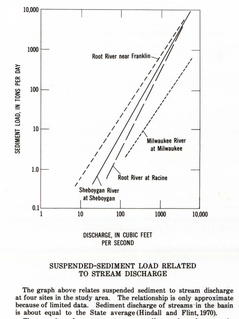
$$\text{Dissolved solids} = \text{specific conductance} \times 0.62$$

This formula represents average conditions, and the numerical relationship varies seasonally and with flow.

The conductivity map above shows the chemical quality of streamflow during a high base flow period (Oct. 2-4, 1968). The quality of water in streams was similar to that of ground water throughout most of the basin (conductance ranging between 500 and 1,000 micromhos). However, the Pike, Root, and Black Rivers, and Oak and Cedar Creeks are influenced locally by pollution and, in addition, impoundments on Cedar Creek cause local changes.

The areas of high conductance of water along stream channels are the expression of pollution downstream from industrial and municipal waste-discharge points.

The low-conductance areas outlined along stream channels result from quality changes in impoundments, which affect water quality downstream. Low-conductance areas along Lake Michigan occur in areas of beach sand, where rapid recharge and short flow paths through the permeable sand result in streams being fed by ground water with low mineral content.



SUSPENDED-SEDIMENT LOAD RELATED TO STREAM DISCHARGE

The graph above relates suspended sediment to stream discharge at four sites in the study area. The relationship is only approximate because of limited data. Sediment discharge of streams in the basin is about equal to the State average (Hindall and Flint, 1970).

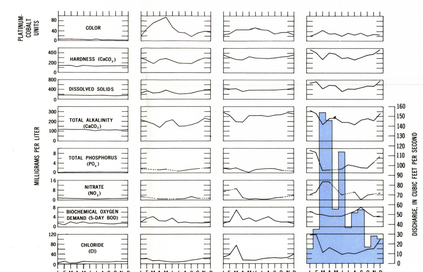
The capacity of a stream to carry sediment depends upon the stream velocity and discharge. The peak concentration of suspended sediment occurs during storm runoff, usually before the stream reaches peak discharge. However, if the suspended sediments are clay and silt size, they tend to remain suspended longer and reach peak concentrations at or shortly after peak stream discharge.

Sediment load also depends upon availability of sediment. Land clearing, road construction cutting, and general excavating greatly increase sediment availability.

The high sediment concentrations in the Root River near Franklin are partly a result of the steep gradient in the headwaters area of the river. The stream near Franklin, like at Racine, drains through populated areas, which also contributes to high sediment concentrations. Sediment concentrations at low flows are less in the Root River at Racine than near Franklin because the impoundment above Racine retains much of the sediment.

The Milwaukee River at Milwaukee has lower sediment concentrations than the Root River because numerous impoundments along the Milwaukee River and some of its tributaries trap some of the sediment.

The Sheboygan River drains an area underlain mostly by clay till, which erodes readily. Abundant clay- and silt-size sediment is transported throughout the course of the stream.



Based on averages from monthly samples (1961-68) by Wisconsin Department of Natural Resources and from average of the mean discharge on days that samples were collected

This series of graphs compares seasonal water quality conditions in Lake Michigan and three streams that represent dissimilar areas of the basin. Average chemical quality of streamflow varies seasonally with discharge. Total hardness, dissolved solids, and alkalinity concentration vary directly with each other and generally inversely to flow.

The chemical quality of water in Lake Michigan at Oak Creek is generally consistent. Hardness and alkalinity make up most of the mineralization in the water, and dissolved solids average about 180 mg/l. Concentrations of the parameters are less in Lake Michigan than in the streams and are more of a contrast to the streams than a comparison.

The Manitowoc River at Manitowoc represents moderately mineralized but unpolluted streams in and north of the Manitowoc River basin. The mineralization consists largely of hardness and alkalinity. However, in the winter months chloride increases slightly. Color is high (near 100 platinum-cobalt units) during spring runoff when organic material is flushed from wetlands.

The Milwaukee River near Milwaukee, like the Sheboygan and Menomonee Rivers, is influenced somewhat by pollution. However, biochemical oxygen demand concentrations are moderate to low, which indicates that the pollution effect is small. Nutrients, although not considered high, are present in nuisance proportions. Most mineralization is due to hardness and alkalinity, but significant increases in chloride occur in winter and early spring. Color in the Milwaukee River is not a problem but is always present in noticeable amounts (ranges from 30 to 50 units).

The Root River at Racine, like the Pike and Black Rivers and Cedar and Oak Creeks, is heavily polluted, especially by sewage. Biochemical oxygen demand is greatest during the hot summer months, further indicating pollution by sewage. Nutrients are present in problem amounts; nitrates and phosphorus concentrations vary inversely, indicating their sources are different. Total mineralization varies inversely to flow, but some parameters such as nitrate and color are highest during spring runoff. Color is generally moderate to low but is always 20 units or greater.

WATER RESOURCES OF WISCONSIN-LAKE MICHIGAN BASIN

By
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1973

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