INTRODUCTION

PURPOSE AND SCOPE

The purpose of this report is to describe the water resources of the Menominee-Oconto-Peshtigo River basin in Wisconsin in order to aid in planning future water management in the basin and in nearby areas. The physical setting, availability, distribution, movement, quality, and use of water are discussed.

The report presents general information on the basin that was derived from data obtained from Federal, State, and other agencies. In addition, new data were collected from areas where available information was scarce and where there is important water use. For more detailed information the reader is referred to the section titled "Sources of Additional Information", (sheet 4).

This atlas is one of a series of 12 river-basin studies designed to describe in general terms the water resources of the State. More detailed studies of problem areas may be required in the future as the need for additional information arises.

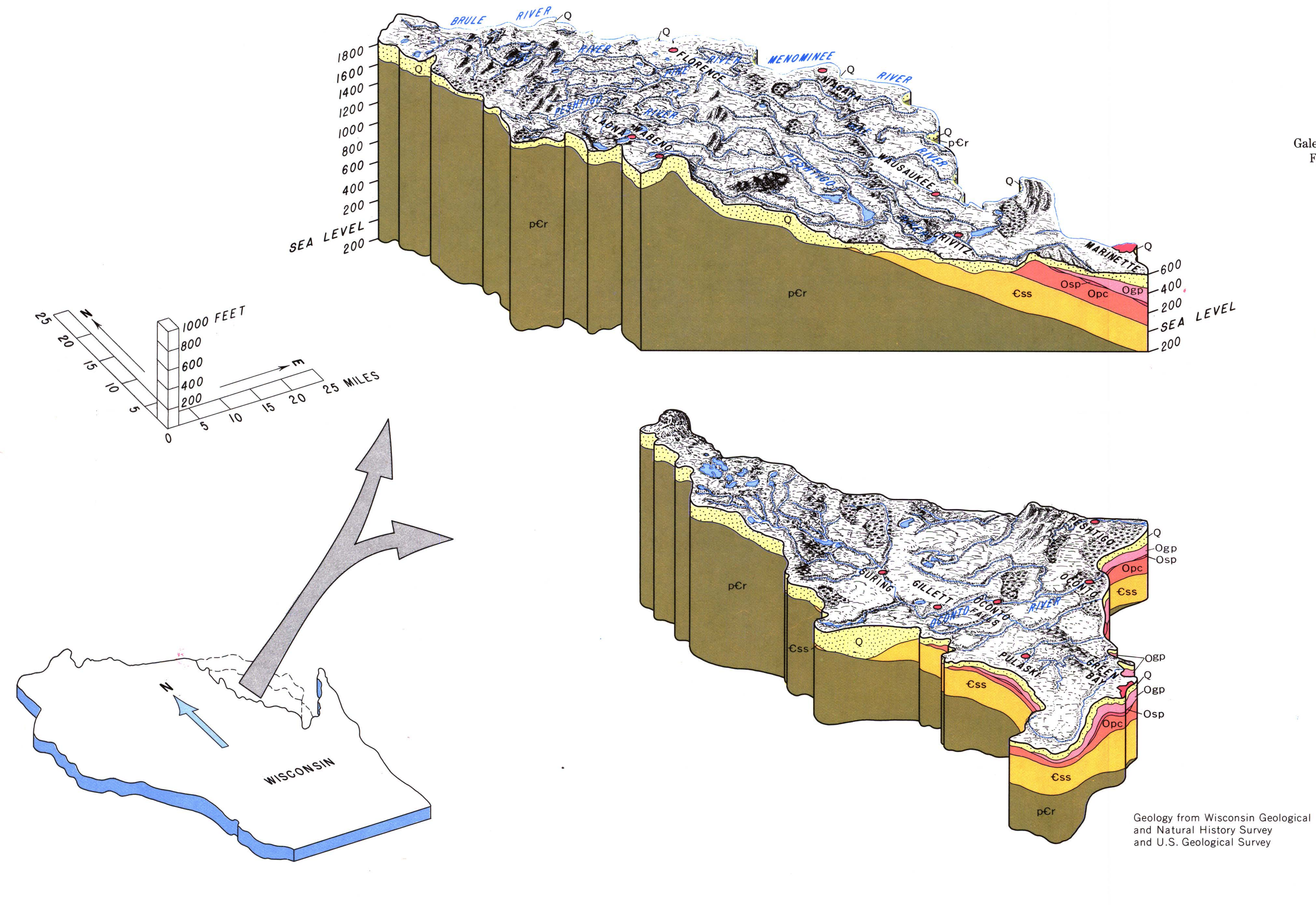
LOCATION AND EXTENT

The basin is bounded by the surface-water divides of the Wisconsin, Wolf, and Fox Rivers, the Wisconsin-Michigan boundary along the Brule and Menominee Rivers, and Lake Michigan (Green Bay). The 4,300-square mile area includes all of Florence and Marinette Counties, most of Oconto County, and parts of Brown, Forest, Langlade, Menominee, Outagamie, Shawano, and Vilas Counties. It includes the area in Wisconsin drained by the Brule, Menominee, Peshtigo, Oconto, Pensaukee, Suamico, and Little Suamico Rivers, Duck Creek, and other small tributaries to Green Bay.

ACKNOWLEDGMENTS

Much data were supplied by State and other agencies. University Extension—the University of Wisconsin Geological and Natural History Survey furnished well logs and geologic and soils maps. Chemical analyses and water-use data were obtained from the Wisconsin Department of Natural Resources and the Public Service Commission of Wisconsin. U.S. Soil Conservation Service personnel supplied land-use information. Municipal and industrial officials and private land owners furnished additional water-use information.

PHYSICAL SETTING

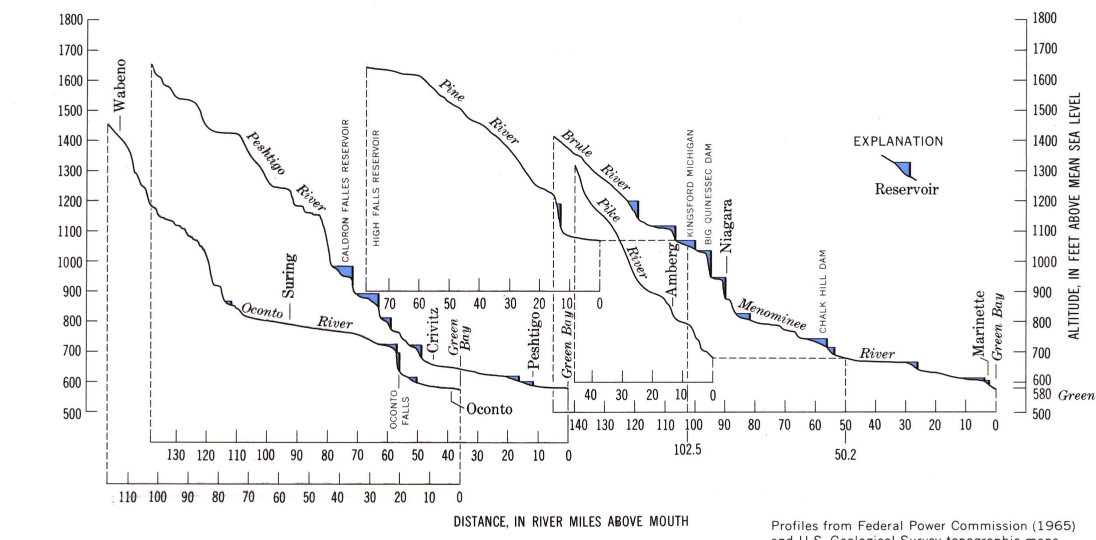


BLOCK DIAGRAM OF THE MENOMINEE-OCONTO-PESHTIGO RIVER BASIN

The basin has an irregular rolling landscape consisting of an uneven cover of glacial deposits overlying an eroded bedrock surface. The overall view of the basin on the surface of the above block diagram is that of a land mass, highest along the west and north edges, sloping to its lowest level along the east and southeast edges. Drainage is toward the east and south. Depressions in the northern two-thirds on the land surface are occupied by lakes or swamps. Local relief is generally not more than 100 feet on the land surface. Maximum relief is about 1,300 feet.

The buried bedrock surface has several hundred feet of relief, with a maximum local relief between hills and valleys of about 600 feet. Maximum relief is about 1,100 feet. In the north the bedrock surface slopes east at about 10 feet per mile. In the south the slope is southeast at about 7 feet per mile.

In the north the bedrock is part of a Precambrian crystalline dome that forms the highlands of northern Wisconsin. In the southern half of the basin crystalline bedrock is overlain by layered sedimentary bedrock. Here the slope on the crystalline rock surface is 30 feet per mile to the southeast, and the rock may be at a depth as great as 200 feet below sea level. The overlying sedimentary bedrock dips 30 feet per mile to the southeast.



STREAM PROFILES

Profiles of streams in the basin reflect very closely the character of the land over which the streams flow. The principal controlling influence on stream profiles is the bedrock surface and, to a lesser degree, the glacial sediments that overlie bedrock.

The Menominee and Brule Rivers flow generally southeastward across Precambrian crystalline bedrock at gradients of about 7 feet per mile, with some reaches having gradients of 20–30 feet per mile. For the last 40 miles of its 147-mile course, the Menominee River flows at a gradient of about 2 feet per mile across ground moraine and glacial lake deposits overlying Paleozoic sedimentary bedrock.

The Pine and Pike Rivers generally slope 10–15 feet per mile, reflecting the slope of the bedrock surface. The gradient is less than 1 foot per mile in the Pine River headwaters because the stream flows over a flat outwash area. The gradient is about 1 foot per mile at the mouth of the Pine River because the stream flows over outwash in the Menominee River valley.

The Peshtigo and Oconto Rivers, for most of their distances, flow on an eroded surface of Precambrian crystalline rock that slopes from 10 to 30 feet per mile. In their lower reaches these rivers flow across ground moraine and glacial lake deposits overlying Paleozoic sedimentary rocks, and stream gradients are from 1 to 2 feet per mile.

Steep reaches of streams in the basin are the locations of dam sites. Most of these reaches are where the rivers flow over very resistant Precambrian crystalline rock. Steep reaches are not common where the streams cross sedimentary rock; however, some occur where the streams cross dolomite.

LAND USE

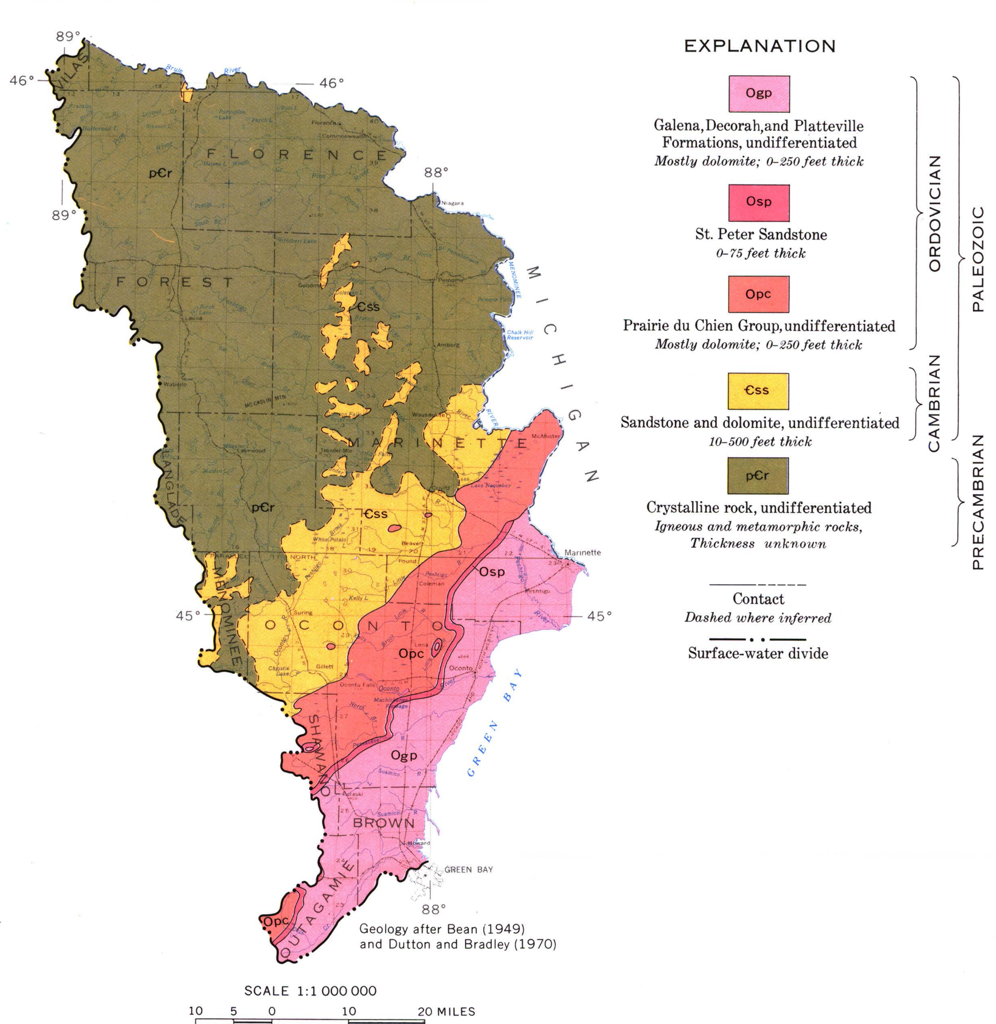
The basin is about 96 percent land and 4 percent water, taking into consideration only that water area which includes streams at least one-eighth mile wide and lakes greater than 10 acres. Of the land area of the basin, 69 percent is in public and private forests, 19 percent is agricultural, 2 percent is urban, and 10 percent is "other land," which includes small lakes and streams, ungrazed wetlands and swamps, and various county-owned lands (oral commun., U.S. Soil Conserv. Service, 1969).

Bedrock is shown on the map as it would appear if the glacial sediments were stripped away. Bedrock in the basin is of two general types: Precambrian crystalline rocks, and Cambrian and Ordovician (Paleozoic) sedimentary rocks.

Precambrian igneous and metamorphic rocks form the bedrock surface in the northern two-thirds of the basin. These rocks, where fractured and decomposed, yield small quantities of ground water.

In the southern one-third of the basin layered Paleozoic sedimentary rocks overlie Precambrian rocks and strike northeast and dip southeast. As a result of erosion and southeast dip, increasingly younger rocks form the bedrock surface toward the southeast. The youngest rocks and greatest sedimentary rock thickness are found along the Green Bay shore (see block diagram above).

Paleozoic rocks are significant sources of ground water. Most large ground-water supplies are obtained from sandstone. Sandstone occurs as the lower part of the Cambrian sandstone and dolomite, and in the St. Peter Sandstone. Many flowing deep wells located near Green Bay were finished in Cambrian sandstone (Weidman and Schultz, 1915). Smaller domestic supplies generally are obtained from the overlying formations, which are mostly dolomite. The St. Peter Sandstone, which is an important source of water elsewhere in the State, is discontinuous across the area of sedimentary rocks (see block diagram above).



BEDROCK GEOLOGY

Glacial drift, which stores water for recharge to bedrock and release to wells and streams, overlies bedrock in most of the basin.

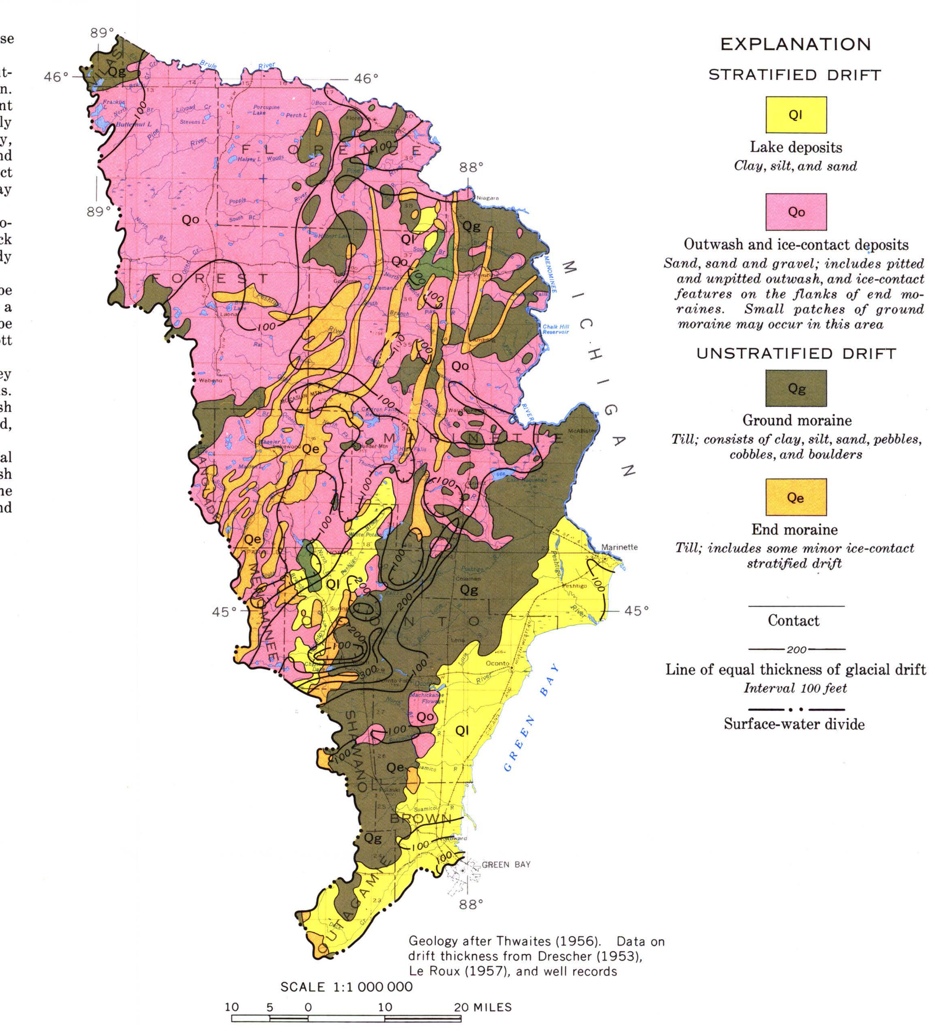
Drift is stratified or unstratified. Most stratified drift is sandy outwash or ice-contact deposits laid down by melt water during glaciation. Some is sandy, silty, or clayey lake deposits laid down in quiescent water. Unstratified drift is unsorted sandy, clay till laid down directly by ice in a thin sheet (ground moraine) or ridges of bouldery, sandy, clay till laid down by ice during pauses in advance or retreat (end moraine). Areas of end moraine usually include stratified ice-contact features and outwash. Outwash may overlie ground moraine or may be buried by till deposited during glacial re-advance.

Lake deposits occur between end moraines and overlie ground moraine and outwash. Extensive lake deposits, as much as 50 feet thick near Green Bay, contain thick beds of silt or clay, sand bars, and sandy beach and deltaic deposits.

The drift is less than 100 feet thick over most of the basin but may be nearly 500 feet thick at Gillett (Thwaites, 1943, p. 118), where it fills a preglacial valley deeply incised in bedrock. This valley appears to be an extension of ancestral Wolf River drainage described by Olcott (1968, sheet 1).

Till and lake deposits are poor sources of ground water because they have low permeability and do not readily yield water to wells or streams. Deltaic sandbar sands may be local sources of ground water. Outwash and ice-contact deposits have high permeability and, where saturated, are excellent sources of ground water.

Along the west edge, central, and northern parts of the basin glacial drift is an important source of ground water due to extensive outwash and ice-contact deposits. In the southern and southeastern parts of the basin glacial drift is a poor source of water due to extensive ground moraine and lake deposits.

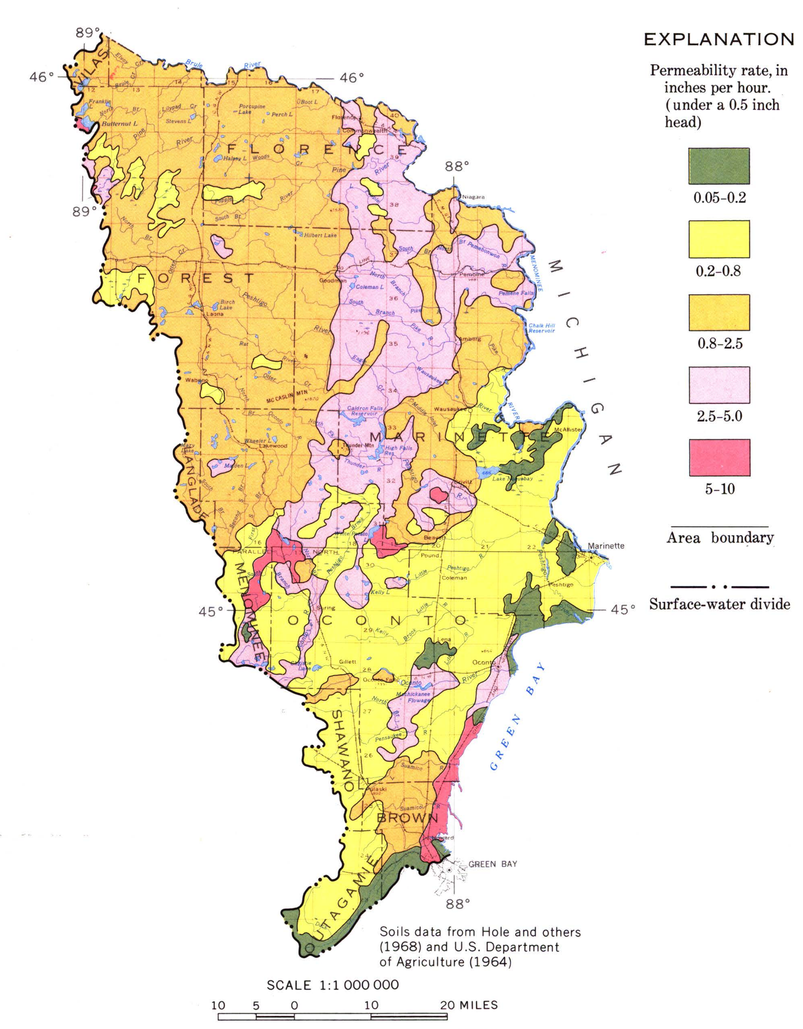


GLACIAL GEOLOGY

Soils in part determine how much rainfall or snowmelt directly runs off to streams and how much enters the ground by infiltration. Part of the precipitation that infiltrates soil replenishes soil moisture; part becomes ground-water recharge. Low soil permeability contributes to rapid surface runoff and low infiltration; high soil permeability allows rapid infiltration of precipitation and low surface runoff.

Soil permeability in the basin is related to the glacial deposits from which the soils were derived. Soils with a permeability of "0.05–0.2" inch per hour are either peat or muck soils or are soils developed on lake clay; the "0.2–0.8" soils are mostly developed on clay till ground moraine; the "0.8–2.5" soils are developed on sandier upland areas of mixed outwash and ground moraine; the "2.5–5.0" soils are developed on sand and gravel ice-contact deposits and outwash sands mixed with end moraine; and the "5–10" soils are developed on very well drained upland outwash sands or on dune sand along the shore of Green Bay. In general the more sandy a soil parent material, the greater is the soil permeability.

The map of soil permeability is based on the least permeable horizon (U.S. Department of Agriculture, 1964).

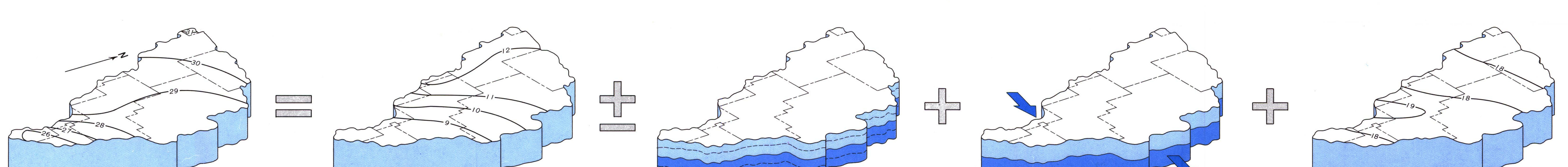


SOIL PERMEABILITY

HYDROLOGIC BUDGET

The hydrologic budget of the Menominee—Oconto—Peshtigo River basin is a quantitative accounting of the balance between the total water gains and losses for a given period of time. The average annual budget for a 30-year period (1931–60) indicates that of the 29.0 inches of precipitation entering the system, 10.7 inches is directly available for man's use. This 10.7 inches of streamflow includes 7.0 inches of ground water discharged to streams as well as 3.7 inches of overland flow, and it is equivalent to 3,400 cfs (cubic feet per second) or 2,200 mgd (million gallons per day). This amount represents only the water emanating from that part of the basin in Wisconsin and does not include Menominee River flow coming from Michigan.

The quantities of these budget items fluctuate from year to year. Underflow remains fairly constant, changes in storage and evapotranspiration vary somewhat, but precipitation and runoff show the greatest relative change. Annual precipitation has been as high as 38.1 inches (1938) and as low as 20.8 inches (1930). Measured annual runoff has been as high as 15.8 inches (1951) and as low as 7.1 inches (1948). The disparity between the occurrence of highest or lowest precipitation and runoff in the same year is due to the amount of water entering or leaving storage during the year.



PRECIPITATION (P)
29.0 INCHES

The average annual precipitation falling on the basin is 29.0 inches based on U.S. Weather Bureau records for the period 1931–60. Precipitation is greatest in the extreme northwest corner of the basin and is least in the southernmost part.

RUNOFF (R)
10.7 INCHES

Average annual runoff (10.7 inches) was computed from streamgaging records on the Brule, Menominee, Pine, Pike, Peshtigo, and Oconto Rivers. Runoff is greatest in the northern part of the basin and is least in the southern part, which is the same general pattern as precipitation.

CHANGE IN STORAGE (ΔS)
NONE

The amount of water stored in lakes and reservoirs, in the soil zone, or in the glacial deposits and bedrock (ground-water reservoir) may increase or decrease over a given time period. However, the net change is negligible (assumed to equal zero) when averaged over the 30-year period of this budget.

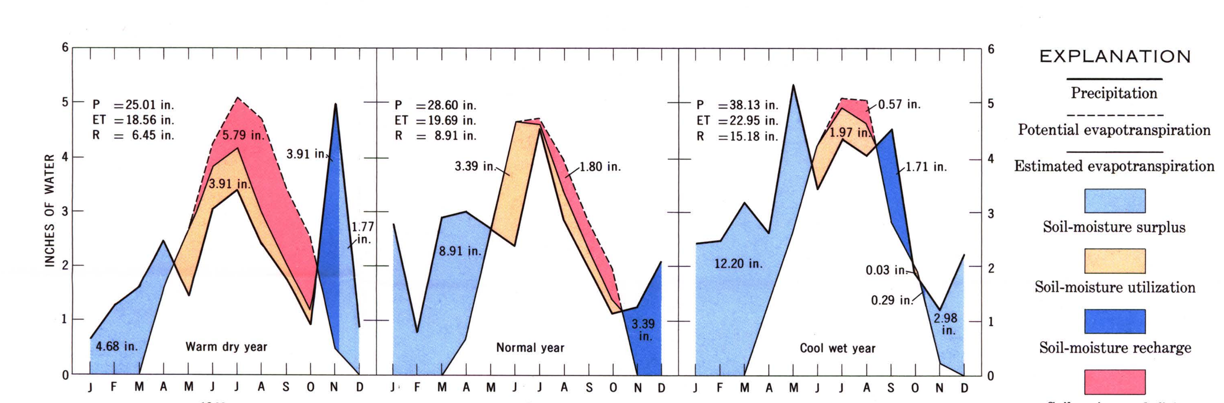
UNDERFLOW (U)
0.3 INCH

Underflow is that water entering or leaving the basin through the ground-water reservoir. No appreciable quantity enters or leaves the basin as underflow through glacial or alluvial deposits. However, about 0.4 inch of water flows downdip through Paleozoic sedimentary rocks and leaves the basin beneath Green Bay. Deducting the 0.1 inch that enters the basin through bedrock from the west, the net underflow from the basin is 0.3 inch, about 17 mgd.

EVAPOTRANSPIRATION (ET)
18.0 INCHES

Evapotranspiration is the return of water to the atmosphere by a combination of evaporation from open water, foliage surfaces, and land surface, and transpiration from plants. Average annual evapotranspiration is estimated to be 18.0 inches, which is the difference between precipitation and the sum of runoff, changes in storage, and underflow. Evapotranspiration is greatest in the southwestern and northern parts of the basin because of the occurrence of high rainfall and wetlands in the north and wetlands and higher temperatures in the southwest.

MONTHLY WATER BALANCE



Hydrologic budgets for individual years are compared by monthly balances in the above figure. These budgets, prepared according to the method of Thornthwaite and Mather (1957), are for the entire basin. Each budget compares recorded precipitation (P) with estimated evapotranspiration (ET). Runoff (R) is derived as a residual amount. Underflow is nearly constant and is not considered in these budgets.

In each year evapotranspiration remained at zero until March, then rose to exceed precipitation during summer and early autumn, and then declined to zero in November or December. The amount of estimated evapotranspiration is dependent upon the quantity of water available. Summer temperatures in the basin are sufficiently high for evapotranspiration to be even greater than the actual amount, assuming the availability of water. This greater amount, which does not represent actual water, is graphed as potential evapotranspiration.

The annual hydrologic budget is divided into the following categories:

Soil-moisture surplus.—Precipitation that is in excess of soil moisture. Some infiltrates to ground-water storage, and some directly runs off to streams. If the moisture occurs as snow, infiltration or direct runoff may not occur until the spring thaw.

Soil-moisture utilization.—Moisture in soil storage that is used for plant growth. The amount utilized is the quantity removed from soil storage.

Soil-moisture recharge.—Precipitation that is in excess of plant requirements. This water surplus is used to replenish soil moisture.

Soil-moisture deficit.—The difference between estimated and potential evapotranspiration. This occurs during a period of soil-moisture utilization when a potential exists for greater evapotranspiration than is actually occurring. This does not necessarily imply a drought but means that plants would use more water if it were available.

In each budget year the bulk of precipitation falls as rain from late spring to early autumn. However, nearly all of this water is evaporated or transpired by plants and evapotranspiration is greater than precipitation during the summer months. In this basin the restoration of ground-water storage is usually dependent upon spring recharge by over-winter precipitation, which usually occurs as snow.

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

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1974

WATER RESOURCES OF WISCONSIN—MENOMINEE-OCONTO-PESHTIGO RIVER BASIN

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