PHYSICAL SETTING

PURPOSE AND SCOPE

The purposes of this report are to (1) describe the geohydrology of the basin, (2) describe and relate the surface- and ground-water systems, (3) discuss existing and possible future water problems in the basin, and (4) to suggest means of possible solutions.

The scope of the study was to interpret and relate streamflow, climatic, geologic, and ground-water information.

Because of its reconnaissance nature, this report should serve as background information. More specific water information for many areas of the Fox-Wolf River basin is available at the offices of the U.S. Geological Survey and the University of Wisconsin Geological and Natural History Survey in Madison.

This study is part of a planned investigation of the geology and water resources of the rapidly developing Fox River valley industrial complex and municipal region extending from Green Bay to Fond du Lac. The related studies in this region cover Fond du Lac County (Newport, 1962), Outagamie County (LeRoux, 1957), Brown County (Drescher, 1953), the Green Bay area (Knowles and others, 1964; Knowles, 1964), Waupaca County (Berkstresser, 1964), Waushara County (Summers, 1965), and Winnebago County (Olcott, 1966).

LOCATION AND EXTENT

The Fox River and its principal tributary, the Wolf River, drain an area of approximately 6,500 square miles in east-central and northeastern Wisconsin. The basin includes all or significant parts of the following 18 counties: Columbia, Adams, Marquette, Green Lake, Fond du Lac, Waushara, Winnebago, Calumet, Portage, Waupaca, Outagamie, Brown, Shawano, Marathon, Langlade, Oneida, Forest, and Menominee.

TOPOGRAPHY AND DRAINAGE

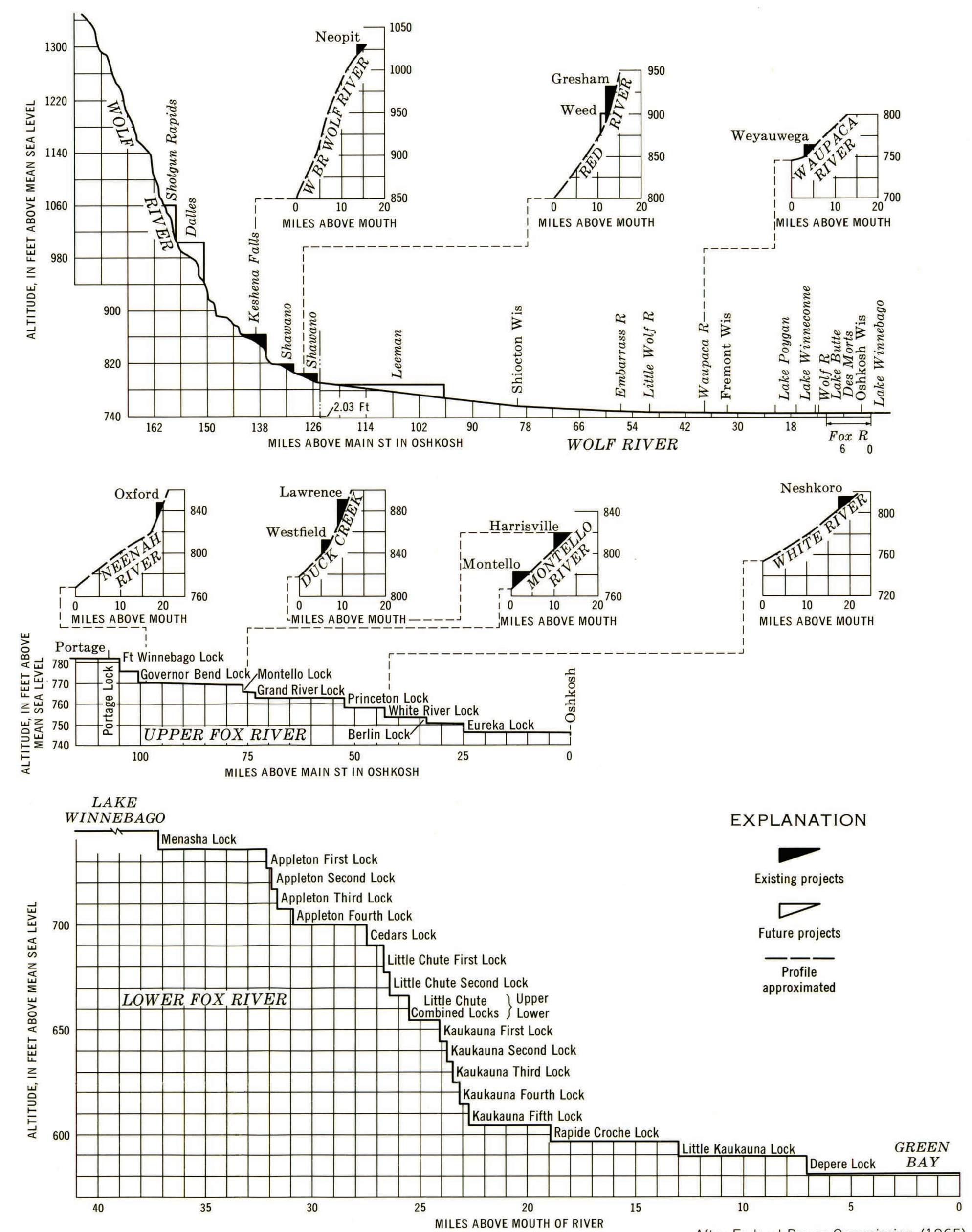
The topography and drainage of the Fox-Wolf basin is controlled by the topography of the bedrock surface, and modified by glacial erosion and deposition. The general topography of the basin includes broad relatively flat plains and some generally north-south ridges. Altitudes in the basin range from about 585 feet at Green Bay to about 1800 feet in the northern part of the Wolf basin. Regional highland and lowland areas on the bedrock surface generally underlie and control the present-day highland and lowland areas in the basin. Glacial sediments cover the bedrock surface with a relatively thin veneer.

The preglacial bedrock valleys, being the lowest topographic areas, held a large glacial lake as the glacier receded (Thwaites, 1943, figs. 19 and 21). Large amounts of sediment, chiefly silt and clay, deposited in this glacial lake formed a flat lake plain and lowland area. The Wolf River from Shawano to Butte des Morts Lake, and the upper part of the Fox River from Portage to Lake Winnebago, flow over this flat lake plain. Consequently, the gradients of both rivers in this area are very flat, the Wolf River dropping only 56 feet in 114 miles and the upper Fox dropping 37 feet in 82 miles.

The lower part of the Fox River from Menasha to Green Bay also flows over glacial-lake sediments. However, this area, which probably had a steep preglacial gradient, was modified by glacial gouging that provided an even steeper bedrock gradient. The glacial-lake sediments have only slightly modified this gradient. The lower Fox River falls about 185 feet in 37 miles in the controlled reach from Menasha to Green Bay.

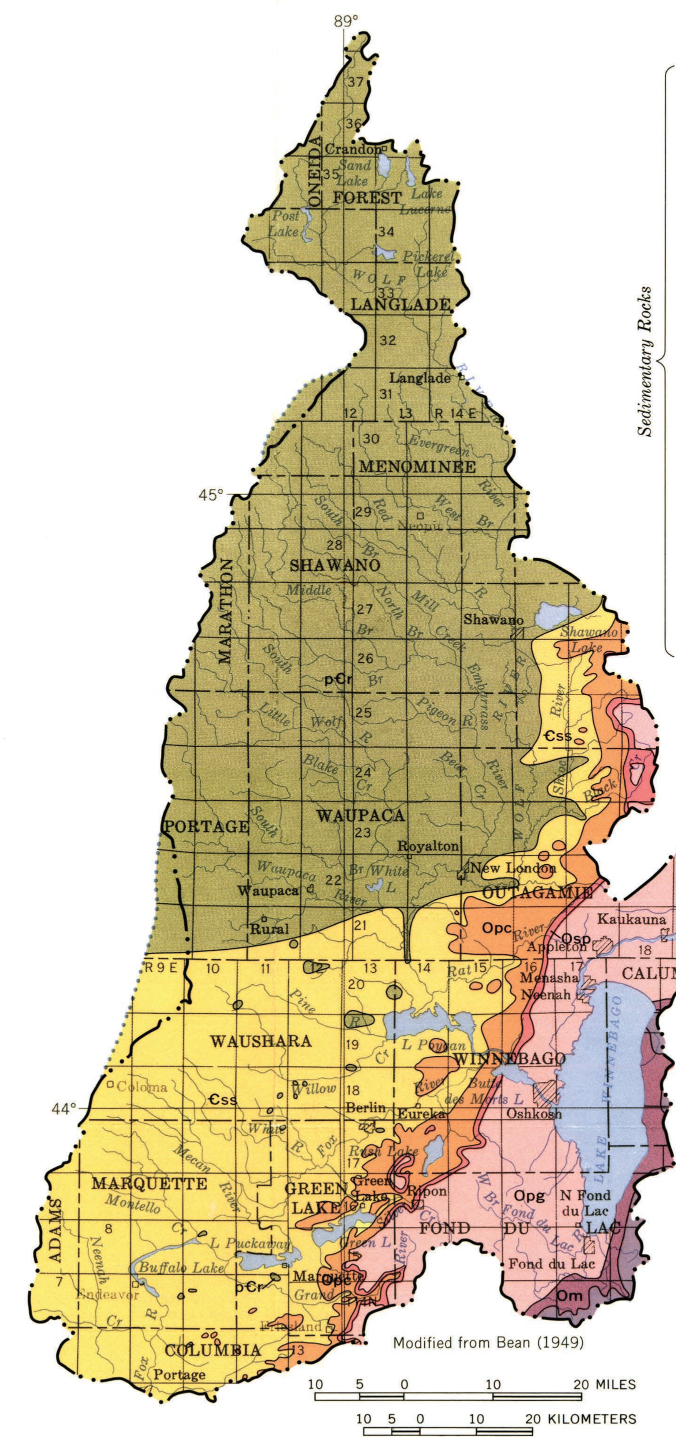
Two northeast-southwest bedrock ridges dominate the topography in the southeastern part of the basin. One ridge extending in a broad arc between Portage and Shawano has a bedrock valley adjacent to its west edge. Another ridge trends northeastward from Fond du Lac to Green Bay, and the Winnebago trough is parallel to the west edge of the ridge.

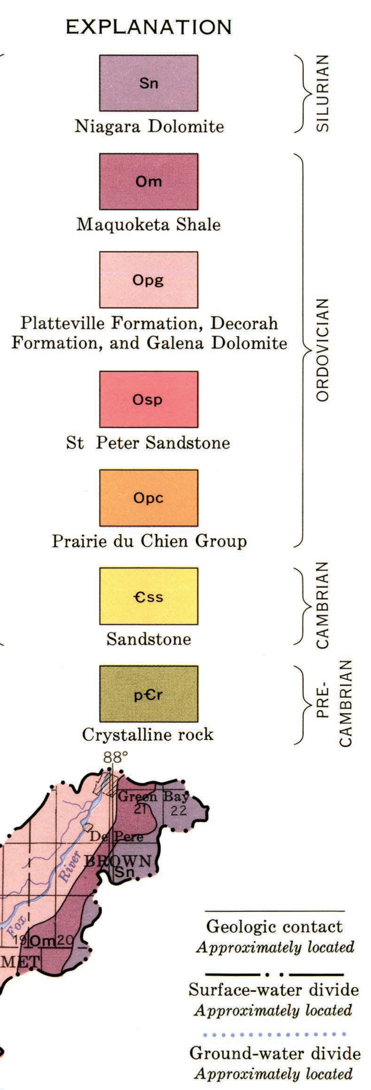
Topography in the northern and western parts of the basin is characterized by broad plains mixed with low hills and generally north-south oriented ridges. The plains slope toward the southeast following the slope of the bedrock surface.



PROFILES OF PRINCIPAL STREAMS

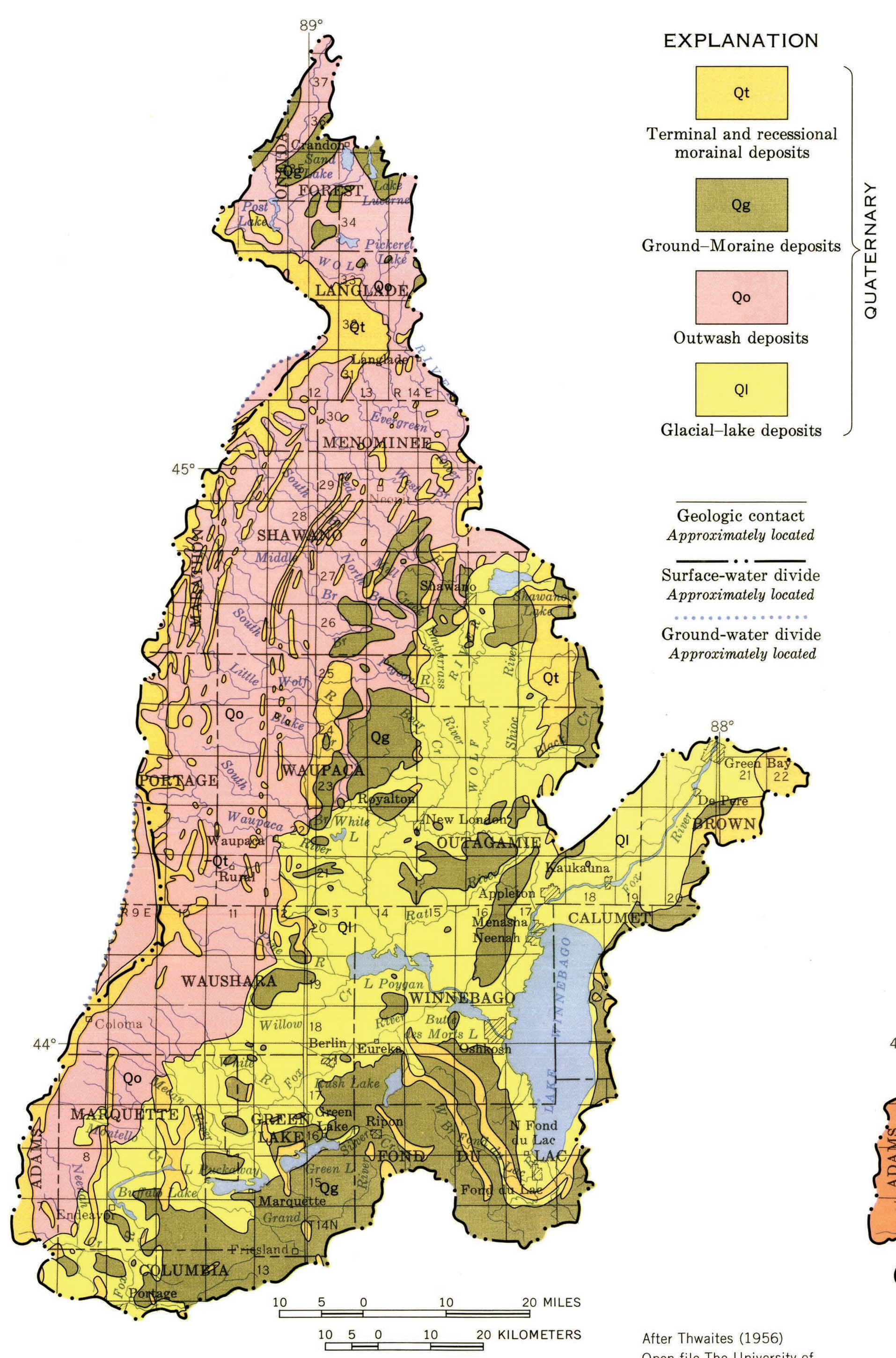
After Federal Power Commission (1965)





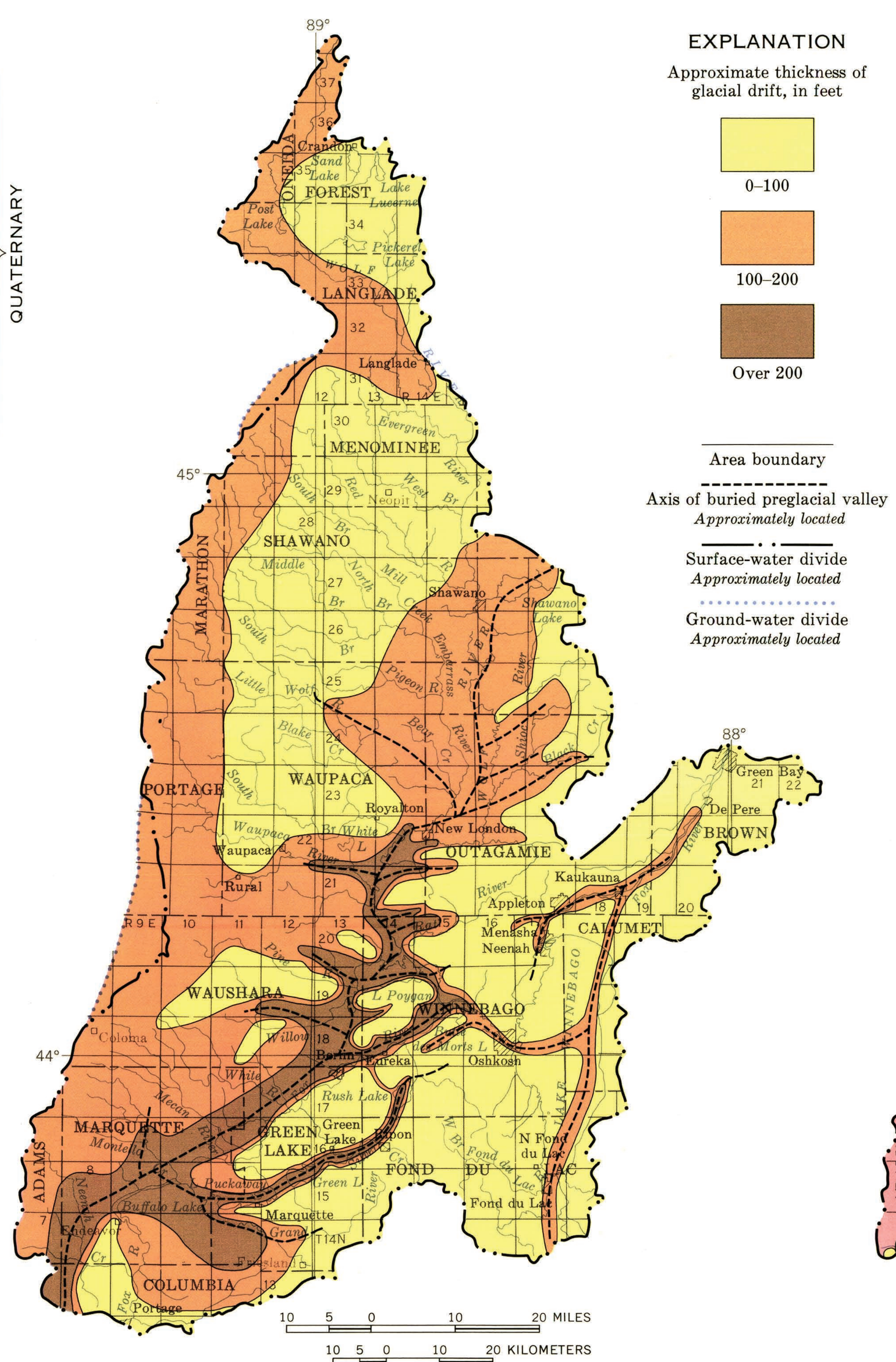
Sedimentary bedrock formations generally dip southeastward at about 15 to 20 feet per mile and conform to the slope of the underlying crystalline rock surface. The sedimentary-rock sequence thickens toward the southeast as successively younger rocks form the bedrock surface. The bedrock in the northern half of the basin is crystalline rock.

BEDROCK GEOLOGY

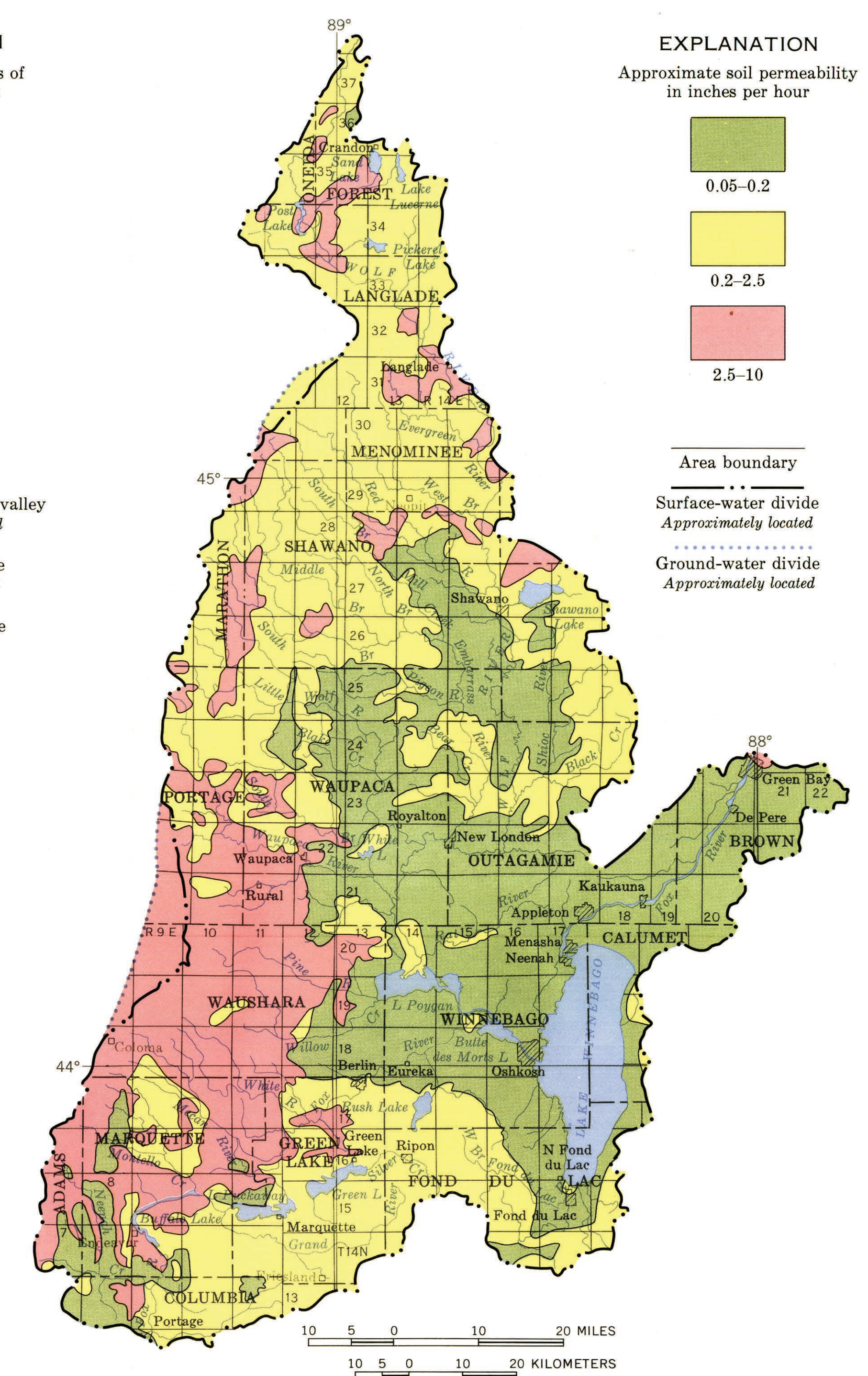


After Thwaites (1956)
Open file The University of Wisconsin Geological and Natural History Survey

GLACIAL GEOLOGY



THICKNESS OF GLACIAL DRIFT



SOIL PERMEABILITIES

GLACIAL GEOLOGY AND DRIFT THICKNESS

Glacial sediments in the Fox-Wolf basin include morainal deposits of unsorted silt, clay, sand, and gravel; outwash deposits of sand and gravel; and lake deposits consisting mainly of silt and clay. The general distribution of these sediments is shown on the glacial geologic map.

Glacial deposits in the Fox-Wolf River basin range in thickness from 0 feet, in small areas where bedrock crops out at the land surface, to 300 feet or more. The glacial deposits are thickest (see thickness of glacial drift map) in deeply incised preglacial bedrock valleys underlying parts of the Wolf and Fox Rivers. The pre-glacial bedrock valleys show the major drainage before glaciation.

An ancient river probably followed the approximate course of the present Wolf River from Shawano to Lake Poygan. From there it followed a southward course adjacent to the Winnebago-Waushara County line, joined the valley of the upper Fox River, and flowed southwestward. The river apparently emptied into the Wisconsin River near the lower narrows of the Baraboo Range, as suggested by Alden (1918, p. 111). Significant tributary valleys to this ancient river valley include the deep valleys in Marquette, Green Lake, and Fond du Lac Counties, which form bedrock basins for Lake Puckaway and Green Lake, and the valley in Winnebago County from Eureka to Butte des Morts Lake, which forms the present course of the Fox River.

The drainage system underlying Lake Winnebago was suggested by Alden (1918) and was extended by bedrock maps in Winnebago County (Olcott, 1966).

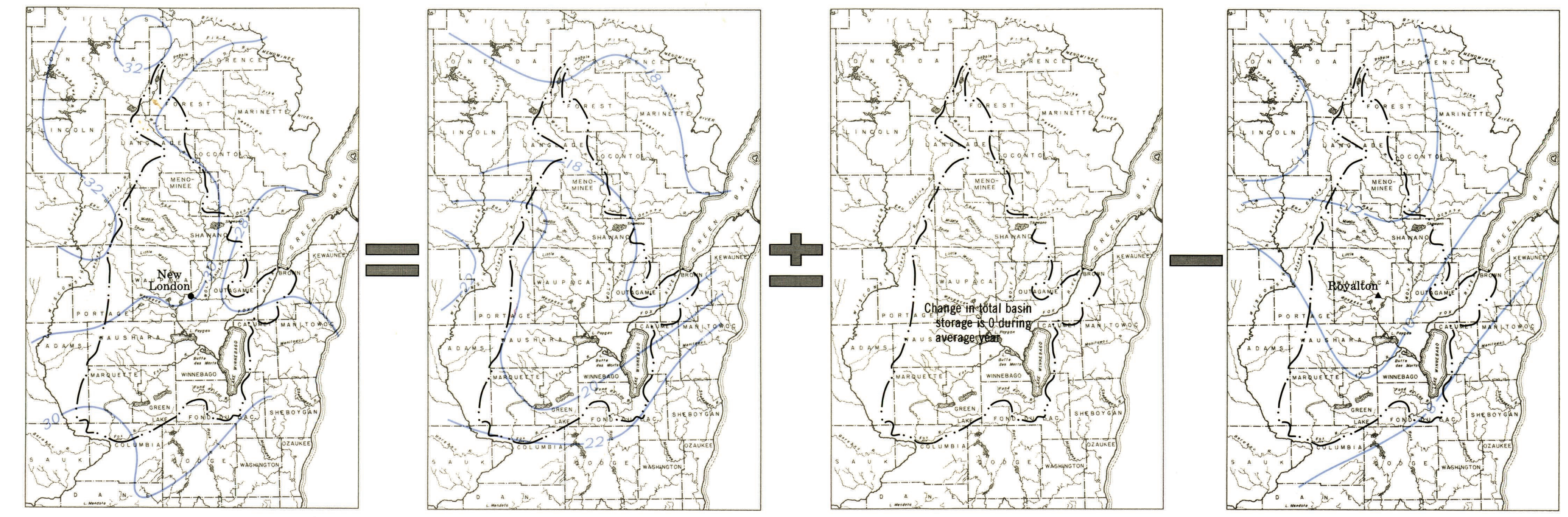
SOILS

Soils are important because ground-water recharge must pass through the soil zone. The type of soil influences the amount of runoff to streams and the amount of infiltration into the ground. A soil permeability map, prepared from a soils map by the Soil Survey Division of the University of Wisconsin Geological and Natural History Survey (F. D. Hole, written commun. 1965), is shown above. Soil types were assigned permeabilities from information taken from a soils engineering publication (U.S. Department of Agriculture, Soil Conservation Service, 1964). Permeabilities are estimates of downward percolation through the least permeable major soil zone.

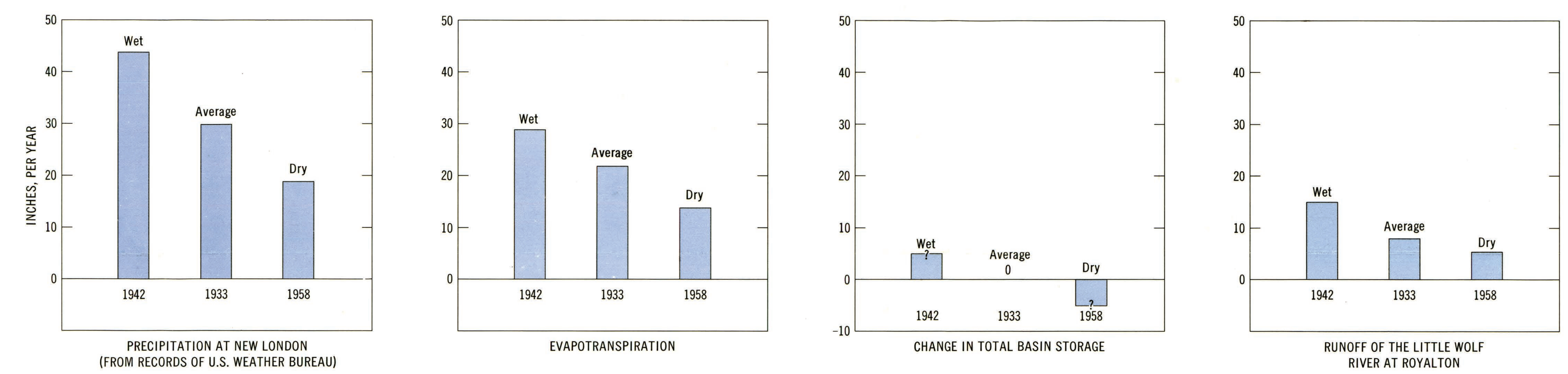
The most permeable soils generally are in the sandy outwash plains. The soils of intermediate permeability generally are in the outwash plains and morainal areas. The least permeable soils generally are in the silty and clayey lake plains.

Soil information is used here only as background material. More intensive studies of the influence of soil type on hydrology can be made by soil scientists to define the relationship of soil to hydrology.

WATER SYSTEM



MEAN ANNUAL PRECIPITATION IN INCHES (BASED ON PERIOD 1931–55 FROM WAITE, 1960) = MEAN ANNUAL EVAPOTRANSPIRATION IN INCHES (PRECIPITATION MINUS RUNOFF) ± TOTAL BASIN STORAGE (GROUND WATER AND SURFACE WATER) — MEAN ANNUAL RUNOFF IN INCHES (BASED ON PERIOD 1914–55)



GENERALIZED HYDROLOGIC BUDGET

The principal source of water in the Fox-Wolf River basin is precipitation. Part of the precipitation runs off directly to streams and flows out of the basin. Part of the water evaporates directly from the land and water surfaces or transpires from plants. Part infiltrates the soil where it replaces soil moisture; the remainder moves downward to the ground-water reservoir.

Water stored in the ground-water reservoir is not static and moves from areas of recharge toward areas of discharge. The amount of water stored in the aquifer changes with the amount of precipitation that recharges the aquifer. During periods of abundant rainfall, ground-water storage increases, and the water table rises causing a rise of water levels in wells and lakes and increased discharge to streams. Conversely, the amount of water in storage decreases during periods of scanty rainfall; and lake levels, water levels in wells, and discharge to streams decline.

A generalized accounting of the water inflow, outflow, and storage in the Fox-Wolf basin is shown above. Although this account is simplified, the figures are basically correct. Mean annual precipitation ranged from about 28 to 32 inches in the basin for the period 1931–55 (Waite, 1960, p. 11). Mean annual evapotranspiration (precipitation less runoff) ranged from about 18 to 22 inches in the basin for the same period. Records are not available to determine changes in basin storage, but during an average year the net change in storage is zero. Mean annual runoff ranged from about 8 to 13 inches per year in the basin. Underflow, water moving into or out of the basin through the aquifer, is not considered in the budget. Some water probably moves out of the basin through the sandstone aquifer eastward under the Niagara escarpment, but the amount of this underflow probably is negligible.

Runoff in the basin increases from south to north as evapotranspiration decreases.

Precipitation, evapotranspiration, storage, and runoff deviate considerably from the long-term mean values throughout the basin. For example, precipitation at New London ranged from 44.63 inches in 1942 to 19.02 inches in 1958. Runoff of the Little Wolf River at Royalton in these years ranged from 15.05 to 4.90 inches.

CLIMATIC AND HYDROLOGIC CHANGES AND SIGNIFICANCE

Seasonal and long-term climatic variations cause fluctuations in both the streamflow and ground-water levels.

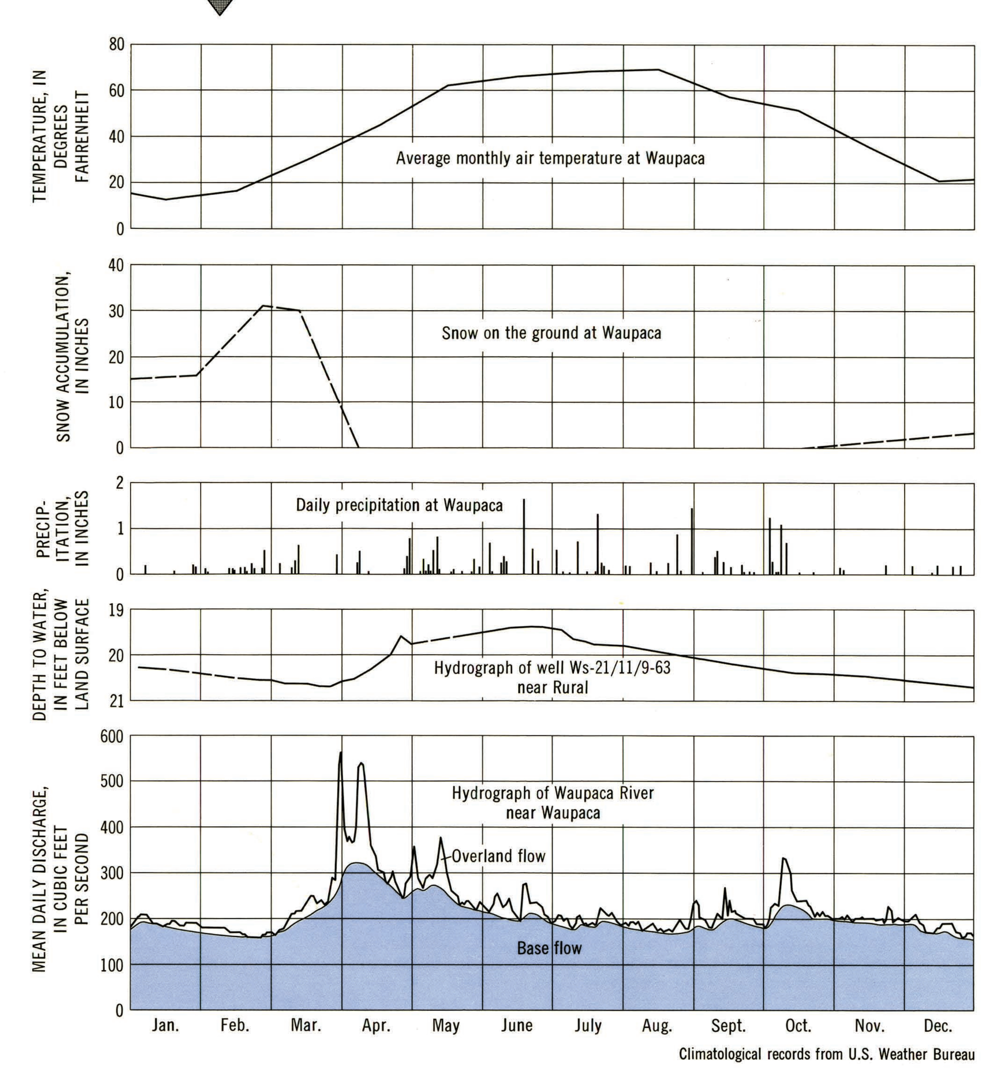
Streamflow in the Fox-Wolf basin fluctuates during the year because of the annual climatic cycle, and changes from year to year because of variations in precipitation. The amount of water stored in the ground-water reservoir that determines the amount of ground-water discharge to the streams follows a similar cycle because of changes in the amounts of recharge that reach the reservoir.

Streamflow is made up of overland flow, water from precipitation or snowmelt that moves directly to the streams, and base flow, water that discharges from the ground-water reservoir. Large volumes of water come to streams by overland flow but leave the basin in a relatively short time after rainstorms or periods of snowmelt. Base flow, continuously discharging from the ground-water reservoir, makes up the streamflow most of the time. The 1962 hydrograph of the Waupaca River near Waupaca illustrates the approximate amount of overland and base flow contributed to the stream.

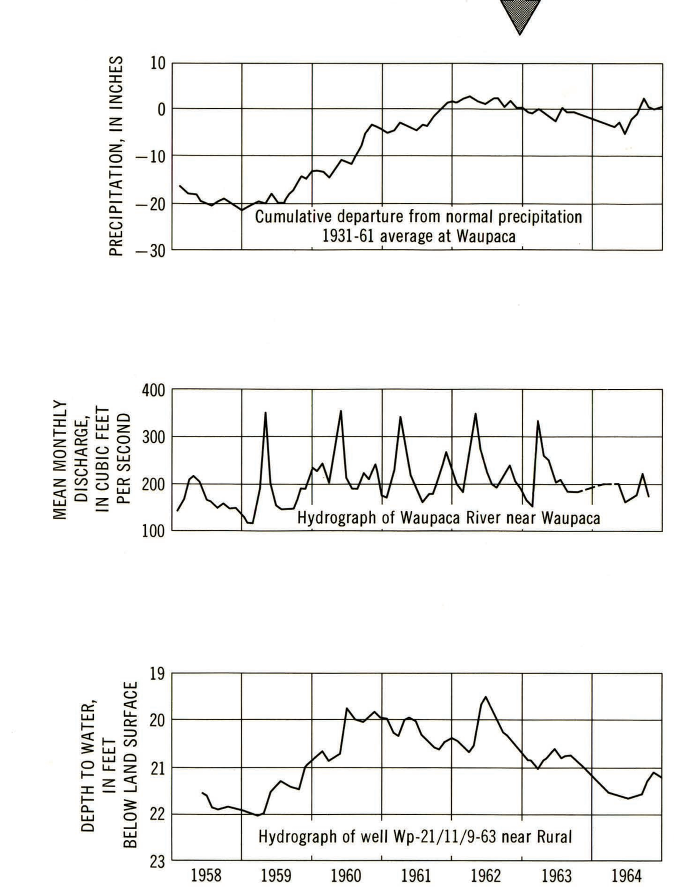
The 1962 hydrographs of flow of the Waupaca River, water levels in a well near Rural, and daily precipitation at Waupaca show the annual fluctuations. Streamflow and ground-water levels are highest in late winter and early spring, diminish throughout the late spring and summer, may increase slightly in the fall, and then subside through the winter until the cycle starts again in the early spring. Abundant water is available in the spring from snowmelt and rainfall. The amount of water available diminishes during the late spring and summer growing season because of evapotranspiration, although rainfall temporarily increases available water during this period. Evapotranspiration nearly stops after the first killing frost in the fall, thus increasing available water. During the winter, precipitation is stored on the land surface as snow and ice. Air temperature also is shown to correlate with spring snowmelt, ground-water recharge, and runoff.

The dependence of streamflow on ground-water storage and its relationship to precipitation are demonstrated by the 1958–64 hydrographs of the Waupaca River near Waupaca, well Wp-21/11/9-63, and a cumulative departure from normal precipitation curve at Waupaca. Each curve generally rises during 1959–60, levels off or falls in 1961, rises in 1962, and falls in 1962–64.

The annual cycle of streamflow fluctuations and long-term variations also are shown in the hydrographs of streamflow at the principal gaging stations.



COMPARISON OF TEMPERATURE, SNOW DEPTH, PRECIPITATION, GROUND-WATER LEVELS, AND STREAMFLOW, IN 1962



COMPARISON OF PRECIPITATION, STREAMFLOW, AND GROUND-WATER LEVELS

Base from U.S. Geological Survey
State base map, 1911

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1968—W68289

WATER RESOURCES OF WISCONSIN—FOX-WOLF RIVER BASIN

By
Perry G. Olcott
1968