DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

UNIVERSITY EXTENSION—THE UNIVERSITY OF WISCONSIN
GEOLOGICAL AND NATURAL HISTORY SURVEY

GROUND WATER

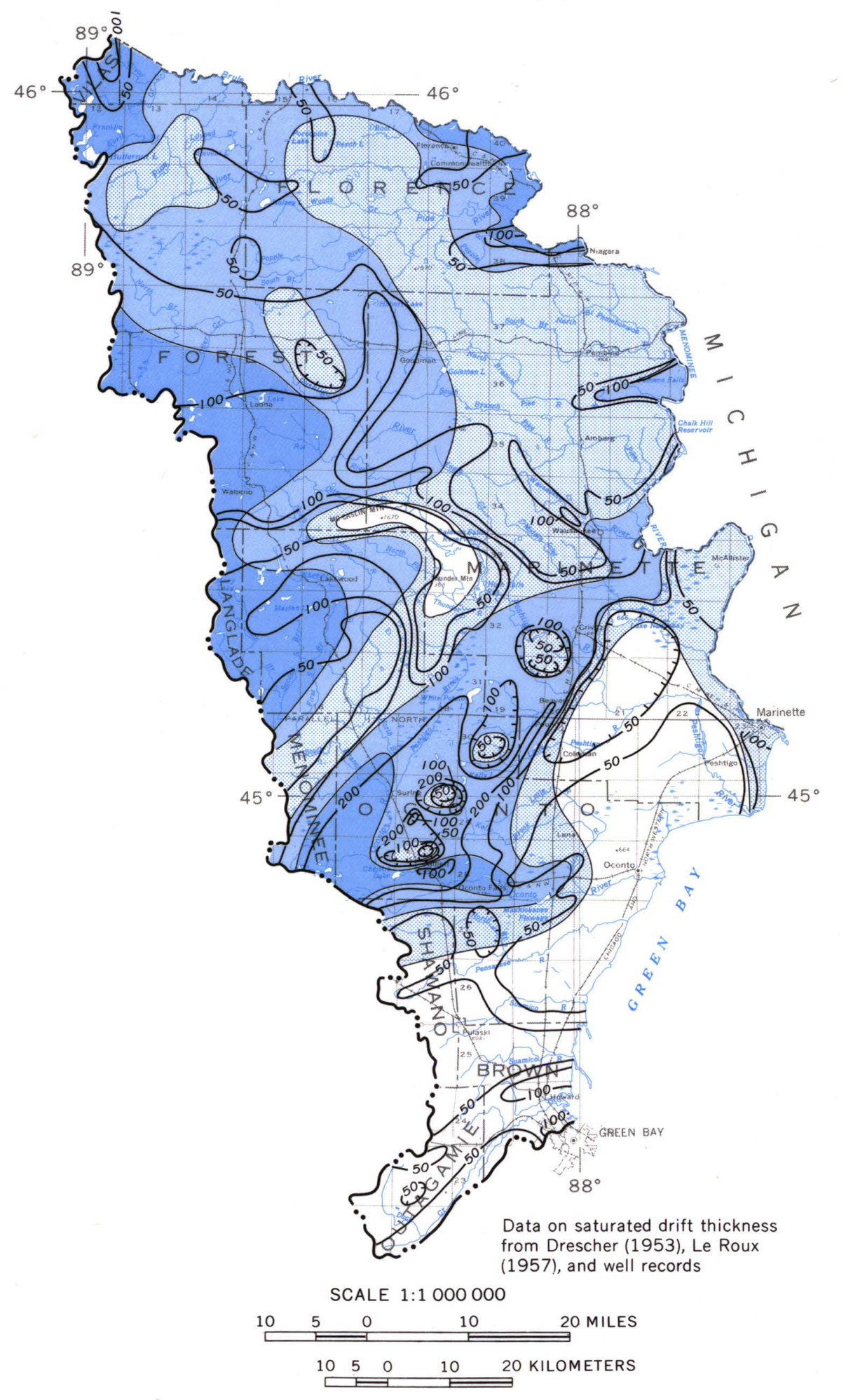
Large undeveloped supplies of good quality ground water are available in the Menominee - Oconto - Peshtigo River basin. About 570 billion gallons of ground water are discharged to streams and wells or leave the basin as underflow each year. This amount, about 5 million gallons for each person in the basin, is less than one-quarter of 1 percent of the total water in underground storage.

Aquifers in the basin provide water supplies to wells and springs and furnish a perennial base to streamflow. The quantity of water that can be continuously pumped from a well or group of wells depends on the thickness and areal extent of the aquifer, the rate of recharge to the aquifer, the ease with which water moves through the aquifer, and the amount of water stored in the aquifer.

Ground water will continue to meet domestic, agricultural, municipal, and industrial needs in the basin because only a small part of the total potential is being utilized. Present areas of large-scale pumpage are relatively few, and population density is low. However, ground-water availability differs locally, and detailed studies are needed to guide ground-water resource development, especially in present and anticipated pumpage centers.

GROUND-WATER AVAILABILITY

Ground water in differing quantities is available nearly everywhere in the basin. There are two major sources of ground water in the basin: the sand and gravel aquifer, and bedrock aquifers.



Data on saturated drift thickness from Drescher (1953), Le Roux (1957), and well records

SCALE 1:1 000 000
10 5 0 10 20 MILES
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EXPLANATION

Approximate yield of water to wells, in gallons per minute

- ☐ 0-10
- ▨ 10-100
- 🟦 100-500
- 🟦 More than 500

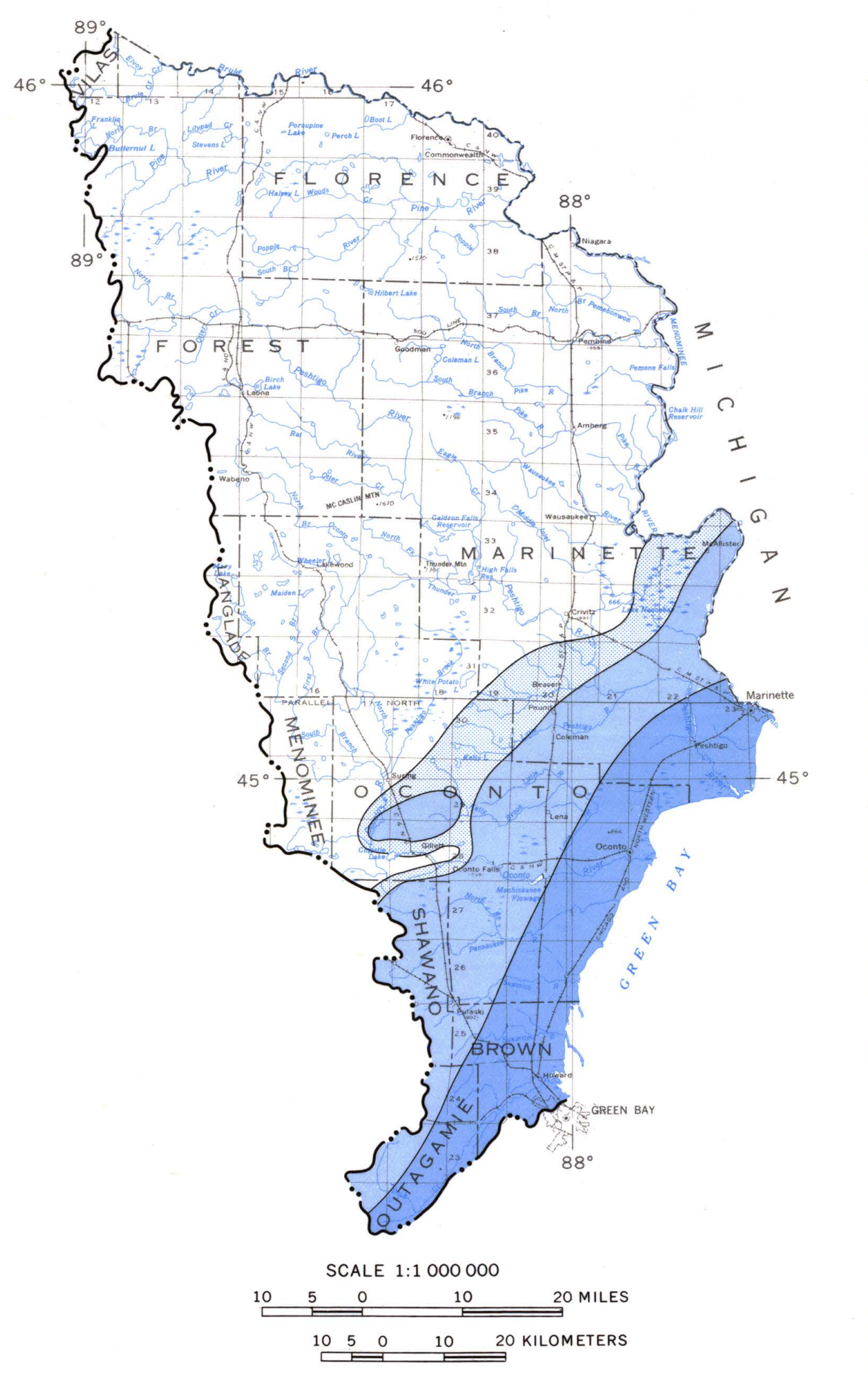
——100—— Line of equal thickness of saturated glacial drift. Interval 100 feet, except for supplemental 50-foot line

——••—— Surface water divide

SAND AND GRAVEL AQUIFER

Available ground water in glacial drift occurs mainly in the sand and gravel aquifer. Large ground-water yields are available where the saturated drift thickness is at least 50 feet. Water-yielding sand and gravel may be found in areas of outwash, in ice-contact deposits associated with end moraine, or in thick channel fillings of bedrock valleys. The areas of greatest ground-water availability are those containing outwash and ice-contact deposits associated with end moraines along the northern and western edges of the basin. An area of very high availability in the southwestern part of the basin is where permeable drift fills a deep bedrock valley. An area of low availability in the central part of the basin is the result of thin drift covering a bedrock high. The low availability of ground water in the southern and southeastern parts of the basin is due to relatively thin ground moraine and lake deposits that contain very little saturated sand and gravel.

Aquifer		Geologic unit	Maximum yield (gpm)	Median yield high-capacity wells (gpm)	Well depths (ft)
Sand and gravel		Sand and gravel	1,000	625	30-308
Bedrock	Galena-Platteville	Galena-Platteville unit	60	No known high-capacity wells in this aquifer	33-360
	Sandstone	St. Peter Sandstone	All wells known to be finished in this unit are open to an overlying or underlying unit		
		Prairie du Chien Group	30	No known high-capacity wells in this unit	50-390
		Cambrian sandstone and dolomite	1,260	415	41-1,005
	Crystalline	Igneous and metamorphic rocks	50	No known high-capacity wells in this aquifer	28-590



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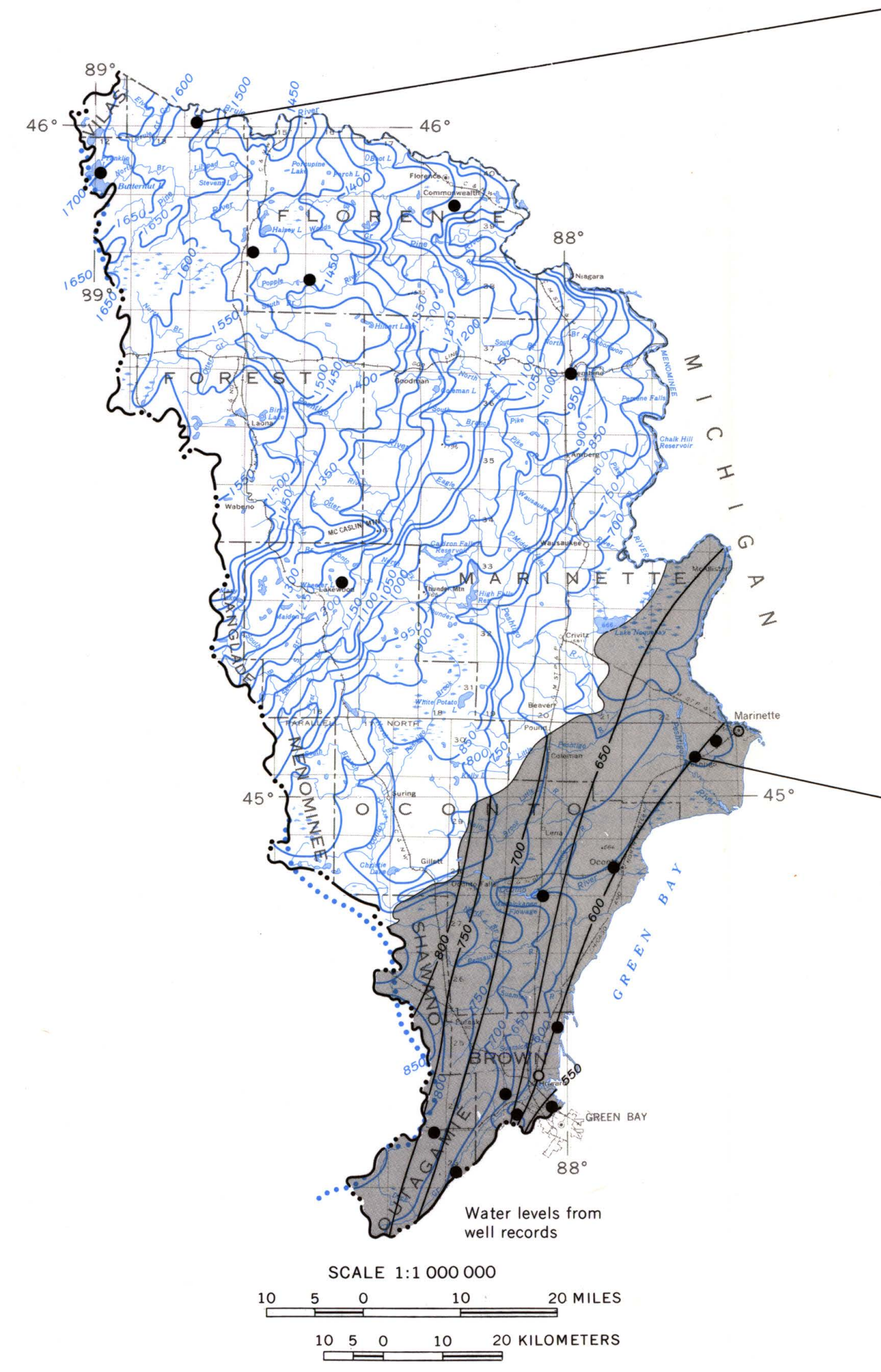
BEDROCK AQUIFERS

Availability of ground water from bedrock aquifers in the basin is limited mainly to Paleozoic sedimentary rocks in the southern and southeastern parts of the basin (sheet 1). The availability of water increases as the thickness of these rocks increases downdip to the southeast.

Yields of 10 gpm (gallons per minute) can be obtained from any of the bedrock units. Relatively shallow wells penetrating a few tens of feet of the uppermost saturated sedimentary rock commonly will yield adequate domestic and stock supplies.

Yields of more than 10 gpm on the map above are based on pumpage from wells that penetrate most of the sedimentary rock sequence. The principal source of large yields from bedrock aquifers is the sandstone aquifer. It includes Cambrian sandstone and dolomite, the Prairie du Chien Group, and the St. Peter Sandstone. The Galena-Platteville unit is a separate aquifer. Individual wells in the sandstone aquifer have produced more than 1,000 gpm.

Precambrian crystalline rock is not considered a significant source of water. Although a single well yielded 50 gpm, more than half the crystalline rock wells considered yielded less than 5 gpm.



Water levels from well records

SCALE 1:1 000 000
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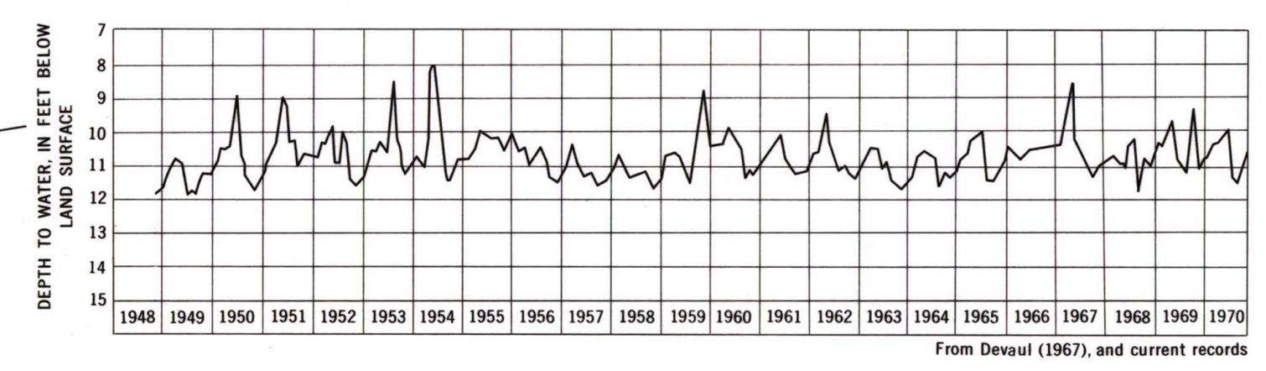
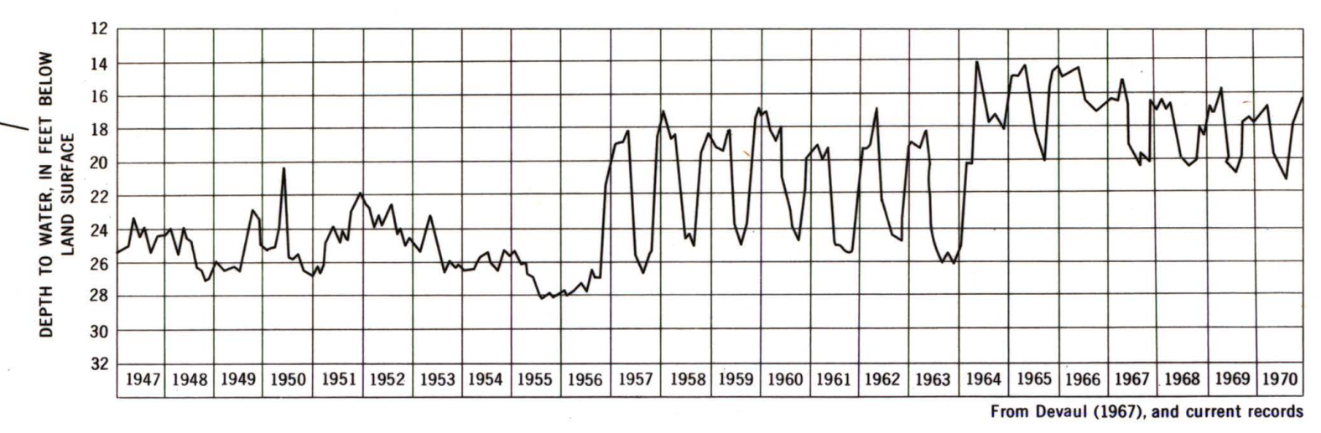


From Devaul (1967), and current records

The water table is continually changing. This hydrograph shows the water-level changes in a shallow water-table well in the sand and gravel aquifer that is not affected by pumping. Recharge from melting snow and local precipitation in spring and summer are followed by rises in the water level in the well. During the late summer evapotranspiration utilizes most of the precipitation, and only extended periods of rainfall raise the water table. In most years the ground is frozen during the winter, preventing recharge, and the level of the water table falls as ground water drains to the Brule River.

No long-term changes in water levels are shown by this hydrograph, and water levels were nearly the same in 1970 as they were in 1950.



From Devaul (1967), and current records

Changes in the potentiometric surface in the artesian system are shown by this hydrograph of a deep well finished in the sandstone aquifer. The hydrograph, from 1947 until 1956, reflects changes in the continuous pumping of a nearby well. The change in the hydrograph pattern beginning near the end of 1956 reflects a changeover to summer and autumn pumping only. Abrupt water-level recovery in the well indicates a decrease in pumping, not annual recharge to the aquifer. The hydrograph shows short-term changes in withdrawal use superimposed on long-term broad trends.

EXPLANATION

- ● Observation well (active as of June 1970)
- ○ Discontinued observation well
- ——1550—— Water-table contour *Contour interval 50 feet. Datum is mean sea level*
- ——650—— Potentiometric contour *Contour interval 50 feet. Datum is mean sea level*
- •••••••••• Ground-water divide
- ▨ Area underlain by bedrock aquifers containing water under artesian conditions
- ——••—— Surface-water divide

THE WATER TABLE, POTENTIOMETRIC SURFACE AND OBSERVATION-WELL NETWORK

Ground water in the basin moves within two systems, the water-table and artesian systems.

The water-table system represents largely unconfined ground water in glacial drift and in Precambrian and Paleozoic rocks; it is present in all parts of the basin. Ground water moves along relatively short paths away from high points on the water table and discharges into lakes, streams, wetlands, and from wells. In general ground-water divides coincide with surface-water divides. This water-table system is not truly a single hydrologic system. Within it there may be areas of local confinement, and adjacent wells may have different water levels. This is due to the layered and lateral heterogeneity of glacial deposits. The composite water-table system described here is a generalization.

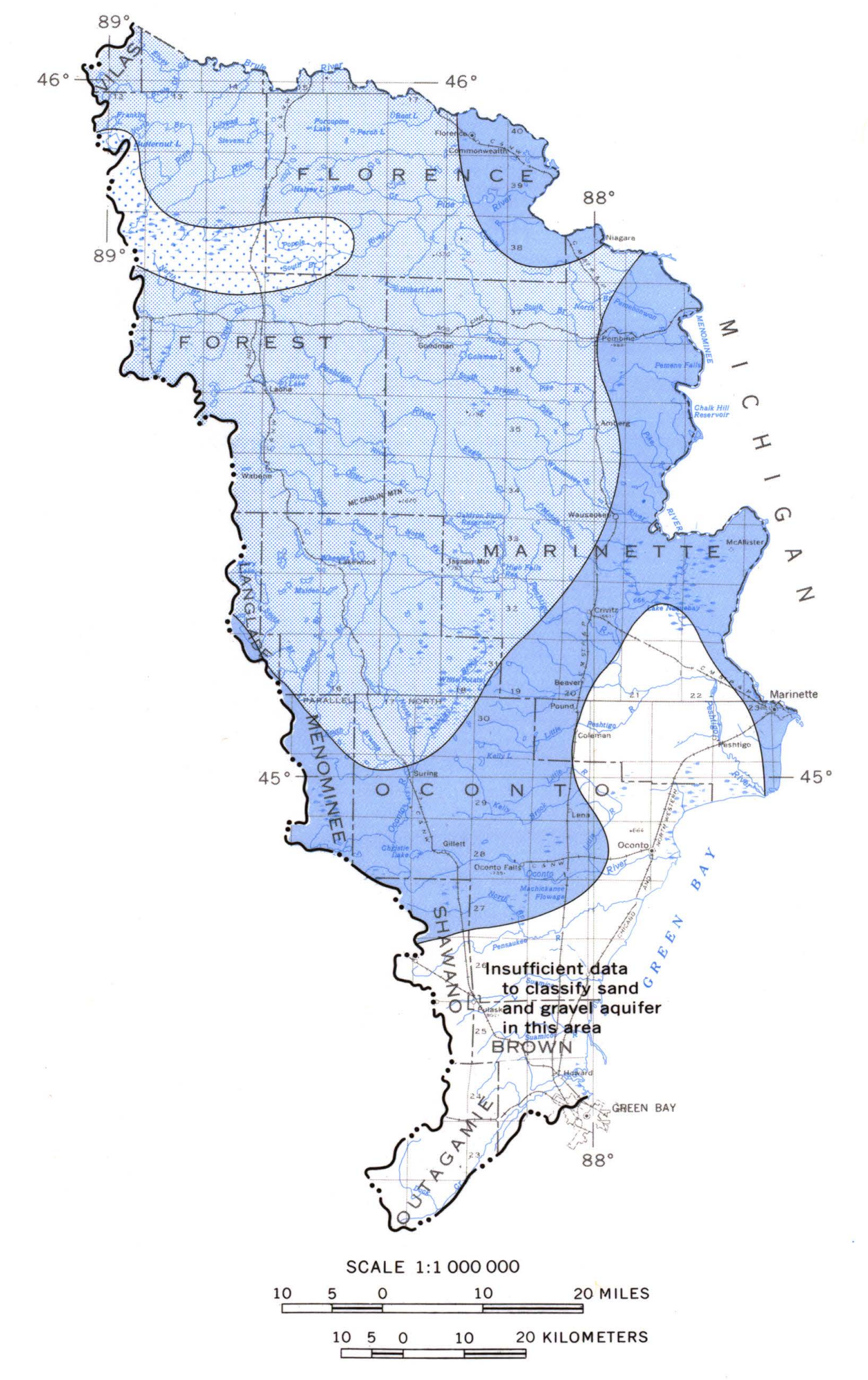
The artesian system includes mainly water in Cambrian sandstone confined beneath Cambrian dolomite and the Prairie du Chien Group, but it also includes, to a lesser degree, water in the St. Peter Sandstone confined beneath the Galena-Platteville unit. Recharge to this system is downdip from the west and by downward percolation. Flow paths are relatively longer than in the water-table system. Within the artesian system potential differs somewhat between adjacent wells of dissimila depths. The potentiometric contours describe a generalized surface

The potentiometric surface and water table are nearly coincident near the city of Green Bay, where the potentiometric surface has been drawn down as the result of large-scale industrial pumping.

GROUND-WATER QUALITY

Ground water in the basin is of good quality, and most has less than 300 mg/l (milligrams per liter) total mineralization. Nearly all of the water is moderately hard to hard, and is principally a calcium magnesium bicarbonate type.

Iron is a problem in the water of many wells in the basin, but it is not a health hazard. The U.S. Public Health Service's (1962, p. 43) suggested maximum limit for drinking water is 0.3 mg/l; iron concentrations greater than this may cause brown precipitates or staining. The areal occurrence and depth of iron is not predictable, and concentrations greater than 0.3 mg/l may be found almost anywhere in the basin.



SCALE 1:1 000 000
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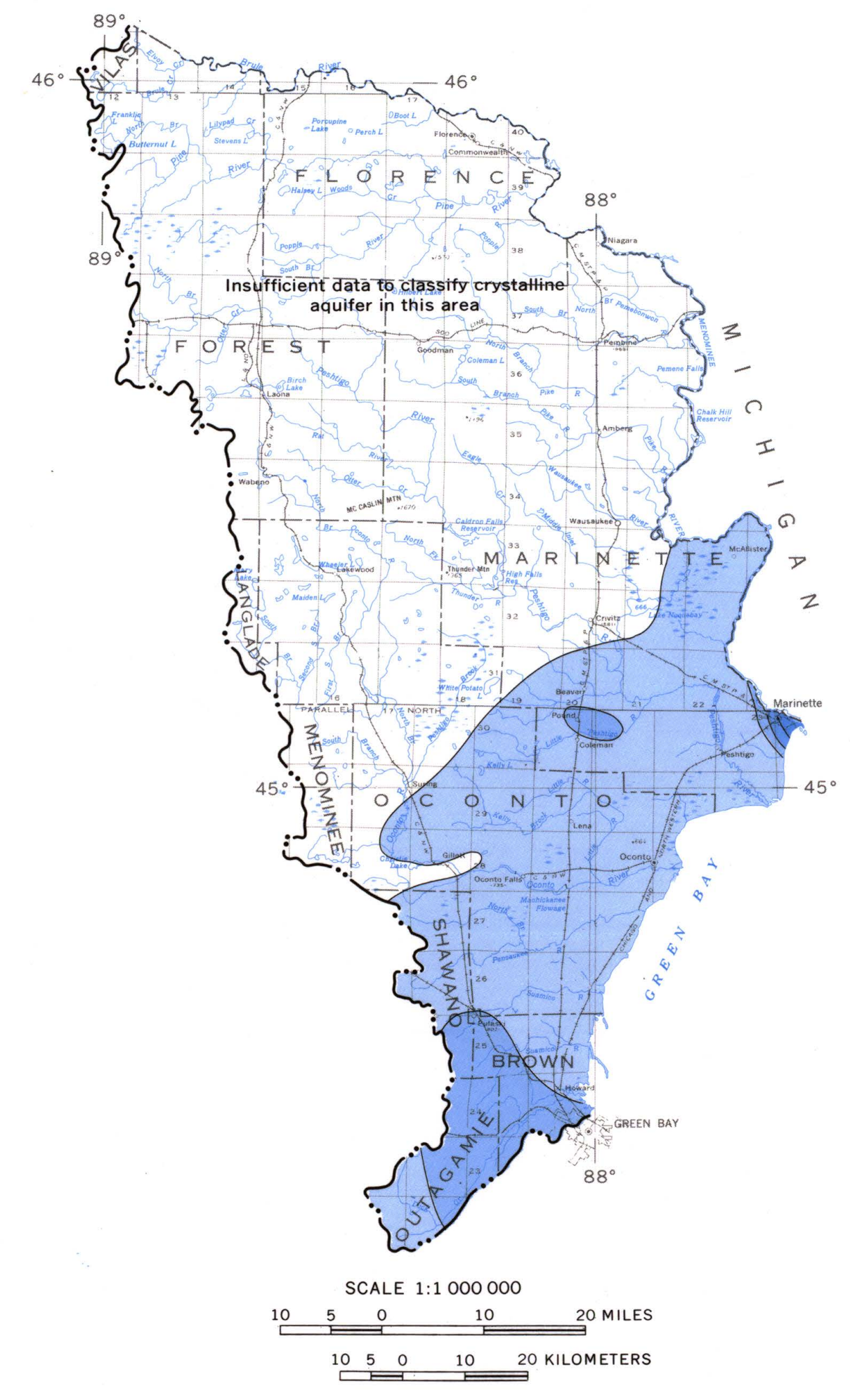
SAND AND GRAVEL AQUIFER

EXPLANATION

Dissolved solids, in milligrams per liter

- ▨ Less than 100
- ▨ 100-200
- 🟦 200-300
- 🟦 300-400
- 🟦 400-500
- 🟦 More than 500

——••—— Surface water divide



SCALE 1:1 000 000
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BEDROCK AQUIFERS

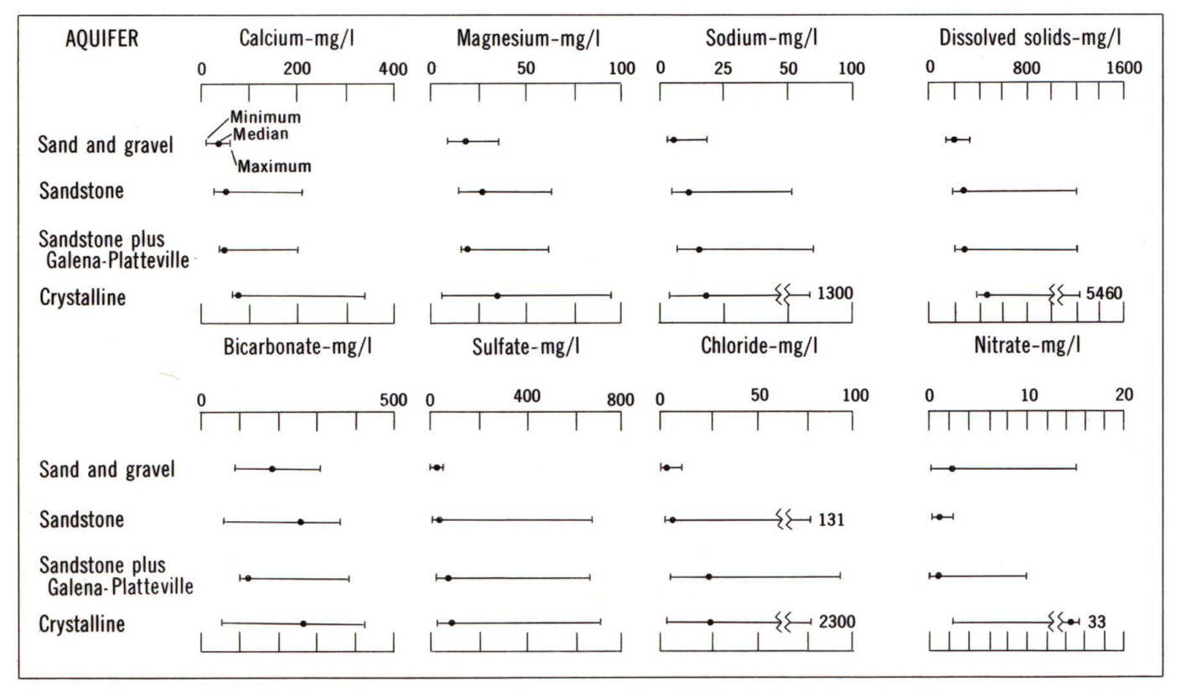
GROUND-WATER MINERALIZATION

Mineralization of ground water may be expressed as total dissolved solids. Variations in total dissolved solids in water from bedrock aquifers and from the sand and gravel aquifer are shown above for the areas in the basin where at least 10 gpm can be obtained from wells.

The area of mineralized ground water on the bedrock aquifer map corresponds with the area of Paleozoic sedimentary rock. The principal water-yielding unit is the sandstone aquifer. Median mineralization of sampled ground water in sedimentary bedrock in the basin is 278 mg/l

The higher mineralization in the Marinette area is due to sulfate concentrations of as much as 667 mg/l (Weidman and Schultz, 1915, p. 447) in water from the sandstone aquifer. This occurrence of high sulfate water has resulted in the city of Marinette using Green Bay as a source for municipal supply.

Mineralization of ground water in the sand and gravel aquifer is higher in areas of ground moraine and lake deposits and lower in areas of end moraine and outwash. In the basin, median mineralization of sampled ground water in the sand and gravel aquifer that supplies at least 10 gpm is 202 mg/l.



WATER QUALITY BY AQUIFER

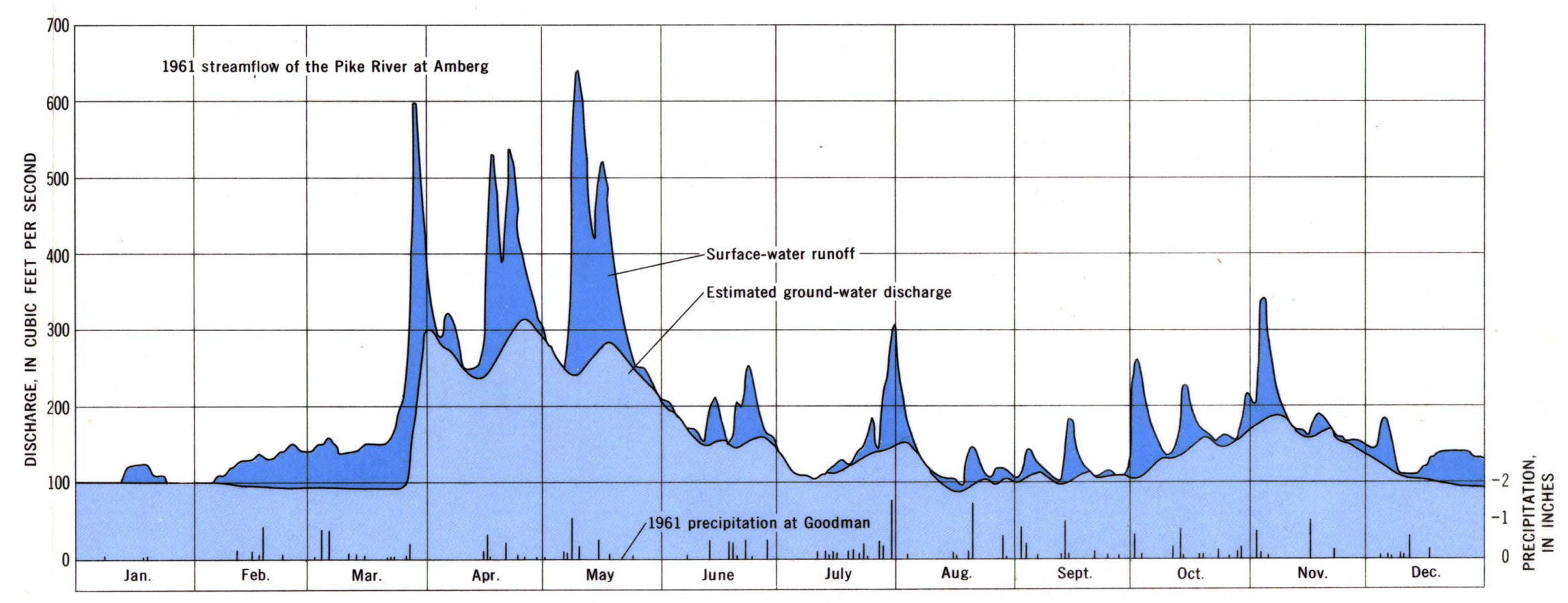
Major chemical constituents in ground water in the Menominee - Oconto - Peshtigo River basin are shown on this diagram according to aquifer. The median quality of ground water differs somewhat between aquifers. However, there is a much wider range of local differences in quality within aquifers. For example, the range of median values for dissolved solids of all aquifers is 264 mg/l, but within crystalline rock the total range is 5,084 mg/l.

The least mineralized water is from the sand and gravel aquifer. This water has moved along relatively short flow paths, usually through sand and gravel of high permeability, and there has been less contact time between the water and soluble minerals.

The range and median values for dissolved solids (total mineralization) are nearly identical for water from sandstone-aquifer wells that are open to the dolomites of the Galena-Platteville aquifer and water from sandstone aquifer wells that are not open to the Galena-Platteville aquifer. However, water from wells open to the Galena-Platteville aquifer contains more sodium, sulfate, and chloride, and less calcium, magnesium, and bicarbonate. All water from the sandstone aquifer, although generally more mineralized, is similar to water from the sand and gravel aquifer in that it is a calcium magnesium bicarbonate type.

Water with the most mineralization and the greatest range in mineralization in the basin is from the crystalline aquifer. The crystalline aquifer is the least permeable of any in the basin, and water in it has had the longest contact time with soluble minerals. Water in the crystalline aquifer may be a calcium magnesium bicarbonate, a calcium magnesium sulfate, or a sodium chloride type.

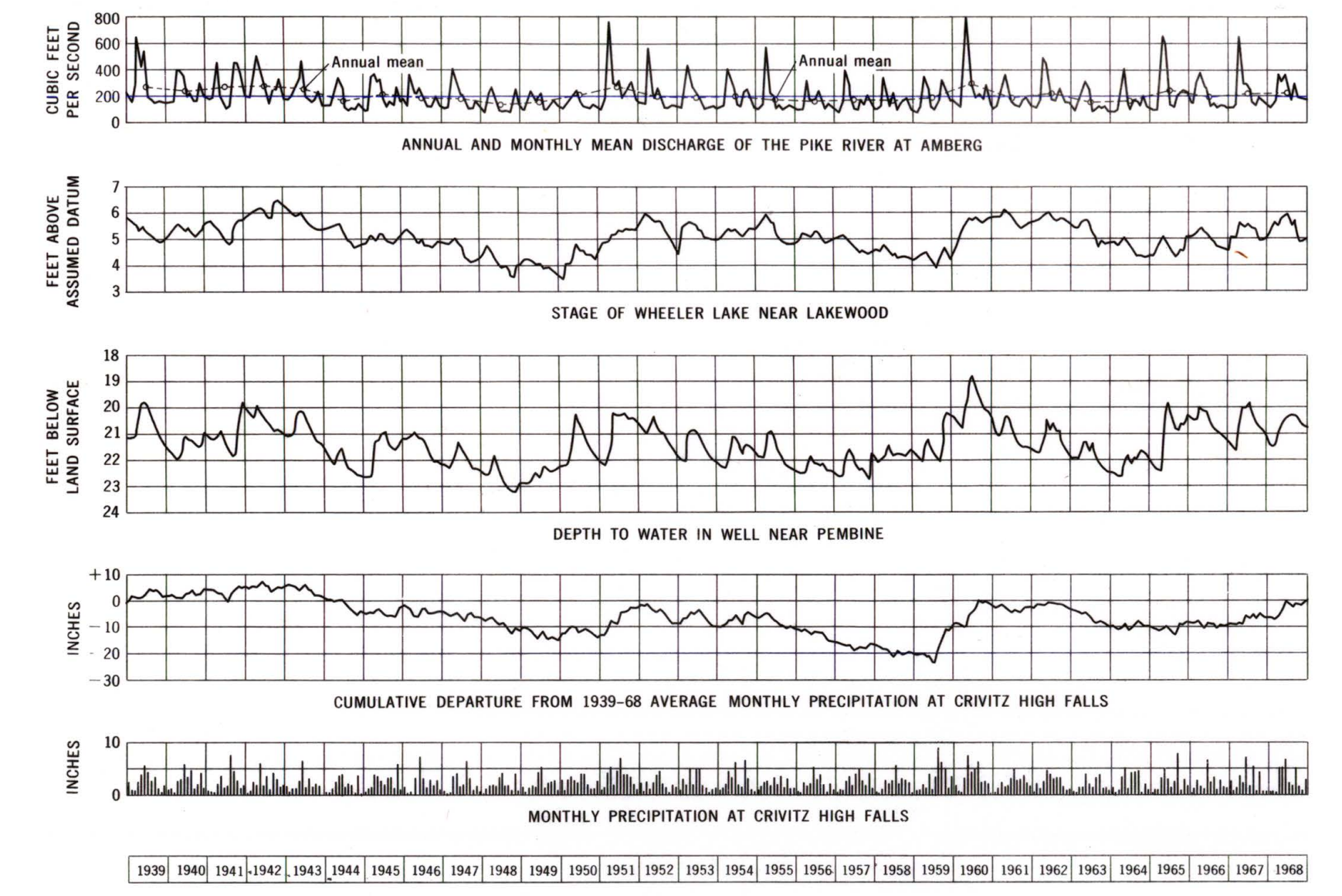
GROUND-WATER—SURFACE-WATER RELATIONSHIPS



GROUND-WATER CONTRIBUTION TO STREAMFLOW

Streamflow is a combination of surface-water runoff and ground-water discharge. During periods of rapidly melting snow or prolonged, heavy rain while frost remains in the ground, surface-water runoff is quickly carried away by streams. In the absence of frost some of this water infiltrates the ground and recharges the ground-water reservoir. Ground water discharges slowly and maintains streamflow during dry periods.

This hydrograph of the Pike River at Amberg has been separated into surface-water runoff and ground-water discharge components of streamflow. The amount and distribution of precipitation at the nearest National Weather Service (U.S. Weather Bureau) station have been plotted below. Although the ground water-surface water contribution separation line is only approximate, it shows that ground-water discharge is the more uniform part, and surface-water runoff the more erratic part, of the total streamflow. It is estimated that ground water contributed 85 percent of the flow of the Pike River at Amberg in 1961.



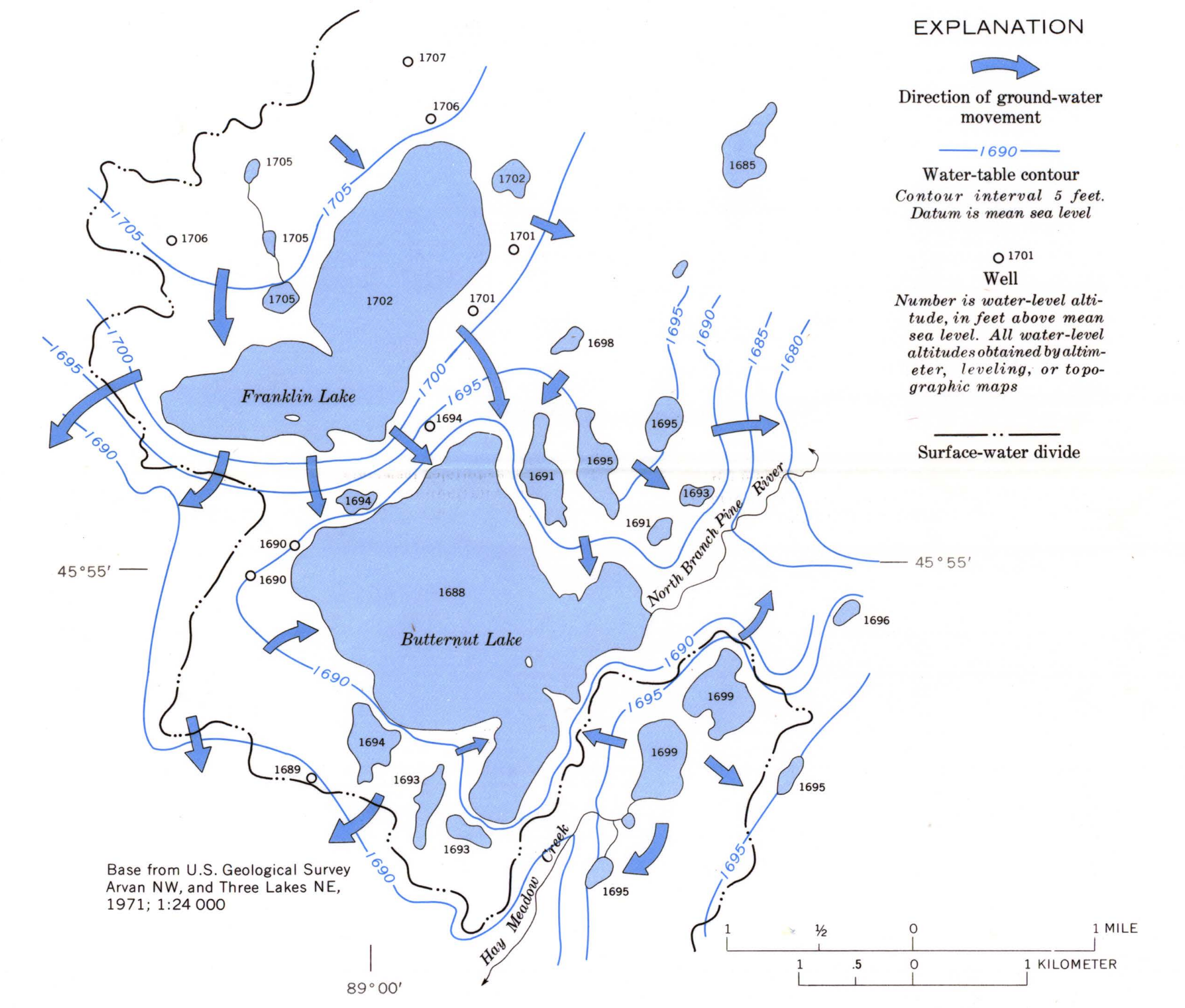
EFFECTS OF PRECIPITATION TRENDS ON WATER LEVELS AND STREAMFLOW

The natural flow of a stream varies greatly throughout the year and from year to year. The principal factors that determine natural streamflow in the basin are precipitation and the release of ground-and surface-water storage. Another important factor is temperature, which determines the melting and, thus, the release of over-winter precipitation.

The above hydrographs compare a 30-year record of precipitation with streamflow, ground- and surface-water storage changes, and a determination of how the precipitation departed from normal during the period.

Streamflow correlates with the amount and distribution of precipitation and the addition of water to streams either by snowmelt or release from ground-water storage. Streamflow achieves its highest peak in spring as the result of melting snow and spring rains. Other streamflow peaks coincide with rainfall during summer and autmn. In years of increased precipitation annual mean streamflow and ground- and surface-water storage increase. During periods when precipitation is less than normal the effect on annual mean streamflow is not as readily apparent because streamflow is maintained by releases of ground and surface-water from storage.

The measurement on the graphs above were not made at the same place. However, all measurement sites are in the central part of the basin in similar geologic settings.



Base from U.S. Geological Survey Arvan NW, and Three Lakes NE, 1971; 1:24 000

EXPLANATION

- ➡ Direction of ground-water movement
- ——1690—— Water-table contour *Contour interval 5 feet. Datum is mean sea level*
- ○1701 Well *Number is water-level altitude, in feet above mean sea level. All water-level altitudes obtained by altimeter, leveling, or topographic maps*
- ——••—— Surface-water divide

GROUND-WATER MOVEMENT IN THE FRANKLIN-BUTTERNUT LAKE AREA

Lakes in the Menominee - Oconto - Peshtigo River basin are part of the water table and are areas of ground-water discharge. Ground water discharged to lakes commonly flows out of the lake through a stream. However, some lakes in the basin have no surface outlets, and water discharges from them back into the ground-water system (water table).

The Franklin-Butternut Lake area is an example of ground-water flow to lakes and flow from one lake to another. Franklin Lake, which has no surface outlet, receives ground water from the north; it discharges ground water southwest to the adjacent basin and south to Butternut Lake and to the North Branch Pine River. Ground-water flow is in the direction of the gradient of the water table. In this area ground- and surface-water divides are not coincident.

Detailed knowledge on water movement of the type shown on this illustration is useful for planning land and water use near lakes and streams. Problems of polluted ground water entering surface water, causing excessive weed growth in lakes and streams, and diminishing fish and wildlife habitat may be lessened by considering ground-water movement when locating wells and points of waste disposal.

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

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

By
E. L. Oakes and L. J. Hamilton
1973