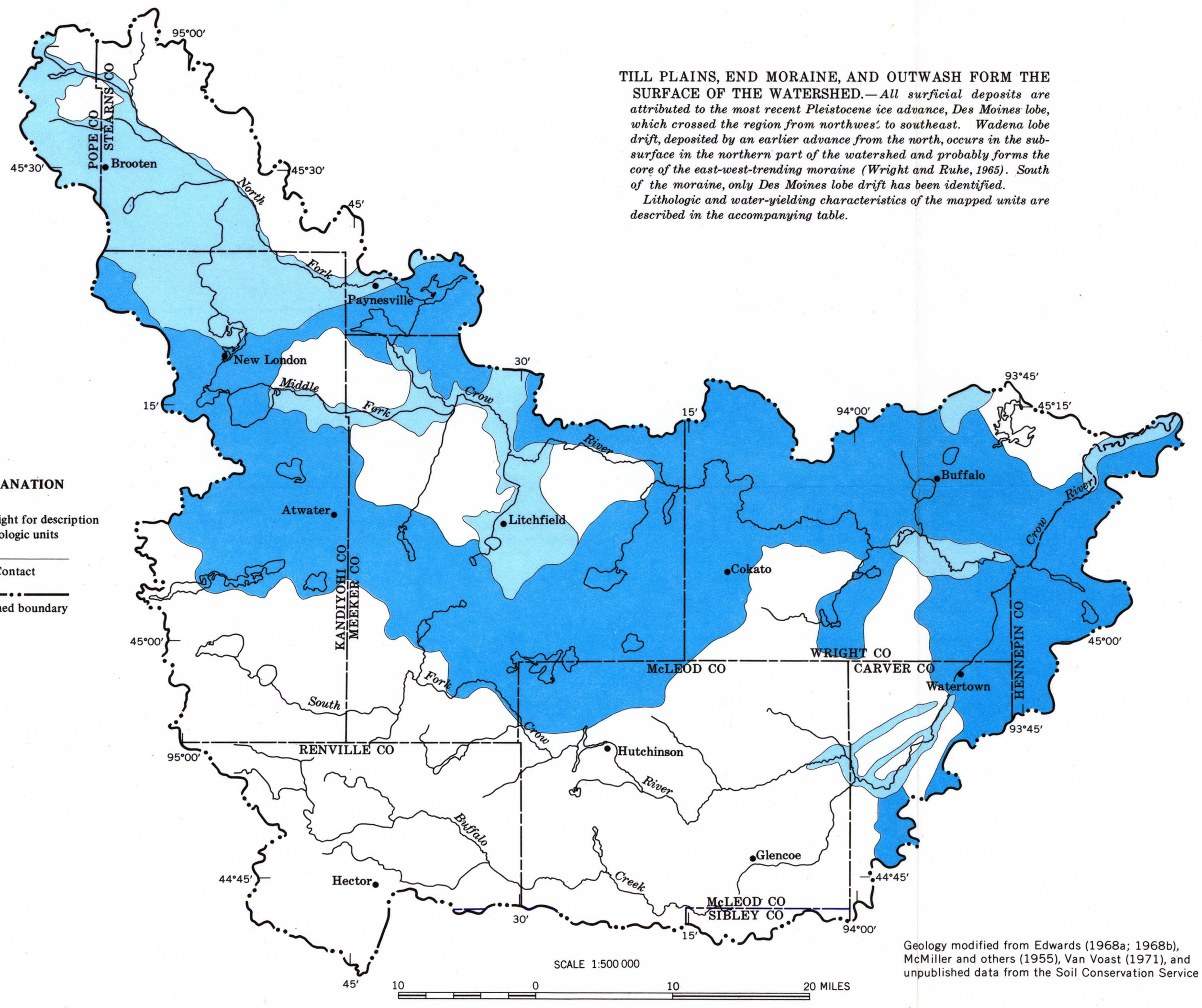
GEOLOGY AND GROUND WATER



TILL PLAINS, END MORAINE, AND OUTWASH FORM THE SURFACE OF THE WATERSHED.— *All surficial deposits are attributed to the most recent Pleistocene ice advance, Des Moines lobe, which crossed the region from northwest to southeast. Wadena lobe drift, deposited by an earlier advance from the north, occurs in the subsurface in the northern part of the watershed and probably forms the core of the east-west-trending moraine (Wright and Ruhe, 1965). South of the moraine, only Des Moines lobe drift has been identified. Lithologic and water-yielding characteristics of the mapped units are described in the accompanying table.*

EXPLANATION

See table at right for description of geologic units

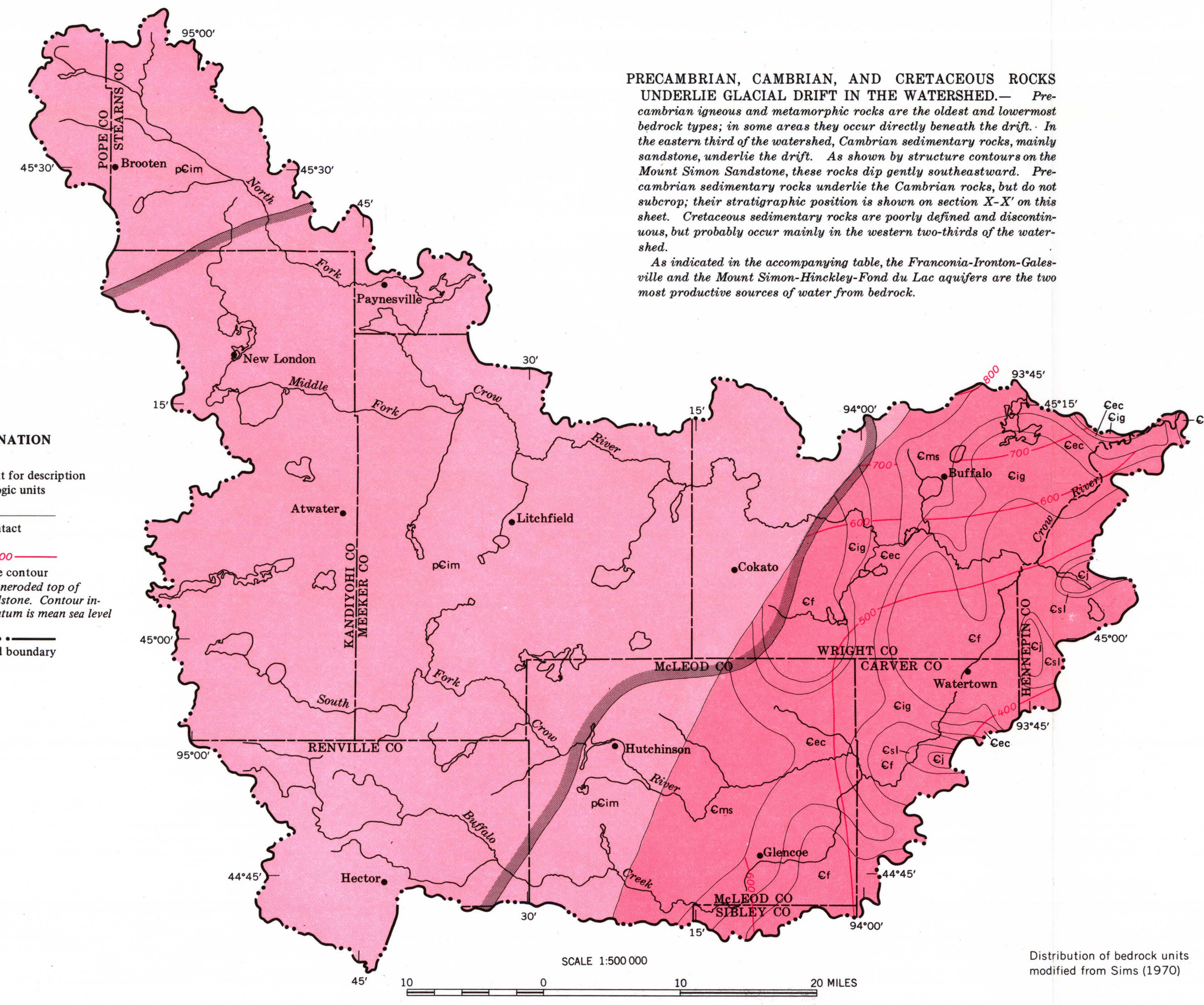
Contact

Watershed boundary

Geology modified from Edwards (1968a; 1968b), McMiller and others (1955), Van Voast (1971), and unpublished data from the Soil Conservation Service

HYDROGEOLOGY OF GLACIAL DRIFT

Age		Unit and map symbol	Thickness (feet)	Lithologic characteristics	Water-yielding capability
QUATERNARY	HOLOCENE	Alluvium	Occurs along streams as generally thin deposits of sand, gravel, silt, or clay which have not been delineated; small areal extent; regionally insignificant as a source of water.		
	PLEISTOCENE	Surficial outwash	0–100 (commonly 20–50)	Primarily fine to coarse-grained sand and gravel; some silt and clay; stratified; commonly moderately to well sorted.	Small to large quantities of water available to wells (SEE FURTHER EVALUATION OF AQUIFERS A AND B BELOW).
		Undifferentiated drift (till plain)	100–500 (commonly 200–500)	Primarily gray, calcareous, silty till; unstratified and unsorted; includes some ice-contact sand and gravel; contains buried sand and gravel deposits of varying extent and thickness.	Small to large quantities of water available to wells from buried sand and gravel (SEE FURTHER EVALUATION OF AQUIFERS C AND D BELOW) and ice-contact deposits; till is of low hydraulic conductivity and yields little water to wells.
		Undifferentiated drift (end moraine)		Primarily gray, calcareous, silty till, unstratified and unsorted; includes some ice-contact sand and gravel of largely unknown extent; contains buried sand and gravel deposits of varying extent and thickness.	



PRECAMBRIAN, CAMBRIAN, AND CRETACEOUS ROCKS UNDERLIE GLACIAL DRIFT IN THE WATERSHED.— *Precambrian igneous and metamorphic rocks are the oldest and lowermost bedrock types; in some areas they occur directly beneath the drift. In the eastern third of the watershed, Cambrian sedimentary rocks, mainly sandstone, underlie the drift. As shown by structure contours on the Mount Simon Sandstone, these rocks dip gently southeastward. Precambrian sedimentary rocks underlie the Cambrian rocks, but do not subcrop; their stratigraphic position is shown on section X–X' on this sheet. Cretaceous sedimentary rocks are poorly defined and discontinuous, but probably occur mainly in the western two-thirds of the watershed.*

As indicated in the accompanying table, the Franconia-Ironton-Galesville and the Mount Simon-Hinckley-Fond du Lac aquifers are the two most productive sources of water from bedrock.

EXPLANATION

See table at right for description of geologic units

Contact

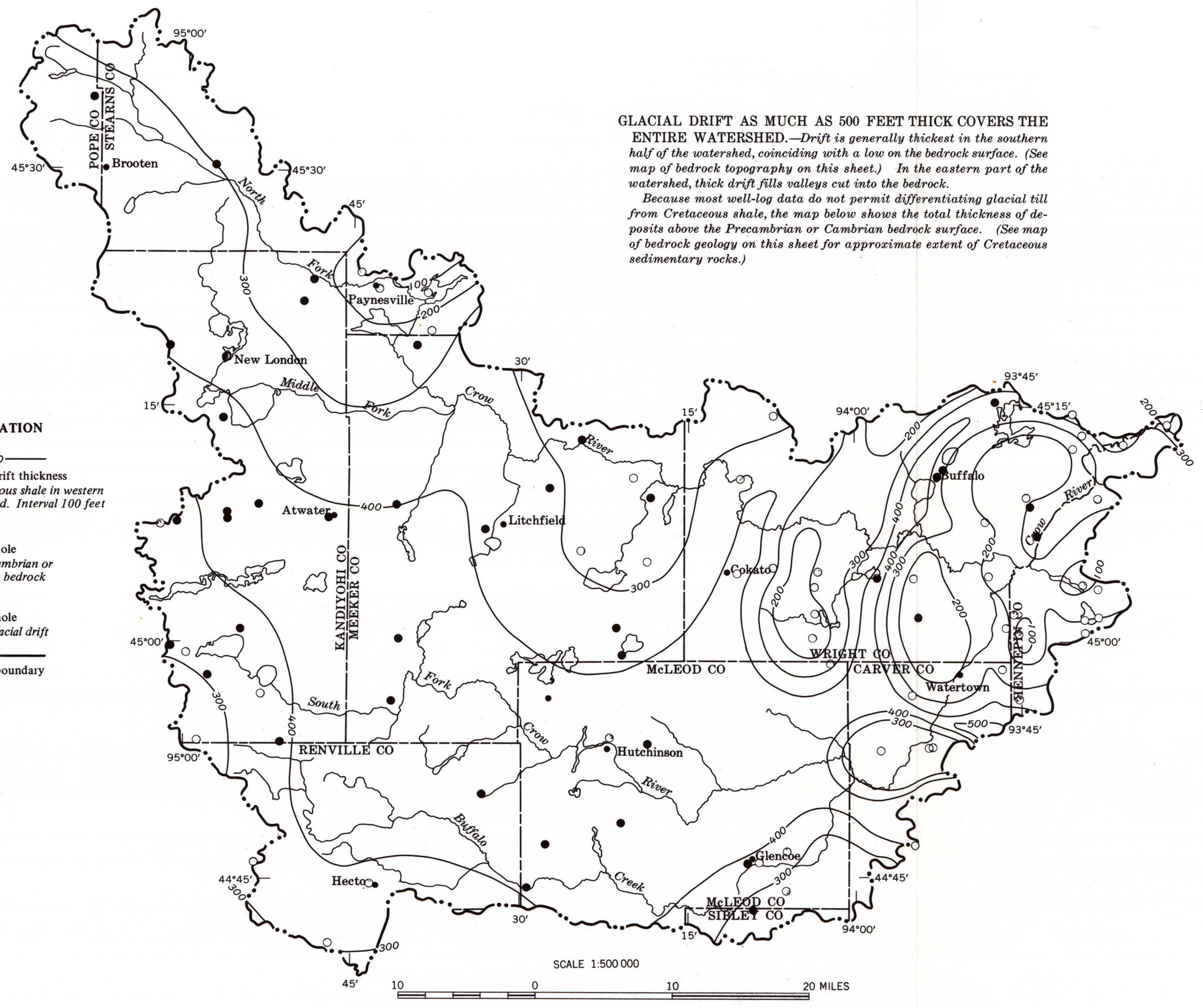
Structure contour — Shows altitude of nonmerodd top of Mount Simon Sandstone. Contour interval 100 feet. Datum is mean sea level

Watershed boundary

Distribution of bedrock units modified from Sims (1970)

HYDROGEOLOGY OF BEDROCK

Age		Unit and map symbol	Thickness (feet)	Lithologic characteristics	Water-yielding capability
MESOZOIC	CRETACEOUS	(Approximate margin) Sedimentary rocks, unnamed	0–150	Predominantly shale; contains some sandstone.	Unknown capability in watershed; elsewhere, small quantities of water available to wells from sandstone.
PALEOZOIC	CAMBRIAN	Єj Jordan Sandstone	0–50	Sandstone, yellow to white, medium to coarse grained, friable, quartzose; locally argillaceous and dolomitic at base.	Unknown capability in watershed; elsewhere, yields large quantities of water to wells; may be capable of several hundred gallons per minute in small areas where thickness is sufficient.
		Єsl St. Lawrence Formation	0–30	Dolomite, buff to gray, silty, sandy; argillaceous in part.	Unknown capability in watershed; elsewhere, has low hydraulic conductivity, acts as confining bed; relatively poor source of water.
		Єf Franconia Sandstone	0–150	Sandstone, very fine to coarse grained, predominantly fine; commonly silty and glauconitic; some shale and dolomite.	Small to large quantities of water available to wells; hydraulic conductivity variable, generally highest in Galesville (SEE FURTHER EVALUATION OF AQUIFER BELOW).
		Єig Ironton and Galesville Formations	0–70	Ironton-sandstone, white to gray, medium grained, poorly to moderately-well sorted; commonly silty. Galesville-sandstone, white to gray, predominantly medium-grained and well sorted; fine grained near base.	
		Єec Eau Claire Sandstone	0–150	Shale and sandstone interbedded, gray to green, fossiliferous; partly glauconitic.	Small quantities of water available to wells; acts as confining bed; relatively poor source of water.
		Єms Mount Simon Sandstone	0–130	Sandstone, white to pink, fine to coarse grained, predominantly medium, quartzose; some shale, particularly near top; very coarse to conglomeratic near base.	Moderate to large quantities of water available to wells; hydraulic conductivity moderate to high in Mount Simon, probably lower in Hinckley and Fond du Lac (SEE FURTHER EVALUATION OF AQUIFER BELOW).
PRECAMBRIAN		Hinckley Sandstone and Fond du Lac Formation of Winchell (1899)	0–200+	Hinckley-sandstone, yellow to red, fine to coarse grained, poorly sorted, quartzose; interbedded shale. Fond du Lac (red clastics)-siltstone, sandstone, and shale, poorly sorted; partly arkosic.	
		pЄm Undifferentiated igneous and metamorphic rocks	?	Predominantly gneiss, granite, and schist; small area of argillite along northern boundary of watershed.	Unknown capability in watershed; elsewhere, small quantities of water available to wells; productivity generally limited by small size and poor interconnection of fractures and joints.



GLACIAL DRIFT AS MUCH AS 500 FEET THICK COVERS THE ENTIRE WATERSHED.— *Drift is generally thickest in the southern half of the watershed, coinciding with a low on the bedrock surface. (See map of bedrock topography on this sheet.) In the eastern part of the watershed, thick drift fills valleys cut into the bedrock. Because most well-log data do not permit differentiating glacial till from Cretaceous shale, the map below shows the total thickness of deposits above the Precambrian or Cambrian bedrock surface. (See map of bedrock geology on this sheet for approximate extent of Cretaceous sedimentary rocks.)*

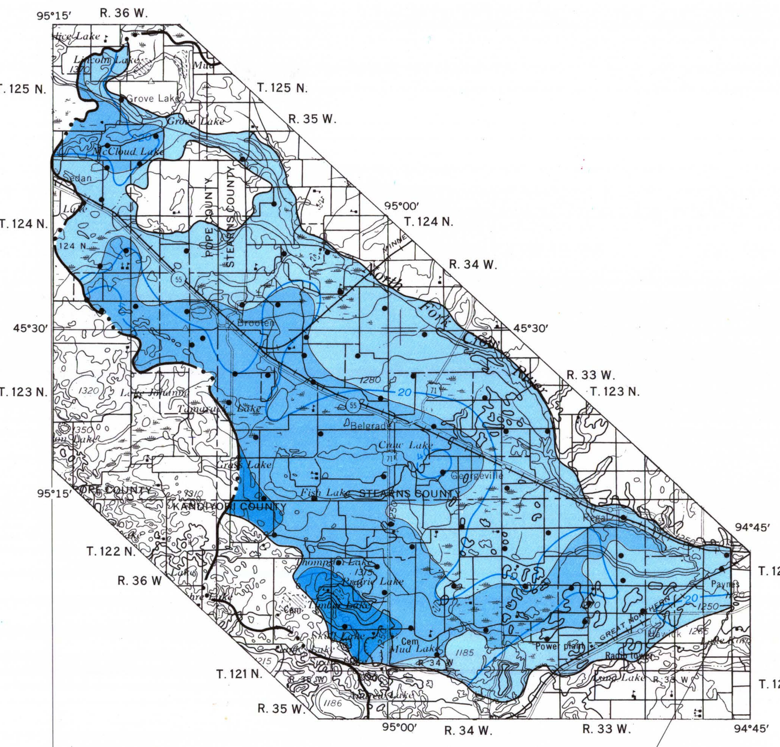
EXPLANATION

Line of equal drift thickness — Includes some Cretaceous shale in western two-thirds of watershed. Interval 100 feet

Drill hole — Bottom in Cambrian or Precambrian bedrock

Drill hole — Bottom in glacial drift

Watershed boundary



Base from U.S. Geological Survey St. Cloud (1953–67)

Adapted from Van Voast (1971)

EXPLANATION

Theoretical short-term well yields, in gallons per minute, from surficial outwash

Less than 100

100–500

500–1000

Auger hole

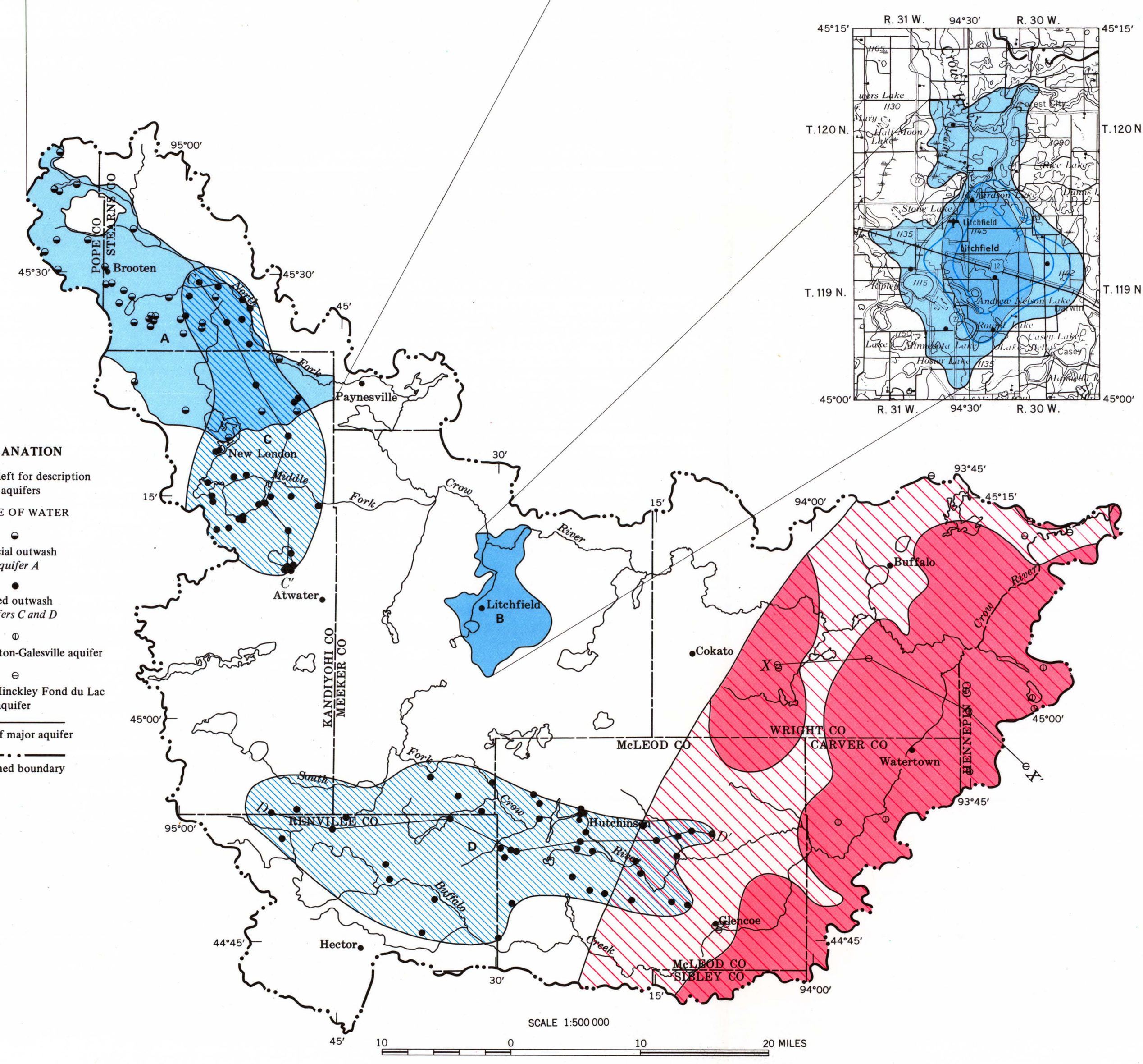
Line of equal saturated thickness of surficial outwash — Interval 20 feet

Extent of major aquifer

Watershed boundary

SCALE 1:250 000

CONTOUR INTERVAL 50 FEET
DATUM IS MEAN SEA LEVEL



EXPLANATION

See table at left for description of aquifers

SOURCE OF WATER

Surficial outwash — Aquifer A

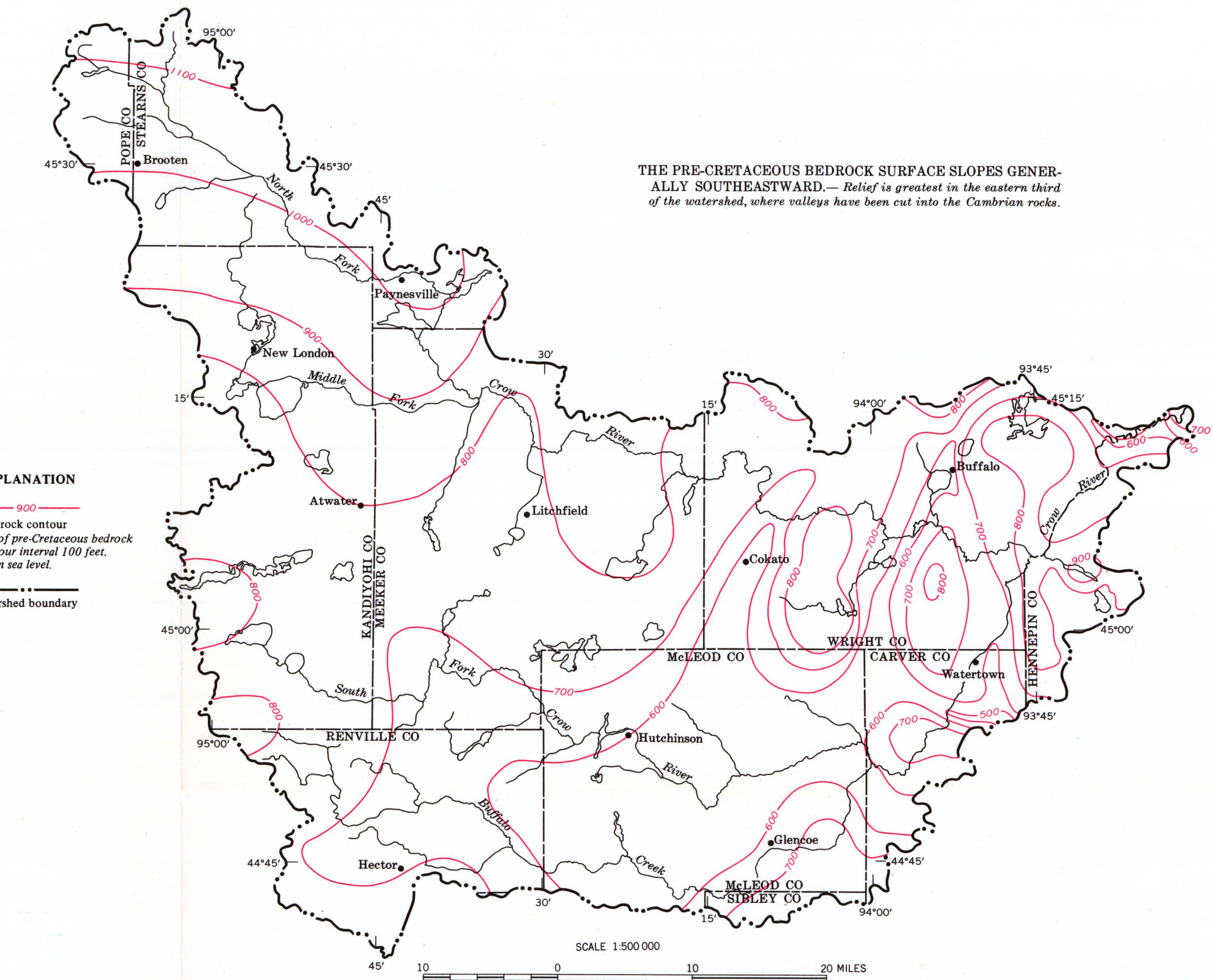
Buried outwash — Aquifers C and D

Franconia-Ironton-Galesville aquifer

Mount Simon-Hinckley-Fond du Lac aquifer

Extent of major aquifer

Watershed boundary

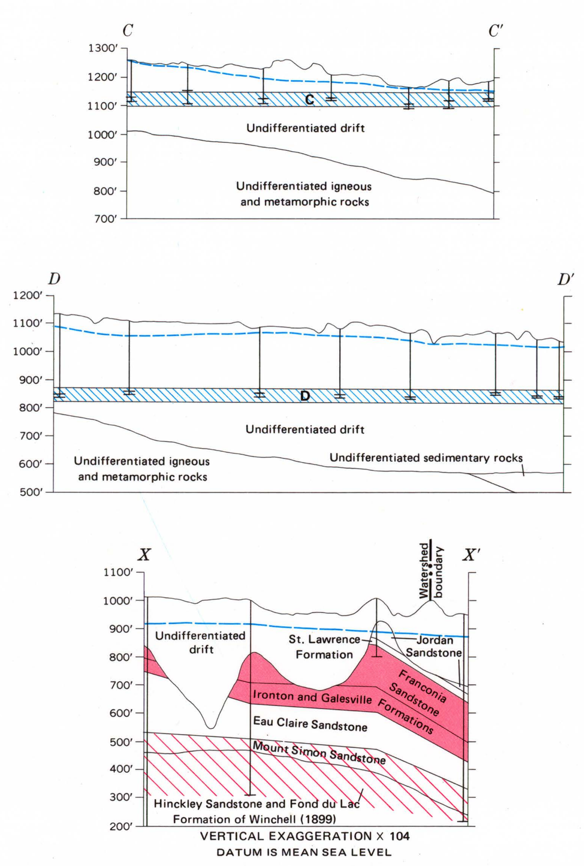


THE PRE-CRETACEOUS BEDROCK SURFACE SLOPES GENERALLY SOUTHEASTWARD.— *Relief is greatest in the eastern third of the watershed, where valleys have been cut into the Cambrian rocks.*

EXPLANATION

Bedrock contour — Shows altitude of pre-Cretaceous bedrock surface. Contour interval 100 feet. Datum is mean sea level

Watershed boundary



VERTICAL EXAGGERATION X 104
DATUM IS MEAN SEA LEVEL

EXPLANATION

See map at left for lines of section

Contact

Probable intervals containing major aquifer

Potentiometric surface of aquifers C and D

Potentiometric surface of Mount Simon-Hinckley-Fond du Lac aquifer

Top of buried outwash zone

Well

DESCRIPTION AND APPRAISAL OF MAJOR AQUIFERS

Aquifer and map symbol	Lithology and type of aquifer	Thickness (feet)	Present development: Reported data: Number of wells	Common well depth (feet)	Yield (gallons per minute)	Specific capacity (gallons per minute per foot of drawdown)	Common available draw down[1] (feet)	Remarks	Potential development
A	Sand and gravel, surficial; unconfined	0–50	33	20–50	15–1000	1.5–130 (21 wells)	15–25	Aquifer moderately developed; data mostly for large-yield irrigation wells; domestic and stock wells also common.	Analog-model study indicates the aquifer will support considerable additional development without adversely affecting ground-water system (Van Voast, 1971); readily available source of water, theoretical well yields variable, as mapped at right; susceptibility to pollution may limit use for drinking water.
B	Sand, surficial; unconfined	0–50	(Insufficient data)					Aquifer probably slightly developed, mostly for domestic and stock supplies.	Aquifer will support additional development; effects of extensive sustained pumping unknown; readily available source of water; theoretical well yields variable, as mapped at right; potential for providing large supplies limited by fine texture of sand and general absence of gravel; susceptibility to pollution may limit use for drinking water.
C	Sand and gravel, buried; confined	0–50 +	35	50–150	5–700	< 1–50 (25 wells)	10–80	Aquifer moderately developed; data mostly for domestic and stock wells; higher specific capacities and yields are for irrigation wells.	Aquifer will support additional development; effects of extensive sustained pumping are unknown; based on available drawdown and specific capacity data, short-term well yields of as much as several thousand gallons per minute are possible; because potentiometric surface slopes southward (see section C–C'), available drawdown and potential yields generally decrease in that direction.
D	Sand and gravel, confined	0–30+	44	200–275	10–750	< 1–15 (34 wells)	120–220	Aquifer moderately developed; data mostly for domestic and stock wells; higher specific capacities and yields are for municipal and industrial wells.	Aquifer will support additional development; effects of extensive sustained pumping unknown; based on available drawdown and specific capacity data, short-term well yields of as much as several thousand gallons per minute are possible; potential yields are variable because of varying thickness and texture of aquifer.
Franconia-Ironton-Galesville aquifer	Sandstone; confined.	0–220	8	250–450	15–450	2–20 (8 wells)	100–200	Aquifer slightly developed; most wells completed in aquifer are for municipal supplies.	Aquifer will support additional development; effects of extensive sustained pumping unknown; based on available drawdown and specific capacity data, short-term well yields of as much as several thousand gallons per minute are possible; lower part of aquifer most productive.
Mount Simon-Hinckley-Fond du Lac aquifer	Sandstone; confined.	0–330+	11	400–700	30–1000	< 1–21 (11 wells)	200–500	Aquifer slightly developed; most wells completed in aquifer are for municipal or industrial supplies.	Aquifer will support additional development; effects of extensive sustained pumping unknown; based on available drawdown and specific capacity data, short-term well yields of as much as several thousand gallons per minute are possible; upper part of aquifer most productive.

[1] For unconfined aquifers, assumed equal to two-thirds of the penetrated saturated thickness; for confined aquifers, vertical distance between static water level and top of aquifer.

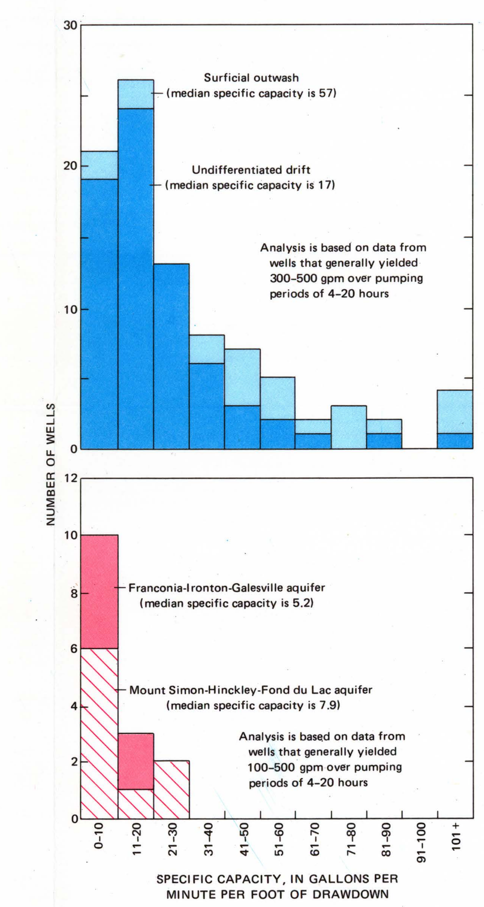
SEVERAL HIGHLY PRODUCTIVE AQUIFERS ARE LATERALLY CONTINUOUS OVER LARGE AREAS

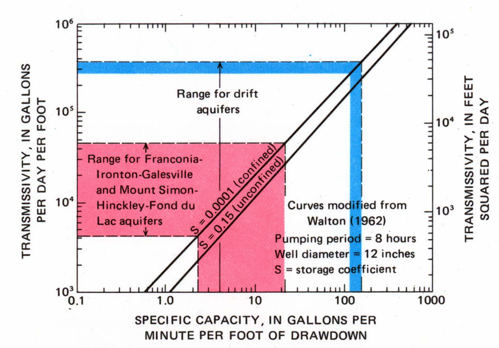
The most readily available ground water occurs in surficial outwash bodies, the largest of which are near Brooten and Litchfield (A and B, above). As evaluated from test augering, parts of these aquifers are capable of yielding several hundred gallons per minute to wells. The evaluation is based on saturated thickness, estimated hydraulic conductivity and storage coefficient, and the following assumptions: (1) the aquifers are homogeneous and of infinite areal extent, (2) wells are 18 inches in diameter, 100 percent efficient, and open to the full saturated thickness of the aquifer, and (3) drawdown after 1 day of pumping is equal to two-thirds of the original saturated thickness. Assumed drawdowns were adjusted for dewatering of the unconfined aquifers. Well yields different from those calculated may be obtained because of textural variations and hydrologic boundaries.

Undifferentiated drift deposits are variable in texture and contain buried outwash aquifers, most of which are of relatively small extent. Reported well data permit the approximate delineation of two major buried aquifers (C and D, above), which are somewhat continuous. Other large buried outwash aquifers may occur at depths greater than those penetrated by present wells.

Sandstones form two extensive aquifers underlying the drift in the eastern third of the watershed. The Franconia-Ironton-Galesville aquifer remains in its entirety only in some extreme eastern parts of the watershed, whereas the deeper Mount Simon-Hinckley-Fond du Lac aquifer is in most places unerroded. (See section X–X' and map of bedrock geology on this sheet.) The potentiometric surface of the upper aquifer, though control does not permit its definition on section X–X', is generally slightly higher than that of the deeper one.

Each of the mapped aquifers is described and appraised in the table at left. The quality of water in the aquifers is similar. (See "Water Quality" on sheet 3.) Because of their extent, these aquifers could support considerable ground-water development. Large available drawdowns in most confined aquifers enhance their water-yielding potential. The eastern part of the watershed is particularly favorable for future development, considering the presence of one or two productive sandstone aquifers in addition to the drift aquifers above.





SPECIFIC-CAPACITY DATA INDICATE A WIDE RANGE IN WATER-TRANSMITTING CAPABILITY FOR GLACIAL-DRIFT AQUIFERS.—*This range reflects the textural heterogeneity of drift. The higher specific-capacity values are generally for wells completed in surficial outwash aquifers. A smaller range in transmissivity is suggested for the Franconia-Ironton-Galesville and Mount Simon-Hinckley-Fond du Lac aquifers. Specific-capacity values for wells completed in the two major bedrock aquifers are comparable, although slightly higher for the Mount Simon-Hinckley-Fond du Lac aquifer.*

The theoretical relationship between specific capacity and transmissivity is necessarily based on the assumptions that wells are open to the entire saturated thickness of the aquifer and that well loss is negligible. This analysis excludes data for wells yielding less than the amounts stated on the graphs because they are usually less indicative of water-transmitting capability than wells of large yield. Wells drilled for large supply requirements generally penetrate a greater percentage of the aquifer thickness, commonly have higher well efficiencies, and are of larger diameter.

Interior—Geological Survey, Reston, Va.—1974

WATER RESOURCES OF THE CROW RIVER WATERSHED, SOUTH-CENTRAL MINNESOTA

By
G. F. Lindholm, D. F. Farrell, and J. O. Helgesen
1974