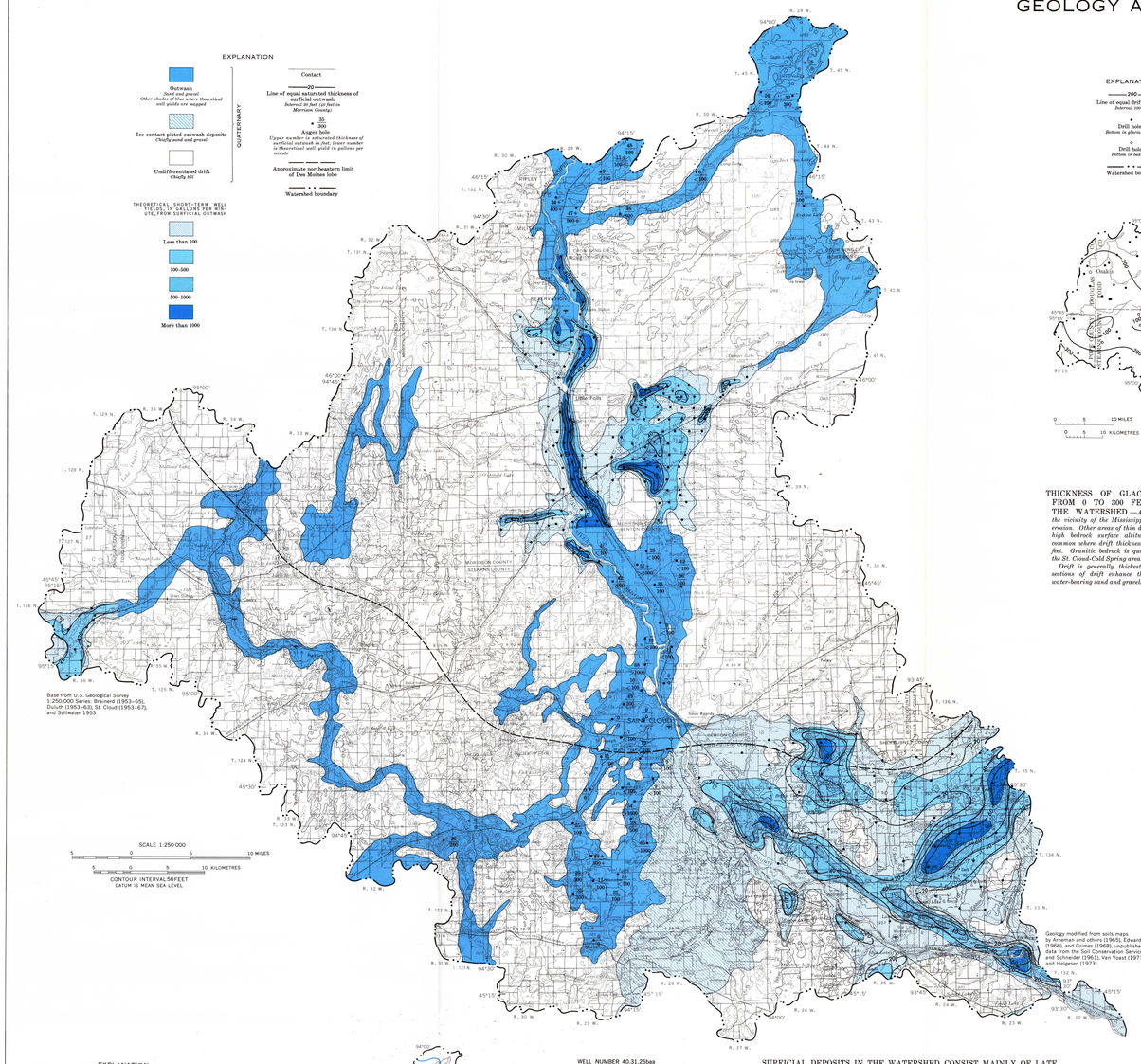
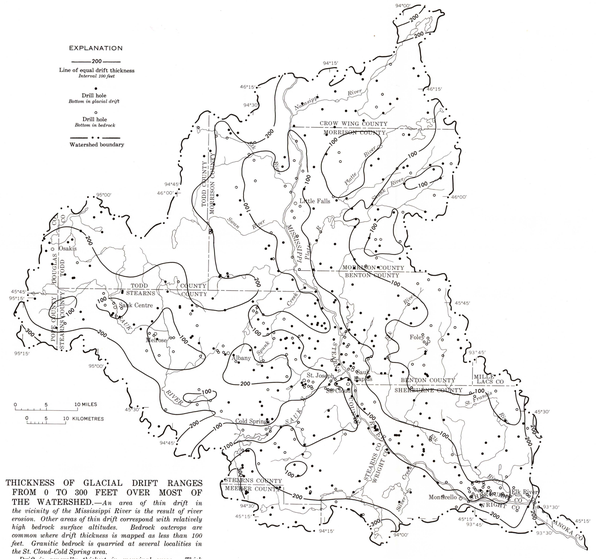
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
MINNESOTA DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATERS, SOILS, AND MINERALS

HYDROLOGIC INVESTIGATIONS
ATLAS HA-534 (SHEET 2 OF 3)

GEOLOGY AND GROUND WATER



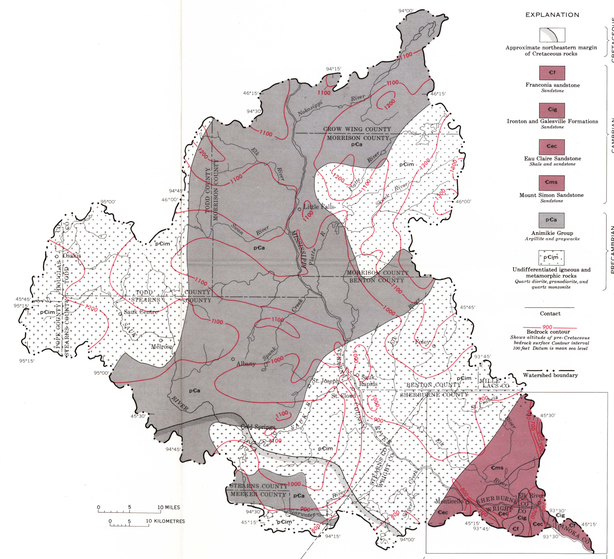


THICKNESS OF GLACIAL DRIFT RANGES FROM 0 TO 300 FEET OVER MOST OF THE WATERSHED.—*An area of thin drift is the vicinity of the Mississippi River is the result of river erosion. Other areas of thin drift correspond with relatively high bedrock surface altitudes. Bedrock outcrops are common where drift thickness is mapped as less than 100 feet. Granitic bedrock is quarried at several localities in the St. Cloud–Cold Spring area.*

Drift is generally thickest in moraineal areas. Thick sections of drift enhance the possibility of penetrating water-bearing sand and gravels.

HYDROGEOLOGY OF BEDROCK

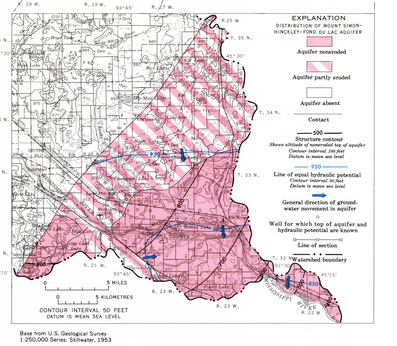
Age	Unit	Thickness (feet)	Lithologic characteristics	Water-yielding capability
MESOZOIC, CRETACEOUS	Sedimentary rocks, unnamed	0–150	Predominantly shale; contains lignite and scattered, thin (less than 10 feet) sandstone beds.	Unknown capability in watershed; elsewhere, small quantities of water available from sandstone.
PALEOZOIC, CAMBRIAN	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; wells may be capable of yielding several tens of gallons per minute; productivity where saturated thickness reduced aquifer thickness; hydraulic conductivity variable, generally highest in Galesville.
	Ironton and Galesville Formations	0–70	Ironton-sandstone, white to gray, medium- to coarse-grained, well- to moderately well-sorted; commonly silty. Galesville-sandstone white to gray, predominantly medium-grained and well-sorted; fine-grained near base.	
	Eau Claire Sandstone	0–110	Shale and sandstone interbedded, gray to green, fossiliferous; partly glauconitic.	Small quantities of water available; acts as confining bed; relatively poor source of water.
	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; estimated maximum well yields of several thousand gallons per minute, based upon specific capacities and available drawdowns; hydraulic conductivity moderate to high in Mount Simon; probably lower in Hinckley and Fond du Lac.
	Hinckley Ss. 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 shale(s)"-siltstone, sandstone, and shale, poorly-sorted; partly arkosic.	
PRECAMBRIAN	Animikie Group	?	Predominantly argillite and graywacke; small amount of iron formation in northern part of watershed.	Small quantities of water available; wells may be capable of yielding several tens of gallons per minute; productivity generally limited by small size and poor interconnection of fractures and joints; hydraulic conductivity is relatively low; water-yielding weathered zones are commonly present.
	Undifferentiated igneous and metamorphic rocks	?	Predominantly quartz diorite, granodiorite, and quartz monzonite.	Small quantities of water available; wells may be capable of yielding several tens of gallons per minute; productivity generally limited by small size and poor interconnection of fractures and joints; hydraulic conductivity is relatively low; water-yielding weathered zones are commonly present.

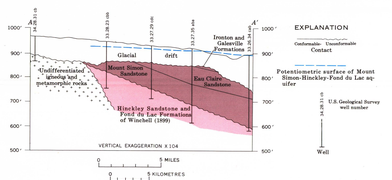


Distribution of bedrock units modified from Sims (1970)

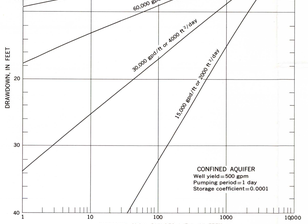
PRECAMBRIAN IGNEOUS AND METAMORPHIC ROCKS DIRECTLY UNDERLIE THE GLACIAL DRIFT IN MOST OF THE WATERSHED.—*A southeastward dipping Cambrian sedimentary sequence (predominantly sandstone) underlies the drift in the southeastern part. Cambrian sandstones are underlain by the Precambrian sandstone and shales of the Hinckley Sandstone and Fond du Lac Formation of Winchell (1899). The stratigraphic position of the Hinckley Sandstone and Fond du Lac Formation of Winchell (1899) is shown on the section (below right), although they apparently do not subcrop in the watershed. Cretaceous sedimentary rocks overlie Precambrian rocks in parts of the watershed. They are most continuous in the southern part, though scattered occurrences have been reported elsewhere. Thickness of the Cretaceous rocks is highly variable. Water-yielding characteristics of bedrock units are described in the table at left.*

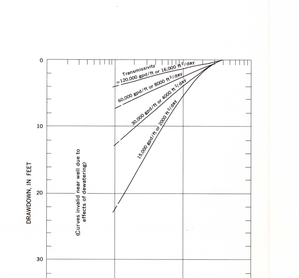
The surface of the bedrock slopes generally toward the Mississippi River. Within this trough-shaped low is a relatively narrow bedrock valley that may be continuous along most of the river's length. Considerable local irregularity of the bedrock surface is common in the area of igneous and metamorphic rock, but is not shown in this regional interpretation.



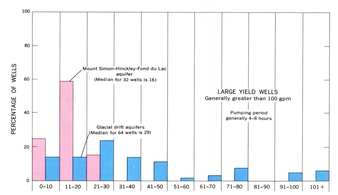


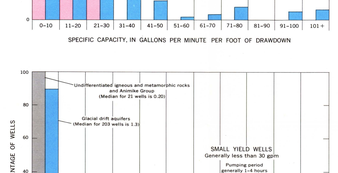
THE MOUNT SIMON-HINCKLEY-FOND DU LAC AQUIFER CONTAINS WATER UNDER CONFINED CONDITIONS THAT WILL GENERALLY RISE IN A WELL 100 TO 400 FEET ABOVE THE TOP OF THE AQUIFER.—*Structure contours indicate the southeastward dip of the unit. The potentiometric surface of the aquifer slopes more gently to the southeast and has a component toward the Mississippi River. Along the line of section, water from a well completed in the Mount Simon-Hinckley-Fond du Lac aquifer will rise nearly to land surface and, in the eastern part, may flow. Distance-drawdown relationships applicable to this aquifer are presented below.*





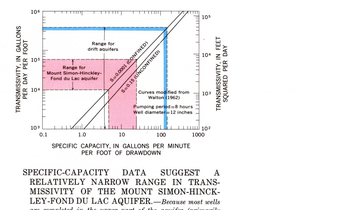
THEORETICAL DISTANCE-DRAWDOWN CURVES FOR TRANSMISSIVITY VALUES REPRESENTATIVE OF AQUIFERS IN THE WATERSHED CAN BE USED AS A GUIDE IN PLANNING AND MANAGING GROUND-WATER DEVELOPMENT.—*Relative effects of pumping from confined (buried sand and gravel or bedrock) and unconfined (surficial sand and gravel) aquifers are shown on the graphs. Although the curves are based on a selected well yield of 500 gpm, they are applicable to other yields because of a direct proportion between yield and drawdown. A well yield of 1,000 gpm, for example, theoretically would cause drawdowns equal to twice those shown.*





SPECIFIC-CAPACITY (YIELD, IN GALLONS PER MINUTE, PER FOOT OF DRAWDOWN) DATA INDICATE THAT GLACIAL-DRIFT AQUIFERS AND THE MOUNT SIMON-HINCKLEY-FOND DU LAC AQUIFER ARE THE MOST PRODUCTIVE IN THE WATERSHED.

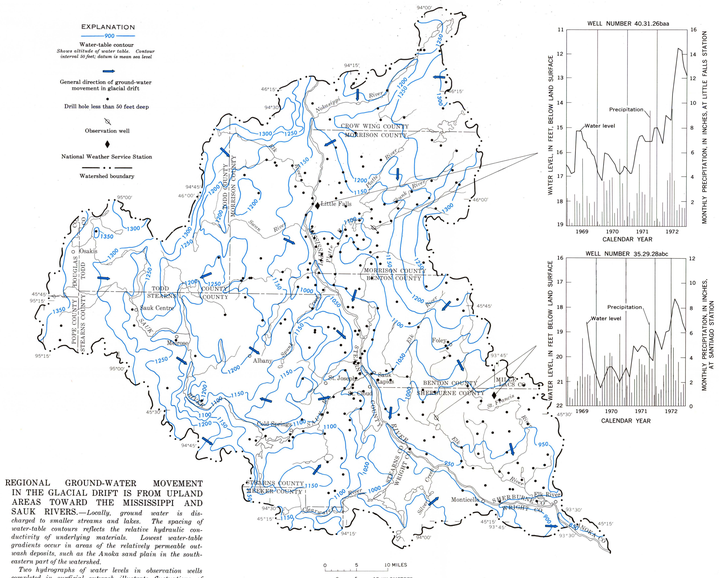
Specific capacities of wells completed in Precambrian igneous and metamorphic rocks are consistently low, usually less than one. Although specific capacity is generally indicative of the water-transmitting capability of an aquifer, it may be greatly affected by well characteristics and by length of testing. The specific capacity determined for wells of large yield is generally more indicative of aquifer capability than that determined for wells of small yield. Wells of large yield generally penetrate a greater percentage of the aquifer thickness, commonly have higher well efficiencies, and are of larger diameter.



SPECIFIC-CAPACITY DATA SUGGEST A RELATIVELY NARROW RANGE IN TRANSMISSIVITY OF THE MOUNT SIMON-HINCKLEY-FOND DU LAC AQUIFER.—*Because most wells are completed in the upper part of the aquifer (primarily Mount Simon Sandstone), indicated transmissivity values are considered to be minimal.*

The suggested large range in transmissivity of drift aquifers reflects the wide specific-capacity distribution shown on the bar graph at left for large-yield wells. The greater modal class of specific capacity (21–30 gpm per foot of drawndown) and the positive skewness indicate common transmissivity values of 1 × 10⁵ gallons per day per foot (5,36 × 10⁴ feet squared per day), or higher. Though drift aquifers vary widely in thickness and areal extent, it is evident that much of the glacial drift has relatively high water-transmitting capability.

The theoretical relationship between specific capacity and transmissivity is based on the assumptions that wells are open to the entire saturated thickness of the aquifer and are 100 percent efficient.



REGIONAL GROUND-WATER MOVEMENT IN THE GLACIAL DRIFT IS FROM UPLAND AREAS TOWARD THE MISSISSIPPI AND SAUK RIVERS.—*Locally, ground water is discharged to smaller streams and lakes. The spacing of water-table contours reflects the relative hydraulic conductivity of underlying materials. Lowest water-table gradients occur in areas of the relatively permeable outwash deposits, such as the Anoka sand plain in the southeastern part of the watershed.*

Two hydrographs of water levels in observation wells completed in surficial outwash illustrate fluctuations of the water table in response to precipitation. Most recharge is from snowmelt in the spring, although excessive precipitation in the summer or fall may result in high water levels. Extremely high water levels in 1972 are attributed to record-breaking rainfall in July in the central part of the watershed.

SURFICIAL DEPOSITS IN THE WATERSHED CONSIST MAINLY OF LATE WISCONSIN GLACIAL TILL AND OUTWASH

Undifferentiated drift in the western and southern parts is composed chiefly of gray calcareous till of the Des Moines Lobe, which entered the area from the northwest. The large areas of undifferentiated drift in the central and northeastern parts are mostly red-brown till deposited by the Superior Lobe, which entered from the east. Older gray drift of the Wadena Lobe from the northwest is buried under much of the northern part. The limits of the Superior and Wadena Lobes are masked by younger drift, and well-log data are not of sufficient detail to map them.

Deposits of buried sand and gravel occur randomly within the undifferentiated drift. Melt waters deposited large amounts of surficial outwash sand and gravel. In much of the area, outwash deposits are in the form of valley trains. Surficial sands in the southeastern part of the watershed are part of the extensive Anoka sand plain (Cooper, 1935).

Descriptions of the water-yielding capabilities of glacial-drift units are included in the table below.

Test augering was used to evaluate the water-yielding capability of parts of the surficial outwash aquifer. Reported data were also used as a guide. Control was sufficient to map theoretical well yields in Morrison County (Helgesen, 1973), in the extreme western part of the watershed (Van Voast, 1971), and on the Anoka sand plain. The yields are based upon saturated thickness, estimated hydraulic conductivity and storage coefficient, and the following assumptions: (1) the aquifer is homogeneous and of infinite areal extent; (2) wells are 16 inches in diameter, 100 percent efficient, and open to the full saturated thickness of the aquifer; and (3) drawdown after 1 day of pumping equals two-thirds of the original saturated thickness. Assumed drawdowns were adjusted for dewatering of the unconfined aquifer. Yields different from those shown may be obtained because of textural variations and hydrologic boundaries.

HYDROGEOLOGY OF GLACIAL DRIFT

Age	Unit	Thickness (feet)	Lithologic characteristics	Water-yielding capability
RECENT	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.	
QUATERNARY, PLEISTOCENE	Surficial outwash	0–100	Primarily sand and gravel; stratified; commonly moderately to well sorted	Small to large quantities of water available; well yields of several hundred to more than 1,000 gpm possible, where sufficient saturated thickness is penetrated. (See evaluation of outwash on map above).
	Undifferentiated drift	0–300	Primarily gray, calcareous till or red-brown, sandy till; unstratified and unsorted; contains stratified sand and gravel bodies of varying extent and thickness.	Small to large quantities of water available; capabilities of stratified zones similar to those of outwash; well yields of several hundred gallons per minute, or more, often possible; till is of low hydraulic conductivity and yields little water; areas of thicker drift hold greater possibilities of penetrating productive zones.
	Ice contact-jotted outwash deposits	0–100	Primarily gravel and sand; mostly stratified; sorting variable; some till.	Small to moderate quantities of water available; widely varying hydraulic conductivity and saturated thickness probable.

WATER RESOURCES OF THE MISSISSIPPI AND SAUK RIVERS WATERSHED, CENTRAL MINNESOTA
By
J. O. Helgesen, D. W. Ericson, and G. F. Lindholm
1975

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