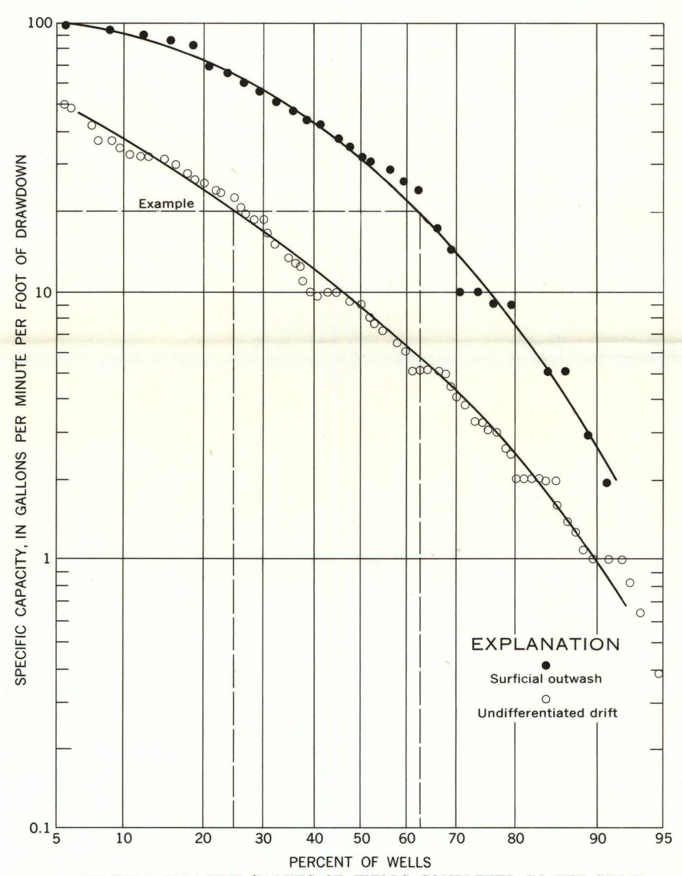
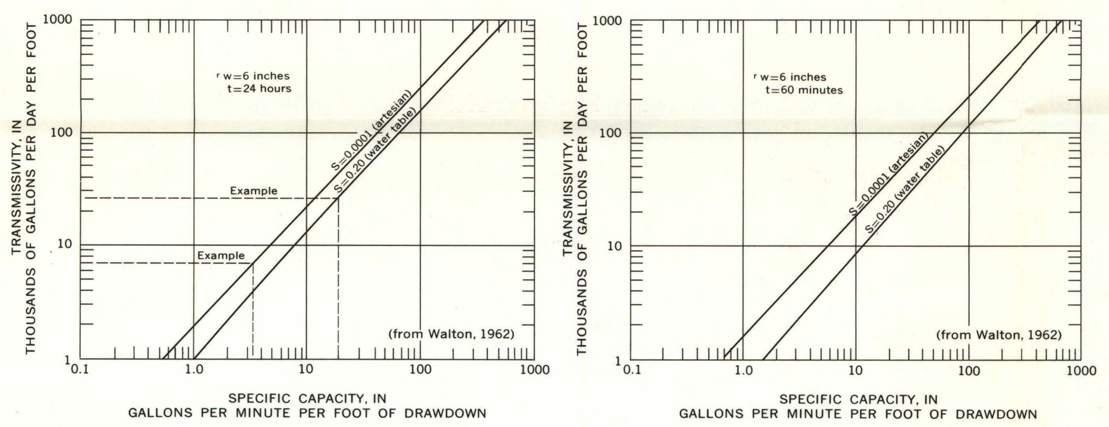
GROUND WATER

DESCRIPTION OF GEOLOGIC UNITS AND AQUIFER CHARACTERISTICS

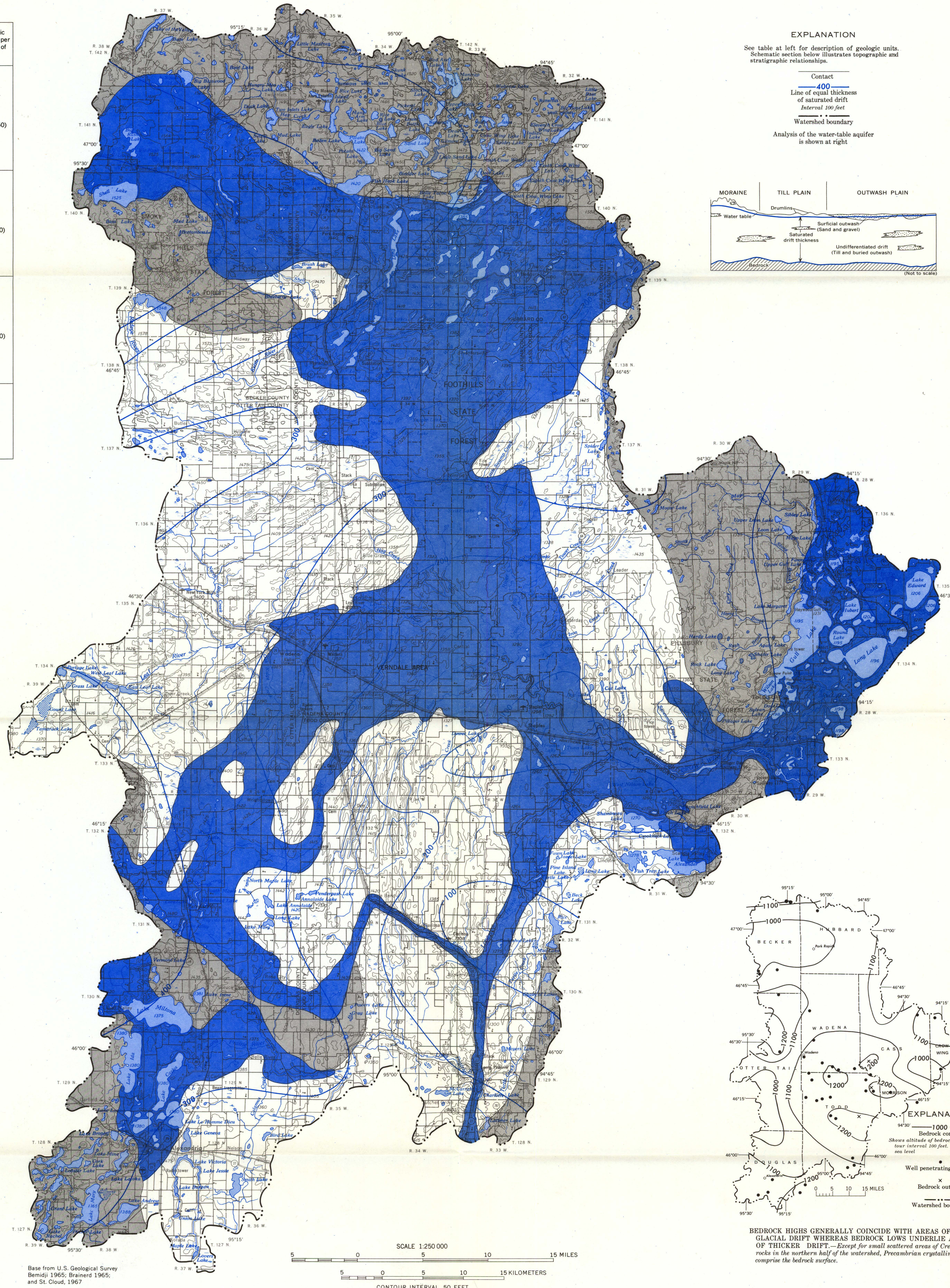
	Geologic unit and map symbol	Topographic and lithologic characteristics	Thickness (feet)	Hydrologic characteristics	Reported water yield (gallons per minute)	Reported specific capacity (gallons per minute per foot of drawdown)
Glacial drift	Surficial outwash	Chiefly sand and gravel forming areas of low relief. Grain size and sorting varies laterally and vertically. Median grain size of much of the outwash is medium sand (diameter ½–1 millimeter). Underlain by undifferentiated drift. Includes small areas of alluvium along present streams.	0–100 (commonly 20–40)	The water table is almost always at shallow depths (<10 feet) and unconfined. High porosity and permeability and high saturated thickness often permit yields of several hundred gallons per minute to large diameter wells. Transmissivity values based on specific capacities and aquifer tests generally range from 10,000 gpd per ft (gallons per day per foot) to 100,000 gpd per ft. Aquifer tests indicate a storage coefficient of about 0.15.	Domestic and stock (40 wells) 3–75 (commonly 3–10) Municipal, industrial, irrigation (27 wells) 50–750	(33 wells) 1–150 (commonly 10–50)
	Moraine	Undifferentiated glacial drift forming areas of undulating relief. Most material is sandy till (heterogeneous glacial deposits). Sand and gravel occur in ice-contact features and as local concentrations within the till.	0–600 (commonly 200–400)	Widely varying water-yielding properties make local conditions difficult to predict. Much of the material is of low permeability because of abundant clay. Wells completed in sand and gravel overlying or within the till may yield large quantities of water. Estimated from specific capacities, transmissivity values for aquifers within morainal deposits commonly range from 1,000–10,000 gpd per ft. Water is generally confined under pressure.	Domestic and stock (50 wells) 2–65 (commonly 4–20) Municipal, industrial, irrigation (2 wells) 32 and 300	(16 wells) 1–32 (commonly 1–10)
	Till plain	Undifferentiated glacial drift forming areas of moderately-undulating relief, partially covered by outwash. Most material is sandy till containing varying amounts of outwash sand and gravel. Many drumlins (elongate hills of till whose long axis is parallel to the direction of ice movement) occur in the till plain area.	0–400 (commonly 150–250)	Water-yielding properties are similar to those of morainal deposits. Till yields little water to wells, but the possibility of tapping buried sand and gravel is good. Yields of several hundred gpm are common from large-diameter wells completed in buried aquifers. Transmissivity, estimated from specific capacities, usually ranges from 1,000–10,000 gpd per ft and may approach 100,000 gpd per ft. Water is generally confined and a few wells flow.	Domestic and stock (219 wells) 1–100 (commonly 4–20) Municipal, industrial, irrigation (63 wells) 35–1,000 (commonly 100–500)	(98 wells) 1–140 (commonly 1–30)
Bedrock		Deeply buried across most of the watershed; very few outcrops. Consists largely of Precambrian slate, graywacke, granite, gneiss, schist. Scattered Cretaceous rocks (limestone, sandstone, shale) overlying the Precambrian rocks have been reported in the northern half of the watershed.	Unknown	Precambrian igneous and metamorphic rocks have been known to yield small amounts of water to wells, but their potential in this watershed is unknown. The only known production from bedrock is that reported as being from Cretaceous limestone (2 wells) in sec. 34, T. 137 N., R. 35 W.	Municipal, industrial, irrigation (2 wells) 225 and 245	(2 wells) 3 and 4



SPECIFIC CAPACITY VALUES OF WELLS COMPLETED IN THE SURFICIAL OUTWASH ARE TYPICALLY HIGHER THAN THOSE OF WELLS COMPLETED IN THE UNDIFFERENTIATED DRIFT.—*Specific capacity is well yield per unit of drawdown, therefore it serves as an approximate indicator of the water-yielding capacity of the producing zone. The frequency distribution curves above, based on reported values of specific capacity, illustrate the marked difference in water-yielding capacity between glacial drift aquifers in the watershed. For example, about 63 percent of wells completed in surficial outwash exceed a specific capacity of 20 gpm per ft but only about 25 percent of those completed in undifferentiated drift exceed this amount.*



TRANSMISSIVITY OF AN AQUIFER CAN BE ESTIMATED FROM SPECIFIC CAPACITY, ASSUMING NEGLIGIBLE WELL LOSS AND COMPLETE PENETRATION OF THE SATURATED THICKNESS BY THE UNCASED PART OF THE WELL.—*The theoretical relationship between transmissivity and specific capacity depends upon r_w (radius of the well), t (time since pumping began), and S (storage coefficient of the aquifer). As shown in the example above, if r_w=6 inches and t =24 hours, a specific capacity of 20 gpm per ft for a well completed in a water-table (unconfined) aquifer indicates a transmissivity for that aquifer of about 25,000 gpd per ft. A specific capacity of 3.5 gpm per ft, more typical of wells in the watershed completed in artesian (confined) aquifers, indicates a transmissivity of about 7000 gpd per ft.*



SATURATED GLACIAL DRIFT RANGING FROM LESS THAN 100 TO MORE THAN 600 FEET IN THICKNESS IS PRESENT OVER THE ENTIRE WATERSHED

The amount of ground water in storage is roughly proportional to the thickness of saturated drift (the vertical distance from the water table to the top of the bedrock). Saturated drift is generally thickest in morainal areas and thinnest in the southeast part of the watershed where water-table altitude is relatively low and bedrock altitude relatively high. Effective saturated thickness of drift is always less than that shown on the map, because most drift consists of till of relatively low water-yielding capacity.

Surficial outwash, which covers nearly half of the watershed, consists of sand and gravel, generally of sufficient thickness and permeability to permit yields of large quantities of water to wells. Over much of this area, the thickness of surficial outwash depends upon the proximity to drumlins, which have been partially or wholly buried by the outwash.

In moraine and till plain areas, wells are usually completed in buried sand and gravel and at greater depths than those in areas of surficial outwash. The greater the saturated thickness, the greater the possibility of penetrating buried aquifers.

EXPLANATION

See table at left for description of geologic units. Schematic section below illustrates topographic and stratigraphic relationships.

Contact

400 — Line of equal thickness of saturated drift
Interval 100 feet

Watershed boundary

Analysis of the water-table aquifer is shown at right

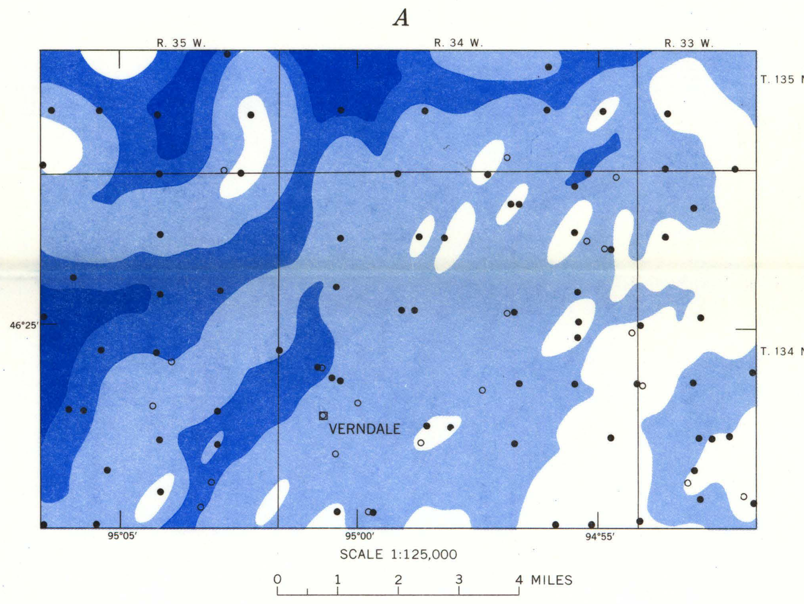
BEDROCK HIGHS GENERALLY COINCIDE WITH AREAS OF THIN GLACIAL DRIFT WHEREAS BEDROCK LOWS UNDERLIE AREAS OF THICKER DRIFT.—*Except for small scattered areas of Cretaceous rocks in the northern half of the watershed, Precambrian crystalline rocks comprise the bedrock surface.*

ANALYSIS OF THE WATER-TABLE AQUIFER IN THE VERNDALE AREA INDICATES APPROXIMATE QUANTITIES OF WATER POTENTIALLY AVAILABLE TO WELLS.—*Areal variations in the saturated thickness of the water-table aquifer (Map A) were determined primarily by test drilling. The general northeast-southwest trend of the oval shaped areas reflects the presence of buried or partially buried drumlins.*

Transmissivity of the aquifer at each drill-hole site was calculated by multiplying the saturated thickness of the aquifer by its hydraulic conductivity, which was estimated from sample examination. These values, supplemented by aquifer test results, indicate that most of the water-table aquifer in the Verndale area has a transmissivity exceeding 30,000 gpd per ft (Map B).

Using the nonequilibrium equation, approximate yields to wells were calculated and mapped (Map C). This interpretation is based upon the estimated transmissivity values, an assumed storage coefficient of 0.15, and the conditions stated in the map explanation. Actual yields at a specific location may vary from those shown, particularly when nearness to a stream or drumlin creates a positive or negative hydrologic boundary.

A



EXPLANATION

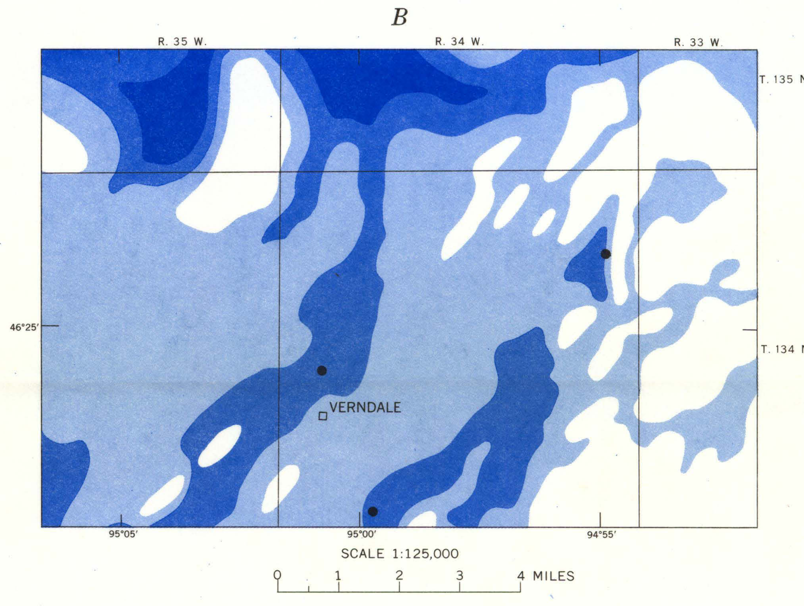
<20 | 20–40 | 40–60 | >60

Saturated thickness of surficial outwash (sand and gravel) in feet

U.S.G.S. test hole

Other test hole or well

B



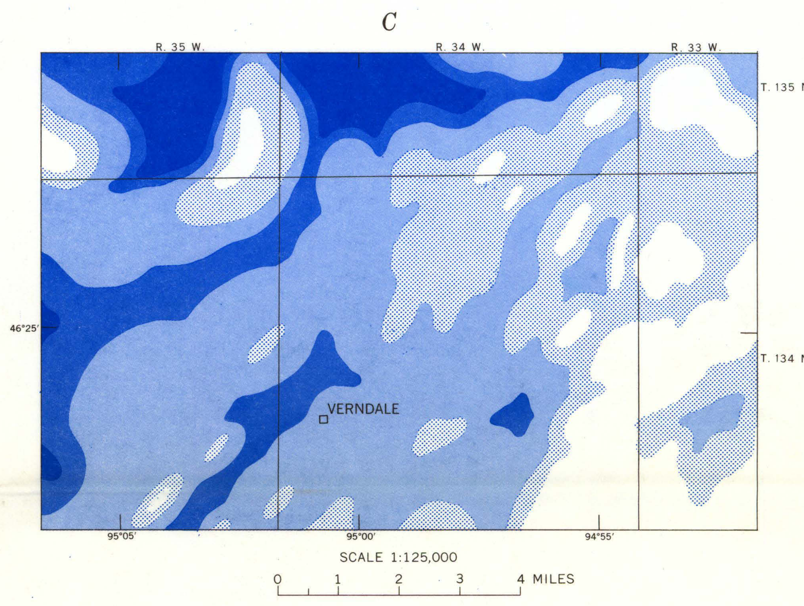
EXPLANATION

<30,000 | 30–60,000 | 60–90,000 | >90,000

Transmissivity of surficial outwash, in gallons per day per foot

Aquifer test site

C



EXPLANATION

<100 | 100–300 | 300–600 | 600–900 | >900

Estimated maximum yield, in gallons per minute, to a well completed in the surficial outwash assuming a pumping period of 30 days and a maximum allowable drawdown of two-thirds the saturated thickness. Corrections were made for decreases in saturated thickness due to dewatering.

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WATER RESOURCES OF THE CROW WING RIVER WATERSHED, CENTRAL MINNESOTA

By
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1972