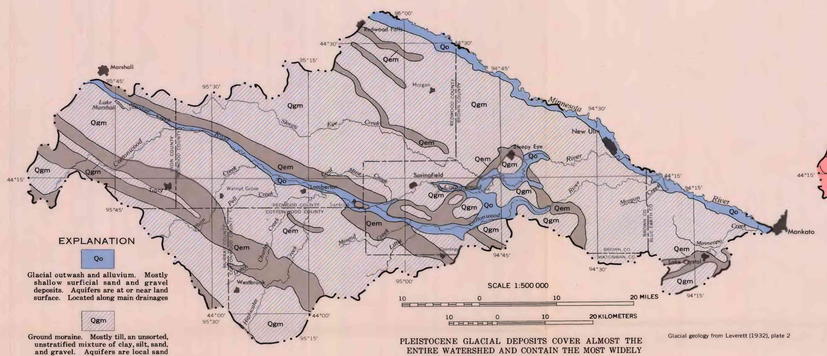
DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY

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

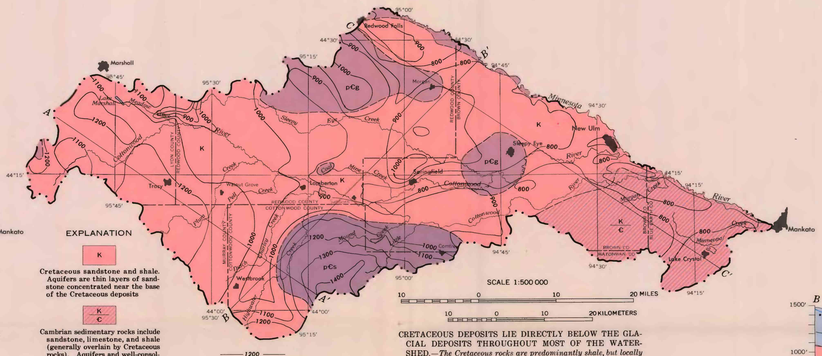
HYDROLOGIC INVESTIGATIONS
ATLAS HA-466 (SHEET 2 OF 3)

GROUND WATER

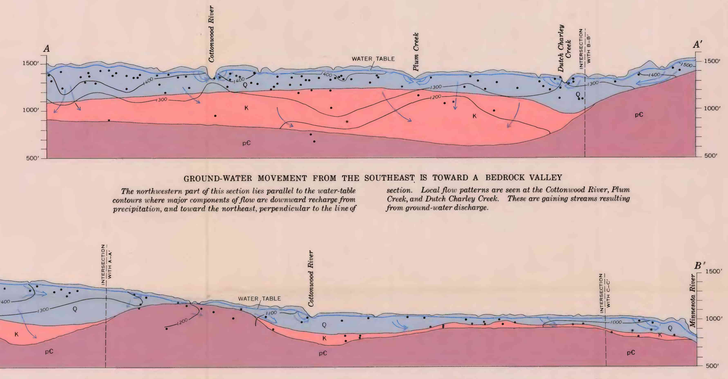


Glacial geology from Leverett (1932), plate 2

PLEISTOCENE GLACIAL DEPOSITS COVER ALMOST THE ENTIRE WATERSHED AND CONTAIN THE MOST WIDELY USED AQUIFERS.—*The glacial deposits are predominantly till, an unsorted, unstratified mixture of clay, silt, sand, and gravel. Beds of sand and gravel within the till are the most widely accessible and widely used aquifers in the watershed. These buried sand and gravel lenses are commonly thin and discontinuous, but provide water supplies adequate for most uses. Generally water supplies can be obtained from glacial outwash where it is present. However, because it is exposed at the land surface it is more susceptible to contamination than buried aquifers.*



CRETACEOUS DEPOSITS LIE DIRECTLY BELOW THE GLACIAL DEPOSITS THROUGHOUT MOST OF THE WATERSHED.—*The Cretaceous rocks are predominantly shale, but locally contain poorly consolidated sandstone aquifers. The most significant and continuous aquifer occurs at the base of the sequence.*

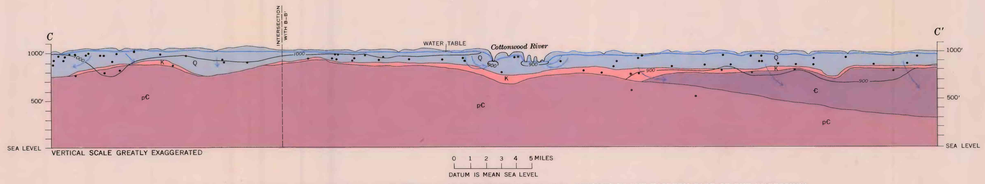


GROUND-WATER MOVEMENT FROM THE SOUTHEAST IS TOWARD A BEDROCK VALLEY

The northwestern part of this section lies parallel to the water-table contours where major components of flow are downward recharge from precipitation, and toward the northeast, perpendicular to the line of section. Local flow patterns are seen at the Cottonwood River, Plum Creek, and Dutch Charley Creek. These are gaining streams resulting from ground-water discharge.

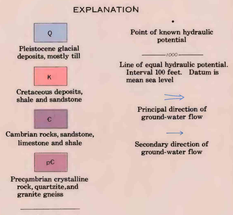
DOMINANT REGIONAL GROUND-WATER FLOW IS NORTHEASTWARD FROM THE TOPOGRAPHIC HIGH TOWARD THE MINNESOTA RIVER

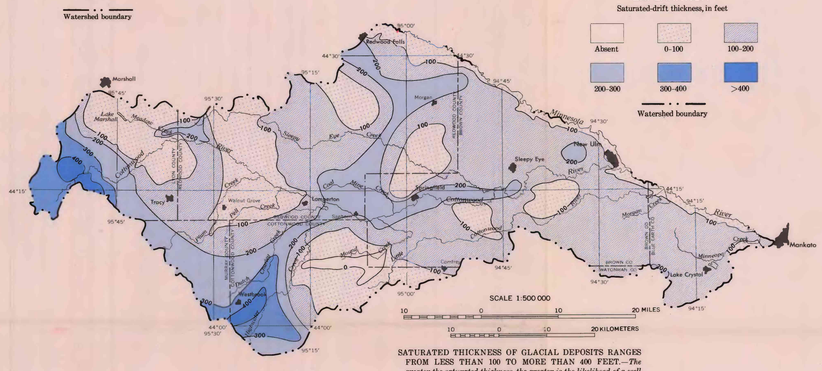
A buried bedrock valley, diverted around a Precambrian quartzite knob, intersects the section twice. Precambrian rocks restricts ground-water movement locally so that much of the flow in the bedrock is along buried valleys. Ground-water discharge is mainly to evapotranspiration and to the Minnesota River.



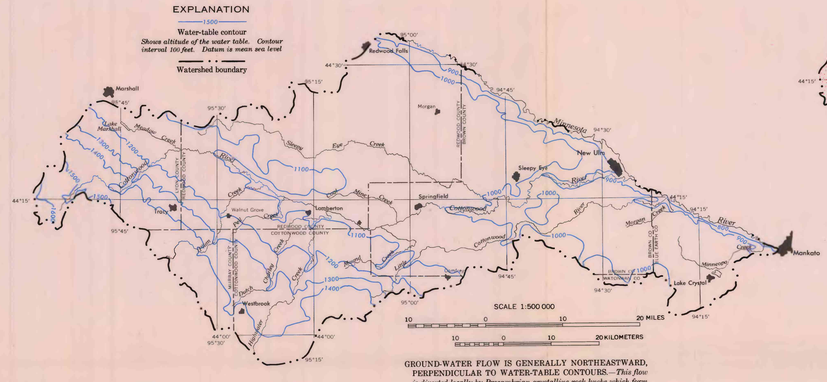
GROUND WATER MOVES INTO CAMBRIAN FORMATIONS THROUGH PLEISTOCENE GLACIAL DEPOSITS IN THE EASTERN PART OF THE WATERSHED

Lines of equal hydraulic potential indicate downward recharge from precipitation except at the Cottonwood River where ground water discharges into the river. The main horizontal component of flow is toward the Minnesota River, perpendicular to the line of section.

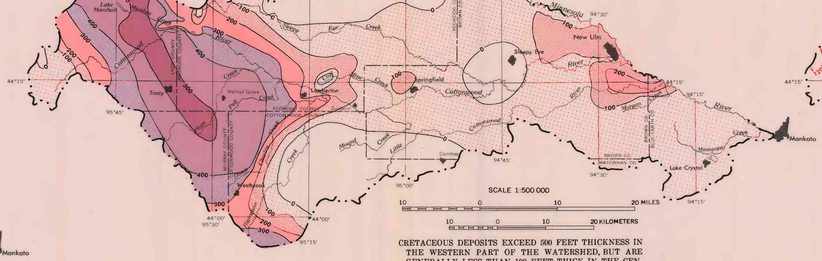




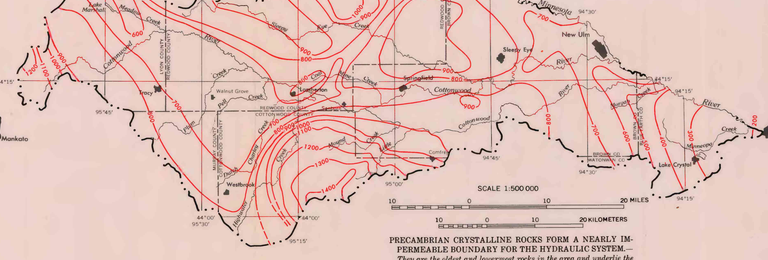
SATURATED THICKNESS OF GLACIAL DEPOSITS RANGES FROM LESS THAN 100 TO MORE THAN 400 FEET.—*The greater the saturated thickness, the greater is the likelihood of a well penetrating a water-yielding sand lens and obtaining a water supply. Only a part of the available ground water has been developed, and no areas of significant ground-water decline are known. However, because ground-water availability varies locally, detailed studies will be needed to guide resource development, especially where large supplies are needed.*



GROUND-WATER FLOW IS GENERALLY NORTHEASTWARD, PERPENDICULAR TO WATER-TABLE CONTOURS.—*This flow is diverted locally by Precambrian crystalline rock knobs which form nearly impermeable barriers to water movement. Ground water enters the watershed primarily as recharge from precipitation. Some also enters as underflow from the south, particularly along the bedrock valley at the south-central tip of the watershed.*

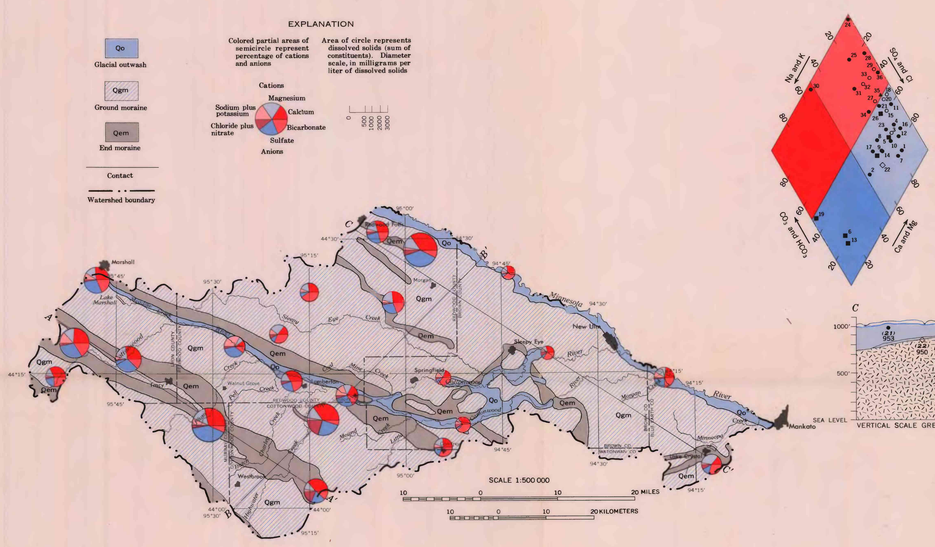


CRETACEOUS DEPOSITS EXCEED 500 FEET THICKNESS IN THE WESTERN PART OF THE WATERSHED, BUT ARE GENERALLY LESS THAN 100 FEET THICK IN THE CENTRAL AND EASTERN PART.—*The highest yields from Cretaceous aquifers are obtained from the area of thick deposits in the western part of the watershed.*



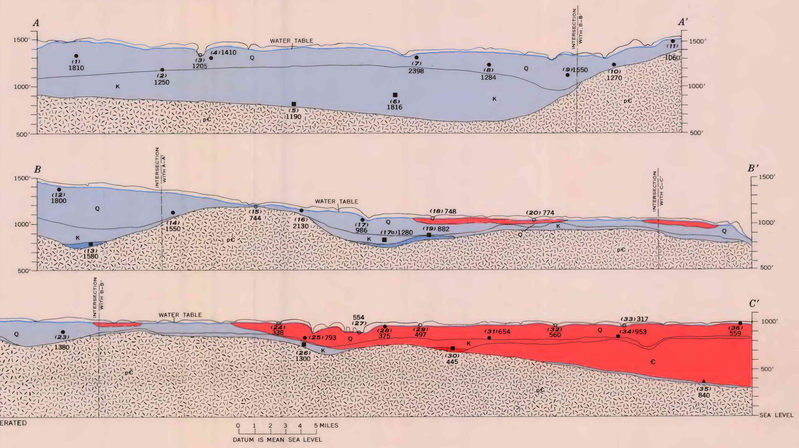
PRECAMBRIAN CRYSTALLINE ROCKS FORM A NEARLY IMPERMEABLE BOUNDARY FOR THE HYDRAULIC SYSTEM.—*They are the oldest and lowermost rocks in the area and underlie the entire watershed. Small amounts of water move through fractures in the Precambrian quartzite and granitic rocks. Wells completed in the Precambrian rocks generally yield only a few gallons per minute.*

QUALITY OF WATER



THE DISSOLVED SOLIDS AND WATER TYPE IN SURFICIAL AQUIFERS (LESS THAN 100 FEET DEEP) DEPEND ON MINERALS COMPOSING THE GLACIAL SEDIMENT, GROUND-WATER MOVEMENT, LEACHING OF SOLUBLE MINERALS, AND POLLUTION FROM FARMING AND BARNYARDS

End moraines having good surface drainage generally contain water having the largest dissolved solids (1000 mg/l and greater) which is of calcium magnesium sulfate type. Water from wells completed in sand and gravel and ground moraine deposits are generally of calcium magnesium bicarbonate type and dissolved solids is less than 1000 mg/l. Exceptions to this are found in sand and gravel deposits located along the Cottonwood River upstream from Sanborn. In this area, mixing of ground water from deeper deposits has caused the surficial aquifers to have a higher percentage of sodium and larger concentrations of boron. Permeable sandstone bedrock underlying glacial deposits allows better passage of water through glacial deposits, resulting in more leaching of the glacial deposits at the eastern end of the watershed. Water from these deposits is calcium magnesium bicarbonate type and dissolved solids are usually less than 700 mg/l in shallow wells.



EXPLANATION

Wells finished in
- Glacial deposits (Q)
- Cretaceous deposits (K)
- Cambrian sandstone (C)
- Precambrian crystalline rocks (pC)

(5) Well no. 5 section (A-A')

1190 Dissolved solids, in milligrams per liter

Water from streams under base flow conditions and lakes

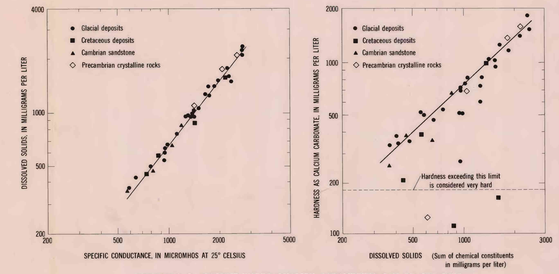
Water type
- Calcium magnesium bicarbonate
- Sodium potassium bicarbonate
- Sodium potassium sulfate
- Calcium magnesium sulfate

QUALITY OF WATER ALONG SECTIONS DEPICT AREAS OF POORLY LEACHED AND WELL LEACHED TILLS

The circuitous path of infiltrating ground water through poorly leached tills (section A-A') and scattered outwash sand and gravel deposits causes water to dissolve large (highly variable) concentrations of soluble sulfate minerals resulting in large and variable dissolved solids (1,200-2,100 mg/l). Partial leaching of till deposits at the eastern end of the section is shown by a higher percentage of bicarbonate ions and smaller dissolved solids in water. Water from one well (6) indicates softening by cation exchange.

Quality of water from wells along the southern end of section B-B' indicate poorly leached deposits in this area. The northern two thirds of this section indicates slight leaching of surface deposits (the higher dissolved-solids water collecting and moving above the bedrock surface).

Water quality along the western end of section C-C' is indicative of irregular leaching. At location (24), bicarbonate type water, common to well-leached till, is found in shallow and intermediate zones. Water from deeper zones and Cambrian sandstone aquifers at the eastern end of the watershed, reflect downward motion of more highly mineralized water resulting from leaching of surficial tills. Softening of water by base exchange occurs in Cretaceous clays (section B-B' and C-C' at locations (13), (17a), and (30)).



ESTIMATES OF GROUND-WATER QUALITY PARAMETERS CAN BE OBTAINED BY MEASURING SPECIFIC CONDUCTANCE OF THE WATER.

Logarithmic relations between specific conductance and dissolved solids, and dissolved solids and hardness, make it possible to estimate dissolved solids by measuring specific conductance of water from wells. Hardness may be approximated by using the estimated dissolved solids and assuming that hardness taken from the graph represents a maximum hardness. This number could be smaller due to softening by cation exchange in any of the geologic units.

TABULATIONS OF INDIVIDUAL CHEMICAL CONSTITUENTS FOUND IN WATER FROM GEOLOGIC UNITS AID IN DETERMINING SUITABILITY OF GROUND WATER FOR VARIOUS USES.

Water from all formations present in the east contain less dissolved solids than water in the same formation in the west. Dissolved solids and major cations and anions are related to the degree of leaching of soluble minerals from glacial and Cretaceous deposits.

Larger concentrations of iron and manganese are associated with reducing environments which maintain soluble concentrations at a pH of 7 and greater. Generally, reducing environments are found in organic deposits buried in glacial and Cretaceous aquifers. Nitrate concentrations greater than 45 mg/l are more frequent in shallow wells affected by infiltration of water through barnyard or feedlot wastes. Boron concentrations are generally greater in deeper wells; however, shallow wells receiving flow from the deeper ground water system also contain larger concentrations of boron in the Cottonwood River watershed. Chlorides are derived from barnyard and feedlot infiltration and solution of minerals from Cretaceous marine deposits. Water containing higher chloride concentrations from Cretaceous deposits is found at depths greater than 75 feet in the area of Sleepy Eye Creek headwaters. Fluoride concentrations are generally less than recommended drinking water limits; however, one well finished in igneous bedrock contained water having a concentration of 2.8 mg/l.

(Analyses by U.S. Geological Survey; samples collected October 2-12, 1968)

Geologic unit		Silica (SiO_2) (mg/l)	Iron Fe (mg/l)	Calcium Ca (mg/l)	Magnesium Mg (mg/l)	Sodium Na (mg/l)	Potassium K (mg/l)	Bicarbonate HCO_3 (mg/l)	Sulfate SO_4 (mg/l)	Chloride Cl (mg/l)	Fluoride F (mg/l)	Nitrate NO_3 (mg/l)	Boron B (mg/l)	Manganese Mn (mg/l)	Dissolved solids (residue at 180° C) (mg/l)	Hardness as $CaCO_3$ (mg/l)	Laboratory pH (std. units)	Color (platinum cobalt units)
Glacial deposits 26 samples	Maximum	34	21	480	130	210	57	634	1400	220	1.0	360	3.0	2.1	2800	1700	8.2	25
	Median	29	1.1	170	58	59	7.5	383	460	9.2	.3	13	.33	.14	981	690	7.6	5
	Minimum	9.9	.02	66	12	3.8	1.0	202	21	1.0	.2	1.3	.02	.00	404	250	7.3	1
Cretaceous deposits 4 samples	Maximum	30	.86	120	31	410	8.0	512	930	24	.4	180	1.2	.07	1700	370	8.5	20
	Minimum	7.5	.34	8.8	.0	46	3.0	256	4.0	1.0	.0	4.1	.75	.02	550	22	7.4	5
Cambrian sandstone 4 samples	Maximum	27	1.6	160	56	92	7.4	512	330	5.2	.4	6.2	.22	.08	1600	640	8.1	15
	Minimum	13	.22	72	15	37	2.0	390	11	1.0	.0	.3	.16	.04	410	240	7.4	2
Precambrian crystalline rocks 5 samples	Maximum	39	4.0	440	120	160	13	512	1300	140	2.8	280	3.0	1.5	2700	1500	8.0	15
	Minimum	19	.03	30	12	34	5.3	209	210	1.0	1	2.0	.37	.00	610	120	7.3	2
Recommended drinking water limits (Minnesota Water Pollution Control Commission, 1967)		None	.3	None	None	None	None	None	250	250	1.5	45	None	.05	500	None	None	15

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WATER RESOURCES OF THE COTTONWOOD RIVER WATERSHED, SOUTHWESTERN MINNESOTA

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1973