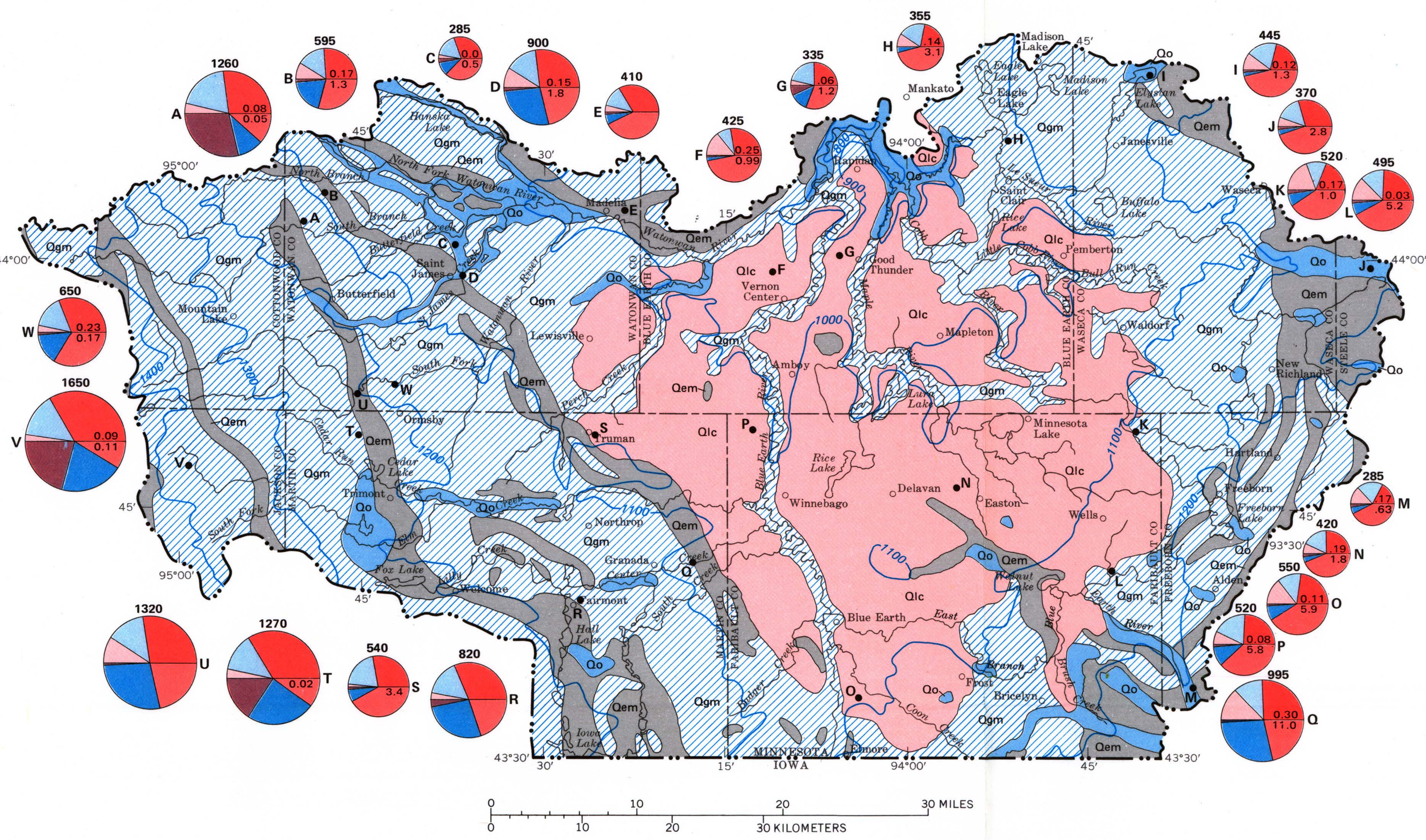
PREPARED IN COOPERATION WITH THE
MINNESOTA DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATERS, SOILS, AND MINERALS

GROUND WATER

GLACIAL DEPOSITS



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. Lenses of sand and gravel buried within the till are the most widely accessible and widely used shallow aquifers. These buried sand and gravel lenses are commonly thin and discontinuous, but generally provide water supplies adequate for private domestic use. In the western part of the watershed, few wells obtain water from bedrock. Eastward, many wells penetrate beneath the glacial deposits to obtain water from bedrock. Locally, water is available from surficial outwash deposits.*

Water movement in the shallow aquifers is perpendicular to water-table contours and is regionally toward the center of the north edge of the watershed at Mankato, similar to the surface-drainage pattern. Ground water enters the watershed primarily as precipitation. Some water also enters the watershed as underflow from the west. Locally, ground water tends to move toward river valleys and to discharge into the rivers. Some water percolates through the glacial deposits into the bedrock aquifers.

Quality of ground water in glacial aquifers changes from heterogeneous bicarbonate sulfate type water in the west to lower dissolved solids bicarbonate type water in the east. Well-leached areas (where many of the soluble minerals have been flushed out of the deposits) in the west contain lower dissolved solids (less than 800 milligrams per liter) bicarbonate type water, and poorly leached areas contain higher dissolved solids, sulfate type water. Water from many wells shows the effects of percolating through barnyards and dissolving large concentrations of nitrate and chloride. The change in water quality in glacial deposits from west to east is related to the low permeability of the underlying Precambrian crystalline bedrock in the west and high permeability of the underlying Cambrian, Ordovician, and Devonian sedimentary bedrock in the eastern part of the watershed.

EXPLANATION

SURFICIAL DEPOSITS

Qo Glacial outwash and alluvium
Mostly shallow surficial sand and gravel deposits. Aquifers are at, or near, land surface. Located along main drainages

Qlc Lake clay
Flat-lying thin clay deposit on top of till

Qgm Ground moraine
Mostly till, an unsorted, unstratified mixture of clay, silt, sand, and gravel. Aquifers are local sand lenses buried at various depths within the till. Ground moraine is generally flatlying and spread throughout the watershed

Qem End moraine
Mostly till with local gravel deposits. Aquifers are sand and gravel lenses generally buried at various depths within the till. The end moraines are elongate ridges of varying height, stretching across the watershed

Contact

800 Water-table contour
Shows altitude of the water table. Contour interval 100 feet: datum is mean sea level

Watershed boundary

Magnesium, Sodium + Potassium, Keyed to map location—A, Chloride + Nitrate; 1260 Dissolved solids (mg/l); Calcium; 0.08 Boron (mg/l); 1 Iron (mg/l); Bicarbonate; Sulfate; CATIONS / ANIONS

Water quality

Chemical analyses represented by the circle diagrams are for wells completed in glacial deposits less than 125 feet deep. Colored parts of the circles represent relative percentages of cations and anions

•A Sampling site

EXPLANATION

BEDROCK

Kr Cretaceous rocks (CRETACEOUS)
Sandstone and shale. Aquifers are thin layers of sandstone concentrated near the base. Range from 25 to 200 feet thick, where present

Dcv Cedar Valley Limestone (DEVONIAN)
Dolomite and dolomitic limestone. Present only as a thin wedge in the southeast corner of the watershed. Water-bearing from fractures and solution cavities

Omdg Maquoketa, Dubuque, and Galena Formations (ORDOVICIAN)
All three formations are limestones or dolomitic limestones, and are water yielding from fractures and solution cavities. Thickness up to 300 feet

Odpg Decorah, Platteville, and Glenwood Formations
The Decorah is a greenish-gray, fissile, fossiliferous shale that contains scattered limestone lenses. Approximate thickness, 80–90 feet.
The Platteville Limestone is dolomite and limestone. Approximate thickness, 35 feet.
The Glenwood is a grayish-green or yellow shale and a basal clayey sandstone. Approximate thickness, 20 feet. These three formations restrict vertical water movement; however, small quantities of water are available from the Decorah and the Platteville

Osp St. Peter Sandstone
Light-yellow or white medium- to fine-grained, massive well-sorted quartz sandstone. Thin clay layer at base retards vertical water movement. Moderate amounts of water available from sandstone. Approximate thickness, 100 feet

Opc Prairie du Chien Group (ORDOVICIAN)
The Shakopee is mainly dolomite, commonly containing chert and a few thin sandstone beds; locally the New Richmond sandstone is at the base.
The Oneota underlies the Shakopee and is mainly dolomite, containing chert locally near the base of the Oneota. Large quantities of water available. The dolomite of the Prairie du Chien and Jordan Sandstone are hydraulically interconnected. Approximate thickness, 250 feet

Cj Jordan Sandstone (CAMBRIAN)
Yellow or white coarse- to medium-grained quartz sandstone, commonly cross-bedded; locally yellow silty fine-grained sandstone. Large amounts of water available. Hydraulically interconnected with Prairie du Chien Group. Approximate thickness, 100 feet

Csfd (Cs, Cf, Cd) St. Lawrence, Franconia Formations and Dresbach Group
The St. Lawrence Formation is silty, sandy dolomite. Generally does not yield water and retards vertical water movement. Approximate thickness, 35 feet.
The Franconia Sandstone is typically green very fine-grained glauconitic quartz sandstones that does not yield water. A thin coarse- to medium-grained sandstone at the base of Franconia (Ironton Sandstone) yields a moderate amount of water. Franconia thickness is generally 100–200 feet. Includes a thin medium- to coarse-grained sandstone at the top.
The Dresbach Group (Galesville Sandstone) which yields moderate amounts of water. Most of the middle 100 to 200 feet of Dresbach Group (Eau Claire Sandstone) is interbedded gray to reddish-brown sandstone, siltstone, and shale and does not yield water. The lower 100 to 300 feet of Dresbach (Mt. Simon Sandstone) is gray to pink, medium- to coarse-grained sandstone, which yields medium to large amounts of water. Dresbach thickness is generally 300–400 feet

pCr Precambrian rocks (PRECAMBRIAN)
Mostly quartzite and granitic crystalline rocks. Very small yields (1–25 gpm) are obtained from fractures in the rock. Locally a buff to reddish coarse-grained sandstone is present at the top and yields moderate amounts of water

Contact, dashed for Cretaceous rocks

A—A′ Line of section

Watershed boundary

Magnesium, Sodium + Potassium, Keyed to map location—T, Chloride + Nitrate, Aquifer, Sulfate; 790 Dissolved solids (mg/l); Calcium; 0.15 Boron (mg/l); 7.1 Iron (mg/l); Bicarbonate; CATIONS / ANIONS

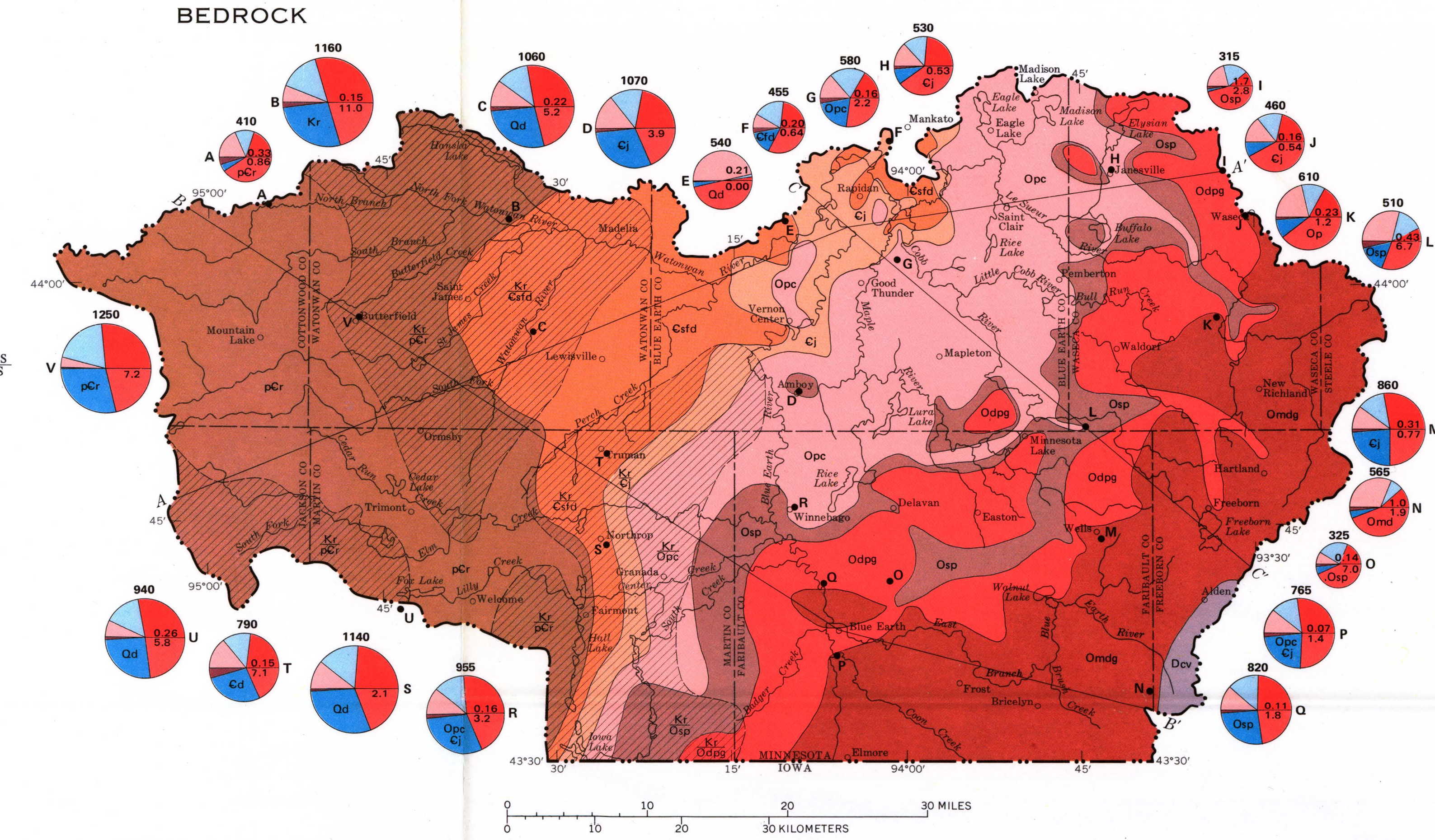
Water quality

Chemical analyses represented by the circle diagrams are for wells completed in bedrock or glacial deposits more than 125 feet deep. Colored parts of the circles represent relative percentages of cations and anions

•T Sampling site

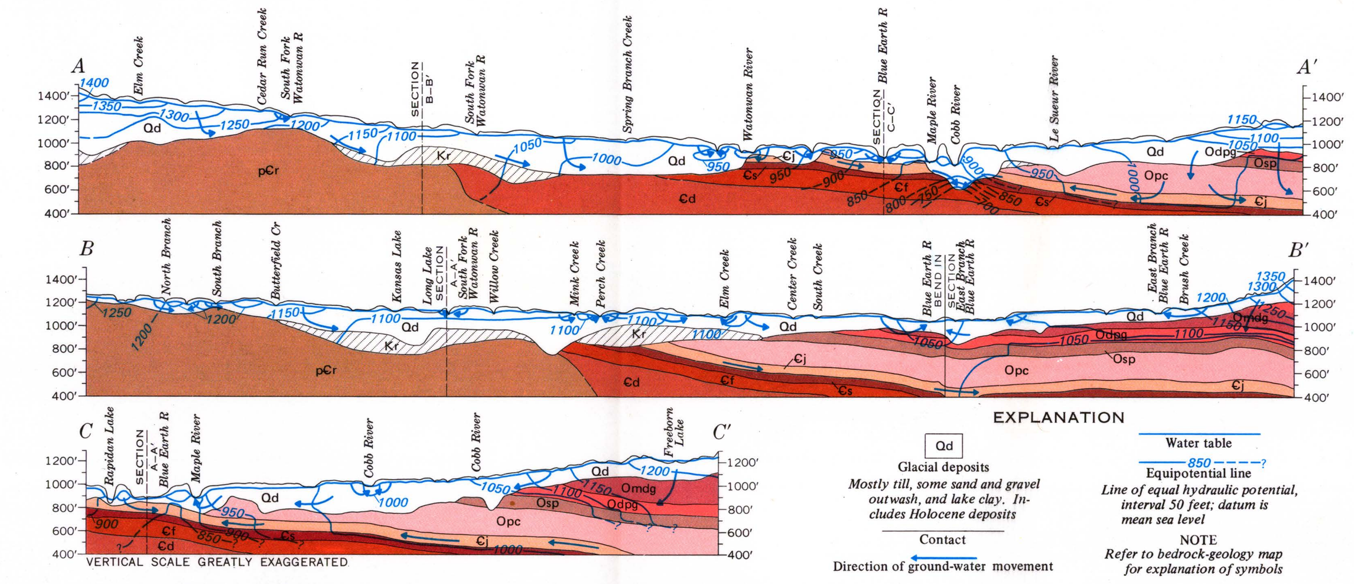
The ground-water system involves the interrelationships of water with thickness, hydrologic characteristics, and areal extent of each geologic unit. The system is dynamic, continually recharging in some places and discharging in others, but always trying to adjust, generally to a minor degree, to changes in climate and activities of man.

BEDROCK

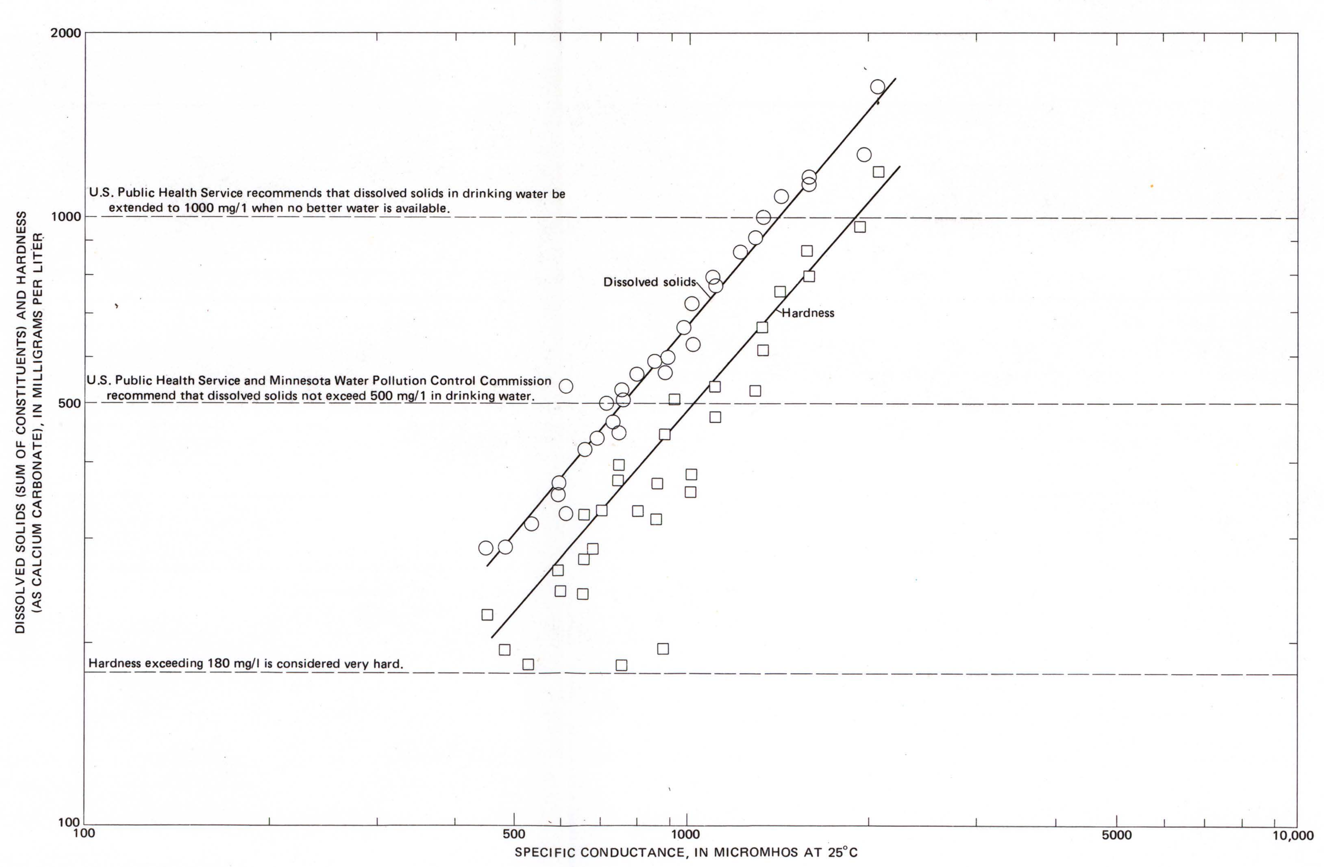


BEDROCK AQUIFERS THAT PROVIDE THE MOST RELIABLE LARGE WATER SUPPLIES ARE THE ST. PETER, JORDAN, AND IRONTON-GALESVILLE, AT THE TOP OF THE DRESBACH GROUP, AND THE MT. SIMON, AT THE BASE OF THE DRESBACH; WATER QUALITY FROM THESE AQUIFERS IMPROVES FROM WEST TO EAST—*Precambrian crystalline rocks are the oldest, then Cambrian and Ordovician sedimentary rocks, and then Devonian limestone. An exception to this progression (from west to east) is scattered patches of Cretaceous sandstone and shale deposited on rocks of various ages. (Several large areas of Cretaceous rocks are outlined.) The Prairie du Chien aquifer has water of good quality in areas where it is buried deeply enough to protect it from contamination. The New Richmond Sandstone, in the Prairie du Chien Group, yields water to many wells in southeastern Blue Earth County. The Cretaceous rocks include sandstone layers, which yield water to several wells in the western part of the watershed; however, most water supplies in the west come from glacial deposits. A particular aquifer may be penetrated anywhere east of the area where it is indicated on the map. The depth to an aquifer can be estimated by adding the thickness of the glacial deposits at the site and the average thickness of bedrock formations. Bedrock formations directly below the glacial deposits are progressively younger from west to east.*

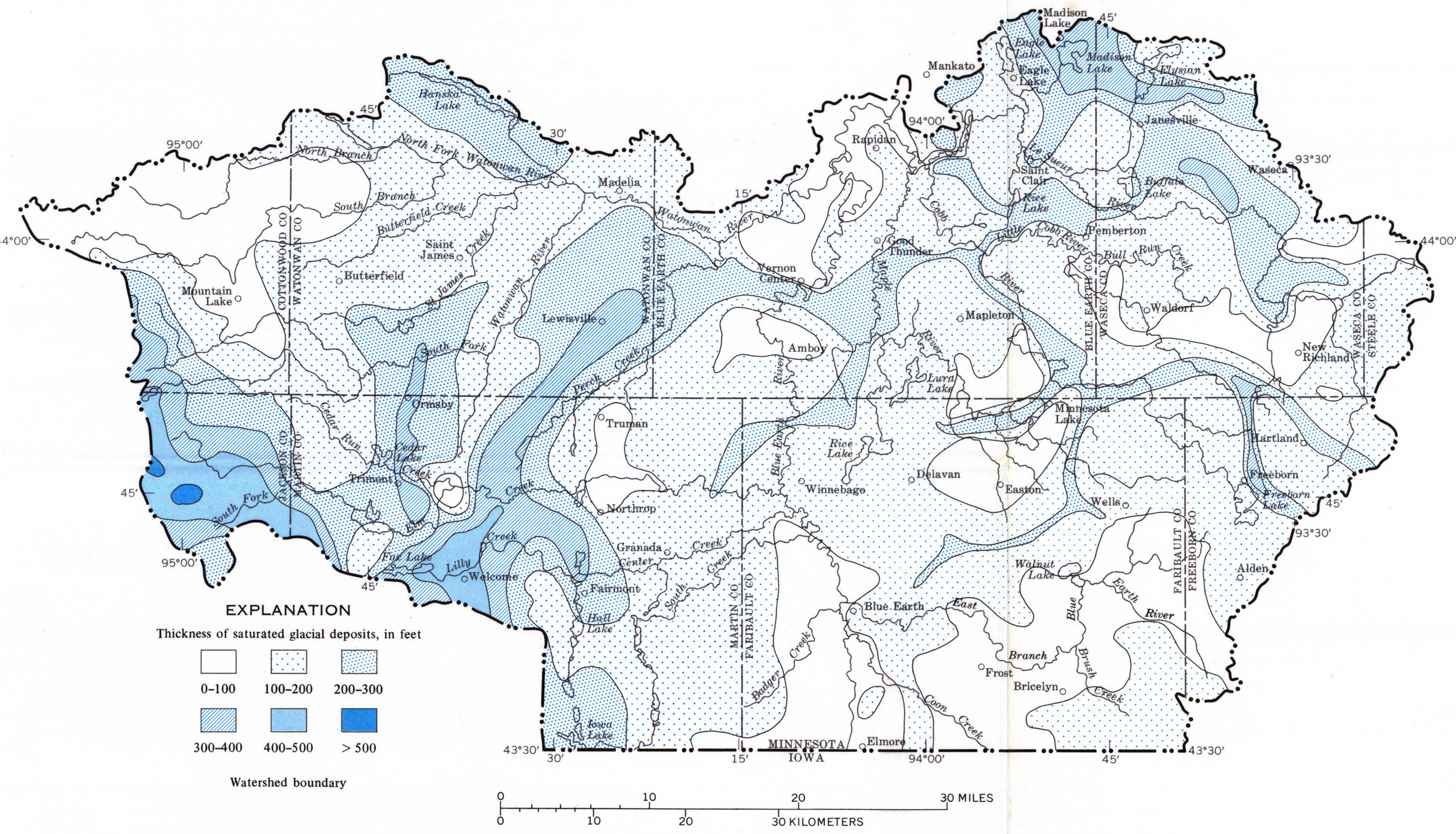
Water quality in bedrock and deep (greater than 125 feet) glacial aquifers is influenced by recharge through surface deposits and by the eastward movement of highly mineralized ground water. West of the Blue Earth River these water supplies are generally of high (more than 800 milligrams per liter) dissolved solids, sulfate type water. In the area east of the Blue Earth River, most water supplies sampled from bedrock are lower (less than 600 milligrams per liter) dissolved solids, bicarbonate type water. However, high dissolved solids, sulfate type water is found at Mapleton, and at Wells, in the Prairie du Chien-Jordan aquifer. All water supplies tested in these areas were very hard (hardness exceeding 180 milligrams per liter calcium carbonate); temporary hardness is dominant in the east, whereas permanent and temporary hardness are generally equivalent in the west. Boron concentrations in bedrock water supplies are generally greater than 0.15 milligrams per liter. High boron concentrations are effected by release of boron from decay of organic material and from Cretaceous marine sediments. High iron concentrations are characteristic of the watershed and result from leaching of iron by reducing potentials related to decay of organic material.



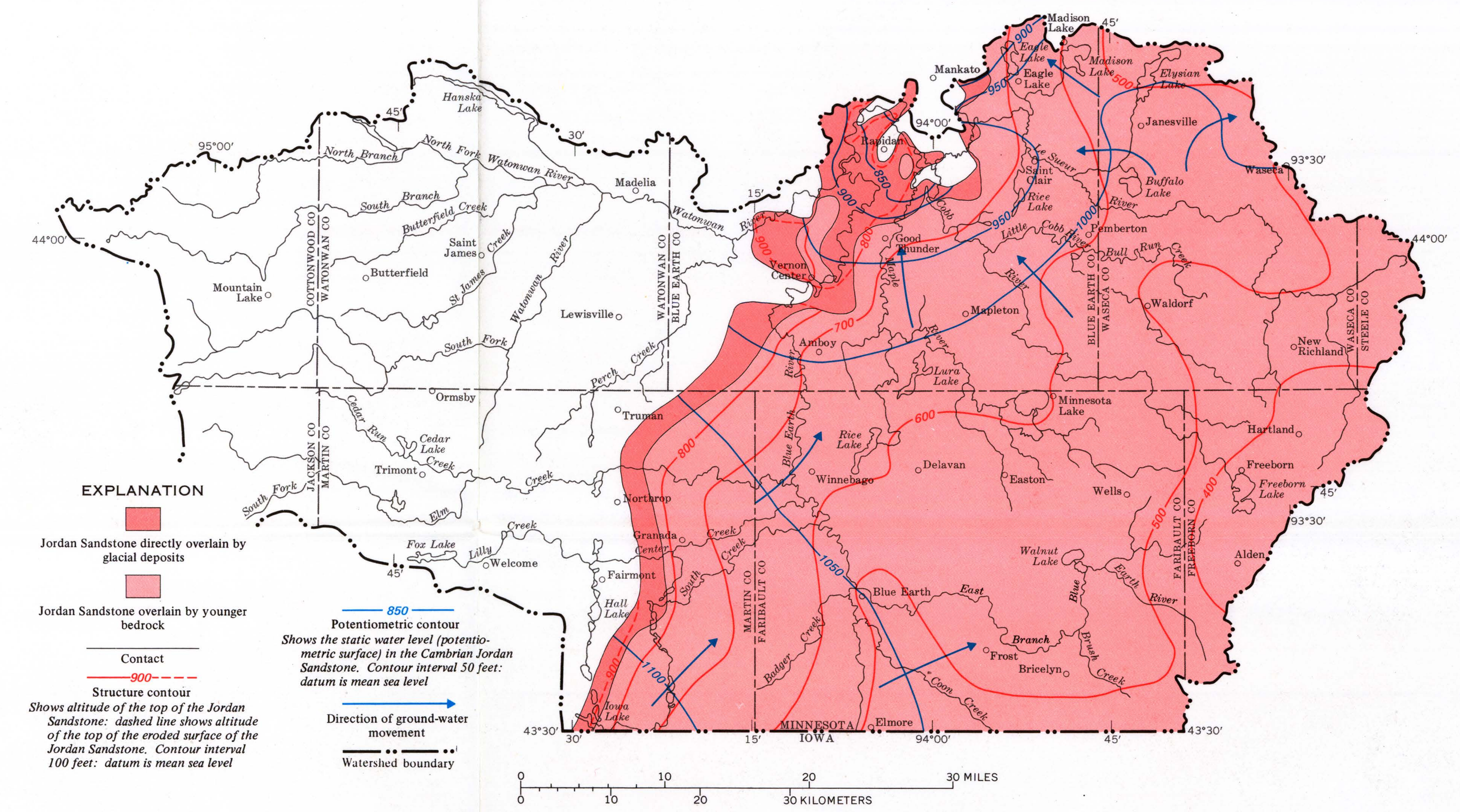
GROUND-WATER MOVES ALONG SECTION A-A′ TOWARD A BURIED VALLEY BELOW THE MAPLE AND COBB RIVERS AND DRAINS INTO THE MINNESOTA RIVER VALLEY AT MANKATO; ALONG SECTIONS B-B′ AND C-C′ GROUND-WATER MOVEMENT IS TOWARD THE BLUE EARTH RIVER.—*Regional ground-water flow patterns were determined by contouring hydraulic potential on vertical sections drawn perpendicular to the water-table contours. In the higher areas, at the ends of the sections, ground-water movement is downward, reflecting recharge by precipitation through the glacial deposits. In Section A-A′, a ground-water divide is located between the Blue Earth River watershed boundary and the Le Sueur River, so that some water moves eastward into the Cannon River watershed. Near the east end of Section B-B′ water percolates downward into the St. Peter Sandstone and deeper aquifers (the Prairie du Chien-Jordan and the Ironton-Galesville) and then moves southward into Iowa. Below Freeborn Lake (Section C-C′) water moves downward into the St. Peter Sandstone and the Jordan Sandstone and then moves up-dip toward the Blue Earth River valley, where it moves northward.*



ESTIMATES OF DISSOLVED SOLIDS AND HARDNESS OF GROUND WATER MAY BE MADE BY MEASURING SPECIFIC CONDUCTANCE.—*A specific conductance of 1,000 micromhos in ground water from the Blue Earth watershed contains about 680 mg/l dissolved solids and has a hardness of about 480 mg/l. Points displaced from the hardness line represent softening, which occurs in clay beds in glacial deposits and Cretaceous rocks.*

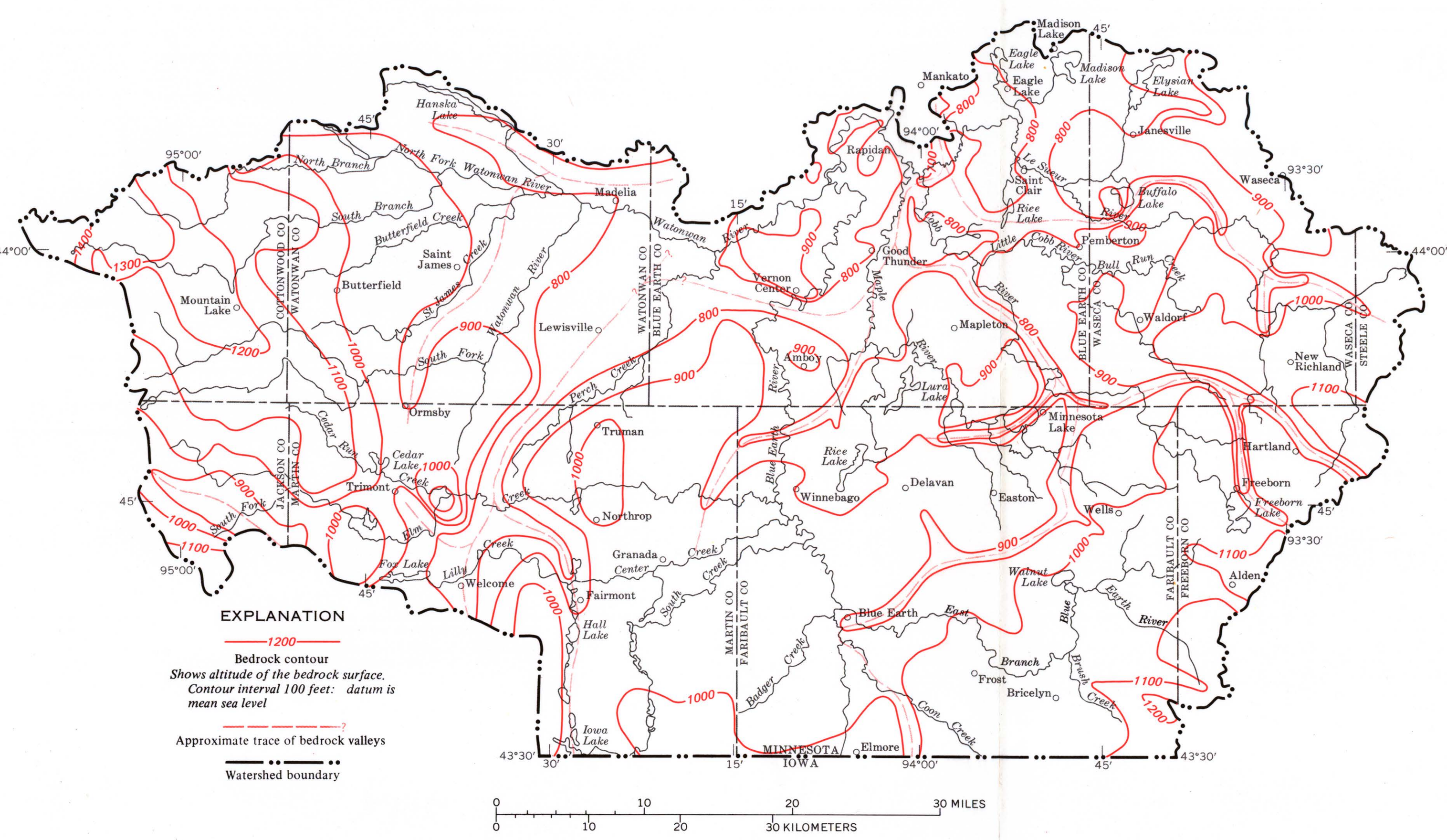


SATURATED THICKNESS OF GLACIAL DEPOSITS RANGES FROM LESS THAN 100 FEET TO GREATER THAN 500 FEET.—*The greater the saturated thickness, the greater is the likelihood of a well penetrating a water-yielding sand lens and obtaining a water supply. Only a part of the available ground water has been developed, and no areas of significant ground-water decline are known. However, because ground-water availability differs locally, detailed studies will be needed to guide resource development efficiently, especially where large supplies are needed.*



THE JORDAN SANDSTONE DIPS TOWARD THE EAST AND SOUTHEAST; WHEREAS, WATER MOVEMENT IN THE JORDAN IS FROM THE SOUTHWEST NORTHWARD TOWARD MANKATO, WHERE WATER DISCHARGES INTO THE BLUE EARTH AND MINNESOTA RIVER VALLEYS.—*The structure of the Jordan Sandstone is characteristic of the general structure of other Cambrian and Ordovician sedimentary rocks. Near Mankato, the Jordan is at the surface; it dips to more than 900 feet below land surface near Freeborn Lake in the southeast. The depth to the Jordan can be estimated by subtracting the altitude of the Jordan surface, indicated on the map, from the land-surface altitude at the point of interest.*

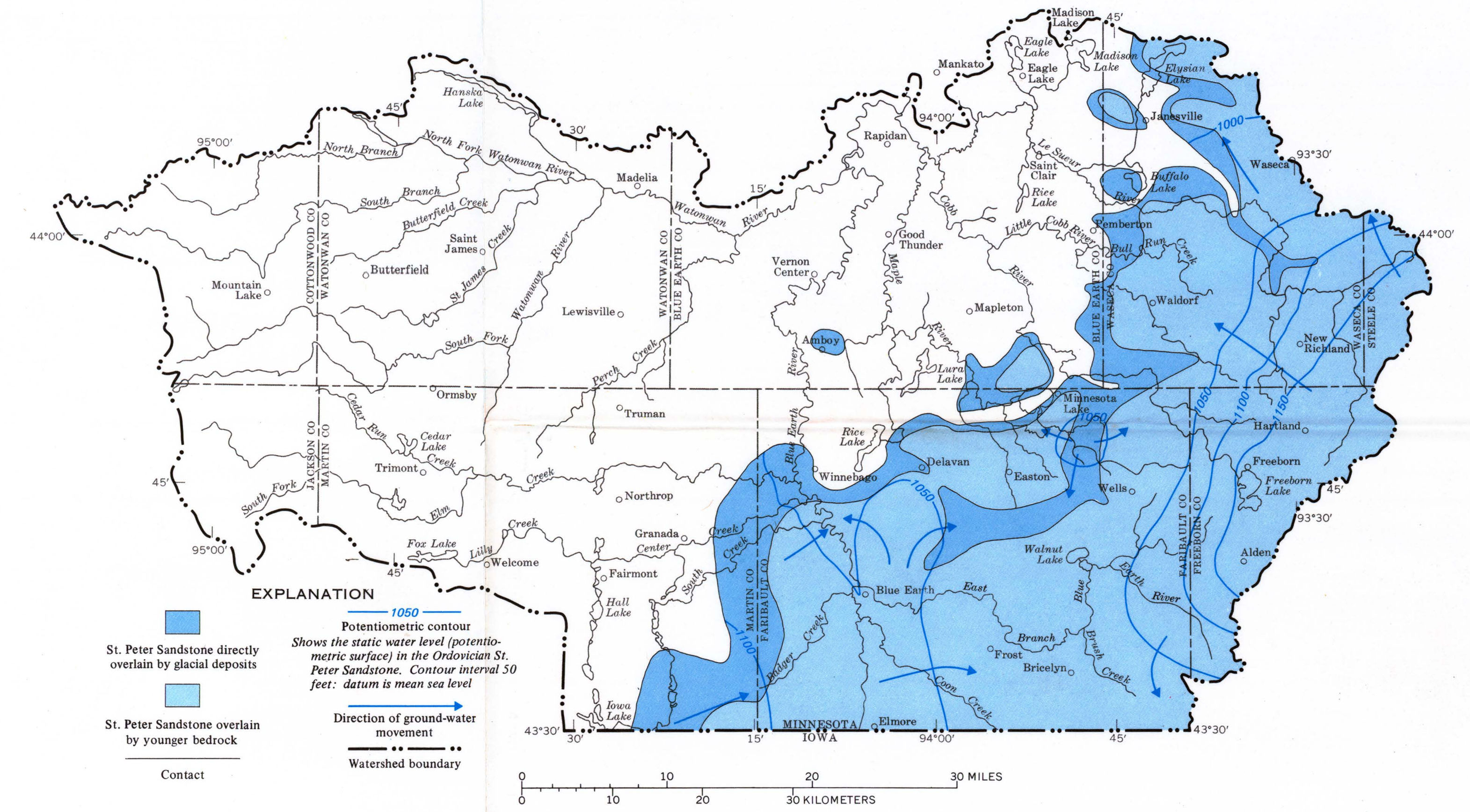
Water in the Jordan aquifer moves into the area from the southwest, and the aquifer is recharged locally by downward leakage of water through overlying formations, primarily in the southern and eastern part of the watershed. A ground-water divide separates Jordan drainage in Waseca County; the eastern part drains eastward into the Cannon River watershed, and the western part drains toward Mankato. The divide is not well defined south of Waseca County, but may extend southwestward below the bedrock valley between the towns of Minnesota Lake and Wells. East of the divide, water moves eastward into the Cedar River watershed and southeastward into Iowa. In the area from the 1,000-foot potentiometric contour to Mankato, artesian pressure is sufficient, locally, to supply flowing artesian wells in stream valleys and to result in upward discharge of water to streams.



BURIED BEDROCK VALLEYS, THOUGH POORLY DEFINED BY PRESENT DATA, SUGGEST PROMISING AREAS FOR EXPLORATION FOR WATER-BEARING BEDS OF SAND AND GRAVEL.—*Buried valleys in the bedrock surface follow drainage patterns that reflect preglacial drainage patterns that were later altered by glacial melt water. These valleys were filled by glacial deposits, including sand and gravel, during subsequent advances.*

AQUIFER AND WATER QUALITY DATA FROM MUNICIPAL WELLS

Aquifer	Approximate thickness (feet)	Number of towns using aquifer	Number of municipal wells in aquifer	Well depth (feet) Range	Well depth (feet) Average	Usual pumping rate (gpm) Range	Usual pumping rate (gpm) Average	Specific capacity (gpm/ft) Range	Specific capacity (gpm/ft) Average	Iron (mg/1) Range	Iron (mg/1) Median	Chloride (mg/1) Range	Chloride (mg/1) Median	Sulfate (mg/1) Range	Sulfate (mg/1) Median	Hardness as $CaCO_3$ (mg/1) Range	Hardness as $CaCO_3$ (mg/1) Median	Dissolved solids, residue (mg/1) Range	Dissolved solids, residue (mg/1) Median
Glacial sand and gravel	20	10	20	40–385	143	50–700	276	5–22	15	0.06–3.6	1.8	0.0–27	2.8	89–800	450	460–790	680	578–1,570	1,180
Cretaceous sandstone	11	1	2	------	180	------	150	------	11	1.8	-----	2.8	-----	885	-----	1,080	-----	1,570	-----
Galena and overlying limestones	300	4	7	124–400	255	160–280	210	8–40	19	0.6–2.2	1.2	0.0–2.5	.5	38–150	76	200–350	290	431–667	480
Plattville Limestone	35	2	2	140–354	247	35–225	130	------	7.5	1.5–5.0	3.2	< 1–5.0	3.0	27–49	38	320–350	340	470–500	485
St. Peter Sandstone	100	6	8	200–638	422	100–300	209	1.2–10	3.3	0.56–3.2	2.5	1.0–3.4	2.5	64–300	130	340–600	400	417–880	578
Prairie du Chien Group	250	6	8	224–473	323	44–500	167	2.5–5.6	4.0	1.8–9.5	2.8	0.0–8.0	1.4	70–440	79	220–630	370	444–967	498
Jordan Sandstone	100	9	16	399–750	542	65–1,400	618	13–62	37	0.72–5.3	2.2	0.0–5.2	1.2	23–510	200	300–630	490	376–1,100	712
Cambrian formations older than Jordan Sandstone	600	7	12	295–1,100	583	100–1,000	556	2.7–33	14	1.6–8.2	3.0	0.5–4.3	2.4	120–390	260	370–690	500	530–940	811
Precambrian crystalline rocks	------	2	5	380–400	390	22–135	90	0.2–0.9	0.6	0.35–1.5	.92	1.0–4.3	2.6	510–1,100	800	930–1,300	1,100	1,100–1,940	1,520



WATER MOVEMENT WITHIN THE ST. PETER AQUIFER IS AWAY FROM THE GROUND-WATER DIVIDE AND DOWNWARD INTO THE UNDERLYING PRAIRIE DU CHIEN-JORDAN AQUIFER AND THE IRONTON-GALESVILLE AQUIFER.—*Recharge comes from downward leakage from glacial deposits and other overlying formations, especially in the southwestern and eastern parts of the aquifer. The area of high potential between the towns of Wells and Minnesota Lake, indicated by the 1,050-foot potentiometric contour, is caused by infiltration from the Maple River, where it crosses the buried bedrock valley, which is cut into the St. Peter Sandstone. This may indicate the position of the ground-water divide. Southeast of the divide, water moves into Iowa and the Cedar River watershed. North of the divide, water moves northwestward and percolates downward into the underlying formations.*

Base from U.S. Geological Survey
1:250,000: Mason City and Fairmont 1954;
New Ulm and St. Paul 1953

INTERIOR—GEOLOGICAL SURVEY, WASHINGTON, D.C.—1974—W73278

WATER RESOURCES OF THE BLUE EARTH RIVER WATERSHED, SOUTH-CENTRAL MINNESOTA

By
H. W. Anderson, Jr., D. F. Farrell, and W. L. Broussard
1974