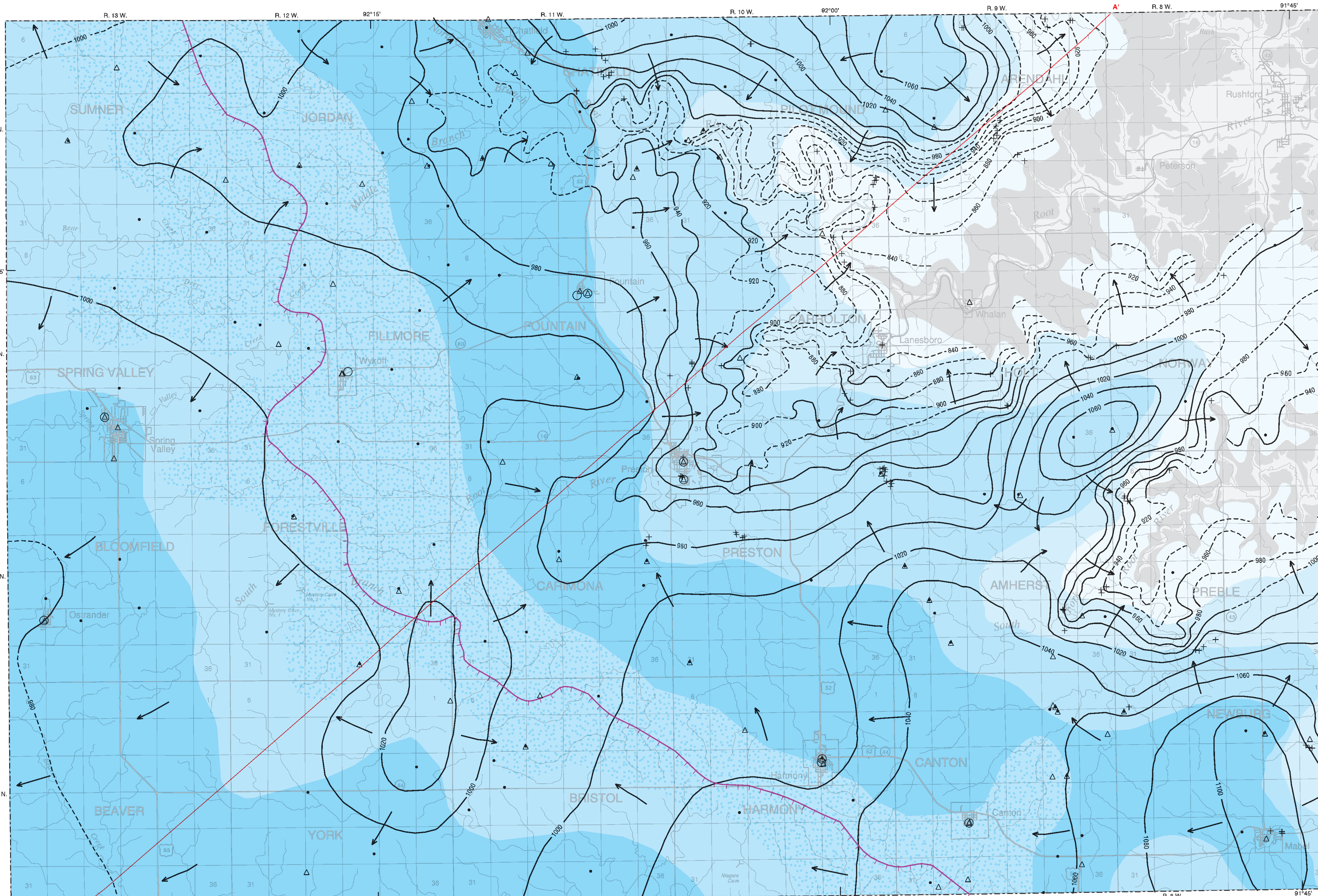
STATE OF MINNESOTA
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF WATERS

Prepared and Published with the Support of
THE MINNESOTA ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

COUNTY ATLAS SERIES
ATLAS C-8, PART B
Plate 6 — Bedrock Hydrogeology



Digital base modified from 1990 Census TIGER/Line Files of the U.S. Bureau of the Census (source scale 1:100,000); digital base annotation by the Minnesota Geological Survey.

Universal Transverse Mercator projection, grid zone 15, 1927 North American Datum. Vertical datum is mean sea level. Compiled 1994.

SCALE 1:100 000

1 0 1 2 3 4 5 6 MILES

1 0 1 2 3 4 5 6 KILOMETERS

Partial funding for this project approved by the Minnesota Legislature M.L. 91, Ch. 254, Art. 1, Sec. 14, Subd. 4(f) and M.L. 93, Ch. 172, Sec. 14, Subd. 11(g) as recommended by the Legislative Commission on Minnesota Resources from the Minnesota Environment and Natural Resources Trust Fund. Base funding established by the 1989 Groundwater Protection Act, M.L. 89, c. 326, art. 10, sec. 1, subd. 6, item a. and b.

ST. PETER–PRAIRIE DU CHIEN–JORDAN AQUIFER POTENTIOMETRIC SURFACE AND YIELD

EXPLANATION

1000

Potentiometric contour—Dashed where inferred, dotted where uncertain. Contour interval 20 feet unless otherwise noted.

Boundary between confined and unconfined conditions—Hachures toward confined conditions.

General direction of ground-water movement

Well measured for water level

Well sampled for water chemistry (*see Part C*)

Spring

Well used for yield data

Aquifer, mostly dewatered

No aquifer

0 - 200	200 - 500	500 - 1000	1000 - 1500

Potential yields in gallons per minute (gpm). Patterned area indicates estimated potential yields of approximately 500 to 1000 gpm.

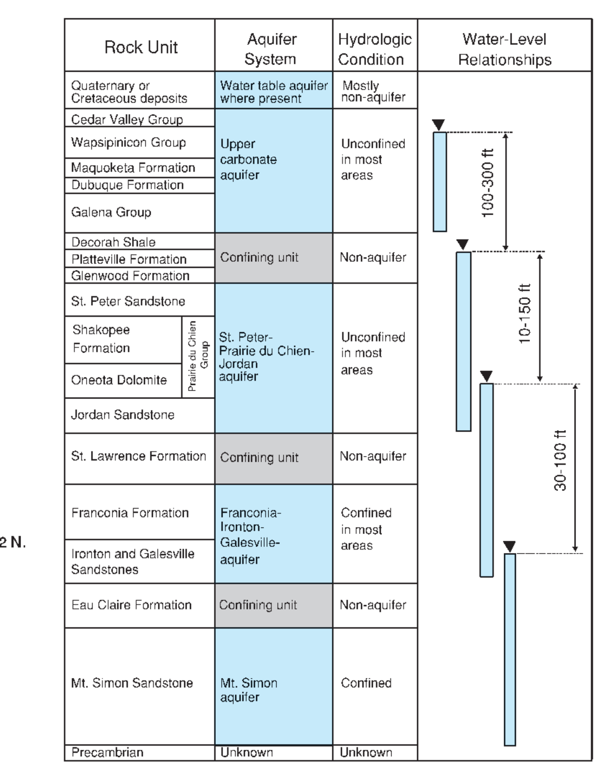


FIGURE 1. *Sequence of aquifers and water-level relationships in Fillmore County.*

BEDROCK HYDROGEOLOGY

By
Hua Zhang[1] and Roman Kanivetsky[2]
[1]Minnesota Department of Natural Resources, [2]Minnesota Geological Survey
1996

INTRODUCTION

In Fillmore County, ground water is the primary water source for domestic, agricultural, and industrial needs. Most of the 2100 identified wells pump water from one or more of the county's three major aquifers: the informally named upper carbonate, the St. Peter-Prairie du Chien-Jordan, and the Franconia-Ironton-Galesville. Above the upper carbonate aquifer, Quaternary and Cretaceous sediments are either absent or too thin to yield significant amounts of water. Beneath the Franconia-Ironton-Galesville aquifer is the Mt. Simon aquifer. It is not used extensively at the present time because of the high cost of drilling and pumping. This plate shows the potentiometric surface and ground-water flow directions of the three major aquifers. Estimated potential yields of the St. Peter-Prairie du Chien-Jordan aquifer are also indicated. Analytical results for water samples from 104 wells are discussed in the Ground-Water Chemistry section of *Part C*.

UPPER CARBONATE AQUIFER

Underlying the southwest half of Fillmore County, the upper carbonate aquifer is composed of about 400 feet of limestones, dolostones and shales of the Cedar Valley Group, Wapsipinicon Group, Maquoketa Formation, Dubuque Formation, and Galena Group (Plate 2 in Part A). These rock units appear to be hydraulically connected, although the Pinicon Ridge Formation of the Wapsipinicon Group and the Dubuque Formation may function as confining units in some areas owing to their fine-grained or shaly textures. Most wells pump water from the Spillville Formation of the Wapsipinicon Group or from the Galena Group.

Most upper carbonate rocks exhibit karst features such as sinkholes, sinking streams and underground rivers. In contrast to the relatively predictable flow patterns in sand and gravel or sandstone aquifers, ground-water flow in the upper carbonate aquifer is complicated and controlled mainly by underground conduit systems in karsted rocks (Plate 9 and *Part C*). Ground water in the upper carbonate aquifer generally flows toward the Root River or underground river systems. In the southern part of the county, ground water flows south to the Upper Iowa River.

At one time, the upper carbonate aquifer was used extensively for domestic and farm water supplies. Increasing problems with contaminants such as nitrate have resulted in drilling restrictions on new wells and the abandoning and sealing of many upper carbonate wells.

DECORAH-PLATTEVILLE-GLENWOOD CONFINING UNIT

The Decorah-Platteville-Glenwood confining unit consists of about 75 feet of shales and limestones of the Decorah Shale and the Platteville and Glenwood Formations (Plate 2 in Part A). Although the karsted limestone of the Platteville Formation can yield some water to wells, the three units together generally function as a confining unit, hydraulically separating the upper carbonate aquifer from the underlying St. Peter-Prairie du Chien-Jordan aquifer. Erosion has removed the confining unit in the northeastern half of the county. Water elevations measured in St. Peter-Prairie du Chien-Jordan aquifer wells can be as much as 300 feet lower than water elevations in upper carbonate aquifer wells (Figure 1), except near the eroded edge of the confining unit where these water elevation differences are much less. Some downward leakage through this confining unit may occur locally, decreasing the water elevation differences between the two aquifers.

ST. PETER-PRAIRIE DU CHIEN-JORDAN AQUIFER

The St. Peter-Prairie du Chien-Jordan aquifer is the most heavily used of the three major aquifers in Fillmore County; more than 60 percent of all wells in the county pump water from this aquifer. The upper part of the aquifer consists of about 80 feet of St. Peter Sandstone. Beneath it is about 280 feet of dolostone and some sandstone of the Prairie du Chien Group. The lower part, about 80 feet thick, is the Jordan Sandstone (Plate 2 in Part A). The three rock units appear to be hydraulically connected, with little (generally about 5 feet or less) difference in hydraulic head. However, Runkel (1996) indicates that their hydrologic relationship may be more complicated than previously assumed. The aquifer underlies most of the county, except parts of northeastern Fillmore County where it has been removed by erosion or is mostly dewatered. As shown in Figure 2, the western part of the aquifer is deeper and confined, while the eastern part is near or at the land surface and unconfined. The boundary between the confined and unconfined areas of the aquifer extends northwest to southeast near the towns of Washington, Wykoff, and Harmony and is two to six miles west of the Glenwood Formation-St. Peter Sandstone contact. In this area, the aquifer is partially dewatered beneath the Decorah-Platteville-Glenwood confining unit.

In the northeastern part of the county where the aquifer is unconfined, it generally discharges to the Root River. West of a ground-water divide extending northwest to southeast near Washington, Wykoff and Granger, ground water flows west, whereas east of the divide the ground water flows east.

In the northeastern half of the county, karst features are developed in Prairie du Chien Group rocks exposed at the land surface. Solution-widened channels appear to be common, but water movement through the conduits in these rocks is generally more complex than in the upper carbonate aquifer (Plate 9 and *Part C*). Scattered sinkholes can be found throughout areas of thin surficial deposits (Plate 8).

Potential yields of the St. Peter-Prairie du Chien-Jordan aquifer vary from less than 200 gpm to as much as 1500 gpm. Higher-yield zones occur where the aquifer is deep and confined, where there is abundant recharge from surface sources, or where large conduit flow systems have developed in the karsted rocks of the aquifer, such as the conduit flow system providing water to the springs at the Lanesboro Fish Hatchery.

ST. LAWRENCE CONFINING UNIT

The St. Lawrence Formation consists of dolomitic siltstone or silty dolostone with a maximum thickness of 130 feet. This confining unit occurs throughout the county except the Root River and the South Fork Root River valleys in northeastern Fillmore County where it has been partially or completely removed by erosion. As indicated in Figure 1, water levels measured in the underlying Franconia-Ironton-Galesville aquifer can be as much as 150 feet lower than in the St. Peter-Prairie du Chien-Jordan aquifer.

FRANCONIA-IRONTON-GALESVILLE AQUIFER

The Franconia-Ironton-Galesville aquifer underlies the entire county (Plate 2 in Part A), except a small area in the Root River valley near Rushford where it has been removed by erosion. The upper part consists of about 150 feet sandstone and siltstone of the Franconia Formation. Beneath the Franconia Formation is about 55 feet of Ironton Sandstone. The lower part is about 70 feet of Galesville Sandstone. These three rock units appear to be hydraulically connected although the thin shaly Tomah Member of the Franconia Formation may act somewhat as a confining unit. In the northeastern part of the county the aquifer is an important ground-water source, but in the western part of the county the aquifer is too deep to be used for water supplies at this time.

Direction of ground-water flow in the Franconia-Ironton-Galesville aquifer is similar to that of the overlying St. Peter-Prairie du Chien-Jordan aquifer. In the eastern part of the county, the aquifer generally discharges to the Root River. Sparse data (Delin and Woodward, 1984) suggests a ground water divide in the western part of Fillmore County; west of the divide ground water will flow southwest.

REFERENCES

Broussard, W.L., Farrell, D.F., Anderson, H.W., Jr., and Felsheim, P.E., 1975, Water resources of the Root River watershed, southeastern Minnesota: U.S. Geological Survey Hydrologic Investigations Atlas HA-548, 3 pls.

Cooper, H.H., Jr., and Jacob, C.E., 1946, A generalized graphical method for evaluating formation constants and summarizing well-field history: American Geophysical Union Transactions, v. 27, no. 4, p. 527.

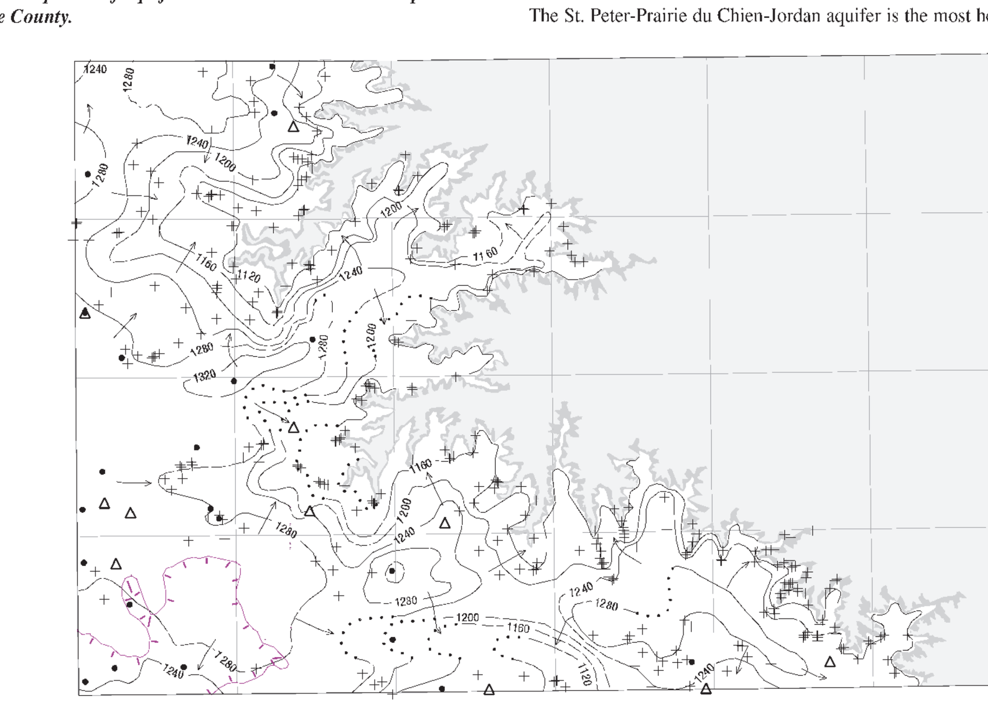
Delin, G.N., and Woodward, D.G., 1984, Hydrogeological setting and the potentiometric surfaces of regional aquifers in the Hollandale embayment, southeastern Minnesota, 1970–1980: U.S. Geological Survey Water-Supply Paper 2219, p. 43.

Farrell, D.F., Broussard, W.L., Anderson, H.W., Jr., and Hult, M.F., 1975, Water resources of the Cedar River watershed, southeastern Minnesota: U.S. Geological Survey Hydrologic Investigations Atlas HA-552, 3 pls.

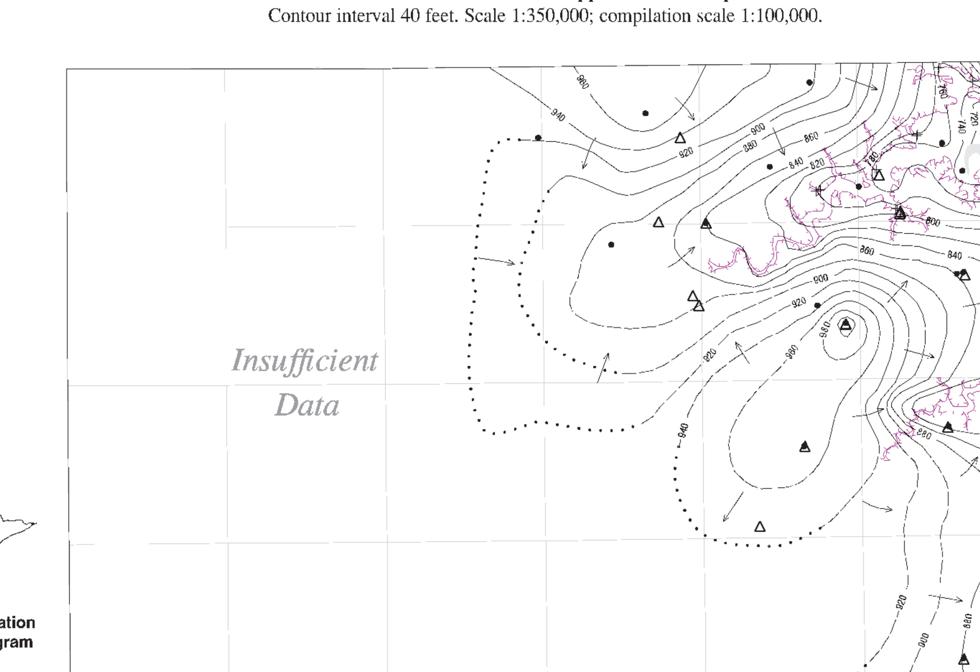
Jacob, C.E., 1944, Notes on determining permeability by pumping tests under water-table conditions, U.S. Geological Survey Open-File Report, p. 4.

Reeder, H.O., 1972, Availability of ground water for irrigation from glacial outwash in the Perham area, Otter Tail County, Minnesota: U.S. Geological Survey Water-Supply Paper 2003, p. 27, 30.

Runkel, A.C., 1996, Geologic investigations applicable to ground-water management, Rochester metropolitan area, Minnesota: Minnesota Geological Survey Open-File Report 96-1, p. 15.



Potentiometric surface of the upper carbonate aquifer
Contour interval 40 feet. Scale 1:350,000; compilation scale 1:100,000.



Potentiometric surface of the Franconia-Ironton-Galesville aquifer
Scale 1:350,000; compilation scale 1:100,000.

The DNR Information Center
Twin Cities: (612) 296-6157
MN Toll Free: 1-800-766-6000
Telecommunication Device for the Deaf:
(612) 296-5484
MN Toll Free: 1-800-657-3929

This information is available in an alternative format upon request.

This map was compiled and generated using geographic information system technology. Digital cartography and design by DNR staff, base by the Minnesota Geological Survey, and digital layout by the Land Management Information Center. Digital data products are available from the Land Management Information Center, Minnesota Planning Office, St. Paul.

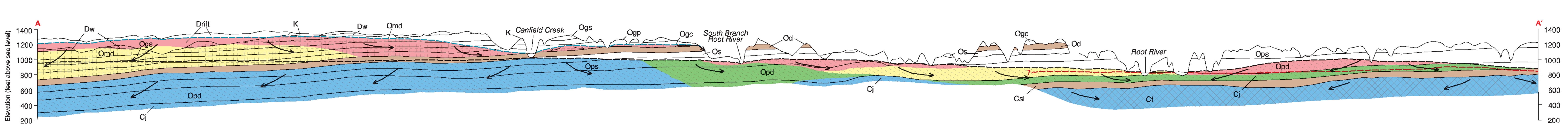


FIGURE 2. *Hydrogeologic cross section A–A'. The potentiometric surface of the upper carbonate aquifer is indicated by the dashed blue line. The potentiometric surface of the St. Peter-Prairie du Chien-Jordan aquifer is indicated by the dashed black line. The potentiometric surface of the Franconia-Ironton-Galesville aquifer is indicated by the dashed red line. Regionally, water moves downward very slowly through the confining units. Rock unit designators (Dw, Opd, etc.) are identified and described on Plate 2 in Part A. Vertical exaggeration x 10.*

Upper carbonate aquifer
St. Peter-Prairie du Chien-Jordan aquifer
Franconia-Ironton-Galesville aquifer
Confining unit

The color overlay shows the distribution of recent, mixed, and vintage waters in the three aquifers. Recent waters have entered the subsurface since about 1953. Mixed waters are probably a mixture of recent and vintage waters. Vintage waters entered the ground prior to 1953, but can be much older. Thanks to Dr. E. Calvin Alexander, Jr., University of Minnesota, for providing the travel-time interpretation for this figure.

Recent waters with tritium greater than ten tritium units and evidence of modern pollutants.
Recent waters with tritium greater than ten tritium units and little or no evidence of modern pollutants.
Mixed waters with tritium less than ten but greater than one tritium.
Vintage waters with tritium less than one tritium unit.

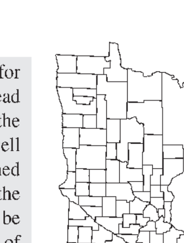
Potentiometric Surface and Potential Yield

The potentiometric surface of an aquifer represents the elevation to which water will rise in wells open to the aquifer. Where no confining layer overlies an aquifer, the aquifer is unconfined. A confined aquifer is overlain by a confining layer and is fully saturated. The potentiometric surface contours represent lines of equal hydraulic head or potential. Water in an aquifer will move from higher to lower potential; arrows perpendicular to the contours and pointing toward lower potential indicate general flow direction.

Water levels in 173 wells in Fillmore County and surrounding areas were measured several times from 1992 to 1993 by Minnesota Department of Natural Resources staff. The seasonal fluctuation of water levels in the aquifers was evaluated by measuring wells in both the spring and late fall of the same year. These data were supplemented with additional information, such as the locations and elevations of major resurgent springs, dye tracing results (see Plate 9), surface topography, and U.S. Geological Survey hydrologic atlases for the area (Farrell and others, 1975; Broussard and others, 1975).

The upper carbonate aquifer is under water-table conditions in most of the county except a small area in the southwest where it is confined. The St. Peter-Prairie du Chien-Jordan aquifer is unconfined in the eastern two-thirds of the county and is confined in the western one-third. Near the Glenwood Formation-St. Peter Sandstone contact the aquifer is partially dewatered and unconfined even though overlain by the Decorah-Platteville-Glenwood confining unit. The Franconia-Ironton-Galesville aquifer is mostly confined, except in limited areas in the eastern part of the county where erosion has removed the St. Lawrence confining unit.

The potential yield of an aquifer is the maximum withdrawal rate an aquifer can sustain without unacceptable changes in storage, water quality, or flow patterns. Estimated potential yields were calculated for both the confined and unconfined portions of the St. Peter-Prairie du Chien-Jordan aquifer. Potential yields for the upper carbonate and Franconia-Ironton-Galesville aquifers were not prepared due to insufficient data. The modified nonequilibrium Jacob equation (Cooper and Jacob, 1946) was used to estimate potential yields of the St. Peter-Prairie du Chien-Jordan aquifer. The distribution of aquifer transmissivity was obtained by multiplying the mean hydraulic conductivity by the aquifer saturated thickness. A mean hydraulic conductivity of 50 gallons/day/foot^2 was estimated from local municipal well pumping tests. The saturated thickness of the unconfined part of the aquifer was obtained by subtracting the elevation of the bottom of the aquifer from the potentiometric surface of the aquifer. The saturated thickness of the confined portion of the aquifer was the thickness of the aquifer (average, 450 feet). The available drawdown (0-200 feet) for the unconfined part of the aquifer was assumed to be two thirds of the saturated thickness (0-450 feet) and was corrected (Jacob, 1944; Reeder, 1972) to account for dewatering during pumping. Available drawdown for the confined portion of the aquifer was the head above the top of the aquifer (0-150 ft). The calculations assumed storage coefficients of 0.005 for the unconfined and 0.0005 for the confined portions of the aquifer, continous pumping for 30 days, and a well diameter of 12 inches. To avoid a discontinuity of estimated yields between the unconfined and confined portions of the aquifer, a 3- to 6-mile wide buffer zone was defined; estimated potential yields along the confined-unconfined boundary are 500 to 1000 gpm. The estimated potential yields shown must be regarded as providing county-scale trends and relative differences in water-yielding capacity. Because of local variations in hydrologic conditions, aquifer yield at a specific site must be determined by test pumping.



Location Diagram

GEOLOGIC ATLAS OF FILLMORE COUNTY, MINNESOTA