Minnesota Department of Natural Resources
County Atlas Program
mndnr.gov/groundwatermapping

Hydrogeologic Cross Sections

By James A. Berg and J. Wes Rutelonis

2019

Groundwater Atlas of Washington County
County Atlas Series C-39, Part B
Plate 8 of 9
Hydrogeologic Cross Sections
A–A′ through G–G′

To accompany atlas Report and Plate 7 and Plate 9.

Northern cross sections A–A′, B–B′, C–C′, and D–D′

See Report Figure 4 for associated geologic units.

On the western side of the county the downward migration of recent or mixed water is restricted by the surficial material (nt), which typically consists of finer-grained loam from the New Ulm Formation. This layer restricts the connection between area lakes and groundwater: no evaporative signatures were found in samples collected beneath and downgradient from Forest Lake (A–A′).

On cross sections C–C′ and D–D′ the western part of the Oneota (Opo) appears to be deep enough beneath the top of the bedrock to remain relatively unfractured and acts as an aquitard, thereby providing protection to the Jordan aquifer (Ꞓj). Mixed tritium-age water had a maximum interpreted depth of approximately 100 feet on A–A′ and B–B′ and 100 to 200 feet on C–C′ and D–D′.

On the eastern side, recent or mixed water reaches greater depths because of more permeable surficial sand conditions, underlying sandy till (cr underlain by ce), and a steeper hydraulic gradient toward the St. Croix River. Mixed tritium age water is found as deep as 200 feet for A–A′ and B–B′ and is approximately 200 to 300 feet for C–C′ and D–D′. The greater permeability is evident below lakes where evaporative signatures were found in several groundwater samples downgradient from Big Marine Lake (B–B′) in buried sand and Jordan aquifers. Two samples collected near Sunset Lake (D–D′) from the top of the Prairie du Chien aquifer (Ops) contained evaporative signatures at depths of 100 to 150 feet.

A groundwater divide causes regional groundwater to diverge from the center of these cross sections outward: west to the county border, or east toward the St. Croix River where some groundwater discharges through underlying alluvium and springs. The east side of cross section C–C′ shows a carbon-14 age of 5,500 years in a sample from a well completed in the Wonewoc–Eau Claire (Ꞓw and Ꞓe). Since the top of the open-hole portion of this well is only approximately 50 feet beneath the base of the river valley sand, the older age of this sample may indicate upwelling of older groundwater from the underlying Mt. Simon aquifer to the St. Croix River.

Central cross sections E–E′, F–F′, G–G′, and H–H′

Note: H–H′ cross section is found on Plate 9.

This group contains areas where the mixed tritium-age water is relatively deep due to permeable surface and near-surface unconsolidated materials and a significant hydraulic gradient toward the St. Croix River. The finer-grained New Ulm till (nt) is only at the surface on the Ramsey County portion of E–E′ west of White Bear Lake. Surficial and near-surface materials are mostly sandy units of the Cromwell and Emerald formations (cr and ce), surficial sands, and interbedded buried sand aquifers.

The east and east-central portions of these cross sections contain buried bedrock valleys. The localized fracturing in the bedrock allows mixed tritium-age water to penetrate deeper than might be expected (Runkel and others, 2003; Runkel and others, 2018). This buried bedrock valley effect is especially apparent on cross sections G–G′ and H–H′ in a large area of the Jordan aquifer (Report Figure 40) and portions of the Upper Tunnel City aquifer (Ꞓtc) (Report Figure 41).

The interpreted depth of mixed tritium-age water is as much as 350 to 500 feet (western F–F′ and G–G′, all of H–H′). This is aided by lateral transport of groundwater from the buried bedrock valley locations. One groundwater sample from the Tunnel City Group (Ꞓtc lower), located east of CSAH 24 on G-G′, had an estimated carbon-14 age of 4,000 years and therefore appears relatively isolated from most of this deep recharging water.

Areas not affected by the buried bedrock valleys have an interpreted depth of mixed tritium-age water of approximately 150 to 300 feet (the center and west of cross sections E–E′, F–F′, G–G′).

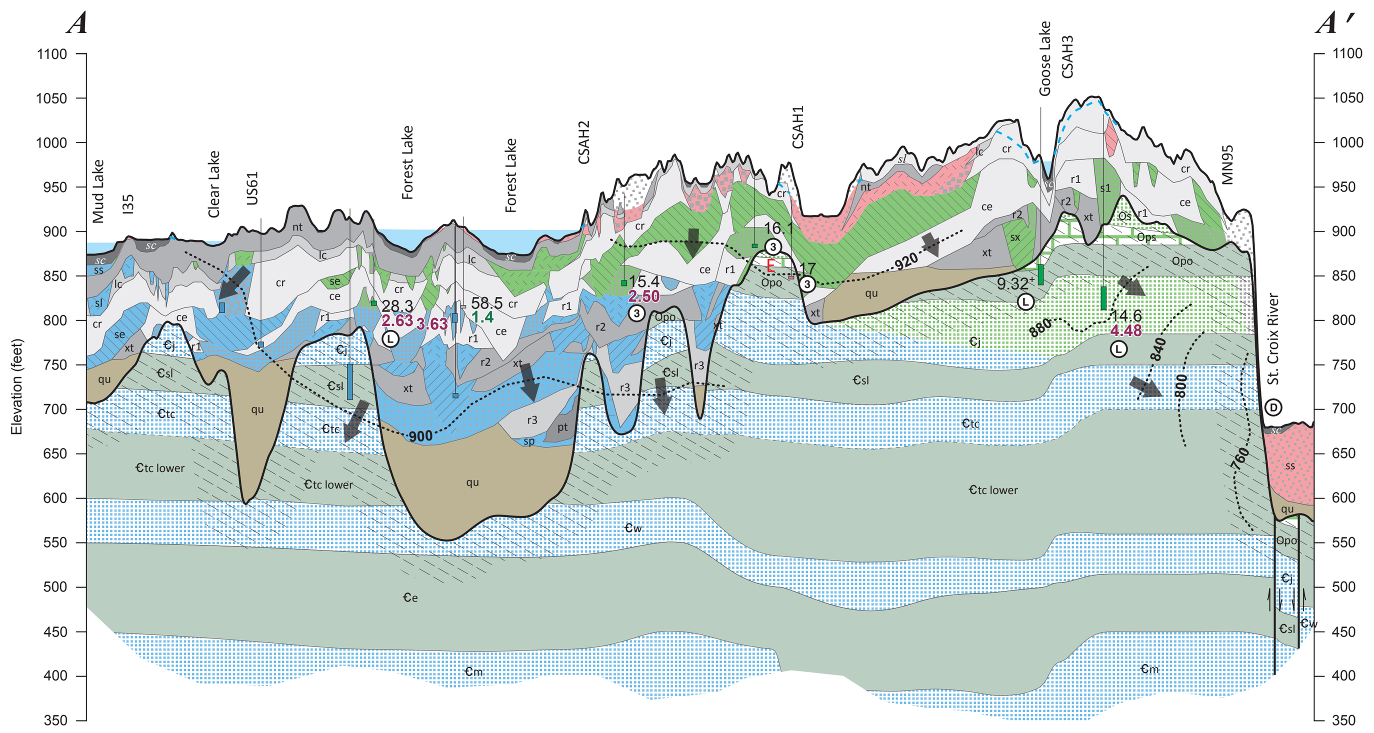
All of these cross sections show evidence of evaporative signature water including the White Bear Lake area on the west side of E–E′ and F–F′, the McDonald Lake area on the east side of G–G′, and the west side of H–H′.

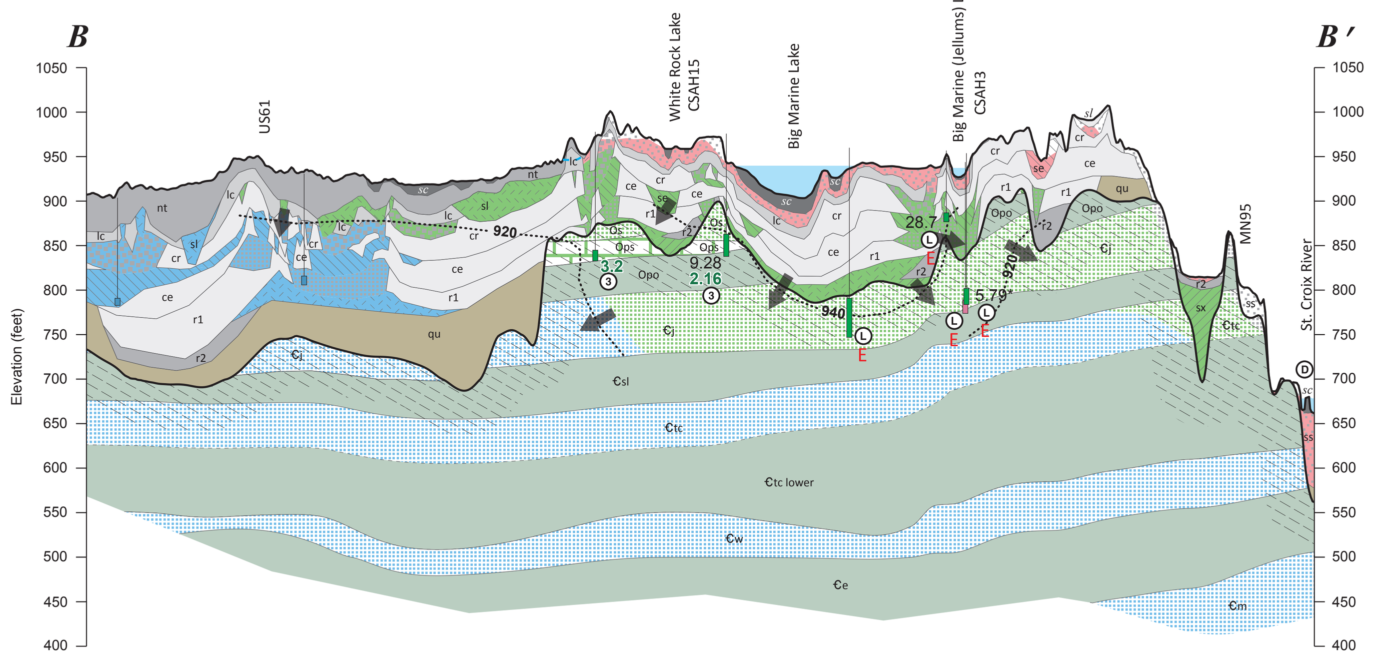
A regional groundwater divide occurs near the west-central portions of E–E′ and F–F′ and on the western portions of G–G′ and H–H′.

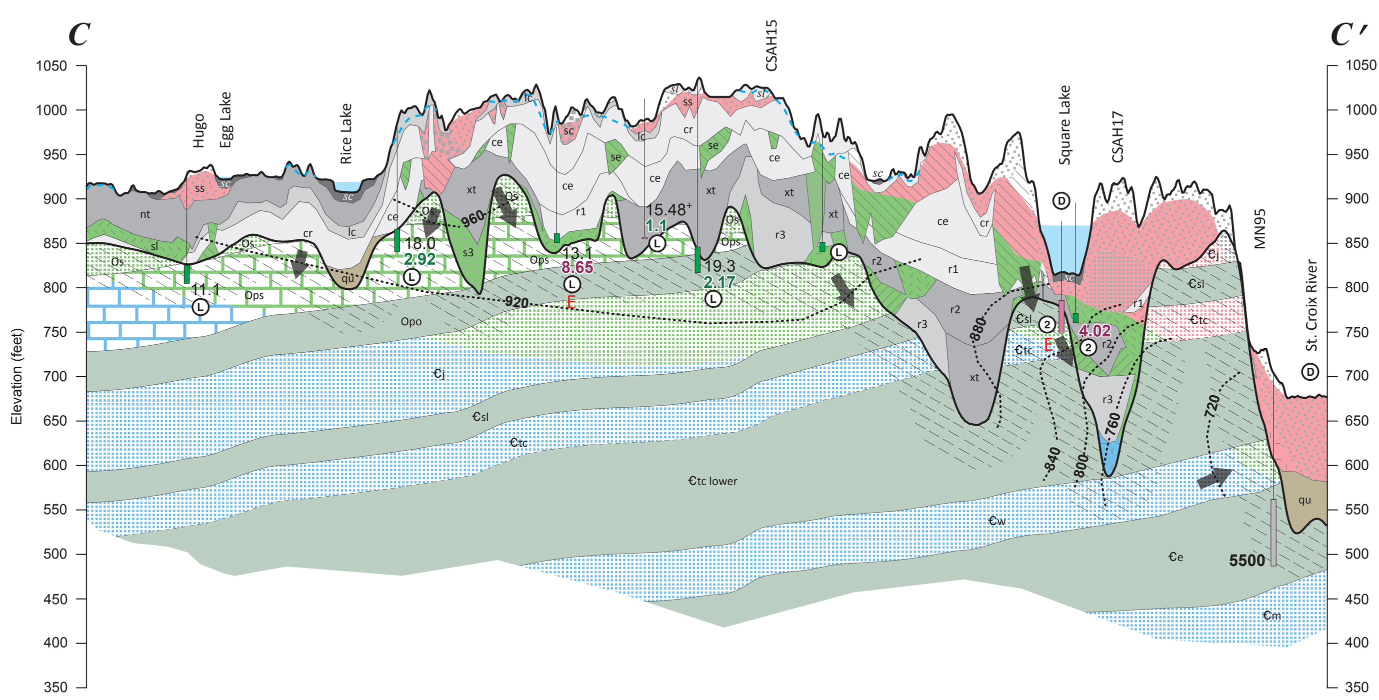
References

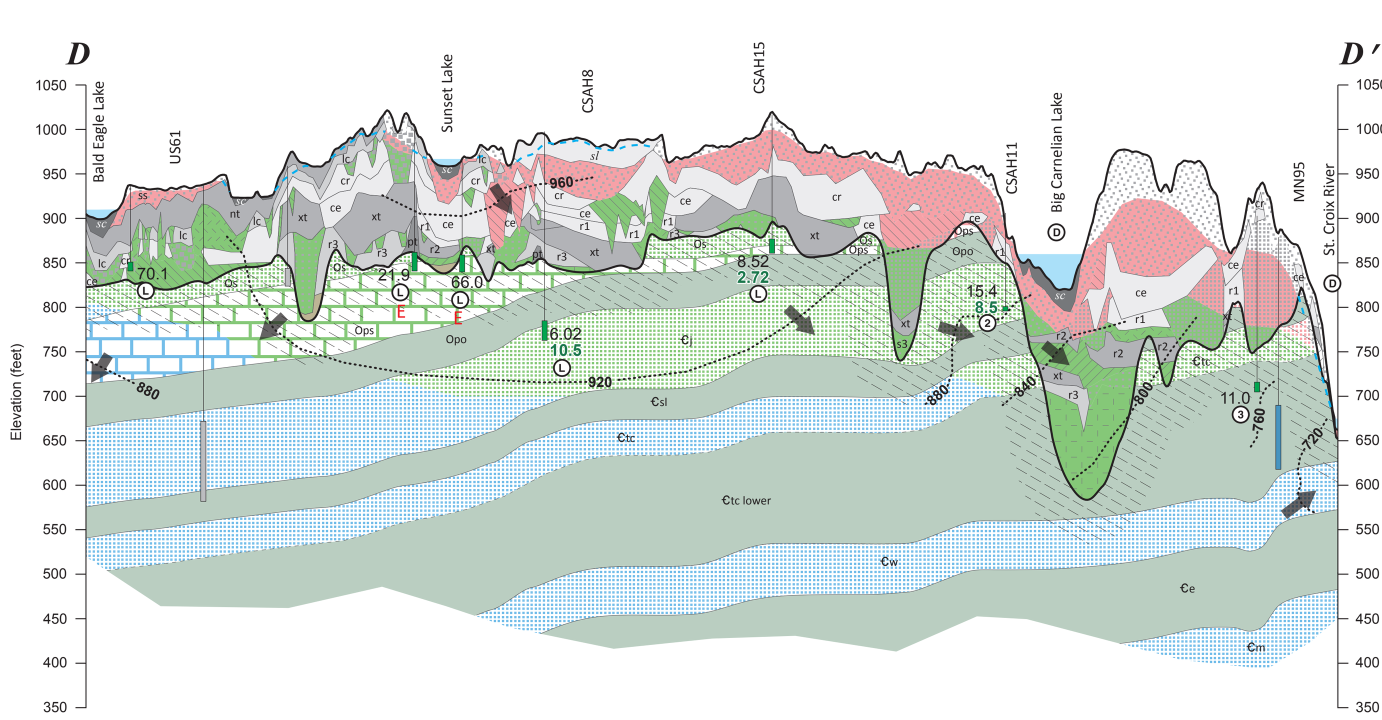
Runkel, A.C., Tipping, R.G., Alexander, E.C., Jr., Green, J.A., Mossler, J.H., and Alexander, S.C., 2003, Hydrogeology of the Paleozoic bedrock in southeastern Minnesota: Minnesota Geological Survey, Report of Investigation 61, 105 p., 2 pls.

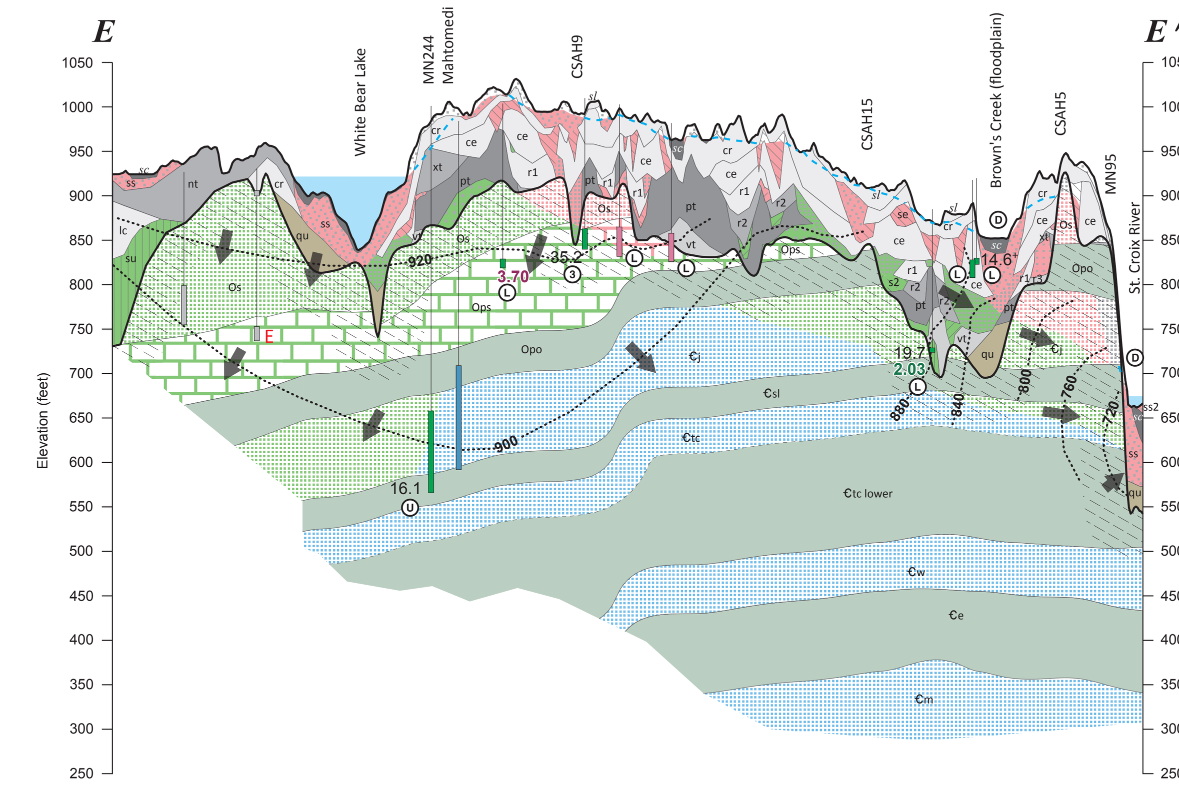
Runkel, A.C., Tipping, R.G., Meyer, J.R., Steenberg, J.R., Retzler, A.J., Parker, B.L., Green, J.A., Barry, J.D., and Jones, P.M., 2018, A multidisciplinary-based conceptual model of a fractured sedimentary bedrock aquitard–improved prediction of aquitard integrity: Hydrogeology Journal, November 2018, v. 26, Issue 7, p. 2133–2159.

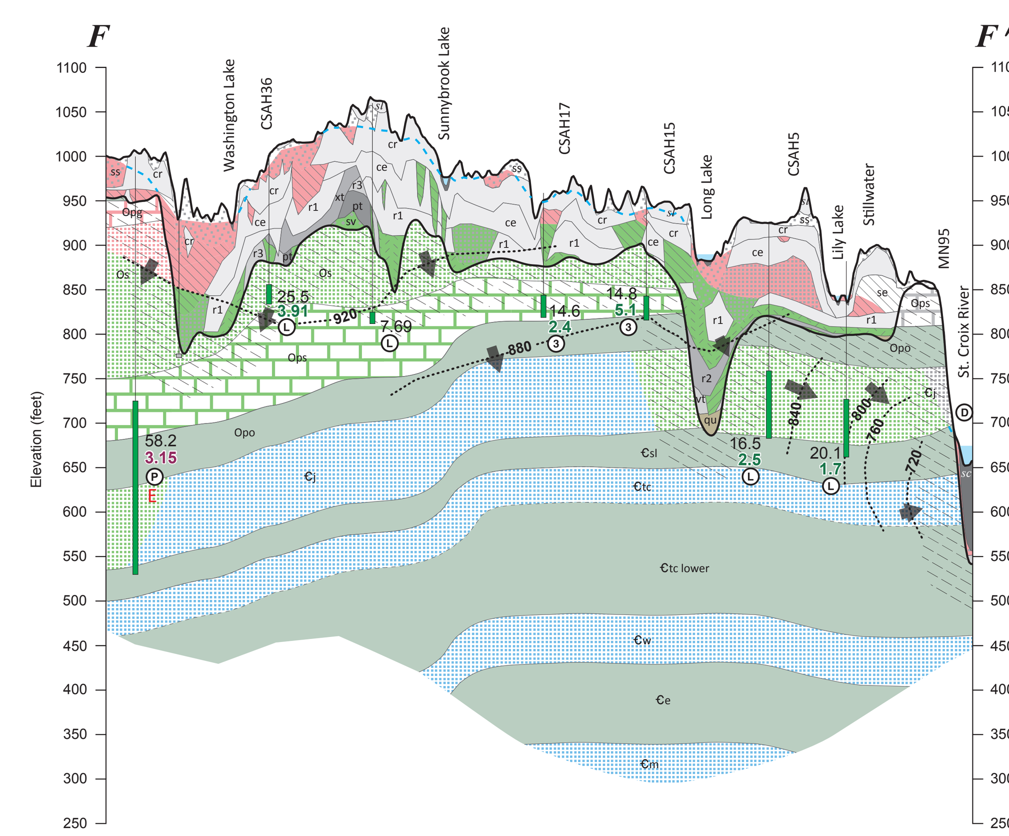


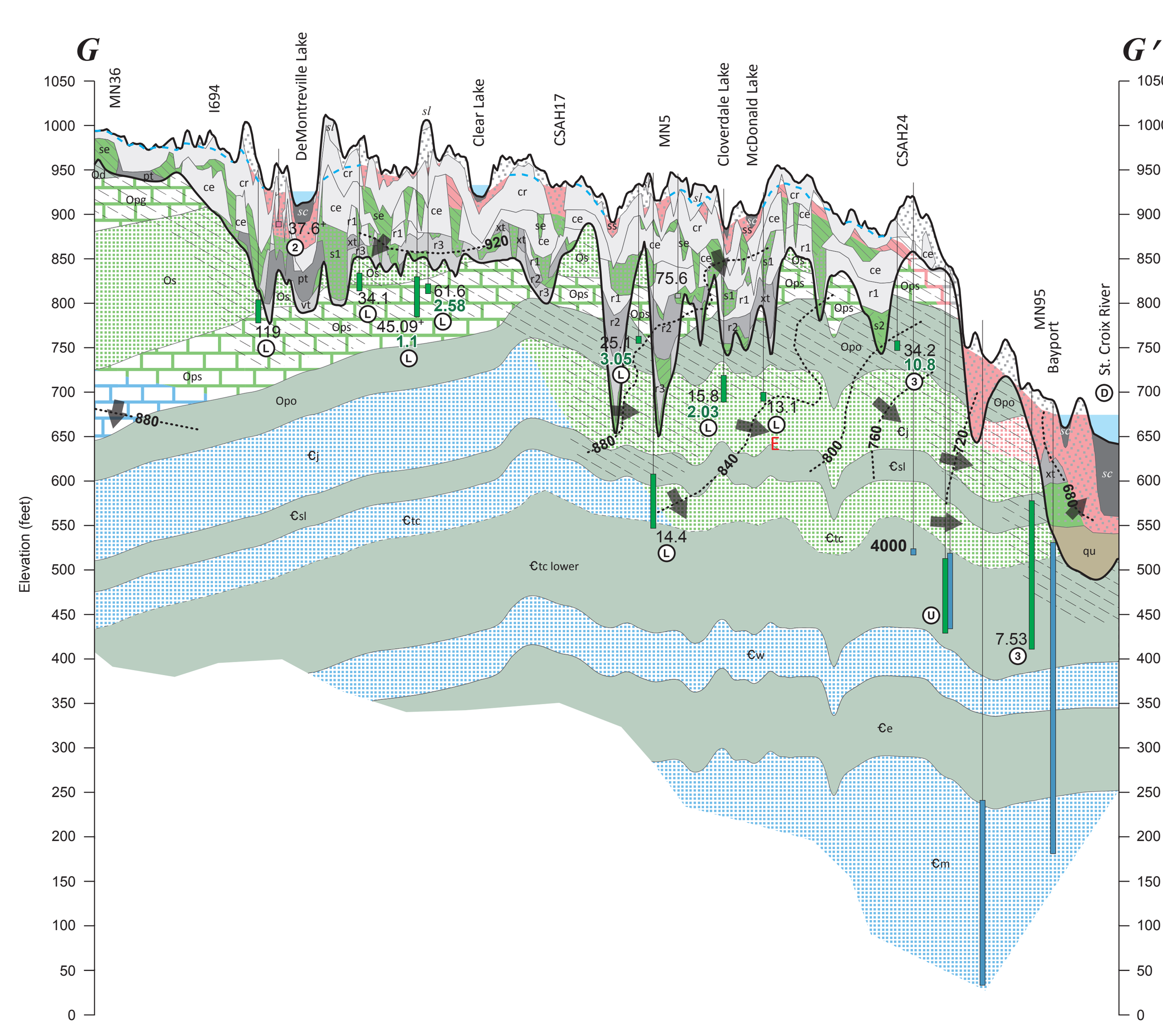












Cross Section Explanation

Aquifers and aquitards

Interpreted tritium age is indicated by background color.

Interpreted tritium age is indicated by pattern color.

Quaternary unconsolidated

See Figure 4 in the report for geologic unit correlation.

- *sc**
- *sl**
- ss, ss1
- nt*
- sl
- lc*
- sc
- cr*
- se
- ce*
- s1
- r1*
- s2
- r2*
- sx
- xt*
- s3
- r3*
- sp
- pt*
- sv
- vt*
- su
- qu

*aquitard

Bedrock

- Od — Decorah Shale*
- Opg — Platteville and Glenwood formations
- Os — St. Peter
- Ops — Shakopee
- Opo — Oneota Dolomite*
- Ꞓj — Jordan
- Ꞓsl — St. Lawrence Formation*
- Ꞓtc — Upper Tunnel City
- Ꞓtc lower — Lower Tunnel City*
- Ꞓw — Wonewoc
- Ꞓe — Eau Claire Formation*
- Ꞓm — Mt. Simon

*aquitard

Quaternary aquitards

Grouped by texture ranging from highest to lowest sand content indicating relative hydraulic conductivity.

Geologic unit code	Percent sand
ce, cr, r1, sl	>60%
lc, r3, vt	>50% and ≤60%
nt, r2, xt	>40% and ≤50%
pt	>30% and ≤40%
sc	≤30%

Tritium age

Darker color in small vertical rectangle (well screen symbol) indicates tritium age of water sampled in well. Lighter color indicates interpreted age of water in aquifer.

- Recent: water entered the ground since about 1953 (8 to 15 tritium units [TU]).
- Mixed: water is a mixture of recent and vintage waters (greater than 1 TU to less than 8 TU).
- Vintage: water entered the ground before 1953 (less than or equal to 1 TU).
- Well not sampled for tritium.

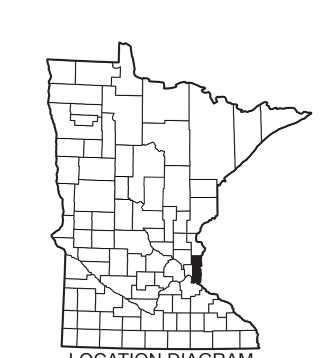
Symbols and labels

- 16.5 — Chloride: if shown, concentration is ≥5 ppm. (* naturally elevated, + source unknown)
- 2.63 — Arsenic: if shown, concentration is ≥2 ppb.
- 2.5 — Nitrate: if shown, concentration is ≥1 ppm.
- 4000 — Carbon-14 (^{14}C): groundwater residence time in years.
- E — Groundwater sample with evaporative signature
- General groundwater flow direction
- 920 — Approximate equipotential contour; contour intervals 20 and 40 feet
- Geologic contact
- Approximate geologic contact
- Land or bedrock surface
- Water table
- Direction of fault movement, arrows indicate relative movement
- Enhanced-permeability zone (see Report page 9)

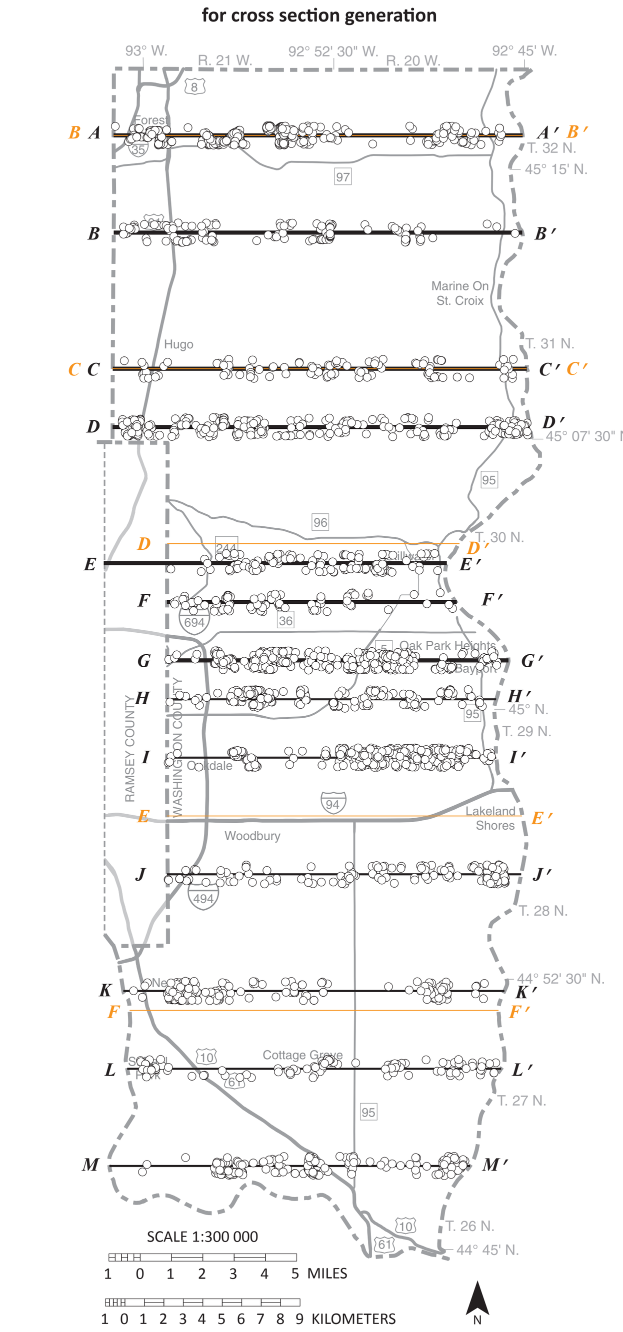
Groundwater conditions

- (2) Groundwater moves from an overlying surficial aquifer to a buried aquifer.
- (3) Groundwater moves from an overlying buried aquifer to an underlying buried aquifer.
- (L) Groundwater flows laterally.
- (P) Tritium concentrations may be artificially elevated by high capacity pumping.
- (U) Groundwater flowpath is unknown.
- (D) Groundwater discharges to a surface-water body.

SCALE 1:100 000
VERTICAL EXAGGERATION X 50
1 0 1 2 3 4 5 MILES
1 0 1 2 3 4 5 6 7 8 9 KILOMETERS



Cross section locations and wells used for cross section generation

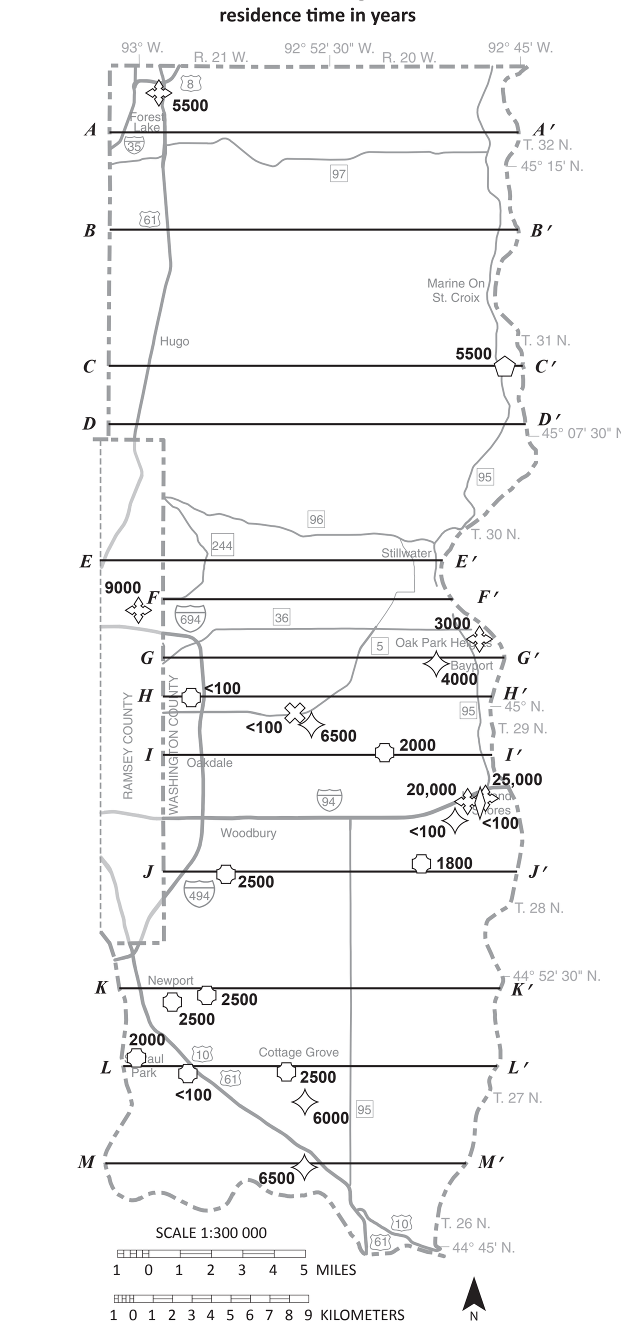


Symbols

- ○ Well used to generate cross section*
- A—A′ Part B line of cross section shown on this plate
- H—H′ Part B line of cross section shown on Plate 9
- B—B′ Part A line of cross section

*Not all wells are displayed in cross section view due to the high density of wells.

Carbon-14: estimated groundwater residence time in years



Sampled well and aquifer symbols

- Prairie du Chien
- Jordan, Jordan–St. Lawrence
- Tunnel City
- Wonewoc–Eau Claire
- Eau Claire
- Wonewoc–Mt. Simon, Mt. Simon, Mt. Simon–Hinckley

Symbols and labels

- 5500 — Carbon-14 (^{14}C): estimated groundwater residence time in years.
- B—B′ Line of cross section (Part B)

This map was compiled and generated in a geographic information system. Digital data products are available from the DNR Groundwater Atlas Program page (mndnr.gov/groundwatermapping).

Base modified from Minnesota Geological Survey, Washington County Geologic Atlas, Part A, 2016.

Universal Transverse Mercator projection, zone 15N, North American Datum of 1983. North American Vertical Datum of 1988.

DEPARTMENT OF NATURAL RESOURCES

500 Lafayette Road
St. Paul, MN 55155-4025
888-646-6367 or 651-296-6157
mndnr.gov

Prepared and published with the support of the Minnesota Environment and Natural Resources Trust Fund and the Clean Water, Land and Legacy Amendment