

Figure 5. Potentiometric surface elevation of the sx buried sand and gravel aquifer. The locations of wells that were sampled for general chemistry and isotope analysis are also shown. The extent, distribution, depth, and thickness of the sx sand and gravel unit is shown in Figure 8, Plate 4, Part A.

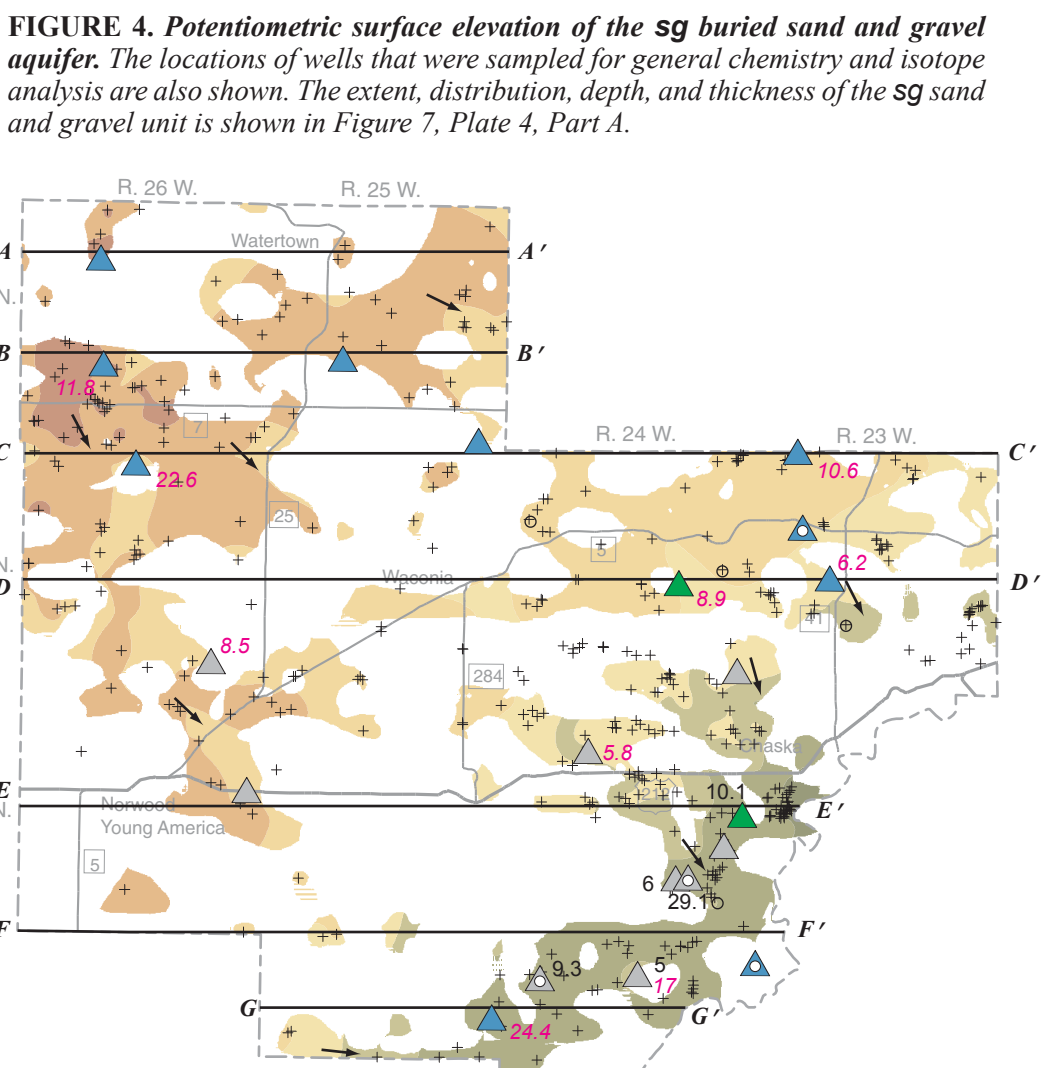
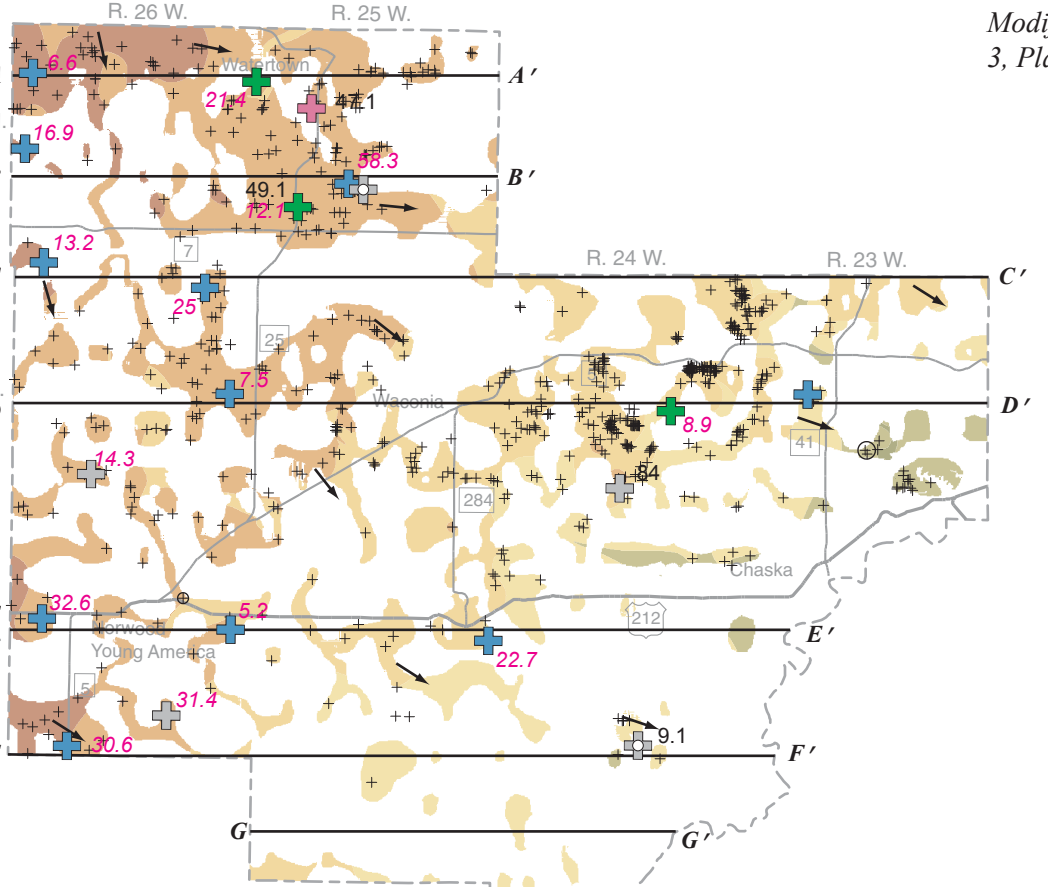
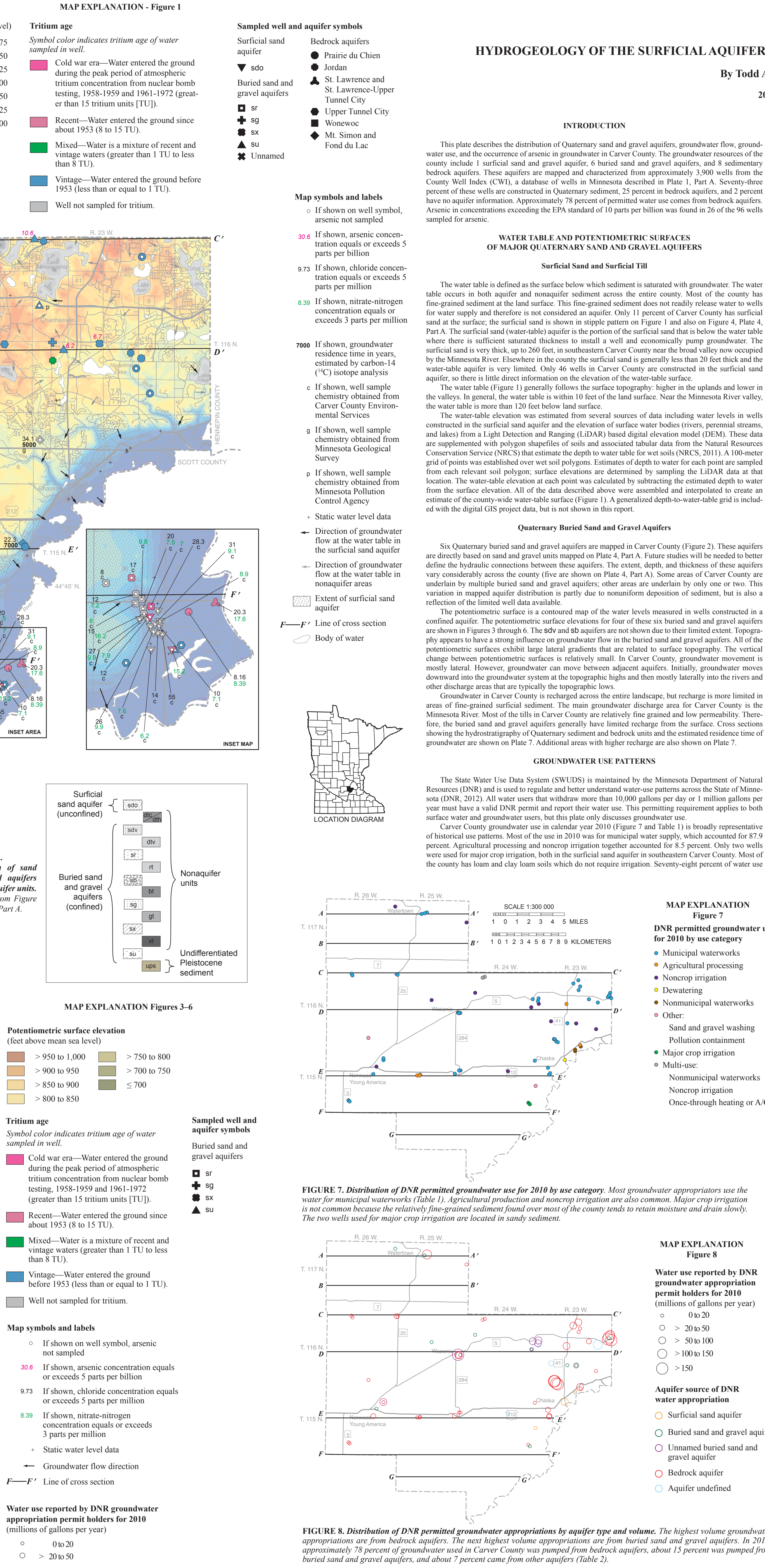


Figure 6. Potentiometric surface elevation of the su buried sand and gravel aquifer. The locations of wells that were sampled for general chemistry and isotope analysis are also shown. The extent, distribution, depth, and thickness of the su sand and gravel unit is shown in Figure 9, Plate 4, Part A.



was from bedrock aquifers (Figure 8 and Table 2). Pumping from Quaternary aquifers accounted for only 17.5 percent. The Prairie du Chien and Jordan are the most-used aquifers; a total of 31.1 percent was withdrawn from these two aquifers. The Prairie du Chien and Jordan are separate aquifers, but most of the water is pumped from nine wells owned by the City of Chanhassen that are constructed across both aquifers. The Upper Tunnel City and Wonewoc aquifers are the second-most used. Wells constructed across these two adjacent aquifers account for 17.5 percent. The Mt. Simon and Fond du Lac aquifers are the third-most used, collectively accounting for 14.1 percent. Two wells constructed over the entire Wonewoc to Mt. Simon interval account for 9.3 percent. Bedrock aquifers are discussed in more detail on Plate 8.

ARSENIC IN GROUNDWATER IN CARVER COUNTY

Arsenic is commonly found in the Quaternary sand and gravel aquifers and in the shallow bedrock aquifers in Carver County. Arsenic is found in many wells constructed in these aquifers. Current science cannot predict the concentrations; therefore all wells constructed in one of the sand and gravel aquifers or in a shallow bedrock aquifer should be tested for arsenic. The Environmental Protection Agency (EPA) requires that community water supplies not exceed 10 parts per billion (ppb) arsenic (Environmental Protection Agency, 2001). Figure 1 shows all water samples that had 5 ppb or more arsenic. Arsenic concentration can vary over time; well-water samples that had 5 ppb or more arsenic should be resampled to determine if the arsenic level of the first water sample is representative.

Arsenic in concentrations greater than or equal to 10 ppb was found in 26 of the 96 wells tested. Twenty-three of these wells were constructed in Quaternary buried sand and gravel aquifers, two wells were constructed in the Jordan aquifer, and one well was constructed across both the St. Lawrence confining unit and the Upper Tunnel City aquifer. Arsenic concentrations greater than or equal to 5 ppb and less than 10 ppb were found in 19 additional wells. Thirteen of these wells are constructed in Quaternary buried sand and gravel aquifers, one was constructed in the St. Lawrence confining unit, three wells are constructed in the Upper Tunnel City aquifer, and two wells are constructed in the Wonewoc aquifer. Eight of the nine bedrock wells with arsenic concentrations greater than or equal to 5 ppb are constructed in a unit that forms the top of the bedrock surface and are probably recharged from Quaternary units.

The factors affecting elevated arsenic concentration in groundwater are not completely understood. Erickson and Barnes (2005) found a strong correlation with wells constructed in aquifers associated with northwest provenance tills. In this atlas northwest provenance tills are subdivided into the Riding Mountain and Winnipeg provenances (Figure 1, Plate 3, Part A). Except for the ft till, all of the mapped tills in Carver County are northwest provenance. The original arsenic reservoir is probably arsenic-bearing pyrite from small shale particles in these tills. Some of this arsenic has been previously released and then adsorbed to surfaces of the pyrite crystals and other small particles during earlier oxidizing conditions. This surface adsorbed arsenic, the most chemically available form, is released under reducing conditions to groundwater (Nicholas and others, 2011; Thomas, 2007).

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TABLE 1. Water use reported by DNR groundwater appropriation permit holders for 2010 by use category		
[Data from Minnesota Department of Natural Resources, State Water Use Data System. MGY, million gallons per year, total permitted wells = 72]		
Use Category	Water Use (MGY)	Percent of Use
Municipal waterworks	3,055.9	87.9
Agricultural processing	179.2	5.2
Noncrop irrigation	113.7	3.3
Dewatering	61.1	1.8
Nonmunicipal waterworks	32.2	0.9
Sand and gravel washing ¹	17.3	0.5
Pollution containment ¹	16.3	0.5
Once-through heating or A/C	1.2	0.03
Major crop irrigation	0.5	0.01
Total	3,477.4	≈100

¹ Categories are combined into "Other" in Figure 7.

² Sum of percentages does not equal 100 due to rounding.

TABLE 2. Water use reported by DNR groundwater appropriation permit holders for 2010 by aquifer			
[Data from Minnesota Department of Natural Resources, State Water Use Data System. MGY, million gallons per year; dashes (—), no data available]			
Aquifer	Number of Wells	Water Use (MGY)	Percent of Use
Surficial sand	3	80.5	2.3
Buried sand and gravel			
sdv	—	—	—
sr	—	—	—
sb	—	—	—
sg	2	30.5	0.9
sk	4	4.0	0.1
su	4	22.9	0.7
Unnamed	8	470.6	13.5
Bedrock			
Prairie du Chien-Jordan ¹	9	862.2	24.8
Jordan	4	220.6	6.3
St. Lawrence-Upper Tunnel City ¹	1	1.6	0.05
Upper Tunnel City	2	12.3	0.4
Upper Tunnel City-Wonewoc ¹	12	546.2	15.7
Upper Tunnel City-Wonewoc-Eau Claire ¹	1	40.4	1.2
Upper Tunnel City-Mt. Simon ¹	4	209.9	6.0
Wonewoc	1	6.8	0.2
Wonewoc-Mt. Simon ¹	2	322.6	9.3
Mt. Simon	7	449.9	12.9
Mt. Simon-Fond du Lac ¹	2	41.2	1.2
Undefined	6	155.2	4.5
Total	72	3,477.4	≈100

¹ Well constructed across more than one aquifer.

² Sum of percentages does not equal 100 due to rounding.

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This map was compiled and generated using geographic information systems (GIS) technology. Digital data products, including chemistry and geophysical data, are available from DNR. Ecological and Water Resources at <http://wdr.dnr.state.mn.us/waters>.

This map was prepared from publicly available information. Every reasonable effort has been made to ensure the accuracy of the factual data on which this map interpretation is based. However, the Department of Natural Resources does not warrant the accuracy, completeness, or any implied uses of these data. Users may wish to verify critical information, sources include both the references here and information on file in the offices of the Minnesota Geological Survey and the Minnesota Department of Natural Resources. Every effort has been made to ensure the interpretation shown conforms to sound geologic and cartographic principles. This map should not be used to establish legal title, boundaries, or locations of improvements.

Project data compiled from 2010 to 2012 at a scale of 1:100,000 to 1:300,000. Universal Transverse Mercator projection, zone 15N. Minnesota Department of Natural Resources, Department of the Interior, Washington, DC 20246. GIS and cartography by Todd Petersen, Shana Pascal, and Greg Massari. Edited by Neil Cunningham.