Buried sand and gravel aquifers of the Breckenridge/Wahpeton area, Minnesota and North Dakota

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http://files.dnr.state.mn.us/publications/waters/breckenridge_wahpeton_aquifer_report.pdf jim.a.berg@state.mn.us, 651-259-5680

Summary and Conclusions

The interstate border communities of Breckenridge, Minnesota and Wahpeton, North Dakota share a buried sand and gravel aquifer called the Wahpeton Buried Valley (WBV). Starting in 1986 efforts to remediate a groundwater contamination problem in Wahpeton by pumping contaminated water from the WBV aquifer led to water level declines in the City of Breckenridge water supply wells. From 1995 through 1998, to better understand the area aquifer recharge characteristics and long term sustainability, the North Dakota State Water Commission (NDSWC), Minnesota Department of Natural Resources (DNR) and Wilkin County Environmental Services collaborated on a groundwater investigation. This investigation consisted of drilling new observation wells, collecting water samples from these wells for analysis of stable isotopes and common ions, and synoptic water level measurements. Until this report these data had never been published.

To help understand the geochemical and water level information generated by this investigation, area aquifers were mapped as part of this report with well log information from North Dakota and Minnesota databases. Closely spaced hydrogeologic cross sections of the area illustrating the distribution of isotopic groundwater types in buried sand aquifers provide evidence that shows hydraulic connections to surficial recharge water are common. Widespread occurrences of groundwater with a mixed warm isotopic type and gradually rising water levels from several observation wells indicate active recharge of area aquifers. The relatively open nature of the area aquifers suggests that water usage in this area appears sustainable at current water usage rates and quantities of precipitation. Should water usage or precipitation change significantly, the sustainability of aquifer usage in the area would need to be reevaluated. Long-term monitoring of the groundwater resources in this area should be continued.

Investigation Summary

• Collection of groundwater samples from 42 wells in Richland (North Dakota) and Wilkin (Minnesota) counties that were analyzed for stable isotopic analysis of 18O and deuterium, and general chemistry

• Drilling through the entire glacial section into Cretaceous bedrock at 11 locations in Minnesota with North Dakota drilling equipment and staff. Eighteen observation wells were installed at these locations with eight of these sites completed with two or more closely spaced wells of different depths (well nests).

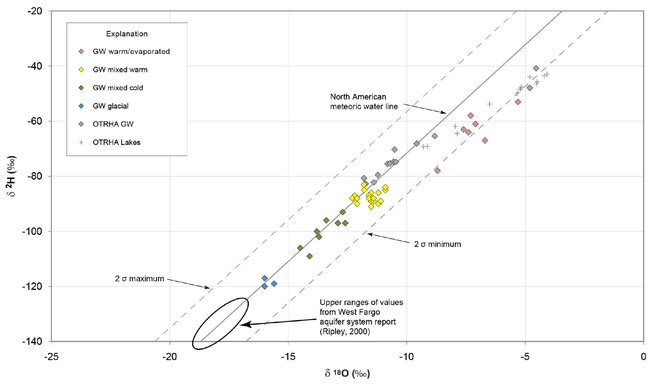
• Completion of water level synoptic measurement events in June and October of 1995. Since the results of this investigation have never been summarized, one of the objectives of this report is to summarize these data and integrate them with all the data available from this area, including approximately 70 new wells that have been drilled in this area since 1995.

The aquifer systems in the study area were mapped by constructing 40 west-east geologic cross sections with a 1-kilometer north-south spacing across the project area. Well information from the Minnesota County Well Index (CWI) and NDSWC within 500 meters on either side of each cross section line was projected to the line. The cross sections were constructed by first creating “stick diagrams” using a custom ArcGIS extension. Each stick diagram consists of a colored representation of the driller’s log of geologic materials encountered during drilling plotted at the correct elevation. This basic diagram also included profile lines representing the land surface and the bedrock surface. The surface geologic unit boundaries from Thorliefson and others (2005) were generalized and added to all the cross sections.

Geochemistry

Stable isotopes, 18O, and deuterium - Source water temperature and mixing

Stable isotope data from Breckenridge/Wahpeton area compared with Otter Tail Regional Hydrogeologic Assessment(OTRHA) and West Fargo.



Of the samples that plot along the same slope as the meteoric water line, the samples more depleted in heavy isotopes (samples that plot closer to the bottom left of the graph) suggest water that precipitated from a colder atmosphere. Deuterium and 18O samples collected from snow and rain samples approximately 80 miles west of the Breckenridge/Wahpeton area (Shaver, 1995) show snow samples plotting beyond the far bottom left range of the graph (deuterium: δ -190 to -125, 18O: δ -25 to -18); whereas, rain samples plotted in the upper right portion of the graph (deuterium: δ -75 to -25, 18O: δ -12 to -2). Most groundwater samples collected from a Fargo area study (Ripley, 2000) had stable isotope values in the same range as the snow samples in Shaver (1995) and were, therefore, interpreted as aquifer recharge water from melting glaciers. The West Fargo Aquifer System is overlain by 70 to 90 feet of lake clay. This clay confining layer trapped Pleistocene water in the area aquifers.

Three stable isotope samples from the Breckenridge/Wahpeton area were slightly outside the snow melt or glacial range. These samples, therefore, consist mostly of glacial water. Groundwater samples with stable isotope values in the mixed cold (green) and mixed warm (yellow) groups apparently represent groundwater that is a mixture of glacial and post-glacial precipitation. The difference in isotopic composition between these two groups (mixed cold versus mixed warm) is probably the relative amounts of post-glacial versus glacial water. Several possible mixing pathways are apparent from the cross sections.

Surficial Geology and Buried Sand and Gravel Distribution

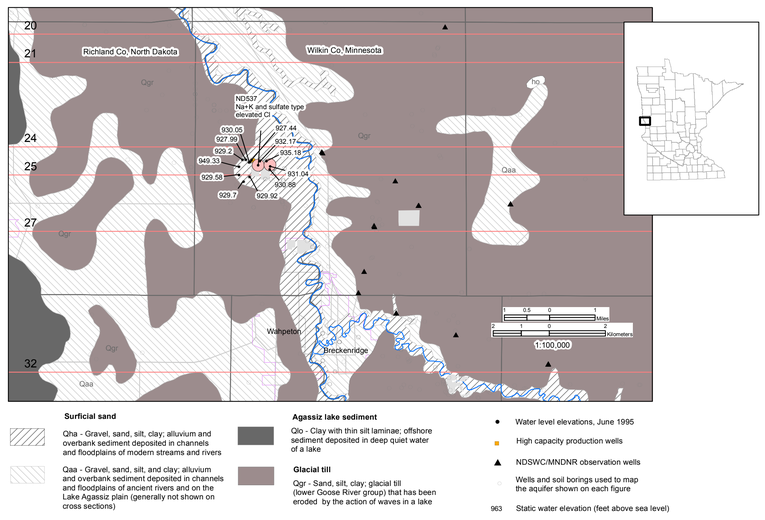


FIGURE 1. Surficial geology emphasizing distribution of surficial sand and gravel deposits. Modified from Thorleifson, H., and others (2005). Also shown are the water level elevations (June 1995) and 18O - deuterium characteristics (October 1995 and November 1996) in the water table aquifer.

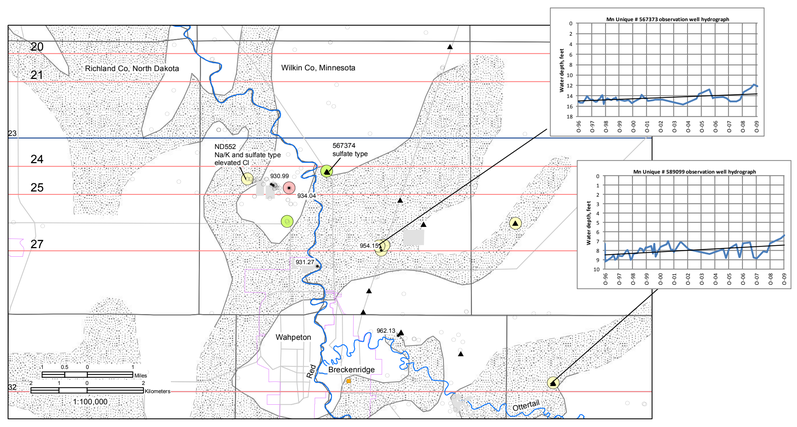


FIGURE 2. Buried aquifer 1 distribution. Also shown are the water level elevations (June 1995) and 18O- deuterium characteristics in aquifer 1.The observation well hydrographs indicate a slight rise in water levels since 1996. The black line on each hydrograph is a linear trendline that best fits the water level data

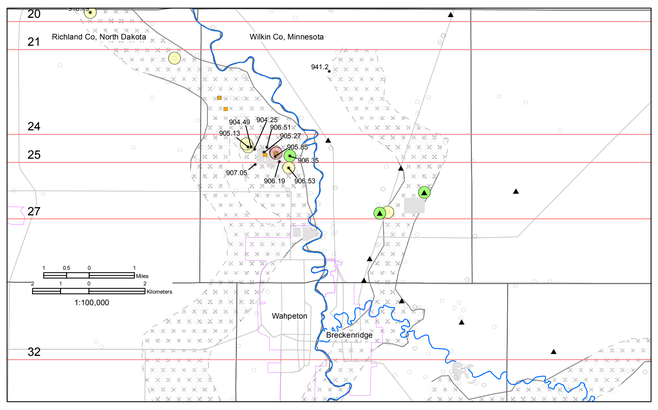


FIGURE 3. Buried aquifer 2 distribution. Also shown are the water level elevations (June 1995) and 18O - deuterium characteristics (October 1995 and November 1996) in aquifer 2.

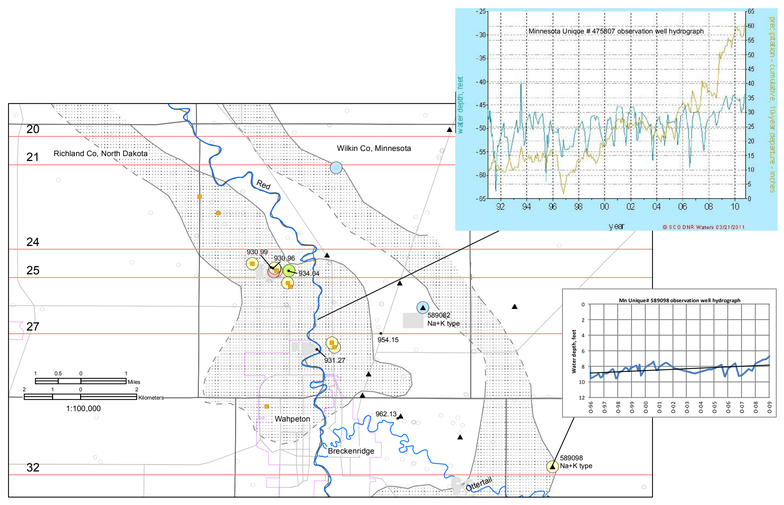
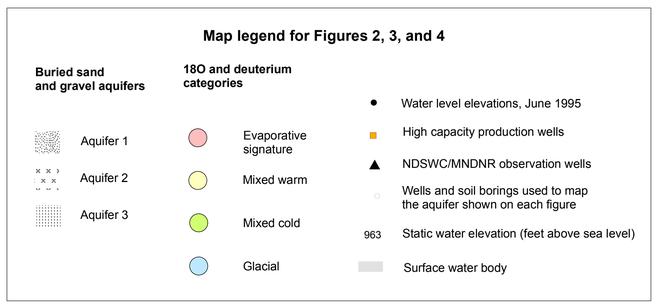


FIGURE 4. Buried aquifer 3 distribution. Also shown are the water level elevations (June 1995) and 18O - deuterium characteristics (October 1995 and November 1996) in aquifer 3. The observation well hydrograph #589098 indicates a slight rise in water levels since 1996. The black line on the hydrograph is a linear trendline that best fits the water level data. The #475807 hydrograph shows water levels from aquifer 3 since 1991 compared to cumulative changes in precipitation. Precipitation has increased since 2008 creating a slight rise in water levels.



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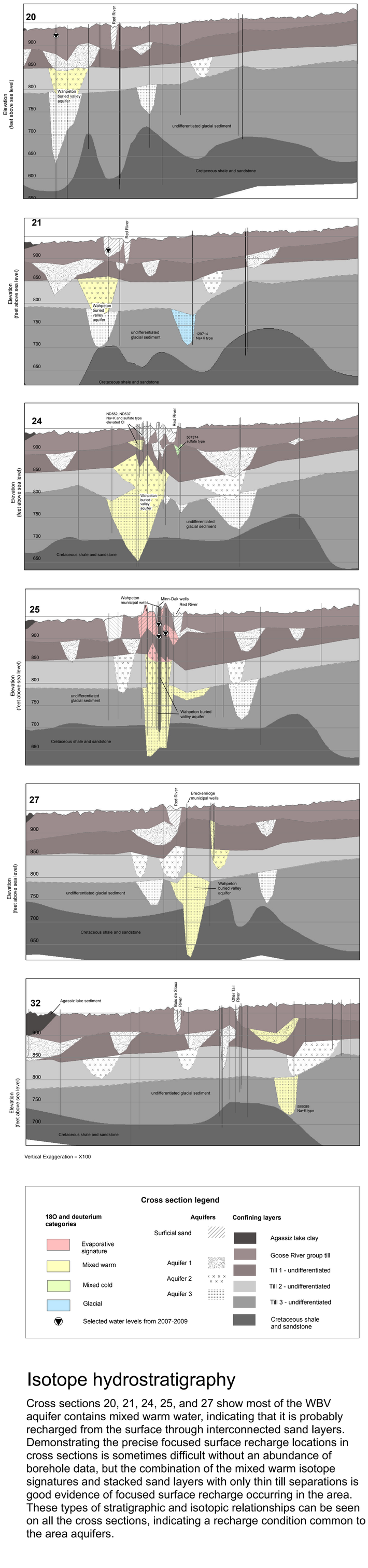
Ripley, D.P., 2000, The water resource characteristics of the West Fargo aquifer system, North Dakota Ground-Water Studies Number 106 [Part II], North Dakota State Water Commission, Bismarck North Dakota.
Shaver, R.B., 1995, Distribution of oxygen-18 and deuterium in precipitation, ponds, sloughs and ground water in the Oakes aquifer study area, southeastern North Dakota: North Dakota Water Resource Investigation No. 30, 72 p.
Thorliefson, L.H., and others, 2005, Geological mapping and 3D model of deposits that host ground-water systems in the Fargo-Moorhead region, Minnesota and North Dakota. A report submitted to the U.S. Department of the Interior, Bureau of Reclamation in support of the red River Valley Water Supply Project, Minnesota Geological Survey, University of Minnesota, St. Paul, Minnesota.

Cross Sections Showing Aquifer Stable Isotope Catagories



Isotope hydrostratigraphy

Cross sections 20, 21, 24, 25, and 27 show most of the WBV aquifer contains mixed warm water, indicating that it is probably recharged from the surface through interconnected sand layers. Demonstrating the precise focused surface recharge locations in cross sections is sometimes difficult without an abundance of borehole data, but the combination of the mixed warm isotope signatures and stacked sand layers with only thin till separations is good evidence of focused surface recharge occurring in the area. These types of stratigraphic and isotopic relationships can be seen on all the cross sections, indicating a recharge condition common to the area aquifers.