Attachment 8

Chisago County CGA Preliminary Findings & Groundwater Level Monitoring Activities Summary June 25, 2012

Water, both surface water and groundwater, is one of the most precious resources in Chisago County. It nourishes communities, maintains crops, offers recreational opportunity, provides aesthetic beauty, and sustains life. Groundwater provides drinking water to all of Chisago County. However, groundwater and surface water are not separate resources. Groundwater discharge typically provides base flow to streams and rivers. In some settings, as in areas of Chisago County, surface water lakes and wetlands provide recharge to groundwater. Effective land and water management requires an understanding of the interaction between groundwater and surface water.

Introduction

Groundwater is generally extracted from two different geologic settings that exist across the county. Wells typically either penetrate saturated sand and gravel units referred to as sand and gravel aquifers or penetrate deeper saturated bedrock units that are referred to as bedrock aquifers. A geologic unit, unconsolidated or consolidated, that can store and transmit water at rates fast enough to supply water to wells is an aquifer (Fetter, 1994). Roughly 78% of wells in Chisago County extract water from unconsolidated sand and gravel aquifers, with the remaining 22% extracting water from consolidated bedrock aquifers that underlie the county. Water extracted from bedrock aquifers within the county is primarily extracted from either the Tunnel City Group (formerly the Franconia Formation), the Wonewoc Sandstone (formerly the Ironton and Galesville Sandstones), or the Mt. Simon Sandstone.

The laterally continuous sand and gravel units that are utilized as aquifers across the county were deposited during the last glaciations. These units were deposited in a layer cake fashion with sand units separated by clayey units. This sequence partially protects the counties aquifers from surface contamination, as the overlying till units with clayey textures impede rapid aquifer recharge. Wells completed in unconsolidated sand and gravel aquifers are typically less expensive to have installed and typically provide enough water for residential use. The high water yield demanded by municipalities often requires them to construct wells in deeper bedrock aquifers. In general, the added distance from the surface to these aquifers can provide the end user with an aquifer less susceptible to contamination from human activities.

Status and Preliminary Findings of the CGA Part B Report

The Department of Natural Resources is currently completing data analysis and starting to prepare the Part B Report of the Chisago County Geologic Atlas. The DNR expects to publish the atlas in winter 2012. The Part B Report will consist of four map sheets (plates) that describe the Counties Quaternary hydrogeology, bedrock hydrogeology, pollution sensitivity, and depict hydrogeologic cross sections. One of the key focuses of the DNR atlas is determining the groundwater residence time for different aquifers across the county.

Groundwater residence time is defined as the approximate time that has elapsed from the time the water infiltrated the land surface to the time when it was pumped from the aquifer. In general, short residence times suggest higher pollution sensitivity and long residence times suggest lower sensitivity.

Groundwater residence time is often estimated using the level of tritium that is present in the groundwater. Tritium is a naturally occurring radioactive isotope of hydrogen. Concentrations of tritium in the atmosphere were greatly increased between about 1953 and 1963 by above-ground nuclear tests (Alexander and Alexander, 1989). The presence of tritium in water samples indicates water has infiltrated the land surface since the early 1950s. Tritium data collected for this investigation showed that 45 well samples contained vintage tritium age water that entered the ground before 1953; 14 well samples contained recent tritium age water that entered the ground since 1953; and the remaining 34 samples contained a mixture of recent and vintage waters. Recent tritium age waters were generally found less than 200 feet from the land surface.

Samples that are classified as vintage through tritium testing can be further dated using the carbon-14 (^{14}C) isotope. Carbon-14 is a naturally occurring radioactive isotope of carbon with a halflife of 5730 years that is useful for estimating groundwater with a residence time between 100 years and 40,000 years. Eight wells sampled for ^{14}C in this study were coupled with eight wells sampled in previous studies by the Minnesota Geological Survey. Of the entire set of sixteen wells with ^{14}C ages, five wells were completed in Quaternary sand aquifer units with groundwater ages ranging from 500 to 3,000 years, eight were completed in the Mt. Simon aquifer with groundwater ages ranging from 500 to 7,000 years, two were completed in multiple bedrock aquifer conditions with ages ranging from 200 to 2,000 years, and one sample was used as a calibration point for recent water. Multiple bedrock aquifer conditions occur when a well intersects more than one aquifer unit. The ages determined through the carbon-14 dating are relatively young for deep groundwater in Minnesota, indicating groundwater flow systems that are recharged relatively quickly.

Stable isotopes of hydrogen (deuterium) and oxygen (^{18}O) can be used to deduce the relative season, or temperature, in which precipitation fell before recharging an aquifer and whether lakes and open water wetlands are a significant source of recharge to an aquifer. This is possible because cold ambient air temperature at the time of precipitation leads to lighter isotopic content, as the heavier isotopes have been preferentially reduced from the air mass as it moved across the continent towards Minnesota. This mechanism leaves wintertime precipitation (snow) with light isotopic values and summertime precipitation with heavier ^{18}O and deuterium signatures. Precipitation that infiltrates rapidly is prone to retain its isotopic signature and has a ratio of deuterium to ^{18}O that varies slightly. Because of this, nearly all precipitation plots with a slope near eight. This relationship is well known and is referred to as the *global meteoric water line*. However, lakes and open water wetlands are subjected to evaporation that overtime changes the isotopic signature of their water. This occurs when the lighter isotopic forms of water preferentially evaporate, leaving behind the heavier isotopes. Waters that have been subject to evaporation have different ratios of deuterium and ^{18}O that decrease the slope to roughly five. This slope is known as the *evaporative water line*. Samples that plot near this slope reveal water that was exposed to considerable evaporation and came from a lake or open water wetland. Stable isotope data, coupled with tritium data, reveals that in the Chisago Lakes region of southeast Chisago County groundwater is partially recharged through the many surface water bodies in the area and recharges relatively quickly through the leaky sandy tills that separate aquifers.

Concentrations of nitrate and arsenic in groundwater are often of interest to residents and water resource managers. Nitrate levels roughly greater than 1 ppm are often from human activities such as land application of fertilizer or from sewage systems (MPCA, 1998). Concentrations greater than 1 ppm can indicate rapid recharge from the land surface. Roughly 80 percent of the waters sampled in Chisago County had nitrate concentrations less than 1 ppm, and no water sampled exceeded the 10 ppm, the Maximum Contaminant Level for nitrate in drinking water. Naturally occurring Arsenic concentrations are elevated in some counties across Minnesota. The factors affecting elevated arsenic concentration in groundwater are complex and likely include the redox condition of the groundwater and the specific groundwater chemistry of the aquifer (Thomas, 2007). Arsenic in concentrations greater than or equal to 10 parts per billion, the EPA standard in drinking water (U.S. Environmental Protection Agency, 2006), can be detrimental to health. One sample collected as part of the Chisago atlas had an arsenic concentration greater than or equal to 10 micrograms per liter.

Groundwater Level Monitoring Network: Adding Well "Nests" in Chisago County

The Department of Natural Resources is currently installing a Groundwater Level Monitoring Network for the 11-County Metropolitan Area. The purpose of the network is to create an integrated monitoring network for sustainable water management. This network uses automated systems capable of frequent measurements that are essential to increase efforts to learn more about flow pathways, rates of water movement, and other characteristics of aquifers such as transmissivity and specific capacity. The network is actively installing multiple wells completed at different depths in common locations. These locations are referred to as well nests and are the most efficient method of monitoring groundwater in three dimensions. Well nests allow hydrogeologists to understand interaction between aquifers.

As part of this program, three new well nests were installed in Chisago County in spring and early summer of 2012. These locations include:

1. Wild River State Park – a shallow quaternary sand well and deep basalt well were installed.
2. Wild Rose WMA– a shallow quaternary sand well and a deep Mt. Simon were installed.
3. Janet Johnson WMA– a shallow quaternary sand well and a deep Mt. Simon were installed.

A fourth well nest is currently scheduled to be completed at the Nessel WMA by August 2012. This nest is expected to have a shallow quaternary sand well and a deep Mt. Simon installed. All of these wells are being added to the existing DNR groundwater level monitoring sites in the county. Information on groundwater level monitoring sites, the aquifers monitored, and links to downloading groundwater level data is available at the DNR website at:
http://www.dnr.state.mn.us/waters/groundwater_section/obwell/waterleveldata.html

References

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