Appendix B: 2015 Groundwater Monitoring Status Report

Minnesota Pollution Control Agency and Minnesota Department of Agriculture

Minnesota Pollution Control Agency

MINNESOTA DEPARTMENT OF AGRICULTURE

September 2015

1. Introduction

The 1989 Groundwater Protection Act (GWPA) (Minn. Stat. ch. 103H.175) requires the Minnesota Pollution Control Agency (MPCA), in cooperation with other agencies participating in the monitoring of water resources, to provide a draft report on the status of groundwater monitoring to the Environmental Quality Board for review every five years. This report is written to provide an update of groundwater monitoring activities in Minnesota to fulfill the MPCA's 2015 GWPA reporting requirements. For additional information on the background and history of groundwater monitoring in Minnesota, see *Minnesota's Groundwater Condition: A Statewide* View (O'Dell 2007) or *The Condition of Minnesota's Groundwater, 2007-2011* (Kroening and Ferrey 2013).

2. Agency Roles in Groundwater Monitoring and Assessment

Minnesota state law splits the groundwater monitoring and protection responsibilities among several state agencies. Each of the agencies involved handles a unique facet of groundwater monitoring and protection. It takes the concerted effort of all these agencies, along with local and federal partners, to build a comprehensive picture of the status of the state's groundwater resources.

Three state agencies, the MPCA; Minnesota Department of Agriculture (MDA); and Minnesota Department of Health (MDH), have important statutory roles and responsibilities in protecting the quality of Minnesota's groundwater as shown in Figure 1. The MPCA and MDA both conduct statewide ambient groundwater quality monitoring for non-agricultural chemicals and agricultural chemicals, respectively. These two agencies share many monitoring resources, including the computer database that stores the data that is collected, the technical staff that manage this information, and occasionally the sampling staff that collects the state's groundwater samples. For example, each year MPCA field staff collects pesticide samples from 20 wells in their network for the MDA. Similarly, the MDA staff collected chloride samples from all of their network wells for the MPCA in 2014 and this summer (2015), the MPCA and MDA staff jointly sampled selected wells in the MDA's network for contaminants of emerging concern (CECs), such as prescription and non-prescription medicines. The MDH conducts monitoring to evaluate and address the human health risk of contaminants in the groundwater that is used for drinking. In addition to these agencies, the Minnesota Department of Natural Resources (MDNR) monitors groundwater quantity conditions across the state through a network of groundwater monitoring wells, and the Metropolitan Council conducts regional water supply planning using the information collected by the MPCA, MDA, MDH, and MDNR.

A 2004 Memorandum of Agreement (MOA) between the MPCA, MDA, and MDH clarifies the agencies' roles in operating a statewide integrated groundwater-quality monitoring system and is provided in Appendix A.

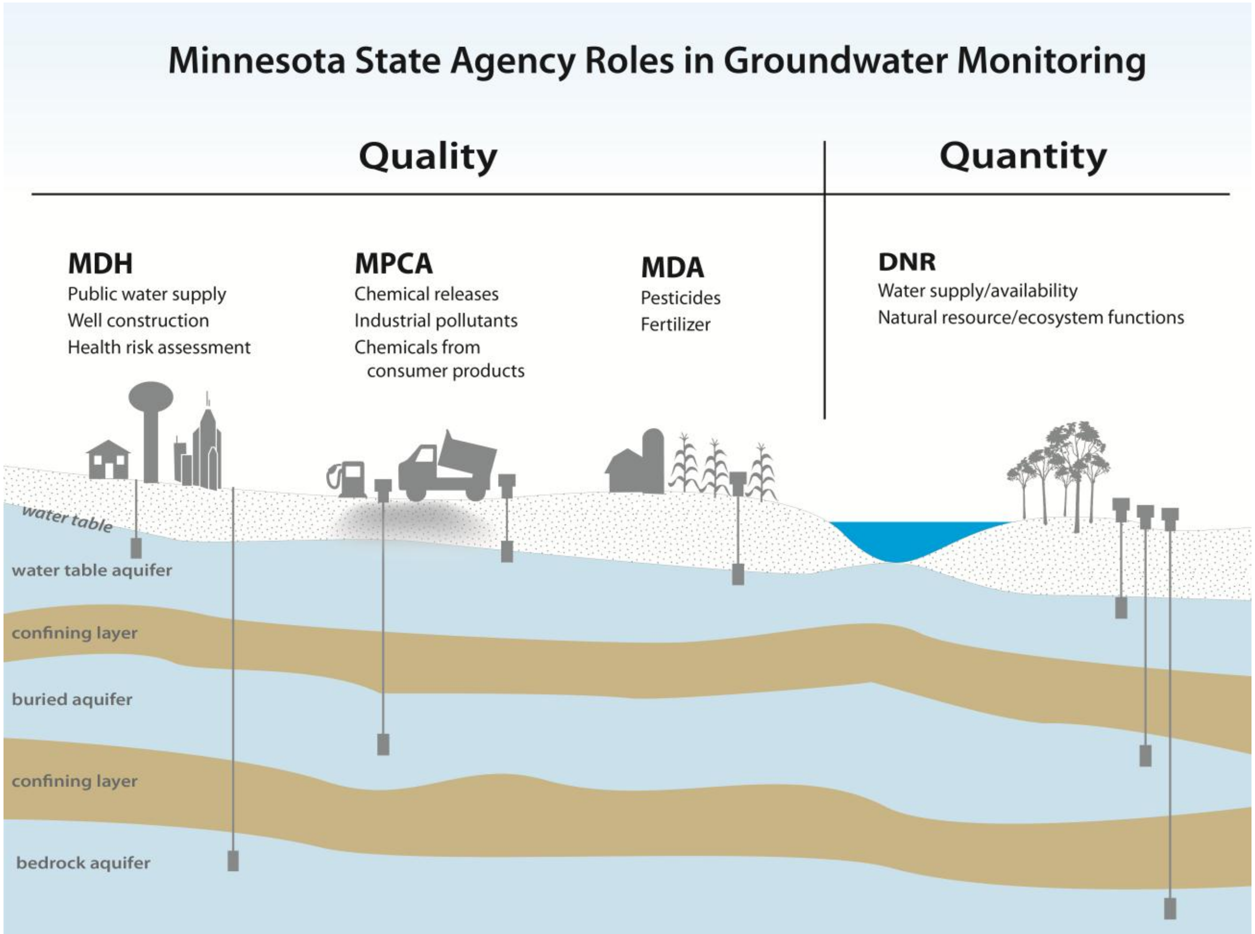


Figure 1. State agency roles in groundwater monitoring [Graphic courtesy of the MDNR].

3. Water Quality Monitoring and Assessment

Between 2010 and 2015, groundwater quality monitoring in Minnesota mainly was conducted by state agencies in partnership with local entities and the federal government. The following sections provide more detail about these monitoring activities.

3.1. National Water Quality Monitoring

The federal government operated two separate national-scale groundwater monitoring programs from 2010-2015: the National Water Quality Assessment (NAWQA) program and the National Groundwater Monitoring Network (NGWMN). The NAWQA program is operated by the U.S. Geological Survey (USGS). The NGWMN is a new national-scale monitoring effort that was fully implemented during this period by the Subcommittee on Groundwater of the Federal Advisory Committee on Water Information (ACWI). The ACWI is a committee that advises the federal government on the effectiveness of the current national programs to meet water information needs. The major differences between the NAWQA program and the NGWMN are described in the following paragraphs.

The USGS's NAWQA program provides an understanding of the nation's water-quality conditions, whether water quality conditions are getting better or worse, and how human activities and natural features affect water quality conditions. The NAWQA program collects data within select study units, which are not located in every state. This program has sampled over 200 wells in Minnesota since 1991 and currently samples 17 wells in the Upper Mississippi River Basin biennially for trend assessments (USGS 2015).

The NGWMN provides information needed for planning, management, and development of groundwater supplies to meet current and future needs and ecosystem requirements. The NGWMN differs from the NAWQA program in that it focuses on the principal and major aquifers of the United States; these are the primary aquifers used for potable water supplies. Additionally, the NGWMN will use information from all 50 states. The NGWMN generally does not collect new information. Instead, the network typically uses data that already is collected by the states, tribes, and other local units of government. The NGWMN initially was developed using data from five pilot studies, one of which was jointly conducted by the MPCA and MDNR (MacDonald and Kroening, 2011). In 2015, the NGWMN received federal funding to encourage other partners, including those in Minnesota, to participate in the network and for the long-term operation and maintenance of the network.

3.2. Statewide Water Quality Monitoring

The MPCA and MDA continued statewide ambient groundwater quality monitoring during 2010-2015. This monitoring still focused on aquifers that are vulnerable to anthropogenic (manmade) contamination from the land surface. Monitoring groundwater in vulnerable aquifers increases the likelihood that human impacts on groundwater quality will be detected within a reasonable time frame. The MPCA ambient monitoring efforts were conducted in non-agricultural areas of the state with a majority of samples collected in quaternary (glacial) sand and gravel aquifers. The MDA monitoring focused on agricultural regions in quaternary sand and gravel aquifers, with additional samples collected from springs in the southeastern part of the state where little or no quaternary deposits are present. The locations for ambient monitoring wells for both of these programs are shown in Figure 2.

MDH water-quality monitoring efforts continued to focus on assessing public water supplies, which often utilize groundwater. The MDH facilitated the water quality sampling of the state’s finished drinking water in cooperation with the public water supply systems to determine contaminant concentrations as part of the Safe Drinking Water Act regulations.

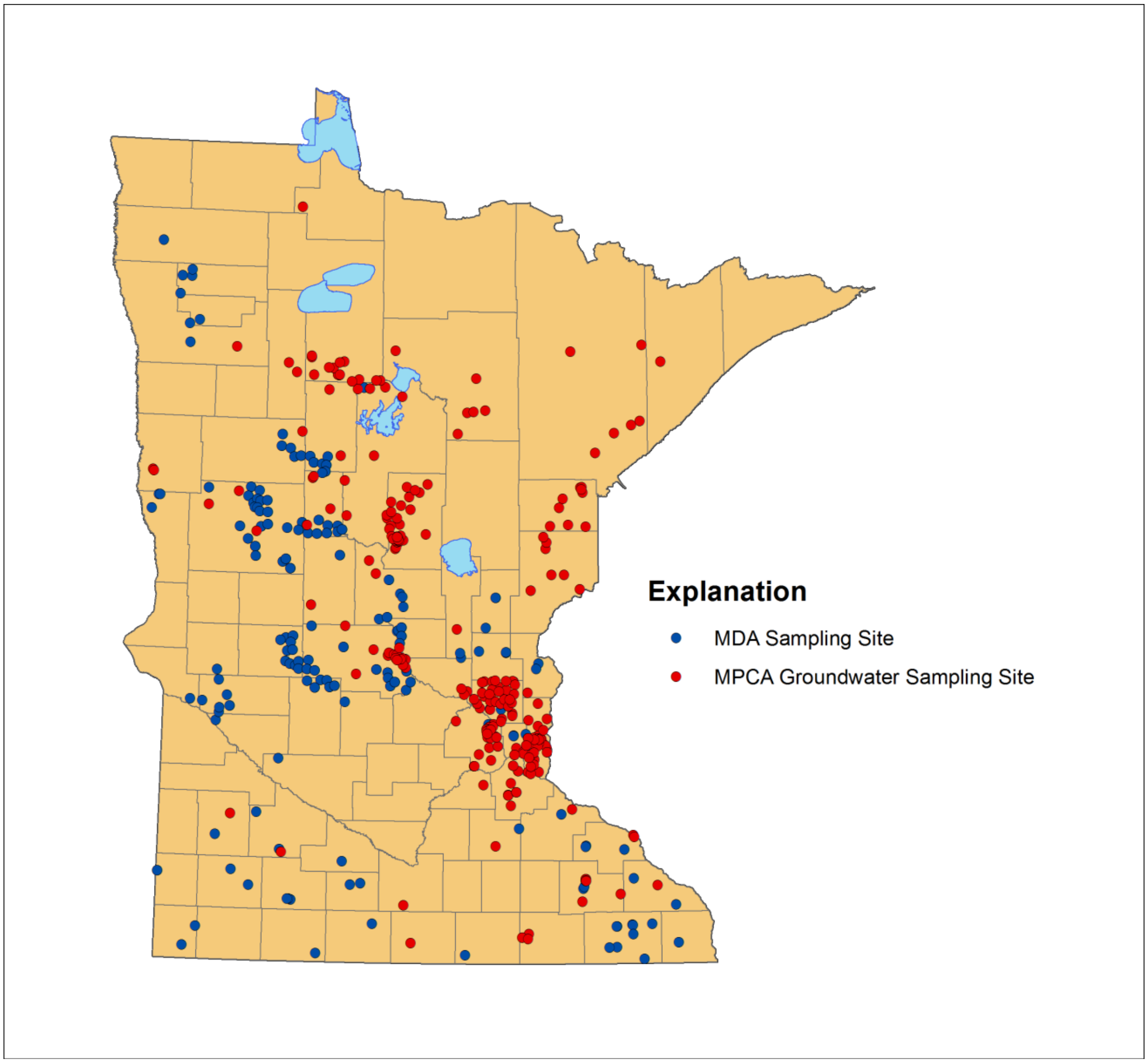


Figure 2. Statewide Ambient Groundwater Monitoring Well Networks maintained by the MPCA and MDA.

3.2.1. Minnesota Pollution Control Agency

The MPCA currently monitors a network that includes almost 250 wells, which are located mostly in typical urban settings. The majority of the wells are sampled to provide an early warning of groundwater contamination within different urban land use settings. This allows the agency to better understand how groundwater quality varies with land use and quickly detect any changes over time. The early warning network wells intersect the water table and are located in commercial/industrial and residential areas served by centralized sewer systems and subsurface sewage treatment systems. The agency also samples some deep wells in areas vulnerable to groundwater contamination; these primarily are domestic wells that supply water to private residences.

Since 2010, the MPCA has enhanced its early warning network wells. This network originally was developed in 2004 solely using existing wells to minimize costs. Most monitoring wells originally sampled by the MPCA's network were installed for the purposes of remedial investigations; the wells that were installed "upgradient" of the suspected contamination (usually a few hundred feet) were also used for ambient monitoring to minimize network installation costs. Using remediation wells resulted in a bias towards detecting gasoline-related volatile organic compounds in surficial aquifers and likely was not representative of ambient groundwater conditions. The network enhancements focus on the groundwater quality underlying vulnerable, shallow sand and gravel aquifers to provide an early warning of groundwater contamination. The well installation associated with these network enhancements is nearly complete, and almost 140 new monitoring wells have been added to the MPCA's network since 2010.

MPCA staff test the groundwater contained in these wells each year for over 100 chemicals, including nutrients, inorganic compounds, volatile organic compounds, and CECs, such as prescription and non-prescription medicines and chemicals in commonly-used household products. Assessing CECs in the groundwater is part of the MPCA's larger efforts to determine the occurrence, distribution, sources, and fate of these contaminants in the hydrologic system.

The MPCA Sentinel Lakes Groundwater Monitoring Network is an offshoot of the larger ambient monitoring network, and is focused on the movement of groundwater near lakes enrolled in the MDNR's SLICE program (Sustaining Lakes in a Changing Environment). These lakes are called Sentinel Lakes and represent the state's most common aquatic environments. The MDNR is studying the lakes to develop management approaches that can reduce and mitigate negative of agriculture, residential development, invasive species and climate change. By placing monitoring wells next to selected Sentinel Lakes, the MPCA can better understand the interaction of groundwater and surface water, contribute to the MDNR project, and help protect these important resources.

Thirteen wells have been installed next to Sentinel Lakes from 2012-2015 in St. Louis, Stearns, Blue Earth, and Lincoln Counties. Transducers have been placed in all wells to collect continuous records of barometric pressure, groundwater temperature, and groundwater elevation. The land use near the monitored lakes selected ranges from farming country with a high density of large capacity groundwater irrigation systems, to isolated north country lying entirely within the boundaries of a state park. The data collected from this monitoring effort has been used to build groundwater models, augment groundwater reviews of selected watersheds, and highlight the relation between groundwater use, lake levels, and quality.

The MPCA also is conducting a three-year study to determine the occurrence of CECs in the shallow groundwater near large subsurface treatment systems and rapid infiltration basins receiving wastewater effluent. The study also will evaluate CECs in the shallow groundwater at a land application site receiving wastewater and solids from domestic septic systems. The project is a collaborative study with the USGS that complements ongoing CEC monitoring being conducted by the MPCA's Ambient Groundwater Monitoring Program. The data from this project will help explain the occurrence of CEC detected in areas of the state where no identified sources of CEC are known to be present and evaluate the effectiveness of MPCA program best management practices designed to prevent groundwater contamination.

In addition to monitoring ambient groundwater conditions, the MPCA continues to collect groundwater quality information at contaminant spill and release sites, permitted landfills, and land treatment facilities. The MPCA remediation programs alone have investigated a cumulative total of 22,321 sites with the main focus of protecting groundwater resources. Approximately 1,798 of these sites have ongoing corrective actions, many of which include groundwater monitoring. Petroleum product spill sites and voluntary investigation and cleanup sites (brownfields) make up the majority of these sites, followed by Superfund, Resource Conservation and Recovery Act (RCRA), and closed landfills. The most common contaminants detected at remediation sites are volatile organic compounds and major and trace inorganic elements.

3.2.2. Minnesota Department of Agriculture

The MDA began monitoring groundwater in November of 1985 and redesigned its network in 1998. New wells were installed in 1999, and the MDA began sampling these wells in 2000, shown as blue dots on Figure 2. Wells were first installed in the vulnerable aquifers located in the central sand plains (Pesticide Management Region 4 (PMR 4) for the purpose of tracking trends over time. Monitoring of other PMRs of the state began in 2004 that included sampling of naturally occurring springs in the southeast portion of the state PMR 9. In 2009 natural spring monitoring was augmented with the sampling of domestic drinking water wells. Groundwater in the north central and northeastern part of the state are not currently monitored due to very limited agricultural production in these heavily forested regions.

The MDA collected samples from 167 wells and springs in 2014. Of the total sites, 142 were monitoring or observation wells, 13 were private drinking water wells, and 12 consisted of naturally occurring springs emerging from karst bedrock formations in southeastern Minnesota. All of the locations are considered sensitive to contamination from activities at the surface (MDA 2014).

The MDA also manages a remediation program which oversees the collection of a large volume of groundwater quality information from contaminant spill and release sites. Over 700 sites have been investigated and one of the main priorities of these investigations is to protect groundwater resources. Soil corrective actions are completed at most sites, and groundwater monitoring is completed at many of these sites. Typical sites include agricultural chemical storage and distribution cooperatives in rural Minnesota, agricultural chemical manufacturing facilities and wood treating facilities. Groundwater monitoring also is conducted at sites managed by the MDA, including the former Kettle River Creosoting Company site in Sandstone, Minnesota. Common constituents that are monitored at MDA remediation sites include fertilizers, herbicides and insecticides and wood treatment compounds

The revised Nitrogen Fertilizer Management Plan outlines a new Township Testing Program (TTP) designed to identify the agricultural areas with the elevated nitrate concentrations in in groundwater. Townships with greater than 20% row crop agriculture and vulnerable groundwater will be sampled. All private wells in these townships will be offered a free nitrate test and the results summarized and prioritized for further action.

3.2.3. Minnesota Department of Health

The MDH continues to facilitate the monitoring of public water supplies across the state as required by the Safe Drinking Water Act. There are roughly 1,000 community public water supply systems in the state and an additional 5,900 non-community public water systems. MDH estimates a total of 4 million or 74% of the state's population relies on groundwater for drinking water.

The MDH routinely monitors public water supply systems for a number of different contaminants, including pesticides and industrial compounds, bacterial contamination, nitrate/nitrite, radioactive elements (radium), disinfection by-products, arsenic, lead, copper, and other inorganic chemicals. MDH reviews monitoring results to determine if they meet applicable federal or state drinking water standards. In the event of an exceedance, the people who use the water are notified and appropriate steps are taken to correct the problem.

The MDH reviews nitrate/nitrite, coliform bacteria, and arsenic data collected by well drillers from newly installed private drinking water wells to determine the potability of the water. Approximately 20% of Minnesotans are served by private water systems (almost entirely wells). State regulations, administered by the MDH, require licensed water well contractors (and anyone constructing a new well for personal use) to have the water from each new drinking water well tested once for arsenic.

The MDH continues to administer the state's Wellhead Protection Program which is designed to protect drinking water from sources of contamination. Public water supply systems serving places where groups of people live (municipalities, subdivisions, etc.) or spend much of their time (offices, schools, etc.) are required to develop and implement wellhead protection plans. MDH reviews, approves and audits the 10-year plans.

3.3. Statewide Water Quantity Monitoring and Assessment

The MDNR and Metropolitan Council continued statewide and regional groundwater quantity monitoring and assessments during 2010-2015. The MDNR conducted statewide groundwater level monitoring and developed more county-scale groundwater sensitivity maps during this period. The Metropolitan Council continued its work with regional water-supply planning, which included groundwater flow modeling.

3.3.1. Minnesota Department of Natural Resources

The MDNR maintains a groundwater level monitoring network across the state with approximately 1,000 wells in the statewide network. Data collected from the network is used to assess groundwater resources, determine long-term trends in water levels, interpret impacts of pumping and climate, plan for water conservation, and evaluate water conflicts. Traditionally, the MDNR has measured water levels monthly in cooperation with soil and water conservation districts or other local units of government. The MDNR is converting to a system with "continuous" water level monitoring; using in-well recording devises which record readings every 15 minutes.

Water level monitoring is also conducted at approximately 400 locations associated with groundwater appropriate permits. Information from these wells helps inform if pumping of groundwater is causing adverse impacts to surface water features or other water users. An ongoing water supply planning effort is guiding establishment or improvement of monitoring plans for all 650 public water suppliers.

Since 1995 the MDNR, in collaboration with the Minnesota Geological Survey (MGS) has produced county geologic atlases. The MDNR part of this atlas series (Part B) have been recently completed for Carlton (2011) Benton (2012), McLeod (2013), Carver (2014), and Chisago (2015) Counties. Atlases for Blue Earth, Sibley, Nicollet, Anoka, Renville, Wright, Sherburne, Clay, Morrison, Houston, and Winona are currently underway. As a part of all these projects, groundwater sampling is done at selected wells to support groundwater sensitivity mapping. Approximately 90 wells are sampled in each investigated county to determine major ion and trace element concentrations. In addition, tritium values, and values of oxygen and hydrogen stable isotopes, are evaluated to help understand groundwater recharge rates and possible surface water body sources, respectively. Additional groundwater samples are collected from 10 wells in each county for analysis of carbon-14 age dating at locations and in aquifers that likely have very old water in the range of thousands to tens of thousands of years.

The MDNR is implementing a plan to improve groundwater level monitoring in the greater Twin Cities Metropolitan Area. This monitoring is necessary to address the ever increasing demands on groundwater resources in this area. The report titled *Plan to Develop a Groundwater Level Monitoring Network for the 11-County Metropolitan Area* (MDNR 2009) is based on the NFGWM and identifies the long-term needs for monitoring to understand aquifers and groundwater movement in the region. This network informs groundwater protection activities, helps reduce water quality degradation, and ensures that water use does not harm ecosystems.

Special MDNR projects included an Environment and Natural Resources Trust Fund (ENRTF) funded aquifer investigation of the shallowest Mount Simon aquifer areas to better understand the physical and recharge characteristics of this important aquifer. The report and companion video were completed in 2013.

In 2014, also with funding from the ENRTF, two other special projects were initiated: the Minnesota Hydrogeologic Atlas (MHA), and Phase 1 of the State Spring Inventory. The purpose of the MHA project is to combine legacy county–scale maps of various hydrogeologic themes supplemented with some newly created information into a single state-wide layer. When completed, the hydrogeologic maps will include near-surface pollution sensitivity, pollution sensitivity for the top of bedrock surface (selected counties in central and southeastern Minnesota only), water table elevation, and water table depth. These compilations should increase the usefulness of these maps for projects and users that span county boundaries for regional or watershed-based evaluations.

The purpose of the Spring Inventory Project – Phase 1 is to devise best methods for researching and compiling legacy spring location and description data and verifying field locations. Springs are critical resources in Minnesota and occur all across the state. They create cold water and cool water fisheries, sustain base flow in streams, and create unique habitats. In order to maintain their flows, it is vital to inventory, assess, and monitor them on a comprehensive, statewide basis. When completed, this Phase 1 project will produce a new in-progress version of state-wide spring locations, a spring inventory guidance document, and a geographic information system database.

3.3.2. Metropolitan Council

At the direction of the Minnesota Legislature, the Metropolitan Council began a regional water supply planning effort in 2005. Five years of community outreach, data collection, and technical analysis culminated in the development and approval of the seven-county Twin Cities Metropolitan Area Master Water Supply Plan. After completing the Master Water Supply Plan in 2010, the Council continued to partner with state agencies, private consultants, and communities to complete several technical and outreach projects that strengthen regional and local water supply planning efforts, including better integration of water supply planning and local comprehensive planning. The 2015 update of the Master Water Supply Plan incorporates new technical information and feedback from many stakeholders, and it reflects changes to the regional development framework, Thrive MSP 2040, and the Water Resources Policy Plan. Most notably, the update incorporates new data and information that has been collected since 2010 and is available on the Council website:

- New Metropolitan Council population forecasts
- Metropolitan Council analysis of groundwater and surface water relationships
- MGS mapping of the vulnerability of bedrock aquifers to flow through glacial sediments
- Aquifer tests by the MDH based on data collected through community source water protection programs since 2009
- New surface water and groundwater level monitoring data from the MDNR
- Water supply alternative feasibility assessments conducted by Metropolitan Council in partnership with communities
- Updated regional groundwater flow model (Metro Model 3)

Tools including the revamped Water Conservation Toolbox and Stormwater Reuse Guide are available to help communities meet water supply challenges. Subregional water supply planning groups and the Metropolitan Area Water Supply Advisory Committee will help guide future efforts to plan for the region's water supply well into the twenty-first century.

3.4. Current and Emerging Groundwater Quality Issues

3.4.1. Nitrate

Nitrate continues to be one of the state's main groundwater quality issues, especially since a few communities have spent millions of dollars to ensure their water supplies do not contain excessive levels of this chemical. Most groundwater quality monitoring in the state includes a nitrate analysis and these data were summarized in several recently-published reports.

An assessment by the MPCA (Kroening and Ferrey 2013) found that nitrate concentrations in the state's shallow groundwater still vary with land use. This assessment was based on data collected from 2007-2011. In agricultural areas, the median concentration in the groundwater near the water table was about 9 mg/L; whereas, the median concentration in the shallow groundwater underlying various urban land uses ranged from 2-3 mg/L.

The MPCA assessment also noted that the shallow sand and gravel aquifers, which usually are the uppermost aquifer in most parts of the state, contained the highest nitrate concentrations. In central Minnesota, about 40% of the shallow sand and gravel aquifer wells that were tested contained nitrate concentrations that were greater than the Maximum Contaminant Level (MCL) of 10 mg/L set by the U.S. Environmental Protection Agency for drinking water. Groundwater data collection was more limited in southwestern Minnesota. However, the available data suggests that about 20% of the tested wells contained nitrate concentrations that exceeded the MCL.

Trends in nitrate concentrations in the groundwater also were quantified as part of the MPCA groundwater quality assessment. The data from almost 90 wells across the state, which primarily tapped the shallow sand and gravel aquifers, were tested for trends as part of this study. The nitrate concentrations in most of these wells had no significant change from the late 1980s to the present.

The MDA initiated two large monitoring efforts to assess nitrate concentrations in private wells across the state. The Central Sands Private Well Network started in 2011 and samples domestic wells in 14 counties in central Minnesota. The TTP was started in 2013 and assesses nitrate concentrations in private wells in selected counties on the township scale.

The MDA's Central Sands Private Well Network testing indicated that only a small percentage of the tested domestic wells in central Minnesota had nitrate concentrations that exceeded the MCL. Of the 1,555 wells tested in 2011, only 4.6% of the wells had a nitrate concentration that exceeded the MCL of 10 mg/L (Kaiser 2012). Almost 89% of the wells had a concentration that was less than 3 mg/L. The measured concentrations varied by county. The highest percentage of wells with nitrate concentrations exceeding the MCL was in Morrison County. In contrast, no tested wells had nitrate concentrations exceeding the MCL in Cass, Crow Wing, and Douglas Counties. Not surprisingly, almost one-half of the wells with nitrate concentrations greater than the MCL were shallow, less than 50 feet deep.

The nitrate data collected by the MDA's TTP further defined the extent of the high concentrations in the groundwater in selected counties in central Minnesota and other parts of the state. For this program, water samples from private wells in townships in Benton, Dakota, Morrison, Olmsted, Sherburne, Stearns, Wadena, and Washington Counties were collected in 2013 and 2014 (MDA 2015). Overall, the preliminary results from this testing indicated that 13% of the tested wells had a nitrate concentration that exceeded the MCL. Similar to the results from the Central Sands Private Well Network, nitrate concentrations also varied among the sampled townships. The preliminary results from this network showed that the percentage of wells with concentrations that exceeded the MCL ranged from 0% in North Folk Township in Stearns County to 52% in Agram Township in Morrison County (MDA 2015). The MDA will resample the wells that had nitrate concentrations greater than 5 mg/L using professional staff. These wells also will be assessed for obvious well construction issues and point sources of nitrate, such as subsurface sewage treatment systems and livestock.

USGS and MDH investigations studied some of the factors that affect nitrate concentrations in the groundwater. The USGS conducted a statistical analysis of the factors that affect nitrate concentrations in private wells in the sand and gravel aquifers (Warner and Arnold 2010). The age of the groundwater and changes in the oxidation/reduction potential with depth were found to be important factors affecting nitrate concentrations. The MDH (2012) assessed the factors affecting nitrate concentrations in the aquifers in southeastern Minnesota using information collected by the Southeast Minnesota Domestic Well Network. This investigation found that wells completed in carbonate bedrock aquifers were more likely to have moderate to high nitrate concentrations compared to those measured in wells completed in other types of aquifers. The nitrate concentration in the private wells also was strongly affected by the presence of materials that give natural geologic protection, such as shale or clay-rich glacial till. Well construction also was found to affect the measured nitrate concentration. The presence or absence of a grout seal in the well was examined by the MDH. About 20% of the wells lacking a grout seal produced water with nitrate concentrations that were greater than the MCL. In contrast, none of the wells that had the grout seal had a concentration that exceeded the MCL.

3.4.2. Chloride

Chloride contamination could affect the potability of some of the state’s groundwater in the future. This water-quality issue was first brought to light about a decade ago when investigators documented high concentrations in the state’s streams, lakes, and groundwater (Novotny et al 2007 and Wenck et al 2006). Stefan et al (2008) found that most of the chloride applied in the Twin Cities Metropolitan Area (TCMA) is either transported to the groundwater or remains in the area soils, lakes, and wetlands.

A recent statewide assessment by the MPCA found that the groundwater in the shallow sand and gravel aquifers in the TCMA is impacted by high chloride concentrations (Kroening and Ferrey 2013). This investigation determined that the median chloride concentration in the sand and gravel aquifers underlying the TCMA was 86 mg/L, which was about five times greater compared to the aquifers in the rest of the state, and concentrations as high as 8,900 mg/L are in some shallow wells in the TCMA. A substantial number of wells had concentrations that exceeded the secondary maximum contaminant level of 250 mg/L Twenty-seven percent of the wells installed in the sand and gravel aquifers in the TCMA had concentrations that exceeded the secondary maximum contaminant level; whereas, very few wells outside of this area contained water that exceeded this standard.

Salt application in urban areas affected chloride concentrations in the groundwater. Chloride concentrations were significantly greater in groundwater underlying urban land compared to those underlying undeveloped parts of the state. The water from the majority of the wells in the shallow sand and gravel aquifers underlying the TCMA also had a chemical signature that was consistent with halite, which typically is applied to de-ice roadways during the winter in Minnesota. The data analysis by the MPCA suggested that groundwater with chloride concentrations greater than 30 mg/L often originated from halite.

Chloride concentrations were found to have increased in about one-third of the wells that had sufficient data for trend analysis. In some wells, concentrations have increased by about 100 mg/L in the last 15-20 years. Most of the wells with increasing trends were shallow and tapped the sand and gravel aquifers, but increasing concentrations were found in two deep wells in the TCMA. If these trends continue, the water from more wells likely will have concentrations that exceed the MCL in the future.

These results were consistent with national-scale assessments of chloride trends in the groundwater. In 2012, the USGS released a report summarizing the decadal-scale changes in chloride across the U.S. from the late 1980s until 2010 (Lindsey and Rupert 2012). In this report, chloride trends were assessed by sampling network. One of the most notable results in this report were that chloride concentrations increased in almost 50% of the assessed networks, and a network of wells in Minnesota had a significant increase in chloride concentrations, with a median concentration change of greater than 20 milligrams per liter.

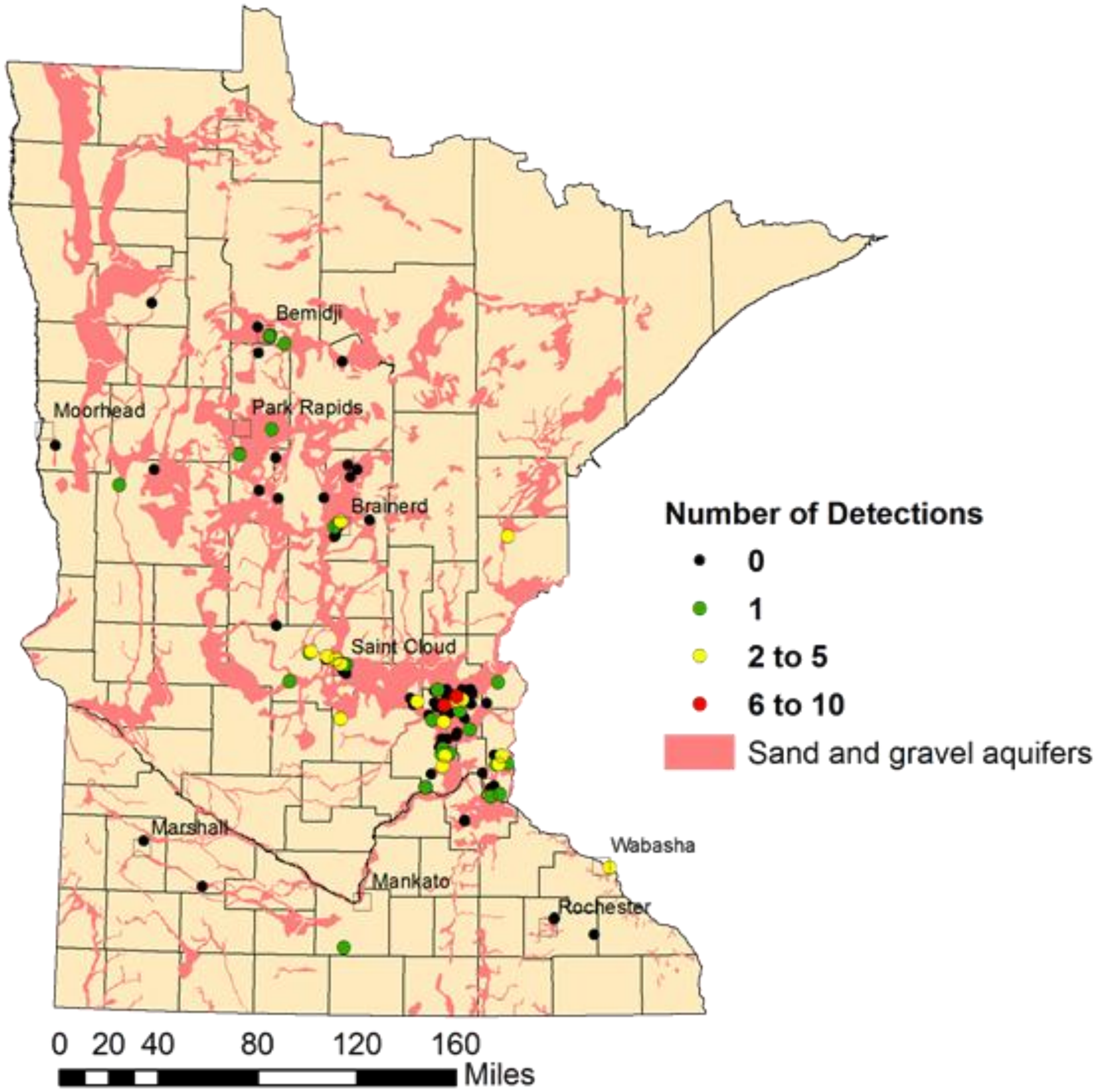
3.4.3. Contaminants of Emerging Concern

The MPCA continued to investigate the extent of any contamination from CECs in the ambient groundwater, such as prescription and non-prescriptions medications and chemicals in commonly-used personal care products. From 2009-2014, the agency sampled over 200 wells in its monitoring network for a large suite of CECs. From 2009-2014, this monitoring was conducted in cooperation with the USGS. In 2015, the MPCA contracted with AXYS Analytical Laboratories in British Columbia, Canada to analyze for CECs in the groundwater samples collected for its network. This change was made to align the agency’s groundwater and surface water monitoring activities.

The CEC data collected in the groundwater across the state from 2009-2012 was interpreted in a USGS report (Erickson et al 2014). Overall, 35 different CECs were detected in the ambient groundwater samples collected for this study. The greatest number of CEC detections in any individual groundwater sample was 10 (Figure 3). Three wells, located near closed landfills, were sampled as part of this study; the greatest numbers of CECs were detected in these wells. The CEC concentrations measured in this study generally were low; no concentrations exceeded any established human-health guidance values.

The antibiotic sulfamethoxazole was the more frequently detected CEC in the ambient groundwater. This chemical was detected in about 11% of the analyzed samples. Most detections of sulfamethoxazole were in samples from domestic wells or monitoring wells located in residential areas. The insect repellent N, N-Dimethyl-meta-toluamide, commonly known as DEET, was detected at the highest concentration in the groundwater, 7.9 micrograms per liter. Bisphenol A was the second most frequently detected chemical.

Figure 3. Number of Contaminants of Emerging Concern detected in ambient groundwater wells in Minnesota, 2009-2012.



4. Groundwater Data Access and Management

Data from the MPCA's ambient groundwater monitoring network, previous monitoring efforts, and the open, closed, and demolition landfills are available on the MPCA's website through the Environmental Data Access (EDA) system. The EDA system was developed to improve access to environmental data and is available at the following web address (URL): http://www.pca.state.mn.us/index.php/data/environmental-data-access.html. The MPCA's and MDA's ambient groundwater information also is available through the EPA's Water-Quality Exchange http://www.epa.gov/storet/wqx/.

The MPCA and MDA now store the groundwater quality data that they each collect in the same database. The database is commercially available from EarthSoft Inc. and called the Environmental

Quality Information System or EQuIS. The DNR's County Well Atlas Program also is in the process of transitioning the storage of their groundwater quality data to this same database. The EQuIS database is managed as follows. A MnIT staff person serves as the EQuIS database administrator, and both the MPCA and MDA employ separate data coordinators to assist the data users in managing the information. The storage of these large sets of groundwater quality in the same database greatly simplifies regional or statewide analysis of groundwater quality conditions since the data are now stored in the same format. The MDH Environmental Laboratory, which analyzes a large number of the samples collected by the MPCA, also modified their systems and processes so the MPCA can easily store the data generated by the MDH laboratory in EQuIS.

5. Needs and Conclusions

The ambient monitoring conducted by the MPCA, MDA, and others, continues to provide valuable, long-term information on the water-quality conditions in aquifers vulnerable to contamination across Minnesota. As the demands for the state's groundwater increase, this record of groundwater quality will become increasingly important for the proper use and management of this resource. A long term commitment to the collection and analysis of groundwater data is necessary to identify changes in water quality and quantity over time and provide information needed to effectively manage and protect this critical resource. Groundwater movement is generally slow and often requires years of monitoring to assess the trends and impacts of human activities on this resource.

Recent groundwater quality assessments indicated that the chloride levels in the state's groundwater need to be watched. The high chloride concentrations present in some aquifers, especially in the shallow ones in the TCMA, either will be discharged into streams and lakes, or this chloride-laden groundwater will move downward into the deep aquifers that supply the state's drinking water. The inflow of groundwater containing chloride concentrations that exceed the chronic water-quality standard (230 mg/L) to streams may cause any chloride impairments to occur during baseflow conditions as well as during the usual winter period. Recent assessments have indicated that chloride concentrations have increased over time in the TCMA, in the shallow as well as parts of some bedrock aquifers. If these trends continue, more bedrock aquifer wells may be impacted by chloride in the future, and the water eventually may become unsuitable for drinking. There are some existing gaps in chloride monitoring that should be filled. A large amount of the groundwater monitoring in the TCMA focuses on conditions at the water table. Additional deep wells should be installed to track how the depth to which chloride has penetrated into the groundwater system.

Nitrate concentrations in the state's groundwater also should continue to be watched, especially since some communities have had problems with high concentrations in their water supplies. The state's ambient monitoring networks should continue to monitor for nitrate in the groundwater, and MDA's two relatively new nitrate-testing programs, the Central Sand Private Well Network and Township Testing Program, should continue to be funded to complete this important work.

The presence of CECs in the groundwater also bears watching. Even though monitoring to date has found these chemicals are low in concentrations, it still is important to assess the presence of these chemicals because this monitoring identifies chemicals in the groundwater for which there are relatively few available human-health guidance values. Similarly, efforts by the MDH to develop human-health guidance values for these chemicals are invaluable because it allows scientists to determine whether the presence of these chemicals makes water unsuitable for drinking.

6. References

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