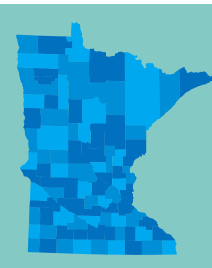
Water quality

September 2025

Appendix A: Five-year Assessment of Water Quality Trends and Prevention Efforts

MINNESOTA POLLUTION CONTROL AGENCY



Prepared by:

Jeff Berg, Kim Kaiser, Matt Ribikawskis, Brennon Schaefer, Dave Tollefson (Minnesota Department of Agriculture, Pesticide and Fertilizer Management Division) Sharon Kroening, Erik Smith, Eileen Campbell Michael Bourdaghs (Minnesota Pollution Control Agency, Environmental Outcomes and Analysis Division) for the Minnesota Environmental Quality Board.

Minnesota Pollution Control Agency
520 Lafayette Road North,
Saint Paul, MN 55155-4194
http://www.pca.state.mn.us
651-296-6300 or 800-657-3864

Minnesota Dept. of Agriculture
625 Robert Street North,
Saint Paul, MN 55155-2538
http://www.mda.state.mn.us
651-201-6141 or 800-967-2474

Minnesota Pollution Control Agency | Minnesota Department of Agriculture

520 Lafayette Road North | Saint Paul, MN 55155-4194 |

651-296-6300 | 800-657-3864 | Or use your preferred relay service. | Info.pca@state.mn.us

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Contents

Tables

Figures

Introduction and Executive summary

This Minnesota Pollution Control Agency (MPCA) and the Minnesota Department of Agriculture (MDA) water quality assessment provides an overview of relevant monitoring data and efforts to reduce, prevent, minimize, and eliminate sources of water pollution to Minnesota's groundwater and surface water resources. This report consolidates information from a number of the most recent reports on the status and trends of Minnesota's water resources. Because of the large amount of information available on this subject, this report is summary in nature and directs the reader to additional information provided through web-based links.

The report was last published in September of 2020 as Appendix A: Five-year Assessment of Water Quality Trends and Prevention Efforts, in conjunction with EQB's 2020 State Water Plan: Water and Climate

This report includes much of the work completed as part of the Clean Water, Land and Legacy Amendment (Clean Water Fund) investment, which includes the Minnesota's Clean Water Roadmap and the 2020 Clean Water Fund Performance Report. These two reports represent the efforts of six state agencies and the Metropolitan Council, receiving Clean Water Funding, to set long range goals to protect, enhance, and restore the state's water resources. Information on groundwater quality is presented first, highlighting nitrates, pesticides, arsenic, chlorides, and contaminants of emerging concern. The groundwater information is followed by descriptions of the efforts to prevent and eliminate groundwater degradation through program activities conducted by the MPCA and MDA.

Surface water quality information is presented next by water resource type (lakes, streams, and wetlands) and emphasizes the status and trends of Minnesota's surface water quality. Lake transparency data, pesticide detections, trends in water quality indicator parameters, and impaired waters listings are presented to highlight Minnesota's surface water quality condition.

For both groundwater and surface water, efforts to reduce and minimize resource degradation involve multiple program activities conducted by the MPCA and MDA. Efforts summarized in this report include the Pesticide and Fertilizer Registration and Outreach Programs, Agricultural and Pesticide Best Management Plan Programs, Nitrogen Fertilizer Management Plan, Clean Water Partnership Program, regulation of wastewater discharges and Subsurface Sewage Treatment Systems (SSTS), Animal Feedlot Program, Stormwater Program, and MDA and MPCA monitoring and assessments efforts.

Within the last 20 to 30 years, most of the pollution originating from point sources (municipal and industrial facilities discharging to state waters) has been controlled, largely due to remediation programs, pollution prevention activities, and permit regulations. Water quality is mainly degraded by the pollutants entering surface waters from non-point sources derived from runoff from land, particularly from watersheds dominated by agricultural and urban land use. This report will focus primarily on non-point sources of pollution of anthropogenic (human) origin that require our continued efforts to realize our state's water quality goals.

It is important to remember that groundwater and surface waters are part of a single, interconnected hydrological system. Therefore, while monitoring assessment and reporting techniques may vary between groundwater, lakes, streams and wetlands, these water resources should not be viewed in isolation from each other.

Overview: Water resources – Benefits of information

The MPCA and MDA conduct water quality assessments to protect the environment and, more specifically, to provide decision makers with good information about the status of water resources, to prevent and address problems, and to evaluate how effective management actions have been. Water quality assessments are also useful in planning and implementing prevention and mitigation efforts to protect water resources, and as a means of tracking the impacts of human activity.

This report provides access to a variety of water quality reports, documents and agency plans, and highlights the status of our water quality resources, in addition to efforts to reduce and minimize water resource degradation.

Five-year water assessments are prepared directly by the agencies and integrated by the Environmental Quality Board (EQB) every five years. The frequency of reports was changed from two- years to five-years in 2015 because groundwater and surface water trends typically do not change within shorter periods of time, thus frequent reporting is not effective or useful. In addition, the five-year cycle ties monitoring results to planning and management efforts via state water planning and is in accordance with Minn. Stat. 103A.43.

Groundwater basics

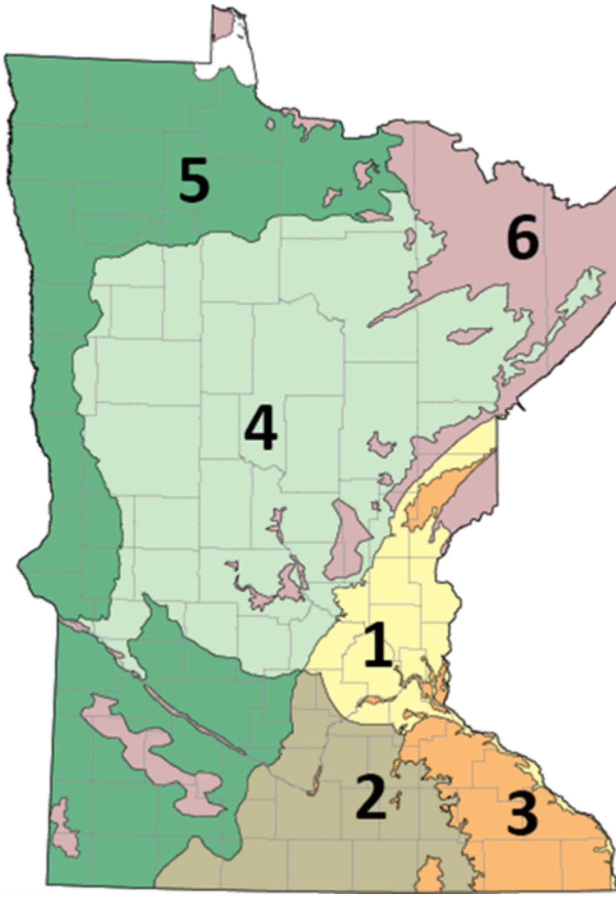
Groundwater provides nearly 75% of Minnesotans with their primary source of drinking water and nearly 90% of the water used for agricultural irrigation (estimated by the Minnesota Department of Health (MDH) and the Minnesota Department of Natural Resources (DNR), respectively). For these reasons alone it is important that we protect, monitor and report on the quality of this valuable natural resource.

The MPCA and MDA collect large amounts of groundwater quality data. Much of this is collected through contamination cleanup or landfill programs and is considered investigation and compliance monitoring. However, data is also collected through ambient or “condition” groundwater monitoring efforts. Ambient monitoring has two primary objectives: to determine the status and quality of the groundwater resources, and to identify trends in water quality over time.

To understand groundwater quality, it is important to recognize that groundwater occurs everywhere in Minnesota within water-bearing soil or rock formations called aquifers (Figure 1). These aquifers create a complex matrix of groundwater resources in many areas of the state that may yield either abundant or very limited water supplies. The water quality in these aquifers is influenced by both natural processes and anthropogenic (human) ones. This report focuses on reporting the ambient condition of groundwater quality in Minnesota as influenced by anthropogenic effects, with less emphasis on natural processes which affect groundwater quality.

Monitoring of Minnesota’s groundwater has identified contamination in many vulnerable aquifers from non-point sources such as agricultural fertilizers and pesticides, urban runoff, manure applications, septic systems, road salt, and stormwater infiltration. The most common contaminants detected include nitrates, pesticides, and, in urban areas, road salt. In addition, chemicals that are not commonly monitored or regulated are being identified at low concentrations in groundwater, including: antibiotics, fire retardants, detergents, and plasticizers. This group of chemicals is referred to as contaminants of emerging concern (CECs) and includes endocrine active chemicals (EACs).

Figure 1. Minnesota groundwater provinces



General availability of groundwater by source			
Prov.	Surficial sands	Buried sands	Bedrock
1	Moderate	Moderate	Good
2	Limited	Moderate	Good
3	Limited	Limited	Good
4	Good	Moderate	Limited
5	Moderate	Limited	Limited
6	Limited	Limited	Limited

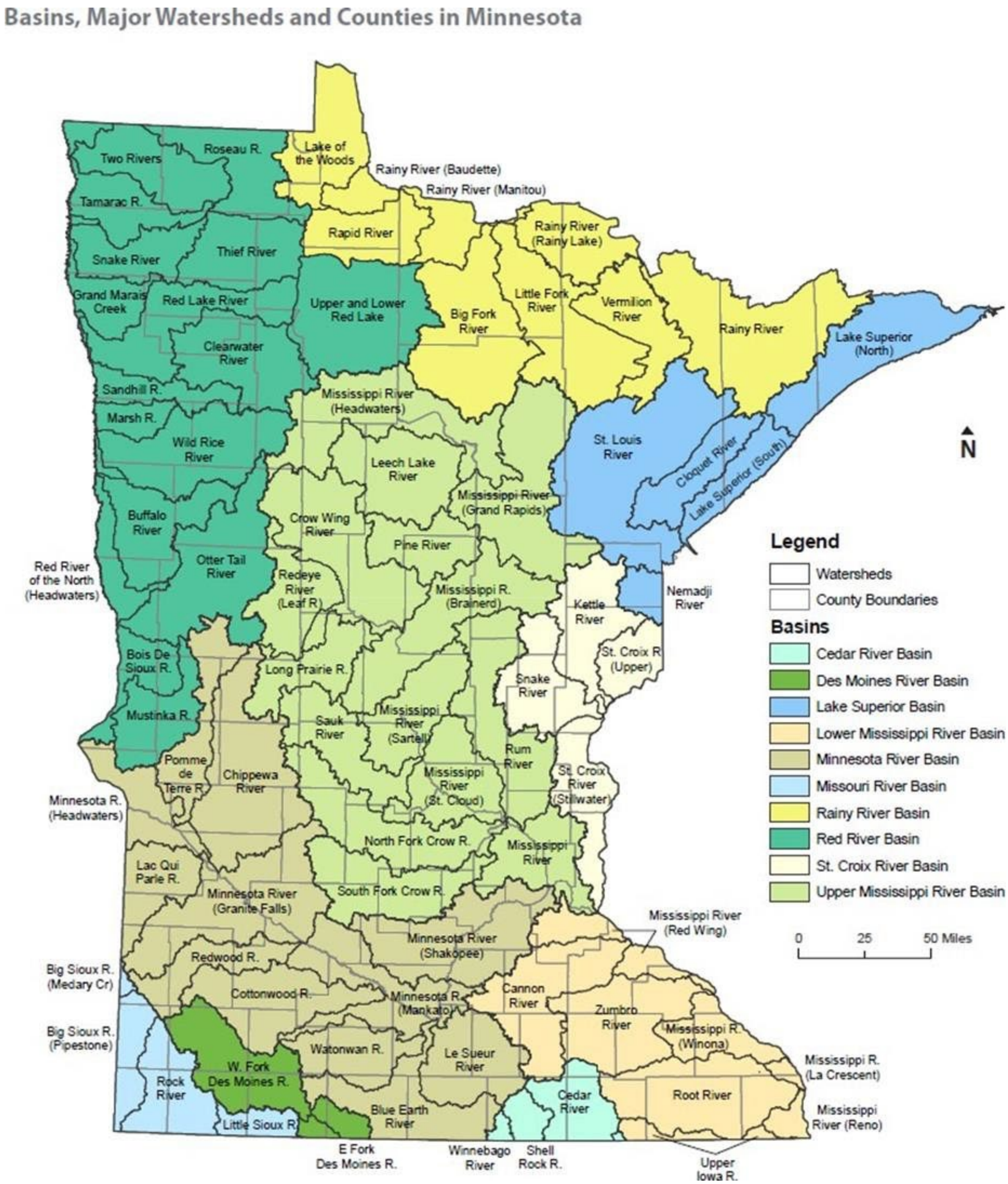
Surface water basics

With more than 10,000 lakes, 100,000-river and stream miles, and about 9.3 million wetland acres, water is a major part of Minnesota's culture, economy, and natural ecosystems. Streams, rivers, lakes, and wetlands are all "surface waters" in Minnesota. State agencies and their partners have an important function in assessing surface waters for contaminants and documenting surface water quality trends.

The MPCA follows a 10-year rotation for assessing waters of the state in Minnesota's 80 major watersheds (Figure 2). This is supplemented by annual monitoring at the outlets of the major watersheds to provide an overview of statewide water quality and identify trends. The first iteration of this monitoring cycle has been completed and monitoring is returning to watersheds in order to track progress towards meeting water quality goals. About 56% of surface waters do not meet basic water quality standards. The MDA focuses on agricultural and urban areas where agricultural chemicals, like pesticides, are used and may impact surface water resources. The MPCA's major watershed approach provides an important unifying focus for all stakeholders.

Minnesota's surface water monitoring has identified that in many vulnerable hydrogeologic settings the source of contamination within a watershed can be attributed to several of the same non-point sources affecting groundwater, e.g., agricultural fertilizers and pesticides, urban runoff, and septic systems, as well as to municipal and industrial wastewater. Some of the most common impacts to surface water come from sediment, phosphorus (agricultural, industrial and residential), coliform bacteria, nitrate, mercury and pesticides. As with groundwater, CECs are commonly being found, even in remote surface waters. Concerns for these pollutants in surface waters include the potential effects of endocrine disrupting compounds that affect aquatic life and reproduction, and human health impacts from bioaccumulation of chemicals, particularly per- and polyfluoroalkyl substances (PFAS), in fish tissue.

Figure 2. Basins, major watersheds and counties in Minnesota



Water quality concerns

Water resource contaminants can come from human or natural sources. Some contaminants, like arsenic, occur due to natural chemical reactions that release them in aquifers. Arsenic can also come from human sources like industrial processes and products. Some contaminants are primarily a concern for groundwater (e.g., nitrate, arsenic and chloride) while others are primarily a concern for surface water (e.g., phosphorus and sediment).

The MPCA and MDA have tracked several key contaminants for years, while other contaminants of emerging concern have recently been discovered, in part due to new analytical capabilities, and are just beginning to be studied. The water quality analyses contained in this summary include both historical key contaminants and those of emerging concern.

Important water resource contaminants reviewed in this summary include: nitrate/nitrogen, chloride, arsenic, pesticides, PFAS, and CECs in groundwater aquifers. The status of surface water quality is reported by water resource (lakes, wetlands, streams) and includes summaries of impairment status and surface water quality trends for several contaminants. Additional information about these and other contaminants can be found in the source documents cited throughout this summary.

The distinction between various groundwater and surface water resources – and their contaminants – can at times be difficult to make, due to the many interactions between lakes, wetlands, streams, and aquifers. However, the statutes that guide MPCA and MDA monitoring and reporting requirements are often aligned along specific water resources and related terms. Thus, while a contaminant may principally be assessed in a surface water resource (e.g., lakes and wetlands), that same contaminant may also move to groundwater resources via infiltration from the surface water body to the aquifer. Similarly, a groundwater contaminant could migrate to surface water through upwelling.

Complicating matters, the impacts to groundwater (drinking water concerns, etc.), and the rate of contaminant degradation in the aquifer may be different from those associated with surface water resources, and subject to unique monitoring methods, spatial and temporal considerations, and risk evaluation.

This report provides an overall picture of water quality with respect to several contaminants, while recognizing statutory requirements for different agencies to monitor and protect specific water resources from specific contaminants.

Groundwater quality: Assessment and analysis

Presented below is information on groundwater quality and trends for select contaminants of known or emerging concern. Additional detail and data for various groundwater monitoring projects and other contaminants in state aquifers and watersheds can be found in on the MPCA groundwater webpage and on the MDA monitoring webpage.

Nitrate/nitrogen

Nitrogen in groundwater is primarily present in the form of nitrate and occurs naturally at low concentrations of less than 1.0 mg/L. Studies of groundwater quality in Minnesota over the last two decades have linked elevated nitrate concentrations to land uses where there are anthropogenic (human-caused) sources of nitrate in combination with vulnerable geology.

Most nitrate which enters groundwater comes from anthropogenic sources such as animal manure, fertilizers used on agricultural crops, failing Subsurface Sewage Treatment Systems (SSTS), fertilizers used at residences and commercially, and nitrous oxides from the combustion of coal and gas. With this array of sources, it is not surprising that nitrate is one of the most common contaminants of groundwater in Minnesota.

Nitrate concentrations in groundwater are monitored by the MPCA and MDA, in urban and rural settings, as a part of their ambient groundwater monitoring programs. The MDA, MPCA, and MDH work collaboratively on a number of fronts to address nitrate contamination and assist state and local efforts aimed at protecting drinking water supplies and preventing further groundwater contamination. Other state and federal agencies such as the DNR and U.S. Geological Survey (USGS) have also generated groundwater nitrate data through county groundwater pollution sensitivity mapping or regional studies of the groundwater.

The MPCA's involvement with nitrate contamination includes providing a framework for local administration of SSTS programs, and administration of the feedlot and storm water programs. The MPCA also monitors nitrate in the ambient groundwater underlying urban parts of the state and has conducted several studies of nitrate concentrations in groundwater relative to non-agricultural land uses.

The most recent MPCA report on ambient groundwater quality (Kroening 2024) found that the amount of nitrate contamination in the state's groundwater remained the same over time. Trends were tested over 2013-2023 using over 170 wells, and the majority of the tested sites showed no significant trend.

High nitrate concentrations primarily were an issue in agricultural parts of the state, where the latest groundwater quality assessment by the MPCA showed over 40 percent of the tested wells installed near the water table exceeded 10 mg/L, the MDH health risk limit (HRL)[1] that sets the safe level of nitrate in drinking water. In contrast, less than six percent of the sampled wells installed near the water table in urban areas had nitrate concentrations that exceeded 10 mg/L.

The high nitrate concentrations observed near the water table most likely resulted from human activities. Concentrations in the groundwater generally decreased with depth, which suggests the source was applied to the land surface.

Geology also has a large influence on nitrate transport to the state's groundwater. In 2013, the Minnesota Geological Survey and MPCA partnered to investigate the geologic controls on nitrate transport to the bedrock aquifers underlying southeastern Minnesota. Thick sand and gravel or clay deposits (> 50 feet) were found to sufficiently retard the flow of water and any associated contaminants like nitrate, resulting in low concentrations in the underlying bedrock aquifers. The transport of nitrate to underlying bedrock aquifers also was influenced by the confining units that separate them like the Dubuque, Decorah, or Glenwood shales. These confining units generally limit the vertical transport of water and any nitrate contamination and results in low concentrations in the underlying aquifers.

For agricultural uses, nitrate is included as an analyte in MDA monitoring efforts.

Nitrate sampling from the MDA's 2023 annual ambient monitoring programs showed that 84% of the shallow groundwater samples collected had detectable levels of nitrates, with 21% exceeding the MDH HRL of 10 mg/L. The Central Sands and East Central portions of Minnesota had the highest percent detection at concentrations exceeding the HRL (51 and 38 percent, respectively). These settings

[1] An MDH-derived HRL is the concentration of a chemical in drinking water that, based on the current level of scientific understanding, is likely to pose little or no health risk to humans, including vulnerable subpopulations. HRLs are promulgated in rule.

represent the most sensitive conditions and may not be representative of some deeper, local aquifer systems used for drinking water.

Private well nitrate monitoring

To evaluate nitrate concentrations and trends in groundwater, MDA and local partners have established regional networks that monitor nitrate in private wells. Currently there are two regional networks established, one in the southeast karst region and one in the central sands area. These areas of the state are the most vulnerable to groundwater contamination. Sampling of private wells within these areas provides a systematic basis to evaluate nitrate concentrations using the same private wells over several years. The data collected from private well owners is useful for evaluating long-term trends and indicates whether nitrate in groundwater is a concern in these vulnerable aquifers. Participation by homeowners is voluntary. One challenge in this design occurs when homeowners decide to drop out.

This tends to be most prevalent when nitrate levels are either non-detectable or very high, introducing inconsistency and possible bias into the data set. Nevertheless, regional monitoring of private wells provides a practical way to monitor groundwater contamination by monitoring the same wells over multiple years.

Southeast volunteer nitrate monitoring network results

Drinking water quality is a concern across southeastern Minnesota due to highly variable hydrogeologic conditions that allow for rapid movement of water and contaminants in groundwater. In 2008, the Southeast Minnesota Water Resources Board (SEMNWRB), and several partners (MPCA, MDA, MDH) began collecting data from the "Volunteer Nitrate Monitoring Network" (VNMN). This region was selected as a pilot because of its vulnerable and complex geology. The network was developed to assess the practicality of establishing a cost-effective, locally driven means of obtaining long-term data on nitrate concentrations in private drinking water supplies. Nitrate concentrations were tested in approximately 600 private drinking water wells across nine counties in southeastern Minnesota. The wells were monitored to determine the impact that well construction and local land use have on drinking water quality, and to describe the regional distribution of nitrate concentrations and any temporal trends.

Between February 2008 and August 2023, 18 sampling events occurred representing approximately 7,287 samples. During this period, the percentage of wells exceeding the HRL for each sampling event ranged between 7.5 and 14.6 percent. As a regional network there is a downward trend in the 90th percentile for the time period of 2008 to 2023. However, there were no significant trends for the 10-year time period of 2014 to 2023. Additional information can be found in the June 2019 Nitrate Monitoring Report.

MDA central sands private well monitoring network results

Due to the success of the southeast volunteer nitrate monitoring network, as well as the availability of funding from the Clean Water Legacy Amendment, the MDA launched a similar project in the Central Sands area of Minnesota. The MDA determined that because high levels of nitrate have been measured in Central Sands monitoring wells, it was important to expand nitrate monitoring to private drinking water wells. If the concentrations were similar to concentrations found in the monitoring wells, there could be concern for human health. In the spring of 2011, the MDA began the Central Sands Private Well Monitoring Network (CSPWN). The goals of this project were to evaluate nitrate concentrations in private wells across the Central Sands region and assess nitrate concentration trends over time using a representative subset of this data.

Homeowners from 14 counties in agricultural areas in the Central Sands were randomly invited to participate in the network. By July 1, 2011, the MDA had analyzed 1,555 samples for nitrate. Over 88% of the wells sampled had nitrate-N concentrations below 3 mg/L, 6.8% of the wells ranged from 3-10 mg/L of nitrate-and 4.6% were greater than the 10 mg/L nitrate HRL (Table 1).

Table 1. Summary of nitrate-N concentrations for the Central Sands Private Well Network (2011)

Number of Samples	Min (mg/L)	Median (mg/L)	75^{th} Percentile (mg/L)	90^{th} Percentile (mg/L)	Maximum (mg/L)	% ≤ 3 mg/L	% 3<10 mg/L	% ≥10 mg/L
1,555	<0.03	0.01	0.66	4.15	31.9	88.6%	6.8%	4.6%

Starting in 2012, approximately 550 homeowners volunteered to participate in long-term annual sampling of their private wells. These 550 homeowners were a subset of the original testing population of 1,555. Between 2011 and 2023, nine sampling events occurred with approximately 4,928 samples collected from the long-term volunteers. During this time, the percentage of wells exceeding the HRL for each sampling event ranged between 1.1% and 4.5%. As a regional network there is a downward trend in the 90^{th} percentile for the 2008 to 2023 time period, as well as the 10-year time period of 2014 to 2023.

Township testing program

In 2015, the MDA conducted a major revision of the Nitrogen Fertilizer Management Plan (NFMP). The plan calls for an assessment of nitrate conditions at the township scale. The MDA determines current nitrate- nitrogen concentrations in private wells through the Township Testing Program. The MDA has identified townships throughout the state that are vulnerable to groundwater contamination and have significant row crop production. More than 90,000 private-well owners have been offered nitrate testing in 344 townships since 2013 (Figure 3 presents the township testing schedule).

The MDA works with local partners such as counties and Soil and Water Conservation Districts (SWCDs) to coordinate private well nitrate testing using Clean Water Funds. Each selected township was offered testing in two steps, the “initial” sampling and the “follow-up” sampling.

In the initial sampling, all township homeowners using private wells were sent a nitrate test kit. The homeowners took the samples and sent them in to a lab for analysis. If nitrate was detected in their initial sample, the homeowner was offered a follow-up nitrate test, pesticide test and well site visit. Trained MDA staff visited willing homeowners to resample the well and conduct a site assessment. The assessment helped to identify possible non-fertilizer sources of nitrate and to see the condition of the well. A well with construction problems can be more susceptible to contamination.

Initial results

As of March 2020, 344 vulnerable townships from 50 counties participated in the TTP from 2013 to 2019 (Table 2). In the 344 townships tested, 143 townships (41%) have 10% or more of the wells over the HRL for nitrate. In contrast, it was determined that in 133 townships less than 5% of the wells were over the HRL for nitrate.

Overall, 9.1% (2,925) of the 32,217 wells exceeded the HRL for nitrate. Table 3 shows the percentage of wells over the HRL for each township during the initial sampling. These results reflect nitrate concentrations in private well drinking water regardless of nitrogen sources, or well construction. The final percentage of wells over the HRL can be different, by township, from the initial analysis based on follow-up sampling and site visits.

Table 2. Number of townships in each nitrate concentration range.

Nitrate concentration criteria	Number of townships (2013-2019)
<5% of wells in a township ≥10 mg/L*	133
5%-9.9% wells in a township ≥10 mg/L	68
≥10% wells in a township ≥10 mg/L	143
Total	344

*nitrate – nitrogen mg/L or parts per million (ppm)

Table 3. Initial Township testing well results of nitrate 2013-2019.

Total wells	<3 mg/L* Number of wells	3 - <10 mg/L* Number of wells	≥10 mg/L* Number of wells	≥10 mg/L* percent
32,217	24,791	4,501	2,925	9.1%

*nitrate – nitrogen mg/L or parts per million (ppm)

Final results

Once the follow-up sampling was completed, the MDA conducted an analysis of the results and prepared a final report for each county. Final results were determined using two rounds of sampling and a process to remove wells with construction concerns, insufficient construction information and those near potential non-fertilizer sources of nitrate. For the final dataset, it was determined that 44 (13%) townships had 10% or more of the wells over the HRL for Nitrate-N. In the final dataset of 28,932 wells, 1,359 (4.7%) exceeded the HRL for Nitrate-N. Final results represent wells that are potentially impacted by a fertilizer source, while initial results represent private well drinking water regardless of source or the condition of the well. Detailed sampling results are available at: www.mda.state.mn.us/townshiptesting . The MDA uses the results to prioritize future work to address nitrate concerns, as described in the Nitrogen Fertilizer Management Plan (NFMP).

Figure 3. Initial township testing private well nitrate results

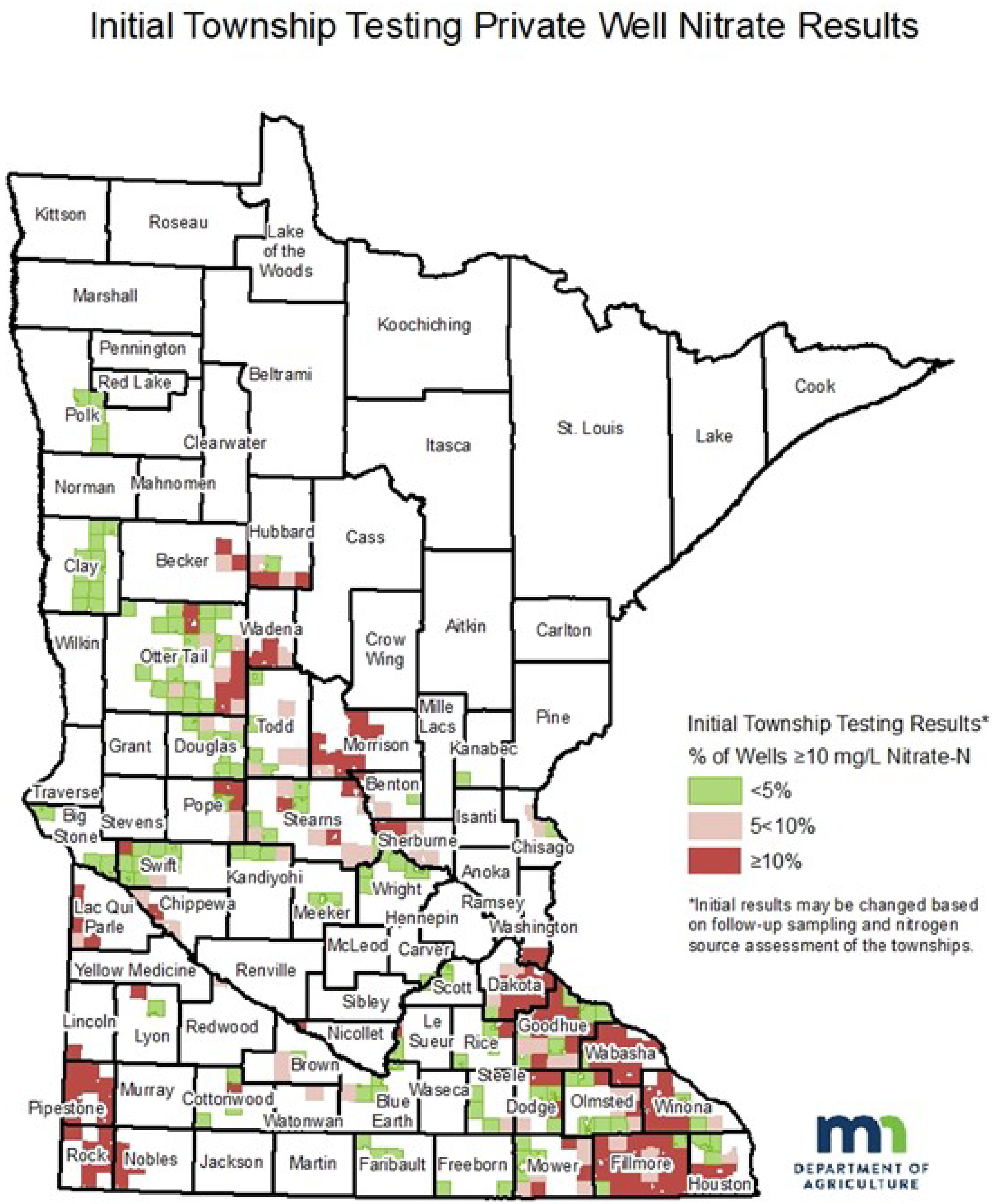
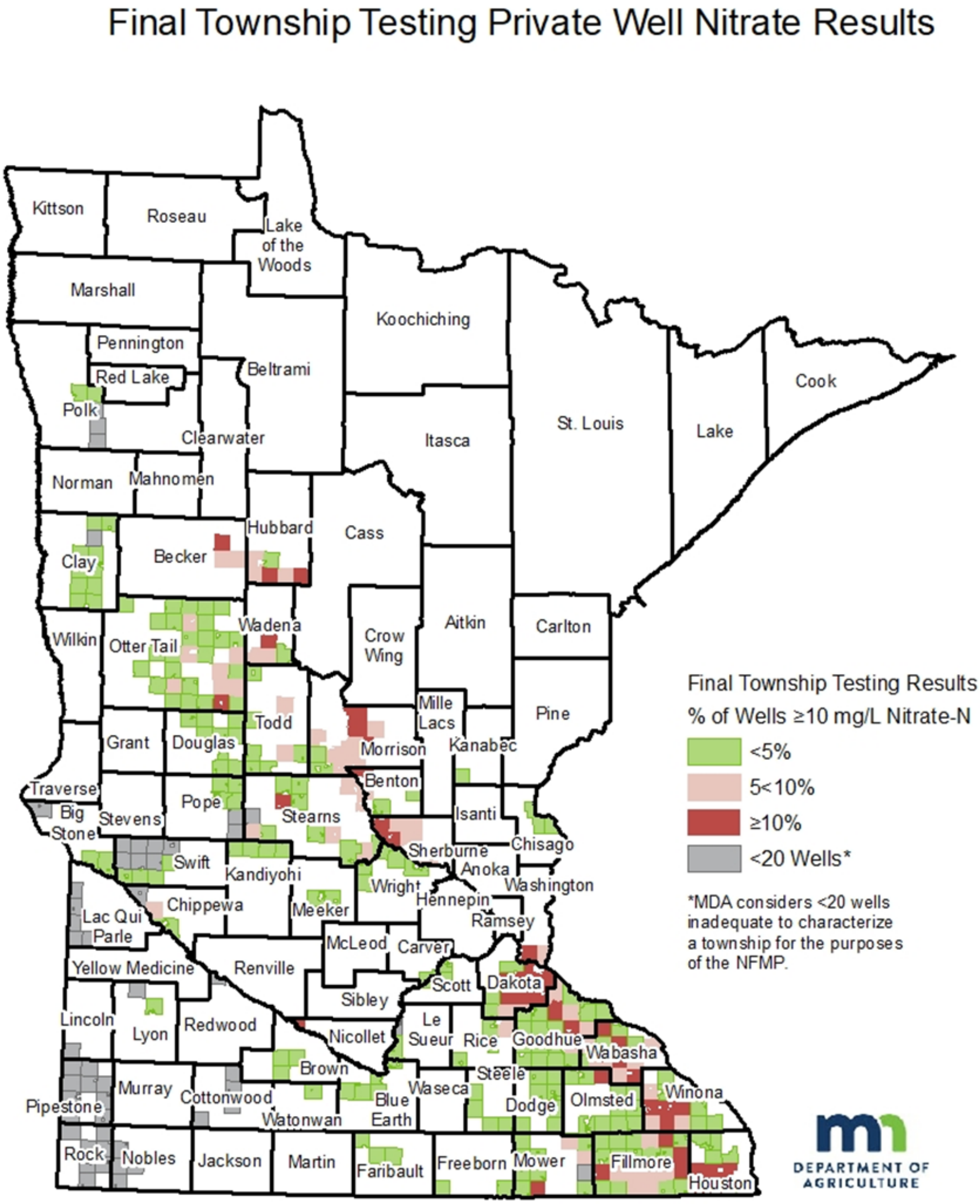


Figure 4. Final township testing private well nitrate results



Pesticides

Ambient Groundwater Monitoring Network

The MDA's groundwater monitoring network provides information on impacts to the state's groundwater from the routine use of agricultural chemicals. Minnesota was divided into 10 Pesticide Monitoring Regions (PMRs) intended to represent areas of different agricultural land use as well as differing geologic and hydrogeologic regions in the state.

Information is made available so management decisions can be made to reduce or eliminate impacts to groundwater. The MDA began monitoring groundwater in 1985 and redesigned the program in 1998. New wells were installed in 1999, and the MDA began sampling the re-designed network wells in 2000.

Samples were collected from 168 groundwater monitoring sites in 2023 (Figure 5). Of these sites, 142 consisted of one or more specifically designed and installed monitoring or observation wells, 13 were private drinking water wells, and 13 consisted of naturally occurring springs emerging from bedrock formations of interest in the southeastern karst area of the state. All of the locations are considered sensitive to contamination from activities at the surface. Network design and sampling protocols are available in the program's groundwater design document on the MDA website.

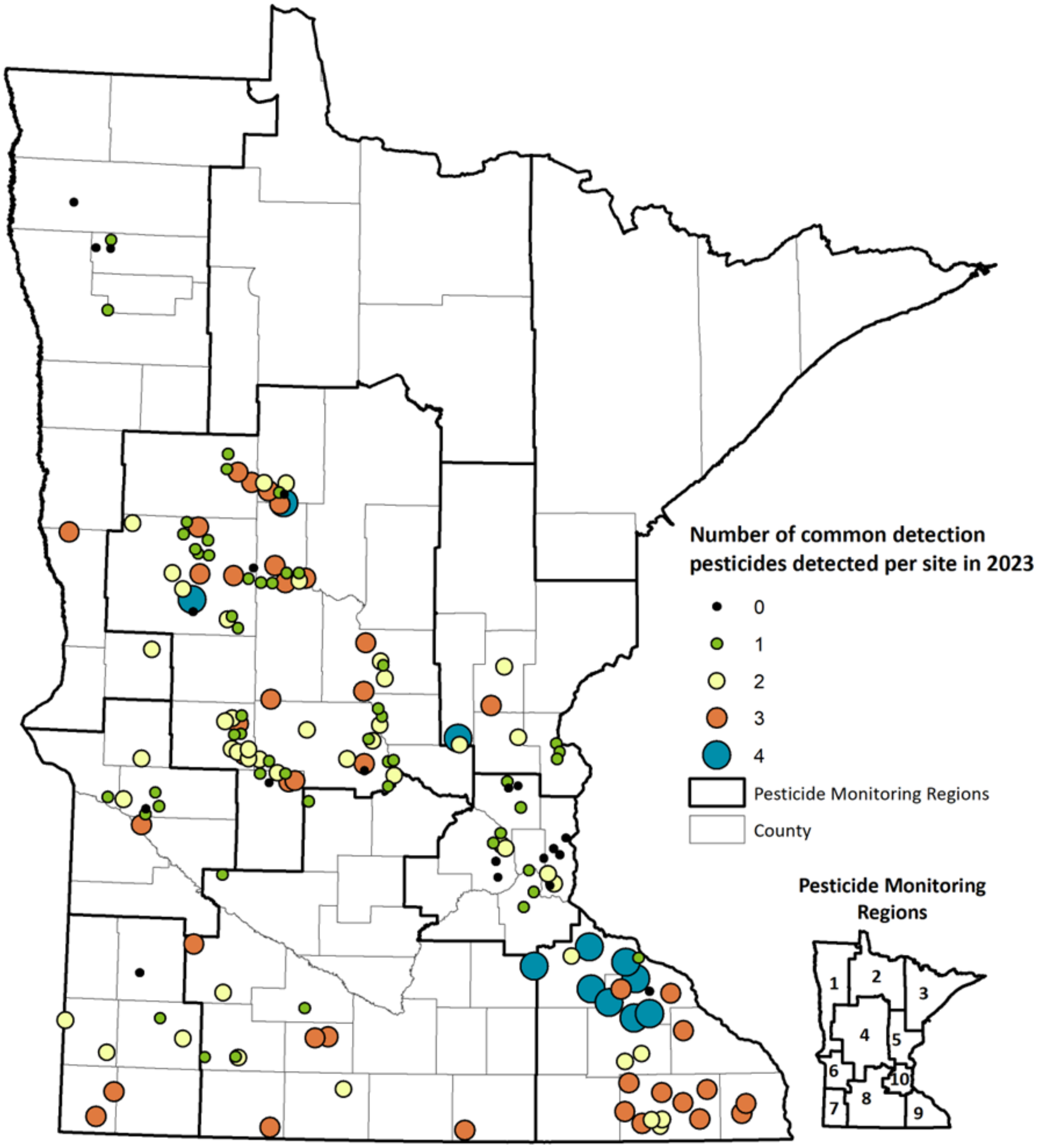
The MDA Laboratory has continued to expand their analytical capabilities, resulting in an increase in the number of compounds evaluated. In 2014, 133 different pesticide compounds were evaluated; by 2023, that number rose to 186. The MDA laboratory has also been able to lower the detection limit for some pesticides, meaning lower concentrations can be found and measured. Forty-nine different pesticides or pesticide degradates were detected in groundwater in 2023. Although exceedances of established reference values (which denote levels of pesticides that could possibly have adverse effects) have historically been very rare, in 2023, twelve samples collected from monitoring wells in PMR 4 had concentrations of 4--hydroxychlorothalonil greater than the drinking water Risk Assessment Advice (RAA) of 2,000 ng/L.

In accordance with statutory requirements in the Groundwater Protection Act (Minn. Stat. chapter 103H) and the Pesticide Management Plan, the MDA has determined that five pesticides are commonly detected in groundwater, leading to the development of Best Management Practices to prevent or reduce ongoing degradation of groundwater resources. The five common detection pesticides are agricultural herbicides including: acetochlor, alachlor, atrazine, metolachlor and metribuzin.

Figure 5 presents the number of common detection pesticides detected at each sampling site in 2023. The locations showing the greatest number of pesticides per site are concentrated in the central sand plains (Pesticide Monitoring Region 4), east central (Pesticide Monitoring Region 5), and in southeastern Minnesota (Pesticide Monitoring Region 9).

Metolachlor ESA (a degradate of the herbicide metolachlor) was the most commonly detected pesticide compound within the MDA dataset in 2023. The most extensive dataset for assessing changes in metolachlor ESA impacts to groundwater over time is the concentration data from Pesticide Monitoring Region 4. Concentration and detection frequency time-trend data for metolachlor ESA is presented in Figure 6 using the median and 90th percentile concentration and detection frequency values for 2002 through 2023. Time-trend analysis on median values is the most widely accepted measure on which to base decisions, and this was evaluated on the data from the most recent 10-year period (2014-2023). The median values indicate a statistically significant increasing trend in concentrations for this period. The trend of the frequency of detection for metolachlor ESA in PMR 4 has also risen in a statistically significant fashion for this period. In 2023, the highest concentration measured for metolachlor ESA was 11,200 ng/L in PMR 4, which is substantially lower than the Health Risk Limit of 1,000,000 ng/L.

Figure 5. Number of common detection pesticides detected in MDA groundwater samples per site in 2023.



Neonicotinoid insecticides were first analyzed by the MDA in groundwater samples in 2010. Currently, MDA analyzes water samples for six neonicotinoid parent pesticides and two degradates including: acetamiprid, imidacloprid, thiamethoxam, clothianidin (analysis began in mid-2011), dinotefuran (analysis began in 2012), thiacloprid (analysis began in 2014), and the degradates imidacloprid-urea and imidacloprid-olefin (analysis began in 2017). Clothianidin, imidacloprid, and thiamethoxam have been detected in groundwater in agricultural areas. Dinotefuran and imidacloprid are the only neonicotinoid insecticides that have been detected in urban groundwater samples. All detections were below applicable reference values in 2023. Acetamiprid, the imidacloprid degradates, dinotefuran, and thiacloprid have not been detected in groundwater.

Additional information about detections, concentrations and time-trend analysis for pesticides can be found in the MDA's annual monitoring reports under "Reports and Resources".

Private well pesticide sampling

The MDA is conducting monitoring to assess impacts of pesticides to private drinking water wells in vulnerable areas (see Township Testing Program section above for details) and provide information to well owners about pesticide presence in their drinking water. The MDA began collecting samples for pesticide analysis in private wells where nitrate was previously detected through the Township Testing Program as a pilot in 2014 and officially began this testing in 2016 as the Private Well Pesticide Sampling (PWPS) Project. The sampling continued through the spring of 2021 as Phase 1. Phase 2 sampling began in the summer of 2021 and continues currently. A summary of the results is reported in the MDA's annual monitoring report.

During the 2014-2015 PWPS Project pilot monitoring effort, a pesticide analytical method was used which was limited to 22 different pesticide compounds. Pesticides were detected above the laboratory method reporting limits in six of the private drinking water well samples (0.3%). Pesticide detections occurred in one well in Benton, Olmsted, Sherburne, and Stearns Counties and two wells in Washington County.

Based on the results of the 2014-2015 sampling, the MDA contracted with a different analytical laboratory capable of analyzing for approximately 125 pesticide related chemicals with lower reporting limits. The MDA offered retesting to well owners in the counties sampled in 2014-2015 using the new laboratory method.

Approximately 5,700 wells were sampled from 2016 through the spring of 2021 using a different laboratory method. All samples were analyzed for at least 125 pesticides and pesticide degradates. Results indicated that pesticides or pesticide degradates were detected in 76% of the wells tested. There were 75 different pesticides and degradates found. Consistent with the MDA's ambient network monitoring, metolachlor ESA was the most frequently detected compound. There were four wells that exceeded a drinking water reference value (for diuron (herbicide), methyl parathion (insecticide), cyfluthrin (insecticide), and total metribuzin (herbicide)), but verification samples from these wells were non-detect. After cyanazine degradates were added to the analytical list in 2019 sampling, 61 wells were found to exceed the HRL for total cyanazine. Verification sampling from these locations indicated that a majority of the water samples from these locations continued to be above the HRL. As a result of these findings, the MDA continued the PWPS Project in the summer of 2021 as Phase 2. The most recent findings from 2023 indicated that total cyanazine was detected in 40% of the samples collected, with 37 wells having a concentration that exceeded the HRL, with those areas indicated in Figure NEW.

In 2019, the MDA also began analyzing the samples in the ambient program for cyanazine degradates.

In 2023, approximately 4% of the ambient groundwater samples had a detection of total cyanazine, but none exceeded the HRL. Additional information on cyanazine monitoring, including an evaluation of reverse osmosis point-of-use water treatment systems, can be found on MDA's cyanazine monitoring webpage.

Figure 6. Metolachlor ESA, a Metolachlor degradate, groundwater sample analysis results over time for the Central Sands monitoring network (PMR 4).

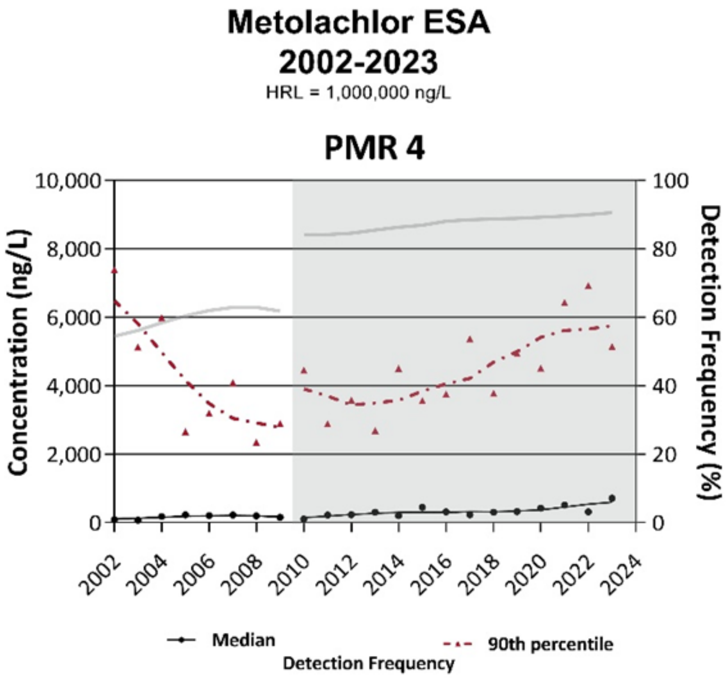
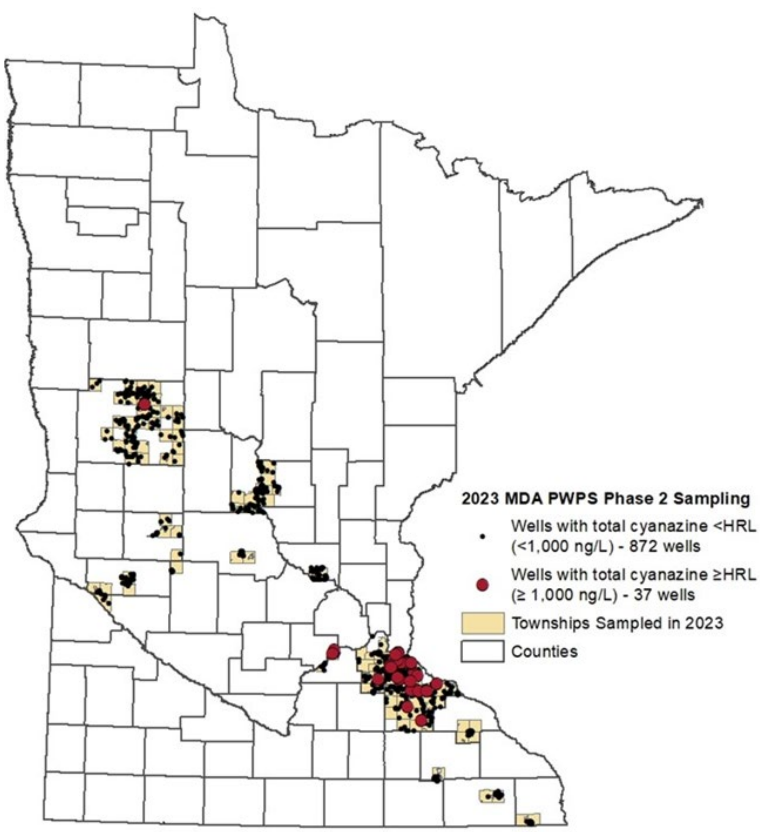


Figure 7. 2023 PWPS Phase 2 townships and wells sampled, with total cyanazine concentrations compared to the HRL.



Arsenic

Arsenic is an element that occurs naturally in soil and rock and can dissolve into groundwater, the primary drinking water source for Minnesota residents. Arsenic can occur in groundwater just about anywhere in Minnesota, but the highest concentrations generally occur in the Twin Cities area and western Minnesota. Consuming water containing low levels of arsenic can be detrimental to human health. The U.S. Environmental Protection Agency (EPA) has set a Maximum Contaminant Level (MCL) of 10 µg/L for arsenic in drinking water. The MDH estimates that, based on monitoring data, about 10 percent of all wells in Minnesota have natural arsenic levels above the MCL. More information on arsenic in Minnesota's groundwater is available on the MDH website.

Most monitoring and research on arsenic in the state's groundwater is conducted by the MDH due to the effects on some of the state's drinking water. Since 2008, the MDH has required all new water- supply wells be tested for arsenic contamination, and about 10 percent of these wells have arsenic concentrations exceeding 10 µg/L.

The MDH recently partnered with the U.S. Geological Survey (USGS) on several studies to better understand how much arsenic is in the water at newly-constructed wells, best ways to collect arsenic samples from wells, and the factors that affect arsenic concentrations in the groundwater. Testing newly-constructed wells for arsenic is complicated by the well construction process, which can temporarily change whether arsenic is dissolved from the aquifer material into the groundwater. This occurs because the drilling process used at most water-supply wells temporarily changes the geochemical conditions in the aquifer that affect arsenic mobilization. A recent study by the MDH and USGS examined how much arsenic concentrations changed over the course of one year in the well water from 250 newly-drilled wells (Erickson et al, 2019). This study found that arsenic concentrations did not significantly change in the bedrock aquifer wells tested during the study, but concentrations increased by 16 percent or more in one-quarter of the in the sand and gravel aquifer wells.

The sample collection process also affects the amount of arsenic measured in the water taken from a new water supply well. Currently, a variety of methods and sampling points are used to collect arsenic samples from newly-constructed water-supply wells because the sampling protocol is not specific in the state well code. Another recent study by the USGS and MDH examined the effect of the sample collection protocol on arsenic concentrations from newly-installed water-supply wells (Erickson et al, 2018). This study found that the variability in measured concentrations was reduced when the samples were filtered, collected from the household plumbing instead of the drill rig pump, and collected several months after well installation (instead of within four weeks of well installation).

The USGS and MDH also partnered together to develop a statistical model that assessed the relation between arsenic concentrations in the groundwater and hydrogeologic, geochemical, and well construction factors (Erickson et al, 2018). Smaller distances between the top of the well screen and the overlying till or glacial lake deposit confining unit and shorter well screen lengths were associated with higher probabilities of elevated arsenic concentrations in the groundwater. Variables describing aquifer properties and materials, position on the hydrologic landscape, and soil geochemistry were among the most influential for predicting the probability of elevated arsenic in the groundwater.

Chloride

Excessive chloride concentrations in groundwater restrict its use for drinking and can be harmful to fish and other freshwater aquatic life if transported to surface waters. Chloride is highly mobile in the environment and once in the environment, is extremely difficult to remove.

The MPCA's monitoring of Minnesota's groundwater has detected elevated concentrations of chloride, mainly in urban areas. The most recent MPCA report on statewide groundwater quality focused on monitoring groundwater underlying urban areas that was naturally vulnerable to contamination, and water table wells mostly were sampled. The highest median concentration (106.0 mg/L) was found in wells underlying commercial/industrial areas, and the second highest median concentration was found in wells underlying sewered residential areas. The lowest median concentration (1.0 mg/L) was in wells underlying undeveloped forested parts of the state. In the Prairie du Chien-Jordan aquifer, an important drinking water source in southeastern Minnesota, the highest chloride concentrations generally occur where the aquifer is close to the land surface and overlain by a thin layer of unconsolidated deposits. These areas include the eastern TCMA and the Prairie du Chien Plateau.

High chloride concentrations result generally from the human use of this substance, such as pavement de-icing or water softening. The distribution of chloride concentrations in the state's various aquifers and the chemical signature of the water suggest a human-caused chloride source in most locations where chloride was found. Concentrations generally are stratified in the groundwater, with the highest concentrations near the water table and the lowest in the deepest aquifers. This distribution suggests the chloride was transported into the groundwater from a land surface source. The chemical signature also suggested that most chloride of the groundwater in the majority of the tested wells in urban areas resulted from sources such as salt used to de-ice pavement or soften water.

The MPCA also routinely examines whether chloride concentrations are changing in the groundwater. The last analysis focused on recent changes from 2013-2023. Overall, about 30 percent of the wells included in this trend analysis had a significant trend in chloride concentrations, and most of these trends were upward. The wells with upward trends were not just restricted to the water table; a substantial number of them were installed in bedrock aquifers.

Additional details of chloride in Minnesota's groundwater are presented in the MPCA's most recent report on groundwater quality.

Contaminants of Emerging Concern (CECs) and Per- and Polyfluoroalkylsubstances (PFAS)

Contaminants of Emerging Concern (CECs) have been identified in both Minnesota's groundwater and surface water. The MPCA has analyzed for CECs in the ambient groundwater since 2009. The monitoring has targeted shallower wells to provide an early warning of groundwater contamination, focusing on different urban land use settings. From 2018-2023, the agency monitored 108 wells for a suite of 135 different pharmaceuticals, personal care products, detergent metabolites, and bisphenol A and its analogs. Most of the wells included in this monitoring effort were selected for sampling because at least one CEC was detected in its water in past sampling campaigns.

Sixty-eight of the 135 CECs were detected in the groundwater samples. Antibiotics were the type of CEC that was detected most often, which is consistent with this group of medications dominating the list of pharmaceuticals that were analyzed in the water samples. Some of the most-commonly detected CECs in the groundwater, such as branched p-nonylphenols, metformin, cotinine, and bisphenol A, also were frequently found in the state's streams and rivers.

The CECs that were most-frequently detected in the groundwater often were very water-soluble chemicals that also had a high use. These CECs include substances such as metformin (anti-diabetic medication), cotinine (present in tobacco products), DEET (insect repellent), sulfamethoxazole (antiobiotic), caffeine, and bisphenol A (plasticizer).

The CEC concentrations measured to date have generally been low; no concentrations exceed any established human-health guidance values. However, only 10 of the 135 CECs measured in groundwater have established human-health guidance.

The MDA collaborates with and provides assistance to the MPCA and MDH as appropriate and when agricultural chemical use and regulation overlap with interagency CEC concerns.

Additional details of CECs occurring in Minnesota's environment can be found at the MPCA emerging contaminants webpage and at the MDA agricultural chemical monitoring webpage.

Organophosphate flame retardants (OPFRs) are a class of chemicals that are used to slow or prevent the growth of fire and whose use has increased over the last 10-15 years. These substances commonly are added to many products including home furnishings, electronics, building materials, and transportation products. The presence of OPFRs in the environment is a concern due to their mobility in water and toxicity. Eight OPFRs were identified by the MDH's Toxic Free Kids Act as chemicals of high concern.

In 2021, the MPCA collected groundwater samples from 116 ambient network wells for a suite of 13 OPFRs. Most of the sampled wells were in urban areas, including the TCMA, Brainerd, and St. Cloud. Like the sampling effort for CECs, a combination of both monitoring and drinking water supply wells was sampled.

Flame retardants and plasticizers were detected in almost 95 percent of the sampled wells. Up to 9 organophosphate flame retardants were detected in an individual wells, and the average number of chemicals detected was three. The large number of detections likely results from a couple of factors. First, most of the sampled wells sampled were in places where these chemicals would be most likely be detected. Most of the sampled wells were in urban areas, where the use products containing organophosphate flame retardants would be concentrated. In addition, the sampled wells were installed in aquifers that had little natural geologic protection against contamination. Many of them intersected the water table and were overlain by permeable sandy sediments, which would allow water and any associated contamination to percolate through it. Secondly, most of the flame retardants targeted in this analysis were high production volume chemicals.

The detected OPFR concentrations generally were less than about 25 ng/L, on average. MDH has set human health guidance for three of the analyzed chemicals in drinking water: TCEP, tris(1,3-dichloro-2-propyl) phosphate, and tris(2-butoxyethyl) phosphate. No concentrations measured in the ambient groundwater in 2021 exceeded these values.

PFAS are a family of over 6,000 synthetic chemicals that have been used for decades to make products that resist heat, oil, stains, grease, and water.[2] Since the early 2000s, some companies in the fluorochemical industry have worked with the EPA to phase out the production and use of the long-chain perfluoroalkyl compounds and their precursors, but chemicals in this class are still used in many

[2] PFAS were previously called perfluorochemicals, or PFCs.

products, including fire-fighting foams, lubricants, packaging, metal-plating, clothing, and other consumer and industrial products.

The presence of PFAS in the environment and the resulting exposure is a concern because these chemicals accumulate in humans and animals and several of them are known to be toxic. PFAS have been found in fish, reptiles, and mammals all over the globe, and these chemicals biomagnify in birds and marine mammals. Toxicity studies indicate that some PFAS cause developmental problems to fetuses, cancer, liver damage, and immune and thyroid effects. In Minnesota, the MDH has set human health guidance for six PFAS: perfluorobutanoic acid (PFBA), perfluorobutane sulfonate (PFBS), perfluorohexanoic acid (PFHXA), perfluorohexane sulfonate (PFHXS), perfluorooctanoic acid (PFOA), and perfluorooctane sulfonate (PFOS).

The MPCA sampled the ambient groundwater intermittently for PFAS over the last 20 years, with the largest sampling events occuring in 2013, 2019, and 2024 (results not yet available). The 2019 sampling event was statewide and included over 250 wells. Most of the sampled wells were specifically installed to monitor the shallow groundwater (the water in these wells is not consumed), and the remaining ones primarily supplied drinking water to private residences.

Laboratory methods also have improved, allowing for over three times as many PFAS to be analyzed in water samples. Twenty additional PFAS were added to the analytical method used by the MPCA's ambient groundwater monitoring network in 2019 and seven additional PFAS were added in 2021. The PFAS in the improved laboratory method included legacy chemicals such as N-MeFOSE and N-EtFOSE which in the past were used to make products to protect carpet and upholstery and paper coatings, fluorotelomer-based substances, and novel PFAS such as HFPO-DA (used in the GenX technology platform), ADONA, and 6:2 Cl-PFEESA (major constituent of F-53B).

The ambient monitoring conducted from 2019-2023 continued to show the PFAS are present in the groundwater outside of areas of known contamination that are part of the MPCA's cleanup programs. This result is consistent with other scientific studies that have found PFAS to be ubiquitous in the environment, including being detected in soils located in remote areas, in biota in the Arctic, in the blood of all Americans. The PFAS with the shortest perfluorinated chains, which are known to be most mobile in water were found most frequently. The two PFAS with the shortest chains measured by the MPCA's ambient monitoring network, PFBS and PFBA, were detected in about 40 to 50 percent of the tested wells, respectively. No PFBA concentrations exceeded the human health guidance set by the MDH. The PFBS concentrations in two shallow monitoring wells in the TCMA exceeded the health risk limit of 100 ng/L set by the MDH in 2023

Several other PFAS were detected in the ambient groundwater at concentrations exceeding MDH's human health guidance values. The PFOA was detected in about 35% of the wells tested from 2019-2023. All wells with PFOA detections exceeded the health-based value (HBV) of 0.24 ng/L set in 2024.[3] PFOS was detected in about five percent of the wells tested. Six shallow monitoring wells contained water with concentrations that exceeded the 23 ng/L HBV set by MDH in 2023. One monitoring well in Anoka County had a PFHxS concentration that exceeded the health risk limit of 47 ng/L set by MDH in 2023.

[3] MDH derives HBVs using the same methods as HRLs. Thus, an HBV is also the concentration of a chemical in drinking water that, based on the current level of scientific understanding, is likely to pose little or no health risk to humans, including vulnerable subpopulations. However, HBVs have not yet been promulgated in rule.

The MPCA and MDH also continued to sample drinking water supply wells in the eastern TCMA. In 2020, both agencies expect to sample approximately 1,500 wells. Sampling or resampling wells is prioritized based on wells not previously sampled, but in areas where: 1) currently data indicates groundwater exceeds human health guidance, 2) wells where PFAS were detected in a previous sample and future monitoring is needed, and 3) wells already on regular monitoring schedules near PFAS waste disposal sites and in areas with changing PFAS concentrations.

Additional details of PFAS occurring in Minnesota's ambient groundwater can be found in this 2013 report and information on investigation and cleanup can be found on the PFAS webpage.

More information on the MPCA and MDH's water-supply well sampling for PFAS in the eastern TCMA can be found on this webpage.

Groundwater quality: Reducing, preventing, minimizing and eliminating degradation

Minnesota has been a leader in addressing many sources of ground-water contamination such as Superfund sites, leaking underground storage tanks (LUST), agrichemical incident cleanup, voluntary investigation and cleanup (Brownfield) sites, landfills, and more. Additionally, examples of Minnesota's strong pollution prevention programs include effective permitting and secondary containment requirements for a variety of industrial and public activities. Minnesota has long had one of the strongest pesticide groundwater monitoring programs in the nation, dedicated to the establishment of long-term monitoring well networks in diverse agricultural regions, as well as individual studies to assess specific issues.

In the past, Minnesota has focused its limited state resources on cleanup, source control, and direct protection efforts, and required groundwater monitoring at many sites to determine individual facilities' compliance. More resources are now dedicated to monitoring for changes in local and regional groundwater quality as a result of these efforts. In recent years, Minnesota has increased its emphasis on nonpoint sources, which should result in increased implementation of Best Management Practices (BMPs) that address nonpoint source pollution concerns such as feedlots, manure management, and agrichemical application.

Efforts to reduce, minimize, prevent and eliminate the degradation of Minnesota's groundwater resources are in almost all cases directed at the source of a specific contaminant or group of contaminants (point source or non-point source) and conducted on a programmatic level by the responsible government agency. The following discussion presents the efforts of MDA and MPCA programs to control (reduce, minimize, prevent and eliminate) specific contaminants or groups of contaminants by their source.

Nitrate/nitrogen

The MPCA and MDA manage a number of different programs that prevent and reduce nitrate impacts to waters of the state. The MPCA and MDA also partner with the MDH in source water protection area program efforts. To prevent water quality degradation MDA, MPCA and MDH programs use a combination of regulatory tools that include: discharge limits, permit requirements, environmental and technical reviews, facility inspections, operator training, technical assistance, compliance and enforcement, guidance documents, fact sheets, BMPs, and more. Some examples of these programs are described below:

Animal Feedlots – Animal manure contains significant quantities of nitrogen which, if improperly managed, can lead to nitrate contamination of surface and groundwater. The animal feedlot program regulates the land application and storage of manure in accordance with Minnesota Rules Chapter 7020 for over 18,000 registered feedlots, as well as 5,000 to 8,000 unregistered smaller feedlots in Minnesota. The feedlot program requires that the land application of manure and its storage in manure storage basins is conducted in a manner that prevents nitrate contamination of waters of the state. A new state SDS general permit became effective on June 1, 2025, and the new federal NPDES general permit will take effect on Feb. 1, 2026. that contains requirements meant to mitigate nitrate leaching and prevent manure-contaminated runoff. Details are available on the MPCA feedlot permits webpage.

Manure management plans, facility inspections, permitting, technical assistance and record keeping are all used to manage nitrogen impacts to water quality. In general, there are more feedlot sites than can be evaluated for groundwater degradation, beyond a few of the larger facilities.

Subsurface Sewage Treatment Systems (SSTS) – As of 2024, there are approximately 648,641 septic systems across the state. The SSTS that do not provide adequate separation between the bottom of the drainfield and seasonally saturated soil are considered to be systems that are failing to protect groundwater. The number of estimated compliant SSTS has increased over the last ten years, from approximately 431,000 systems in 2015 to approximately 541,150 systems in 2024. The wastewater in SSTSs contains bacteria, viruses, parasites, nutrients and some chemicals. SSTSs discharge treated sewage into the soil for treatment, ultimately traveling to the groundwater. In some cases, the sewage is pretreated before soil dispersal. Additionally, non-compliant SSTSs located adjacent to surface waters can discharge untreated contaminants to these surface waters and cause excessive aquatic plant growth leading to degradation in water quality. Therefore, SSTSs must be properly sited, designed, built and maintained to minimize the potential for disease transmission and contamination of groundwater and surface waters.

The SSTS program is engaged in a number of different efforts to prevent and minimize impacts to water quality degradation that can be found on the MPCA SSTS website.

Nutrient Management – The MDA nutrient management programs help identify potential sources of nitrate contamination and evaluate and implement practices and tools to reduce nitrate in groundwater**.** The goal of these programs is to prevent or minimize nitrate losses from nitrogen fertilizer in accordance with the Ground Water Protection Act (Minn. Stat. chapter 103H). The Ground Water Protection Act requires that MDA work to properly manage nutrients and to adequately protect groundwater from their impacts.

Nitrogen Fertilizer Management Plan – The Nitrogen Fertilizer Management Plan (NFMP) outlines how the MDA addresses elevated nitrate levels in groundwater. The purpose of the NFMP is to prevent, evaluate and mitigate nonpoint source pollution from nitrogen fertilizer in groundwater. The NFMP provides the blueprint for the MDA's activities to address nitrate in groundwater. It outlines three major activities: 1) prevention, 2) monitoring and prioritization and 3) mitigation.

Nutrient management programs occur statewide, however, there is a greater focus in areas of the state that are vulnerable to groundwater contamination. Much of this effort is directed to implementation of the NFMP and development of best management practices (BMPs) for nitrogen fertilizer use in townships with high nitrate in private wells. The MDA works with many important partners including soil and water conservation districts, counties, farmers, agricultural dealers, the University of Minnesota and local communities.

In March 2015, the MDA completed the revised NFMP. First developed in 1990, the NFMP is the state's blueprint for prevention or minimization of the impacts of nitrogen fertilizer on groundwater. This revision process updated the plan to reflect current water protection activities and integrate new scientific information about groundwater protection. In addition, the revision better aligns the plan with current water resource programs. The plan was updated in 2019 to reflect the passage of the groundwater protection rule.

Groundwater Protection Rule – The state's new Groundwater Protection Rule (GPR) became effective on June 24, 2019. The GPR will reduce the risk of nitrate from fertilizer impacting groundwater in areas of the state where soils are prone to leaching and where drinking water supplies are threatened. Nitrate is one of the most common contaminants in Minnesota's groundwater. Elevated nitrate levels in drinking water can pose serious health concerns for humans. The rule restricts fall application of nitrogen fertilizer in areas vulnerable to contamination, and it outlines steps to reduce the severity of the problem in areas where nitrate in public water supply wells is already elevated.

Research and Technical Assistance to develop and promote nitrogen fertilizer BMPs – The MDA is the lead agency for developing and evaluating agricultural best management practices. The MDA works closely with University of Minnesota (U of M) to develop, promote, and provide education on nitrogen fertilizer BMPs.

Research – The MDA funds and supports applied research projects to identify processes that affect water quality and evaluate the costs and benefits of specific agricultural practices. Best management practices (BMPs) for nitrogen fertilizer are developed and evaluated to protect and restore water resources. Since 2008, the MDA has supported 43 research projects through their Clean Water Research Program; 16 of these projects have elevated practices to reduce nitrate-nitrogen loss. Examples of these practices include nitrification inhibitors, optical sensing tools, perennial and vegetative cover for water quality benefits, and treatment of agricultural drainage systems.

The MDA supports additional research projects to refine understanding and management of nitrogen fertilizer management and the associated water quality impacts on irrigated, sandy soils, such as the project at Rosholt Farm in Westport.

To further understand nitrate in groundwater, the MDA is supporting an ongoing research project to calibrate and refine computer-based modeling tools to estimate nitrate leaching losses to groundwater from different cropland and nitrogen management scenarios. This information is used by MDA to refine agricultural management practice modeling using the (EPIC and SWAT) models to evaluate nitrate losses to groundwater in Drinking Water Supply Management Areas (DWSMA) where nitrate in groundwater is a concern. These predictive tools estimate changes in nitrate loading based on changes in cropland use and a range of nitrogen management practices and is used by the MDA for implementation of the GPR and the NFMP.

Technical Assistance – The MDA supports two positions at the University of Minnesota-Extension to develop and promote best management practices. This includes a technical position who is reviewing and revising nitrogen fertilizer BMPs and an irrigation water quality specialist who develops guidance and provides education on irrigation and nitrogen BMPs. The irrigation position was requested by the irrigator community to provide greater outreach and education. The MDA works with local partners to assess groundwater in agricultural areas and works directly with farmers and agri-business in areas that are vulnerable to nitrate contamination. These activities include technical assistance and on-farm demonstration sites. Overall, the MDA works with 38 local partners on nitrate monitoring and reduction activities. For example, the MDA partners with East Otter Tail Soil and Water Conservation District to support activities in central Minnesota. Partners offer an irrigation scheduler program and access to local weather data (Ag Weather Network).

Minnesota Agricultural Water Quality Certification Program: The Minnesota Agricultural Water Quality Certification Program (MAWQCP) is designed to accelerate adoption of on-farm practices that protect Minnesota's waters. MAWQCP is a voluntary opportunity for farmers and agricultural landowners to take the lead in implementing conservation practices that protect our water. Trained conservationists conduct comprehensive risk assessments to identify all risks to water quality, including nitrate leaching and runoff. If a risk exists, in field and edge of field mitigation measures are implemented as part of the certification agreement. A farmer certified through the MAWQCP is deemed to comply with the Groundwater Protection Rule for the duration (10 years) of the water quality certification.

Nutrient Management Initiative – The Nutrient Management Initiative (NMI) provides a simple tool for farmers to evaluate their current nutrient management practices compared with an alternative practice on their own field. Participants often work with a certified crop adviser, who assists with site design, and validates cropping information, and yield results. The goal is for farmers to evaluate practices that may improve nitrogen efficiency by lowering fertilizer inputs. Farmers can compare nitrogen rates, timing or use of a stabilizer product. Many of the NMI sites are located in southeast Minnesota and complement the Southeast Region Grant that is supporting on farm BMP demonstrations, U of M fertilizer BMP trials, and farmer-to-farmer nitrogen management learning groups.

Discovery Farms Minnesota is a farmer-led effort to gather field scale water quality information from different types of farming systems, in landscapes all across Minnesota. The goal is to provide practical, credible, site-specific information to enable better farm management. Discovery Farms is a collaborative program between farmers, the Minnesota Agricultural Water Resources Center (MAWRC), the MDA, the University of Minnesota Extension, soil and water conservation districts and watershed districts throughout the state. The program began in 2010 and currently has five farms) three with paired watersheds) in five counties throughout Minnesota. Additionally, the program has historical data from eight past participating farms. The program is designed to collect accurate measurements of sediment, nitrogen and phosphorus movement over the soil surface and through subsurface drainage tiles. This work leads to a better understanding of the relationship between agricultural management and water quality. Near real-time data and dashboards can be found on MDA's onerain website.

Arsenic

Since 2008, state regulations have required all newly constructed drinking water wells be tested for arsenic before being placed into service. If no arsenic is detected, further testing is not necessary. If arsenic is detected above the MCL of 10 µg/L in water used for drinking and cooking, the MDH recommends installing a treatment system or finding an alternate source of drinking water and provides an instructional Q&A on the MDA website.

Chloride

The MPCA released a Statewide Chloride Management Plan (CMP) in 2020. The statewide CMP characterizes the water resources across Minnesota, the overall impacts of chloride on them, and includes implementation strategies, monitoring recommendations, and measurement and tracking of results in a performance-based adaptive approach for the entire state of Minnesota. The statewide CMP is an adaption of the Twin Cities Metropolitan Area chloride management plan and includes all statewide chloride sources, stakeholder groups, and management techniques.

Streams interact with groundwater and the causes of chloride contamination to surface waters in the seven county TCMA are in part due to contributions from groundwater with elevated chloride concentrations discharging into streams. Implementation of the BMPs in the statewide CMP will help protect groundwater as a source of drinking water and its contribution to stream baseflow and other surface water bodies.

Hazardous waste site clean-ups

Efforts to prevent and reduce hazardous substance degradation of Minnesota's groundwater resources have included the cleanup of soils, groundwater and soil vapors at VOC contaminant release sites, in addition to pollution prevention (P2) programs.

Cleanup (Remediation) – Over the past 35 years, MPCA's cleanup (Remediation) programs including the petroleum remediation, Superfund, Hazardous Waste, Closed Landfill, Spills, and voluntary investigation and cleanup (Brownfields) programs have addressed the contamination of groundwater from hazardous substances at thousands of chemical release sites. The main focus of remediation activities is the cleanup of soil, groundwater and soil vapor to control human exposure to hazardous substances. This includes insuring that the quality of the groundwater we drink meets drinking water standards.

Emerging issues for the remediation programs include vapor intrusion into homes and other buildings as a result of historic releases of volatile organic compounds (VOCs) into soil and groundwater and the reduction of drinking water quality standards for a number of hazardous substances that require additional efforts at sites that previously were considered safe.

The remediation programs have worked on over 35,000 sites since 1990. There are approximately 1,310 sites that remain open, where cleanup activities (remediation) have yet to be completed. The reduction in these groundwater contaminant sites has been a result of remediation efforts, preventative programs and a change in societal and business knowledge and ethics

Several of the remaining cleanup sites have long-term operation and maintenance activities such as the CLP - Closed Landfill Program, where all 110 sites are under operation and maintenance. Overall, the remediation of these sites in tandem with pollution prevention and environmental regulation have prevented and reduced most controllable causes of hazardous substance releases to the environment, however, hazardous substance releases may continue to occur as a result of spills and other accidents. Historic releases along with emerging concerns will continue to require significant effort by the remediation programs into the future to limit risk to human health and the environment.

Additional details of efforts to prevent and clean-up hazardous substances in the environment can be found on the MPCA Minnesota Superfund Sites website.

Pollution Prevention – Pollution prevention is the best way to avoid the risk posed by contaminants to groundwater resources. Pollution prevention means eliminating or reducing at the source, the use, generation or release of toxic chemicals, hazardous substances and hazardous waste. Examples of pollution prevention include waste reduction and use of less persistent and less toxic chemicals. Some of the Best Management Practices (BMPs) to decrease the risk of contamination include: proper storage of VOC-containing chemicals; proper disposal of VOC-containing waste; locating water supply wells upgradient of VOC sources; and locating industries in areas where aquifers are less sensitive.

The MPCA in partnership with the Minnesota Technical Assistance Program (MnTAP) and Retired Engineers Technical Assistance Program (ReTAP) provides technical assistance and financial assistance for businesses and institutions seeking ways to reduce waste to achieve pollution prevention goals. For 2024, pollution prevention technical assistance efforts resulted in 661,200 pounds of waste reduced, 1.3 million pounds of materials reused, 41.9 million gallons of water conserved, 2.94 million kWh and 124,600 therms of energy conserved. Current reporting of pollution prevention efforts can be found on the MPCA webpage for Pollution Prevention activities.

Agricultural chemical site clean-ups

The MDA actively prevents and reduces degradation of Minnesota's groundwater resources from investigations and cleanups at agricultural chemicals at storage, manufacturing and distribution sites.

Cleanup (Remediation) – Since 1989, MDA's cleanup programs including the Superfund, Comprehensive, Emergency Response (Spills) and Voluntary Investigation and Cleanup (Brownfields) programs have addressed the contamination of groundwater from agricultural chemicals at hundreds of primarily pesticide and fertilizer storage, manufacturing or distribution sites, and at thousands of emergency spill sites. This is accomplished through the oversight of investigation and cleanup of agricultural chemicals in groundwater, surface water, soil, sediment and air from historical releases at these agricultural chemical sites, and the immediate cleanup of spilled agricultural chemicals. These activities help to ensure that the concentrations of agricultural chemicals in groundwater at these sites are reduced and meet drinking water guidance values.

Emerging issues for the MDA remediation programs include the analysis of newer pesticides that require more advanced and expensive laboratory analytical methods to ensure that these pesticides are included in site investigations and cleanups.

The MDA remediation programs have worked on a cumulative total of over 7000 sites. Work on these sites has included the elimination or reduction of agricultural chemical contamination of groundwater, surface water, soil, sediment, air and private and municipal drinking water or industrial supply wells. The MDA has additional sites that are not currently active in remediation programs but will be addressed as time and staffing allow. The MDA works with other programs to promote pollution prevention through improved storage and operational practices. Agricultural chemical facilities that have gone through a cleanup often construct new facilities with features that promote pollution prevention.

Historic releases along with emergency concerns will continue to require significant effort by the MDA remediation programs into the future to limit risk to human health and the environment to agricultural chemical incidents. Additional information on MDA remediation programs can be found on the MDA spills & cleanup website.

Pesticides

The MDA has developed the Minnesota Pesticide Management Plan (PMP): A Plan for the Protection of Groundwater and Surface Water. The plan was last revised in 2007 and is currently in the process of being updated in 2025. The PMP is the primary tool for preventing, evaluating and mitigating pesticide impacts to water resources, and it established the delineation of Pesticide Management Areas (PMAs) based on similar hydrologic, geologic, and agricultural management characteristics occurring within a region/area of the state. The PMAs provide the MDA with a framework for outreach and education to agricultural stakeholders.

The PMP establishes a multi-stakeholder Pesticide Management Plan Committee to annually review pesticide water quality data and provide comment to the Commissioner of Agriculture regarding the detection and concentration of pesticides in vulnerable aquifers, as well as the need for BMP development to minimize and prevent pesticide contamination of water resources. The PMP also establishes a Pesticide BMP Education and Promotion Team made up of state and local pesticide and water quality specialists, along with others interested in developing and delivering consistent messages to pesticide users about BMPs and water quality protection.

In 2004, the MDA developed "core" BMPs for all agricultural herbicides, and separate BMPs specific to the use of the "common detection" herbicides acetochlor, alachlor, atrazine, metolachlor and metribuzin.

These BMPs have been revised and updated since they were first developed. The most recent revisions occurred between 2022 and 2024. The MDA has also developed core BMPs for insecticides , as well as specific BMPs for the insecticide chlorpyrifos and for neonicotinoid insecticides.

The MDA conducts special registration reviews of pesticides that might have specific concerns to use in Minnesota, including water quality protection. The scope of these special registration reviews varies depending on the potential education, outreach, and enforcement needs identified by the MDA. The MDA reviews new active ingredients recently approved by the U.S. EPA along with currently registered pesticides that have significant new uses or have undergone a major label change. At times, more in-depth reviews are necessary to provide stakeholders and the MDA Commissioner with more information about specific pesticide products and issues.

Contaminants of Emerging Concern (CECs) and Per- and polyfluoroalkyl substances (PFAS)

Currently, the MPCA ambient groundwater monitoring program is monitoring for CECs in the groundwater as part of its efforts to address the rising concerns associated with these chemicals in Minnesota's environment. This monitoring will significantly expand the existing knowledge of the occurrence of CECs in the groundwater and this information will help to evaluate the sources of any contamination found in the groundwater. The MDA shares these objectives as it coordinates with other state agencies its own pesticide-related CEC monitoring and response activities.

The MDH has a CEC program to identify contaminants in the environment for which current health-based standards do not exist or need to be updated to reflect new toxicity information. Through the CEC program, the MDH investigates the potential for human exposure to these contaminants and develops guidance values. Information on the CEC program and a list of chemicals that have been evaluated is available on the MDH CEC website.

PFAS is an important and complex emerging contaminant. The MPCA has been working on issues related to PFAS since the early 2000s when we started addressing what were then called PFCs (perfluorinated chemicals) at four waste disposal sites in Washington County used by the 3M Company. There have since been several periods of renewed interest and activity as we learned more about these chemicals and their potential effects on human health and the environment. While PFAS were once seen as a problem primarily related to manufacturing and disposal of waste, PFAS are ubiquitous in the environment and latest research shows health effects at lower levels than previously thought. Working together, Minnesota state agencies developed Minnesota's PFAS Blueprint to support a holistic and systematic approach to address PFAS. Minnesota's PFAS Blueprint provides an in-depth discussion of PFAS concerns in 10 key issue areas. For each issue area, the blueprint outlines many PFAS initiatives taken and underway in Minnesota and identifies key areas of opportunity for moving forward on managing and addressing PFAS.

Efforts continue in the eastern TCMA to supply drinking water with safe levels of PFAS and other contaminants and clean up contaminated sites under the 2018 settlement between 3M and the State of Minnesota. On February 20, 2018, the State of Minnesota settled a Natural Resources Damage lawsuit with the 3M Company for PFAS contamination in the eastern TCMA. Under the terms of the settlement, the 3M Company made an $850 million grant to the state to be used for clean drinking water and natural resources protection projects, and to pay for the state's lawsuit and other expenses. The MPCA and DNR are co-trustees of these funds. The top priority for the 3M settlement funds are to enhance the quality, quantity, and sustainability of drinking water in the eastern TCMA. The second priority is to restore and enhance the area's water resources, wildlife, habitat, fish and other aquatic resources, and outdoor recreation in the eastern TCMA and on the Mississippi and St. Croix Rivers downstream of these areas. Any remaining grant funds will be used for statewide environmental improvement projects. The 2018 settlement also preserves the 3M Company's obligations under the 2007 Consent Order negotiated between the MPCA and 3M. To ensure clean drinking water in the eastern TCMA, the MPCA, DNR, and other stakeholders are developing a drinking water supply plan for the area. Biannual reports and spending plan updates on the 3M settlement are completed by MPCA and DNR.

Groundwater summary

The MPCA and MDA continue to lead the way in addressing sources of groundwater contamination, particularly through monitoring, remediation, permitting and BMP activities. It is critical, though, to maintain a continued concern for this valuable resource.

Some of the most common contaminants detected include nitrates and specific pesticides in rural settings, and chloride from road salt in urban areas. State agencies continue to monitor from the forefront, identifying new contaminants of emerging concern to groundwater quality and continuing to manage known risks.

Continued effort is needed to fully realize the state's groundwater quality goals. In particular, ongoing monitoring of vulnerable aquifers is critical to identify and track trends and evaluate the success of management efforts.

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. Continued monitoring efforts by the MPCA and MDA provide the baseline from which to base critical decisions and future analyses.

Surface water quality: Assessment and analysis

The Minnesota Pollution Control Agency (MPCA) is charged under both federal and state law with protecting the water quality of Minnesota's lakes, rivers, streams, and wetlands. This responsibility involves routine monitoring and assessment of water quality status statewide. Presented below is information that defines the status and trends of water quality in Minnesota's streams, lakes and wetlands. Somewhat different from the groundwater quality data presented in the previous section, the surface water quality data includes a combination of water chemistry, water clarity and measures of fish and aquatic insect health (biological integrity); which are used to determine a waterbody's suitability for drinking, swimming, and fishing.

A large number of reports have been published on Minnesota's surface water condition over the past decade, providing baseline information at a watershed scale. To guide the reader, report summaries are provided, accompanied by figures, graphs and tables of some of the more relevant monitoring and assessment data contained in these reports. Web-based links are also provided for additional information on the following surface water quality topics:

- The impaired waters list and watershed approach,
- Lake and stream water quality trends - clarity, swimming & recreation, pesticides,
- Minnesota milestone historic data - pollutants & clarity in streams and rivers,
- Stream water quality - pesticides, fish & aquatic life,

- Streams and rivers pesticide monitoring
- Chloride
- Wetland water quality trends,
- Statewide nitrogen study,
- CECs and PFAS, and
- Pesticide water quality monitoring report.

Impaired waters listings and watershed approach

Impaired waters – The Clean Water Act of 1972 requires states to adopt water quality standards to protect waters from pollution. These standards define how much of a pollutant can be in a water and still allow it to meet designated uses, such as drinking water, fishing, swimming, irrigation or industrial purposes. Impaired waters are those waters that do not meet water quality standards for one or more pollutants, thus they are "impaired" for their designated use(s). In 2006, the passage of Minnesota's Clean Water Legacy Act and the 2008 Clean Water, Land and Legacy Constitutional Amendment provided policy framework and money for state and local governments to accelerate efforts to monitor, assess, and restore impaired waters, and to protect unimpaired waters.

In 2008, the MPCA began a 10-year cycle to monitor and assess about eight of Minnesota's 80 watersheds each year, to identify impaired and "unimpaired" waters. The first iteration of this monitoring cycle (Cycle 1) has been completed and in 2018, the monitoring team began returning to watersheds in order to track progress towards meeting water quality goals. Details on the second iteration of the monitoring cycle (Cycle 2) can be found at the MPCA's watershed approach webpage.

The MPCA assesses waters and lists the impaired waters every two years in accordance with the Clean Water Act. The table below (table 4) provides the *2024* Impaired Waters List and the number of impaired waters that need total maximum daily load (TMDL) plans to restore protection of fish and swimming uses. Further details can be found in the 2024 Integrated Report to Congress.

The 2024 list also includes 56 water bodies that are impaired for sulfate; a naturally occurring nutrient that can also be found in discharges from mining operations, wastewater treatment plants, and industrial facilities. Sulfate negatively impacts the growth of wild rice, which is an important part of the biological community in many Minnesota lakes, streams, and wetlands and a cultural and economic resource to many, particularly Tribal Nations.

Table 4. Impaired Waters and TMDL-Listed Waters for Minnesota

202 Inventory of Impaired Waters Summary

Pollutant in 2024 draft Waters List	Total number of impairments	Number of impairments requiring a TMDL
Mercury in fish tissue & mercury in water column	1696	422
Nutrient/Eutrophication Biological Indicators	740	135
Escherichia coli / Fecal coliform	915	112
Total suspended solids (TSS) & Turbidity	455	70
Aquatic Macroinvertebrate Bioassessments	948	854
Fishes Bioassessments	1066	978
PCB in fish tissue	75	75
Oxygen, Dissolved	196	144
Chloride	68	15
Nitrates	32	5
Aquatic Plant Bioassessments	12	12
Perfluorooctane Sulfonate (PFOS) in fish tissue	28	28
pH	4	3
Arsenic	8	0
Aluminum	10	6
Ammonia (Un-ionized)	4	4
Copper	1	0
DDT	4	4
Dieldrin	4	4
Sulfate	56	56
Dioxin (including 2,3,7,8-TCDD)	2	2
Toxaphene	2	2
Chlorpyrifos	10	10
Acetochlor	1	1
Temperature, water	1	0
Total	**6338**	**2942**

Lake and Stream Water Quality Trends

One of the goals of MDA and MPCA water quality monitoring efforts is to identify and track trends in Minnesota waters. The following sections highlight available trend information for Minnesota's lakes and streams. As a part of this assessment, it is important to note that trend analysis can be very challenging, in part due to the amount of data needed over multiple years to detect a trend.

Lake Water Quality – Minnesota has about 12,200 lakes greater than 10 acres in size and another 50 lakes greater than 5,000 acres, totaling roughly 4.5 million acres. Detecting changes (trends) in water quality over time is a primary goal for many monitoring programs. Secchi transparency is a good indicator of lake water clarity and a preferred parameter for monitoring lake water quality trends as it relates to recreational use.

A total of 1,067 volunteers monitored lakes and streams in 2024 under the Volunteer Water Monitoring Program. Data collected from 1973 through 2024, show that 540 lakes had improving trends, 152 had declining trends and 1,010 had no clear trend, for lakes with sufficient data for trend analysis as shown in the table below.

Table 5. Secchi disk trends in Minnesota lake water quality

Description	Number of Lakes	% Lake Clarity Trend
Assessed for Trends	1,702	
Improving	540	32%
Degrading	152	9%
No Clear Trend	1,010	59%

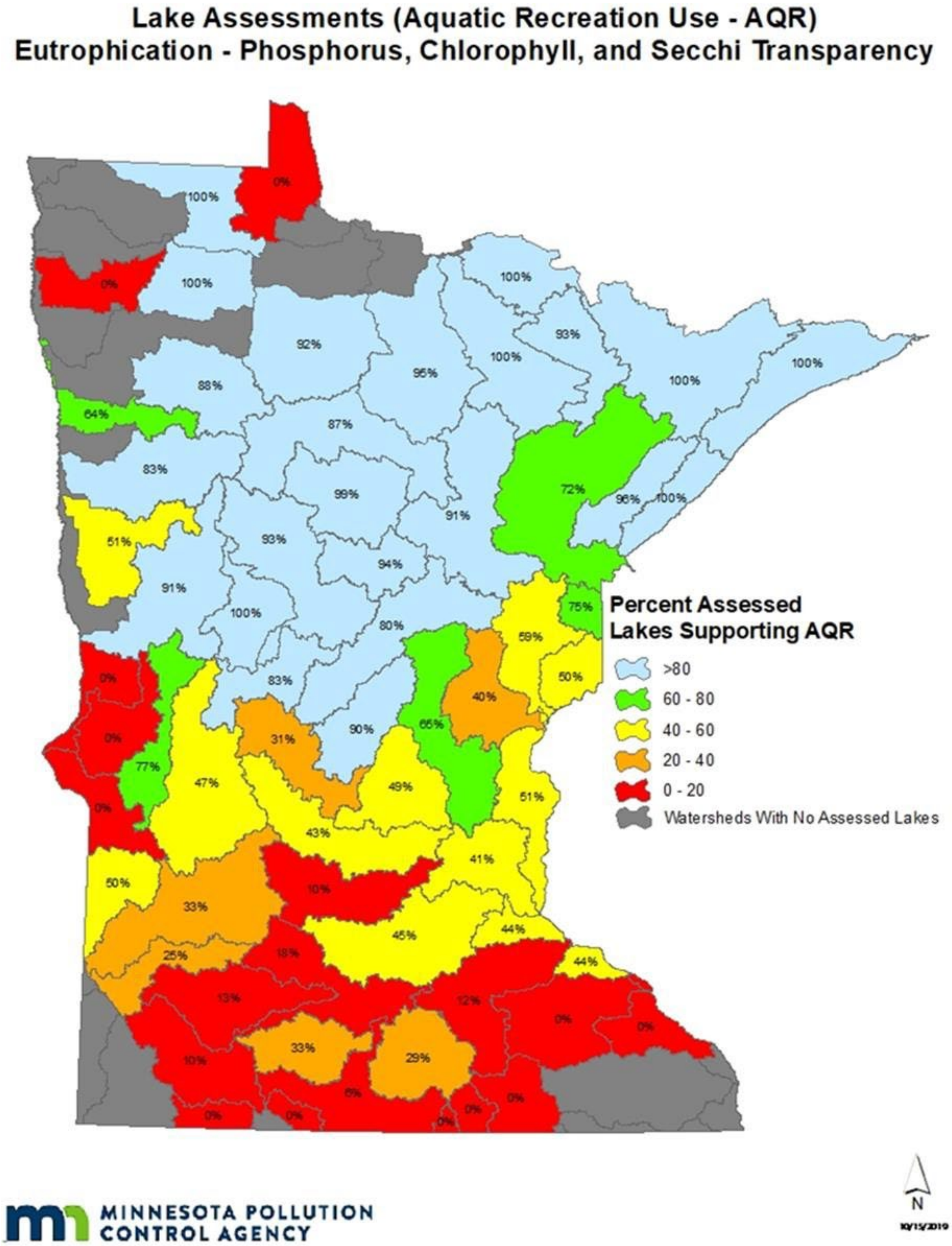
In general, water clarity is poorer in southern Minnesota, and both increasing and decreasing trends are scattered throughout north and south-central Minnesota. Water clarity has stayed the same in roughly two-thirds of the lakes, as presented on page 38 of the Clean Water Fund Performance Report.

Lakes – swimming and recreation – Statewide, roughly 75% of lakes meet the water quality standard for recreational use. The map below shows color shading for the percentage of lakes that fully support swimming and recreation in half of Minnesota's watersheds tested to date. The fact that a lake does not fully support swimming does not mean no one should ever swim there. However, during at least part of the summer, the lake is green and slimy with algae – to the point where swimming is not desirable. In some cases, the algae growth is so bad that a "bloom" forms that can release toxins harmful to pets and people.

Watersheds with just half or fewer of the lakes fully supporting swimming tend to be dominated by agricultural land that is known to contribute excessive phosphorus to water bodies. Phosphorus is the primary driver of algae in lakes.

Higher percentages of lakes fully support swimming in the more forested and wetland rich landscape of the north-central and northeastern part of the state. Natural watershed characteristics such as soil type also play a role in lake phosphorus levels. The MPCA lake water quality webpage can provide further detail.

Figure 8. Percentage of lakes by watershed that fully support swimming and recreation



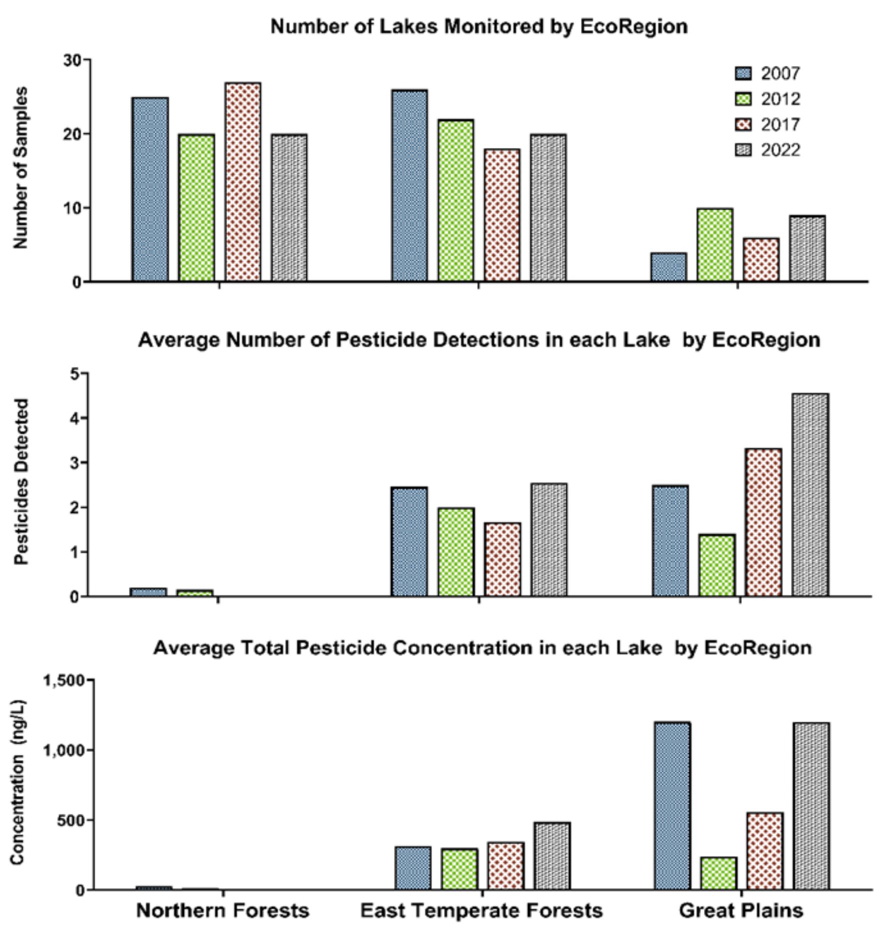
Lake Pesticide Monitoring

Pesticide water quality samples were collected from randomly selected lakes in Minnesota in 2007, 2012, 2017, and 2022 in conjunction with the U.S. EPA National Lake Assessment (NLA). All pesticide detections were very low compared to the applicable water quality reference values except for chlorpyrifos detections in two lakes, and diuron detections in one lake. In each of the NLA years, most detections were herbicide degradates and herbicides. The number of pesticide compounds detected and associated concentration of those compounds tended to increase with an increasing amount of row crop production in a lakeshed. In contrast, increasing amounts of forest in a lakeshed lead to fewer pesticide detections and lower pesticide concentrations.

There was little variability in the pesticides that were detected, and the concentration of detected pesticides, between the 2007, 2012, 2017 and 2022 NLA (Figure 9). The full report, Pesticides in Minnesota Lakes, is available on the MDA Water Monitoring Reports and Resources webpage.

The MDA will align future lake pesticide monitoring efforts with the U.S. EPA National Lakes Assessment that occurs every 5 years. This shift to the 5-year cycle allows MDA to look at many lakes in a single year, and to have comparable data over time for trend analysis.

Figure 9. Analysis of lakes sampled by Minnesota ecoregion during the 2007, 2012, 2017 and 2022 National Lakes



Assessment

Watershed Pollutant Load Monitoring Network - pollutants & clarity in streams and rivers

Stream Water Quality – Some of the best available information on pollutant trends in rivers and streams comes from Watershed Pollutant Load Monitoring Network sites, volunteer-collected stream transparency data, MDA pesticide monitoring sites, and watershed biological conditions for fish and aquatic life.

Watershed Pollutant Load Monitoring Network – This program pairs flow monitoring with water chemistry monitoring to determine trends over time. This network covers sites at basin, major watershed and subwatershed scales. The sampling is designed to capture major runoff and rainfall events and baseflow to allow for the calculation of annual yields, loads, and flow weighted mean concentrations. Parameters include total suspended solids, nitrogen, and phosphorus, and trends are shown in Table 6.

Table 6. Pollutant long term trends (2008-2022) in rivers and streams.

	Total Number of Sites	Decreasing	Increasing	Trend Not Detected
Total Suspended Solids	58	4	2	52
Nitrate	52	2	5	45
Total Phosphorus	55	19	3	39

Volunteer Stream Monitoring – Trend analysis of stream water clarity data (Table 10) has been done using transparency-tube measurements collected by volunteers through the MPCA's Volunteer Stream Monitoring Program (VSMP). Trend results for data collected through 2023 are shown in Table 7. Of note, 538 additional sites had water quality that was too clear to determine a trend. This indicates high quality water at these locations, with very clear water. A map showing the locations of these streams is provided at the MPCA website.

Table 7. Trends in Minnesota stream water clarity.

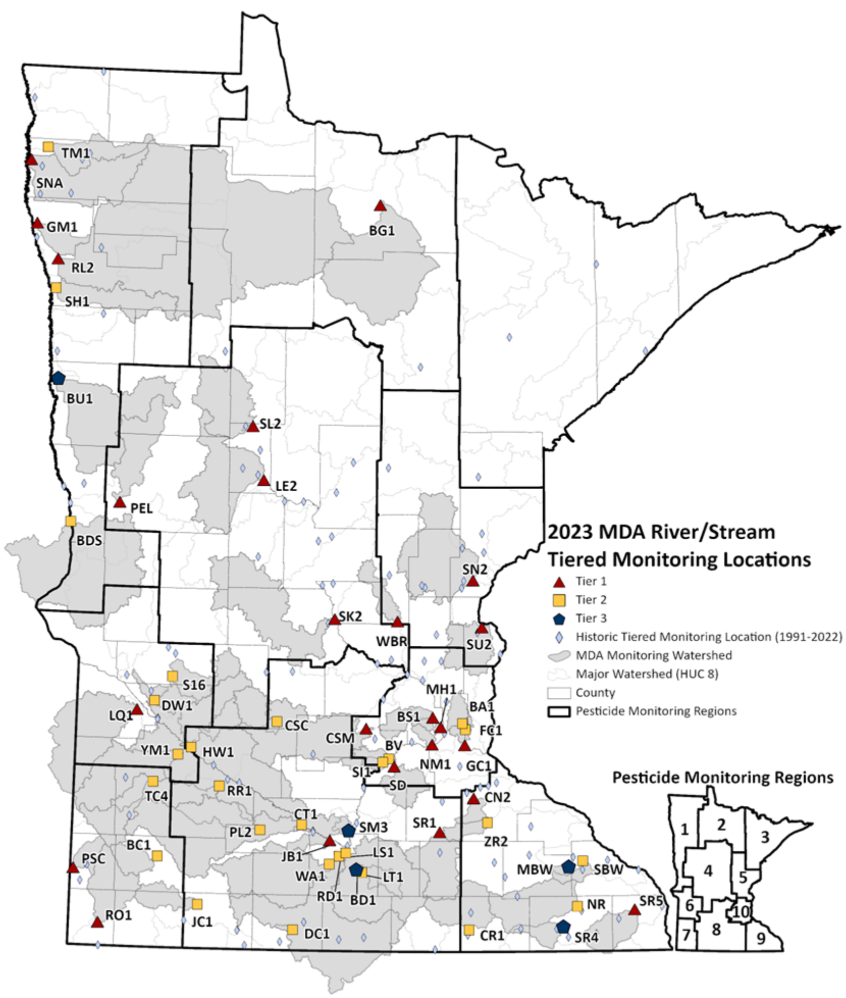
Description	Number of Streams	Percent of Streams with Trend
Assessed for Trends	770	
Improving	330	43%
Declining	180	23%
No Clear Trend	260	34%

Streams and Rivers Pesticide Monitoring

The Minnesota Department of Agriculture (MDA) has been conducting pesticide monitoring in surface waters since 1991. Annually, the MDA completes approximately 600 sample collection events from over 50 river and stream locations (Figure 10). In general, the MDA collects water samples from long-term monitoring networks in agriculture and urban areas of Minnesota and analyzes water for up to approximately 185 different pesticide compounds that are widely used and/or pose the greatest risk to water resources. All monitoring is completed following annual work plans and standard operating procedures (SOP's) developed by the MDA.

The purpose of the MDA's pesticide monitoring program is to determine the presence and concentration of pesticides in Minnesota waters, and present long-term trend analysis. Trend analysis requires a long-term investment in monitoring within the MDA's established networks. The MDA releases an [Annual Water Quality Monitoring Report] that includes all pesticide water quality data and long term trends. The MDA will continue to conduct statewide pesticide monitoring in the future and will provide additional information related to the occurrence of pesticides in Minnesota waters.

Figure 10. Current and historic surface water sampling location.

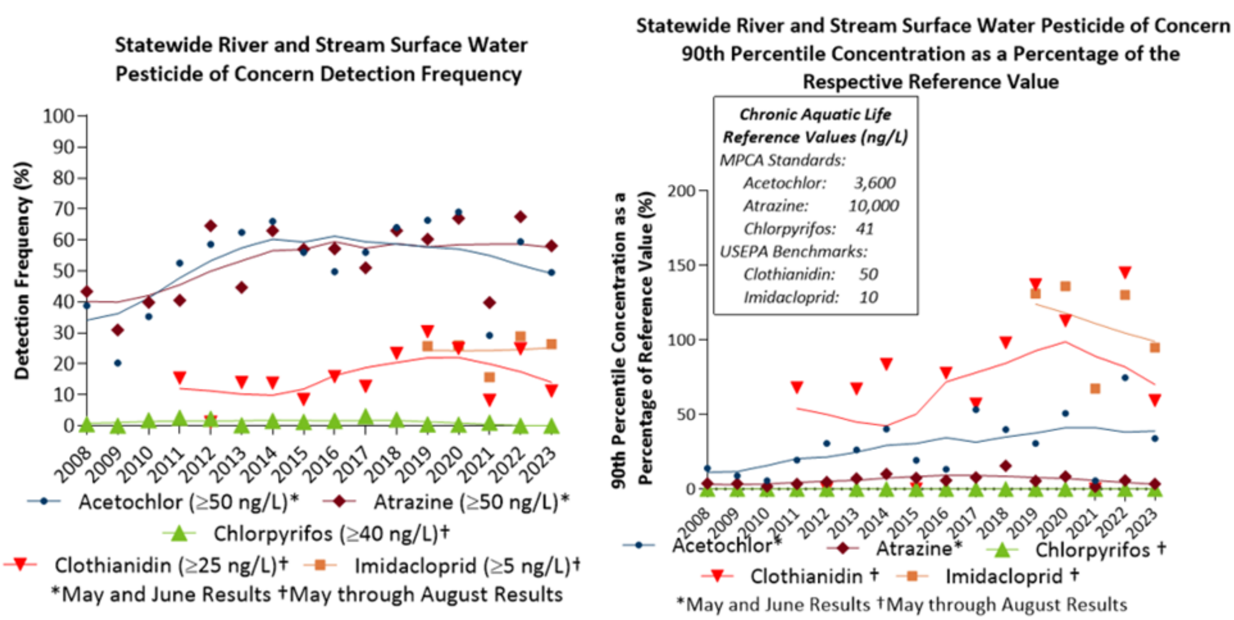


Because pesticides, especially agricultural and home and garden pesticides, are typically applied to coincide with the seasonal need to control weeds, insects and other pests or plant diseases, the presence of pesticides in streams and rivers is often linked to application timing, and subsequent rainfall and runoff events. The MDA detects less than half of the pesticide compounds in rivers and streams that are analyzed in any given year. Most detections are either herbicides or herbicide breakdown compounds and are very low when compared to aquatic life reference values. Concentrations can be temporarily elevated in rivers and streams immediately following runoff periods shortly after pesticides are applied. The MDA's monitoring structure increases monitoring intensity at locations that had a pesticide detection at a concentration greater than a reference value, and the more intense monitoring occurs for at least three years following the elevated detection. The MDA meets with the MPCA annually to review all water quality data for possible water quality impairments.

The Minnesota Commissioner of Agriculture designated five pesticides as a "surface water pesticide of concern" (SWPOC). Designation as a SWPOC initiates the development of chemical specific best management practices (BMPs) and increased water quality monitoring and data analysis. The criteria for such designations are presented in the Pesticide Management Plan (PMP). Acetochlor and atrazine, both herbicides, were designated as a SWPOC in 2002. Three insecticides have also been designated as a SWPOC: chlorpyrifos (2012), clothianidin (2020), and imidacloprid (2020). In 2023, the only pesticide compounds detected in rivers and streams over a reference value were those designated as a SWPOC.

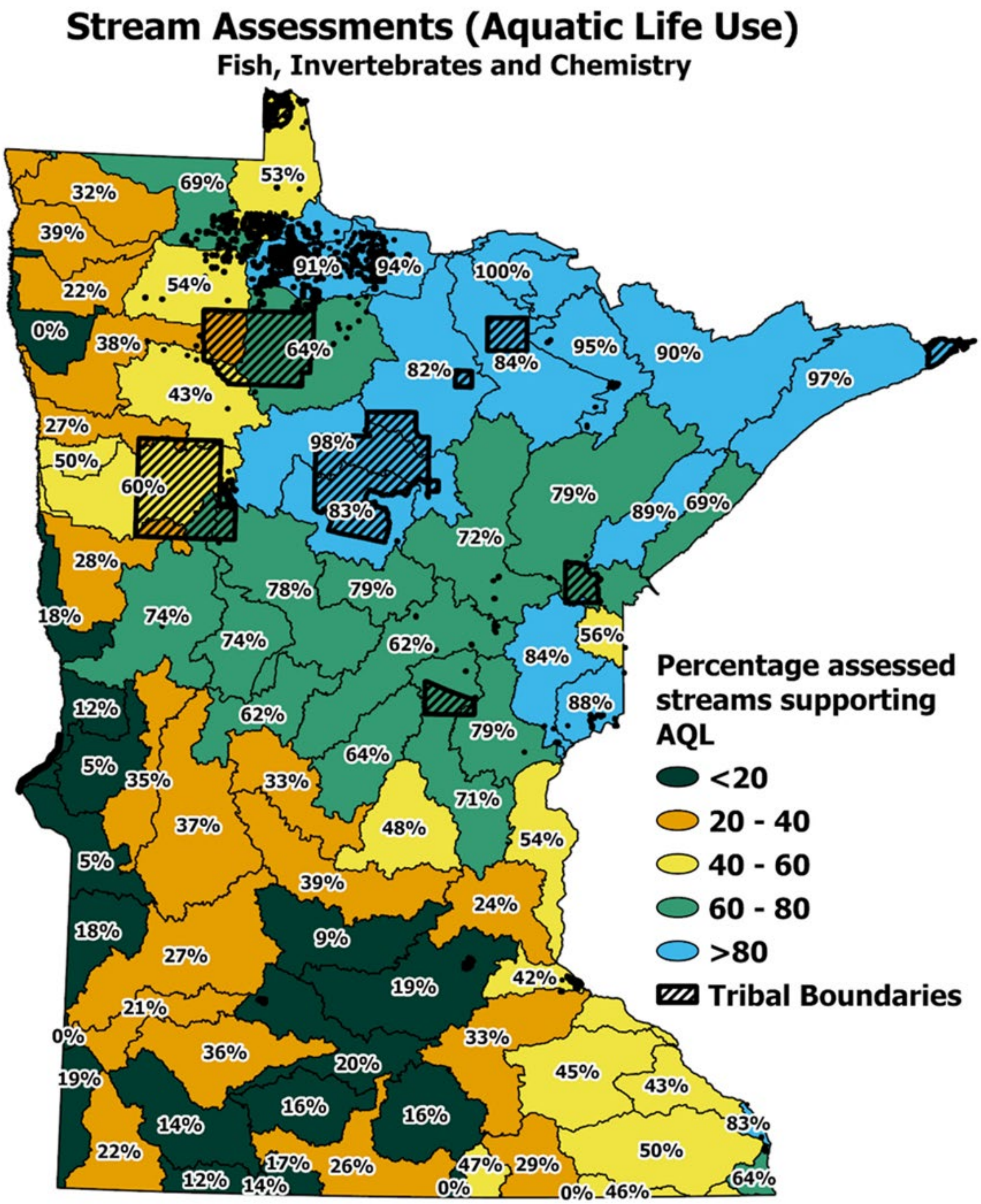
The MDA analyzes data from its network of sampling locations to track SWPOC statistics. Figure 11 presents statewide river and stream detection frequency and 90th percentile concentrations relative to the reference value (right) for the SWPOC. Additional information isavailable in the [Annual Water Quality Monitoring Report](#).

Figure 11. Surface water pesticide of concern statewide detection frequency (left) and 90th percentile concentration relative to the reference value (right), 2008 through 2023



Streams and rivers – fish and other aquatic life – The MPCA and partners have assessed a total of 2,681 stream and river sections statewide for fish and other aquatic life under the watershed approach. The map below (Figure 12) shows the percentage of streams and rivers that fully support fish and aquatic life by watershed. Patterns in this map are similar to the previous map for swimming and recreational suitability, and for watersheds that have been identified as needing pollutant source reductions.

Figure 12. Percentage of streams and rivers by watershed that support fish & aquatic life



The northwest exhibits somewhat better conditions for recreation, while showing poor stream life. The southeast on the other hand shows somewhat better stream life, with poor conditions for recreation. This may be due to the steeper landscape of southeastern Minnesota, which facilitates runoff of bacteria and other pollutants, but results in better habitat for aquatic life. Further information is available at the MPCA rivers and streams webpage.

Chloride

At present, there are over 65 chloride impairments in the across the state for streams, lakes and wetlands as shown on the Minnesota's chloride conditions map.

The Twin Cities Metropolitan Chloride Management Plan provides a detailed analysis of the status, sources and trends of chloride observed in many Twin Cities streams, lakes and groundwater. A summary of the data analysis from this report shows that:

1. Chloride use increased in the TCMA in the latter half of the 20^{th} century, 1950-2000,
2. Levels of chloride are continuing to increase in both groundwater and surface waterbodies in the TCMA,
3. The highest chloride concentrations have been found during snowmelt conditions during winter months and low flow periods in streams,
4. Chloride levels tend to be higher in the bottom of a lake versus the surface,
5. Chloride concentrations in TCMA waterbodies are positively correlated to road density in the contributing watersheds,
6. There is a lot that is not known about chloride concentrations in TCMA waterbodies, since a large majority of the TCMA waterbodies do not have any data and do not have data that would represent critical conditions, and

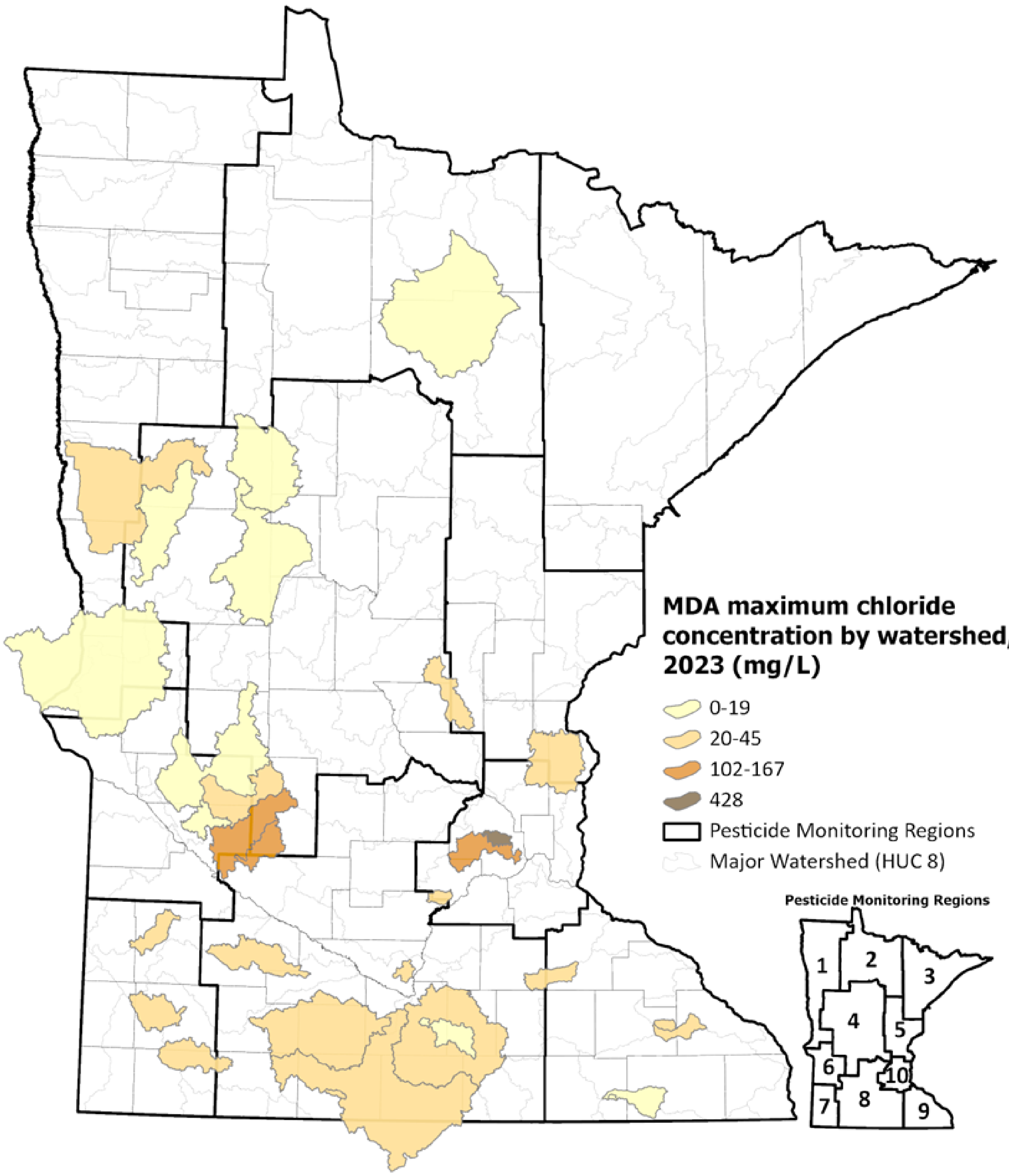
Winter maintenance activities as well as wastewater treatment plants tend to be the primary sources of chloride to TCMA waters.

Chloride impacts are not limited to the Metro Area, and to address this, the MPCA in collaboration with several partners has published the State Chloride Management Plan (CMP). The CMP outlines a comprehensive strategy to reduce salt (chloride) use from a variety of sources to protect Minnesota's lakes, rivers, and other water resources. It is intended to provide guidance to local government units, winter maintenance professionals, decision-makers, among others.

Other reports and resources on chloride management are available on MPCA's Statewide chloride resources webpage.

The MDA added chloride analysis at select locations in greater Minnesota in 2023. Sample collection was limited to the summer months (May through August). Maximum chloride concentrations were generally <50 mg/L in 2023 for most watersheds outside of the Twin Cities Metropolitan Area, while chloride levels were much higher in urban streams (Figure 13).

Figure 13. 2023 maximum chloride concentration (May through August) in greater Minnesota



Wetlands water quality trends

The MPCA works in conjunction with EPA on the National Wetland Condition Assessment (NWCA) and an intensification survey to broadly track wetland vegetation quality trends at statewide and regional scales. Three survey cycles have been completed (2011, 2016, and 2021) and wetland vegetation quality is largely unchanged over that time period. Approximately 60% of Minnesota's wetlands have exceptional/good vegetation quality, but quality varies greatly in different parts of the state. In the northern forest (where roughly three quarters of Minnesota's wetlands occur), 72% of the wetland extent is in exceptional/good quality. Conversely, over 74% of the wetland extent in the former hardwood forest and prairie regions have degraded quality. The MPCA anticipates continuing this survey on the 5-year NWCA schedule and is prepping for the next iteration beginning in 2026.

In addition, the MPCA conducts an independent survey of macroinvertebrate and water quality in open-water depressional wetlands in the former hardwood forest and prairie regions of Minnesota. Four survey cycles have been completed (2007-09, 2012, 2017, and 2023) showing that macroinvertebrate and water quality have largely remained stable over the time period with an estimated 57% of the extent in good condition. The MPCA anticipates continuing the depressional wetland survey in 2028.

Nitrogen

Nutrient Reduction Strategy – The Minnesota Nutrient Reduction Strategy (NRS) compiles the latest science, research, and data and recommends the most effective strategies to reduce nutrients in our waters from both point and nonpoint sources. The strategy serves as a framework, outlining how voluntary and regulatory actions can reduce nutrient pollution to meet long-term goals. When nutrient levels exceed natural conditions, they can cause excessive algae growth, low levels of oxygen, toxicity to aquatic life, and unhealthy drinking water. Reductions in Minnesota's nitrogen and phosphorus pollution are needed to reach our in-state water quality goals and the goals that aim to restore the Gulf, Lake Winnipeg, and Lake Superior.

The Minnesota NRS was finalized in 2014, with a five-year progress report in 2020. In late 2022, the interagency group that compiled the original strategy reconvened to begin the scheduled 10-year update, which will be finalized by the end of 2025.

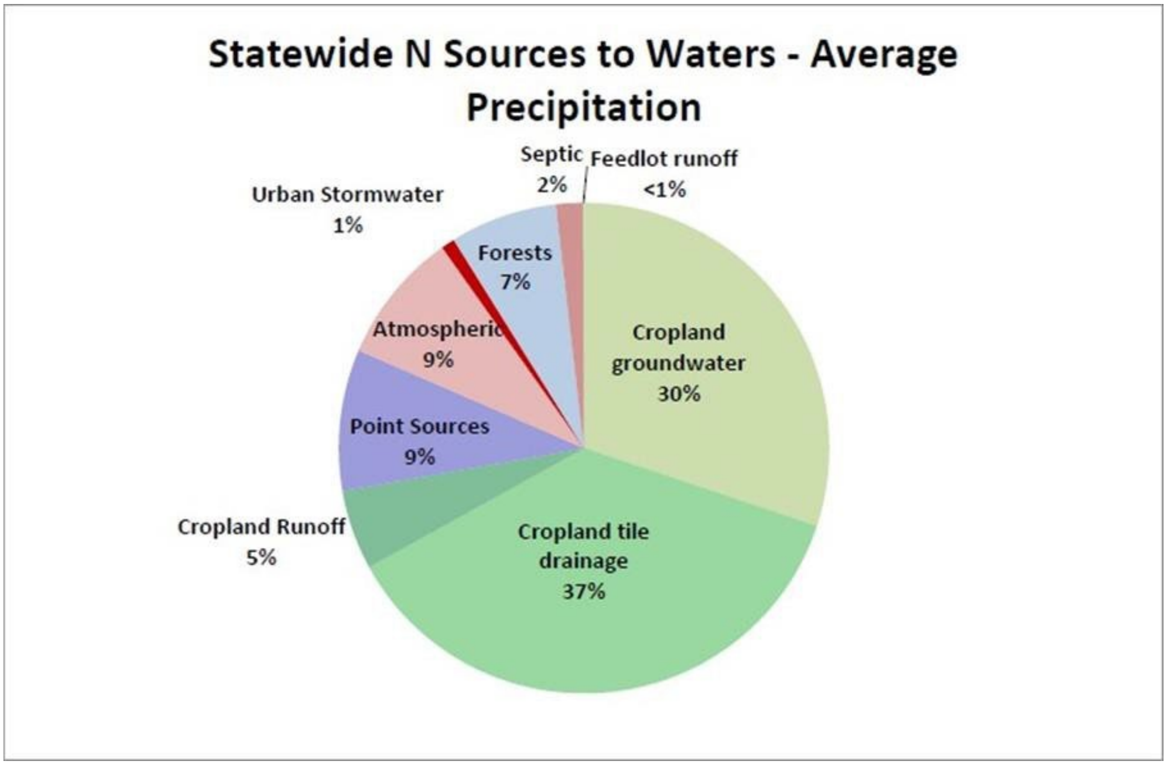
The most recent NRS five-year progress report as well as BMP's and other information can be found on the MPCA's Minnesota Nutrient Reduction Strategy webpage.

Nitrogen loading - The MPCA, working in collaboration with the University of Minnesota and U.S. Geological Survey, completed a study in 2013 to characterize total nitrogen loading to Minnesota's surface waters. The Minnesota Legislature provided funding for the study, which used more than 50,000 water samples collected at 700 streams sites, 35 years of monitoring data, and findings from 300 published studies. The resulting report, titled **Nitrogen in Minnesota Surface Waters – conditions, trends, sources and reductions**, provides a scientific foundation of information for developing and evaluating nitrogen reduction strategies.

An estimated 73% of statewide nitrogen (N) entering surface waters is from cropland sources and 9% is from wastewater point sources, with several other sources adding the other 18% (see figure 14 below).

Most of the cropland N reaches waters through subsurface agricultural tile drainage and groundwater pathways, with a relatively small amount in overland runoff.

Figure 14. Estimated statewide N contributions to surface waters during an average precipitation year



The study concluded that surface water N concentrations and loads are high throughout much of southern Minnesota, contributing to the N enriched hypoxic zone in the Gulf of Mexico, nitrate in excess of drinking water standards in certain cold-water streams, and a potential to adversely affect aquatic life in a large number of Minnesota rivers and streams. Northern Minnesota has relatively low river N levels, and pollution prevention measures should be adopted in this area as landscapes and land management change. Additionally, nitrogen loss reductions are needed in the Red River Valley so that Minnesota can do its part to reduce algal blooms in Lake Winnipeg.

Contaminants of Emerging Concern (CECs) and Per- and Polyfluoroalkylsubstances (PFAS)

In the last two decades, national and statewide studies have revealed that in addition to toxicological effects, many chemicals found in the aquatic environment have known or suggested endocrine-disrupting potential. These chemicals include pharmaceuticals, personal care products, chemicals associated with wastewater effluent, and a variety of industrial compounds. There is a growing concern that even at low concentrations chemicals, or mixtures of them, may adversely affect fish, wildlife, ecosystems and possibly human health.

A 2021 report on pharmaceuticals and chemicals of concern in Minnesota lakes shows that pharmaceuticals and micro-pollutants are more ubiquitous in surface water than was previously suspected. This study was the third in a series of large-scale, probabilistic investigations that were designed to understand the extent to which these chemical contaminants are present in surface water on a statewide level. Of the 163 chemicals tested, 55 were found in lakes at least once. All 50 lakes contained at least one contaminant. Twenty-one of these chemicals may pose a risk to aquatic ecosystems, with five of these – the frequently detected insect repellant DEET, the hormone estrone, bisphenol A, 4-nonylphenol, and 4-n-octylphenol – of the greatest level of concern due to their toxicity, potential for bioaccumulation, frequency of detection, persistence, and the concentrations at which they were found.

Per- and Polyfluoroalkylsubstances (PFAS)

PFAS constitute an important and complex class of contaminants with. The MPCA has been working on issues related to PFAS since the early 2000s, when we started addressing what were then called PFCs (perfluorinated chemicals) at four waste disposal sites in Washington County used by the 3M Company. Since then, PFAS have been detected in water, sediment, soil, and fish across Minnesota. PFAS are in air emissions from industrial facilities, wastewater from industrial and municipal sources, soil and water surrounding firefighting training sites, groundwater surrounding landfills, and are sometimes found with no obvious source at all.

Scientists and environmental regulators have reached an overwhelming consensus that significant actions are needed to prevent adverse impacts from PFAS. While management and mitigation actions have significant positive effects, ultimately Minnesota cannot clean our way out of the PFAS problem. Instead, the pollution must be prevented from the outset through restrictions or bans on PFAS uses and assistance and financial support for reformulation.

Some PFAS compounds build up in fish tissue, potentially causing harm to consumers. The MPCA studies detected perfluorooctane sulfonate (PFOS) at elevated concentrations in fish taken from the Mississippi River near the 3M Cottage Grove plant and downstream. These fish tissue PFOS concentrations prompted the MDH to issue a one-meal per month fish consumption advisory for certain species in Pool 2. The lower reach of Mississippi River Pool 2, which received 3M Cottage Grove effluent during the years of PFOS and perfluorooctanoic acid (PFOA) manufacturing, is listed as an impaired water due to PFOS in fish tissue and water. Other fish harvested from Twin Cities Metro Area lakes, some with no known connections to 3M's manufacturing or waste disposal, also contained elevated concentrations of PFOS. Subsequent investigation revealed that PFAS emitted from a metal plating facility contributed significant amounts of PFOS to these Metro Area waterbodies. Currently, a total of 11 waters are impaired for PFOS in fish tissue based on fish consumption advice. This fish contamination and subsequent consumption advice disproportionately impacts Minnesotans who rely on locally harvested fish as a free and healthy source of protein for themselves and their families.

Concern over PFAS exposure from fish consumption has motivated continued monitoring of fish tissue and surface water around the state. The fish contaminant monitoring program added PFAS in 2004. Since then, MDH has issued specific fish consumption guidance on 51 of Minnesota's rivers and lakes due to PFAS in fish. Thousands of fish from more than 200 different segments of lakes, rivers, and streams have been tested for PFAS. Since methods were standardized in 2017, about 85% of waters tested had fish containing PFAS, although usually at levels far below those used by MDH for fish consumption guidance. Perfluorooctane sulfonate (PFOS) is one of the oldest and most common types of PFAS found in fish, but many other types of PFAS, including those recently created, are also detected.

In 2023, the Minnesota Legislature approved budget requests and PFAS pollution prevention measures that directly address concerns about PFAS in fish. Funds were appropriated for several aspects of the state's comprehensive PFAS Blueprint, including $910,000 from the Clean Water Fund to expand the fish monitoring program. New prohibitions on PFAS in firefighting foam, which is a significant contributor to PFAS in fish, took effect in January 2024. Under Amara's Law, restrictions on PFAS in many everyday products took effect in 2025 and further prohibitions on avoidable PFAS use are scheduled for 2032. New statewide water quality standards for six types of PFAS are due July 2026, which will enable the MPCA to reduce PFAS entering the environment through permitting.

There is significant work to be done in continuing to monitor PFAS in Minnesota's water resources and developing strategies to ensure that PFAS levels in water are safe for human health and aquatic life. The MPCA is working in an integrated way, across the MPCA and MDH, DNR, and MDA, to develop approaches to effectively address this complex environmental problem statewide. MPCA has hired a PFAS Coordinator to lead the PFAS Lateral Team and guide the development of a cross-agency PFAS Action Plan. MPCA is also partnering with other states to share information on environmental monitoring results, regulatory strategies, and solutions to the unique technical challenges posed by PFAS. MN is member of the PFAS Great Lakes Taskforce, which includes representatives from U.S. States and Canadian Provinces in the Great Lakes Watershed. Minnesota is also regularly sharing information with New England State associations working on PFAS and other national groups like the Environmental Council of States (ECOS) and the Interstate Technology and Regulatory Council (ITRC). Finally, MPCA and MDH are actively partnering with EPA's Office of Research and Development (ORD) to conduct state of the art research and develop new tools that will be implementable in our State.

Surface water quality: Reducing, preventing, minimizing and eliminating degradation

The major goal in preserving water quality is to enable Minnesotans to protect and improve the state's rivers, lakes, wetlands and groundwater so that they support healthy aquatic communities and designated public uses such as fishing, swimming and drinking water. The key strategies for accomplishing this goal include regulating point source discharges, controlling nonpoint sources of pollution, and assessing water quality to provide data and information to make sound environmental management decisions.

The MDA also considers the watershed approach for water quality protection, and has been guided for pesticides by the 2007 (update in progress) Minnesota Pesticide Management Plan (PMP) and for nitrate by the Nitrogen Fertilizer Management Plan.

The PMP established the delineation of Pesticide Monitoring Regions (PMRs) and Pesticide Management Areas (PMAs) as indicated earlier in this report. The PMRs and PMAs are generally identical and are based on similar hydrologic, geologic, and agricultural management characteristics occurring within the region/area. The PMAs provide the MDA with a framework for outreach and education to agricultural stakeholders and is further described in the Pesticide Management Plan (Chapter 8: Prevention).

The watershed approach involves multiple program efforts focused on water quality protection and restoration. Information on the following efforts to prevent surface water quality degradation are provided below:

- Wastewater Discharges (point sources),
- Nonpoint Source Pollution:
  - Minnesota's Nonpoint Management Plan (2021),
  - Watershed Achievements Report (2022),
  - Clean Water Partnership Program,
  - Nitrogen in Minnesota's Surface Waters; Conditions, trends, sources and reductions (2013),
  - The Minnesota Nutrient Reduction Strategy
  - Chloride (road salt)
- Pesticides and Fertilizers

***Wastewater Discharges* (point sources)** – The MPCA regulates the discharge of treated wastewater to surface waters of the state (primarily rivers and streams) from both municipal and industrial facilities through NPDES/SDS permits. Minnesota has been successful in controlling end-of-pipe (point source) discharges from wastewater treatment plants to our state's surface waters.

Improvements to wastewater treatment plants and a high level of regulatory compliance in meeting effluent standards are improving the overall quality of discharges to Minnesota's surface waters. For more details, please see the **2022 Pollution Report to the Legislature. Point source pollutant loading trends,** pages 25-30.

In addition, significant wastewater mercury loading reductions have been achieved since 2005/2006. (Mercury loads prior to 2005 are no longer referenced because of changes in the ability to detect mercury in effluent. Information on mercury in fish and mercury reductions in air emissions can be found in the **2024 Clean Water Fund Performance Report** on pages 43-44.

Nonpoint Source Pollution – Water quality in Minnesota is mainly degraded by the pollutants entering surface waters from nonpoint sources derived from both air pollution and runoff from land, particularly from watersheds dominated by agricultural and urban land use. Nonpoint source pollution is the major cause of degradation of Minnesota's surface and groundwater.

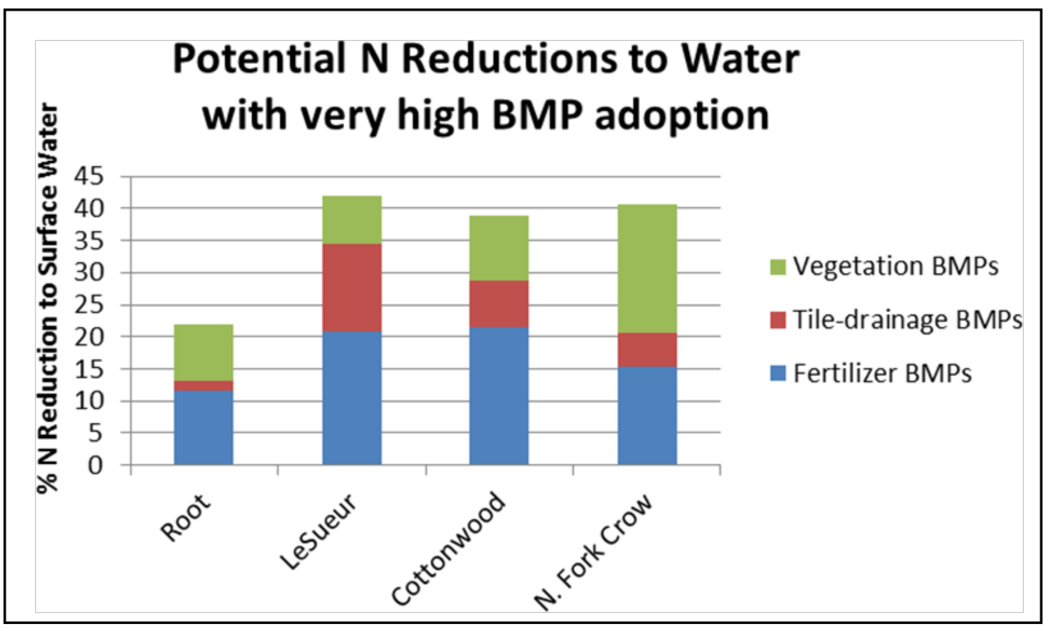
Minnesota's Nonpoint Source Management Program Plan 2019-2029 – This plan describes Minnesota's ten-year plan to control nonpoint sources of water pollution and the numerous activities directed towards this effort.

Watershed Achievements Report – The 2022 **Watershed Achievements Report** describes statewide and watershed-based projects being implemented that are cleaning up nonpoint sources of pollution, mainly through funding from the Section 319 Grant Program and the Minnesota Clean Water Partnership Program.

The Report presents numerous examples of BMP implementation that have led to reductions in nonpoint source pollution, including: shoreline restoration, sedimentation ponds, manure management, conservation tillage, terraces, new ordinances, wetland restoration, fertilizer management, and education.

Nitrogen in Minnesota Surface Waters – The Statewide Nitrogen Study, referenced above, concluded that reducing nitrogen levels in rivers and streams in southern Minnesota will require a concerted effort over much of the land in this region, particularly tile-drained cropland and row crops over permeable soils and shallow bedrock. The figure below (figure 15) depicts the potential nitrogen reductions needed in four southern Minnesota watersheds with a very high adoption of BMPs.

Figure 15. Potential N reduction to water with BMP adoption



The Minnesota Nutrient Reduction Strategy – is a guide for Minnesota to reduce excess nutrients in water to meet both in state and downstream water quality goals. The strategy sets goals and milestones to meet phosphorus and nitrogen reductions for the Great Lakes, Lake Winnipeg, the Mississippi River, and the Gulf of Mexico.

The strategies are included in Watershed Restoration and Protection Strategies (WRAPS) reports. To date, 52 watersheds have approved WRAPS, with 4 more watersheds out for public comment or approval.

For the 52 watersheds (as of June 2020) that have completed the WRAPS, some general themes have emerged:

- In watersheds where agriculture dominates the landscape, prominent strategies for restoration include: stream buffers; nutrient and manure management; wetland restorations; drainage management and other forms of water storage and soil health practices including reduced tillage, cover crops and extended crop rotations.
- In watersheds where forest dominates the landscape, strategies focus more on protection and include: shoreland protection practices; forest management; and in lake management such as aquatic invasive species management, aquatic vegetation management and fish management.
- For more urbanized areas, strategies focus on stormwater runoff controls ranging from reduction of impervious surfaces, site planning and rain gardens, to the construction of stormwater ponds and wetlands. In many heavily urbanized areas, chloride management's strategies are also needed.
- Not all strategies relate to traditional water pollutants. Throughout Minnesota, common strategies include improving habitat and reducing barriers (connectivity) for fish and other aquatic life such as the replacement of perched or undersized culverts. Addressing altered hydrology is the most common need across Minnesota as nearly 50% of the stream miles in Minnesota have been altered by humans and are greatly affecting water quality across the state.
- Most of the changes that must occur to improve and protect water resources are voluntary; therefore, communities and individuals ultimately hold the power to restore and protect waters in Minnesota. Meaningful civic engagement is key to achieve clean water in a system that relies heavily on voluntary adoption. By engaging in greater civic engagement in watershed planning, more citizens become leaders for change in their communities and individuals become personally responsible for making needed changes that could reduce water pollution.

Beyond voluntary adoption, some strategies call for stronger and more targeted application of state and local laws on feedlots, wastewater, stormwater, shoreland, drainage and septic systems.

Chloride – The Twin Cities Metropolitan Chloride Management Plan (CMP) highlights the impacts of chloride on Twin Cities Metropolitan Area water quality with an overarching purpose to set goals for restoration and protection of water quality, improve winter maintenance practices and policy needs, and demonstrate the success and economic benefits of improved practices.

The CMP provides in-depth strategies for reducing chloride through pollution prevention activities and BMPs that will help protect and restore water quality in Twin Cities' streams, lakes and groundwater. The MPCA also provides guidance on road-salting strategies to limit impacts to water quality.

Pesticides and Fertilizers – The foundation of the MDA's programs to reduce, prevent minimize and eliminate degradation of water resources from pesticides and fertilizers begins with the registration of products and, for pesticides, EPA's risk assessments and development of product labels. Pesticide regulation also includes the certification and licensure of certain commercial and private applicators, and education and regulatory oversight of label use provisions (e.g., restrictions on use rate per acre and according to soil type; application setbacks from water bodies; and other water resource-related use restrictions or hazard statements) through outreach and inspections.

The MDA surface water programs for prevention, evaluation and mitigation of pesticide and fertilizer impacts adhere to guidance documents and plans such as the Pesticide Management Plan (PMP), or other efforts that are implemented through monitoring, assessment and multi-stakeholder committees that review the activities of MDA and cooperators. These plans, along with cooperator assistance, guide the MDA in evaluating Best Management Practices established to prevent and minimize agricultural chemical impacts to water resources. In addition, groups external to the MDA play a role in advancing key issues related to environmental protection and farming profitability. Information about the Pesticide Management Plan Committee is available at the PMP link above, along with links to the biennial PMP Status Reports required under statute. The PMP Status Reports provide additional detail about MDA prevention, evaluation and mitigation efforts to protect Minnesota's water resources from pesticide impacts. Information about nutrient-related research and outreach conducted via the Agricultural Fertilizer Research & Education Council is available on this MDA website.

Once pesticides are observed in water resources, the MDA's PMP provides guidance for evaluating monitoring results and addressing any impacts through voluntary or regulatory actions supported by the Pesticide Control Law (Minn. Stat. chapter 18B), and the Clean Water Act as administered by the MPCA (Minn. Rules chapter 7050).

Other examples of MDA programs and efforts related to protecting water resources from pesticide and fertilizer impacts include:

- Education and promotion of pesticide BMPs;
- Protection of public drinking water supplies from nitrogen fertilizers;
- Guidance to homeowners on testing domestic wells for pesticides;
- The Nutrient Management Initiative (NMI) program provides a framework for farmers to evaluate their current nutrient management practices compared with an alternative practice on their own field;
- General pesticide management education and outreach;
- General guidance on nutrient management, and;
- MDA Clean Water Fund activities.

Surface water summary

Within the last five years, there has continued and expanded environmental monitoring and assessment, which has resulted in the numerous reports and updates cited above. To a large degree, this has been the result of the Clean Water Legacy Act and amendment. Because of this, we continue to identify problems and threats to the water quality conditions of our lakes, streams and wetlands, but have also begun to implement remedies and protective measures.

Most of the pollution originating from point sources (municipal and industrial facilities discharging to a state water) has been controlled for total phosphorus, ammonia, and bacteria, as cited in the reports above. Surface water quality is mainly degraded by the pollutants entering surface waters from nonpoint sources derived from runoff, particularly from watersheds dominated by agricultural and urban land use. Nonpoint source pollution is the major cause of degradation of Minnesota's surface water; impairing recreation, fish consumption, drinking water use, and aquatic life (2014 Integrated Report).

Starting in 2008, the MPCA began a 10-year cycle to monitor and assess about eight of Minnesota's 80 watersheds each year, to identify impaired and "unimpaired" waters. The first iteration of this monitoring cycle has been completed and we are more than halfway through the second cycle in order to track progress towards meeting water quality goals. In some regions of the state, our major watersheds are characterized as moderately to severely polluted. Constituents of concern often include: suspended sediments, excess nutrients (primarily nitrogen and phosphorus), pesticides, pathogens and biochemical oxygen demand. The sources of pollutants have been defined by major watershed for the areas studied during the first 10-year cycle of monitoring and assessment of the state's watersheds.

The challenge now will be to implement the strategies to restore and protect our water resources to meet the water quality goals and nutrient load reductions, defined in our reports and planning documents; that include:

- The Minnesota nutrient reduction strategy,
- Minnesota's clean water roadmap, setting long-range goals for Minnesota's water resources,
- Watershed restoration and protection strategies (WRAPS),
- Total maximum daily load (TMDL) reports, and
- Nitrogen in Minnesota surface waters, conditions, trends, sources, and reductions.

Finally, implementation of all of the tools available for reducing and preventing pollution, from regulatory permits to voluntary BMPs, is key to achieving water quality standards and ensuring that the designated uses of Minnesota's surface waters are restored and maintained.

Conclusion

In accordance with 2008 legislation that modified state agency reporting requirements for water assessments and reports, this report summarizes relevant water quality monitoring data for both groundwater and surface water in Minnesota from the MPCA and MDA.

The MPCA and MDA collect water quality information in response to both broad and specific statutory mandates to explore water quality issues of current and emerging concern, and in accordance with formal interagency agreements, and through continuous cooperation and open communication.

Significant progress has been made by MPCA, MDA and stakeholders in addressing sources of groundwater contamination, particularly through remediation, permitting and BMP activities. However, concerns still exist, and continued effort is needed to fully realize the state's groundwater quality goals.

Improvements in state surface water quality have also been significant, along with voluntary and regulatory reduction of point and nonpoint sources of pollution through MDA and MPCA programs and stakeholder support. Coupled with these gains are opportunities for continued improvements, and additional actions are needed to realize Minnesota's surface water quality goals.

For both groundwater and surface water resources, ongoing monitoring is required to characterize vulnerable aquifers and landscape settings. Additionally, MDA and MPCA must continue to identify and investigate contaminant problems, including the presence and extent of emerging contaminants.

Ongoing monitoring provides the trend data that is critical to evaluating progress and refining management actions. Protection strategies – whether regulatory or voluntary –must be developed that avoid the occurrence of new problems, and all strategies should be periodically re-evaluated and refined to adapt to changing situations in chemical and land use.