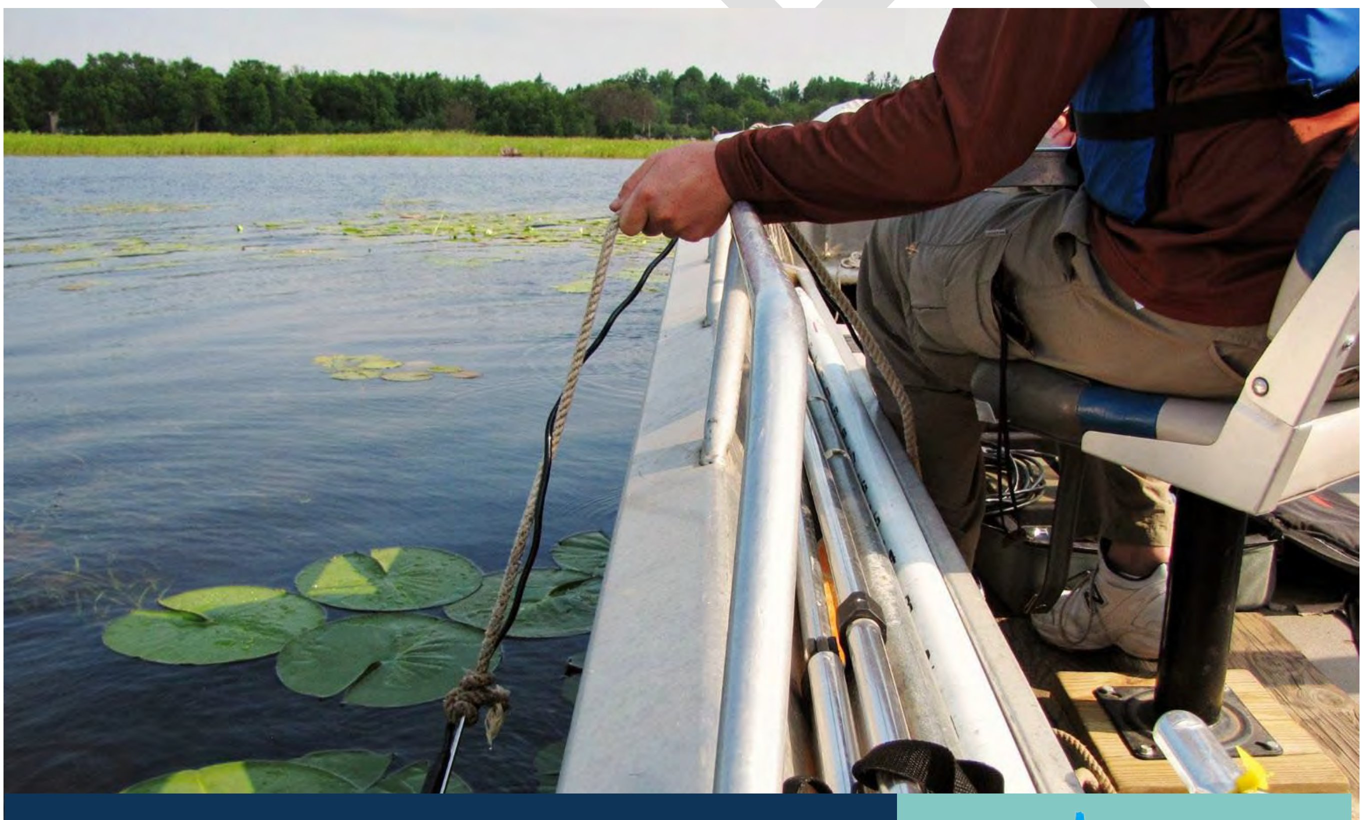
Water quality

August 2025

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



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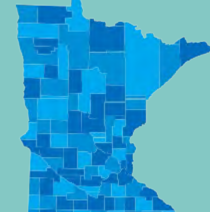

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# Contents

# 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

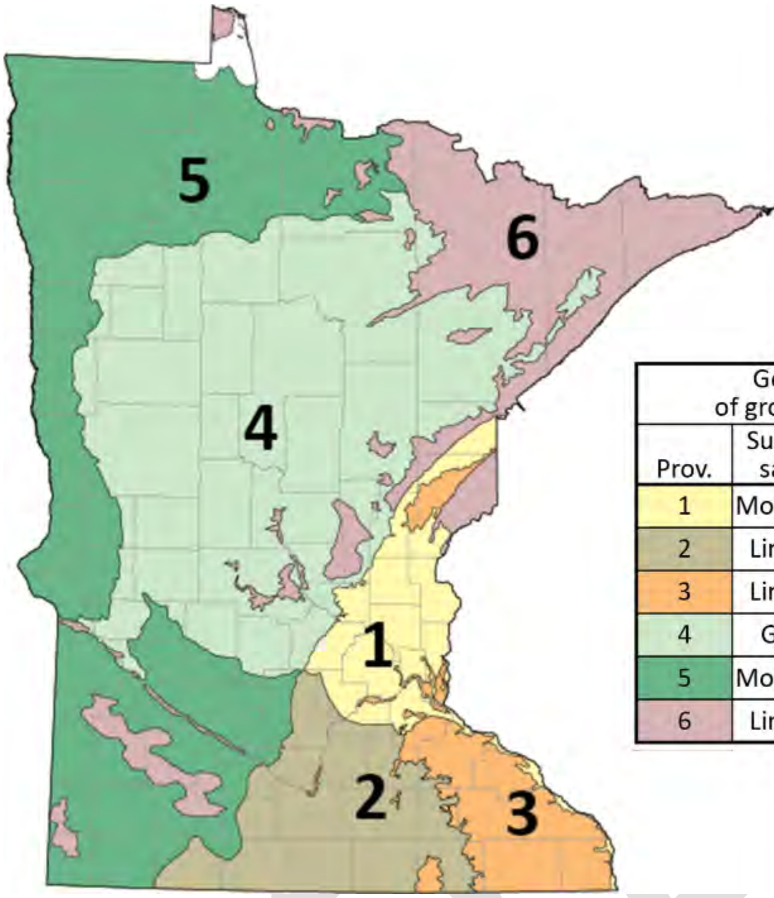
Groundwater provides nearly 75% of Minnesotans with their primary source of drinking water and nearly 90% of the water used for agricultural irrigation (estimated by the Minnesota Department of Health (MDH) and the Minnesota Department of Natural Resources (MDNR), respectively). For these reasons alone 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 |



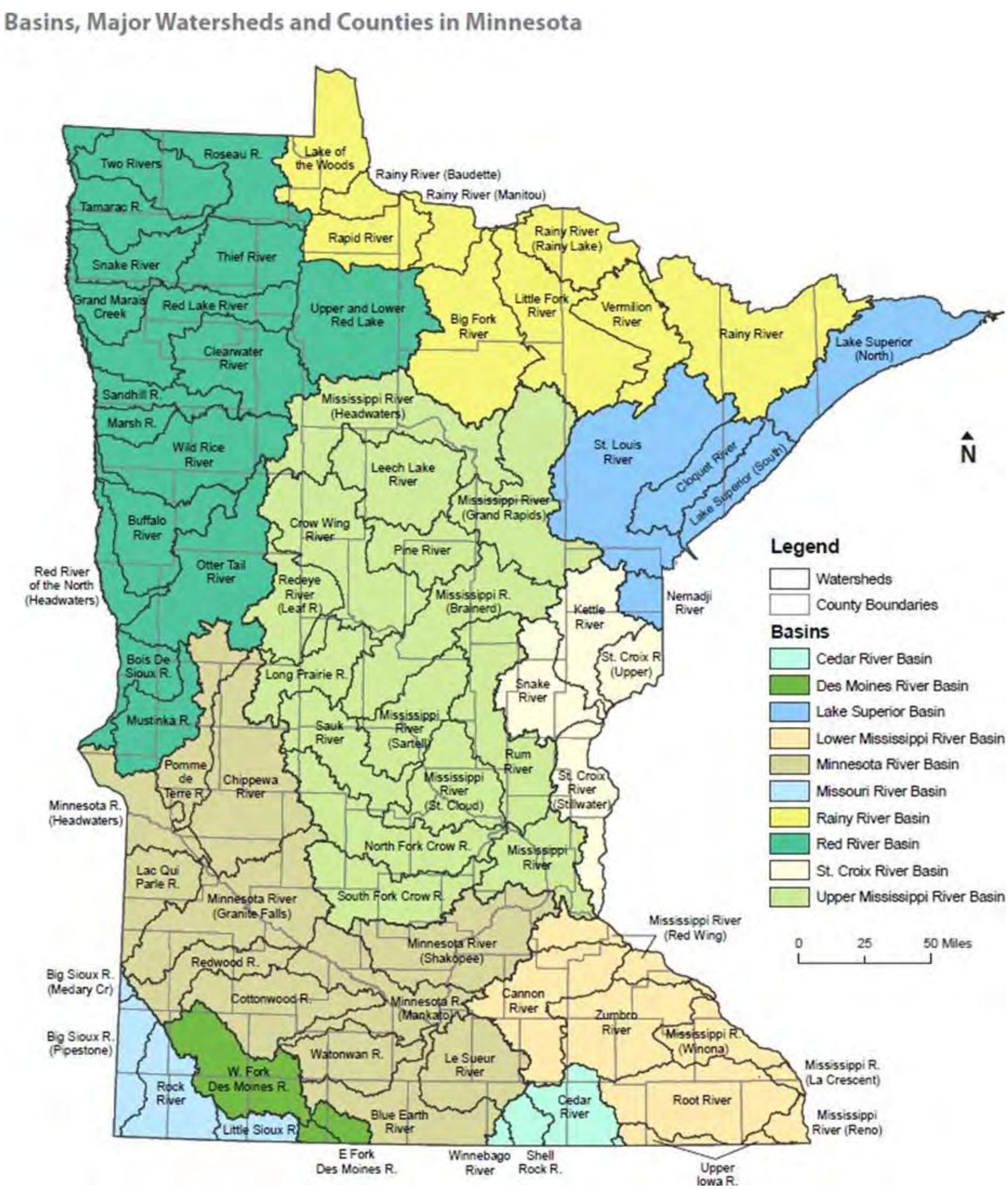
## Surface water basics

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 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 MDNR and United States 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.

[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.

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 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) | 75th Percentile (mg/L) | 90th 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 90th 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**

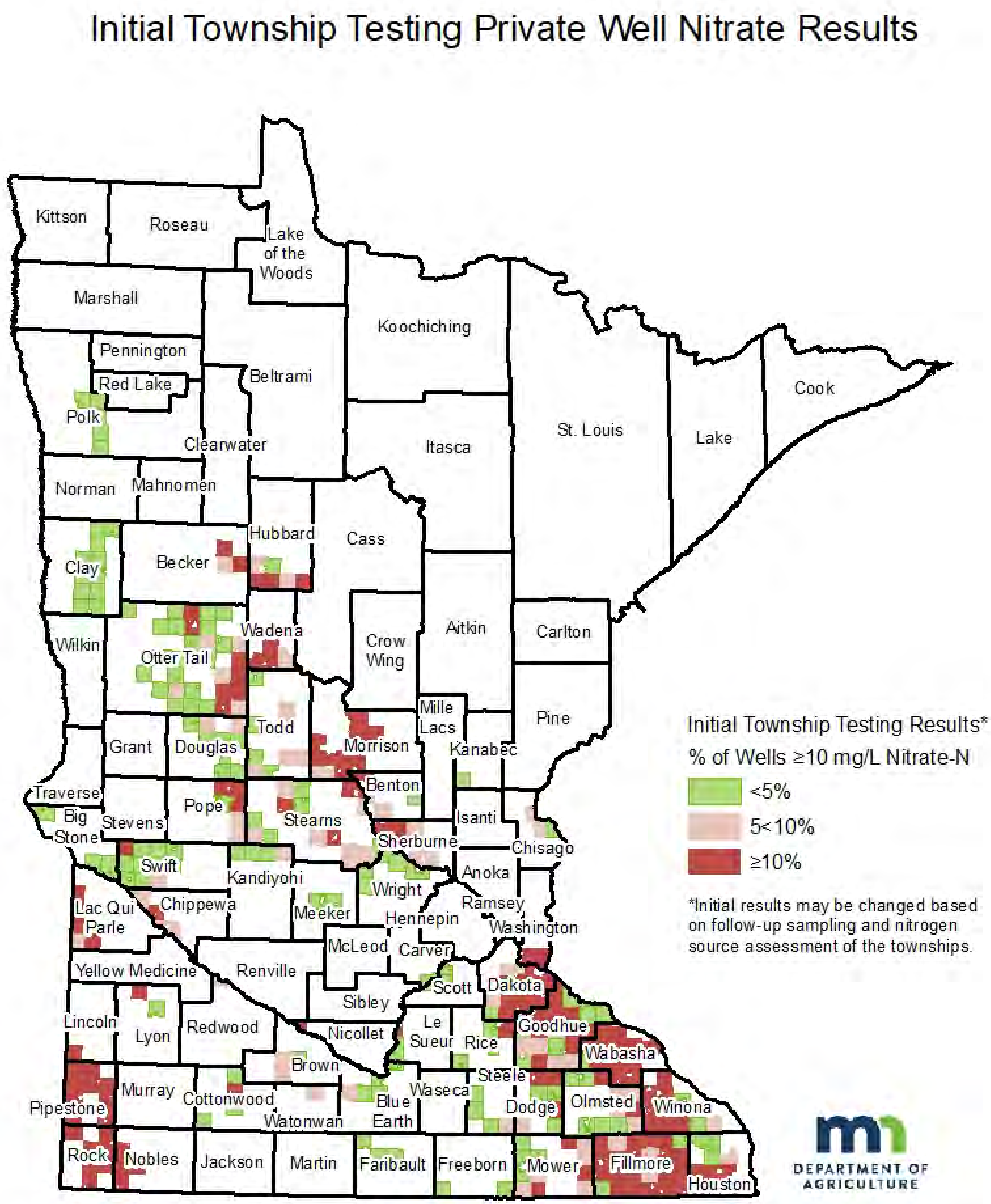
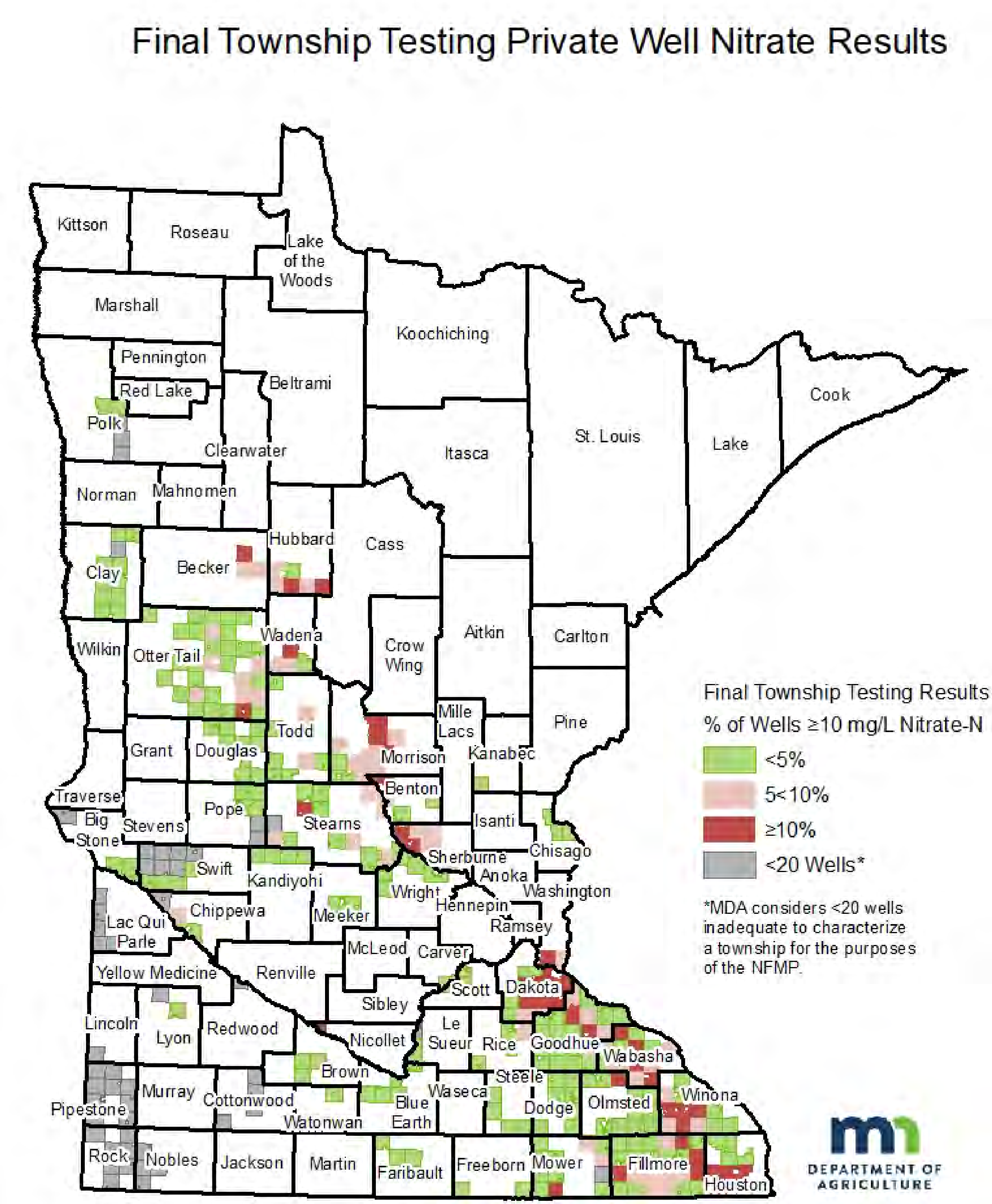


**Figure 4. Final township testing private well nitrate results**



# Pesticides

## Ambient Groundwater Monitoring Network

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.

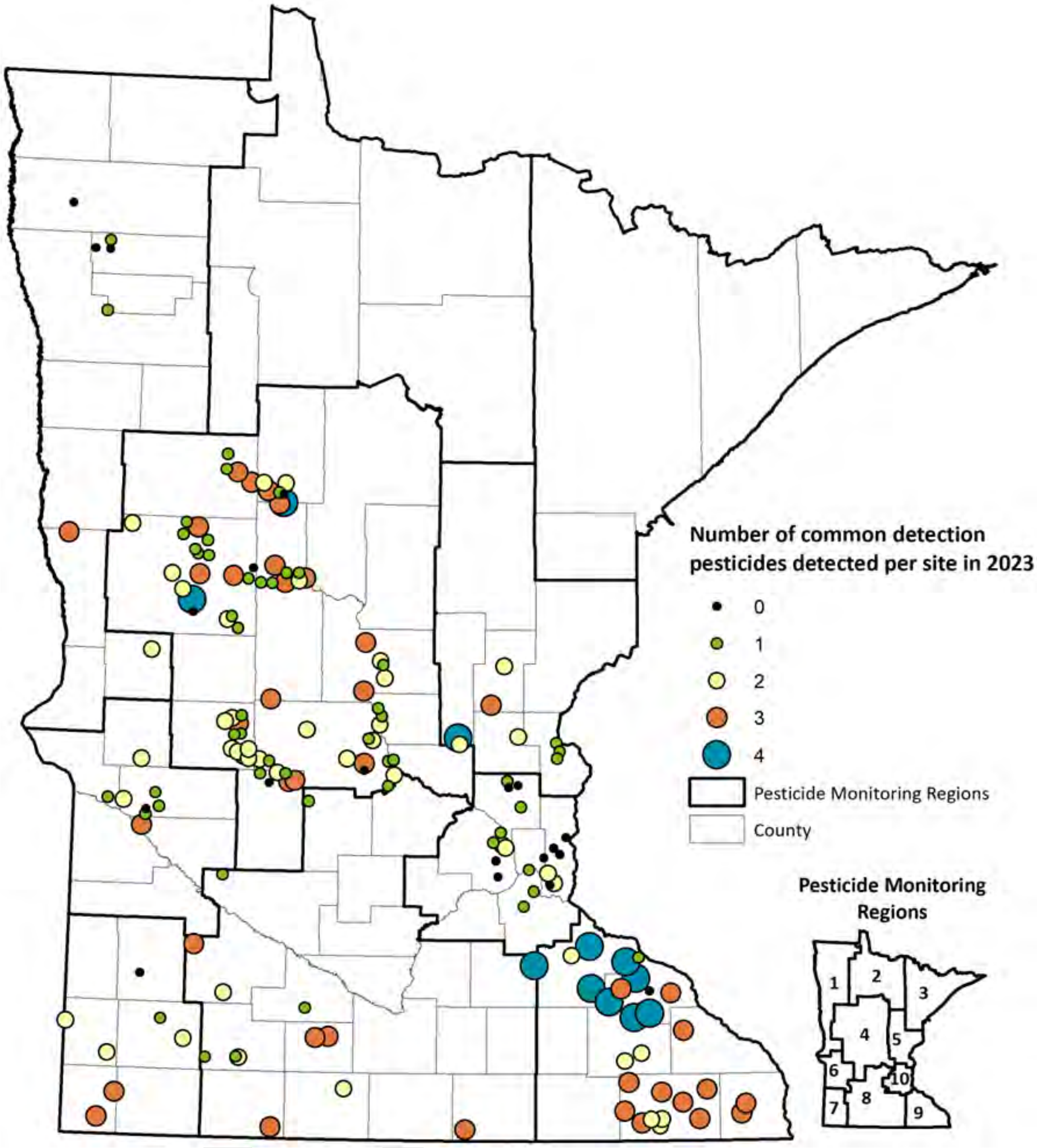
The MDA Laboratory has continued to expand their analytical capabilities, resulting in an increase in the number of compounds evaluated. In 2014, 133 different pesticide compounds were evaluated; by 2023, that number rose to 186. The MDA laboratory has also been able to lower the detection limit for 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 $90^{th}$ 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).**

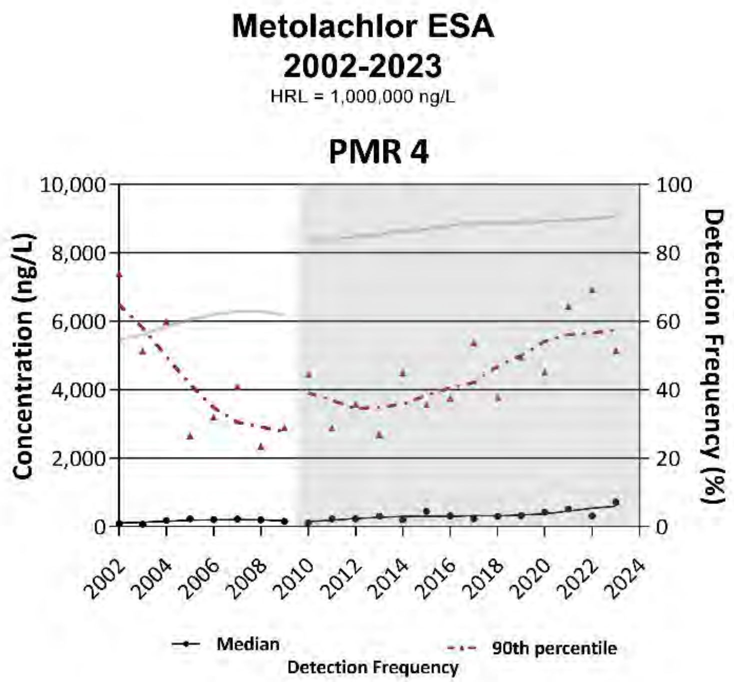
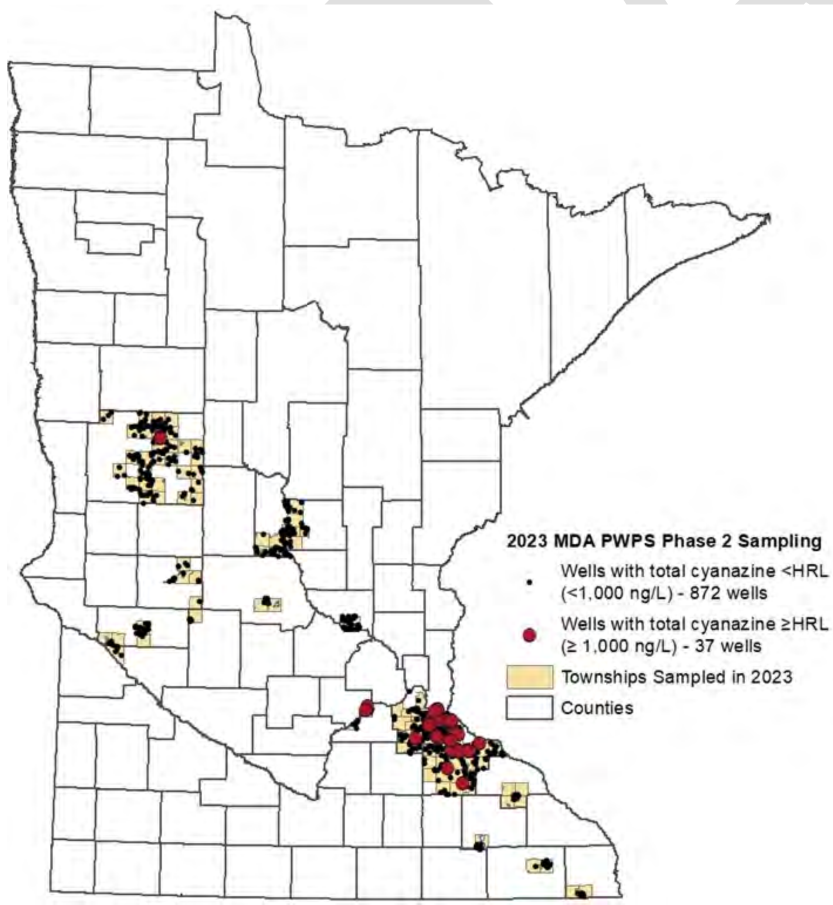



**Figure 7. 2023 PWPS Phase 2 townships and wells sampled, with total cyanazine concentrations compared to the HRL.**



## 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 US 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 US 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 4 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.

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

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

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. 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. 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.

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.



[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.

# 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. 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 5 farms )3 with paired watersheds) in5 counties throughout Minnesota. Additionally, the program has historical data from 8 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. Environmental Protection Agency 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 *draft* 2026 Impaired Waters List (as placed on public notice) 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 2026 draft 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**

**2026 Draft Inventory of Impaired Waters Summary**

| **Pollutant in 2026 draft Waters List** | **Total number of impairments** | **Number of impairments requiring a TMDL** |
|---|---|---|
| Mercury in fish tissue & mercury in water column | 1697 | 423 |
| Nutrient/Eutrophication Biological Indicators | 742 | 128 |
| Escherichia coli / Fecal coliform | 931 | 113 |
| Total suspended solids (TSS) & Turbidity | 463 | 75 |
| Aquatic Macroinvertebrate Bioassessments | 958 | 864 |
| Fishes Bioassessments | 1095 | 1003 |
| PCB in fish tissue | 75 | 75 |
| Oxygen, Dissolved | 201 | 149 |
| Chloride | 69 | 16 |
| Nitrates | 32 | 1 |
| 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** | 6410 | 2979 |

## 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% |

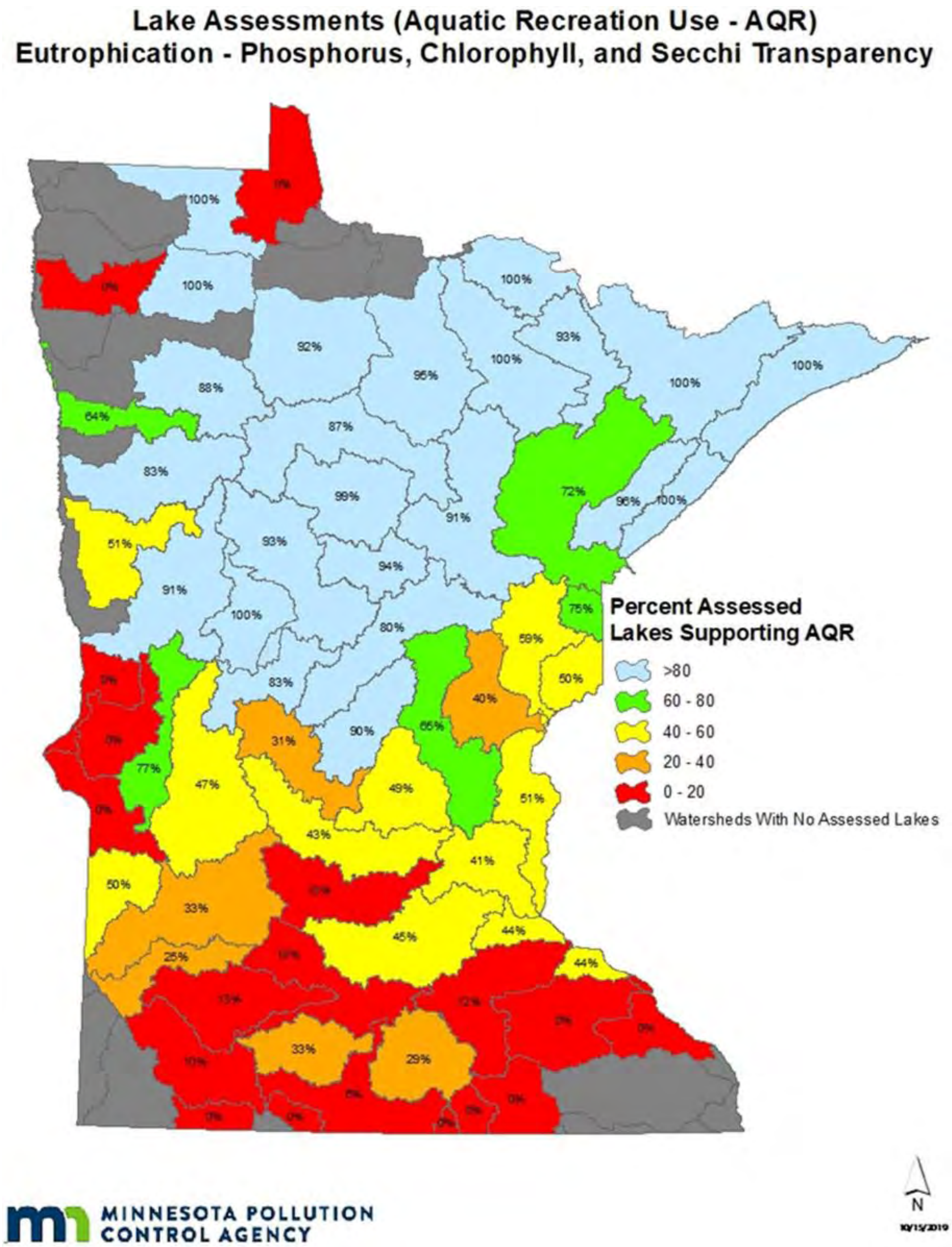
In general, water clarity is poorer in southern Minnesota, and both increasing and decreasing trends are scattered throughout north and south-central Minnesota. Water clarity has stayed the same in roughly two-thirds of the lakes, as presented on page 38 of the Clean Water Fund Performance Report.

***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**



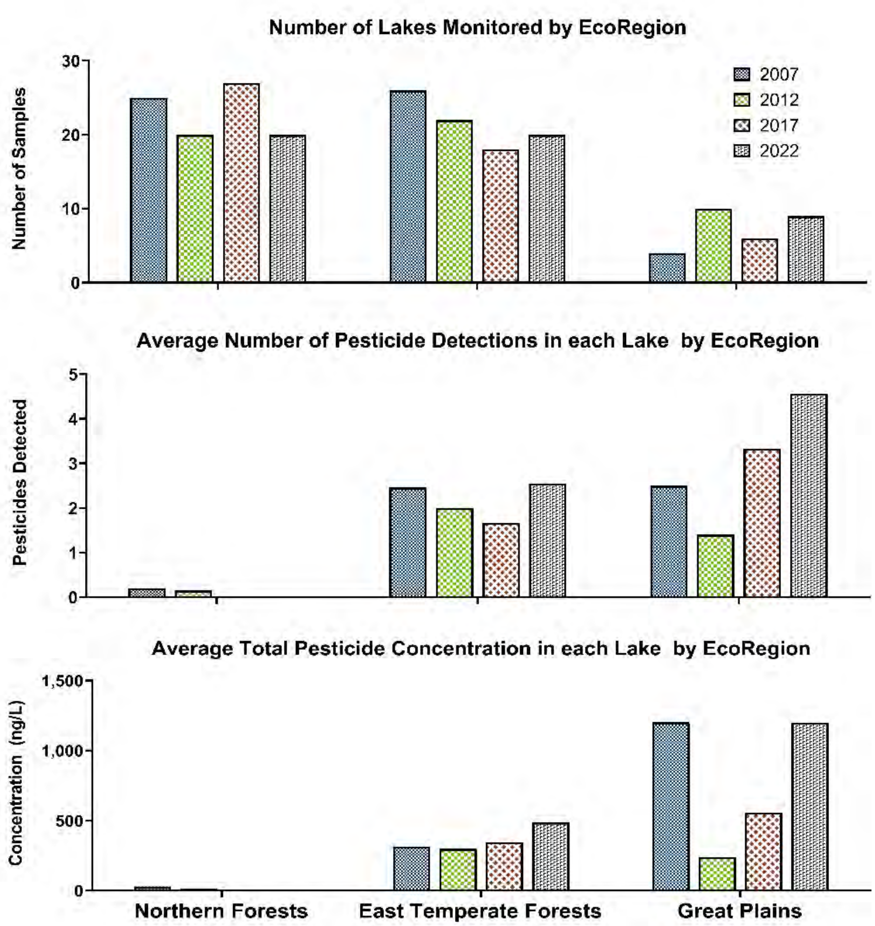
### *Lake Pesticide Monitoring*

Pesticide water quality samples were collected from randomly selected lakes in Minnesota in 2007, 2012, 2017, and 2022 in conjunction with the United States Environmental Agency's (USEPA) 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](water monitoring reports and resources) webpage.

MDA will align future lake pesticide monitoring efforts with the USEPA 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.**

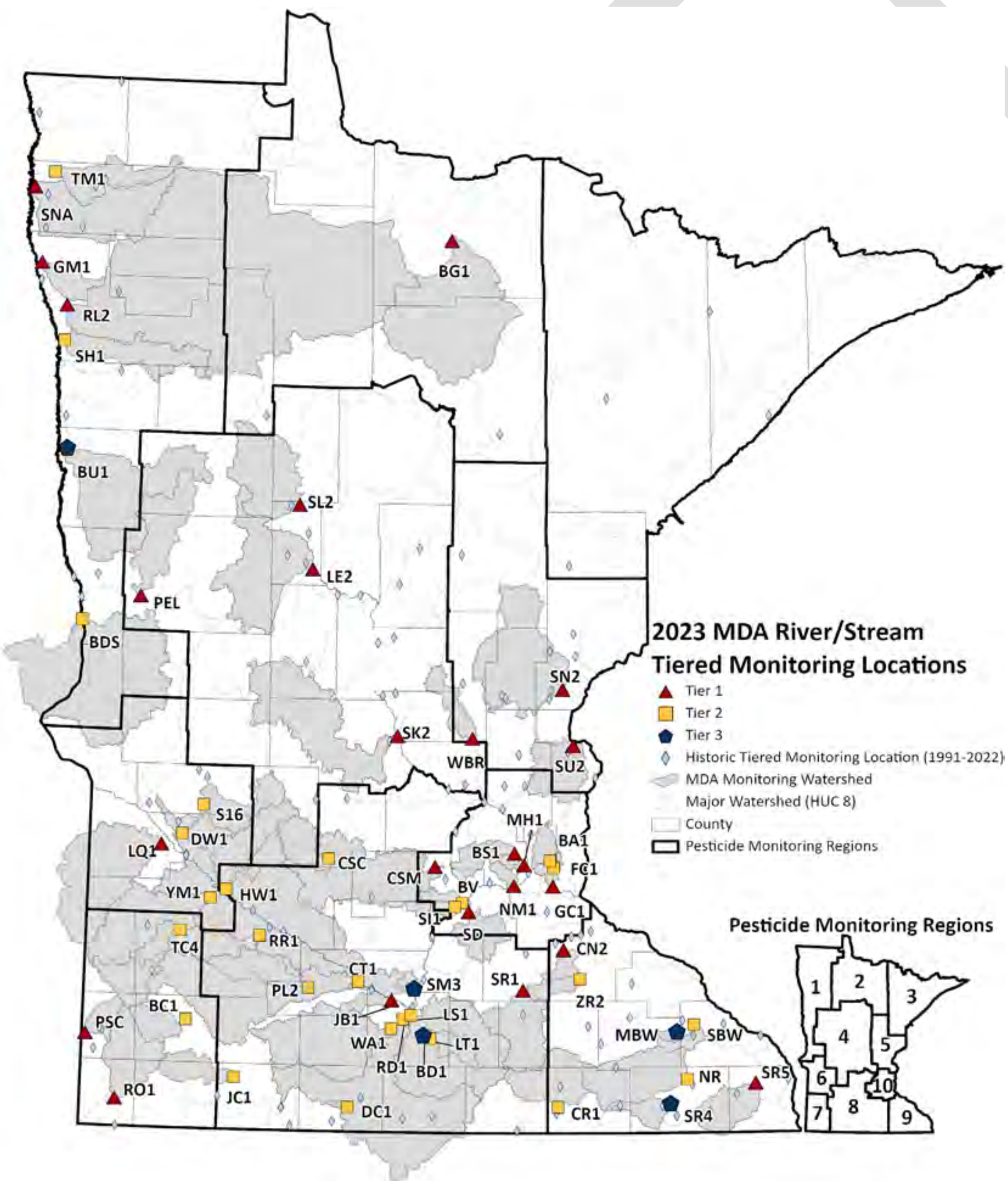
| Description | Number of Streams | Percent of Streams with Trend |
|---|---|---|
| Assessed for Trends | 770 | |
| Improving | 330 | 43% |
| Declining | 180 | 23% |
| No Clear Trend | 260 | 34% |

# 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.**

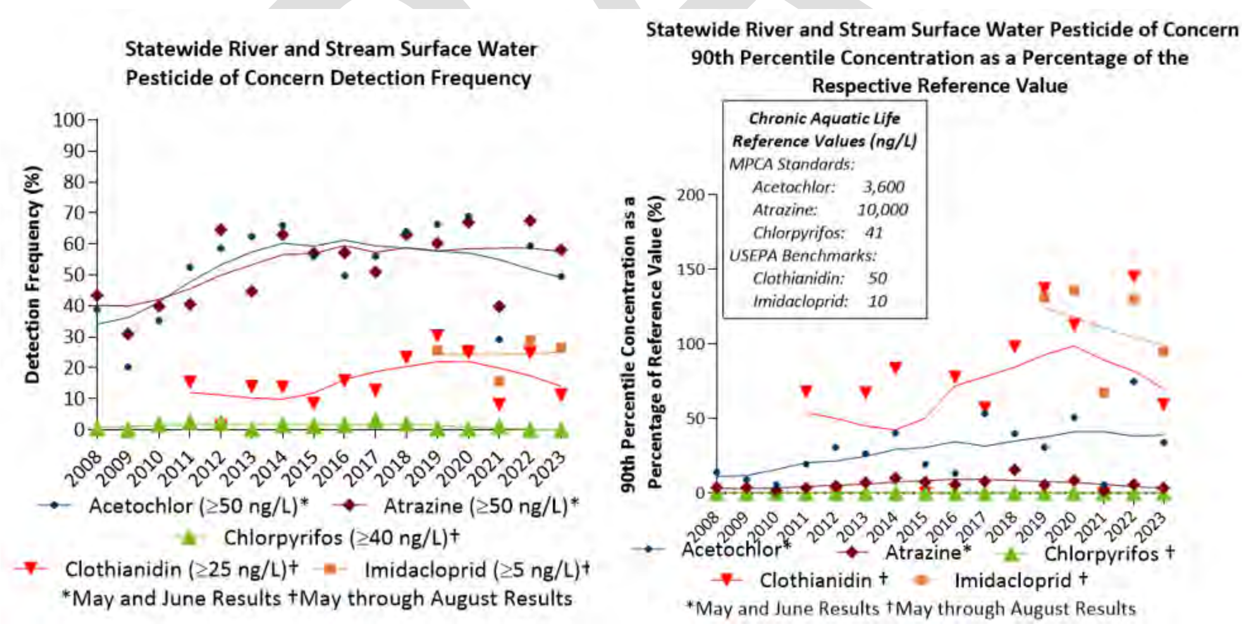


Because pesticides, especially agricultural and home and garden pesticides, are typically applied to coincide with the seasonal need to control weeds, insects and other pests or plant diseases, the presence of pesticides in streams and rivers is often linked to application timing, and subsequent rainfall 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 5 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.

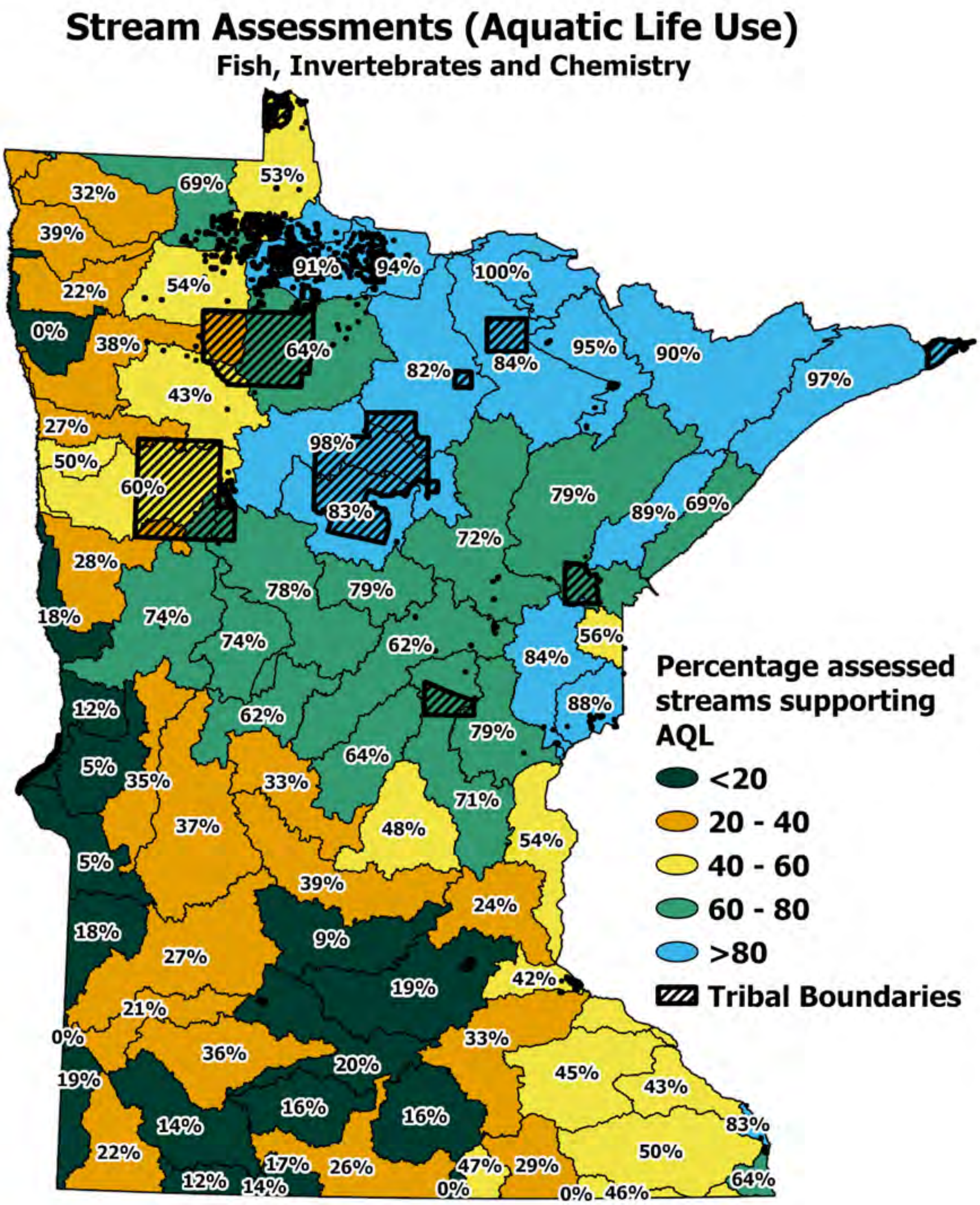
The MDA analyzes data from its network of sampling locations to track SWPOC statistics. Figure 11 presents statewide river and stream detection frequency and 90th percentile concentrations relative to the reference value (right) for the SWPOC. Additional information in available in the [Annual Water 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 20th 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

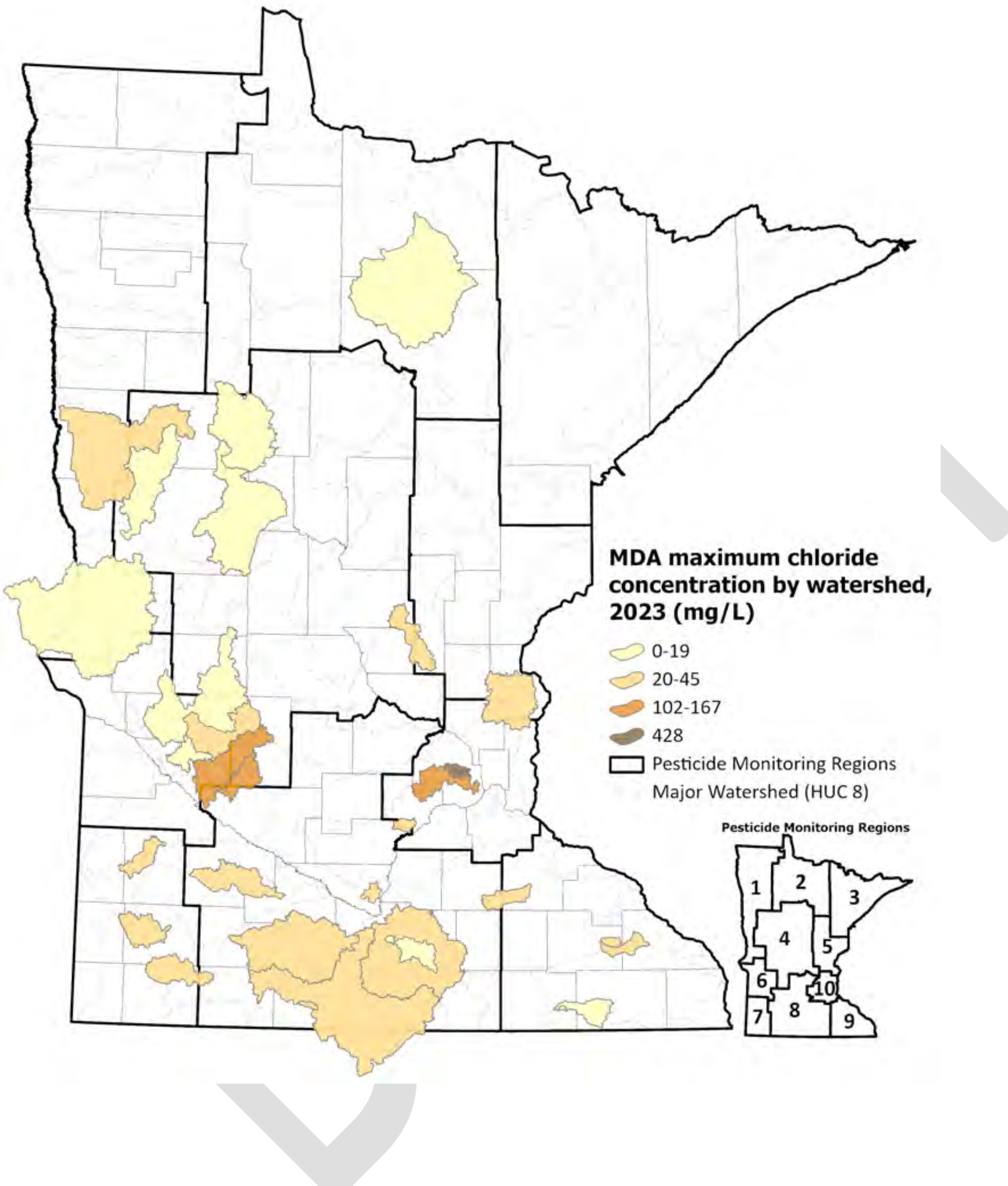
Winter maintenance activities as well as wastewater treatment plants tend to be the primary sources of chloride to TCMA waters.

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.

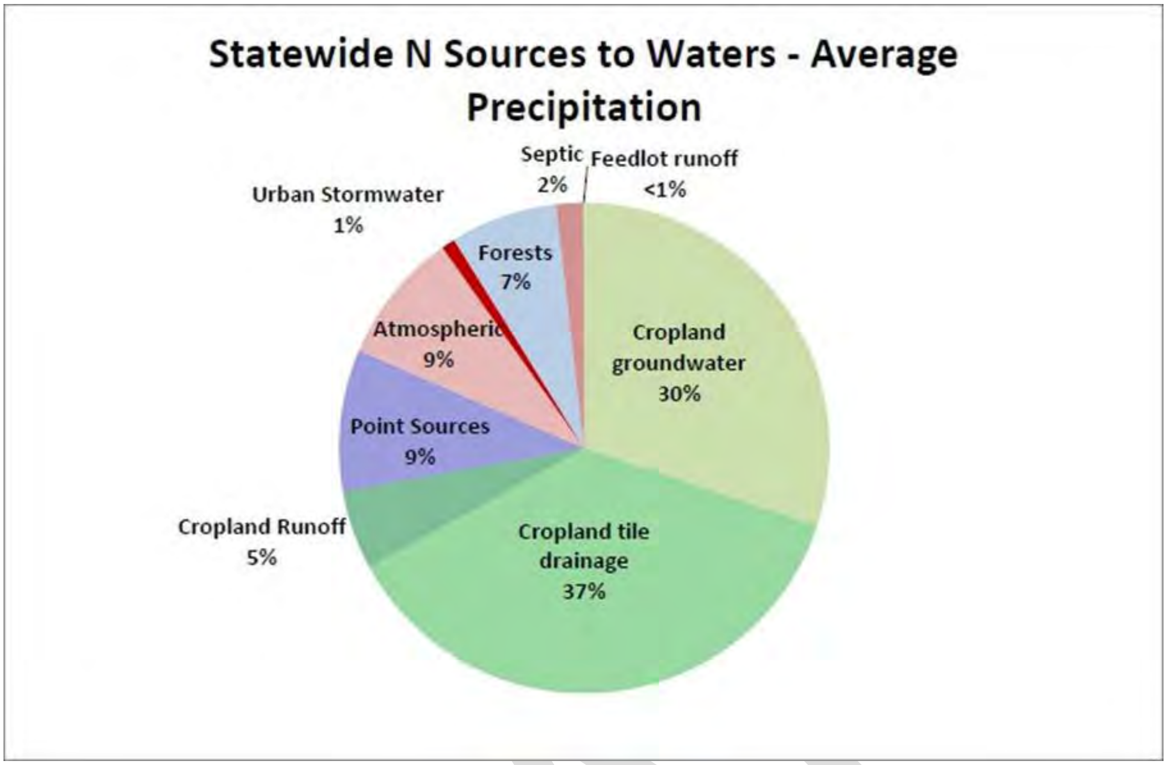
The Minnesota NRS was finalized in 2014, with a five-year progress report in 2020. In late 2022, the interagency group that compiled the original strategy reconvened to begin the scheduled 10-year update, which will be finalized by the end of 2025.

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. 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, MDNR, 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 US States and Canadian Provinces in the Great Lakes Watershed. MN 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.

Land use is a major factor in our current water quality problems — agricultural drainage, urban and rural runoff, and erosion caused by removing vegetation from shorelines. MPCA **How's the water**? Website describes what the MPCA is doing and what you can do to prevent pollution, rather than just controlling it. Found at: https://www.pca.state.mn.us/hows-the-water.

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.

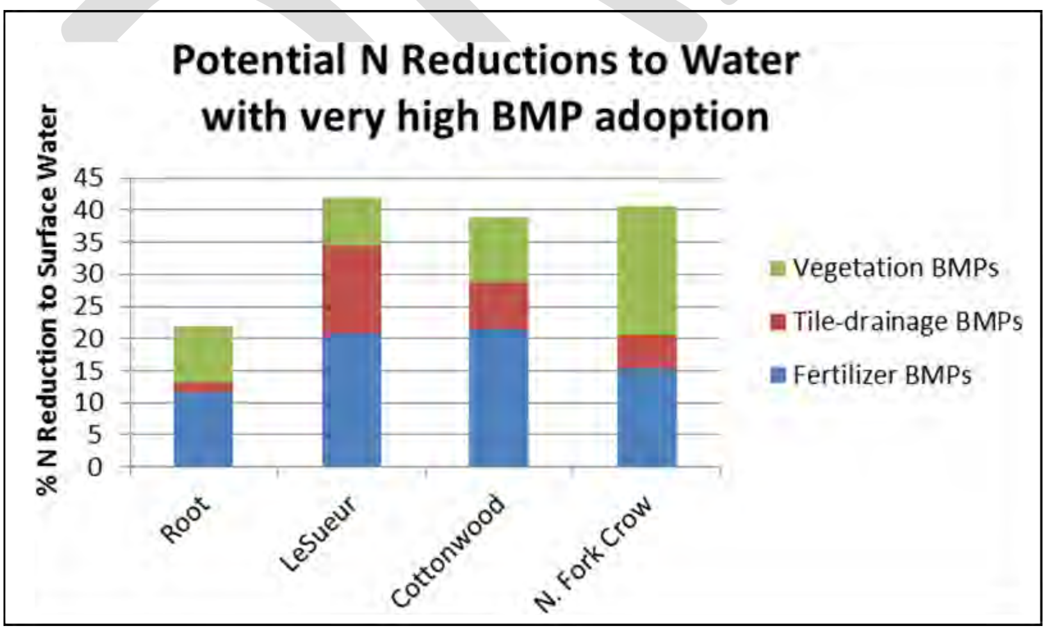
***Minnesota's Nonpoint Source Management Program Plan 2019-2029 –*** This plan describes Minnesota's ten-year plan to control nonpoint sources of water pollution and the numerous activities directed towards this effort.

***Watershed Achievements Report*** - The 2022 **Watershed Achievements Report** describes statewide and watersheds-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 5 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 now have a better understanding of the water quality conditions of our lakes, streams and wetlands, than ever before.

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.

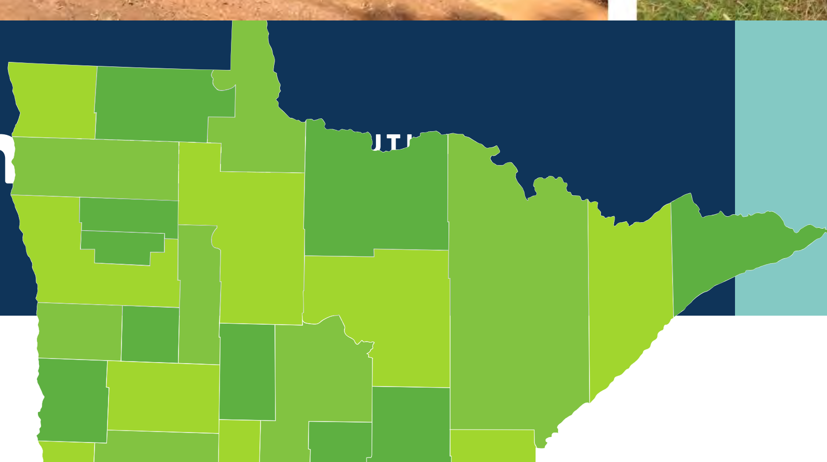
For both groundwater and surface water resources, ongoing monitoring is required to characterize vulnerable aquifers and landscape settings. Additionally, MDA and MPCA must continue to identify and investigate contaminant problems, including the presence and extent of emerging contaminants.

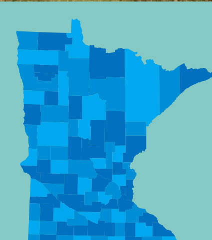
Ongoing monitoring provides the trend data that is critical to evaluating progress and refining management actions. Protection strategies – whether regulatory or voluntary –must be developed that avoid the occurrence of new problems, and all strategies should be periodically re-evaluated and refined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

Groundwater monitoring

August 2025

# Appendix B: 2020 Groundwater Monitoring Status Report





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**Document number:**

# Contents

# Introduction

The 1989 Groundwater Protection Act (GWPA) (Minnesota Statutes, Chapter 103H.175) requires the Minnesota Pollution Control Agency (MPCA), in cooperation with other agencies participating in the monitoring of water resources, to provide a draft report on the status of groundwater monitoring to the Environmental Quality Board (EQB) for review every five years. This report is written to provide an update of groundwater monitoring activities in Minnesota to fulfill the MPCA's 2025 GWPA reporting requirements. For additional information on the background and history of groundwater monitoring in Minnesota, see *The Condition of Minnesota's Groundwater Quality, 2018-2023* (Kroening, 2024) available at: The Condition of Minnesota's Groundwater Quality, 2018-2023.

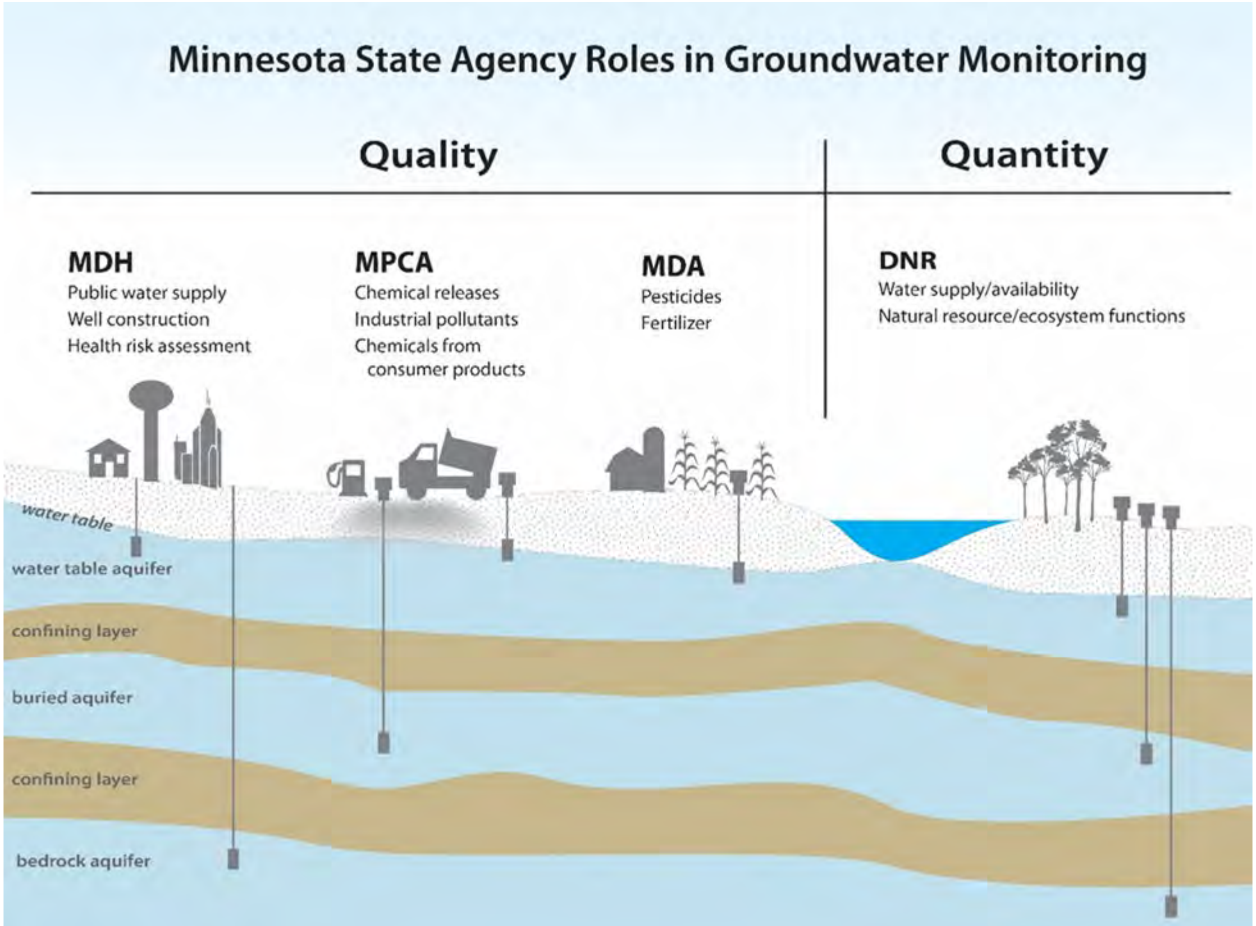
# Agency roles in groundwater monitoring and assessment

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

Three state agencies, the MPCA; Minnesota Department of Agriculture (MDA); and Minnesota Department of Health (MDH), have important statutory roles and responsibilities in protecting the quality of Minnesota's groundwater as shown in Figure 1. The MPCA and MDA both conduct statewide ambient groundwater quality monitoring for non-agricultural chemicals and agricultural chemicals, respectively. These two agencies share many monitoring resources, including the computer database that stores the data that is collected, the technical staff that manage this information, and occasionally the sampling staff that collects the state's groundwater samples. For example, each year MPCA field staff collects pesticide samples from 20 wells in their network for the MDA. MDH conducts monitoring to evaluate and address the human health risk of contaminants in the groundwater that is used for drinking. Beginning in 2025 the Drinking Water Protection Section at MDH developed a new monitoring program to test drinking water sources for CECs and other contaminants on an ongoing basis. This initiative is being referred to as the Drinking Water Ambient Monitoring Program (DWAMP). In addition to these agencies, the Minnesota Department of Natural Resources (MDNR) monitors groundwater quantity conditions across the state through a network of groundwater monitoring wells, and the Metropolitan Council conducts regional water supply planning using the information collected by the MPCA, MDA, MDH, and MDNR.

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

**Figure 1. State agency roles in groundwater monitoring [Graphic courtesy of the Minnesota Department of Natural Resources**




# Water quality monitoring and assessment

Between 2020 and 2025, groundwater quality monitoring in Minnesota mainly was conducted by state agencies in partnership with local entities and the federal government. The following sections provide more detail about these monitoring activities.

## National water quality monitoring

The National Groundwater Monitoring Network (NGWMN) was the primary national-scale groundwater monitoring program operated by the federal government from 2020-2025. The NGWMN is a collaborative effort between Federal, state, and local agencies, and the NGWMN compiles groundwater level and quality data from selected wells monitored by these governments according to a national monitoring network design. This network was authorized by the SECURE Water Act in 2009. The NGWMN provided information needed for planning, management, and development of groundwater supplies to meet current and future needs and ecosystem requirements. The NGWMN does not collect new information. Instead, the network typically used data that already was collected by the states, and other local units of government. The NGWMN initially was developed using data from five pilot studies, one of which was jointly conducted by the MPCA and MDNR, available at National Groundwater Monitoring Network Report. As of 2025, the NGWMN continued to receive federal funding to encourage other partners, including those in Minnesota, to participate in the network and for the long-term operation and maintenance of the network.

## Statewide water quality monitoring

The MPCA and MDA continued statewide ambient groundwater quality monitoring during 2020-2025. This monitoring continued to focus on aquifers that are vulnerable to anthropogenic (manmade) contamination from the land surface. Monitoring groundwater in vulnerable aquifers increases the likelihood that human impacts on groundwater quality will be detected within a reasonable time frame. The MPCA ambient monitoring efforts were conducted in non-agricultural areas of the state with a majority of samples collected in quaternary (glacial) sand and gravel aquifers. The MDA monitoring focused on agricultural regions in quaternary sand and gravel aquifers, with additional samples collected from springs and domestic wells in the southeastern part of the state where little or no quaternary deposits are present. The ambient monitoring targets pesticides and also collects nitrate samples. The locations for both MPCA and MDA monitoring programs are shown in Figure 2.

MDH water-quality monitoring efforts through 2024 continued to focus on assessing public water supplies, which often utilize groundwater. The MDH facilitated the water quality sampling of the state's finished drinking water in cooperation with the public water supply systems to determine contaminant concentrations as part of the Safe Drinking Water Act regulations. MDH also conducts additional groundwater monitoring in support of public water supply protection to evaluate potential threats in wellhead protection areas and where groundwater may be recharged by surface water.

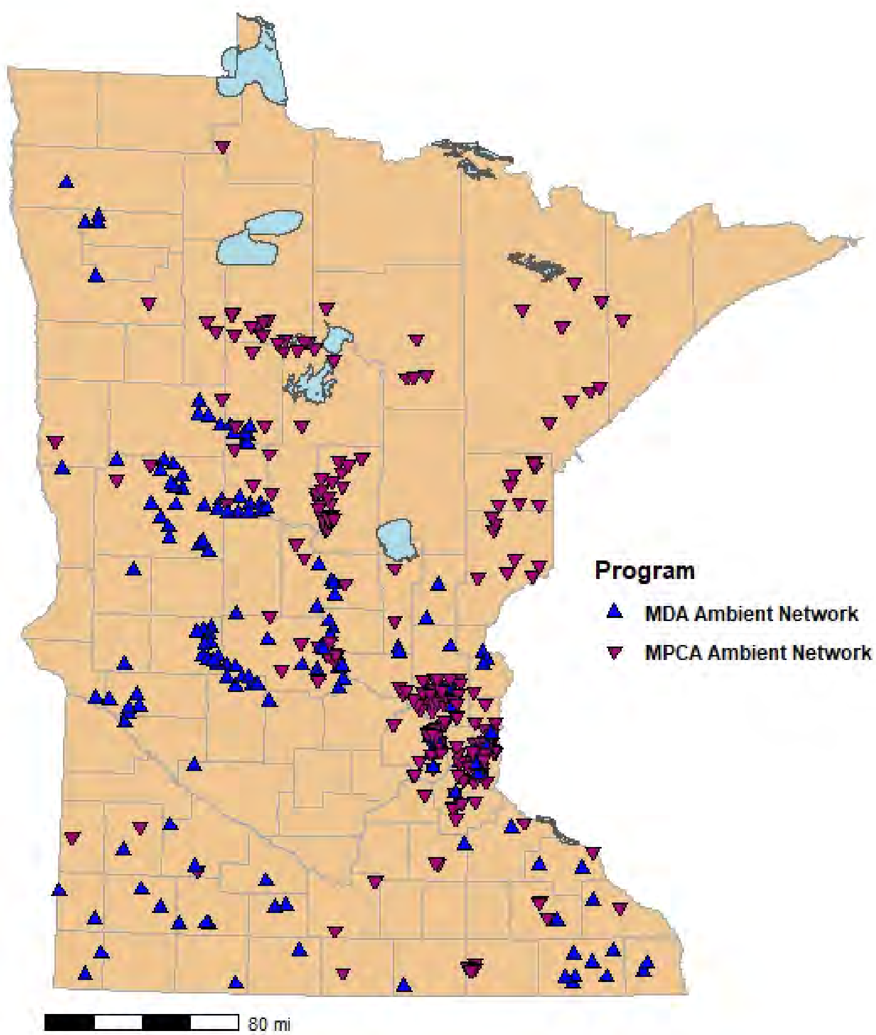



**Figure 2. Statewide Ambient Groundwater Monitoring Networks maintained by the Minnesota Pollution Control Agency (MPCA) and Minnesota Department of Agriculture (MDA)**

# Minnesota Pollution Control Agency

The MPCA currently monitors a network that includes almost 270 wells, which mostly are located in typical urban settings. The majority of the wells are sampled to provide an early warning of groundwater contamination within different urban land use settings. This allows the agency to better understand how groundwater quality varies with land use and quickly detect any changes over time. The early warning network wells intersect the water table and are located in commercial/industrial and residential areas served by centralized sewer systems and subsurface sewage treatment systems. The agency also samples some deep wells in areas vulnerable to groundwater contamination; these primarily are domestic wells that supply water to private residences.

From about 2010-2015, the MPCA enhanced its early warning network. This network originally was developed in 2004 solely using existing wells to minimize costs. Most monitoring wells originally sampled by the MPCA's network were installed for the purposes of remedial investigations; the wells that were installed “upgradient” of the suspected contamination (usually a few hundred feet) were also used for ambient monitoring to minimize network installation costs. Using remediation wells resulted in a bias towards detecting gasoline-related volatile organic compounds in surficial aquifers and likely was not representative of ambient groundwater conditions. The network enhancements focus on the groundwater quality underlying vulnerable, shallow sand and gravel aquifers to provide an early warning of groundwater contamination. The well installation associated with these network enhancements is complete, with almost 140 new monitoring wells added to the MPCA’s network from about 2010-2015.

MPCA staff test the groundwater contained in these wells each year for nitrate and other nutrients, and inorganic compounds such as arsenic, chloride, cadmium, and copper. A subset of these wells is typically tested each year for contaminants of emerging concern (CECs), such as prescription and non-prescription medicines and chemicals in commonly-used household products. Assessing CECs in the groundwater is part of the MPCA’s larger efforts to determine the occurrence, distribution, sources, and fate of these contaminants in the hydrologic system.

MPCA conducted two special projects by leveraging its Ambient Groundwater Monitoring Well Network to monitor for Per- and Polyfluoroalkylsubstances (PFAS) and organophosphate flame retardants (OPFRs). In 2019, the roughly 250 wells that comprised the network at that time were sampled for PFAS. Similarly, the MPCA monitored 116 ambient monitoring network wells for a suite of 13 OPFRs. The results from both of these studies were reported in *The Condition of Minnesota’s Groundwater Quality, 2018-2023* (Kroening, 2024) available at: The Condition of Minnesota's Groundwater Quality, 2018-2023. Most recently, another full sampling of the network was conducted in 2024 with analytical results still pending.

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

Thirteen wells were installed next to Sentinel Lakes from 2012-2015 in St. Louis, Stearns, Blue Earth, and Lincoln Counties. Transducers were placed in all wells to collect continuous records of barometric pressure, groundwater temperature, and groundwater elevation. The land use near the monitored lakes selected ranged from farming country with a high density of large capacity groundwater irrigation systems, to isolated North Country lying entirely within the boundaries of a State Park. The data collected from this monitoring effort was used to build groundwater models, augment groundwater reviews of selected watersheds, and highlight the relation between groundwater use and lake levels and quality. Most recently, this data was used to evaluate a sudden resurgence of eutrophic conditions in Lake Shaokatan after conditions had been steadily improving in the years prior.

In addition to monitoring ambient groundwater conditions, the MPCA continued to collect groundwater quality information at contaminant spill and release sites, permitted landfills, and land treatment facilities. The MPCA remediation programs alone have investigated a cumulative total of 35,024 sites since 1990, with the main focus of protecting groundwater resources. Approximately 1,310 of these sites have ongoing corrective actions, many of which include groundwater monitoring. Petroleum product spill sites and voluntary investigation and cleanup sites (brownfields) make up the majority of these sites, followed by Superfund, RCRA, and closed landfills. The most common contaminants detected at remediation sites are volatile organic compounds and major and trace inorganic elements.

## Minnesota Department of Agriculture

**Ambient Monitoring Program**

The MDA developed a regional water quality monitoring design based on Pesticide Monitoring Regions (PMRs). The PMRs established geographical areas for the purposes of collecting, analyzing, and reporting water quality monitoring data (Figure 3). Minnesota was divided into 10 Pesticide Monitoring Regions (PMRs) intended to represent areas of different agricultural land use as well as differing geologic and hydrologic regions in the state.

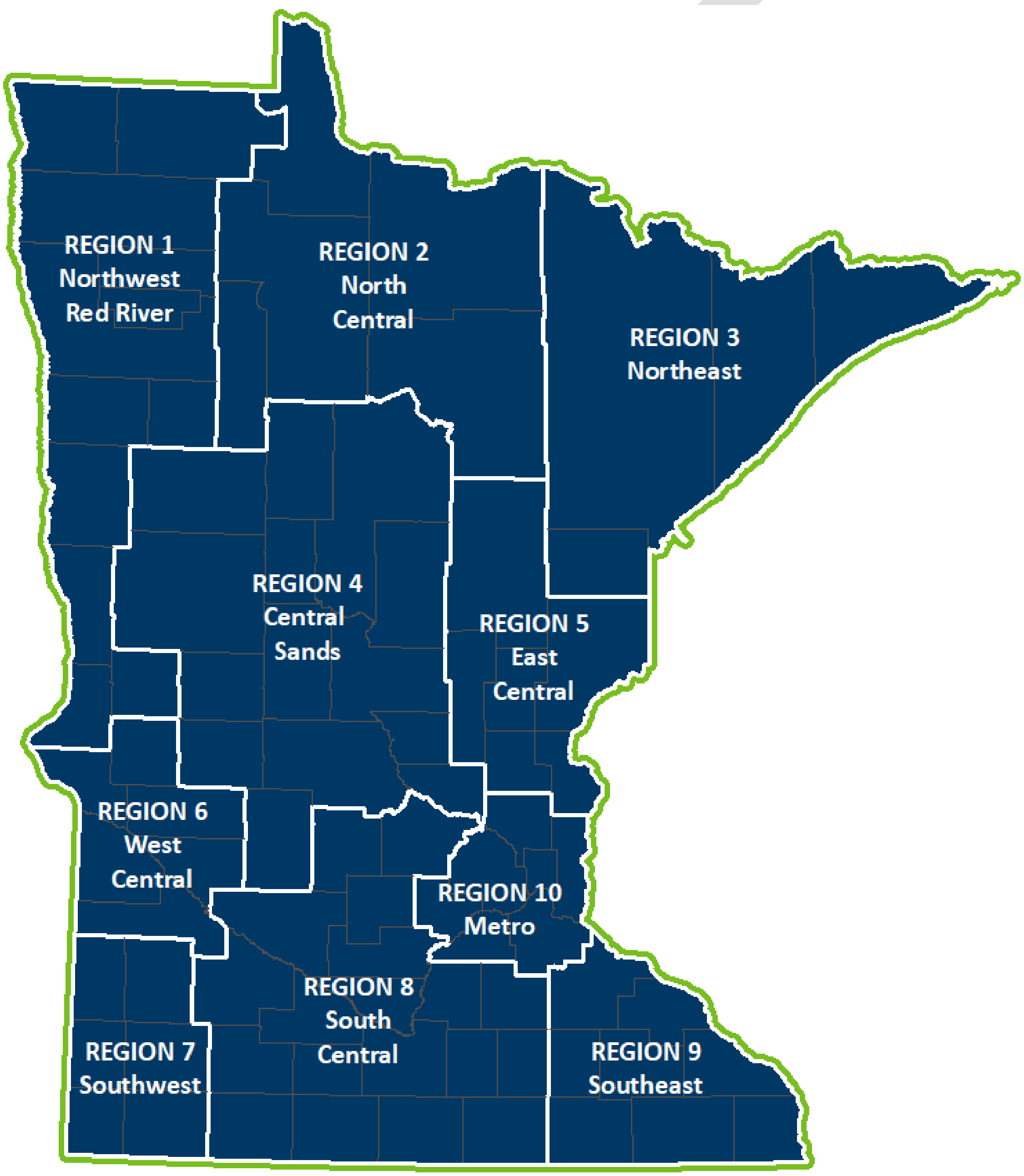



**Figure 3. MDA Pesticide Monitoring Regions**

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

The MDA collected pesticide samples from 168 wells and springs in 2023. Of the total sites, 142 were monitoring or observation wells, 13 were private drinking water wells, and 13 consisted of naturally occurring springs emerging from karst bedrock formations in southeastern Minnesota. All locations are considered sensitive to contamination from activities at the surface. These locations are considered the MDA's ambient groundwater network, shown as blue triangles on Figure 2. Pesticide concentrations in MDA's ambient groundwater network are generally detected well below drinking water standards, although some of the pesticide degradates do occur frequently in some areas.

**Private Well Pesticide Sampling Program**

The MDA began evaluating pesticide presence and magnitude in private drinking water wells in 2014 as part of the Private Well Pesticide Sampling (PWPS) Project. The PWPS Project is a companion project to the nitrate focused Township Testing Program (TTP), where sampling was targeted in townships with both vulnerable groundwater and row crop agriculture. Homeowners with a nitrate detection in their drinking water well as part of the TTP were offered pesticide sampling free of charge. A follow-up sample collected from their well, by the MDA, was analyzed again for nitrate and for a suite of pesticides similar to the list used in the MDA's ambient monitoring network.

Through 2023, the PWPS Project has sampled approximately 7,700 wells in 51 counties. With the exception of the degradates of the herbicide cyanazine (discussed below), concentrations of detected pesticides are generally well below drinking water standards but can occur frequently in certain regions.

**Township Testing**

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

**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.

The MDA also manages a remediation program which oversees the collection of a large volume of groundwater quality information from contaminant spill and release sites. Over 800 sites have been investigated and one of the main priorities of these investigations is to protect groundwater resources. Soil corrective actions are completed at most sites, and groundwater monitoring is completed at many of these sites. Typical sites include agricultural chemical storage and distribution cooperatives in rural

Minnesota, agricultural chemical manufacturing facilities and wood treating facilities. Groundwater monitoring also is conducted at sites managed by the MDA, including the former Kettle River Creosoting Company site in Sandstone, Minnesota. Common constituents that are monitored at MDA remediation sites include fertilizers, herbicides and insecticides and wood treatment compounds.

## Minnesota Department of Health

Groundwater quality monitoring activities support the mission of the MDH, "to protect, maintain, and improve the health of all Minnesotans," by providing data that are used to evaluate the level of contaminants in groundwater used for drinking water. These data help verify compliance with federal and state regulations, establish baseline water quality conditions for drinking water sources, inform the process for producing health-based guidance, and guide development of groundwater models and vulnerability assessments for source water protection and other water supply planning efforts to safeguard our drinking water. The following paragraphs provide additional information about MDH's groundwater quality monitoring activities.

MDH assists approximately 6700 community and non-community public water systems to provide safe and adequate drinking water as outlined in the federal Safe Drinking Water Act (SDWA). Most of these systems utilize a groundwater source of supply. MDH staff and laboratory personnel collect and analyze water samples from public water systems for required parameters on a schedule that is dependent on the type of water system. Factors that influence the schedule and required parameters conform to SDWA criteria. They include well vulnerability, system type (community or non-community) and population served.

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

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

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

MDH is also involved in other source water protection monitoring initiatives that are focused on specific issues or geographic areas. Several of these are highlighted below.

### Unregulated Contaminants Monitoring

From the standpoint of MDH and drinking water utilities, unregulated contaminants are those that lack specific water quality standards (e.g., Maximum Contaminant Levels or MCLs). MCLs exist for approximately 100 compounds. The set of compounds that are known to exist in the environment is far larger and grows regularly because research into contaminants of emerging concern is active and on-going. Some of these contaminants have known health impacts to humans. Investigative monitoring to assess the occurrence and distribution of contaminants of emerging concern is important to help understand the scope and scale of such contamination, to guide the development of health-based guidance, to inform other best management practices to avoid or limit occurrence in drinking water sources, and to provide solid information to maintain trust and confidence in public drinking water systems.

MDH currently lacks firm capacity to conduct CEC monitoring on a regular basis. Instead, current efforts have been carried out as part of specific projects, some of which are described below.

## Federal Unregulated Contaminants Monitoring Rule Sampling (UCMR)

Federal rules require public water systems meeting certain size criteria to collect samples and have them analyzed for approximately 30 unregulated contaminants as identified in a national nomination and vetting process. Sampling sites consist of public water systems served by both surface water and groundwater. MDH coordinates UCMR sampling in Minnesota. Up to 2020, there have been four rounds of this mandated sampling. A fifth is in the planning stage and will start in 2023. MDH obtains the data and evaluates the results – EPA compiles results on a national level.

## Minnesota's Unregulated Contaminants Monitoring Project (UCMP)

With the support of the Environment and Natural Resources Trust Fund, MDH initiated a project in 2018 to sample selected public water systems at risk of impact from several different classes of unregulated contaminants. Three networks of sampling sites comprised of public water system sources (wells or intakes) was established. The first consisted of systems that use surface water for supply. Public water systems with vulnerable wells in close proximity to potential wastewater sources comprise the second network. The third network is made of vulnerable wells in close proximity to agricultural land uses. Parameters selected for analysis varied depending on the network and the likely types of sources. Sampling was conducted at both the source and at the entry point. Major parameter classes included pharmaceuticals, personal care products, pesticides, industrial contaminants, and hormones. Sampling was completed in 2019.

Results from the MDH UCMP are illustrative of the widespread and varying nature of CECs in groundwater. Lithium, an unregulated metal, was detected in 100% of groundwater systems, with bromoform (a disinfection byproduct) and metalochlor SA (a pesticide) detected at a majority of the groundwater wells in which they were tested, and several pesticide and PFAS compounds detected in at least 20% of groundwater wells in which they were tested. Overall detections included 84 distinct pesticide compounds, 51 pharmaceuticals, 43 wastewater indicators, 15 PFAS, 8 benzotriazoles and 1 inorganic compound (lithium). Most of the compounds tested were not detected in groundwater at any system, illustrating the array of potential CECs in the ambient environment and variability in occurrence. Importantly, findings from UCMP indicated that groundwater in vulnerable geologic settings was more likely to contain detectable CECs than groundwater in nonvulnerable settings.

The Unregulated Contaminant Monitoring Project (UCMP) served as the basis for an inaugural program to survey CECs in groundwater on an annual basis, the Drinking Water Ambient Monitoring Program (DWAMP). Through DWAMP, MDH will continue to test for CECs in groundwater and drinking water sourced by groundwater in a more focused manner, with large-scale testing similar to UCMP performed every 5 years. In 2024, DWAMP focused on monitoring 1,4-Dioxane at public water systems and nontargeted analysis of PFAS and pesticides in public wells. We expect the nontargeted work to provide valuable information about the presence of unregulated PFAS and pesticide compounds that cannot be measured through conventional analytical techniques. In 2025, DWAMP will focus on neonicotinoids and select targeted unregulated pesticides in both public and private groundwater wells.

### Pathogen (aka Virus) Project

From 2014-2016, MDH sampled 145 public water supply wells for 23 pathogens and microbial indicators, including viruses, bacteria, and protozoa. The results indicate that genetic material from these organisms is widespread in groundwater, although transient in nature. On-going projects are currently underway to assess the potential pathways for microbial occurrence in wells so MDH can better safeguard consumers of well water from pathogen exposure.

### Pesticides (2010, 2015)

MDH and MDA cooperated on two projects in 2010 and 2015 to evaluate occurrence and distribution of pesticides in selected public water system wells deemed to be most vulnerable to water quality impacts in vulnerable parts of the state. Sampling sites were selected statewide due to varying agricultural practices across the state. A summary of findings was published in October 2016, titled 2015 Reconnaissance Study of Pesticide Compounds in Community Public Water Supply Wells.

### Per- and poly-fluorinated alkyl substances (PFAS)

MDH collaborates with public water systems, other state programs, federal partners and local governments on the investigation and response to potential threats to water supplies from emerging contaminants, such as PFAS. Various strategies are being employed to sample all community water systems for selected PFAS compounds by 2025. These efforts will start in 2020 in a targeted fashion. This work will rely on data and information of known PFAS presence in the environment from MPCA and others to identify high-risk locations for sampling.

In the eastern portion of the Twin Cities Metro Area, the MDH has collaborated with the MPCA to sample over 1,000 private wells in multiple areas of Washington County to determine the extent of PFBA (i.e. one of the PFAS compounds) in the aquifers and continues to work with the MPCA to monitor over 400 of those wells.

# Water quantity monitoring and assessment

The MDNR continued statewide and regional groundwater quantity monitoring and assessments during 2020-2025. The MDNR conducted statewide groundwater level monitoring and developed more county-scale groundwater sensitivity maps during this period.

## Department of Natural Resources

The MDNR's statutory responsibilities for groundwater are centered on monitoring and managing groundwater levels, groundwater availability and the long-term sustainability of Minnesota's groundwater and surface water resources. MDNR maintains a Groundwater Observation Well Network, conducts aquifer tests, develops county groundwater atlases and administers the preliminary well assessment program and a water appropriations permit program. As part of this work, the MDNR collects groundwater quality data under specific circumstances, which are described below.

The MDNR maintains a groundwater level monitoring network across the state with approximately 1,250 actively measured wells, over 800 of which are instrumented to record level data hourly. Data collected from the network is used to assess groundwater resources, determine long-term trends in water levels, interpret impacts of pumping and climate, plan for water conservation, and evaluate water conflicts.

MDNR offers access to the observation well network for water quality studies. A recent example is partnering with MDH for their Pathogen Project using a well in Cottage Grove. USGS has installed real-time data equipment and MDH is using that data to determine when they need to sample the well for water quality.

MDNR and MPCA have partnered with the USGS in their National Ground-Water Monitoring Network (NGWMN) since their pilot in 2010. The (NGWMN) is a network of selected wells from Federal, multistate, State, and local groundwater monitoring networks brought together under a set of defining principles and is designed to provide information essential for national and regional scale decisions to be made about current ground-water management and future ground-water development. MDNR created a database connection to the NGWMN and supplies information for approximately 375 wells in Minnesota. NGWMN also has awarded MDNR funds to drill new observation wells in areas of interest for both networks.

Starting in the late 2000s dedicated funding allowed for planned network expansion to study specific aquifers and areas of groundwater management concern. Funds from the Legislative-Citizen Commission on Minnesota Resources (LCCMR) were used to install wells to study the edge of the Mt. Simon aquifer and Clean Water Funds were specifically dedicated to fill gaps in the bedrock aquifers located in the Twin Cities Metro Area. MDNR's goal is to add 50 new observation wells each year; prioritized around the state in areas of known high use, areas that serve public water supplies, and areas with little information. When possible and as funding allows, new wells in the network are intended to be constructed to enable water quality sampling in addition collection of water level data.

Water level monitoring is also conducted at over 850 monitoring wells associated with groundwater appropriations permits. Information from these wells helps inform if pumping of groundwater is causing adverse impacts to surface water features or other water users. An ongoing water supply planning effort is guiding establishment or improvement of monitoring plans for all 650 public water suppliers.

Since 1995 the MDNR, in collaboration with the Minnesota Geological Survey (MGS) has produced county geologic atlases. The MDNR completes groundwater focused investigations as part of the atlas series. Atlases have recently been completed for Becker (2023), Cass (2023), Dodge (2024), Hennepin (2021), Hubbard (2024), Wadena (2024), and Winona (2021) counties. In addition to these completed groundwater atlases the Isanti and Houston County reports are expected to be published by Fall of 2025. As a part of all these projects, groundwater sampling is completed at selected wells to better understand groundwater movement and support groundwater sensitivity mapping. Approximately 80-100 wells are sampled in each investigated county to determine major ion and trace element concentrations. In addition, tritium values, and values of oxygen and hydrogen stable isotopes, are evaluated to help understand groundwater recharge rates and possible surface water body sources, respectively. Additional groundwater samples are collected from a few wells in each county for analysis of carbon-14 age dating at locations and in aquifers that likely have very old water in the range of thousands to tens of thousands of years.

Since 2016, the MDNR, MPCA, and partners with the Olmsted County and Fillmore County Soil and Water Conservation Districts have collaborated on spring characterization throughout southeast Minnesota. The project measures spring level, temperature, nitrate concentration, and flow. Continuous or "time series" data is collected at these sites and coupled with collected water chemistry samples.

These data capture hydraulic dynamics such as recharge response and lag time, helping to understand groundwater recharge and nitrate mobilization.

# Current and emerging groundwater quality issues

## Chloride

Excessive chloride concentrations in groundwater limits 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. MPCA's monitoring of Minnesota's groundwater has detected elevated concentrations of chloride within specific land use settings.

The most recent MPCA report on statewide groundwater quality (Kroening, 2024) found that 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.

Concentrations are typically highest in the groundwater underlying urban areas that was naturally vulnerable to contamination. MPCA's monitoring also found that chloride concentrations were highest in water table wells underlying urban parts of the state. 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.

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% 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.

MPCA will continue to make chloride sampling a focus of its groundwater monitoring efforts, specifically evaluating the potential for downward migration from surficial sand and gravel aquifers to the sedimentary aquifers underlying the TCMA and southeast Minnesota.

## Nitrate

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

Assessments by the MPCA (Kroening and Ferrey 2013; Kroening and Vaughan 2019; Kroening, 2024) found that nitrate concentrations in the state's shallow groundwater still varied with land use. The most recently analyzed data found the median concentration in the groundwater near the water table in agricultural areas was 6.9 mg/L; whereas, the median concentration in the shallow groundwater underlying various urban land uses ranged from 0.9-1.5 mg/L.

The MPCA assessment also noted that the shallow sand and gravel aquifers, which usually are the uppermost aquifer in most parts of the state, contained the highest nitrate concentrations. About 40 % of the shallow sand and gravel aquifer wells that were tested, mainly in agricultural areas in Central Minnesota, contained nitrate concentrations that were greater than the Maximum Contaminant Level (MCL) of 10 mg/L set by the US Environmental Protection Agency for drinking water. Trends in nitrate concentrations in the groundwater also were quantified as part of the MPCA's groundwater quality assessments. The most recent study used data from over 250 wells and springs across the state, which primarily tapped the shallow sand and gravel aquifers to determine whether nitrate concentrations changed. The nitrate concentrations in most of these wells had no significant change from 2013-2023 (Figure 4).

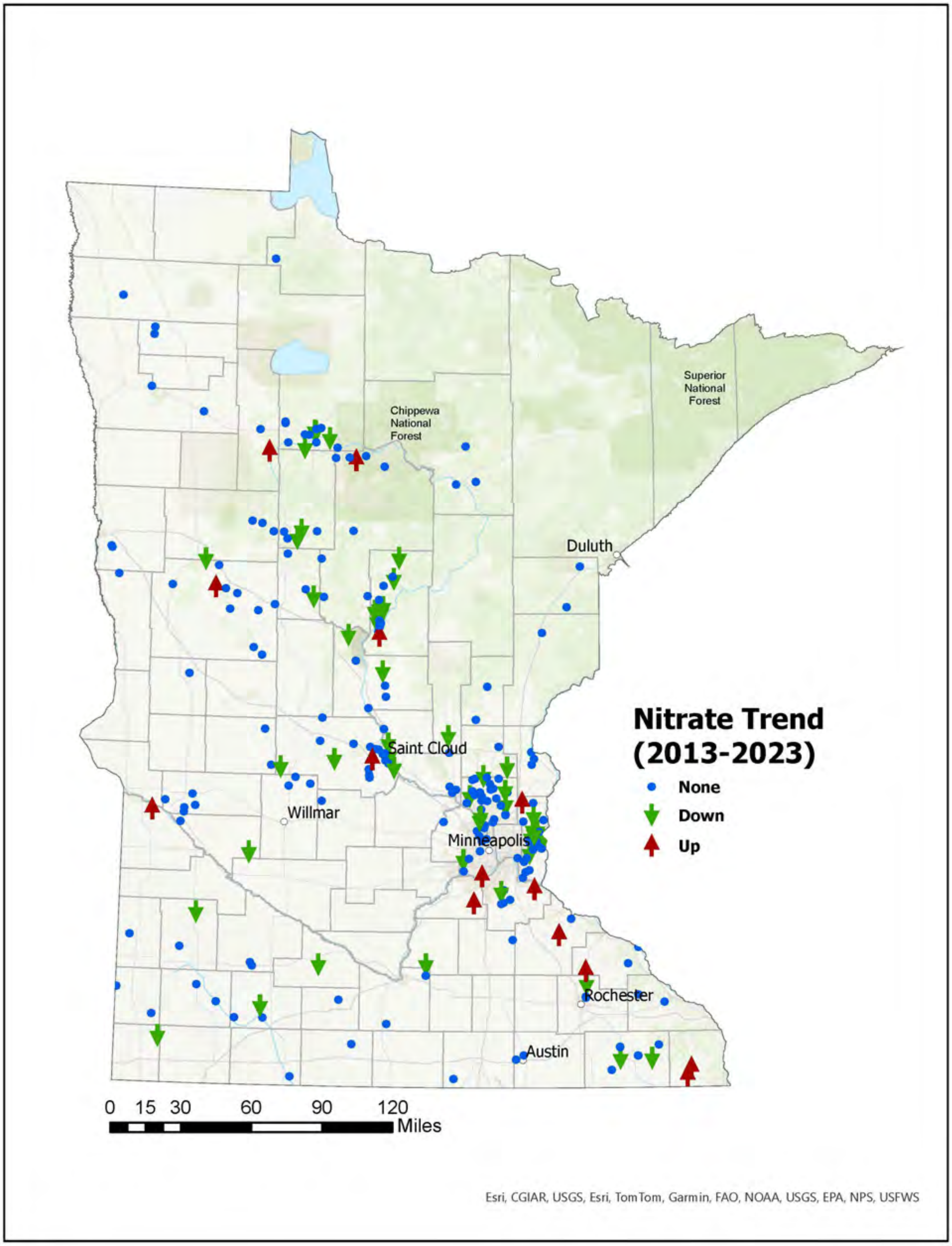



**Figure 4. Nitrate trends in Minnesota's groundwater, 2013-2023 [Data from the MPCA and MDA ambient groundwater monitoring networks].**

MDA maintains three different private well nitrate monitoring efforts; the Southeast Volunteer Nitrate Monitoring Network (VNMN), the Central Sands Private Well Network (CSPWN) and the Township Testing Program. The CSPWN and the Southeast VNMN are designed to be sampled annually long term, while the Township Testing was a short term program and has been completed.

## The Southeast Volunteer Nitrate Monitoring Network (VNMN)

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.

Before data collection began, well network coordinators (county staff) enrolled volunteers (well owners) into the program by collecting detailed information about well location, well construction, and nearby nitrate sources. Between February 2008 and August 2023, 18 sampling events occurred representing approximately 7,287 samples. During this period, the percentage of wells exceeding the Health Risk Limit (HRL) for each sampling event ranged between 7.5 and 14.6%. As a regional network there is a downward trend in the 90$^{th}$ 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.

More information can be found at: https://www.mda.state.mn.us/southeast-minnesota-volunteer-nitrate-monitoring-network

## MDA Central Sands Private Well Monitoring Network (CSPWN)

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

Approximately 550 homeowners from the first Central Sands sampling event (2011) 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.

A report with the data from 2008-2018 from both networks can be found at MDA's Nitrate in Private Well Monitoring Networks webpage.

## Township Testing Program (TTP)

The MDA worked 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 homeowner collected the sample and sent it to the lab. 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 conducted a site assessment. The assessment helped identify possible non-fertilizer sources of nitrate and to see the condition of the well. A well with construction problems may be more susceptible to contamination.

As of March 2020, 344 vulnerable townships from 50 counties participated in the TTP from 2013 to 2019. In the 344 townships initially tested, 143 townships (41%) indicated 10% or more of the wells over the HRL for Nitrate-N.

Overall, 9.1% (2,925) of the 32,217 wells exceeded the HRL for Nitrate-N. 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.

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 MDA’s Township Testing webpage. The MDA uses the results to prioritize future work to address nitrate concerns, as described in the Nitrogen Fertilizer Management Plan (NFMP).

**Cyanazine**

In 2019, the MDA began analyzing samples in both the ambient program and the PWPS Project for cyanazine degradates. Cyanazine is an herbicide that was discontinued from use in 2002. The Dakota County Environmental Resources Department has sampled private wells within the county for cyanazine and cyanazine degradates and detected concentrations of these chemicals that, when added together (total cyanazine), exceed the Minnesota Department of Health (MDH) established Health Risk Limit (HRL) for cyanazine. Until 2019, the United States Geological Survey (USGS) Organic Geochemistry Research Laboratory was the only laboratory in the United States that was able to analyze for these compounds. In 2019, the MDA Laboratory developed methods to test for these compounds and they were added to the regular suite of compounds analyzed for the ambient program. The MDA contract laboratory used for the PWPS Project also added these compounds to their analyte suite.

From 2019-2023, the MDA collected 3,929 private well pesticide samples across 50 counties in Minnesota). Samples were analyzed for nitrate and several pesticides including atrazine, cyanazine and their degradates. Total cyanazine, which is the summation of cyanazine parent plus its applicable degradates, was detected in approximately 30% of the targeted wells. During this period 174 private drinking water wells were identified with total cyanazine concentrations above the health risk limit of

1,000 ng/L, while 35 were above the acute health risk limit of 3,000 ng/L. Most of the detections identified to date occurred in Dakota, Goodhue, Scott and Washington Counties.

Additional information on cyanazine monitoring including an evaluation of reverse osmosis point-of-use water treatment systems can be found at MDA's Cyanazine Monitoring webpage.

# PFAS

PFAS is another one of the state's major water-quality issues. PFAS are present in the environment and will remain so for generations. In Minnesota, the first discovery of PFAS contamination occurred in the early 2000s, when drinking water contamination was found in the East Metropolitan area of the Twin Cities. Since then, PFAS have been detected in water, sediment, soil, and fish all across Minnesota—from Duluth to Bde Maka Ska and Pine Island and places in between.

In 2021, the Minnesota state agencies developed the state's PFAS Blueprint to support a holistic and systematic approach to address PFAS contamination. This document provides in-depth discussions of concerns in 10 key issue areas. The MPCA and MDH continue to monitor for PFAS in the groundwater and utilize the agency's ambient groundwater monitoring network as an early warning system for PFAS migration into drinking water supplies in addition to monitoring the state's community water systems and private wells in known areas of PFAS contamination.

The MPCA continues to collect samples to assess PFAS in the ambient groundwater. From 2019-2023, the agency sampled over 250 wells from its ambient groundwater monitoring network for this suite of chemicals. Most of this monitoring was conducted in 2019, when the entire network was sampled for PFAS, with limited monitoring occurring from 2021-2023. Laboratory analytical methods have improved and now can test for more types of PFAS compared to past studies. The most recent assessment of PFAS in the ambient groundwater included 20 additional PFAS such as replacement chemicals for legacy PFAS (i.e. PFOA and PFOS) including HFPO-DA (used in the GenX technology platform) and ADONA.

These monitoring results continued to show that perfluoroalkyl acids, such as perfluorobutanoic acid (PFBA), perfluorooctanoic acid (PFOA), and perfluorooctane sulfonate (PFOS). PFBA continued to be the most-frequently detected PFAS. PFOA was detected in 110 wells, which mostly were shallow monitoring well in the TCMA and other urban areas. All measured PFOA concentrations were greater than the health-based value of 0.24 ng/L set by MDH for drinking water in 2024, since the laboratory method reporting limit was greater than this value. Six shallow monitoring wells, ranging from 15-19 feet deep, had PFOS concentrations exceeding the human health criteria of 23 ng/L set by the MDH in 2023, and thirty-one wells had concentrations exceeding the USEPA's PFOS MCL of 4 ng/L. Five of the wells exceeding the USEPA's PFOS MCL supplied drinking water.

MPCA will continue to measure PFAS in the ambient groundwater. In 2024, the agency monitored the ambient groundwater for these chemicals using MDH's recently-developed laboratory method.

# Contaminants of Emerging Concern

The MPCA continued to monitor contaminants of emerging concern (CECs) in the groundwater, including pharmaceuticals, bisphenol A and its analogs, triclosan, and flame retardants. The MPCA has utilized its Ambient Groundwater Monitoring Network to monitor for CECs like these since 2009. To date, the agency has sampled over 250 wells in its monitoring network for over 200 CECs. The CEC data collected in the groundwater from 2018-2023 was interpreted in a report (Kroening, 2025). CEC data collection from 2018-2023 focused on wells that CEC detections in them in past sampling campaigns.

Most of the sampled wells were shallow monitoring wells that primarily were in urban areas. The average depth of these wells was 27 feet.

Sixty eight different CECs were detected in the groundwater samples. Antibiotics were the type of CEC detected most often, which is consistent with this group of medications dominating the list of CECs that were analyzed in the groundwater samples. The twenty most-frequently detected CECs are shown in Figure 5, and all of the chemicals detected are listed in Kroening (2025).

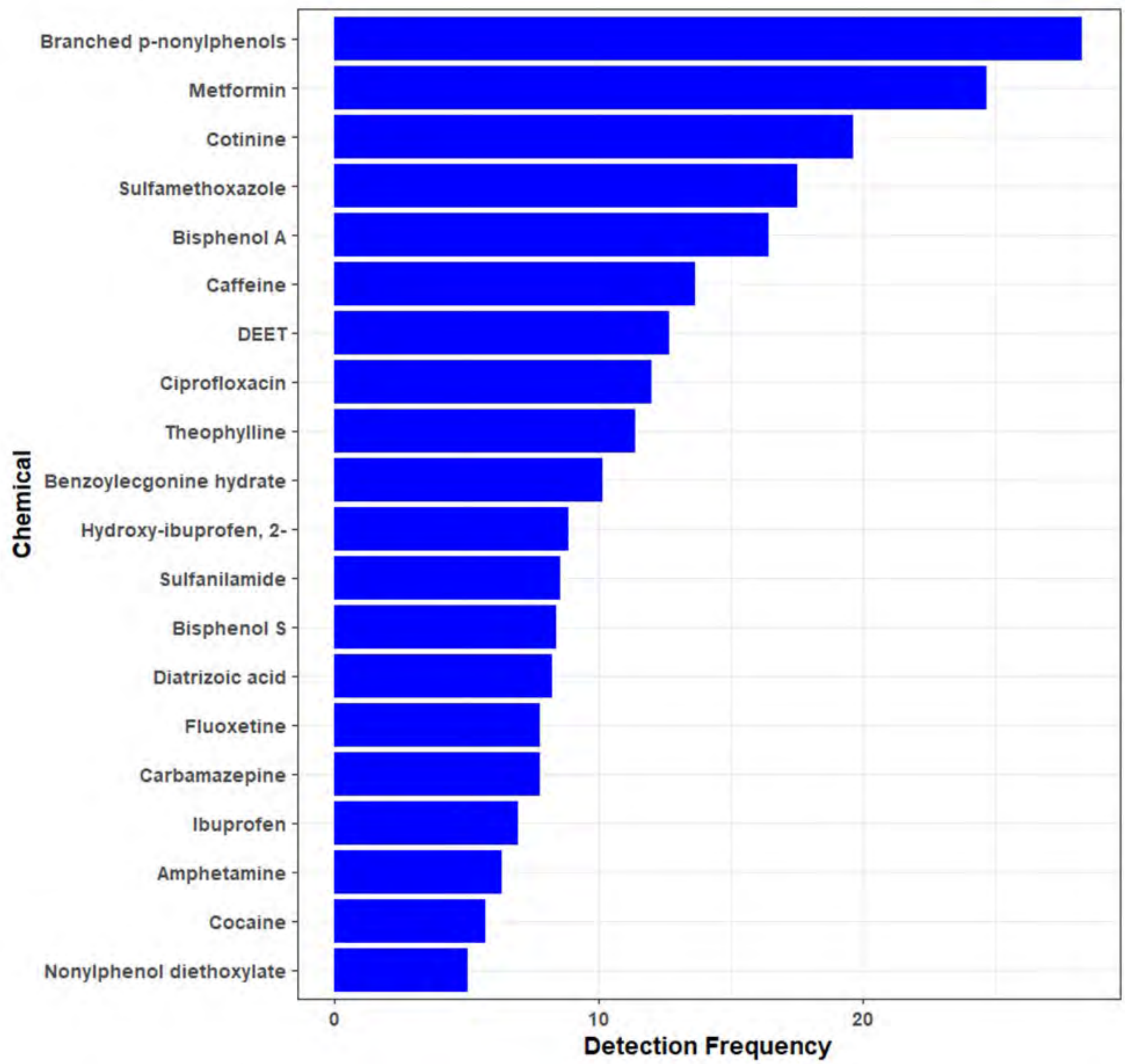



**Figure 5. CEC detection frequency in the ambient groundwater, 2018-2023 [Chart shows top 20 detected CECs].**

The CECs detected in Minnesota's ambient groundwater typically had physical/chemical properties that permitted them to be present in the water. The most-frequently detected CECs in the ambient groundwater generally had high water solubilities and do not sorb to sediments or accumulate in human or animals. This result is consistent with the findings from other groundwater studies.

Many of the most-frequently detected CECs in the groundwater had a high water-solubility combined with a high use. Several of the most-frequently detected pharmaceuticals, such as the anti-diabetic medication metformin and the antibiotics sulfamethoxazole and ciprofloxacin were among the most-prescribed medications in the U.S. Cotinine, which is present in tobacco products, was the third most-frequently detected substance, and these tobacco products were estimated to be used by almost 140 million people in the U.S. at least once a month in 2019. Caffeine, the sixth most-frequently detected CEC in the groundwater, is well-known to be a frequently consumed product in the U.S. The plasticizers bisphenol A and bisphenol S and the insect repellent DEET are all high production volume chemicals and are estimated to have a nationwide production volumes ranging from one million up to five billion pounds each year in 2019.

The CEC concentrations measured to date have generally been low; no concentrations exceed any established human-health guidance values. However, many of the CECs measured in groundwater do not have established human-health guidance.3

# Organophosphate Flame Retardants

The MPCA leveraged its ambient groundwater monitoring network to assess the presence and distribution of organophosphate flame retardants (OPFRs) in the ambient groundwater in 2021. These are a class of chemicals that have been added or applied to materials since the 1960s to slow or prevent growth of a fire. These substances are commonly 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 toxicity and mobility in water, which can permit them to be transported long distances. The MDH has set human health guidance for drinking water for three chemicals in this class and eight of these chemicals were identified by MDH's Toxic Free Kids Program as chemicals of high concern. In 2021, groundwater samples were collected from 116 ambient monitoring network wells and analyzed for organophosphate flame retardants. Most of the sampled wells were in urban areas, including the TCMA, Brainerd, and St. Cloud.

Organophosphate flame retardants were detected in almost 95 percent of the sampled wells. The large percentage of detections likely is related to the fact that most of the analyzed substances were classified as high production chemicals and the sampled wells were installed in aquifers that had little natural geologic protection from contamination. In addition, the sampled wells were installed in urban areas where most OPFR use was expected to occur. The most frequently detected chemicals were tris(2-chloroethyl) phosphate, triphenyl phosphate, and triethyl phosphate, which were detected in over one-half of the sampled wells.

The detected concentrations generally were low. No concentrations exceeded the available human health guidance set by the MDH for drinking water.



# Groundwater data access and management

Data from the MPCA's ambient groundwater monitoring network, previous monitoring efforts, and the open, closed, and demolition landfills are available on the MPCA's website through the Environmental Data Access (EDA) system. The MDA ambient groundwater data can also be accessed through the EDA system. The EDA system was developed to improve access to environmental data and is available at the MPCA Science and Data website. The MPCA's and MDA's ambient groundwater information is also available through the [Water Quality Portal](), which is a partnership of the USGS, EPA and National Water Quality Monitoring Council.

The MPCA ,MDA, and MDNR now store the groundwater quality data that they each collect in the same database. The database is commercially available from EarthSoft Inc. and called the Environmental Quality Information System or EQuIS. The MDH is also in the process of transitioning the storage of some of their groundwater quality data to this same database. The EQuIS database is managed as follows; a MnIT staff person serves as the EQuIS database administrator, and the MPCA, MDA, and MDNR employ separate data coordinators to assist the data users in managing the information. The storage of these large sets of groundwater quality in the same database greatly simplifies regional or statewide analysis of groundwater quality conditions since the data are now stored in the same format. The MDH Environmental Laboratory, which analyzes a large number of the samples collected by the MPCA, and the MDA Laboratory have modified their systems and processes so the data generated by the laboratories can be easily uploaded to EQuIS.

# Needs and conclusions

The ambient monitoring conducted by the MPCA, MDA, and more recently MDH, continues to provide valuable, long-term information on the water-quality conditions in aquifers vulnerable to contamination across Minnesota. As the demands for the state's groundwater come under increasing pressure (e.g. data centers) and variables such as climate change are introduced, this record of groundwater quality will become increasingly important for the proper use and management of this resource. A long-term commitment to the collection and analysis of groundwater data is necessary to identify changes in water quality and quantity over time and provide information needed to effectively manage and protect this critical resource. Groundwater movement is generally slow and often requires years of monitoring to assess the trends and direct and indirect impacts of human activities on this resource.

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

Nitrate concentrations in the state's groundwater also should continue to be tracked, especially since some communities have had problems with high concentrations in their water supplies. The state's ambient monitoring networks should continue to monitor for nitrate in the groundwater, and MDA's nitrate-testing programs should continue to be funded to complete this important work. The newly implemented Groundwater Protection Rule should reduce the risk of nitrate from fertilizer impacting groundwater.

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

# Water Availability and Assessment Report 2025

Appendix C to the 2025 EQB Water Policy Report | 9/15/25

*Cover photo:* The Cloquet River, Riverlands State Forest.

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# Contents

# Introduction

The Land of 10,000 Lakes, the Mighty Mississippi and Lake Superior — the largest freshwater lake in the world — are just some of Minnesota's water resources woven into our state's identity. Our water resources provide habitat, recreational opportunities, drinking water supplies and economic vitality. Minnesotans value these resources as part of our way of life.

This report explores water in Minnesota's atmosphere, economy, communities and landscapes from 2020 to 2025. It presents data and information on the amount of water in and flowing through Minnesota and describes how individuals, businesses and communities use that water. The report also summarizes water law changes, supporting the Minnesota Department of Natural Resources' (DNR) efforts to ensure sustainable water use.

The water resources data and information in this report lead us to the following conclusions:

1. **Climate**: Minnesota's climate is changing outside of the range of normal variation. The trend toward more precipitation continues, even when accounting for recent dry years in the state. The dry years are unusual because they had more precipitation than any other dry period on record in Minnesota. Minnesota also experienced multiple shorter episodes of significant drought and significant flooding.
2. **Water use**: The total volume of water used decreased over the last 20 years, most notably in the energy sector due to reduced water use in power plants. Statewide, groundwater use increased by one-third in the drought years of 2021 to 2023, largely due to irrigation during dry periods.
3. **Streams**: Stream flows were generally normal to above normal compared to historical records, with notable swings between extreme highs and lows.
4. **Lakes**: Lake levels have generally been normal but show similar swings between extreme highs and lows as streams.
5. **Wetlands**: Around the state, there was a slight increase in the acreage of wetlands, and some wetlands are shifting toward wetter types. This is likely due to wetland restoration policies and programs, as well as beaver activity.
6. **Groundwater**: Groundwater levels have been generally stable around the state, although some locations show decreasing trends. In some places, this is due to demand for groundwater exceeding its recharge; in others, it is from increasing seasonally intensive groundwater use.

# Assessment and availability of Minnesota's waters

In this report, we describe water availability in terms of elements seen on the landscape: climate and precipitation, streams, lakes, wetlands and groundwater, and how we use water. Precipitation either soaks into the ground or runs off into lakes, rivers and wetlands. Much of the water that infiltrates the ground is stored in the soil to be taken up by plants. Evaporation from plants and land and water surfaces returns moisture to the atmosphere, which perpetuates the hydrologic cycle. Each of these components is influenced to some degree by human activities at or near the land surface. Streamflow, storage in wetlands and lakes, and groundwater use can be influenced by people; however, natural variability of other components, such as drought, flood and the geographic distribution of aquifers, cannot be controlled. This variability presents challenges for the long-term sustainability of both human and ecological water needs. The following sections describe Minnesota's water availability from 2020 to 2025 through trends in climate, surface water, groundwater system, and water use.

## Overview of climate trends and projections

Climate is a fundamental driver of Minnesota's water supply. The amount of precipitation received and moisture lost through evaporation determines surface and groundwater quantities. Wet periods generally increase surface and groundwater levels, whereas dry periods decrease levels. Understanding Minnesota's climate can provide important insight into water availability issues now and in the future.

Minnesotans are accustomed to cold and snowy winters, along with warm and humid summers, but also know that any season can be far warmer, colder, wetter or drier than normal. The high variability that we expect from Minnesota's climate can make it difficult to notice where, when and how climatic conditions have changed in our state. **More than 130 years of climate data, however, clearly show widespread changes outside of the past range of normal variation are already underway in Minnesota.**

Indeed, Minnesota's climate is changing rapidly, and more changes are coming. In the past several decades, our state has seen increased rainfall and snowfall, heavier downpours and snow, and substantial warming, especially during winter and at night. Winter rain is now more common than at any other time on record, which, combined with warmer winters, has decreased the average depth of snow cover. Although significant drought shows no long-term increases, it has dominated the growing seasons of the early 2020s, representing a major shift from the record wetness of 2019 and the 2010s in general.

An overwhelming base of scientific evidence projects that Minnesota's climate will see additional, significant changes through the end of this century, with even warmer winters and nights, and even larger precipitation events — along with the likelihood of increased summer heat and the potential for longer dry spells. Planning for the future of Minnesota's water must account for the likelihood of both wet and dry hydroclimatic extremes.

## *Wetter and warmer conditions*

Minnesota has become wetter and warmer in the past several decades. Each of the 10 combined wettest and warmest years on record occurred after 1998 (Figure 1). In fact, since 1970, all but two years had some combination of wetter and warmer conditions than 20th century averages. Minnesota's wettest year on record was 2019, with 2024 as the warmest year on record. Although the climate will vary from year to year, with occasional cool or dry years, climate scientists expect precipitation and temperature to continue increasing through the 21st century.

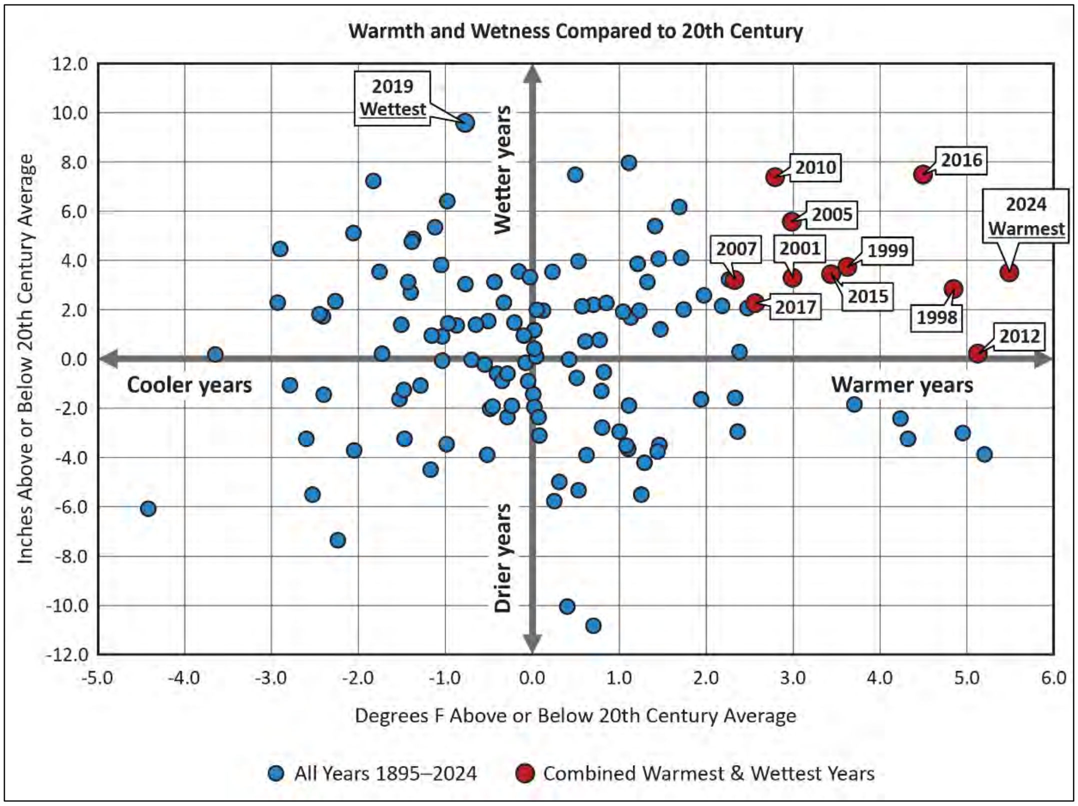



**Figure 1.** Plot of annual temperature and precipitation in Minnesota, with the combined warmest and wettest years labeled and shown in red.

## *Increasing total precipitation but with recent dry years, too*

Minnesota's climate swings regularly from relatively dry to relatively wet periods, but, on average, the state has become about 3.5 inches wetter over the last 130 years. Minnesota experienced its wettest decade on record in the 2010s and its wettest year on record in 2019.

During the first half of the 2020s, however, dry conditions and drought were much more common than in recent decades. Annual precipitation for the state plunged below 30-year averages each year from 2020 through 2023, resulting in accumulated precipitation deficits of around 15 inches during the period. Although precipitation totals surged in 2024, the first half of the decade saw an average of 14% less precipitation than the 2010s.

The dry period of the early 2020s is too short to reverse the ongoing, more than five-decade trend toward increased wetness. Additionally, the early 2020s had more precipitation than virtually all other historical dry years in Minnesota. **Even when accounting for the recent drop in annual precipitation totals, the long-term trend toward more precipitation continues.**

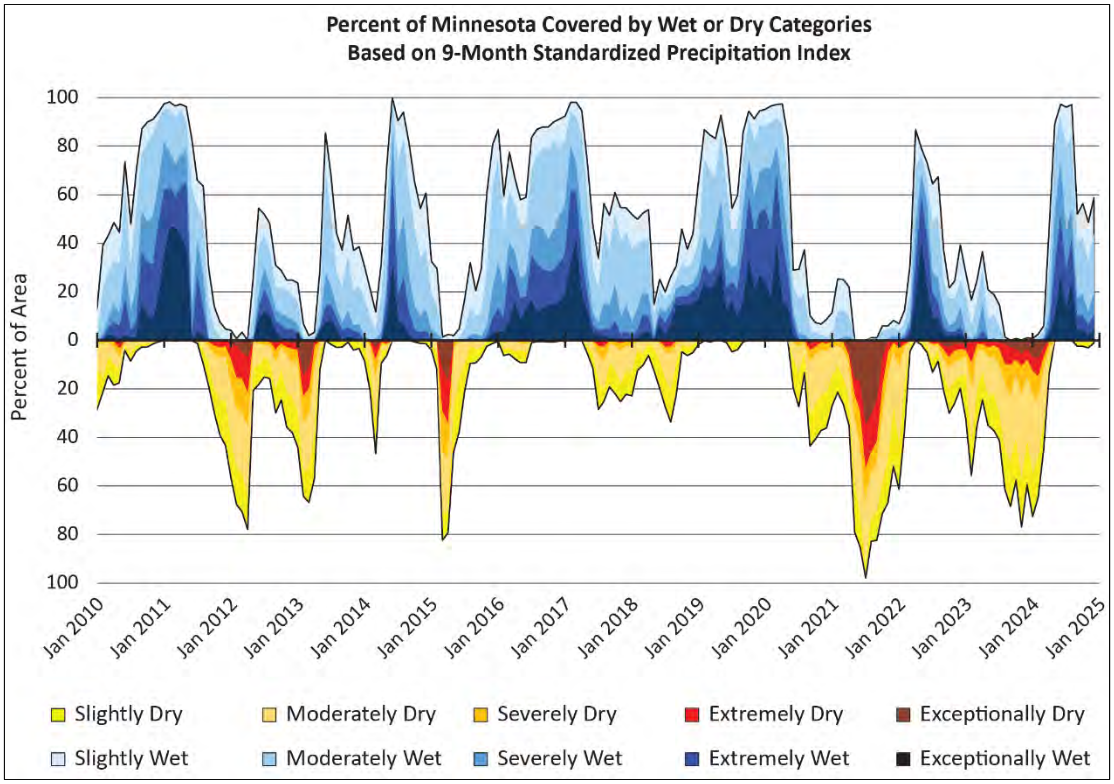



**Figure 2.** Proportion of Minnesota covered by different levels of wetness and dryness using the nine-month Standardized Precipitation Index. Produced by Minnesota State Climatology Office; data from the National Oceanic and Atmospheric Administration (NOAA), National Integrated Drought Information System.

## *Enhanced wet and dry extremes*

Minnesota had more heavy precipitation in the 2010s than at any other time on record, with stations setting numerous all-time and statewide precipitation records. The excessive precipitation flooded communities and rivers, damaged infrastructure and left water standing in fields.

Since the 2010s, Minnesota's hydroclimate has become much more variable, with alternating extremes of wet and dry cycles (Figure 2). These wet and dry periods have varied in their timing, geographic extent and magnitude. **As a result, Minnesota has experienced multiple episodes of significant drought and significant flooding in a short amount of time, at scales ranging from localized to statewide.** Some areas have faced swings from the worst levels of drought on the U.S. Drought Monitor to historic or even unprecedented flooding in nine months or less (see Wet and dry extremes in the Rainy River Basin).

Climate projections for Minnesota show greater extremes of precipitation and also longer dry spells throughout the century. Planning for the future should account for even greater extremes of wetness and dryness than Minnesota has experienced recently.

## *Warmer but not hotter, yet*

**Minnesota is warming quickly, but mostly at night and during the winter.** Annual temperatures have climbed by an average of 3.3 degrees (°) Fahrenheit (F) since 1895, but winters have warmed by 5.5°F and winter nights have warmed by 6.9°F, while summers have warmed by just 2.0°F, and summer daytime high temperatures have decreased slightly in southern Minnesota (Figure 3). Although the records go back to 1895, the vast majority of temperature increases have occurred since 1970.

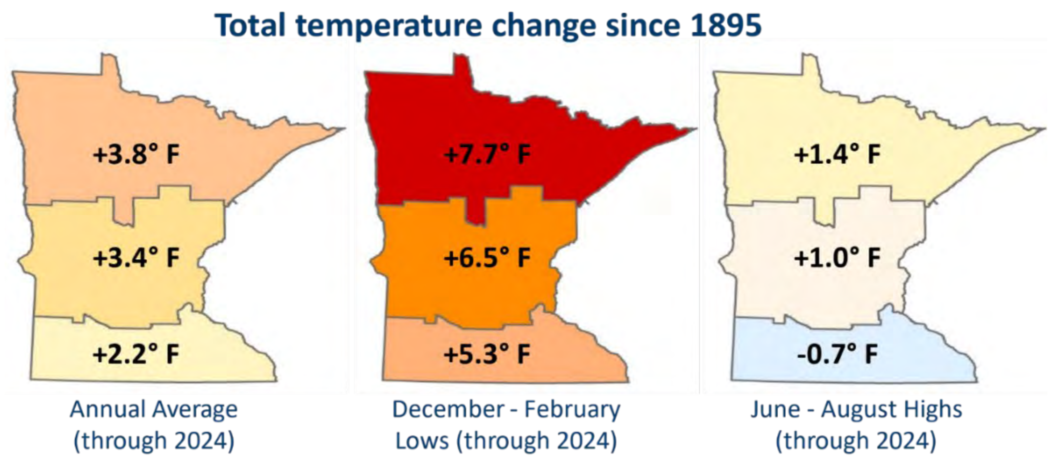
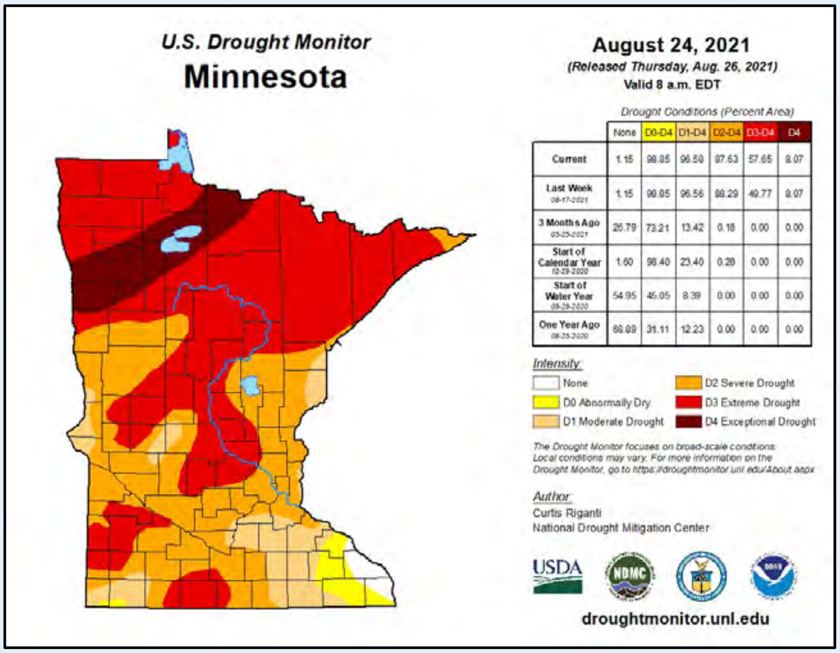



**Figure 3.** Temperature change by region produced by the Minnesota State Climatology Office — part of the DNR Ecological and Water Resources Division; data courtesy of NOAA National Centers for Environmental Information.

Winter cold extremes have become less frequent and less severe, while the state has observed no change in the frequency or severity of summer high temperature extremes. Extremes of humid heat have begun increasing, however, with many record and near-record heat index values observed in Minnesota in the 2010s and 2020s. Climate models are virtually unanimous in their predictions that hotter summers will arrive by the middle of this century (if not sooner), and recent trends suggest that humid heat waves will continue increasing in frequency and intensity. Winter is likely to continue warming faster than summer throughout the century.

## *Wet and dry extremes in the Rainy River Basin*

The Rainy Lake and Rainy River area along the Canada-Minnesota border serves as a classic, recent example of wet and dry extremes occurring in rapid succession. From May through August 2021, the area received just half of its normal precipitation and ended up with the worst drought conditions since 1980. The next nine months, September through May, however, were by far the wettest on record for that period, exceeding normal precipitation by 80%. Rainy Lake rose to its highest levels in 115 years of record, with historic flooding on the Rainy River and Lake of the Woods. These two images show the effects of alternating extremes along the Rainy River.




Above: The U.S. Drought Monitor map for August 24, 2021. The dark red band across northwestern Minnesota extending through part of the Rainy River indicates exceptional drought, the highest level possible, and the worst drought conditions in the area since 1980.

Left: Historic flooding of the Rainy River just 10 months later, in June 2022, following several months of excessive precipitation falling in the basin. *Photo courtesy of Zachary Moore.*

## Status of Minnesota's water use

Minnesotans get their water from both groundwater (underground aquifers) and surface water (streams, rivers and lakes). Total water use in Minnesota generally increased over the last decades of the 20th century. Since about 2005, water use has been declining, even as Minnesota's population has grown. In total, **Minnesota's water use has decreased over the past 20 years, from about 1.4 trillion gallons in the first decade of the century to about 1 trillion gallons at the start of the third decade** (Figure 4). This translates to an approximate 27% decline in overall water use.

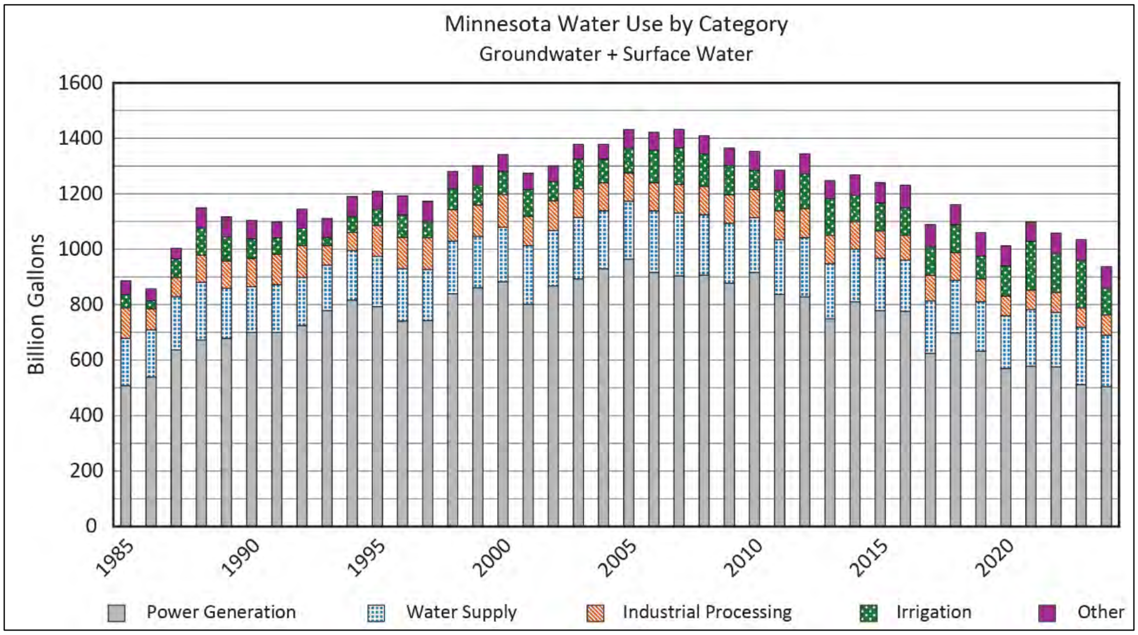



**Figure 4.** Water use by category[1]

### *Decreasing water use for generating electricity*

The largest portion of Minnesota's water use is from surface water for power generation. Most of the decrease in the state's water is from a decrease in water needed for power plant cooling — a reduction of 48% from 2005 to 2024.

- This reduction occurred even as the overall demand for electricity remained constant.
- Several large power plants converted from coal to natural gas. Natural gas plants require less cooling water. The share of the state's electricity produced by coal-fired power plants declined from 65% to 22% over the period from 2003 to 2023.
- The amount of electrical power generated in Minnesota from renewable sources, including wind, solar, hydropower and biomass, has increased. These sources of electricity mostly do not require cooling water. In 2023, 32% of the state's electricity generation was from renewable sources, mostly from wind turbines. In comparison, only 5% came from renewable resources in 2003.

[1] Water supply is defined as water supplied to municipalities, rural water districts, institutions, and private sources to potable water supply distribution systems, where it is used for drinking water and other uses.

## *Drought in the early 2020s starts a new trend*

Water use for non-power generation declined from 2007 through 2020. This trend abruptly stopped as drought conditions during the summer months of 2021 to 2023 caused increased demand from water suppliers and irrigators. Both water use categories show rising and falling trends based on precipitation patterns. Water supply use increased by 10% and irrigation use increased by nearly 80% over a short time. In the summer of 2024, the state experienced a sharp reversal from the 2021 to 2023 period, with a 100-billion-gallon reduction of water use, also attributable to lower irrigation and water supply use demands.

## *Increasing groundwater use*

Water use from surface water sources declined over the past five years. That reduction was mainly in the power generation and industrial processing categories. Minnesotans get 25% of their drinking water from surface water sources via public water supply systems. Of all the water supplied by these systems, 63% is for residential customers. The remainder is for various non-residential purposes.

While the overall use of surface water has gone down, short-term use of groundwater has increased. From 2014 to 2020, total groundwater use remained steady. On average, **statewide groundwater use increased by one-third** during the 2021 to 2023 drought period, and 2021 was the first year that groundwater use for irrigation surpassed its use for public water supply (Figure 5). In 2024, groundwater use returned to the former three-year average.

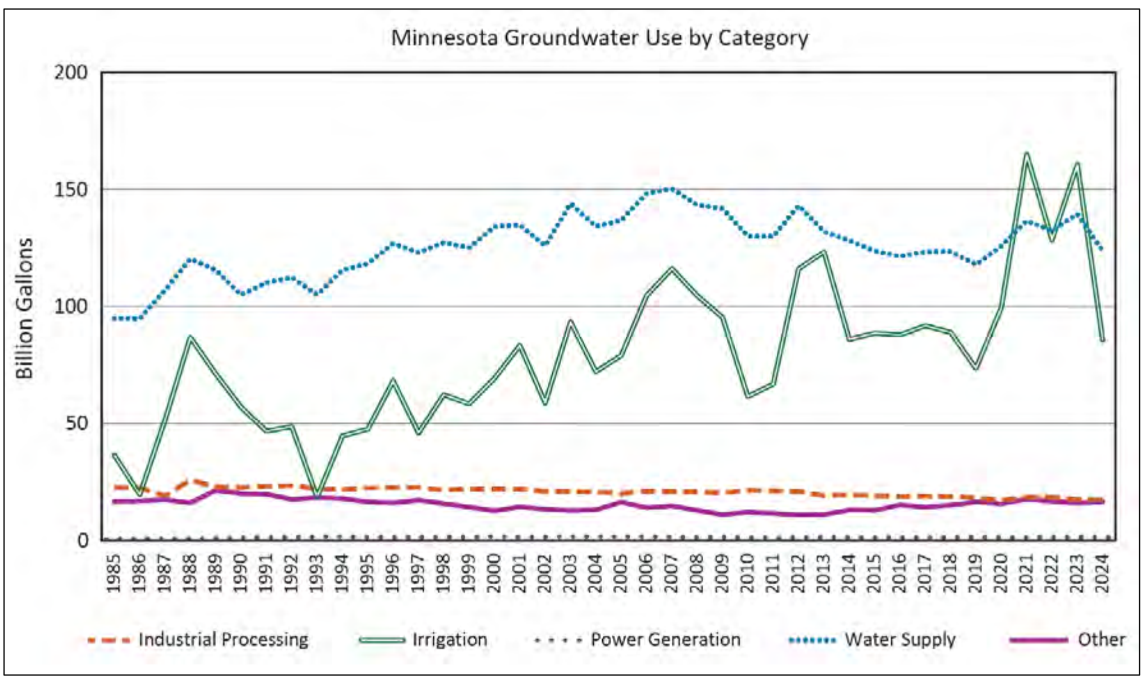



**Figure 5.** Groundwater use by permit category.

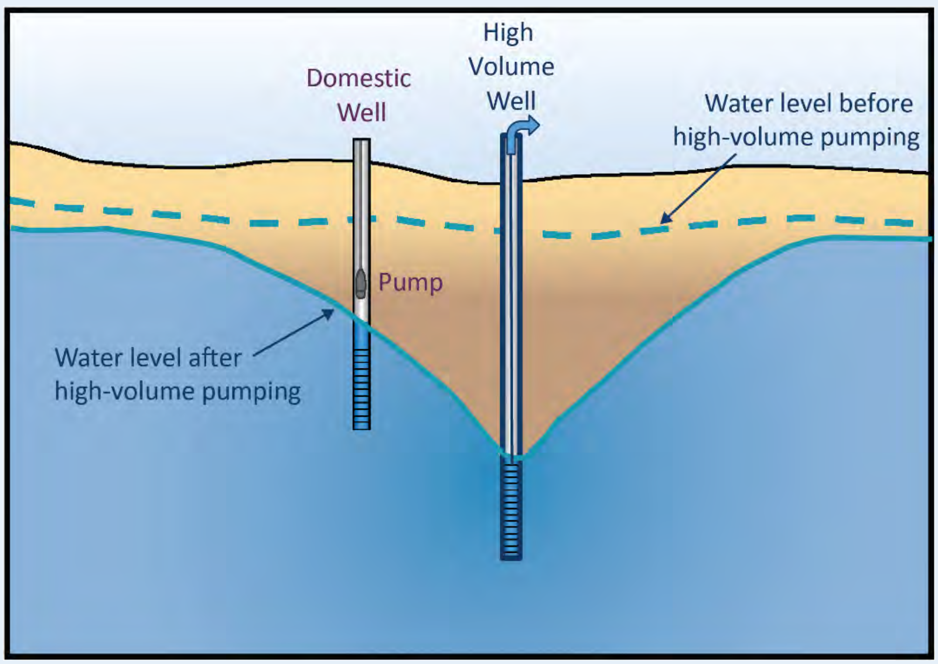
## *Leadership in per capita water use*

In 2023, 83% of reporting water suppliers had a residential water use of 75 gallons per capita per day (GPCD) or less. Conversely, in 2018, 92% of water suppliers who voluntarily reported used 75-gallon GPCD or less. The increase in residential per capita water use from 2018 to 2023 is likely because the summer of 2023 was extremely dry, leading to higher water use (such as for lawn irrigation) than in 2018. Many cities use two to three times more water in the summer than in the winter, mostly for outdoor water use, such as lawn irrigation.

## *Well interferences*

Since 2020, agricultural irrigation using groundwater has increased sharply, due to variable precipitation patterns. With more precipitation coming in extreme events, with long dry stretches in between, more farmers have turned to groundwater for irrigation needs. One consequence of increased groundwater irrigation has been an increase in well interferences or situations where domestic wells, which have the highest water allocation priority, are no longer able to reach the water table due to drawdown from a high-volume well (often an irrigation well). The DNR paid out approximately $210,000 from a drought recovery fund to remedy interferences that happened during the 2021 drought. Between 2021 and 2023, the DNR received more than 200 verbal complaints of well interference, with almost half requiring investigation or settlement.

Additionally, many of these complaints were driven by high outdoor water use within a municipal supply system. These continuing trends highlight the importance of water conservation and demand reduction for water uses for appropriations permit holders, municipal water customers and domestic well owners alike.




High-capacity wells, like those commonly used for irrigation, can draw large volumes of water from deeper in the water table. As levels drop below the pumps in domestic wells, it can prevent those wells from drawing water for household use.

## Status of Minnesota's streams

When it rains or when snow melts, some of that water infiltrates into the groundwater system, but most is stored in lakes or wetlands or becomes flow in streams. When precipitation is high or low, streams and rivers tend to respond quickly. From 2020 to 2024, streamflow varied widely across both time and location. On average, flows were normal to above normal compared to historical records. There were, however, significant periods of flooding as well as prolonged low flows that led to the suspension of surface water appropriation permits.

Stream flow extremes are important, so hydrologists use a metric called Q90 to assess times of low stream flow. The Q90 is the level of flow in a stream at which, over the period of record for that stream, the flow is above that level 90% of the time. During water years 2020 to 2024, stream flow was at or below the Q90 at more gages, and for longer time periods compared to water years 2015 to 2019, because of the drought.

- For water years 2015 to 2019, 30 gages were at or below Q90 threshold for more than one day. Collectively, gages statewide were at or below their respective Q90 threshold for 1,924 days during this period.
- During water years 2020 to 2024, 60 gages were at or below Q90 threshold for more than one day. Collectively, gages statewide were below the designated Q90 for 6,754 days during water years 2020 to 2024.

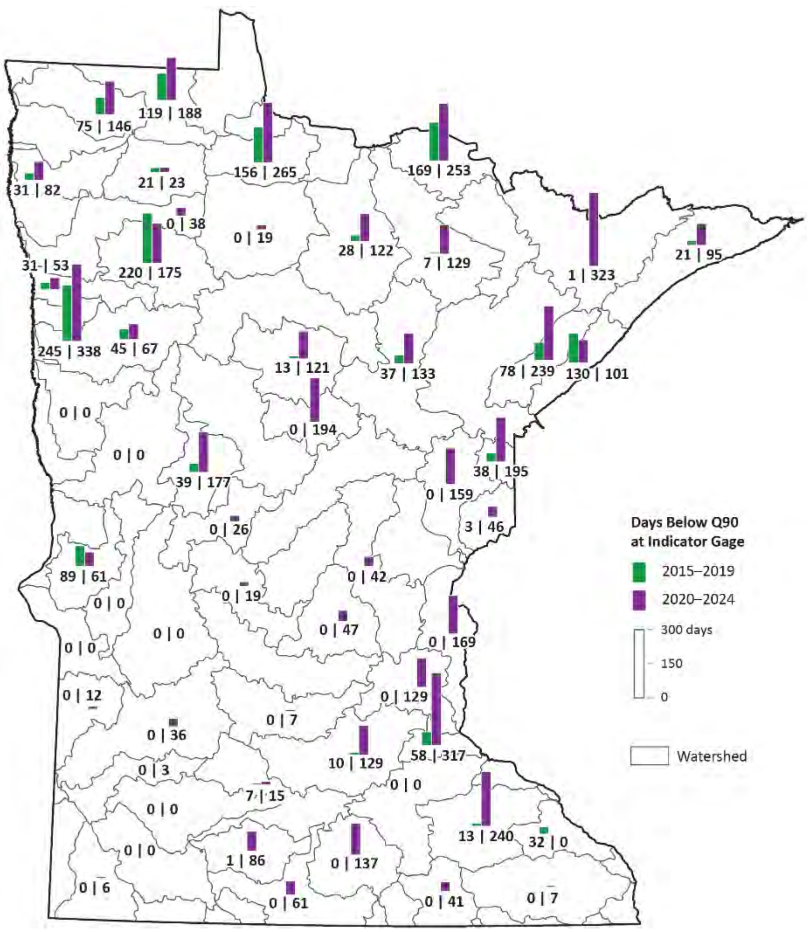



**Figure 6.** Days below Q90 for each indicator gage. The recent five-year period is in purple and depicts drought years, and the prior five-year period is in green, depicting wetter years.

When stream flow at designated gages falls below the Q90, the DNR is required to curtail surface water appropriation in those watersheds. From 2021 through 2024, the DNR temporarily suspended 454 surface water appropriation permits to protect other water users, instream flows and downstream supplies. The permit use types suspended during this time were:

- 45% agricultural crop irrigation
- 13% golf course irrigation
- 12% wild rice irrigation
- 3% construction non-dewatering
- Less than 3% of a variety of use types

Most of these permits were suspended in 2021 and 2023 during extensive, long-duration drought conditions throughout the growing season.

## Status of Minnesota's lakes

Lakes hold a special place in Minnesota's history, culture, and identity. They provide recreational opportunities, support a thriving tourism industry, and help modulate the impacts of high and low precipitation. Lakes are also important ecosystems that support fish and wildlife. They are arguably the most visible and valued aspects of Minnesota's water resources — it's right there on our license plates.

One critical ecosystem service of lakes is their ability to slow down and store water. We benefit from lakes storing water, trapping sediment and slowing runoff. Water levels in lakes are the difference between water coming in, such as precipitation or inflow from streams and groundwater, and water leaving, such as evaporation, human use, or outflow to streams and groundwater. Most lakes naturally experience variability in water levels. **A statewide characterization of lake levels over the last five years highlights the ability for lakes to serve as storage over periods of drought and deficits in precipitation** (Figure 7).

The most recent five-year averages (2021 to 2024) of water levels from lakes with sufficient data were compared to the average water levels from the same lake over the past 30 years. Over 90% of the 464 lakes in the analysis had the recent average water levels that were within 0.5 feet higher or lower than the 30-year average at that lake. This is a good indication that lake levels tend to center around their average water levels, even with periods of increased drought. Dry conditions and drought were much more common from 2020 to 2024 than in recent decades, and yet only 14 of the 464 lakes had recent average water levels that were more than 0.5 feet below their 30-year average. In fact, 25 lakes exceeded their 30-year record by 0.5 feet or more (Figure 7). Large fluctuations can be observed during prolonged drought, but even then, levels appear to recover to the average level with time.

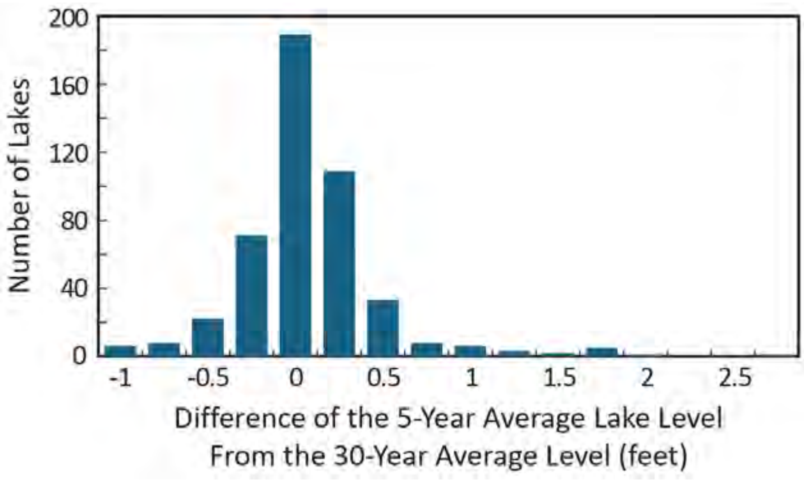



**Figure 7.** The difference in the 2021 to 2024 average lake level from the 30-year average lake level at 464 Minnesota lakes.

Each lake has unique characteristics that can impact water levels. Some lakes annually fluctuate 0.5 feet or more in any given year, while other lakes don't fluctuate much at all.

Lakes with the most variation in levels seem to be congregated in the eastern Twin Cities metropolitan area (Figure 8). These lakes had the greatest fluctuation in water levels over the 30-year period of analysis.

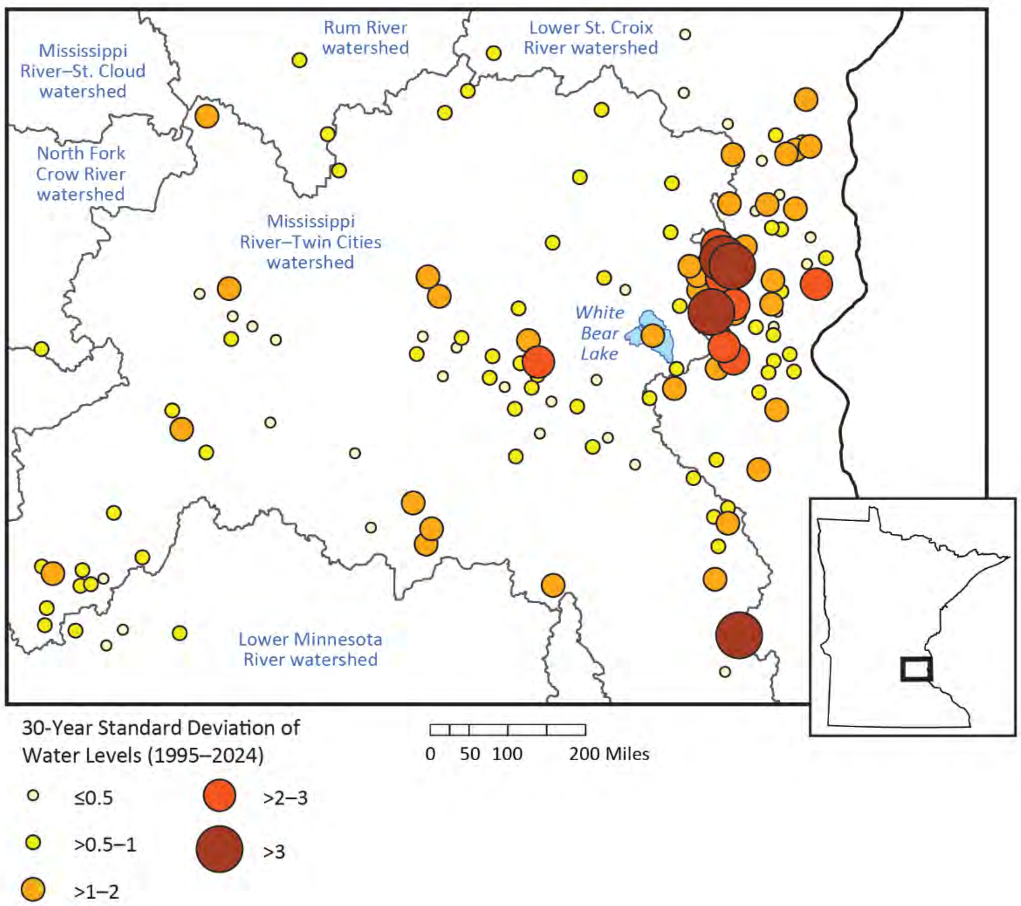



**Figure 8.** The location of lake level records that have large standard deviations of two or more feet over the 30-year period of analysis.

## *White Bear Lake (Ramsey and Washington counties)*

From 2009 to 2014, White Bear Lake went through a period of low water levels that garnered significant public and political attention.

Consequently, in 2016, the DNR established a protective elevation based on recreational use (922 feet above mean sea level). Hydrological models indicated that White Bear Lake water levels naturally fluctuated but would likely have been higher during the low water years with reduced groundwater pumping. However, the groundwater use did not appear to harm the White Bear Lake ecosystem. For example, water level fluctuations and associated low water levels are essential for a healthy emergent plant community in the lake, which provides valuable fish habitat.

For those water appropriations that are likely to influence White Bear Lake water levels, the DNR may modify the permits to incorporate the protective elevation. Permit modifications might include implementing use restrictions, such as lawn watering, to promote water conservation.

White Bear Lake's low water levels in autumn 2014.

High precipitation contributes to higher lake water levels, and severe droughts reduce lake water levels as inlet flows and groundwater levels decrease. In the last 60 years, the largest changes in lake water levels for most lakes occurred when high precipitation years were quickly followed by a severe drought year. Three periods stand out for large, quick lake water level fluctuations: 1975-1977, 1986-1988 and 2019-2021 (Figure 9).

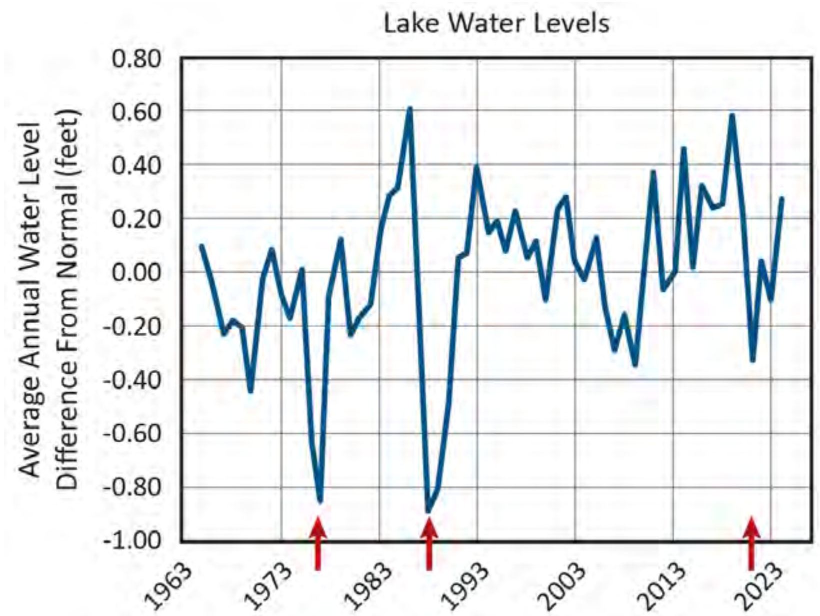



**Figure 9.** The average difference from normal lake water levels, with red arrows highlighting 1975-1977, 1986-1988 and 2019-2021.

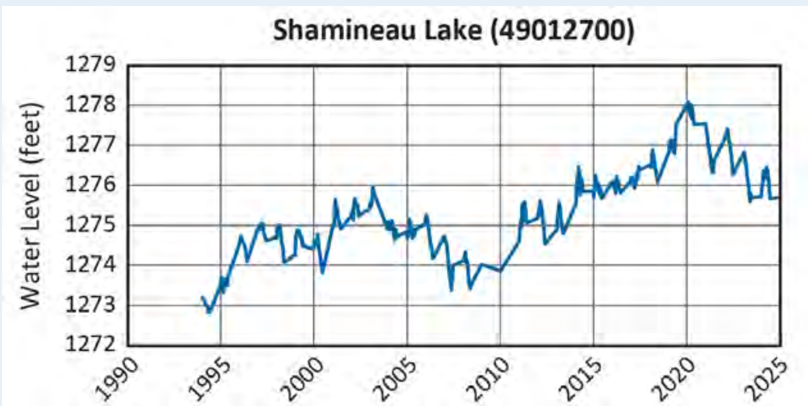
Lakes are not only culturally important, but they are also literally in many Minnesotans' backyards, and fluctuations can have significant economic impacts. Some lake level fluctuation is expected and normal — in fact, occasional lower lake levels promote healthy aquatic plant communities and clearer water. Some additional human-driven changes, such as groundwater pumping, can affect individual lake water levels, but these are not isolated from both normal fluctuations and changing climatic precipitation drivers.

Minnesotans can expect lake levels to continue fluctuating, and the impacts will vary by year and by lake. Predicting how much each lake will fluctuate is difficult, but we expect that lake levels will fluctuate even more than in the past as the climate changes. Lake users, lakeshore property owners and infrastructure managers should expect lake levels to fluctuate to higher highs and lower lows than in the past.

## *Shamineau Lake (Morrison County)*

Human development along lakeshores leads to increased public expectations for managing lake levels to a very narrow range. In most cases, water resource managers have limited ability to control lake levels.

A good example of the challenges of managing lake levels is Shamineau Lake in Morrison County. Shamineau Lake experienced high water levels in 2020 (below), due to higher groundwater levels in the area after years of high precipitation. The lake has no outlet, and the lake level rose significantly, resulting in substantial property damage.




Water levels at Shamineau Lake.

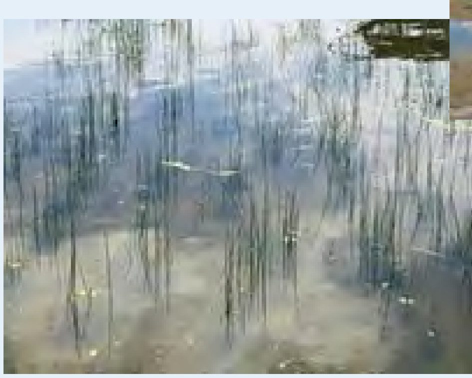
## *Little Rock Lake (Benton County)*

An example of using a drawdown to improve fish and wildlife habitat is Little Rock Lake in Benton County. For more than 100 years, since the Sartell Dam was built, Little Rock Lake water levels were not allowed to fluctuate naturally, and the lake was prone to harmful algal blooms.

In 2019, a three-foot drawdown was initiated for six weeks to promote germination of emergent aquatic plants, and lakeshore property owners planted aquatic plants to accelerate the restoration of a healthy aquatic plant community.

By 2021, water clarity improved slightly, more aquatic vegetation was found growing in the lake, and wildlife frequented new areas. Initial results were positive, yet the efficacy and duration of benefits from lake drawdowns vary by lake.

Many lakes have naturally fluctuating water levels, and their aquatic plants have evolved with large water level fluctuations. For example, bulrush protects shorelines from erosion by buffering waves and stabilizing sediments. It also provides vital aquatic habitat for fish and wildlife. However, bulrush requires periodic, large fluctuations in water levels, including long wet periods followed by long dry periods. Similarly, lowering the lake level of an impounded lake can improve water clarity and habitat for fish and migratory birds.



Clockwise from top left: A significant algae bloom on Little Rock Lake; property owners planting aquatic plants during the down-down period; improved water clarity and wildlife are visible in restored areas.

## Status of Minnesota's wetlands

Minnesota's wetlands perform many crucial functions. They store water from snowmelt and rain, thereby reducing flooding that can cause erosion, and provide habitat for wildlife. Wetland plants take up nutrients, which improves water quality in downstream lakes and rivers, store carbon and provide food for wildlife. Some wetlands, such as calcareous fens, host globally and locally rare plants and receive special protection in Minnesota.

Minnesota has 12.2 million acres of wetlands, second in total acreage among the 48 conterminous states, behind only Florida. However, about half of our state's historic wetlands have been drained or filled for agriculture, housing and other forms of development (Figure 10). Most of the remaining and the least impacted wetlands are concentrated in the northern and northeastern parts of the state. Draining wetlands and straightening the connecting riverways has resulted in a loss of water storage capacity, decreased groundwater recharge and reduced ecological benefits.

Restoration and protection of peatlands (a specific type of continually saturated wetland) has been recognized as a priority, to mitigate climate change through the sequestration and storage of carbon from the atmosphere. The Minnesota Legislature and the U.S. Environmental Protection Agency (EPA) have allocated more than $21.5 million for peatland restoration in Minnesota.

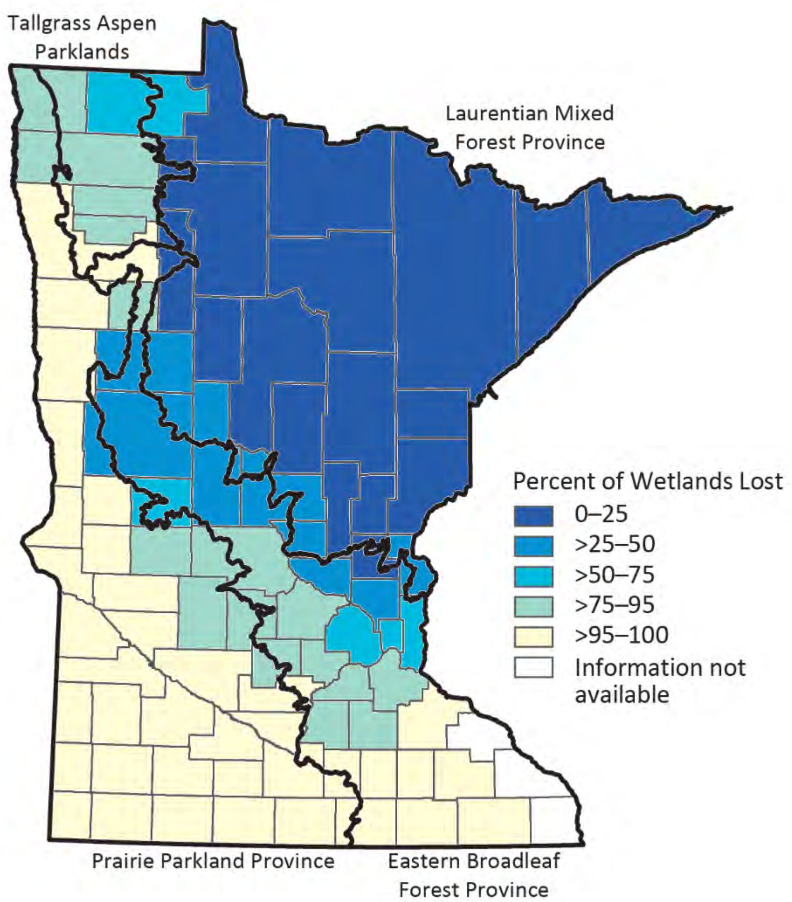



**Figure 10.** The historical loss of wetlands by county, using data from Anderson and Craig (1984).

Wetland regulation and protection programs have reduced wetland losses, including the passage of the Minnesota Wetland Conservation Act in the early 1990s. The DNR's Wetland Status and Trends Monitoring Program shows that Minnesota had a net gain of approximately 43,000 acres, or 0.3%, of wetland from 2006 through 2020. Preliminary data collected suggest that this trend of net wetland gains has continued, with an additional net gain of 0.1% from 2020 through 2023 (Figure 11). Wetland gains are most common in agricultural areas and can be promoted by restoration programs such as the Outdoor Heritage Fund and Reinvest in Minnesota.

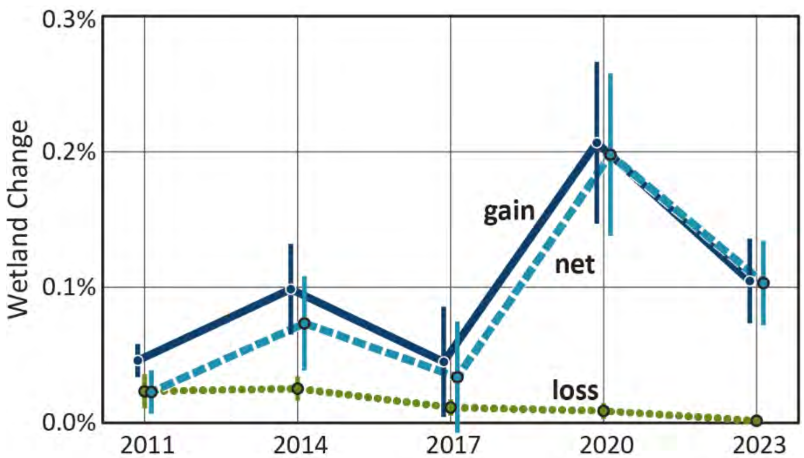



**Figure 11.** Change[2] in wetland area over time based on the DNR's Wetland Status and Trends Monitoring Program.

## *Climate directly influences wetland water levels*

Wetland water levels are influenced by precipitation, groundwater levels, runoff and evapotranspiration.

Many wetlands are directly connected to groundwater, and increased use of groundwater, especially during droughts, can cause wetland water levels to decline. While water levels in wetlands often fluctuate naturally, groundwater appropriations can reduce water levels further and for longer periods of time. In turn, the wetland plant communities can change, diminishing ecological function.

Unlike streams and lakes, we do not have statewide historical records of wetland water levels that can be used to assess the impacts of extreme weather events and human activities on wetlands in Minnesota. Therefore, the DNR initiated a monitoring network to measure water levels in relatively undisturbed natural wetlands across the state. Monitoring sites were established between 2018 and 2025 and will be in place for 10 years. Data from this monitoring network will be used to characterize water levels for different wetland types across a range of climatic conditions. Funding for this network was provided by the U.S. EPA and the Minnesota Environment and Natural Resources Trust Fund, as recommended by the Legislative-Citizen Commission on Minnesota Resources.

[2] Changes are categorized as gain, loss, or net (difference between gain and loss). Wetland change is expressed as a percentage of the previous monitoring cycle's total wetland area, and the year is the final year in each monitoring cycle. Points represent statewide estimates, and error bars represent 95% confidence intervals. Points and error bars are offset from one another at each year for visibility.

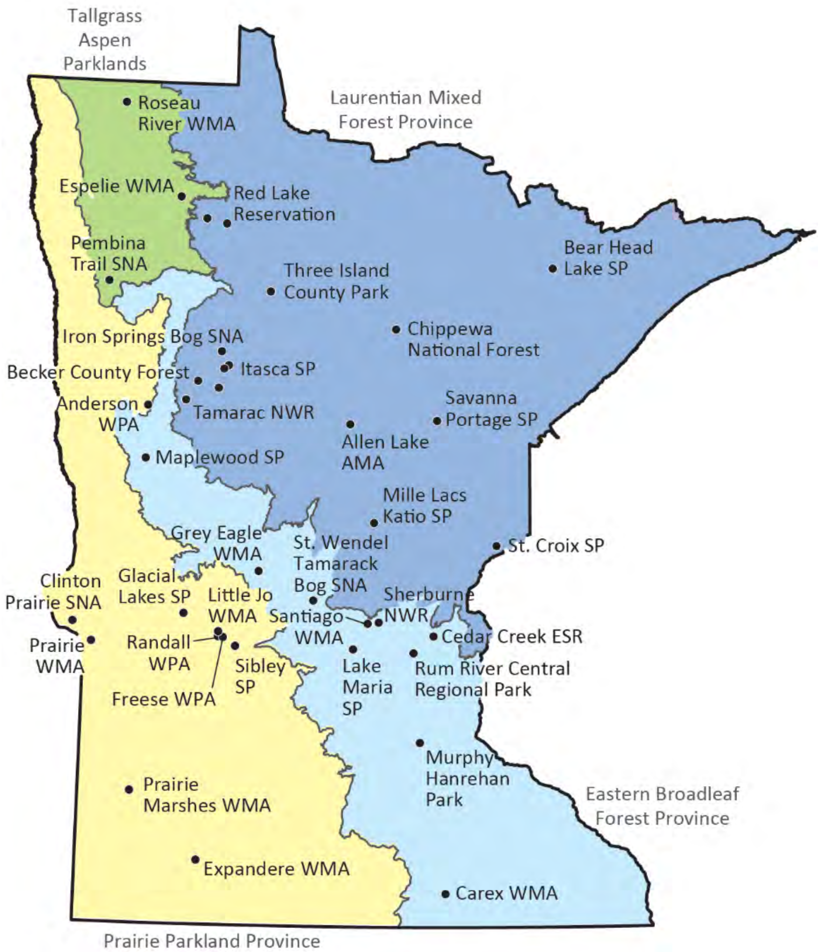



**Figure 12.** A map of locations with wetland water level monitoring sites. The full network will include 60 sites, spanning a range of geographies and wetland types.

## Status of Minnesota's groundwater

Approximately three out of every four Minnesotans rely on groundwater for their drinking water. Minnesota's aquifers also support agriculture, industry, and the natural resources that are vital to Minnesota's quality of life, such as streams, wetlands and lakes. Our aquifers recharge by the percolation of precipitation through the soil. Some aquifers receive precipitation readily and can recharge quickly. Other aquifers are buried deep in the ground and can take years or decades to recharge.

The DNR maintains a statewide network of approximately 1,250 observation wells to monitor our hidden groundwater resource. We evaluated trends at 374 wells, where groundwater levels were measured from 2005 to 2024. Statewide, 5.3% of these observation wells showed downward trends over the period.

Of those 374 wells, 284 were also evaluated for the period from 2000 to 2019. By comparing how trends changed in each well from one period to the next, it is possible to observe how water level trends have changed. Nine wells changed from a stable trend to a downward trend, and 42 wells changed from an upward trend to a stable trend. Multiple episodes of drought over the last five years are likely the cause of the change in trend direction.

There are differences in annual minimum groundwater-level trends across the six groundwater provinces (Figure 13):

- In the metro province, all but one of the observation wells showed an upward or stable trend over the past 20 years. The continued focus on water conservation by large water users contributed to stabilizing groundwater use rates. Wet climatic conditions during the first 20 years of the century also contributed to upward groundwater trends.
- In the central province, 4.7% of observation wells are trending downward, representing a slight decrease from the previously recorded 6%.
- In the western province, 7.5% of wells are trending downward.
- In the south-central province, 15.4% of wells exhibit a downward trend.
- In the northeast and southeast portions of Minnesota, the observation well network is currently too sparse to draw conclusions about the overall state of the aquifers in those areas.

Downward trends in groundwater levels may result from a variety of influences, including extended periods of reduced precipitation, increased reliance on groundwater sources, and alterations in land use or recharge rates. Wells showing declining annual minimum levels might reflect intensified local groundwater consumption during the analysis period. If extraction rates stabilize, associated aquifer level declines could reach equilibrium.

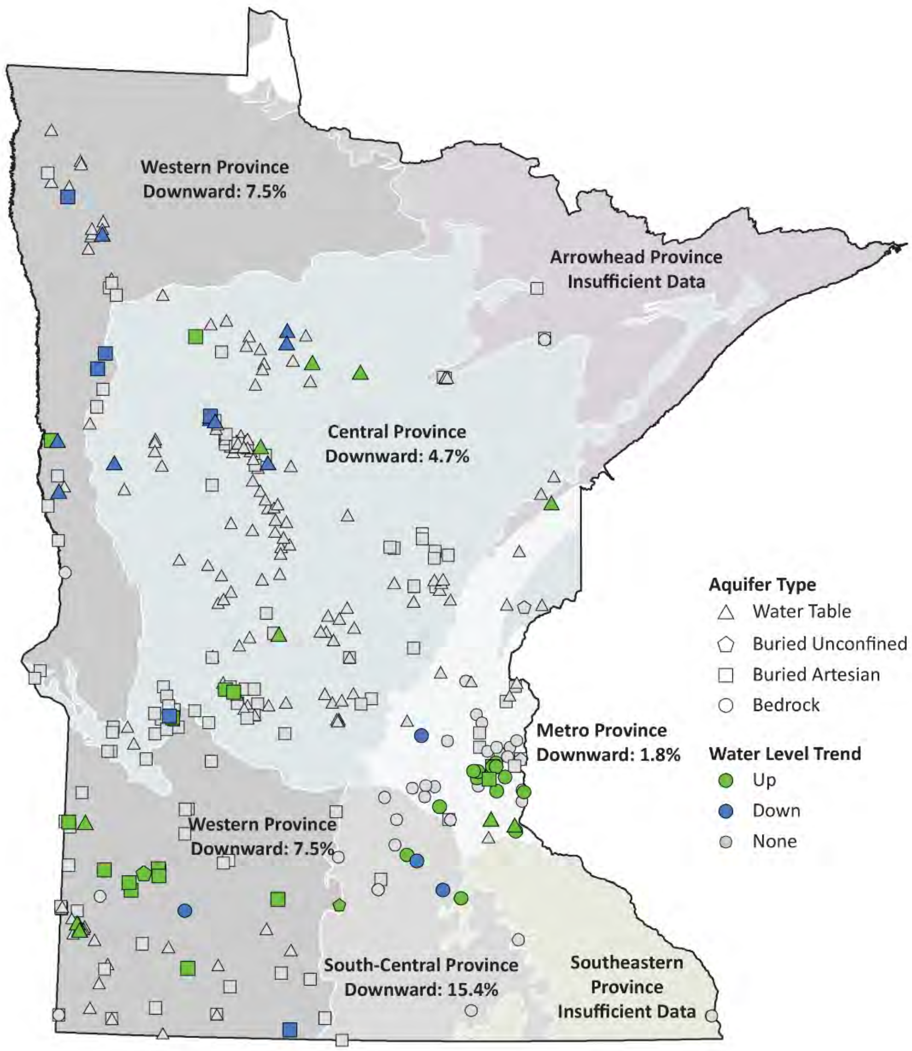



**Figure 13.** A map of Minnesota's groundwater provinces and their water level trends.

## *Declining Red River Watershed groundwater levels*

In the Red River watershed in northwest Minnesota, 16% of wells have declining groundwater levels, compared to 3.9% of wells in the rest of the state.

Decreasing groundwater levels in northwest Minnesota are likely due to a combination of factors. The aquifers in the western groundwater province are small and usually recharge very slowly. It is also likely that, as the climate of northern Minnesota is warming more rapidly than the rest of the state, commodity crops are being grown that could not have been grown decades ago, resulting in increased groundwater use for crop irrigation.

Groundwater use in the Red River Valley of Minnesota has increased from around 5 billion gallons per year in the late 1980s to 15 to 20 billion in 2021 to 2023. Because many parts of the Red River watershed do not have aquifers, there is high demand placed on the scarce aquifers that do exist.

The lines visible on the rocks along the Red Lake River highlight decreased water levels in recent drought years; groundwater levels, which primarily recharge through precipitation, have also been impacted.

# Water law changes: 2020 to 2025

The DNR plays an important role in supporting sustainable water use through its permit programs, data collection and analysis activities, law enforcement responsibilities, education, and technical assistance services. The DNR and other agencies in the executive branch have adopted a three-pronged approach to sustainable water resource management. This approach involves mapping, monitoring and managing water resources adaptively, over time. Since the previous Water Availability and Assessment Report five years ago, the DNR's approach to water management has continued to evolve (see Appendix A).

Thus far, this report has provided data and information on water related to our economy, communities, landscapes, atmosphere and geology. This section of the report describes some of the drivers surrounding policy changes made to Minnesota's water laws since the last report.

## 2021

A Minnesota-based company proposed to extract 500 million gallons per year of groundwater from Dakota County, Minnesota and transport it via railcar to arid states in the U.S. Southwest. This proposal was the first of its kind in the state, and it faced strong objections due to concerns about depleting Minnesota's water resources. It also sparked discussions surrounding state and interstate water rights. The source of the proposed water appropriation was the Mt. Simon–Hinckley aquifer, a significant source of drinking water in the Twin Cities metropolitan area.

The legislature passed changes in water laws to provide additional protection for the Mt. Simon–Hinckley aquifer and limit the ability to move water outside of the state, while still allowing a certain amount of movement to support regional water systems, such as rural water supply systems.

> **Note**: When the protections for the Mt. Simon aquifer were expanded to the extent of the aquifer beyond the seven-county metropolitan area, it had an unexpected impact of eliminating non-potable uses for those who don't have other options. The DNR has been working with legislators to find a solution that provides some opportunity for accessing water while also protecting the aquifer from non-essential uses.

The statutory changes signed into law in 2021 are listed below:

**Minnesota Statute 103G.271: Appropriations and Use of Waters**

Subdivision 4a. Mt. Simon-Hinckley aquifer. ~~(a)~~ The commissioner may not issue new water-use permits that will appropriate water from the Mt. Simon-Hinckley aquifer ~~in a metropolitan county, as defined in section~~ 473.121, subdivision 4~~,~~ unless the appropriation is for potable water use, there are no feasible or practical alternatives to this source, and a water conservation plan is incorporated with the permit. ~~(b) The commissioner shall terminate all permits authorizing appropriation and use of water from the Mt. Simon-Hinckley aquifer for once-through systems in a metropolitan county, as defined in section~~ 473.121, subdivision 4~~, by December 31, 1992.~~

Subdivision 4b. Bulk transport or sale (a) To maintain the supply of drinking water for future generations and except as provided under paragraph (b), the commissioner may not issue a new water-use permit to appropriate water in excess of one million gallons per year for bulk transport or sale of water for consumptive use to a location more than 50 miles from the point of the proposed appropriation.

## 2023

In 2016, as directed, the DNR published a report to the legislature titled *Definitions and Thresholds for Negative Impacts to Surface Waters*. This report was required by legislation in the 2015 session, seeking clarity about how much water can be diverted and used without harming ecosystems (a statutory requirement). A comprehensive review of scientific literature indicated that the practice of relying on the Q90 as the protection level for low flows was likely causing adverse impacts to ecosystems. The team of scientists ultimately recommended using a maximum percentage of water relative to an index flow that can be removed or diverted to establish protection levels that avoid causing harm or negative impacts to surface water bodies. Between 2016 and 2023, the DNR invested in developing groundwater models and completing fish habitat analyses to apply the percentage of flow approach to parts of Minnesota. Coupled with growing concerns about overusing groundwater, the technical report and analyses helped support the statutory revisions described below. The result is a holistic, systems approach to water resources management that recognizes the groundwater to surface water connections.

Additionally, amidst the second consecutive year of drought in Minnesota, it was becoming clear there were some egregious and repeated violations of water appropriation regulations in the state. The DNR proposed more effective regulatory tools to enforce statutes and revised the Administrative Penalty Order Plan to ensure water users comply with water appropriation laws.

The DNR also proposed increasing the water use permit processing fees for peak water use by municipal water suppliers during the summer months. This was one way to signal the importance of conservation associated with the stresses of high-water use demands in the summer. The additional revenue generated by fees helps support the DNR's water resource programs, provide ongoing and improved technical assistance, and ensure timely permitting and review processes for water permit applications.

The statutory changes signed into law in 2023 are listed below:

### Minnesota Statute 103G.005: Definitions

Subdivision 9 b/c. Ecosystem harm. "Ecosystem harm" means to change the biological community and ecology in a manner that results in loss of ecological structure or function.

Subdivision 13a/b. Negative impact to surface waters. "Negative impact to surface waters" means a change in hydrology sufficient to cause aquatic ecosystem harm or alter riparian uses long-term.

Subdivision 15h/i. Sustainable diversion limit. "Sustainable diversion limit" means a maximum amount of water that can be removed directly or indirectly from a surface water body in a defined geographic area on monthly or annual basis without causing a negative impact to the surface water body.

### Minnesota Statute 103G.287: Groundwater Appropriations

Subdivision 2. Relationship to surface water resources**.** Groundwater appropriations ~~that will have negative impacts to surface waters are subject to applicable provisions in section 103G.285~~ may be authorized only if they avoid known negative impacts to surface waters. If the commissioner determines that groundwater appropriations are having a negative impact to surface waters, the commissioner may use a sustainable diversion limit or other relevant method, tools, or information to implement measures so that groundwater appropriations do not negatively impact the surface waters.

Subdivision 3. Protecting groundwater supplies**.** The commissioner may establish water appropriation limits to protect groundwater resources. When establishing water appropriation limits to protect groundwater resources, the commissioner must consider the sustainability of the groundwater resource, including the current and projected water levels, cumulative withdrawal rates from the resource on a monthly or annual basis, water quality, whether the use protects ecosystems, and the ability of future generations to meet their own needs. The commissioner may consult with the commissioners of health, agriculture, and the Pollution Control Agency and other state entities when determining the impacts on water quality and quantity.

### Minnesota Statute 103G.299: Administrative Penalties

Subdivision 1. Authority to issue administrative penalty orders a) As provided in paragraph (b), the commissioner may issue an order requiring violations to be corrected and administratively assessing monetary penalties for violations of sections 103G.271 and 103G.275, and any rules adopted under those sections.(b) An order under this section may be issued to a person for water appropriation activities without a required permit or for violating the terms of a required permit.(c) The order must be issued as provided in this section and in accordance with the plan prepared under subdivision 12.

Subdivision 2. Amount of penalty; considerations (a) The commissioner may issue orders assessing administrative penalties ~~based on potential for harm and deviation from compliance. For a violation that presents:~~ up to $40,000.

~~(1) a minor potential for harm and deviation from compliance, the penalty will be no more than $1,000;~~
~~(2) a moderate potential for harm and deviation from compliance, the penalty will be no more than $10,000; and~~
~~(3) a severe potential for harm and deviation from compliance, the penalty will be no more than $20,000.~~

Subdivision 5. Penalty Subd. 5. **Penalty.** (a) Except as provided in paragraph (b), if the commissioner determines that the violation has been corrected or appropriate steps have been taken to correct the action, the penalty must be forgiven. (b) For repeated or serious violations, the commissioner may issue an order with a penalty that is not forgiven after the corrective action is taken. The penalty is due ~~by~~ 31 days after the order ~~was~~ is received, unless review of the order under subdivision 6 or 7 ~~has been~~ is sought. (c) Interest at the rate established in section 549.09 begins to accrue on penalties under this subdivision on the 31st day after the order with the penalty ~~was~~ is received.

### Minnesota Statute 103G.271: Appropriation of Waters

(b) The commissioner ~~is authorized to~~ must revise the map of public waters established under Laws 1979, chapter 199, to reclassify those types 3, 4, and 5 wetlands previously identified as public waters wetlands under Laws 1979, chapter 199, as public waters or as wetlands under section 103G.005, subdivision 19. (f) $1,000,000 is appropriated from the general fund each year in fiscal years 2025 through 2032 to the commissioner to update the public water inventory as required in this section. The commissioner must develop and implement a process to update the public water inventory. This paragraph expires June 30, 2032.

## 2024

Public waters are defined in statute and include lakes, wetlands and watercourses of certain sizes and characteristics. The original Public Waters Inventory (PWI) was compiled in the 1980s. This tool is valuable in identifying public waters in Minnesota, but it does not determine whether a waterbody is a public water. A waterbody is a public water if it meets the statutory definition of public waters.

A drainage authority project on Limbo Creek in Renville County, Minnesota initiated a dispute about whether a waterbody needed to be on the PWI to be a public water. An environmental advocacy group petitioned for an Environmental Assessment Worksheet (EAW), arguing the project could have significant environmental effects on the creek. The EAW petition was denied by Renville County, stating that a portion of the creek was not a public water because it was not listed in the inventory. This was appealed and led to a Minnesota Supreme Court ruling that Limbo Creek is indeed a public water despite its omission from the PWI, and the proposed project required an EAW. However, the court ruling did not address the larger question of whether a waterbody needed to be on the PWI to be a public water. The court said that was an issue the Minnesota Legislature needed to clarify.

A 2024 statute revision clarified that public waters are not determined by their inclusion in or exclusion from the PWI. However, because the PWI is such an important tool, the legislature appropriated $1,000,000 from the general fund each year in fiscal years 2025 through 2032 and directed the DNR to update the PWI over the next eight years. The PWI update will provide better water resource protection and a shared understanding for landowners, local governments and the public at large.

The statutory changes signed into law in 2024 are listed below:

### Minnesota Statute 103G.201: Public Waters Inventory

(b) The commissioner is authorized to must revise the map of public waters established under Laws 1979, chapter 199, to reclassify those types 3, 4, and 5 wetlands previously identified as public waters wetlands under Laws 1979, chapter 199, as public waters or as wetlands under section 103G.005, subdivision 19. (f) $1,000,000 is appropriated from the general fund each year in fiscal years 2025 through 2032 to the commissioner to update the public water inventory as required in this section. The commissioner must develop and implement a process to update the public water inventory. This paragraph expires June 30, 2032.

## 2025

Minnesota had just emerged from four consecutive years of drought in various parts of the state and was preparing for the possibility of the fifth. The DNR was closely monitoring water use and potential conflicts during this time. Simultaneously, large water users, such as dairies, sustainable aviation fuel production centers and data centers were proposed or expanding across the state. Smaller-scale data centers have been in Minnesota for many years. However, with the demands for cloud storage and artificial intelligence, nearly a dozen large-scale data centers have been proposed near the Twin Cities metropolitan and surrounding areas. Data centers demand large amounts of energy and water. This has created controversy in some Minnesota communities. Early coordination is key to managing the effects of data centers on Minnesota's communities and environment.

As Minnesota's economy grows, so does water demand. Demand for groundwater is high in western Minnesota, where the groundwater supply is limited. Not all projects will be able to access the amount of groundwater they want, and water use conflicts are emerging in places where the groundwater supply is inadequate to meet all the proposed needs. As climate extremes lead to unprecedented rates of intensive groundwater use, we are seeing high rates of well interference. In some places, such as the east Twin Cities metropolitan area or Bemidji, groundwater contamination is severely restricting how groundwater can be used. These problems collectively require more analysis and are more complex and time-consuming to permit, which has created an application backlog.

A proposed fee increase was approved to support the changing demands in the DNR's services for permit application review and analysis across the state, including:

- Technical review and analyses of new applications and existing permits.
- Reducing the backlog in technical review and analysis for more complex project proposals.
- Supporting DNR compliance efforts in areas with limited water availability and increasing demands for water resources.
- Improved understanding of aquifers across the state.

The statutory changes signed into law in 2025 are listed below:

### Minnesota Statute 103G.265: Water Supply Management

Subdivision 5. Preapplication evaluation of certain water appropriation projects. (a) This subdivision applies to a data center, as defined in section 216B.02, subdivision 11, whose proposed consumptive use exceeds 100,000,000 gallons per year and which requires a permit amendment or a new individual permit. (b) In response to a contact from a data center regarding a project that is likely to be subject to this subdivision, the department may request preapplication information from the data center that is helpful in assisting the department to assess the factors affecting the ability of a water source to meet a project's water use needs at a proposed location.

### Minnesota Statute 103G.271: Appropriation and Use of Waters

Subdivision 5b. Large water appropriation projects; permit conditions.

(a) In issuing new or modified water use permits to applicants that meet the definition of a data center, as defined in section 216B.02, subdivision 11, whose proposed new or additional consumptive use exceeds 100,000,000 gallons per year, or for existing permits where the permittee intends to provide more than 100,000,000 gallons of water per year to a data center, the department shall ensure that:

(1) public health, safety, and welfare are adequately protected;
(2) technologies or measures that promote water conservation, the efficient use of water, and watershed health, are reasonably considered, including but not limited to using water efficient fixtures and practices, recycling water before discharging, partnering with local water utilities to use discharged water from the data center, using reclaimed water, installing closed-loop systems, and supporting water restoration and replenishment in local watersheds; and
(3) water use conflicts are addressed as prescribed in Minnesota Rules, part 6115.0740.

(b) The commissioner shall require an applicant to conduct an aquifer test as provided under section 103G.287, if the commissioner determines that the test results are necessary in order to ensure compliance with paragraph (a), clause (1).

## Minnesota Statute 103G.271: Appropriation and Use of Waters

Subdivision 6. Water-use permit processing fees (a) Except as described in paragraphs (b) to (g), a water-use permit processing fee must be prescribed by the commissioner in accordance with the schedule of fees in this subdivision for each water-use permit in force at any time during the year. Fees collected under this paragraph are credited to the water management account in the natural resources fund. The schedule is as follows, with the stated fee in each clause applied to the total amount appropriated:

(1) $~~140~~ $200 for amounts not exceeding 50,000,000 gallons per year;
(2) ~~$3.50~~ $6 per 1,000,000 gallons for amounts greater than 50,000,000 gallons but less than 100,000,000 gallons per year;
(3) ~~$4~~ $7 per 1,000,000 gallons for amounts greater than 100,000,000 gallons but less than 150,000,000 gallons per year;
(4) ~~$4.50~~ $8 per 1,000,000 gallons for amounts greater than 150,000,000 gallons but less than 200,000,000 gallons per year;
(5) ~~$5~~ $9 per 1,000,000 gallons for amounts greater than 200,000,000 gallons but less than 250,000,000 gallons per year;
(6) ~~$5.50~~ $10 per 1,000,000 gallons for amounts greater than 250,000,000 gallons but less than 300,000,000 gallons per year;
(7) ~~$6~~ $11 per 1,000,000 gallons for amounts greater than 300,000,000 gallons but less than 350,000,000 gallons per year;
(8) ~~$6.50~~ $12 per 1,000,000 gallons for amounts greater than 350,000,000 gallons but less than 400,000,000 gallons per year;
(9) ~~$7~~ $13 per 1,000,000 gallons for amounts greater than 400,000,000 gallons but less than 450,000,000 gallons per year;
(10) ~~$7.50~~ $14 per 1,000,000 gallons for amounts greater than 450,000,000 gallons but less than 500,000,000 gallons per year; and
(11) ~~$8~~ $15 per 1,000,000 gallons for amounts greater than 500,000,000 gallons per year.

(b) For once-through cooling systems, a water-use processing fee must be prescribed by the commissioner in accordance with the following schedule of fees for each water-use permit in force at any time during the year:
(1) for nonprofit corporations and school districts, $200 per 1,000,000 gallons; and
(2) for all other users, $420 per 1,000,000 gallons.

(c) The fee is payable based on the amount of water appropriated during the year and~~, except as provided in paragraph (f),~~ the minimum fee is $100.
(d) For water-use processing fees other than once-through cooling systems:
(1) the fee for a city of the first class may not exceed ~~$250,000~~ $325,000 per year;
(2) the fee for other entities for any permitted use may not exceed:
(i) $~~60,000~~ $75,000 per year for an entity holding three or fewer permits;
(ii) ~~$90,000~~ $125,000 per year for an entity holding four or five permits; or
(iii) ~~$300,000~~ $400,000 per year for an entity holding more than five permits;
(3) the fee for agricultural irrigation may not exceed ~~$750~~ $1,500 per year;

(h) A surcharge of $50 per million gallons in addition to the fee prescribed in paragraph (a) shall be is applied to the volume of water used in each of the months of May, June, July, August, and September that exceeds the volume of water used in January for municipal water use, irrigation of golf courses, and landscape irrigation. The surcharge for municipalities with more than one permit shall be is determined based on the total appropriations from all permits that supply a common distribution system.

## Minnesota Statute 103G.301: General Permit; Application Procedures

Subdivision 2: Permit application and notification fees (c) The fee to apply for a permit to appropriate water, in addition to any fee under 142.6 paragraph (b), is ~~$150~~ $600. The application fee for a permit to construct or repair a dam 142.7 that is subject to a dam safety inspection, to work in public waters, or to divert waters for 142.8 mining must be at least $1,200, but not more than $12,000. The fee for a notification to 142.9 request authorization to conduct a project under a general permit is $400, except that the 142.10 fee for a notification to request authorization to appropriate water under a general permit 142.11 is $100.

# Conclusion

Minnesota's climate is changing outside of the range of normal variations, and that change is evident on our landscape. Despite the increased precipitation and long-term wetter trends, the state is experiencing multiple intense drought events alongside historical flooding events. In combination, these conditions are creating a highly dynamic and variable landscape in this predominantly wet period. In response, streamflow is increasing, floods are bigger, some lake levels are higher and some wetlands are wetter. We also have more wetlands now than a decade ago — likely due to state and federal programs that protect and restore them. Groundwater levels are generally stable, but there are areas where groundwater levels are falling, resources are overallocated and the groundwater supply is limited. Groundwater use has increased by one-third, largely due to irrigation needs during periods of drought, and the state experienced a record number of well interferences between 2021 and 2023. Water suppliers and the energy sector have improved water use efficiency and conservation over the past decade and, consequently, Minnesota's total water use has declined, even as our population has grown.

While some of this is unpredictable and out of Minnesotans' control, below are recommendations from DNR water experts to help communities adapt and remain resilient, considering the observed trends:

- Despite the wet regime the state is currently experiencing, Minnesotans should expect and plan for drought.
- Improve water conservation and water use efficiencies wherever possible.
- Expect natural lake level fluctuations and plan for water level increases, despite potential swings in lake levels within a season.
- Engage with your community and with surrounding communities to advance sustainable water resources management.

The DNR is committed to working with other regulators and water users to enhance resiliency and sustainability in Minnesota in the face of these trends and anticipated future changes.

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# Appendix A

## The DNR's role in supporting water use

The Water Availability and Assessment Report has provided data and information on water in relation to our economy, communities, landscapes, atmosphere and geology. This appendix outlines how the DNR continues to support the development of sustainable water use by individuals, businesses and communities.

### *Implementation of Minnesota's water laws*

DNR efforts are mandated under a variety of statutes. Here are highlights of some of the most important statutes and rules that govern DNR work around water availability, as well as how the DNR has applied those statutes to programs:

**Minnesota Statute 103A.201: Regulatory Policy**

- To conserve and use water resources of the state in the best interests of its people, and to promote the public health, safety, and welfare, it is the policy of the state to regulate Minnesota's public waters, subject to existing rights, and control the appropriation and use of waters of the state.

**Minnesota Statute 103A.43: Water Assessments and Reports**

- The DNR shall provide an assessment and analysis of the quantity of surface and groundwater and the availability of water to meet the state's needs.

**Minnesota Statute 103G.101: Water Conservation Program**

- The commissioner shall develop a water resources conservation program for the state.
- The program must include conservation, allocation, and development of waters of the state for the best interests of the people.
- The commissioner must be guided by the program in issuing permits for the use and appropriation of the waters of the state.

**Minnesota Statute 103G.255: Allocating and Controlling Waters of the State**

- Directs the commissioner to administer the use, allocation, and control of waters of the state; establish, maintain, and control lake levels and water storage reservoirs; and determine ordinary high-water level of waters of the state.

**Minnesota Statute 103G.261: Water Allocation Priorities**

- Directs the commissioner to adopt rules for allocation of water based on six priorities for the consumptive appropriation and use of water. Outlines where and when use of surface water should be encouraged or discouraged.

**Minnesota Statute 103G.265: Water Supply Management**

- Requires the DNR to manage water resources to assure an adequate supply to meet long-range seasonal requirements for domestic, municipal, industrial, agricultural, fish and wildlife, recreational, power, navigation, and quality control purposes. This law also requires DNR approval for large volume water diversions to places out of state and diversion from the Great Lakes.

**Minnesota Statute 103G.271: Surface Water Appropriations**

- Limits appropriations from the Mt. Simon–Hinckley aquifer to potable water use, unless there are no feasible or practical alternatives, and a water conservation plan is incorporated.
- Bulk transport or sale describes limitations on shipping or distributing bulk water to a location more than 50 miles from the point of appropriation. Public water suppliers, rural water suppliers, or tribal nations may distribute water up to 100 miles from the point of the appropriation.

**Minnesota Statute 103G.285: Surface Water Appropriations**

- Limits appropriation from watercourses during periods of low flow, requires protective elevations for lakes, restricts use of trout streams, and requires contingency plans.

**Minnesota Statute 103G.287: Groundwater Appropriations**

- Identifies information needed an evaluation to be done for groundwater appropriation permits and allows for the designation of groundwater management areas. Also describes sustainability criteria: The commissioner may issue water-use permits for appropriation from groundwater only if the commissioner determines that the groundwater use is sustainable to supply the needs of future generations and the proposed use will not harm ecosystems, degrade water, or reduce water levels beyond the reach of public water supply and private domestic wells.

**Minnesota Statute 103G.291: Public Water Supply Plans; Appropriations During Deficiency**

- Every public water supplier serving more than 1,000 people must submit a water supply plan to the commissioner that must address projected demands, adequacy of the water supply system and planned improvements, existing and future water sources, natural resource impacts or limitations, emergency preparedness, water conservation, supply and demand reduction measures, and allocation priorities. Plans must be updated every 10 years.

**Minnesota Statute 103G.299: Administrative Penalties**

- This section describes the penalties that could be applied to a landowner that appropriates water without a permit or violates the terms and conditions of an existing permit. The maximum penalty amount was increased to $40,000 following language changes during the 2023 legislative session. Additional revisions related to these changes in 103G.299 include 103G.134 (Orders and Investigations).

**Minnesota Rule: Chapter 6115, Public Water Resources and Water Appropriation and Use**

- These rules exist to provide for the orderly and consistent review of permit applications in order to conserve and utilize the water resources of the state in the best interest of its people.
- These rules set forth minimum standards and criteria pertaining to the regulation, conservation, and allocation of the water resources of the state, including the review, issuance, and denial of public water work permit applications and water appropriation applications and the modification, suspension, or termination of existing permits.

## *Water appropriation permitting*

The DNR is required to administer a permit system to manage the use of groundwater and surface water throughout the state, and to conserve these same waters for everyone to enjoy. In times of shortage, this may include restricting permitted water use, consistent with legislatively established priorities. A water appropriation (use) permit is required for anyone who uses more than 10,000 gallons of water per day or 1 million gallons of water per year. The number of water use permits for irrigation of agricultural crops represents 63% of all permits issued. Today, the DNR manages more than 10,000 water use permits throughout the state. All water users must submit annual reports of their monthly water use to the DNR. These reports assist the DNR in managing the resource, especially during times of drought.

The DNR has established three groundwater management areas (GWMAs) in locations with heavy use, to ensure that groundwater resources remain sustainable: the North and East Metro GWMA in 2015, the Bonanza Valley GWMA in 2016 and the Straight River GWMA in 2017. The DNR followed guidance contained in Minnesota Statute (Minn. Stat.) 103G.287 in creating these GWMAs. DNR staff, in collaboration with local stakeholders in those areas, have developed implementation plans to improve the management of groundwater for all users and for the natural resources and fish and wildlife habitat that depend on that same water.

Over the past several years, drought conditions have stressed aquifers and surface waters, and in some situations have limited the availability of water for domestic well owners. Minn. Stat. 103G.261 outlines the allocation priorities in the state, and domestic supplies are listed as the highest priority in times of shortages. Additionally, the DNR is required to curtail surface water appropriation when flows and levels are below established minimum thresholds. Minn. Stat. 103G.285, subd. 2, describes how the DNR may limit appropriation from watercourses during low flows. From 2021 through 2024, the DNR suspended 454 surface water appropriation permits to protect other water users, instream flows and downstream supplies. Most of those permits were suspended in 2021 and 2023, as those years experienced extensive, long-duration drought conditions during the growing seasons.

## *Water permitting and reporting system*

The DNR uses the online MNDNR Permitting and Reporting System (MPARS) to manage a variety of water permits. This system allows the public to apply for six DNR permit types (water appropriation, public waters work, dam safety, water aeration, aquatic plant management, and invasive aquatic plant management) online, as well as request changes to existing permits, pay permit-related fees, report water use and communicate with DNR staff. DNR staff use the system to record the decision-making process and issue water appropriation permits. More than 10,000 customers, DNR water regulations staff and interagency partners statewide use this system. Using MPARS, the DNR processes an average of 1,100 water appropriation permits annually and receives 10,700 water use reports. This system helps streamline much of the administrative work that comes with water regulatory programs, allowing DNR employees to devote more time to assisting applicants, gathering the information needed to inform decisions, and related work.

## *The protection of surface waters*

The DNR protects public waters, which include most lakes and many wetlands and watercourses, under the statutory authority of Minn. Stat. 103G.245. Alterations to public waters, such as fill placement, excavation, water level controls, restoration, culvert and structure placement, and mining, are regulated through the DNR public waters permitting program. Regulating activities on other public waters, such as wetlands and watercourses upstream of lakes in the watershed, has profound positive impacts on the lakes downstream. Activities that are categorically harmful or unreasonable are prohibited, while most other activities are conditionally allowed to some degree. This program seeks to balance the protection and use of the water resource.

### *Shoreland protection*

With Minnesota experiencing more intense precipitation and warming waters, risks are increasing for greater shoreline erosion and accelerated algae growth. The risks increase for lakes with reduced naturally vegetated shorelines. Natural vegetation stabilizes shorelines, reducing sediment-laden nutrients from entering surface waters, and it also filters out nutrients washing off of lawns before they enter the water. Nutrients are food for algae, and algae grow faster as the waters warm. In response to eroding shorelines, many property owners are installing excessive riprap. These actions can have negative impacts, including displacing natural vegetation that is important for fish and wildlife habitat and nutrient uptake. The DNR administers the state shoreland program in cooperation with local governments that implement the state shoreland rules through local zoning. The DNR provides technical support and training services to local governments to help staff, planning commissions and boards of adjustments make decisions consistent with the state's shoreland laws.

## Engagement with water users

Active engagement with water suppliers and users supports practical planning and conservation efforts. Highlights of our engagement in these areas are listed below.

### *Water supply planning*

Planning for future water use helps avoid surprises for suppliers, customers and other appropriators. Minn. Stat. 103G.291 requires all water suppliers serving more than 1,000 people and all communities within the seven-county metropolitan area with a municipal water supply system to submit a water supply plan to the DNR for approval every 10 years. These plans address topics including water demand projections, the adequacy of their existing and planned water supply systems and water sources, water conservation, and demand reduction measures.

The DNR is about to launch the latest generation of water supply planning, working with the Metropolitan Council to support suppliers within the seven-county metropolitan area and directly with water suppliers across the rest of the state ahead of plan submission to help flag concerns with water availability, potential impacts to natural resources, and opportunities for conservation. A major aspect of water supply planning in this cycle will focus on the need to factor water conservation into the strategy to meet demand, rather than as a separate commitment. The DNR is preparing resources to provide suppliers ahead of conversations to reduce the burden on suppliers and ensure they have the best information to make these decisions.

Recent droughts and associated increases in water use have highlighted the importance of water supply planning in preparing contingencies and preventing domestic well interferences. As the DNR improves the connection between water supply planning and future permit amendment requests, communication with suppliers will be key to developing successful processes.

Local water utilities and communities are becoming leaders in water conservation strategies, to ensure protection of their own local and regional supplies. We can expect additional water conservation efforts and innovations in the future, including expanded use of smart meters and associated behavior change reductions, such as those in the electrical utility field.

### *Water conservation*

Water conservation actions.

**Reduce**

- Withdrawals from any water supply sources
- Consumptive water uses
- The loss or waste of water

**Increase**

- The efficiency of water use
- Recycling and reuse of water

The DNR integrates water conservation into all aspects of water regulations and permitting through Minn. Stat. 103G.101, including statewide water conservation education and outreach.

Since 2017, Minnesota has used the Minnesota Water Conservation Reporting System via ESP Water, a software platform that allows water users to track their water losses and conservation efforts. The Minnesota Water Conservation Reporting System provides municipal water suppliers with a way to compare their water losses and conservation work with other suppliers and from year to year. The DNR continues working with suppliers to improve data collection and the value that the reporting provides. Additionally, the DNR can get a high-level view across the state of where there are challenges or opportunities in water conservation activities and use this information to improve recommendations and policies.

## Water resources science in decision-making

The following sections describe the DNR efforts that contribute to a better understanding of water availability in Minnesota through collecting, analyzing and applying water resource data to our decisions, and making those data available for others to use.

### *Climatology*

The State Climatology Office (SCO) is part of the DNR. The SCO collects, maintains, analyzes and shares climate information for the benefit of the state's citizens, communities, organizations and units of government at all scales. With an extensive website, many custom tools and through partnerships with local, state and federal entities, the SCO provides public access to an array of raw, summarized, mapped and narrative climate data and information. DNR climatologists give around 80 presentations and more than 100 media interviews annually, lending expertise on floods, drought, the changing climate and recent weather extremes to reports, project teams and other work groups.

Minnesota has more volunteer precipitation observers than any other state. The SCO has worked with local soil and water conservation districts to manage a single network for more than 50 years, with more than 1,000 daily observers. From 2020 through 2024, the DNR partnered with the National Weather Service to recruit three times more new precipitation observers into the nationwide Community Collaborative Rain, Hail and Snow Network, referred to as CoCoRaHS, than any other state, accounting for 25% of all new volunteer observers recruited nationally.

Minnesota's large population of volunteer rain and snow observers gives DNR climatologists unmatched capabilities to analyze the state's often extreme hydroclimate and produce data products, including weekly maps of precipitation and snow depth, that are not possible elsewhere.

In addition to maintaining and expanding volunteer precipitation observer networks, from 2020 to 2024, the DNR also upgraded each of its 40 real-time weather monitoring stations. Additionally, DNR climatologists advised the development and expansion of an agricultural weather network overseen by the Minnesota Department of Agriculture (MDA), and a local high-density mesonet, a network of automated weather and environmental stations operated by Hennepin County Emergency Management.

Outside the SCO, the DNR also has experts in climate impacts, resilience and mitigation in every division, and has an internal climate team that provides guidance, coordination and leadership for climate strategies across the agency. The DNR also advises and collaborates with the University of Minnesota's Climate Adaptation Partnership, which became a critically important provider of climate preparedness resources for Minnesota's agencies and communities between 2020 and 2024.

### *Water resource data collection*

The DNR collects hydrologic data across the state, to facilitate resource management decisions related to our statutory responsibilities. These data are collected from a variety of networks and include data on lake and wetland levels, stream flow, groundwater levels, precipitation and climate. The DNR relies heavily on partners and volunteers in our data collection efforts. Soil and water conservation districts are contracted to measure groundwater levels at observation wells and record precipitation data for our volunteer precipitation observation program. MNgage is a volunteer-driven program that monitors daily precipitation. It began in the 1960s and has had about 1,500 volunteers for the past four decades. Similarly, the Lake Level Minnesota program includes around 1,000 volunteers and cooperative organizations, such as lake associations, that take readings throughout the summer at DNR-surveyed gages.

The DNR continues to improve our hydrologic monitoring networks, database and website. We updated our cooperative stream flow and groundwater webpages to provide users with better access to more types of data. We built and currently maintain a new network of 40 climate stations to supply data to agricultural producers, inform irrigation schedules and grow coverage of climate data. The long-term wetland monitoring network continues to expand to new sites across the state. These sites record water levels at 62 reference-quality wetlands, to inform scientists on the eco-hydraulic requirements of different wetland types in Minnesota. Stream flow monitoring continues in partnership with the Minnesota Pollution Control Agency (MPCA), the MDA, local governments and contractors. The DNR drilled and established more than 400 new groundwater observation wells between 2015 and 2024 and installed data loggers in more than 800 of our active observation wells across the state.

As resources allow, the DNR will continue to maintain and improve its hydrologic monitoring networks, databases and webpages. We launched a project with Minnesota IT Services, or MNIT, to enhance our web products through improved data access and new analytical tools to help interpret and explain the data to our users. We also installed cellular technology in several of our well nests and stream gages for more current and timely data delivery. Goals were set to expand the observation well and wetland networks, and staff publish annual records for many of these sites.

### *Stream ecological thresholds*

The DNR has been collecting data on fish habitat associations from numerous streams across Minnesota since 1987, used in conjunction with models of stream hydraulics and discharge. The information helps establish the relationship between stream flow and ecological function and is fundamental to understanding the potential impact of cumulative water appropriations on the natural stream environment and ecology, which is key to sustainable water resource management.

The flow regime is the key driver of aquatic ecosystems, and its alteration, typically by increasing the variability or decreasing flows, can have negative impacts. Even during periods of normal precipitation, concentrated water use can lead to significant streamflow depletion and ecological harm. In April 2024, the Minnesota Department of Natural Resources issued a Commissioner's Order to protect the ecology of Little Rock Creek. For context, during the Little Rock Creek study period from 2006 to 2018, Augusts were predominantly wet but variable, and from the early 1990s on, the total reported water use steadily increased. The Commissioner's Order was the culmination of a Benton County stressor identification report and a Little Rock Creek watershed total maximum daily load report, followed by modeling of streamflow depletion related to groundwater use and an assessment of ecological impacts related to streamflow depletion. The Commissioner's Order describes that authorized water use in the Little Rock Creek is negatively impacting the Little Rock Creek stream ecosystem in violation of the sustainability standard and other provisions of Minn. Stat. 103G.287. The Commissioner's Order establishes the sustainable diversion limit at 15% of the August median base flow, to prevent negative impacts.

A similar process is underway on the North Branch of the Pipestone Creek (NBPC) in Pipestone County. NBPC is a warm water stream connected to the surficial aquifer and under the scope of Minn. Stat. 103G.287. Where Little Rock Creek was dominated by agricultural irrigation, water use near the NBPC includes agricultural and water supply. Similar tools will be used to assess streamflow depletion resulting from groundwater pumping, and an instream flow incremental methodology study will help assess the degree of habitat alteration, and consequently, whether the habitat change rises to the level of ecosystem harm.

### *Wetland science program*

The DNR wetland programs provide important information to help understand wetlands and their role in Minnesota's water protection and management efforts. Wetland science programs include maintaining a statewide wetland inventory, ongoing operation of a wetland status and trends program to track gains and losses, and a wetland hydrology monitoring program. This information is used to inform decisions about wetland policy and guide wetland protection and restoration efforts.

### *Watershed health assessment framework*

With ongoing support from the Clean Water Fund, the DNR continues to develop and enhance the Watershed Health Assessment Framework (WHAF). The WHAF has expanded into a suite of web-based platforms for accessing data and information on watershed health and natural resource context. The WHAF Explorer includes health scores and data related to each of the five components used to define the framework (hydrology, geomorphology, water quality, connectivity and biology). The WHAF has a wide range of scores and data, including information on water availability, wetland loss, stream alterations and groundwater, delivered in a dynamic map designed for exploring spatial scales.

Other WHAF applications include WHAF Lakes, which delivers health scores and related data for 3,000 scored lakes, and WHAF Land Cover, which summarizes land cover, crop cover, and water use data for user-selected boundaries. These applications also deliver many other data sets and variables for any user-selected location of interest in Minnesota.

In this way, users can note patterns and relationships between ecological context, health conditions, and the system's response. The WHAF is intended to provide information and guidance for natural resource managers, but is also used by other natural resource professionals, teachers, landowners and city planners.

**WHAF highlights from 2020 to 2025**

- Launched the WHAF Lakes interactive web application, to provide lake health scores for 3,000 Minnesota lakes. Using multiple ecological metrics and components, the scores help resource managers, local governments and the public better understand a range of health conditions impacting overall lake health.
- Updated the annual and seasonal 30-year climate normals with recent data for 1991 to 2020. The climate departures were recalculated to compare more recent climate data to the entire climate record. These new data layers are available online in the WHAF Explorer and for download.
- Provided annual updates on the status of impaired waters, in collaboration with the MPCA, and expanded the suite of impairment data layers available in the WHAF Explorer. Impairment changes are also incorporated annually in the stream protection priorities data layer used by our Clean Water partners for planning.

**Future WHAF enhancement efforts**

- Continue expansion of groundwater restoration and protection strategies-related data, in collaboration with the Minnesota Department of Health, and provide guidance for applying these data to decision-making for informed land management and groundwater protection.
- Create an updated climate health score that will better represent changing temperature and precipitation patterns, to help inform the potential impact on a range of watershed processes.
- Track watershed and lake health, to expand our reporting of trends over time.

## *Groundwater modeling*

The relationship between groundwater and surface water bodies, and the impacts of groundwater uses on aquifers and connected water bodies, are often complex. Groundwater-flow models can be used to assess the cumulative impacts of groundwater uses on aquifer levels, and water levels and flows in surface-water bodies. Complex computer models are data-intensive and time-consuming to build. The DNR develops and applies flow models for areas of intensive groundwater use, where negative impacts are a concern and sufficient data are available.

Since 2020, the DNR has expanded the use of groundwater-flow models to examine the sustainability of groundwater use and inform water-supply planning and appropriations management in several parts of the state. DNR staff are using groundwater models to evaluate the impacts of existing and proposed groundwater uses and proposed mitigation plans on water levels in White Bear Lake (North and East Metro Groundwater Management Area) and on streamflow in Cold Spring Creek (Stearns County), Little Rock Creek (Benton and Morrison counties) and the NBPC (Pipestone County).

Finally, DNR groundwater modelers continue to work closely with managers at the City of Rochester and the City of Moorhead, who use groundwater-flow models to guide efforts in sustainably expanding their water supply systems.

## *Groundwater atlas mapping*

Since 1995, the DNR and the Minnesota Geological Survey (MGS) have produced the County Geologic Atlas series. Each Part A atlas, completed by the MGS, describes a county's geologic and mineral resources, and the Part B, produced by the DNR, covers its groundwater resources.

The atlases describe the properties and distribution of sediment and rocks in the subsurface and characteristics of aquifers, such as sensitivity to pollution. Currently, atlases are complete for the central portion of the state, the southeast and most metropolitan area counties, and 12 other counties are in progress. The DNR makes all Part B atlas materials available as PDFs and as Geographic Information System, or GIS, files through our Groundwater Atlas Program webpage.

Geologic atlases are critical tools for a broad range of resource issues. They provide comprehensive information for planners, managers, scientists, researchers and other individuals statewide for a wide variety of projects, such as water supply planning, land use decisions, resource development, resource protection, transportation planning, agricultural water supplies, groundwater research and studies, and environmental impact statements.

The DNR Groundwater Atlas program also maintains three databases critical to understanding groundwater issues in southeastern Minnesota: the Minnesota Spring Inventory, the Minnesota Groundwater Dye Tracing Database and the Karst Features Inventory. Additionally, Groundwater Atlas staff routinely work with colleagues from other state agencies to address important groundwater issues.