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RESEARCH BRIEF

Clean Wisconsin Environmental Health Initiative

Nitrates & Health: Drinking Water in Wisconsin

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SUMMARY – Nitrates are Wisconsin's most widespread groundwater contaminant, threatening the drinking water of over two-thirds of Wisconsinites who rely on groundwater as their primary source of drinking water. This includes all private wells and any public water system not getting its water from the Great Lakes or Lake Winnebago. Broadly, the primary source of nitrate to groundwater is the agricultural application of nitrogen fertilizers and manure, although in some places septic systems can be an important source. Typically, less than half of the nitrogen that is applied to fields actually gets used by crops, leaving most of it to escape into the environment, including contaminating drinking water sources.

The current health-based drinking water quality standard of 10 parts per million was established decades ago to protect against Blue Baby Syndrome in infants, where nitrate ingestion interferes with the blood's ability to carry oxygen. However, there is increasing evidence that nitrate contamination of drinking water is associated with increased risk of certain cancers and adverse birth outcomes, including birth defects. Concerningly, these risks are being reported at nitrate concentrations well below the current health-based standard. This suggests that the current drinking water standard may be inadequate to protect against all types of harm from nitrate contamination of drinking water.

In this brief, we examine what nitrates are, how they get into our drinking water and the health risks associated with drinking water contaminated by nitrates. We then explore the extent of nitrate contamination of drinking water in Wisconsin.

Key Takeaways:

- There is strong evidence that consumption of drinking water contaminated by nitrate increases the risk of developing colorectal cancer, neural tube birth defects, and thyroid disease.
    - There is also some evidence suggesting an increased risk of thyroid, ovary and kidney cancers, and preterm and low birthweight births, though more research is needed to clarify nitrate's role in these outcomes.
- There is an increased risk of cancers and birth defects are seen at contamination levels of 2 to 5 parts per million (ppm), well below the current drinking water standard of 10 ppm.
- Around 5-10% of private wells in the state have nitrate levels above 10 ppm, while an additional 15-25% have elevated concentrations above 5 ppm.

  - Nitrate contamination rates are more than double in areas that are both dominated by agricultural land use and have groundwater vulnerable to contamination from surface pollutants (such as shallow aquifers, soils that let water—and any contaminant in that water—move through quickly).

- In the past decade, 11 municipal community water systems (systems serving a city, town or village) that collectively provided water to 50,000 residents experienced at least one year with nitrate concentrations above the current drinking water standard of 10 ppm. No systems have maintained a long-term average above 10 ppm.
  - An additional 29 municipal community water systems, serving a combined 140,000 residents, reported average annual nitrate concentrations above 5 ppm from 2015-2024.

- Groundwater nitrate contamination is found across Wisconsin, with higher levels in south-central, central, and west-central Wisconsin.

- Broadly, groundwater nitrate concentrations appear to be holding steady statewide, with localized examples of concentrations increasing or decreasing.

- Based on elevated drinking water nitrate exposure rates, an estimated 170 cases of cancer, 95 cases of very low birth weights, 51 cases of very preterm births, and 2 neural tube defects annually could be attributed to nitrate-contaminated drinking water in Wisconsin.
  - Nitrate-contaminated drinking water in Wisconsin is estimated to cause $44 million in direct medical costs annually, with indirect costs such as lost productivity due to sickness and premature death adding nearly $100 million more each year.

Definitions

- **Drinking water standard:** Drinking water regulatory standards developed by the United States Environmental Protection Agency to ensure public water systems deliver safe, healthy drinking water, pursuant to the Safe Drinking Water Act. These regulations do not apply to private wells.
- **Nitrate:** A chemical compound composed of nitrogen and oxygen (NO_3-). This is one of the chemical forms nitrogen naturally takes within the nitrogen cycle as it moves through the atmosphere, soil, water, and living organisms.
- **Private drinking well:** a drinking water source not part of a public water system, typically serving a single home.
- **Public water system:** a system providing water for human consumption to at least 15 connections or regularly serving an average of 25 people each day for at least 60 days each year.
  - **Community public water systems:** public water systems serving people where they live
    - **Municipal community systems:** public water systems owned by a municipality
    - **Other-than-municipal community systems:** community public water systems privately-owned and serving residences in mobile home parks, apartments, and housing subdivisions.
  - **Non-Community public water systems:** public water systems serving people at work, school or dining or entertainment establishments.
    - **Non-transient, non-community systems:** non-community public water systems serving the same people day after day (e.g., workplaces, schools, daycares)
    - **Transient non-community systems:** non-community public water systems not serving the same population consistently (e.g., bars, restaurants, motels, campgrounds, gas stations).

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Nitrates in Drinking Water

Nitrogen is an essential nutrient for plant and animal growth and is commonly used as a fertilizer for agricultural crops. Nitrogen exists in many natural and synthetic fertilizers in the form of ammonium ions (NH_4^+). Bacteria in the soil then converts ammonium into nitrate ions (NO_3^-), which plants use to grow (Samuel & Dines 2023). Through this process, nitrogen-based fertilizer is the main contributor of nitrate in the environment (Ward et al. 2018). In Wisconsin, approximately 90% of nitrate pollution comes from agricultural uses, like fertilizer and manure, although other sources like septic systems may be locally important (Shaw et al. 1994).

While valuable for crop production, not all the nitrogen applied to fields is taken up by crops. When nitrate is applied as fertilizer, manure, or in other forms, it does not bind to soil particles as other nutrients like phosphorus do. Instead, nitrate is highly mobile and will move with water down through the soil and into groundwater aquifers used for drinking water. As a result, approximately half of all applied nitrogen from fertilizer escapes the soil and ends up volatilizing into the air, running off into surface water, or leaching to groundwater (Ward et al. 2018).

This has led to an increased concentration of nitrate in drinking water, creating a serious public health concern in the state. Indeed, nitrate is Wisconsin's most widespread groundwater contaminant (Wisconsin Groundwater Coordinating Council 2025).

Health Effects of Nitrates in Drinking Water

The drinking water quality standard for nitrate of 10 ppm was developed in 1962 to protect against methemoglobinemia (also known as "Blue Baby syndrome") in infants (Ward et al. 2018), and then codified as the state and federal drinking water standard in 1991. Methemoglobinemia¬ is a condition in which excess nitrate in the body interferes with the blood's ability to carry oxygen. Fortunately, diagnosed cases of methemoglobinemia are currently rare (Fossen Johnson 2019). In Wisconsin, only eight diagnosed cases of Blue Baby Syndrome were reported between 1990 and 1999 (Knobeloch & Proctor 2001).

However, there is increasing evidence of other adverse health effects that can result from consuming nitrate contaminated drinking water (Ward et al, 2018). Concerningly, some adverse health outcomes may occur from nitrate contamination below the current drinking water standard, with studies reporting increased health risks at concentrations as low as 2 to 5 ppm (Ward et al. 2018, Temkin et al. 2019, Mendy & Thorne 2024, Chambers et al. 2022).

Ward et al. (2018) conducted the most comprehensive review of studies evaluating linkages between elevated drinking water nitrate levels and human health effects beyond Blue Baby Syndrome. This review found that among the health outcomes studied, colorectal cancer, neural tube birth defects, and thyroid disease had the strongest evidential link to consumption of elevated nitrate drinking water (Ward et al. 2018). Although less consistent, there was also evidence of connections between drinking water nitrate exposure and thyroid, ovary and kidney cancers, spontaneous abortion, and preterm and low birthweight births.

Since the 2018 Ward et al. review, several additional studies support the correlation between these increased health risks and drinking water nitrate contamination.

In one of the largest studies to date that evaluated one million births in Denmark, adverse birth outcomes were reported (Stayner et al. 2022). This study found that elevated exposure to nitrates in drinking water was related to birth defects of the eye, as well as some evidence of increased risk of other birth defects like nervous system defects and facial defects.

Similarly, several meta-analyses and reviews have also reported links between elevated drinking water nitrate levels and increased cancer risk, including colorectal and gastric cancer (Chambers et al. 2022, Picetti et al. 2022, Rowell 2023).

Additionally, a long-term study of more than 2,000 participants in the United States found that drinking water nitrate levels are associated with a higher risk of cancer mortality, even at levels below the drinking water standard (Mendy & Thorne 2024), and concluded that nitrate contamination of drinking water may be an overlooked contributor to cancer mortality in the US.

How Nitrates Cause Harm

Once ingested, nitrates can be converted into harmful N-nitroso compounds (NOCs) in the body in a process called nitrosation (Bryan & van Grinsven 2013) (Fig. 1). In turn, NOCs are known to increase cancer risk and cause birth defects through damage to the DNA (Ward et al. 2018, Chambers et al. 2022). Of NOCs evaluated to date, 90% have been found to have carcinogenic effects (Chambers et al. 2022). Indeed, the International Agency for Research on Cancer has concluded that ingesting "nitrate under conditions that result in nitrosation in the body is probably carcinogenic to humans" (IARC 2010). A key aspect of this conclusion is that the conditions for the conversion from nitrate to NOC need to be favorable.

However, there are numerous factors that control this conversion in any given individual (Bryan & van Grinsven 2013, Ward et al. 2018, Chambers et al. 2022). First, nitrate needs to be reduced into nitrite by bacteria in the mouth, stomach and intestines. The amount of nitrate-reducing bacteria in one's mouth and digestive tract varies from person to person and can be influenced by oral hygiene habits, with increased bacteria associated with poor oral hygiene (Chambers et al. 2022).

In turn, nitrite is further broken down and then reacts with other molecules present in the body—known as nitrosatable compounds—to form NOCs. Nitrosatable compounds are breakdown products of dietary intake, common in red meats and cured foods. Conversely, dietary intake of antioxidants like vitamin C inhibit the production of NOCs. Thus, diets high in red and processed meats will tend to promote NOC formation when paired with nitrate ingestion from water sources; diets high in vitamin C and other antioxidants will inhibit NOC production (Figure 1).

Although significant evidence exists that exposure to nitrate in drinking water can lead to cancers and birth defects, there is still some uncertainty about the strength of the link due to the indirect pathway for harm harm in the body and the range of potential confounding factors affecting this pathway. This is evidenced by various studies coming to different conclusions regarding the same health endpoint (Ward et al. 2018). Additional well-designed studies are needed to better understand this risk.

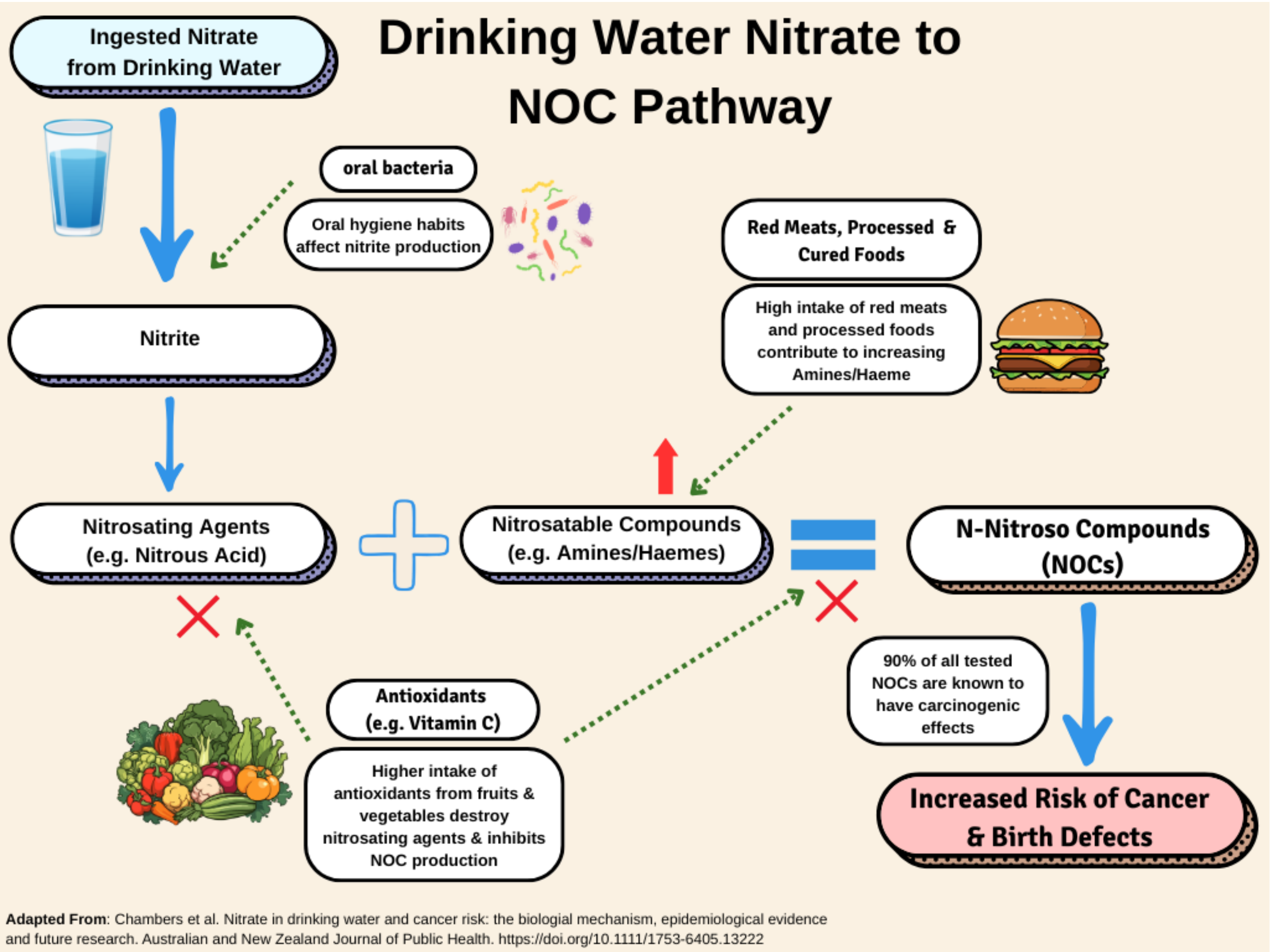


Figure 1. Summary of the drinking water nitrate to NOC Pathway. Nitrates can be converted into harmful N-nitroso compounds (NOCs) through the process known as nitrosation. Multiple factors control the conversion of nitrate to NOCs.

Extent of Drinking Water Nitrate Contamination in Wisconsin

To better understand the public health risk of consumption of high nitrate in drinking water, it is important to understand the extent of drinking water contamination across Wisconsin. By analyzing drinking water quality test results across the state, we can describe the scope and severity of nitrate contamination, as well as give insight into how this problem has changed over time. Details of the analysis methods are provided in the Appendix.

Contamination of Public Water Systems

Public drinking water systems[1] are required to test the water they are distributing to people (i.e., testing the water after any treatment or filtering) for nitrates at least once every year, providing a robust dataset of nitrate concentrations throughout the state. We analyzed nitrate tests taken between 2015 and 2024 to identify how many public systems experienced elevated nitrate levels at two thresholds: 10 ppm (the regulatory drinking water standard established to protect against Blue Baby Syndrome) and 5 ppm (indicative of elevated nitrate levels at which adverse health effects have been identified, as discussed above).

Transient non-community systems (e.g., restaurants, churches) had the highest rates of elevated nitrates, while municipal community systems had the lowest rates of elevated nitrate (Table 1, Figure 2).

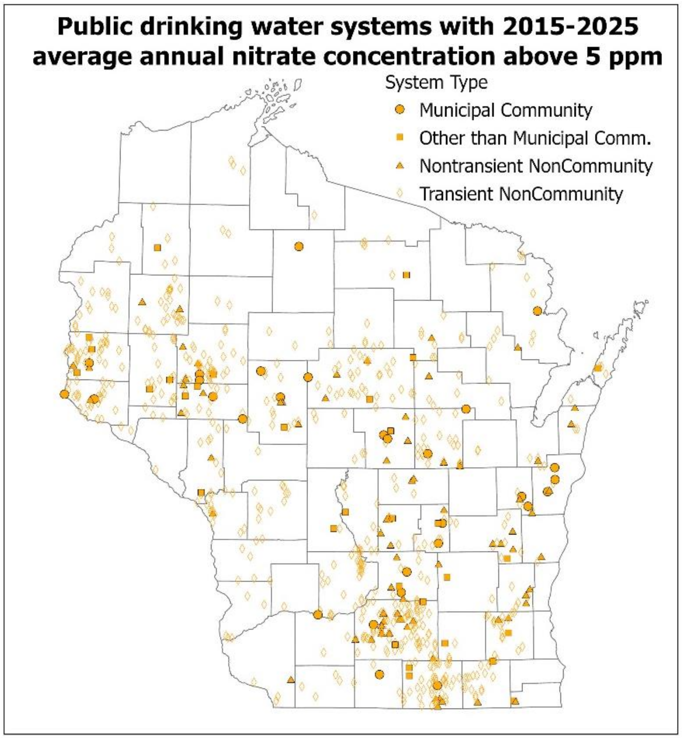
Between 2015 and 2024, the share of water systems with long-term average nitrate concentrations above 5 ppm ranged from 5% among municipal community systems to 11% among transient non-community systems, serving an estimated total of 156,000 residents across all system types. No community systems had long-term average concentrations above 10 ppm, but over one hundred non-community systems (like schools, churches, offices, restaurants, etc.) had long-term annual concentrations above 10 ppm. Wisconsin rules allowed certain non-community systems to continue to operate even with nitrate levels above the drinking water standard so long as a warning is posted and nitrate concentrations do not exceed 20 ppm (Wis. Admin. Code s. NR 809.11(3)).

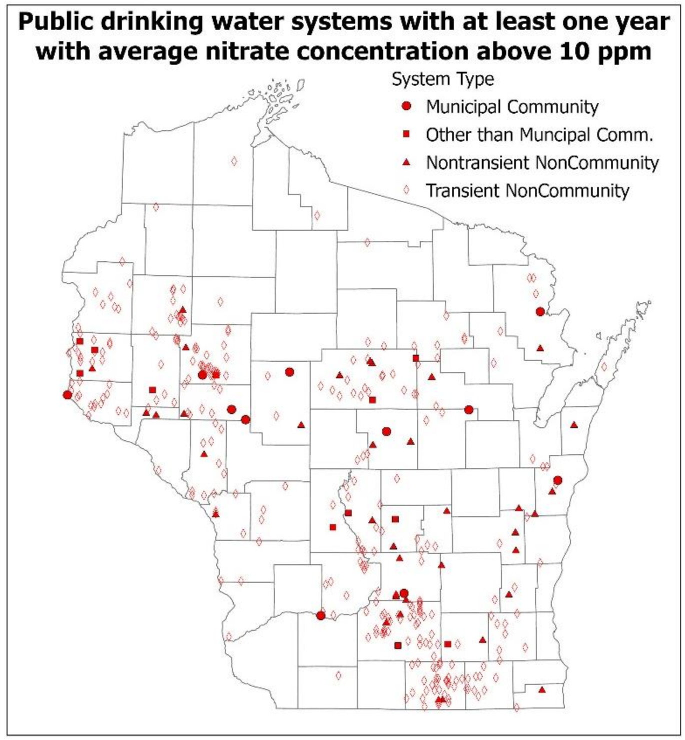
However, in response to new health data and a request from the EPA, starting in April 2026, all systems must comply with the 10 ppm MCL. Between 2015 and 2024, the share of systems with at least one year exceeding 10 ppm nitrate ranged from 2% among municipal community wells to 5% among transient non-community wells, serving a combined population of 55,000 residents.

Table 1. Summary of public water systems with long-term (2015-2024) annual nitrate concentrations greater than 5 ppm or 10 ppm (identifying systems with chronically elevated nitrate) and at least one year between 2015-2024 with an annual concentration greater than 10 ppm (identifying systems with acute spikes in nitrate levels).

PWS Type	Number (%) of systems with average annual concentration > 5 ppm	Population served by systems with average annual concentration > 5 ppm	Number (%) of systems with average annual concentration > 10 ppm	Population served by systems with average annual concentration > 10 ppm	Number (%) of systems with maximum annual test > 10 ppm	Population served by systems with maximum annual test > 10 ppm
Municipal Community	29 (5%)	142,323	0 (0%)	0	11 (2%)	50,233
Other than Municipal Community	34 (8%)	3,421	0 (0%)	0	13 (3 %)	1,032
Non-transient, Non-community	79 (9 %)	8,234	1 (<1%)	92	41 (5%)	3,294
Transient, Non-community	707 (11%)	1,668	129 (2%)	386	323 (5%)	727

[1] Public water systems are categorized as either community systems, which provide water to people where they live, or non-community systems, which provide water to people at work, school or entertainment areas. Municipal community systems are owned by municipalities such as cities or villages and serve homes in their distribution area. Other than municipal community systems serve homes from privately-owned wells and include mobile home parks, apartment buildings or subdivisions. Non-transient non-community systems serve at least 25 of the same people for six months or more per year, and include schools and office buildings. Transient non-community systems serve at least 25 people (though not necessarily the same people) for 60 days or more per year, including restaurants, campgrounds and churches (WDNR 2025a)





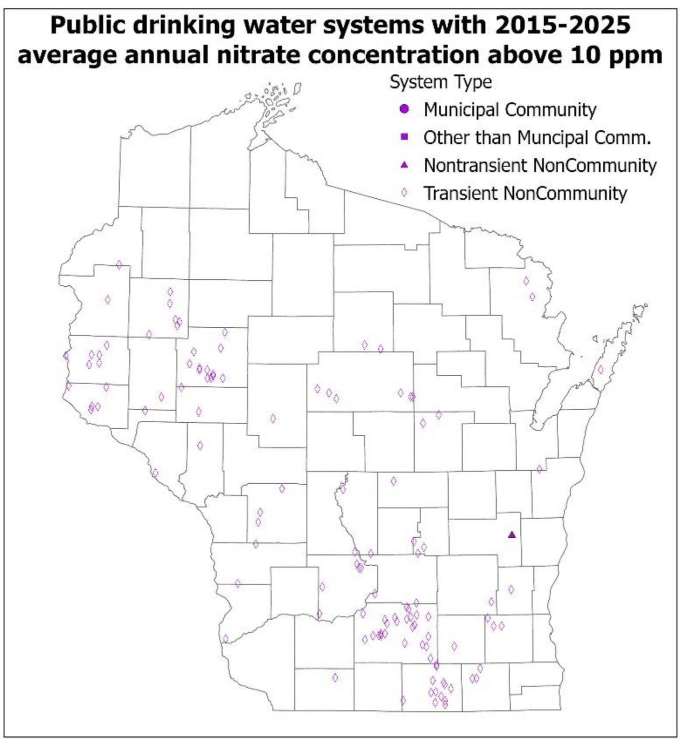


Figure 2. Public drinking water systems with 2015-2024 annual average concentrations above 5 ppm (top left), systems with at least one annual average concentration above 10 ppm between 2015-2024 (top right), and systems with 2015-2024 annual average concentrations above 10 ppm.

Contamination of Private Wells

In Wisconsin, about one-quarter to one-third of residents rely on private wells for their primary drinking water, all sourced from groundwater (Dieter et al. 2018, WDNR 2025b, WDHS 2025, UW Extension 2025). Unlike public water systems, there is no requirement for private well owners to regularly test their water for contamination; however, many will voluntarily test their water, especially if they suspect a problem may exist. Since 2015 the state has required nitrate tests be taken when a new private well is drilled or an existing private well is modified. For our analysis of private well nitrate contamination, we use the data from required tests of new or modified wells to remove the potential bias towards higher nitrate concentrations that could be present in datasets of voluntary well water samples.

Across the state, 5% of samples from new or modified wells between 2015-2024 exceed the health-based drinking water standard of 10 ppm and another 10% of wells had concentrations between 5 and 10 ppm, indicating elevated nitrate concentrations that could be harmful to health (Table 2).

Rates of elevated nitrate contamination are highest in areas with more agricultural activity. Wells in areas where the majority of land cover is agricultural were 1.5 times more likely to have nitrate concentration between 5-10 ppm and nearly two times more likely to have concentrations greater than 10 ppm (Table 2, Figure 3).

Wells in majority agricultural areas *and* with groundwater vulnerable to contamination from surface pollution[2] had the highest rates of elevated nitrate. Wells in such areas were over twice as likely to have nitrate concentrations between 5-10 ppm (22% vs. 10%) or above 10 ppm (12% vs. 5%) (Table 2, Figure 3).

The Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) also conducts extensive sampling of the state's groundwater to evaluate the levels of agricultural chemicals in our water resources. To evaluate the extent of nitrate contamination, DATCP sample approximately 400 wells using a stratified sampling protocol designed to be representative of private well use in the state between 2016 and 2023. This sampling suggested that 7-8% of private wells in the state exceed the 10 ppm drinking water standard and 20-25% of private wells in the state have nitrate levels above 5 ppm.

Finally, statewide, 11% of private well nitrate samples exceed 10 ppm in the UW Stevens Point Private Well Water Quality dataset of private well nitrate tests between 2019-2024 (Center for Watershed Science 2025a). We note that these include voluntary tests, and may be potentially biased towards higher concentrations, since private owners are more likely to test if they already suspected a problem.

Table 2: Statewide summary of percent of wells with nitrate concentrations above 5 ppm and above 10 ppm, using nitrate test results from the Department of Natural Resources well construction database. Wells in agricultural areas refer to private wells in townships with >50% agricultural land use. Wells in vulnerable agricultural areas refers to wells in townships with >50% agricultural land use and with median groundwater contamination susceptibility greater than the statewide average. See Appendix for additional details.

Geographic Subset	% Wells between 5-10 ppm	% Wells >10 ppm
All Wells (n= 84,197)	10%	5%
Wells in Majority Agricultural Areas (n=12,330)	15%	9%
Wells in Both Majority Agricultural Areas and Vulnerable Groundwater Areas (n=3,801)	22%	12%

[2] Such as shallow aquifers, soils that water carrying contaminants can move quickly through. See Appendix for additional details.

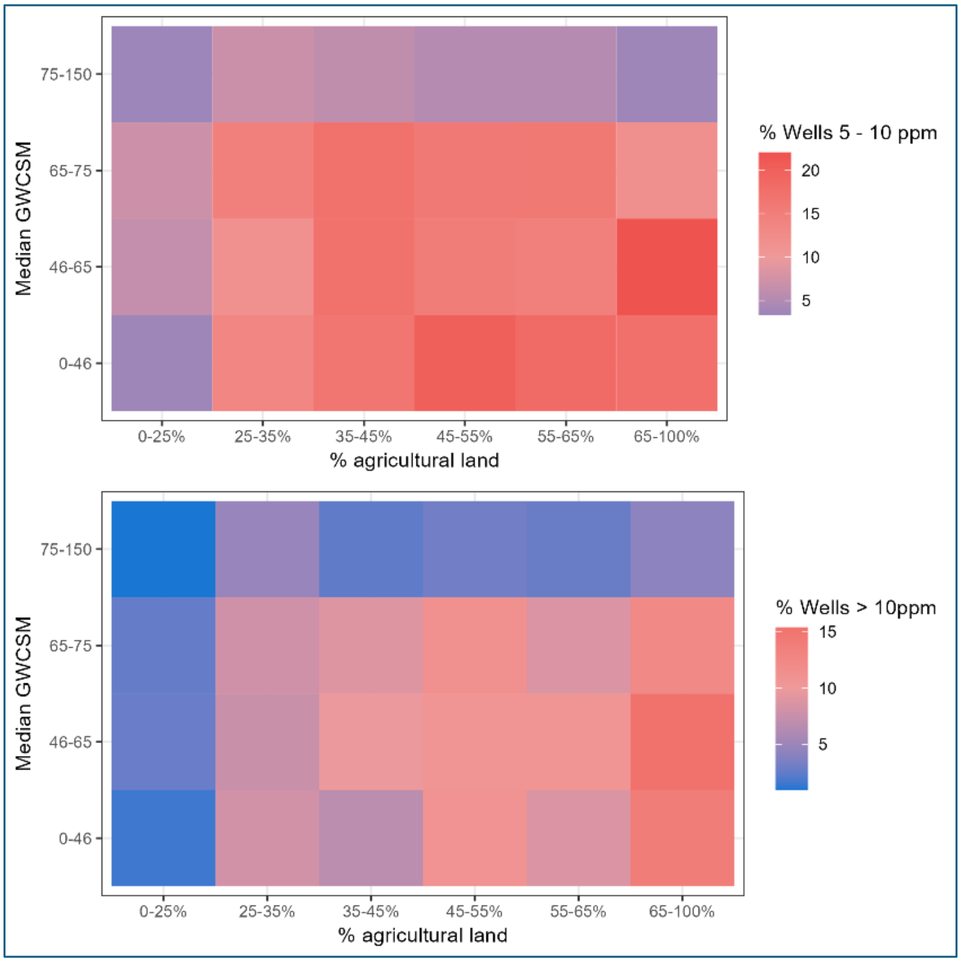


Figure 3. Heat maps illustrating the interaction between agricultural land use, groundwater contamination vulnerability and private well nitrate contamination. Percent agricultural area refers to the percent of agricultural land cover in the township. Groundwater vulnerability is based on the median Groundwater Contamination Susceptibility Model (GWCSM) score for the township (lower GWCSM scores indicate greater vulnerability to contamination). Each square represents a different combination of agricultural land cover and groundwater vulnerability. These squares are color coded by the percent of private wells in these townships with elevated nitrate in the drinking water. Bluer colors indicate lower percentages of wells with elevated nitrate; darker red colors indicate higher percentages of wells with elevated nitrates. Note how wells in low agricultural areas, regardless of groundwater vulnerability (left-most column in the heat maps) and wells in low vulnerability areas, regardless of agricultural land cover (top row in the heat maps) have the lowest rates of contamination. In contrast the highest rates of elevated nitrates occur in townships with both high percentages of agricultural land cover and higher groundwater vulnerability (squares in the lower right portions of the heat maps).

To visualize the extent of private well nitrate contamination across the state, we use three datasets: the Wisconsin Department of Natural Resources (WDNR) database of new or modified wells described above, all voluntary private well tests in the state between 2019-2024 in the UW Stevens Point dataset and annual tests from non-community public water systems. Non-community wells are more likely than community wells to use the same shallower aquifers as private wells and can thus be used as a proxy for private well drinking water quality. Further, public systems are required to test for nitrates annually, providing a consistent, unbiased dataset that provides insight into the quality of groundwater aquifers used by private wells.

Despite the respective limitations of each of the three datasets used to examine groundwater contamination across the state, certain geographic hot spots of nitrate contamination are consistently observed (Figure 4). Wells in the south central, central, and west central regions have elevated rates of high nitrate readings compared to the rest of the state.

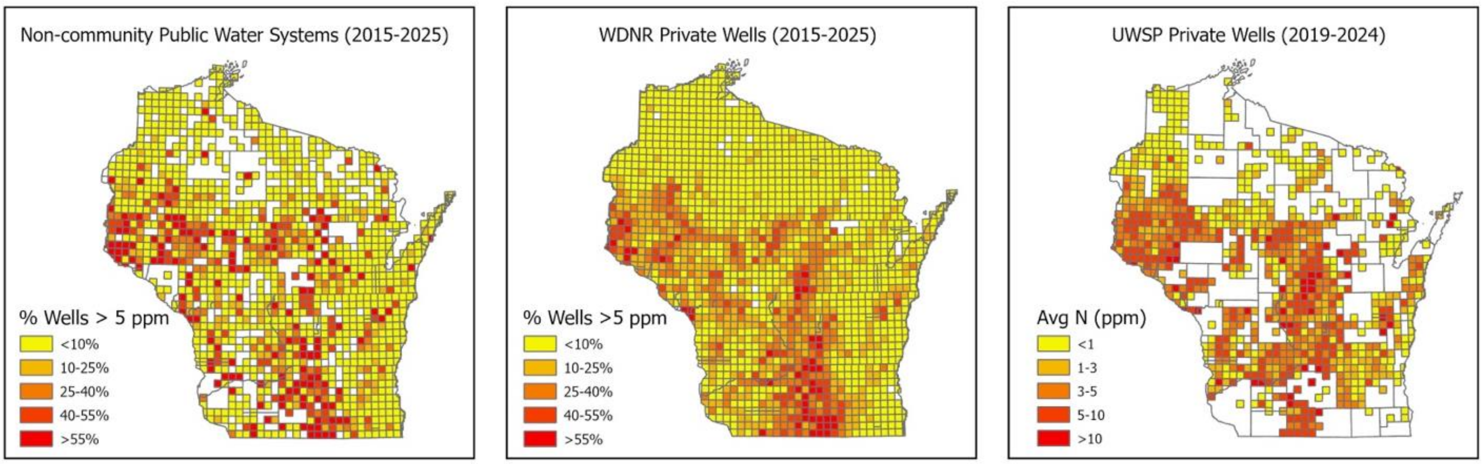


Figure 4. Nitrate groundwater contamination by township in Wisconsin using data from annual compliance testing at noncommunity water systems (left), private well test results from new or modified wells submitted to the WDNR (center) and voluntary nitrate testing submitted to UW Stevens Point Center for Watershed Science and Education (right). Across all three datasets, high rates of elevated nitrate are seen in south-central, central, and west-central Wisconsin.

Historic Trends of Groundwater Contamination

To examine long-term nitrate trends in groundwater used by private wells for drinking water in Wisconsin, we used data from non-community public water systems (e.g., schools, restaurants, churches, campgrounds). Because these systems are required to test for nitrate annually, and are likely to use the same aquifers as private wells, this dataset is well-suited for evaluating long-term nitrate contamination trends. As such, we used nitrate concentration data from non-community public water systems that conducted consistent testing between 1990 and 2025 for our analysis.

Across all non-community public systems included in our long-term dataset, most systems (64%) did not show a statistically significant increase or decrease in nitrate concentration from 1990 – 2025 (Figure 5a). For the remaining 36% of systems that did show a trend, 19% had a declining trend and 17% had an increasing trend. Similar trends were seen in the subsets of systems in majority agricultural areas (Fig. 5d) and systems in majority agricultural areas with geologically vulnerable aquifers (Fig. 5e).

Among systems with elevated nitrate concentrations (i.e., systems with at least one sample of 5 ppm or higher between 1990-2025), the most common outcome was no trend, and among systems with an observable trend, more were decreasing than increasing (Fig 5b-c). This is particularly true for systems with at least one elevated test result between 1990-1995, where the majority of systems had a decreasing trend. This may indicate systems that experienced elevated concentrations long enough to need and implement corrective action), where the majority of systems had a decreasing trend (Fig. 5c).

To see whether there were certain counties or watersheds where the well testing consistently indicates an increasing trend, indicating priority areas to address, we mapped the trends (Figure 6). Whether a well showed an increasing or decreasing trend followed no discernible geographic trend. Within any given area, there are wells with increasing trends, decreasing trends, and no trends, illustrating the site-specific nature of nitrate groundwater contamination trends.

There are a couple of limitations of this analysis to note. First, some of observed decreases could be due to installation of treatment systems or obtaining new water sources (e.g., new or deeper wells) rather than improvements in the source water as opposed to being due to improvement in the groundwater quality. We visually inspected the time series analyses and removed systems that had abrupt reductions in nitrate concentrations after confirming in the WDNR well inventory that new wells were drilled or treatment systems were implemented. However, the listing of systems with treatment in the inventory is known to be incomplete. Thus, there could be additional systems with new wells or with treatment installed not noted in the inventory where reductions were not as immediately visually obvious and were included in the analysis.

Furthermore, our dataset was limited to systems that conducted regular testing since 1990, representing about 10% of all active noncommunity wells. This was done to ensure a robust dataset from which to identify statistical trends. Using less strict inclusion criteria to include more wells could alter results.

For example, an analysis of trends for all public water systems with at least 6 years of nitrate test data by the USWP Center for Watershed Science also found that the majority of wells have no trend in nitrate concentrations (90% in their analysis) (Center for Watershed Science 2025b). However, they found that of wells that had a statistically significant trend, slightly more (5%) were increasing than were decreasing (4%). Similarly, an analysis by the Groundwater Coordinating Council that included all public wells with at least three samples between 2000 and 2020 identified several counties in south-central, central and western Wisconsin where 15-30% of public wells had increasing nitrates (Wisconsin Groundwater Coordinating Council 2025).

Estimated Health Burden of Nitrate Contamination

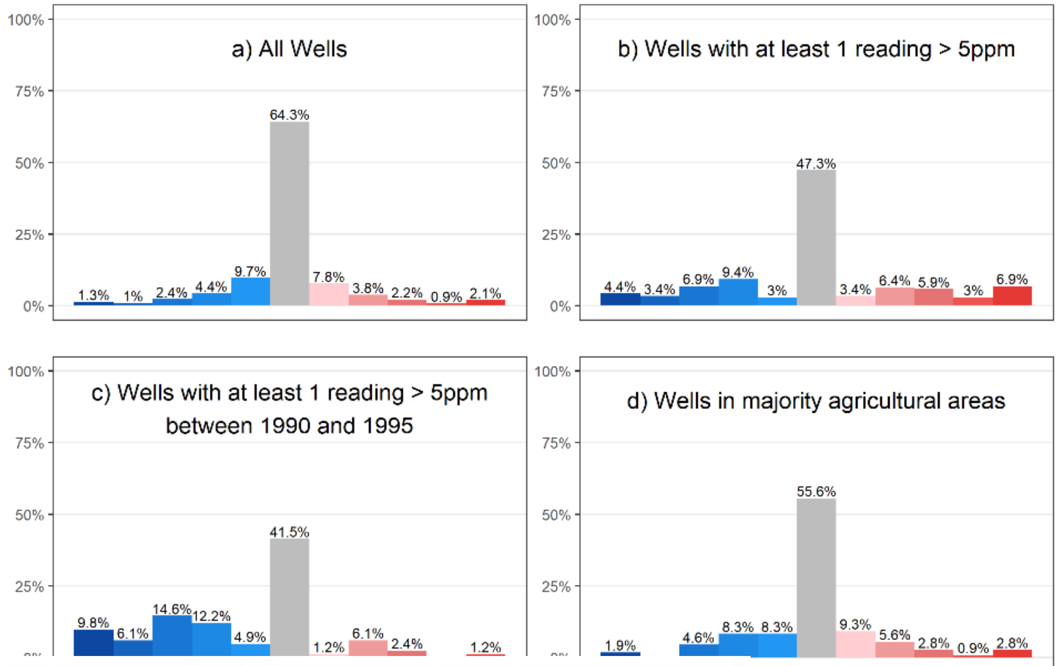
We are aware of only one evaluation of the health burden of drinking water nitrate contamination in Wisconsin. Mathewson et al. (2020) estimated the health burden caused by exposure to nitrate contaminated drinking water in Wisconsin. The analysis first estimated the total population exposed to drinking water with nitrate contamination. Then, using the increased risk of adverse health outcomes resulting from that level of nitrate drinking water exposure reported in epidemiological studies, it estimated a range of yearly health outcomes attributed to nitrate contamination of drinking water in Wisconsin.

The analysis estimated 169 (range:111-298) combined cases of colorectal, ovarian, thyroid, bladder, and kidney cancer cases annually could be attributed to nitrate contaminated drinking water in Wisconsin. The estimated direct medical costs associated with these cases was $22 million (range: $14-$39 million) per year.

Among adverse birth outcomes, the analysis estimated 1-2 cases of neural tube birth defects, 95 (range:46-149) cases of very low birth weights, and 51 (range: 26-70) cases of very preterm births annually could be attributed to nitrate contaminated drinking water in Wisconsin. For neural tube defects, the estimated medical costs associated with these cases range from $0.6 to $1.7 million per year. For very preterm and very low birthweight, the estimated medical costs associated with these cases was $21 million (range: $8 -$39 million) per year (Mathewson et al. 2020).

The total estimated direct medical costs resulting from exposure to nitrate contaminated drinking water was $44 million (range: $23-$80 million) annually. Indirect medical costs like lost productivity due to sickness and premature death would add nearly another $100 million in costs annually (Mathewson et al. 2020).

Figure 5. Percent of long-term non-community public water systems with consistent long-term (1990-2025) nitrate test data that have increasing trends, no trends, or decreasing trends in nitrate contamination. Red indicates an increasing trend, blue indicates a decreasing trend, and gray indicates no trend.



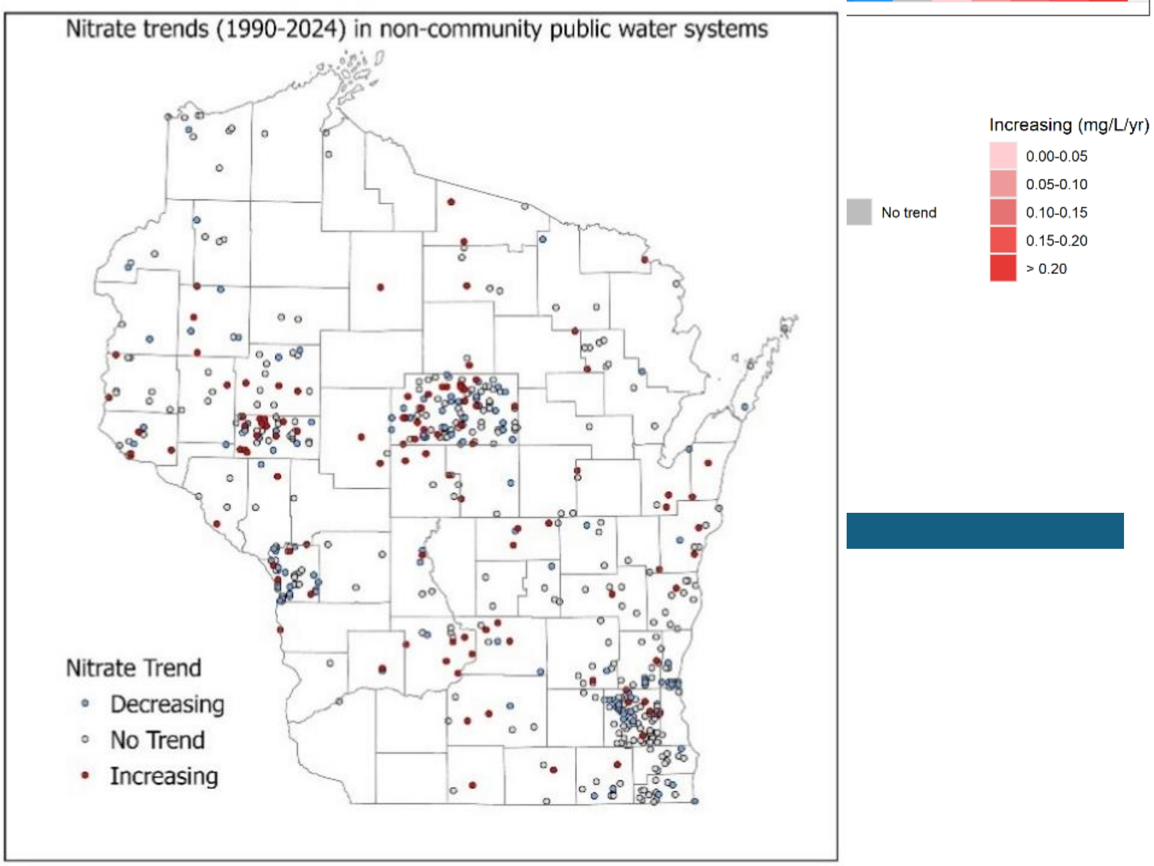


Figure 6. Locations of long-term trend noncommunity public water systems (n=713; representing about 10% of non-community systems), color coded by nitrate concentration trend to visualize geographic patterns of where groundwater nitrate contamination appears to be increasing, decreasing or holding constant. Note that symbols for systems with decreasing and increasing nitrate trends are plotted over symbols for systems with no trend, obscuring

some systems with no trend. There are no clear hotspots of increases or decreases, indicating the location-specific nature of groundwater nitrate trends.

Policy Implications & Recommendations

Given the extent of contamination and associated health risks as described in this brief, addressing nitrates continues to be a pressing issue in Wisconsin policy. The Wisconsin Groundwater Coordinating Council (GCC), an interagency group focused on helping state agencies coordinate and exchange information related to groundwater programs, provides annual recommendations for groundwater regulations and programs in Wisconsin. The GCC has identified nitrate as a priority groundwater contaminant in the state in every annual report since the Council's establishment in 1985.

The last regulatory update attempting to help reduce nitrate contamination was made in 2018, but only applied to very specific areas of shallow soils overlying Silurian bedrock in eastern Wisconsin. In 2019, the WDNR proposed updates to restrictions on nitrogen fertilizer and manure applications that would be applicable more broadly to vulnerable areas of the state to achieve groundwater protection; however in 2021 the WDNR decided to halt that effort due to constraints in the rulemaking process (Tiboris 2021).

Lastly, resources intended to help well owners experiencing high levels of nitrates have proved challenging to access. The Well Compensation Program provides funding to eligible landowners or renters to replace, reconstruct or treat contaminated private water supplies that serve a residence and provide water to livestock (WDNR 2025c), however it is limited by strict requirements. To be eligible, nitrate concentrations need to exceed 40 ppm (four times the health-based limit), the well must provide more than 100 gallons per day for livestock, and household income must be less than $65,000. These restrictions severely limit the program's ability to help residents who are impacted by nitrate pollution. In fact, fewer than 1,000 people in Wisconsin actually meet the nitrate level requirements alone, let alone also meeting the other requirements (Davies 2021).

Addressing nitrate contamination of groundwater will require creative and innovative policy approaches that address the causes of contamination and also help owners and municipalities with contaminated source water to remediate their systems so they have access to safe, clean drinking water.

While not all in-inclusive, policy recommendations to address Wisconsin's nitrate contamination challenges could include:

- **Create a statewide water testing program for private well owners.** Health professionals recommend testing private well water annually for contamination. Access to water testing programs and the cost of water sample analysis have been identified as obstacles to private well testing for rural homeowners. Establishing water testing programs through county health departments would reduce these barriers of participation.
- **Revisit rulemaking for Wisconsin Nitrate Performance Standards**. Halted in 2021, the WDNR should reconsider establishing targeted performance standards for areas of the state that are most susceptible to groundwater contamination. Targeted standards should (WDNR 2021):
    - Strengthen performance standards for all nitrogen-sensitive soils in the state as identified by the Natural Resources Conservation Service.

  - Strengthen protections for drinking water sources by applying enhanced standards to lands within and surrounding municipal wellhead protection areas.
  - Restrict the application of fertilizer and liquid manure in the fall and winter when it is most likely to run off the fields.
  - Require cover crop planting to scavenge excess nitrate in nitrate-sensitive areas of the state.
- **Expand WDNR's Well Compensation Grant Program.** Using federal grant money, the state administered a $10 million well compensation grant program with fewer restrictions than the state-funded version. All funding was quickly exhausted in 2024, indicating the need for additional assistance. Program expansion should:
  - Remove the requirement that the well must service both humans and livestock to be eligible for well compensation grant funds.
  - Reduce the minimum nitrate concentration eligible for support for 40 ppm to 10 ppm to align with the current health-based standard from of 10ppm.
  - Increase the household income limitation from $65,000 to $100,000 and adjust with inflation over time.
- **Make safe drinking water and public health a state priority.** As the WDNR works to revise the state's Nutrient Loss Reduction Strategy, specific focus should be on widespread implementation of practices, programs and policies that have been shown to reduce agrichemical contamination of drinking water resources.
- **Continue support for the Commercial Nitrogen Optimization Pilot Program (NOPP).** This program supports on-farm research to help farmers determine appropriate nitrogen application rates, timing, and methods for their crops and identify innovative ways to reduce nitrogen losses. Program results should be distributed widely and included in outreach and educational sessions for farmers, agronomists and other agricultural and conservation professionals to expand adoption of practices that reduce nitrate losses.
- **Revamp, fund, and enforce farm nutrient management planning in the state.** Nutrient management plans are developed to ensure that manure and fertilizer are applied in the right places, in the right amounts, at the right time, and with the right method (4R's) to minimize nitrogen losses to the environment.
- **Educate agricultural industry professionals on practices that reduce nitrogen leaching and runoff.** Farmers rely heavily on agronomists, seed dealers, and fertilizer retailers when making annual crop and nutrient management decisions. Establish an educational program for staff at agricultural cooperatives, seed retailers, and fertilizer dealers that focuses on the 4-Rs of nutrient management planning and emphasizes the role agricultural professionals have in reducing the impact of nutrient loss from agriculture on our water resources.
- **Re-evaluate the human health risks associated with nitrate consumption.** The current nitrate groundwater standard of 10 ppm was established in the 1960's (and codified as the drinking water standard in 1992) to protect against blue baby syndrome; however a growing body of research indicates additional health impacts from exposure of nitrate, even at lower levels. The health-based groundwater and drinking water standard should be re-evaluated to determine a more protective maximum contaminant level.

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Additional Resources

Clean Wisconsin: Clean Water, Clean Air, Clean Energy - Clean Wisconsin

Wisconsin Department of Health Services: Drinking Water: Nitrate and Nitrite

Wisconsin Department of Agricultural, Trade and Consumer Protection: Wisconsin Groundwater Quality Reports

Wisconsin Groundwater Coordinating Council: Groundwater Quality

Center for Watershed Science and Education: Nitrate in Wisconsin's Public Water Systems

Wisconsin's Green Fire: Nitrates in Wisconsin Waters

Appendix A: Analysis Methods

Contamination of Public Water Systems

All compliance sample nitrate test results from active public water systems between 2015-2025 were obtained from Wisconsin Department of Natural Resources' (DNR) drinking water portal (WDNR 2025d). For each type of public water system (community municipal, community other than municipal, transient non-community, non-transient noncommunity)[3], we calculated the following:

- The number and percent of systems whose long-term (2015-2025) average annual nitrate concentration above 5 ppm (used as an indicator of elevated nitrate at which some adverse health effects have been identified)
- The number and percent of systems whose long-term (2015-2025) average annual nitrate concentration above 10 ppm (the current health-based drinking water standard)
- The number and percent of systems with at least one year between 2015-205 with an annual nitrate concentration greater than 10 ppm (the current health-based drinking water standard).

The total population served by wells with elevated levels of nitrate was also calculated to estimate the total population exposed to elevated levels of nitrate contamination in their drinking water.

Contamination of Private Wells

In Wisconsin, between a quarter and third of residents use private wells as their primary source of drinking water, all of which use groundwater (Dieter et al. 2018, WDNR 2025b, WDHS 2025, UW Extension 2025). Unlike public water

[3] Community municipal systems are owned by municipalities such as cities or towns. These systems include normal city drinking water. Community other than municipal serve systems residents from privately owned wells. These systems include mobile home parks or apartment buildings. Transient noncommunity systems serve at least 25 of the same people for six months or more per year. These systems include schools and office buildings. Transient non-community systems serve at least 25 people (though not necessarily the same people) for 60 days or more per year. These systems include campgrounds and churches (WDNR 2025b)

systems, there is no requirement for private well owners to regularly test their water for contamination. However, nitrate tests have been required for any new or modified private wells in the state since 2015. We consider this to be the least biased and most extensive dataset of nitrate contamination in private wells. Other datasets are made up of voluntary tests, which may be biased towards higher concentrations, since private well owners are more likely to test if they suspect a problem may exist.

We obtained nitrate tests for all new or modified private wells since 2015 from the Wisconsin DNR groundwater retrieval network (WDNR 2025e). This created a dataset of nitrate test results from 84,160 unique private wells. From this overall dataset, we created two additional subsets intended to focus on areas potentially more vulnerable to nitrate drinking water contamination:

- Wells in areas where the land use is largely agricultural, defined as wells in townships where greater than 50% of the land use is agricultural. Land use in each township was calculated using the Wiscland2 dataset.
- Wells in areas where the land use is largely agricultural, as defined above, *and* where groundwater is particularly vulnerable to contamination from surface pollution. Groundwater contamination susceptibility was determined using the Groundwater Contamination Susceptibility model developed by the USGS, Wisconsin Geological and Natural History Survey, and the Wisconsin Department of Natural Resources (WDNR 1987). This model takes into account type of bedrock, depth to bedrock, depth to water table, soil type, and surface deposits to estimate relative vulnerability to surface contaminants. We defined a township as having groundwater particularly vulnerable to contamination if its median vulnerability score is more vulnerable than the statewide average.

Within each category of private well (all wells, wells in predominantly agricultural areas, or wells in predominantly agricultural areas + vulnerable groundwater), we calculated the percent of wells with concentrations between 5-10 ppm (indicating elevated nitrate) and the percent of wells above 10 ppm (the current health-based standard).

Recognizing that this dataset of nitrate tests from new or modified wells has its own limitations such as being biased towards areas higher rates of new housing development, we also evaluated two additional datasets to look at the geographic extent of contamination of groundwater in Wisconsin.

First, we calculated the percentage of non-community public water systems in townships with at least one year with an annual nitrate concentration above 5 and 10 ppm between 2015 and 2024. These data were obtained from Wisconsin DNR's drinking water portal (WDNR 2025d) All public water systems are required to test for nitrate every year, and non-community system wells are more likely than community wells to use the same shallower aquifers as private wells. Thus, noncommunity wells can be used as a proxy for private well drinking water quality (Temlin et al. 2019).

Second, we used voluntary private well nitrate tests submitted to the UW Stevens Point Center for Watershed Science and Education between 2019 and 2024 (Center for Watershed Science 2025a) to calculate average concentration in each township. These data are provided as average nitrate concentrations in PLSS sections and thus the percentage of wells above 5 or 10 ppm could not be calculated to directly compare to the other two datasets.

Historical Groundwater Contamination Trends

To examine long-term trends in groundwater used for drinking water in Wisconsin, we used data from non-community public water systems. Public drinking water systems are required to test for nitrate annually, generating consistent, long-term datasets of nitrate concentrations. Among public systems, non-community systems are more likely to use the same aquifers as private wells than community water systems.

To obtain a dataset of non-community systems with regular testing from which to detect reliable trends, we used nitrate tests from systems that had at least one test every five years between 1990-1995 and 2020-2025 were identified. These data were obtained from Wisconsin DNR's drinking water portal (WDNR 2025d). This created a dataset of 713 non-community systems. We also analyzed four additional subsets in order to look at trends within specific subsets of systems):

1. Systems with at least one test result above 5 ppm at any point between 1990 – 2025 (to examine trends only within areas with elevated nitrate levels as one might expect more attention and thus mitigation efforts to be focused in these areas)

2. Systems with at least one test of 5 ppm from 1990-1995 (to examine trends only in areas known to have elevated nitrate at the beginning of the analysis period, providing adequate time for any mitigation efforts to have an effect)

3. Systems where greater than 50% of land use within a 1-mile radius of the system is agricultural (to examine trends only in predominantly agricultural areas because one might expect nitrate contamination to be more likely to be increasing in these areas)

4. Systems where greater than 50% of land use within a 1-mile radius of the system is agricultural and the median groundwater contamination susceptibility within a 1-mile radius of the system is greater than the statewide average (to examine trends only in predominantly agricultural areas with groundwater susceptible to contamination because one might expect nitrate contamination to be more likely to be increasing in these areas).

Within each set of wells, a timeseries analysis was conducted using linear regression on the data for each well to determine the rate at which nitrate concentration increased or decreased between 1990 – 2025. A significant trend in either direction was defined as a linear regression with a p-value < 0.05, indicating that the odds of the observed trend happening by chance are less than 5%.