

# Lake of the Woods Watershed

## Rainy River Basin

### Summary

The Minnesota Pollution Control Agency (MPCA), Minnesota Department of Natural Resources (DNR), and partners have completed a study of the Lake of the Woods Watershed (Figure 1). This watershed includes the namesake Lake of the Woods and its direct stream tributaries within Lake of the Woods and Roseau Counties, excluding the Rainy River and the Northwest Angle. Major tributaries in the watershed include the Warroad River, Zippel Creek, Bostick Creek, and Williams Creek.

Overall water quality within the Lake of the Woods Watershed is generally fair. The East and West Branches of the Warroad River continue to support some of the most well-preserved fish and communities of macroinvertebrates (such as insect larvae, snails, and worms) in northwestern Minnesota. Lake of the Woods has also shown improvement, with a 19% decline in mean summer-average total phosphorus (TP) concentrations since 2015. Despite these positive trends, several water quality concerns persist. These include degraded fish and aquatic macroinvertebrate communities in portions of the watershed, elevated *Escherichia coli* (*E. coli*) bacteria concentrations in stream tributaries, and the ongoing need for nutrient reductions to protect and enhance water quality in Lake of the Woods.

This study incorporates both chemical water-quality monitoring and biological surveys of fish and aquatic macroinvertebrate communities. Using multiple lines of evidence provides a more comprehensive understanding of watershed health over time. The assessment, which is funded by Minnesota's Clean Water, Land, and Legacy Amendment, also draws on data collected by volunteer water quality monitors. The findings presented in this report will help guide watershed management decisions and future pollution-reduction efforts.

### Watershed Study

Water monitoring is essential to determining whether water bodies (lakes, streams, and ditches) meet water quality standards. While local partners and state agencies monitor water quality on an ongoing basis, the MPCA and local partners conduct an intensive survey of lakes and streams in each of the state's 80 watersheds every 10 years to detect any changes in water quality. In the Lake of the Woods Watershed, the MPCA and local partners conducted the first round of this intensive monitoring in 2012-2013 ([see results published in 2016](#)). Intensive monitoring was conducted for the second time in 2023-2024, and chemistry data collected by local partners between 2015 and 2024 were also used for assessment. Monitoring during both intensive monitoring efforts focused on whether water bodies met water quality standards that support aquatic life, recreation, and/or consumption use. Waters that fail

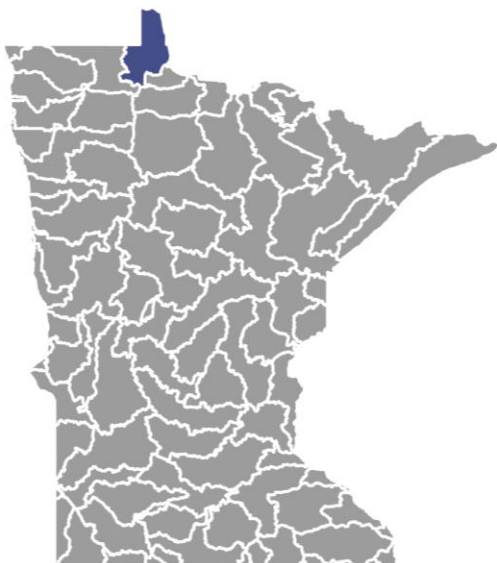


to meet these use standards and were assessed as not supporting aquatic life, recreation, and/or consumption use are considered impaired. The overall goal of these assessments is to determine which waters are healthy and may need protection or are polluted and require restoration. For more information on the MPCA's approach to water quality monitoring see: [Watershed Approach to Water Quality Minnesota's water quality Monitoring Strategy 2021 to 2031](#). For more information about trends across the state see: [Flowing Forward: Trends in Minnesota's lakes and rivers](#).

## Changes in water quality

To detect any changes in water quality, this recurring exam looks at fish and macroinvertebrate communities as well as water chemistry. Scientists use a tool called the Index of Biological Integrity (IBI) to assess the health of biological communities in lakes, rivers, streams, and wetlands. High IBI scores indicate a healthy aquatic community, which can only be attained when water quality, habitat, and hydrology are minimally disturbed by human activities.

**Figure 1. The Lake of the Woods Watershed is one of 80 major watersheds partially or fully within Minnesota.**



Over the past decade, scientists observed little change in water quality within streams throughout this watershed. While the biological condition of individual streams has improved in some areas and declined in others between 2012-2013 and 2023-2024, the watershed-scale condition of assessed fish and macroinvertebrate communities has not significantly changed (Figure 6). Persistent water-quality concerns include impaired biological communities, elevated levels of *E. coli* bacteria, and low dissolved oxygen (DO) levels within some streams. In contrast, streams with high water quality and well-preserved biological communities generally remained in good condition.

Significant progress has been made toward achieving water-quality goals on the Lake of the Woods over the

past decade. Monitoring by the MPCA and its partners (Red Lake Nation Water Resources, the Science Museum of Minnesota, and DNR) shows that mean summer-average TP concentrations have declined 19% between 2014 and 2025. This reduction in phosphorus appears to coincide with a long-term, gradual decline in algal bloom intensity in the lake (see success story below).

Continued water-quality monitoring is essential to determining whether lakes and streams meet water quality standards designed to ensure that waters are fishable and swimmable. Although some routine water monitoring occurs annually in the Lake of the Woods Watershed, the MPCA and local partners conduct an intensive survey of lakes and streams in the watershed every 10 years. To detect changes in water quality, this intensive survey looks at fish and macroinvertebrate communities as well as water chemistry. The MPCA uses the data to identify waters that are healthy and may need protection, as well as those that are polluted and need restoration.

- Macroinvertebrate communities collected from the East Branch of the Warroad River have shown consistent improvement over the past decade. As a result of this sustained increase in IBI scores, the existing aquatic life (AQL) use impairment for the East Branch of the Warroad River was removed from the Impaired Waters List in 2025.
- Both the East Branch and the West Branch of the Warroad River continue to support some of the most well-preserved fish and macroinvertebrate assemblages within Northwestern Minnesota.
- Fish communities throughout the watershed were stable between the two cycles of monitoring, with 85% of species shared between 2012-2013 and 2023-2024. Four additional species were collected during the more recent monitoring.
- Williams Creek, East Branch of the Warroad River, Bostic Creek, and West Branch of Zippel Creek are now impaired for aquatic recreation use due to high *E. coli* bacteria levels measured during the summers of 2023 and 2024. An existing aquatic recreation impairment was confirmed on the West Branch of the Warroad River due to monitoring in 2023 and 2024. *E. coli* bacteria levels have increased at Williams Creek, East Branch of the Warroad River, and Bostic Creek when compared to the data available during the first cycle of monitoring.
- Monitoring by the MPCA, Red Lake Nation Water Resources, the Science Museum of Minnesota, and DNR shows that mean summer-average TP concentrations in the Lake of the Woods have declined 19% over the past decade. This reduction in phosphorus appears to coincide with a long-term, gradual decline in algal bloom intensity in the lake (see success story).
- Lake of the Woods County used money from the Clean Water Funds to stabilize more than one mile of stream channel paralleling Lake of the Woods County Road 8 Northwest. Project activities included replacing and armoring side-inlet structures, installing numerous rock riffles and grade-control structures to prevent head cutting, and making improvements to enhance fish passage. Construction was completed between 2022 and 2023 and is projected to reduce sediment losses by approximately 100 tons per year. Water-quality monitoring conducted downstream of the project area on the West Branch of Zippel Creek during the 2023-2024 monitoring period showed no exceedances of the 15 milligrams per liter (mg/L) total suspended solids (TSS) standard. While these results indicate improved conditions, additional monitoring is needed to confirm sustained improvements and support potential removal of the existing TSS impairment.

## Highlights of monitoring

- Northern Brook Lamprey (*Ichthyomyzon fossor*) have been collected from multiple locations on the East and West Branch of the Warroad River. This non-parasitic species of lamprey is listed as a Minnesota species of special concern, and their habitat should be prioritized for restoration and protection efforts where possible. [See DNR website for more information on the Northern Brook Lamprey.](#)

- Upstream of Minnesota State Highway 11, Tomato Creek is heavily influenced by groundwater inputs and maintains cold temperatures throughout the summer. Several coldwater-adapted, pollution-intolerant aquatic insects and other small organisms (macroinvertebrates) have been collected from this section of the creek. These individuals are uncommon across northwestern Minnesota and include the caddisfly genera *Lepitostoma*, and the stonefly genera *Amphinemura* and *Isoperla* (Figure 2).

**Figure 2. An MPCA staff person collects an aquatic macroinvertebrate sample from Tomato Creek.**



- The lower section of the East Branch of the Warroad River (north of County Road 2) continues to support a uniquely well-preserved macroinvertebrate community. Several pollution-intolerant types of midge (small, flying insects) were collected in this stream section in 2023, including *Xylotopus par*, *Synorthocladius*, *Nilothauma*, and *Stempellina*. The caddisfly species *Phyloctropus placidus* was also collected, which is notable as this represents its farthest western record in Minnesota.

- Phosphorus levels in Willow Creek collected during June - September of 2023 and 2024 average 215.3 micrograms per liter (ug/L), well above the standard of 50 ug/L. Further monitoring of chlorophyll-*a* concentrations (a nutrient response variable) is necessary to establish a relationship between these elevated phosphorus levels and impaired

conditions for aquatic life. Willow Creek is currently impaired for AQL use because of low fish IBI scores and low DO conditions.

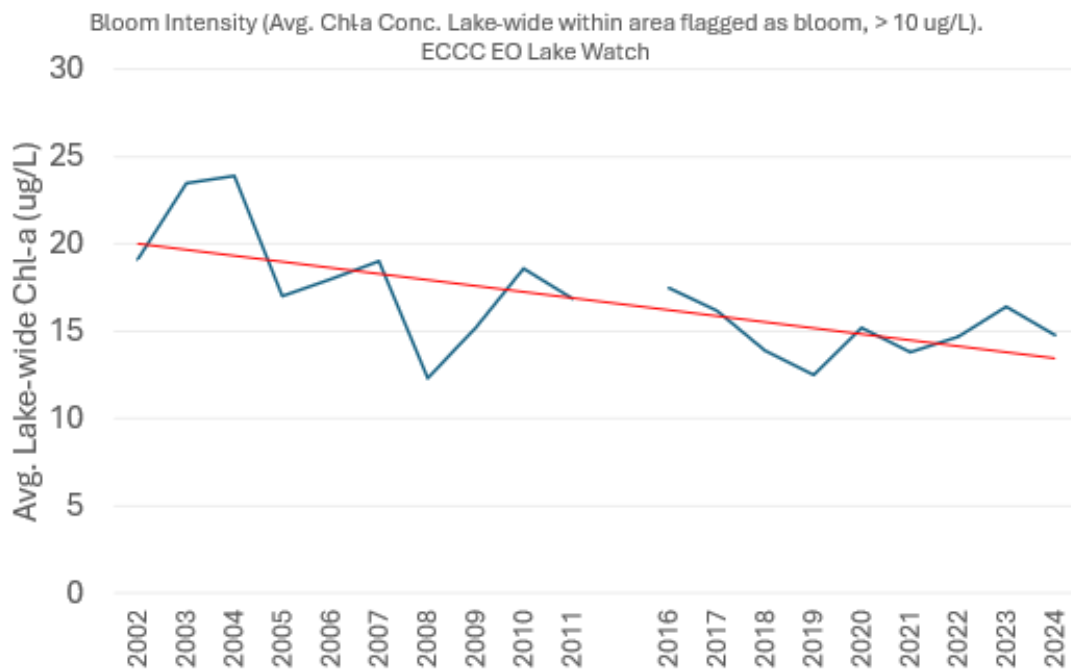
- Fish and macroinvertebrate communities were sampled within the restored reach of Judicial Ditch 28 in 2023, and results indicated that both communities were meeting AQL use standards. This restoration work was part of a \$378,000 Clean Water, Land, and Legacy grant project administered by the Minnesota Board of Water and Soil Resources (BWSR) and completed in 2020 by the Lake of the Woods Public Works Department and Soil and Water Conservation District. The project was designed to reduce sediment and nutrient contributions to Lake of the Woods by converting a half-mile segment of this ditch into a two-stage ditch design. Improvements included widening the channel and installing rock riffles to enhance channel stability and improve fish passage. The project is estimated to reduce erosion within this stream reach by approximately 300 tons of sediment per year.

## Success story

The MPCA declared the Lake of the Woods main basin and Fourmile Bay impaired for excess nutrients in 2007. This finding resulted in the development of the [Lake of the Woods Excess Nutrients TMDL Report](#), which detailed over a decade of cooperative monitoring and research to understand the causes of the lake's late-summer algal blooms, and the nutrient reductions needed to meet water quality standards long-term. In summary, a 17% reduction in TP load is needed to meet the MPCA's goal. Recent monitoring by Red Lake Nation Water Resources, the Science Museum of Minnesota, DNR, and MPCA show a positive finding, mean TP summer-average concentrations declined 19% over the last decade from assessments completed in 2014 versus 2025.

The decline in phosphorus appears to be mirrored by a long-term gradual decline in algal bloom intensity in the lake, as monitored by Environment and Climate Change Canada's sophisticated [real-time satellite-derived datasets](#) (Figure 3). Concurrently, many international agencies and organizations working together via the International Joint Commission's Rainy Lake of the Woods Watershed Board have developed internationally agreed upon long-term water quality objectives for TP in all of Lake of the Woods. The southern basin's goal is 30 ug/L, matching the MPCA's water quality standard, while the Canadian northern basins have a goal of 20 ug/L; both based on long-term science and data. The MPCA's Watershed and Outcomes Divisions, and numerous partners, continue to monitor nutrients and algal levels in the lake to track restoration objectives set in the TMDL; future research is focused on the roles of nitrogen and algal toxins associated with the blooms.

**Figure 3. Environment and Climate Change Canada's remote sensing datasets show a decline in chlorophyll-*a* (i.e. algae) concentrations in Lake of the Woods.**

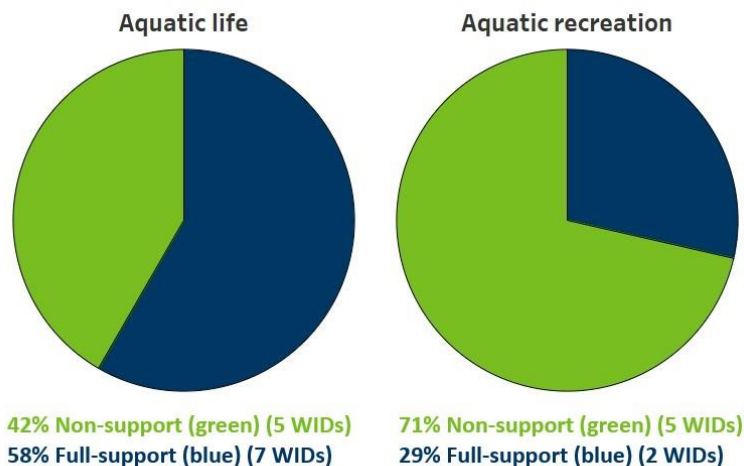


## Watershed assessment results

### Aquatic life use

Across the watershed, conditions for aquatic life are variable. While the Lake of the Woods itself has not been assessed for AQL use, five of the 12 stream reaches (WID) evaluated in 2024 are currently impaired (Figure 4). Monitoring conducted in 2023-2024 confirmed existing AQL use impairments on Unnamed Ditch (Parallel to Rocky Point road NW), Williams, Willow, and the West Branch of Zippel creeks. Monitoring also identified a new AQL use impairment on Tomato Creek south of 24th St NW.

**Figure 4. Watershed assessment results for aquatic life and aquatic recreation use in streams. The Lake of the Woods (main basin) remains impaired for AQL use due to excess nutrients (phosphorus) despite improvement since the last assessment.**



Historical changes in land cover (e.g., native vegetation to cropland) and alterations to drainage patterns (e.g., building ditches and channels) are the primary human factors contributing to impairments across the watershed ([Lake of the Woods Watershed Stressor Identification Report](#)). These modifications accelerate peak flows and prolong periods of low or no-flow, creating “flashy” stream conditions (water levels that quickly rise and fall) prone to erosion. The resulting increase in erosive force elevates sediment transport, degrades physical habitat, and contributes to low DO conditions.

While AQL use remains impaired on several stream reaches within the watershed (Figure 5), state and local governments, along with watershed partner organizations, have made substantial investments to improve water quality and habitat conditions across the watershed. Macroinvertebrate communities collected from the East Branch of the Warroad River have shown consistent improvement over the past decade, and as a result, the AQL use impairment for this reach was removed from the Impaired Waters List in 2025.

In 2019, the Warroad River Watershed District completed a \$414,000 Disaster Relief Assistance Program grant funded by the BWSR. This project reconnected a previously ditched section of the West Branch of the Warroad River to its natural channel. The restoration is projected to reduce bank erosion by

approximately 35 tons per year and has substantially improved fish habitat and passage for species such as the northern brook lamprey, northern pike, walleye, white sucker, and redhorse.

Significant restoration efforts have also been implemented within the Bostick Creek and West Branch of Zippel Creek drainages to mitigate erosion and reduce nutrient inputs to Lake of the Woods. Work in these systems included improving existing ditch infrastructure through the construction of armored side-inlet structures, installed rock riffle grade-control structures, and the creation of a two-stage ditch within Judicial Ditch 28 upstream of Bostick Creek. Combined, these projects are estimated to reduce sediment loss by roughly 400 tons annually. Early biological and water-quality responses indicate improving conditions in these systems. Fish and macroinvertebrate samples collected from Judicial Ditch 28 in 2023 met AQL use standards, and water-chemistry monitoring conducted on the West Branch of Zippel Creek during the 2023-2024 monitoring period showed no exceedances of the 15 mg/L TSS standard.

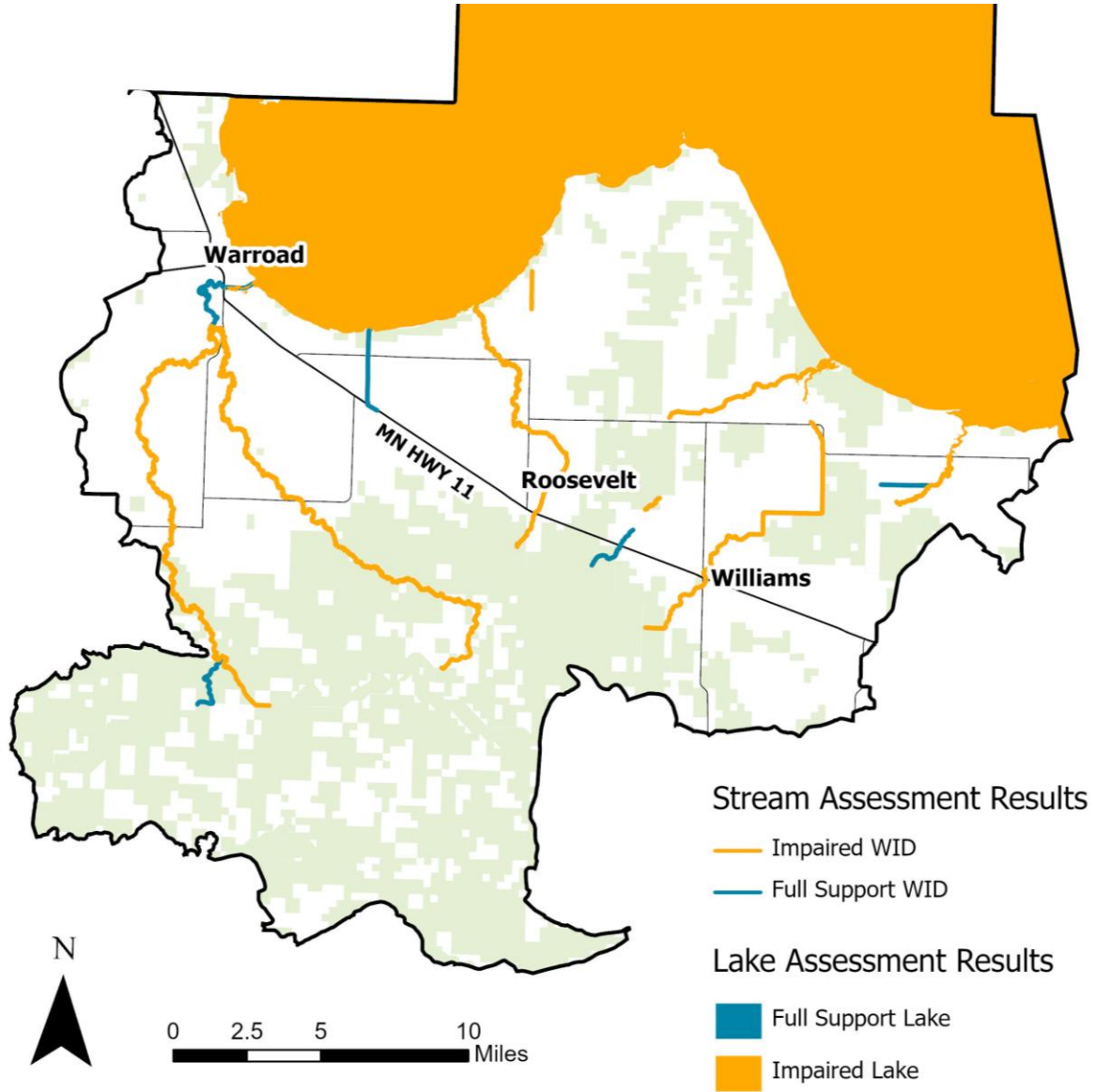
Although conditions for aquatic life have degraded across numerous tributaries within the watershed, both the East and West Branch of the Warroad River continue to support some of the most well-preserved fish and macroinvertebrate assemblages within northwestern Minnesota. Northern brook lamprey, a Minnesota species of special concern, has been recorded from numerous sites in both East and West Branch of the Warroad River. Several pollution intolerant types of midges were collected in this stream section in 2023 including *Xylotopus par*, *Synorthocladius*, *Nilothauma*, and *Stempellina*. The caddisfly species *Phyloctropus placidus* was also collected, which is notable as this represents its farthest western record in Minnesota. Both branches of the Warroad River are excellent targets for future restoration or protection efforts due to the presence of these unique and well-preserved biological communities.

### Aquatic recreation use

Of the seven streams assessed for recreational use within this watershed, five were found to be impaired due to high *E. coli* levels. Williams Creek, East Branch of the Warroad River, Bostic Creek, and West Branch of Zippel Creek are now impaired for aquatic recreation use due to high *E. coli* levels measured during the summers of 2023 and 2024. An existing aquatic recreation impairment was confirmed on the West Branch of the Warroad River after monitoring in 2023 and 2024. *E. coli* bacteria levels have increased at Williams Creek, East Branch of the Warroad River, and Bostic Creek when compared to the data available during the first cycle of assessment in 2014. *E. coli* bacteria levels measured at Willow Creek and the mainstem Warroad River meet standards for aquatic recreation use.

For more information on the existing aquatic recreation use impairment on the Lake of the Woods, and Fourmile Bay, please refer to the [Lake of the Woods Excess Nutrients TMDL Report](#), which details over a decade of cooperative monitoring and research to understand the causes of the lake's late-summer algal blooms, and the nutrient reductions needed to meet water quality standards long-term.

Figure 5. Assessment results for aquatic life and aquatic recreation on rivers, streams, and lakes in the Lake of the Woods Watershed.



## Trends

A key objective of the 2023-2024 monitoring effort was to evaluate if and how water quality has changed since the initial monitoring in 2012-2013. If water quality has improved, it is important to understand to what extent human actions may be responsible for the change. It is equally important to understand if water quality does not appear to be changing or is declining. Either way, the knowledge will help inform future activities.

Trends in three different aspects of water quality were analyzed to determine whether environmental conditions are changing in the Lake of the Woods Watershed:

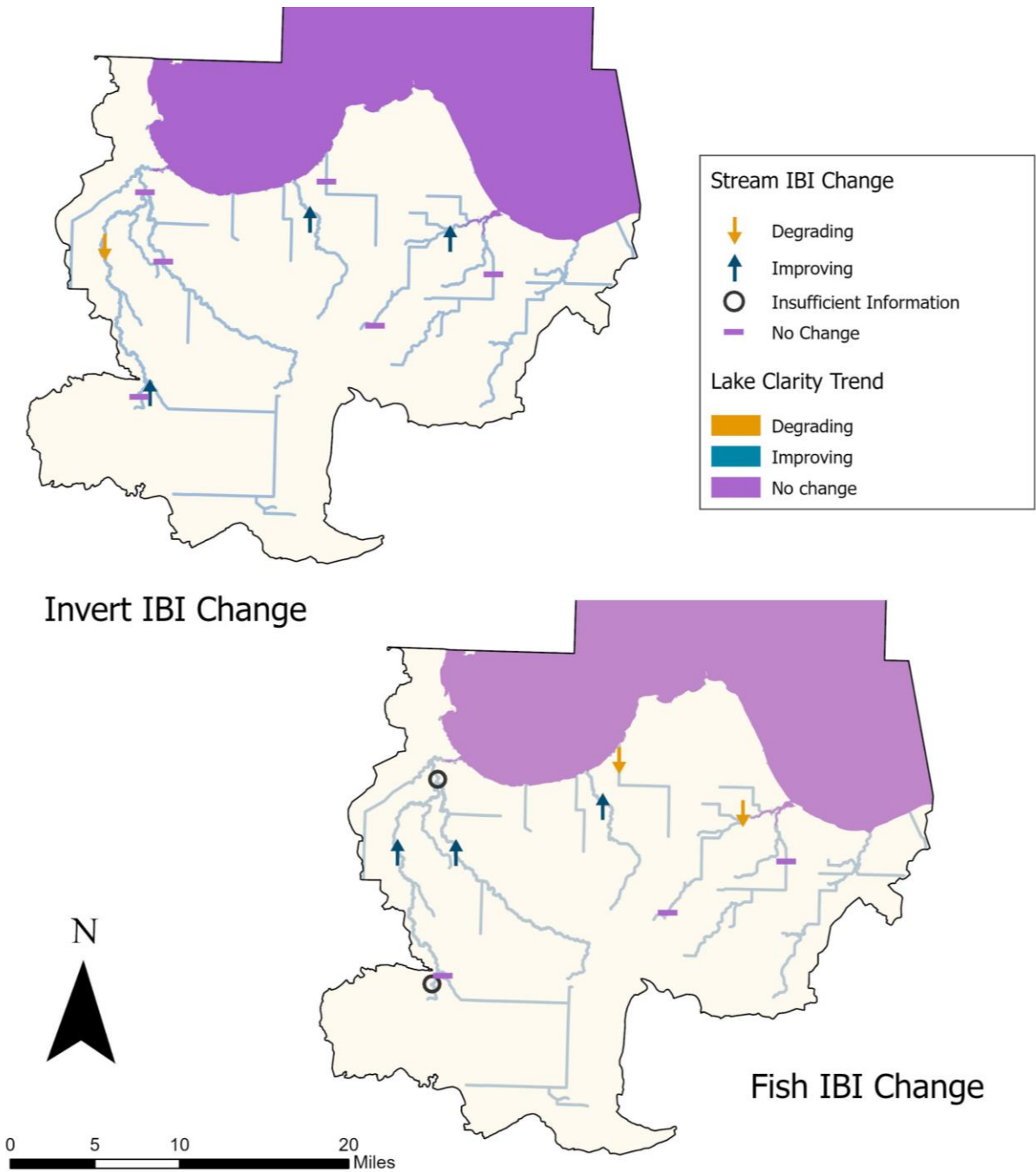
1. Streamflow, sediment (total suspended solids), TP, and nitrogen (nitrate)
2. Biological communities
3. Climate

### Streamflow and pollutant concentrations

The Watershed Pollutant Load Monitoring Network (WPLMN) collects long-term water quality and visual assessment data at approximately 200 stream sites statewide. Due to the small size and drainage areas of streams within the Lake of the Woods Watershed, lack of road access, and backwater issues from Lake of the Woods, there are no WPLMN river or stream monitoring sites located within this watershed.

The closest WPLMN monitoring location is the Rainy River at Manitou Rapids, which is notable as the Rainy River is the largest tributary to the Lake of the Woods. At this WPLMN site, the Rainy River is showing a decrease in phosphorus load while nitrate and sediment loads show no trend. The Rainy River and its tributaries (mainly the Little Fork River) are the single largest source of phosphorus loading to the Lake of the Woods, which is currently impaired for AQL use due to excess nutrients. A declining trend in phosphorus load on the Rainy River mirrors a 19% decline in summer-average phosphorus concentrations measured in the Lake of the Woods as well as a gradual decline in algal bloom intensity. For more information on the existing aquatic recreation use impairment on the Lake of the Woods, and the Lake of the Woods - Fourmile Bay, please visit the [Lake of the Woods Excess Nutrients TMDL Report](#), which details over a decade of cooperative monitoring and research to understand the causes of the lake's late-summer algal blooms, and the nutrient reductions needed to meet water quality standards long-term. See this link for further information about [Minnesota's Watershed Pollutant Load Monitoring Network](#).

Figure 6. Trends in both fish and macroinvertebrate IBI scores in streams across the Lake of the Woods Watershed.



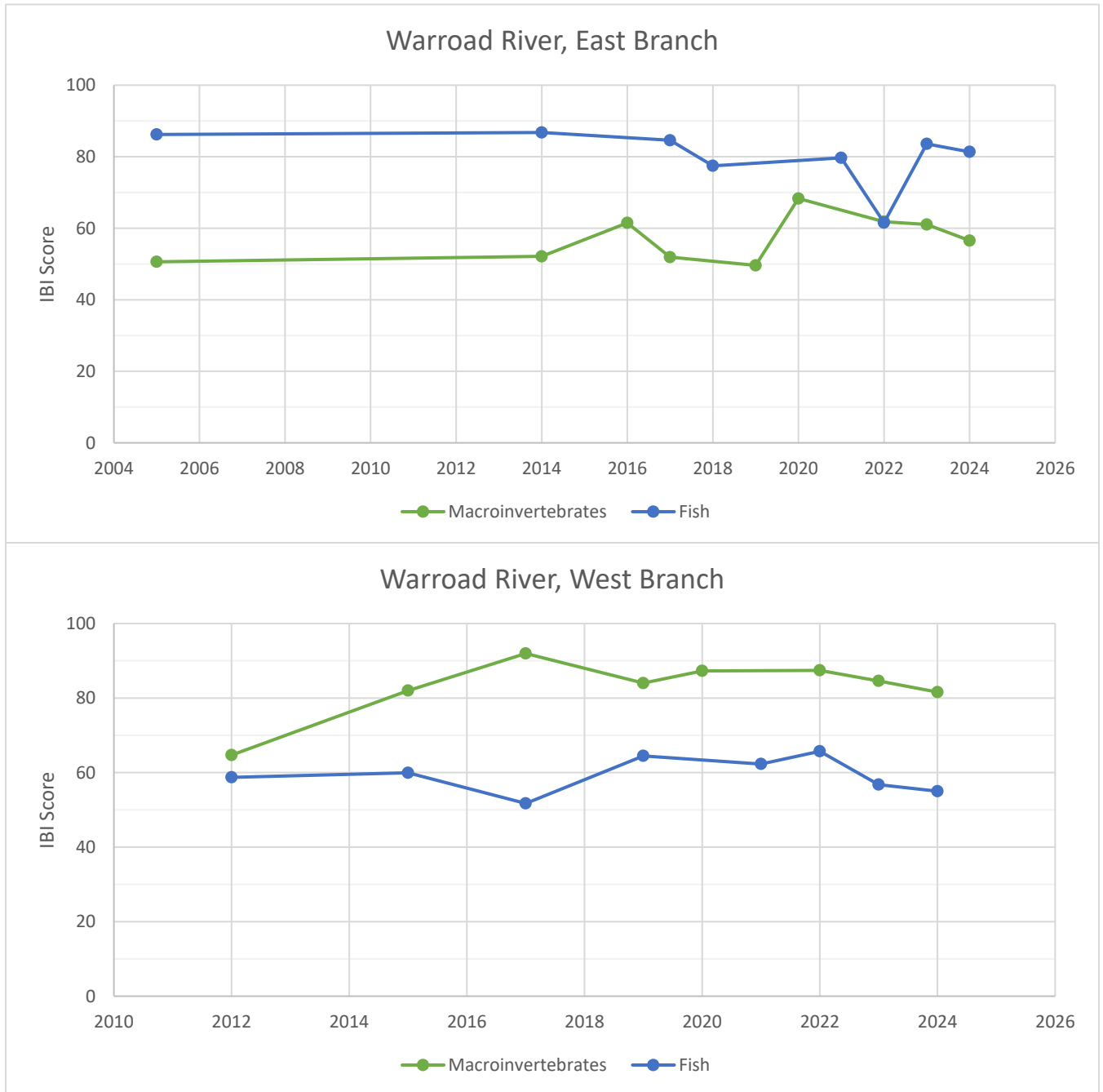
## Biological communities

Paired t-tests of fish and macroinvertebrate IBI scores were used to evaluate if the biological condition of the assessed rivers and streams has changed between sampling in 2012-2013 and 2023-2024. Independent tests were performed on each community with eight sites evaluated for macroinvertebrates and 10 sites evaluated for fish (sites that were sampled in both time periods). The average macroinvertebrate IBI score for the watershed increased by 4.1 points between 2012-2013 and 2023-2024; however, this does not represent a statistically significant change. Fish IBI scores decreased by 6.8 points, which was also not statistically significant.

While the overall health of fish and macroinvertebrate communities across the watersheds did not change between time periods, biological condition at individual stream sites has significantly improved or degraded ( $\pm 10$  IBI points) (Figure 6). Improvement was particularly notable on the East Branch of the Warroad River, where two sites sampled in 2023-2024 both produced higher IBI scores when compared to results in 2012-2013. Macroinvertebrate IBI scores now indicate that the entirety of the East Branch contains well preserved macroinvertebrate communities. As a result of this improved IBI performance, the existing AQL use impairment on the East Branch was removed from the Impaired Waters List in 2025.

While most of the fish and macroinvertebrate sampling in the watershed is conducted during the intensive watershed monitoring effort (every 10 years), the MPCA's Biological Monitoring Program also maintains a network of approximately 80 minimally disturbed sites across Minnesota, which it samples on an every-other-year schedule. This monitoring network allows the MPCA to track broad changes in the health of biological communities across the state and helps the MPCA to measure variation within its IBI assessment tools. Two of these minimally disturbed reference sites are located within the watershed and have been sampled regularly over the last 10-15 years (Figure 7). At both the East Branch and the West Branch of the Warroad River, long-term biological monitoring site, fish and macroinvertebrate IBI scores have remained relatively stable across numerous samples. Both sites are located in the upper Warroad River drainage and serve as some of the best representations of well-preserved fish and macroinvertebrate communities in streams across Northwestern Minnesota.

**Figure 7. Fish and macroinvertebrate IBI scores have remained relatively consistent for across multiple visits to the long-term biological monitoring sites on the Warroad River, East Branch and the Warroad River, West Branch. Both locations continue to support well preserved fish and macroinvertebrate communities.**

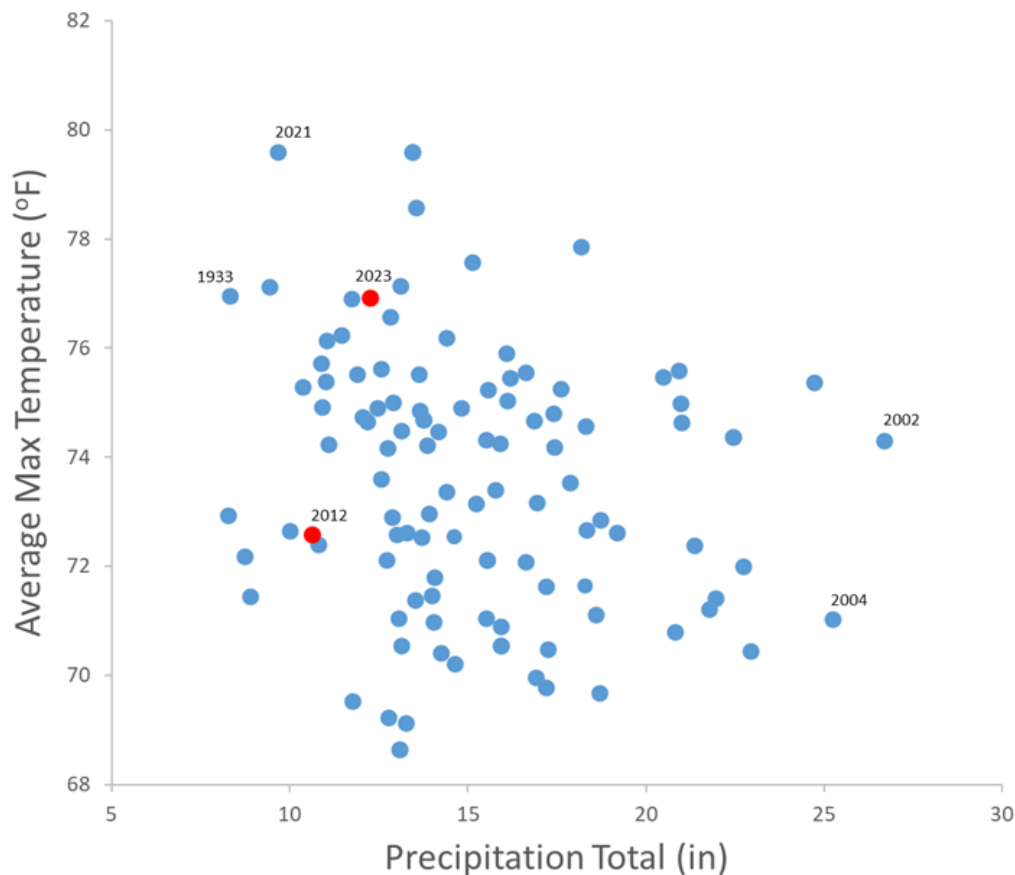


## Climate

This watershed now receives on average 1.8 additional inches of rain from the historical average (1895-2018). Furthermore, climate scientists suggest that precipitation events are becoming more intense. In addition, yearly average temperatures in the watershed have increased by 1.8°F over this time period with warming most severely pronounced during the winter months (3.8° winter average increase). Increased rainfall and temperature can worsen existing water quality problems. More precipitation and reduced snow cover can increase soil erosion, pollutant runoff, and streamflows. Increased streamflow, in turn, can lead to stream channel erosion and degraded habitat for fish and other aquatic life. Longer growing seasons with higher temperatures can lead to increased frequency and intensity of algal blooms, which threatens recreational use and the health of fisheries within the Lake of the Woods.

The watershed experienced below average precipitation in both the summer of 2012 and 2023, when the bulk of the intensive monitoring was conducted. Broadly comparable rainfall and summer average temperatures minimize a source of potential variability when comparing data from the two periods of intensive watershed monitoring (Figure 8).

**Figure 8. Characterization of air temperature and rainfall conditions (total measured in inches) for May-September period across historical record for the Lake of the Woods Watershed. Biological monitoring years for the watershed highlighted in red.**



## For more information

This study of the Lake of the Woods Watershed was conducted as part of [Minnesota's Watershed Approach](#) to restoring and protecting water quality. Efforts to monitor, assess, study, and restore impaired waters, and to protect healthy waters are funded by Minnesota's Clean Water, Land, and Legacy Amendment. Stressor identification for new impairments and updates to the Watershed Restoration and Protection Strategy follow the completion of monitoring and assessment. This approach allows for efficient and effective use of public resources in addressing water quality challenges across the state. The data and assessments produced by this study can inform local efforts to restore and protect waters in the Lake of the Woods Watershed, such as the One Watershed, One Plan document, a comprehensive watershed management plan that targets projects to protect and restore the watershed's most valuable resources. For more information on assessment decisions and reports, visit the [MPCA's Lake of the Woods Watershed](#) webpage, or search for "Lake of the Woods" on the [MPCA](#) webpage.

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