

Pine River Watershed

Upper Mississippi River Basin



The Pine River just downstream of Lake Hattie.

Summary

The Minnesota Pollution Control Agency (MPCA), Minnesota Department of Natural Resources (DNR), and local partners have completed a study of the Pine River Watershed. This heavily forested watershed contains prominent lakes such as the Whitefish Chain of Lakes and Pelican Lake, along with numerous other lakes used for recreational activities that are important to the local economy. Healthy fish and macroinvertebrate communities were found throughout the Pine River Watershed. In fact, half of the 46 lakes assessed for aquatic life contained exceptional fish communities. Exceptional fish communities were also found in many streams, along with healthy macroinvertebrate communities. Additionally, most lakes and streams met water quality standards designed to protect aquatic recreation (i.e., swimming).

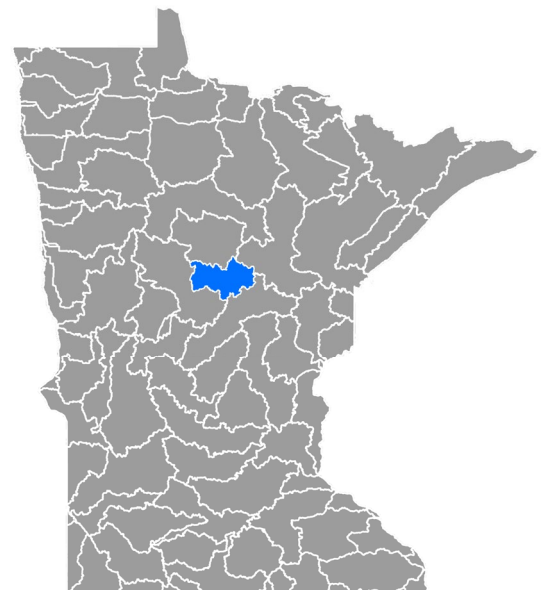
Instead of relying on chemical testing of the water alone, scientists reached their conclusions through also studying the variety of fish and macroinvertebrates (aquatic insects) living in these waters. Doing so offers a more comprehensive understanding of the watershed's health over time. Volunteer water quality monitors contributed to the assessment, which is funded by Minnesota's Clean Water Land and Legacy Amendment. Details in the full report will shape decisions on watershed management and pollution reduction measures for years to come.

Watershed Study

Water quality monitoring is essential to determine whether lakes and streams meet water quality standards designed to ensure that waters are fishable and swimmable. The MPCA and local partners conduct an intensive exam of major lakes and streams in each of the state's 80 watersheds every ten years to detect any changes in water quality (Figure 1). This intensive monitoring looks at fish and macroinvertebrate communities as well as water chemistry to gauge water quality. The data are used to determine which waters are healthy and need protection and which are impaired and need restoration. Waters are considered impaired if they fail to meet water quality standards.

The MPCA and partners monitored water quality conditions within the Pine River Watershed in 2012-2013 and again in 2023-2024. Any additional chemistry data collected by local partners between 2014 and 2023 were used for assessment. The data were used to assess the condition of waterbodies, with a focus on whether they are meeting water quality standards for aquatic life, recreation, and consumption. The overall goal of these assessments is to ultimately determine which waters are healthy and in need of protection or are polluted and require restoration.

Figure 1. The Pine River Watershed (highlighted in blue) is one of 80 major watersheds within Minnesota.



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.

Over the past decade, scientists observed little change in water quality within the Pine River Watershed. Most waterbodies continued to exhibit excellent water quality that supports aquatic recreation and aquatic life. Numerous intolerant fish species (i.e., blackchin shiner, longnose dace, burbot, pugnose shiner, logperch) were found in lakes and streams throughout the watershed. Sensitive and/or intolerant macroinvertebrate species were found in the Pine River and several of its tributaries. Intolerant species are among the most sensitive to any disturbance or degradation in their environment; the presence and persistence of these species are an indicator of good water quality. Large tracts of forested land, combined with numerous wetlands and light development, contribute to stable stream flow and good stream habitat. These conditions have also helped maintain water quality within the many lakes that have streams flowing through them. Some of these waterbodies support populations of cisco, lake whitefish, and lake trout—all species that are dependent upon cold, oxygenated water for their survival. Eutrophication (excess nutrients) would reduce the availability of oxygen within the deeper areas of these lakes that meet the temperature requirements for these species. Overall, sediment and nutrient levels throughout the watershed have remained low; however, excess nutrients (phosphorus) were still an issue in lakes with previous known impairments.

- During the last ten years, there hasn't been any significant change in the condition of fish and macroinvertebrate communities. Most monitoring stations produced good IBI scores for both assemblages. The Pine River Watershed continues to support numerous fish and macroinvertebrate species that are intolerant of pollution.
- Two small headwater streams, Thompson Creek and Stony Creek, were found to have poor fish communities and are impaired for aquatic life. Recent monitoring data confirmed the existence of a previously known aquatic life impairment on Wilson Creek.

A total of 56 lakes had sufficient data to assess for aquatic recreation; all were found to be fully supporting. Most of the lakes within the watershed are in good condition, with no new impairments resulting from the latest assessment cycle. Recent monitoring data confirmed the existence of a previously known aquatic recreation impairment on Lake Emily.

A portion of the headwaters of the Little Pine River was found vulnerable to nutrients and low dissolved oxygen. Though not impaired, the vulnerable status indicates nutrient and dissolved oxygen concentrations are close to exceeding the standard.



The combination of forested land, lower development, and numerous wetlands have allowed the Pine River Watershed to continue to support high quality aquatic resources.



The Pine River Watershed continues to support numerous fish species that are intolerant to pollution, including the least darter and northern sunfish, two species of special concern. Pugnose shiner, a threatened species, are also found in the watershed.

Highlights of monitoring

- A total of 50 fish species were collected in lakes during fish IBI sampling. Of these, 16 are considered intolerant species—susceptible to pollution, shoreline habitat disturbance, and watershed disturbance. Least darter and northern sunfish are State Species of Concern, and the pugnose shiner is State Threatened. Notable species included burbot, cisco (tullibee), lake whitefish, and lake trout which are considered cold water species, requiring cold, oxygenated water to survive.
- 50% of the 46 lakes assessed for aquatic life contained exceptional fish communities. Exceptional fish communities are high quality assemblages that are similar to what may have been present in pre-settlement times. Forested lands and other undeveloped lands within the watershed have helped to maintain the high quality water and healthy habitat necessary to support the exceptionally diverse fish communities and/or cold water species found in many of the sampled lakes.
- Exceptional fish communities were found in the lower reaches of the Pine River, the Little Pine River, Pelican Brook, and the headwaters of the South Fork of the Pine River.
- Two species of special concern, the least darter and northern sunfish, as well as the pugnose shiner, a state threatened species, were found in Daggett Creek near Fifty Lakes. Least darters were also found at stations located on the lower Pine River and Pelican Brook.
- Seven out of nine stations sampled on the Pine River had macroinvertebrate IBI (MIBI) scores exceeding the general use upper confidence interval. The other two stations had MIBI scores very close the upper confidence interval. These communities contained good diversity including sensitive and intolerant taxa.



Numerous intolerant fish species, including lake whitefish, were collected from lakes within the Pine River Watershed during fish index of biotic integrity (FIBI) sampling. Photo courtesy of Derek Bahr.



Pelican Brook, a tributary that flows from Ossawinnamakee Lake to the Pine River, supports excellent fish and macroinvertebrate communities. This stream produced the highest fish and macroinvertebrate IBI scores in the Pine River Watershed.

Success story

Willow Creek, a small tributary stream that flows into the Whitefish Chain of Lakes, was found impaired for aquatic life due to a poor fish community. Stressor identification determined the cause to be an area of severe erosional deposition, located further downstream in the reach. Cattle access to the stream had resulted in eroded banks and severe channel instability. The landowner and Crow Wing County Soil and Water Conservation District (SWCD) worked cooperatively to restore the stream banks by stabilizing them through the establishment of protective vegetation. Cattle were removed from the pasture and native vegetation was planted along the stream banks.

Since the restoration effort, the stream channel has begun to recover, and vegetation has successfully grown along the banks. Recent monitoring data collected from the original monitoring location have confirmed that the fish community is improving. Fish were also sampled within the restoration site, and the fish community was exceptional. The fish community will continue to improve throughout this system because of this restoration effort. In time, Willow Creek will no longer be considered impaired for aquatic life due to the efforts of the landowner and Crow Wing County SWCD.



Bank stabilization efforts undertaken along Willow Creek.



Bank stabilization and riparian restoration areas along Willow Creek.



The restoration area of Willow Creek, as seen during June of 2023.

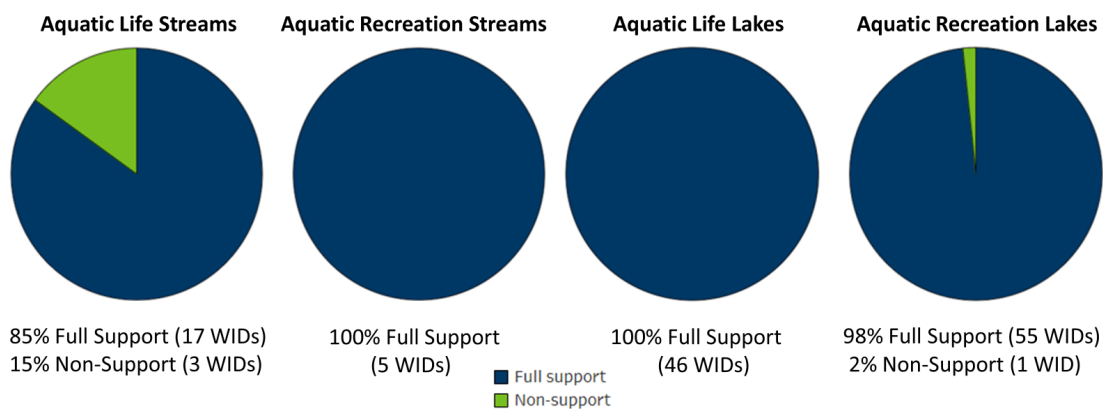
Watershed assessment results

Streams and rivers

Seventeen out of the 20 stream reaches that were assessed for aquatic life were fully supporting (Figure 2). Most fish samples contained several sensitive and/or intolerant insectivorous species, which is indicative of good water quality and low watershed disturbance. The continued presence of species of special concern and threatened species is a testament of the overall excellent health of this watershed. Macroinvertebrate samples indicate that stream conditions are healthy and stable. Most stations produced MIBI scores above general-use thresholds, reflecting diverse and well-balanced assemblages.

Aquatic life impairments were found in smaller headwater streams that are more easily affected by beaver activity and immediate surrounding land use. Stony Brook and Thompson Creek both had poor fish communities that were likely the result of downstream barriers (beaver dams). Recent monitoring data confirmed the previous aquatic life impairment on Wilson Creek. The 2024 macroinvertebrate sample was dominated by tolerant taxa, resulting in a low MIBI score similar to the results found during 2012. One reach located in the headwaters of the Little Pine River was found vulnerable to nutrients and low dissolved oxygen (DO) but is not currently impaired. Land use for this catchment consists primarily of mixed forest and wetlands, along with small areas of development and pasture land. Upstream wetlands could be contributing to low DO and elevated nutrient concentrations found in this reach. The fish and macroinvertebrate communities collected from this reach indicate support for aquatic life. Across the watershed, bacteria levels were low. All the stream reaches that had sufficient bacteria data to assess for aquatic recreation use were fully supporting (Figure 2).

Figure 2. Watershed assessment results for aquatic life and aquatic recreation in streams and lakes.



Lakes

Within the Pine River Watershed, the DNR assessed 46 lakes for aquatic life for the first time using a fish-based IBI developed for Minnesota lakes. Data was available for 54 lakes. However, after excluding the eight lakes with inconclusive or insufficient information, the remaining 46 lakes were found to fully support aquatic life. A large percentage of those lakes (i.e., 50%) contained exceptional fish communities, including Whitefish, Cross Lake, Pine Mountain, Ossawinamakee, Roosevelt, O'Brien, and Five Point Lakes. None of the lakes were determined to be impaired, but 7.4% (i.e., Mary, Ruth, Adney, and Island-Loon lakes) are vulnerable to impairment based on the fish IBI. Stressors that are likely influencing these fish communities include excess nutrient inputs from developed land uses and degraded and/or developed shorelines.

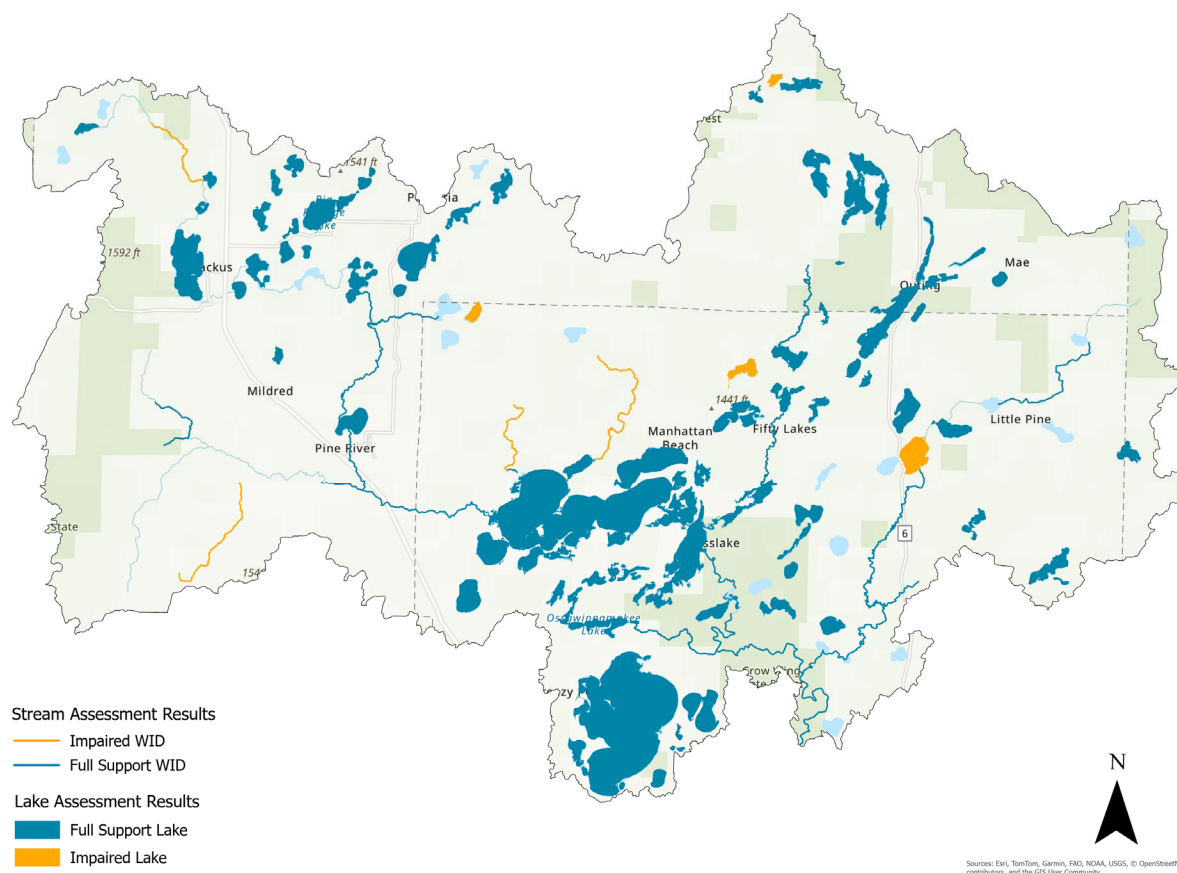
Similarly, temperature and DO profiles were collected in 27 lakes to evaluate the quality and quantity of cold, well-oxygenated habitat available to cold water species such as lake whitefish and cisco. Preliminary analysis indicates that all but one have sufficient habitat to support these species. The contributing watershed of lakes supporting aquatic life were generally forested and/or contained wetlands. The shoreline conditions of these lakes ranged from poor to high-quality and averaged slightly lower than the statewide average; noticeable development pressure is occurring within the watershed. Efforts to protect the forested lands and undeveloped, natural shorelines associated with these lakes should continue to ensure the water quality and habitat remains intact to support the diverse suite of species residing in these lakes.

The MPCA assesses lakes against eutrophication standards, which are the primary basis for the aquatic recreation beneficial use assessments in lakes. Excessive nutrient loads, in particular Total Phosphorus (TP), lead to increased algae blooms and reduced transparency—both of which may significantly impair or prohibit the use of lakes for aquatic recreation. Seventy-eight lakes within the watershed had available eutrophication data from the 2015-2025 assessment window. A total of 55 lakes were found to be fully supporting aquatic recreation. Overall, the lakes are in good condition, with no new aquatic recreation impairments resulting from the 2025 assessment cycle.

Four lakes had existing nutrient impairments; one of these was confirmed by recent data. Available data for Lake Emily indicate that this lake is still impaired, with all three eutrophication parameters exceeding regional standards. Long-term clarity trends provide evidence of degrading water clarity (decreasing approximately 1.5 feet per decade). Land use disturbances from increased shoreline development were noted, particularly on upstream Mary Lake, as contributing to excess nutrient concentrations. Kego Lake has been impaired for nutrients since 2009; however, data available for this assessment indicate some improvements in nutrients and clarity for this lake. Chlorophyll-a continues to exceed regional eutrophication standards. Additional restoration and protection strategies that target nutrient reduction should continue to be prioritized for Kego Lake. An approved Total Maximum Daily Load (TMDL) study for Kego Lake found shoreline, private on-site septic systems and logging operations to be the primary source of excess nutrients.

Protection priority should be given to lakes particularly sensitive to an increase in phosphorus. This includes lakes with a documented decline in water quality (measured by Secchi transparency), a comparatively high percentage of developed land use in their watershed, or monitored phosphorus concentrations close to the water quality standard. George, Norway, Beuber, Ross, Island (18-0183-00), Perry, Smokey Hollow and Arrowhead Lake are not currently impaired but were identified as vulnerable to exceeding water quality standards for aquatic recreation use. Mary Lake is not currently impaired but was identified as vulnerable to exceeding water quality standards for both aquatic life and aquatic recreation use. In particular, Ross and Mary Lake had assessments near the threshold of impairment for eutrophication; algal concentrations and low clarity were the primary driving factors.

Figure 3. Assessment results for aquatic life and aquatic recreation on rivers, streams, and lakes.



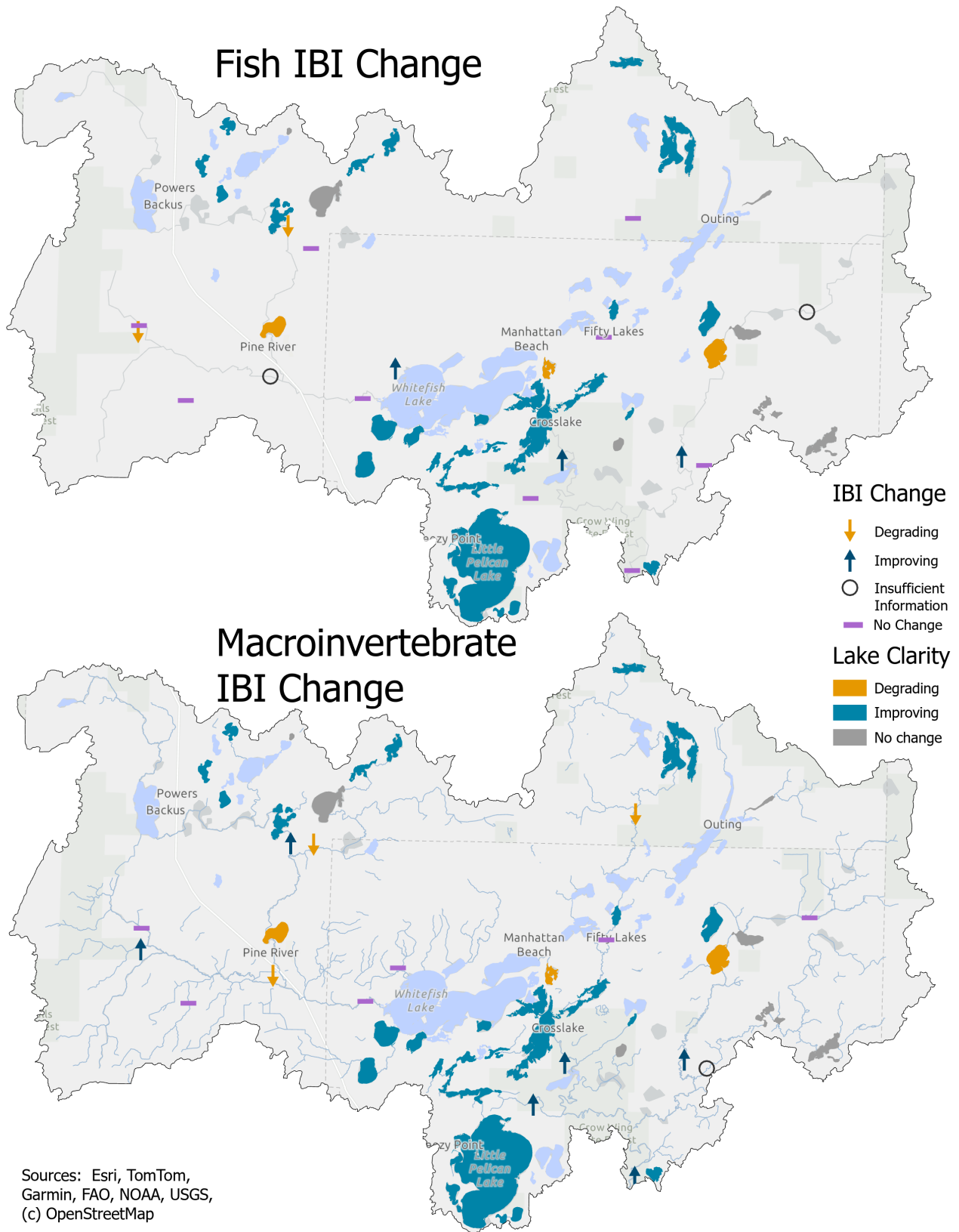
Trends

A key objective of the 2023 monitoring effort was to evaluate if water quality has changed since 2012 (Figure 4). If water quality has improved, it is important to understand to what extent strategy development, planning, and implementation may be responsible. 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 four different aspects of water quality were analyzed to provide as robust a picture as possible of what is happening in the Pine River Watershed:

- 1) Streamflow, sediment (total suspended solids), TP, and nitrogen (nitrate)
- 2) Biological communities
- 3) Clarity of lakes
- 4) Climate

Figure 4. Change in water quality in the Pine River Watershed.



Streamflow and pollutant concentrations

Long-term water quality and stream flow monitoring occurs annually throughout Minnesota, with intensive sampling across a range of flow conditions. For more information about this sampling, please visit: <https://www.pca.state.mn.us/wplmn>. Annual streamflow (discharge) data for the Pine River Watershed were available since 2008, and water chemistry data available since 2009. Both parameters were measured at the watershed outlet on the Pine River near Mission at CSAH 11, approximately one mile upstream of the confluence with the Mississippi River.

Seasonal Kendall trend testing (statistical analysis) on suspended sediment (TSS), phosphorus (TP), and nitrate-nitrogen concentrations were used to determine if changes over time were statistically significant. In this case, trends were analyzed using data from 2009-2023 at the outlet station. TP concentrations showed a significant decreasing trend while TSS showed no significant change during the sampling period. Nitrate-nitrogen had over 50% of sample results below the lab detection limit (meaning low concentrations), in which case the parameter cannot be analyzed for long term trends with the high number of below detection limit samples.

Streamflow and water chemistry data were also available at an additional site on the Pine River, located near the town of Jenkins, roughly one mile upstream of Upper Whitefish Lake. Although only sampled since 2015, which does not yet provide enough data for statistical trend analysis, general analysis can be performed to analyze pollutant concentrations during this timeframe. From 2015-2023, nitrate-nitrogen and TP are both slightly increasing while TSS is slightly decreasing at this station.

Interestingly, when the two sites are compared during the same timeframe (2015-2023), pollutant concentrations at the downstream station contradict concentration trends during the long term dataset (2009-2023). Contrary to the 2009-2023 dataset from the downstream station, nitrate-nitrogen and TP both are slightly increasing, while TSS is slightly decreasing. It is important to analyze both the long and short term pollutant datasets (when available) for a comprehensive understanding of watershed health, environmental impacts and change. The results of both analyses show the long and short term history of pollutant concentrations within this watershed and how they may be changing. The analysis also allows for comparisons of the two sites during the same timeframe.

These two stations, one located upstream (Jenkins) and one located downstream (Mission) of the Whitefish Chain of Lakes, show how these lakes may have an effect on the concentrations of pollutants within this watershed. In addition to the Pine River flowing through this chain of lakes, there is also a dam at the outlet of Cross Lake, all of which may influence pollutant concentrations. Pollutant flow weighted mean concentrations decreased for all parameters from upstream to downstream; nitrate-nitrogen from 0.07 milligrams per liter (mg/L) to 0.05 mg/L, TP from 0.5 mg/L to 0.02 mg/L and TSS from 4.5 mg/L to 3.6 mg/L, respectively. With all three parameters declining in concentrations from upstream to downstream, the lakes appear to be diluting and/or allowing pollutants to settle and be retained within their respective basins.

Figure 5. Pine River Watershed percent deviation from normal flow (cfs) over time.

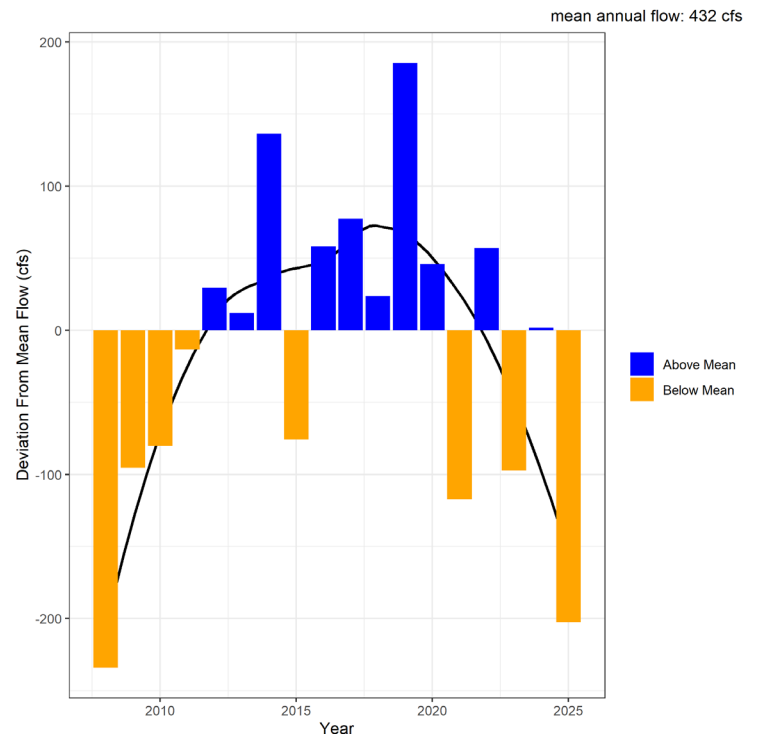


Figure 5 shows the percent deviation from normal flow over time at the Pine River outlet station (Mission). The changing yearly average flow (black line) is calculated using LOESS (locally estimated scatterplot smoothing) with the yellow and blue bars showing each year's deviation as above (blue) or below (yellow) the mean (432 cubic feet per second [cfs]). For reference, the difference of average flow per year is significant between sites, with the outlet station averaging 320,028 acre feet per year versus 83,779 acre feet per year, respectively. Significant increases in flow have negative implications for stream channel conditions and pollutant loading. This could result in more channel erosion and possible increased pollutant loading, even if pollutant concentrations are stable. Loads represent the total amount of a pollutant moving through a system, providing important information for downstream resources such as the Mississippi River, where these pollutants may accumulate.

It should be noted from a watershed and statewide perspective, the parameters within the Pine River Watershed have low concentrations when compared to other watersheds throughout the state. The watershed is located within a transitional area of the state where the concentrations of all parameters are nearly the same or lower in watersheds to the east and northeast but slightly higher in watersheds to the west and southwest (Figure 6). Nitrate-nitrogen and TP are the primary pollutants of concern within this watershed based on apparent increasing short-term trends at both stations. However, as mentioned previously, these concentrations are low when compared to other watersheds in Minnesota.

Biological communities

Paired t-tests (statistical analysis) of fish and macroinvertebrate IBI scores were used to evaluate if biological condition of the watershed's rivers and streams has changed between time periods. (A similar change analysis was not completed for lakes because comparable fish community data had not been collected during the first time period). Independent tests were performed on each community with 15 sites evaluated for macroinvertebrates and 14 sites evaluated for fish (i.e., sites that were sampled in both time periods). Between 2012 and 2023/2024, the average macroinvertebrate IBI score increased by 5.0 points and fish IBI scores decreased by 0.4 points. However, neither change was statistically significant. While individual stations demonstrated variability in IBI scores relative to Cycle I, overall fish and macroinvertebrate communities in the Pine River Watershed remain stable.

Climate and extreme weather events can influence the condition of waterbodies and obscure changes that result from restoration/protection efforts, changes in land use, and hydrologic alteration (i.e., changes related to policies, regulations, and management activities). Therefore, it is important to compare climatic conditions that occurred

Figure 6. Pine River Watershed (black outline) TP concentrations compared to statewide TP concentrations (mg/L).

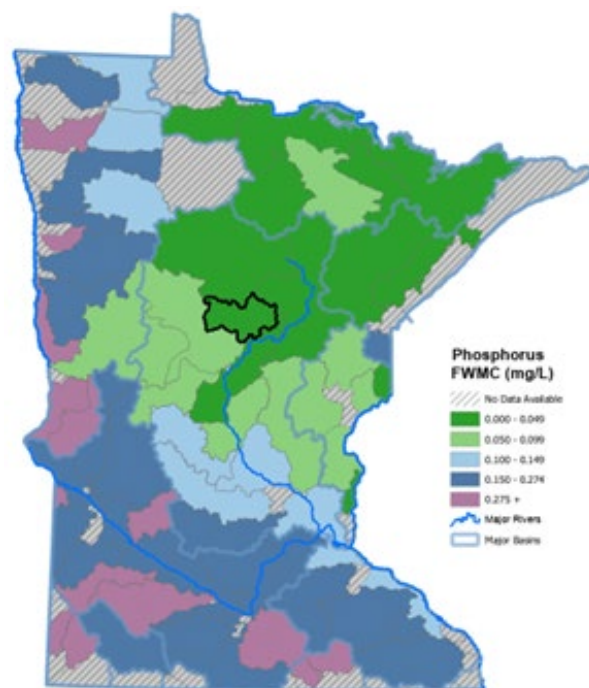
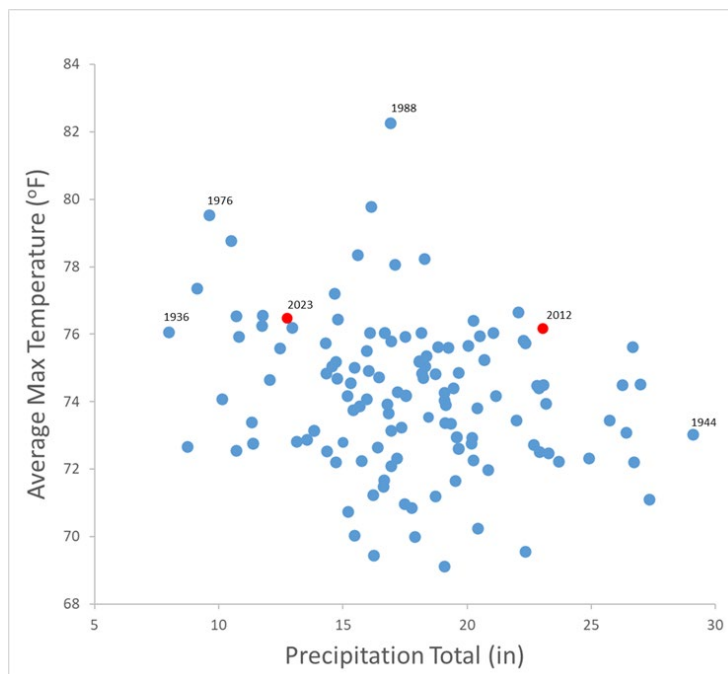


Figure 7. Characterization of air temperature and rainfall conditions for May-September period across historical record of climate data for the Pine River Watershed (1898-2024). Intensive watershed monitoring (IWM) years highlighted in red.



during each monitoring cycle to better understand and interpret the results (Figure 7). In 2012, the Pine River Watershed experienced greater than normal precipitation (+5.2 inches) and was abnormally warm (+1.8 °F) during the May to September time period. In comparison, the watershed had a severe rainfall deficit (-5.1 inches) and was abnormally warm (+ 2.0 °F) in 2023 over the May to September time period, resulting in drought conditions that summer. Overall, given the wetter than normal conditions affecting the watershed in 2012 and the extremely dry conditions of 2023, there is a high likelihood that any observed changes in biological condition at either the watershed or individual site scale are at least partially due to differences in climatic conditions between the two periods.

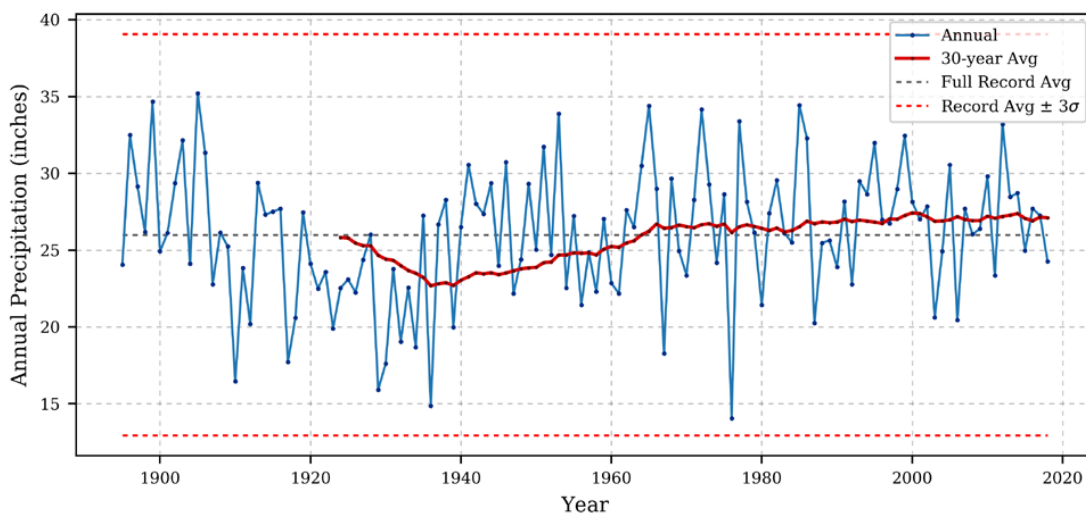
Clarity of lakes

One-hundred lakes within the Pine River Watershed had at least some transparency data available. A trend analysis was conducted on 80 lakes that met data requirements (50 Secchi measurements, eight years of data). Like statewide results, most lakes do not exhibit a significant trend, and there were more lakes with improving water clarity than with declining clarity. Twenty-nine lakes had increasing clarity, three lakes had degrading clarity, nine lakes showed no change, and the thirty-nine remaining lakes analyzed showed no trend (Figure 4). The three lakes with degrading clarity are Norway, Ox and Emily. All three of these lakes have highly developed shorelines or fall within highly developed watersheds, which may help to inform protection and prioritization efforts in this region of the watershed. Much of the data needed to determine these trends was collected by local volunteers through the [MPCA’s Volunteer Water Monitoring Program](#).

Climate

The Pine River Watershed now receives an additional 1.1 inches of rain compared to the historical average (1895-2018, Figure 8). Furthermore, climate scientists suggest that precipitation events are becoming more intense. Temperatures over this period have also increased by about 1.4 degrees during spring and fall, and 3.1 degrees during the winter (see [Pine River Watershed Climate Report MNDNR](#)). Increased rainfall and temperature can worsen existing water quality problems. More precipitation and reduced snow cover can increase soil erosion, pollutant runoff, and streamflow. 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 more algal blooms. These changes will complicate efforts to protect and restore the watershed.

Figure 8: Average annual precipitation for the Pine River Watershed (1989-2018).



For more information

This study of the Pine River 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 Pine River 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, go to the [MPCA Pine River Watershed](#) webpage, or search for “Pine River” on the [MPCA website](#).

Contact

Dave Dollinger
Minnesota Pollution Control Agency
david.dollinger@state.mn.us
218-316-3918

