Watershed assessment and trends update

Sauk River Watershed

Upper Mississippi River Basin

Why is it important?

Water monitoring is essential in determining whether lakes and streams meet water quality standards designed for protecting beneficial uses like fishing and swimming. Regional and local water-stewardship groups, along with some state and federal agencies, continually monitor their respective watersheds. Once every 10-years, the Minnesota Pollution Control Agency (MPCA) joins local partners and the Minnesota Department of Natural Resources (DNR) in conducting intensive monitoring of the lakes and streams in each of the state's 80 watersheds. This intensive monitoring looks at fish (all species) and macroinvertebrate communities as a measure of aquatic life health, in addition to water chemistry, to evaluate water quality. Macroinvertebrates are animals that can be seen with the naked eye and have no backbone such as aquatic insects (adult or larval stages), crayfish, and snails. Agency staff and local stakeholder partners collaborate to review the data gathered, which helps to identify healthy (or stressed) waters in need of protection, and impaired waters in need of restoration. This data review and assessment helps to focus future watershed funding and on-the-ground work.

Is the water quality improving?

Scientists observed positive and negative changes in water quality in the Sauk River Watershed since the first round of Intensive Watershed Monitoring (IWM) which occurred in 2008. Macroinvertebrate Index of Biological Integrity (MIBI) scores have improved when averaged across the watershed, whereas the fish (FIBI) scores were similar between monitoring periods. Phosphorous concentrations at the mouth of the Sauk River decreased while nitrate concentrations increased. Fourteen lakes had improving clarity, including Maple, Maria, Sand, Schneider, and Westport which are all currently impaired. Two large and deeper lakes in the watershed (Carnelian and North Brown's), had decreasing clarity trends. As a whole the aquatic life in the smaller headwater streams and ditches were in worse condition than the larger streams and rivers including the Sauk River. Similarly, the sections of the Sauk below the chain of lakes has lower bacteria levels than the upstream sections of the Sauk and its tributaries. Continued problems in the watershed include higher than desired phosphorus (despite some improvement), bacteria levels, and low dissolved oxygen levels.

Highlights of monitoring

- Two lakes (Kings, Bass) have exceptional fish communities.
- Cold Spring Creek (aka Brewery Creek) and Trout Creek are coldwater resources that support trout. Cold Spring Creek, in particular, was found to be very cold and supported a naturally reproducing trout population.
- Overall health of macroinvertebrate communities in the Sauk Watershed has improved from 2007 to 2019. MIBI scores averaged from the same stations sampled in cycle one and cycle two (23 stations) increased by 8.5 points.
- Macroinvertebrate taxa *Amphinemura* and *Glossosoma* were found in Trout Creek. These taxa are rarely found in central Minnesota.
- A macroinvertebrate aquatic life impairment was removed from County Ditch 6 as a result of a sampling visit in 2018 that had a nearly 30 point increase in MIBI score. The riparian zone surrounding the site where MPCA conducted its sampling has been put into the Re-invest in Minnesota (RIM) conservation easement program.
- Pearl is part of the Sentinel Lakes Program, which is an intensive, long-term lake ecosystem monitoring program created to detect and understand the physical, chemical and biological changes occurring in Minnesota's lakes Monitoring Minnesota's changing lakes | Minnesota DNR.

Watershed assessment results

The Index of Biological Integrity (IBI) is a tool that measures a lake, stream, or river's health, using aquatic communities. The IBI is able to discern changes in the aquatic community that are linked to disturbances at the site and in the watershed. The tool uses characteristics of species that are linked to reproduction, feeding (trophic), habitat, and tolerance to pollution. Fish and macroinvertebrate IBIs are used by the MPCA in streams and rivers. The DNR uses a fish based IBI for assessing aquatic life in lakes.

A total of 44 stream segments within the Sauk River Watershed were assessed for aquatic life using either fish and or macroinvertebrates communities in the most recent assessment. Between the first and second rounds of biological monitoring in the Sauk River Watershed, the MPCA adopted new rules to assess aquatic life in channelized streams and ditches (https://www.pca.state.mn.us/water/tiered-aquatic-life-uses-talu-framework). The new rules provide reasonable aquatic life protections for waterbodies that were legally altered prior to the advent of the Clean Water Act. As a result of the new rules, 27 altered (ditched) reaches that were not assessed during the first round of assessments in 2010 were assessed in 2018.

Fish communities in un-channelized streams throughout the watershed generally support aquatic life while channelized (ditched) streams are more likely to be impaired. Twenty-two of the 27 channelized reaches that were assessed are impaired. A consequence of channelization in any watershed is degraded habitat. Aquatic communities typically respond to degraded habitat and or stress from pollutants through a dominance of pollution tolerant taxa and a declining number and or absence of more sensitive taxa. Fish community response to disturbance is reflected through lower IBI scores.

Although relatively rare in this watershed, two streams (Cold Spring, Trout Creek) streams have trout. Cold Spring Creek (aka Brewery Creek) in particular was found to be very cold and have a naturally reproducing brook trout population.

In streams, macroinvertebrate communities exhibit moderate signs of stress when averaged over the entire watershed. Two new macroinvertebrate aquatic life impairments were added as a result of cycle two sampling efforts in the watershed, namely a stretch of the upper Sauk River between Sauk Centre and Melrose and a small tributary to an unnamed creek just west of Farming. With the addition of these two impairments, 28 of the watershed's 51 stream reaches are currently listed as impaired for macroinvertebrates. While the health of macroinvertebrate communities in the Sauk River Watershed is often diminished, a number of relatively intact communities persist. *Glossosoma* and *Amphinemura*, two highly pollution intolerant species that require cold water temperatures, were collected at Trout Creek in 2018. Both of these taxa are rarely found in this portion of the state and speak to this system's combination of well-preserved habitat and uncommon coldwater conditions (one of only two coldwater streams sampled in the watershed). Improvements in MIBI scores in conjunction with changes in use class (biological community expectation) have also resulted in the removal of existing macroinvertebrate impairments on Getchell Creek and County Ditch 6.

Fish IBI data is also used to help determine stressors affecting lakes and make recommendations for protection and restoration activities. Thirty lakes within the Sauk River Watershed were assessed for aquatic life using a FIBI developed for Minnesota lakes. A total of 18 lakes fully supported aquatic life, of those, two are considered exceptional (Kings, Bass). Two lakes (Pearl and Vails) are considered vulnerable to future impairment, and nine lakes (Smith, Carnelian, Pleasant, Eden, St. Anna, Sauk, Little Sauk, Maple, and Osakis) did not support aquatic life.

The diversity of fish in the watersheds lakes was high relative to other Minnesota watersheds. The connection of many lakes to the Sauk River and/or the Mississippi River make species colonization in lakes possible. Across the Sauk River Watershed, 53 total fish species were captured in 30 lakes during FIBI sampling. Fourteen of these species are considered to be intolerant to anthropogenic stressors within the watershed, while five species were considered to be tolerant to these stressors. Lakes that did not support aquatic life had an increased percentage of land use disturbance when compared to fully supporting lakes (Figures 1 and 2). Likewise, lakes that supported aquatic life tended to have lower dock densities with 44% of fully supporting lakes having above average dock densities, compared to 67% of impaired lakes.

Figure 1. Watershed assessment results for aquatic life and aquatic recreation in streams and rivers.

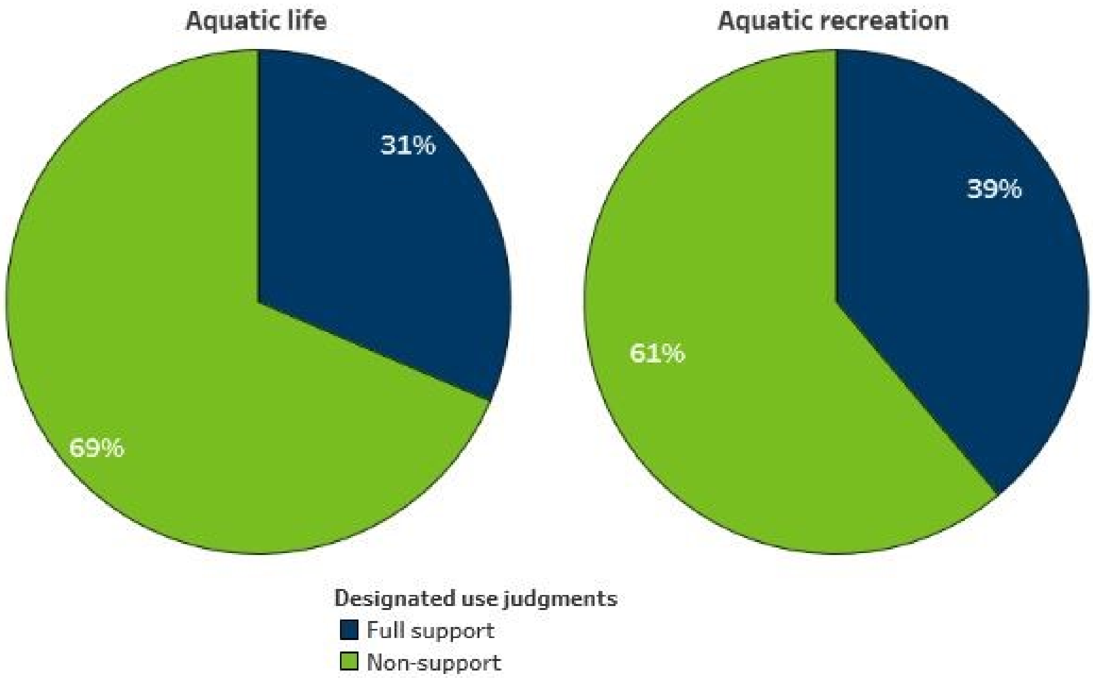


Figure 2. Watershed assessment results for aquatic life and aquatic recreation in lakes.

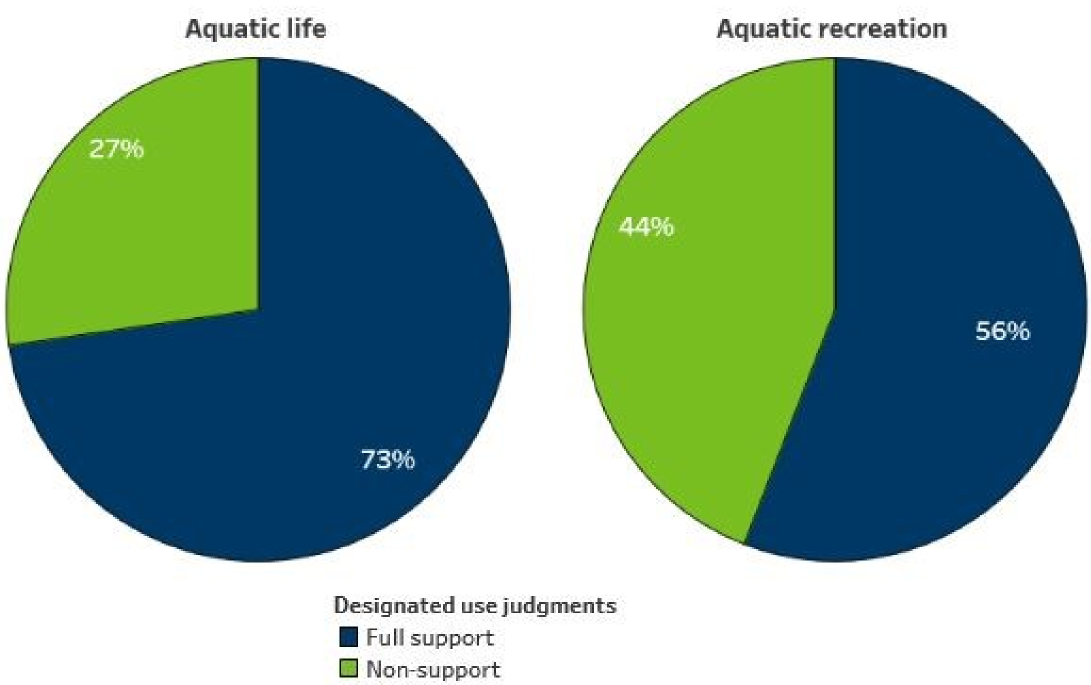
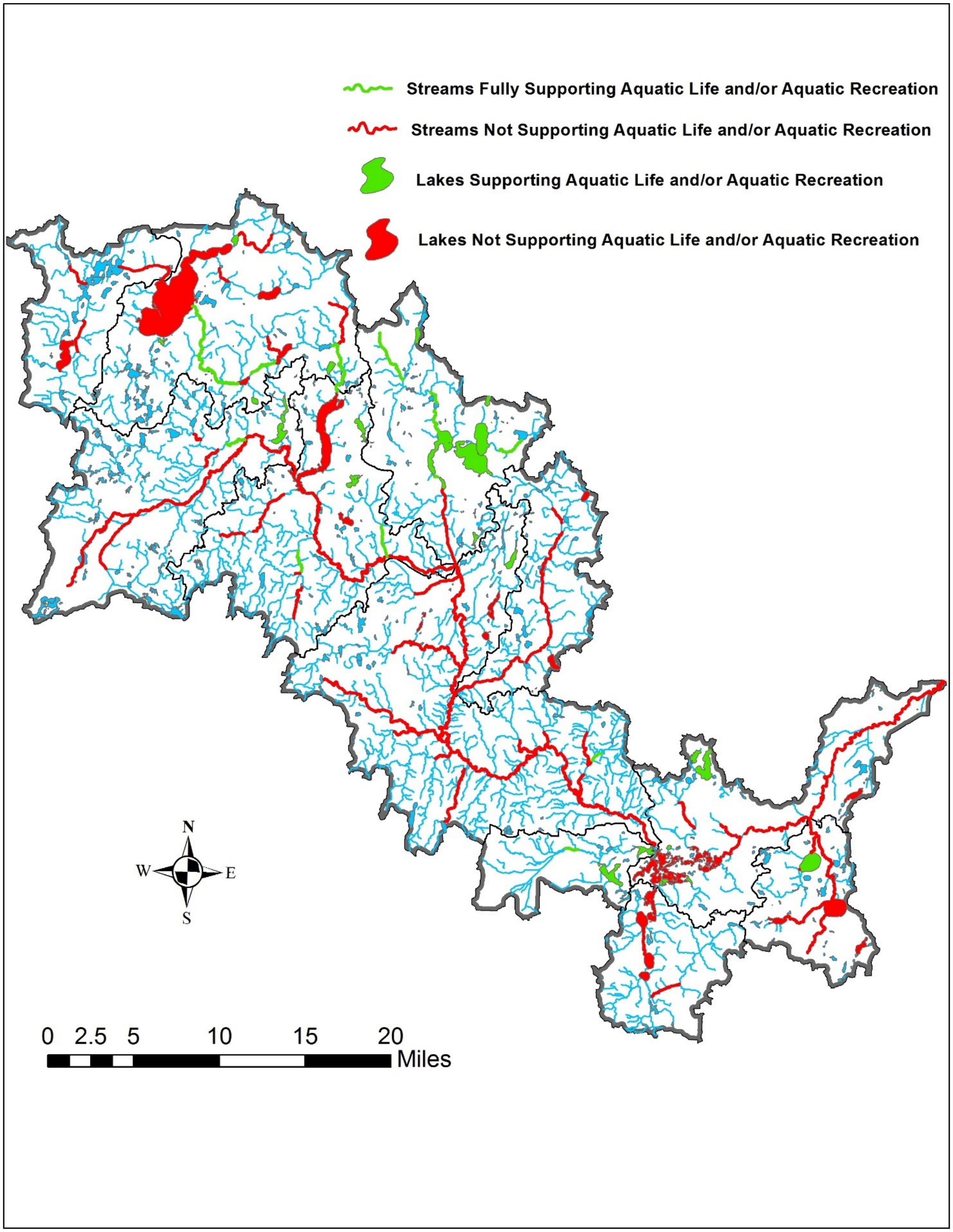
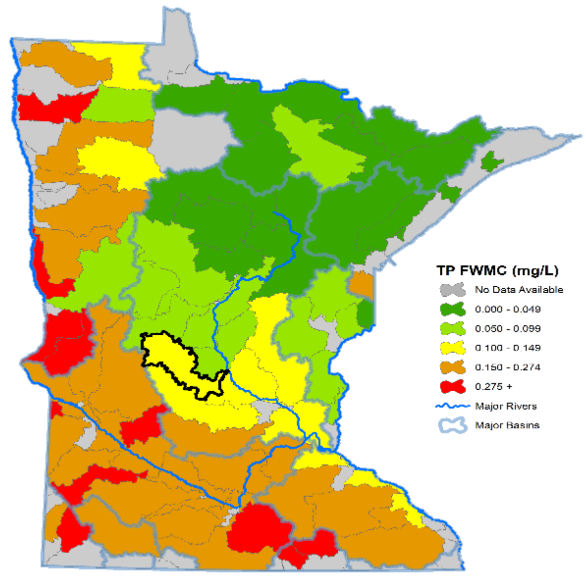


Figure 3. Assessment results for aquatic life and aquatic recreation on rivers, streams, and lakes in the Sauk River Watershed.



In the Sauk River Watershed, elevated nutrients, bacteria, and low dissolved oxygen were prevalent across the watershed. New impairments for dissolved oxygen were added on segments of Crooked Lake Ditch, Adley Creek, Boss Creek, Fairfield Creek, and Silver Creek. The most upstream portion of Crooked Lake Ditch has excess nutrients, while the most downstream segment is impaired for total suspended solids. Impairments for *E. coli* were also added on a small unnamed creek that flows east into Grand Lake, as well as the unnamed creek that flows out of the lake.

Figure 4. Average total phosphorus flow weighted mean concentrations (FWMC) by major watershed. The Sauk River Watershed is outlined in black.



Pollutant load monitoring

The Watershed Pollutant Load Monitoring Network (WPLMN) has two monitoring stations within the Sauk River Watershed. The furthest upstream is a seasonal site located near St. Martin and has been operating every year since 2015, when this station was added to the WPLMN Program. The station was monitored by the Sauk River Watershed District (SRWD) since 2003. The downstream (outlet) station is located near Sauk Rapids at the confluence with the Mississippi River and has been operating each year since 2007. Stream water samples are collected at St. Martin from snow melt through October 31, annually and at the Sauk River outlet throughout the year. These sites are monitored for:

- Total suspended solids (TSS) – a combination of soil, sediment and other particles - in the water that can make it hard for fish to breathe, find food, escape predators and reproduce.
- Phosphorus which can grow algae.
- Nitrogen which can contribute to algal growth and be toxic to fish.

TSS average concentrations are well below the state TSS standard of 30 mg/L and are often less than half of the standard.

Phosphorous concentrations are slightly higher than desired at both stations. (Figure 4)

Nitrate concentrations at both stations are higher than watersheds to the north, but lower than those to the south. Furthermore, the nitrate concentrations vary depending on time of year. The concentrations are higher during fall through early spring than during the summer months. At the upstream station, concentrations are roughly 24% higher from October through March than April through September. This is notable since samples are not collected from November through February at the upstream site. During the same timeframe, concentrations are roughly 61% higher at the downstream station which is sampled throughout the winter months. Higher nitrate concentrations during low flow months could be attributed to groundwater inputs, which likely contain higher amounts of nitrates, than other possible sources. With the abundant cropland found throughout this watershed, it is likely that nitrates from fertilizers, manure applications, and decomposition of soils and organic matter are infiltrating the soil and groundwater below. The groundwater (and nitrates) then enter the Sauk River during a time when flows are low and there is less water to dilute the nitrates. Other possible sources of nitrates could include overland flow, municipal and industrial wastewater, as well as other point and non-point sources. See Table 1 for the average flow weighted mean concentrations (FWMC). A FWMC is the average concentration of a pollutant in each liter of water that passed a monitoring station over the course of the monitoring period.

Two common themes exist among the three pollutants: first, concentrations within the watershed decrease from upstream to downstream (Table 1); and second, at a statewide scale all concentrations are in a transition zone from lower concentrations to the north and higher to the south. It should be noted that TSS and phosphorous concentrations in the watershed often become elevated immediately following heavy rain events, but these conditions are short-lived and decrease quickly.

Table 1. Comparison of average total flow weighted mean concentrations (FWMC) from the upstream (sub-watershed) to downstream (outlet) stations within the Sauk River Watershed.

Station	TP (mg/L)	TSS (mg/L)	NO2+NO3 (mg/L)
Upstream (St. Martin)	0.14	16.7	2.35
Downstream (Sauk Rapids)	0.13	11.2	1.45

The dynamics of the Sauk River Watershed are complex. The main-stem river flows through wooded, wetland, and agricultural lands, many lakes, cities, and has industrial impacts. A possible explanation for the consistent pollutant load decreases from upstream to downstream may be that the Sauk River flows directly through seven lakes and indirectly through an additional six lakes, all known as the "Sauk Chain of Lakes". It is possible that the higher concentrations found at the upstream station (upstream of the Chain of Lakes) are either consumed by aquatic vegetation or settle out within these lakes, resulting in lower levels leaving the lakes and thus lower concentrations at the outlet station. Furthermore, the additional input of water from smaller streams and ditches along the river's course to the outlet may dilute the pollutants.

At a local scale, water quality impacts from the Sauk River on the central portion of the Mississippi River in Minnesota are fairly low for all three parameters when compared to the average loads measured in the Mississippi River at Anoka, MN, the first monitoring location on the Mississippi River downstream of the Sauk River confluence. The Sauk River contributes an average of five percent of the total flow volume at Anoka, with phosphorus being the largest contributing pollutant at six percent of the annual load. Nitrate and TSS inputs have a lesser impact, contributing five and three percent of the average loads, respectively.

At a regional scale, water quality impacts of the Sauk River on the entire Upper Mississippi River Basin is minimal. The furthest downstream monitoring station on the Mississippi River in Minnesota is at Lock and Dam #3, above Lake Pepin. This station is often used to characterize the entire Upper Mississippi River Basin within Minnesota. Overall, the Sauk River contributes less than two percent of the total flow volume at Lock and Dam #3, with the largest contributing pollutant again being phosphorus, contributing an average of two percent of the annual load. The nitrate and TSS loads are the equivalent of one percent and less than one percent of the average annual load, respectively.

Yearly average discharge data collected at the Sauk River outlet station from 1991-2018 indicate that flows have had no significant change (Figure 6). Although significant increases in daily flow do occur at this station, they generally occur only periodically throughout the year and are associated with snow/ice melt in the spring and heavy rain events throughout the open water season. Once flows begin to rise, they typically peak within 48-96 hours, then begin to recede thereafter. Interestingly, the rises in flow at both stations are often directly related to rain events that occur nowhere near the station location. For example, it has been observed on many occasions that heavy rain events occurring in the headwaters of the watershed near Osakis (roughly 40 miles upstream of the seasonal station) effect the upstream station roughly 24 hours after the rain event. It is at this time that the flows begin to rise and pollutant levels often increase. Furthermore, it takes an additional 24 hours for the outlet station to see the effects of the event that occurred roughly 60 miles upstream. The data indicates that rain and snowmelt conditions existing anywhere in the watershed can affect the entire system.

The watershed has approximately 132 publicly accessible lakes. Thirty of these lakes are considered impaired for nutrients, and as a result are more prone to excessive algae blooms in the summer months, reducing recreation opportunities. Several lakes in the watershed are large, flow-through lakes and have a site specific standard. These lakes are East, Koetter, Zumwalde, Great Northern, Krays, Knaus, Horseshoe, and Cedar Island, which make up the Sauk River chain of Lakes near the cities of New Richmond and Cold Spring. These lakes were previously listed as impaired in 2004, and newer data confirms they still do not meet the lake eutrophication standard. Lakes Grand, St. Anna, and Kings have phosphorus and/or chlorophyll-a levels that are close to exceeding the lake eutrophication standard and are therefore vulnerable to aquatic recreation impairment. Impairment could be avoided by preventing excess phosphorus from entering these lakes. In general, lakes in intensively developed watersheds, either agricultural or urban, are more likely to be impaired (e.g. Lake Osakis in Douglas County, and Sauk Lake and the Sauk River Chain of Lakes in Stearns County). Lakes with smaller or more forested sub-watersheds generally meet standards, such as Big Birch and Little Birch in Stearns County.

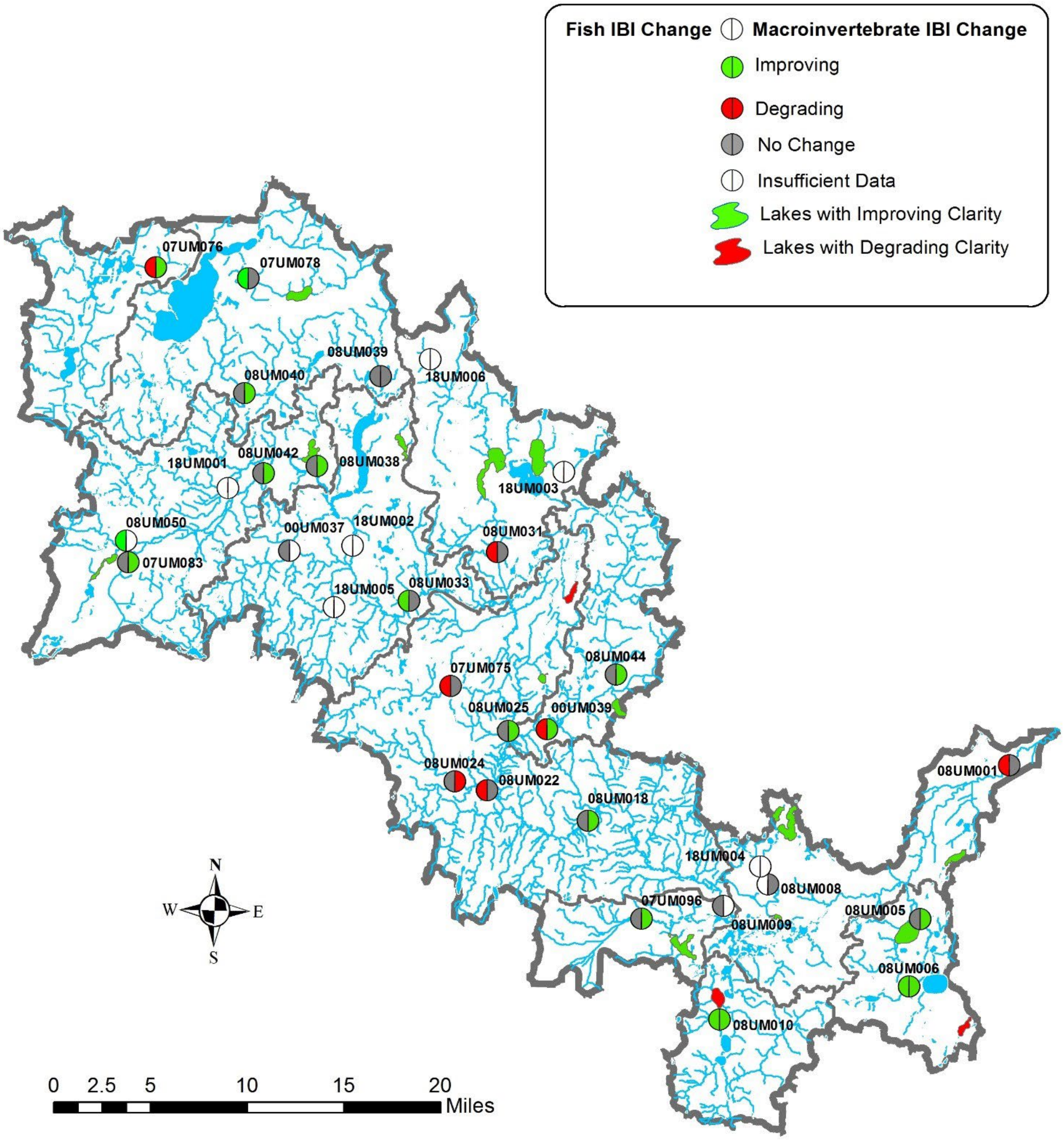
Trends

A key objective of the 2018 monitoring effort was to evaluate if and how water quality has changed since 2008. This knowledge will help inform future activities in the watershed.

Trends in four different aspects of water quality were analyzed to provide as robust a picture as possible of what is happening in the Sauk River Watershed:

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

Figure 5. Water quality trends in the Sauk River Watershed.



Fish and macroinvertebrate communities

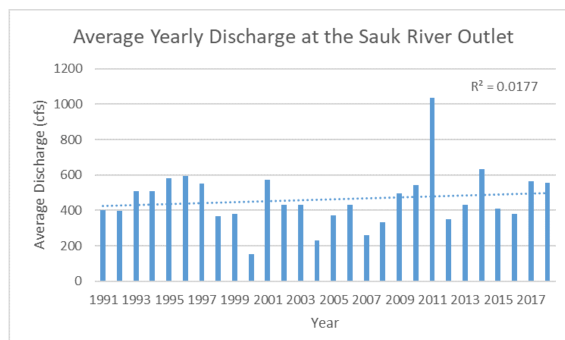
The overall change in the health of aquatic communities in rivers and streams was measured by comparing fish and macroinvertebrate IBI scores from 2008 and 2018. Assessments were not conducted on channelized streams during the first assessment cycle but IBI scores were calculated for both time periods allowing for a direct comparison of channelized and non-channelized streams. Statistically, fish communities indicate little to no change whereas Macroinvertebrate communities have improved. The average FIBI score increased approximately 1.5 points, and the average macroinvertebrate score increased approximately 8.5 points between time periods.

Of the 23 stations sampled in both cycle one and cycle two monitoring efforts, 14 showed improvement in MIBI score. Notably, MIBI scores improved substantially at both stations sampled on Getchell Creek. The higher MIBI score resulted in a correction to an existing macroinvertebrate impairment for one of the two reaches sampled in this system. The existing macroinvertebrate impairment on County Ditch 6 was also removed because the MIBI score improved by nearly 30 points. Much of the riparian area surrounding the station has been put into a conservation easement managed by Re-invest in Minnesota (RIM). MIBI scores also increased at stations sampled on Trout Creek and Mill Creek, two of the highest scoring systems in the watershed. Despite measurable improvements in average MIBI performance across the watershed, aquatic macroinvertebrate communities continue to exhibit signs of stress. Of the 51 streams currently assessed with MIBI scores across the watershed, 55% are currently impaired for macroinvertebrates.

Streamflow and pollutant concentrations

Yearly average discharge data collected at the Sauk River outlet station from 1991-2018 indicate that flows have had no significant change. A trend analysis was performed for TSS, phosphorus, and nitrate concentrations to determine if changes over time are statistically significant at the outlet station. With an abundance of data available, two separate analyses were performed, a 10-year and a 20-year, respectively. TSS showed no significant change over the past 10 years, but showed a significant decreasing trend over 20 years. Phosphorus showed a significant decreasing trend for both periods. Nitrate showed significant increasing trends for both periods.

Figure 6. Sauk River annual flow (cfs)



Clarity of lakes

The Sauk River Watershed has roughly 332 lakes. About 62 of the lakes have some level of water quality data, and only 41 of those lakes had sufficient data (i.e. 50 Secchi measurements and a minimum of eight years of data) to conduct a water clarity trend analysis. Much of the transparency data was collected by citizen scientists through the MPCA's Citizen Lake Monitoring Program (CLMP). Those data end up playing a large role in statewide data analysis, which help to inform water quality assessments and track trends over time. Similar to statewide results, most lakes in the watershed do not exhibit a trend, and more lakes are improving in clarity than declining. Two large and deeper lakes in the watershed, Carnelian and North Brown's, had decreasing clarity trends. Fourteen lakes had improving clarity, including Maple, Maria, Sand, Schneider, and Westport which are all currently impaired.

Climate

In 2008, the Sauk River Watershed experienced a moderate to severe drought and was abnormally cool during the May to September time frame. This information was then used to estimate the likelihood (high, medium, or low) that climate influenced biological condition in either IWM cycle (Table 2). In 2018 over the same time period, the watershed had near normal rainfall amounts (+0.6 in) and near normal temperatures. Overall, given the dry conditions affecting the watershed in 2008 and the near normal conditions present in Cycle 2 (Figure 7), there is a moderate 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. See link below for further climate information.

Although currently facing severe drought conditions, on a much longer time scale, the Sauk River Watershed currently receives on average an additional 2.8 inches of rain annually compared to the historical average (1895-2018), with the largest increases in the eastern portions of the watershed. Furthermore, climate scientists suggest that precipitation events are becoming more intense. Meanwhile, the average annual temperature across the watershed has increased by 1.5°F, with a more pronounced increase (+2.7°F) observed during the winter (Dec-Feb). More precipitation and reduced snow cover can increase soil erosion, pollutant runoff, and stream flow. Increased stream flow in turn can lead to in-stream channel erosion and degraded habitat for aquatic life. Longer growing seasons with higher temperatures can lead to more algal blooms, especially in lakes. These changes will complicate efforts to protect and restore the aquatic resources in the watershed.

http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/climate_summary_major_16.pdf

Figure 7. Characterization of air temperature and rainfall conditions for May-September period across the historical record of climate data for the Sauk River Watershed. IWM years are highlighted in red.

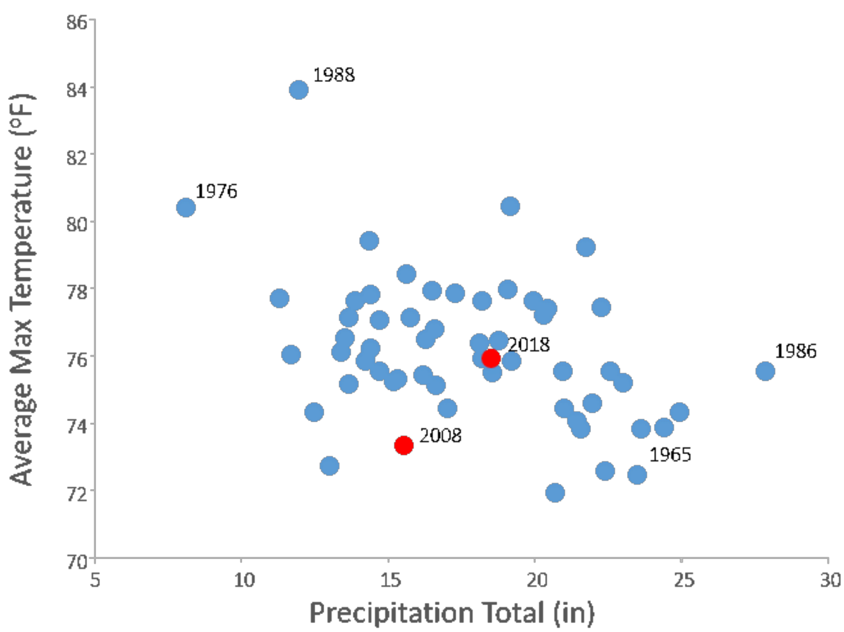


Table 2. Criteria used to characterize May - September rainfall and temperature conditions across the watershed.

Departure from Avg. Maximum Temperature (°F)	Departure from Normal Precipitation Total (in)				
	< -6	< -2 to -6	-2 to +2	> +2 to +6	> +6
> +3	Extreme Drought Conditions	Moderate-Severe Rainfall Deficit & Extreme Heat	Near Normal Rainfall & Extreme Heat	Above Normal Rainfall & Extreme Heat	Extreme Flooding & Extreme Heat
> +1 to +3	Extreme Rainfall Deficit & Abnormally Hot	Moderate-Severe Rainfall Deficit & Abnormally Hot	Near Normal Rainfall & Abnormally Hot	Above Normal Rainfall & Abnormally Hot	Extreme Flooding & Abnormally Hot
-1 to +1	Extreme Rainfall Deficit & Normal Temps	Moderate-Severe Rainfall Deficit & Normal Temps	At or Near Normal Conditions	Above Normal Rainfall & Normal Temps	Extreme Flooding & Normal Temps
< -1 to -3	Extreme Rainfall Deficit & Abnormally Cool	Moderate-Severe Rainfall Deficit & Abnormally Cool	Near Normal Rainfall & Abnormally Cool	Above Normal Rainfall & Abnormally Cool	Extreme Flooding & Abnormally Cool
< -3	Extreme Rainfall Deficit & Cold	Moderate-Severe Rainfall Deficit & Cold	Near Normal Rainfall & Cold	Above Normal Rainfall & Cold	Extreme Flood Conditions

Likelihood of climate/weather influence on biological condition results: low ; medium; high.

For more information

Stressor identification for new impairments and updates to the Watershed Restoration and Protection Strategy (WRAPS) follow the completion of monitoring and assessment. For more information, go to https://www.pca.state.mn.us/water/watersheds/sauk-river or search for "Sauk River" on the MPCA website.

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