Watershed assessment and trends update

Little Fork River Watershed

Rainy River Basin

Little Fork River near Linden Grove

Why is it important?

Water quality 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 on an ongoing basis. Once every 10-years, the Minnesota Pollution Control Agency (MPCA) joins local partners and the Minnesota Department of Natural Resources (MnDNR) in conducting intensive monitoring of the lakes and streams in each of the state's 80 watersheds. This intensive monitoring effort looks at fish and macroinvertebrate (aquatic insect) communities as a measure of aquatic life health, in addition to water chemistry, to evaluate water quality. 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 process and assessment helps to focus future watershed funding and on-the-ground work.

Waters in the Little Fork River Watershed are an important resource used for recreational activities such as fishing, swimming, boating, hunting and other leisure; these uses provide an economic benefit to local economies. The Bois Forte Reservation is located within the watershed and contains Nett Lake, the world's largest wild rice lake. The wild rice produced by this waterbody provides an important source of sustenance for the Band. Some of the most pristine and remote waters in the State of Minnesota flow through this watershed.

In addition, the Little Fork River directly affects the water quality of other highly valued resources such as the Rainy River and Lake of the Woods. Suspended sediment from the Little Fork River Watershed is perhaps the most noticeable impact on downstream waters. The Little Fork River is the largest contributor of sediment to the Rainy River and Lake of the Woods; phosphorus bound to the fine sediment (clay) particles contributes to Lake of the Woods' summer algal blooms (Lake of the Woods was declared impaired in 2008, due to exceedances of eutrophication criteria).The US Geological Survey, MPCA, and Koochiching and North St. Louis County Soil and Water Conservation District (SWCD) partners are currently working on a sediment fingerprinting study to understand the in-stream and watershed sources of sediment and their delivery dynamics to the Little Fork River and downstream waters shared with Canada. Water quality monitoring within the Little Fork River Watershed is an important component for the development of restoration and protection strategies for these valuable resources.

Is the water quality improving?

Overall, scientists have observed little to no change in water quality within the Little Fork River Watershed over the past decade. High levels of turbidity and total suspended solids (TSS) on some sections of the Little Fork River and its tributaries such as the Sturgeon River continue to be a concern. Despite high levels of sediment, the Little Fork River continues to support thriving aquatic communities. The condition of fish and macroinvertebrate communities within the Little Fork River and other streams and rivers, as measured by the fish or macroinvertebrate index of biotic integrity (FIBI or MIBI), has largely remained the same since 2008. The presence of extensive forests and numerous wetlands, combined with the low amount of human land disturbance, maintains the excellent condition of aquatic communities. Large stretches of the Little Fork River, some of its tributaries, and two lakes have been identified as exceptional resources because of the high quality aquatic biological communities they support. Exceptional ecosystems of this nature are relatively rare in the state and are therefore worthy of protection.

Highlights of monitoring

- Over 76 miles (48% of the entire 160-mile flow length) of the Little Fork River have been designated as exceptional use waters. Exceptional use waters have fish and macroinvertebrate communities that are similar to the communities that existed before European settlers inhabited the region.
- 34 of the 62 fish samples (55%) collected from streams and rivers produced exceptional fish index of biological integrity (FIBI) scores. The highest FIBI scores were associated with samples collected from the Little Fork River, Sturgeon River, and Beaver Brook.
- 19 of the 54 macroinvertebrate samples (35%) were exceptional. The highest macroinvertebrate index of biotic integrity (MIBI) scores were associated with samples collected from the Little Fork River, Sturgeon River, Nett Lake River, Shannon River, and Rice River.
- Thistledew and Owen Lakes were considered exceptional based on the fish community. These lakes were classified as lakes of biological significance and submitted as candidates for protection.
- Johnson Creek, in photo at right, showed a decline in biological condition between 2008 and 2018. Sensitive fish species and numerous macroinvertebrate taxa that were present within the 2008 sample were absent in 2018. Both the FIBI and MIBI score declined significantly, likely due to natural phenomenon such as wetland influence and/or increased beaver activity

- The MPCA and local County SWCD partners monitored 28 large to moderate size lakes during the summers of 2018-2019. Results overall indicate an abundance of high quality lakes, with 26 of 28 lakes meeting regional eutrophication standards for total phosphorus, algae (chlorophyll-a), and Secchi transparency.
- Long term monitoring data collected from a Water Pollutant Load Monitoring Network (WPLMN) Station located on the lower Little Fork River (in the town of Littlefork) indicate a significant decreasing trend for TSS for both the 11 year (2008-2018) and 20 year (1999-2018) dataset.

Watershed results

Assessment results

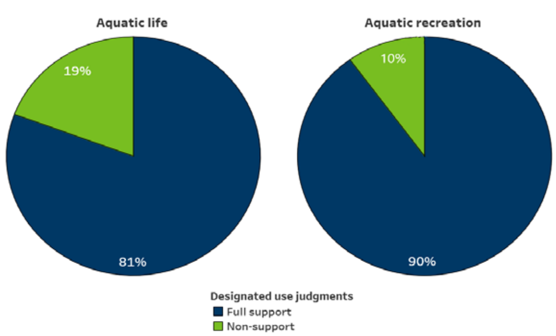
The MPCA and local partners monitored water quality conditions in 2008-2009 and again 10 years later in 2018-2019. Additional chemistry data collected by local partners and citizen volunteer monitors between 2009 and 2019 were also used to assess the condition of the Little Fork River Watershed. The assessment focused on whether or not waterbodies meet water chemistry standards protective of aquatic life, recreation, and consumption uses. The overall goal of these assessments is to ultimately determine which waters are healthy, are in need of protection, or are polluted and require restoration. In addition to the data associated with the 10-year monitoring cycle, there are five Watershed Pollutant Load Monitoring Network (WPLMN) stations that operate annually on a long-term basis. One of these stations represents the entire watershed and is located in the town of Littlefork, 20 miles above its confluence with the Rainy River. Other station locations include the Little Fork River near Linden Grove and Silverdale and the Sturgeon River near Meadowbrook. The long-term nature of these stations is critical for trend analysis, measuring between-year differences in pollutant loading, and helping determine pollutant sources and their contributions.

Another way to assess the health of a stream is to look at the organisms that live in it. The index of biological integrity (IBI) is a tool that is used to measure a lake, stream, or river's health, utilizing aquatic communities. Fish and macroinvertebrate IBIs are used by the MPCA in streams and rivers. The Minnesota Department of Natural Resources (MnDNR) uses a similar IBI tool for assessing aquatic life in lakes, using fish communities. These indices are scaled 0 – 100; the higher the score the better the condition of the aquatic community. Between the first and second rounds of biological monitoring in the Little Fork 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 consequence of the new rules, the most recent assessments include aquatic life use designations and assessment results for five legally altered stream segments. In addition, IBI's for cold water streams have also been developed allowing for the assessment of biological data collected from the Little Fork's cold water tributary streams such as the Dark River and Stony Brook.

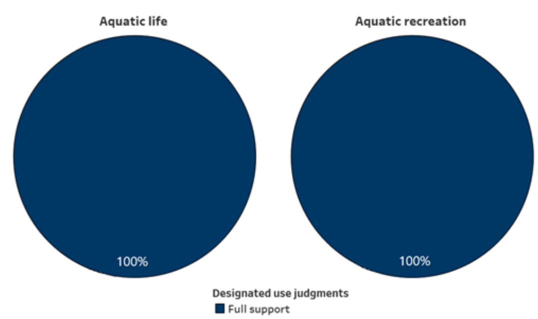
Throughout the watershed, aquatic communities met and often far exceeded the standards designed to protect aquatic life. In fact, over 50% of the stream fish communities sampled were exceptional. Over 76 miles of the Little Fork River and 38 miles of the Sturgeon River have been designated as exceptional waters because of the high quality of the fish and macroinvertebrate communities. Other exceptional waters include the lower 14 miles of the Nett Lake River and portions of the Bear and Shannon Rivers. Good stream habitat and stable flow regimes (unaltered hydrology) correspond with the low amount of disturbance within this watershed to support the development of healthy aquatic communities. Interestingly, many of these systems experience high levels of turbidity and are impaired for aquatic life based on seasonal exceedances of the total suspended solids (TSS) standard. The MPCA is investigating the causes and significance of the discrepant results.

Although three new biological impairments were identified, these were mainly attributed to natural phenomenon such as stream habitat alteration due to beaver activity and/or low dissolved oxygen from wetland water contributions. One such type of impairment occurred on the small tributary stream Johnson Creek, which showed a considerable decline in biological condition between 2008 and 2018. Sensitive fish species captured within the 2008 sample were absent in 2018; the FIBI score declined significantly (from 55.8 to 29.5). The 2008 macroinvertebrate sample contained 42 taxa while the 2018 sample contained only 26 taxa. The 2018 sample was also dominated by taxa tolerant of low dissolved oxygen. The MIBI score declined from 74.1 to 22.2. The other two new biological impairments also occurred on small tributary streams (Timber Creek and Gilmore Creek) that are hydrologically connected to wetland habitat. The Rice River was taken off the impaired waters list because the most recent data collected in 2012, 2015, and 2018 strongly indicate that this stream supports aquatic life.

Within the Little Fork River Watershed, five lakes were sampled and assessed for aquatic life. Similar to flowing waters, these fish communities are a reflection of the cumulative effects of natural and human-caused influences to a lake's contributing watershed. Overall, fish diversity was fairly low relative to many other watersheds within Minnesota. This is likely caused by the geology of the area, where there is generally low alkalinity and low connectivity, which could make colonization difficult for some fish species. A total of 25 fish species were captured in five lakes during fish IBI sampling. Six of these species are considered intolerant to anthropogenic stressors within the watershed (e.g., blackchin shiner, blacknose shiner, Iowa darter, mimic shiner, rock bass, smallmouth bass) while two species are considered tolerant to these stressors (e.g., black bullheads and fathead minnows). Three of the assessed lakes featured FIBI scores above the designated impairment thresholds and were considered fully supporting; two of these (Thistledew and Owen) had scores that exceeded the exceptional threshold. The remaining two lakes had insufficient information to make an assessment decision.



Assessment results for streams and rivers.



Assessment results for lakes.

Figure 1. Watershed assessment results for aquatic life and aquatic recreation in streams and rivers (left) and lakes (right).

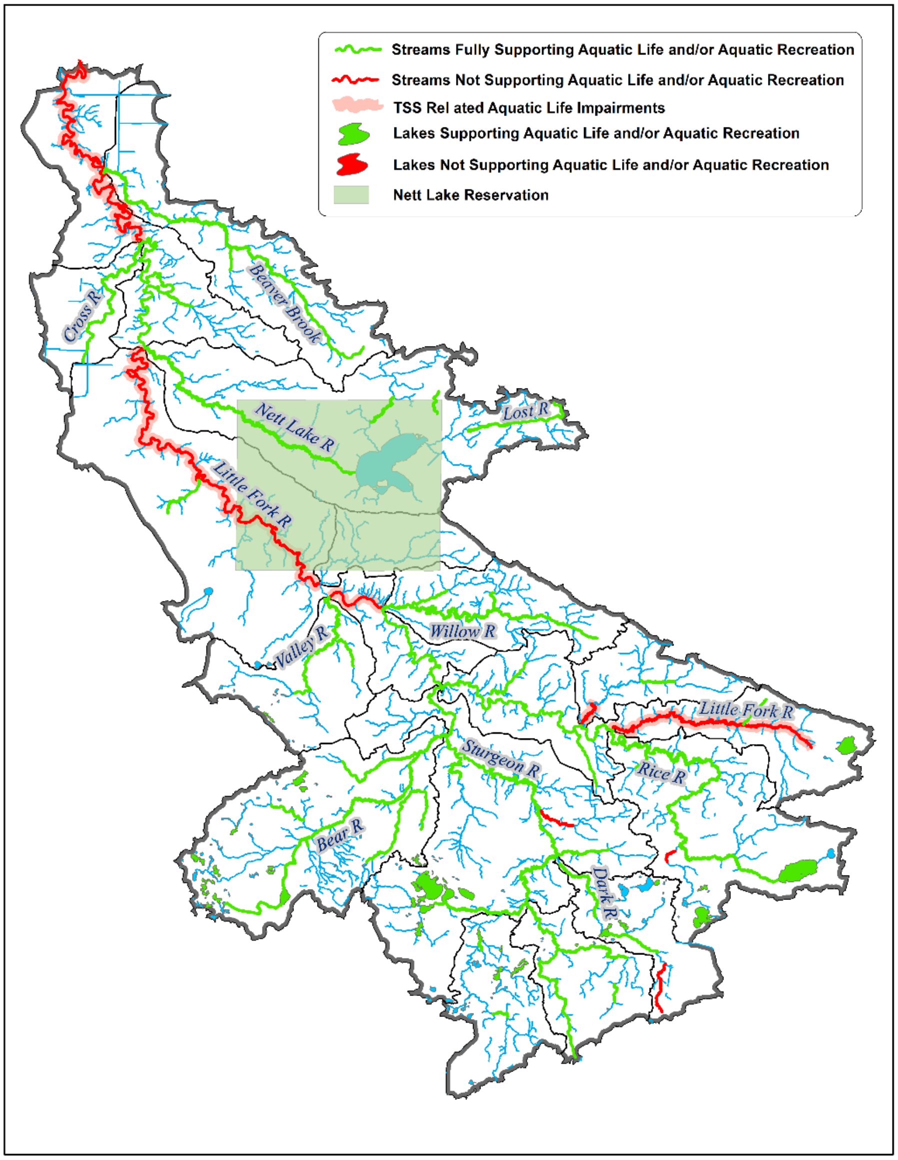


Figure 2. Assessment results for aquatic life and aquatic recreation on rivers, streams, and lakes.

Lakes are abundant and provide important base flow to the headwaters of several Little Fork River tributaries, such as the Sturgeon, Bear, and Dark River watersheds. The MPCA and local County SWCD partners monitored 28 large to moderate size lakes in the watershed during the summers of 2018-2019. Results overall indicate an abundance of high quality lakes, with 26 of 28 lakes meeting regional eutrophication standards for total phosphorus, algae (chlorophyll-a), and Secchi transparency. The remaining two lakes, Shannon and Bear, did not meet standards; these lakes periodically have high phosphorus and chlorophyll-a concentrations, and low Secchi transparency. Both lakes are shallow flowage lakes with abundant wetlands in their watersheds; in these settings, it is common for lakes to naturally exceed water quality standards and have low water clarity. The Sturgeon Chain of Lakes, located adjacent to McCarthy Beach State Park, are prominent resources in the watershed. These lakes are high quality and all meet eutrophication standards and fully support aquatic recreational use. The largest lake in the watershed, Nett Lake, is located entirely within the boundaries of the Nett Lake Reservation and therefore was not sampled or assessed by the MPCA. This 7,400-acre shallow lake contains extensive stands of wild rice and is a very important resource for Tribal members. The Boise Forte Department of Natural Resources continuously monitors water quality on this lake and restricts access to protect wild rice.

Several segments of the Little Fork River are impaired for aquatic life based on high turbidity or total suspended solids (TSS).The River continues to exceed regional standards for TSS and also has the highest sediment concentration and load of any Rainy River Basin watershed (see section on Load Monitoring). The clay soils in the lower portions of the watershed and the river channel itself are a remnant of Glacial Lake Agassiz. Once eroded, these fine clay particles stay suspended in water for long periods of time. Recent monitoring found several tributaries that also periodically exceed the TSS standard, notably the Sturgeon, Valley, Nett Lake, and Willow Rivers, and Flint Creek. Other conventional water quality parameters monitored within the watershed's rivers and larger streams, such as dissolved oxygen, pH, and nutrients, often meet water quality standards. Low dissolved oxygen (DO) concentrations (below the 5 mg/L water quality standard) were often observed in smaller streams during fish and invertebrate sampling. The available DO data from these streams were limited to one or two field measurements and therefore were insufficient for assessment. The low DO concentrations are likely the result of natural phenomenon resulting from wetland influence; this is a common occurrence in watersheds across northern Minnesota, especially during the warmer months (July and August) of summer. Bacteria levels (*E. coli*) at all monitored locations were low and indicated support of aquatic recreation.

Load monitoring results

All WPLMN sites within the Little Fork River Watershed have a TSS flow weighted mean concentration (FWMC) that is above average for the northern part of the state as well as above the state standard (Figure 3). The FWMC is a "volumetric average" representing the quality of the entire volume of water that passed the monitoring site during the monitoring season. This statistic essentially conveys how clean or dirty the water is.

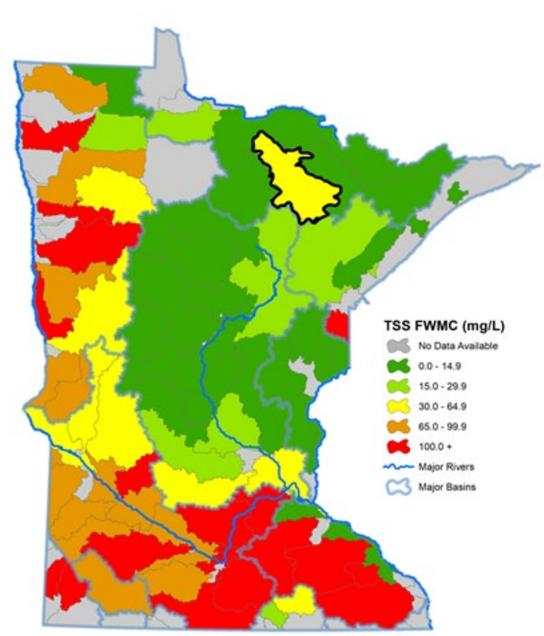


Figure 3. Average total suspended solids (TSS) flow weighted mean concentrations (FWMC) by major watershed. The Little Fork River Watershed is outlined in black.

Data have shown TSS concentrations to be very predictable throughout the year in the Little Fork River. The concentrations appear to be based largely on stream energy eroding bank sediments; the greater the flow, the higher the TSS concentration. However, there are a handful of days each year when other erosive forces contribute and have an undue effect on the Little Fork River, accounting for up to 25% or more of the annual sediment load in some years. One "high loading" sediment source is the ice scour that occurs during spring snowmelt when floating river ice can gouge and erode large quantities of streambank sediment. The other source is surface eroded sediment during and immediately after high intensity rain events. More information on daily and annual loads and concentrations for the Little Fork River Watershed can be found in the WPLMN Data Viewer.

Regionally, sediment concentrations and loads from the Little Fork Watershed have a greater impact on the Rainy River than any other contributing watershed on the Minnesota side of the Rainy Basin. While the drainage area of the Little Fork River accounts for less than 9% of the drainage area of Rainy River basin above Manitou Rapids (the furthest downstream WPLMN monitoring site on the Rainy River), the average sediment load from the Little Fork is the equivalent of 37% of the average TSS load measured at Manitou Rapids. Sediment yields (lbs./acre) from the outlet of the Little Fork River are at least double the next highest yielding watershed in Minnesota's portion of the Rainy River basin.

Elevated Total Phosphorus (TP) levels are also a concern for the Little Fork River Watershed. The ten-year average flow weighted mean TP concentration at the mouth of the Little Fork is 0.08 mg/L, which is substantially higher than the other monitored watersheds within the basin. Most of the phosphorus is assumed to be sediment bound as the dissolved fraction typically accounts for less than 15-20% of the total phosphorus values.

Nitrate nitrogen values for the Little Fork River are very low, similar to other watersheds in this part of the State.

Trends

A key objective of the 2018 - 2019 monitoring effort was to evaluate if and how water quality has changed since 2008. If water quality has improved, it is important to understand to what extent strategy development, planning, and implementation of BMPs, based on the initial work and combined with actions that were already underway, may be responsible. It is equally important to understand if water quality does not appear to be changing, or is declining. In any matter, 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 Little Fork River watershed:

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

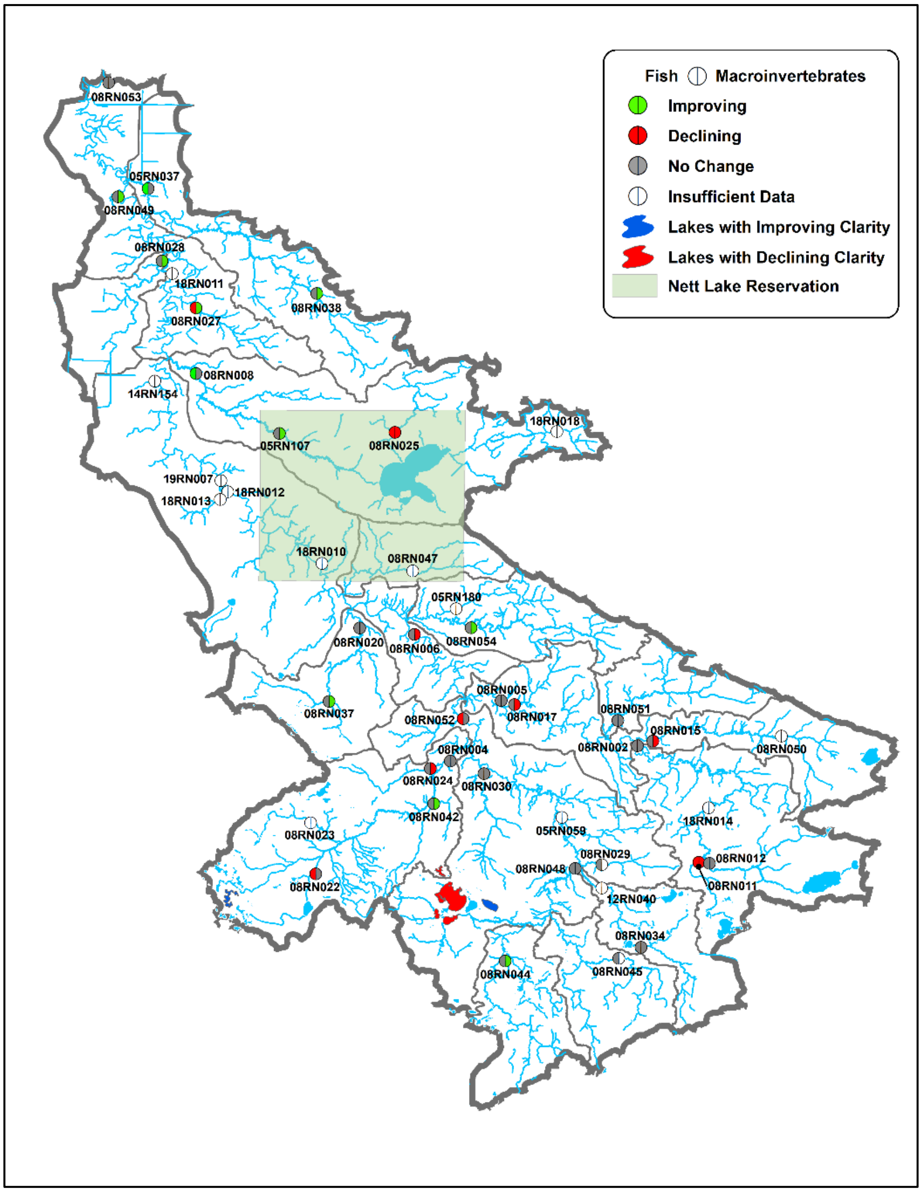


Figure 4. Water quality trends in the Little Fork River Watershed.

Streamflow and pollutant concentrations

The farthest downstream WPLMN station on the Little Fork River had sufficient data to analyze trends for TSS, phosphorus, and nitrate concentrations. With an abundance of data available, two separate analyses were performed, an 11-year (2008-2018) and a 20-year (1999-2018) trend analysis. Both time periods showed a significant decreasing trend for TSS. No trends were observed for phosphorus in either time periods. The nitrate concentrations were very low for both time periods, with over 50% of the samples below the reporting limit, which does not allow for proper analysis. A review of the streamflow record for this site shows no clear trend in average annual flows.

Fish and macroinvertebrate communities

The overall change in the health of aquatic communities in rivers and streams was measured by studying the difference in fish and macroinvertebrate community IBI scores between time periods. Fish community data were available for comparison at 33 stations (i.e., these stations were sampled during both time periods), and macroinvertebrate community data were available for comparison at 29 stations (Figure 4). Eight newly established stations were not included in this trend analysis since data were only available from the 2018-2019 time period. Nevertheless, these new locations provided valuable insight into the condition of aquatic communities at previously unmonitored locations.

Between 2008 and 2018, the average macroinvertebrate IBI score for the watershed increased by 4.0 points and the average fish IBI score decreased by 2.4 points; however, neither of these changes were statistically significant.

While the overall changes in IBI scores were not signigicant at the watershed level there were some changes in the structure of the communities that had an influence on the IBI scores at individual sites. For example, macroinvertebrate samples collected from stations located on the Bear River, Cross River, Esther Brook, and lower Valley River saw an increase in the number of predator taxa (e.g., dragonflies, damselflies, and stoneflies) between 2008 and 2018. Many of these stations also saw an increase in the number of clinger taxa (often mayflies and caddisflies) and/or Trichopertera (caddisflies) which also positively influenced the MIBI score. At other stations, such as those located on the Shannon River, lower Nett Lake River, and headwaters of the Valley River, the number of predator taxa decreased or did not change yet clinger taxa and/or intolerant taxa (very sensitive caddisflies and mayflies) increased, resulting in a higher MIBI score. Other factors contributing to an increasing MIBI score included the presence of more stonefly taxa and/or fewer tolerant taxa. Across the watershed, most changes to macroinvertebrate community structure were indicative of a healthy aquatic ecosystem.

Although the FIBI score declined at 16 stations between 2008 and 2018, most of these changes were minor (< 10 points). Most often, a combination of changes in the composition of the fish community lead to the relatively minor changes in FIBI score. For example, from 2008 – 2018 a reduction in the number of insectivorous cyprinid individuals (such as longnose dace, pearl dace, and hornyhead chubs) occurred at stations located on the Cross River, Ester Brook, and Flint Creek, which resulted in lower FIBI scores. At some of these stations the number of headwater taxa also decreased (negatively affecting the FIBI score) while simulataneously the number of pioneering taxa and/or tolerant taxa decreased (positively affecting the FIBI score). Most of these differences were quite small and can be attributed to the natural variability of fish community structure or variation in sampling. Most of the stations with decreasing scores were located on smaller headwater streams where we often see the most variability in FIBI scores.

Climatic conditions can affect aquatic communities in a variety of ways by altering flow volumes, increasing water temperatures, decreasing dissolved oxygen concentrations, degrading habitat, and decreasing connectivity. The impact of climatic conditions/weather events on stream aquatic life are dependent on the timing, magnitude, frequency and duration of events as well as the type of stream or biological community.

In 2008, the Little Fork River Watershed experienced a moderate to severe rainfall deficit (-3.0 in) and was colder than normal (-3.4 °F) during the May to September time period. The watershed had near normal rainfall amounts (+1.7 in) and was abnormally cool (-1.1 °F) in 2018 over the May to September time period. Overall, given the dry conditions affecting the watershed in 2008 and the near normal conditions present in 2018 (Figure 5), there is a moderate likelihood that the changes in biological condition between time periods at either the watershed or individual site scale are at least partially due to differences in climatic conditions between the two periods (Table 1).

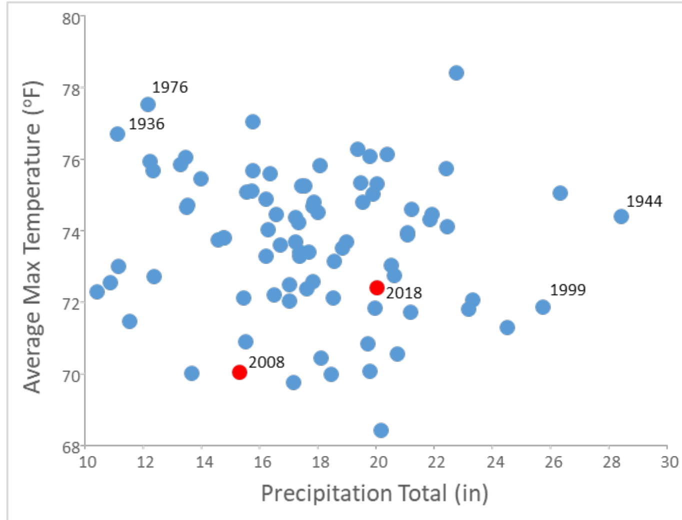


Figure 5. Characterization of air temperature and rainfall conditions for May-September period across the historical record for the Little Fork River Watershed. IWM years highlighted in red.

Climate

The MnDNR Climate Summary for Watersheds summarizes regional climate data (available from 1895 through 2018) and provides a comparison of the most recent 30-year average against the entire data record. Compared with the historical average (1895-2018), the Little Fork River Watershed currently receives on average an additional 0.4 inches of rain. Most of this increase occurs in the fall (September-November) while overall precipitation declines during the summer months. Meanwhile, the average annual temperature across the watershed has increased by 1.8°F, with a more pronounced increase (+3.1°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. For a more comprehensive analysis of climate trends for the Little Fork River Watershed.
See: http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/climate_summary_major_76.pdf

Departure from Normal Precipitation Total (in)

Departure from Avg. Maximum Temperature (°F)	< -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

Table 1. Criteria used to characterize May - September rainfall and temperature conditions across the watershed. Likelihood of climate/weather influence on biological condition results: low; medium; high.

Clarity of lakes

Citizen volunteers have worked for years to monitor the Sturgeon Chain of lakes, and trends in long-term transparency have been determined (Figure 4). Three lakes in the chain (Sturgeon, West Sturgeon, and Little Sturgeon), have statistically significant declining trends in transparency. A nearby high quality lake, Beatrice, with 30 years of citizen collected transparency data, also has a declining trend. The cause is unknown and likely is not associated with anthropogenic land use change, as Beatrice Lake has limited development and a very small-forested watershed. Over the decades, the reduction in clarity within these lakes is small, often less than one foot per decade. Perch Lake is the only lake in the chain that has increasing clarity.

More information

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

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