Watershed assessment and trends update

Crow Wing River

Upper Mississippi River Basin

Key characteristics

The Crow Wing River Watershed covers approximately 1,964 square miles in north central Minnesota within the Upper Mississippi River Basin. The watershed is divided between the Northern Lakes and Forests and North Central Hardwood Ecoregions. This transitional landscape situated between the two ecoregions supports diverse populations of fish and wildlife. The watershed provides important ecosystem services and extensive opportunities for fishing, hunting, hiking, and watercraft recreation due to its richness of lakes, rivers, and forests.

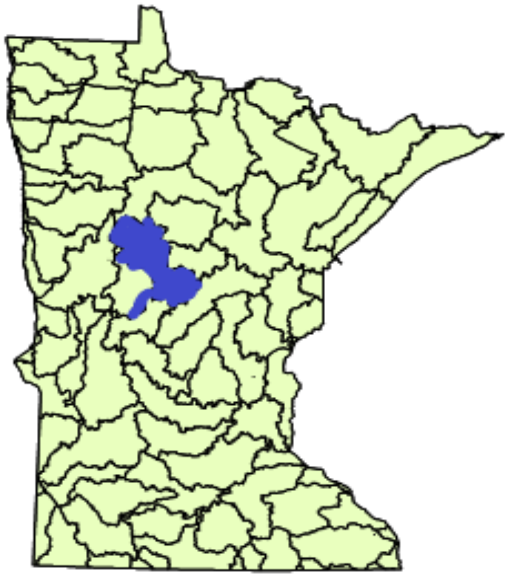
Land use within the watershed includes a mixture of forest, wetland, residential/developed, and agricultural. The area is also lake rich, including approximately 627 lakes greater than 10 acres in size. The Crow Wing River itself originates in a series of 11 lakes which together comprise an area of roughly 5,000 acres and are named sequentially from the First Crow Wing Lake through the Eleventh. The river flows through this chain of lakes for roughly 20 miles in a southward direction, then flows approximately 80 miles to its confluence with the Mississippi River south of Brainerd at Crow Wing State Park.

The Minnesota Pollution Control Agency (MPCA) and partners conducted biological and chemical surveys on lakes, rivers, and streams between 2010 and 2021 to determine if the waterbodies met water quality standards for aquatic life, recreation, and fish consumption. These surveys were part of the initial Intensive Watershed Monitoring effort in 2010, the follow up effort in 2020 and 2021, and any additional work in between. 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. The biological data collected from streams and rivers was also used to determine if any change in condition had occurred between the two time periods.

Water monitoring is essential to determining whether lakes and streams meet water quality standards designed to ensure that waters are fishable and swimmable. While local partners and state agencies monitor water quality on an ongoing basis, the MPCA and local partners conduct monitoring and assessment of major lakes and streams in each of the state's 80 major watersheds every 10 years to detect any changes in water quality. This monitoring and assessment analyzes fish and macroinvertebrate (bug) communities as well as water chemistry to gauge water quality. Waters are considered impaired if they fail to meet biological and/or water quality standards.

Changes in water quality

Over the past decade, scientists observed little change in water quality in the Crow Wing River Watershed. The overall health of fish communities did not change from 2010 to 2020. Statistically macroinvertebrate communities did improve slightly (see trends section for additional details). The overall health of the watershed is good, although elevated bacteria, increased nitrogen and impaired biological communities in some waters are primary concerns. The Crow Wing River Watershed is a relatively healthy one compared to many others in the state, and little to no change can be viewed as positive compared to degradation which is occurring in others.



Highlights of monitoring

- Eighty two percent of assessed streams support aquatic life but only 30% support aquatic recreation (note: most samples for aquatic recreation were collected at exiting impairment locations).
- A majority (96%) of assessed lakes support aquatic life and aquatic recreation (92%).
- Many sensitive fish species were collected throughout the watershed.
- Least Darter and Northern Sunfish (State Species of Concern) as well as Pugnose Shiner (Threatened Species) were present at some locations within the watershed.
- Nitrate increased in the Straight River Subwatershed from 2005-2010 to 2015-2016 when much of the land use shifted from CRP to agriculture. The Straight River is a well-known Brown Trout fishery https://www.dnr.state.mn.us/gwmp/area-sr.html

Success stories

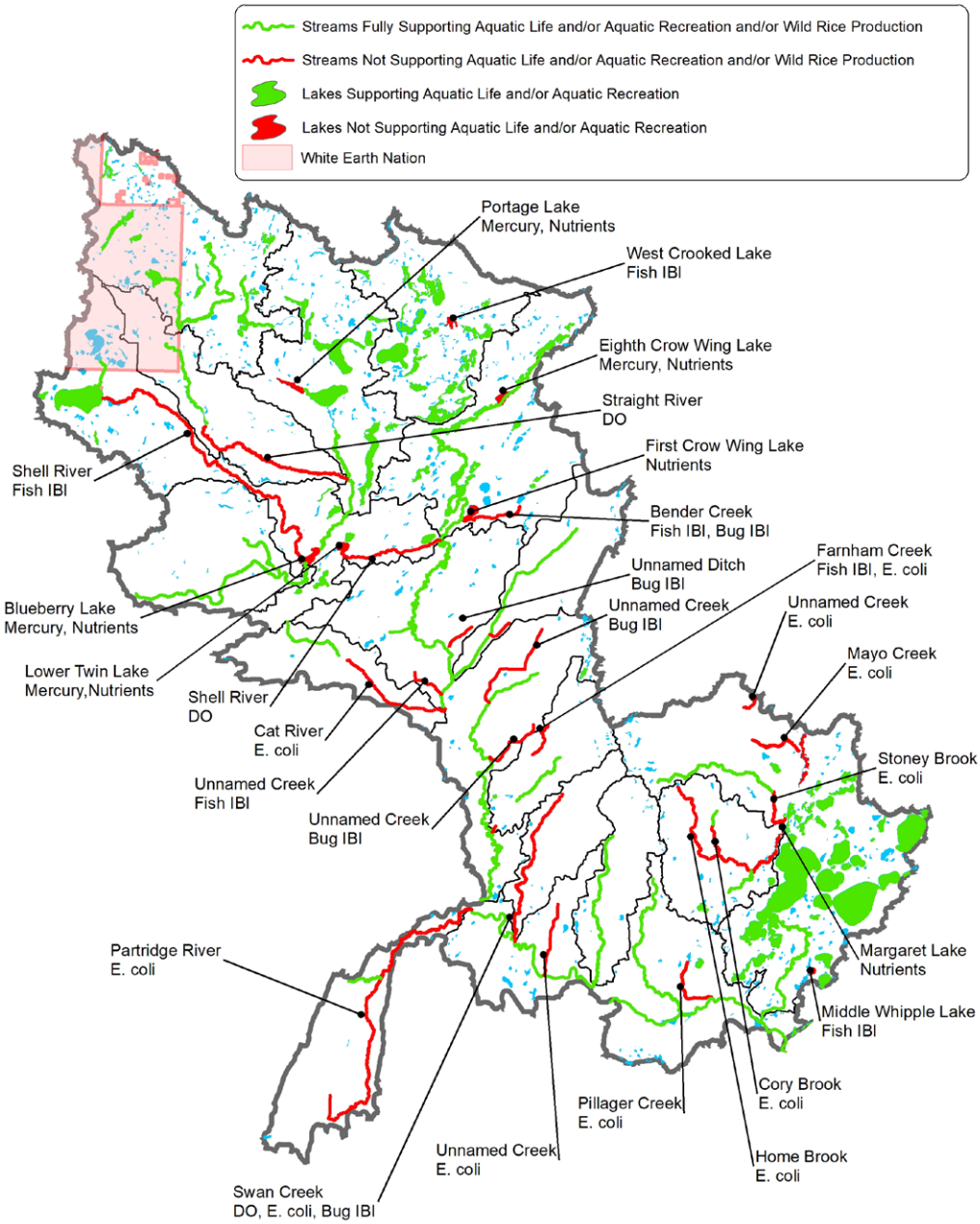
A Minnesota Department of Natural Resources (MNDNR) fisheries construction crew removed the low head dam at the outlet of Shell Lake that was blocking fish migration and replaced it with rock weirs to allow fish passage and aeration. Furthermore, MNDNR Fisheries obtained Lessard Sams Outdoor Heritage Funding (LSOH) to work with Carsonville Township and Becker County to improve fish passage at three road crossings. These improvements occurred at Smokey Hills Forest Road, Guyles Road (Twp 694) and 520th Avenue; with further anticipated improvements to also occur at several other crossings in the future. Recent biological fish surveys suggest that the

number of fish species and total numbers of fish are already increasing. Several partners cooperated on the dam removal project, which was funded through several state programs, including the Clean Water Fund.

To address the *E. coli* impairments in the Partridge River Watershed, the Todd County SWCD is working with landowners to improve manure pit management, although associated resulting improvements at this point have not been documented.

Watershed assessment results

Figure 1. Watershed assessment results



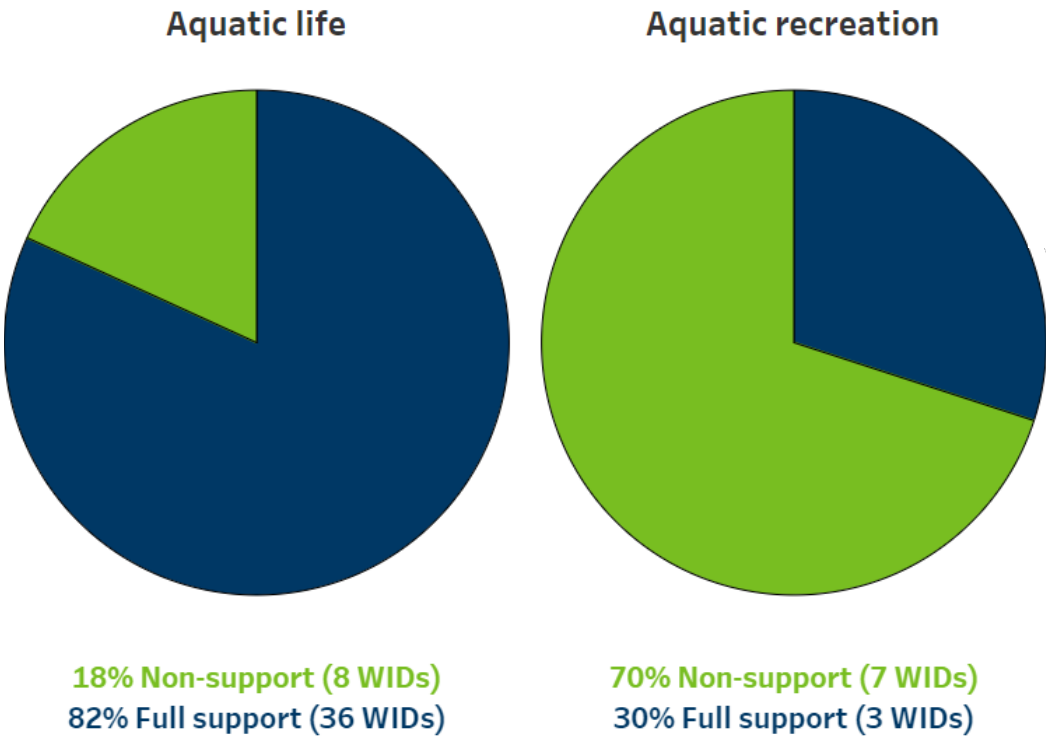
Streams and rivers

From a water chemistry perspective, the streams in the watershed are in good condition, with most of the stream segments showing support for aquatic life designated uses. Previous monitoring and assessment along with stressor identification efforts in the watershed have identified three stream reaches as impaired for Dissolved Oxygen (DO). These reaches with existing impairments remain impaired. Two of the impaired stream reaches, Swan Creek and the Shell River, are showing signs of improving DO concentrations in recent data, although the datasets for each were not strong enough to support delisting. Additional DO data on Swan Creek will be collected to identify stressors and inform future assessments and watershed work in the area. The Straight River from Straight Lake until its confluence with the Fishhook River south of Park Rapids is also impaired for DO, which was confirmed through additional monitoring between 2012 and 2021. The Straight River is highly influenced by groundwater and supports a trout fishery. Due to this coldwater fishery, it is subject to more-stringent Class 2A standards for DO (not less than 7 mg/L as a daily minimum). In addition to these existing DO impairments, the downstream-most reach of Farnham Creek, just above the confluence with the Crow Wing River, has a new DO impairment. This reach of Farnham Creek had an existing impairment for fish. Dissolved oxygen was identified as a primary stressor. Newly collected data confirmed this and resulted in an impairment listing for the DO parameter.

In terms of aquatic recreation, stream water quality standards are designed to protect for both primary (swimming and other recreation where immersion and inadvertently ingesting water is likely) and secondary (boating and wading where the likelihood of ingesting water is much smaller) body contact. Within the watershed, ten stream reaches have existing impairments for aquatic recreation due to elevated levels of bacteria. All ten of these stream reaches remain impaired, with five of them having new data confirming the existing impairments and five of them with no new data collected in this assessment window; some sites were not monitored if no reason for change in condition was suspected. There are two stream reaches with new impairment listings for *E. coli* bacteria: Mayo Creek (07010106-603) and Unnamed Creek (07010106-728) (Figure 1). The reach of Mayo Creek is directly upstream of a reach with an existing impairment for *E. coli* bacteria, which is more likely a function of improved data richness than an indicator of any significant condition change in watershed condition since initial monitoring was completed in the watershed. This is likely also the case for the unnamed creek (07010106-728), which is a headwaters tributary to an unnamed tributary of Mayo Creek.

Overall, fish and macroinvertebrate communities are in relatively good condition in the watershed. In the lake-dominated upper headwaters portions of the watershed, little disturbance exists, and few impairments are present. In the middle portion of the watershed, more disturbances from agricultural practices and/or development with associated hydrological alterations exist and this is where most of the impairments are. Further downstream, the watershed transitions back to a more natural, heavily forested condition and few impairments exist. Forested lands within the watershed have helped to maintain the good water quality and habitat necessary to support exceptionally diverse fish communities as well as sensitive and/or coldwater species found in many of the sampled lakes and streams. Fifty-seven fish species were collected in streams and rivers during biological monitoring efforts. This includes 20 species which are sensitive to pollutants such as various shiners, dace, and darter species as well as many others like Greater Redhorse and Burbot. Game fish species were also sampled such as Smallmouth Bass, Largemouth Bass, Bluegill, Northern Pike, and Walleye as well as coldwater species such as Brook and Brown Trout. It should be noted that Least Darter (State Species of Special Concern) and Pugnose Shiner (Threatened) were also identified during stream sampling efforts in addition to those which were captured during lake sampling.

Figure 2. Aquatic life and aquatic recreation use assessments in rivers, streams, and ditches



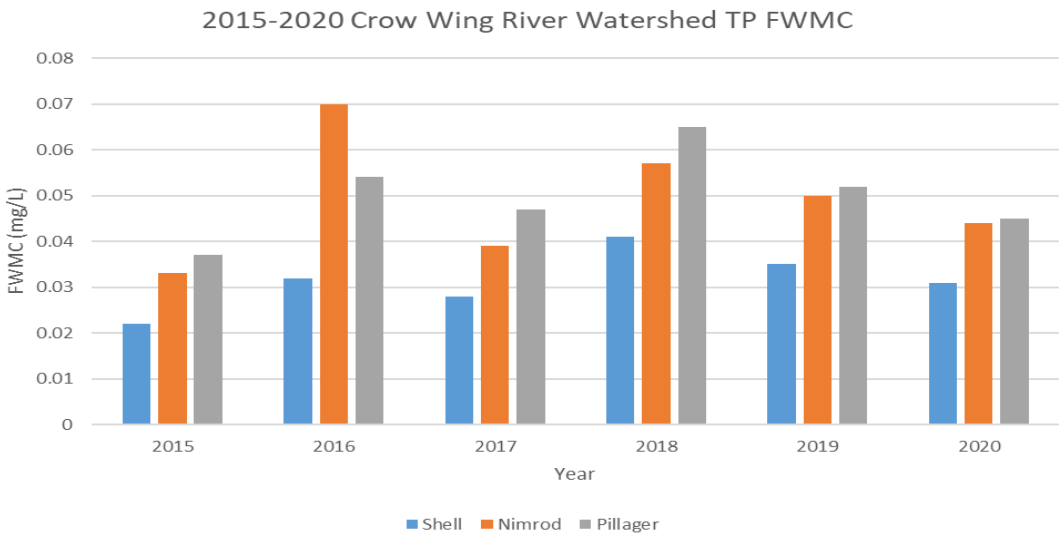
Streamflow and pollutant concentrations

The Watershed Pollutant Load Monitoring Network (WPLMN) has three monitoring stations within the Crow Wing River Watershed, two on the Crow Wing River and one on the Shell River. All three stations are considered long-term with monitoring continuing indefinitely into the future. 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 (TP) – grows algae.
- Nitrate-Nitrogen – can contribute to algal growth, can be toxic to fish, and is a concern in drinking water.

The watershed lies within a transition zone of northern Minnesota's forests and southern/western Minnesota's agricultural lands. In addition to landcover transitions, the watershed is located along the transition of Minnesota's River Nutrient Regions (RNR). The Shell River and Crow Wing River at Nimrod are in the "Central" region which has a TP standard of 0.10 mg/L. Crow Wing River at Pillager is located in the "North" region which has a standard of 0.05 mg/L, however this station has a Site-Specific Standard (SSS) for TP of 0.075 mg/L. Although the Shell and Crow Wing Rivers have mostly intact and natural riparian zones, the water quality within these systems do show some signs of increasing pollutant concentrations.

Figure 3. Total phosphorous Flow Weighted Mean Concentrations (FWMC)



Each of the three stations have TSS concentrations (Table 1) well below the state standard (30mg/L) and nitrate-nitrogen concentrations—while quite low on a statewide basis—in the moderate range for the region. TP concentrations are well below the Central RNR but do show an increase from the upstream Shell River station to the Crow Wing River at Nimrod station. Further downstream at the Crow Wing River at Pillager, the TP concentration continues to rise, however, is below the standard for this station (Table 1).

Table 1. Comparison of average FWMC for the Shell and Crow Wing Rivers (C.W. River at Nimrod and Shell River 2015-2020, C.W. River at Pillager 2008-2020).

Station	Station ID	TSS (mg/L)	NO2+NO3 (mg/L)	TP (mg/L)
Shell River near Huntersville	S003-442	3.5	0.61	0.032
C.W. River at Nimrod	S001-326	5.7	0.34	0.049
C.W. River at Pillager	S001-926	4.7	0.37	0.055

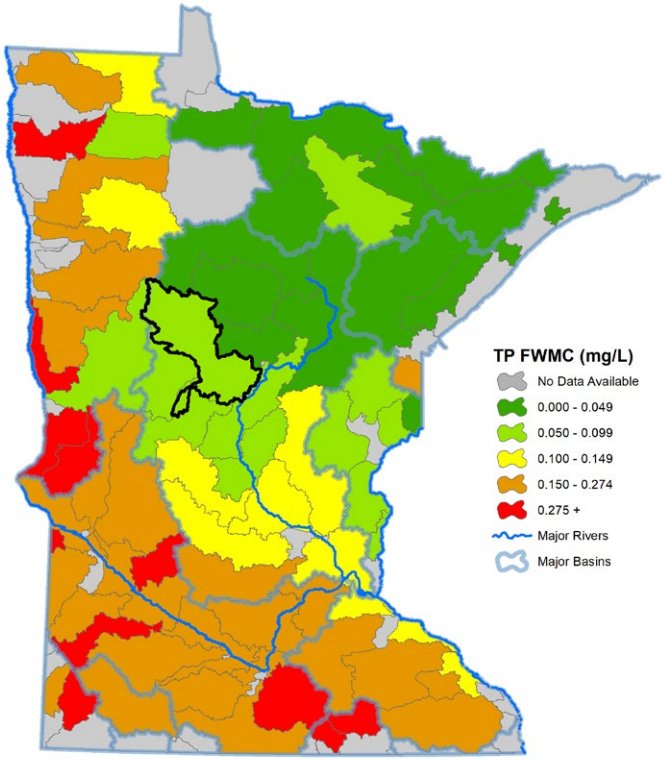
Nitrate-nitrogen concentrations at the three stations are slightly higher than the watersheds to the north and east but lower than those to the south and west. Furthermore, the nitrate concentrations are variable depending on time of year within these systems, with higher concentrations during spring and late fall and lower concentrations during early summer to early fall. As more cropland is found within this portion of the watershed and more specifically near the headwaters and along the Shell River, 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 enters these rivers 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 as well as other point and non-point sources.

Similarly, TP and TSS concentrations within the watershed are both increasing from lower concentrations found north and east to the higher concentrations in the southern and western portions of the state. A common pattern exists at all three stations where TSS and TP concentrations increase with flow. This relationship is strong at the two Crow Wing River stations and although the relationship is weaker, a relationship still exists at the Shell River station. Increased flow and pollutant concentrations are commonly associated with rising flows following

heavy rain events. This information likely suggests that phosphorus is bound within the sediment particles on the landscape and when rain events erode the topsoil and/or riverbanks surrounding these rivers, the sediment that is washed into the river contains phosphorus. Pollutant concentrations are reduced as flow decreases within the rivers.

At a broader scale, the concentrations found within this watershed can be compared to those within the Mississippi River to gage the impact that the Crow Wing River Watershed has on the Mississippi River, specifically the section located within central Minnesota. The Crow Wing River Watershed's pollutant concentrations were compared to those found at the next downstream monitoring location on the Mississippi River, located two miles west of Royalton. In total, the Crow Wing River Watershed contributes 17 percent of the total drainage area and 31 percent of the total flow volume to the Royalton station. Nitrates are the largest contributing pollutant at 46 percent of the annual load at Royalton while TP and TSS inputs have a lesser impact, although still significant, contributing 35 and 20 percent of the average loads, respectively.

Figure 4. Average total phosphorus FWMC by major watershed, with the Crow Wing River Watershed outlined in black.



Lakes

The hundreds of lakes within the watershed vary in size and physical characteristics and reflect lakes typical of both ecoregions of the watershed – the North Central Hardwood Forests and Northern Lakes and Forests. The watershed's lakes range from relatively undisturbed to extensively developed and intensively used for recreation. Dozens of the lakes are noted by the MNDNR to be of outstanding biological significance, and are a valued resource enjoyed by many.

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. The MNDNR assesses aquatic life use in lakes using a fish-IBI tool that will be discussed in greater detail later in this section. There were 141 lakes within the watershed that had available eutrophication water quality data within the 2012-2021 assessment window. Overall, the lakes in the watershed are in good condition, with no new aquatic recreation impairments resulting from the assessments completed in 2022.

Eight lakes had existing nutrient impairments and all of them were confirmed to still be in an impaired condition through new monitoring data. Total Maximum Daily Load (TMDL) studies have been completed for all these lakes and restoration work is underway to implement projects that will address these impairments. Local partners are active across the watershed in implementing best management practices to improve water quality in the valued lakes found in the area, but ultimately the condition of the lakes is changing slowly (if at all). Best management practices to improve lake water quality will require time to be reflected in monitoring results. Internal loading (the recycling of phosphorus within a lake) will also have to be addressed while watershed inputs of nutrients are controlled for the impaired lakes in the watershed.

Three lakes are currently meeting water quality standards but are close to the applicable standards and vulnerable to impairment for the aquatic recreation designated use. Two of these lakes are in the Crow Wing Chain, which forms the headwaters of the Crow Wing River. Seventh Crow Wing Lake is meeting but very close to exceeding TP criteria. Chlorophyll-a in Seventh Crow Wing Lake is showing a definitive response to excess nutrients; if the lake degrades further, it will likely be listed as impaired for excess nutrients. Watershed partners discussed the need to address upstream impairments—the immediately-upstream Eighth Crow Wing Lake is impaired for nutrients—to protect downstream Seventh Crow Wing Lake and Third Crow Wing Lake. In Third Crow Wing Lake, TP meets the standard while both response parameters, chlorophyll-a and Secchi, are showing a response to excess nutrients. Ultimately, the upstream lake impairments are impacting downstream lakes, with the entire connected system demonstrating how nutrients move downstream through the Crow Wing River.

Rock Lake is also vulnerable to impairment, with elevated TP concentrations that are near the applicable standard and both response parameters (chlorophyll-a and Secchi disk) exceeding their respective criteria. Rock Lake's watershed is relatively intact, and a relatively isolated basin compared to many other lakes in the watershed. Internal nutrient cycling and nutrient cycling through riparian wetlands are likely contributors and will be explored in the Watershed Restoration and Protection Strategies (WRAPS) update for the Crow Wing River Watershed.

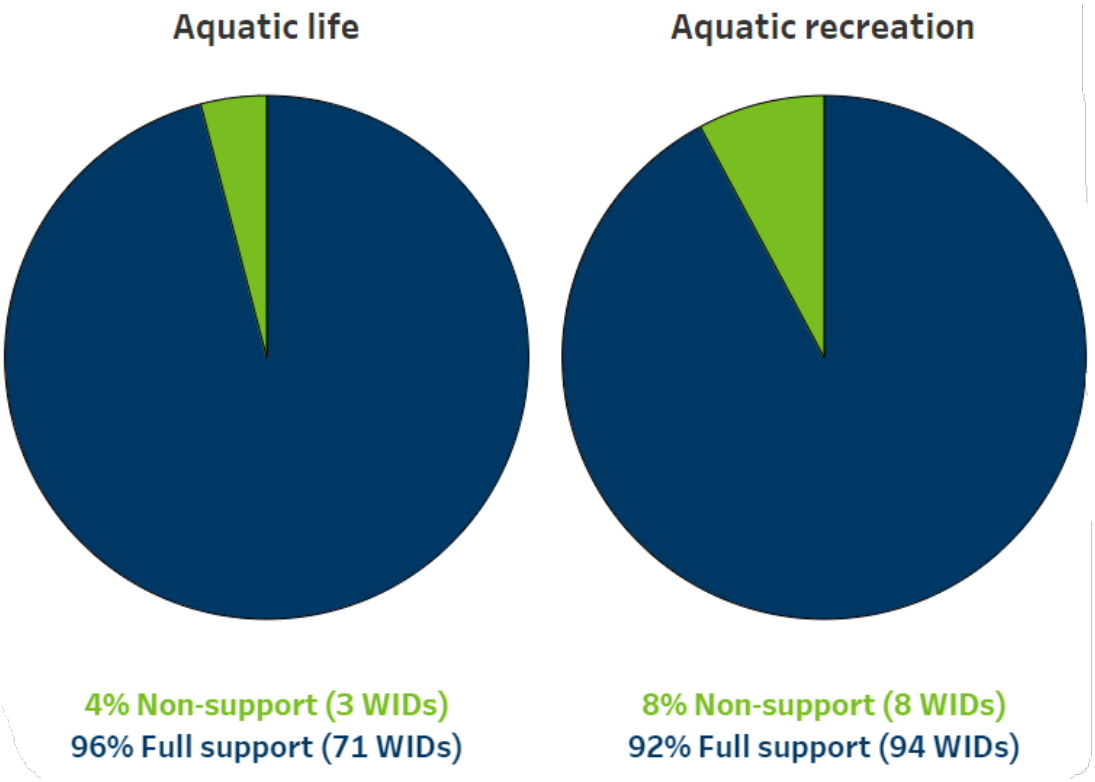
Seventy-four lakes (81 basins) within this watershed were assessed for aquatic life for the first time using a fish based IBI. The vast majority (i.e., 96%) of the assessed lakes were found to fully support aquatic life, and a large percentage of those (i.e., 36%) contained exceptional fish communities, including Fish Hook, Potato, Long, Gull, Sylvan, and many of the Crow Wing Chain lakes. Lakes that fully supported aquatic life were in watersheds that were forested with less developed shorelines. Because of development pressure in the watershed, efforts to protect the

forested lands and undeveloped, natural shorelines around lakes should remain in the future to ensure that fish communities, water quality and habitats remain intact.

A total of 57 fish species were collected in lakes during fish IBI sampling. Of these, 18 are considered intolerant species—susceptible to pollution and watershed disturbance. Burbot, Cisco (Tullibee), and Rainbow Trout were also sampled and are considered coldwater species, requiring cold, oxygenated water to survive. Other notable species included Least Darter and Northern Sunfish which are State Species of Concern, and the Pugnose Shiner; a State Threatened Species.

Only a very small percentage (i.e., 4%) of the lakes were determined to be impaired (i.e., Sibley and Middle Whipple lakes) or vulnerable to impairment (i.e., Bass Lake (03-0127-00) based on the fish IBI. Stressors that are likely influencing these fish communities include excess nutrient inputs from agricultural and urban land uses and degraded and/or developed shorelines. Natural factors were the main cause of impairment on West Crooked Lake.

Figure 5. Aquatic life and aquatic recreation use assessments in lakes



Trends

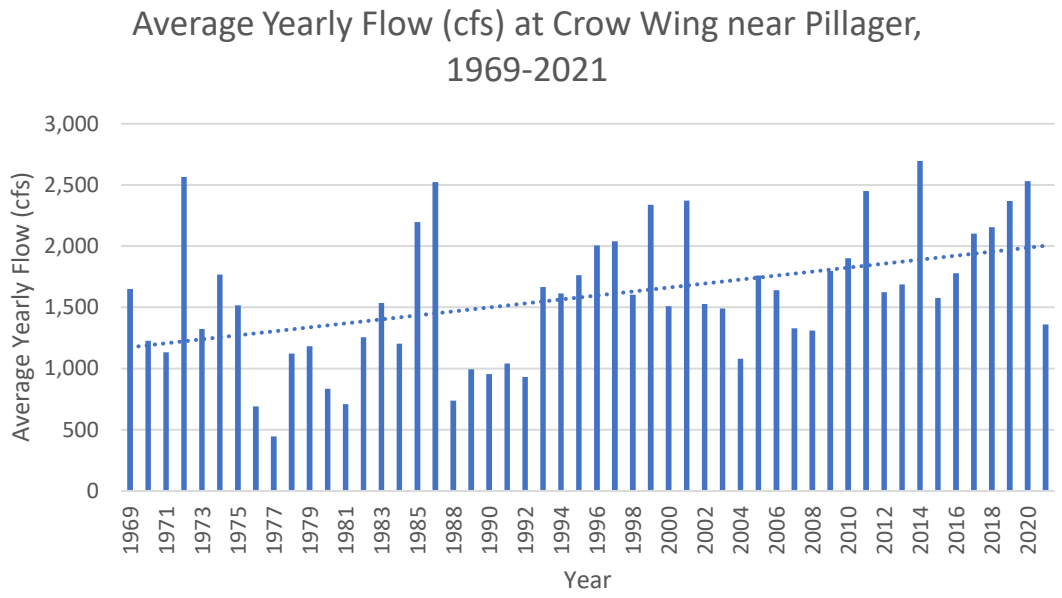
Figure 6. Change over time relating to biological communities and lake clarity

A key objective of the 2020 and 2021 monitoring effort was to evaluate if and how water quality has changed since the monitoring that had occurred in 2010. If water quality has improved, it is important to understand to what extent strategy development, planning, and implementation; 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. 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 Crow Wing River Watershed:

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

Figure 7. Average yearly flow in cubic feet per second (cfs) of the Crow Wing River near Pillager, 1969-2021 (1987 flows not available).



Streamflow and pollutant concentrations

Trend results were analyzed for the Crow Wing at Pillager (2008-2020) and showed mixed results between parameters. Nitrate-nitrogen results showed a significant increasing trend, TP showed a decreasing trend, while TSS showed no significant change over this time period. Figure 7 displays the long term yearly average flow data of the Crow Wing River near Pillager from 1969 to 2021. The figure shows that over the 53-year period of record, average yearly flows have increased by roughly 800cfs (approximately 65 percent). Flow changes are very important for downstream waters (i.e., the Mississippi River) because more flow means more overall pollutant load (mass), even if pollutant concentrations are unchanged. It should be noted that the flows at this station are controlled by the Sylvan Dam located immediately upstream of the sampling location; however, the dam would have a limited impact on long-term average flows. Additional maps and

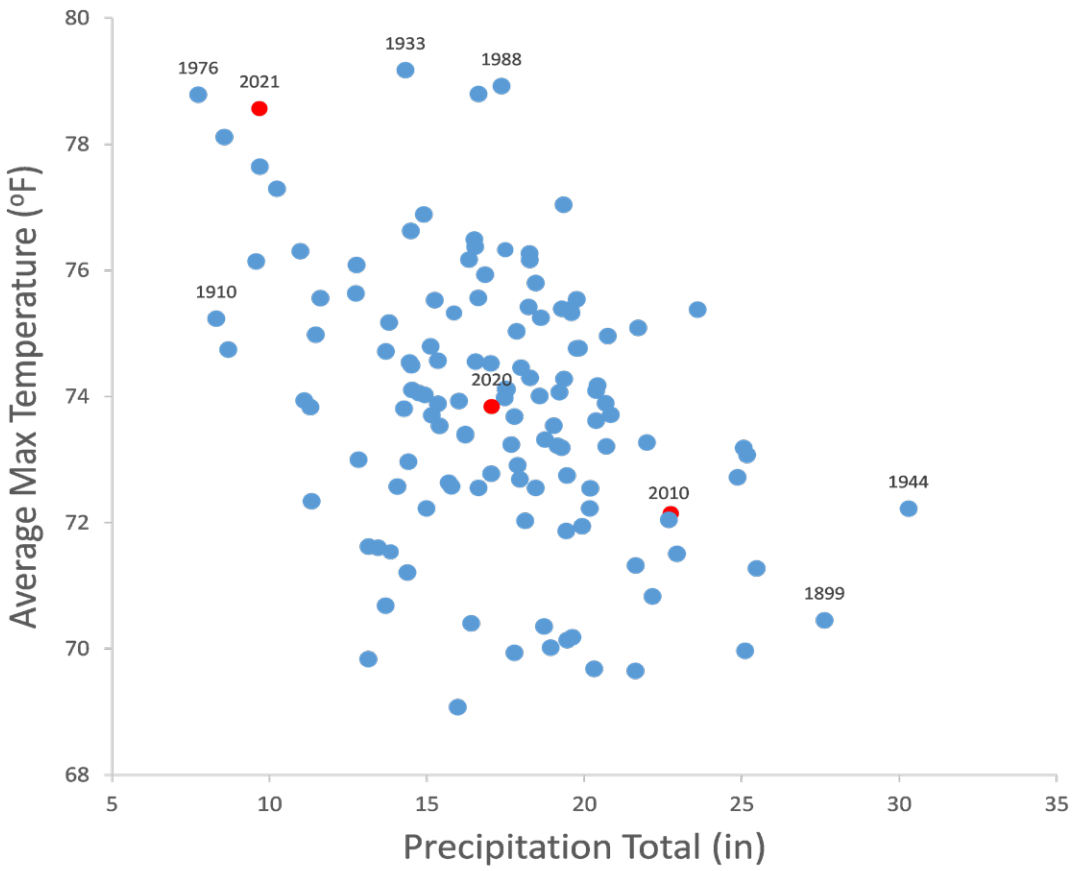
supporting data can be found at https://www.pca.state.mn.us/water/watershed-pollutant-load-monitoring.

Biological communities

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 34 sites evaluated for macroinvertebrates and 29 sites evaluated for fish (i.e., sites that were sampled in both time periods). The average macroinvertebrate IBI score for the watershed increased by 9.6 points between 2010 and 2021, representing a statistically significant positive change. This considerable improvement in macroinvertebrate IBI performance may reflect improvements in water quality and/or habitat conditions, but also may be partially explained by slight changes in the way certain habitat types are sampled now, compared to the first round of watershed monitoring. Fish IBI scores across the watershed decreased by 0.2 points, which did not indicate a statistically significant change.

Prevailing weather patterns during each sampling period (2010 and 2020/21) may influence the results. In 2010, the watershed experienced above normal rainfall (+ 5.1 in) and below normal temperature (-2.0 ^{o}F) during the May to September time period (Figure 8). In 2020, the watershed had normal rainfall (-0.5 in) and air temperature (-0.3 ^{o}F) over the May to September time period. Due to protocols and safety measures put into place because of COVID-19, fish communities were not sampled in rivers and streams until 2021. The summer of 2021 was characterized by extreme drought conditions (-7.9 in/+4.4 F). Since there was such variation between the three years of biological monitoring in this watershed, there is a high likelihood that changes observed at either the watershed or individual site scale are at least partially due to differences in climatic conditions.

Figure 8. Average precipitation and maximum temperature by year



Water clarity

Lakes

The watershed has 173 lakes with at least some transparency data. A trend analysis was conducted on 100 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 are more lakes with improved water clarity than there are lakes with declining clarity. Thirty-six lakes had increasing clarity, 16 lakes had degrading clarity, 12 lakes showed no change, and the 36 remaining lakes analyzed showed no trend (Figure 9). Ten of the 16 lakes with a degrading water clarity trend are in Hubbard County in the northeast corner of the watershed, which may help to inform protection and prioritization efforts in this region of the watershed. Much of the data needed to determine these trends is collected by local volunteers through the MPCA's Volunteer Water Monitoring Program.

Streams

The watershed has 74 stream stations that have at least some transparency data, measured with a Secchi tube. A trend analysis was conducted on 31 stream stations that met data requirements to run a trend test. Stream water clarity must change at least 2 centimeters per decade to be considered a detectable change, or trend.

Degrading clarity was observed at a station on the Shell River (S003-853-Change to location), near its inlet to the nutrients-impaired Blueberry Lake. Improving clarity was observed at two stations, one of which was also on the Shell River, at the outlet of Blueberry Lake — this station is likely heavily influenced by the lake and not representative of the stream conditions in this reach. The other station with improving clarity was the Cat River at Wadena County Highway 26. One station (S006-086, Unnamed Ditch to Big Swamp Creek at 336th St.) showed no trend. The remaining 27 stations were too clear to run trend tests, indicating consistently high Secchi tube readings. Multiple stations may exist on an individual stream reach, and different results at monitoring stations along an individual reach are possible and reflect the variability present in stream systems.

Climate

The MNDNR Climate Summary for Watersheds describes 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 Crow Wing River Watershed currently receives on average an additional 0.6 inches of rain. Most of this increase occurs in the fall (September/November, 0.6"). Meanwhile, the average annual temperature across the watershed has increased by 1.4° F, with a more pronounced increase (+2.8° F) observed during the winter (December-February). More precipitation and reduced snow cover can increase soil erosion, pollutant runoff, and stream flow. Increased stream flow can lead to in-stream channel erosion and degraded habitat for aquatic life. Longer growing seasons with higher temperatures can cause more algal blooms, especially in lakes. These changes will likely complicate efforts to protect and restore the aquatic resources in this watershed. For a more comprehensive analysis of climate trends for the Crow Wing River Watershed see: Climate Summary for Watersheds, Crow Wing River (http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/climate_summary_major_12.pdf)

For more information

This study of the Crow Wing 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 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 Crow Wing River webpage, or search for "Crow Wing River" on the MPCA website.

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CLEAN WATER LAND & LEGACY AMENDMENT