July 2025

Upper Big Sioux, Lower Big Sioux, and Little Sioux Watershed Assessment and Trends Update

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

Summary

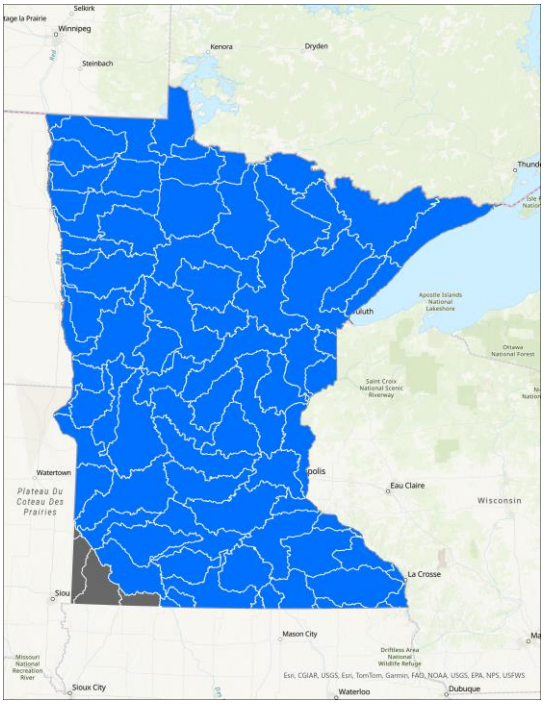
The Minnesota Pollution Control Agency (MPCA), Minnesota Department of Natural Resources (DNR), and partners completed a study of the Upper Big Sioux, Lower Big Sioux, Rock and Little Sioux watersheds, which includes the rivers themselves along with tributaries and lakes. These watersheds form Minnesota's contribution to the Missouri River. Lakes and streams in these watersheds continue to struggle with symptoms of poor water quality. Biological communities in streams are revealing changes compared to the previous round of this work effort. Lakes continue to suffer from poor water quality for recreational enjoyment. A dam removal and stream restoration in Mound Creek led by DNR was found to be directly linked to improved macroinvertebrate community health in that stream. For the first time, lakes in these watersheds were studied by measuring fish community health. It was found these lakes were of poor water quality for supporting aquatic life. Excess sediment, nutrients, and bacteria continue to be a problem for streams of various sizes and locations across these watersheds.

Instead of relying on chemical monitoring of the water alone, scientists also studied the fish and bugs living in the waters. Doing so offers a more comprehensive understanding of the watershed's health over time. Volunteer water clarity 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 monitoring is essential to determine whether lakes and streams meet water quality standards that are designed to ensure waters are fishable and swimmable. While local partners and state agencies monitor water quality on an ongoing basis, the MPCA and local partners conduct an intensive examination of major lakes and streams in each of the state's 80 watersheds every 10 years to detect any changes in water quality. This intensive monitoring looks at fish and macroinvertebrate (bug) communities as well as water chemistry to gauge water quality. Data is then passed on to local partners to guide their work in the watershed.

Figure 1. The Missouri River Basin watersheds are in the southwest corner of Minnesota. These are the only watersheds in Minnesota that flow into the Missouri River.



The MPCA and partners monitored water quality conditions in 2011 and 2012, and again in 2022 and 2023. Chemistry data collected by local partners between 2011 and 2022 were used for assessment. The data used to assess the condition of Minnesota waterbodies, focus on whether they are meeting water quality standards for aquatic life, recreation, and consumption. The overall goal of these assessments is to determine which waters are healthy and in need of protection or are polluted and require restoration.

Changes in water quality

Figure 2. Tributary to Beaver Creek waterfall in Touch the Sky National Wildlife Refuge.

Water quality monitoring is essential to determining whether lakes and streams meet water quality standards designed to ensure that waters are fishable and swimmable. To detect changes in water quality, this recurring monitoring effort looks at water chemistry, fish, and macroinvertebrate communities. Scientists use a tool called the Index of Biological Integrity (IBI) to assess the health of biological communities in lakes, rivers, and streams. High IBI scores indicate a healthy aquatic community, which occurs when water quality, habitat, and hydrology are minimally disturbed by human activities. They use the data to see which waters are healthy and need protection, and which are polluted and need restoration.

Over the past decade, scientists have observed some clues to changes in water quality.

- The condition of stream macroinvertebrate communities improved significantly at monitoring locations across all four watersheds.
- Meanwhile, fish communities in streams significantly declined in condition across the same network of monitoring locations in these four watersheds.
- Three macroinvertebrate impairments are proposed for removal from the Impaired Waters List due to improved condition, one specifically linked to stream restoration activities.
- One fish impairment is proposed for removal from the Impaired Waters List due to improved condition.

Local partners and landowners installed best management practices to restore and protect water quality. It takes time for these practices to drive change in water quality condition.

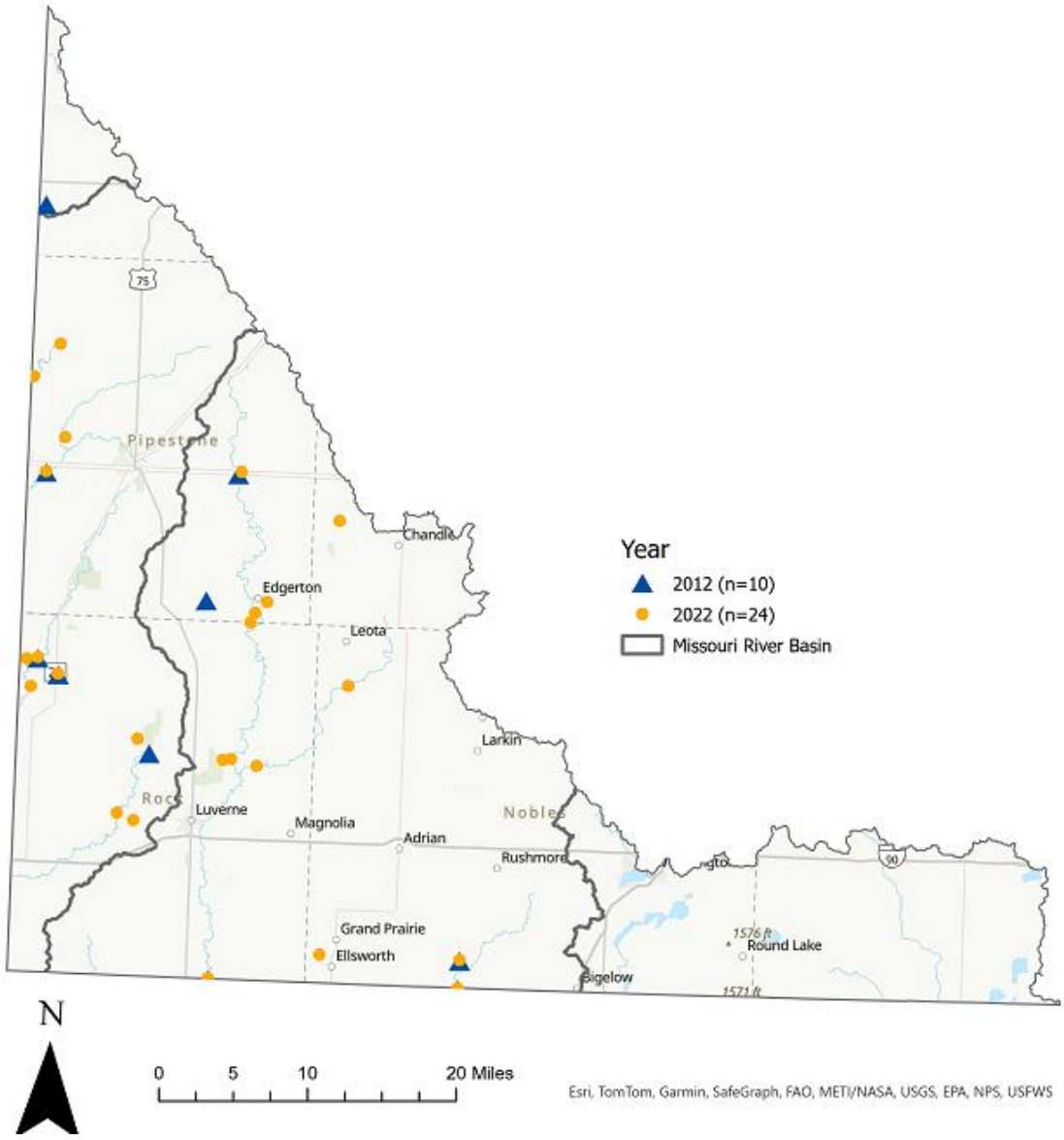
Highlights of monitoring

- Thirty-three fish species were collected in lakes during fish IBI sampling. Of these, four are considered intolerant species (i.e., Iowa Darter, Logperch, Muskellunge, and Smallmouth Bass) —susceptible to pollution, shoreline habitat disturbance, and watershed disturbance.
- Other notable fish species captured in lake surveys included Quillback, Shorthead Redhorse, and Shortnose Gar, which are more common in rivers.

- No threatened, endangered, or State Species of Concern were found within the lakes that were sampled for fish in this watershed.
- An exceptionally high amount of insectivore (i.e., Bigmouth Buffalo, Bluegill, Freshwater Drum, and Yellow Perch) biomass was captured during the trap netting survey on Loon Lake.
- A relatively high biomass of top carnivore species (i.e., Channel Catfish, Northern Pike, and Walleye) was captured during the gill netting survey on Okabena Lake, these metrics contributed positively towards the Fish IBI models and are typically components of healthy fish communities.
- Recent monitoring of Clear and Round lakes highlights some improvement in data used to understand the quality of recreational condition for lake users.
- Field observations by MPCA during Round Lake recreational monitoring visits indicate the lake regularly fluctuates from a clear, vegetation dominated state to a green, algal dominated state.
- In recent years, flow monitoring at long-term watershed monitoring locations in the Missouri Basin highlight a pattern of springtime flooding followed by prolonged periods of extreme drought.
- Over 200 distinct macroinvertebrate taxa were collected in streams during cycle 2 surveys.
- Cycle 2 fish sampling resulted in the collection of 49 distinct fish species, including the federally endangered Topeka Shiner and state threatened Plains Topminnow.
- The Topeka Shiner was found in both higher numbers and at more locations compared to past monitoring work (Figure 4).
- Stream biological monitoring efforts in 2022 were cut short due to intense flooding in the spring transitioning into extreme drought conditions later in the summer months, shifting some biological monitoring efforts into 2023.

Figure 3. Topeka Shiner observed by a MPCA stream monitoring crew in 2022.

Figure 4. Comparison of Topeka Shiner observations by stream monitoring efforts between 2012 and 2022.



Success story

In 2019, the DNR removed a dam on Mound Creek, a tributary to the Rock River located in in Blue Mounds State Park. The dam was originally built in the 1930s creating Lower Mound Lake; in 2014 the dam failed during a flood event. The dam removal allowed for a significant stream restoration project.

The DNR, along with US Fish and Wildlife, and the Federal Emergency Management Agency, cooperated on a restoration of the previously impounded lakebed into a meandering, stable stream channel, providing improved habitat for species native to southwestern Minnesota, such as the Topeka Shiner and Plains Topminnow. The project renewed the creeks connection to the flood plain, which will provide water storage in high water events and allow for the retention of nutrients and sediment from upstream sources. The bank reshaping and grade control riffles returned natural flow patterns, which will promote maintenance of clean, coarse substrates and natural stream habitat, giving aquatic life better places to feed, shelter, and reproduce.

Figure 5. Stream restoration project in Mound Creek. Stream channel re-meandering, bank shaping, and grade control riffles restore natural features of the creek which improve conditions for aquatic life.

In 2023, the MPCA biological monitoring crews sampled Mound Creek for macroinvertebrates below the dam removal site and adjacent to the stream bank restoration. Monitoring results showed a significant improvement in the macroinvertebrate community, including improved habitat conditions that have a positive impact on all aquatic life. Based on data from the 2023 monitoring, biologists are proposing to remove the macroinvertebrate impairment from the Impaired Waters List on this section of Mound Creek. This delisting was found to be directly linked to stream restoration activities of this project.

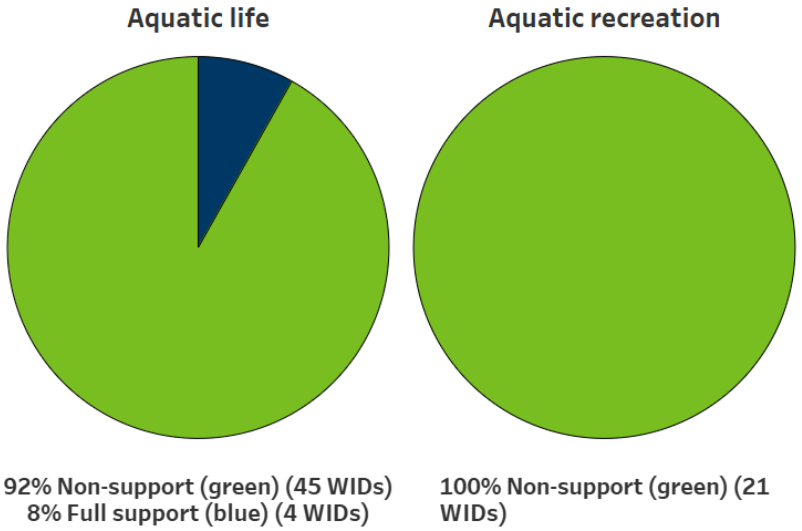
Watershed assessment results

Streams and rivers

Overall, 8% of the stream reaches meet aquatic life use (Figure 6, Figure 7) standards in the Missouri Basin watersheds. Stream reaches that meet aquatic life use standards have biological communities indicative of good water quality and habitat conditions. Most streams meeting aquatic life use conditions are smaller headwater streams scattered across each of the Missouri basin watersheds.

There were no new water chemistry impairment listings or delistings in Missouri Basin watersheds during the

Figure 6. Watershed assessment results for aquatic life and aquatic recreation use in streams in the Missouri River Basin watersheds.



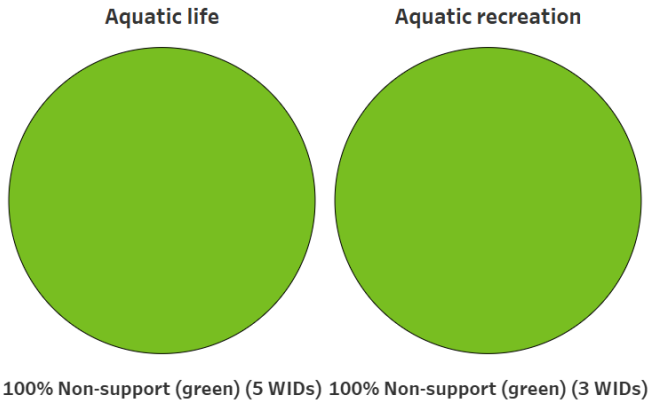
recent assessment. All water chemistry problems identified previously were either confirmed as impaired or did not have sufficient new data to delist the impairment. Excess suspended sediment, also referred to as turbidity, impact many of the Missouri Basin's streams. There are nine stream reaches with existing sediment problems that were confirmed to remain as impaired based on recent data. Sixteen stream reaches without more recent sediment data will remain impaired for suspended sediment. Many of the turbidity impairments listed are within the Rock River Watershed. Additionally, one stream reach, Judicial Ditch 8 (Clear Lake to Loon Lake) in the Little Sioux River Watershed was identified as being vulnerable to suspended sediment impairment based on monitoring data. The high pH values suggest there could be a high amount of primary production occurring in stream reaches within the Little Sioux River Watershed. Elevated phosphorus levels were prevalent across the watersheds. Split Rock Creek (Pipestone Creek to Minnesota/South Dakota border) has an existing impairment for river nutrients; newer data used in this assessment confirmed this condition. Eight stream reaches within the Rock River Watershed were found to have elevated pH readings; these were identified as vulnerable to future pH impairment but lack complete data for a confident assessment at this time.

Poor aquatic recreation conditions due to elevated bacteria levels are widespread across streams in the Missouri Basin watersheds. There was one new *E. coli* impairment was added on the Rock River between Champepadan Creek and Elk Creek. There were three streams (Medary Creek, Split Rock Creek, and Judicial Ditch 8) that are identified as vulnerable to poor aquatic recreation use conditions in the future due to elevated levels of *E. coli*. Overall, none of the streams assessed were found to be fully supporting for aquatic recreation use (Figure 6).

Lakes

Excess algal growth or a loss of water clarity may impair the recreational use of a lake (e.g. swimming, boating). For this reason, the MPCA relies on an ecoregion-based eutrophication standard to determine whether a lake meets its aquatic recreation use. Excessive nutrient concentrations, in particular phosphorus, may lead to increased algae blooms under certain conditions (i.e., sunlight, warm weather). If nutrient concentrations exceed the standard, the MPCA utilizes water clarity data (Secchi disk), and/or algal growth data (chlorophyll-*a*) to determine if excess nutrients have resulted in a eutrophication response sufficient to trigger an aquatic recreation impairment.

Figure 7. **Watershed assessment results for aquatic life and aquatic recreation use in lakes in the Missouri River Basin**



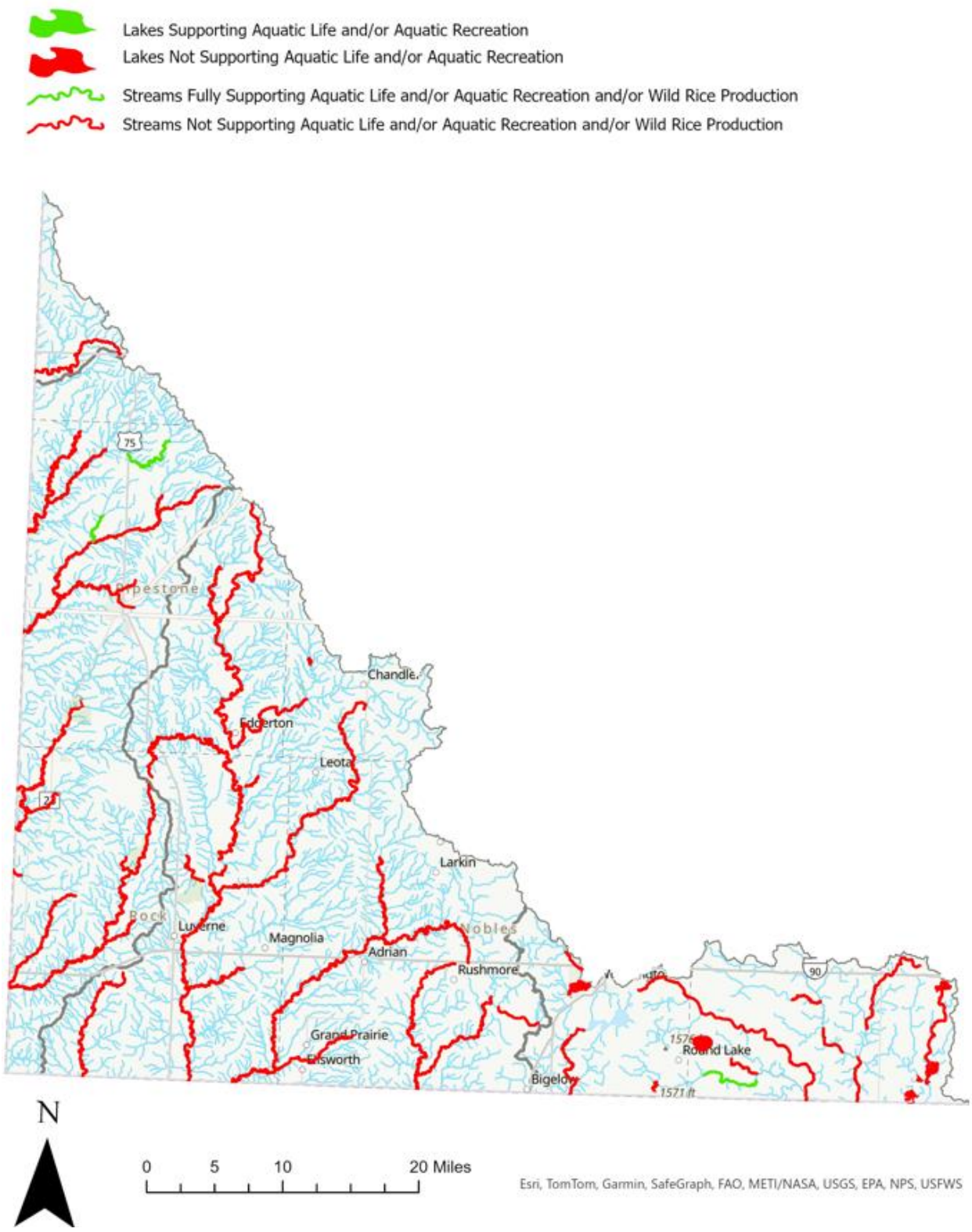
Twelve lakes were assessed this cycle, eleven in the Little Sioux River Watershed and one in Lower Big Sioux Watershed (Figure 7, Figure 8). Of the 12 lakes assessed, ten are currently impaired for aquatic recreation use, the other 2 lakes (Summer Marsh and Ocheda Lake-Middle Bay) lack enough information to make a designation for support or nonsupport. Bella Lake had insufficient information to make a use support designation, and its legacy aquatic recreation impairment will

remain. Split Rock Reservoir and Pearl Lake were not previously impaired and will now be considered impaired for aquatic recreation use. There were five lakes (Loon Lake, Little Spirit Lake, Indian Lake, Ocheda Lake-West Basin, and Lake Okabena) that were sampled for just one year in this cycle as a check-up to confirm their aquatic recreation status. Data from this single year of monitoring is consistent with the prior nonsupport decision and will remain impaired. Round Lake data shows to be meeting phosphorus and chlorophyll-a with Secchi disk being right around the state standard, but field observations suggest this lake goes through regular fluctuations from clear water, macrophyte dominated state to a green, algal dominated state.

In general, the lakes assessed in the Missouri Basin watersheds are not meeting state standards for recreational use. Most lakes in this area are shallow which leads to regular mixing of the water column resuspending existing nutrients in sediment. This increases the availability to fuel nuisance algae blooms. Disturbances in the form of shoreline alteration and nutrient inputs from land use can quickly create eutrophic conditions.

Five lakes within this watershed were assessed for aquatic life for the first time using a fish-based IBI developed for Minnesota lakes (i.e., Loon, Clear, Little Spirit, Round, and Okabena). All five lakes were found to not support the expected fish community (Figure 7) and will be considered impaired based on the aquatic life use standards. Overall, efforts to reduce the impacts of agriculture and urbanization in the lake catchments should be continued to improve the water quality and habitat to support a more balanced and diverse fish community. Although huge strides have been made to improve the water quality in some of these lakes, it may take multiple generations for the fish community to respond to the improved water conditions. Connectivity of waterways from the impaired waterbodies to neighboring lakes streams and rivers can be important in the process of extirpated fish species recolonizing a lake.

Figure 8. **Assessment results for aquatic life and aquatic recreation on rivers, streams, and lakes.**



Trends

A key objective of the 2022 monitoring effort was to evaluate if and how water quality has changed since the initial monitoring. If water quality has improved, it is important to understand to what extent human actions may be responsible for the change. It is equally important to understand if water quality does not appear to be changing or is declining. Either way, the knowledge will help inform future activities.

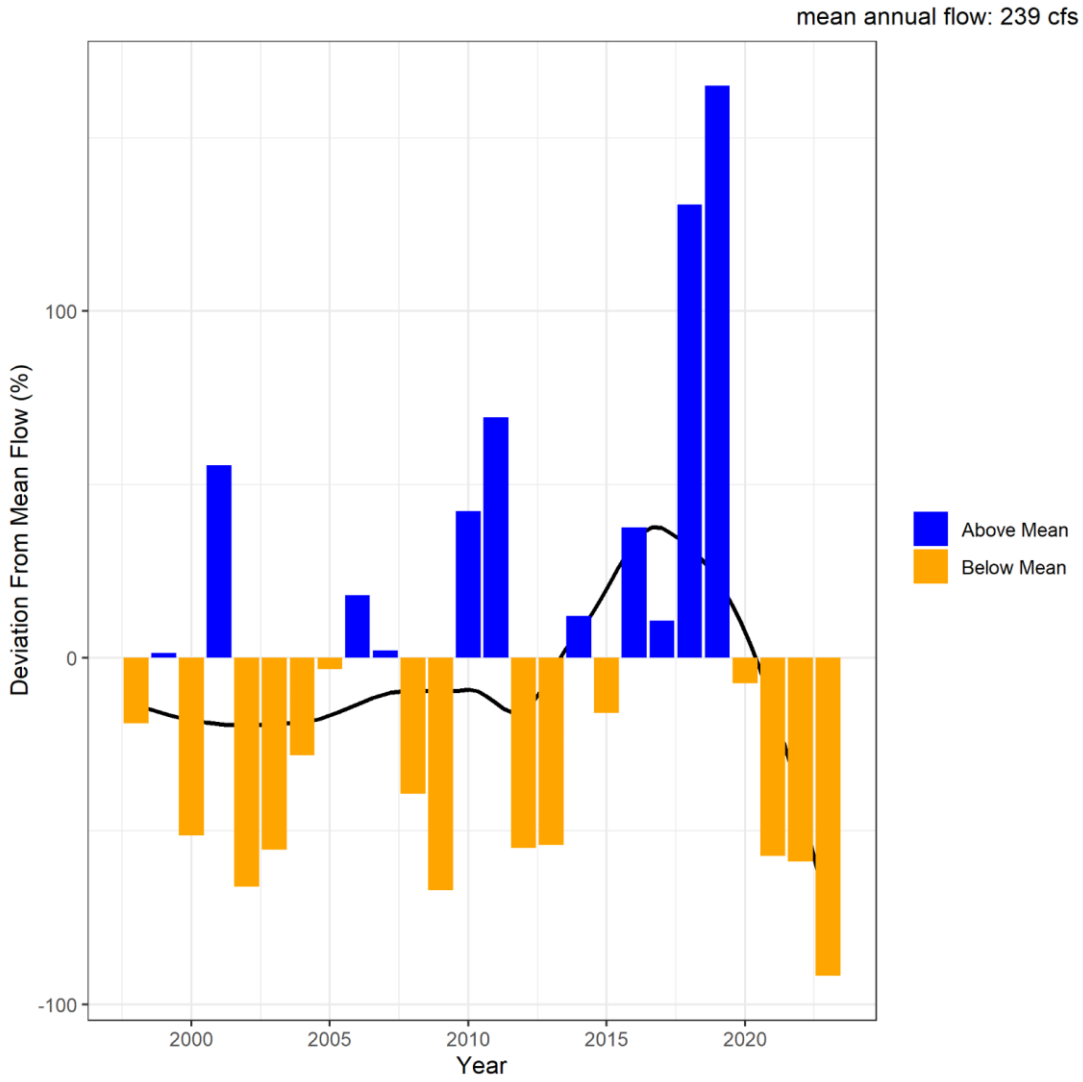
Trends in four different aspects of water quality was analyzed to provide as robust a picture as possible of what is happening in the Missouri River Basin watersheds:

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

Streamflow and pollutant concentrations

Annual stream flow (discharge) data is available from Minnesota DNR for all three long term monitoring sites in this watershed. Figure 9; however, refers only to the Rock River outlet station. The changing yearly average flow (black line) is calculated using LOESS (locally estimated scatterplot smoothing) with the yellow and blue bars showing each years' deviation as above or below the average (239cfs). The last few years have had higher flows in the springtime followed by prolonged drought conditions the rest of the year at all three sites. Increasing streamflow has implications for stream channel conditions and pollutant loading. This could mean more channel erosion and possibly more pollutant loading, even if pollutant concentrations are stable. Whereas, drought conditions can lead to warmer waters, loss of habitat for aquatic life, and increased algae growth. Loads represent the total amount of pollutant moving through a system, which is a important way of measuring water quality.

Figure 9. The percent deviation from normal flow over time at the Rock River monitoring station.



Seasonal Kendall trend for 2008 through 2022 tests on suspended sediment, phosphorus, and nitrate-nitrogen concentrations at the Rock River and Split Rock Creek long-term monitoring stations were used to determine if changes over time were statistically significant. There were no trends found at either site for turbidity, phosphorus, or nitrate-nitrogen.

In a statewide comparison of pollutants (suspended solids, phosphorus, and nitrate nitrogen), the Missouri River Basin has high values compared to other parts of Minnesota; however, data is not available for several HUC-8 watersheds (Figure 10). Within the Missouri basin there are three long-term monitoring stations: the Rock River at Luverne, Split Rock Creek near Jasper, and Pipestone Creek near Pipestone. Concentrations in the Rock, Split Rock, and Pipestone watersheds are relatively like each other for all pollutants. Typically, the subwatershed site on Pipestone Creek has lower concentrations than the major watershed sites on Split Rock Creek and Rock River. The only difference is in Nitrate + Nitrite nitrogen (NO2+ NO3), where the opposite can be seen. Figure 11 Highlights the NO2+ NO3 flow weighted mean concentrations (FWMC) calculated for each site. Pipestone Creek typically has a higher concentration than both major sites.

Figure 10. Average suspended sediment flow weighted mean concentration by major watershed.

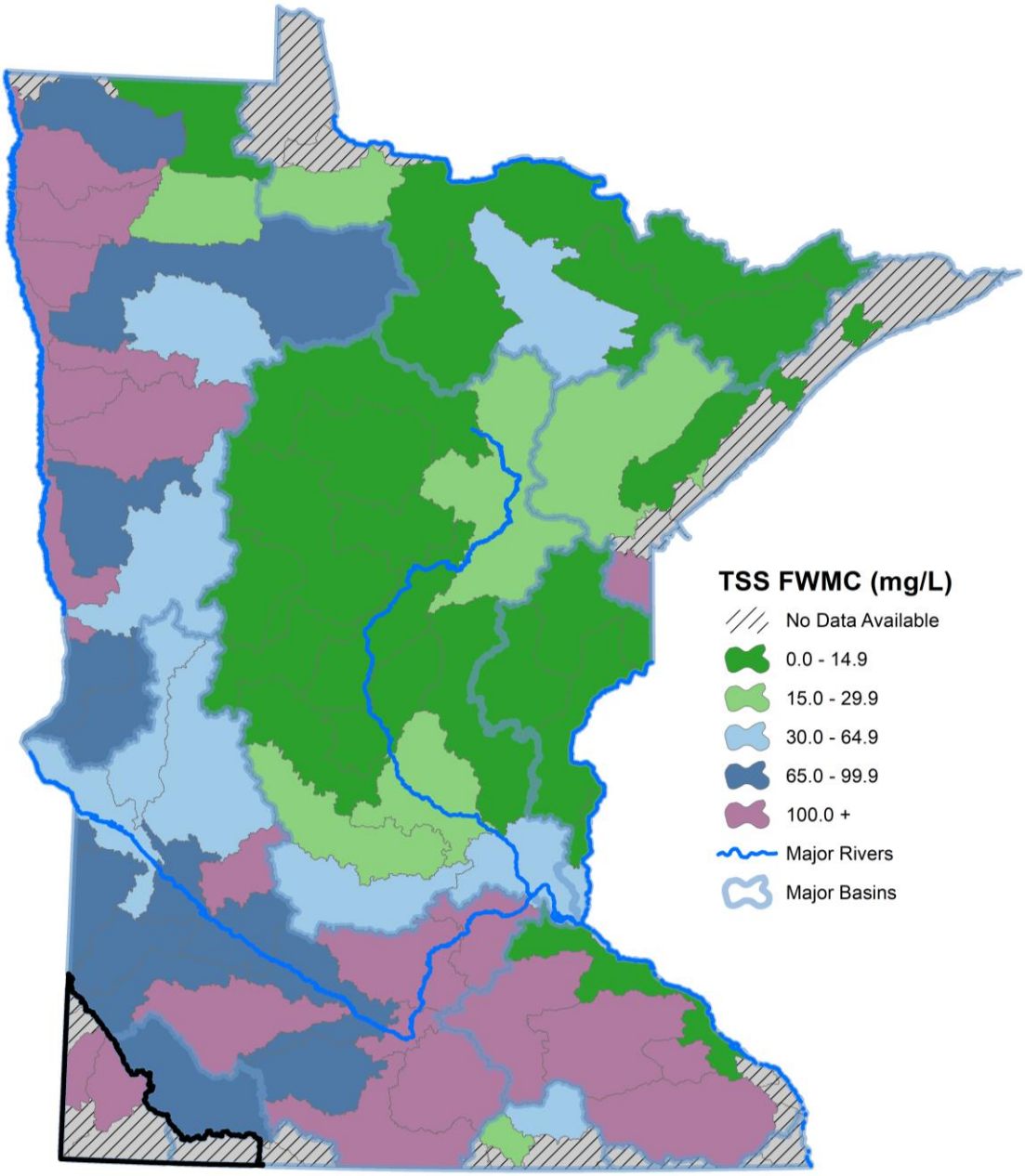
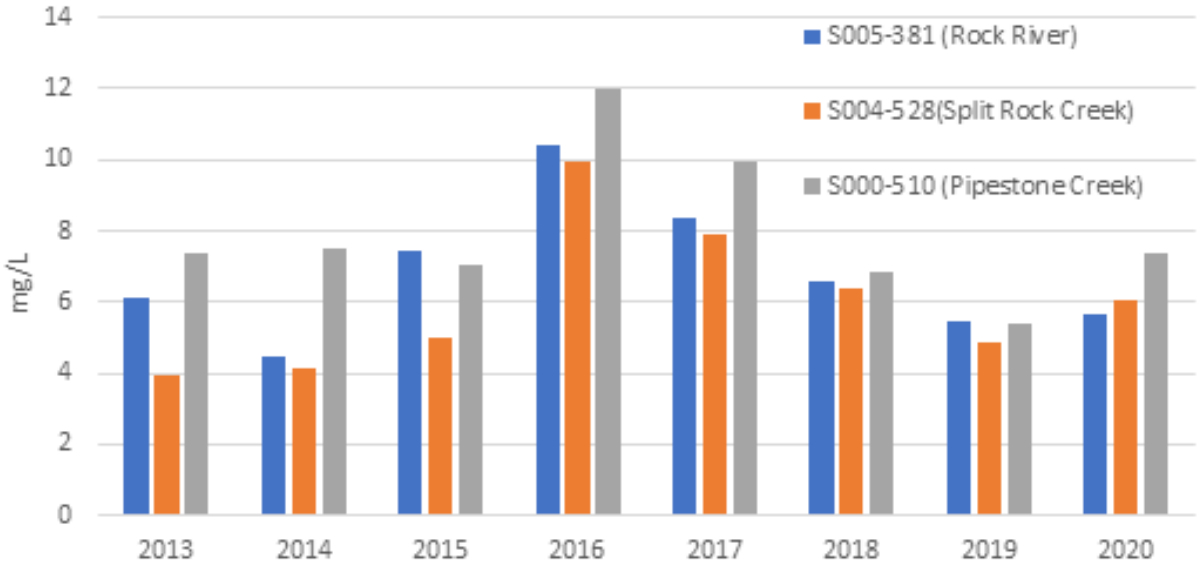


Figure 11. NO2+ NO3 FWMC (mg/L) for Rock River, Split Rock Creek, and Pipestone Creek.



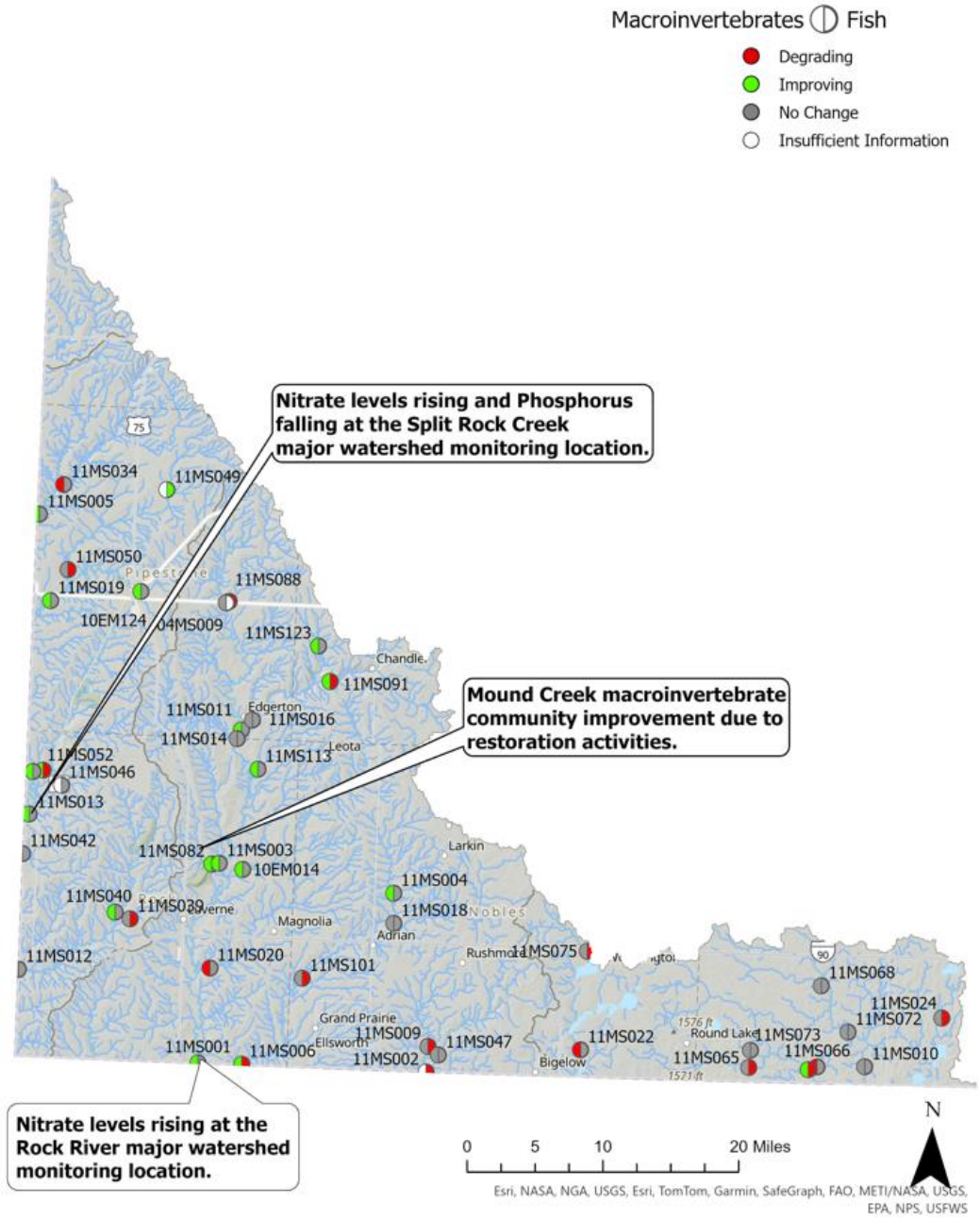
Biological communities

Paired t-tests of fish and macroinvertebrate IBI scores were used to evaluate if the biological condition of the Missouri River Basin's rivers and streams changed between time periods. A similar change analysis was not completed for lakes because comparable fish community data was not collected during the first sampling cycle. Independent tests were performed on each community with 41 sites evaluated for macroinvertebrates and 42 sites evaluated for fish (i.e., sites that were sampled in both time periods). The average macroinvertebrate IBI score for the watershed increased by 7.9 points between 2011 and 2022, this represents a statistically significant increase in biological condition across these watersheds. In contrast, fish IBI scores across the Missouri River Basin watersheds decreased by 5.1 points, this represents a statistically significant decrease in biological condition across these watersheds. While the overall health of fish and macroinvertebrate communities across the watersheds changed significantly between monitoring efforts in 2011 and 2022, biological condition at individual stream sites may have improved or degraded independently (Figure 12).

In 2011, the Missouri Basin watersheds experienced near normal rainfall (1.8 inches above normal) as well as near normal temperatures (0.8 °F below normal) during the May to September period (Figure 13). Additionally, several sites were monitored for fish in the subsequent year, 2012, and those data were included in the IBI change analysis as part of the Cycle 1 data set. The summer months of 2012 experienced a severe drought with a 3.6 in rainfall deficit and air temperatures 4.0 °F above normal. In comparison to Cycle 1, the watershed had a moderate rainfall deficit (-3.2 in) and abnormally warm temperatures (+1.4 °F) in 2022 over the May to September period. Once again, biological monitoring (fish and bugs) occurred the following year and those results contributed to the Cycle 2 data sets in the change analyses. The summer of 2023 saw another severe drought in this part of the state with rainfall amounts estimated to be 8.4 inches below normal and temperatures 4.2 °F above normal from May to September.

Overall, given the near normal conditions present in 2011 and the drought conditions affecting the watershed in 2012, 2022, and 2023, there is a high likelihood that 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.

Figure 12. Changes in water quality in the Missouri Basin watersheds.



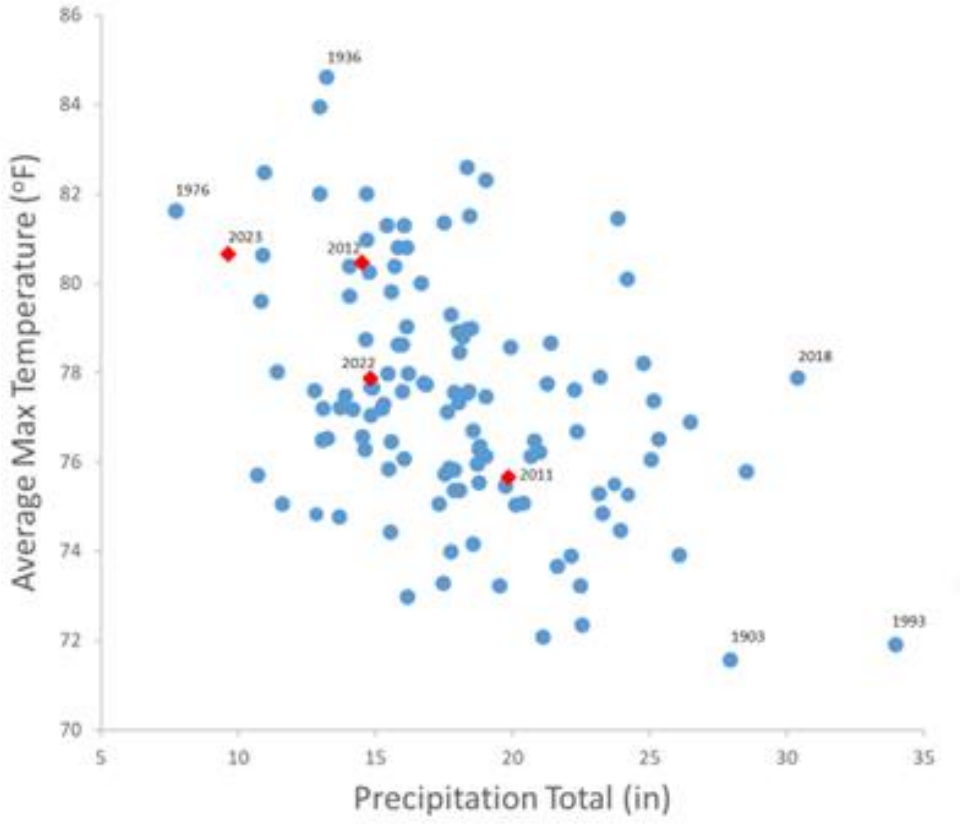
Lake clarity

The Missouri Basin has 12 lakes with transparency data. Trend analysis was conducted on five lakes that met the data requirements (50 Secchi measurements, eight years of data). Like statewide results, most lakes do not exhibit a significant trend. Loon Lake, Clear Lake, Little Spirit Lake, Ocheda Lake-West Basin, and Lake Okabena show no significant trends in water clarity within the last 10 years.

Climate

The Rock River Watershed was used to explore climate differences in the Missouri River Basin watersheds between time periods of monitoring. The watershed now receives on average 1.5 additional inches of rain compared to the historical average (1895-2018). Climate scientists suggest that precipitation events are becoming more intense. In addition, temperatures in the watershed have increased by about 0.8 degree (F) over the same time. More precipitation and reduced snow cover can increase soil erosion, pollutant runoff, and streamflow. Increased streamflow from more intense rainfall patterns 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 persistent algal blooms. These changes will complicate efforts to protect and restore water quality in these watersheds. For further details, see DNR climate summary for the Rock River Watershed.

Figure 13. Characterization of air temperature and rainfall conditions for May-September period across the historical record (1900-2023) of climate data for the Missouri Basin watersheds. Red diamonds highlight monitoring years through these efforts.



For more information

This study of the Missouri River Basin watersheds 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 Missouri River Basin watersheds, such as the One Watershed One Plan document or a comprehensive watershed management plan that targets projects to protect and restore water resources. For more information, go to the MPCA Rock River webpage, or search for Missouri River on the MPCA website.

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