Stressor identification update

Mississippi River Winona/La Crescent Watersheds

April 2026

Introduction/Goals

Water monitoring is essential to determining whether lakes and streams meet water quality standards that ensure healthy aquatic communities and safe recreation. The stressor identification (SID) process studies and diagnoses negative impacts on fish and macroinvertebrate communities. The scope of Cycle 2 SID work was broadened beyond this specific intention to include field and technical work supporting local water planning goals and priorities.

Accordingly, the Mississippi River-Winona/La Crescent (WinLaC, Figure 1) Cycle 2 SID work focused on a few select subwatersheds (Figure 2). Some watersheds are new biological impairments, while others have been studied previously but need more investigation. Some were identified as high priority during local watershed planning or were the focus of implementation projects. Overall, the goal of the new SID work was to add value and better understand the water resources and problems in the watershed. Identifying impairments and subsequent stressors will aid in focusing on restoration and protection efforts.

Figure 1. Location of the Mississippi River-Winona and La Crescent watersheds in Minnesota.

What have we learned about stream health in the Mississippi River-Winona/La Crescent Watersheds?

The Mississippi River-Winona (MR-Winona) Watershed was first sampled intensively for biology by MPCA in 2010, then revisited in 2021. The Mississippi River-La Crescent (MR-La Crescent) Watershed was first sampled in 2015 and then revisited in 2021 because it was included in watershed planning activities with the MR-Winona. The Mississippi River - Winona and La Crescent Watersheds Assessment and Trends Update Report (MPCA, 2024) summarizes the findings from the recent monitoring in 2021-2022 for both watersheds. The information in that report is one of the building blocks for the SID work in this report.

Some of the recent monitoring (MPCA, 2024) and SID highlights include:

- In the MR-La Crescent Watershed, the biological impairment in Pine Creek (07040006-576) is a proposed delisting (fish). No additional biological impairments were identified in the MR-La Crescent during the recent assessments, and no further SID work has been completed.
- In the MR-Winona Watershed, two streams were removed from the impaired waters list for biological impairment covered in the original SID report (MPCA, 2013) (Beaver Creek-07040003-566, South Branch Whitewater-07040003-F16).
- New biological impairments in the MR-Winona Watershed that are detailed in this report include: two adjacent sections of the headwaters of the North Branch Whitewater (07040003-F38, 07040003-F39), Speltz Creek (07040003-555), and Gorman Creek (07040003-569).
- The Middle Branch Whitewater (07040003-F19) includes a MPCA long-term biological monitoring of rivers and streams station (10LM007) and an existing macroinvertebrate impairment with previous SID work; additional detailed analysis is included in this report. The more frequent and comprehensive monitoring has provided information that builds on the previous SID work.
- Recent study related to hydrology in area watersheds (see hydrology section) provides the information needed to conclude flow alteration as a stressor. It is a contributor (either directly or indirectly) to the stressors observed throughout the watershed (i.e., habitat, nitrate, total suspended solids [TSS], etc.). This is a regionwide issue, not specific to MR-Winona streams.
- Overall, the most prevalent stressors in the watershed relate to habitat and sediment. Habitat loss due to bedded sediment remains one of the most common stressors identified here and in Minnesota. Other stressors identified in this report include dissolved oxygen (DO), connectivity, and nitrate.

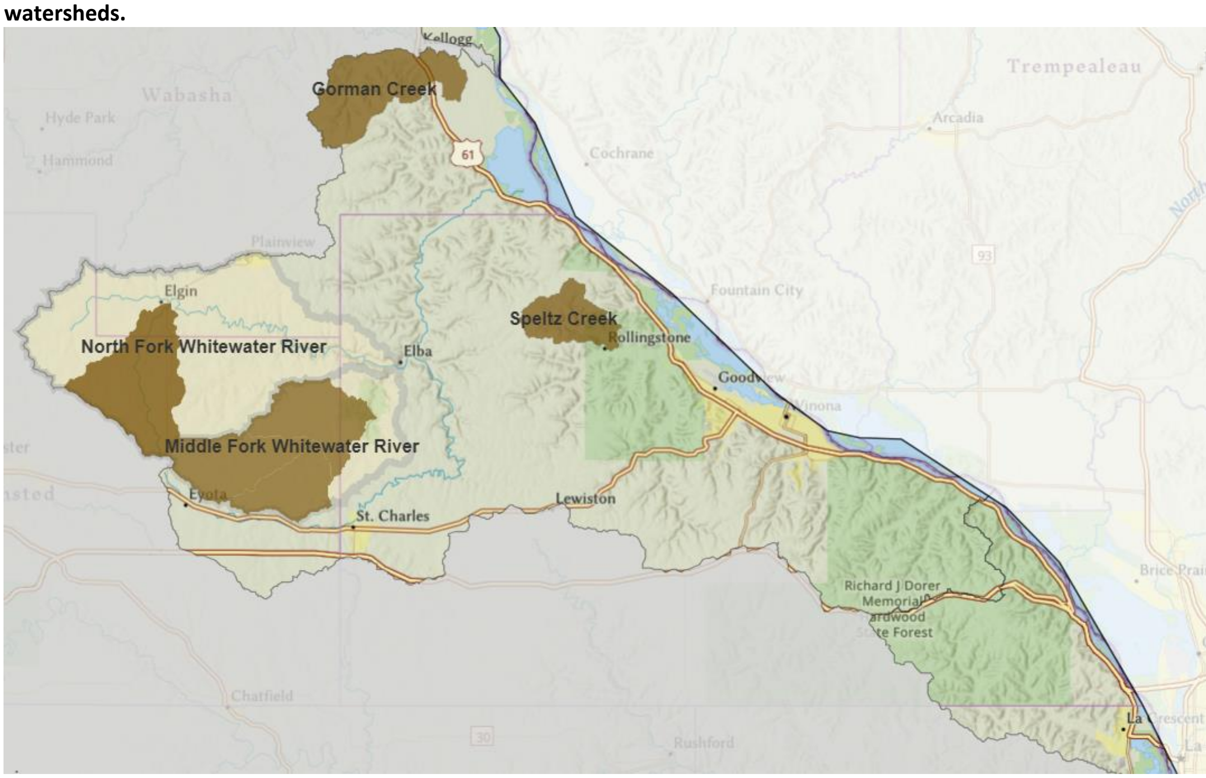
Part 1: Mississippi River-Winona/La Crescent SID Overview

1.1 Areas of focus

Select streams were studied and are further detailed in the next sections of this report. Many of these streams are new biological impairments that hadn't been studied previously. Some are also areas that are considered local water planning priorities and were considered focus areas for additional data collection and analysis. During the process of assessment and SID work, some streams have also been identified as vulnerable and needing protection and are mentioned in a subsequent "protection recommendations" section. The watersheds that were areas of focus in this SID update report include:

- Gorman Creek (07040003-569)
- Upper North Branch Whitewater (07040003-F38 and 07040003-F39)
- Middle Branch Whitewater (07040003-F19)
- Speltz Creek (07040003-555)

Figure 2. Areas of focus that are detailed in this report (brown highlighted areas) are in the MR-Winona/La Crescent watersheds.



1.2 Watershed hydrology summary

Hydrology is one of the most important variables impacting stream health in most watersheds of Minnesota because it's linked to many other stressors. Recent developments related to hydrology information for the adjacent Root River Watershed and Zumbro River Watershed have allowed for better analysis of the connections between hydrology to stream health in the region. The Root River and Zumbro River Evaluation of Hydrologic Change (EHC) Technical Summaries, completed by the Minnesota Department of Natural Resources (DNR, 2023), summarize hydrology for the last 90 years and provide conclusions that can be extrapolated and applied to the adjacent MR-Winona/La Crescent watersheds.

Specific hydrological information includes:

- There have been increases in precipitation, which is consistent with regional and statewide climate data. Specifically, the MR-Winona Watershed receives 5.3 inches more precipitation on average (a 17% increase) compared to the pre-1997 period of record going back to the 1890s.
    - Heavy rains are now more common in Minnesota and more intense than at any time on record. There have been dramatic increases in 1-inch rains, 3-inch rains, and the magnitude of the heaviest rainfall of the year.
- Annual streamflow data are available since 2009 for the Whitewater River at Beaver. This shows an increasing trend in flow (MPCA, 2024), which has direct linkages to sediment transport, stream channel erosion, and pollutant loading. Streams that are entrenched (not connected to their floodplains) and have consistently higher channel velocities are likely eroding at correspondingly higher rates. Many streams in this watershed have poor floodplain connections and severe bank erosion. Historical land use practices have left substantial legacy sediment stored as deep alluvial deposits throughout the Whitewater River Watershed, which continue to influence sediment loads and channel dynamics today.
    - This is further supported by sediment loading water chemistry information collected at the North Branch Whitewater at Elba and Whitewater at Beaver Watershed Pollutant Load Monitoring (WPLMN) stations. Both sites (Beaver and Elba) rank in the highest 10% of all sites monitored statewide (N=199) for average sediment yield (lbs./acre) and flow-weighted mean concentration (FWMC), demonstrating the high sediment contributions these watersheds have compared to others in the state.
    - Similarly, the Beaver site shows an increasing trend in nitrate concentrations, like many other streams in the region (MPCA, 2024). Because baseflow accounts for much of the nitrate load, increases in baseflow often coincide with greater nitrate transport to streams. Baseflow varies with hydrology, and more recent elevated baseflow conditions observed followed several years of unusually high precipitation.
- The Root and Zumbro DNR EHC technical summaries highlight several hydrological changes, including baseflow and mid-range flow increases since 1991 DNR, 2023). Additionally, the "rise rate" has been increasing. The rise rate calculates the average increase in discharge during every period of increasing flow from day to day for each period. Increases in this metric may be due to storm intensity or land alterations that move water off the landscape faster. These changes in flow all contribute to higher stream channel velocities, increased erosion rates, and stream instability, all of which are connected to common stressors related to habitat and sediment.
- Utilizing the MPCA "climate change and MN surface waters analysis", the average and peak flows of rivers in Minnesota have increased, especially in the south and west. Compared to historical records, most rivers have had two to three times more high flow years than expected over the past 10 and 20 years. This has large implications for how sediment and pollutants move through stream systems and causes stress on biology in various ways.

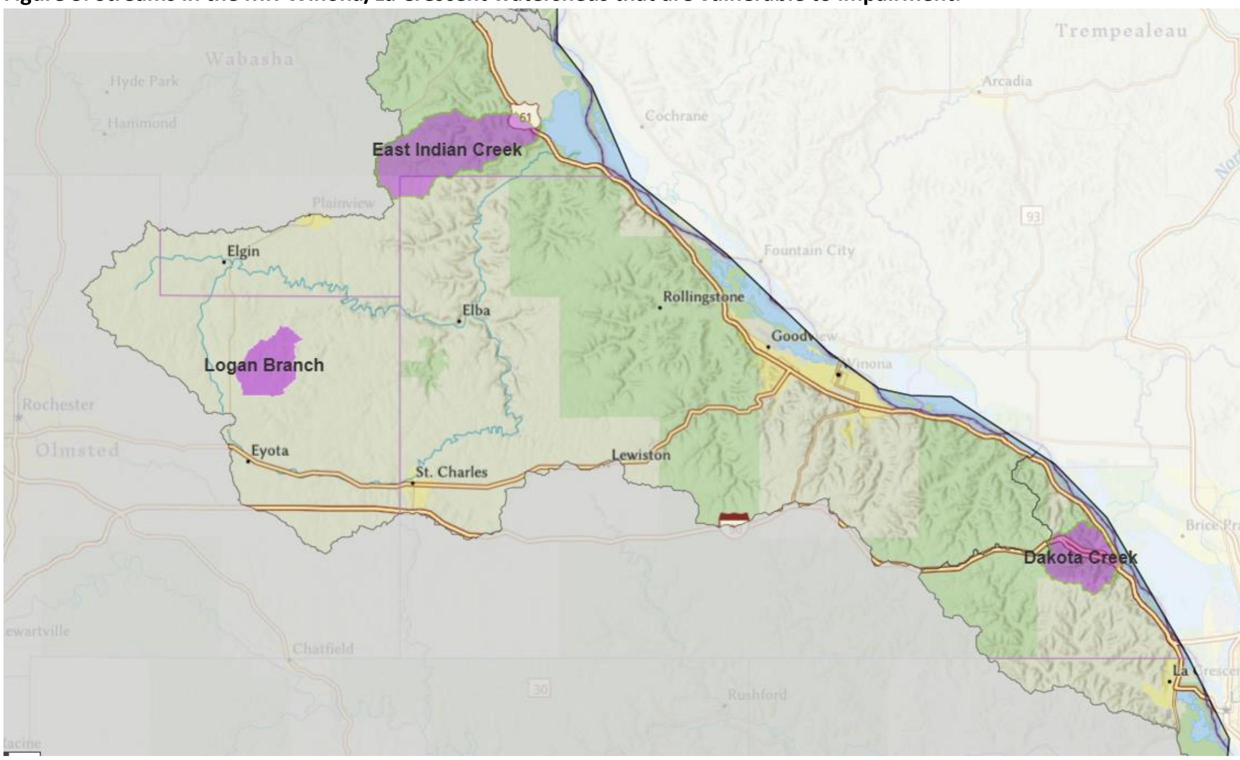
Flow alteration and climate change are impacting stream systems in southeast Minnesota. Impacts are variable depending on location and the watershed-specific hydrology each year. However, the evidence indicates that the region has had significant flow and precipitation changes in the past 20 to 30 years.

This change drives stream dynamics, including sediment and pollutant transport, sediment/habitat impacts, all of which are consistent stressors in this watershed.

1.3 Protection recommendations

Vulnerable Streams: Some streams were identified as vulnerable to biological impairment during the most recent watershed assessment (Figure 3). These streams need continued study and attention to monitor aquatic life health. Streams in the MR-Winona/La Crescent watersheds that are considered threatened, or vulnerable to future aquatic life impairment, include: East Indian Creek (07040003-573), Dakota Creek (07040006-512), and Logan Branch (07040003-F36).

Figure 3. Streams in the MR-Winona/La Crescent watersheds that are vulnerable to impairment.



East Indian Creek (07040003-573)

Biological communities in East Indian Creek are vulnerable and considered a high priority for protection. Protection efforts on this stream should be focused on improving the middle section of the stream, near monitoring station 10LM031, where bank erosion and habitat impacts are evident. Additional biological samples collected in 2022 (good biological scores both upstream and downstream of 10LM031) demonstrate that these conditions do not extend throughout East Indian Creek. Temperature logger information confirms that the thermal regime is also adequate throughout the creek at all monitoring stations and is not a stressor.

Sedimentation and localized habitat impacts are the largest limiting factors to the biology in East Indian Creek, specifically in the middle part of the watershed at 10LM031. Livestock grazing is a working lands best management practice, and pastures near the stream should be managed to prevent overgrazing. Limiting livestock access, protection from bank erosion, and soil conservation practices in the uplands, will help ensure excess sediment in the watershed does not end up causing biological impairments in East Indian Creek in the future.

Dakota Creek (07040006-512)

Dakota Creek fish scores have been exceptional, but macroinvertebrates have shown some variability and potential stress in the more recent years of monitoring. In 2016, the macroinvertebrate scores were good, but a new site sampled in 2021 did not score well for macroinvertebrates, showing they may be vulnerable to future impairment. The biological sample occurred two weeks after a very intense rain event (four to five inches) that caused some severe scour and erosion of the stream channel. A revisit to this same station in 2022 showed the macroinvertebrates had recovered, even though there was evidence of recent storm events and severe channel erosion/over-widening occurring in 2022 as well. Habitat availability is highly variable due to the instability of the stream channel in Dakota Creek. Data indicates that water chemistry, temperature, and DO are normal. Baseflow nutrient concentrations have been low during biological sampling (nitrates 0.85 and 0.80 mg/L and total phosphorus (TP) 0.044 and 0.05 mg/L) and are not a cause for concern, based on limited data. TSS concentrations were right at the standard or below the standard (11 mg/L and 7 mg/L). Transparency data from 2016-2022 show that of 62 samples, 12 exceeded the surrogate standard value of 55 cm. The average transparency of those samples is 76.2 cm, which is considered good water clarity. This indicates the stream is clear most of the time but does have periods of high turbidity. Like many other high gradient streams in southeast Minnesota, this is not surprising due to the evidence of erosion documented, near-channel land use, and stream channel disturbances. Gravel and sand are the predominant substrates that are shifting regularly, causing habitat stress.

The headwaters and some of the drainage of this small creek are in Great River Bluffs State Park. However, I-90 surrounds this stream for much of its length as well, which has a potential impact. Chloride levels appear normal based on limited data (4 samples in 2022, average 15 mg/L). Large beaver dams have been documented downstream of the reach, yet fish scores have been high; there is no indication that they are adversely affecting the fish community at this time. Beaver dams are often ephemeral due to flooding and natural variations and may provide intermittent impacts. Overall, bank erosion, instability, and sedimentation are the main threats to aquatic life in this stream moving forward. Practices to slow flow/runoff in this valley (including impacts from I-90) and managing near-channel land use (protection from overgrazing/erosion) can help keep the aquatic life in this stream thriving.

Logan Branch (07040003-F36)

The Logan Branch (a tributary to the North Branch; upper portion) has an existing turbidity impairment. During previous assessments, this stream has met expectations for aquatic life based on two biological monitoring sites in the middle and lower parts of the watershed (i.e., fish and macroinvertebrate assessments). During recent assessment and monitoring, an additional biological monitoring station was added in the upper part of the Logan Branch, which also met expectations for aquatic life. However, both fish and macroinvertebrates at the upper biological station (20LM009) are very close to the impairment threshold and vulnerable to impairment. This is the same section of the stream that has had a long history of monitoring and resulted in the turbidity listing in 2002 (S002-072). Current TSS and Secchi tube readings confirm the historic turbidity listing and show that sediment loading is still a concern.

Limited SID work was completed in 2022 in anticipation of potential impairment here and revealed that the likely limiting factors to this stream are related to flow, sediment, nitrate, and habitat. During the summer months, there is very little flow in the upper section of the stream. However, the thermal regime is adequate and shows aquatic life that is characteristic of coldwater streams, with abundant mayflies, caddisflies, amphipods, and sculpin. Additionally, the summer average temperature was a very cold 13.9˚C, demonstrating that the groundwater and small springs are feeding this section of the stream. As a result of limited flow and less gradient, excess sediment gets trapped in this area, severely impacting available habitat for fish and macroinvertebrates. The Minnesota Stream Habitat Assessment (MSHA) information revealed a "poor" rating, with substrates limited to fine materials and sparse cover. Further downstream in the Logan Branch (main trout water), where the gradient increases, the habitat and sediment conditions improve considerably. Nitrate concentrations here are also elevated from data collected in 2021/2022, showing a consistent concentration of around ~8 mg/L. This upper section of the Logan Branch Watershed needs protection from excess sediment and nutrients to prevent further degradation, as it remains vulnerable to future impairment and impacts the downstream portion of the Logan Branch.

Exceptional use streams

Two streams that have been recently added to the "exceptional use" designation in the watershed include Miller Valley Creek (07040006-583) and Little Trout Creek (Little Pickwick Creek 07040003-593). Both streams are small drainages in protected watersheds with very high-quality fish and macroinvertebrate communities present. Other high-quality streams like Garvin Brook need protection as well. Garvin Brook has a history of very high biological scores, with exceptional habitat.

Other protection: fish kills

There have been three fish kills in the MR-Winona Watershed since its original assessment and SID work in 2014. The first was on the South Branch Whitewater in 2015, followed by Garvin Brook in 2019, and Trout Valley Creek in 2021. These fish kills all occurred after intense short-burst rainfall/runoff events. The landscape is susceptible to impacts from intense summer storms and watershed land use activities. In each of the impacted watersheds, fish and macroinvertebrate communities returned to typical conditions following these fish kills. However, biological community fluctuations and the stress that biology may experience year to year could be highly variable in any given stream. Regular monitoring or utilizing long-term monitoring sites can help better understand these impacts over time. Mitigating runoff risk and promoting BMPs are ongoing efforts and a continued need in these high-risk areas of southeast Minnesota. For more information, see the Minimizing fish kills in Minnesota webpage.

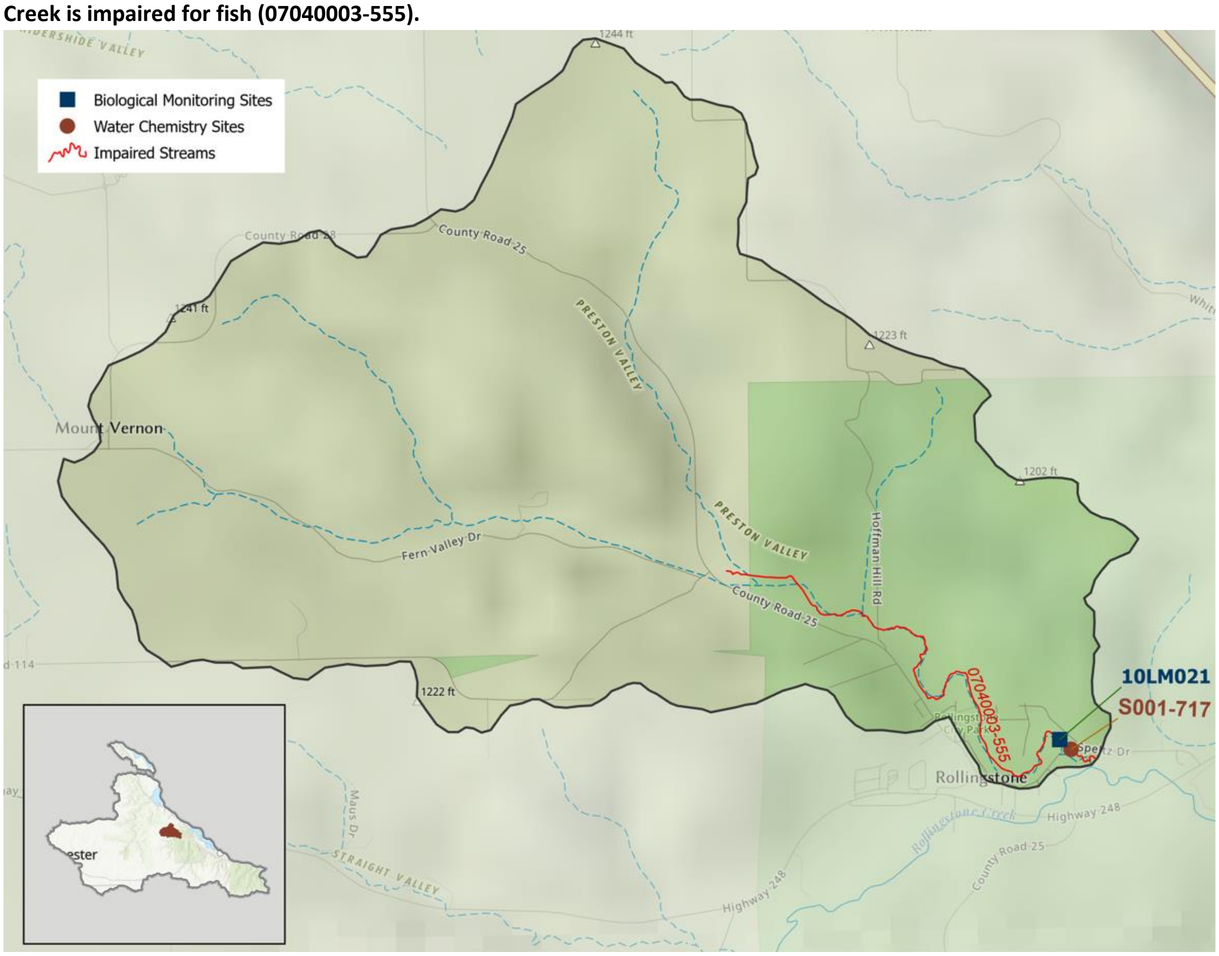
Part 2: SID focus areas

2.1 Speltz Creek (07040003-555)

2.1.1 Biological community summary

Speltz Creek is a small coldwater stream, just outside of the village of Rollingstone. It is a <10 square mile watershed that is a mix of agricultural land use and forest. Speltz Creek (07040003-555) was added to the impaired waters list for fish in 2019. This stream has one biological monitoring station, 10LM021, located just upstream of the confluence with Rollingstone Creek (Figure 4). It has been sampled for fish twice, once in 2010 and again in 2021. Both fish scores were below the impairment threshold and the confidence interval, indicating a degraded fish community, with few trout and a community dominated by johnny darters. Macroinvertebrates scored right at the impairment threshold in 2010, and above the threshold in 2021, meeting aquatic life standards.

Figure 4. Map of the Speltz Creek Watershed showing biological monitoring and water chemistry stations (10LM021). Speltz Creek is impaired for fish (07040003-555).



2.1.2 Stressors of concern

The fish community in Speltz Creek is atypical of most small southeast coldwater streams, which often have good trout populations and high fish IBI scores. In other such streams demonstrating fish impairments in the region, the stressors are typically physical as opposed to chemical.

Channel stability in Speltz Creek is poor, with fine sand and silt substrates predominating. The MSHA scores related to substrate scores were very poor between 2010 and 2021, indicating this is an ongoing issue in Speltz Creek. Photos and site visits also show a stream channel that is shallow in most locations, with very little depth variability that fish require (Figure 5). Many woody debris/fallen trees are resulting in disruptions in bank erosion and sediment transport. Relatively low numbers of brown trout are present at this site, but other coldwater taxa are also lacking, and pioneer individuals such as Johnny Darter predominate. Pioneer fish species thrive in unstable environments and are the first to invade a stream after disturbance. They were found in high abundance in both years it was sampled (2010 and 2021). The macroinvertebrate samples during both visits were from bank and wood only; no coarse substrates were able to be sampled---something that is common and expected in a small coldwater stream.

Figure 5. Photo in Speltz Creek showing the stream channel substrate, excess sedimentation, lack of depth, and habitat diversity.

Beaver dams found within the biological monitoring station disrupt flow and sediment dynamics, in addition to partially blocking the migration of fish throughout the stream system (Figure 6). These dynamics are important because fish need to freely move upstream to reach spawning habitat and/or move from Rollingstone Creek to repopulate. This issue is likely ephemeral and always changing, but heavy beaver activity in this area may be resulting in persistent connectivity stress and lack of free movement as fish are unable to migrate and repopulate from Rollingstone Creek. Beaver dams may also be contributing to the habitat and sedimentation impacts observed in the stream channel. Lastly, road crossings upstream were assessed and do not appear to be causing any connectivity/barrier issues (two bridges and one culvert are upstream of the biological site). The main issue appears to be within and near the biological monitoring station.

Figure 6. Large beaver dam/log jam resulting in a barrier to fish movement (2022). This same beaver dam was photographed in 2021, within the biological monitoring station. Other log jams/beaver activity were also noted throughout.

2.1.3 Summary of stream health and recommendations in Speltz Creek

The fish community in Speltz Creek is being stressed by habitat, connectivity, and flow alteration in combination (Figure 7). Habitat quality and diversity are limited, and biological data indicate a community negatively impacted by poor substrates, embeddedness, and a lack of varied habitat types. Extensive beaver activity has further degraded conditions and restricted fish movement, impeding migration and recolonization from Rollingstone Creek. TSS are currently inconclusive due to limited water quality data, though sediment is still contributing to habitat degradation. DO, nitrate, and temperature levels appear adequate and are not impacting the fish community.

Figure 7. Stressor summary information for Speltz Creek. Green=Not a stressor, Orange=Inconclusive stressor, Red=Stressor.

Temperature

- Continuous temperature data confirm temperatures are adequate and normal and not limiting the coldwater biological communities. Coldwater fish are lacking, but due to other stressors. Coldwater macroinvertebrates are abundant and healthy, indicating temperature is not the limiting factor to biology.

Nitrate

- Nitrate concentrations are low, at less than 2.5 mg/L. This is well below the aquatic life draft standard for nitrate of 5 mg/L for coldwater streams. Macroinvertebrates are not impaired and would respond if elevated nitrate were an issue.

TSS (Total Suspended Solids)

- Elevated TSS concentrations (>10) and low secchi tube measurements are documented, but the data are not recent and are minimal. The fish and macroinvertebrate species present show a mixed response to high TSS, therefore a TSS stressor cannot be confirmed but is still connected to the habitat/sedimentation issues observed.

DO/Eutrophication

- DO measurements in Speltz Creek are limited but what is available does not suggest stress to fish. Additionally, 80%-90% of the macroinvertebrate community is intolerant to low DO helps confirm that DO levels are sufficient.

Habitat

- Habitat is degraded and impacting the fish community. The quality and diversity of habitat types are limited in this reach and the biological metrics match, signaling a community being negatively impacted by the poor substrate, embeddedness, and lack of diverse habitat types.

Connectivity

- There is evidence of connectivity issues (beaver dams) within the biological sampling station, with very few migratory fish present. This disrupts flow and sediment dynamics, in addition to partially blocking the migration of fish throughout the stream system.

Flow Alteration

- All watersheds in the MR-Winona are either directly or indirectly impacted by flow alteration (see the hydrology section at the beginning of the report). Sedimentation dynamics, including TSS and sediment-related habitat stress, are connected to changes in land use, precipitation, and flow.

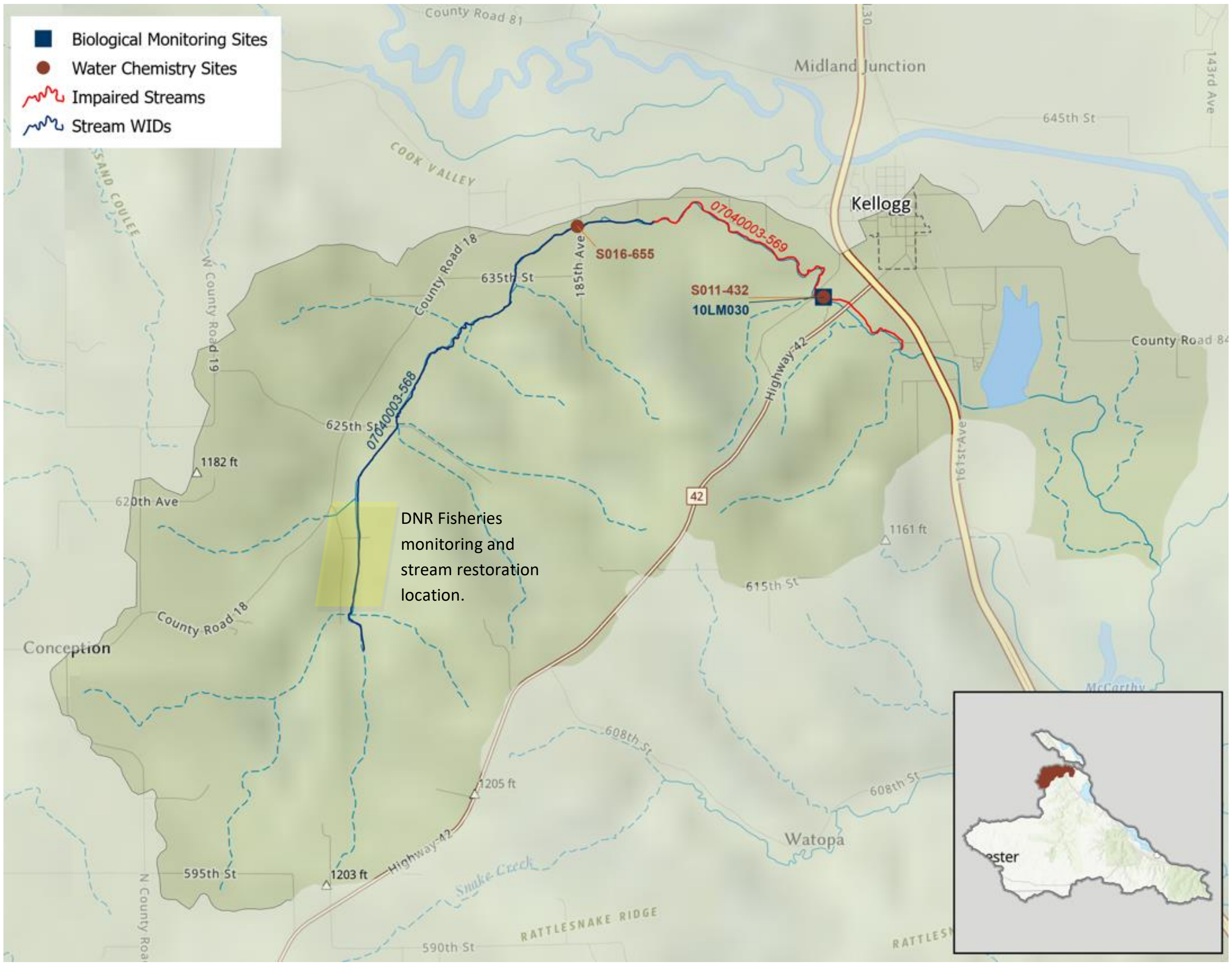
2.2 Gorman Creek (07040003-569)

2.2.1 Biological community summary

Gorman Creek (07040003-569) has one biological monitoring station: 10LM030, sampled once in 2010 and again in 2021 (Figure 8). It is impaired for both fish and macroinvertebrates and is considered warmwater in this lower section. The macroinvertebrate community scored below the impairment threshold during both visits. However, the 2021 fish score dropped significantly compared to 2010 (58.8 to 27.85). This drop in fish score initiated a repeat sample in 2022, which also scored below the threshold, demonstrating clear impairment of the fish community. The dramatic reduction in the number of fish at this site is atypical, going from 224 total individuals in 2010 to 30 in 2021 and then only 8 in 2022.

In contrast, in the headwater area of Gorman Creek, DNR fisheries have documented a well-established reproducing brook trout population in the coldwater section (MPCA does not have a biological monitoring station in this upper section). Recent stream restoration work in 2023 (~2000 ft) has also been completed in this area to stabilize the stream channel and improve water quality and habitat. This area is a stark contrast to the downstream impaired reach.

Figure 8. Map of the Gorman Creek Watershed showing biological monitoring and water chemistry stations. Gorman Creek (07040003-569) is impaired for fish and macroinvertebrates. There is one MPCA biological monitoring station: 10LM030, located near the lower end of the stream.



2.2.2 Stressors of Concern

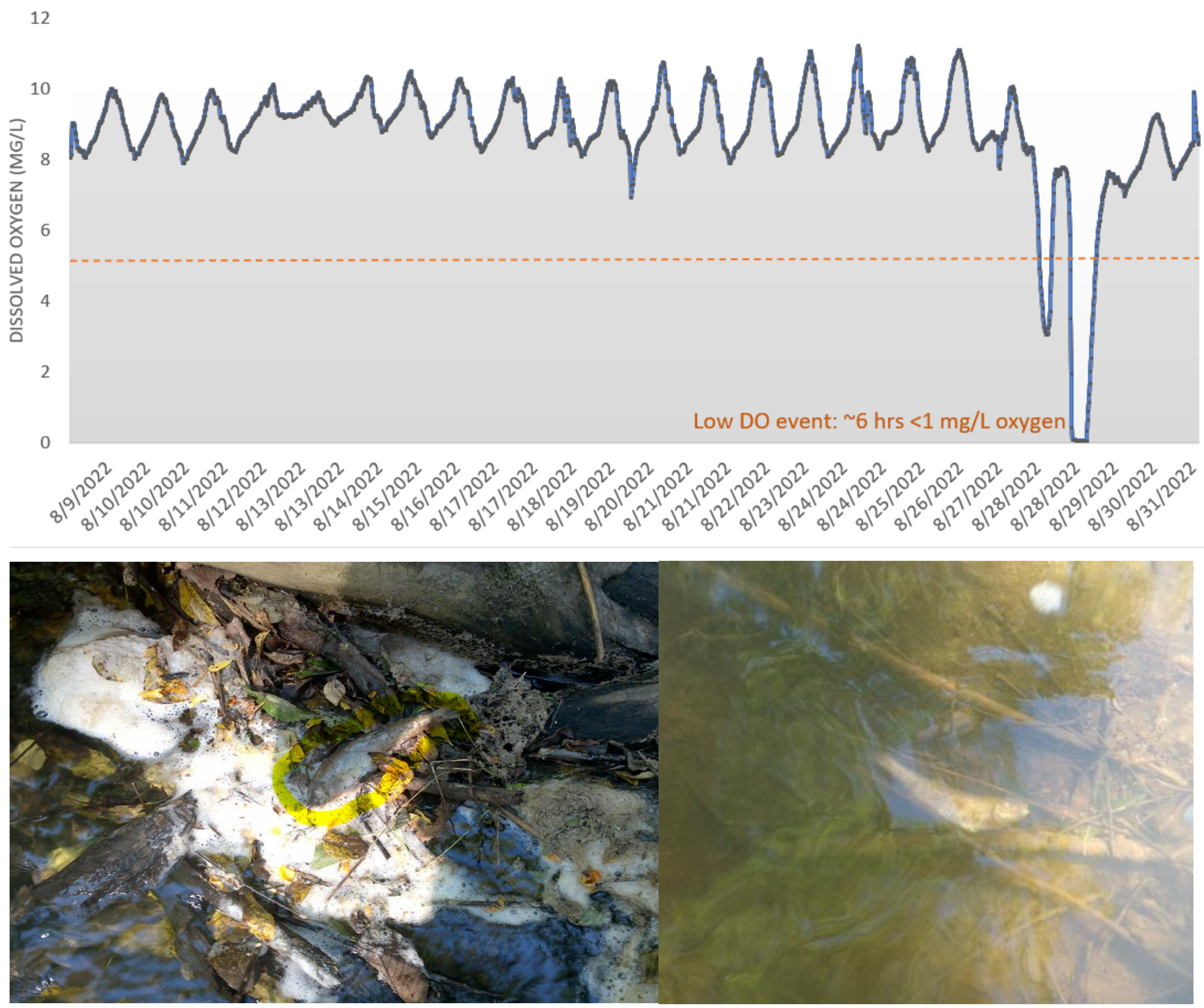
Gorman Creek was initially studied in the 2015 [Mississippi River-Winona Watershed Biotic Stressor Identification Report]. That work revealed habitat and connectivity-related stressors as contributing to the macroinvertebrate impairment at that time. Since then, further monitoring of aquatic life shows fish are also impaired (MPCA, 2024), and additional stressors are contributing to the impairments in Gorman Creek. Additional investigative monitoring occurred in the watershed to help understand some of the differences between water chemistry in the upper/middle portion (S016-655) compared to the downstream section (S011-432/10LM030; Figure 8). This monitoring included two years of grab sampling (2022 and 2023), with additional water chemistry parameters and continuous DO and temperature monitoring.

Habitat impacts show general degradation in the monitoring station, where the MSHA score went from fair in 2010 to poor in 2021-2022. The site is grazed heavily, and this is impacting several in-stream habitat characteristics like substrate and cover. A dam just downstream (Hwy 42) of the monitoring station that was changing the slope of the stream was removed in 2020. Just downstream at Hwy 61, a six-foot dam still exists. Additionally, a velocity barrier upstream of the monitoring station at a private driveway was also recently identified. These two barriers (Figure 9), restrict this reach’s fish population, preventing movement to the headwaters and to the Mississippi River downstream, thus negatively impacting repopulation dynamics.

Figure 9. Two connectivity barriers are currently identified on Gorman Creek. Left: A 6 ft drop/box culvert barrier at Hwy 61, downstream of 10LM030. Right: velocity/culvert barrier at private drive, upstream of 10LM030.

Continuous DO monitoring in 2022 and 2023 reveals that low DO is occurring on this stream regularly. Low DO levels are variable in source, location, and magnitude. The low DO events often occur simultaneously with runoff events. More intensive continuous DO monitoring occurred in 2023 after a sonde deployment in 2022 found low DO and a limited number of dead fish (creek chubs). Upon retrieval of the sonde on August 31, 2022, it was found that low DO occurred following rainfall on August 28, 2022 (1.4 inches of rain recorded in Wabasha). This low DO event was significant, logging six hours at 0 mg/L (Figure 10). A short investigation at the site after the low DO was discovered found dead creek chubs on August 31. Creek chubs are considered tolerant of low DO and pollution in general. It is worth noting that only eight fish were sampled on June 27, 2022. This suggests an ongoing, recurrent stressor that was already impacting the fish population before this low DO event, which ultimately killed the few remaining individuals.

Figure 10. Top: Gorman Creek sonde deployment data, showing DO levels in August of 2022. The DO standard of 5 mg/L is represented by the orange dashed line. Bottom: Photographs document the presence of dead fish at site 10LM030 on August 31, taken during a subsequent investigation following the discovery of the low DO event. Photographs document the presence of dead fish at site 10LM030 on August 31, taken during a subsequent investigation following the discovery of the low DO event.



Additional follow-up monitoring was initiated after the August 2022 low DO event was discovered. Continuous DO/temperature loggers were deployed from May through October of 2023. The goal was to capture an entire season of DO dynamics at two different sites, one at 10LM030 and one upstream. *E. coli* analysis was also added to the water chemistry sampling in 2023 to gain further clarity on potential impacts and sources of pollution and low DO. This comparison dataset showed that at times the DO dynamics at the two sites were similar but at other times notably different, indicating more than one source or area of the stream had impacts on DO levels. *E. coli* levels never met the standard, and all results were >126 for the 8 samples collected at both sites in 2023. Additionally, 6 of the 8 samples at 10LM030 exceeded the maximum standard of 1,260 cfu/100mL, demonstrating high *E. coli* levels consistently. Near channel land use, in the form of feedlot runoff/direct cattle access to the stream (Figure 11 and Figure 12), appears to be the most likely source of high TP, low DO, high *E. coli*, elevated ammonia, and total Kjeldahl nitrogen (TKN) found in water sampling from the two sites. Additionally, on July 5, 2023, during routine water sampling, low DO was observed in the field (4.31 mg/L at the upper site, less than the 5 mg/L standard for warmwater streams). This low DO was observed following a

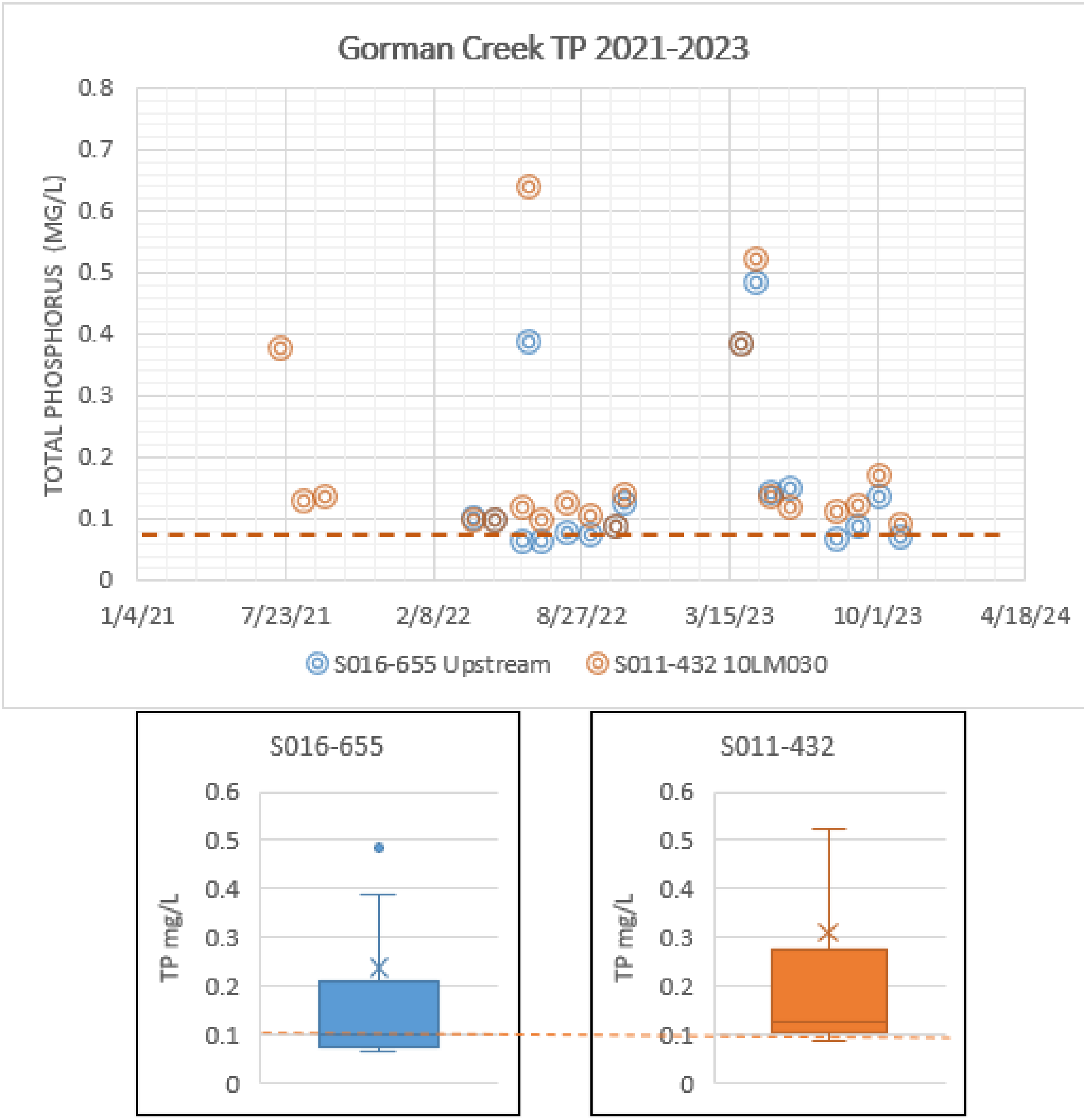
1.32-inch rain event. Other water quality parameters collected during this sample event also indicated that this low DO was connected to agricultural runoff, with very high values of *E. coli*, ammonia, TSS, TP, and TKN. *E. coli* values were >240,000 at both locations (the max lab reporting limit), total ammonia was elevated (0.98 mg/L and 0.72 mg/L) in addition to TSS (200 mg/L and 500 mg/L), TP (1.66 mg/L and 2.66 mg/L), and TKN (5.98 mg/L and 8.16 mg/L). Of the 13 samples collected at these two locations in 2022 and 2023, July 5 produced the maximum/high concentrations for all these parameters in Gorman Creek. The combination of all the elevated water quality parameters with low DO is a strong indicator that feedlot or manure runoff was the cause of low DO on July 5 and is also a likely contributor during other instances of low DO. In addition, during the July 5, 2023, rain event sampling, DO was measured at the road crossing upstream of the feedlot areas (625th Street; dead-end road) to confirm adequate upstream conditions. DO levels were within the normal range at 9.39 mg/L, further identifying these feedlot concern areas and their contribution to low DO levels in Gorman Creek on that day.

Figure 11. Upstream near channel land use impacts to water quality measurements in Gorman Creek (Google Earth, 2020).

Figure 12. Upstream near channel land use impacting water quality measurements. (Beacon, 2022).

TP was noted as regularly elevated in Gorman Creek during the original SID analysis, and that trend continues currently (Figure 13). The average TP concentration from 36 samples collected in 2022/2023 was 0.291 mg/L. Elevated levels were found during both storm events and baseflow conditions, implicating active sources of phosphorus to the stream during both periods. Despite elevated TP levels, this does not appear to be causing eutrophication issues as pH, DO flux, and chlorophyll-*a* are within expected ranges. Overall, pH levels are all normal with values around 8, and none were greater than the standard of 8.5. One chlorophyll-a sample was taken on 8/17/2021 and resulted in a very low value of 1.23 ug/L. Additionally, DO flux values are around 2-3 mg/L on average. When low DO occurs, it is not during large daily swings or high DO flux. This helps provide evidence that eutrophication and excessive algae growth are not likely occurring due to high phosphorus, nor is it connected to the low DO values that are being observed. High phosphorus is an indication of chronic pollution sources in the watershed.

Figure 13. Gorman Creek TP sample results from 2021-2023, at two stations. The TP standard value for reference is 0.100 mg/L (orange dashed line). Top: Scatterplot of sample values and dates showing many values above the standard, especially at biological monitoring station 10LM030. Bottom: boxplots comparing the two stations, showing median concentrations of samples are right at standard or above.



Elevated or detectable ammonia levels have been found in more than half of all the samples collected from 2022 and 2023. Ammonia is most often detected during runoff events but has also been documented during baseflow conditions when ammonia is not typically found unless there is a pollution source. The samples that were taken did not exceed the standard for unionized ammonia, meaning it was detected as present but not at a toxic level in those samples. Non-detectable ammonia or results less than the reporting limit (<0.05) are observed and typical in most streams in Minnesota. In fact, 88% of almost 1,000 ammonia samples that have been taken from biological monitoring (MPCA dataset from 2004-2018) were not detectable or <0.05 mg/L. In Gorman Creek, 6 of the 11 sample days, or over half, showed detectable levels (average of 0.26 mg/L) of ammonia in Gorman Creek. The pattern between the ammonia at the two monitoring sites was not consistent; in some instances, the upper site was higher, while in other instances, the lower site had higher ammonia, also indicating the potential for more than one source in the watershed. This also aligns with the observed inconsistent patterns in DO. Additionally, when ammonia was the highest, so were other parameters like *E. coli*, TSS, TP, and TKN—all of which can be indications of animal or human waste. The biological sample from 2021, taken during baseflow conditions, also corresponds to the highest unionized ammonia calculated from all the samples (7.01 mg/L). Dramatic decreases in the number of fish individuals in the 2022 and 2023 samples, including a documented fish kill, are evidence that ammonia levels are a cause of stress, as fish are more susceptible to ammonia than macroinvertebrates.

2.2.3 Summary of stream health and recommendations in Gorman Creek

Aquatic life in Gorman Creek is being impacted by multiple stressors: habitat, connectivity, DO, flow alteration, and ammonia (Figure 14). Habitat and connectivity were previously identified as stressors (MPCA, 2015). Additional data have confirmed the stressors of DO, flow alteration, and ammonia.

Temperature and nitrate are not stressors to Gorman Creek. Recent data suggest that lower Gorman Creek has a cooler thermal regime. The monthly temperatures in June, July, and August were 2˚F to 3˚F colder in 2021 compared to 2012. However, it’s not known if the cooler temperatures observed are due to more recent wet periods (driving increased groundwater/baseflow), or if this is a new normal or a temporary divergence in the thermal regime. Coldwater macroinvertebrates were much more abundant in 2021 compared to 2012, potentially indicating a cooler thermal regime in 2021. However, there was no indication within the fish community that coldwater fish are present in this section of the stream. Continued monitoring will be needed to understand the temperature dynamics in this section of the stream. At present, temperature is not a stressor to aquatic life.

Nitrate concentrations are low, averaging 3.5 mg/L (21 samples collected from 2021-2023). This is well below the aquatic life draft standard for nitrate of 8 mg/L for warmwater streams. However, the lone nitrate sample collected in Gorman Creek in 2010 was 2.7 mg/L, compared to almost 4 mg/L in 2023-both collected during baseflow conditions.

TSS is still considered inconclusive as a stressor. With additional sampling data and conflicting biological responses, a TSS stressor cannot be confirmed or ruled out. Macroinvertebrates appear more sensitive in 2021 compared to 2010, with a better community index score and fewer TSS-tolerant macroinvertebrates. The fish community is very tolerant, but with few individuals, it’s difficult to assess TSS tolerance as the fish community is so severely degraded. Additional sampling data from 2021-2023 show TSS levels are elevated during storm events (4 samples of 24 total samples exceeded the TSS standard for warmwater streams; all taken during storm events). However, this period was dry with only a few storm events. Overall, additional sampling data to understand the duration of high TSS in this stream would be helpful, especially during higher flow/precipitation years. The other identified stressors are connected to high TSS concentrations; therefore, it's difficult to completely rule out this stressor without more information.

Cattle access and feedlots near the riparian areas of Gorman Creek appear to be contributing to degraded water quality conditions in the form of low DO, elevated ammonia, *E. coli*, and elevated TP. Reducing cattle access points to the stream in these locations may be a useful strategy to help improve water quality in Gorman Creek. Removal of the culvert at the private drive in the middle of the watershed would also help reconnect the downstream areas to the upstream parts of Gorman Creek.

Figure 14. Stressor summary information for lower Gorman Creek (07040003-569). Green=Not a stressor, Orange=Inconclusive stressor, Red=Stressor.

Temperature

- Temperature was previously ruled out as a stressor and recent data confirm temperatures are still adequate and not limiting warmwater biological communities in lower Gorman Creek. Additional temperature information over time may inform if this section of stream could support coldwater communities as current temperature data appears to be trending colder.

Nitrate

- Nitrate concentrations are fairly low, averaging 3.5 mg/L. These concentrations are well below the aquatic life draft standard for nitrate of 8 mg/L for warmwater streams. Nitrate-tolerant macroinvertebrate individuals are in moderate numbers but not overwhelming the community. Trichoptera taxa generally have increased since 2010, including non-hydropsychid trichoptera that are often found to be sensitive to nitrate.

TSS (Total Suspended Solids)

- Additional sampling data from 2021-2023 show TSS levels elevated at concerning levels during storm events and seem to be fairly low during baseflow. However, biology has shown a mix of responses to TSS, making it difficult to conclude it is a stressor at this time. It's also possible TSS may be connected to other stressors present, therefore it is considered inconclusive.

DO/Eutrophication

- Continuous DO monitoring in 2022 and 2023 reveals that low DO is occurring on this stream regularly. Low DO levels appear to be variable in source, location, and magnitude. Low DO and dead fish were also observed together in 2022 at 10LM030-strong evidence supporting low DO is connected to the biological impacts and stress observed. TP levels are regularly elevated in Gorman Creek but do not have corresponding response variables that indicate eutrophication is occurring or connected to the low DO observed.

Habitat

- Habitat conditions haven't changed and are still degraded in Gorman Creek causing stress. MSHA scores show the site has poor scores for substrate, riparian area (pasture impacts), lack of cover, and reduced channel morphology. These factors reduce available habitat for both fish and macroinvertebrates.

Connectivity

- Connectivity was identified as a stressor previously and is still relevant. Two barriers (a new one found upstream and one still present downstream) of the biological monitoring station cut off fish populations by not allowing repopulation from nearby water bodies or the ability to move freely throughout the stream.

Flow Alteration

- All watersheds in the MR-Winona are either directly or indirectly impacted by flow alteration (see the hydrology section at the beginning of the report). Sedimentation dynamics, including TSS and sediment-related habitat stress, are connected to changes in land use, precipitation, and flow.

Ammonia

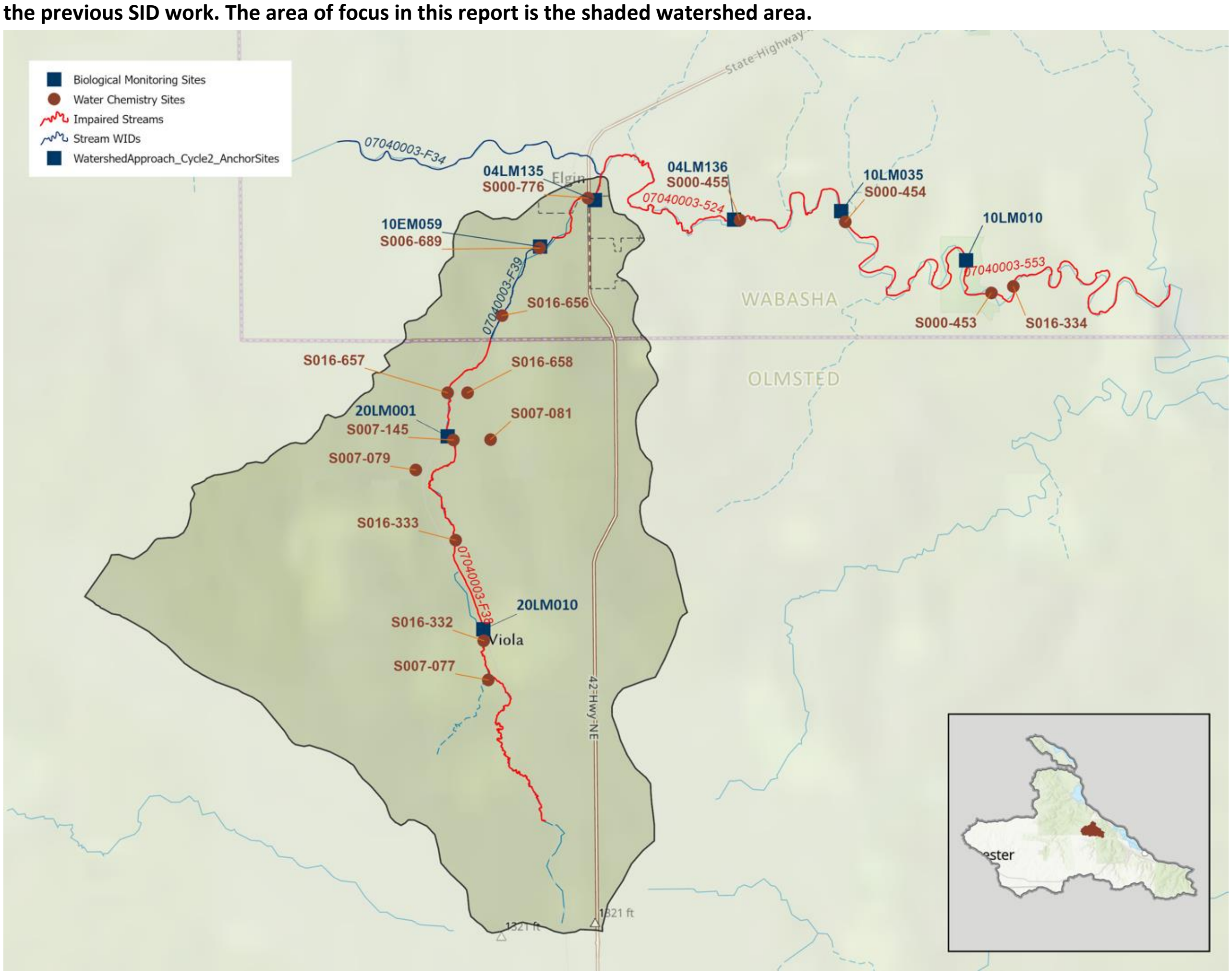
- Elevated or detectable ammonia levels have been found in more than half of all the samples collected from 2022 and 2023. The elevated levels occur often during runoff events but have also been documented during baseflow conditions. Dramatic decreases number of fish individuals in 2022 and 2023 samples, including a documented fish kill, are evidence that ammonia levels are a cause of stress.

2.3 North Branch Whitewater (07040003-F38 and 07040003-F39)

2.3.1 Biological community summary

The North Branch Whitewater (NBWW) 07040003-F38 and 07040003-F39 were both listed as impaired for aquatic life. These two stream segments are adjacent portions of the upper NBWW that had not been assessed previously for fish and macroinvertebrates (shaded subwatershed in Figure 15). The warmwater section (F38) stream has two biological monitoring stations: 20LM001 and 20LM010 and is listed for macroinvertebrates. The coldwater section (F39) has one biological monitoring station, 10EM059, occurring in a thermal transition zone from warmwater to coldwater, and is listed for both fish and macroinvertebrates.

Figure 15. Map of the upper headwater area of the NBWW showing biological monitoring and water chemistry monitoring stations. Adjacent downstream parts of the North Branch are included in the map for reference, as they were addressed in the previous SID work. The area of focus in this report is the shaded watershed area.



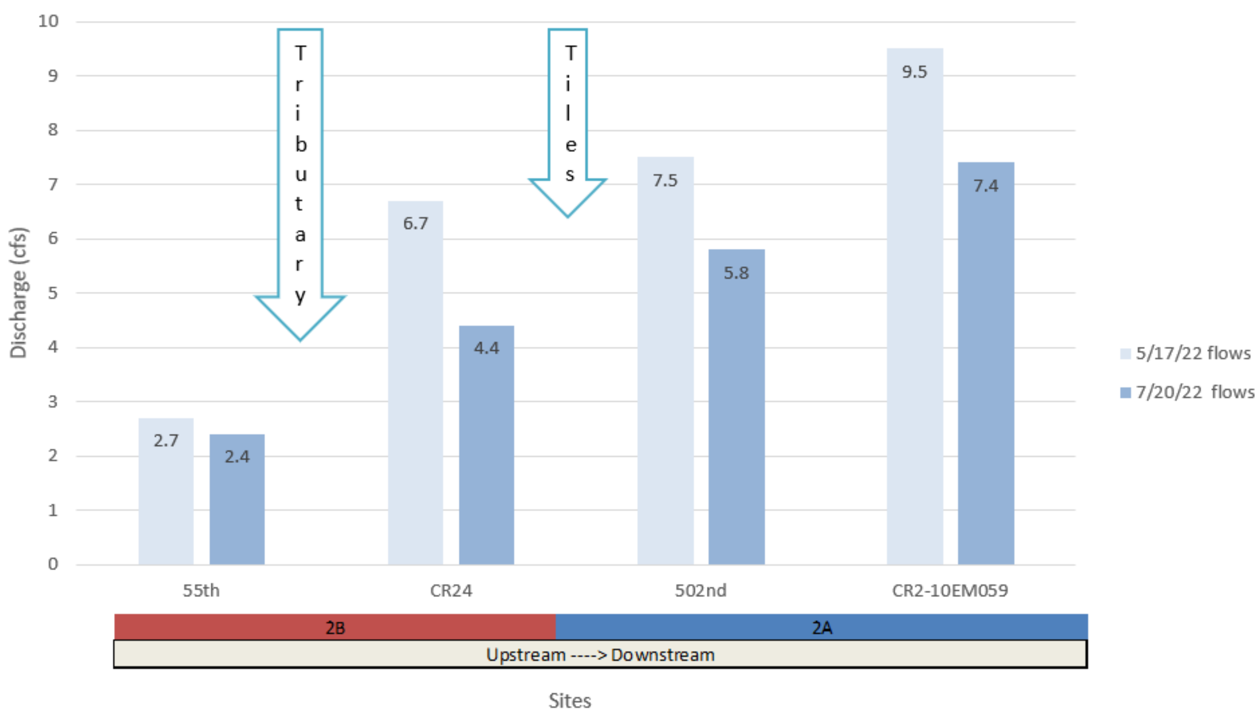
2.3.2 Stressors of concern

The NBWW has previous impairment listings (MPCA, 2013), but farther downstream of Elgin for TSS, fish, and macroinvertebrates (WID 553). The previous nearby SID work (See Mississippi River-Winona Watershed Biotic Stressor Identification Report) on the reach (553) includes nitrate, TSS, and habitat as the identified stressors. This work pointed to the headwaters area as an important contributor to the sediment and nitrate stress observed. As a result, more intensive water chemistry sampling began in late

2020 and continued through 2022 in efforts to understand the sediment and nutrient contributions throughout the upper portions of the North Branch Watershed. The multiple water sampling locations were sampled and are shown in brown in Figure 15.

Flow alteration has multiple influences in this watershed and is connected to all the stressors observed. Both channelization and tile drainage are common and can negatively impact variables such as habitat, nutrients, DO, and flow. Most of the stream length of the upper north branch has been channelized according to the altered watercourses data. Additionally, flow measurements taken at four stations in 2022 (Figure 16) demonstrate the changes in baseflow moving from the warmwater section upstream to the downstream coldwater section. The upper part of the watershed showed a larger increase in baseflow in May, early in the year, demonstrating a seasonality component to baseflow, translating to increases in pollutants like nitrate from 55th St to CR24. The tributary was noted as an important contribution to flows in May, as it was flowing moderately; however, by July, there was minimal flow. The 55th St site, which is between the two upper warmwater biological sites, showed less variability in flow from spring to summer than farther downstream, demonstrating fewer inputs in this section; it's more likely dominated by surface water runoff/flow and potentially experiences periods of very little flow. Moving downstream towards the coldwater section, there is more influence from other flow sources, like shallow groundwater flow and/or tile, as flows there are steady into the mid-summer months. This also corresponds to colder temperatures observed in the stream and increases in nitrate. Overall, flow alteration is complex and can impact biology throughout the watershed in various ways and at different times throughout the year (i.e., high/increased flows lead to increased pollutant loading and erosion, while periods of low/no flow lead to habitat issues and/or other stress).

Figure 16. Flow measurements taken on the upper North Branch at four sites in 2022. Each site was approximately 0.5 miles apart from one another, with the locations of a tributary and tiles noted.



Longitudinal monitoring demonstrates increasing nitrate moving downstream approaching the coldwater reach, where not only groundwater is likely increasing, but tile drainage is impacting concentrations (Figure 17 and Figure 18). The upper north branch watershed is 76% cultivated crops with significant tile drainage and groundwater influence, primary pathways for nitrate loading to the stream system. Nitrate concentrations from 2020-2022 show an average of around 8 mg/L in the farthest upstream sampling location. In the coldwater section, the average concentration was higher at around 9.1 mg/L. A few tiles sampled in this area indicated nitrate concentrations from 12 to 19 mg/L, higher than the typical in-stream concentrations. In-stream nitrate concentrations demonstrated a sharp increase near the county line (2020-2021), where tiles and groundwater are thought to be likely contributors (Figure 17). The concentrations increase through the upper north branch moving downstream and appear to peak just upstream of Elgin (near CR2-10EM059). From there concentrations are more stable moving downstream. This is likely a combination of land use change and geological influence moving downstream, allowing for more dilution.

The headwaters of the North Branch are an important source area for high nitrate contributions to the NBWW. Focused reductions from 65th St to CR2 (where increases/higher concentrations are more evident and flow increases) could help reduce overall nitrate loading to the entire NBWW. The biological response is consistent throughout this area as well, with high percentages of nitrate-tolerant macroinvertebrates and very few macroinvertebrates that are intolerant to high nitrate. This also aligns with the downstream nitrate stressor confirmed in the previous SID analysis. Overall, the evidence is consistent that nitrate is a stressor to biology in this area, and nitrate should be reduced to help prevent further degradation.

Figure 17. Nitrate concentrations from longitudinal monitoring through the upper North Branch Watershed in 2020 and 2021. Results demonstrate a notable increase near the county line, just upstream of Elgin. Nitrate reductions in this area (highlighted in the map to the right) may be particularly impactful in reducing overall stream nitrate concentrations.

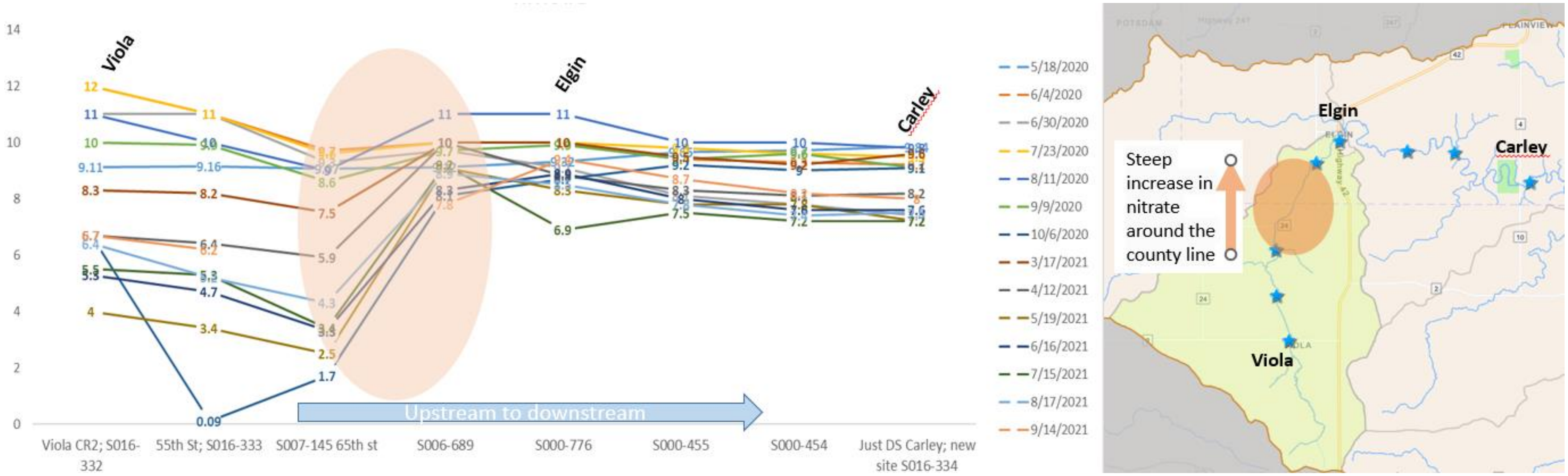


Figure 18. Various photos of tile drainage in the area of nitrate increase. Left photo: lift station and streamside tile both contribute to tile water at various times of the year. On 7/22/22, the streamside tile was sampled with a result of 19.5 mg/L. Right photo: Multiple tiles contribute to a tributary that had an average concentration of 12 mg/L, as determined from 9 samples taken in 2022.

Like nitrate, TSS samples collected in recent years have consistently shown elevated TSS levels throughout the watershed, which often occur during and beyond rain events. This is especially relevant in this coldwater transition reach, which has high sediment loading, with increasing flow and bank erosion. During sampling in 2020 and 2021, the majority of TSS samples did not meet the 10 mg/L standard for TSS, even during baseflow conditions. The biological metrics point to the likelihood that TSS is shaping the aquatic life communities present. The amount of embeddedness is significant and indicates a lot of sediment moves through this part of the stream and gets trapped as well (Figure 19). Further downstream, sediment issues in the North Branch are also well documented, including a previously documented TSS stressor (MPCA, 2015) and a completed turbidity TMDL. Generally, TSS concentrations increase moving downstream during storm events.

A 1977 DNR report detailed the fishing conditions in the North Branch Whitewater, noting “This stream remains turbid after a rain longer than any other stream in the Whitewater system because of the agricultural stream length and the large pools with slow water turnover.” A DNR WARSSS (Watershed Assessment of River Stability and Sediment Supply) Study concluded that the North Branch is heavily impacted by floodplain aggradation and straightening, and remains deeply incised, in addition to the uplands being dominated by silty loess. These observations and physical characteristics translate into a high erosion potential and explain the sedimentation and turbidity issues observed. All the headwater areas of the Whitewater River branches are steep initially in the headwaters and uplands. However, in the uplands of the North Branch, the longitudinal profile shows the stream elevation starts steep, then flattens for a longer distance moving downstream. This impacts sediment transport potential, as areas where the profile flattens, the particles stay in suspension longer. This explains why the North Branch is more turbid for a longer length than the other branches of the Whitewater drainage.

Related to TSS, habitat conditions are degraded at all biological sites in the upper north branch. The sites show bank erosion, siltation/embedded substrates (Figure 19). Past channelization and flow alteration/hydrology are contributing to the poor habitat conditions and sedimentation observed, in addition to other limiting factors. Biologically, there are reduced clingers and high numbers of legless macroinvertebrates throughout, pointing to a lack of good substrate and siltation impacting available habitat. In the fish-impaired coldwater section, pioneers that are tolerant to disturbance are abundant, along with a lack of riffle-dwelling species or simple lithophilic spawners. These all indicate that fish and macroinvertebrates are impacted by habitat stress, further confirming the habitat stressor that was also identified downstream previously and the current TSS/turbidity listings.

Figure 19. Photos of severe embeddedness and siltation at 10EM059.

2.3.3 Summary of stream health and recommendations in the NBWW

The biology in the NBWW is being stressed by habitat, nitrate, TSS, and flow alteration (Figure 20). Flow and hydrology are central drivers of many of the stressors observed in the watershed, tying directly to sediment and nutrient transport.

Intensive monitoring from 2020–2022 confirmed high nitrate concentrations increasing downstream—driven by extensive agricultural land use and transported via both tile drainage and groundwater flow, with the headwaters identified as a major source area. TSS levels also remain elevated throughout the watershed, with significant sediment deposition, erosion, and poor substrate conditions affecting aquatic life. Channelization, tile drainage, and altered hydrology contribute to both flow variability and habitat loss, compounding stress on fish and macroinvertebrate communities. The biological data, including dominance by tolerant species, confirm nitrate, sediment, and habitat alteration as key stressors. Nitrate reductions in the upper watershed (particularly between 65th Street and CR2) will yield the greatest water quality improvements.

DO is considered inconclusive as a stressor in the North Branch. The data from grab sampling does not indicate that low DO or eutrophication is occurring, but the data are limited. The stream may experience periods of low DO, especially in the upper sections where there are fewer water inputs during certain hydrologic conditions, and flows get low. Multiple years of monitoring would be required to fully understand the DO dynamics in this reach. Biologically, the evidence is conflicting and not consistent, which may indicate other stressors are involved. Until additional data can be collected to completely rule out this stressor, it remains inconclusive.

Connectivity and temperature are adequate and not causing stress. However, the unique thermal regime could be highly variable depending on yearly or seasonal hydrological conditions. Temperature measurements show suitable temperatures in the warmwater reach, showing good average water temperatures. The farthest headwater section is coldwater and influences this section with springs and seeps providing cool groundwater. Moving downstream to the warmwater section there are fewer coldwater inputs and springs. Near Elgin, there begins another thermal transition to coldwater, where more groundwater and springs enter the stream. In 2020 and 2021, the coldwater section near Elgin had summer monthly averages in the 16˚ to 18˚ range, which is normal for coldwater streams, but slightly elevated. These years were considered dry, and these temperatures are not surprising given the thermal transition zone and dry year. Biologically, temperatures did not appear to have a strong influence on species observed; fish did show a lack of coldwater species, but good percentages of coldwater macroinvertebrates were present, especially in 2021. It's more probable that the fish response is due to other stressors, and there is little evidence to suggest that temperature or connectivity are driving stress in this reach.

Figure 20. Stressor summary information for the NBWW. Green=Not a stressor, Orange=Inconclusive stressor, Red=Stressor.

Temperature

- Temperature data confirm temperatures are adequate and not limiting biological communities throughout the upper North Branch watershed. However, the smaller section of the stream near Elgin is in a thermal transition zone from warmwater to coldwater and does not fit a typical coldwater or warmwater thermal regime.

Nitrate

- Nitrate concentrations are high throughout this watershed. There are high amounts of nitrate tolerant inverts and few nitrate intolerant inverts. Nitrate concentrations show elevated concentrations throughout the upper part of the watershed, with concentrations above the proposed standards for aquatic life in both the warmwater (8 mg/L) and coldwater (5 mg/L) stream reaches.

TSS (Total Suspended Solids)

- Elevated TSS concentrations and low secchi tube measurements are well documented throughout this area of the North Branch. Downstream turbidity listings and previous SID work pointed to this upper area as a source of sediment. Fish and macroinvertebrates present are very tolerant to high TSS and further corroborate that TSS and sedimentation are contributing to the stress observed. The headwater/upper reach (F38) is warmwater and inconclusive for TSS stress.

DO/Eutrophication

- DO data is lacking in this section of the stream, and the biological response is mixed, not pointing strongly to DO or eutrophication as a stressor. It is probable some of the mixed response can be attributed to other stressors, however the data are limited.

Habitat

- Habitat was also identified as a stressor on the immediate downstream reach of the North Branch. The biological metrics show that poor habitat, especially impacts from sedimentation are a driver of stress in this reach. Additionally, photo documentation of channel disruptions at one of the biological sites has caused more dramatic stress in that area.

Connectivity

- The downstream section is in the thermal transition zone (where fish are impaired) and a mixed community is present. However, other stressors are impacting their ability to thrive. Some beaver dams have been documented and perched culverts in the upper warmwater sections (the area not impaired for fish).

Flow Alteration

- All watersheds in the MR-Winona are either directly or indirectly impacted by flow alteration (see the hydrology section at the beginning of the report). Sedimentation dynamics, including TSS/sediment, nutrient, and related habitat stress, are connected to changes in land use, precipitation, and flow.

2.4 Middle Branch Whitewater (07040003-F19)

2.4.1 Biological community summary

The Middle Branch Whitewater (MBWW) was listed as impaired during the Intensive Watershed Monitoring Cycle 1 assessments for macroinvertebrates. This stream has three biological monitoring stations: 10LM002, 10LM007, and 10LM037 (Figure 21). Station 10LM007, which is located within Whitewater State Park and lies along a popular trout-fishing reach, was added to the Long-Term Biological Monitoring (LTBM) program in 2013 and has been sampled every other year since. Data from this expanded monitoring show consistently strong IBI scores for the coldwater fish community, but variability in the macroinvertebrate community (Figure 22). The goal of the recent data analysis was to continue examining potential stressors to the macroinvertebrate community.

Figure 21. Map of the MBWW Watershed showing biological monitoring and water chemistry stations. The MBWW (07040003-F19) is impaired for macroinvertebrates and flows through Whitewater State Park.

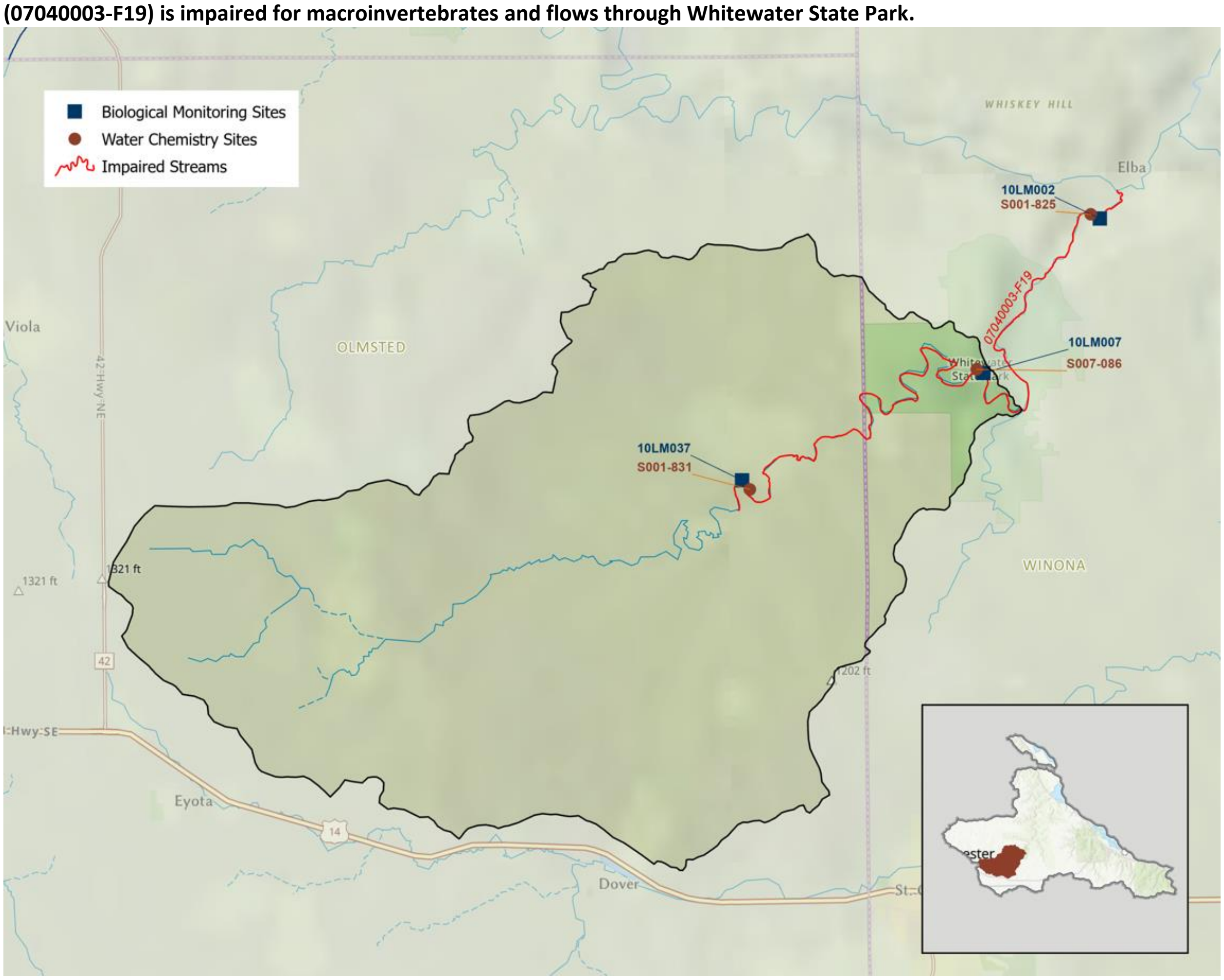
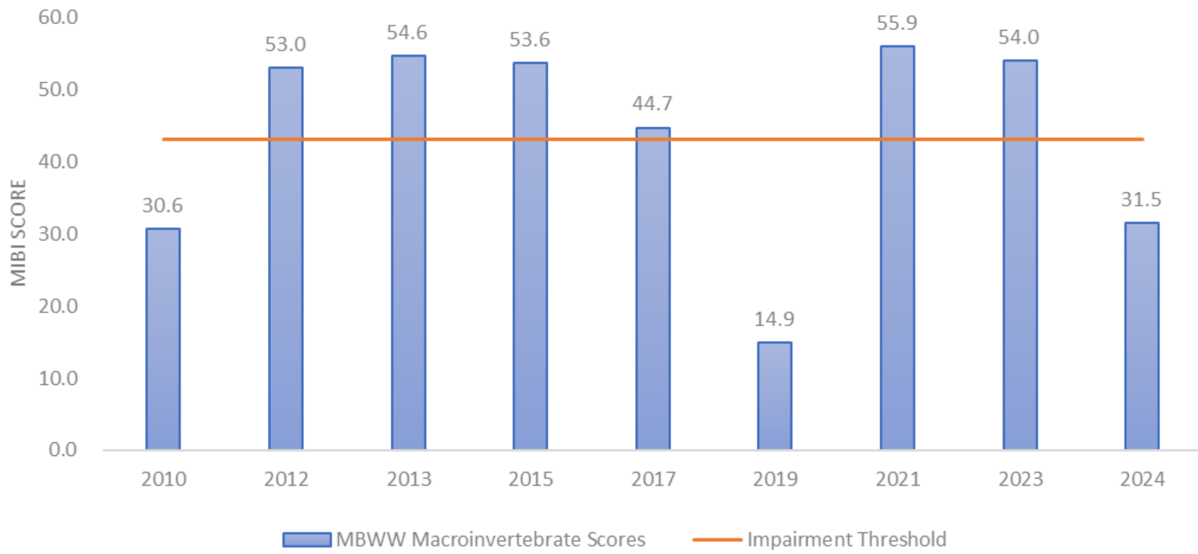


Figure 22. Macroinvertebrate IBI scores for long-term biological monitoring station 10LM007 2010 - 2024.



2.4.2 Stressors of concern

Overview and background

Previous work (MPCA, 2015) confirmed that nitrate and TSS are primary stressors to the macroinvertebrate community in this reach. Details are further described and analyzed in the original SID report, and only new, connecting information is presented in this SID report. Impacts from pesticides and flow alteration were inconclusive previously and other factors—temperature, habitat, DO/eutrophication, and connectivity—were ruled out as stressors.

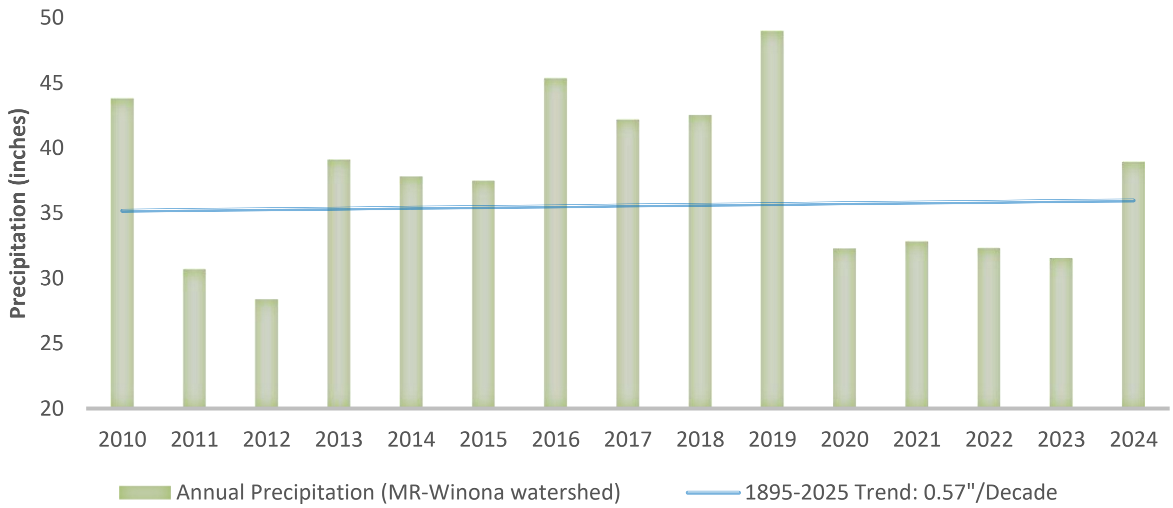
One station on this stream is an LTBM site (10LM007), allowing for additional data and analysis related to any biological changes since the original SID work was completed. Only the 2010 and 2012 biological samples were available for analysis when the original SID work was completed. Since then, seven more macroinvertebrate samples were collected, showing varying results (Figure 22). A long-term MDA water monitoring station is situated upstream from this location, which provides additional chemical and pesticide water quality data for analysis. The pairing of the LTBM site (10LM007) with the upstream MDA station provides a unique opportunity to re-evaluate stressor impacts using multiple years of combined hydrologic, chemical, and biological evidence.

Precipitation, hydrology, and pollutant transport

To understand the potential stressors and associated biological responses, knowledge of precipitation patterns was a key foundational piece (Figure 23). Since 1895, the average annual precipitation for the MR-Winona Watershed has increased by 0.57 inches per decade (DNR). Although the long-term annual average is about 35 to 36 inches, recent years show substantial variability. In 2019, the watershed experienced its wettest year on record at nearly 49 inches, followed by a stretch of below-average precipitation from 2020 through 2023 (around 32 inches annually). In 2024, the annual precipitation rebounded to slightly above normal at about 39 inches, driven largely by an exceptionally wet June. The LTBM site measured more than 10 inches of rain that month alone, about twice the long-term June average (~5 inches). A prolonged wet period with above-average precipitation also occurred earlier in the record, from 2013 to 2019.

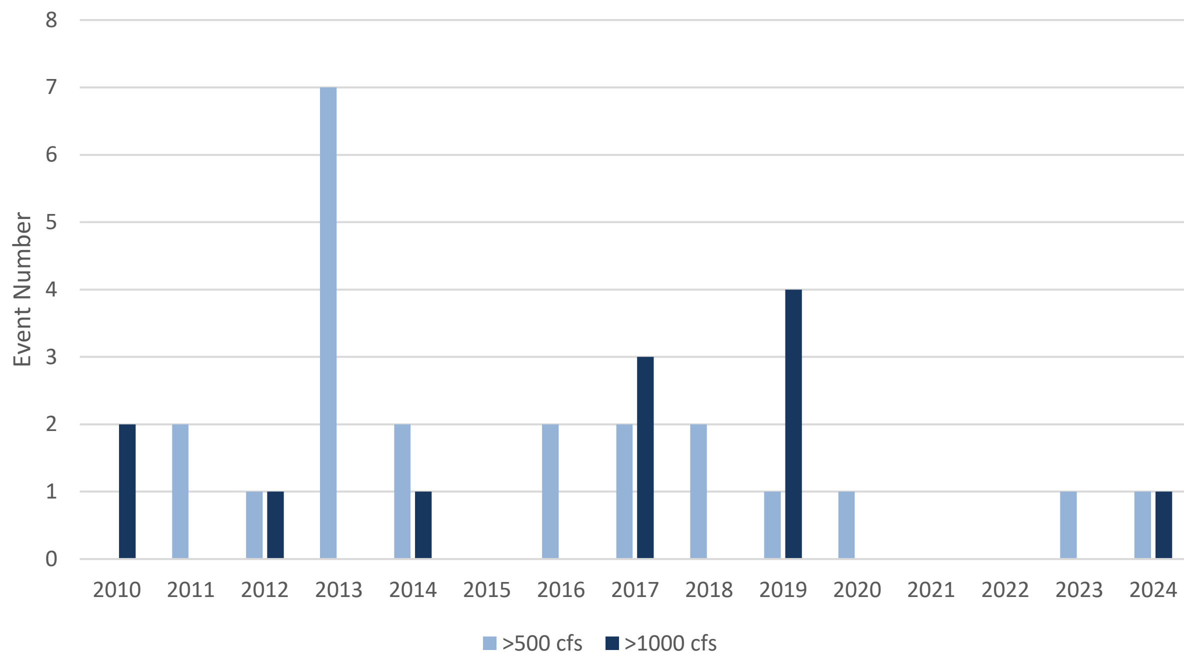
Precipitation is the primary driver of streamflow. Flow itself influences stream health, both through direct hydrologic shear stress and enhanced pollutant transport. In the MBWW, annual precipitation averages approximately 36 inches, but yearly variation is important (Figure 23). Key factors influencing the amount of runoff and pollutant transport include rainfall timing—early-season events pose a higher risk—and antecedent moisture conditions, with saturated soils promoting greater runoff.

Figure 23. Annual precipitation for the MR-Winona Watershed from 2010 to 2024, with a trendline showing a 0.57" increase in precipitation/decade since 1895. Years 2020-2023 had less than average precipitation, while 2019 had the highest annual precipitation on record, following an above-average precipitation period from 2013-2019. (Minnesota Climate Trends, DNR).



Substantial streamflow events normally occur in MBWW each year. Most years have had at least one event during which the stream reached 500 cfs (cubic feet per second), with many years also exhibiting events that reached 1,000 cfs (Figure 24). A flow of 500 cfs represents a moderately impactful, periodic peak flow event, while 1,000 cfs represents a more severe, less frequent peak flow event. With baseflow around 20 cfs in this stream, these high flow events demonstrate the flashy hydrology that is typical of the karst region. High flows are tied to various impacts on aquatic life, including increased sediment and pollutant transport/exposure.

Figure 24. MBWW flow events by year. *Data from 2021 and 2022 are missing, and 2023-2024 are provisional.



Note: *Discharge data from 2021–2024 are provisional (Elba site), while 2010–2020 data are from the MDA station. However, DNR-verified stage data supports the validity of the provisional flow records.*

In 2010, streamflow exceeded 1,000 cfs on August 13, five days before the biological sampling on August 18. This high-flow event influenced the sample results that year, with the macroinvertebrate community being comprised of a mix of organisms from both wetland and coldwater stream habitats, which is atypical for this monitoring station. This may have been the result of the high-flow event flushing out upstream riparian wetlands and/or warmwater streams into this section of the MBWW. No other year recorded a >1,000 cfs flow event within one week of biological sampling. In other years, three to four weeks elapsed between a high-flow event and biological sampling. As a result, comparing the 2010 biological sample to others is more difficult.

The low Macroinvertebrate Index of Biological Integrity (MIBI) scores in 2019 and 2024 provide a critical hydrologic contrast. 2019 was characterized by sustained, above-average baseflow and frequent high-flow events (part of the 2013-2019 wet period), suggesting high potential for pollutant and flow-related stressors. In 2019, there were 4 high flow events >1,000 cfs. In contrast, 2024 had only one high-flow event >1,000 cfs, in late June, nearly three months prior to biological sampling (Figure 24), indicating that the low MIBI score was likely driven by other additional stressors.

Pesticide monitoring overview

The MDA has conducted ambient surface water monitoring at the MBWW site since 1993, making it the longest-running pesticide monitoring location in Minnesota. It is one of MDA's Tier 3 surface water monitoring program stations with year-round monitoring, sampling 20 to 30 times each year. The MDA collects grab samples during base flow periods and uses time-based composite sampling to target runoff periods in the open water season. Samples are currently analyzed for up to 194 pesticide analytes, including parent and degradate compounds. Other inorganic parameters are selectively analyzed as well throughout the season. Overall, this site has a comprehensive water quality dataset that is valuable for long-term data analysis.

Many different pesticide analytes have been detected in MBWW since 1993. While not all pesticide analytes have MPCA established Minnesota specific pesticide water-quality standards, the MBWW is meeting all current standards for the analytes detected. Four pesticide analytes have been detected above the numeric component of the MPCA water quality standard or the U.S. Environmental Protection Agency (EPA) aquatic life benchmark (ALB), shown in Table 1. ALB values are based on toxicity data available and are used to assess detected pesticide concentrations. ALBs are estimates of the concentrations below, which pesticides are not expected to represent a risk of concern for aquatic life. Since most pesticides do not have a water quality standard(s) established in Minnesota or elsewhere, they are often compared to the ALB. The term "reference value" is used collectively to include the water quality standards (if available) or ALBs used when screening a numeric sample result to assess the risk of the detection. To be considered an exceedance of the standard or ALB, both the concentration component and the duration component must be considered, and multiple exceedances must be documented to violate some reference values.

Of the 194 pesticides analyzed, only 4 pesticides have been detected over the numeric component of the lowest applicable reference value since 2010 (Table 1). One herbicide (acetochlor) was detected twice at a concentration above the numeric component of the water quality standard since 2010; however, neither concentration was sustained over the four-day duration component of the standard necessary to have an exceedance of the standard. Three insecticides have also been detected above their respective ALB reference values. One of these, dichlorvos, was only detected in one sample in 2012. Two neonicotinoid (also referred to as "neonics") insecticides, clothianidin and imidacloprid, have been detected in fourteen and seven samples, respectively, above the numeric component of their ALBs. As a result, these two neonicotinoid insecticides were further evaluated as potential stressors of macroinvertebrates in MBWW.

Table 1. Pesticide analytes in MBWW with detections greater than the numeric component of the reference values (RV) at the MBWW from 2010 through 2024.

Analyte	Pesticide Type	Sample Number	# Detections above reference value	Reference Value (ng/L)	Notes
Acetochlor	Herbicide	280	2	3,600	MDA SW Pesticide of Concern
Clothianidin	Insecticide *(Neonicotinoid)*	182	14	50	MDA SW Pesticide of Concern
Dichlorvos	Insecticide	228	1	5.8	Detection > RV in 2012
Imidacloprid	Insecticide *(Neonicotinoid)*	198	7	10	MDA SW Pesticide of Concern

Neonicotinoid background and water quality data

Neonicotinoids are a class of synthetic insecticides chemically related to nicotine that target insects' nervous systems by binding to nicotinic acetylcholine receptors, causing paralysis and death (Jeschke, 2011). As systemic insecticides, they are absorbed and distributed throughout plants, providing broad protection against insects that feed on the plant. While effective in controlling certain agricultural insect pests, neonicotinoids have raised environmental concerns due to their potential harm to pollinators and other nontarget species. Some neonicotinoids are highly toxic to aquatic invertebrates and can cause negative effects at very low concentrations in rivers and streams (Morrissey et al., 2015; Schmidt et. al, 2022). Since their introduction in the 1990s, neonicotinoids have become the most widely used class of insecticides worldwide. While they are useful tools for managing insect pests, they are highly soluble in water, which favors movement to nearby water bodies or groundwater. Neonicotinoids are persistent in soils, and they are also mobile in aquatic environments, with degradation rates ranging from weeks to years depending on soil characteristics and environmental conditions (Hladik et al. 2018, EPA 2017). Two neonicotinoids, clothianidin and imidacloprid, were designated as "Surface Water Pesticides of Concern" by the Minnesota Commissioner of Agriculture in 2020.

The EPA has developed chronic invertebrate ALBs for clothianidin (50 ng/L), imidacloprid (10 ng/L), and thiamethoxam (740 ng/L) based on chronic toxicity to aquatic invertebrates. When comparing detected concentrations to these chronic invertebrate ALBs, a 21-day exposure duration is used. The acute ALBs for clothianidin (11,000 ng/L), imidacloprid (385 ng/L), and thiamethoxam (17,500 ng/L) have not been exceeded in any sample at the MBWW to date.

Of the eight neonicotinoid compounds analyzed at the MBWW since 2010, only three were detected in samples through 2024: clothianidin, imidacloprid, and thiamethoxam (Table 2). Among these, only clothianidin and imidacloprid were found at concentrations above the numeric component of chronic invertebrate ALB. Thiamethoxam has been detected, but infrequently and below the ALB.

The MDA prioritized lowering the method reporting limit (MRL) for clothianidin and imidacloprid to better assess the occurrence of these pesticides below their chronic ALBs. For example, the MRL for clothianidin was lowered from 25 ng/L to 5 ng/L in 2024. While this change allowed for the reliable quantification well below the ALB, it has increased the detection frequency in recent years (Table 2). Multiple rows for some neonicotinoids in Table 2 represent the various reporting limits in the noted time period. Clothianidin and imidacloprid warranted closer examination in relation to potential stress to macroinvertebrates based on detections above the numeric component of the ALB values (highlighted cells).

Table 2. MBWW neonicotinoid detection summary, 2010 to 2024. Highlighted cells show neonicotinoid detections above the numeric component of the ALB benchmark value. Note: Clothianidin analysis began in 2011, while imidacloprid analysis began in 2010.

Analyte	MRL	Samples	Detections	Detection Frequency (%)	Maximum Concentration (ng/L)	Chronic Aquatic Life Benchmark (ALB) ng/L	Detections ≥ Numeric component of the chronic ALB	Years Analyzed	Years with a detection
Acetamiprid	15	12	0	0	< 15	2,100	0	2010	None
Acetamiprid	25	186	0	0	< 25	2,100	0	2011-2024	None
Clothianidin	25	165	20	12	115	50	10	2011-2023	2013, 2014, 2017-2022
Clothianidin	5	17	17	100	140	50	4	2024	2024
Dinotefuran	25	176	0	0	< 25	6,360,000	0	2012-2024	None
Imidacloprid	20	101	1	1	30.4	10	1	2010-2017	2013
Imidacloprid	10	10	0	0	< 10	10	0	2018	None
Imidacloprid	5	87	11	13	154	10	6	2019-2024	2019, 2022, 2024
Imidacloprid-olefin	50	111	0	0	< 50	Not Available	0	2017	None
Imidacloprid-urea	50	111	0	0	< 50	>47,400,000	0	2017	None
Thiacloprid	50	152	0	0	< 50	970	0	2014	None
Thiamethoxam	25	198	8	4	130	740	0	2010	2010, 2013, 2017, 2019, 2024

Neonicotinoid sources and transport

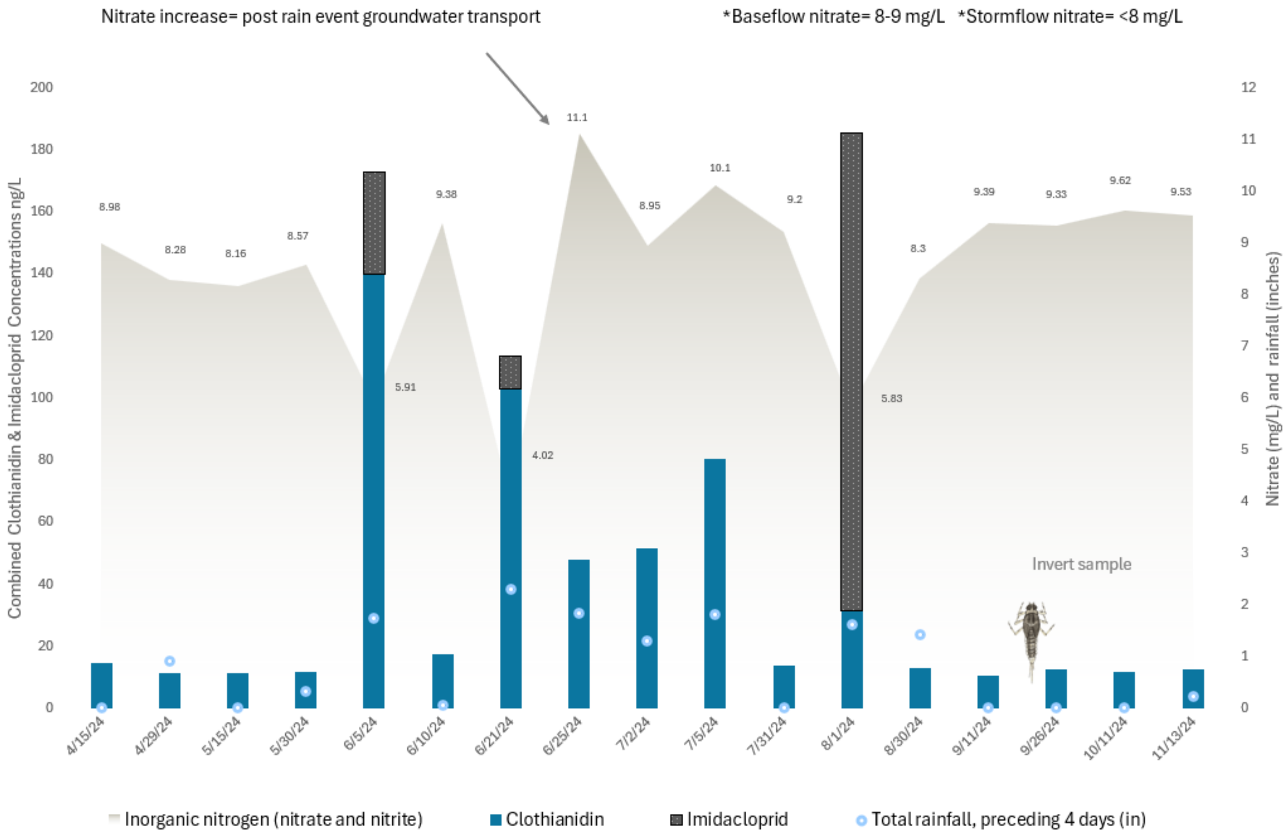
Seasonal patterns and sources of neonic contamination are detailed in the MDA's report on Detection Patterns of Neonicotinoids in Minnesota Rivers and Streams (MDA, 2023). Seed treatments—used on nearly all corn and most soybean crops—are a major source of neonicotinoids in Minnesota's agricultural watersheds. Elevated concentrations most typically occur during spring runoff and into early summer, coinciding with planting season. Watersheds with extensive agricultural land use, such as the MBWW (~60% agricultural), are at risk. Additional inputs of neonicotinoids can occur from foliar applications later in the growing season. Neonicotinoids tend to be highly soluble and mobile, allowing for movement with water as they move through soil, into tile drainage, and shallow groundwater before reaching streams.

A closer examination of MDA surface water quality pesticide data from 2024 highlighted key differences in pollutant transport and timing of nitrate and pesticides, specifically neonicotinoids (Figure 25). According to MDA reports, overland flow and/or subsurface tile drainage are the primary pathways for neonic transport to surface waters (MDA, 2023). In the MBWW Watershed, subsurface tile drainage is limited to the headwaters; however, the karst geology provides minimal filtration and facilitates rapid subsurface transport of pollutants into groundwater aquifers. Figure 25 also illustrates temporal patterns in these pollutant dynamics, with increased neonicotinoid (clothianidin and imidacloprid) concentrations that coincided with periods of increased flow and rainfall. Elevated (at or near ALB reference value) clothianidin concentrations were observed in all samples collected between 6/21/24 and 7/5/24, with multiple rainfall events that occurred over this period. The rainfall within four days of each sample is shown in Figure 25**,** which indicated that when elevated neonics were detected, there typically was one to two inches of rain in the preceding days.

Conversely, nitrate in the stream exhibited a relatively steady baseflow concentration of 8 to 9 mg/L, which reflected a contribution from deeper groundwater. During storm-event runoff, these concentrations were diluted, producing inverse spikes in nitrate. A rebound was observed in late June 2024 when concentrations rose to 11.1 mg/L on June 25 (Figure 25). This post-event increase likely reflected the influx of shallower groundwater carrying additional nitrate, driven by enhanced infiltration and saturated soils during this period.

After early August, nitrate, clothianidin, and imidacloprid concentrations remained stable through the fall months during baseflow conditions. Sediment concentrations in the MBWW, while not depicted in the graphic, are known to be highest when flow is elevated and following rain events. During baseflow conditions, sediment and TSS concentrations are minimal, and the stream is clear (see subsequent section "Chemical and physical stressor interactions" for more details related to sediment).

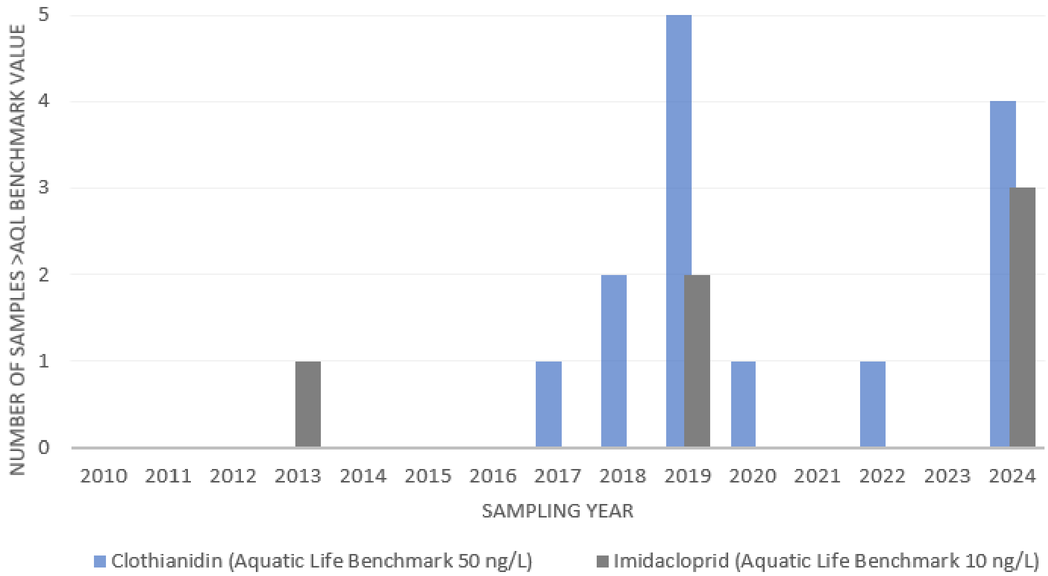
Figure 25. Nitrate and neonicotinoid (clothianidin and imidacloprid) concentrations from April–November 2024 at the MBWW showing elevated concentrations of the pollutants with varying transport and delivery mechanisms.



Neonicotinoid detections and ALB benchmark exceedances

General neonicotinoid exposure includes impacts on survival, reproduction, growth, emergence, and behavior (Morrissey et al., 2015). The potential additive and/or synergistic impacts of clothianidin and imidacloprid mixtures pose a great risk to stream health (Schmidt, 2023). Several individual samples from 2024 exceeded the numeric chronic ALB value for both compounds simultaneously (e.g., June 5: clothianidin 140 ng/L; imidacloprid 32.7 ng/L, and June 21: clothianidin 107 ng/L; imidacloprid 11.1 ng/L), indicating the potential for additive effects. Overall, at MBWW in 2024, individual samples exceeded the numeric chronic ALB four times for clothianidin and three times for imidacloprid, comparable only to 2019. (Figure 26). This indicated there were sample results greater than the numeric benchmark values, while the ALB 21-day average concentration was not exceeded. Although these concentrations were well below the acute ALB values for clothianidin (11,000 ng/L) and imidacloprid (385 ng/L), their concurrent detection indicated a possible potential for additive effects that are currently not well understood. An individual sample had a concentration of imidacloprid that was the highest recorded at MBWW on August 1, 2024 (154 ng/L; ~40% of its acute ALB).

Figure 26. Individual sample values above the numeric component of the EPA chronic ALB benchmark for the MBWW, 2010 to 2024, for clothianidin and imidacloprid. Note: Clothianidin was not being analyzed in 2010.



The MDA integrates the water quality samples collected each year and calculates 21-day average concentrations for clothianidin and imidacloprid for six 21-day periods starting May 1 through early September. These calculated 21-day average concentrations are then compared to the ALB to determine if an exceedance of the chronic ALB possibly occurred.

Review of the 21-day average concentrations indicated that concentrations over the ALB reference value for clothianidin and imidacloprid have increased since 2013 (Figure 27). Since 2013, the MBWW has recorded seven total 21-day chronic ALB exceedances—five for clothianidin and two for imidacloprid—with the highest number for any year occurring in 2024 (Figure 28). Clothianidin remained the most frequently detected neonicotinoid at this site and statewide; in 2024, its statewide detection frequency (>5 ng/L) reached 80%, with the greatest number of ALB exceedances recorded statewide to date (MDA 2025). Similarly, the greatest number of clothianidin 21-day ALB exceedances at the MBWW occurred in 2024, compared with all other years of neonicotinoid monitoring.

Timing and duration of exposure were also important considerations in 2024. From June 14–July 25, two consecutive 21-day clothianidin sample periods exceeded the chronic ALB, followed by a 21-day imidacloprid exceedance from July 26–August 15, resulting in a continuous two-month period of potentially elevated neonicotinoid exposure (Figure 27). All 21-day exceedances and elevated concentrations of imidacloprid and clothianidin occurred before annual macroinvertebrate sampling (late July–September).

Figure 27. MBWW imidacloprid and clothianidin ALB 21-day average concentrations (ng/L) from 2010 to 2024. Years with macroinvertebrate sampling are included. The red circles indicate MIBI values below the impairment threshold. Note: Clothianidin analysis did not begin until 2011; imidacloprid started in 2010.

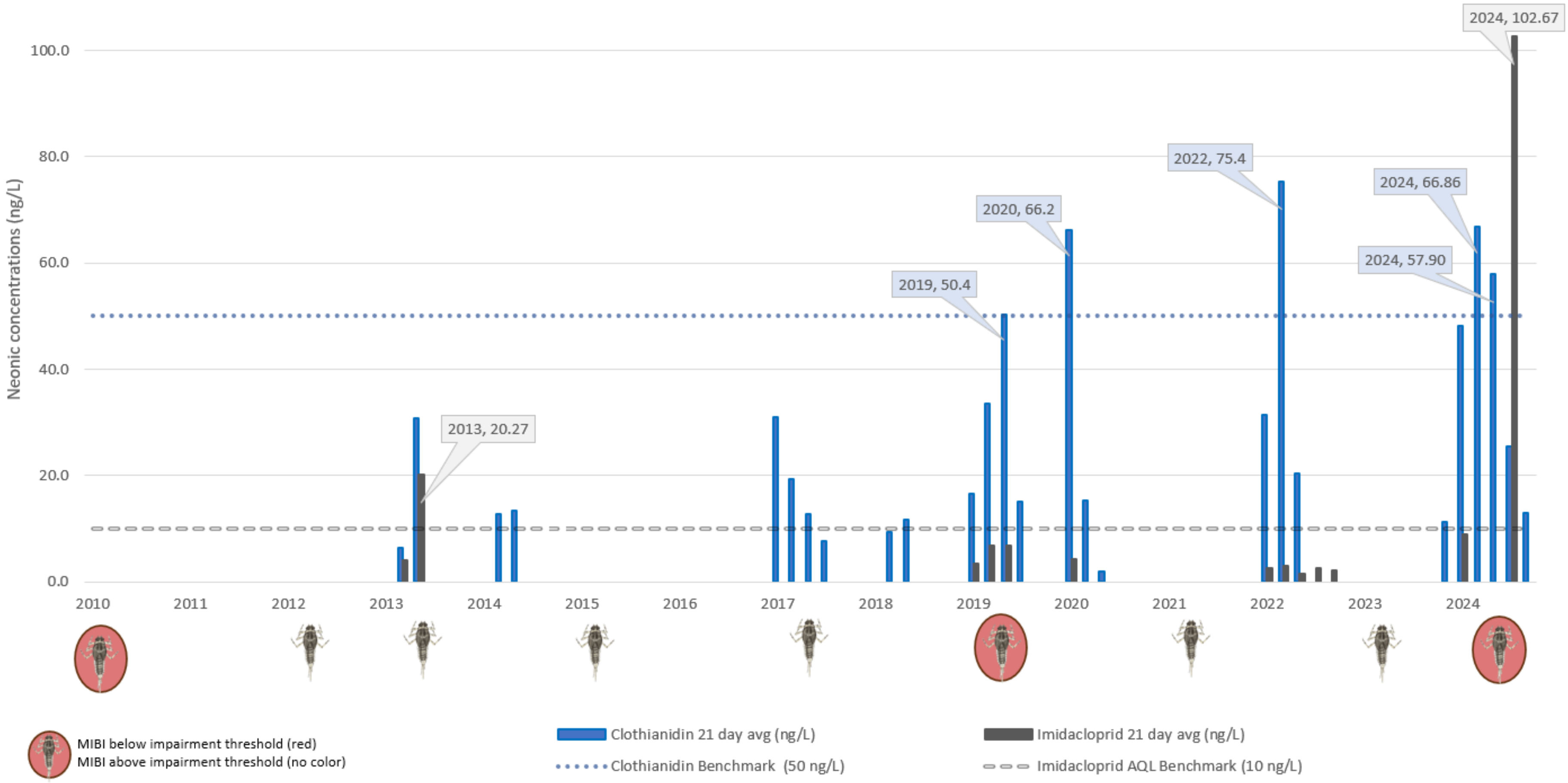
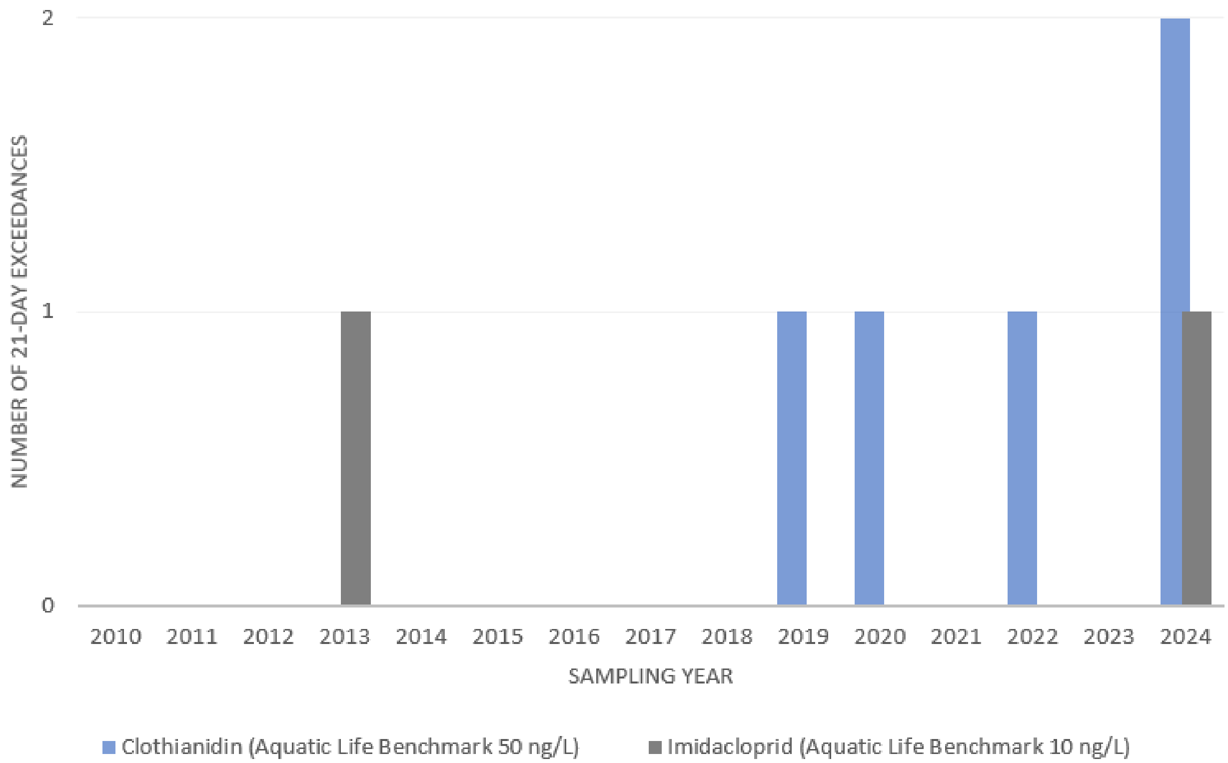


Figure 28. The number of 21-day (chronic) neonicotinoid aquatic life benchmark exceedances in the MBWW, 2010 to 2024, for clothianidin and imidacloprid. Note: Clothianidin was not being analyzed in 2010.

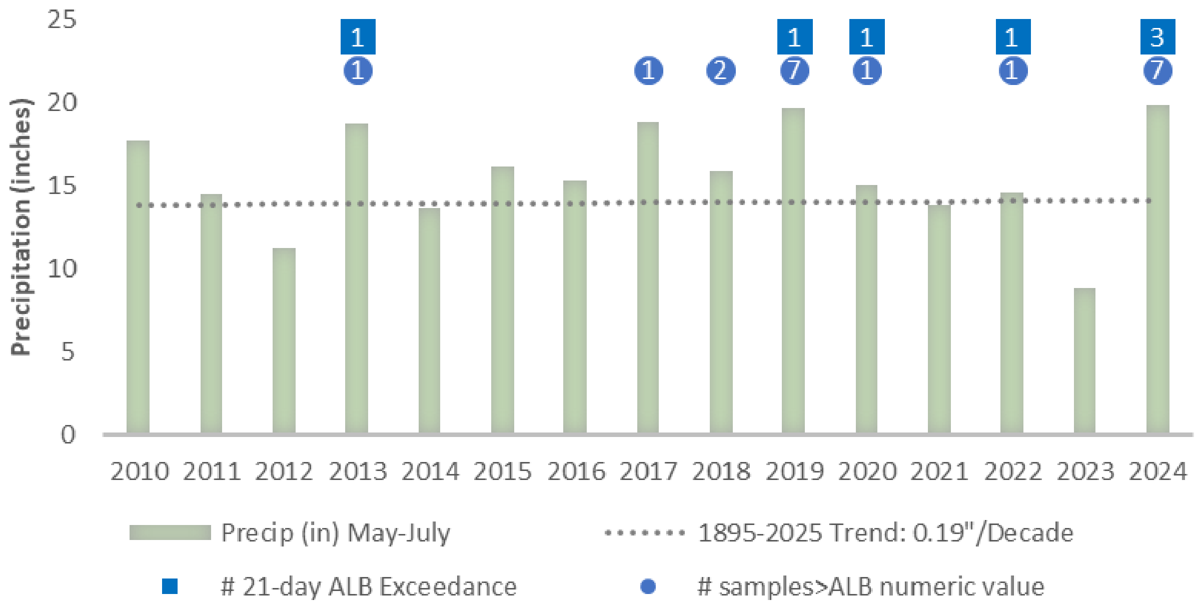


Note that bridge construction at the MDA monitoring site necessitated a shift from the traditional Equal Time Interval (ETI) composite sampling to grab sampling during sampling years 2023–2024. Because grab samples represent a single point in time, the observed 2024 concentrations may have been somewhat higher than those captured by ETI methods in prior years. Unlike ETI sampling, which collects a small volume of water every hour over four days, grab samples represent a single point in time. While this change in sampling approach may have contributed to the elevated 21-day average concentrations seen in 2024, MPCA believes it does not diminish the significance or use of the sample results. Rather, it suggests that 2024 data may show somewhat higher values relative to other years, due in part to the sampling method, but that is dependent on the exact timing of the grab sample. After the completion of the bridge construction, ETI sampling resumed in 2025.

Chemical and physical stressor interactions

Daily precipitation records indicate that in some years, rainfall was more concentrated over short periods, which may increase runoff and neonicotinoid mobilization among other stressors. Neonicotinoid transport tends to coincide with elevated streamflow, particularly during spring or early summer (May–July) when crop planning is completed, and runoff potential is highest. All observed 21-day ALB exceedances for clothianidin at the MBWW have occurred during years in which May–July precipitation totals exceeded the long-term average for those months (Figure 29). In other words, when the spring months have more rainfall, there are more frequent detections of neonicotinoids in the MBWW.

Figure 29. May-July precipitation totals (inches) for the MR-Winona from 2010 to 2024 compared to the long-term trend (1895-2025). Blue squares indicate the number of 21-day ALB exceedances, and blue circles represent the number of individual samples exceeding the ALB numeric value each year. Values include both clothianidin and imidacloprid combined.



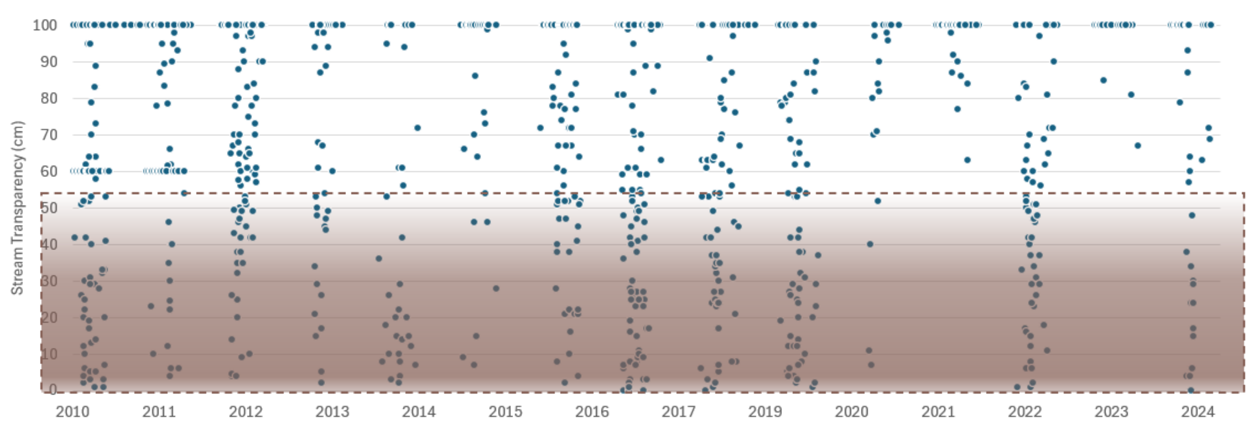
However, yearly precipitation patterns do not fully predict neonicotinoid transport. In some years—such as 2020 and 2022, substantial early-season rainfall produced elevated neonicotinoid concentrations (each year had 1 ALB exceedance of clothianidin) despite below-normal annual precipitation totals. Conversely, wet spring conditions (high early-season rainfall) in 2015, 2016, and 2017 did not result in 21-day exceedances. In 2015 and 2017, MIBI scores also remained above threshold, suggesting that existing stressors weren't significant enough to depress biological condition, and notably, neonicotinoid exposures were not elevated (above the ALB value) in those years either.

Additionally, neonicotinoid exceedances during the wet period of 2013–2019 were generally limited. An exception occurred in 2019, which experienced extremely high flows and TSS, alongside notable clothianidin detections. An imidacloprid exceedance was also recorded in 2013 (June 14–July 4), though MIBI scores that year remained unaffected—likely due to the brief duration, marginal exceedance magnitude, and otherwise favorable in-stream conditions. These mixed patterns highlight that hydrologic conditions alone do not predict neonicotinoid transport or biological response. Instead, exceedances—and subsequent biological effects—appear linked to specific runoff dynamics (timing/antecedent moisture condition) and exposure duration rather than simply the amount of rainfall. More years of data collection will be needed to further understand these dynamics at the MBWW.

In contrast to 2019, 2024 exhibited fewer large flow events (Figure 24), yet clothianidin and imidacloprid concentrations were elevated and more frequent. This suggests that, unlike years with historically high flow events, neonicotinoid concentrations—rather than hydrologic or sediment stress—may have played a more prominent role in the biological impact observed in 2024. However, it is also recognized that the different sampling regime (grab samples) may have played a role in the difference in detections in 2024 compared to the other years.

As shown in Figure 30, the MBWW frequently experiences elevated turbidity or reduced transparency, with many secchi tube readings at or below the 55-cm threshold, which is the reference equivalent for the coldwater 10 mg/L TSS standard (brown shaded portion of the graph). Overall, there were 357 of 1011 readings from 2010- to 2024 below the 55-cm threshold (i.e., 35%). There are on average, about 60 secchi readings on this stream each year, with a range of 26 to 108 readings/year. Secchi tubes have a maximum length of 100 cm; considered the best reading possible (i.e., the user can see through the full length of the 100 cm tube). Turbidity increases and reduced transparency are closely tied to storm-driven runoff events that mobilize fine sediments from upland fields, eroding banks and the stream channel. Although turbidity spikes decline relatively quickly once flows subside, the magnitude and frequency of these episodic events remain ecologically significant. Sudden pulses of suspended sediment can reduce light penetration, impair feeding efficiency for visual predators, destabilize benthic habitats, and increase physiological stress on macroinvertebrates through gill abrasion and altered respiration (EPA, 2025). Repeated high-intensity events, even if short-lived, can cumulatively weaken aquatic communities.

Figure 30. Secchi tube results on the MBWW stream WID (F19) from 2010 to 2024. The brown shaded area corresponds to transparency readings below 55 cm: the coldwater reference for 10 mg/L TSS.



Turbidity and sediment transport are only one component of a broader stressor complex in this stream. A key difference between turbidity pulses and other stressors is that turbidity is episodic, while nitrate concentrations remain chronically elevated year-round. The MBWW consistently exhibits nitrate concentrations at baseflow of 8 to 9 mg/L, reflecting the predominance of row-crop agriculture and complex groundwater and surface water interactions within the watershed. These land use and hydrogeologic factors allow nitrate to move readily through subsurface pathways into the stream and deeper aquifers, producing continuous, not event-driven, nitrate exposure.

Ecologically, chronically elevated nitrate acts as a persistent background stressor in several ways:

1. **Physiological and other stress on invertebrates:** Elevated nitrate can interfere with cellular-ion exchange, reduce survivorship during early life stages, reduce growth, and increase sensitivity to other contaminants. (MPCA, 2022, Camargo et al., 2005)

2. **Nutrient-driven shifts in primary production:** Increased nitrogen availability can change periphyton biomass and species composition, affecting food quality for grazers and overall food web structure. (EPA, 2025)

3. **Interaction with turbidity and sediment:** High nutrient availability may increase periphyton growth during clear-water periods, only for subsequent turbidity pulses or flow events to repeatedly scour

these communities, contributing to unstable and low-quality food resources or habitat. (EPA, 2025; Biggs, 2000)

4. **Synergistic effects with pesticides or other pollutants:** Any chronic stressor, like elevated nitrate, can reduce resilience, making macroinvertebrates more vulnerable to other additional stressors. (EPA, 2025, Gomez et al., 2020)

Interannual variability in hydrology helps separate these chronic and episodic factors. Years such as 2021 and 2023 exhibited consistently clear water with no transparency values below 55 cm due to below-average precipitation, which reduced sediment mobilization. In contrast, nitrate concentrations remain elevated every year regardless of precipitation because the baseflow delivery of this stressor is decoupled from hydrologic variability and provides a constant physiological and ecological burden.

In contrast, years such as 2012, 2013, and 2017 had hydrologic conditions conducive to elevated turbidity, yet MIBI scores remained above the impairment threshold. Because nitrate was also elevated during those years, the biological condition suggests that chronic nitrate alone—and episodic turbidity alone—were insufficient to cause reduced MIBI scores and were without additional stressors such as elevated neonicotinoids.

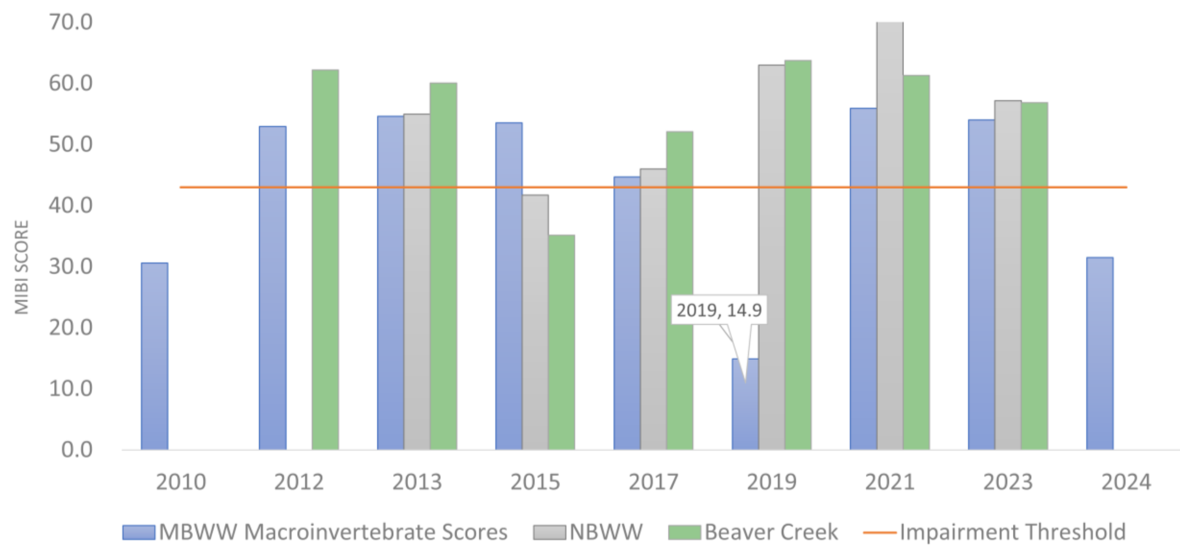
This distinction is crucial for interpreting more recent conditions. From 2013–2019, even substantial hydrologic and sediment stress didn't consistently coincide with elevated detections or exceedances of neonicotinoids. Only in certain years, such as 2019, did high flow/TSS coincide with notable clothianidin detections. In contrast, 2024 did not exhibit unusually elevated turbidity or large flow events (Figure 24), yet both clothianidin and imidacloprid concentrations were elevated. As noted previously, the 2024 pesticide grab sampling regime may have influenced comparability with prior years. Importantly, these pesticide exposures occurred against a persistently elevated nitrate background, increasing the likelihood of additive or synergistic biological effects (EPA, 2025).

The combination of chronically high nitrate concentrations, episodic turbidity pulses, and sustained clothianidin and imidacloprid exposure may explain why biological condition in 2024 declined despite the absence of extreme sediment or hydrologic disturbance. Each stressor alone may be tolerable, but together they may create a multi-stressor environment that reduces resilience and increases the likelihood of impairment and/or reduced MIBI scores.

Biological responses and community change

Data from other LTBM stations in the MR–Winona Watershed provided useful context for interpreting potential stressor responses at the MBWW (Figure 31). Two nearby stations—the NBWW and Beaver Creek—are nearby coldwater streams with similar land use, hydrology, and potential stressors, but are currently not impaired. All three sites were sampled for macroinvertebrates consistently from 2013 through 2023. However, sampling in earlier or later years was inconsistent: in 2010 and 2024, only the MBWW was sampled, and in 2012, only the MBWW and Beaver Creek were sampled. The LTBM program had not yet reached full implementation until 2013. The only location with pesticide monitoring presented in this section is the MBWW.

Figure 31. MIBI scores for LTBM stations in the MR-Winona from 2010 to 2024, including North Branch Whitewater and Beaver Creek, which are not impaired for macroinvertebrates.



Across the monitoring record, MIBI scores at the three sites generally track one another, reflecting similar watershed conditions. However, 2019 stands out as a clear deviation. In that year, NBWW and Beaver Creek both scored well for MIBI, whereas MBWW showed a pronounced decline. This divergence suggests that the factors driving the 2019 biological response at the MBWW were site-specific rather than larger watershed-wide factors. Notably, 2019 at the MBWW was characterized by neonicotinoid detections (particularly clothianidin), coupled with high flows and turbidity. Elevated neonicotinoids coincide with the observed drop in MIBI scores, highlighting the potential role of clothianidin and/or imidacloprid as contributing stressors. The 2019 contrast reinforces the importance of considering site-specific exposures in causal analyses, particularly when interpreting declines in macroinvertebrate condition. Neonicotinoid data at the NBWW and Beaver Creek would be useful to fully compare impacts across the watersheds, but as of 2025, surface water quality samples have not been analyzed for neonicotinoids. Similarly, macroinvertebrate data from 2024 for NBWW and Beaver Creek would be useful to compare to the MBWW, further highlighting the need for more coordinated long-term monitoring.

The long-term monitoring of macroinvertebrates at the MBWW has revealed notable variability in biological condition over time (Figure 31 and Figure 32). Separating the MIBI into its component metrics (Figure 32), with definitions in Figure 33, helps clarify which aspects of the community are most responsive to the overall MIBI score. The larger the metric value bar, the better, based on the stressor response expected for that metric. For example, the smaller bars/components in 2019 are combined and produce the lowest MIBI score observed at this site. Conversely, for other years with higher MIBI scores, the bars for each metric are larger (2012, 2015, 2021, and 2023).

Figure 32. MIBI metrics for the MBWW from 2010 to 2024. Note: 2013 and 2021 have replicated sample results displayed.

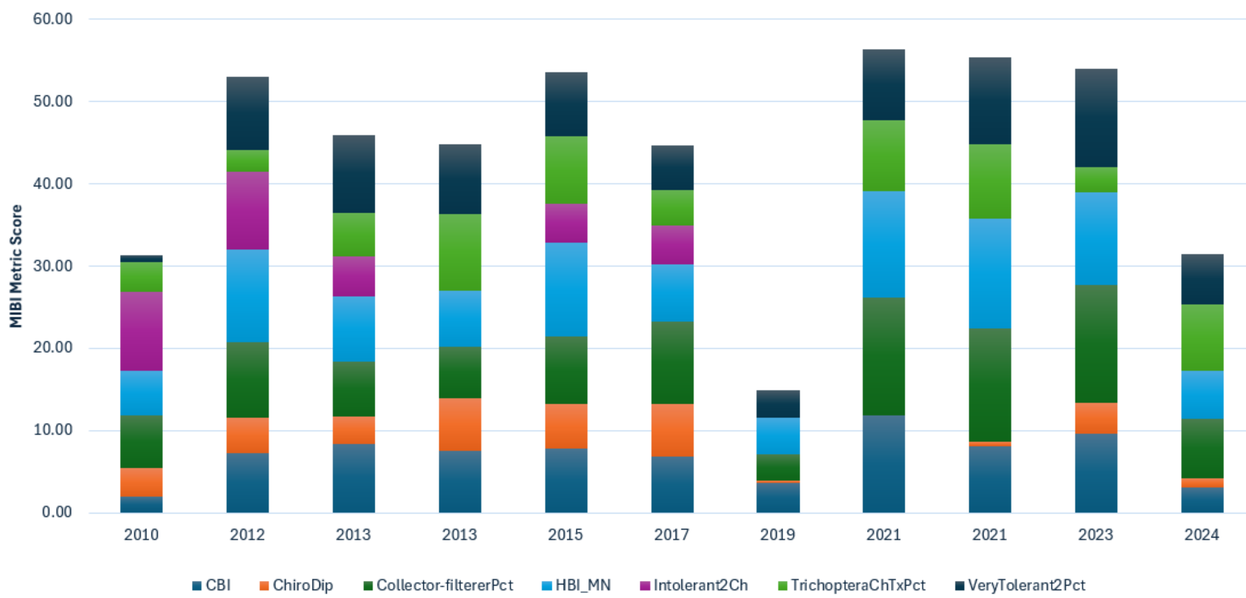


Figure 33. MIBI metric definitions for Class 9 Coldwater MIBI.

Metric Abbreviation	Metric Name	Metric Description	Category	Response
CBI	Coldwater Biotic Index[1]	Coldwater Biotic Index score based on coldwater tolerance values derived from Minnesota taxa/temperature data.	Tolerance	Increase
ChiroDip	ChiroDip[1]	Ratio of Chironomidae abundance to total Dipteran abundance.	Tolerance	Increase
Collector-filtererPct	Percent (%) Collector – Filterers	Relative abundance (%) of collector-filterer individuals in a subsample	Trophic	Decrease
HBI_MN	Hilsenhoff Biotic Index, MN TVs[1]	A measure of pollution based on tolerance values assigned to each individual taxon, developed by Chirhart	Tolerance	Increase
Intolerant2Ch	Intolerant Taxa Richness, 2 ch	Taxa richness of macroinvertebrates with tolerance values less than or equal to 2, using MN TVs	Tolerance	Decrease
TrichopteraChTxPct	Percent (%) Trichoptera Taxa	Relative percentage of taxa belonging to Trichoptera	Compositi on	Decrease
VeryTolerant2Pct	Percent (%) Very Tolerant, 2[1]	Relative abundance (%) of macroinvertebrate individuals in subsample with tolerance values equal to or greater than 8, using MN TVs	Tolerance	Increase

[1]metric value adjusted for drainage area

Overall, there have been three years with MIBI scores below the impairment threshold: 2010, 2019, and 2024. In 2019 and 2024, all metrics scored low. While many of the metrics show variations over time, some general patterns are evident. The “intolerant2Ch” metric has scored 0 since 2019 (purple box,

Figure 32). The taxa in that metric that have been sampled at 10LM007 include Ephemerella (mayfly), Nigronia, and Glossosomatidae (caddisfly). This indicates that since 2019, these most sensitive taxa have not been present in biological samples. While those taxa were only present in small numbers previously, their complete absence in recent years is notable. In Schmidt et al. (2022), Ephemerella spp. abundance was found to be the most sensitive larval taxon to clothianidin exposure ($EC_{(20)}$) among those measured. The "ChiroDip" metric is also of interest; it is defined as the ratio of Chironomidae to total dipteran abundance (Figure 33). That metric (shown in the orange component of the bar in Figure 32) is smaller/less in more recent years, and in years where the MIBI is below the impairment threshold. Together, these trends indicate a shift away from sensitive taxa toward more tolerant macroinvertebrate groups from 2010 through 2024. These same macroinvertebrate metric responses are not observed at the other two LTBM sites (Beaver and NBWW), indicating they weren't subjected or responding to the same stressors.

Looking closer in 2010, that year does not correlate with high levels of neonicotinoids or detections (however, clothianidin was not being analyzed in 2010, making it unknown). Association with high frequency of elevated concentrations and/or exceedances of clothianidin and imidacloprid with low macroinvertebrate score occurred in 2019 and 2024. These two years had high precipitation, but 2019 was more extreme, while 2024 was just above the annual average; however, the highest month of precipitation measured at this location occurred in June of 2024.

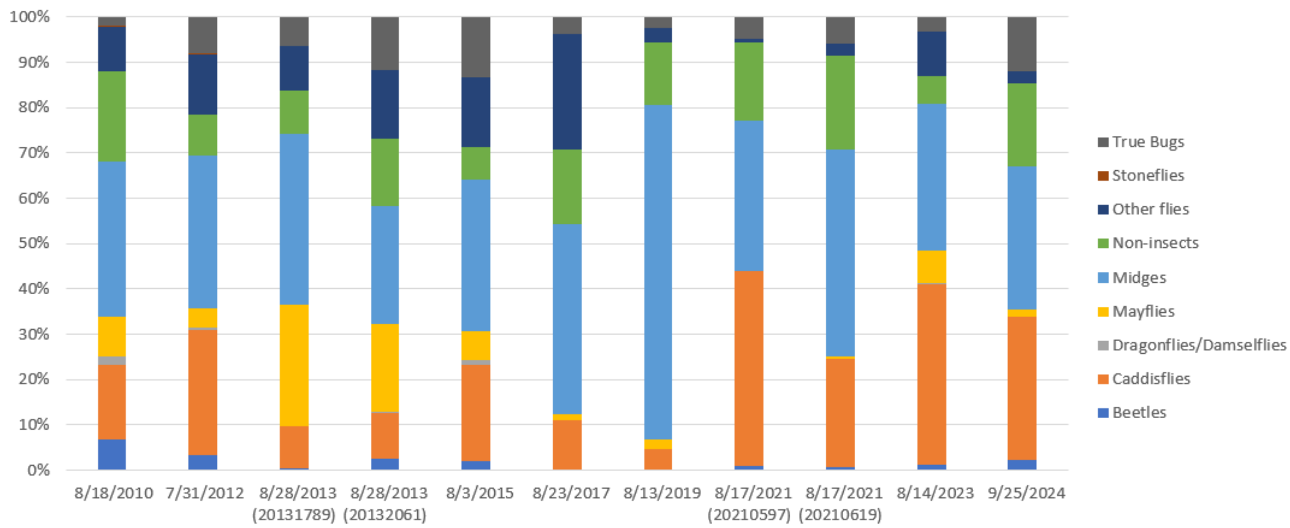
Several years had MIBI scores above the impairment threshold, with no exceedances of clothianidin and imidacloprid: 2012, 2015, 2017, 2021, and 2023. The only year with a 21-day exceedance of the chronic ALB that had a macroinvertebrate score above the impairment threshold was 2013. That minimal 21-day exceedance of imidacloprid (20 ng/L) was June 14 through July 4, and macroinvertebrates were sampled on 8/28/2013. This also preceded the period before there were more regular elevated sample results and exceedances of clothianidin and imidacloprid at this site. The first clothianidin 21-day exceedance of the chronic ALB occurred in 2019, and additional 21-day exceedances were observed in four of the six years between 2019 and 2024.

While the IBI score is an important basic understanding of the signal of health within the community, many other biological metrics can be critical in understanding how the community is responding to specific stressors. Certain groups and families are well known to be more sensitive or tolerant than others with some more sensitive to specific stressors.

Mayflies (Ephemeroptera), Caddisflies (Trichoptera), and True flies (Diptera/Midges) are among the most neonicotinoid-sensitive groups according to the literature. Across 49 invertebrate species tested globally, these orders consistently showed the highest sensitivity to neonicotinoid exposure among various studies (Morrissey et al, 2015). Other studies point to neonicotinoids impacting macroinvertebrates in the form of not only mortality, but developmental disruption, reduced emergence, altered growth and development, shift in community composition (favoring tolerant taxa), or reproductive issues (Schmidt et al, 2022, etc.). This can result in sensitive taxa declining or disappearing, or lower biodiversity, which ultimately compromises community resilience and function. Therefore, responses to the community can be subtle and variable, which is why many years of data are required to begin to understand the potential effects. Sublethal effects accumulate, resulting in community shifts over time—going unnoticed unless long-term monitoring is in place.

When looking at these various macroinvertebrate groups, dissecting them further by looking at the various tolerances helps understand these subtle shifts in the community. Figure 34 shows several notable patterns within the various macroinvertebrate groups at the MBWW. First, mayflies and other flies have not been abundant in recent years, with particularly low abundances observed in 2019 and 2024—both years characterized by low MIBI scores and elevated concentrations of clothianidin and imidacloprid.

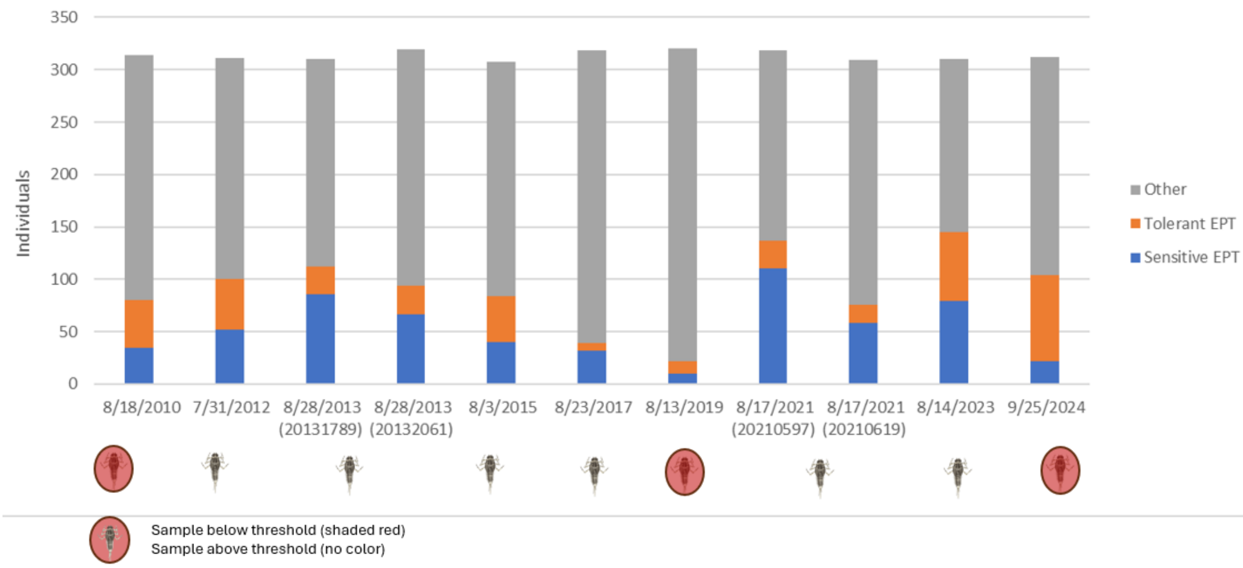
Figure 34. Macroinvertebrate groups at MBWW from 2010 to 2024.



Caddisflies (Trichoptera), in contrast, appear to have increased in relative abundance in recent years, comprising 30% to 40% of the community, including 2024. However, this apparent recovery warrants further scrutiny, as caddisfly families vary in their tolerance levels. As shown in Figure 35 a shift toward more tolerant caddisfly taxa is occurring, offset by fewer sensitive caddisflies, masking the broader community degradation.

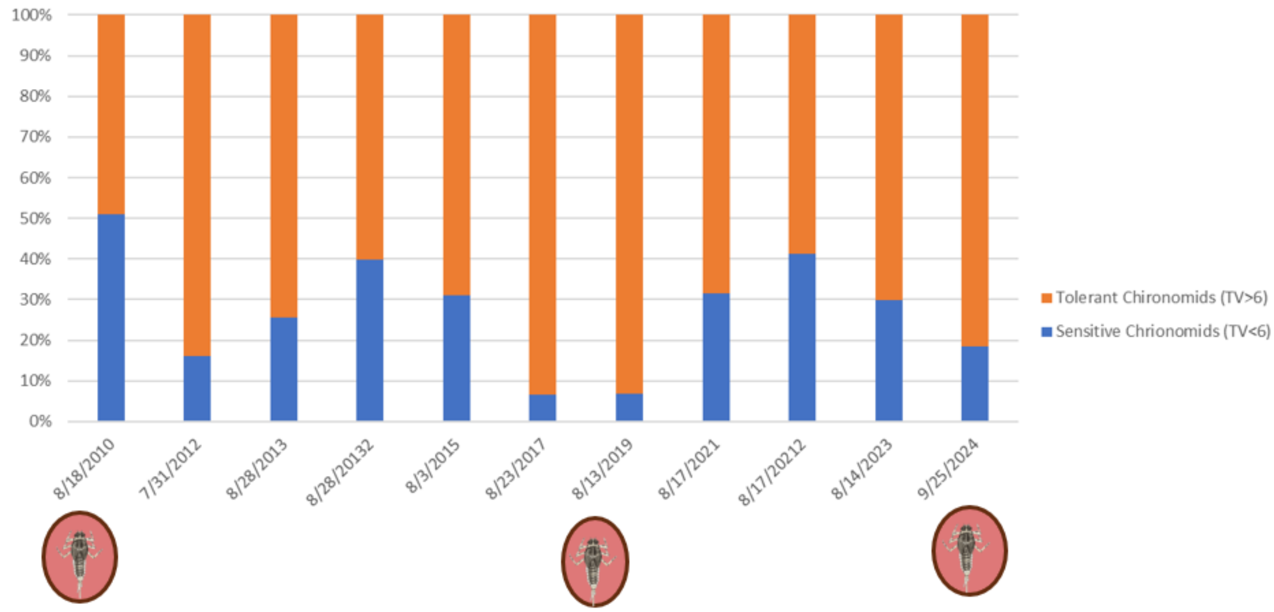
An overall evaluation of EPT (Ephemeroptera, Plecoptera, Trichoptera) taxa at the MBWW site from 2010 through 2024 indicates that stoneflies (Plecoptera) were only observed in 2010 and 2012, with no detections in subsequent years. Since then, the EPT community has consisted exclusively of mayflies (Ephemeroptera) and caddisflies (Trichoptera). In 2019 and 2024, both years with elevated clothianidin or imidacloprid concentrations and exceedances of the 21-day ALB, showed the lowest counts of sensitive EPT taxa (Figure 35). While EPT taxa are known to respond to a range of environmental stressors, and this pattern is not uniquely diagnostic of neonicotinoid exposure, the decline in sensitive mayflies and caddisflies during these years suggests a biological response consistent with additional stressors. Also, the relatively high abundance of tolerant caddisfly species in 2024 obscured broader community-level impacts, giving the impression of EPT stability despite a loss of sensitive taxa.

Figure 35. Tolerant vs sensitive EPT taxa individuals in the sample (Ephemeroptera-Mayflies, Plecoptera-Stoneflies, and Trichoptera-Caddisflies) over time at the MBWW from 2010 to 2024. Other includes all other macroinvertebrates present.



Midges (Chironomidae) consistently represent 30% to 40% of the macroinvertebrate community across most sampling years. Figure 36 shows the proportion of them that are considered sensitive (tolerance value less than six) and more tolerant (tolerance value greater than six) in all the samples from 2010 to 2024. Like sensitive EPT, sensitive chironomids were fewest in 2017, 2019, and 2024, when clothianidin and imidacloprid detections were more frequent and exceeded the ALB values. In those specific years, sensitive midges made up less than 20% of the community. Notably, in 2019, the community was dominated by *Polypedilum*, a genus recognized for its high tolerance to environmental stressors. Among the 33 chironomid taxa documented at the MBWW, *Polypedilum* ranks among the top five most tolerant. Similarly, Van Dijk et al. (2013) reported a significant positive relationship between *Polypedilum nubeculosum* abundance and imidacloprid concentrations in surface water. Thus, while chironomid abundance in 2019 may initially appear positive, it instead reflects a shift toward more tolerant chironomid taxa and a corresponding decline in sensitive chironomids, as further described in Figure 36. This shift of more sensitive to more tolerant chironomid taxa may be an additional reflection of a biological response to elevated clothianidin and imidacloprid concentrations, which is also consistent with patterns observed in caddisfly and mayfly communities. Continued sampling of both biological and water quality data in the coming years will help in further understanding this complex system.

Figure 36. Tolerant vs sensitive chironomids at the MBWW 2010 to 2024. Tolerant chironomids have tolerance values >6, while sensitive chironomids have tolerance values <6.



Sublethal effects of neonicotinoids, including developmental disruption, reduced emergence, altered growth, and shifts in community composition—can accumulate over multiple years, leading to long-term declines in sensitive taxa and overall biodiversity (Morrissey et al., 2015; Schmidt et al., 2022). These effects may not be immediately apparent in short-term sampling, highlighting the importance of long-term monitoring to detect gradual community shifts.

An integrated evaluation of MIBI metrics, EPT, and chironomid responses indicates that macroinvertebrate communities at MBWW exhibit a pattern consistent with contaminant-driven stress, potentially from clothianidin and imidacloprid in 2019 and 2024. Although other environmental stressors (e.g., high precipitation and turbidity) contribute to variability, the temporal alignment between clothianidin and/or imidacloprid exceedances and declines in the specific sensitive taxa provides strong evidence of additive biological stress.

Further, regional evidence supports the plausibility of pesticides as contributing stressors. Nowell et al. reported that pesticide (specifically insecticides and neonicotinoids) concentrations in weekly water and sediment samples from ~435 wadeable streams across five U.S. regions frequently exceeded toxicity benchmarks and species-sensitivity distributions, indicating widespread potential for adverse effects on invertebrates. Their multiple lines of evidence approach, including toxicity modeling, statistical associations with community metrics, and comparison with mesocosm studies—demonstrated that pesticides, including neonicotinoids such as imidacloprid, occur at concentrations likely to impair and stress aquatic invertebrate communities.

2.4.3 Summary of stream health and recommendations in the MBWW

The macroinvertebrate community in the MBWW is influenced by multiple stressors, including nitrate, TSS, flow alteration, and clothianidin and imidacloprid (neonicotinoid insecticides; Figure 37). Nitrate and TSS remain persistent stressors, with nitrate concentrations consistently around 9 mg/L during baseflow conditions. In contrast, sediment, clothianidin, and imidacloprid impacts vary with flow, causing stress primarily during high precipitation or runoff events. During high precipitation years, especially precipitation that occurs in the spring, the cumulative stressor impacts are heightened due to the increased high flows, sediment loading, and higher clothianidin and imidacloprid detection frequency. Overall, nitrate, TSS, and flow are identified as primary stressors based on consistent evidence and temporal patterns, while neonicotinoids are considered contributing secondary stressors. Fish IBI scores consistently exceed impairment thresholds and reflect a representative coldwater community. Continued monitoring is recommended to ensure that fish condition remains stable and does not decline over time.

Temperature, DO, habitat, ammonia, and connectivity are not stressors of concern. Data confirm that water temperatures in this reach are adequately cold and not limiting coldwater biological communities. Additional continuous DO data collected in the spring/summer of 2019 (low macroinvertebrate score year) revealed adequate DO levels and did not suggest that DO is a stressor. Low DO macroinvertebrate intolerant taxa are present, including the dominant fish (sculpin), which are low DO sensitive. The habitat here remains stable, with good substrate and habitat metrics, even during years with low macroinvertebrate scores, such as 2019 and 2024, indicating that it is not a contributing stressor. Ammonia sampling conducted between 2010 and 2024 yielded all non-detect results with no elevated values (32 samples). Furthermore, fish are not impaired and would respond or be stressed if ammonia levels were consistently high. Connectivity is not a concern for the macroinvertebrate impairment; the fish community is normal and healthy, with several migratory individuals.

Key stressor findings summary

Neonicotinoid Exposure and Biological Health

- Exposure to clothianidin and imidacloprid is documented and appears to be increasing over time, contributing to stressed macroinvertebrate communities in certain years.
- In the MBWW, 2019 and 2024 were high-risk years for clothianidin and imidacloprid exposure, and coincided with low MIBI scores, indicating a potential link between neonicotinoids (clothianidin and imidacloprid) and reduced biological condition.
- In years without clothianidin and imidacloprid exceedances (i.e., 2012, 2015, 2017, 2021, 2023), MIBI scores remained above impairment thresholds, reinforcing the potential connection between neonicotinoid exposure and biological degradation.
- The most sensitive taxa—mayflies, caddisflies, and midges—show notable impact in years with high clothianidin and imidacloprid concentrations, consistent with literature identifying these groups as most vulnerable to neonicotinoid exposure.

Other Stressors and Interactions

- Nitrate concentrations are persistently elevated, acting as a chronic background stressor; reducing nitrate levels would improve biological condition overall.
- Similar levels of other stressors (e.g., TSS, flow events) have occurred in years where macroinvertebrate scores remained above the impairment threshold, indicating these stressors alone do not fully result in observed biological degradation. Each stressor alone may be tolerable, but in combination creates a stressor environment that reduces resilience and increases the likelihood of impairment and reduced MIBI scores.

- Lower precipitation years generally correspond to better biological condition, while wetter years (especially wet springs) amplify stressors such as TSS, flow, and clothianidin and imidacloprid (neonicotinoids) transport.

Cumulative, regional, and long-term monitoring considerations

- Multiple interacting stressors—including neonicotinoids, nitrate, flow, and sediment—affect stream health at the MBWW, but the distinct biological responses during years with elevated neonicotinoids (clothianidin and imidacloprid) underscore their potential for additive and/or synergistic impact.
- Long-term and expanded monitoring are essential to detect trends, evaluate cumulative effects, and improve understanding of how these stressors interact over time, across sites, and among both fish and macroinvertebrate communities.
- Continued study and monitoring at additional sites will help clarify the regional impacts of neonicotinoid exposure in southeast Minnesota and guide targeted management actions to protect aquatic life. (See next section on “Future monitoring needs”).

Figure 37. Stressor summary information for the MBWW. Green=Not a stressor, Orange=Inconclusive stressor, Red=Stressor.

Temperature

- Temperature was previously ruled out as a stressor and recent data confirm temperatures are still adequate and not limiting coldwater biological communities.

Nitrate

- Nitrate concentrations are high, and this stream is currently impaired for nitrate (drinking water, 10 mg/L). The draft aquatic life standard for nitrate in coldwater streams is 5 mg/L; the majority of samples are above this level. There are high amounts of nitrate-tolerant invertebrates and few nitrate-intolerant invertebrates present. Nitrate concentrations haven't changed much over the past 10 years, but do show a slight increasing trend in this location (1993 to 2024). Nitrate was previously identified as a stressor, and data confirm that concentrations remain elevated, with consistent biological response.

TSS (Total Suspended Solids)

- Elevated TSS concentrations (>10 mg/L) and low secchi tube measurements are well documented in this stream. The fish and macroinvertebrates present are very tolerant to high TSS. All the information supports the existing turbidity impairment and TSS is still considered a stressor as it was identified previously. Impacts from TSS are variable based on yearly hydrology and are acting in combination with other stressors.

DO/Eutrophication

- Additional continuous DO data collected in the spring/summer of 2019 (low macroinvertebrate score year) revealed adequate DO levels. Additionally, low DO macroinvertebrate intolerant taxa are present, including the dominant fish (sculpin) which are low DO sensitive.

Habitat

- Habitat was not identified as a stressor in the original SID work. Additional info shows that habitat is fairly stable across recent years, even through 2019 and 2024 (low macroinvertebrate score years).

Connectivity

- There are no connectivity stressor concerns related to the macroinvertebrate impairment. Fish communities are normal and healthy and have an abundance of migratory individuals.

Flow Alteration

- All watersheds in the MR-Winona are either directly or indirectly impacted by flow alteration (see the hydrology section at the beginning of the report). Pollutant transport and sediment-related stress, are connected to changes in land use, precipitation, and flow.

Pesticides (Neonicotinoid insecticides: Clothianidin and Imidacloprid)

- While most pesticide detections in MBWW appear to pose little impact to the aquatic life, two neonicotinoids, clothianidn and imidacloprid, have exceeded chronic aquatic life benchmark (ALB) values intermittantly. Years with low MIBI scores align with years of ALB exceedences. Additionally, certain sensitive macroinvertebrate groups show responses, especially in years when neonicotinoids are elevated or surpass benchmark levels.

Ammonia

- Ammonia sampling that occurred between 2010 and 2024 were all non-detect with no elevated values. Additionally, fish are not impaired and would respond or be stressed if ammonia levels were high. Macroinvertebrate community metrics show good numbers of ammonia-intolerant taxa and very few ammonia-tolerant macroinvertebrates. The biological and chemical evidence is sufficient to rule out this stressor.

2.4.4 Additional supporting information

Evaluating the evidence/yearly probability of stress

The process of SID involves a strength-of-evidence analysis, which indicates how confidently stressors can be linked to observed harm, based on the quality, consistency, and clarity of the available data. Given the amount of data available at MBWW, additional analysis was completed to assess yearly conditions beyond the normal strength-of-evidence analysis.

The matrix (Figure 38) evaluates the temporal stressor probability each year, to help determine the most probable cause of biological stress and demonstrate how this may be variable. The sampling years are represented in the columns, with years when a biological sample has occurred also shown by the invertebrate icon. The criteria for impact/probability of stress have three categories: high, medium, and low, and are further defined below.

This summary matrix shows fluctuations annually but indicates ongoing stress from multiple stressors. Nitrate, TSS, and flow generally show consistently high probability of stress. In contrast, the neonicotinoids (clothianidin and imidacloprid) show low to medium probability of stress in some years, with increases in risk in more recent years (notably low MIBI years, 2019 and 2024). Accordingly, nitrate and TSS are identified as primary stressors based on the more consistent body of evidence and yearly patterns, while neonicotinoids are contributing secondary stressors.

Figure 38. MBWW yearly stressor probability matrix-based on information obtained through stressor analysis for identified stressors. *Clothianidin was not analyzed in 2010.

Middle Branch Whitewater

Yearly Stressor Risk/Probability Matrix

Stressors	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Nitrate	High	High	High	High	High	High	High	High	High	High	High	High	High	High	High
TSS	High	Low	Low	High	Medium	Low	High	High	High	High	Low	Low	Low	Low	Medium
Flow	High	Low	Low	High	Medium	Low	High	High	High	High	Low	Low	Low	Low	Medium
Neonics (Clothianidin/Imidacloprid)	Low*	Low	Low	Medium	Low	Low	Low	Medium	Low	High	Medium	Low	Medium	Low	High

Nitrate

High= Nitrate concentrations elevated >draft AQL standard (5 mg/L)

Medium= Concentrations sometimes elevated > draft AQL standards

Low= Concentrations below draft AQL standard

TSS/Flow

High=High flow year/high precip year with high TSS concentrations.

Medium: Moderate high flow/precip year, some high TSS likely

Low: Lower flow year/below average precip, likely few high TSS events

Neonics (Clothianidin/Imidacloprid)

High: Multiple exceedances of the 21-day ALB or detections above the numeric ALB reference values for neonics

Medium: Few or minor exceedances of the 21-day standard or detections above the numeric ALB reference value for neonics

Low: No exceedances of the 21-day standard or detections above the numeric ALB reference values for neonics

Regional information/other stations in Minnesota

Several sites are currently being monitored in Minnesota for pesticides (currently 58 locations statewide). However, the opportunity to look at pesticide impacts on other coldwater streams is limited, as most pesticide monitoring stations are on warmwater streams. This is an important distinction because aquatic life impacts may be different on sensitive macroinvertebrates inhabiting coldwater streams compared to the more tolerant macroinvertebrates that inhabit warmwater streams. This makes comparisons between these stream types complicated.

Two other coldwater streams in southeast Minnesota have regular pesticide monitoring with available neonicotinoid data: South Branch Root River at Carimona, and South Branch Whitewater River near Elba. Neither of these locations are within the LTBM network. At the Carimona site, there were only two biological samples; the MIBI in 2008 was 64 (good), and in 2018 was 45 (fair, near impairment threshold). A 21-day average exceedance of clothianidin was recorded in May/June of 2018, preceding the macroinvertebrate sample on 8/1/2008. Additional biological data over time are needed at this site to determine if there is a connection to any related pesticide/neonicotinoid exceedances. The South Branch Whitewater is the only other coldwater site in SE MN with corresponding pesticide and macroinvertebrate data, collected in 2021 and 2023. In 2021, there was one exceedance of the 21-day average for clothianidin that year. The corresponding MIBI score that year was 39.4, which is below the impairment threshold. In 2023, the macroinvertebrate score was similar at 41.3. These two values represent a slight increase from the IBI scores collected at this site in 2004 (33.5) and 2012 (31.9). Overall, these scores have been similar over time and are all below the impairment threshold. This site has also undergone a stream restoration project, occurring before the 2022 sample. It is an existing macroinvertebrate impairment and could benefit from additional monitoring.

Overall, due to a lack of coldwater MIBI and coincident pesticide/neonicotinoid information, it's difficult to discern what the MIBI impacts may be on a larger scale within the region or statewide. Comprehensive monitoring locations on coldwater systems, examining biology and pesticides/neonicotinoids together, will help improve understanding of regional issues and patterns.

Future monitoring needs

Both MPCA and MDA operate robust monitoring programs with goals that align with their respective agency missions. Identifying a subset of coincident monitoring locations—or monitoring certain locations in more detail—will help improve understanding of the impacts of pesticides on aquatic life. For example:

1. Identify additional sites with aquatic life data (MPCA) that can be paired with pesticide sampling that includes neonicotinoids (MDA). Currently, these opportunities are very limited, and no site in Minnesota has more data than the MBWW. Aligning biological and pesticide water quality monitoring at coldwater sites would provide useful comparisons to the MBWW, while warmwater sites could help assess impacts in different stream types.

2. Conduct additional aquatic life sampling early in the season—before peak neonicotinoid (clothianidin and imidacloprid) impacts—alongside a traditional mid-summer sample to assess seasonal changes in specific taxa. Although MIBI scores cannot be calculated for early samples (as the index is calibrated for August), comparing community composition across the season could reveal biological responses to neonicotinoid exposure.

The MPCA and MDA are working together to address these future monitoring needs as they relate to this work. Additional monitoring sites and locations will be added based on resource availability.

The MBWW site is currently an LTBM station that has been upgraded to yearly macroinvertebrate sampling (typically monitoring is two years; yearly sampling began in 2023).

Additionally, new data collection on the MBWW includes the installation of a continuous DO /temperature sensor and a continuous nitrate sensor. This will allow better resolution of information related to potential impacts to this stream from these stressors. To see this information in real-time, visit: https://mda.onerain.com/site/?site_id=3&site=e9c94e98-9a34-47ba-829c-9014b61077f1.

Part 3: Mississippi River-Winona SID conclusions and recommendations

Summary of stressors in the MR-Winona

The stressors identified in this watershed are included in Table 3. The table includes information for both existing and new biological impairments. Gray shading indicates new stressor conclusions based on the most recent data and analysis. There was a total of 12 biological impairments covered in the 2015 MR-Winona SID Report, and two of them (Middle Branch Whitewater and Gorman Creek) are also covered in this report. The entire list of biological impairments in the MR-Winona/La Crescent watersheds (covered in both Cycle 1 and Cycle 2 SID reports/assessments) is included in Appendix Table A1-1.

Table 3. Updated (2025) stressor determinations for the MR-Winona Watershed.

Stream Name	WID	Impaired	STRESSORS: Temp	Nitrate	TSS	DO/ Eutro	Habitat	Connect	Flow Alteration	Pesticides (Neonics*)	Ammonia
New impairments/streams studied since the previous SID											
North Branch Whitewater	F38	Macros	---	●	●	o	●	---	●	NE	NE
North Branch Whitewater	F39	Fish and Macros	---	●	●	o	●	---	●	NE	NE
Speltz Creek	555	Fish	---	---	o	---	●	●	●	NE	NE
Previously studied impairments are also covered in this report.											
Middle Branch Whitewater	F19	Macros	---	●	●	---	---	---	●	●*	---
Gorman Creek	569	Fish and Macros	---	---	o	●	●	●	●	NE	●

KEY: ● = stressor; o = inconclusive/potential stressor; --- = not an identified stressor; NE=not evaluated

Gray shading= new or change in stressor status from the previous report **Specific neonicotinoids, clothianidin and imidacloprid*

MR-Winona recommendations and additional monitoring

In the MR-Winona and La Crescent watersheds, the most frequently identified stressors are habitat, nitrate, and TSS. These stressors are connected to the land use activities in the watershed and are heavily impacted by changes in hydrology/flow alteration. With increased precipitation and climate challenges forecasted, BMPs should focus on slowing water flow to the extent possible and creating more storage of water on the landscape. Nitrate is a stressor with higher concentrations in the upper parts of the watersheds where row crop agriculture predominates. Table 4 contains general recommendations to address many of these stressors in the larger watershed, but also some watershed-specific actions as well.

Table 4. Recommended prioritization of restoration activities relative to the stressors contributing to the biological impairments in the MR-Winona and La Crescent watersheds.

	Priority	Example restoration activities or BMPs to address stressors
Habitat	High	Re-establish quality riparian corridors to increase woody debris, stream stability, and stream shading. Protect streambanks and reduce erosion and overall stream sedimentation near the stream channel.
Nitrate	High	Utilize source control, vegetative scouring via more living roots in the ground during shoulder seasons, and diversification of crop rotations. These recommendations are further detailed in the NRS (Nutrient Reduction Strategy) and very recently in the Southeast Minnesota Nitrate Work Group Recommendations. The North Branch and Middle Branch watersheds have nitrate stressors and elevated concentrations that would benefit from nitrate reduction.
Flow Alteration	High	Slow water flow on the landscape. Promote additional water storage on the landscape and increase infiltration through perennial vegetation, buffer strips, grassed waterways, floodplain restoration, soil health practices, etc.
Suspended Solids	High	Focus on reducing sediment input from the near-channel riparian corridor (like overgrazed cattle pastures) and immediate near-stream channel (stream banks), in addition to steep ravines and gullies that transport sediment. Promote soil health practices, managed grazing, and additional water storage in uplands to reduce erosive flows, grassed waterways/perennial cover, and buffers.
Dissolved Oxygen/Ammonia	High	Gorman Creek has watershed land use that could be addressed to reduce the amount of runoff near the stream channel that is impacting water chemistry, including DO and ammonia levels during storm events.
Connectivity	Low/Med	Many connectivity issues that are identified are ephemeral (beaver dams). New connectivity barriers that have been identified in Gorman Creek could be addressed to improve fish passage within that stream.
Neonicotinoids (Clothianidin and Imidacloprid)	High	The Middle Branch Whitewater has had periods of elevated levels of neonicotinoids; refer to: BMPs for Clothianidin and Imidacloprid factsheet and the Water Quality Best Management Practices for Agricultural Use of Clothianidin and Imidacloprid guide.

Many other monitoring efforts in the region will provide useful information related to these important regional sediment and nutrient issues. A 2020 memo by the Basin Alliance for the Lower Mississippi in Minnesota (BALMM) specifically described the importance of continued nitrate monitoring and study in the region. Similarly, understanding hydrology and sediment dynamics, as described in the hydrology section of this report, will remain useful. The current network of water sampling and streamflow gaging in the region is a critical foundation for understanding these issues. Long-term and continuous water monitoring of streams remains one of the most effective tools for understanding watershed health and pollutant transport, so continuing these monitoring efforts is crucial.

Other potential monitoring efforts could include:

1. Streams that have aquatic life impairments that need more information to help understand the issues:
    a. Example: streams that weren't studied previously due to low priority may need to be revisited to determine if priorities have changed.
    b. Example: streams with changes in aquatic life use or other watershed changes.
    c. Example: emerging issues like neonicotinoids; the Middle Branch Whitewater (10LM007) will be a key site moving forward to understand the relationship between the detection of pesticides and the results from frequent biological monitoring. Additional coordinated monitoring will help improve understanding of these relationships. Currently, clothianidin and imidacloprid are under consideration for water quality standard development but remain in Group 2 of technical development.
2. Streams that are identified as vulnerable or need protection (Some are listed in the protection section of this report). This may include streams that have had previous fish kills or are at risk for fish kills.
3. Streams with increasing nitrates, or above draft standards, and those showing vulnerability to aquatic life impairment.
    a. Water quality standards for nitrate (aquatic life) are still in development. For details see: Aquatic Life Water Quality Standards Technical Support Document for Nitrate.

    Additional nitrate-related priorities:

    a. Maintain long-term/continuous nitrate monitoring
    b. Support nitrate-related BMP and effectiveness monitoring projects
    c. Continue problem-investigation monitoring for nitrate as needed, including local priority areas

For more information

Watershed Restoration and Protection Strategy (WRAPS Update) development, including necessary TMDL work, follows the completion of the SID process. For more information, go to Watershed information | Minnesota Pollution Control Agency (state.mn.us) or search for “Mississippi River Winona Watershed” or “Mississippi River La Crescent Watershed” on the MPCA website.

The information presented in this report is a general summary of the recent SID findings. Detailed stressor analysis and more specific monitoring data and information related to each stream are available upon request; see contact person below.

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Appendix 1: MR-Winona Biological Impairment History

This section includes a tabulation of all the streams that have been studied as part of the SID process in the MR-Winona Watershed (Table A1-1). Some streams were studied previously in Cycle 1 (C1) of this process, which was completed in 2014, as opposed to the more recent Cycle 2 process (C2). Additionally, some streams were new impairment listings, while others were delisted or corrected after new data were collected. A subset of streams was selected and further detailed in this report, mostly due to new impairments or relevant new information.

Table A1-1. Biologically impaired AUIDs in the MR-Winona Watershed; C1 vs C2 (Cycle 1 vs Cycle 2).

				Cycle		Impairments		
Watershed	**Stream name**	**AUID/WID 07040008-###**	**AQL Impairments**	**C1**	**C2**	**NEW impairment since Cycle 1?**	**Delisting/ Correct**	**In this report?**
South Branch	South Branch Whitewater	07040003-F16	Fish and Macros	✓	✓		✓-Fish	
	South Branch Whitewater	07040003-512	Macros	✓	✓			
	South Branch Whitewater	07040003-F17	Macros	✓	✓			
Middle Branch	Middle Branch Whitewater	07040003-515	Fish and Macros	✓	✓		✓-Fish	
	Middle Branch Whitewater	07040003-F19	Macros	✓	✓			✓
	Crow Spring	07040003-611	Macros	✓	✓			
North Branch	North Branch Whitewater	07040003-553	Fish and Macros	✓	✓			
	North Branch Whitewater	07040003-F38	Macros		✓	✓-Macros		✓
	North Branch Whitewater	07040003-F39	Fish and Macros		✓	✓-Fish and Macros		✓
Direct Tributaries	Beaver Creek	07040003-566	Macros	✓	✓		✓-Macros	
	Bear Creek	07040003-581	Fish and Macros	`✓				
	Big Trout (Pickwick Creek)	07040003-592	Macros	✓				
	Unnamed Creek	07040003-609	Macros	✓				
	Gorman Creek	07040003-569	Fish and Macros	✓	✓	✓-Fish and Macros		✓
	Speltz Creek	07040003-555	Fish	*	✓	✓-Fish		✓
MR-La Crescent	Pine Creek	07040006-576	Fish	✓	✓		✓-Fish	

✓=yes *=deferred. AUIDs in red text were studied in Cycle 1 SID, but not in Cycle 2 SID. Note: some streams have proposed delisting/corrections and will be taken off the impaired waters list, as noted in the delisting/correction column.

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