

Stressor Identification Update

Mustinka River Watershed

September 2026

Introduction

Stressor identification (SID) is a formal and rigorous process for identifying the pollutant and nonpollutant causes, or “stressors”, that are likely contributing to the impairment of aquatic ecosystems. The Minnesota Pollution Control Agency (MPCA) conducts SID on fish and macroinvertebrate bioassessment impairments as a key component of the major watershed restoration and protection projects being carried out under Minnesota’s Clean Water Legacy Act. Once completed, the findings from SID are used to support the development of Watershed Restoration and Protection Strategy (WRAPS) and Total Maximum Daily Load (TMDL) reports, which help inform local water planning efforts to address impaired conditions.



The findings provided in this update are from the evaluation of bioassessment impairments associated with watercourses in the Mustinka River Watershed (MRW) that were part of Cycle 2 SID. A total of 20 bioassessment impairments associated with 14 watercourse reaches in the watershed were evaluated during Cycle 2 SID. Candidate causes investigated as stressors included: a loss of longitudinal connectivity, flow regime instability, insufficient physical habitat, high total suspended solids (TSS), low dissolved oxygen (DO), and high nitrate-nitrogen. Table 1 provides a summary of the stressors associated with each of the bioassessment impairments in the watershed. Data and information specific to each bioassessment impairment, including stressor analysis, can be provided by contacting the SID staff listed at the end of the update. The following subparts summarize the Cycle 2 SID findings for the watershed.

Loss of Longitudinal Connectivity

Connectivity in aquatic ecosystems refers to how waterbodies and watercourses are linked to each other on the landscape and how matter, energy, and organisms move throughout the system (Pringle, 2003). Dams, culverts, and other water control structures on river systems alter hydrologic (longitudinal) connectivity, often obstructing the movement of migratory fish and causing a change in the population and community structure (Brooker, 1981; Tiemann et al., 2004).

Findings

- According to Table 1, each of the reaches with a fish bioassessment impairment appeared to be adversely affected by one or more connectivity-related barriers (e.g., dams, grade control structures, and perched culverts).
- The Mustinka River Dam (Figure 1), located at the outlet of the Mustinka Flowage along the Mustinka River (AUID 09020102-582), completely obstructs connectivity with all upstream watercourses, including the following reaches with a fish bioassessment impairment: Mustinka River (AUID 09020102-506), Unnamed Creek (AUID 09020102-561), and Unnamed Creek (AUID 09020102-563).

Table 1. Summary of the stressors associated with the bioassessment impairments in the MRW that were evaluated during Cycle 2 SID.

Reach Name (AUID)	Reach Extent	Bioassessment Impairment ¹	Candidate Cause ²					
			Loss of Longitudinal Connectivity	Flow Regime Instability	Insufficient Physical Habitat	High Total Suspended Solids	Low Dissolved Oxygen	High Nitrate-Nitrogen
Mustinka River (09020102-506)	Headwaters to Lightning Lake	F-IBI ^D	++	++	+++	0	++	0
		M-IBI ^D	NA	++	++	0	++	0
Judicial Ditch 4 (09020102-512)	Headwaters to Twelvemile Creek	F-IBI ^N	+++	++	+++	0	+ ^{TMDL}	-
		M-IBI ^D	NA	++	+	-	++ ^{TMDL}	-
Unnamed Creek (09020102-532)	Unnamed Creek to Unnamed Creek	F-IBI ^D	+++	++	+++	0	++ ^{TMDL}	-
		M-IBI ^N	NA	++	++	+	++ ^{TMDL}	-
Unnamed Creek (09020102-561)	Unnamed Creek to Mustinka River	F-IBI ^N	+	++	+	++ ^{4A RECAT}	++ ^{4A RECAT}	-
		M-IBI ^D	NA	++	+	++ ^{4A RECAT}	+	0
Unnamed Creek (09020102-563)	Unnamed Creek to Mustinka River	F-IBI ^N	+	++	++	INSUF	INSUF	INSUF
		M-IBI ^N	NA	++	+	INSUF	INSUF	INSUF
Unnamed Ditch (09020102-564)	Unnamed Creek to Unnamed Ditch	M-IBI ^D	NA	++	++	-	+++	-
Mustinka River (09020102-582)	Mustinka River Flowage to County Line	M-IBI ^N	NA	++	+	+++ ^{4A RECAT}	+	-
Mustinka River (09020102-583)	Twelvemile Creek to Unnamed Creek	M-IBI ^D	NA	++	++	+++ ^{4A RECAT}	+	-

Reach Name (AUID)	Reach Extent	Bioassessment Impairment ¹	Candidate Cause ²					
			Loss of Longitudinal Connectivity	Flow Regime Instability	Insufficient Physical Habitat	High Total Suspended Solids	Low Dissolved Oxygen	High Nitrate-Nitrogen
County Drain 27 (09020102-589)	Unnamed Ditch to Unnamed Creek	F-IBI ^N	++	+	++	INSUF	INSUF	INSUF
Fivemile Creek (09020102-590)	T127N, R45W, S24 to T127N, R45W, S12	M-IBI ^N	NA	++	++	0	++	INSUF
Twelvemile Creek, West Branch (09020102-593)	T125N, R46W, S33 S line to -96.424, 45.692	F-IBI ^N	+	++	++	INSUF	INSUF	-
Twelvemile Creek, West Branch (09020102-594)	-96.424, 45.692 to Twelvemile Creek	F-IBI ^N	+	+	++	0	+++ ^{TMDL}	-
		M-IBI ^N	NA	++	++	0	+++ ^{TMDL}	-
Mustinka River (09020102-596)	T129N, R43W, S35 N line to S line	M-IBI ^N	NA	++	++	+	++ ^{4A RECAT}	-
Mustinka River (09020102-597)	T128N, R43W, S2 to Mustinka River Flowage	M-IBI ^N	NA	+	+	+	+	-

¹ Aquatic life impairment for fish bioassessment (F-IBI) or benthic macroinvertebrate bioassessment (M-IBI).

² **Weight of Evidence:** +++ the multiple lines of evidence **convincingly support** the case for the candidate cause as a stressor; ++ the multiple lines of evidence **strongly support** the case for the candidate cause as a stressor; + the multiple lines of evidence **somewhat support** the case for the candidate cause as a stressor; 0 the multiple lines of evidence **neither support nor refute** the case for the candidate cause as a stressor; - the multiple lines of evidence **refute** the case for the candidate cause as a stressor; INSUF there is **insufficient information** to evaluate the candidate cause as a stressor; and NA the candidate cause is **not applicable** as a stressor due to type of bioassessment impairment or the use classification of the reach.

^D Deferred (Cycle 1 Intensive Watershed Monitoring) bioassessment impairment added to the 2020 Impaired Waters List.

^N New (Cycle 2 Intensive Watershed Monitoring) bioassessment impairment added to the 2024 Impaired Waters List.

^{4A RECAT} 4A recategorization recommended by Tetra Tech (August 28, 2025, memo) as stressor is addressed by an existing EPA-approved TMDL.

^{TMDL} TMDL development recommended by Tetra Tech (August 28, 2025, memo) to address stressor.

- A grade control (sheet pile) structure was noted at the downstream end of County Drain 27 (AUID 09020102-589) during fish monitoring in 2022 and likely contributed to the fish bioassessment impairment. This structure has subsequently been removed.
- Perched culverts impact fish passage on six out of the eight reaches with a fish bioassessment impairment. Figure 1 shows perched culverts associated with a Texas-style crossing along Unnamed Creek (AUID 09020102-563). Additionally, undersized culverts, which can act as a velocity barrier, are also a general concern.
- Beaver dams were noted along three of the eight reaches with a fish bioassessment impairment. Several of these beaver dams were a partial or complete barrier to fish passage.
- Reaches affected by a loss of longitudinal connectivity generally scored below their respective statewide average in the abundance of migratory and late-maturing fish taxa.

Figure 1. Images of connectivity barriers, including the Mustinka River Dam located at the outlet of the Mustinka Flowage (Pine Ridge Park) along the Mustinka River (09020102-582) on July 18, 2023 (left) and perched culverts associated with a Texas-style crossing located upstream of the 170th St crossing along Unnamed Creek (09020102-563) on September 14, 2023 (right).



Flow Regime Instability

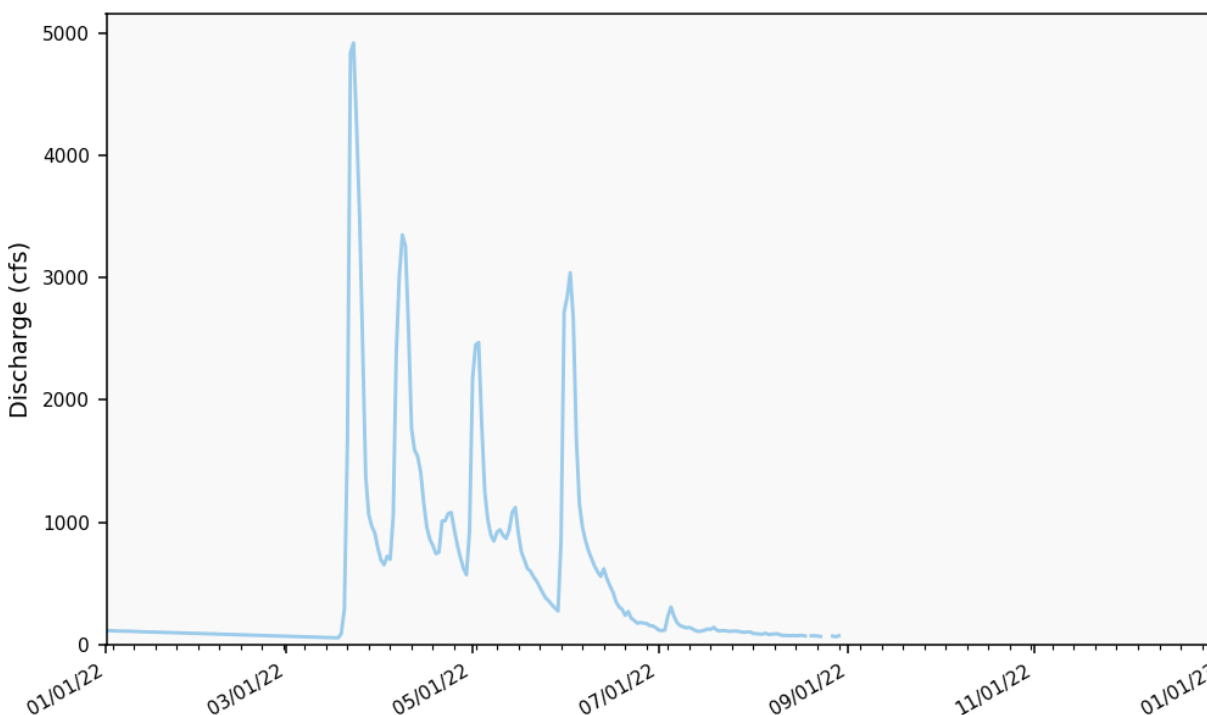
Flow is considered a “master variable” that affects many fundamental characteristics of stream ecosystems, including biodiversity (Bunn and Arthington, 2002; Hart and Finelli, 1999; Poff et al., 1997; Power et al., 1995). According to Poff and Zimmerman (2010), the flow regime of a stream is largely a function of climate and runoff-related controls. A characteristic trend of streams in the Red River of the North Basin is the high frequency of intermittent flow due to natural (i.e., evapotranspiration exceeding precipitation) and anthropogenic (i.e., changes in land cover and drainage) factors (EOR, 2009). Headwater streams (<200 sq mi drainage area) in the basin commonly have an intermittent flow regime (EOR, 2009). The natural flow regime of most watercourses in the basin has been anthropogenically altered by changes in land cover and drainage for agricultural purposes. Drainage practices, including

ditching, channelization of natural streams, modification/cultivation of headwater streams, subsurface tiling, and wetland drainage, can cause increased and quicker peak discharges following rain events and reduced base flows during dry periods (EOR, 2009; Miller, 1999; Mitsch and Gosselink, 2007; Moore and Larson, 1979; Verry, 1988). These effects are further exacerbated by climate-related challenges, including an increase in the frequency and magnitude of large rain events and droughts. Collectively, the “flashiness” or instability in stream flow tends to limit species diversity and favor taxa that are tolerant to disturbances (Bunn and Arthington, 2002; Bragg et al., 2005; Poff and Zimmerman, 2010).

Findings

- As identified in Table 1, flow regime instability was found to be a stressor for all the bioassessment impaired reaches.
- According to the MPCA (2019), all the impaired reaches have an associated subwatershed with a high proportion (>50%) of physically altered watercourses (i.e., channelized, ditched, or impounded).
- Reaches affected by flow regime instability often experience high and rapid peak flows following the spring snow melt and large rain events, as well as extended periods of minimal to no baseflow during the late summer when precipitation and runoff are generally low.
- Mean annual precipitation in the MRW increased at a rate of 0.17 inches/decade between 1895 and 2025 (DNR, 2025).
- The USGS has monitored flow on the Mustinka River (AUID 09020102-583) near Wheaton (Station 05049000; US Hwy 75) beginning in 1915. The highest peak flow logged at the station was 11,500 cfs (April 16, 1997), while the lowest flow was 0 cfs (many dates); 20% of flow values were less than or equal to 0.1 cfs. High and rapid peak flows, like those shown in hydrograph below (Figure 2), commonly occur at the station. Additionally, the four highest annual peak flows measured at the station have occurred since 1997.
- Flow regime instability was found to limit biotic diversity and favor fish and macroinvertebrate taxa that are generalist, early maturing, pioneering, short-lived, and tolerant to disturbances.

Figure 2. Continuous flow data (2022) for Station 05049000 (US Hwy 75) along the Mustinka River (AUID 09020102-583). High and rapid peak flows occurred following the spring snow melt and larger rain events.



Insufficient Physical Habitat

Physical habitat is primarily a function of channel geomorphology (Rosgen, 1996) and flow (Bovee, 1986). Geomorphology is determined naturally by geology and climate (Leopold et al., 1994) but may be altered directly by channelization and indirectly by land use changes affecting runoff and the removal of riparian vegetation (Aadland et al., 2005). A high frequency of bank-full flows often results in a subsequent increase in channel cross-sectional area (Verry, 2000) and a decrease in sinuosity (Verry and Dolloff, 2000). These geomorphic changes can result in reduced habitat quality and diversity, loss of interstitial space due to embeddedness, loss of pool depth due to sedimentation, and loss of cover (Aadland et al., 2005). Biotic population changes can result from decreases in availability or quality of habitat by way of altered behavior, increased mortality, or decreased reproductive success (EPA, 2012).

Findings

- All the bioassessment impaired reaches are affected by insufficient physical habitat as a stressor (Table 1).
- All the impaired reaches had at least one MPCA Stream Habitat Assessment (MSHA) score that was characterized as “poor” ($\leq 44/100$).
- Common habitat deficiencies noted for the bioassessment impaired reaches included: bank erosion, minimal shading, absence of riffle habitat, limited coarse substrate, embeddedness of coarse substrate, limited cover types (e.g., deep pools, and undercut banks), limited velocity types, poor channel stability, and poor channel development. These deficiencies can be

attributed to a combination of natural (e.g., surficial geology) and anthropogenic (e.g., channel alteration) factors.

- According to the MPCA (2019), nine of the bioassessment impaired reaches had a channel that was mostly (>50%) altered, along with a subwatershed with mostly (>50%) altered watercourses.
- Reaches with insufficient physical habitat generally had a low abundance of riffle dwelling, simple lithophilic spawning, and benthic insectivorous fish taxa, while the macroinvertebrate communities commonly had a low abundance of clinger taxa and contained a high percentage of burrower, legless, and sprawler taxa. These community compositions often indicate that critical habitat facets (e.g., coarse substrate and riffles) have been degraded or are naturally lacking.

High Total Suspended Solids

TSSs is a measurement of the weight of suspended mineral (e.g., soil particles) or organic (e.g., algae) sediment per volume of water. Instream and soil erosion are commonly the largest sources of sediment to streams in the Red River of the North Basin (EOR, 2009; Lauer et al., 2006). According to Waters (1995), high TSS can cause harm to fish and macroinvertebrates through two major pathways: 1) direct, physical effects (e.g., abrasion of gills) and 2) indirect effects (e.g., increase in sediment oxygen demand). High TSS can also reduce the penetration of sunlight and thus impede photosynthetic activity and limit primary production (Munavar et al., 1991; Murphy et al., 1981).

Findings

- As identified in Table 1, high TSS was found to be a stressor for six of the bioassessment impaired reaches. This stressor was most pronounced for the lower portion of the Mustinka River (AUIDs 09020102-582 and 09020102-583); both reaches had a monitoring site with a TSS standard (65 mg/L) exceedance rate of greater than 39% (minimum of 200 TSS values). Figure 3 displays images of bank erosion along these reaches of the Mustinka River that are adversely affected by high TSS.
- Four reaches of the Mustinka River (AUIDs 09020102-582, 09020102-583, 09020102-596; and 09020102-597) have an existing turbidity impairment on the Impaired Waters List. A TSS TMDL was completed for each of these impairments in 2017; TSS was used as a surrogate for turbidity.
- Generally, there is a direct relationship between TSS concentrations and flow in the watershed. High TSS is common during the spring snowmelt, when agricultural fields are particularly vulnerable to erosion, as well as following larger rain events during other seasons.
- Reaches affected by high TSS generally had a high mean TSS tolerance indicator value and a low abundance of high TSS intolerant taxa.

Figure 3. Images of bank erosion along the Mustinka River, including Station 10RD034 (near State Hwy 9; AUID 09020102-582) on May 19, 2021 (left) and Station 21RD075 (near CSAH 11; AUID 09020102-583) on August 4, 2022 (right).



Low Dissolved Oxygen

DO refers to the concentration of oxygen gas within the water column. Oxygen diffuses into water from the atmosphere (turbulent flow enhances this diffusion) and from aquatic plants during photosynthesis. The concentration of DO changes seasonally and daily in response to shifts in ambient air and water temperature, along with various chemical, physical, and biological processes within the water column. Low or highly fluctuating DO concentrations can cause adverse effects (e.g., avoidance behavior, reduced growth rate, and fatality) for many fish and macroinvertebrate species (Allan, 1995; Davis, 1975; Marcy, 2007; Nebeker et al., 1992; EPA, 2012). The critical conditions for DO usually occur during the late summer, when the water temperature is high and stream flow is low. Additionally, eutrophication (i.e., increased phosphorus) results in increased aquatic plant and algal growth, which can ultimately result in a decline in daily minimum DO concentrations and an increase in the magnitude of daily DO concentration fluctuations.

Findings

- Low DO was a stressor for most (11/14) of the bioassessment impaired reaches (Table 1). This stressor was most pronounced for Twelvemile Creek, West Branch (09020102-594).
- Eight bioassessment impaired reaches also have an existing DO impairment on the Impaired Waters List, including the Mustinka River (AUID 09020102-506), Judicial Ditch 4 (AUID 09020102-512), Unnamed Creek (AUID 09020102-561), Unnamed Ditch (AUID 09020102-564), Twelvemile Creek, West Branch (09020102-593), Twelvemile Creek, West Branch (09020102-594), Mustinka River (AUID 09020102-596), and Mustinka River (AUID 09020102-597). A TMDL

was completed for the last four reaches listed above in 2017. The MPCA will further evaluate the need for a TMDL to address the remaining DO impairments in the future.

- The amount of discrete DO data was limited for Unnamed Creek (AUID 09020102-563), County Drain 27 (AUID 09020102-589), and Twelvemile Creek, West Branch (09020102-593); less than five discrete DO measurements were available in the past 15 years for each reach. Additional monitoring is needed to investigate the effects of low DO on the biology of these reaches.
- Continuous DO monitoring was performed on 11 of the bioassessment impaired reaches between 2020 and 2023. Monitoring was conducted during the months of July and August, when the water temperature is often the highest; there is an inverse relationship between temperature and DO. Each reach was monitored at least once for a minimum period of seven consecutive days. Of the monitored reaches, seven had at least one monitoring period in which at least 10% of the recorded values were below the 5.0 mg/L DO standard.
- Eutrophication appeared to adversely impact the DO regime of nine of the low DO stressed reaches. The effects of eutrophication, such as high DO flux (Figure 4), were often exacerbated by low flow conditions. Figure 5 displays images of eutrophication documented in the watershed.
- Total phosphorus (TP) is a causative variable for eutrophication. All the low DO affected reaches had at least one monitoring site with a TP standard (150 µg/L) exceedance rate of greater than 10% (minimum of five TP values).
- Response indicators of eutrophication include chlorophyll-*a* (chl-*a*) and DO flux. Four reaches had at least one monitoring site with a chl-*a* standard (40 µg/L) exceedance rate of greater than 10% (minimum of 10 chl-*a* values). The DO flux data for the reaches were derived from the continuous DO monitoring. A total of nine reaches had at least one monitoring period in which the mean daily DO flux exceeded the 5.0 mg/L DO flux standard.
- Wetland conditions appeared to contribute to low daily minimum DO concentrations along the upstream segment of the Mustinka River (AUID 09020102-506). This reach flows through an extensive wetland riparian corridor.
- Reaches prone to low DO generally scored above their respective statewide average in the abundance of low DO tolerant taxa, as well as below their respective statewide average in the abundance low DO sensitive taxa.

Figure 4. Continuous DO data (August 5-12, 2020) for Site W55012001 (140th St crossing) along the Mustinka River (AUID 09020102-506). Primary production photosynthesis caused DO supersaturation during the day (maximum concentration of 17.4 mg/L), low DO concentrations at night (minimum concentration of 1.1 mg/L), and high daily DO flux (mean of 13.6 mg/L).

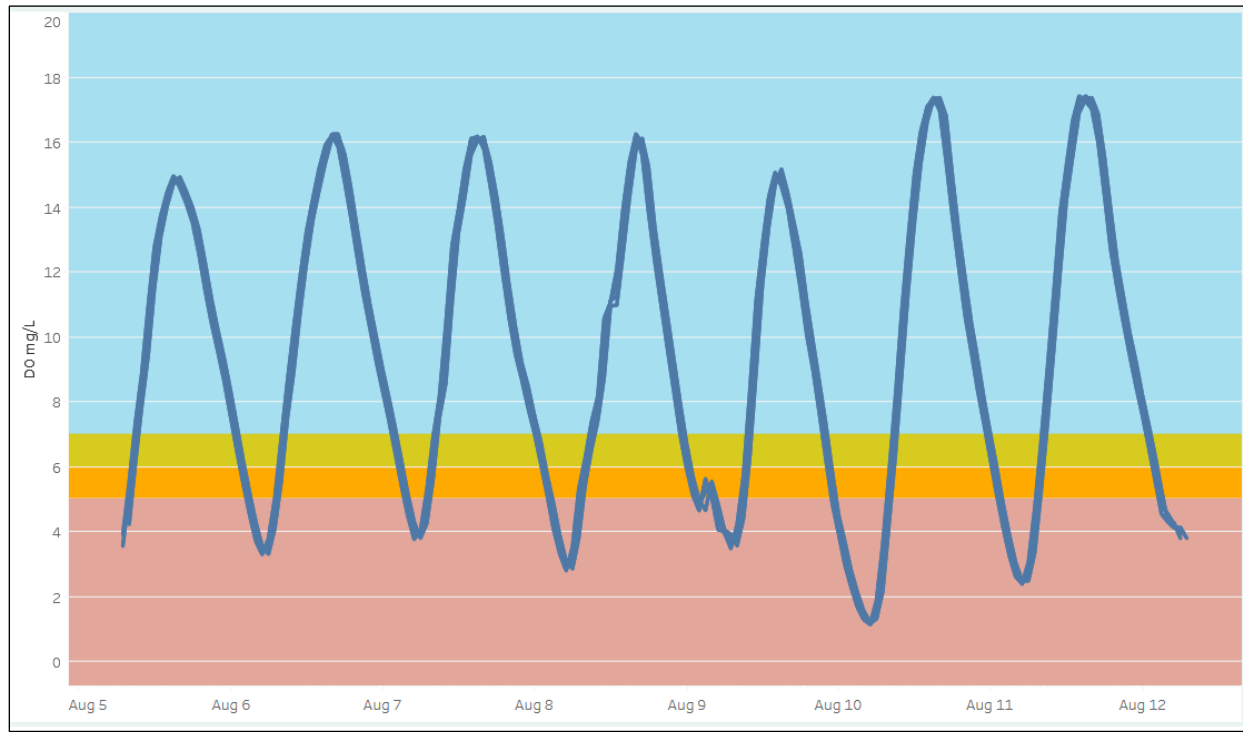


Figure 5. Images of eutrophication-related conditions, including filamentous algae covering the stream channel at Site S011-560 (320th Ave crossing) along Unnamed Ditch (AUID 09020102-564) on June 10, 2021 (left) and filamentous algae and duckweed at Site S011-559 (140th St crossing) along the Mustinka River (AUID 09020102-506) on July 12, 2022 (right).



High Nitrate-Nitrogen

Nitrate (NO₃) is the most abundant form of nitrogen in aquatic ecosystems and is a common biotic stressor. The transport pathways of nitrogen in the environment vary depending on geology and hydrology. When water moves quickly through the soil profile, as in the case of areas that are heavily tilled or dominated by outwash, nitrate transport through leaching can be substantial. Apart from its function as a biological nutrient, some levels of nitrate can become toxic to organisms. Nitrate toxicity can affect fish and macroinvertebrates depending on the concentration, length of exposure, and sensitivity of the individual organism (Grabda et al., 1974; Camargo and Alonso, 2006).

Findings

- High nitrate-nitrogen was not found to be a stressor for any of the bioassessment impaired reaches (Table 1).
- Currently, Minnesota has no aquatic life use standards for nitrate, though the MPCA (2022) has developed proposed nitrate criteria for the protection of aquatic life. The proposed nitrate chronic criteria value is 8.0 mg/L for Class 2B (cool/warm) waters. Three reaches had at least one sample value that exceeded the chronic criteria value.
- The Mustinka River (AUID 09020102-506) had the highest proportion (40%) of nitrate values above its chronic criteria value. Sampling performed at Site S011-559 (140th St crossing) yielded a maximum nitrate concentration of 24.1 mg/L, along with an overall mean of 9.5 mg/L.
- According to *The Minnesota Nutrient Reduction Strategy* (MPCA, 2025), tile drainage is expected to further expand in the Red River of the North Basin, which could result in higher nitrate loading to surface waters.
- While high nitrate-nitrogen is not a concern for the bioassessment impaired reaches at this time, nitrate monitoring should be continued.

Recommendations

Table 2 provides recommended actions to address the stressors that are limiting the aquatic life of the bioassessment impaired reaches. Among the most common stressors identified for these reaches were flow regime instability, insufficient physical habitat, high TSS, and low DO. These stressors are directly influenced by land use activities and changes in hydrology. Additionally, climate-related challenges (e.g., an increase in the frequency and magnitude of large rain events) are expected to continue to exacerbate these stressors. The implementation of best management practices (BMPs) should focus on the detention and retention of water on the landscape. Recently completed and future projects in the watershed that address water storage and sediment reduction (e.g., Redpath Flood Impoundment and Mustinka River Rehabilitation Project) will be critical in addressing the bioassessment impairments.

Table 2. Recommended actions to address the stressors associated with the bioassessment impairments in the MRW that were evaluated during Cycle 2 SID.

Stressor	Recommended Action
Loss of Longitudinal Connectivity	• When feasible and practicable, remove/modify barriers that are impeding fish passage.
Flow Regime Instability	• Increase runoff detention/retention efforts to attenuate peak flows and restore a more natural flow regime. • Mitigate activities that will further alter hydrology.
Insufficient Physical Habitat and High Total Suspended Solids	• Increase runoff detention/retention efforts to attenuate peak flows and restore a more natural flow regime. • Establish and/or protect (e.g., enforcement of the state Buffer Law) riparian corridors, using native vegetation whenever possible. • Reduce soil erosion through the implementation of BMPs, such as side inlet structures and conservation tillage. • Incorporate the principles of natural channel design into stream restoration and ditch maintenance activities.
Low Dissolved Oxygen	• Increase runoff detention/retention efforts to attenuate peak flows and restore a more natural flow regime. • Reduce soil erosion through the implementation of BMPs, such as side inlet structures and conservation tillage. • Improve agricultural nutrient management.

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Document Number: wq-ws5-09020102b



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