Watershed

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Cedar and Upper Wapsipinicon Rivers Watershed Restoration and Protection Strategies Report Update 2026

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Key terms and abbreviations

1W1P	One Watershed, One Plan
BMP	best management practice
BWSR	Board of Water and Soil Resources
CIP	Capital Improvement Plan
CRW	Cedar River Watershed
CRWD	Cedar River Watershed District
CWF	Clean Water Fund
CWMP	Comprehensive Watershed Management Plan
DNR	Minnesota Department of Natural Resources
E. coli	Escherichia coli
EAO	Environmental Analysis and Outcomes
ESA	enhanced source assessment
FIBI	Fish Index of Biological Integrity
FWMC	flow weighted mean concentration
HSPF	Hydrologic Simulation Program–Fortran

HUC	Hydrologic Unit Code
IBI	index of biological integrity
IWM	intensive watershed monitoring
LA	load allocation
mg/L	milligrams per liter
MIBI	Macroinvertebrate Index of Biological Integrity
MPCA	Minnesota Pollution Control Agency
N	nitrogen
NRS	Nutrient Reduction Strategy
P	phosphorus
PRAP	Performance Review and Assistance Program
SAM	Scenario Application Manager
SID	stressor identification
SSTS	Subsurface Sewage Treatment Systems
SWCD	soil and water conservation districts
TMDL	total maximum daily load
TN	total nitrogen
TP	total phosphorus
TSS	total suspended solids
WASCOB	water and sediment control structure
WPLMN	Watershed Pollutant Load Monitoring Network
WRAPS	Watershed Restoration and Protection Strategy
WRTDS	Weighted Regressions on Time, Discharge, and Season
WWTF	Wastewater Treatment Facility

Executive Summary

This update shows that the Cedar River Watershed (CRW) and the Minnesota portion of the Upper Wapsipinicon continue to face persistent water-quality challenges, but local partners have made meaningful implementation progress since the 2019 *Cedar River Watershed Restoration and Protection Strategy* (WRAPS) and the 2019 *Cedar-Wapsipinicon Comprehensive Watershed Management Plan* (CWMP). Restoration work is moving in the right direction—especially where it has been targeted to headwaters storage, soil health, erosion control, and focused subwatershed work—yet nitrate, bacteria, sediment, phosphorus (P), and altered hydrology remain major concerns that will require sustained long-term action.

Key takeaways

- Implementation is producing measurable benefits. The BWSR Performance Review and Assistance Program (PRAP) found the partnership effective and strategic, most work-plan outcomes were achieved, and P and total suspended solids (TSS) goals were met or exceeded in priority areas.
- Dobbins Creek remains the clearest example of targeted progress. Modeling indicates existing best management practices (BMPs) are reducing nitrogen, P, and sediment, and notably recent analysis suggests flow-normalized sediment concentrations have fallen sharply since about 2017.
- Water-quality problems are still widespread. Cycle 2 monitoring confirmed persistence and in some cases newly listed impairments tied to *Escherichia coli* (*E. coli*), sediment, nutrients, habitat stress, and altered flow.
- Nitrate remains one of the watershed's most important concerns. Cedar River nitrate concentrations are among the highest in Minnesota, with continuous monitoring showing prolonged periods of elevated concentrations and strong seasonal patterns.
- Climate and hydrologic change are intensifying watershed stress. The basin is warmer and wetter than in the past, with higher low, moderate, and peak flows after about 1990, increasing erosion, pollutant transport, and flood risk.

Since the first WRAPS cycle, implementation has centered on retaining water on the landscape and reducing pollutant delivery before it reaches downstream channels. This WRAPS Report Update highlights major investment in Dobbins Creek through berms, upstream storage, soil-health practices, easements, and targeted stabilization work. This strategy is consistent with the original WRAPS finding that headwater retention is one of the most important restoration tools in the watershed. The update also documents important point-source progress - wastewater P loads have fallen substantially since 2005, driven largely by optimization at the Austin Wastewater Treatment Facility (WWTF) and additional reductions at smaller facilities.

At the same time, new monitoring confirms that many core problems remain unresolved. Cycle 2 assessment found modest improvement in some biological conditions, including continued support of aquatic life in several reaches and delisting or correction of a few earlier impairments, but many streams still do not meet standards. *E. coli* remains pervasive, including in Dobbins Creek, where the enhanced source assessment (ESA) indicates that livestock and manure pathways and failing septic systems are the dominant controllable sources. Stressor identification (SID) work in Dobbins, Roberts, and Turtle creeks, and the Upper Cedar River also continues to point to recurring interactions among nitrate, sediment, habitat degradation, fish passage constraints, and altered hydrology.

This update gives particular weight to nitrate because it affects both local biology and downstream water quality. Long-term and high-frequency monitoring show that the Cedar River continues to carry very high nitrate concentrations, with especially elevated conditions in spring and early summer and identifies priority source areas in the upper watershed. This reinforces the need to keep nitrogen reduction as a core implementation goal alongside sediment, bacteria, and P reduction. It also suggests that local partners will need to combine edge-of-field practices, drainage management, water retention, nutrient management, and continued monitoring to better understand where the largest reductions can be achieved.

Looking ahead, the update supports a clear strategic direction: continue targeted implementation in priority subwatersheds such as Dobbins Creek, upper Roberts Creek, Turtle Creek, and the Upper Cedar River; protect the limited stream reaches that currently meet aquatic-life goals, especially places such as Otter Creek and the Woodson Creek coldwater system; and design restoration with future climate conditions in mind. Because the watershed is now experiencing warmer temperatures, wetter springs, higher flows, and greater swings between floods and drought, the most durable investments will be those that slow runoff, restore storage, stabilize channels, improve habitat, and reduce pollutant transport while also improving resilience for communities, landowners, and aquatic resources.

Overall, this updated WRAPS report presents a watershed that is making real implementation progress but still requires long-term, place-based restoration and protection work to achieve durable water-quality gains.

1. Watershed approach, background, and existing planning context

1.1 Watershed Approach

The State of Minnesota developed a watershed approach to focus on each watershed's condition as the scientific basis of permitting, planning, implementation, and measurement of results (Figure 1). This process looks strategically at the drainage area as a whole instead of focusing on lakes and stream sections one at a time, increasing effectiveness and efficiency.

Figure 1: Minnesota Watershed Approach.

The arrow emphasizes the important connection between state water programs and local water management. Local partners are involved – and often lead – in each stage of this framework.

Every 10 years, each of Minnesota's 80 major watersheds are evaluated through monitoring/data collection and assessed against water quality standards to show trends in water quality and the impact of permitting requirements, as well as any restoration, or protection actions. A WRAPS report is then updated to provide technical information to support the implementation of restoration and protection projects by local partners through their One Watershed, One Plan (1W1P) comprehensive local water plan. The Minnesota Pollution Control Agency's (MPCA's) watershed work is tailored to meet local conditions and needs, based on factors such as watershed size, landscape diversity, and geographic complexity.

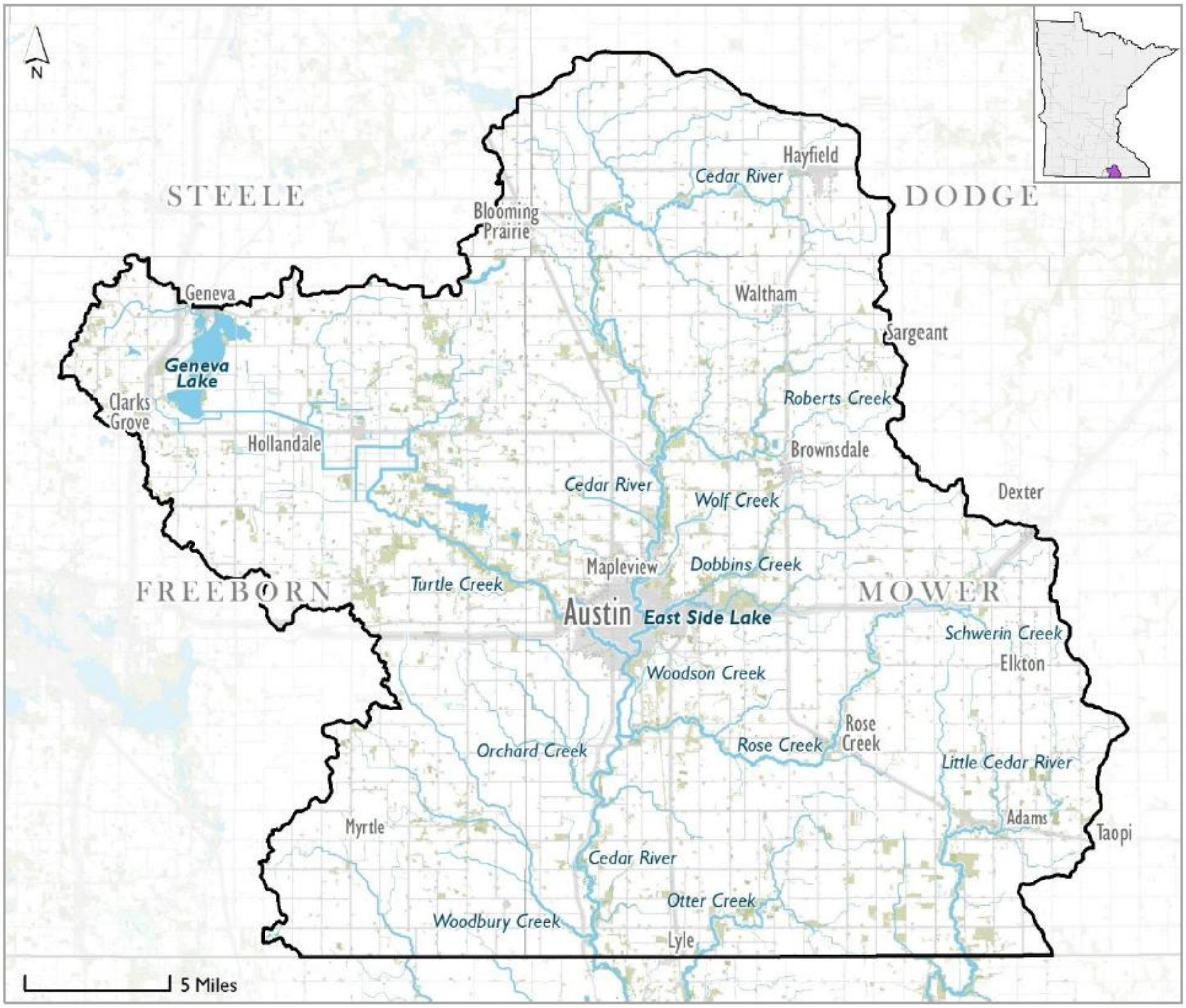
Key aspects of the MPCA's watershed work are to develop and utilize watershed-scale computer models for data analysis, perform biological SID, conduct problem investigation monitoring, summarize new monitoring data, and identify strategies for addressing point and nonpoint-source pollution that will cumulatively achieve water quality targets. Point-source pollution comes from sources such as wastewater treatment plants or industrial facilities; nonpoint-source pollution is the result of runoff or contaminants delivered from the landscape. For nonpoint source pollution, the WRAPS Update report informs local planning efforts, but ultimately the local partners decide what work will be included in their local plans.

Minn. Stat. § 114D, also known as the Clean Water Legacy Act, sets out the policy framework for the Watershed Approach, including requiring the development and updating of WRAPS for all watersheds of the state. The Clean Water, Land, and Legacy Amendment approved by Minnesota voters in 2008 directs dollars from an increase in sales tax to a Clean Water Fund (CWF), which is overseen by the Clean Water Council. The CWF provides resources to implement the Clean Water Legacy Act to achieve and maintain water quality standards in Minnesota through activities such as monitoring, watershed characterization and scientific study, planning, research, and on-the-ground restoration and protection activities.

1.2 Watershed background and planning context

The CRW covers approximately 709 square miles (454,029 acres) in southeast Minnesota, including portions of Dodge, Freeborn, Mower, and Steele counties (Figure 2). The watershed is part of the greater Cedar–Iowa Rivers system, which drains to the Mississippi River in Iowa. Land use is dominated by cultivated cropland (approximately 80% of land use; MPCA, 2019) and livestock production is prevalent across the basin.

Figure 2: Cedar River Watershed.



Two major planning and implementation frameworks, Cedar River WRAPS and Cedar River CWMP, have guided water resource work in the Cedar River Watershed and together provide thorough watershed background and planning context. The Upper Wapsipinicon River Watershed is included in this WRAPS Update as well, due to its relatively small area within Minnesota and its incorporation into the Cedar-Wapsipinicon CWMP. Although the *Upper Wapsipinicon River WRAPS* (2020) remains a comprehensive stand-alone report, local partners determined that this update would be most useful as a combined effort with the *Cedar River WRAPS Report Update (2026)*. This approach supports a more integrated summary of new data and trends across the shared CWMP planning area.

- The *Cedar River WRAPS Report* (MPCA, 2019) compiled monitoring and assessment results, identified pollutant sources and stressors, and outlined restoration and protection strategies.

  Key Takeaways:

  - Aquatic life: 39% of assessed stream reaches were not supporting aquatic life; 18% were supporting, and 43% needed additional information for assessment.

- Aquatic recreation: None of the assessed stream reaches were supporting aquatic recreation due to high counts of indicator bacteria.
- Lakes: Of the seven lakes in the watershed, Geneva Lake was assessed and found nonsupporting for aquatic recreation due to high nutrient concentrations and low transparency.
- Trends: Long-term monitoring showed significant decreases in TSS, total phosphorus (TP), ammonia, and biochemical oxygen demand since the late 1960s; more recent trend analyses showed many of these declines leveling off (often 'no trend' during roughly 1995–2009).
- Nitrate: Nitrite+nitrate concentrations increased over time; the Cedar River is among the highest nitrate-nitrogen streams in Minnesota, and the watershed was identified among the state's higher nitrate-loading basins.
- Protection: Given the limited number of stream reaches in the CRW that fully supported aquatic life, the WRAPS identifies Otter Creek as the highest-priority area for protection and recommends safeguarding the remaining high-quality reaches before degradation occurs.
- Restoration targeting: The WRAPS identifies headwater water retention as a central restoration strategy for reducing flashy runoff, erosion, pollutant transport, habitat degradation, and flooding. Priority implementation areas included Dobbins Creek and the upper Roberts Creek and Turtle Creek subwatersheds, with recommended practices including buffers, soil-health practices, cover crops, and erosion-control BMPs.

- The *Wapsipinicon River WRAPS Report* (MPCA, 2020) compiled monitoring and assessment results, identified pollutant sources and stressors, and outlined restoration and protection strategies.

  Key Takeaways:

  - Very small Minnesota footprint (13 square miles) and largely agricultural landscape (about 91% row crop). Streams are mostly human-made ditches/modified channels, with limited wetlands and extensive agricultural drainage.
  - Designated-use results show nonsupport for both aquatic life (fish and invertebrates) and aquatic recreation (*E. coli*/bacteria). One reach failed aquatic recreation standards for bacteria; of three reaches evaluated for aquatic life, one is impaired and two lacked sufficient data for a full assessment.
  - Hydrology and flood mitigation are key priorities in the basin. The Iowa Flood Center and University of Iowa along with Generic Hydrologic Overland-Subsurface Toolkit (GHOST) model was used to simulate flows and evaluate landscape scenarios. Modeling suggests potential reductions in annual peak flows of about 53% with prairie conversion, 22% with cover crops + no-till, and 5% with installation of water and sediment control structure (WASCOBs) in select areas.

- The *Cedar-Wapsipinicon CWMP* (1W1P) was completed in 2019 by a partnership of counties, soil and water conservation districts (SWCDs), watershed districts, and the City of Austin. The CWMP provides a locally led, prioritized, targeted, and measurable implementation program for the next 10 years.

  Key Goals of CWPM:

  The CWMP's purpose is to document coordinated practices and programs to achieve the water and natural resource goals established by the partnership, while effectively leveraging local and state resources. The plan includes measurable goals (e.g., meeting water-quality standards for *E. coli* and biological integrity, reducing nutrient and sediment loading, and addressing hydrology-related flooding and erosion risks) and an implementation schedule that identifies projects, programmatic actions, and milestones.

  - Achieve *E. coli* concentrations with monthly geometric means <126 CFU/100 mL during the recreation season (April 1–October 31).
  - Achieve applicable Fish Index of Biological Integrity (FIBI) and Macroinvertebrate Index of Biological Integrity (MIBI) thresholds by stream class/ecoregion.
  - Support statewide downstream nutrient-reduction goals (e.g., P reduction by 2040) while also addressing local water-quality standards.

This WRAPS Update is grounded in these existing comprehensive watershed planning efforts, which provide baseline assessment, prioritized concerns, implementation framework and strategies, and supporting technical analyses. Where details are not repeated in this update, readers should refer to the original WRAPS and CWMP for full context, supporting data, and methodology.

- Cedar-Wapsipinicon Comprehensive Water Management Plan
- Cedar River Watershed Restoration and Protection Strategy Report
- Upper Wapsipinicon River Watershed Restoration and Protection Strategy Report

While this WRAPS Report Update will not revisit the full suite of strategies and goals established in the *Cedar River Watershed Restoration and Protection Strategy Report* (2020), it provides a focused summary of new data, monitoring results, and water quality trends within the watershed. Existing goals and implementation strategies are well documented in the *Cedar River Watershed Restoration and Protection Strategy Report* and continue to be refined through the ongoing *Cedar-Wapsipinicon Comprehensive Watershed Management Plan* (2019). Engagement with local partners indicated that this data-focused update format would be most useful for supporting future planning and helping inform the 5-year and 10-year updates to the *Cedar-Wapsipinicon Comprehensive Watershed Management Plan*.

1.3 Review of WRAPS and CWMP goals

The *Cedar-Wapsipinicon Comprehensive Watershed Management Plan* was written by the same stakeholders with whom the MPCA worked to construct the *Cedar River Watershed Restoration and Protection Strategy Report Update*. As such the CWMP goals draw very directly on the WRAPS in that they are for the most part described as attainment of water quality standards (*E. coli* and TSS), biological criteria goals (thresholds per indices of biological integrity), and Gulf Hypoxia Task Force nutrient reduction goals included in the *Minnesota Nutrient Reduction Strategy* (NRS; MPCA, 2026a). The CWMP references the WRAPS in 146 instances and the *Cedar River Watershed Total Maximum Daily Load Report* (MPCA, 2019) in 104 instances; this integration is evident in Tables 5-2 and 5-3 of the CWMP, which summarize measurable goals.

Implementation of BMPs in the CRW has been focused on reducing flow peaks and reducing sediment and P loading to surface waters. Associated strategies and BMPs align with the goals forwarded in the *Cedar River WRAPS*.

The *Cedar River WRAPS* identifies several protection and restoration priorities that are less explicitly framed as CWMP goals and are thus emphasized in this WRAPS Report Update. The WRAPS (2019) designated Otter Creek as the watershed's top stream-protection priority and described the Otter Creek Subwatershed as a protection demonstration area, emphasizing proactive measures to sustain fully supporting aquatic-life uses and high-quality habitat. The WRAPS (2019) also highlighted Woodson Creek—the watershed's DNR-designated coldwater stream—with recommendations to restore coldwater conditions through targeted habitat improvements and consideration of brook trout reintroduction, while addressing constraints such as the rock dam that may limit movement and influence flow, temperature, and habitat connectivity. While the CWMP includes projects and implementation actions relevant to these waters, the WRAPS is more direct in articulating a "protect this creek" and "restore this coldwater reach" intent—an emphasis that remains pertinent for this update.

1.3.1 Downstream goals

The CWMP does well in referencing the Gulf Hypoxia Task Force nutrient reduction goals described in the *Minnesota Nutrient Reduction Strategy* (MPCA, 2014). The measurable goals tables include:

- Reduce P loading by 45% (from average 1980-1996 conditions) by 2040.
- Reduce total nitrogen (TN) loading by 45% (from average 1980-1996 conditions) by 2040.

Subsequent to the completion of the CWMP, the MPCA, Board of Water and Soil Resources (BWSR) and LimnoTech (project consultant) completed an analysis of [Watershed nutrient loads to accomplish Minnesota's Nutrient Reduction Strategy Goals](). The primary purpose of this guidance document is to provide updated nutrient load reduction estimates needed from each watershed to collectively reduce Minnesota's nutrient contribution to waters outside of the state (MPCA, 2024).

The following Hydrologic Unit Code (HUC)-8 watershed load reduction targets may be useful as the CWMP is updated. For all watersheds in Minnesota, load reduction planning goals were set equitably, such that each would pursue reductions representing a similar fraction of its reducible/anthropogenic nutrient load. While adjustments were made to account for in-stream nutrient losses between each watershed and the state line, the nutrient reduction planning goals were not developed to set disproportionately higher reduction goals for watersheds closer to the state line as compared to those further from the state line. These planning goals should be viewed as approximate, recognizing that they are based on statewide modeling and monitoring. They closely approximate the existing NRS goals cited in the current CWMP:

- Reduce P loading by 44% (from average 1980-1996 conditions) by 2040.
- Reduce TN loading by 48% (from average 1980-1996 conditions) by 2040.

The Gulf Hypoxia Task Force TN reduction goal is greater than the nitrate-nitrogen reduction goal of 35% for the Upper Cedar River in Minnesota approved by the EPA in 2006 in the Cedar River Total Maximum Daily Load (TMDL) for Nitrate, Linn County Iowa, Document. A 35% nitrate-nitrogen reduction would be the equivalent of a TN reduction of approximately 30%. While the two goals are not identical, they are directionally aligned; for planning purposes they could be cited together as one goal indicating the need for a significant focus on reducing nitrogen export from the CRW. Reference Table 1 for the nitrate-nitrogen TMDL for the Cedar River.

In October 2022, the Iowa DNR forwarded a plan to withdraw the Cedar River TMDL for Nitrate. However, as of February 2026, the TMDL is still approved and applicable with no plan to withdraw it (Iowa DNR, personal communication, 2026).

Table 1: Minnesota nitrate-nitrogen TMDLs for the Cedar River TMDL for nitrate.

Subbasin	Percent in Minnesota	Minnesota Load	TMDL
Upper Cedar River	42%	5,811 tons N/yr	3,777 tons N/yr

2. Implementation update since Cedar River WRAPS

Post-WRAPS implementation in the Cedar River Watershed District (CRWD) has emphasized upland water storage in headwaters—especially in the Dobbins Creek system—paired with soil-health and erosion-control practices and targeted channel and ravine stabilization. CRWD and partners have made substantial investments through the Capital Improvement Plan (CIP), supplemented by state and federal funding, including a Clean Water Act Section 319 Focus Watershed implementation project in Dobbins Creek (2020–2036).

The *Cedar River Watershed Restoration and Protection Strategy Report* (2019) identified the Dobbins Creek system as a long-standing priority area and described a targeted implementation strategy that combines management practices and structural practices to reduce peak flows and runoff volumes. The WRAPS noted that this emphasis increased beginning in 2015, supported by targeted BMP funding and additional planning, monitoring, and modeling efforts (including EPA Section 319 support) to guide implementation and evaluate hydrologic response.

Since the WRAPS (2019), CRWD and partners have advanced a “treatment train” approach that links upland stormwater storage with field-scale practices (e.g., cover crops, buffers, grassed waterways) and focused stabilization work to reduce runoff peaks, sediment transport, and nutrient delivery. Implementation has been closely connected to effectiveness monitoring to document changes in habitat and biological condition and to inform future project prioritization.

Overall, CRWD has demonstrated strong technical and financial capacity to deliver projects at scale, with continued implementation and expanded effectiveness monitoring planned—particularly in Dobbins Creek—supported by ongoing state and federal investments.

The MPCA’s Healthier Watersheds tool summarizes the substantial BMP progress achieved in the CRW and illustrates the depth of technical and financial partnership required to implement practices across the landscape. While the tool may not capture every investment (for example, private landowner spending or program funding not reported through State of Minnesota tracking), it provides a consistent and credible accounting of documented implementation and funding leveraged through major state and federal programs and partners. Table 2, Figure 3, and Figure 4 summarize the substantial implementation effort in the CRW, showing tabular and geographic data on BMPs implemented and money spent on nonpoint source BMP implementation.

Table 2: Top 10 BMPs from Healthier Watersheds tabulation.

Practice	Total installs	Share
Septic system improvement	316	16.5%
Cover crop	252	13.2%
Nutrient management	161	8.4%
Grassed waterway	147	7.7%
Residue and tillage management, no-till	131	6.9%
Critical area planting	94	4.9%
Mulching	80	4.2%
Conservation cover	79	4.1%
Residue and tillage management, reduced till	76	4.0%
Wetland restoration	65	3.4%

Figure 3: BMPs in the CRW.

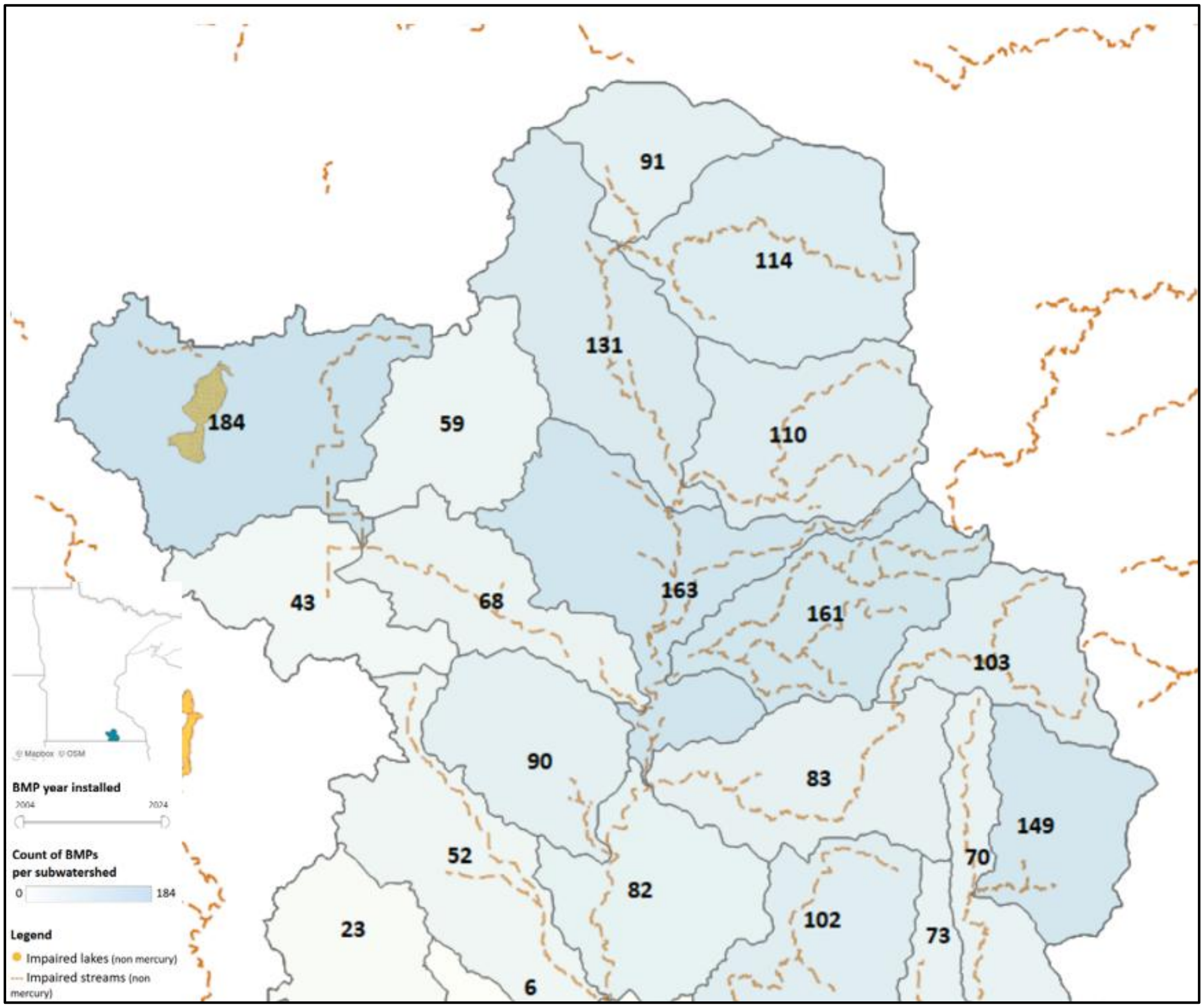
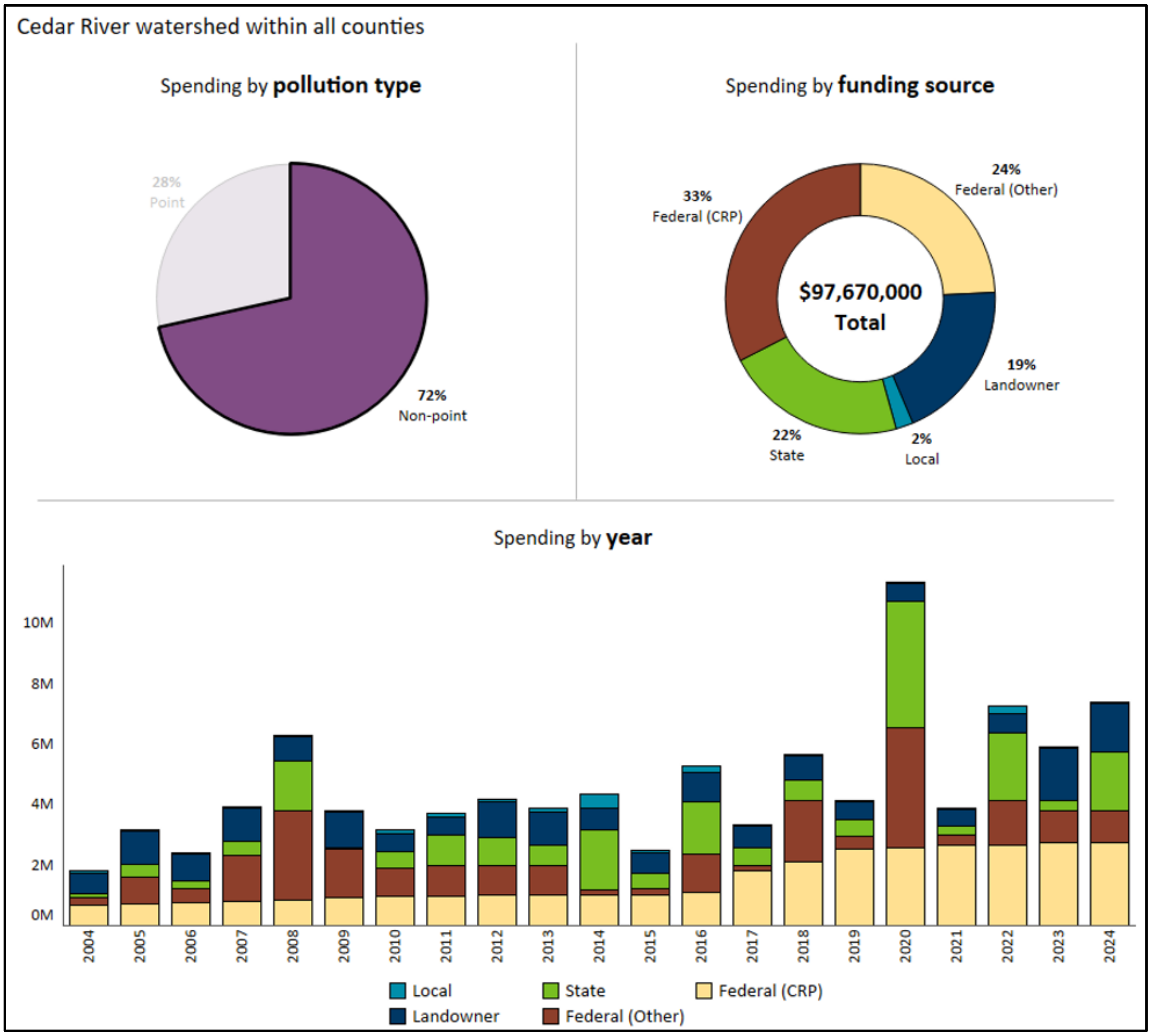


Figure 4: Dollars spent nonpoint BMPs in the CRW 2004-2024.



2.1 PRAP Summary

In early 2026, the Board of Soil and Water Resources (BWSR) conducted a PRAP review of the Cedar-Wapsipinicon Watershed Partnership. The PRAP report portrays BMP implementation in the partnership as productive and increasingly strategic. BWSR concluded that the partnership has clearly demonstrated effectiveness in implementing BMPs on the landscape and is making measurable progress toward clean-water goals through Watershed-Based Implementation Funding (WBIF) (BWSR, 2026). Reported work-plan outcomes were achieved approximately 70% to 90% of the time, P and TSS goals were met or exceeded, and most project development and implementation occurred within identified priority areas. The PRAP report also indicates that grant-funded work has remained on schedule and on budget, while outside grant dollars have helped expand implementation efforts.

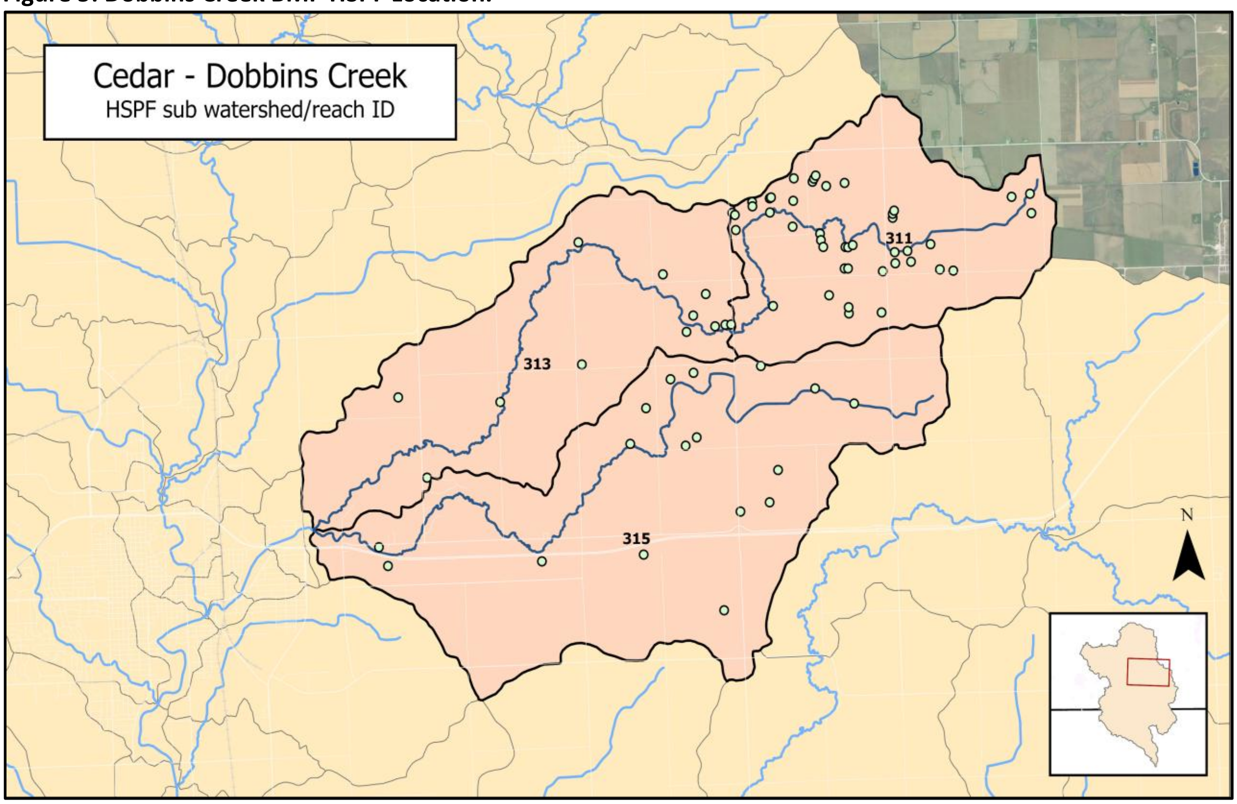
BMP implementation progress (BWSR, 2026)

- BWSR found that the partnership has "clearly demonstrated effectiveness" in implementing BMPs across the landscape.
- Measurable grant work-plan outcomes were achieved roughly 70% to 90% of the time, and planned P and TSSs goals were met or exceeded.
- Project development was directed to priority areas 90% or more of the time, and project outcomes occurred in priority areas about 70% to 90% of the time.
- BMP-related implementation was supported by full expenditure of the WBIF grant on time and on budget, while also leveraging about $869,000 in nonstate funding.

2.2 Evaluating BMP impacts on water quality in Dobbins Creek

The Hydrologic Simulation Program–Fortran (HSPF) Scenario Application Manager (SAM) was used in early 2026 by MPCA modelers to evaluate the impact of the BMPs on flow, TSS, TP, and TN. A single scenario was created, applying all recorded BMPs for the full simulation period. BMPs were summed (Figure 5) to generate a total treated area for each BMP type within a subwatershed. Results from the BMP scenario were compared to the existing model (base scenario) outputs which had no BMPs applied. The simulation results are reported as average annual percent load reductions.

Figure 5: Dobbins Creek BMP HSPF Location.



HSPF model results indicate that currently implemented BMPs in the Dobbins Creek HUC-12 are likely providing measurable water quality benefits, even though changes in total flow volume remain modest. The 23,555-acre study area spans three agricultural subwatersheds, with cropland comprising roughly 79% to 92% of each subwatershed and BMP treatment covering about 11% to 45% of cropland. The BMPs represented in the simulation significantly reduce pollutant loads but are generally not designed to reduce overall flow volume; rather, they change the hydrograph by slowing flow and reducing peak discharges. As such, under the modeled full-BMP scenario, annual flow reductions are small, generally around 0.2% to 1.1%, but pollutant reductions are more substantial. TN reductions range from about 1.4% to 4.6% at the edge of field and 2.5% to 4.4% at subwatershed outlets. TP shows the strongest response, with reductions of about 4.6% to 21% at the edge of field and 13% to 22% at subwatershed outlets. TSS also improved meaningfully, with reductions of about 5.6% to 24% at the edge of field and 7.1% to 16.4% at outlets. Across parameters, subwatershed 311 shows the greatest benefit, which aligns with its larger share of cropland under BMP treatment. Seasonally, the largest modeled reductions generally occur in March for flow, TN, and TP, while TSS reductions peak in July. Overall, the results confirm that existing BMP implementation is effective at reducing nutrient and sediment loads. Table 3 is a summation of reduction estimates from the HSPF scenario. For further information, please see Appendix A.

Table 3: 2026 HSPF reduction estimate results.

Scenario Components & Results	Details
Study area	23,555 acres across 3 subwatersheds
Cropland share	79%–92% of total subwatershed area
BMP coverage	11%–45% of cropland treated
Annual flow reduction	0.2%–1.1% (edge of field); 0.5%–1.1% (outlet)
Annual TN reduction	1.4%–4.6% (edge of field); 2.5%–4.4% (outlet)
Annual TP reduction	4.6%–21% (edge of field); 13%–22% (outlet)
Annual TSS reduction	5.6%–24% (edge of field); 7.1%–16.4% (outlet)
Largest monthly effects	March for flow/TN/TP; July for TSS

2.3 Cedar River Watershed flood reduction and conservation progress

In the Cedar River, CRWD and partners pursued a deliberate strategy to curb flash flooding in the Dobbins Creek system by slowing runoff before it reached Austin and the Cedar River. As upland-storage berms were added through a Capital Improvement Plan, stormwater and snowmelt from agricultural headwaters were temporarily captured, peak flows were reduced, and sediment and nutrients had more time to settle out before water moved downstream. By 2020, work in the Dobbins Watershed had pushed modeled peak-flow reductions at the Cedar River-Dobbins Creek confluence past the local goal, achieving at least a 10% reduction compared with an 8% target, including completion of a major structure known as the nearly 2,000-foot Dexter 30-Dam 2 berm. Example shown in Figure 6.

The approach continued to expand in 2023 with two additional earthen berms built in the south-branch headwaters of Dobbins Creek in Red Rock Township. Spanning roughly a combined half mile and draining about 467 acres, the new berms were designed to hold back high flows during intense rain and rapid melting events and then release water more gradually, reducing risks such as overtopped roads and streambank erosion. Modeling suggests the added storage would cut peak flows at East Side Lake by about 14% during a 100-year rainfall scenario. At the same time, permanent conservation accelerated on the landscape: in 2025, Mower SWCD approved 457 acres for restoration into native prairies and wetlands through permanent easements, building on a record 407 acres the year before. Together, engineered storage and long-term restoration helped keep water on the land longer while improving habitat and reducing erosion and nutrient runoff across the watershed.

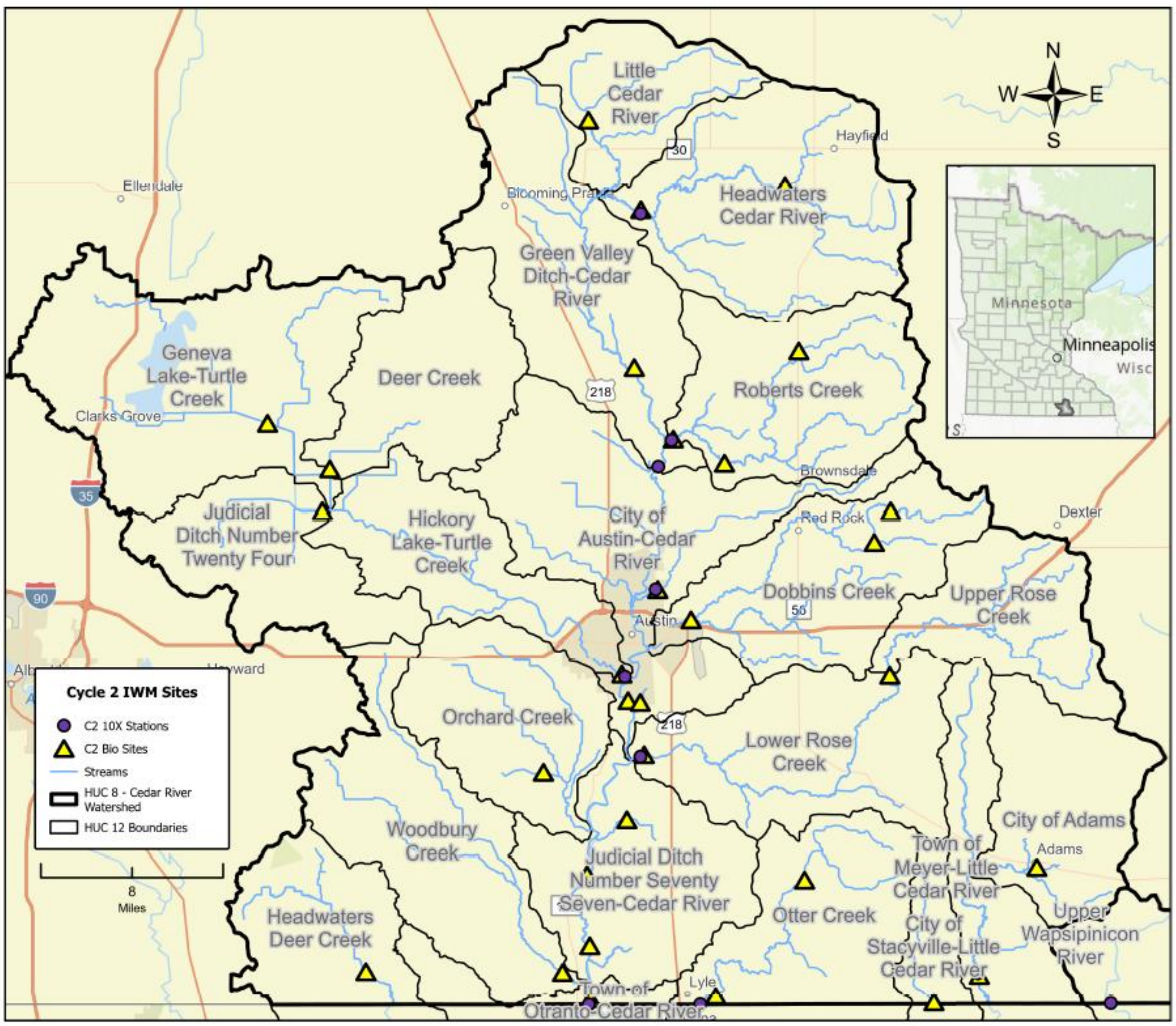
Figure 6: Sept. 7, 2023, berm being built by CRWD in Dobbins Creek.

3. Watershed assessment and new monitoring data

3.1 Cycle 2 intensive watershed monitoring summary

Assessing the condition of the CRW's water quality was repeated in 2021 following two years (2019-2020) of intensive watershed monitoring (IWM) (Figure 7). The Upper Wapsipinicon River Watershed was also included in this assessment. This second assessment of water chemistry and aquatic life data allowed MPCA to evaluate recent data and review Cycle 1 data and decisions. In addition to IWM sites, several long-term monitoring sites in the CRW provide continuous water chemistry and aquatic life data.

Figure 7: Cedar River Watershed Cycle 2 monitoring sites.

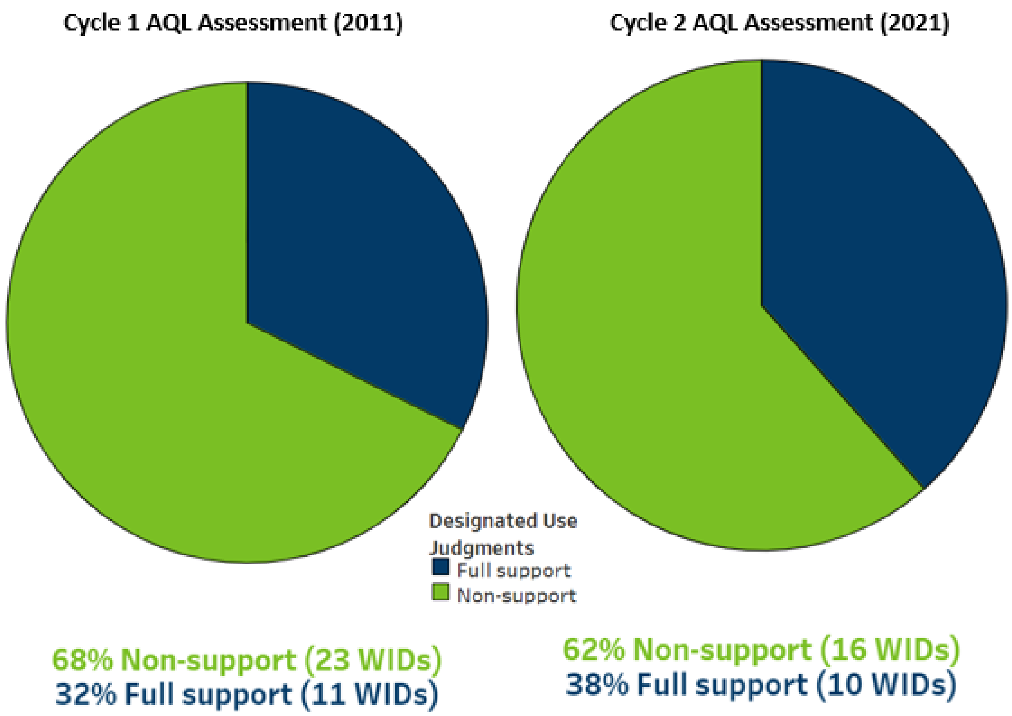


Assessment decisions for the CRW and Upper Wapsipinicon are detailed below and full details on Watershed assessment and trends update report are available on MPCA's website (https://www.pca.state.mn.us/sites/default/files/wq-ws3-07080201c.pdf).

Assessment decisions for CRW Cycle 2 monitoring data were made in 2021 (Figure 8). While there are water quality impairments of aquatic life, aquatic consumption and aquatic recreation throughout the CRW, the watershed also includes waters meeting their designated uses. The Cycle 2 assessment mostly focused on the condition of CRW streams. While Geneva Lake and East Side Lake were monitored during IWM, 2019 water quality data did not significantly change relative to previous collected data.

Twenty-six stream WIDs were assessed for aquatic life; eight of these were also assessed for aquatic recreation. Thirty-eight WIDs did not have enough information to make a complete assessment decision. Fish and macroinvertebrate assessments in 2021 found the aquatic life communities slightly improving compared to 2011.

Figure 8: Comparison of assessed aquatic life results from Cycle 1 (2011) to Cycle 2 (2021; MPCA 2022).

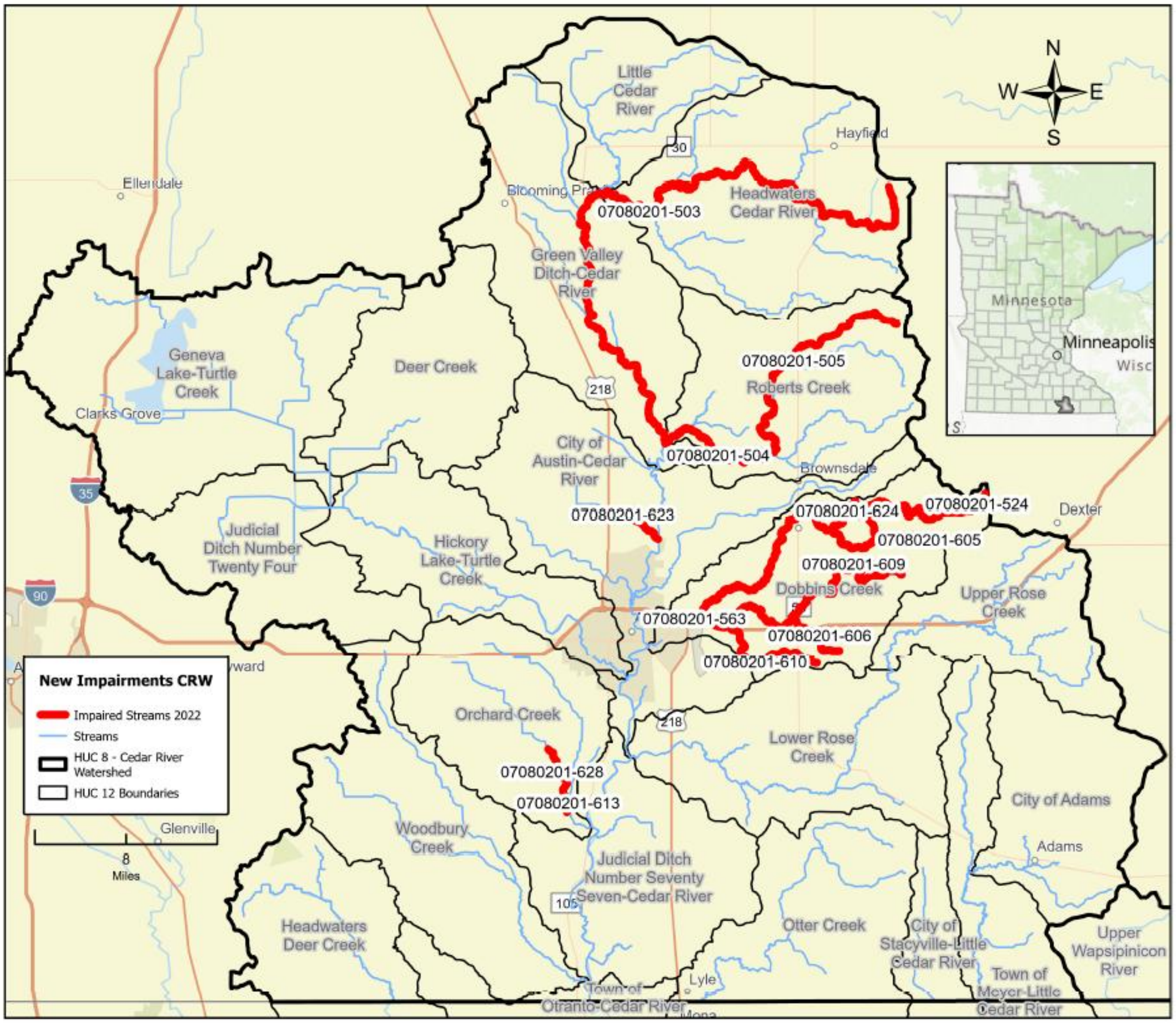


Of the 26 WIDs assessed for AQL, 10 met designated uses and 16 did not. All 21 WIDs assessed for aquatic recreation failed to meet standards due to *E. coli*. Water chemistry showed little change since the 2011 assessment, with primary concerns including nutrients, sediment, *E. coli*, and altered hydrology. Not all WIDs failing to meet designated uses resulted in new impairment listings; 18 WIDs assessed in Cycle 2 were confirmed as impaired from Cycle 1. Cycle 2 identified 19 new impairments across 16 streams for the 2024 impaired waters list, including 3 macroinvertebrate, 1 fish, 4 TSS, and 11 *E. coli* listings. Most new listings reflect additional monitoring data from local partners rather than changed water quality conditions. For a complete list of all waters in the CRW on the impaired waters list, see Minnesota 2024 Impaired Waters List.

Table 4: New impairments in the Cedar River Watershed.

Water body name	WID 07080201-XXX	Use class	Year listed	Affected use	Impaired Water Listing
Cedar River	07080201-503	2Bg	2022	AQL	TSS
Dobbins Creek	07080201-524	2Bg	2022	AQL	MIBI
Dobbins Creek	07080201-524	2Bg	2022	AQL	FIBI
Dobbins Creek	07080201-524	2Bg	2022	AQL	TSS
Dobbins Creek	07080201-524	2Bg	2022	AQR	*E. coli*
Judicial Ditch 5	07080201-623	2Bg	2022	AQR	*E. coli*
Orchard Creek	07080201-613	2Bg	2022	AQR	*E. coli*
Roberts Creek	07080201-504	2Bg	2022	Aquatic Life	TSS
Unnamed creek	07080201-505	2Bg	2022	Aquatic Life	MIBI
Unnamed creek	07080201-562	2Bg	2022	AQR	*E. coli*
Unnamed creek	07080201-563	2Bg	2022	AQR	*E. coli*
Unnamed creek	07080201-605	2Bg	2022	AQR	*E. coli*
Unnamed creek	07080201-606	2Bg	2022	AQR	*E. coli*
Unnamed creek	07080201-607	2Bg	2022	AQR	*E. coli*
Unnamed creek	07080201-608	2Bg	2022	AQR	*E. coli*
Unnamed creek	07080201-609	2Bg	2022	AQR	*E. coli*
Unnamed creek	07080201-610	2Bg	2022	AQR	*E. coli*
Unnamed creek	07080201-624	2Bg	2022	AQL	TSS
Unnamed creek	07080201-628	2Bg	2022	AQL	MIBI

Figure 9: 2022 CRW Impairments.



Four WIDs listed as impaired in Cycle 1 have been recategorized in Cycle 2 (Table 5).

- Delisting: Cycle 2 data confirmed water quality standards are now being met.
- Correction: Cycle 2 data did not support the assessment decision of Cycle 1.

Table 5: Waters in the CRW with Cycle 2 recategorization.

Water body name	AUID	Use class	Year listed	Impaired Water Listing	Recategorization
Roberts Creek	07080201-504	2Bg	2012	Macroinvertebrates	Delisting
Turtle Creek	07080201-540	2Bg	2012	Fish	Correction
Un-named Creek	07080201-593	2Bg	2012	Macroinvertebrates	Correction
Woodbury Creek	07080201-615	2Bg	2020	Macroinvertebrates	Delisting

A positive finding of IWM Cycle 2 is that 10 WIDs in the CRW continue to meet aquatic life standards. Seven of these WIDs meet both fish and macroinvertebrate standards (Table 6). While these waters are currently meeting aquatic life standards, active management is needed to protect them from future degradation. Table 6 identifies waters especially vulnerable to impairment.

Table 6: Stream reaches meeting aquatic life use goals in the CRW.

Water body name	AUID	Use class	Meeting Fish standards?	Meeting Macroinvertebrate standards?	Vulnerable to impairment?
Wolf Creek	07080201-510	2Bg	X	X	
Little Cedar River	07080201-518	2Bg	X	X	X
Turtle Creek	07080201-525	2Bg*	X	X	
Deer Creek	07080201-546	2Bg*	X		
Unnamed creek	07080201-556	2Bg	X	X	
Unnamed creek	07080201-572	2Bg*	X		
Deer Creek (County Ditch 71)	07080201-580	2Bg	X	X	
Unnamed creek	07080201-593	2Bg		X	
Woodbury Creek	07080201-615	2Bg	X	X	
Unnamed creek	07080201-627	2Bg*	X	X	

*Potential use class change being considered for these stream reaches.

3.2 Cycle 2 stressor identification summary

SID following IWM Cycle 2 in the CRW was conducted by MPCA to directly support local implementation planning by compiling recent biology/chemistry/physical data, comparing changes from Cycle 1 to Cycle 2, and pinpointing priority restoration "hot spots" and the most likely stressors.

The work combined a watershed-wide nitrate screening starting in 2018 with follow-up monitoring in 2019–2020 that prioritized the upper Cedar River (highest nitrate), resulting in targeted nitrogen-reduction priority areas for partners.

In parallel, the MPCA completed focused SID updates in three priority subwatersheds—Dobbins Creek (MPCA, 2022), Roberts Creek (MPCA, 2022), and Turtle Creek (MPCA, 2023), selected through partner conversations and technical judgment.

Across these subwatersheds, SID generally confirmed nitrate, habitat limitations, and flow alteration as recurring drivers of biological stress. It also identified fish passage/connectivity as an added stressor where fish impairments occurred.

Where evidence was mixed, DO/eutrophication and TSS were treated as candidate or inconclusive stressors. Turtle Creek was the main exception: TSS and flow alteration were confirmed, while nitrate, DO/eutrophication, and habitat shifted to inconclusive. For Unnamed Creek -547, no new data was available, so Cycle 2 SID was not conducted.

Table 7: CWR SID summary.

Stream Name	AUID	HUC12 subwatershed	Biological monitoring stations	Aquatic Life Impairment	Temperature	Nitrate	TSS	DO/Eutrophication	Habitat	Connectivity	Flow Alteration
Dobbins Creek	07080201-524	Dobbins Creek	14CD002, 14CD003, 14CD004	Fish and Macros	---	●	●	o	●	●	●
Unnamed Creek	07080201-505	Roberts Creek	09CD016, 15EM086	Macros	---	●	O	O	●	NE	●
Roberts Creek	07080201-506	Roberts Creek	09CD018	Fish and Macros	---	●	O	O	●	●	●
Unnamed Creek	07080201-534	Roberts Creek	09CD051	Fish and Macros	---	●	o	O	●	●	●
Mud Creek	07080201-528	Turtle Creek	09CD038	Macros	---	●	O	O	●	NE	●
Turtle Creek	07080201-540	Turtle Creek	04CD010, 09CD062	Macros	---	O	●	O	O	NE	●
Unnamed Creek	07080201-547	Turtle Creek	04CD041	Macros	NE	O	O	O	O	NE	●
Unnamed Creek	07080201-572	Turtle Creek	09CD061	Macros	---	●	O	O	●	NE	●
County Ditch 8	07080201-584	Turtle Creek	09CD035	Fish and Macros	---	●	O	O	●	O	●
Judicial Ditch 24	07080201-587	Turtle Creek	09CD039	Macros	---	●	O	O	●	NE	●

KEY: ● = stressor; o = inconclusive/potential stressor; --- = not an identified stressor; NE = not examined; grey shade indicates Cycle 1 SID (no Cycle 2 SID conducted)

Links to the following comprehensive reports are provided for readers who want more detailed methodology and the full results underlying the Cycle 2 SID work completed in the CRW:

- Cedar River Watershed Cycle 2 Stressor Identification Nitrate Summary
- Dobbins Creek Watershed Cycle 2 SID Update
- Roberts Creek Watershed Cycle 2 SID Update
- Turtle Creek Watershed Cycle 2 SID Update

3.3 Cedar River nitrate sources and monitoring

The *Cedar River WRAPS* (MPCA, 2019) provided a comprehensive evaluation of nitrogen sources within the watershed, drawing on monitoring data, modeling, land use analysis, and point source inventories. That document identified row-crop agriculture—particularly corn–soybean systems with associated fertilizer application and subsurface tile drainage—as the dominant contributor to nitrate loading in the Cedar River system, with additional contributions from municipal WWTFs, individual subsurface sewage treatment systems, atmospheric deposition, and background sources. The WRAPS further discussed the role of hydrology, soil characteristics, and seasonal precipitation patterns in mobilizing nitrate to surface waters, emphasizing the importance of spring and early summer transport dynamics. Readers seeking detailed source apportionment methods, modeling assumptions, and uncertainty discussion are referred to the original WRAPS document for comprehensive treatment of these topics.

This WRAPS Update does not revisit that underlying source assessment. Instead, it builds upon the established understanding of nitrogen sources by examining newly available monitoring data to evaluate recent trends in nitrate concentrations and loads in the Cedar River. The following sections focus on observed conditions, seasonal and interannual variability, and implications for watershed management, with particular attention to whether recent data indicate measurable changes in transport dynamics or overall nitrate delivery to the river.

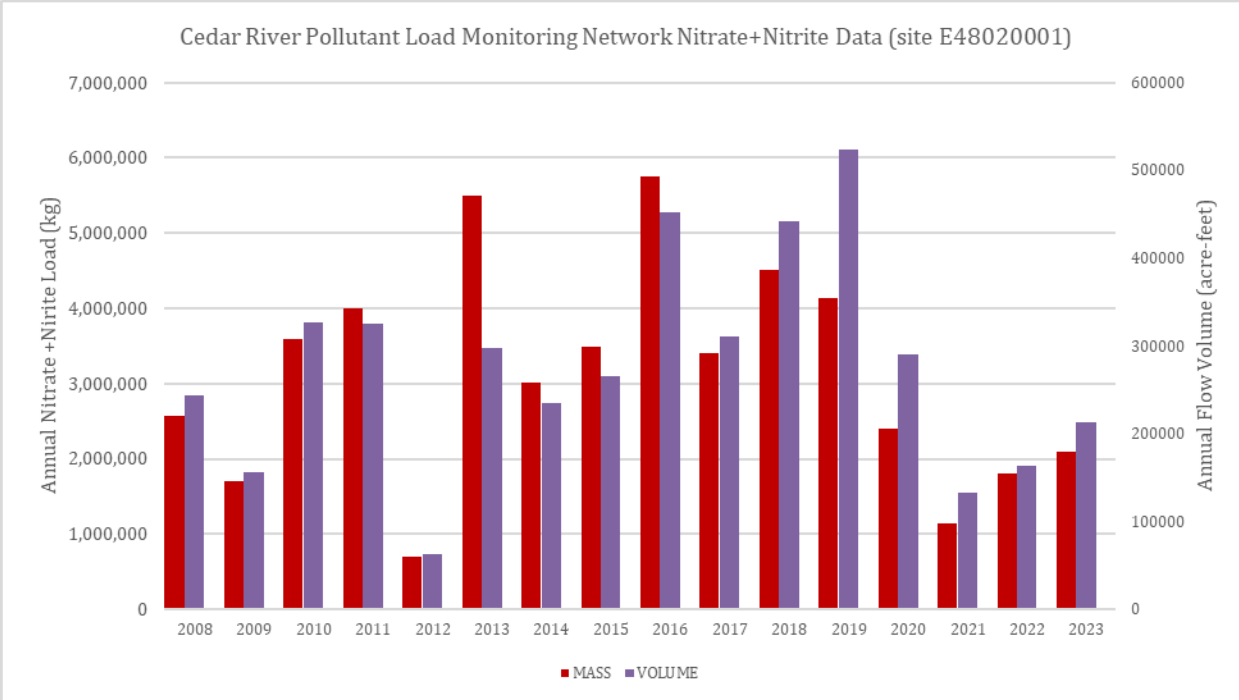
3.3.1 Watershed pollutant load monitoring

The Watershed Pollutant Load Monitoring Network (WPLMN) is a partnership including state and federal agencies, Metropolitan Council Environmental Services, state universities, and local partners across Minnesota. Since 2007, the network of partners has collected data to understand long-term trends and observe changes over time (MPCA website, 2026).

Water quality monitoring data are collected at the Cedar River near Austin (2008 to present) and Turtle Creek near Austin at 43rd (2013 to present) (Figure 10). The data can be viewed and downloaded via the WPLMN interactive tool.

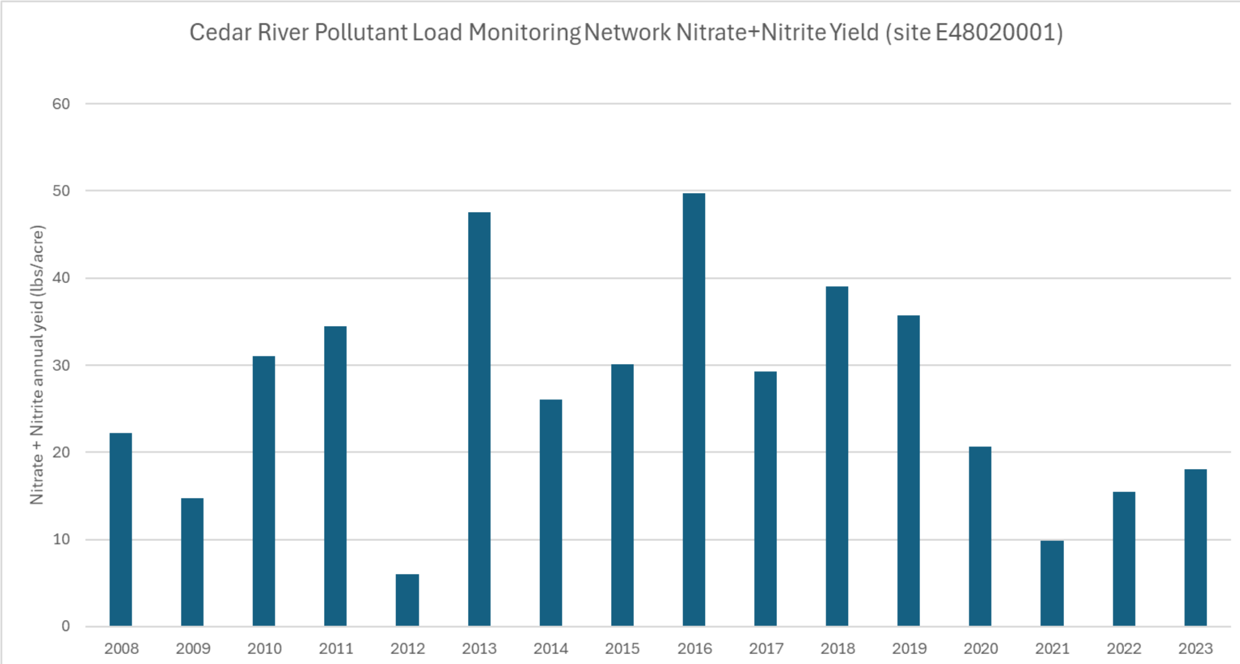
Figure 10: Cedar River Watershed WPLMN Sites.

Figure 11: WPLMN annual nitrate +nitrite load data at Cedar River (site E48020001), 2008 -2023.



The 2025 *Minnesota Nutrient Reduction Strategy* (NRS; MPCA, 2026a) provides a comparison of annual nitrogen and P yields for each of the major river basins in Minnesota. The headwater areas of the Cedar Basin (which includes the Cedar, Shell Rock, Winnebago, and Wapsipinicon watersheds) are in Minnesota and are largely cultivated (e.g. the Cedar River Watershed in Minnesota is approximately 80% cultivated (MPCA, 2019)). Further, most of the cultivated land is underlain by agricultural drainage (local conservation professionals estimated that 84% of cultivated land in the Cedar River Watershed is tiled (MPCA, 2019)). Without the expanse of an entire basin in Minnesota (approximately 70% of the basin is downstream in Iowa) and without a diversity of land use in Minnesota's portion, the Cedar Basin stands out as a disproportionately high per-acre yield of both nitrogen and P (see NRS Table 2-25 MPCA, 2026a). Nitrate + Nitrite Nitrogen yield data at the Cedar River WPLMN are included in Figure 12.

Figure 12: Annual nitrate +nitrite yield data at Cedar River (site E48020001), 2008 -2023.



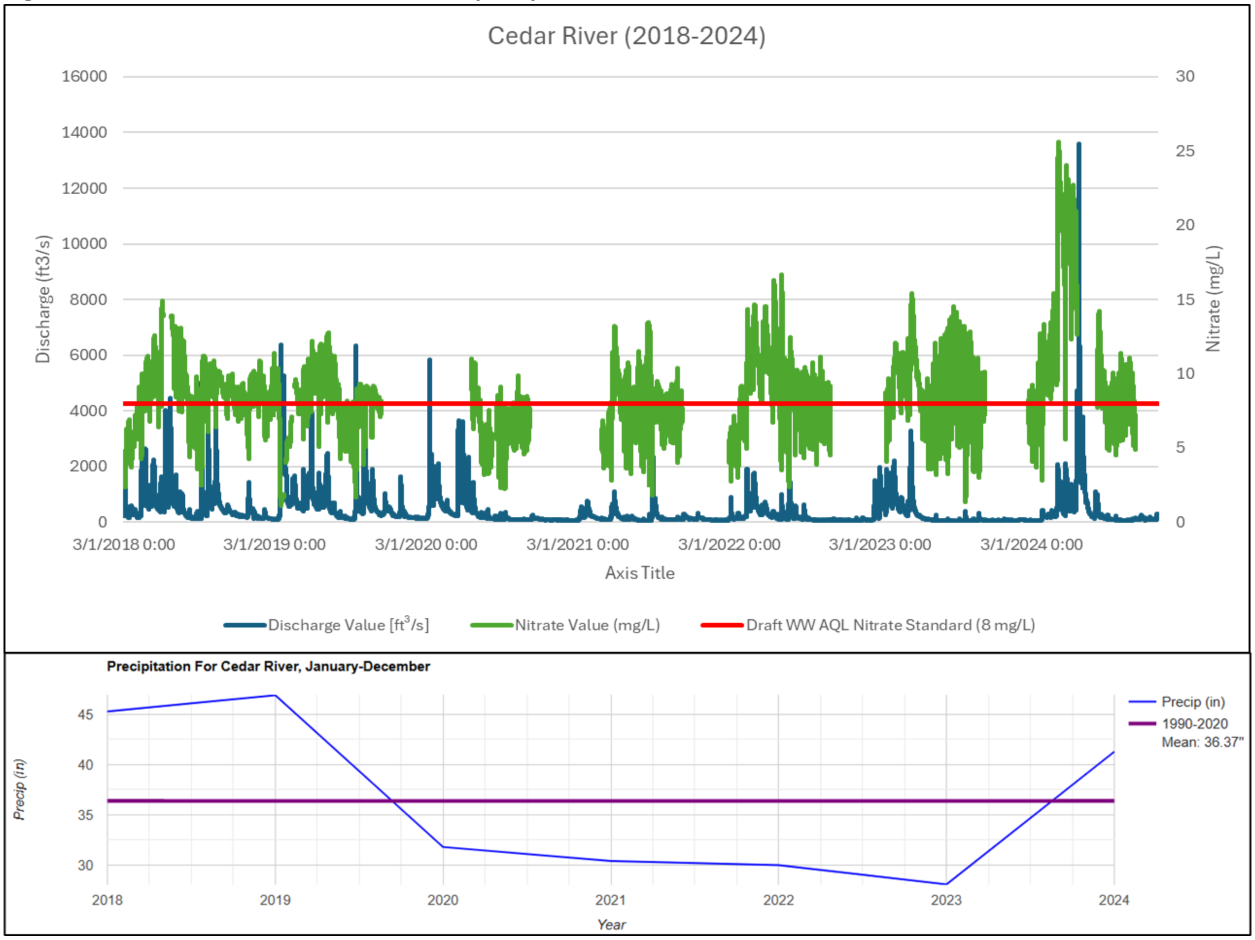
3.3.2 Nitrate time series data

In 2018, the MPCA Watershed Division and Environmental Assessment and Outcomes (EAO) Division staff partnered with Mower SWCD and the United States Geological Survey (USGS) to pilot deployment of a continuously recording nitrate probe at the Cedar River WPLMN site (see Figure 10). While the WPLMN program collects periodic grab samples at this location, the Nitratax sensor records a nitrate + nitrite-nitrogen concentration value every 15 minutes.

Beyond improving load estimation, the high-frequency time series data allow for examination of the magnitude, frequency, timing, and duration of concentration responses to hydrologic events. This level of resolution captures short-term peaks and recession dynamics that are not detectable through routine grab sampling alone. As a result, the continuous record provides improved insight into seasonal patterns, storm-driven transport, and prolonged periods of elevated nitrate concentrations, thereby strengthening both trend interpretation and stressor-response evaluation.

The sensor is now part of a statewide network and data are available at the DNR Cooperative Stream Gaging site and displayed in Figure 13. The nitrate reference value of 8 mg/l indicated in the figure is from MPCA's technical summary examining nitrate toxicity to aquatic organisms.

Figure 13: Flow, nitrate concentration and precipitation data at Cedar River site E48020001, 2018 – 2024.



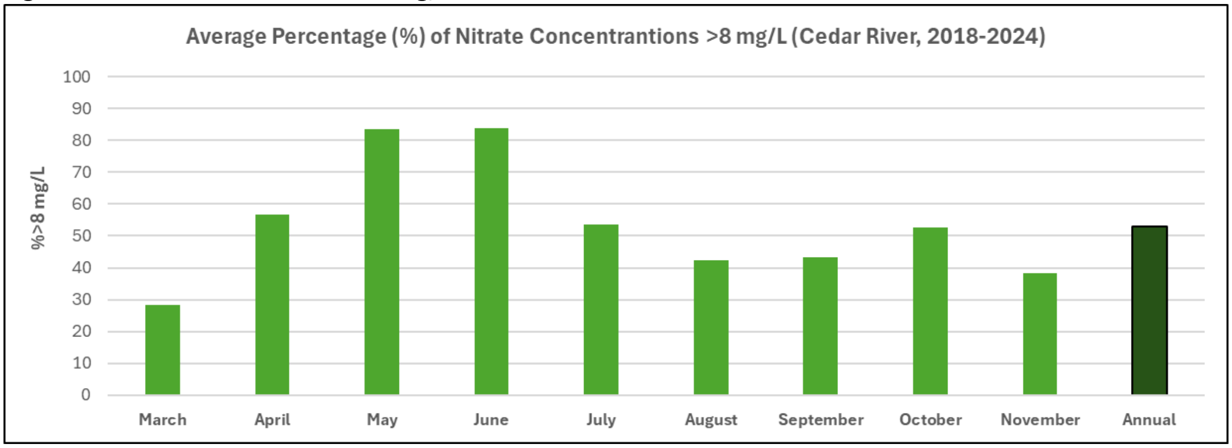
While loading or export of nitrogen represents both an economic loss of the nutrient and a downstream drinking water concern, the Cedar River is also impaired locally by persistent high nitrate concentrations. Nitrate is a confirmed stressor of aquatic biota in the Cedar River (WIDs -501 and -515 downstream of Austin) and its tributaries (including Dobbins Creek) (MPCA, 2019). This stressor confirmation is summarized in the Cedar River Watershed Stressor Identification Report (excerpted below, pertaining to WID -515 immediately downstream of Austin) and its subsequent updates.

The macroinvertebrate community shows an indication of stress from nitrate. The macroinvertebrates in this reach were made up of 85.2% tolerant taxa and lacked intolerant taxa. Biological station 09CD069 was lacking non-hydropsychid Trichoptera in 2009. Trichoptera are often considered sensitive to nitrate and respond with decreases in taxa. At station 09CD069, there were 12.8% nitrate tolerant macroinvertebrates, with 16 nitrate tolerant taxa and no nitrate intolerant taxa. Nitrate is a stressor to the biological community within this reach (MPCA, 2016).

The time series data in Figure 13 corroborates the nitrate stressor, indicating that nitrate concentrations are typically 5 to 10 mg/L with regular exceedances of 10 mg/L. In the months of May and June 2024, nearly all recorded values were greater than 15 mg/L, including a thirty day period during which more than half the values were greater than 20 mg/L. The data in Figure 13 are summarized below in Figure

14. Values accumulated over a period of seven years (2018-2024) indicate that the nitrate concentration during the months of May and June exceeded 8 mg/L more than 80% of the time.

Figure 14: Percent exceedance of 8 mg/L nitrate concentration at the Cedar River E48020001, 2018 - 2024.



Over the period of record, the high-resolution nitrate time series has documented a consistent diel oscillation under low-flow conditions. When discharge falls below approximately 200 cfs, nitrate concentrations typically increase through the morning, peak near midday, and decline through the evening. Although the amplitude and timing of the oscillation vary, there are numerous multi-day periods during which concentrations fluctuate by as much as 3 to 5 mg/L within a 24-hour cycle. See Figure 15 and Figure 16.

During a March 2025 presentation and discussion with the Upper Mississippi River Conservation Committee (UMRCC), participating experts provided opinion and a reference suggesting that in-stream biological processes may be driving the observed pattern (Moraetis et al, 2010). In response, the MPCA staff and partners are deploying additional continuous monitoring probes within the Cedar River to further evaluate the mechanisms underlying this phenomenon.

Figure 15: July to October 2023 nitrate + nitrite and flow data at Cedar River E48020001.

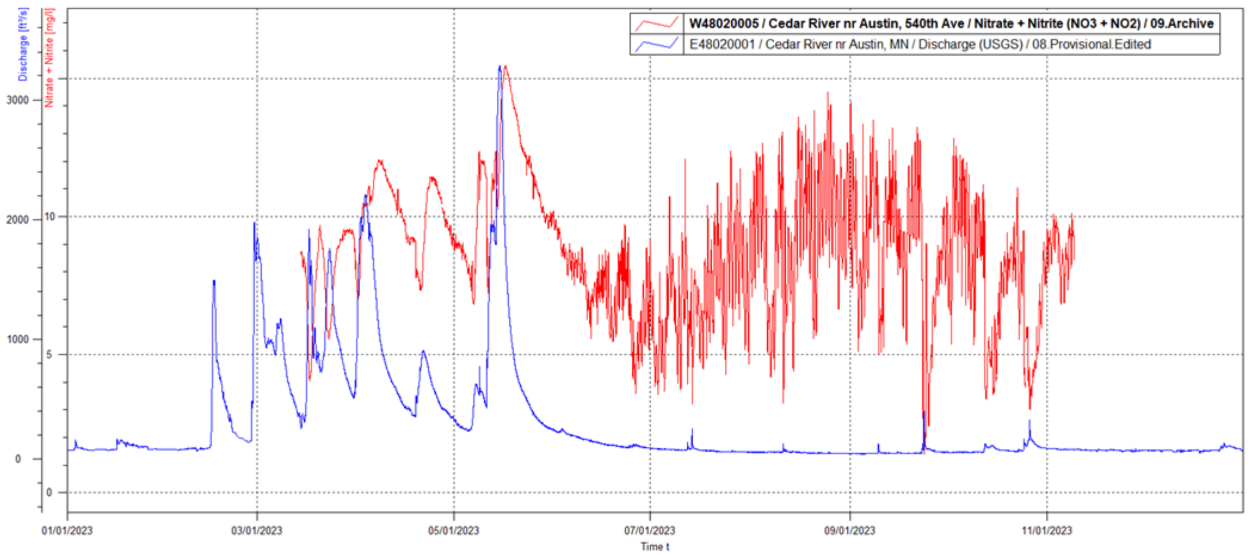
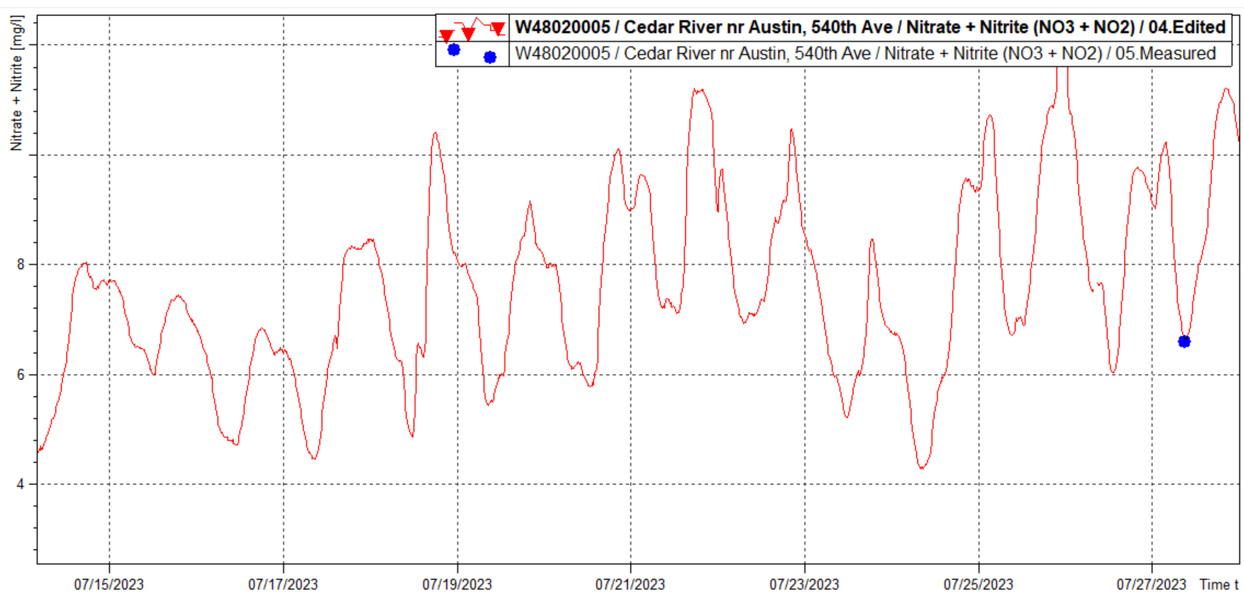


Figure 16: Eight days of nitrate + nitrite time series data illustrating daily oscillation at Cedar River E48020001.



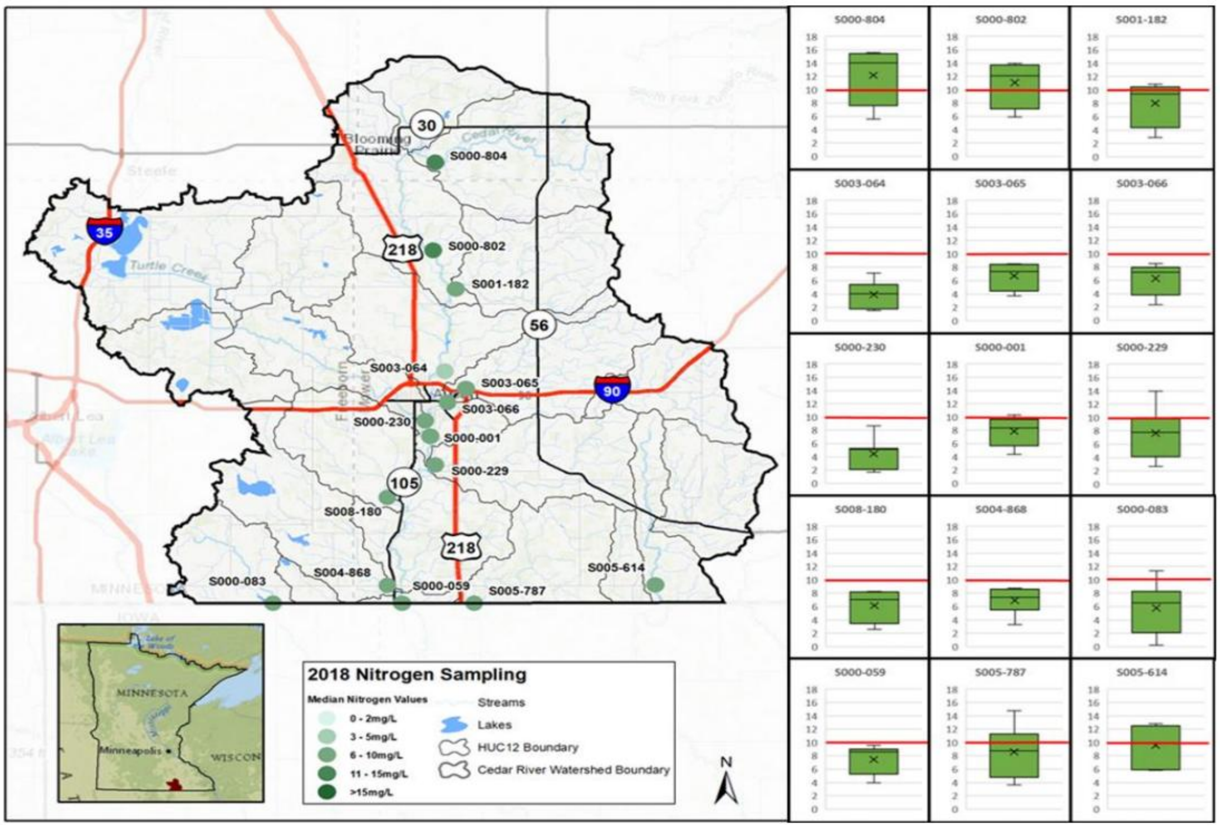
Note: blue dot is a grab sample nitrate concentration in agreement with the probe concentration.

3.3.3 Subwatershed nitrate monitoring

In addition to nitrate loading and concentration data, MPCA staff and partners designed and implemented longitudinal nitrate monitoring in the Upper Cedar River Watershed (Figure 17). This effort was conceived by the local water planning group and supported by MPCA to provide actionable information for implementation planning. The primary objective is to characterize nitrate dynamics across the watershed and identify priority areas for nitrogen reduction. Reducing nitrogen loading in the CRW has been identified as a priority in previous efforts, including the *Cedar River WRAPS*, the *Cedar-Wapsipinicon CWMP*, and the *Cedar River Nitrate TMDL* developed in Iowa.

This monitoring is ongoing and summarized in the [Cedar River Watershed Stressor Identification Nitrate Summary](). The MPCA will continue to support and adapt this effort as steered by the local water planning group.

Figure 17: Longitudinal nitrate monitoring sites and 2018 data summary (MPCA 2022).



3.4 Dobbins Creek data summary

Dobbins Creek, a tributary of the Cedar River, drains approximately 38 square miles of predominantly agricultural land before entering East Side Lake and ultimately the Cedar River (Figure 5). Over the past two decades the Dobbins Creek Watershed has been the focus of extensive monitoring, modeling, and restoration planning due to documented impairments related to bacteria and elevated sediment and turbidity levels. These efforts have included TMDL development, hydrologic and sediment modeling, and targeted watershed implementation projects designed to reduce peak flows and sediment delivery through upstream storage, erosion control, and stream stabilization practices.

The *Cedar River WRAPS* and the *Cedar River CWMP* provide a comprehensive summary of sediment sources within the watershed, including detailed discussion of conditions and sediment contributions in the Dobbins Creek Subwatershed. These documents synthesize the best available information on sediment dynamics and source areas across the basin. The information presented below builds on this strong foundation by providing additional monitoring data and analysis to further inform watershed planning and implementation efforts.

3.4.1 Dobbins Creek time series turbidity data summary

To further examine aquatic life use support for Dobbins Creek, a continuous-recording turbidity sensor was deployed at County Road 61 (WID 07080201-535 near Hormel Nature Center) in 2009 and continues to operate. This location is downstream of the confluence of the two main subwatersheds of Dobbins Creek and upstream of East Side Lake (a significant change in hydrology at the downstream end of the drainage). The sensor (a DTS-12 or Digital Turbidity Sensor – 12) was provided by MPCA and is maintained by Mower County SWCD and MPCA in partnership. The MPCA corrects and archives the time series data, storing them in the WISKI database. The data can be viewed and retrieved at the Cooperative Stream Gauging site.

The sensor deployment allows for sample collection every fifteen minutes, thereby providing a very high frequency of collection of an optical measure of suspended solids without direct grab sampling (filling bottles with water for lab analysis). This provides turbidity measurements during rain events, evening hours, high and low flow conditions, etc. The DTS-12 records FNU (Formazin Nephelometric Units) values that can be paired with far less frequent grab samples of TSS to arrive at a predictive relationship between the two parameters. Such a regression allows for transformation of the turbidity (FNU) time series to an estimated TSS (mg/L) time series. This in turn provides an exceedingly high-resolution dataset over many years that constitutes a valuable line of evidence in assessing use support for Dobbins Creek.

The following linear regression model includes turbidity and TSS pairs for which the TSS concentrations are less than or equal to 201 mg/L (Figure 18). This range of values was chosen to eliminate the greater variability commonly observed for both parameters (at Dobbins Creek and also generally) at very high concentrations; the regression is built on data pairs that more closely encompass the 65 mg/L TSS water quality standard. The data pairs include some composite water samples and, in those cases, make use of the mean value from the 15-minute turbidity data recorded over the course of the automatic sampler's pulse window.

Figure 18: Dobbins Creek TSS and FNU regression using values filtered to <200 mg/L TSS.

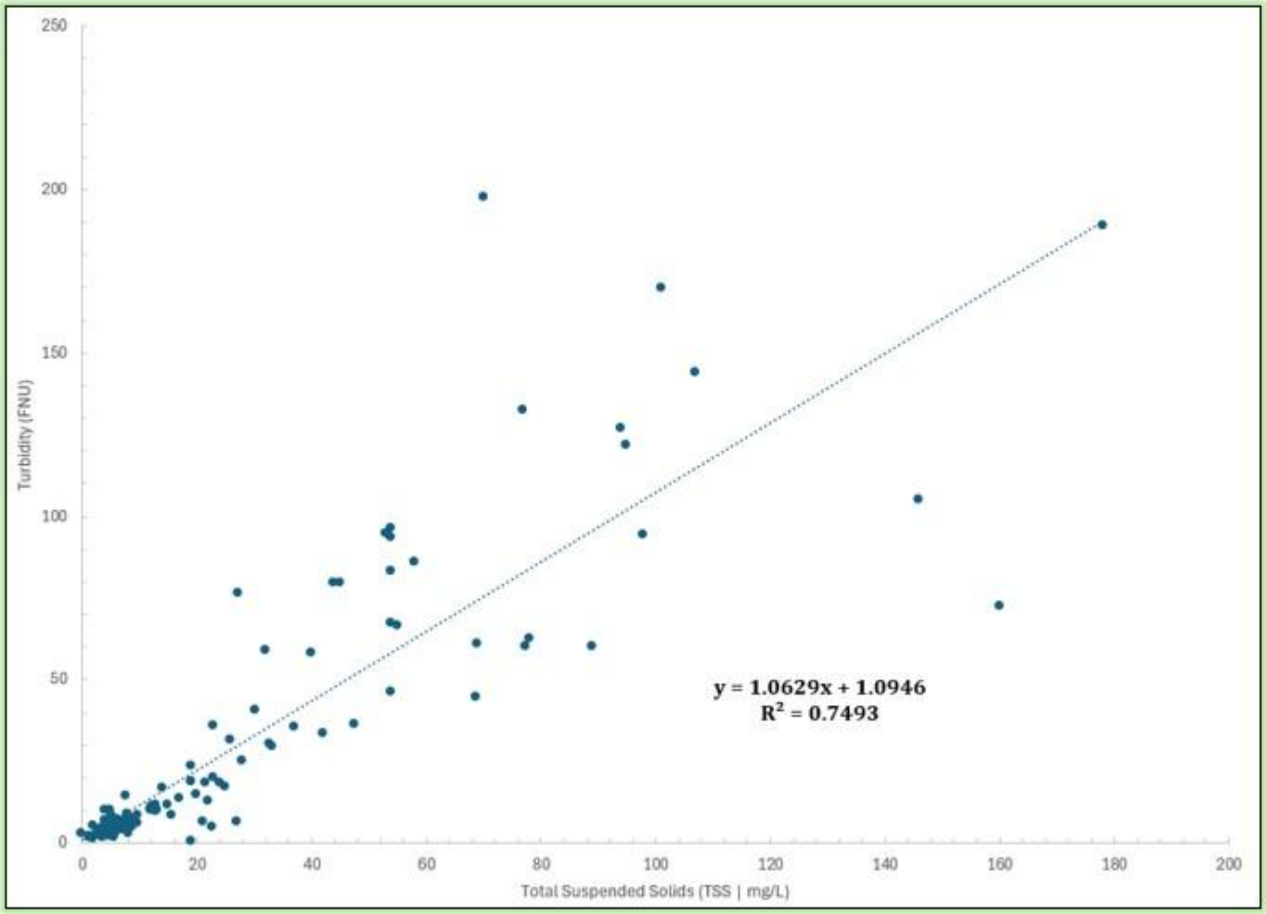
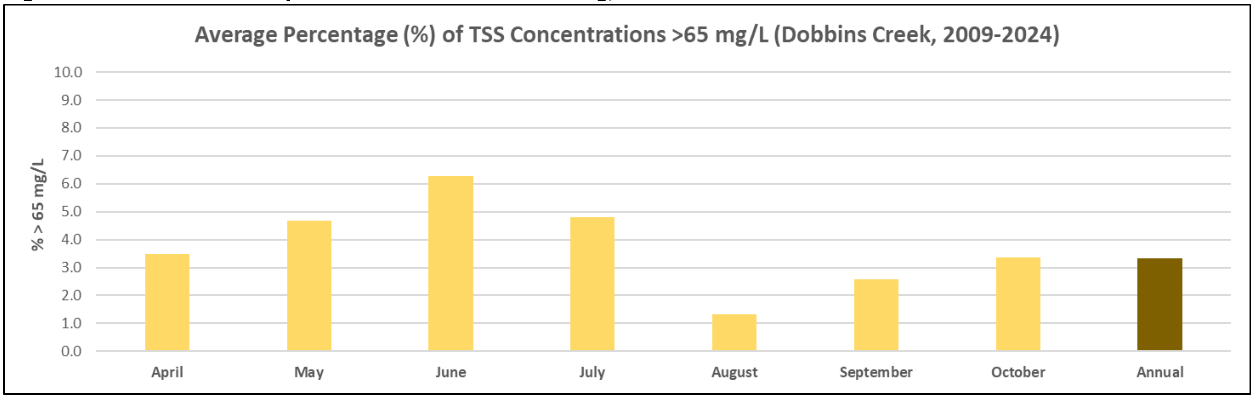


Figure 19: Turbidity equivalent to 65 mg/L TSS water quality standard for Dobbins Creek.

65 mg/L TSS ≈ 70 FNU
(Turbidity Equivalent)

Applying this regression, the turbidity data summarized in Figure 20 indicate that during high flow years (e.g. 2016-2019) Dobbins Creek may have exceeded the TSS standard approximately 5% to 7% of the time. In lower flow years, the exceedance percentage was less than 5%. As such, these data confirm attainment of the TSS water quality standard (exceed 65 mg/L less than 10% of the time) for Dobbins Creek WID -535. This goal attainment is corroborated by the biological data summarized in the following section.

Figure 20: Dobbins Creek percent exceedance of 65 mg/L TSS concentration.



3.4.2 Dobbins Creek biological monitoring

The Dobbins Creek Clean Water Act Section 319 Project area's Fish Index of Biotic Integrity (FIBI; DeZiel, 2024) shows persistent biological impairment in the upper North Branch (AUID 07080201-524) alongside improving habitat in some locations. SID studies and the Cedar Basin assessment/trends update point to multiple stressors of biota—sediment/habitat, altered flow regime, and nutrients (notably nitrate). Figure 21 shows the FIBI monitoring sites, branch (N and S) and location from outlet in miles are included in the first line names in bold. The unbolded is the MPCA station designation. Note: S5.0 is on a tributary to the South Br. The blue dots are EQUIS sites.

Combined key points across FIBI, SID, and basin assessment

- **Hydrologic extremes complicate year-to-year signals:** FIBI scores on both branches were variable in some years, likely influenced by high flows and drought carryover, but the overall spatial pattern is consistent.
- **Persistent impairment in the upper North Branch (AUID 07080201-524):** Even after removing drought/flood-impacted years, the North Branch impaired reach remains below fish-assemblage standards, indicating both habitat and water-quality limitations; SID confirms fish and macroinvertebrate impairment in AUID -524.
- **Downstream/lower reaches are healthier:** The downstream reach WID -535 (Hormel Nature Center reach) remains above fish standards; basin assessment similarly notes consistently healthy fish and macroinvertebrate communities in lower/restored reaches. The 2021 assessment notes for WID -535 include:
    - All fish samples had 16 to 21 taxa, with 1 to 2 considered intolerant, and 2 to 5 sensitive taxa, representing a balanced and diverse fish community on this reach. Sensitive species comprised 5% to 15% of the individuals in the samples. With the preponderance of data, recommend support for fish based on current fish data.
    - Current data agree with previous full-support assessment. Recommend full support of general aquatic life use based on macroinvertebrate data.

- **South Branch generally meets standards, with localized concerns:** Most middle and lower South Branch stations are above threshold most years, but two WIDs show variability (above and below standards). A small tributary (S5.0) shows excess sand/channel instability and possible eutrophication; the headwater station (S9.4/S9.5) is not representative for assessment due to very small drainage area/clay substrate.
- **Sediment/habitat limitations remain central (especially sand/embeddedness):** FIBI documents excess sand/embeddedness at upper sites even as some stations improved (e.g., less sand at S0.04); SID identifies TSS and habitat as stressors.
- **Hydrology/flow alteration is a key driver:** FIBI variability and habitat instability are linked to altered flow regimes; floodplain reconnection is suggested. SID also identifies flow alteration as a stressor.
- **Nitrate is the clearest actionable chemistry signal; eutrophication/DO may be episodic:** SID reports nitrate 1.7 to 13 mg/L (2019; avg 7.2; 10% >10 mg/L) and 0.8 to 21.4 mg/L (2011–2020; 31% >10 mg/L); FIBI recommends localized nitrate/TP/DO monitoring to pinpoint where chemistry limits fish response and notes eutrophication indicators (e.g., algae/high DO saturation) at some sites.
- **Other contributing constraints to track:** Fish passage constraints are noted at some locations and may be limiting recovery in parts of the system.

See Appendix B for the full report (FIBI Monitoring in the Dobbins Creek Watershed 2021-2024).

Figure 21: FIBI monitoring stations in Dobbins Creek (brown squares).

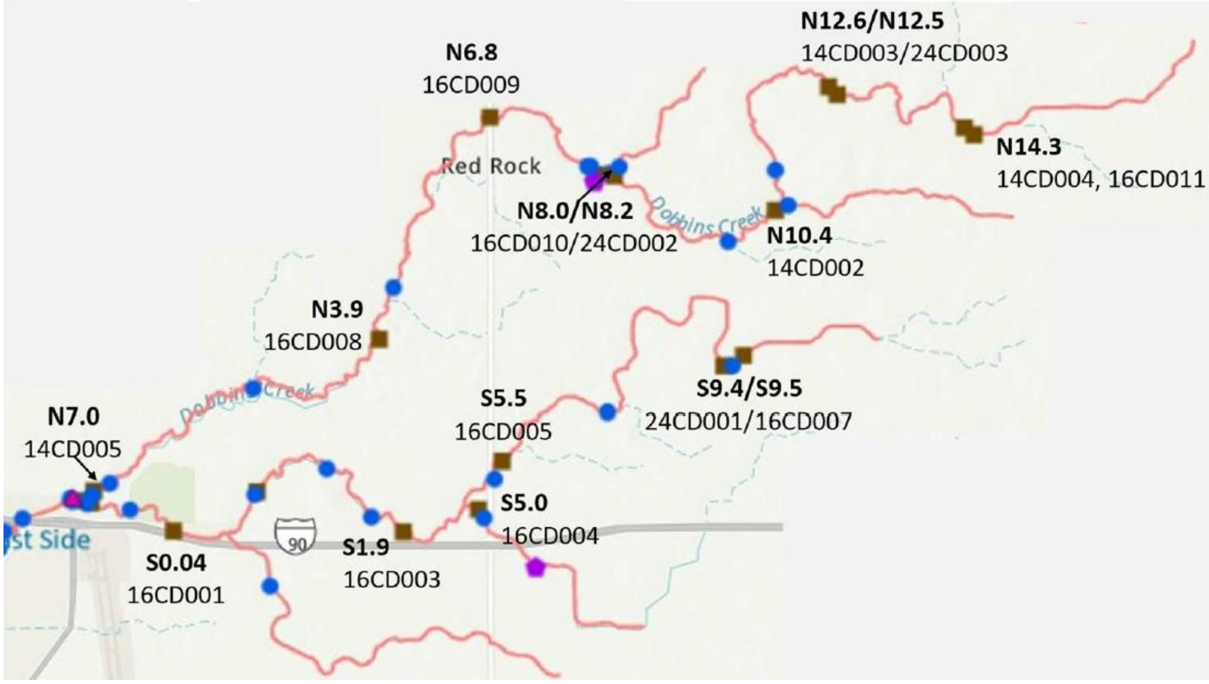


Figure 22: Photo reference of site N12.6 (Dobbins Cr North Branch) and S0.04. (Dobbins Cr South Branch)

	
N12.6 -2024: Headwaters of the North Branch. Severe excess sand aggradation, reduced pool depth and smothered spawning gravels. Very high banks on both sides limits riparian flow refuge.	**S0.04 -2022**:–Near outlet of the South Br. Stream is overwidened with excess sand on bottom, lacks depth variability. Surprisingly, this reach was much improved with far less sand in 2024, possibly moved out during the June flood prior to sampling in late July.

3.4.3 Dobbins Creek analysis of sediment from 2009-2025

A Weighted Regressions on Time, Discharge, and Season (WRTDS) analysis was completed by MPCA for Dobbins Creek in 2026. This is a statistical trend method used to understand how water quality changes over time while accounting for changing streamflow. In the Dobbins Creek Report, WRTDS was run through the EGRET package. The method estimates daily concentrations, removes the effect of wet vs.

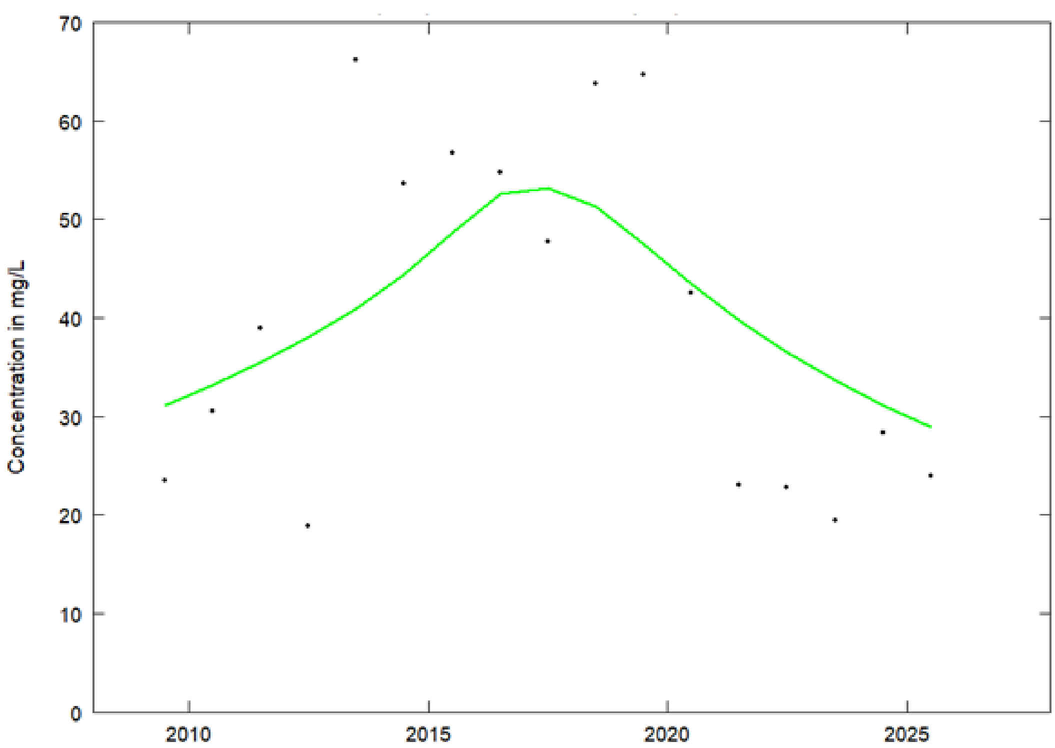
dry years through flow-normalization, evaluates long-term trends, and shows how concentrations behave across different flow conditions.

The WRTDS analysis indicates that suspended sediment concentrations in Dobbins Creek increased until about 2017 and have since declined by approximately 70%, with most sediment transport occurring during storm events. Recent improvements indicate reduced sediment mobilization during high flows.

Key findings from this data analysis:

Flow-normalized TSS concentrations increased between 2009 and approximately 2017, peaking near 53 mg/L. Concentrations subsequently declined steadily through 2025 to approximately 29 mg/L, indicating a substantial reduction in sediment delivery independent of hydrologic variability (Figure 23). The clear hump shaped pattern is likely a reflection of several factors. Phase 1 (increasing sediment) is plausibly a result of construction projects, existing channel instability, land use changes, and periods of extreme rainfall. The declining trend is plausibly linked to stabilization after disturbance, BMP implementation that resulted in channel adjustment, decreased erosion rates, and stabilization after construction.

Figure 23: Flow normalized concentration trend for Dobbins Creek: black dots indicated observed annual mean concentration, and the green line indicates the flow-normalized concentration based on WRTDS trend analysis, 2009 - 2025.

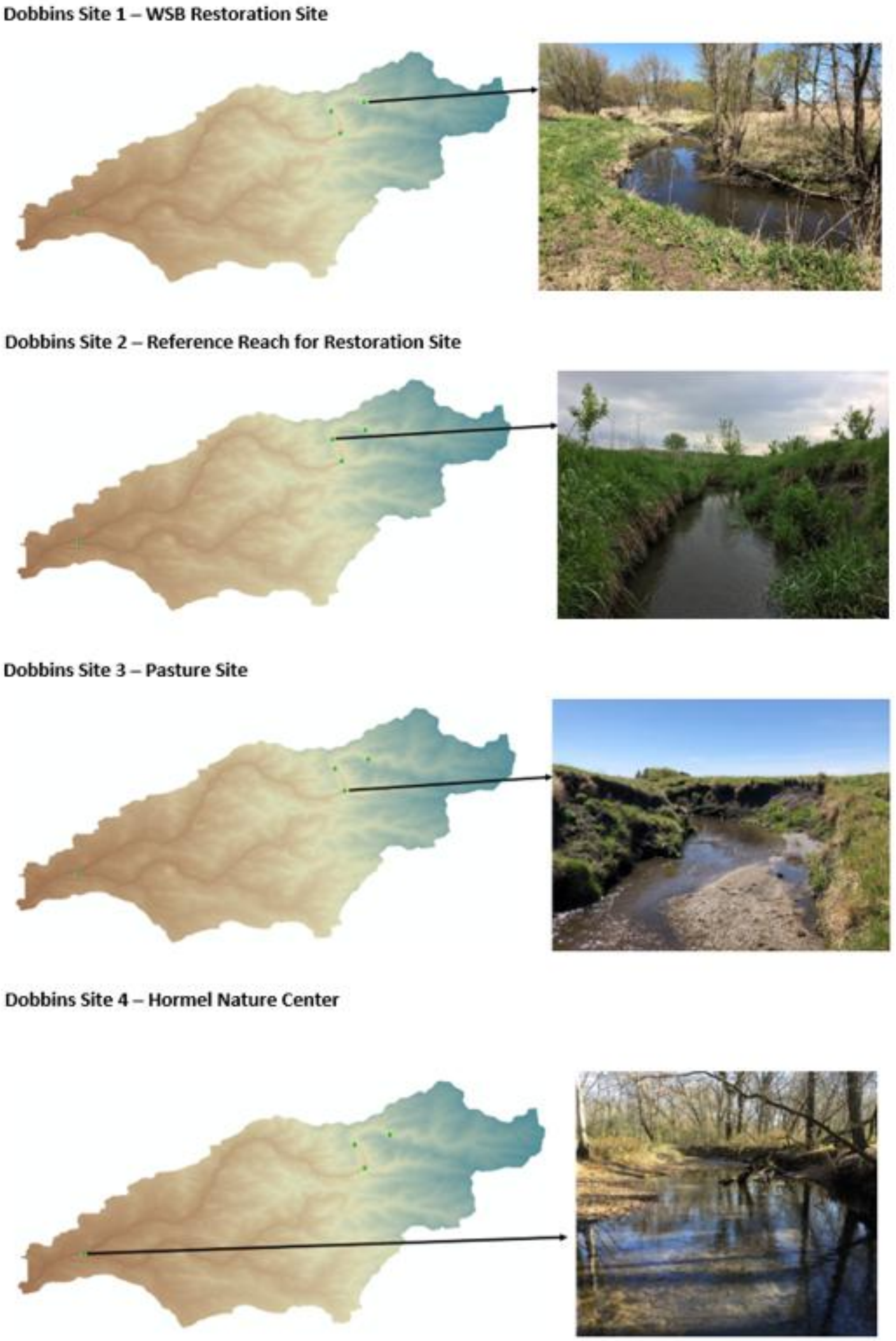


Sediment peaked around 2017 and has steadily declined since. The overall trend provides an estimate of approximately 4.9% reduction in sediment rates; however, the post-peak declined sharply. From the 2017 peak to 2025, flow-normalized concentrations declined approximately 70%, indicating substantial reductions in sediment delivery independent of hydrologic variability. See Appendix C for full report and documentation.

3.4.4 Dobbins Creek geomorphology report

A Dobbins Creek geomorphic survey completed by Minnesota Department of Natural Resources (DNR) and stored in the DNR Stream Geomorphology Survey Database, evaluated geomorphic conditions at four representative reaches of Dobbins Creek to document channel form, stability, erosion potential and floodplain connectivity. This technical work can support restoration planning and future habitat improvement projects. The reaches included an upstream restoration site, a downstream reference reach used to inform that design, a pasture reach with active instability, and a downstream comparison site at Hormel Nature Center as shown in Figure 24. The report reflects work completed over several years rather than a single field season: the pasture site was initially surveyed in 2014 and resurveyed in 2021, the reference reach was surveyed in 2017, and post-project bank erosion assessments at the restoration site were completed in 2021 after implementation.

Figure 24: Dobbins Creek Geomorphic Survey Sites.



The report concluded that Dobbins Creek is a largely incised, sand-dominated system shaped by long-term watershed changes that have reduced floodplain access, increased bank erosion and sediment inputs, and degraded in-stream habitat. While several reaches remain unstable—especially the pasture reach—the Hormel Nature Center reach offers an encouraging example of greater stability, with less incision, lower predicted bank erosion, better floodplain connectivity, and stronger tree-root bank protection. Overall, the report emphasizes that future projects should consider the full watershed system so flood management, fish passage, sediment transport, water quality, and habitat improvements can work together effectively.

Full reports are available here:

- Fluvial Geomorphology Survey Site Summary: Dobbins Creek Site 4 (Hormel Nature Center)
- Fluvial Geomorphology Survey Site Summary: Dobbins Creek Site 1 (Restoration Site),
- Fluvial Geomorphology Survey Site Summary: Dobbins Creek Site 2 (Reference Reach for Dobbins Creek Site 1)
- Fluvial Geomorphology Survey Site Summary: Dobbins Creek Site 3 (Pasture Site)

3.4.5 Dobbins Creek drone/geomorphic reconnaissance

Dobbins Creek is undergoing drone-based geomorphic reconnaissance (2025-2036) using repeat, high-resolution drone LiDAR and supporting imagery to generate fine DTMs/DEMs and compare surfaces over time to quantify erosion and deposition and interpret channel, bank, and hillslope change within the Dobbins Creek Watershed (HUC-12: 070802010205) (Figure 25 and Figure 26). This project will provide an accurate method for separating true soil movement from data and processing noise by (1) measuring absolute vertical accuracy against independent Real-Time Kinematic (RTK) checkpoints and (2) producing matched-resolution DTMs and a difference surface (Drone DTM − Statewide DTM), with results stratified by land cover to characterize performance across conditions (e.g., open ground versus vegetated or wet areas).

Next steps are to operationalize this approach into a repeatable monitoring program by establishing stable control and permanent checkpoints/targets; standardizing datums and processing settings for every survey; and completing the statewide-versus-drone comparison to define a realistic minimum detectable change threshold so mapped differences reflect significant change rather than uncertainty. Monitoring will then shift to event/time-based repeat surveys (pre-runoff baseline, post-major storms, end-of-season, and pre/post BMP installation), with consistent deliverables (change maps, cross sections, and volume summaries) and 3D point-cloud change methods applied where steep or complex banks limit raster differencing.

Together, this methodology will quantify soil movement over time under changing upstream landscapes and support evaluation of headwater BMP effectiveness; paired with flow and water chemistry data, it will strengthen understanding of BMP impacts and watershed response.

Figure 25: Dobbins Creek point cloud from LiDAR drone November 2025.

UAV LiDAR Flight raw point cloud data: RGB

UAV LiDAR Flight raw point cloud data: Elev gradient

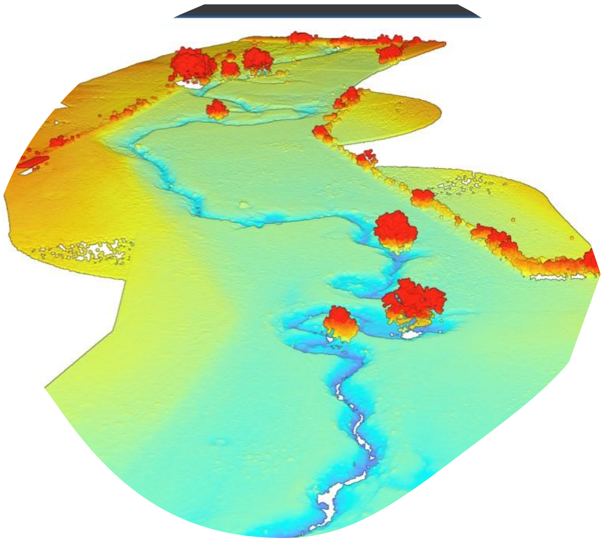
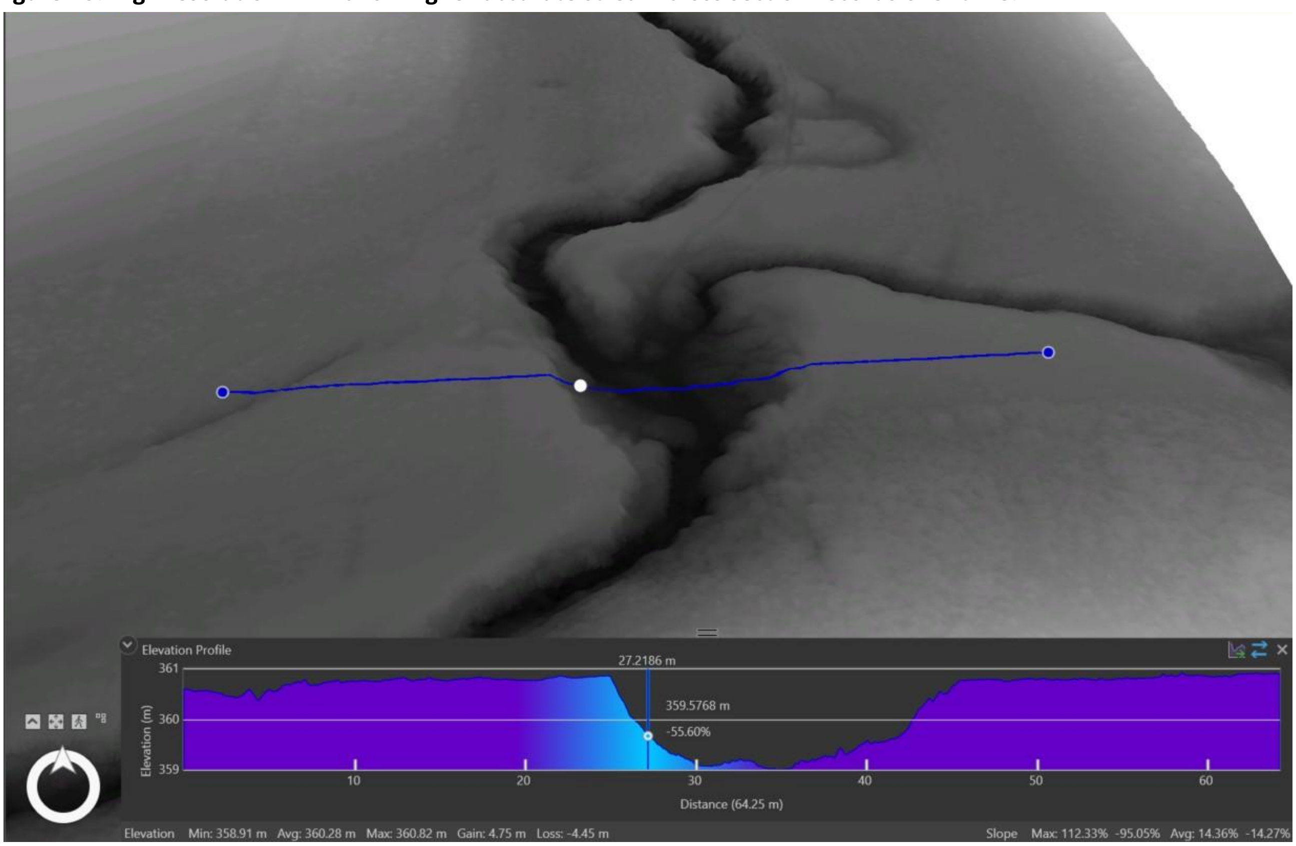


Figure 26: High resolution DEM allowing for accurate stream cross section records over time.



3.5 Concentration trends

The 2019 *Cedar River Watershed Restoration Protection Strategy Report* presented an initial screening of water-quality trends at select mainstem sites, noting that these analyses were based on available concentration data and were not flow-corrected; therefore, should be interpreted cautiously with respect to hydrologic variability. Building on that foundation, this WRAPS Update incorporates additional years of monitoring data and applies flow-adjusted trend analyses to better isolate underlying water-quality changes from the effects of variable discharge. Updated results are presented for TP and nitrate+nitrite (NOx) at Cedar River mainstem sites (2008–2022) and for the first time, at the Turtle Creek tributary site (2014–2023). See Figure 11 for WPLMN site locations. The following figures and tables summarize these updated trends, including decreasing flow-corrected TP and NOx concentrations in the Cedar River, decreasing NOx in Turtle Creek, and an apparent increase in flow-corrected TP in Turtle Creek. The Cedar River trend indications are also depicted in the 2025 Minnesota Nutrient Reduction Strategy; Figures 3-9 and 3-23 (MPCA, 2026).

Figure 27: Flow corrected nitrate concentration trend at Cedar River WPLMN site E48020001 (2008-2022)

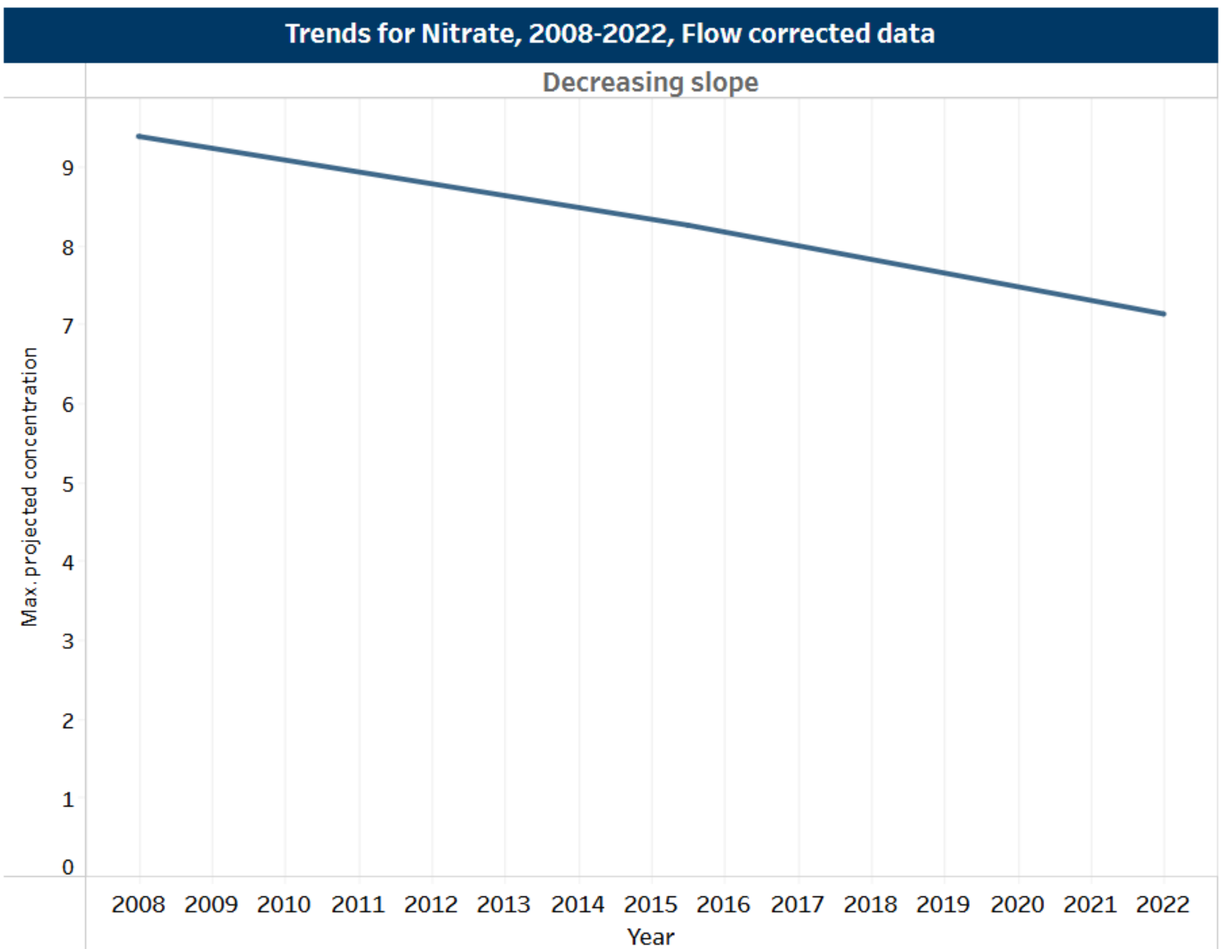
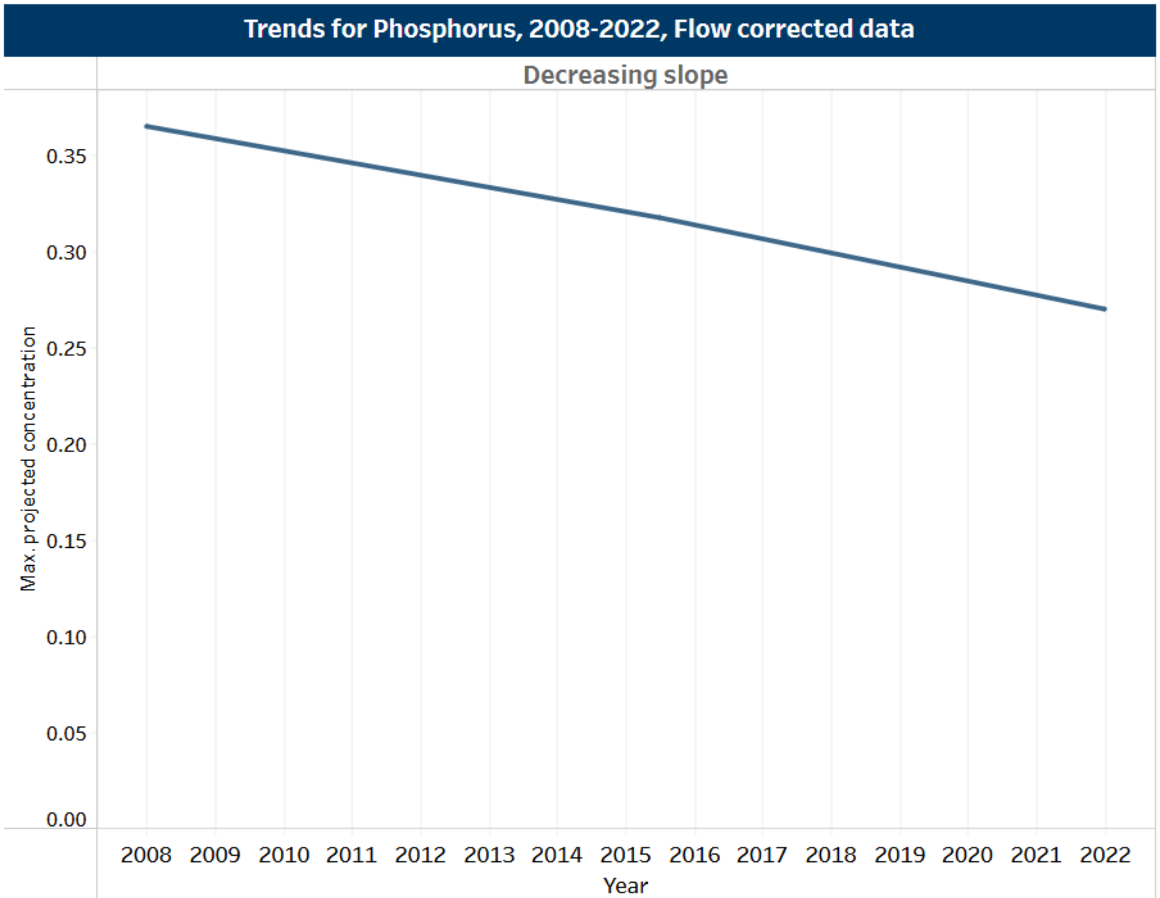


Figure 28: Flow corrected TP concentration trend at Cedar River WPLMN site E48020001 (2008-2022).



Note: sloped lines convey approximate magnitude of change over time.

Kuehner et al. examined the nitrate trend at the Turtle Creek site summarized in the following table and figures. No trend was detected; however, the analysis was of concentrations only (not flow-adjusted) and the period of record was 2007-2021. The results found a p-value that was less than 0.05 for this site, but the trend was not considered significant (Kuehner et al, 2025).

Considering both Kuehner et al 2025 and the WPLMN trend analysis in summary, the Turtle Creek nitrate concentrations appear to be in approximate equilibrium with the nitrate concentrations leaching below the root zone of the crops cultivated in the watershed. The samples at the WPLMN site are "younger water" largely dominated by precipitation patterns moving nitrate into drain tiles and then downstream into Turtle Creek. Note that while concentrations at this site are decreasing, they are still often very high (Figure 30).

Table 8: Turtle Creek trend analysis results from MPCA WPLMN.

	EQUIS site	WISKI site	Parameter	2014-2023 trend analysis
Turtle Creek at Austin, 43rd St	S004-432	H48027001	NOx	SIGNIFICANT DECREASING
Turtle Creek at Austin, 43rd St	S004-432	H48027001	TP	SIGNIFICANT INCREASING
Turtle Creek at Austin, 43rd St	S004-432	H48027001	TSS	NO SIGNIFICANT TREND

Figure 29: Turtle Creek TP data 2014 -2024.

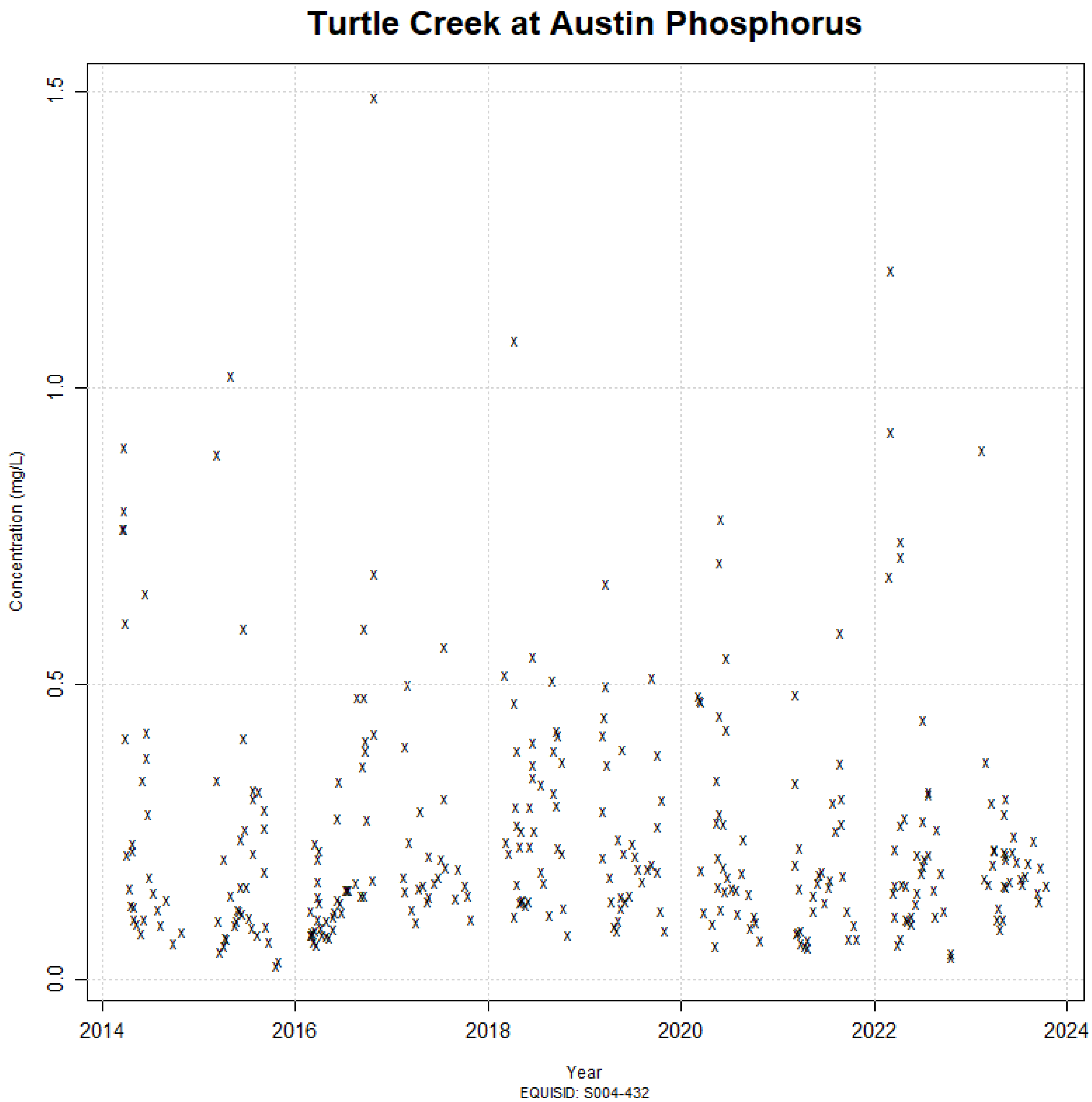
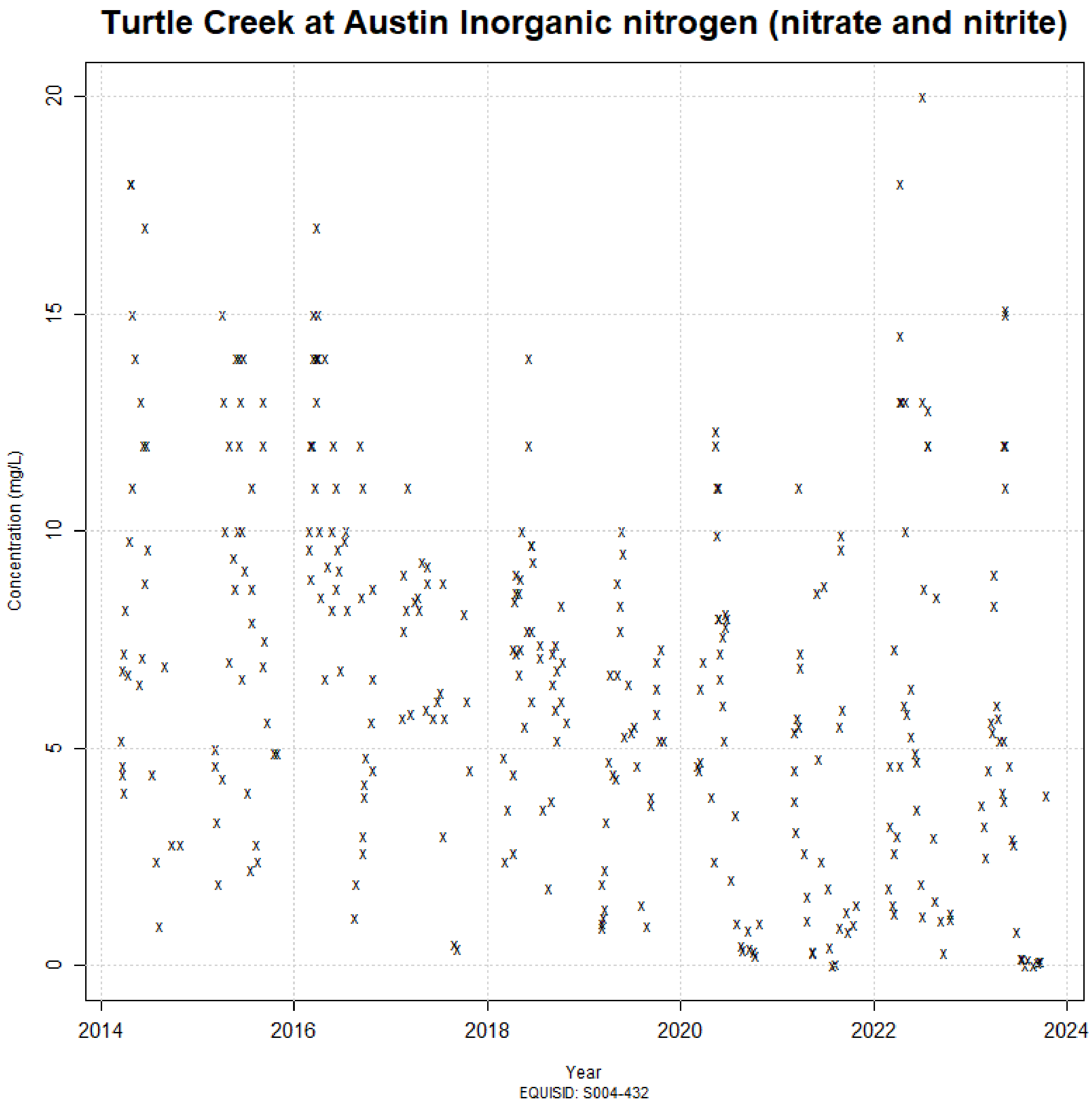


Figure 30: Turtle Creek nitrate + nitrite data 2014- 2024.



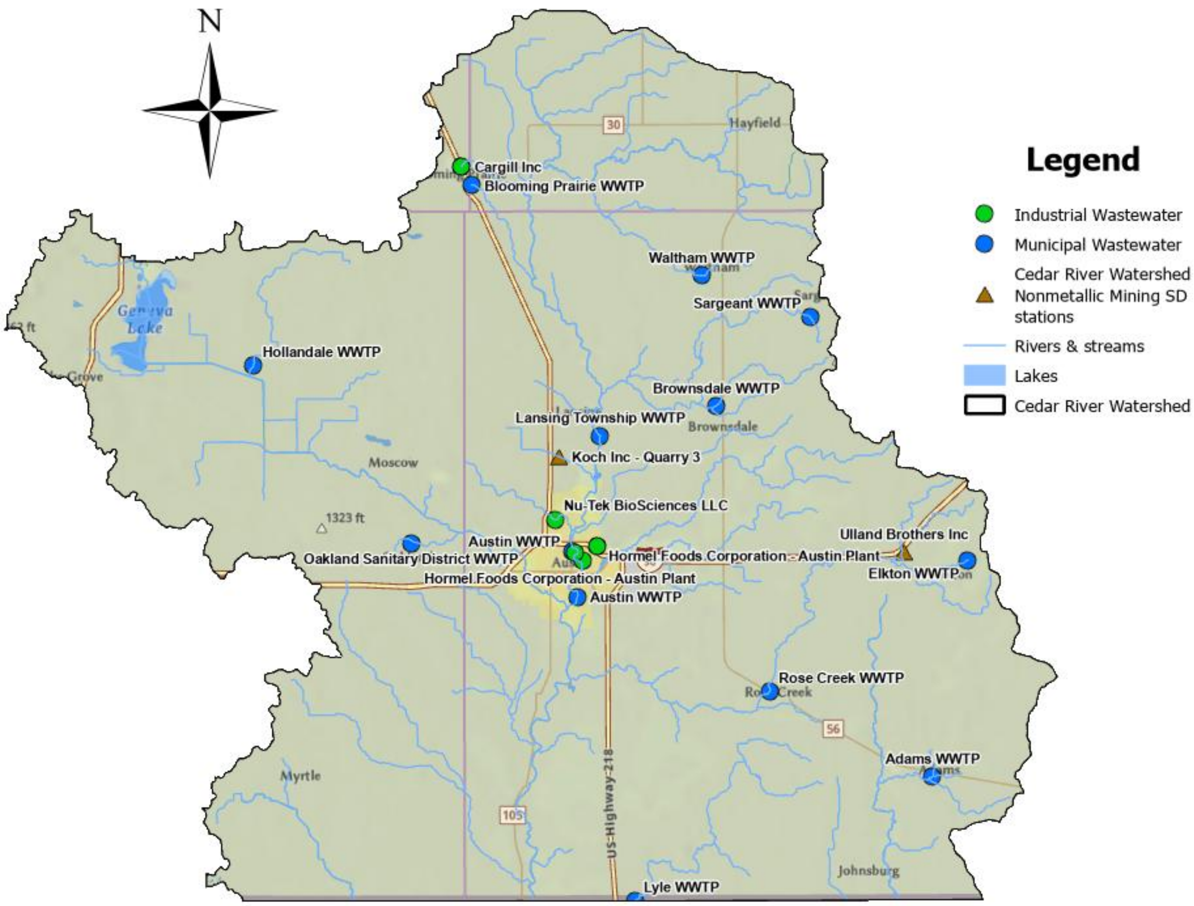
The WPLMN annual values dashboard for both Cedar River and Turtle Creek sites can be viewed and downloaded at the [WPLMN tool](#) interface.

3.6 Wastewater effluent total phosphorus data and trends

Twelve municipal and four industrial surface water discharge wastewater facilities have been operating in the Cedar River Watershed since 2005 (Figure 30). One of the municipal facilities (Oakland Sanitary District WWTF) has only reported one discharge event in September 2010. Two industrial facilities have ceased operations (Austin Utilities – Downtown in 2011, Austin Utilities – Northeast Power Plant in 2016). Two nonmetallic mining (sand and gravel) operations discharge industrial stormwater in the watershed.

The Austin WWTF is the largest facility in the watershed and provides wastewater treatment service for the city of Austin and for processing wastewater from the Hormel Foods Corporation. The facility discharges over 80% of the watershed's wastewater volume.

Figure 31: Wastewater dischargers in the Cedar River Watershed.



Even though none of the wastewater permits for facilities in the Cedar River Watershed currently require compliance with TP effluent limits[1], wastewater effluent P loads have decreased by 48% from a 2005-2009 annual average of 58,811 kilograms per year to a 2020-2024 annual average of 30,840 kilograms per year (MPCA data).

The Austin WWTF is the largest wastewater facility in the watershed and most of the effluent P reductions have been a result of optimization activities by the Austin WWTF (Figure 32). However, many of the smaller facilities in the watershed have also reduced their effluent P loads by 38% to 71% (Figure 33).

[1] The Austin WWTP will be subject to a 1 mg/L TP effluent limit following completion of a facility upgrade that is currently underway. Upon completion of the project (fall 2026) the facility's effluent load is expected to be reduced by a further 18,600 kg/year.

Figure 32: Wastewater TP loads in the Cedar River Watershed.

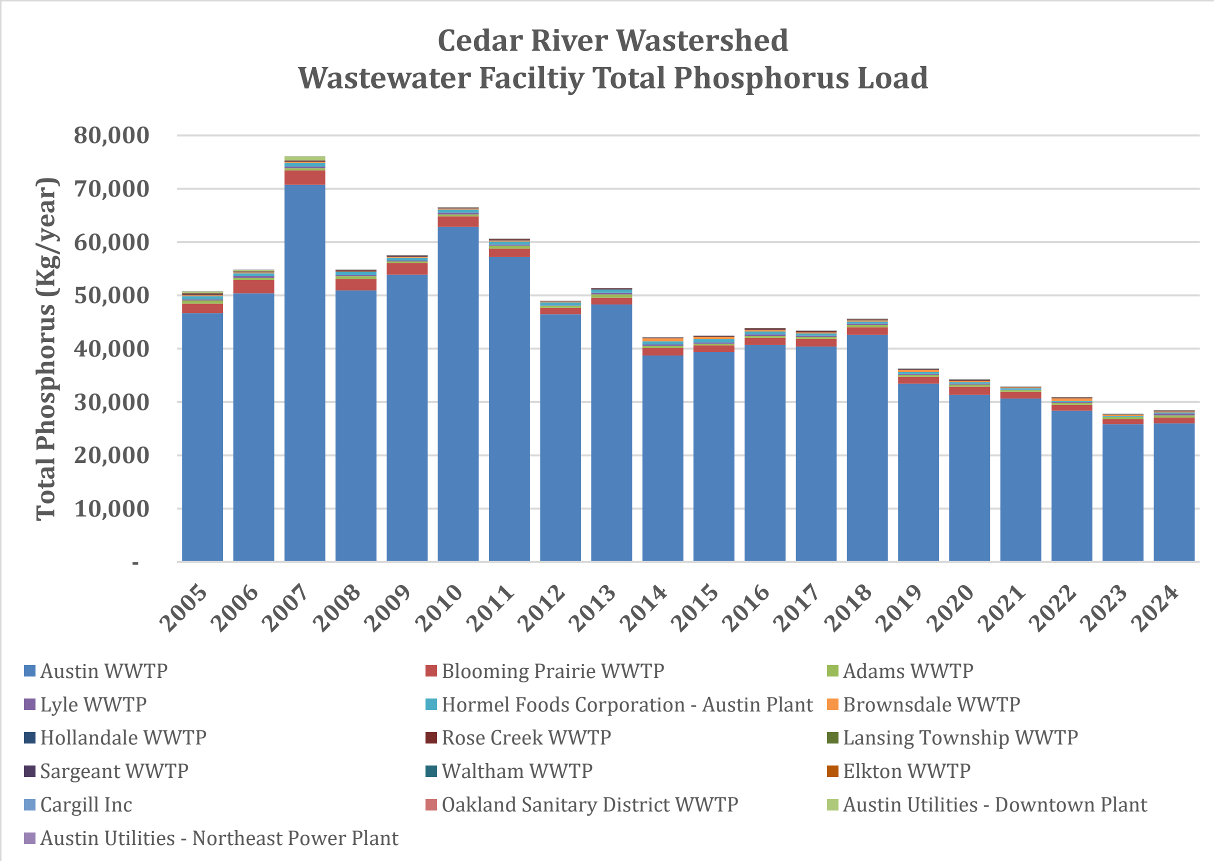
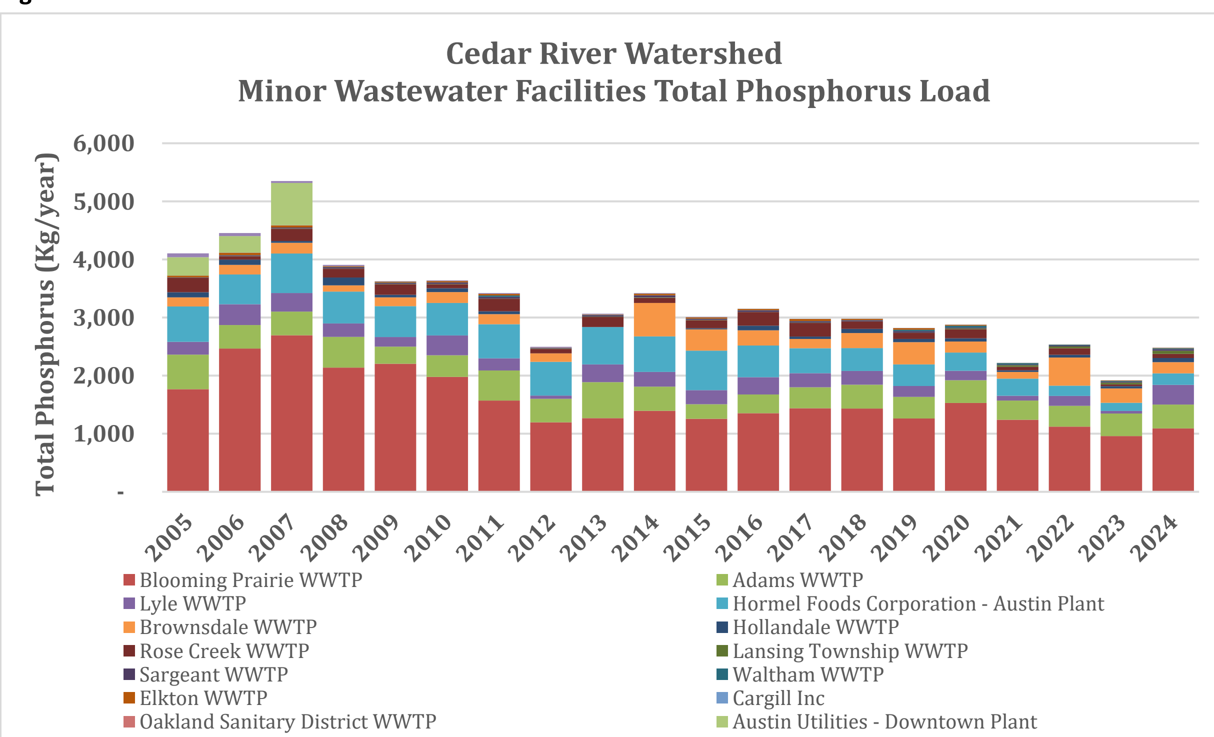
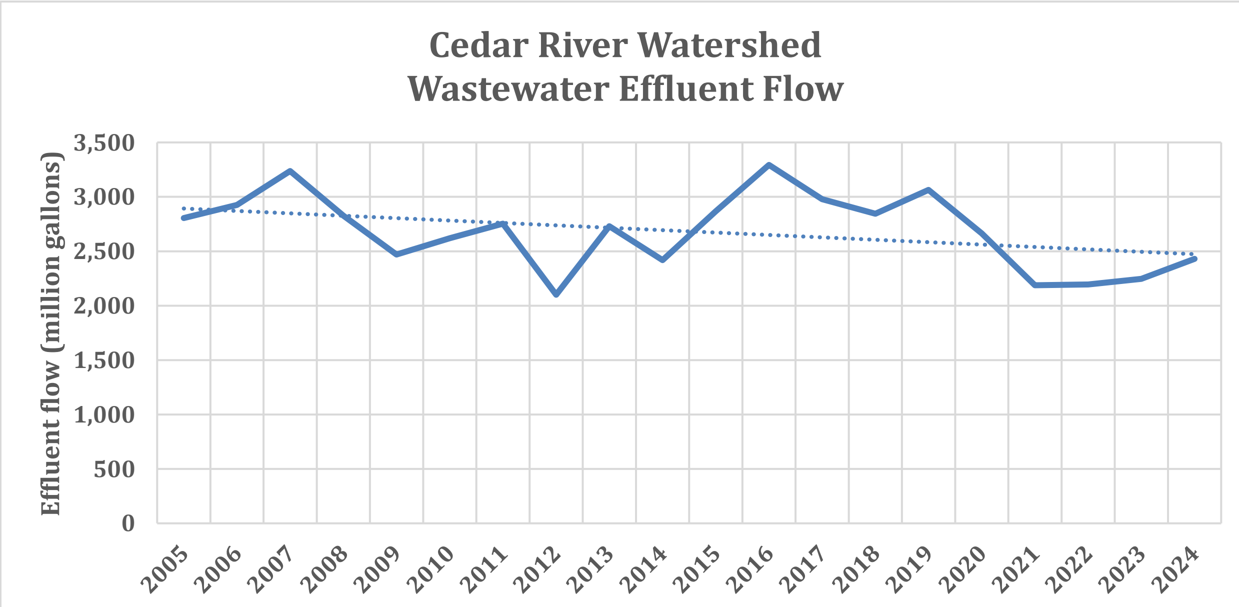


Figure 33: Wastewater TP loads for minor facilities in the Cedar River Watershed.



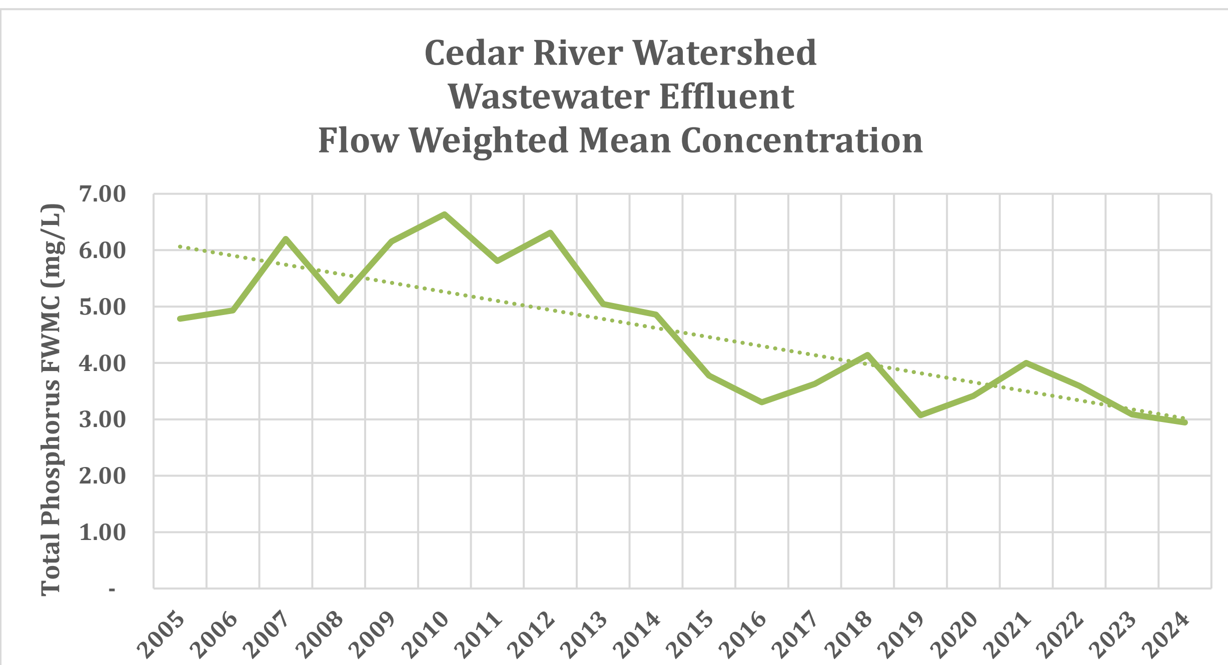
Phosphorus load reductions have largely resulted from source reduction and facility optimization efforts. Effluent flows have remained relatively stable since 2005 (18% reduction in effluent flow volumes from a 2005-2009 average of 2,853 million gallons per year to a 2020-2024 average of 2,345 million gallons per year; Figure 34).

Figure 34: Wastewater effluent flows in Cedar River Watershed, 2005 – 2024.



Effluent P flow weighted mean concentrations have declined significantly since 2005, decreasing by 37% from a 2005-2009 average of 5.43 mg/L to a 2020-2024 average of 3.41 mg/L (Figure 35).

Figure 35: Wastewater effluent TP flow weighted mean concentration over time in the Cedar River Watershed, 2025 - 2024.

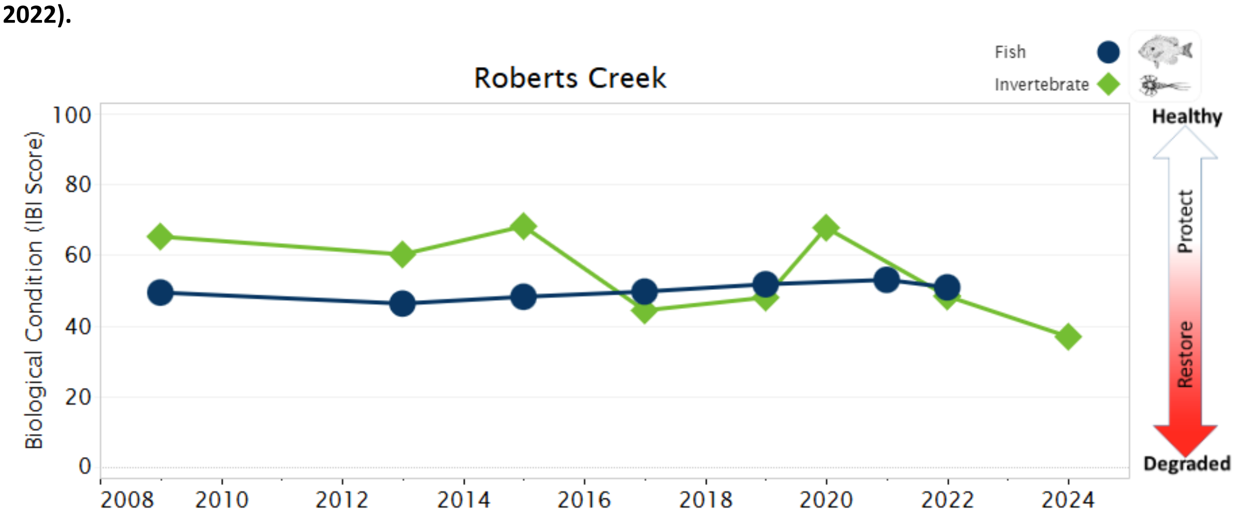


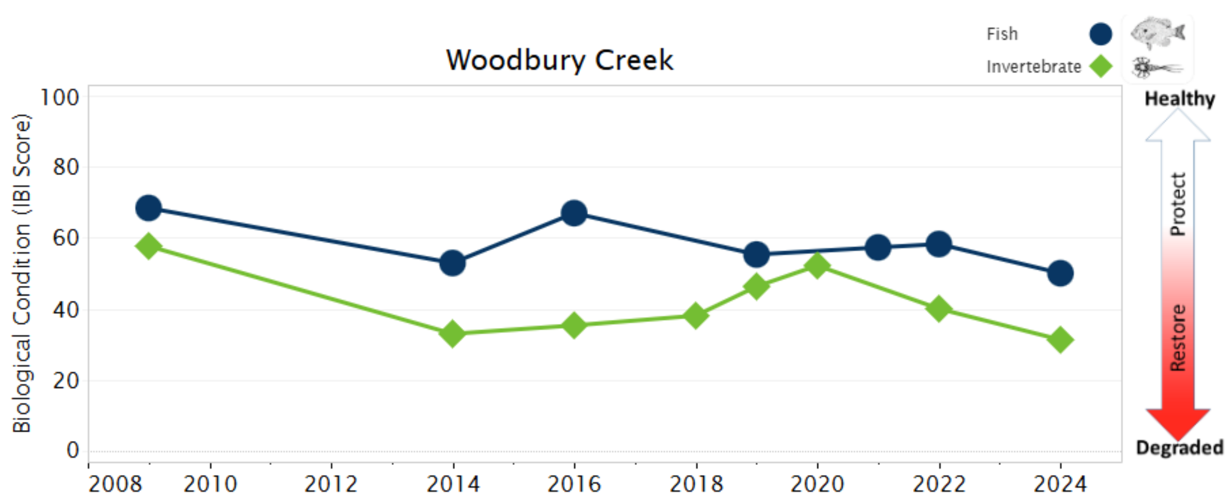
The preceding data (as well as TSS and nitrogen data) can be viewed at MPCA's [Wastewater Progress Dashboard].

3.7 Long-term biological monitoring trends

Two stations in the Cedar River Watershed have been designated as long-term biological monitoring locations. Each have been sampled eight times between 2009 and 2024. After initially being listed as impaired in 2009, long-term monitoring stations on Woodbury and Roberts Creeks have consistently yielded macroinvertebrate index of biological integrity (IBI) scores indicative of a healthy community, resulting in the removal of the macroinvertebrate impairments from the 2022 Impaired Waters List. Roberts and Woodbury Creeks currently support quality fish communities (MPCA, 2022).

Figure 36: Indices of biological integrity at long term monitoring stations in the Cedar River Watershed (MPCA, 2022).





3.8 TMDLs

Bacteria impairment remains an important water-quality issue in Dobbins Creek and the broader Cedar River Watershed. The approved 2019 Cedar River Watershed TMDL established the existing bacteria-reduction framework for multiple impaired reaches, including Dobbins Creek, while more recent work has refined understanding of local sources and priorities. This section summarizes the 2024 Dobbins Creek *E. coli* ESA and places its findings in the context of the approved 2019 TMDL and the TMDL update recently developed (MPCA, 2026b) for reaches added to the impaired waters list in 2022. Together, these efforts indicate how recent source-assessment work is sharpening implementation priorities while building on the watershed's existing TMDL foundation.

3.8.1 *E. coli* enhanced source assessment for the Dobbins Creek Subwatershed

The Dobbins Creek *E. coli* enhanced source assessment (ESA) completed in 2024 (Appendix D) indicates that impairment is both widespread and persistent across the subwatershed, with the strongest evidence pointing to livestock/manure pathways and failing septic systems as the dominant controllable sources. This conclusion is consistent with the watershed's predominantly agricultural land use, which is about 81.5% cultivated cropland, 4.2% hay/pasture, and 9.1% developed land. *E. coli* impairment is extensive, with 10 stream segments listed for aquatic recreation, including lower mainstem reaches first listed in 2006 and several headwater and tributary segments added in 2022. Monitoring data from 2015 through 2022 showed highly variable but frequently elevated bacteria levels, with individual samples ranging from 10 to more than 24,000 org/100 mL and monthly geometric means exceeding the standard from May through October.

The ESA also shows that *E. coli* problems are not limited to major runoff events, as exceedances occurred under all flow conditions and were often observed during mid-flow conditions. Spatial patterns suggest that concentrations generally increase from upstream to downstream along mainstem Dobbins Creek, while East Side Lake appears to reduce bacteria levels and Unnamed Creek (-563) may provide some dilution after its confluence with the mainstem. For implementation, the report points most clearly to livestock-related source areas, especially feedlots near surface waters, overgrazed pastures, and cropped fields with high runoff potential. Failing septic systems are also an important likely contributor in some areas, with 51% of reviewed individual systems in the 2023 community assessment area found to be noncompliant. In contrast, the ESA does not identify developed-area stormwater, industrial by-product land application, natural background sources, or naturalized *E. coli* as major drivers of impairment. Figure 37 and Figure 38 summarize *E. coli* geometric means and some priority areas for reduction efforts. See full report in Appendix D.

Figure 37: Median *E. coli* concentrations by monitoring station (April Oct, 2015-2022) in the Cedar River Watershed.

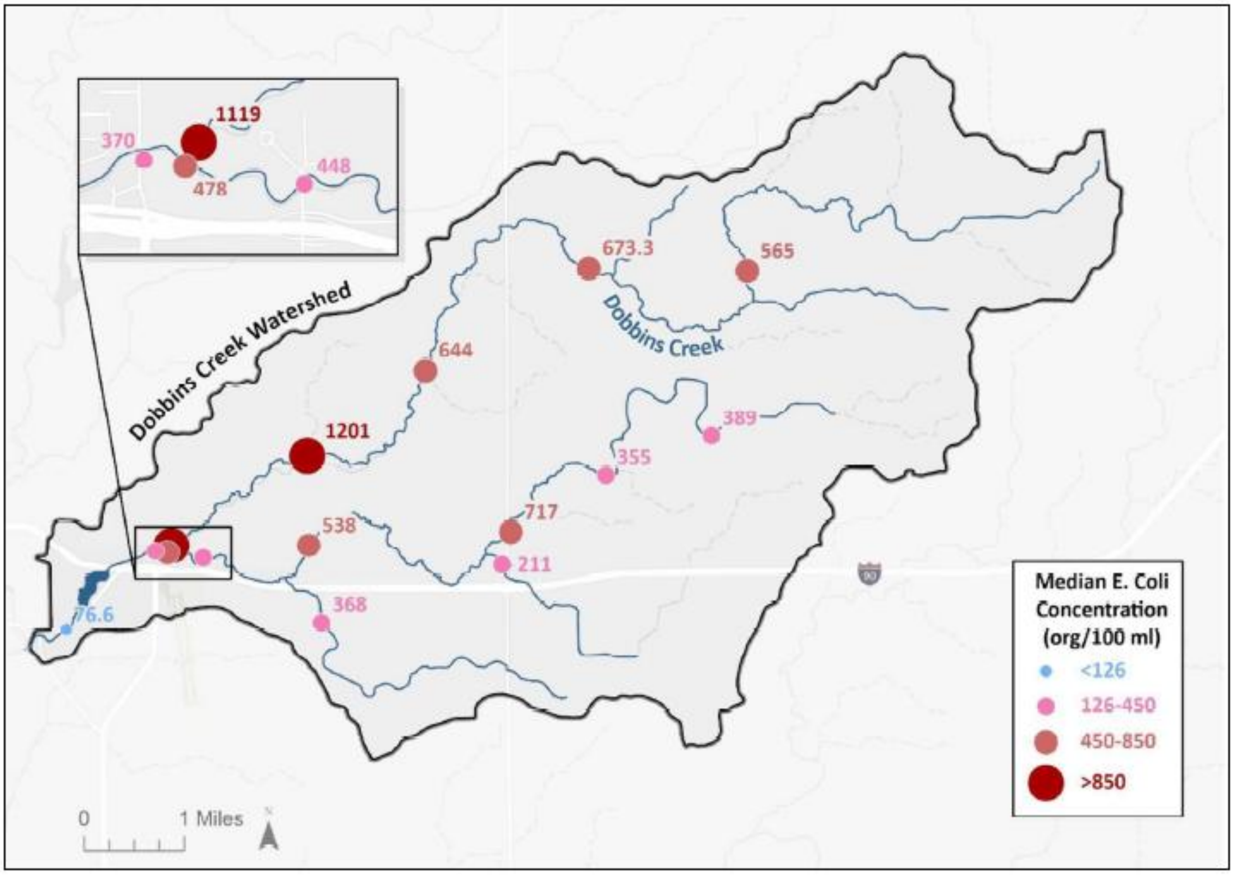
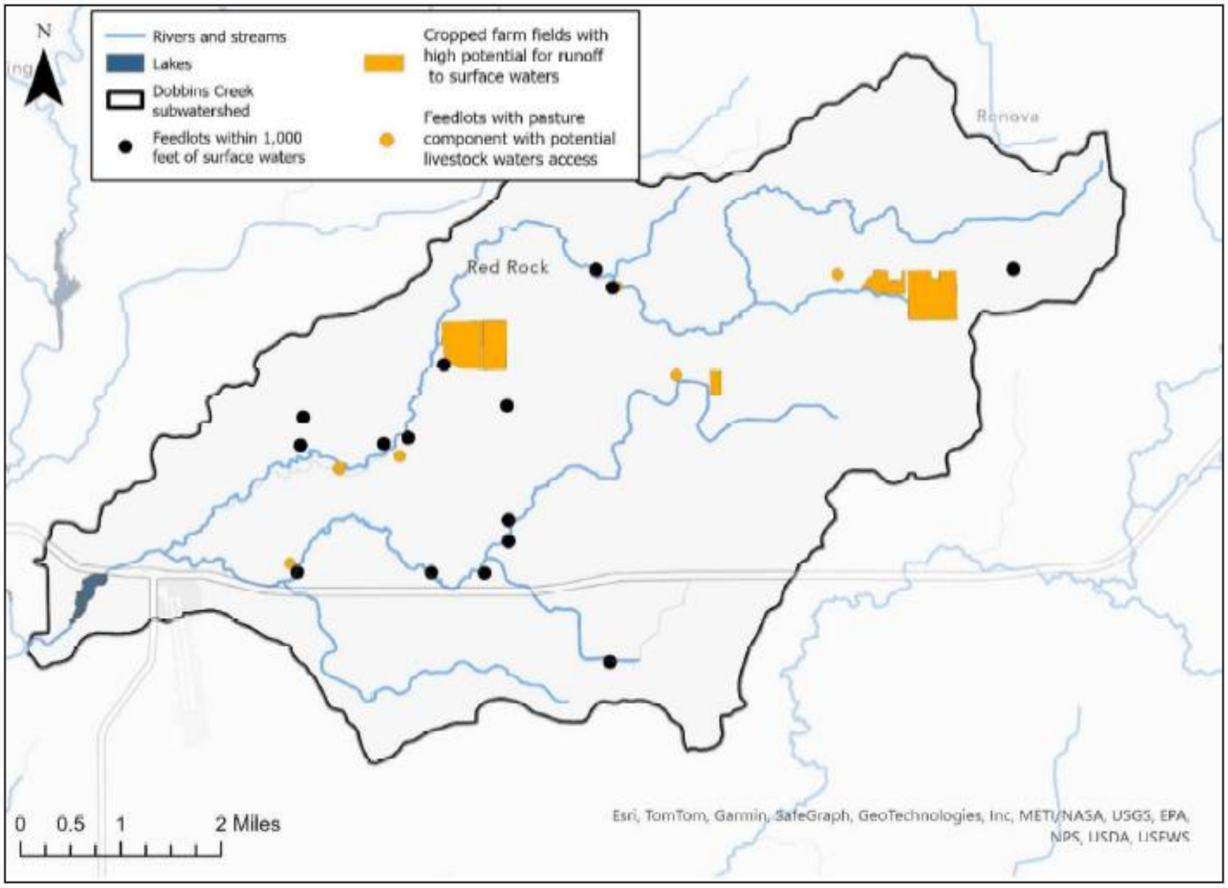


Figure 38: Priority area for livestock sources of *E. coli* in the Cedar River Watershed.



3.8.2 New Cedar River TMDLs

The Cedar River Watershed has numerous approved TMDLs for both sediment (TSS) and bacteria (*E. coli*). Fecal coliform (an indicator that was predecessor to *E. coli*) TMDLs were approved for the Cedar River in 2006 prior to the watershed-wide 2019 TMDL that established load allocations (LAs) and reduction targets for multiple impaired river and tributary reaches. The TMDL Update (MPCA, 2026b) is intended to extend—not supersede—those existing plans by addressing additional impairments added in 2022. As the document notes, the new TMDLs in this report do not replace or revise previously approved TMDLs; instead, they build on the established technical foundation (monitoring, source understanding, and implementation strategies) and add updated targets and allocations for newly listed reaches (Table 9) so that ongoing sediment- and bacteria-reduction efforts can be coordinated under a consistent watershed framework.

Table 9: Key impaired reaches addressed in the 2026 TMDL (Table 1) (MPCA, 2026b).

WID (AUID)	Water body	Designated use affected	Listing year	Parameter
07080201-524	Dobbins Creek	AQR	2022	*E. coli*
07080201-524	Dobbins Creek	AQL	2022	TSS
07080201-563	Unnamed Creek	AQR	2022	*E. coli*
07080201-504	Roberts Creek	AQL	2022	TSS

4. Climate and hydrologic change summary

The Cedar River Watershed has become warmer, with the largest warming signal in winter minimum temperatures (DNR WHAF climate summary). The watershed has become wetter since 1990, with more precipitation during spring and early summer (April–July), increasing runoff potential.

Hydrology has shifted toward higher low, moderate, and peak flows after approximately 1990, increasing flood duration and channel stress and underscoring the need for storage/retention practices (DNR EHC). Despite long-term wetting, episodic drought continues to occur (e.g., since 2000 in Mower County per the U.S. Drought Monitor), creating a wider range of hydrologic extremes.

4.1 Observed climate trends in the Cedar River Watershed

Minnesota DNR's WHAF climate summary for the Cedar River Watershed evaluates an observed record from 1895–2018 and compares the most recent 30-year period (1989–2018) to the full record. The WHAF summary shows a clear warming signal and an overall shift toward wetter conditions, with minimum temperatures increasing most strongly—especially during winter months.

In the DNR assessment, annual minimum temperatures in 1989–2018 are roughly 1.6˚ F warmer than the 1895–2018 average (Figure 39), and winter minimum temperatures are about 2.9˚ F degrees warmer (DNR 2019). Precipitation has also increased; since about 1990, average annual precipitation has been approximately 35.5 inches—about 5 inches (18%) higher than pre-1990 conditions (Figure 40), with the largest increases typically occurring during April–July (DNR 2023).

An updated CRWD observed record through 2025 reinforces and extends these findings. Annual average temperature increases about 0.18° F per decade (2.2° F warmer in 1996–2025 than 1895–1924), while annual maximum temperature increases more modestly (0.06° F per decade, 1.0° F higher in 1996–2025 than 1895–1924). Minimum temperature (derived from annual average and maximum temperature series) shows the strongest long-term warming at 0.30° F per decade; the 1996–2025 30-year average is about 2.0° F above the record mean.

Annual precipitation in the CRWD record increases about 0.52 inches per decade, with 1996–2025 averaging 4.7 inches more precipitation than 1895–1924. Despite these upward trends, year-to-year variability remains high—wet and dry years still occur, but around a warmer and generally wetter long-term baseline.

Figure 39: Annual minimum temperature, 1895-2025 Cedar River Watershed.

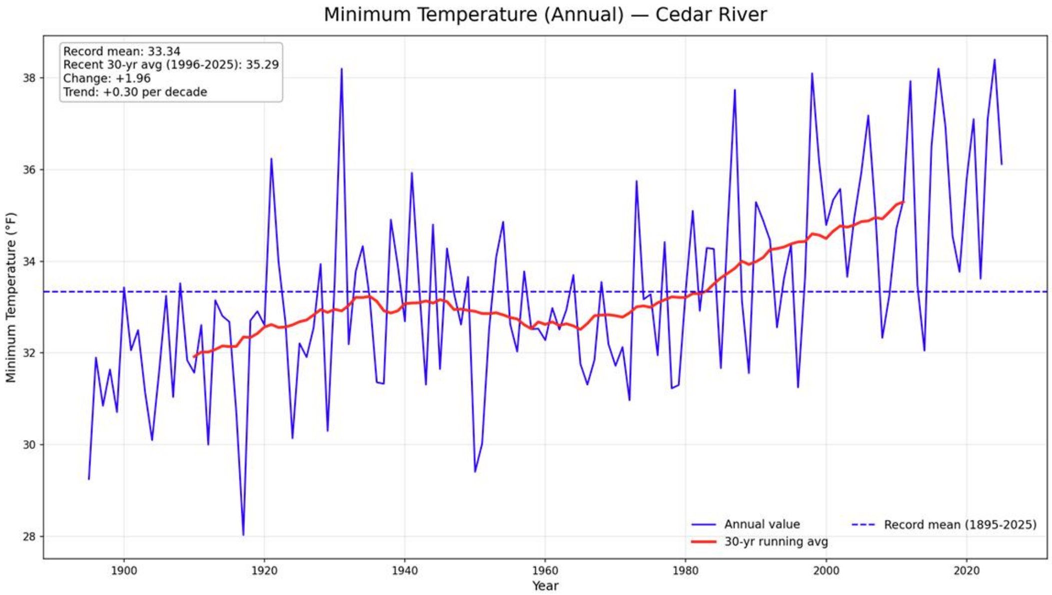
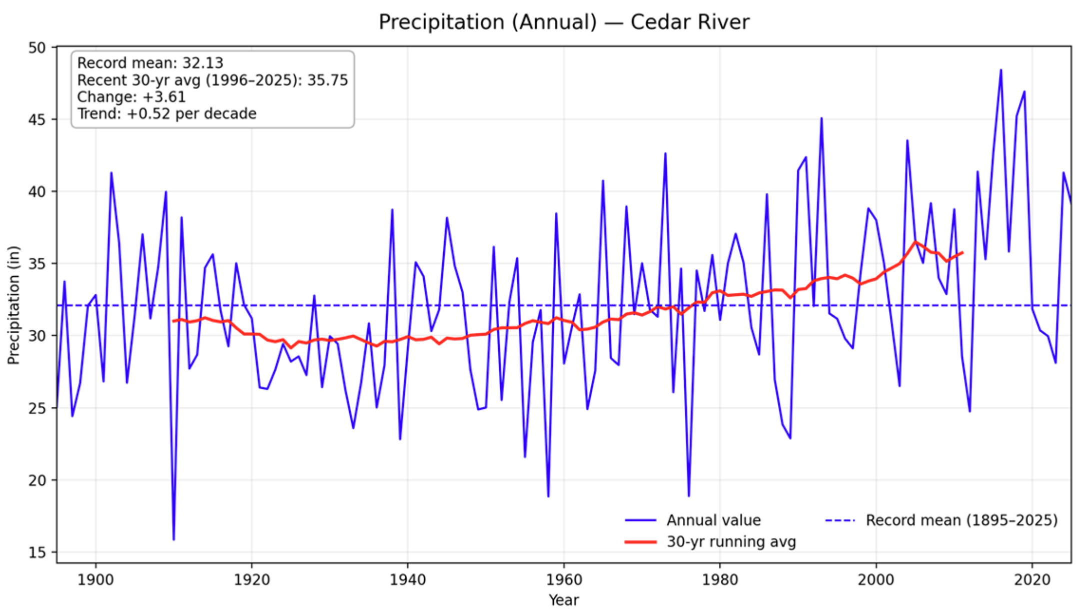


Figure 40: Annual precipitation, 1895-2025 Cedar River Watershed.



4.2 Hydrologic response and increasing flow extremes

The DNR's Evaluation of Hydrologic Change (EHC) for the Cedar River Watershed (published 2023) similarly concludes that all flow metrics increased after 1990 (low, moderate, and peak flows). The EHC interpretation notes that modest changes in precipitation paired with more extreme changes in streamflow (Figure 41) and flood duration (Figure 42) reflect combined influences of climate and landscape alteration (e.g., tile drainage, channel ditching, drained wetlands, and reduced soil water storage). The EHC report emphasizes watershed-wide practices that improve water retention and storage.

Figure 41: Annual mean discharge for the Cedar River near Austin (DNR 2023).

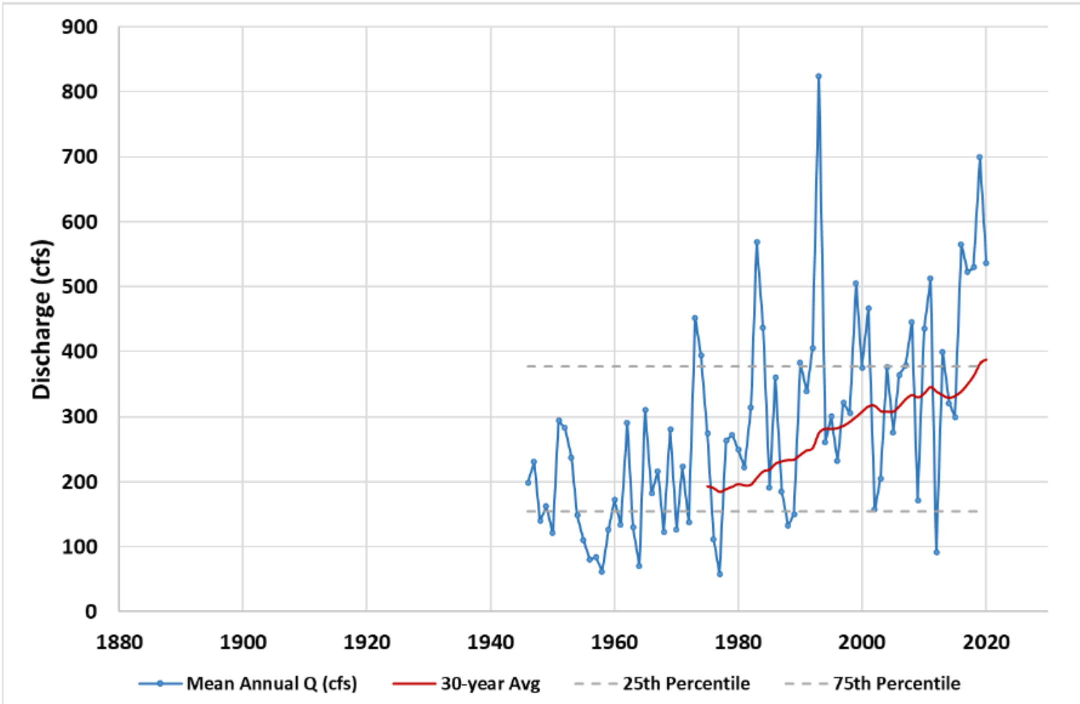
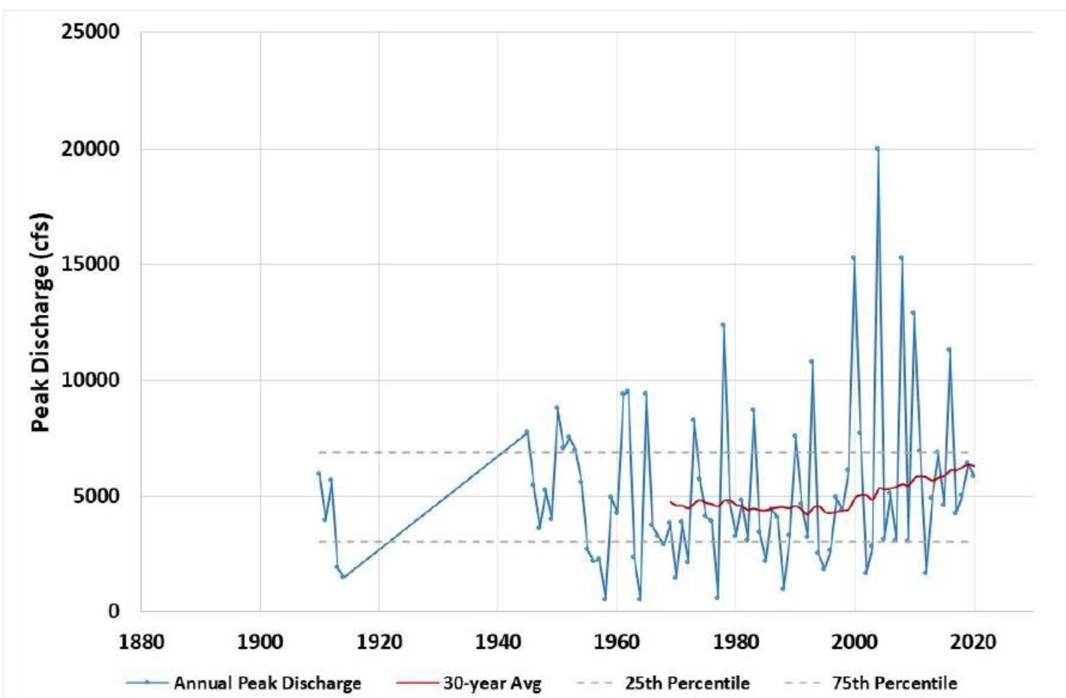
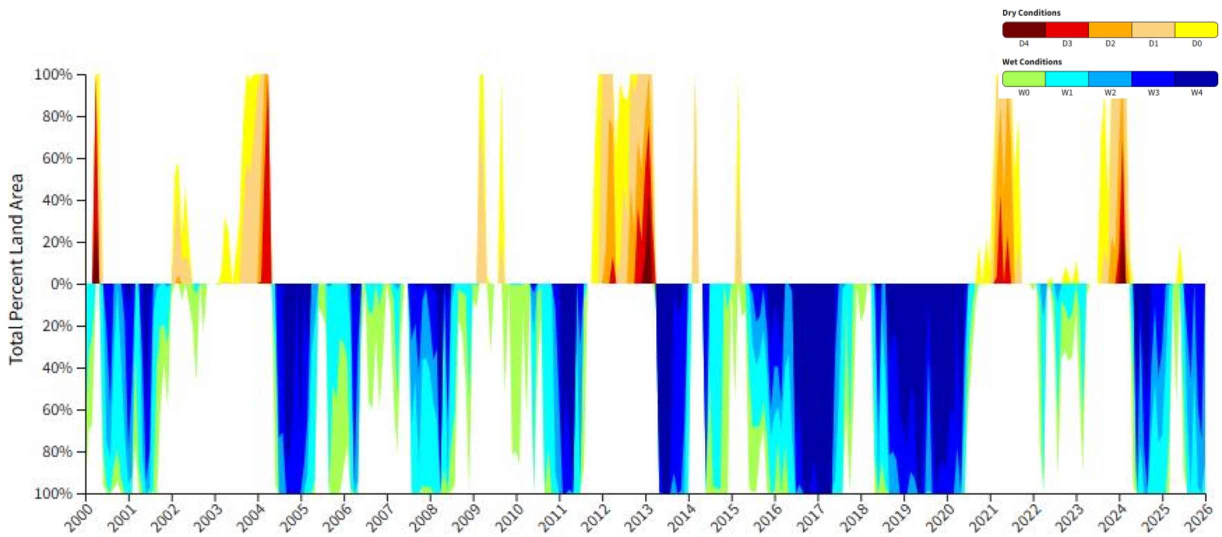


Figure 42: Annual peak discharge for the Cedar River near Austin (DNR 2023).



While long-term precipitation increases support higher flows, droughts continue to influence water availability and ecological conditions. The U.S. Drought Monitor provides a county-scale drought history (available since 2000 for Mower County), documenting periodic drought years interspersed with wet and flood-prone periods. This increasing swing between wet extremes and drought increases risk for both flood damage and water-quality stressors (Figure 43).

Figure 43: Yearly Wet/Dry Conditions Mower Co (U.S. Drought Monitor).



4.3 Implications for water quality, habitat, and management

A warmer and wetter climate, paired with reduced watershed storage, tends to increase runoff volumes and peak flows. In the Cedar River Watershed, these changes can intensify bank erosion and sediment transport, mobilize P and other surface-transport pollutants during storms, and alter habitat availability for aquatic life—especially where channels are already incised or simplified.

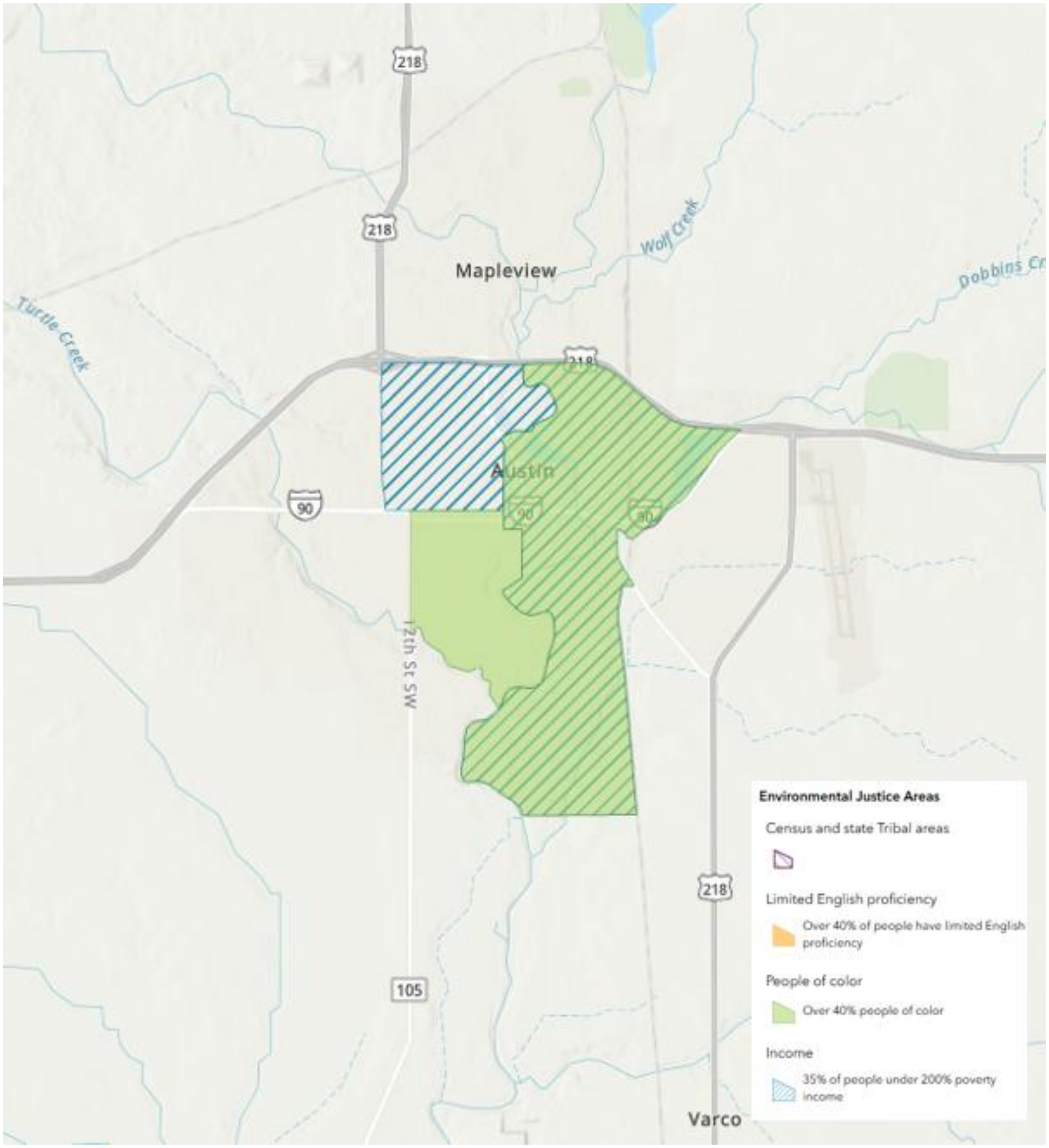
The hydrologic-change signal also increases the value of implementation strategies that restore storage and slow water movement across the landscape (e.g., wetland restoration and protection, water and sediment basins, saturated buffers and drainage water management, floodplain reconnection, perennial cover, soil-health practices, and riparian buffers). These actions support both climate resilience (flood/drought buffering) and water-quality goals.

5. Environmental justice

The environmental justice (EJ) component of WRAPS Update work aims to provide fair treatment and meaningful involvement of underserved and/or under-represented communities. In the CRW, low income and communities of color represent EJ communities located in the watershed. It is recommended that outreach for private wells and septic systems be focused in these areas so these communities can be informed of cost share opportunities for well or septic upgrades, if needed. The MPCA has grant funds from the Clean Water Fund and low interest Clean Water Partnership loan funds available to address septic system upgrade needs for low-income households. No part of the CRW is located within the boundary of a federally recognized Tribal Nation (Figure 44).

The MPCA provided resources to local watershed partners to produce a SSTS factsheet translated from English to Hmong and a Mower County Planning and Zoning factsheet translated from English to Spanish and Karen/Karenni (Appendix E). These resources will aid local partners in reaching non-English speaking communities throughout the CRW and their larger jurisdictions.

Figure 44: MPCA Environmental Justice Areas.



6. Public participation

Public notice for comments

An opportunity for public comment on the draft WRAPS report was provided via a public notice in the *State Register* from June 22, 2026, through July 22, 2026. There were no comments received and responded to as a result of the public comment period.

7. Literature cited

Barr Engineering Company. 2019. Cedar-Wapsipinicon Comprehensive Watershed Management Plan Prepared for the Cedar-Wapsipinicon Watershed Partnership.

Board of Water and Soil Resources (BWSR). 2026. Performance Review and Assistance Program (PRAP) review of the Cedar-Wapsipinicon Watershed Partnership.

DeZiel, Brenda. 2024. Report of FIBI Monitoring for the Dobbins Creek 319 Project, 2021-2024. Caddis Fish Consulting, LLC, for Cedar River Watershed District. December 18, 2024.

Iowa Department of Natural Resources (Iowa DNR), Watershed Improvement Section. 2006. Intent to Withdraw the Nitrate TMDL in the Cedar River Watershed

Kuehner, Kevin J., Anthony C. Runkel, and John D. Barry. 2025. Informing nitrate concentration trends: estimating groundwater residence time in a karstic, multiaquifer system using anthropogenic tracers (Minnesota, USA) Hydrogeology Journal 33(1): 167-192. https://doi.org/10.1007/s10040-024-02871-2.

Minnesota Department of Natural Resources (DNR). 2019. Climate Summary for Watersheds: Cedar River. June 2019.

Minnesota Department of Natural Resources (DNR). 2023. Evaluation of Hydrologic Change (EHC) Technical Summary: Cedar River Watershed.

Minnesota Pollution Control Agency (MPCA). 2012. Cedar River Watershed Monitoring and Assessment Report.

Minnesota Pollution Control Agency (MPCA). 2014. Minnesota Nutrient Reduction Strategy.

Minnesota Pollution Control Agency (MPCA). 2016. Cedar River Watershed Stressor Identification Report.

Minnesota Pollution Control Agency (MPCA). 2019. Final Cedar River Watershed Total Maximum Daily Load Report.

Minnesota Pollution Control Agency (MPCA). 2019. Final Cedar River Watershed Restoration and Protection Strategies Report.

Minnesota Pollution Control Agency (MPCA). 2020. Final Upper Wapsipinicon River Watershed Restoration and Protection Strategy Report. February 2020.

Minnesota Pollution Control Agency (MPCA). 2022. Cedar Basin Cycle II Monitoring Report: Watershed Assessment and Trends Update.

Minnesota Pollution Control Agency (MPCA). 2022. Cedar River Watershed Cycle 2 Stressor Identification Nitrate Summary.

Minnesota Pollution Control Agency (MPCA). 2022. Dobbins Creek Watershed Stressor Identification Update.

Minnesota Pollution Control Agency (MPCA). 2022. Turtle Creek Watershed Stressor Identification Update.

Minnesota Pollution Control Agency (MPCA). 2023. Roberts Creek Watershed Stressor Identification Update.

Minnesota Pollution Control Agency (MPCA). 2024. Watershed (HUC 8) Load Reduction Needs to Accomplish Minnesota's Nutrient Reduction Strategy Goals: Guidance for Watershed Strategies and Planning.

Minnesota Pollution Control Agency (MPCA). 2024. Attachment: Methods for Watershed Load Reduction Needs to Accomplish NRS Goals.

Minnesota Pollution Control Agency (MPCA). 2024. Dobbins Creek *E. coli* enhanced source assessment

Minnesota Pollution Control Agency (MPCA). 2026. Dobbins Creek WRTDS sediment analysis report

Minnesota Pollution Control Agency (MPCA). 2026a. Minnesota Nutrient Reduction Strategy.

Minnesota Pollution Control Agency (MPCA). 2026b. Cedar River Watershed Total Maximum Daily Load Report 2026.

Minnesota Department of Natural Resources (DNR). 2021 Dobbins Creek geomorphology reports

https://files.dnr.state.mn.us/legacy/cwf/wp/rcwp/sitesumm-dobbins4-hormel-2021.pdf

https://files.dnr.state.mn.us/legacy/cwf/wp/rcwp/sitesumm-dobbins1-resto-2021.pdf

https://files.dnr.state.mn.us/legacy/cwf/wp/rcwp/sitesumm-dobbins2-ref-2017.pdf

https://files.dnr.state.mn.us/legacy/cwf/wp/rcwp/sitesumm-dobbins3-pasture-2021.pdf

Moraetis, D., Efstathiou, D., Stamati, F., Tzoraki, O., Nikolaidis, N. P., Schnoor, J. L., & Vozinakis, K. (2010).
High-frequency monitoring for the identification of hydrological and bio-geochemical processes in a Mediterranean river basin.
Journal of Hydrology, 389(1–2), 127–136.

Sullivân, S. M. P., Hughes, R. M., Vadas, R. L., Jr., Davies, G. T., Shirey, P. D., Colvin, S. A. R., Infante, D. M., Danehy, R. J., Sanchez, N. K., & Keast, R. B. (2025). Waterbody connectivity: Linking science and policy for improved waterbody protection. *BioScience, 75*(1), 68–91. https://doi.org/10.1093/biosci/biae117

U.S. Drought Monitor. n.d. County-scale drought history: Historical Conditions for Mower County. Accessed 2026.

8. Appendices

Appendix A: Evaluating the impacts on water quality in Dobbins Creek between pre- and post-BMP application scenarios

Evaluating the Impacts on Water Quality in Dobbins Creek Between Pre- and Post-BMP Application Scenarios

Sagor Biswas, Ian Ackman
Dated: 03/12/2026

Overview

MPCA's Southeast Watershed Unit and local partners requested help defining the magnitude of water quality improvements achieved through BMP implementation in Dobbins Creek (HUC 12-070802010205), which is situated in the northeastern corner of the Cedar River watershed (HUC 8-07080201) (Figure 1). Using available empirical data to determine the impact of these changes is difficult for two primary reasons. First, implementation of these practices did not begin at one explicit point in time; rather, it occurred over a span of time, with greater intensity in the past three to five years. Second, the pre- and post-implementation periods of record are not comparable. The pre-implementation period of record may be 10 to 15 years, whereas the post-implementation period may be only 3 to 5 years. Annual summer climate variability may bias results, making meaningful comparisons difficult.

Accordingly, the MPCA Watershed Analysis and Modeling (WAM) unit used a modeling approach. The Simulation Application Manager (SAM) was used with the recently extended and calibrated Cedar River watershed HSPF model to evaluate the impact of available BMPs on flow and three water quality parameters: total nitrogen (TN), total phosphorus (TP), and total suspended solids (TSS). The current HSPF model has a simulation period from 1996 to 2022. The Dobbins Creek HUC 12 area is 23,555 acres and is represented by three HSPF model subwatersheds (Reaches 311, 313, and 315) (Figure 1).

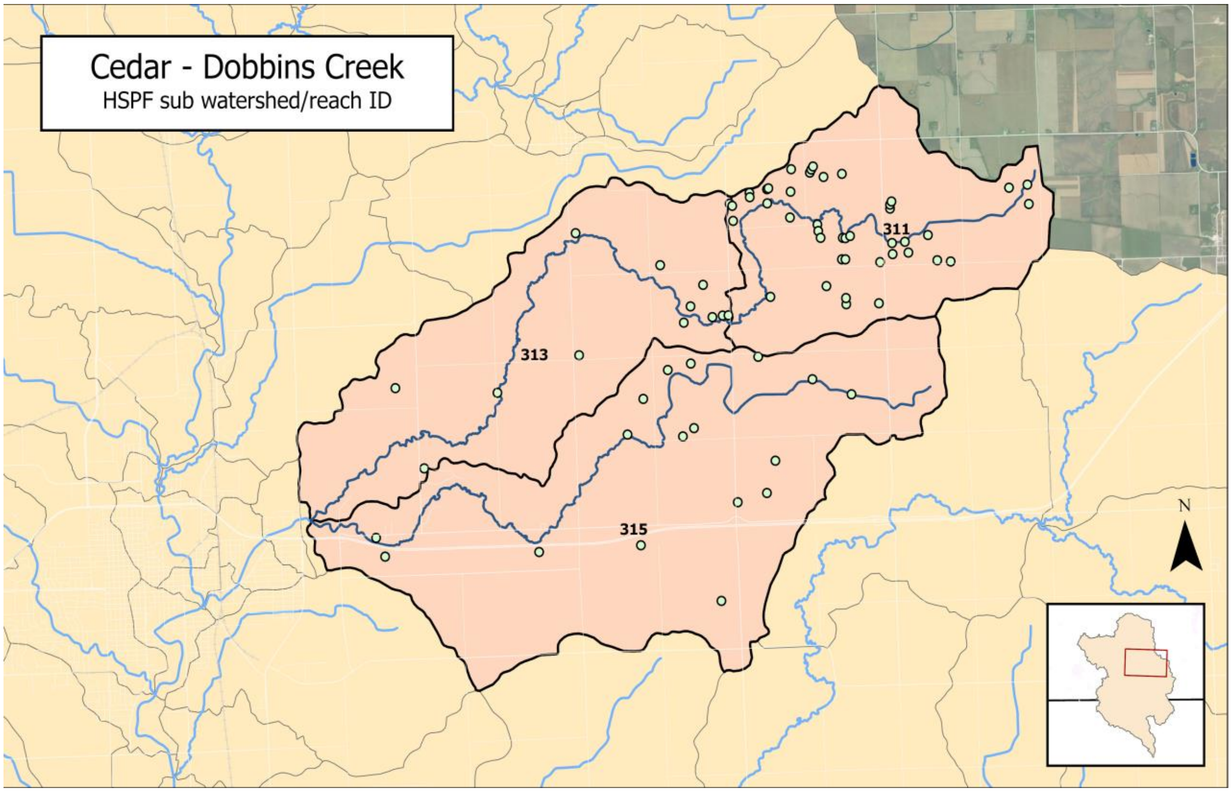


Figure 1: Dobbins Creek location map

The subwatersheds are predominantly cropland, ranging from 79% to 92% of the total area. Over the last 10 years, local watershed districts, SWCDs, and counties have taken significant steps to improve local water quality by installing several BMPs in the three subwatersheds. A large portion of the cropland (11% to 45%) in the three subwatersheds is now treated with BMPs (Table 1).

Table 1: Snapshot of Dobbins Creek under BMP coverage

HUC 12	HUC 12 Name	HSPF Reach ID	Subwatershed area (acre)	Cropland area (acre)	% of Cropland	BMP treated area (acre)	BMP % of Cropland
070802010205	Dobbins Creek	311	5278	4840	92%	2184	45%
		313	7100	5615	79%	590	11%
		315	11177	8933	80%	2493	28%

Several BMPs are currently installed in the three subwatersheds, ranging from Drainage Side Inlet Improvements, which cover about 58% of the cropland (3,035 acres), to Riparian Buffers from Pasture, which cover 0.02% of the area (1.4 acres) (Table 2). SAM used different load-reduction efficiencies for each BMP based on NRCS documents, the

Agricultural BMP Handbook for Minnesota, the Minnesota Nutrient Reduction Strategy, the Minnesota Stormwater Manual, consultant input, and expert opinion applicable to the state. Among the BMPs used in Dobbins Creek, Saturated Buffer has the highest flow-reduction efficiency at 20%; Conservation Cover Perennials have the highest TN and TSS reduction efficiencies, ranging from 91% to 96%; and Water and Sediment Control Basin has the highest TP reduction efficiency at 85%. The BMP efficiencies used in this project are provided for reference in Appendix Table 3.

SAM does not allow the user to insert a BMP in a particular year. As a result, a single scenario was created in which all recorded BMPs were applied across the full simulation period. SAM also does not have the ability to place a BMP spatially, so when multiple BMPs of the same type were installed within a subwatershed at different times, they were summed to obtain the total treated area for that BMP within the subwatershed. Results from the BMP scenario were compared with outputs from the existing model (base scenario), which had no BMPs applied.

Table 2: List of BMPs installed in Dobbins Creek

Subwatershed ID	SAM Classification	Acres Treated
311	Drainage Side Inlet Improvements	893.0
	Grassed Waterways	1057.0
	Riparian Buffers, 50 ft wide (Pasture)	0.4
	Saturated Buffer	15.0
	Water and Sediment Control Basin (Cropland)	219.0
313	Conservation Cover Perennials	20.0
	Cover Crop with corn and soybeans	91.0
	Drainage Side Inlet Improvements	379.0
	Grassed Waterways	99.0
	Riparian Buffers, 50 ft wide (Pasture)	1.0
315	Drainage Side Inlet Improvements	1763.0
	Grassed Waterways	543.0
	Saturated Buffer	187.0

Results are reported for the edge of field and for each HSPF model subwatershed outlet (Table 1, Figure 1). Potential reductions at the edge of field are generally higher than those at the subwatershed outlets because of fate and transport losses within the channel. At the edge of field, only nonpoint sources from pervious and impervious areas are considered for pollutant loading. At the subwatershed outlet, point sources, atmospheric deposition, and other instream processes (bed scour and bank erosion) are considered. Channels are generally considered nutrient sinks (for inorganic N or P) because of consumption by benthic algae and other microorganisms; however, they may also be considered sediment sources because of bed scour and bank erosion.

Flow

Generally, BMPs do not result in substantial changes in long-term annual average total flow volume. The potential annual percent reduction in flow/discharge after BMP application, compared with the base model (without BMPs), ranged from 0.2% (313) to 1.1% (311) at the edge of field. At the subwatershed outlets, the range was 0.5% (315) to 1.1% (311) (Figures 2-4). This is equivalent to a potential annual flow reduction of 13.44 to 62.73 ac-ft/yr at the edge of field and 56.95 to 76.3 ac-ft/yr at the subwatershed outlets across the three reaches (Appendix Table 4). The potential impacts of BMPs in the upstream reaches are shown in Figure 18, where fate and transport losses are carried through to the watershed outlet.

It is worth noting that this flow analysis did not examine changes in high- and low-flow characteristics. It is possible that total volume has not changed substantially and that BMPs have nonetheless reduced peak-flow volumes and increased low-flow volumes, thereby resulting in minimal net monthly or annual flow change. However, these types of changes, if realized, may have significant impacts on biological communities and pollutant transport. Examination of high- and low-flow events is outside the scope of this study but may be a subject for future analysis.

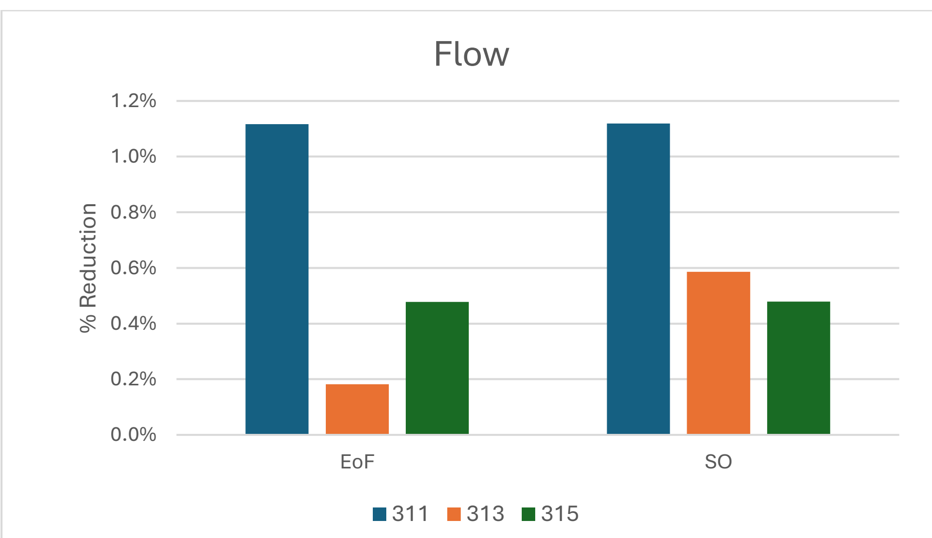


Figure 2: Potential % flow reduction after BMP application. Results are presented at the edge of field (EoF) and at the subwatershed outlet (SO).

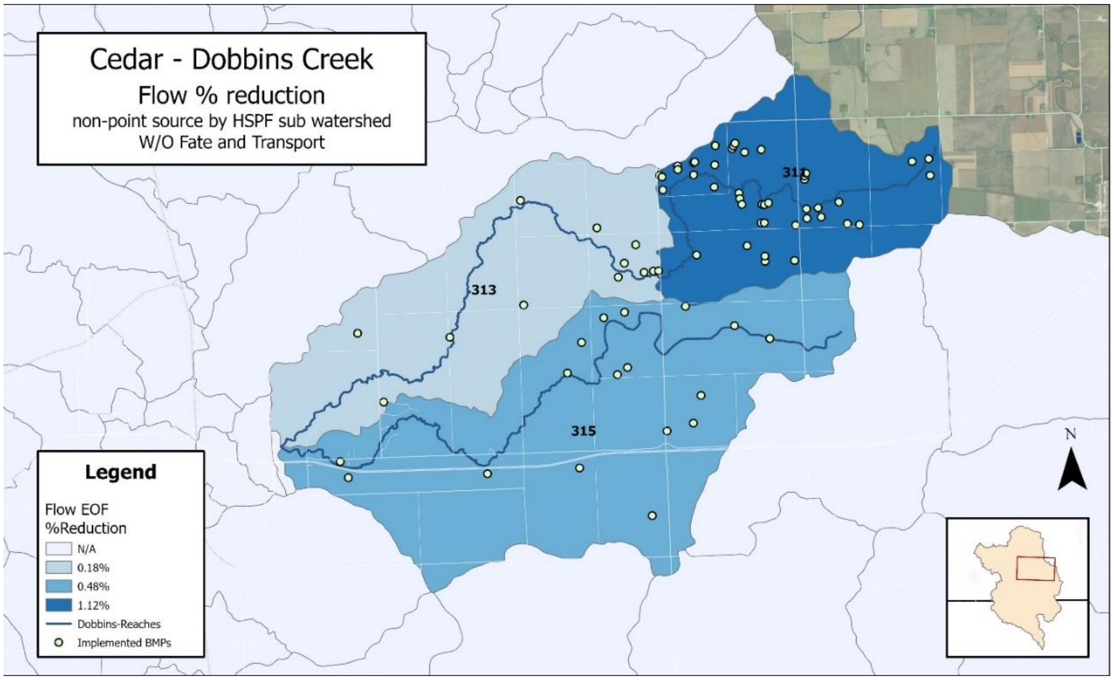


Figure 3: Potential % flow reduction at the edge of field

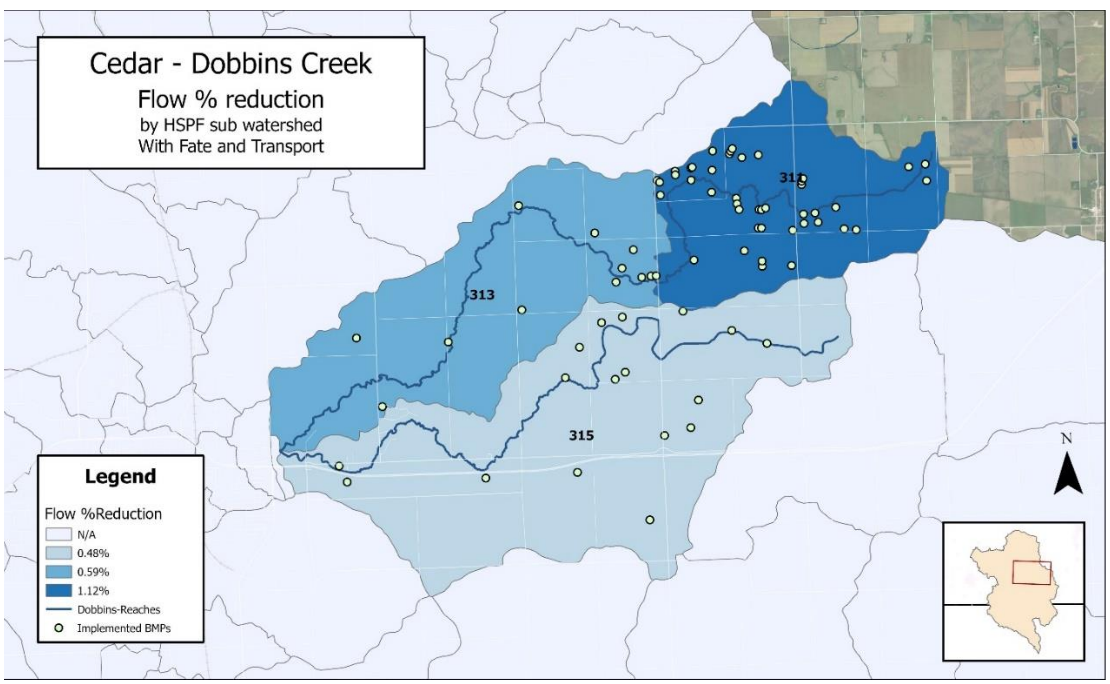


Figure 2: Potential % flow reduction at the subwatershed outlet

Percent flow reduction showed variable monthly trends between the two scenarios (pre- and post-BMP application) (Figure 5). The highest percent flow reduction was observed in March (Reach 311: 2.3%; Reach 313: 1.2%; Reach 315: 1.1%), followed by February and

September in all three reaches. Comparisons of monthly flow (ac-ft/month) between the two scenarios for all three reaches are reported in Figures 22-24 (Appendix).

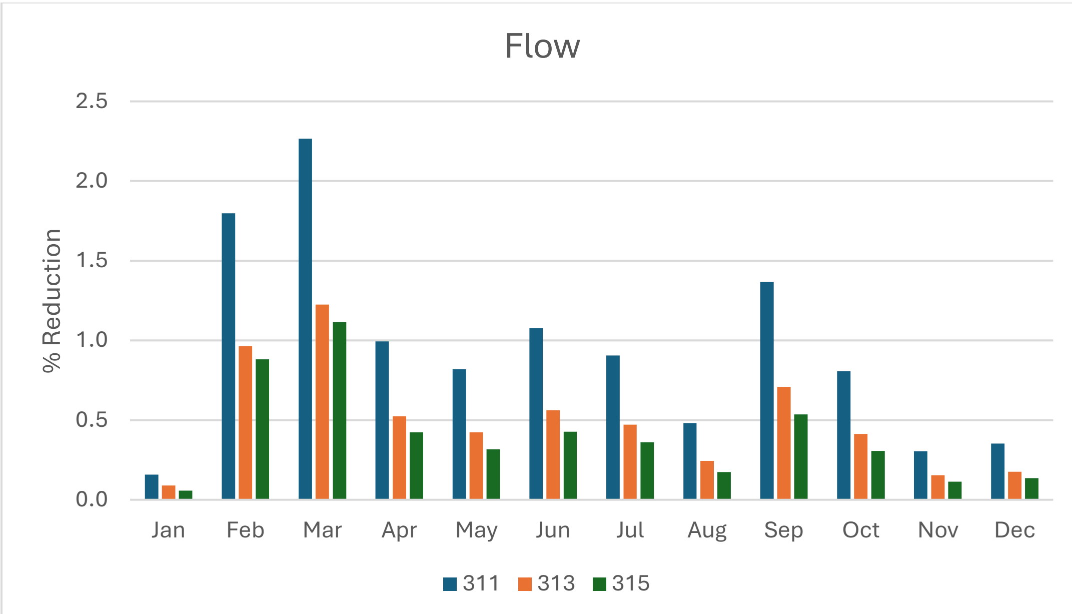


Figure 3: Monthly % flow reduction at the subwatershed outlet

TN

In HSPF, TN is calculated by adding dissolved ammonia and nitrate+nitrite to labile and refractory organic nitrogen. Considering the two scenarios (base and BMP applied), the highest potential edge-of-field TN load reduction was observed in subwatershed 311 (4.6%), and the lowest was 1.4% in subwatershed 313 (Figures 6-8). A similar trend is observed at the three subwatershed outlets, where load reduction varied from 2.5% to 4.4%. Subwatershed 311 has nearly 45% of its cropland area covered by BMP treatments, which may directly explain the higher reduction rates. These reductions are equivalent to TN load reductions ranging from 2,616.48 lbs/yr to 8,318.24 lbs/yr at the edge of field and from 6,322.86 lbs/yr to 7,638.25 lbs/yr at the subwatershed outlets across the three reaches (Appendix Table 4). Notably, the highest absolute load reduction does not necessarily correspond to the highest percent reduction because of differences in subwatershed size, agricultural practices, and implemented BMPs. Figure 19 (Appendix) shows the potential impact of BMPs in the upstream reaches and their downstream effects as fate and transport are carried to the watershed outlet.

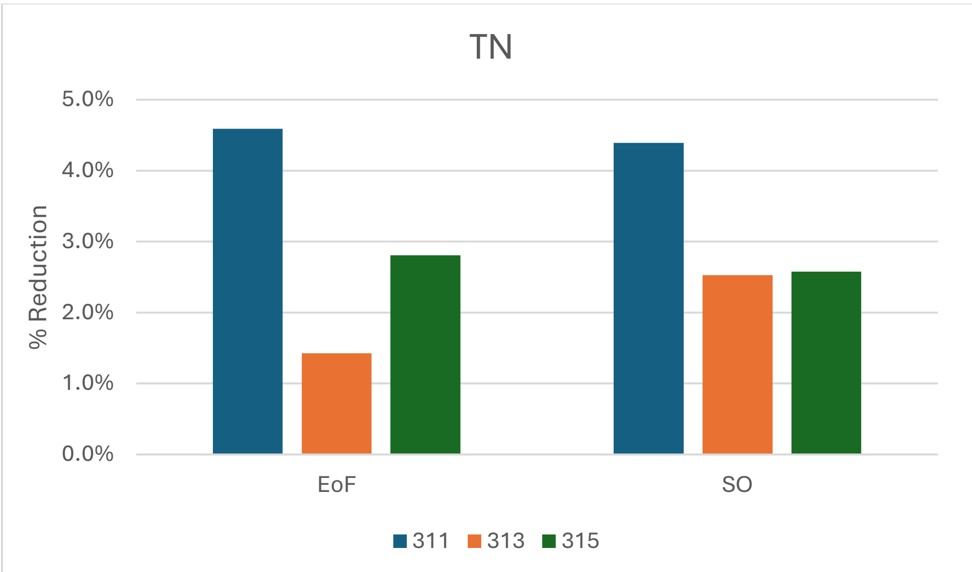


Figure 4: Potential % load reduction of TN after BMP application

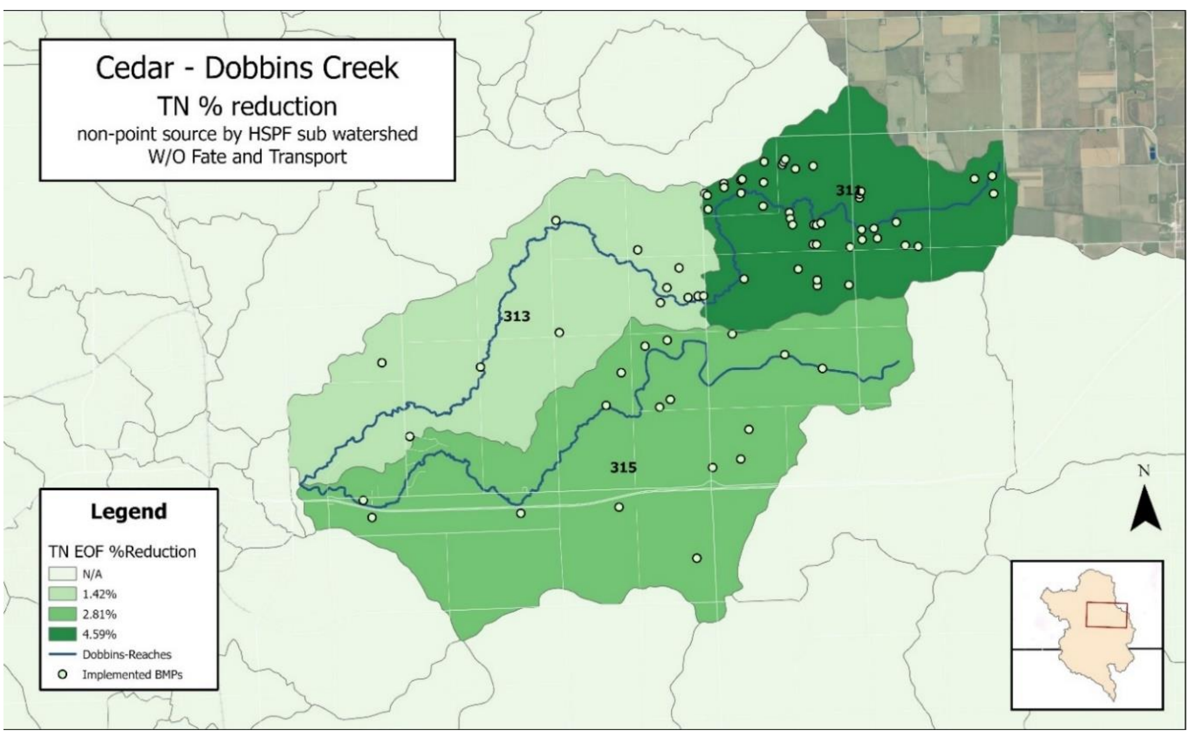


Figure 5: Potential % load reduction of TN from the edge of the field

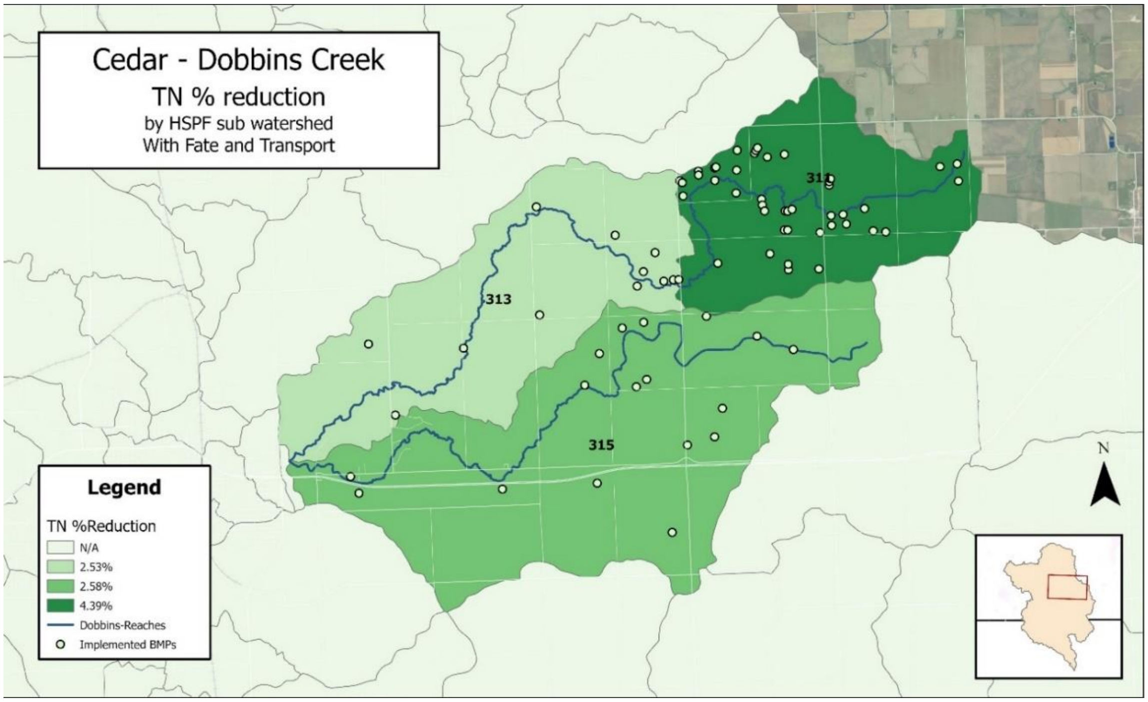


Figure 6: Potential % load reduction of TN at the HSPF subwatershed outlets

Percent TN load reduction showed variable monthly trends between the two scenarios (pre- and post-BMP application). The highest TN load reduction was observed in March (Reach 311: 6.3%; Reach 313: 3.8%; Reach 315: 3.7%), followed by September and October in all three reaches (Figure 9). Comparisons of monthly TN load (lbs/month) between the two scenarios for all three subwatershed outlets are reported in Figures 25-27.

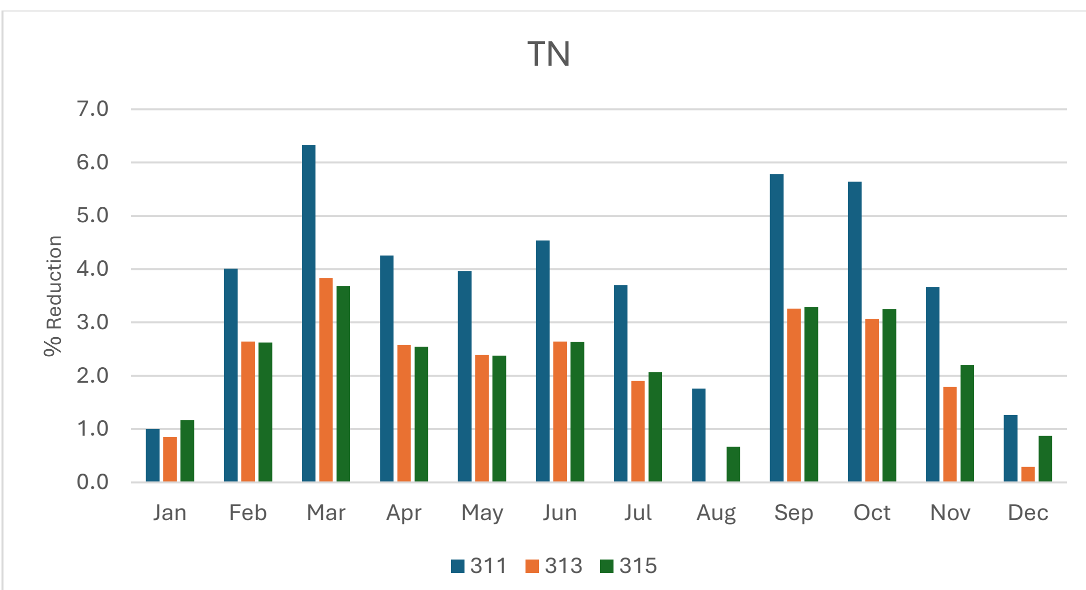


Figure 7: Monthly % load reduction of TN at the subwatershed outlets

TP

In HSPF, TP is calculated by adding dissolved and particulate orthophosphate to labile and refractory organic phosphorus. Considering the two scenarios (base and BMP applied), the highest potential edge-of-field TP load reduction was observed in subwatershed 311 (21%), and the lowest was 4.6% in subwatershed 313 (Figures 10-12). A similar trend is observed at the three subwatershed outlets, where load reduction varied from 13% (313, 315) to 22% (311). Notably, subwatershed 313, which is downstream of subwatershed 311, shows a relatively low percent load reduction at the edge of field but a relatively high percent reduction at the subwatershed outlet because upstream BMP treatments in subwatershed 311 reduce some of the incoming loads before they cross the boundary/outlet of 311. The high reduction efficiency in subwatershed 311 may be directly associated with the fact that nearly 45% of its cropland area is covered by BMP treatments. The higher reduction rate for TP than for TN may also be associated with the fact that the system contains nearly 30 times more TN load than TP load. These reductions are equivalent to TP load reductions ranging from 284.94 lbs/yr to 1,204.12 lbs/yr at the edge of field and from 971.04 lbs/yr to 1,093.06 lbs/yr at the subwatershed outlets across the three reaches (Appendix Table 4). Notably, the highest absolute load reduction does not necessarily correspond to the highest percent reduction because of differences in subwatershed size, agricultural practices, and implemented BMPs. Figure 20 (Appendix) shows the potential impact of BMPs in the upstream reaches and their downstream effects as fate and transport are carried to the watershed outlet.

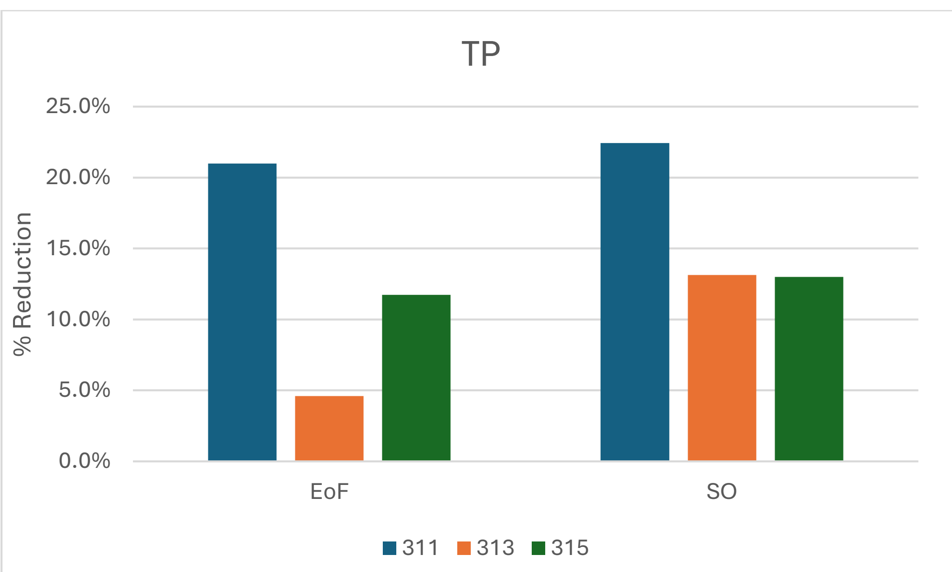


Figure 8: Potential % load reduction of TP after BMP application

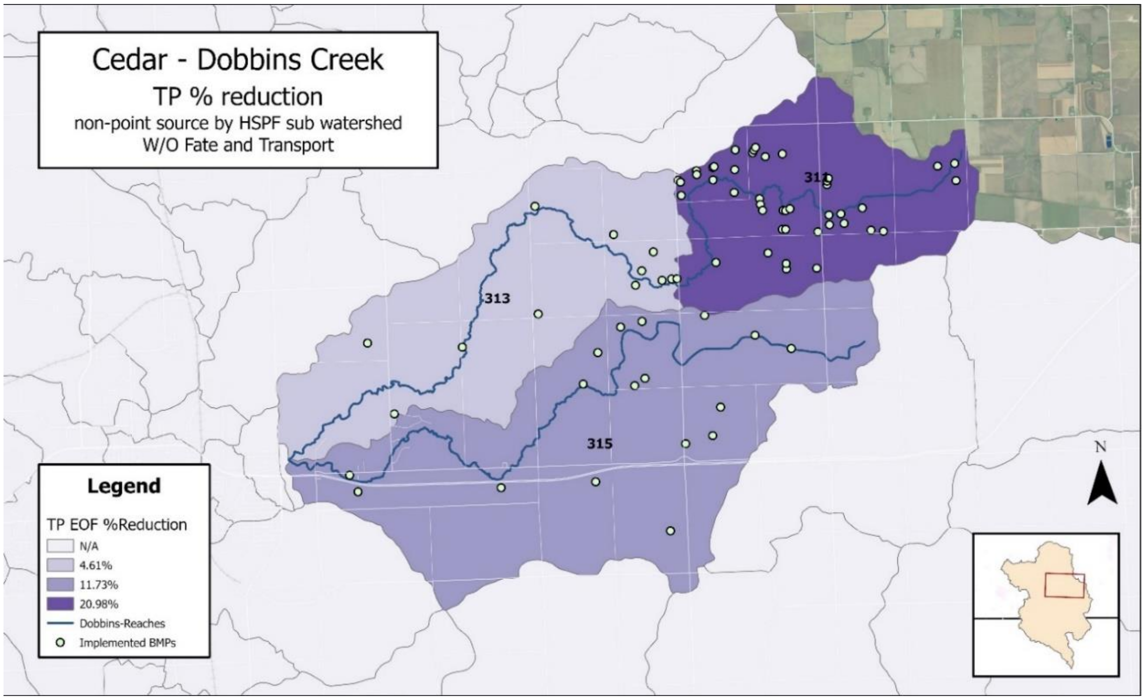


Figure 11: Potential % load reduction of TP from the edge of the field

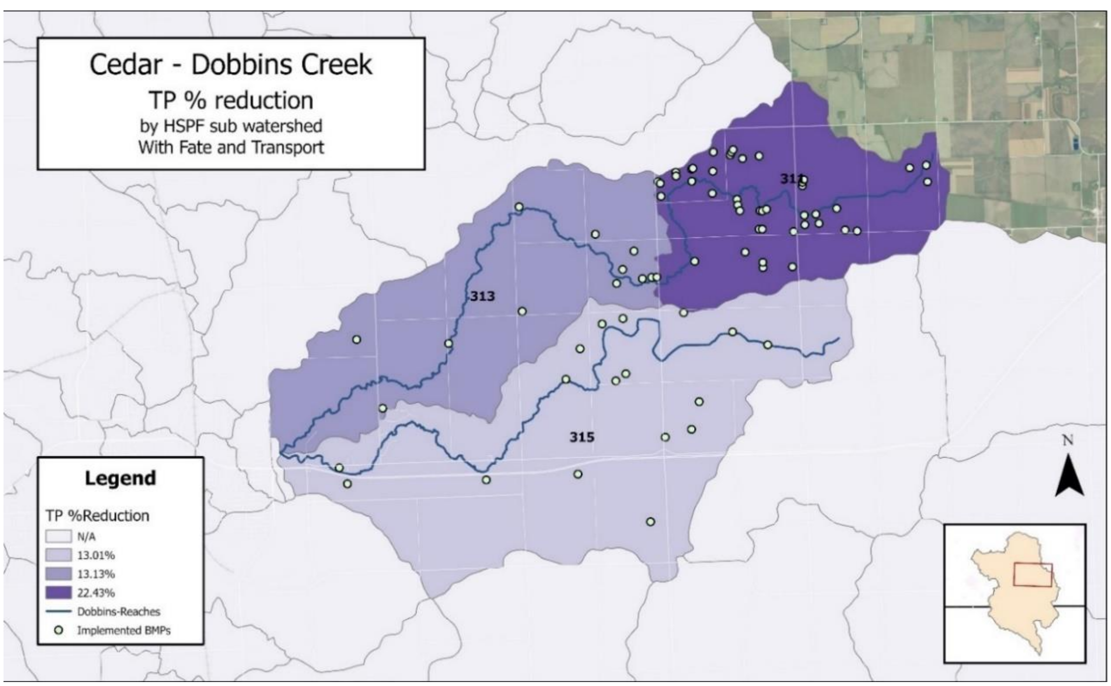


Figure 12: Potential % load reduction of TP at the HSPF subwatershed outlet

Percent TP load reduction showed variable monthly trends between the two scenarios (pre- and post-BMP application). The highest TP load reduction was observed in March (Reach 311: 23.5%; Reach 313: 14.3%; Reach 315: 14.0%), followed by June and July in all three reaches (Figure 13). Comparisons of monthly TP load (lbs/month) between the two scenarios for all three subwatershed outlets are reported in Figures 28-30.

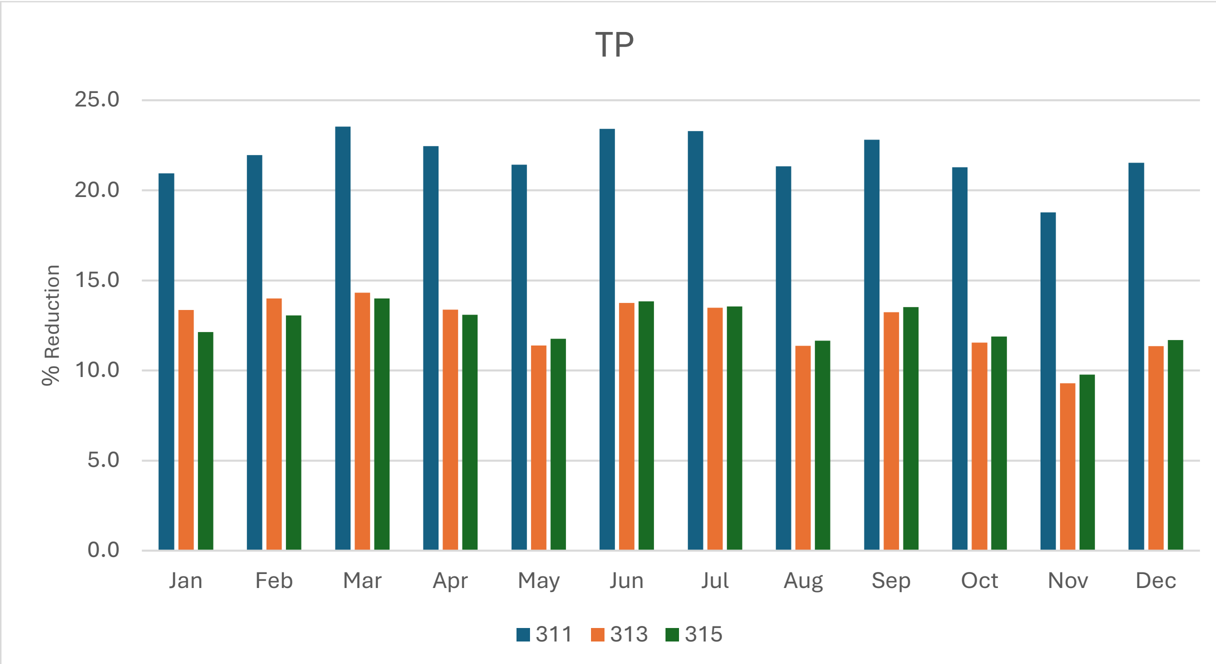


Figure 9: Monthly % load reduction of TP at the subwatershed outlets

TSS

Considering the two scenarios (base and BMP applied), the highest potential edge-of-field TSS load reduction was observed in subwatershed 311 (24%), and the lowest was 5.6% in subwatershed 313 (Figures 14-16). A similar trend is observed at the three subwatershed outlets, where load reduction varied from 7.1% to 16.4%. The lower reduction rate at the subwatershed outlets is directly associated with fate and transport losses from the edge of field to the subwatershed outlet. Like the other two nutrients, subwatershed 311 shows the highest TSS load reduction. This subwatershed also has the largest area coverage (45%) under BMP treatments. These reductions are equivalent to TSS load reductions ranging from 10.9 tons/yr to 42.33 tons/yr at the edge of field and from 38.27 tons/yr to 49.06 tons/yr at the subwatershed outlets across the three reaches (Appendix Table 4). Notably, the highest absolute load reduction does not necessarily correspond to the highest percent reduction because of differences in subwatershed size, agricultural practices, and implemented BMPs. Figure 21 (Appendix) shows the potential impact of BMPs in the upstream reaches and their downstream effects as fate and transport are carried to the watershed outlet.

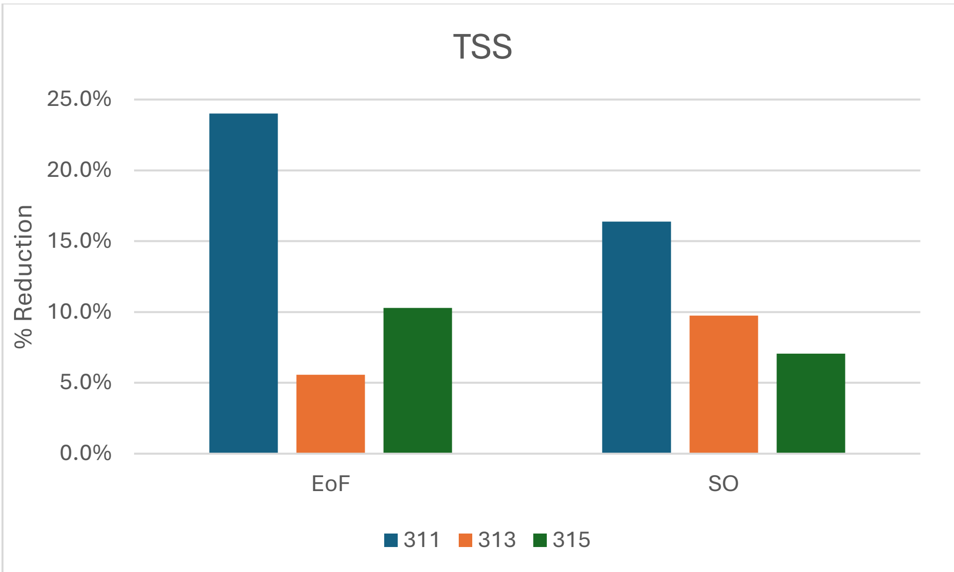


Figure 10: Potential % load reduction of TSS after BMP application

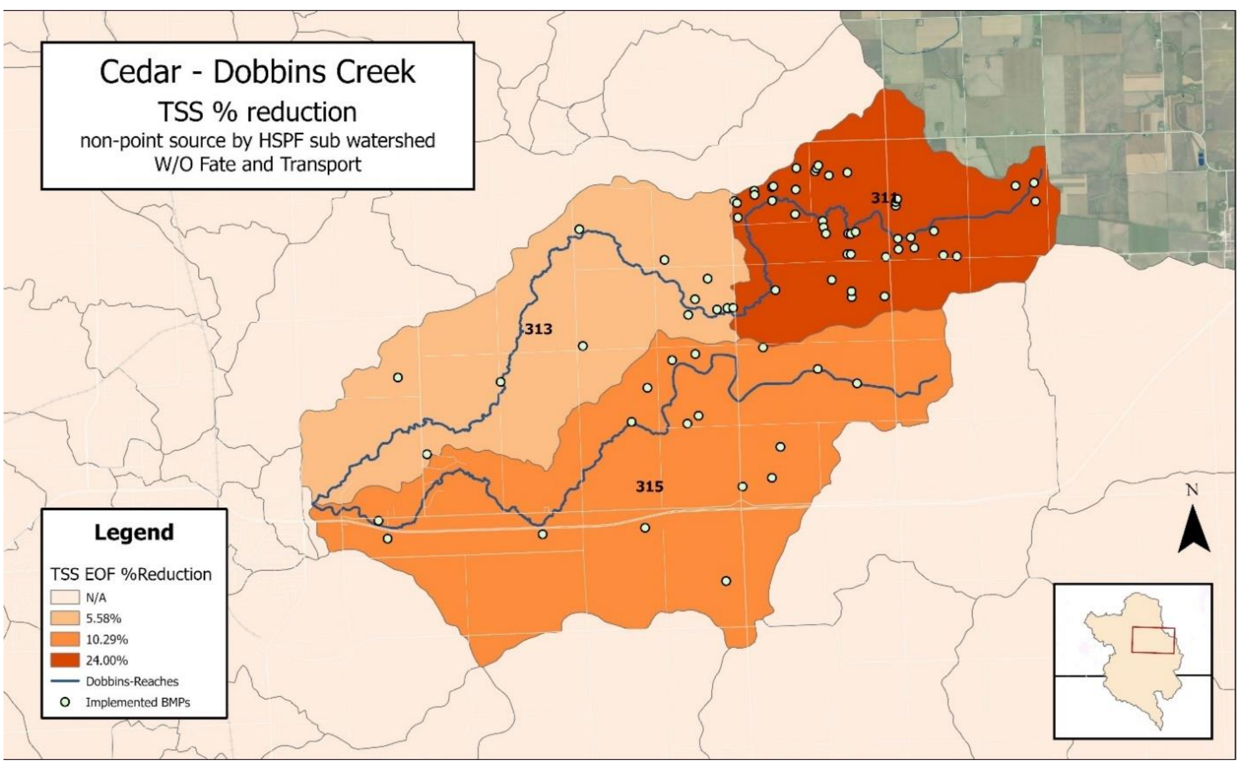


Figure 15: Potential % load reduction of TSS from the edge of the field

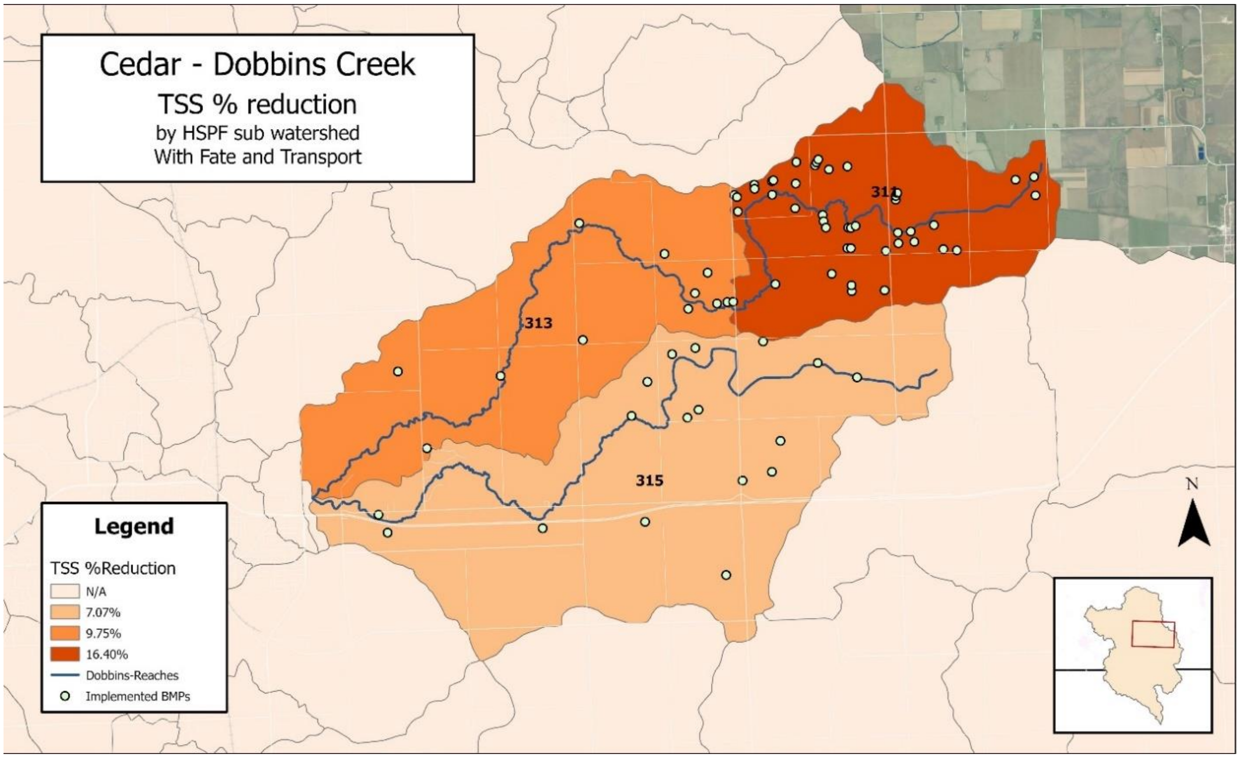


Figure 16: Potential % load reduction of TSS at the HSPF subwatershed outlet

Percent TSS load reduction showed variable monthly trends between the two scenarios (pre- and post-BMP application). The highest TSS load reduction was observed in July (Reach 311: 23%; Reach 313: 13.8%; Reach 315: 11%), followed by February and September in all three reaches (Figure 17). Comparisons of monthly TSS load (lbs/month) between the two scenarios for all three subwatershed outlets are reported in Figures 31-33.

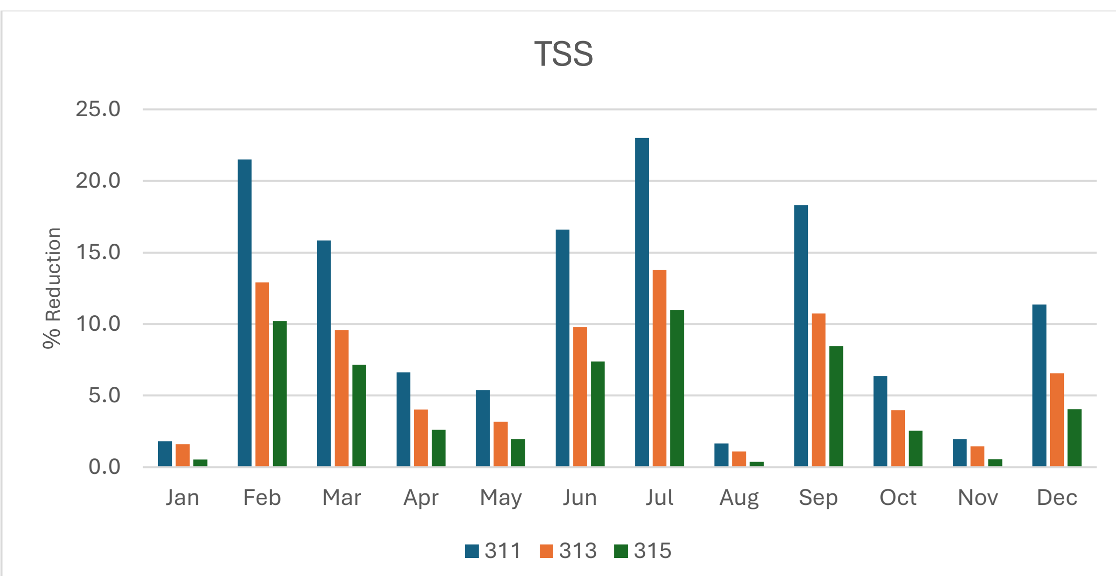


Figure 11: Monthly % load reduction of TSS at the subwatershed outlets

Appendix

*Table 3: Reduction efficiency of BMPs used in SAM (**Installed in Dobbins Creek**)*

Constituents	**Flow**	**TN**			**TP**			**TSS**
Flow Path	**Surface**	**Surface**	**Interflow**	**Baseflow**	**Surface**	**Interflow**	**Baseflow**	**Surface**
Tile Line Bioreactors	0%	0%	22%	0%	0%	0%	0%	0%
Restore Tiled Wetlands (Cropland)	30%	52%	52%	0%	43%	43%	0%	75%
Controlled Tile Drainage	30%	0%	43%	0%	0%	43%	0%	0%
Saturated Buffer	***20%***	***0%***	***45%***	***0%***	***0%***	***0%***	***0%***	***0%***
Ditch Buffers, 16.5 ft wide (replacing row crops)	5%	43%	0%	35%	50%	0%	0%	74%
Riparian Buffers, 50 ft wide (replacing row crops)	7%	66%	0%	35%	67%	0%	0%	84%
Riparian Buffers, 100 ft wide (replacing row crops)	10%	79%	0%	35%	80%	0%	0%	90%
Riparian Buffers, 50 ft wide (Pasture)	***5%***	***44%***	***0%***	***23%***	***45%***	***0%***	***0%***	***50%***
Conservation Crop Rotation	10%	42%	42%	42%	30%	0%	0%	50%
Conservation Cover Perennials	***15%***	***91%***	***93%***	***93%***	***84%***	***0%***	***0%***	***96%***
Corn & Soybeans to Rotational Grazing	0%	75%	75%	75%	59%	0%	0%	75%
Corn & Soybeans with Cover Crop	***10%***	***28%***	***28%***	***28%***	***29%***	***0%***	***0%***	***74%***
Short Season Crops with Cover Crop	10%	43%	43%	43%	29%	0%	0%	74%
Water and Sediment Control Basin (Cropland)	***0%***	***82%***	***0%***	***0%***	***85%***	***0%***	***0%***	***90%***
Terrace	10%	38%	0%	0%	75%	0%	0%	87%
Grassed Waterways	***10%***	***25%***	***0%***	***0%***	***45%***	***0%***	***0%***	***62%***
Filter Strips, 50 ft wide (Cropland field edge)	2%	66%	0%	35%	67%	0%	0%	84%
Contour Buffer Strips	10%	50%	27%	27%	62%	0%	0%	75%
Contour Stripcropping	10%	37%	20%	20%	44%	0%	0%	70%
Feedlot Manure/Runoff Storage	90%	90%	0%	0%	90%	0%	0%	90%
Feedlot Runoff Reduction/Treatment	75%	75%	0%	0%	75%	0%	0%	70%
Nutrient Management: Precision/Variable Rate	0%	10%	26%	26%	15%	5%	0%	0%

Constituents	Flow	TN			TP			TSS
Flow Path	**Surface**	**Surface**	**Interflow**	**Baseflow**	**Surface**	**Interflow**	**Baseflow**	**Surface**
Nutrient Management: Improved Rates/Timing	0%	10%	13%	13%	10%	5%	0%	0%
Manure/Fertilizer Incorporation (no surface spreading)	0%	29%	5%	5%	35%	0%	0%	0%
Alternative Tile Intakes	5%	66%	0%	0%	66%	0%	0%	90%
Drainage Side Inlet Improvements	***5%***	***60%***	***0%***	***0%***	***61%***	***0%***	***0%***	***65%***
Traditional Pasture to Rotational Grazing	10%	62%	0%	10%	65%	0%	0%	60%
Livestock Access Control/Fencing (to waters)	10%	55%	0%	0%	65%	0%	0%	75%
Reduced Tillage (30%+ residue cover)	5%	33%	0%	0%	33%	0%	0%	50%
Reduced Tillage (no-till)	8%	79%	0%	0%	68%	0%	0%	80%
Forestry Erosion Control	25%	0%	0%	0%	0%	0%	0%	75%
Forestry Riparian Management Zones	5%	70%	0%	0%	70%	0%	0%	70%
Streambank/In-Channel Restoration	0%	90%	0%	0%	90%	0%	0%	90%
Constructed Stormwater Pond	90%	27%	0%	0%	36%	0%	0%	76%
Constructed Wetland	90%	27%	0%	0%	45%	0%	0%	66%
Infiltration Basin	90%	90%	0%	0%	90%	0%	0%	90%
Bioretention	90%	45%	0%	0%	40%	0%	0%	72%
Biofiltration	90%	45%	0%	0%	40%	0%	0%	72%
Permeable Pavement	90%	48%	0%	0%	45%	0%	0%	67%
Sand Filter	90%	28%	0%	0%	45%	0%	0%	77%

Table 4: Modeled potential annual load reduction from the three subwatersheds after BMP applications

Subwatershed	Flow (ac-ft/yr)		TN (lbs/yr)		TP (lbs/yr)		TSS (tons/yr)	
ID	**EoF**	**SO**	**EoF**	**SO**	**EoF**	**SO**	**EoF**	**SO**
311	62.73	62.86	7,212.30	6,322.86	1,082.69	971.04	40.75	38.27
313	13.44	76.30	2,616.48	7,638.25	284.94	1,093.06	10.90	49.06
315	56.84	56.95	8,318.24	6,820.69	1,204.12	1,021.11	42.33	39.91

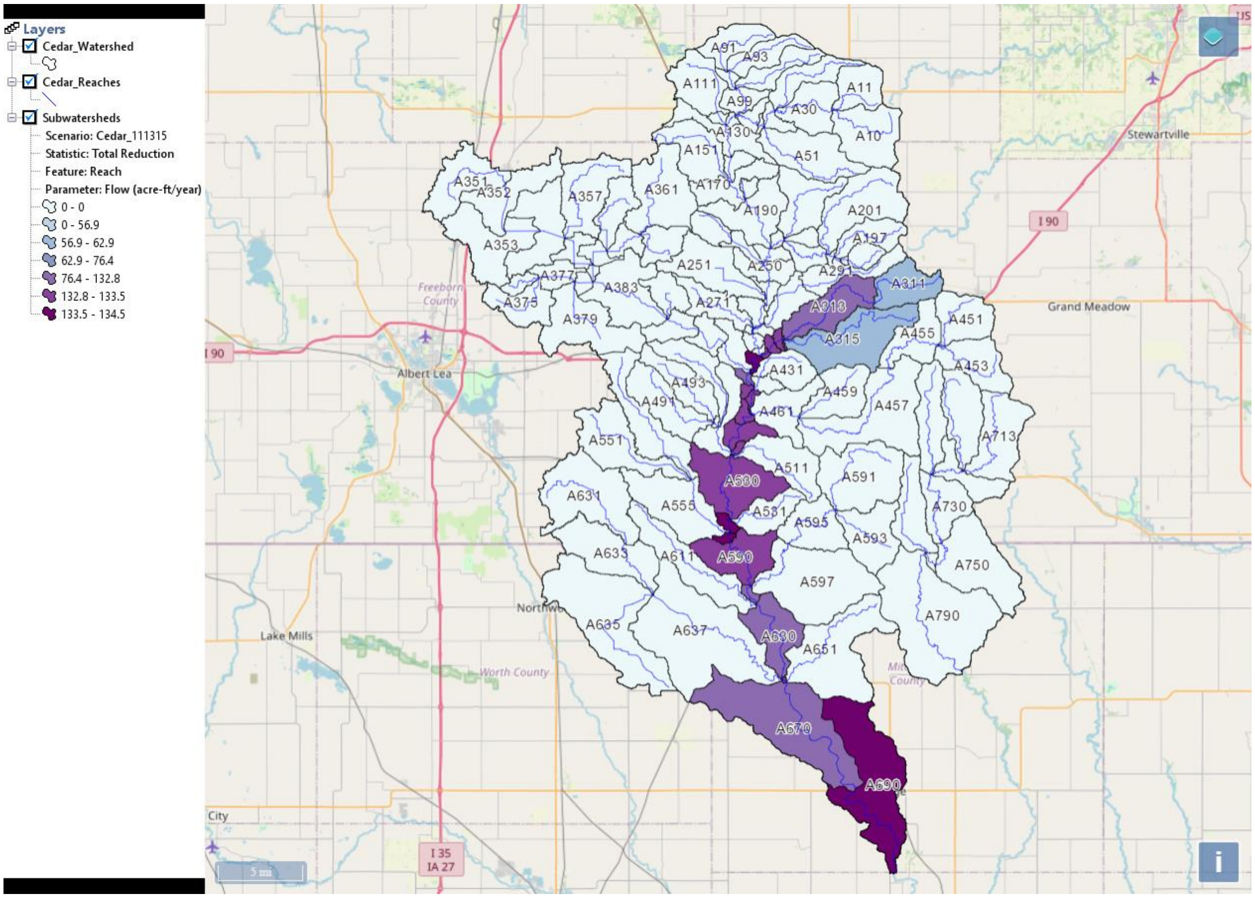


Figure 12: Potential annual flow reduction (ac-ft/yr) at the watershed after BMP installation at the three upstream reaches

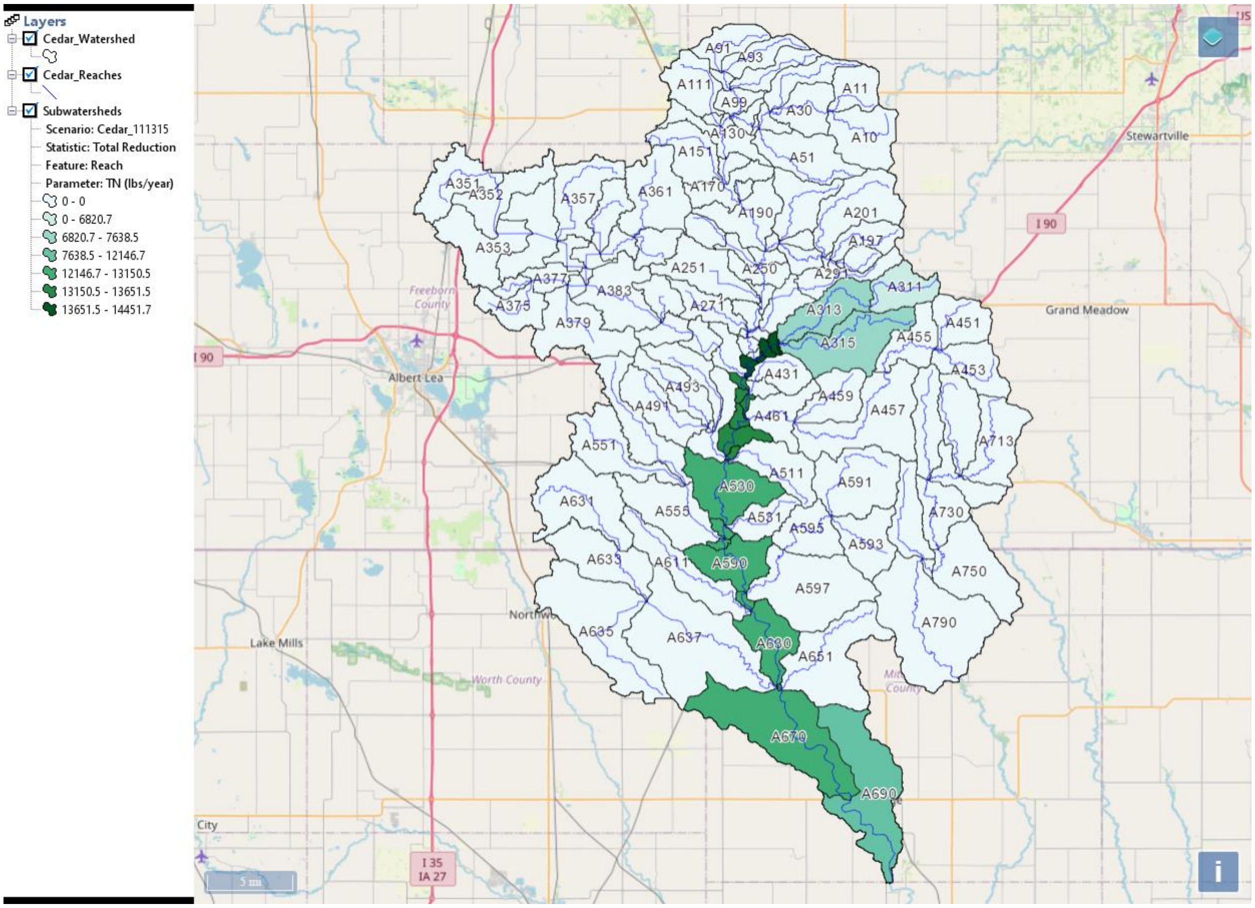


Figure 13: Potential annual TN load reduction (lbs/yr) at the watershed after BMP installation at the three upstream reaches

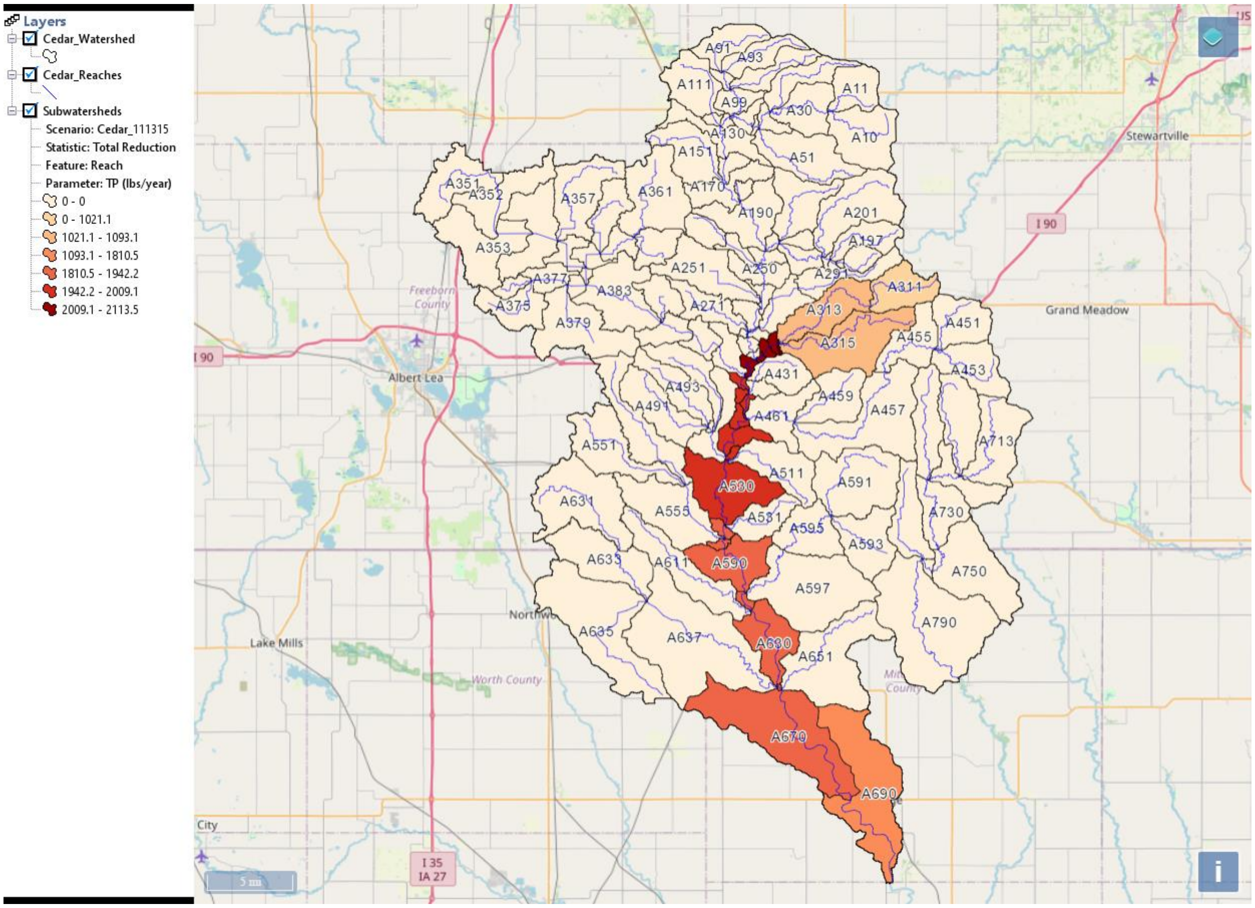


Figure 14: Potential annual TP load reduction (lbs/yr) at the watershed after BMP installation at the three upstream reaches

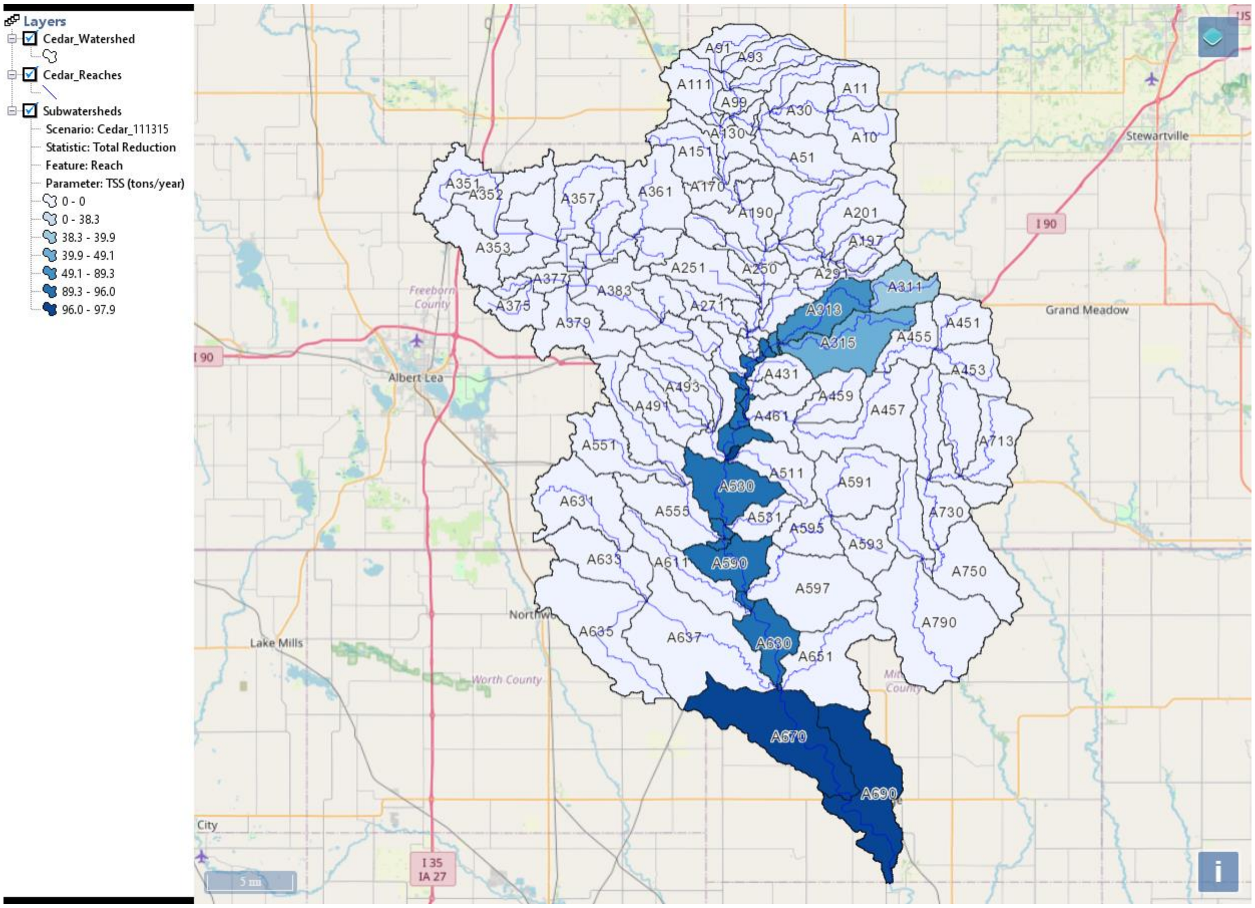


Figure 15: Potential annual TSS load reduction (tons/yr) at the watershed after BMP installation at the three upstream reaches

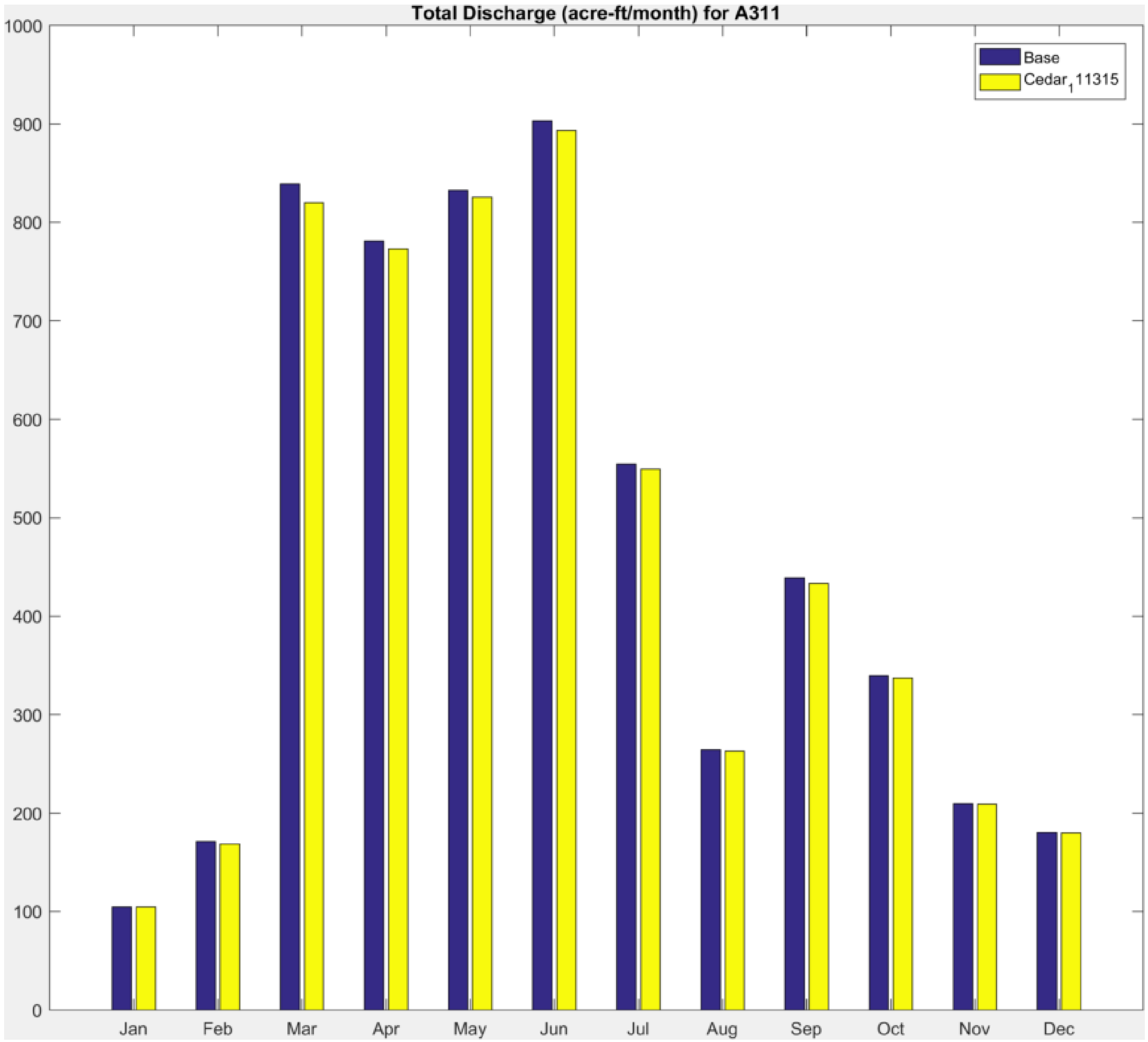


Figure 22: Comparison of monthly discharge from Reach 311 in pre- and post-BMP application scenarios

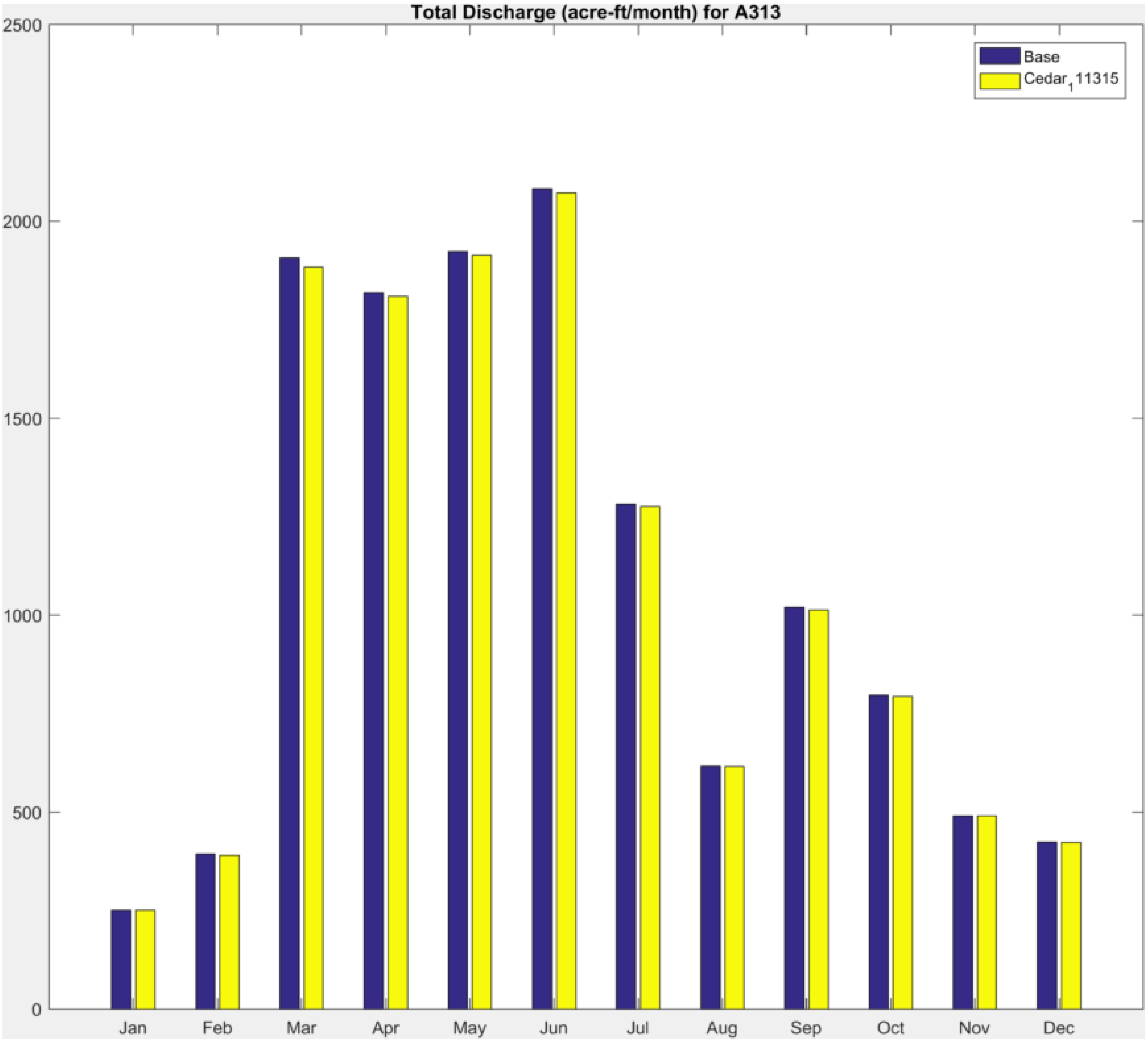


Figure 23: Comparison of monthly discharge from Reach 313 in pre- and post-BMP application scenarios

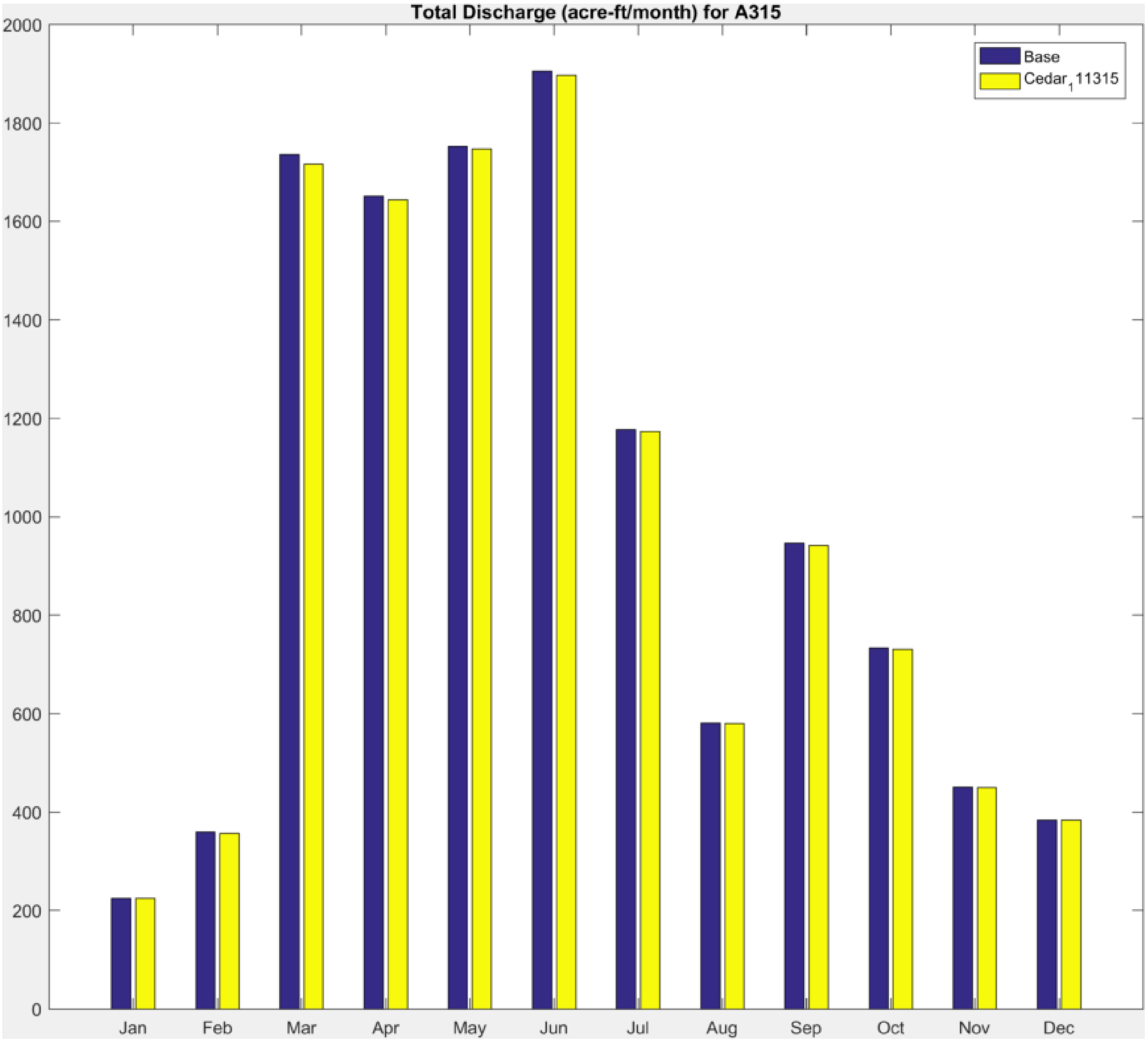


Figure 24: Comparison of monthly discharge from Reach 315 in pre- and post-BMP application scenarios

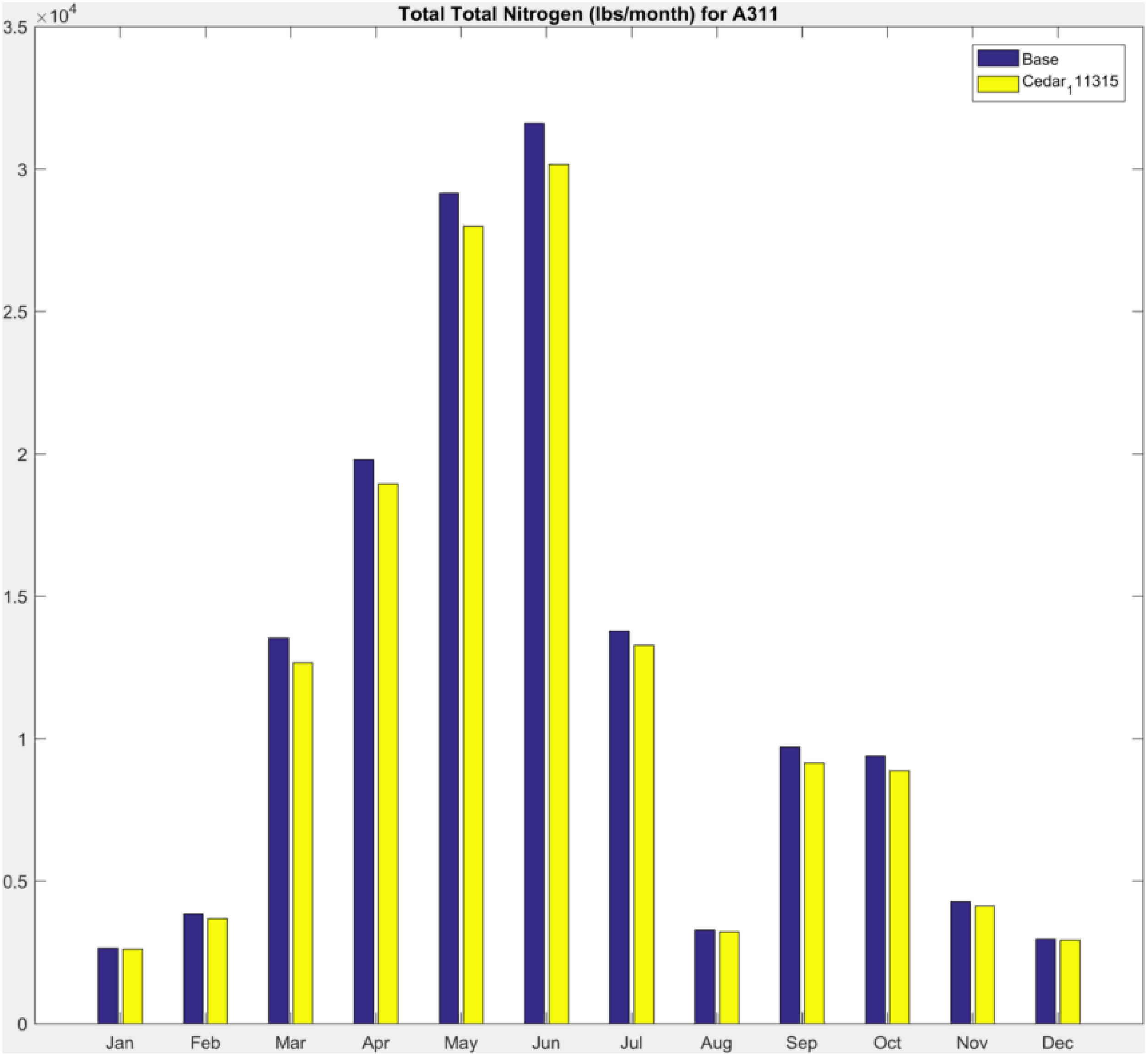


Figure 25: Comparison of monthly TN load from Reach 311 in pre- and post-BMP application scenarios

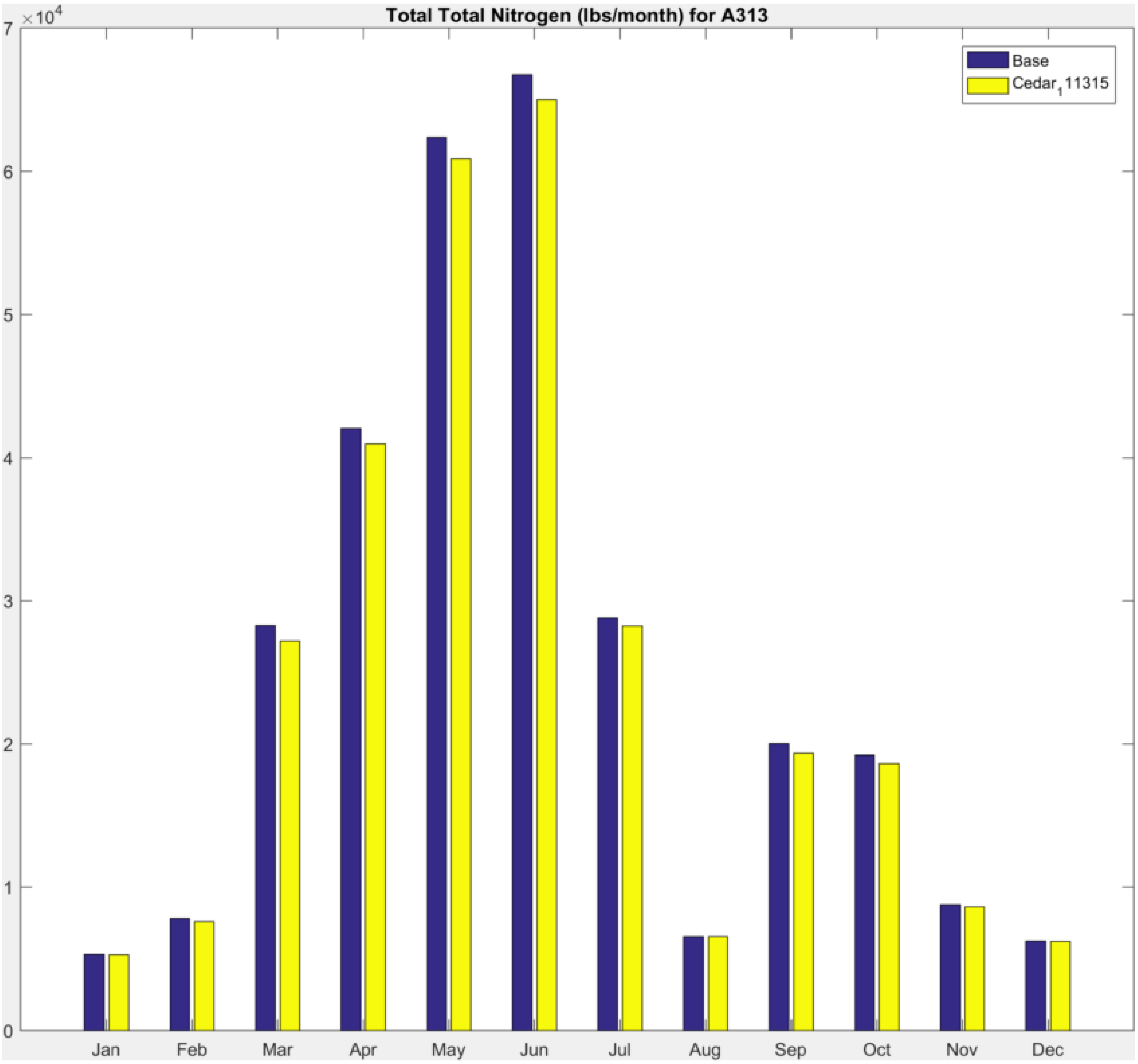


Figure 26: Comparison of monthly TN load from Reach 313 in pre- and post-BMP application scenarios

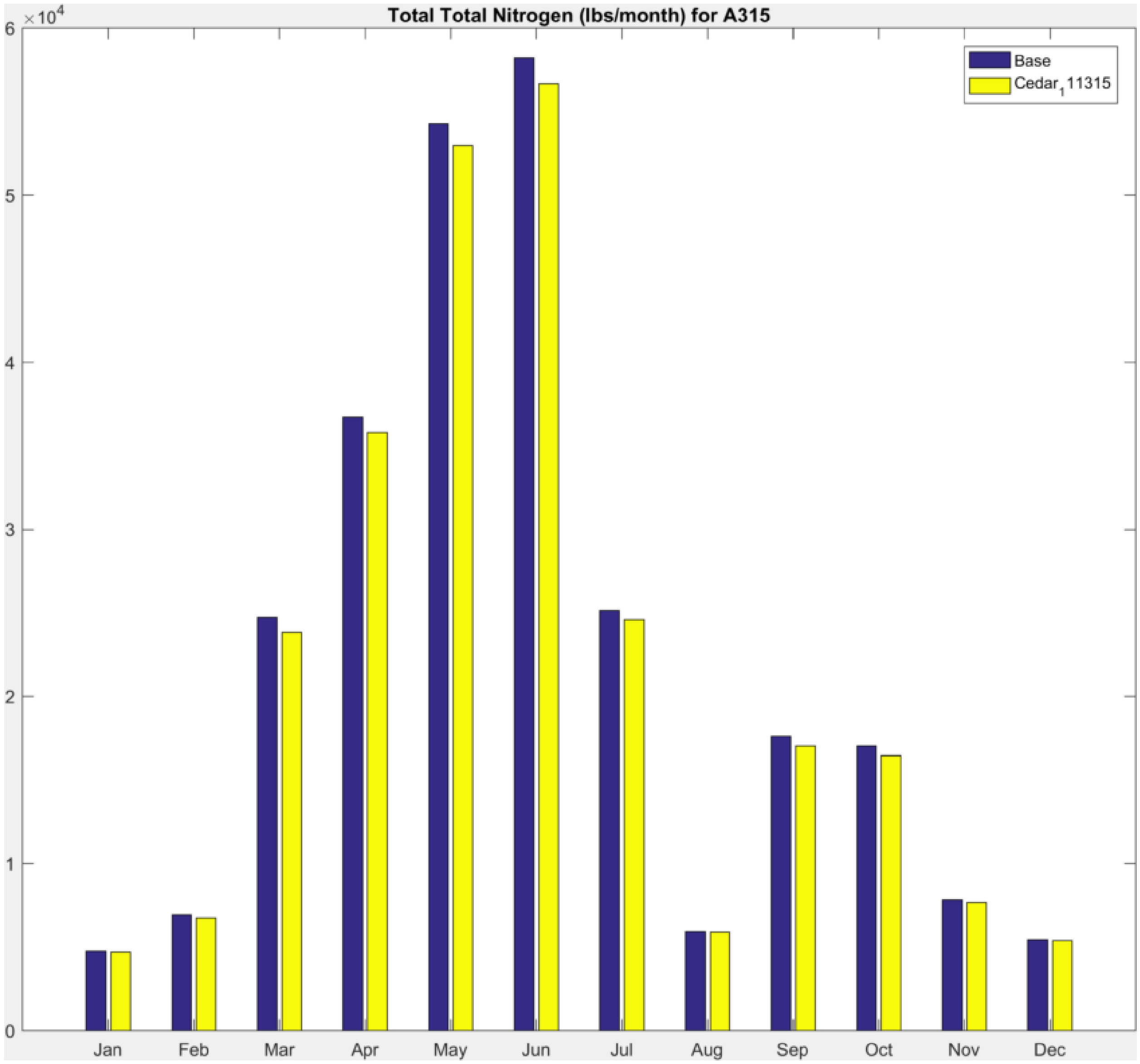


Figure 27: Comparison of monthly TN load from Reach 315 in pre- and post-BMP application scenarios

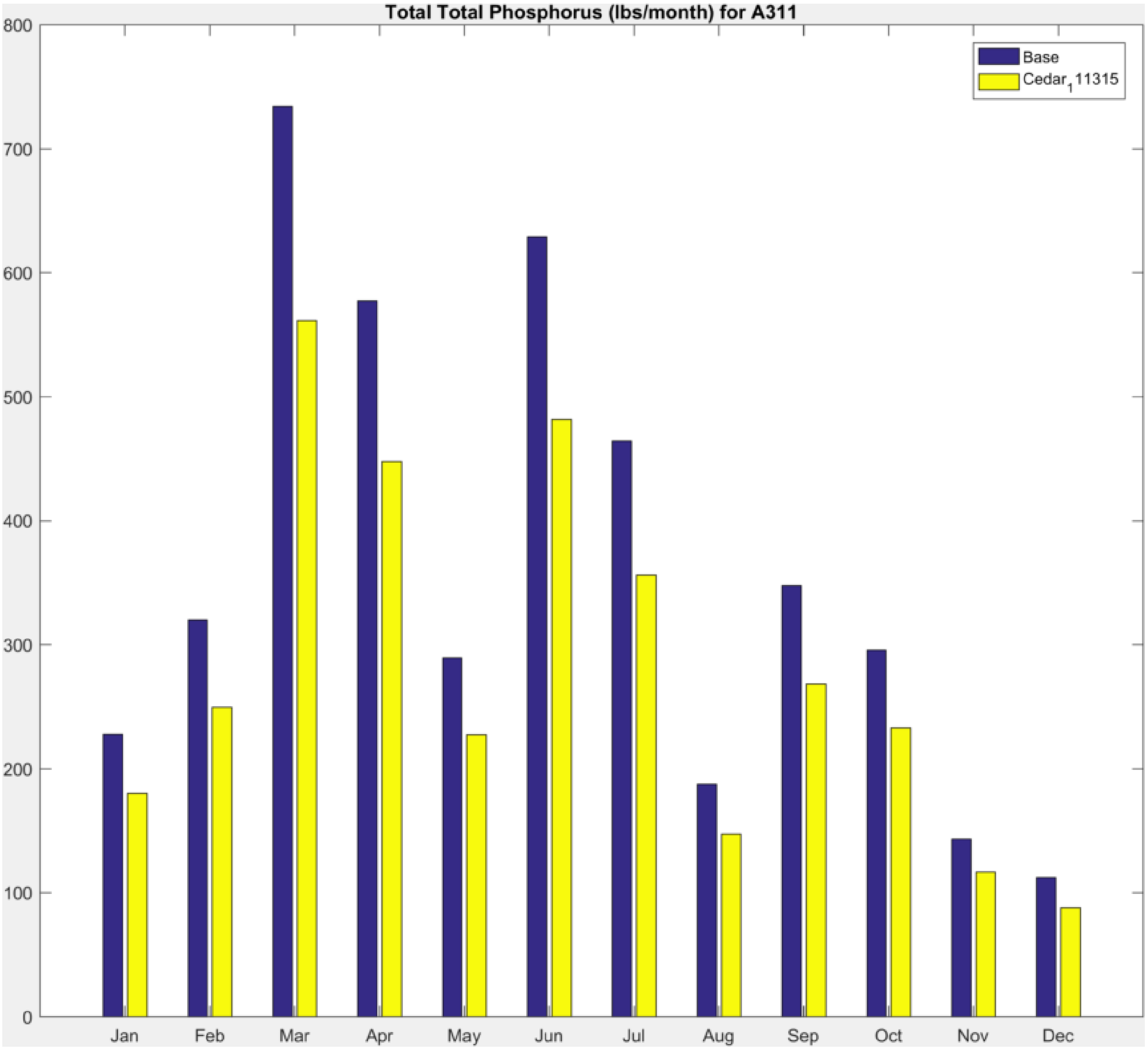


Figure 28: Comparison of monthly TP load from Reach 311 in pre- and post-BMP application scenarios

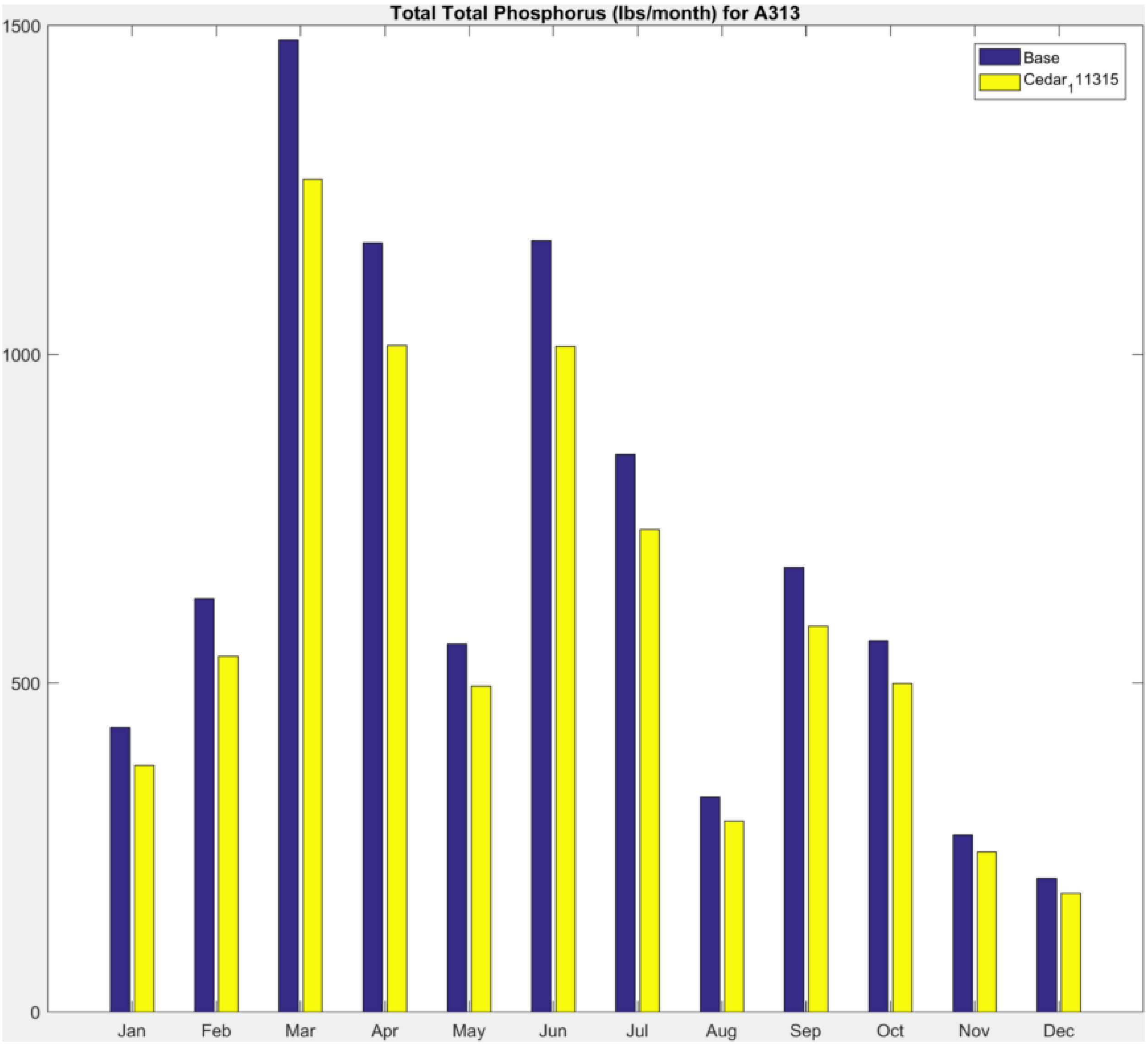


Figure 29: Comparison of monthly TP load from Reach 313 in pre- and post-BMP application scenarios

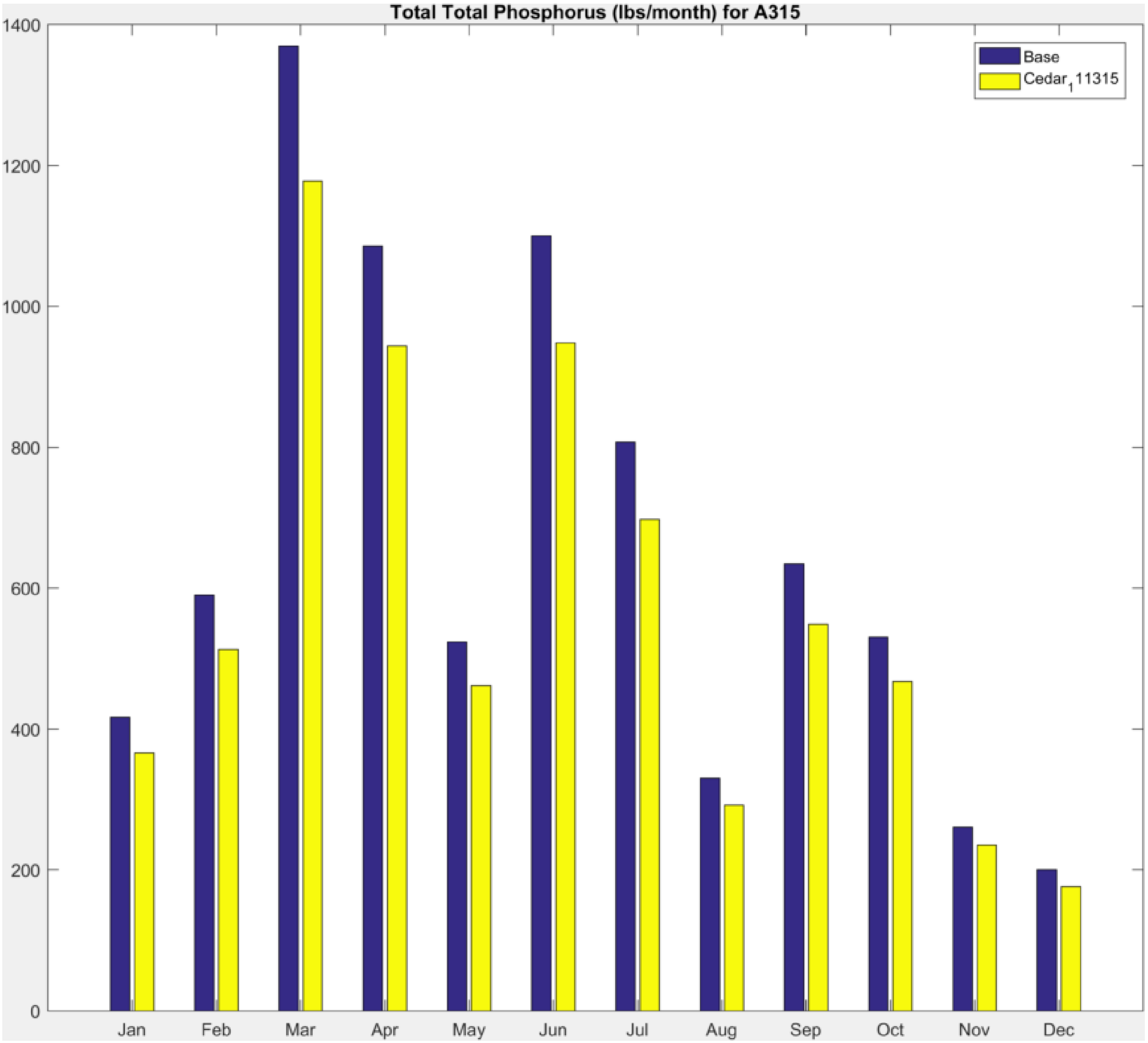


Figure 30: Comparison of monthly TP load from Reach 315 in pre- and post-BMP application scenarios

Figure 31: Comparison of monthly TSS load from Reach 311 in pre- and post-BMP application scenarios

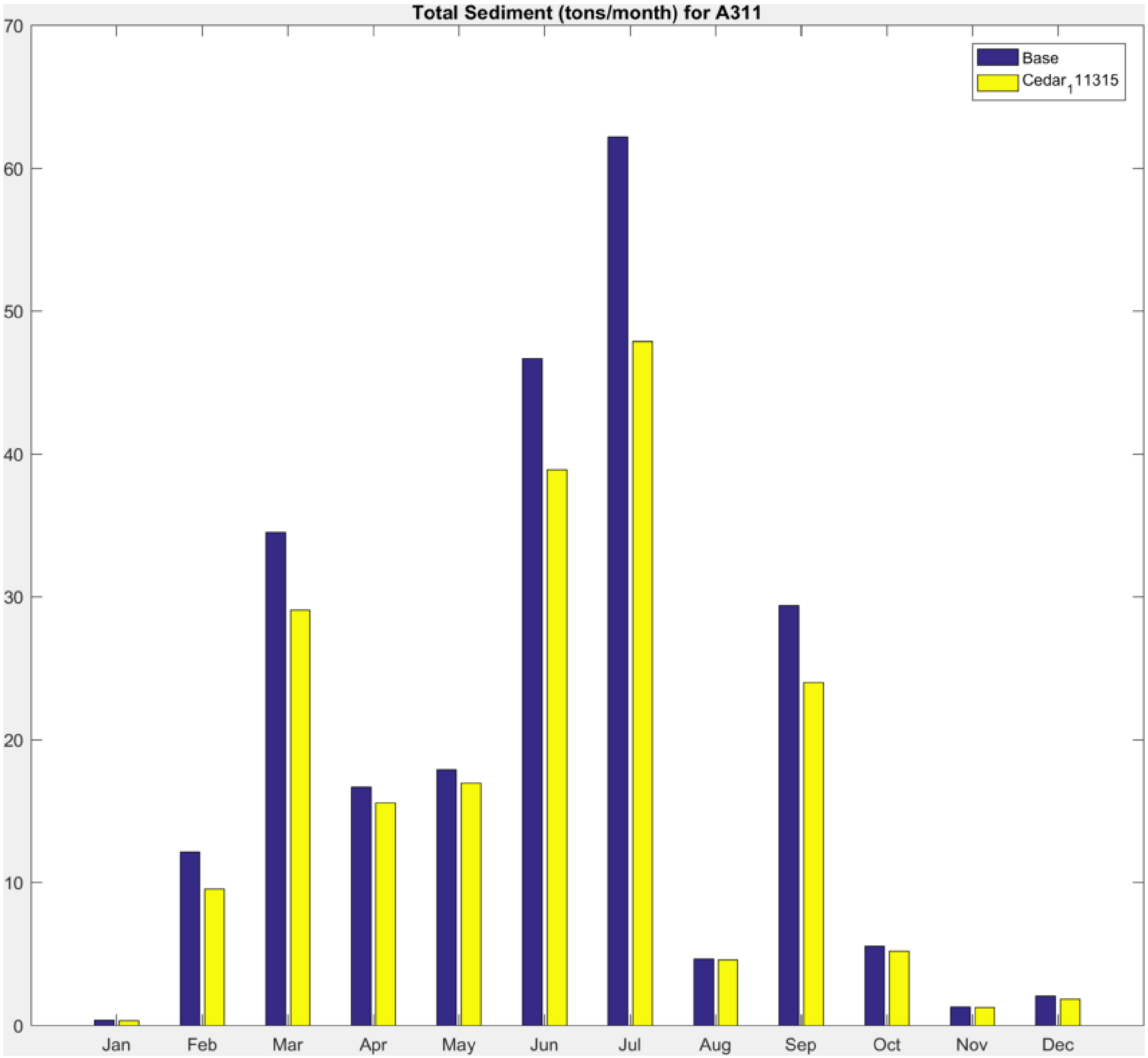


Figure 16: Comparison of monthly TSS load from Reach 311 in pre and post BMP application scenarios

Figure 32: Comparison of monthly TSS load from Reach 313 in pre- and post-BMP application scenarios

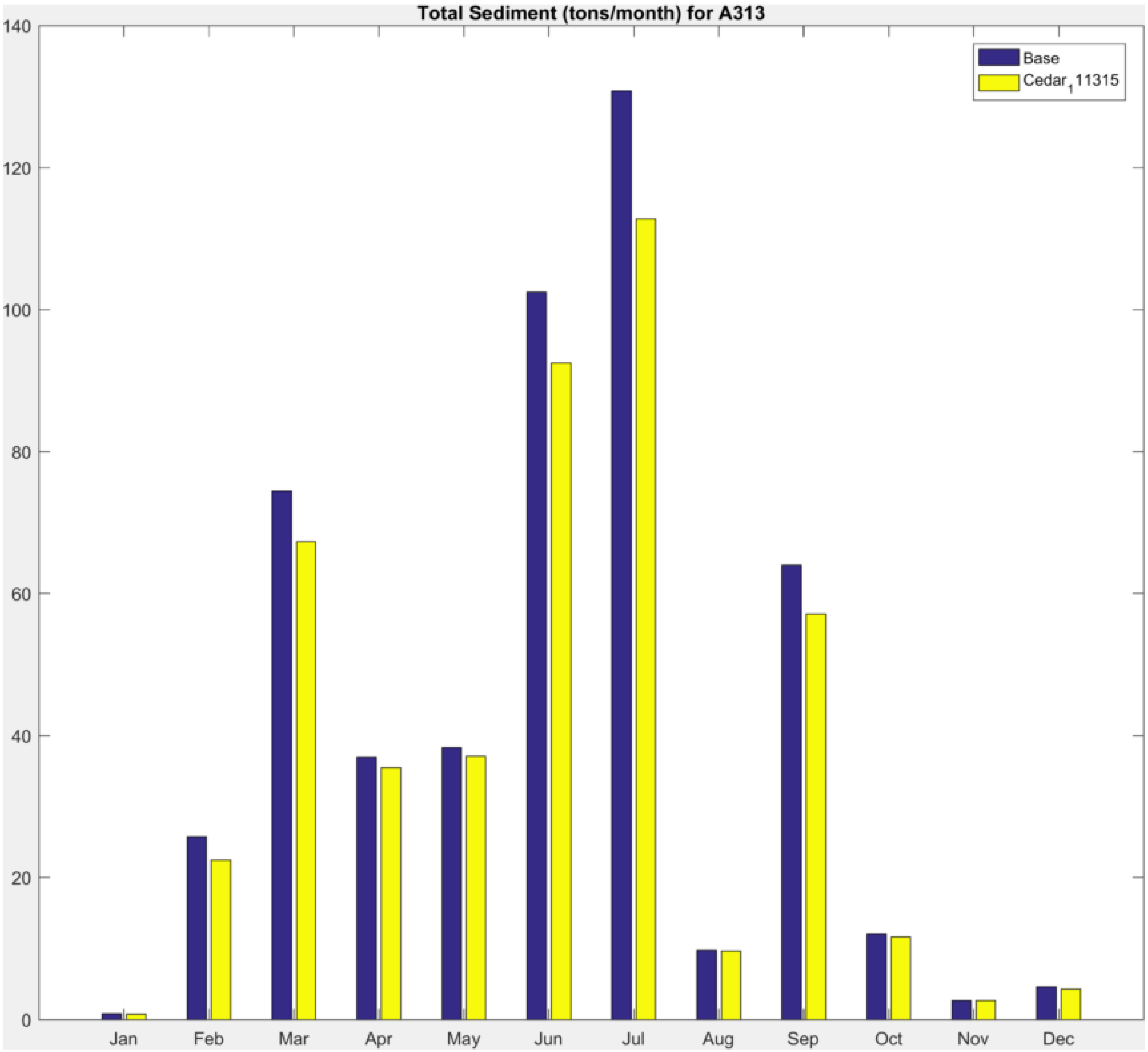


Figure 17: Comparison of monthly TSS load from Reach 313 in pre and post BMP application scenarios

Figure 33: Comparison of monthly TSS load from Reach 315 in pre- and post-BMP application scenarios

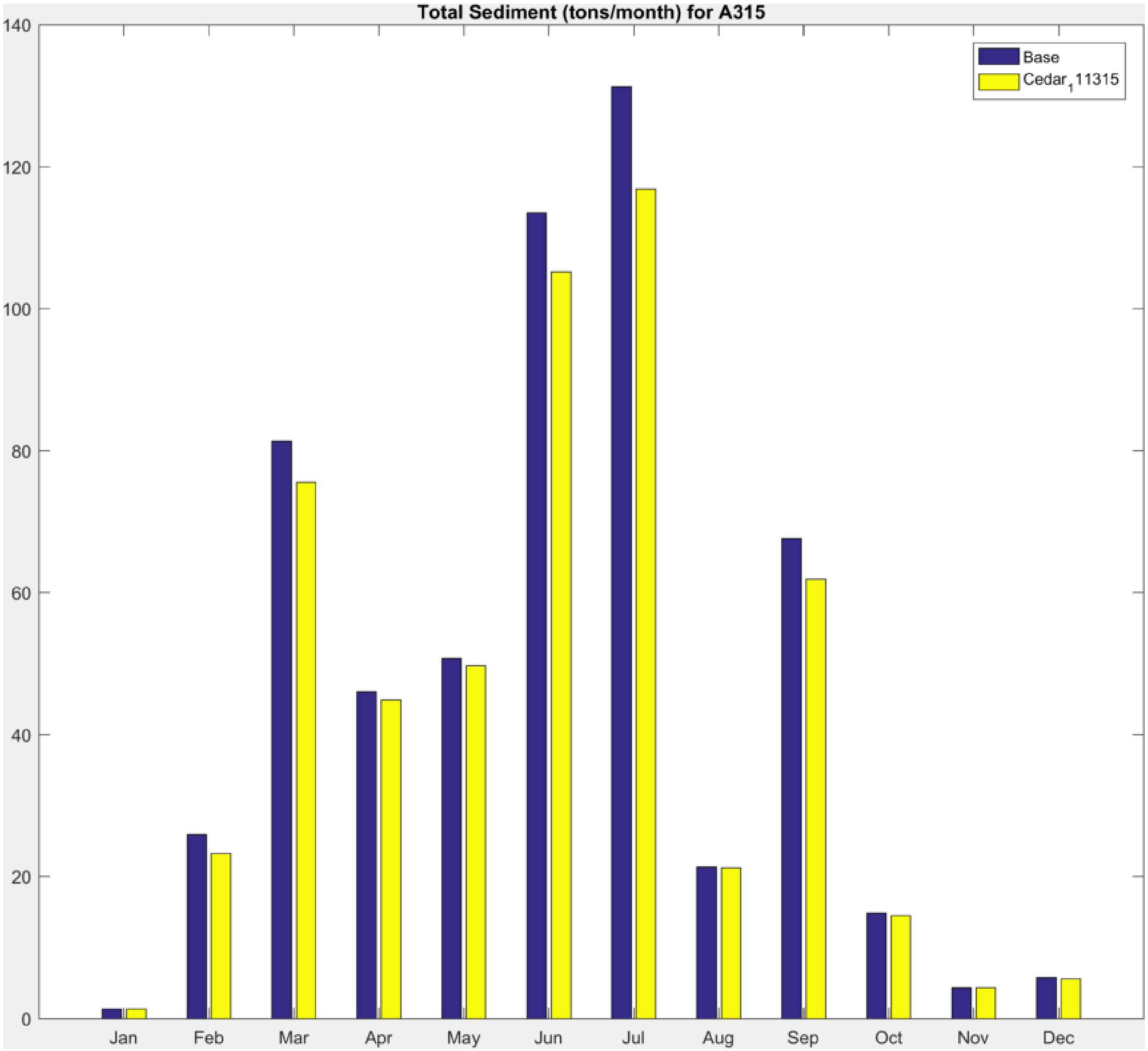


Figure 18: Comparison of monthly TSS load from Reach 315 in pre and post BMP application scenarios

Appendix B: Dobbins Ck FIBI Report 2021-2024

Report of FIBI Monitoring for the Dobbins Creek 319 Project

2021-2024




By Brenda DeZiel

Caddis Fish Consulting, LLC

For Cedar River Watershed District

December 18, 2024

Executive Summary

The following is a general accounting of the Dobbins Creek FIBI Effectiveness Monitoring.

FIBI trends: FIBI scores on both the North and South Branches were variable some years likely due to high flows or previous year droughts. When questionable drought and flood impacted years were removed, the FIBI scores were less variable, but still show that the impaired AUID on the North Br. (07020201-524) remains below standards for the fish assemblage. There are both habitat quality and water quality issues. The FIBI scores at the downstream AUID (-535) in the Hormel Nature Center remain above standards. For the South Br, FIBI scores were above threshold at all stations on the middle mainstem and lower AUID most years. Two AUIDs are showing variable FIBI scores, both above and below standards. A small tributary (station S5.0) shows channel stability issues, with excess sand accumulation and possible eutrophication issues. The headwater station (S9.4/S9.5) has a very small drainage area and a clay bottom, not representative of the AUID and should not be included for assessment. Biological stressors are present along both branches. These stressors should be explored and addressed in order to maintain or increase FIBI scores to prevent future impairment listings on the South Br. as well as allow for a possible future delisting for the middle of the North Br.

Habitat quality trends: Habitat quality improved at most stations. Notably, habitat quality at S0.04, the outlet of the South Br. has improved considerably, with much less sand. A few stations showed extreme variability in scores (N10.4, N12.6) likely in response to channel instability, lack of floodplain connection, and extreme flow dynamics from drought to floods. The main habitat issues at many stations on both branches are excess sand and embeddedness due to high sediment loads entering from upstream and over-widened stream cross-sections that slow the flow and are unable to transport the excess sand annually.

Potential biological stressors: With the added BMPs to store water and reduce stream flashiness, habitat quality has shown some improvement in the headwaters of the North Br. It may take time for the streams to move the excess sediment and gain greater channel stability (balance between stream discharge and annual sediment load). This should allow for improved gravel spawning habitat, deeper pools, and better flow refuge. However, water quality issues such as eutrophication and high nitrates may also need to be addressed as well in order to see improved FIBI scores at some stations, especially in the impaired reach of the North Br. Filamentous algae and high saturated dissolved oxygen at N12.6 and N6.8 indicate possible eutrophication issues, along with elevated phosphorus. Fish passage issues may also need to be addressed.

Suggestions for next 4-year cycle (2025 – 2028): 1) If possible, determine where excess sand is coming from and if BMPs could further reduce the sand loading. This should improve habitat quality. 2) Localized water quality monitoring for nitrates, phosphorus, and DO flux could be considered for the North Br. middle stations as well as the middle stations of the South Br. This more localized monitoring should provide guidance on where water quality stress is also limiting the fish community and which type of BMPs could be considered, planned, and implemented during the remainder of this 16-year 319 grant. 3) Possibly consider additional BMPs such as riparian oxbow ponds to reconnect the floodplain where streams on both branches are very incised. These could provide important stream benefits such as: a) high flow refuge for fish, b) dissipation of flood flow erosive energy, c) better sediment and nutrient attenuation, and d) and a higher degree of water infiltration into shallow groundwater to help recharge to stream during lower flows. 4) Discontinue sampling the uppermost headwater stations <5 sqmi. This will reduce the variation and depression in FIBI scores due to the small DA and possible natural intermittency of these stations (N14.3, S9.4) and possibly a few others (S5.0, N12.6). However, flow alteration from tiling and land use may also be contributing to the late-summer low-flow conditions observed in many years as well.

1.0 Background: Dobbins Creek Monitoring, AQL Listings, and Stressors

1.1 Effectiveness Monitoring

Effectiveness Monitoring started in 2014 with four stations on the North Br. Since then, additional stations have been added to the North Br as well as the South Br. While the South Br is not presently impaired for the fish community, it is of interest since it is a part of the HUC-14 of Dobbins Creek where BMPs have recently been implemented or planned.

Effectiveness Monitoring is intended to track improvements in water quality, habitat quality, and ultimately biological quality (fish and macroinvertebrates) overtime. Observed changes in the fish community can provide information on how BMPs installed in the watershed are helping to improve habitat and water quality. A number of projects have already been implemented within the watershed of the North Br with projects soon to be implemented in the South Br. These projects attempt to store and slow the water volume that is released back to the stream after large precipitation events. It is anticipated that with these water storage BMPs installed, less flashy flood flow conditions will result in less sediment production from stream banks and improve overall stream channel stability. This should then reduce the level of *Total Suspended Solids* (TSS) and bedded sediment which causes a stress to fish due to a lack of good quality habitat with clean gravel substrates for spawning and lack of deep pool refuge during low flow conditions. Habitat assessments and photographs will be used to document changes in habitat quality. Changes in the fish community, in both FIBI scores as well as calculated attributes (percent of gravel spawners, riffle, and pollution sensitive species) will be tracked overtime and should respond positively to improvements in habitat quality. However, there may be additional water quality stressors (high nitrates, eutrophication) that may require a different approach in BMPs to fully bring the impaired AUIDs up to standards as well as prevent future listings on others.

1.2 Aquatic Life Impairments and Stressor Identification

Dobbins Creek (07080201-524) is listed as impaired for Aquatic Life (2021) for three indicators: fish and macroinvertebrate assemblages, and Total Suspended Solids (TSS). The lower reach of Dobbins Creek before East Side Lake (-535) is only listed for turbidity (2011) while fish and macroinvertebrates are not impaired. The lower AUID of the South Br (Unnamed creek, -563) was assessed in 2015 and found to be meeting Aquatic Life standards. The upper reaches of the South Br and tributaries have not been assessed for Aquatic Life.

The table below includes the AUIDS, Aquatic Life Assessments, and station information, including the drainage area (DA), station gradient, and GPS coordinates of the center of the sampling reach. These stations are all in the Cedar River HUC 07080201. Stations with drainage areas (DAs) in red are smaller than the >5.0 mi^2 typically used by MPCA for Intensive Watershed Monitoring and Assessment, although some stations with small DAs have been used. These stations may be more problematic in assessment as there is often greater uncertainty regarding if these stations are intermittent (go naturally dry every few years in late summer) which is not related to land use and agricultural tile drainage. The FIBI was developed for perennial streams (maintain water annually).

North Br AUIDs	AUID length mi^2	Use class	AQL Assessment*	North Br Stations	Drainage Area ($mi^{2)}$	Gradient (ft/mi)	Lat X GPS	Lon X GPS
-524	16.2	2Bg	**IMP** (2021) TSS	**N14.3**	2.7	3.08	43.72254	-92.78932
				N12.6	4.4	2.35	43.72647	-92.81025

			fish macroinverts	**N10.4**	7.5	1.52	43.71250	-92.82102
				N8.0/ N8.2	10.1		43.71699	-92.85137
				N6.8	11.4	1.05	43.72364	-92.86828
				N3.9	14.8	0.88	43.69664	-92.88787
-535	1.2	2Bg	**IMP** (2011) Turbidity	**N0.7**	19.0	1.62	43.67822	-92.93589

*IMP = Impaired for Aquatic Life (AQL)

South Br AUIDs	AUID Length mi^2	Use Class	AQL Assessment	South Br Stations	Drainage Area (mi^2)	Gradient (ft/mi)	Lat X GPS	Lon X GPS
-609	4.0	2Bg	IF (2021)	**S9.5/S9.4**	2.9	3.48	43.69337	-92.82808
-607	0.8	2Bg	IF (2021)	**S5.5**	6.5	**0.55**	43.68189	-92.86732
-606	2.2	2Bg	IF (2021)	**S5.0**	4.8		43.67588	-92.87107
-562	3.4	2Bg	IF (2021)	**S1.9**	13.5		43.67813	-92.90847
-563	1.5	2Bg	**MS** (2015)	**S0.04**	17.6		43.67645	-92.93620

*IF = Insufficient information; MS = Met Standards for Aquatic Life (AQL)

The MPCA's Stressor Identification Report completed in 2022 has listed the main biological stressors for AUID -524 on the Dobbins Creek North Br (Dobbins Creek Watershed Stressor Identification Update (state.mn.us). The main stressors included: *Flow Alteration*, *Habitat*, *Fish Passage*, and *Nitrate.* Note: while Eutrophication and DO are "inconclusive" at this time, they may also be present stressors during certain times (e.g., low-flow, high temps, seasonally) but did not have enough data to validate during Stressor Identification in 2021.

Table 2: Summary of stressors in the Dobbins Creek Watershed (• = stressor, ○ = inconclusive stressor, blank = not a stressor, NE = not evaluated).

Waterbody	AUID	Biological Stations	Biological Impairment	Class	Stressors: Temperature	Nitrate	Eutrophication	DO	TSS	Habitat	Fish Passage	Flow Alteration
Dobbins Creek	524	14CD002, 14CD003, 14CD004	Fish, Macroinvertebrates	2Bg		●	○	○	●	●	●	●

Flow Alteration – This can mean both higher, flashier, flood flow when too much water enters the stream too soon due to watershed land use changes, or low-flow conditions are exacerbated due to a lack of water with less summer-time groundwater recharge. In the Dobbins Creek Watershed, flow conditions are very flashy after storm events, in response to the land use, tile drainage, and from shifting the plant growing season to summer with row-crops without cover crops or perennials in spring. Ditching and tiling speed up the delivery of water. Late summer low flow conditions are often seen in August. When efficient tiling systems remove water from rootzones of crops and enters tile lines, the water does not infiltrate deeper as it would have without tiling, so less water enters into surficial groundwater that then enters streams to support late summer conditions. This can cause dry or low water depths between pool refuge and downstream areas to where fish can no longer migrate, causing trapping in shallower pools, increased water temperatures and higher density of fish, increasing DO demand and mortality through suffocation, predation, and desiccation.

Turbidity/Total Suspended Solids (TSS)- Turbidity is a measure of the cloudiness of the water from high sediment loads and sometimes high algae. TSS is a similar proxy as turbidity, as they both measure the degree of sediment/algae suspended in the water column at time of collection. High Turbidity/TSS with fine sediment (silt, sand) can not only cloud water during high flow events, the silt and sands can also settle on the bottom of the stream and reduce habitat quality (i.e., cover and smother coarse gravel used by fish for spawning or cobbles for algal grazing or macroinvertebrate colonization for feeding, fill in pools used for thermal and drought refuge). TSS can also be high if eutrophic conditions cause high levels of suspended algae. The combination of flashy flows and banks comprised of easily erodible silts (loess) and sand contributes to high TSS and excess embeddedness that reduces habitat quality. Flow alteration as flashy conditions after rain and low-late summer flow add stress to the fish community. High density of tile drainage and ditching in the watershed can affect the speed at which precipitation on the land drains into the stream channels. Faster drainage and straightening increases erosive flows and causes bank erosion and bottom scouring that can add excess sediment to the stream bottom, fill in pools and cause embeddedness. With scouring flows, streams deepen and riparian refuge for fish is disconnected during storm flows, which causes community dispersal and death. These conditions can cause an issue for many habitat specialist fish species and allow more tolerant fish to thrive, leading to an imbalance in the fish community, which is reported as lower FIBI scores and when low enough, an AQL impairment.

Habitat and Bedded Sediment- The habitat quality issues in Dobbins Creek are also directly and indirectly related to flow alteration, bank erosion, and high TSS load. Higher flow conditions that normal can also lead to channel instability as more water works to scour the bottom and deepen the channel so that high flows are contained in channel and not overflowing the banks, trapping fish that are not able to use the side channel and adjacent flat areas for refuge from scouring and damaging flood flow. The larger volume of water now contained in the deeper channel has more power to scour banks and cause more bank erosion and transport of sediment to downstream areas. It is apparent from station visits and photographs that excess bank erosion and other sources (e.g., unstable gullies) are contributing to too much sediment instream (bedded sediment) that is affecting habitat quality as sand cover and smothers gravel for spawning, cobble for feeding on insects, and reduction in flow refuge space as deep pools are filled in with sediment.

N12.6 -2024: Headwaters of the North Branch. Severe excess sand aggradation, reduced pool depth and smothered spawning gravels. Very high banks on both sides limits riparian flow refuge.	**S0.04 -2022**:–Near outlet of the South Br. Stream is overwidened with excess sand on bottom, lacks depth variability. Surprisingly, this reach was much improved with far less sand in 2024, possibly moved out during the June flood prior to sampling in late July.

Nitrates - This reach (-524) and the two others are also listed as impaired for Aquatic Recreation for e. coli, as well as the headwaters of Dobbins Creek. While not an AQL impairment, the presence of e. coli may indicate a manure source that contributes to the potential for elevated nitrates. There are also additional sources of added nitrates within the watershed (e.g, fertilizer for cropland production) which may be also contributing to the elevated nitrates seen at times in the water chemistry collections. The draft chronic standard for nitrate levels in warmwater streams to protect Aquatic Life is 8.0 mg/L, while the proposed acute standard is 60 mg/L. Aquatic Life Water Quality Standards Technical Support Document for Nitrate. While not a standard in statute, the research by the MPCA in creating the draft standard provides a level at which some level of negative impacts to fish and macroinvertebrates are likely.

DO and Eutrophication- Additional stressors such as low-DO (< 5mg/L), highly saturated DO (>120%) and high concentrations of phosphorus (River Nutrient Standard for southern rivers <150 ug/L) should also monitored for biological stress levels. This large swing in daily DO (low in morning, very high in afternoon) can occur through increased production of plants and filamentous algae (eutrophication) fueled by higher additions of nutrients, like phosphorus. There was both abundant algae and super saturated DO% conditions observed a few North Br. Stations (N12.6).

2.0 FIBI Monitoring History of Dobbins Creek

The Dobbins Creek FIBI Monitoring proceeded in stages over the years and is outlined below. Figure 1 shows the locations of sampling for Effectiveness Monitoring for the start of the 319 grant (2020-2024).

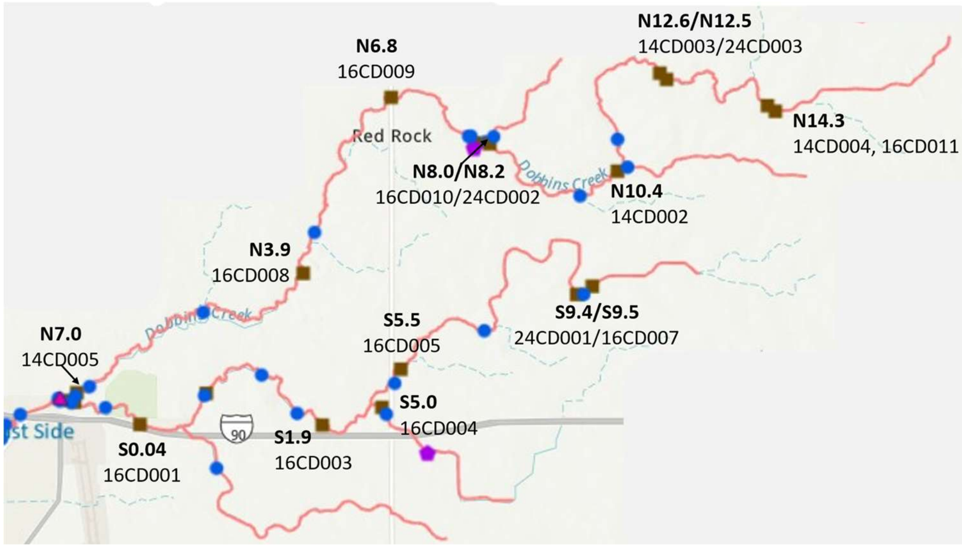


Figure 1: FIBI monitoring stations (brown squares). The branch (N and S) and location from outet in miles is included in the first line names in **bold**. The unbolded is the MPCA station designation. Note: S5.0 is on a tributary to the South Br. The blue dots are water quality monitoring stations with various chemical, nutrient, and bacteria measurements.

In 2009, the Cedar River Watershed was sampled by MPCA for Intensive Watershed Monitoring. There was only one monitoring station on Dobbins Creek (09CD064) which was not assessed due to proximity to lake and the community having many sunfish and bass, not typical of headwater streams.

In 2014, Effectiveness Monitoring started with four stations along the North Br; these sites were sampled by the MPCA. These same 4 stations as well as 10 additional stations (14 total) were sampled by staff from the UMN along both the North and South Branches of Dobbins Creek for three consecutive years (2015, 2016, and 2017). N14.3 (14CD003) was positioned slightly downstream near the road due to very low flow conditions upstream but better near the downstream end (16CD004)

In 2019, MPCA revisited two of the original 2014 stations (N10.4/14CD002, N12.6/14CD003). The low FIBI scores collected at these stations provided the AQL listing of the fish and macroinvertebrate assemblages in 2021 (see table below).

With the 319 grant, Effectiveness Monitoring continued with FIBI monitoring at 12 stations in 2022 and 2024. The fish monitoring is planned every two years (bi-annually). Adjustments to the targeted years sampled were made in response to drought conditions in 2021 and 2023.

In 2024, a few stations were moved slightly due to local and other factors. (discussed in report). Due to the position changes, new stations were established (i.e., N8.2, S9.4). One station was established (N12.5) to compare observed differences in habitat quality with N12.6 to see if differences would show in FIBI scores.

3.0 Methods - Data Collection and Analysis

3.1 Sampling the Fish Community - For the most part, fish sampling followed MPCA protocols for collecting fish samples using electrofishing. For some very small headwater stations (<3 sqmi) only about half of the length of a regular reach was sampled as these were too narrow and covered with grass or too shallow to sample a full reach. Fish were collected during a limited summer season (mid-June to early September) and under normal, base flow conditions (not too high or too low). During the start of the sampling window (mid-June), Mower SWCD staff were sent out to monitor water level conditions with photographs and tape-down distance measurements from road culverts. Target sampling is at normal, baseflow water level. This is MPCA protocol to ensure that the fish community sampled is not influenced by too low (near drought) or high flows, which can disrupt the fish community from their normal habitat locations. This pre-sampling monitoring is especially important in the headwater and middle reach stations with small drainage areas, as fish communities present can change in response to changing flow conditions, by migrating upstream and downstream, or can become stranded and die in pools if migration corridors are interrupted. We did not sample in certain target years due to low-flow drought conditions or when streams were high. We adjusted field work years and days to sample when stream water levels were near baseflow conditions.

For 2015 and 2016 data, there were no notes on flow conditions, and a former stream sampler compared baseflow conditions to 2016 sampling conditions which suggested some stations were high. Those years are included but there is a "non-reportable" flag on these samples in the MPCA database.

We also attempted to sample during the same week or as near to as possible as was sampled in previous years. There are many young-of-year (YOY) fish that were collected, and mid-July is our start of sampling in order to allow the size to be identifiable and reportable. Fish at the Dobbins Creek monitoring stations are collected from a segment of the stream reach (station) using a Smith-Root LR24 electrofishing backpack. The electrical pulse gently stuns the fish which momentarily stops swimming and then floats on the side or upside down so they can then be easily captured with a pole-handled net. The netted fish are transferred into a large bucket with water until they are brought to the sorting station on the edge of the stream. There, multiple buckets of water are waiting for staff to identify and sort by species each fish sampled. After data is collected, fish are released.

	
Figure 4.32a: Bucket sorting by species, gravel sorting for smallest fish.	**Figure 4.32b:** Example of small YOY. Top to bottom: Blacknose Dace, Common Shiner, Creek Chub and a YOY too immature for identification.

Most fish were identified in the field at time of sampling. Total counts of fish by species, measurements of the smallest and largest fish (mm) within each species, and condition (Deformities, Eroded Fins, Lesions, Tumors, i.e., DELTs) were recorded on field datasheets. After data was recorded, all other fish are released back into the stream. Some expired fish (fish that died during collection) were kept for vouchers and preserved in formalin to be later ID confirmed by staff at the Bell Museum of Minnesota. In 2015 and 2016, UMN sampled, but no vouchers were retained for lab confirmation. For 2017, 2022, and 2024 vouchers were retained of at least 1 or 2 fish of each species collected within the 12 stations. Photo vouchers are taken at least once of each species collected during the 12 station visits. Young-of-year (YOY) specimens were also retained as vouchers for lab confirmation of identification by the Bell Museum.

3.2 Calculation of FIBIs

The fish data and sampling information was sent to MPCA South Biological Monitoring Staff in excel spreadsheets. The data was uploaded into the MPCA's StmBioMon database where FIBI scores, FIBI metrics, and additional fish community attributes were computed. Also sent were GPS locations of the stations, length sampled, and time fished.

The Fish IBI includes a number of metrics that were tested for a response to watershed stressors, using different categories, from sensitivity to pollution, habitat requirements, reproductive strategies, and feeding preferences. The streams and rivers were categorized according to the drainage area size, thermal regime, gradient, and basin location being in the northern or southern part of the state. The metrics were tested against level of watershed disturbance for each station. Metrics that responded to the level of watershed stress were selected. The FIBI is intended to detect when conditions are stressful for the biological community, such as low dissolved oxygen, warmer water temperatures, lack of suitable habitat, watershed flow alteration that changes the speed and volume of water during storms, or exacerbates low-flow conditions in late summer when groundwater is not recharged as fully due to ditching and tiling practices, and elevated pollutants such as nitrates and others. The fish community sampled during the summer should reflect any concerning habitat and water quality issues experienced during different seasons (e.g., spring groundwater nitrates and ammonia toxicity, presence or lack of overwintering pools, ability to migrate between headwaters and downstream areas), or under different flow conditions (e.g., presence or lack of refuge during extreme high and low flows).

All Dobbins Creek stations are within the *Southern Headwaters FIBI* stream class. The criteria are gradient (>0.5 ft/mile) and drainage area (<30 sqmi). There is one site that is near the gradient threshold (S5.5, 0.55 ft/mi). This station changes between a Rosgen type C channel (meandering, gravel/sand bed with depth variability as pools and riffles) to an E channel (highly sinuous low-gradient steam, naturally lacking depth variability and all pool/run). This reach has been sampled in recent years (2017 and 2022) below the point at which the stream changes, and hence at a shorter reach (95m) than MPCA protocol (150m to 156m). The fish community at this station seems to change between sampling years, and conditions habitat conditions change as well. The station information was sent to MPCA to be re-reviewed to ensure it is being placed in the most appropriate FIBI class.

3.3 Habitat Quality Assessment – MSHA

Habitat Quality at each station and visit was rated using MPCA's Stream Habitat Assessment (MSHA) MPCA Stream Habitat Assessment (MSHA) protocol for stream monitoring sites. Observations were also documented with notes and photographs. The MSHA rates watershed land use, near-stream riparian quality and severity of bank erosion, presence and type of stream substrates, condition (level of embeddedness), inventory of habitat types and amount, as well as condition of the stream channel morphology (channel stability, depth variably, frequency of stream feature changes – pool, riffle, run).

3.4 Biological Stressor Checklist – SCSI

As a companion to the MSHA, the *Stream Condition and Stressor Identification* (SCSI) checklist was also collected. MPCA Stream Condition and Stressor Identification (SCSI) Protocol for Stream Monitoring Sites. This checklist notes presence of stream condition attributes that are useful for noting good spawning and feeding habitats, groundwater presence, and stressors that were observed. These stressors include things such as perched culverts (when the road crossing culvert is scoured at the downstream side and higher than the bottom preventing fish passage under normal flow levels), bank erosion and causes (e.g., trampling from cattle, or flow related bank erosion), and channel instability indicators. These can be used to support the documentation of MSHA ratings and better document observations of additional biological stressors not captured with the MSHA.

Some additional observations were added by fish sampler and consultant B. DeZiel, such as: a) *riparian flow refuge* (i.e., how well the stream is connected to its floodplain and not down-cut too deep for fish to swim off channel during high flows with instream bank and bottom scouring events); b) *measurements of deepest pool depths and shallow riffle depths* to calculate the residual pool depth (pool depth – riffle depth). This has been used by federal agencies (e.g., the US Forest Service, Lisle87.pdf) to see if the absolute pool depth provides sufficient refuge during low-flow periods and hot summer months. Residual Pool Depth can diminish greatly when excess sediment delivery or overwidened streams lose the ability to move the annual sediment.

3.4 Water Quality

Infield measurements were collected with a hand-held meter or sonde prior to fish sampling: water temperature, DO, pH, and specific conductance (concentration of minerals in the water). Water clarity was measured with a transparency tube (T-tube), For MPCA visits, grab samples were collected in Nalgene bottles with preservatives, and analyzed for nutrients (phosphorus, nitrate) and suspended sediment (Total Suspended Solids, TSS) and volatile organic material (Total Suspended Volatile Solids, TSVS). These are only one-time measurements collected, so they may not capture water quality stressors occurring at other times of day or seasons.

4.0 Analysis – Patterns and Trends

FIBI and MSHA scores at each station were placed in bargraphs to observe patterns or trends. The FIBI scores will be tracked overtime to see if there is a directional and sufficient change in the fish community bring the FIBI scores consistently above the impairment threshold. Habitat quality (MSHA) scores will also be tracked overtime. The bar graphs for the North and South Br, are within the results below.

In order to understand pre-sampling flow conditions that may have had an effect on the fish community, graphs of flow and precipitation events during the summer (June 1 to September 1) from the DNR Cooperative Stream Gage station on Dobbins Creek were reviewed with sampling dates to show where high flow events may have been a factor if sampled too close to the decent of the stormflow, or if preceding low-flow drought conditions could have also been a climatic impact that year. See the document *Flow and Precipitation Record for Dobbins Creek 2012 – 2024.*

Additional analysis and photographs are included in the *Individual Station Reports*. Besides the total scores for FIBI and MSHA, the FIBI metrics and other fish community measures were analyzed as well. Individual metrics for MSHA are also graphed and year to year differences analyzed. It is expected that with flow management BMPs installed, that the flow will be less flashy, and habitat quality will improve. This is anticipated as less flashy flows should lessen sediment production from eroding stream banks. More flow storage in the headwaters could also support late summer baseflows and maintain better fish communities. Excess sediment accumulated currently within the stream should also be removed to downstream areas overtime or deposited locally as point bars along the side margins. Ultimately, less flash flows and less sediment production should allow the point bars to direct flow and velocity to deepen a thalweg (meandering inset stream, visible under low flow) and recover a deeper, stable stream configuration with gravel sorting in riffles and deeper pools overtime. These improvements in habitat quality then should also assist in the fish community recovery and be reflected in higher FIBI scores and other attributes (e.g., percent gravel spawners, % riffle fish), barring other water quality stressors (e.g., eutrophication, high nitrates, fish passage issues).

5.0 Results

The following includes the general results of the fish species collected, FIBI, Habitat Quality, Water Quality, and Stressors Observed. More detailed information and photographs are included in each *Individual Station Report.*

5.1 Fish Species Sampled in Dobbins Creek

Table 4.2 below provides the species collected at each station and the frequency (visits sampled/total visits). Stations are arranged from outlet station to headwaters of both branches.

Table 4.2: Number of visits per station (2014-2024), with range of species counts, and frequency of collection*.

Stations	**N0.7**	**N3.9**	**N6.8**	**N8.0/ N8.2***	**N10.4**	**N12.6**	**N14.3**	**S0.04**	**S1.9**	**S5.0**	**S5.5**	**S9.5/ S9.4***
Number of visits	**6**	**5**	**5**	**5**	**7**	**7**	**6**	**5**	**5**	**5**	**5**	**5**
Species count range (Min – Max)	11-17*	7-13	3-13	4-12	9-13	9-12*	5-10	8-16	9-13	10-12	11-14	9-12
Bigmouth Shiner	6/6	5/5	5/5	4/5	7/7	7/7	4/6	3/5	4/5	5/5	5/5	4/5
Black Bullhead	0	0	0	0	0	1/7	0	0	0	0	0	0
Blacknose Dace	6/6	5/5	5/5	5/5	7/7	7/7	6/6	5/5	5/5	5/5	5/5	5/5
Bluntnose Minnow	5/6	2/5	5/5	4/5	7/7	7/7	5/6	5/5	4/5	3/5	4/5	5/5
Brook Stickleback	4/6	2/5	3/5	2/5	4/7	2/7	6/6	2/5	1/5	5/5	4/5	5/5
Central Mudminnow	4/6	3/5	3/5	1/5	0	0	0	2/5	2/5	1/5	4/5	1/5
Central Stoneroller	6/6	2/5	3/5	1/5	6/7	7/7	5/6	2/5	5/5	4/5	4/5	5/5
Common Shiner	6/6	5/5	4/5	4/5	3/7	2/7	0	5/5	5/5	5/5	5/5	2/5

Creek Chub	6/6	5/5	5/5	5/5	7/7	7/7	6/6	5/5	5/5	5/5	5/5	5/5
Fantail Darter	6/6	5/5	5/5	4/5	7/7	7/7	5/6	5/5	5/5	5/5	5/5	4/5
Fathead Minnow	5/6	1/5	1/5	2/5	5/7	4/7	3/6	4/5	3/5	3/5	4/5	3/5
Green Sunfish	4/6	3/5	1/5	2/5	1/7	0	0	4/5	4/5	2/5	3/5	3/5
Hornyhead Chub	5/6	3/5	0	0	0	0	0	5/5	4/5	2/5	0	0
Johnny Darter	6/6	5/5	5/5	4/5	7/7	7/7	6/6	5/5	5/5	5/5	5/5	5/5
S. Redbelly Dace	6/6	3/5	5/5	5/5	7/7	7/7	5/6	1/5	3/5	5/5	5/5	4/5
White Sucker	6/6	4/5	5/5	3/5	7/7	6/7	3/6	5/5	5/5	5/5	5/5	5/5
lamprey amnocete	3/6	0	0	0	0	0	0	3/5	2/5	0	0	0
Largemouth Bass	2/6	0	0	0	0	0	0	0	0	0	0	0

*Species in **bold** are considered pollution sensitive. Dark green box = collected all visits. Red box (0) = has never been collected. Fractions (e.g., 3/5) are number of years sampled/total number of visits with green (>50% of visits), yellow (~ ½ of visits), orange (< ½ of visits), to purple (rare, only collected at 1 station, few visits). In *italics* are the *gravel spawners*, and underlined are the *pool dwelling* species.

Total species -The highest number of fish species collected was 18; however, two were very rare. *Largemouth bass* young-of-year were only collected at N0.7 in 2014 and 2017. It is likely that a few adults come upstream from the lower Dobbins reach to spawn in the spring and then migrate back downstream in mid-summer. There was only 1 *black bullhead* collected in 2024 at N12.6. Not including these two rare species, the highest species potential for Dobbins Creek stations is 16.

There was high variability in the number of species collected at many stations. This may be due to being sampled during higher than baseflow (2015 and 2016), right after extreme floods (2019) that may have dispersed the fish community, and/or low flow conditions (drought) the year prior to sampling and spring recovery was not yet sufficient, exacerbated low-flow conditions from extensive ditching and tile drainage or upper headwater stations that limits fish species refuge in summer, water quality issues, habitat issues, or naturally intermittent headwater stations with annual low flows in later summer.

Flow and Climate Effects on the Fish Community- Variability at some stations was likely due to sampling during too high of flows (possibly 2015, 2016) or where previous year drought and low flows may have altered the fish community and recovery was not complete (2022, 2024). More years than not, spring is typically a time of high flows in Dobbins Creek, whereas, late summer can be a time with little or no rain, so the smallest headwater stations and even the middle stations go dry or have very low water levels with interrupted flow as pools and dry riffles and runs. This can have a devastating impact on the local fish community, as they either migrate further downstream or are stuck in disconnected pools where low-dissolved oxygen, high ammonia, high temperatures, etc cause high mortality, especially of sensitive species. When streams are unstable, pool refuge can be impacted as high sediment load fills them in and depth and volume is reduced. It takes time for the fish community to recover through migration from other downstream areas when flows are again higher. In contrast, high flow years can also be a factor, either decreasing, or in some cases, increasing FIBI scores. High scouring flows can displace or injure fish and mobilize freshly spawned eggs, thereby disrupting yearly reproduction of some species. At other stations, high flows can allow the downstream migration of other fish further into headwater stations, which can also affect the FIBI scores. Conversely, low flow conditions in the headwaters can also force fish to migrate to downstream stations, sometimes improving FIBI scores (DeZiel *et al*, 2019).

Notable FIBI and Habitat Indicator Species – The following groups of species are important indicators of good habitat and water quality. These species should show improvement when habitat improves with BMP effectiveness. Conversely, these species have also not been collected or numbers greatly reduced when water quality/habitat quality conditions were impacted.

FIBI metric – Sensitive- The FIBI is used mostly as its cumulative score, rather than the individual metrics. Tables of the FIBI metrics and species assignments are included in the *Individual Station Reports*. One useful FIBI metric on its own, is count of *Sensitive* species. There were three FIBI *sensitive* species collected: *fantail darter, hornyhead chub,* and *lamprey ammocoetes* (young lamprey too immatures to identify). All three species need clean, coarse gravel for spawning. *Fantail darter*s were collected at all stations in all years except at three stations (N8.0, N14.3, S9.5). In 2015, N8.0 had very poor habitat quality; notes included "lack of habitat, siltation" while the two other sites are very small headwater streams where flow conditions prior to sampling may have been a factor. The two other *sensitive* species were found at fewer stations (*hornyhead chub* -5 stations, *lamprey ammocoetes* -3 stations). These species require good habitat and water quality; they do not do well in streams with excess sedimentation. *Hornyhead chub* inhabit rocky pools and need riffle/gravel areas for spawning. They take the gravel in their mouths and form domes with the rocks. They are also visual predators. Therefore, *hornyhead chub* are negatively affected by turbidity and siltation. it is likely that the *ammocoetes* are young *chestnut lamprey,* which were collected and identified at 009CD064, downstream of the confluence of both branches. *Chestnut lamprey* are filter feeders and also use rocks for spawning and cover their eggs with gravel for protection. Therefore, they do not do well in streams with turbidity which reduces vegetation, and high embeddedness (sand mixed within gravel or covering). They also seek out shady areas during the day, so less likely to occur in streams lacking shade from trees or overhanging vegetation.

Fish Community Measures - While the following categories are not FIBI metrics, they can be useful for monitoring habitat conditions. The percentages and year to year comparisons are included in the *Individual Station Reports.* Below is a summary of findings.

Gravel spawners – There were 8 fish species that require clean gravel conditions to spawn and reproduce successfully. This attribute is a combination of *simple lithophilic spawners* (broadcast spawn, no gravel maintenance or parental care), *complex lithophilic spawners* (build gravel redds and fan with tails to keep gravel clean, parental guarding/care), and *nest associates* (fish that sneak into gravel redds and spawn, allow larger fish to provide parental care). In addition to the three sensitive species above that are gravel spawners, there were five others, including: *central stoneroller*, *white sucker, creek chub, blacknose dace,* and *southern redbelly dace. Central stonerollers* and *white suckers* also scrape algae off rocks to feed, so clear water and clean cobble areas also very important for food. The fish community at some stations has shown notably improved percentages of gravel spawners (e.g., **N14.3, N10.4) i**n certain years). Other stations show reductions in gravel spawners in relation to high embeddedness and excess sand (e.g., **N3.9, N12.6, S1.9, S5.0, S5.5**).

Riffle fish – These species require habitat with faster flows over coarse substrates (*central stoneroller, fantail darter, hornyhead chub, white sucker*). These species are also *gravel spawners*, but at a higher level of habitat specialization. *Riffle%* has shown noteable improvement at **N14.3, N8.0, N10.4**, some improvement at N12.6, and high variability at **N0.7, N6.8, S5.0**; with notable reductions at **N3.9, S1.9, S5.5**, and **S9.5/S9.4**. Some of the improvement correlates with improved gravel sorting and better habitat conditions. Variability appears to be related to years with more or less sand accumulation, and reductions appear related to high degree of bedded sand and overwidened conditions that reduce flow variation (more moderate/slow, fewer or no areas of fast flow). **S9.4/S9.5** might also be related to the lack of flow at times due to the rock dam. There was pond weed at the station that suggests ponded conditions at times, even though there was flow during time of sampling.

Pool dwelling species - While larger fish utilize pools for refuge (e.g., adult *white sucker* and *creek chub*), two species (*common shiners* and *green sunfish*) were more often found where pools were deep and in good quality (not filled in with sediment). From table 4.2 below, *common shiner* were found in the lower reaches of the

North Br, and not in every year in the middle reaches, while rarely found in the headwaters. This may also be due to the small drainage area (DA) at N14.3 (2.7 sqmi) and natural lack of very deep pools due to stream size, or it could be due to the poorer habitat conditions and excess sediment in downstream areas that these fish might use for winter refuge. Interestingly, *common shiner* were collected in all reaches of the South Br, even the most headwater station (**S9.5**) with also a small DA (2.9 sqmi). *Green sunfish* were found also where pools were formed near rootwads of large trees where flows had scoured around the roots and created deep pools. *Green sunfish* were found in the lower reaches of the North Br, but not at every station or year where/when channel instability and excess sedimentation were habitat issues (**N6.8, N8.0, N10.4, N12.6, N14.3**). *Green sunfish* were collected at all stations but not in every year on the South Br. Again, when pool depth was diminished filled in with sand), *green sunfish* were not collected those years (**S5.0, S5.5, S9.4/S9.5**).

All the species mentioned above therefore need good habitat quality that is not diminished by excess TSS and embeddedness. Excess sedimentation is an issue on both branches of Dobbins Creek. Some streams are overwidened with less overhanging vegetation and shade than could be. As flow velocity is slowed with BMPs that aim to store water and allow flow to more gradually go downstream, habitat quality should improve, with less bank erosion and narrower, normal stream channels that move excess sediment allowing for cleaner gravel, deeper pools, and better shade cover for all three sensitive fish species, and other habitat specialist species. Their presence is important also for the FIBI scores to return above threshold or remain. Additionally, a balance in species is also required, especially species that are not *short-lived* (an FIBI metric, species that recover quickly after a disturbance and tend to have a quick maturity age). A high proportion of these species could suggest a biological stressor or disturbance is present or occurred in past that is negatively impacting the community collected that year.

5.2 Fish Index of Biological Integrity (FIBI)

The results for the North Branch and South Branch FIBIs are displayed and discussed separately. The *Individual FIBI metrics* are displayed and discussed in the *Individual Station Reports* along with the fish collection data that shows species and counts, as well as additional fish community measures (e.g., *percent sensitive*, *gravel spawners*, *riffle*, and *pioneer*). The following are general notes about items in the report and interpretation.

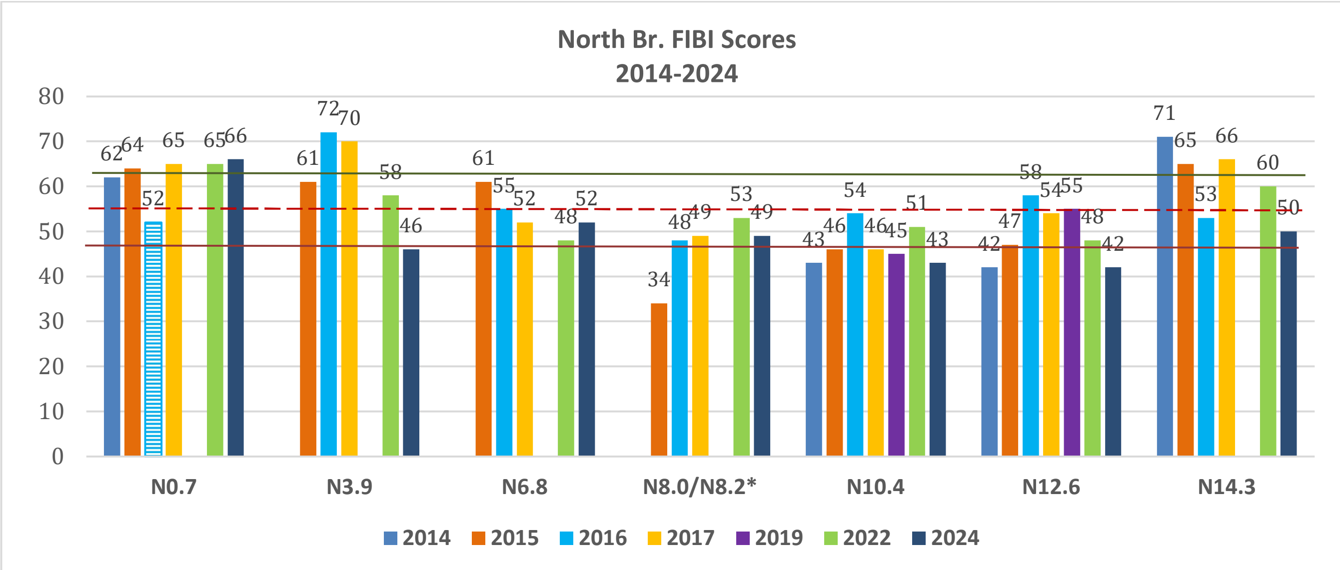
<u>FIBI difference indicating significant/noteworthy change</u>: Some natural variability in the fish collections between visits at a station are expected, so the MPCA uses a Confidence Interval (CI, +/- 7 points) for the *Southern Headwaters* fish class, outside of which the FIBI score is considered reflecting a significant/noteworthy change. This CI was developed by comparing samples collected at the same station twice within the same summer sampling season.

<u>For reading graphs:</u> The top green line is the top of the confidence interval (FIBI threshold 55 +7 points) while the red line is the bottom of the confidence interval (FIBI threshold 55 -7 points).

<u>For reading tables:</u> Trends or patterns of change for the individual stations are included in the tables below the bargraphs. The patterns are indicated by up and down arrows. The “!” indicates when change was considered significant (above FIBI confidence interval +/-7 points), and when there are two “!!” the change was +/- 11 points or more, which is a substantial change.

5.21 North Branch - FIBI

The FIBI scores for all stations on the North Branch and all years sampled (2014-2024) are displayed in the bargraph below. Note: Many of the 2024 FIBIs are very low compared to 2022; this may be due to the extreme drought in 2023 where some stations were more negatively affected than others. Or could be affected by the extreme high flow event in June prior to sampling in July. Oddly, the FIBI scores on the South Branch as not as different between 2024 and 2022. Ideally, two consecutive years with normal flow conditions would provide more confident reading of the current fish community conditions.



Looking at the bargraphs of FIBI scores above, there was a high range in FIBI scores across years (>10 points) at some stations. Some lower scores are possibly related to previous year drought conditions (2022, 2024). Conversely, some lower scores in other years could be the result of sampling during higher flows (N0.7 in 2016) while other stations may have had higher FIBI scores during higher flows (N10.4, N3.9, N12.6 in 2016) as higher flows can allow more fish to move further upstream than usual or be sustained longer in upstream areas before moving downstream for summer refuge. Severe drought can cause a nearly or total loss of the fish community. It takes a return of flow conditions and time for the fish community to recover. The timing of this is uncertain, but can take up to 2 or more years. Not only is the water level in the stream due to precipitation and runoff, but also groundwater. When droughts are severe (2014, 2021) and extreme (like in 2023) the groundwater levels drop, so less groundwater is entering the stream. In contrast, extreme high flows can cause bank erosion and mobilize substrates one year, causing more concerning habitat issues that year. In other years, less erosive flows or time for recovery allows normal flows to move out excess sediment and improve the thalweg condition, thereby both increasing pool depths and less embeddedness and better sorted gravel in riffles and runs. This change in habitat quality and pool depth between years can alter the resident fish community which can be observed as variation in FIBI scores. While some seasonal and annual flow variability is normal, the hydrology of the watershed with row-crop, ditches in the headwaters, and extensive tiling exacerbate both high flows and low-flow conditions. This is what BMPs intending to hold back water during storm stages is intending to do, dampen the erosive peak flows.

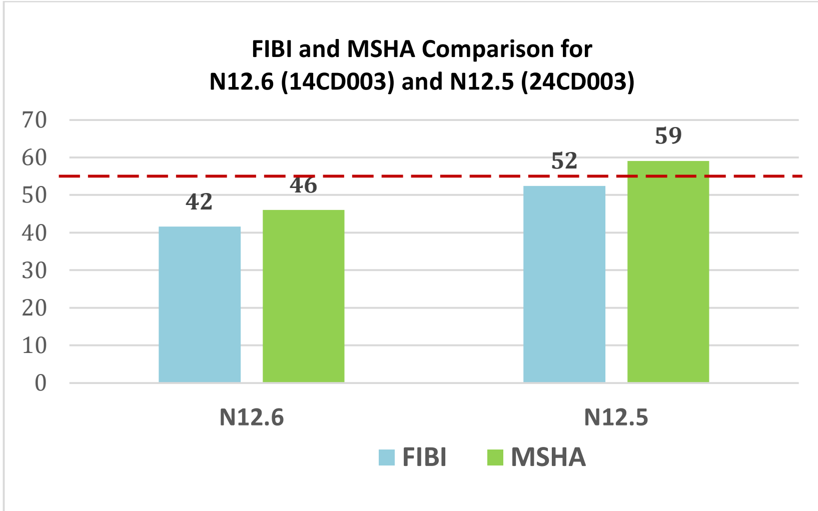
N0.7 has the most stability in scores with a slight improvement overtime. There is an outlier (dot below boxplot) that was collected in 2016 and it is suspected that fish were sampled during higher than baseflow conditions when water was deeper and faster than normal, which would have reduced the catch rate. The number of darters was much lower than other years, as well as 2015 which also did not have water level indicated.

N3.9 showed the most significant drop in FIBI scores followed by **N6.8.** There are channel stability issues at both stations which are downcut and very overwidened. There is excess sand accumulation that has progressed in recent years, possibly due to the overwidened condition that slows flow velocity and so excess sand is not moved. As a consequence, habitat quality is very limited.

N8.0/N8.2 showed the most improvement, but all FIBI scores are still below threshold. Habitat conditions improved somewhat overtime (deeper pools) but still had excess sedimentation issues. The very low FIBI at N8.0 in 2015 was collected and notes were “lack of habitat, siltation”. This station was sampled after a summer after multiple large precipitation events and high flows which could have eroded the banks and deposited more silt and sediment on the stream bed during lower flows when sampled. The lack of habitat resulted in very few fish being sampled (35 fish). In 2024, a different station was sampled (N8.2) due to lack of access at the other station (N8.0). There was deeper pool habitat, but also a lack of gravel substrate. This station is slightly different than N8.0 with less woody debris and more low-gradient characteristics; however, the FIBI scores were not much different between 2022 and 2024.

N10.4 and **N12.6** (the two assessed stations) both have shown initially positive trends but then lower in recent years. It is possible that some of this reduction in scores is due to the severe and extreme drought conditions experienced in the years prior to sampling, as well as the flood in June 2024 before sampling in July. These events may have had a climatic effect on the fish communities, as both can disperse or eliminate all or a portion of the fish community. *Pioneer* percentages were compared to see if these fish that are more able to quickly recolonize after a disturbance would show that the fish community was still recovering. There was no notable difference. This is not always a good indicator of a disturbance, but can be (MPCA personal communication). A few other species were compared that are small bodied and not able to move quickly, and therefore may be a better indicator of an impact in the expected fish community when compared to other years with more normal flow conditions (2017, possibly 2022). Notable is that *fantail darter* numbers (see tables in *Individual Station Reports*) for both N10.4 and N12.6 were very low; much higher numbers were collected in 2017 and 2022. There are also channel stability and habitat issues, water quality issues, and possibly flow alteration issues, given the watershed land use in row-crop and extensive tiling, that may exacerbate low flow conditions without good opportunity for groundwater recharge. These conditions were more apparent at N12.6 which also has a smaller DA. In 2024, when revisiting three weeks after sampling in early August, the water was very low with much more filamentous algae. There was also an abundance of sand that reduced depth. So, it is not clear how much the previous year drought, or high flow in June impacted the fish community above the already present biological stressors.

[***N12.5***] – Was a comparison station established just downstream of N12.6. The habitat was much better with less sedimentation, a cobble riffle, and narrower cross-section so sediment transfer was better. Only a ½ reach was sampled as an initial comparison to see if habitat quality differences would translate into FIBI differences as well, which it did. *See Bargraph below*. The MSHA score at N12.5 was 13 points higher than N12.6. And the FIBI score followed the habitat differences, with the FIBI at N12.5 13 points higher than N12.6, but still 3 points below threshold (55, dotted red line). This small comparison shows that with less sand accumulation, habitat quality can be better with a higher FIBI score. However, habitat quality improvement alone may not get the reach to achieve the FIBI standard. Other biological stressors were evident (eutrophication, DO saturation), and potentially also a factor (elevated nitrates). This is also a very small DA station (4.4 sqmi), which is smaller than the station DAs preferred to be used in assessment by MPCA, as low DA stations go dry naturally during late summer. However, watershed land use and tiling can also be a factor that exacerbates low flow conditions.



N14.3 has had very high variability in FIBI scores as well. This is a very small DA station (<3 sqmi). This is a historically channelized reach. Overtime, the habitat quality has become very good. The extreme variability in FIBI may be due to either the natural low-flow conditions for this small DA, or complete loss of fish community during droughts, or other stressors not related to habitat quality (e.g., elevated nitrates, phosphorus). There was relatively dense filamentous algae in 2024, which might suggest a eutrophication issue.

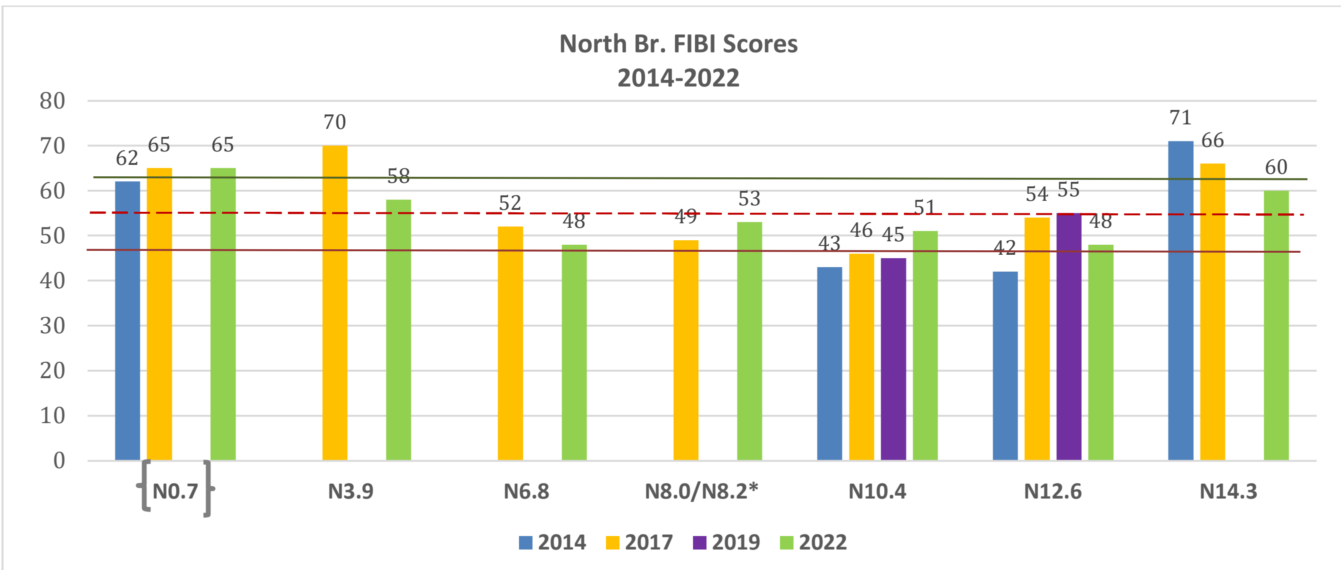
Overall directional trends and magnitude of change are included in the table below along with the potential of each station to achieve the FIBI standard as shown with FIBI scores past and presently. The Possible Stressors has been compiled from SID work and local evidence during sampling and assessment of habitat conditions. There may be others to be considered. These are discussed in more detail with photographs in the *Individual Station Reports*.

North Br Stations	FIBI Trend	Fish Quality Change	Possibility of Achieving FIBI Standard	Possible Stressors
N0.7	↑	**Fair+** to **Good**	**Good** (all above, omit 2016)	fish passage issue at foot bridge
N3.9	↑ ! ↓ !! ↓ !	**Fair+** to **Very Good** to **Fair+** to **Poor**	**Pretty Good** (all above, except 2024)	habitat quality, bedded sediment, high nitrate?
N6.8	↓ !!	**Fair+** to **Fair-**	**Possible, but concerning** (above, now below)	habitat quality, bedded sediment, high nitrate?
N8.0/N8.2*	↑ !!	**Very Poor** to **Fair-**	**Possible, but very concerning** (all below)	habitat quality, bedded sediment, high nitrate?
N10.4	↑ ! ↓ ! ↑ ! ↓ !	**Poor** to **Fair-** to **Poor** to **Fair-** to **Poor**	**Possible, but very concerning** (all below)	flow alteration, habitat quality, high nitrate?
N12.6	↑ !! ↓ !!	Poor – Fair+ - Fair - Poor	**Possible, but concerning** (most below)	flow alteration, smaller DA, habitat quality, bedded sediment, eutrophication, high nitrate?

[N12.5]	*1x FIBI – ½ reach*	**Fair-** *[FIBI 52]*	**Possible, better habitat, but still below threshold**	flow alteration, smaller DA, eutrophication, high nitrate?
N14.3	↓**!!**↑ **!!**↓**!!**	**Very Good** – **Fair-** - **Very Good** – **Fair-**	**Possible, Pretty Good;** NA, very small DA	flow alteration, eutrophication high nitrate?

Comparison of FIBI results when certain years removed

As there are questions as to the impact of the extreme drought the year prior in 2023 and flood stage conditions in 2024, the best, normal flow conditions may be from 2017. Habitat conditions were also better than in 2022 than 2017, but there was a severe drought in 2021 that could also be a factor. And the unknown flow conditions in 2015 and 2016 that were likely high could also be a factor those years. In 2019, flows were very high prior to sampling the only two stations sampled by MPCA that year (**N10.4, N12.6**) as well, especially at **N12.6** so those are also excluded. The most confident readings then may be from the years 2014, 2017 and possibly 2022. The bargraph and table below shows the results.



While some stations have shown improvement in FIBI scores (**N8.0, N10.4**) others have either gone down (**N3.9, N6.8**) or shown an increase then a decrease in scores (**N12.6**). However, only three stations showed a significant change (noted with "**!**" in table below), one station had a significant improvement (**N10.4**) with fish quality going from *poor* to *fair-* (still below threshold), while two stations went down significantly: **N3.9** dropped from *very good* to *fair+ (*still above threshold) and **N12.6** dropped from *fair* to *fair-* (below threshold).

North Br Stations	FIBI Trend	Fish Quality	Possibility of Achieving FIBI Standard	Possible Stressors
{N0.7}	↑	**Fair+** to **Good**	**Good** (all above)	fish passage issue at foot bridge
N3.9	↓ **!**	**Very Good to Fair+**	**Pretty Good** (far above, slightly above)	habitat quality, bedded sediment, high nitrate?
N6.8	↓	**Fair+** to **Fair-**	**Possible, but concerning** (both below)	habitat quality, bedded sediment, high nitrate?

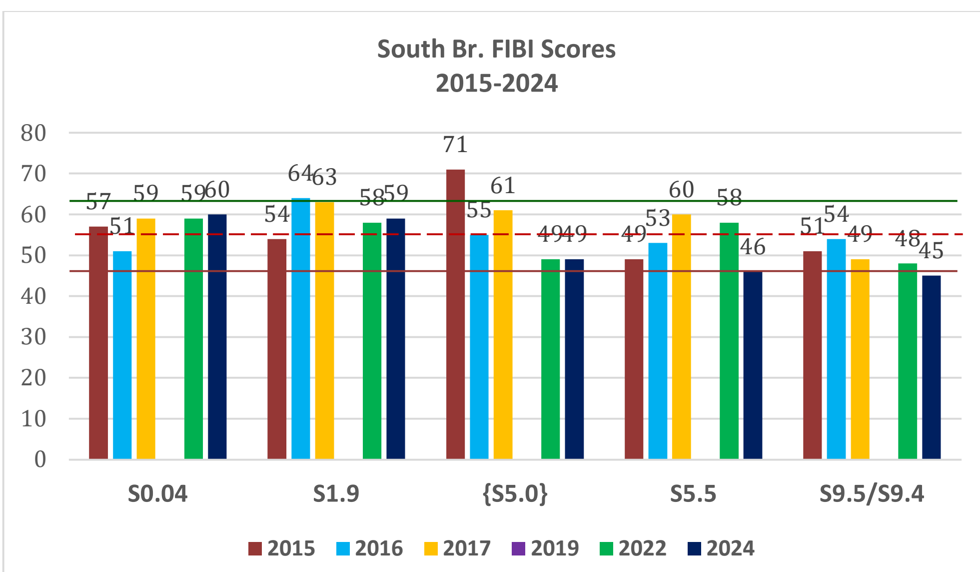
N8.0/N8.2*	↑	**Fair-**	**Possible, but very concerning** (both below)	habitat quality, bedded sediment, high nitrate?
N10.4	↑ !	**Poor** to **Fair-**	**Possible, but very concerning** (all below)	Flow alteration, habitat quality, high nitrate?
N12.6	↑ ↓ !	**Poor** to **Fair** to **Fair-**	**Possible, but concerning** (all below)	flow alteration, habitat quality, bedded sediment, eutrophication, high nitrate?
N14.3	↓	**Very Good** – **Fair+**	**Possible, Pretty Good** Not assess? very small DA	flow alteration, eutrophication, high nitrate?

While removing a few questionable years reduced the variability in scores, the *Possibility of Achieving the FIBI Standard* stayed exactly the same. N0.7 on the lower AUID remained above the threshold. Please note: N14.3 has a very small DA and might not be suitable for assessment; however, scores area all above threshold and habitat quality was pretty good; especially for a historically channelized reach. For the other five stations on the upstream AUID, one was above threshold (N3.9) while the four other stations were at or below threshold. If assessed today, this AUID would likely still be listed as impaired for the fish assemblage, due to the multiple FIBI scores below threshold at the middle stations (**N6.8, N8.0, N10.4, N12.6**).

5.22 South Branch- FIBI

The FIBI scores for all stations on the South Branch and all years sampled (2014-2024) are displayed in the bargraph below. [Note: S5.0 is on a tributary to the South Br, hence the brackets; all other stations are on the same AUID]. Oddly, the 2024 FIBIs were not much different than 2022 at most stations, except for **S5.5** and a little lower at **S9.4/S.5**. It is not clear if the South Br was affected differently during the extreme drought in 2023 or the high flood flow event in June, prior to sampling in July. Ideally, two consecutive years with normal flow conditions would provide a more confident reading of the current fish community conditions.

Overall, there was a slight increase in FIBI score at one station (**S0.04**), a significant downward trend at two stations (**S5.0, S9.4/S9.5**), and high variation (up than down) at two stations (**S1.9, S5.5**).



Variation at S5.0 and other stations could be related to variation in summer precipitation and flow conditions, similarly as the North Br. as there were notable differences in annual flow conditions. High flow years can exacerbate habitat quality issues while moderate flow years or after drought allows banks to stabilize with vegetation and low flow has time to move excess sediment, so habitat appears better. This variation in habitat quality could affect the fish community collected, and hence, the resulting FIBI scores. A second analysis is included later below, where the same years that may have been influenced by previous drought or within year high flow conditions (or both) was removed (2015, 2016, and 2024).

South Br Stations	FIBI Trend	Fish Quality	Possibility of Achieving FIBI Standard	Possible Stressors
S0.04	↓ ↑ !	Fair+ to Fair- to Fair+	Good, somewhat concerning (Most slightly above)	Variation in sand load, lack of habitat
S1.9	↑ ↓ !	Fair to Good to Fair+	Good, somewhat concerning (well above to slightly above)	Variation in sand load, lack of habitat
{S5.0}	↓! ↓!	Very Good to Fair+ to Fair-	Possible, but concerning (far above, below)	Lack of habitat, eutrophication?
S5.5	↑! ↓!	Fair- to Fair+ to Poor	Possible, but concerning (above, below)	Lack of habitat, bedded sediment, low-gradient?
S9.5/9.4	↓ !	Fair- to Poor	Possible, but very concerning (all below) or not asses?	Flow alteration, lack of habitat, fish passage issue, small DA

Only **S9.5/S9.4** has consistently scored below the FIBI threshold. At **S9.5** (the original station on the upstream side of the road), while habitat quality improved, the FIBI scores did not. This station had surprisingly good habitat quality for a historically channelized reach. No water quality issues were noted. So, it is possible that the low FIBI scores are due to the very small DA (2.7 sqmi) and potential natural intermittency (dry or low flow in some if not all late summers). The FIBI was developed and calibrated to assess streams that are typically >5 sqmi. Therefore, the FIBI may not be appropriate to apply to this small headwater station. At S9.4, sampled in 2024, the stream bottom was mostly clay, and not representative of the AUID. Given these conditions (small DA and clay bottom), it is recommended to discontinue this station for Effectiveness Monitoring.

Except for a few years, **S0.04** and **S1.9** show the least variability in scores and are maintaining scores slightly above threshold. There were a few sensitive species collected that keep FIBI scores slightly above threshold (*lamprey ammocoetes, hornyhead chub*) as well as the combination of other metrics. There are habitat issues at both stations. However, the sand load has been dramatically variable at S0.4. There was an abundance of sand overwhelming the bottom in 2022 and much less of it in 2024 when habitat quality was better. Keeping the habitat quality and water quality conditions suitable for these sensitive fish will be necessary to keep FIBI scores above the impairment threshold.

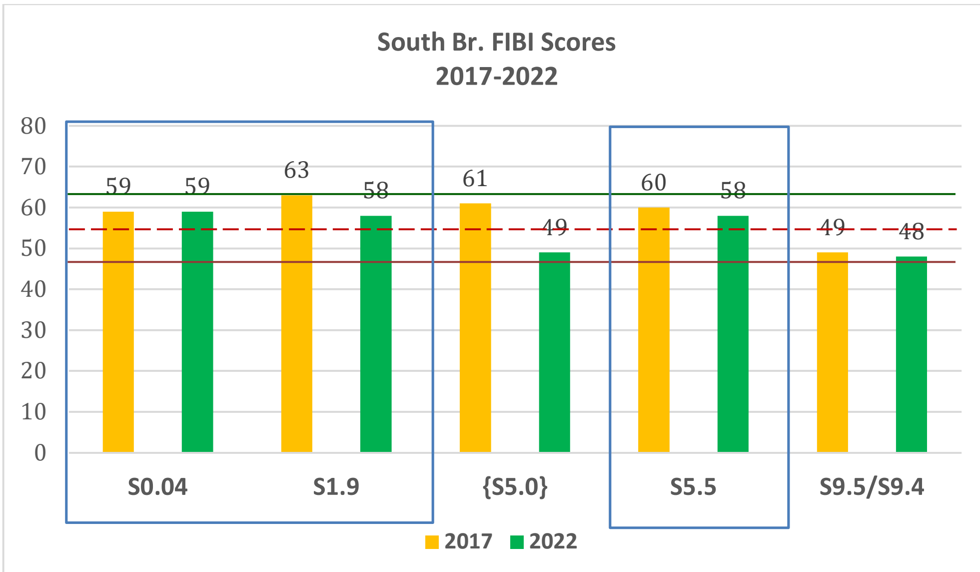
S5.5 showed the most improvement in FIBI scores, prior to 2024. Habitat quality assessments and photographs were not taken during 2015 or 2016, so it remains unclear if there has been an improvement in habitat conditions that would also improve FIBI scores. The reach in 2024 had excessive sand deposition, likely freshly deposited during the June flood. There was aggraded sediment at this station which could have caused the depressed FIBI score this year.

S5.0 showed the biggest negative change in FIBI scores. This station has considerable channel stability issues as well as possible eutrophication issues. Since S5.0 is on a tributary to the South Br, it would be assessed separately from the other stations. This station will need to continue to maintain or improve in FIBI scores to not be assessed as impaired in the future.

As erosive flows are diminished, sediment sources are managed, and the over-widened areas narrow to normal width, habitat conditions should improve overtime, and subsequently result in improved and more stable FIBI scores. This would prevent this AUID from being listed as impaired for aquatic life in the future, if there are no other limiting water quality stressors (e.g., high nitrates, DO issues).

Comparison of FIBI results when certain years removed

To compare the results with some years excluded as was done for the North Br. above, the bar graph and table below show the results.



There is less variability in the trend arrows, and the poorest scores for some stations were removed. However, while there were two shifts in the confidence in the *Possibility of Achieving the FIBI Standard* (Asterisks (*), only one station (S5.5) showed better confidence with both scores above threshold. Please note: while there are down arrows in trends for many of the stations, only the FIBI scores at S5.0 were outside the confidence interval (+/-7 points), the others were all within expected sample variability, so in essence, no difference.

Only two stations had FIBI scores below threshold (S5.0, and S9.5). Station S5.0 is also a tributary to the South Br, so on a different AUID. If this one would be assessed today, the lower score might take precedence in an assessment, along with noted channel stability and habitat quality issues, and be listed as impaired for the fish assemblage. For the other station, S9.5 has a very small DA and might not be appropriate to assess with the *Southern Headwater* FIBI.

Many of the stations are on unique AUIDs. Currently, FIBI scores appear to support the Aquatic Life assessment for the fish assemblages. However, both the fish and macroinvertebrate assemblages need to be supporting to pass. These scores are also 7 years old and might not be reflective of current conditions. Hopefully, future monitoring with adequate flow conditions, both the year prior and in the early summer before sampling, will be sufficient for a more confident reading of the current conditions.

South Br Stations	FIBI Trend	Fish Quality	Possibility of Achieving FIBI Standard	Possible Stressors
S0.04	no change	**Fair+**	**Good, somewhat concerning** (slightly above)	Variation in sand load, lack of habitat
S1.9	↓ **!**	**Fair+**	**Good, somewhat concerning** (well above to slightly above)	Variation in sand load, lack of habitat

{S5.0}	↓ !	**Fair+** to **Fair-**	**Possible, but concerning** (far above and below)	Lack of habitat, eutrophication?
S5.5	↓	**Fair+**	***Good, somewhat concerning** (slightly above)	Lack of habitat, bedded sediment, low-gradient?
S9.5/9.4	↓	**Fair-**	**Possible, but concerning;** (both below) or not asses?	Flow alteration, lack of habitat, fish passage issue, small DA

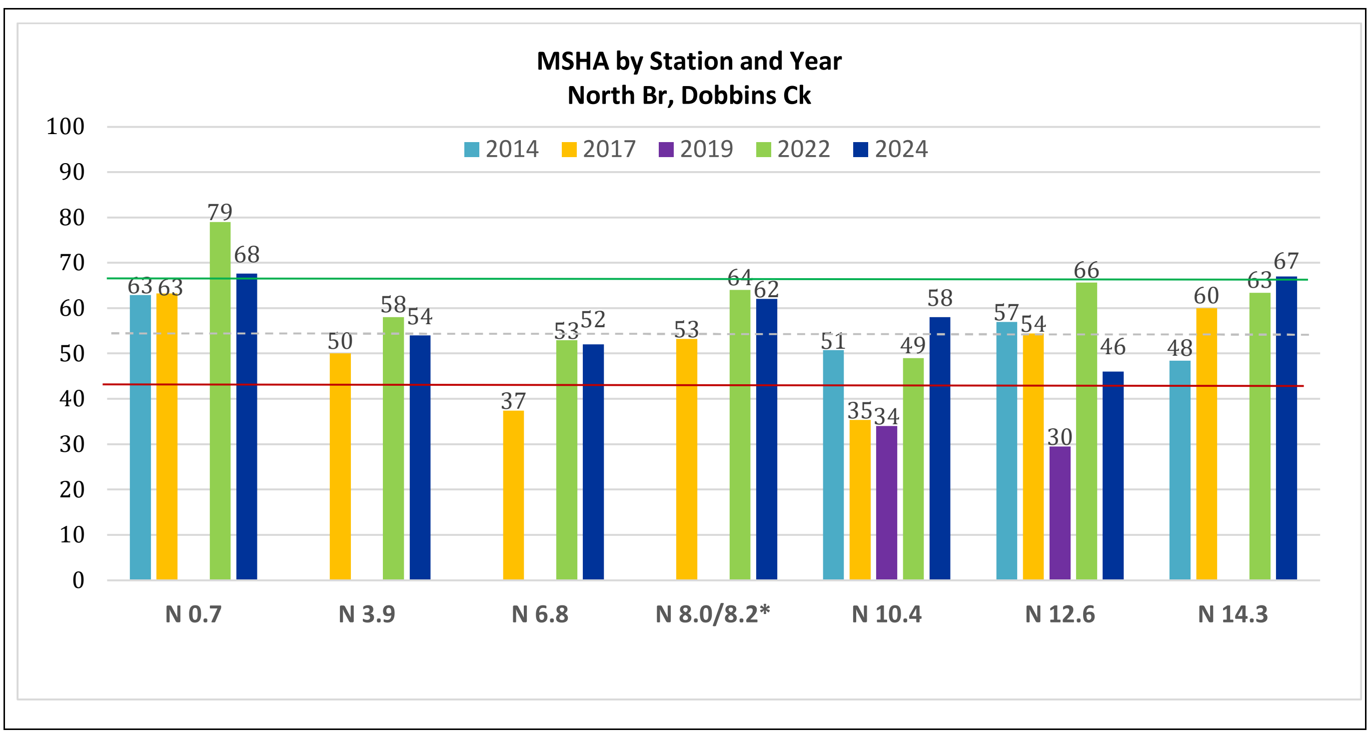
5.3 Habitat Quality – MSHA

MSHA scores are included in the bargraphs below. Scores on both branches have improved at most stations. There are a few possible reasons for habitat improvements. One is that, with the completion projects installed by CRWP to increase the water storage capacity is starting to have a positive effect on reducing the flashy, highly erosive stream flows to a slower release after storm events. This should result in a more normal stream hydrograph which should help to re-stabilize stream banks and improve instream habitat quality Another possibility is that flow events and precipitation were different in 2017 and 2022. For example, very high water and a flood event came through before the August sampling in 2017 which likely eroded banks and widened stream channels before habitat assessments. In contrast, 2021 experienced drought conditions, preceding the 2022 habitat assessments. Fewer higher flow and flood conditions could have allowed vegetation to grow on exposed low banks and bars and narrowed previously over-widened stream channels and led to improved habitat ratings for *Channel Stability*, *Depth Variability* and *Substrate*. 2024 had a large flood event in June, prior to sampling in July. There was more bank erosion observed, and the gravel was not well sorted. So, there were slightly lower MSHA scores for most stations. N10.4 and N12.6 have been going through channel evolution. When streams are unstable and downcut, they tend to widen when higher flows are contained within the banks and cause more erosion. N10.4 and N12.6 both showed at times that there was a heavy load of sand that moved into these reaches. The difference was that at N10.4, the stream has started to narrow to a normal cross-section, and so the excess sand was deposited on point bars and the deeper meandering thalweg was able to move the excess sediment, so there was some depth variability in 2024 that was lacking in 2022. The opposite occurred at N12.6 where the sand was in excess and overwhelming the bottom in 2024 which was not present in 2022. This station in 2024 was very overwidened, and so the flow is shallow and not able to move the sand effectively. There was noticeable lack of deep pools and not much depth variability due to the excess sand accumulation. This was not present in 2022 and so MSHA scores were higher for many *Instream Zone* and *Channel Morphology* metrics. (See *Individual Station Reports* for more information and photos).

Overall, currently both branches are showing signs of channel instability and adjustment, likely due to the flashier hydrology from ditching and tile drainage. There is evidence of downcutting (bottom scouring), and erosive flow cutting along banks and below the rootzone of trees and grasses. The bank materials (sand/silt) are sensitive to erosion when not protected. As stream banks erode, the stream width widens and as the water volume is spread out it is shallower and velocity is slower and not as able to transport the annual supply of sediment, thereby accumulated on the bottom. There are many stations presently (2024) with overwidened conditions and excess sand accumulation. Excess bedded sediment is currently affecting the habitat quality on both branches, especially in the middle stations. Where streams are over-widened and lack depth variability (where stable streams have deep pools, shallow riffles or side margins), and most importantly for habitat specialist fish have minimal areas of clean, unembedded gravel. Excess sediment smothers coarse substrates used by gravel spawning fish and larger gravel and cobble for feeding on aquatic insects or algae. Excess sediment fills in deep pool areas that provide rest and cool water for larger fish. Some streams that are unstable with steep banks no longer have access to the riparian corridor and vegetation. The middle of both branches and the tributary of the South Br are very incised and disconnected from their floodplains. This causes a lack of flood flow refuge, prevents normal, annual overbank flows to dissipate flood flow energy, causes more erosive bank and bottom erosion, excessive velocity conditions that can displace fish or injure, causes a reduction in shallow rearing locations for small minnows and young-of-year fish, and reduces the natural processes of stable streams to use the riparian to attenuate nutrients such as phosphorus and nitrogen, and remove excess TSS. More specifics are included below and in the *Individual Station Reports*.

5.31 North Branch - MSHA

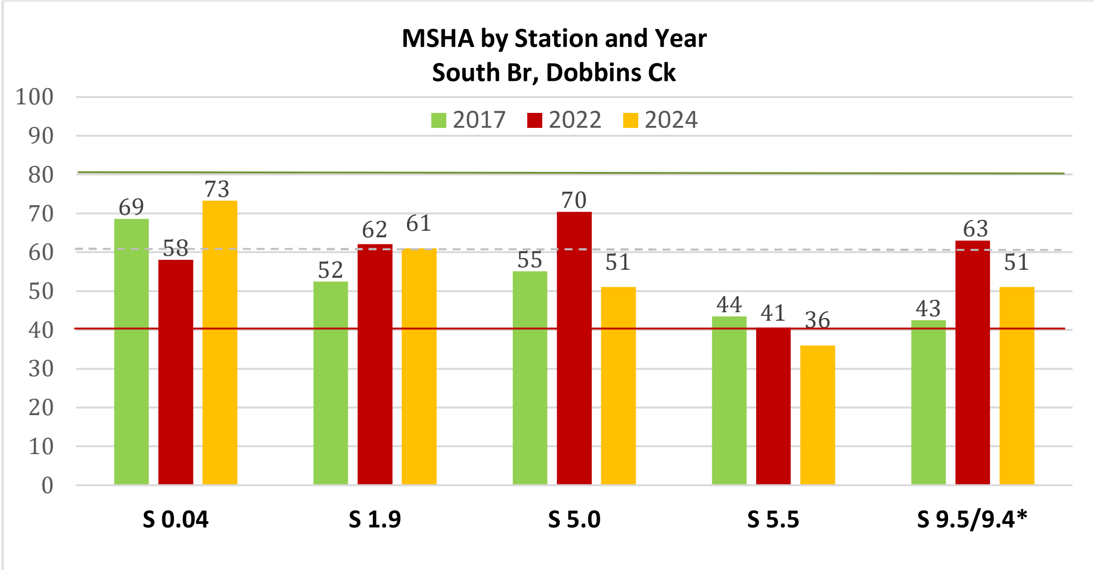
A few stations were rated with the MSHA in 2014 and 2019 with all stations rated in 2017 and 2022 (not by UMN in 2015 and 2016). The best habitat quality was at the outlet station (**N0.7**). The most improvement observed was at **N6.8,** and **N14.3**. Stations **N3.9** and **N8.0/N8.2** also showed improvement in scores. These stations have been progressing through channel evolution stages (*see SCSI below* and in the *Individual Station Reports*). Two stations showed extreme variability in scores (**N10.4** and **N12.6**). These stations with high variability also have channel stability issues that due to downcutting and erosive flows contained, fluctuate between better and worse habitat conditions depending on the flow conditions that year. For example, during years with high flows, bank erosion is worse and sediment mobility can reduce pool depth and increase embeddedness. Better habitat quality can occur during times when annual flows are not as high or a previous year drought has allowed some vegetation to grow on lower banks and forcing flows into a more confined width, providing more efficient excess sediment removal, cleaner gravel, and deeper pools (DeZiel et al. 2019). These differences can all translate into better MSHA metrics (e.g., *bank erosion, shade, substrate coarseness, embeddedness, cover amount, depth variability, channel development, channel stability*).



North Br Stations	Trend	Habitat Quality	Habitat Quality Comments
N0.7	↑!! ↓ !	**Fair+** to **Very Good** to **Good**	Good quality. Some variation with degree of sand aggradation, and if woody debris scour pools more prevalent.
N3.9	↑ !	**Fair-** to **Fair+**	Habitat quality has improved, but has excess sedimentation issues.
N6.8	↑ !!	**Poor** to **Fair-**	Habitat quality has improved, but has excess sedimentation issues. Very disconnected from floodplain. Possible fish passage issue at culvert.
N8.0/N8.2*	↑ !	**Fair-** to **Fair+**	Habitat quality has improved at N8.0. Stream is N8.2* more low-gradient and lacks woody debris, hence lacks depth variability.
N10.4	↓!! ↑ !! ↑!	**Fair-** to **Poor** to **Fair-** to **Fair+**	High variability due to channel incision and flow alteration, habitat quality varies with flow conditions. Very disconnected from floodplain.
N12.6	↓ !!↑!!↓ !!	**Fair+** to **Very Poor** to **Fair+** to **Fair-**	High variability due to excess sedimentation that varies with seasonal flow conditions. Very disconnected from floodplain. Water level goes very low in late summer= flow alteration and/or naturally small DA.
N14.3	↑!!↑ !!	**Fair-** to **Fair+** to **Good**	Habitat quality has improved, good pool/riffle formation. Surprising for channelized reach.

5.32 South Branch-MSHA

The MSHA was only completed in later years (2017, 2022, 2024). There are some stations that improved notably in scores (**S0.04, S1.9,** and **S9.5** between 2017 and 2022, before **S9.4** sampled in 2024) with **S5.0** with high variability in scores. MSHA scores at one station has remained low and has decreased in scores (**S5.5**), likely due to natural low-gradient characteristics and evidence of widening and more sand accumulation. Many of the stations on the South Br. are moving through channel evolution, from being overwidened with excess sedimentation to narrower channels with better gravel sorting and deeper pool habitat. If the stream width and banks are more stable, future high flows should not cause a lot of bank erosion. If still in a state of instability, the banks will likely unravel and widen again. More detailed information and photos at each station is included in the *Individual Station Reports*. The following is a summary of each station.



S0.04 had the highest MSHA scores, with a lower score in 2022. The MSHA score was lower in 2022 due to the excess sand accumulation in this channel which was extreme (see photo near beginning of report). This caused a lack of depth variability. However, in 2024, after a series of high flow events, the excess sand was removed from the bottom and there was an abundance of sand deposited on point bars that were narrowing the channel (photo below). There were many very deep pools and areas of coarse substrates (gravel/small cobble) that were fairly clean and unembedded. The habitat quality in 2024 was good.

S1.9 has improved in habitat quality from fair-poor to fair. There were still issues with excess sand. Downed tree limbs provided some localized scour pool development. There were many (10-12) gravel redds throughout the 165m reach. These gravel redds were large and unembedded, providing excellent nesting habitat for chubs (hornyhead chub, or creek chub).

	
Photo – S0.04 – 2024: Less sand accumulation on bottom, some deposited on point bars. Deeper thalweg and scour pools by downed trees.	**Photo – S1.9 – 2024:** Gravel piled up by chubs.

S5.5 had the lowest MSHA scores. This station is on the border of being low-gradient (Rosgen E channel), so naturally the stream lacks depth variability, riffles, and is dominated by sand and silt. However, this reach is within an active cattle pasture, with a few access areas with most trampling. This stream has increased in width (at least since 2017) and is presently overwidened, so flows cannot efficiently move the excess sand and diminishes pool depth.

S9.5 had the most improvement in habitat ratings, increasing 22 points between 2017 and 2022, from "fair" to "good" habitat quality. This reach narrowed considerably between 2017 and 2022 with greater depth variability and better gravel sorting. Some of this improvement may have occurred during the severe drought in 2021 and extreme drought in 2023. This is also a very small DA station, which may be naturally intermittent, and more likely to go dry, especially with lack of precipitation in late summer and during drought. When flow is very low or the bottom is dry, grasses can grow along the inside margins of the stream and build banks that narrow the channel, which likely occurred between 2017 and 2022. This can increase the ability of the stream to move out excess sediment that accumulated from upstream bank erosion more so than the previous over-widened cross-section that slows the velocity and is not able to transport the annual load of sediment. When the stream bottom is dry, as was likely during the extreme drought in 2023, grasses can grow across the bottom of the channel. In 2024, the channel was only sampleable 35m before the grasses were too dense across the channel and it was too shallow to sample. Also, with the drought, the groundwater level was much lower, which may have also contributed to the lack of water in the channel in 2024. Due to the lack of a sampleable reach >75m, a new station (S9.4*) was placed on the opposite side of the road. The score is included in the bar graph with S9.5 since it is in the same area of the South Br. This station also had a clay bottom but also had gravel and some cobble/boulder that provided better habitat conditions. The riparian is mowed to the edge of the channel and there is bank erosion, so the riparian zone scores were lower as well as other habitat quality metrics. There is currently a boulder dam that restricts flow. In future, if funds are provided, these cobble/boulders could be removed to provide improved flow conditions, and possibly better habitat quality.

5.4 Stream Condition/Stressor Observations - SCSI

The tables below (5.4a, 5.4b) include observations recorded on both the North and South Br. stations in 2022 and 2024. Some of the most concerning stressors are discussed below. *Individual Station Reports* provide more descriptions and photos.

Lack of suitable substrates for spawning/feeding: Some stations have lack or little suitable substrate quality for spawning due to channel stability issues (e.g., N6.8, N3.9, S9.5) as well as due to more low-gradient characteristics where sand is often dominate naturally (N8.2, S5.5). Both N8.2 and S5.5 are also somewhat downcut and overwidened. When channels evolve and develop some small inset floodplain characteristics, the channel narrows and is more able to remove excess sand and uncover and sort the gravel where flow is faster. This occurred at the original S9.5 overtime. Characteristics in 2017 appeared to be very low-gradient, as there was a lack of depth and the bottom was uniformly sand with little gravel. In 2022, the stream was much narrower, possibly due to the encroachment of grass on the banks during the previous year drought. The habitat was more variable and very different from 2022. There was some gravel, but conditions were not well sorted and still of questionable quality/extent for spawning. In 2024, the station was moved to the downstream side of the road and the clay bottom was dominant for most of the reach, but there was some limited gravel, suitable for spawning.

Riparian Flow refuge: Ability of fish to move off channel during high, scouring flood flows. N14.3 is a historically dredged ditch, so the walls of the channel are higher than would be. Other stations have downcut overtime and have narrow widths and steep banks. Some of these stations are starting to evolve through widening and small inset floodplains from bank collapse and sedimentation on sides of channels as point bars.

Table 5.4a: Habitat Condition and Stressors at the North Br stations.

SCSI checklist – North Br	N14.3		N12.6		N10.4		N8.0 - N8.2*		N6.8		N3.9		N0.07	
	22	24	22	24	22	24	22	24	22	24	22	24	22	24
A. Quality Spawning/Refuge														
run/riffle substrates suitable - spawning	+	+	+	+	+	+	+	-	+	-	?	?	+	+
run/riffle substrates suitable - feeding	+	+	+	+	+	+	+	N8.0	+/-	-	?	-	+	+
Logs/WD w/ fast flow (like riffles)							+				+	+	+	+
gravel/sand spongy, moved recently		-				-				-		-	-	-
pool refuge present, one deep (>20 in)	+	+	+		+			+	+	+	+	+	+	+
pool depths mostly all shallow (<20 in)				-		-	-	-			-			
riparian flow refuge – access/extent	X!	X!	-		-	-	-	+	-	-	-	+	+	+
B. Groundwater														
springs/seeps observed				+		+	+	+	+	+	+	+	+	
C. Hydrologic Influences														
draintiles	-	-				-								
D. Blockage to Fish Passage														
culvert issue									X	X!			X!	X!
rock dams														
F. Excess Nutrients														
filamentous algae	-	-	X!	[X!]		-								
algae slimy on rocks						-								-
G. Riparian Management														
heavily grazed pasture/feedlot														
grazed pasture					?	x/-								
animal access to stream					-	-								
H. Bank Erosion														
cutting below rootline (incised)		-			X	-		-	-	-		-		-
GW seeps at toe of bank						-		-	-	-				
flow deflectors - logs, tree fall			X										-	-
flow deflectors - lateral bar build-up			-		-				-			-	-	-
flow-deflector- mid channel bars				-					-				-	-
steep banks, non-cohesive soil			-		-	-		-	-	-	-	-		-
clay at toe of bank, armoring						+			+	+				
trampling (cattle)					X									
I. Channel Instability														
incised - excess scouring (CEM II)		-				-		-	-	-	-	-		
knick-point observed (CEM II)				-		-		-	-	-		-	-	-
diagonal riffle observed (CEM II)				-		-			-				-	-
excess aggradation-sand ripples (CEM III)				-	-	-			-	-	-			-
overwidened (CEM III)		-		-	-	-		-	-	-		-	-	-
midchannel bars (CEM III)	-			-					-				-	-
point bars, thalweg re-developing (CEM IV)	+	+	+		+/-	+/-		+/-	+/-	+/-	-	+/-	+/-	+
pretty near stable condition (CEM V)														

Groundwater seeps – The more groundwater that is able to enter the streams, the cooler the thermal regime. This is especially important during the hot air temperatures of summer.

Fish passage issues at **N0.7, N6.8**, **S0.04** and **S9.4**. It is not clear how much these could influence the fish community but are noted as a stressor in the headwaters of the North Br. in the MPCA SID report. *See Individual Station Reports for Photos.*

Filamentous algae is concerning, especially at **N12.6** which may indicate a eutrophication issue. When sampled in July, after high flow conditions in June, there was no filamentous algae observed. However, when revisited in early August, flows were low and filamentous algae was prevalent.

Riparian Management – A few stations are used regularly (**S5.5**) or occasionally (**N10.4**) as pasture for cattle. The level of grazing and bank trampling was variable. One station had riparian grasses mowed to the edge of the stream (**S.9.4**). The lack of deep-rooted vegetation from mowing or trampling can reduce infiltration and add to nutrient and soil runoff to streams. There was one year at **N10.4** that the cattle were present and manure/nutrient inputs were more likely. It does not appear that these conditions are the most concerning; there are other stressors also present.

Table 5.4b: Habitat Condition and Stressors at the South Br stations.

SCSI checklist – South Br.	S9.5	S9.4*	S5.5		S5.0		S1.9		S0.04	
	22	24	22	24	22	24	22	24	22	24
A. Quality Spawning/Refuge										
run/riffle substrates suitable - spawning	?	+	?	-	+	+	+	+	+	+
run/riffle substrates suitable - feeding		+	-	-	little	?	-	+	+	+
logs/WD w/ fast flow (like riffles)							+	+		
gravels bright and spongy, moved recently									-	
pool refuge present, one deep (>20 in)			+		-	-	+	+	+	+
pool refuge limited; pool depths mostly shallow (<20in)	-	x		-	-	-			-	
riparian flow refuge – access/extent		x								
B. Groundwater										
springs/seeps observed			+	+		+	+			+
C. Hydrologic Influences										
draintiles						x[1]			x[2]	
flow limited – rock dam	x (DS)	x								
D. Blockage to Fish Passage										
culvert issue									x	x
rock dams	x (DS)	x								
F. Excess Nutrients										
filamentous algae		-			-					
algae slimy on rocks										-
G. Riparian Management										
landscaping to stream edge		x								
grazed pasture/feedlot			-	-						
animal access to stream			-	-						
H. Bank Erosion										
cutting below rootline (incised)		-	-		-	x	-	-		-
GW seeps at toe of bank			-			-				
flow deflectors - logs, tree fall					-		-	-	-	-
flow deflectors - lateral bar build-up		-			-	x	-	-	-	-
flow-deflector- mid channel bars					-	x			-	
steep banks, non-cohesive soil		-			-	x	-	-		-
clay at toe of bank, armoring					+	+				
trampling (cattle)			-	-						
I. Channel Instability										
incised - excess scouring (CEM II)		x						-		
knick-point observed (CEM II)						-		-		-
diagonal riffle observed (CEM II)						-	-		-	-
excess aggradation-sand ripples (CEM III)			-	-	-			-	x	-
overwidened (CEM III)		-	-	-		-	-	-	x	-
midchannel bars (CEM III)			-	-	-	-			x	
point bars, thalweg re-developing (CEM IV)	+	+/-	+/-		+/-	+/-	+/-	+/-	+/-	+

Bank erosion – Trampling by cattle was a cause of bank erosion at concerning levels at only a few stations and years (**N10.4, S5.5**). Most of the bank erosion observed was due to these channels having downcut in response to flow alteration (more flashy hydrology) and high susceptibility of the bottom to scour away (sand/gravel, highly mobilizable). After these stations have been downcut, the flow is now undercutting below the rootzone of grasses and trees at many stations, adding additional erosion and widening (see stations below), and tree fall with erosive flows directed to banks by the downed branches and trees. The most concerning evidence of cutting and flow deflectors causing lots of bank erosion was at **S5.0** both years and **N12.6** in 2022). There was much less woody debris on the bottom of **N12.6** in 2024. It is possible that the high flow in June moved some of the downed trees and branches out of the station, unless they were removed by someone inbetween years due to the obvious bank erosion issues from the downed trees.

Channel instability – multiple indicators of various levels of channel instability were observed, from indicators that show downcutting/excess bottom erosion (CEM II), overwidening/excess aggradation (CEM III) and some degree that these channels are progressing into more stable cross-sections and narrower widths as point bars develop (CEM IV). Only one station was looking fairly stable (**S9.5** in 2022). Table 1 below (from the MPCA [Channel Condition and Stability Index (CCSI): MPCA Protocol for Assessing the Geomorphic Condition and Stability of Low-Gradient Alluvial Streams]) describes the sequence of channel evolution and impacts to habitat quality.

Table 1. Channel Evolution Model (CEM) stages. Modified from Schumm et al. (1984) and Thorne (1999).

I. Sinuous, premodified 	**I. Pre-adjustment** – Channel is in regime (processes of degradation and aggradation may occur between spring and fall, but remain overall consistent year to year and in balance). Channel exhibits little evidence of excessive bank erosion and cutting. For sinuous alluvial streams, the outside bends demonstrate some bank erosion and the inside bends some deposition. However, the degree of bank erosion and deposition is in balance and is characteristic of the natural hydrologic regime of alluvial streams.
II. Degradation 	**II. Degradation/Widening** – An increase in channel slope, discharge or decrease in sediment supply has tipped the scale toward degradation. The channel cross-section is deepening due to excess scouring. Channel has disconnected from the floodplain. Bank erosion and cutting is excessive along the inside and outside bends. Bank angles are starting to steepen. Trees may be seen leaning into the stream from one or both sides of the channel. Note: Degradation may not be observed when coarse substrates are armoring the channel bottom. In this case, channel widening will be the dominant process. Cutting along both banks may be observed.
III. Degradation and widening 	**III. Widening and Aggradation** – Banks have steepened to the point where the banks are destabilized and are collapsing. Cutting may be observed along one or both banks. New tree fall or areas of mass wasting/bank failure may also be observed. At this stage, the channel cross-section is overwidened and consequently, sediment transport capacity is reduced leading to excess aggradation in pools and runs.
IV. Aggradation and widening 	**IV. Thalweg Channel Adjustment** – During this stage, the stream may be re-developing a thalweg on the outside bend and a depositional bar on the inside bend. Consequently, some degree of cutting and bank collapse may still be observed as flow is directed along the outside bend by the developing point bar (Thorne 1999).
V. Quasiequilibrium 	**V. New Dynamic Equilibrium** – Thalweg reformed, banks stable, and sand bars revegetated. Smaller floodplain within active channel. Old terraces may be visible. Seasonal periods of degradation and aggradation are occurring; however, no net degradation or aggradation observed. Channel is once again in regime. However, due to the lower base level and channel confinement by relic terraces, stream is sensitive to high flows.

5.5 Water Quality

Table 5.5 below shows the water chemistry collected by station and year. Mower SCWD is also collecting field measurements and grab samples for nutrient analysis at sites along both the North and South Branches. However, this data reported below is what was collected at the same time as fish collection. MPCA collected field measurements and grab samples for lab analysis of sediment and nutrients at a few of the North Branch stations in 2014 and 2019. No field measurements or grab samples were collected by UMN in 2015, 2016, and 2017. Brenda DeZiel with UMN and Caddis Fish collected field measurements in 2022 and 2024.

There are some stations where supersaturated DO (>120%) and/or elevated nitrates (>8.0 mg/L) were found during at least one visit. If possible, more measurements during the summer may show whether or not these are noteworthy stressors that are negatively affecting the fish (and aquatic insect) communities and to what degree. This knowledge would possibly direct the type of BMPs could be considered and implemented.

Table 5.5a: Water Chemistry collected at time of fish sampling for the North Br. Stations are ordered upstream to downstream. Note: FIBI scores in red are at or below threshold (55). Other color-coded cells are described below the table.

Station ID	Visit Date	FIBI	Time	H20 oC	Cond.	DO mg/L	DO %	pH	Water Clarity cm	NH4 mg/L	Total N mg/L	Phos ug/L	TSS mg/L	TSVS mg/L
N14.3	7/08/14	71	8:42	15.6	664	9.47	101.0	7.2	100	<0.05*	24.0	8	1.2	--
N14.3	7/19/22	60	11:23	19.6	667	8.42	97.2	7.8	100	--	--	--	--	--
N14.3	7/16/24	50	8:38	16.9	820	8.3	90.6	--	100	--	--	--	--	--
N12.6	7/08/14	42	10:23	17.8	635	8.56	95.0	7.6	100	<0.05*	4.8	46	2.4	
N12.6	6/25/19	55	16:31	18.9	602	8.67	93.5	8.0	89	<0.05*	13.0	35	13.0	3.6
N12.6	8/11/22	48	16:01	23.8	605	9.98	124.7	8.2	100	--	--	--	--	--
N12.6	7/16/24	42	11:56	19.2	805	8.7	98.8	--	100	--	--	--	--	--
N10.4	7/08/14	43	9:15	16.7	597	8.69	95.0	7.9	100	<0.05*	22.0	13	1.0	
N10.4	7/31/19	46	12:05	20.4	529	11.21	124.5	8.0	75	<0.05*	6.8	34	8.4	2.8
N10.4	8/02/22	51	9:30	18.5	619	9.23	103.4	7.9	80	--	--	--	--	--
N10.4	7/17/24	43	9:03	17.5	654	8.94	97.5	7.7	100	--	--	--	--	--
N8.0	8/11/22	55	8:12	18.1	633	8.38	92.2	7.7	63	--	--	--	--	--
N8.2	7/18/24	49	8:32	16.1	604	8.2	86.3	--	100	--	--	--	--	--
N6.8	8/23/22	48	13:15	20.8	525	11.23	130.4	8.0	100	--	--	--	--	--
N6.8	7/17/24	52	13:05	19.6	540	9.6	108.6	--	100	--	--	--	--	--
N3.9	8/23/22	58	8:55	17.4	483	8.77	95.5	7.7	72	--	--	--	--	--
N3.9	8/12/24	46	--	--	--	--	--	--	90	--	--	--	--	--
N0.7	8/28/14	62	11:25	15.9	382	7.71	81.0	8.1	100	<0.05*	20.0	28	3.6	--
N0.7	8/24/22	65	8:30	17.2	475	7.91	85.3	7.7	90	--	--	--	--	--
N0.7	7/31/24	66	8:31	18.6	401	7.4	82.6	--	90	--	--	--	--	--

Asterisks (*) for ammonia (NH4) = below lab detection levels.

Water Temperature was fairly cool at many sites (<18.5F, *in blue*). Typically, an average temperature reading below 18.5F is considered cool enough to support coldwater species, often due to a groundwater support. These one-time measurements are not averages, so there might be higher summer temperatures. Also, there might be a few more stations that have a strong groundwater support as well, but are not captured with the location of the 1x measurement. (e.g., S1.9, table 5.5b below).

Table 5.5b: Water Chemistry collected at time of fish sampling for the South Br. Stations are ordered upstream to downstream. Note: FIBI scores in red are at or below threshold (55). Other color-coded cells are described below the table.

Station ID	Visit Date	FIBI	Time	H20 oC	Cond.	DO mg/L	DO %	pH	Water Clarity cm	NH4 mg/L	Total N mg/L	Phos ug/L	TSS mg/L	TSVS mg/L
S9.5	7/20/22	48	8:30	19.6	523	6.12	70.6	7.37	94	--	--	--	--	--
S9.4	7/29/24	45	8:33	--	--	--	55.5	--	100	--	--	--	--	--
S5.5	8/11/22	59	10:53	18.5	537	8.75	96.7	7.74	100	--	--	--	--	--
S5.5	7/18/24	49	16:48	19.7	473	8.7	99.3	--	100	--	--	--	--	--
S5.0	8/16/22	49	14:09	15.1	524	9.06	93.4	7.37	100	--	--	--	--	--
S5.0	7/29/24	46	--	--	--	--	--	--	--	--	--	--	--	--
S1.9	8/16/22	58	13:45	18.8	524	9.57	106.4	8.14	100	--	--	--	--	--
S1.9	8/8/24	59	8:12	18.5	461	8.0	88.9	NA	90	--	--	--	--	--
S0.4	8/16/22	59	8:21	16.1	519	8.33	87.6	7.74	100	--	--	--	--	--
S0.4	7/31/24	60	17:55	22.5	435	9.6	115.9	--	100	--	--	--	--	--

Asterisks (*) for ammonia (NH4) = below lab detection levels.

Conductivity **-**Lower conductivity (<550 umhos, *in purple*) may also indicate that there is a supporting or strong groundwater influence that is helping to maintain and regulate cooler stream temperatures. At some of these stations, there were recorded observations of groundwater seeps and small tributary springs. Groundwater springs can be an important habitat requirement that supports cold and coolwater fish species, such as trout, lamprey, and southern redbelly dace. *Lamprey ammocoetes* were found at the Hormel stations (N0.7, S0.04) and one other station just upstream on the South Branch (S1.9). A DNR springs GIS layer was reviewed online (Minnesota Spring Inventory (state.mn.us) and only one spring was noted as present within the Dobbins Creek watershed. This one was within the Austin Country Club located just upstream of the confluence of the branches, near the Hormel Nature Center. There may be unreported spring locations, as this layer is populated with many public reports of observations. In conversation with the DNR staff who manage this GIS springs layer, visible spring locations can and should be reported so that they can review and incorporate more locations in this layer.

Nitrates: The MPCA draft standard for chronic levels of Nitrate-N for warmwater 2Bd streams is 8.0 mg/L (Aquatic Life Water Quality Standards Technical Support Document for Nitrate). Above this level, some fish species and life stages are negatively affected (e.g., egg and juvenile stages of fish are most sensitive, while adults are generally less sensitive); macroinvertebrates are generally more sensitive. Of the stations with reported values, we see that there is at least one very high value (in yellow) at all stations where nitrates were collected. However, there is some variability in values within stations across years. This can be a result of different precipitation and flow conditions and degree of high nitrates coming into streams via drain tile within or upstream of the stations or through high nitrates in groundwater. Nitrate values at the EquIS stations show elevated nitrates on both branches, but possibly higher, chronic levels on the North Br. For example, at EQuIS station (S008-958), of the 78 nitrate samples collected, the nitrate levels exceeded the draft chronic standard (8.0 mg/l) for 73.1% of the samples (range 1.1 mg/l to 20.4 mg/L, median 10.4 mg/L). High nitrate levels are likely impacting the fish community at this station (N8.2) and others along the North Br. For the South Br, at EQuIS station (S009-281), shows elevated nitrate at times (2016-2023). Of 88 samples, 25 were above the draft nitrate standard (8.0 mg/L) for 28.4% of the samples (range 0.8 mg/L– 14.1 mg/L, median 5.6 mg/L). This is less than at the outlet of the North Br, station, but may still be a contributing stressor. In future, additional review of nitrate stress signals in the fish and macroinvertebrate community should be explored further to see the level and extent of seasonal nitrate stress with water quality monitoring, or using MPCA's Tolerance Indicator Value (TIV) analysis for fish and macroinvertebrates.

Dissolved oxygen: All one-time measurements of DO were above the standard (5 mg/L). The lowest DO was at **S9.5** (6.0 mg/L, *in yellow*). At a few stations (**N12.6, N10.4, N6.**8) the percent DO (DO Sat) are very high (>120%, *pink*). Supersaturated DO during the day can be from a high level of photosynthesis (DO production) from excess plants (eutrophication). This high DO is often paired with low DO during the nighttime (<5 mg/L). This large diel (daily) swing in DO can be stressful – and lethal - to sensitive fish. Some fish are very tolerant of low DO conditions (e.g., fathead minnow). These streams should have more measurements collected.

Phosphorus: This is a measure of the free phosphorus in the water. No values were above the MPCAs River Eutrophication standard (150 ppm). Phosphorus can be taken up in plant material during the summer and released when plants die in winter. There was *filamentous algae* present at a few stations on the North Br (**N12.6**, all years; **N10.4** in 2024) and South Br (**S5.0** both years and **S0.4** in 2024). Phosphorus can be attached to sediment and released to water during bank erosion events, like what occurred in 2019 and 2024. Phosphorus can also be brought into the stream from plant materials (e.g., leaves, grasses, crops) that fall or are washed into the stream. During fish sampling, most of the phosphorus is bound into plant material or settles on the bottom in sediment, so free phosphorus might not up at these times. Early spring or late fall might be better. Phosphorus is released when plants die and decompose or when DO is low and phosphorus bound to sediment is released. This free phosphorus can feed plants and algae and cause eutrophication issues.

Total Suspended Solids (TSS): While the TSS values are not very high, sampling often occurs when flows are low and not after large storm events. Also, sampling does not occur when water is cloudy (high TSS) due to the need for clarity for effective fish capture with nets. So, higher values may be seen at other times (e.g., storm events) but not captured in these samples. Mower SCWD does collect grab samples during and between storm events. That data would be reviewed during AQL assessments and Stressor Identification.

6.0 Potential Biological Stressors and Options to Address

These stressors were listed in MPCA's Dobbins Creek Watershed Stressor Identification Update and additional observations during fish sampling. These include: a) flow alteration, b) lack of habitat, excess bedded sediment, c) eutrophication (dissolved oxygen issues), d) high nitrates, and e) fish barriers. However, the level of stress seems to also be different between the two branches and more so in the headwaters and middle reaches. These areas also have the lowest or more variable FIBI scores. The level of stress impacts can be related to flow conditions such as floods and droughts as well.

a and b) Flow Alteration, Habitat and Bedded Sediment appear linked: This watershed is largely in row-crop production with some pasture. The growing season of row-crops is mostly confined to the mid-summer which can change the volume of water that saturates soil and enters tile lines in the spring. Cover crops and more perennial vegetation could provide additional benefit to reducing the spring pulse of water that damages banks and scours bottoms, producing more sediment. The high density of tile drainage and ditching further alters the speed and volume of water that drains below rootzones and moves into ditches and streams during the growing season as well. The BMPs in the headwaters should help reduce some of the flow flashiness if enough volume is retained. Also, groundwater is not able to be recharged as much as it would have been without ditching and tile drainage, so the level of groundwater support to these streams in summer is probably less, causing lower water levels or dry conditions, especially in the headwaters and middle reaches where there is excess sand accumulation. This can cause interruption of flow that prevents fish from traveling between pool refuge and downstream areas causing trapping and reducing the number of sensitive fish. The source of the excess sand should be explored, possibly by DNR to see if additional projects could provide reductions in sediment production. Or, perhaps overtime, as stream become more stable, the sediment produced from stream banks will become less and the sand currently in the system will be deposited on point bars or move through to downstream, where it can be periodically dredged and removed as it has been in the Nature Center. One other BMP consideration might be to increase water storage and infiltration in riparian oxbow ponds. Much of the Dobbins Creek corridor has room to allow for this. The ponds could be filled during high flow events. Storage of water would allow the ponds to lower in response to less water in the stream, through sideways movement of water, surficial groundwater infiltration, or deeper groundwater infiltration that helps to raise the baselevel of groundwater and help to maintain adequate water levels in late summer and times of less precipitation. Additional benefits for these ponds could be for benefitting wildlife or for cattle watering.

c) Eutrophication: At some stations, presence of algae and supersaturated oxygen conditions indicate eutrophication issues. Phosphorus bound sediment may be the source, but should be explored. Sediment production from gullies, stream banks, and other overland sources should be investigated, especially in or near where eutrophic conditions have been observed.

d) Nitrates are also elevated, especially on the North Branch where levels were far above the draft standard (8.0 mg/L), not only in the spring, but sustained at high levels throughout summer and early fall. These high nitrate levels can reduce the survival of fish eggs, young-of-year fish, and add stress to sensitive adult fish. Macroinvertebrates can also be impacted that fish feed upon, changing the food quality available. Not enough nitrate collections were available on the South Branch to determine if there is as high of an issue, but there were values from 2019 that show high nitrate levels at times. More work may be needed to determine which source (field and tile drainage, manure runoff, or high nitrates in groundwater) to see what other watershed projects could reduce the nitrate stress (e.g., additional acres using soil health practices such as no till and/or cover crops, more targeted nitrate application or timed-release agents, better manure management, etc).

e) Fish passage: Fish species migrate to headwaters to spawn and travel downstream in summer and fall/winter for thermal refuge and deeper pools. There was one perched culvert on the North Branch (at N6.8) and possible fish barriers with the undersized pipes and culvert with the footbridges at the Hormel Nature Center. Possibly, MnDNR could be consulted (if they have not been already) to see if these are fish barrier concerns and replacement options explored. There are likely other perched culverts at road crossings, so a survey should be completed, if it has not already been.

7.0 Suggestions for Next 4-year Cycle (2025-2028)

Additional Water Chemistry Collection - While water chemistry is collected during the summer at N8.2, early spring (May) and late summer (later August) samples could also be collected at these headwater stations (N10.4, N12.6 and N6.8). Additional water chemistry collection may help to better understand the longitudinal extent and the timing (seasonal?) and duration (short term or longer) of potential water quality stressors that are limiting the fish community (e.g., high nitrates, DO/DO%, eutrophication), especially at these stations that appear to be the most impacted.

Analysis of biological response indicators to stressors – MPCA Stressor Identification work has created computations of Tolerance Indicator Values (TIVs) for Fish and Macroinvertebrates. Community samples could be further analyzed for their response to nitrate stress and other stressors (e.g., phosphorus, TSS). This analysis could further support the water chemistry collection and support the evidence that there are biological stressors related to water quality issues, and their specifics. This should be done for both fish and macroinvertebates, as they can respond differently to stressors.

Determine the sources of excess sand in the headwaters and middle reaches of the North Branch (N12.6, N6.8, N3.9) and South Branch (S5.5, S5.0, S1.9). Perhaps consult the MnDNR for review and suggestions. Possibly consider restoration methods that might re-connect areas of the riparian floodplain (e.g., oxbows, lower the bank angles for water to expand to riparian during floodflow. A reconnected riparian corridor, to some extent, could reduce flow velocity, benefit habitat quality with better channel stability, provide fish refuge, attenuate TSS and nutrients, and more water infiltration to shallow groundwater.

Discontinue sampling at very small headwater stations (N14.3, S9.5) have very small drainage areas (<3.0 sq mi). The FIBI was calibrated with stations >5 sqmi to limit natural variability with uncertainty in determining if these low DA stations are perennial or naturally intermittent streams. The watersheds above these stations are heavily tile drained, so, it is not known if these stations would have good groundwater support naturally in the late summer or if tile drainage is contributing to late summer low-flow periods. I would recommend going with MPCA guidance that these stations are too small to confidently assess. Other stations downstream are sufficient to characterize biological quality along both AUIDs. Two other stations (N6.8, N5.5) should also be dropped due to challenges in assigning the appropriate FIBI fish class.

8.0 Public Outreach and Education

Media - During fish sampling between 2021 and 2024, media coverage was coordinated with reporters from TV stations and newspapers. The following articles and news segments highlight Dobbins Creek fish sampling activities:

<u>Newspaper articles:</u>

- Mussel, fish surveys around Austin document the health of the Cedar River Watershed - Post Bulletin | Rochester Minnesota news, weather, sports
- Positive signs of improving water, habitat health on Dobbins - Austin Daily Herald | Austin Daily Herald

TV Station Reporting:

- Electrofishing in Dobbins Creek to track environmental health - ABC 6 News - kaaltv.com
- Checking out trends through electrofishing | News | kimt.com

Social media:

- ***Hormel Nature Center*** (5) Video | Facebook

Education/experience - Mower SWCD interns, high school students, graduate students, Hormel Nature Center staff, and others had the opportunity to assist in fish sampling between 2022 and 2024. There assistance was needed to complete the sampling that requires between 2 to 4 staff to complete efficiently. Their participation was very appreciated.

Additionally, landowners, neighbors, and area residents observed sampling at stations in their neighborhood or at the Hormel Nature Center. They were introduced first-hand to different fish species, and were interested in the Dobbins Ck project.

9.0 Appendix

- *Individual Station Reports* – includes more indepth analysis, discussion and photos
- *Information on How to Review the Individual Station Reports*
- *Flow Record for Dobbins Creek (2012 – 2024)* – includes precipitation and flow gage information

Appendix C: Total Suspended Solids (TSS) trends – Dobbins Creek (2009-2025)

DRAFT Suspended Sediment (TSS) – Dobbins Creek (2009-2025)

Executive Summary

After years of increasing sediment, Dobbins Creek reached a major turning point in 2017. Since that peak, sediment concentrations have dropped by approximately 70%.

While the overall change from 2009 to 2025 looks small on paper, this is because a period of worsening conditions (2009–2017) is being canceled out by a period of significant recent recovery (2017–2025). This improvement is "flow-normalized," meaning it isn't just because of dry weather, the watershed itself is becoming more stable and resilient to erosion, likely due to the cumulative impact of conservation practices.

1. Condition Status and Trend Summary

Analysis of total suspended solids (TSS) in Dobbins Creek indicates a transition from increasing sediment conditions (2009–2017) to sustained improvement (2017–2025). Flow-normalized concentrations derived from modeling analysis declined by approximately 70% following peak conditions in 2017, indicating a substantial reduction in sediment delivery independent of hydrologic variability. The apparent difference between the large reduction since 2017 (~70%) and the relatively small net change over the full period (2009–2025) reflects a turning point, with an initial period of increasing sediment followed by substantial recent improvement.

Statistical analysis supports this improvement. Recent trends indicate a likely decrease in sediment concentrations, meaning the improvement is real and not simply due to changes in weather or streamflow.

Sediment movement in Dobbins Creek is highly influenced by storm events. A small number of high-flow days account for most of the sediment transport (73%), meaning changes during storms have a large impact on overall watershed condition and water quality.

The 70% reduction in sediment since 2017 suggests that recent conservation efforts and land management practices are working, effectively 'decoupling' sediment levels from heavy rainfall.

2. Methods Summary

Total suspended solids (TSS) trends were evaluated using a modeling approach. Specifically, the EGRET R package (Hirsch *et al.*, 2023) implementing the Weighted Regressions on Time, Discharge, and Season (WRTDS) modeling framework (Hirsch *et al.,* 2010). This approach allows for estimation of daily concentrations, flow-normalization to remove hydrologic variability, evaluation of long-term trends, and assessment of concentration patterns across the flow regime.

Because the Dobbins Creek gage operates under open-water conditions only, daily flow records were extended through winter periods using regression-based methods:

- 2009–2022: HSPF-derived flows (R^2 = 0.902)
- 2023–2025: Regional regression using Cedar River gage (R^2 = 0.654)

These methods produced a continuous daily flow record suitable for WRTDS modeling and reliable for analysis of long-term trends.

The TSS dataset includes 256 samples collected between 2009 and 2025, with a median concentration of 12 mg/L and a range of 1 to 1,120 mg/L (Table 1). Sampling included a range of flow conditions, with approximately 45% of samples collected during flows above the 75th percentile and 17% collected during low-flow conditions. This distribution reflects an emphasis on capturing sediment transport during higher flow events while maintaining representation across the full range of hydrologic conditions. The WRTDS modeling framework accounts for this sampling distribution when estimating long-term trends. Occasional high TSS values (>1,000 mg/L) were observed during large storm events and correspond to elevated streamflow conditions. These values are consistent with sediment transport dynamics in runoff-driven systems and were retained in the analysis. Most samples fall below 160 mg/L (95th percentile), indicating that extreme sediment concentrations are infrequent but associated with high-flow events.

Table 1. Summary of Total Suspended Solids (TSS) Dataset (2009-2025)

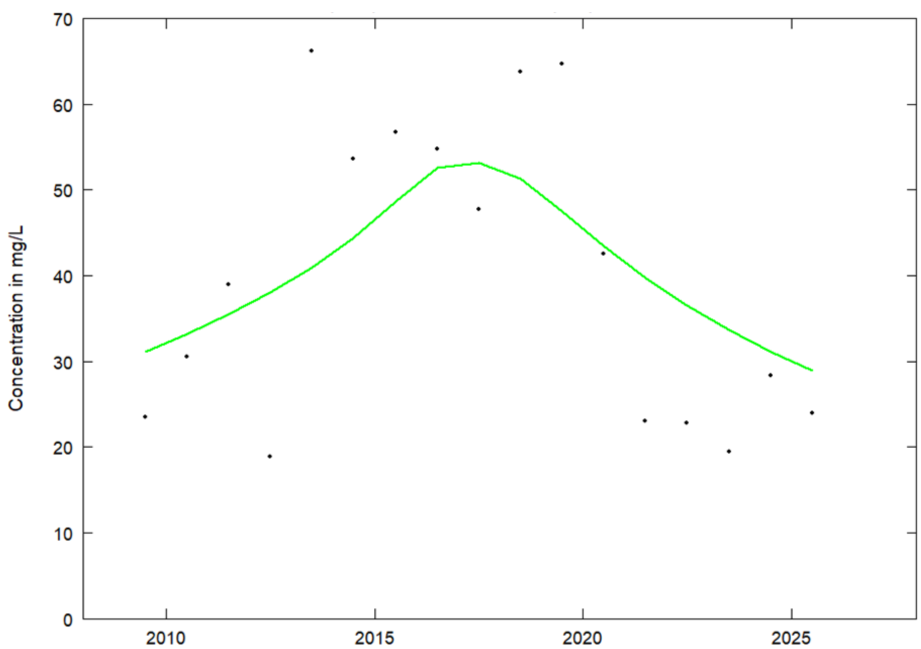
Metric	Value
Total number of samples	256
Period of record	2009–2025
Median TSS concentration (mg/L)	12
Range of TSS concentrations (mg/L)	1 – 1,120
Samples collected during high-flow conditions (>75th percentile)	116
Samples collected during low-flow conditions (<25th percentile)	44
Estimated storm-event sampling (%)	45.3%

Suspended sediment concentrations exhibit a strong positive relationship with streamflow, with the highest concentrations occurring during large runoff events. While most samples fall below approximately 160 mg/L (95th percentile), rare high-flow events can produce concentrations exceeding 1,000 mg/L. These extreme values, although infrequent, represent important sediment transport conditions and are consistent with a system where a small number of storm events contribute disproportionately to total sediment export. This pattern reinforces the importance of managing runoff and erosion during high-flow conditions to achieve meaningful reductions in sediment loading.

3. Long-Term Trends in Flow-Normalized Total Suspended Solids (TSS)

Flow-normalized TSS concentrations show a rise-and-fall pattern, where sediment levels peaked in 2017 and have been dropping steadily ever since (Figure 1).

Figure 1. Flow-normalized TSS concentrations in Dobbins Creek, 2009-2025, estimated using EGRET/WRTDS (plotConcTime with flow-normalization). The solid green line represents the modeled trend in concentration with discharge variability removed, and the black dots indicate observed annual mean concentration. The downward slope after 2017 represents the recovery phase.



Flow normalization removes the influence of year-to-year hydrologic variability, allowing evaluation of underlying watershed conditions. Concentrations increased from approximately 2009 through 2017, peaking near 53 mg/L, followed by a steady decline to approximately 29 mg/L by 2025. The post-2017 decline represents an approximate 70% reduction from peak conditions.

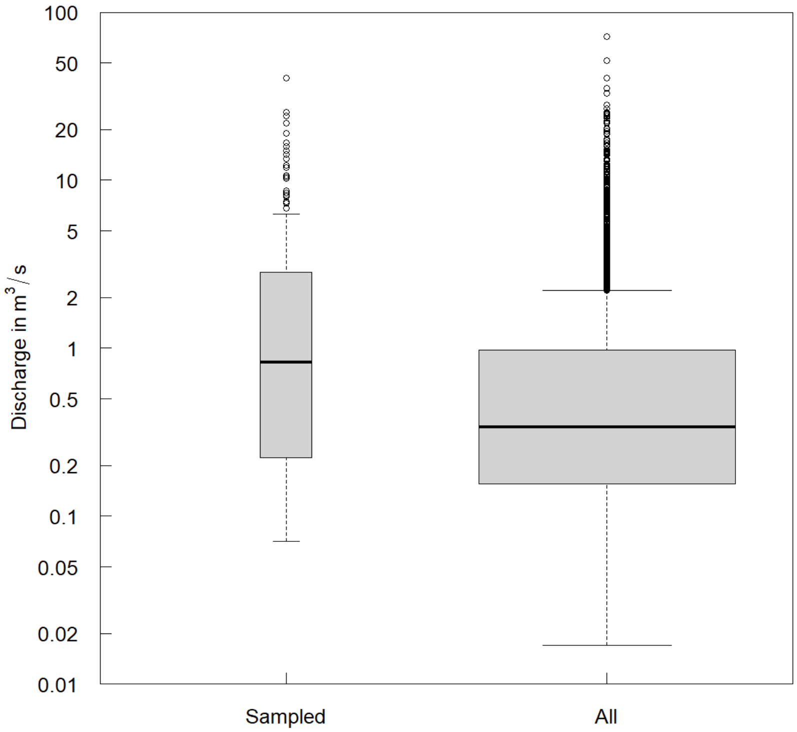
Statistical trend results help contextualize this pattern. When evaluated over the full period of record (2009–2025), flow-normalized concentrations show relatively little net change (approximately −7%), reflecting offsetting periods of increase and decline. In contrast, evaluation of the more recent period (2015–2025) indicates a likely downward trend, demonstrating that current watershed conditions are improving despite earlier degradation.

The increasing phase likely reflects a combination of watershed disturbance factors, including construction activity, channel instability, and periods of elevated precipitation. The subsequent decline is consistent with system recovery, stabilization processes, and the cumulative effects of best management practice (BMP) implementation.

4. Sampling Distribution and Model Representation

Sampling in Dobbins Creek was intentionally targeted toward runoff conditions to ensure characterization of sediment transport during storm events.

Figure 2. Comparison of sampled discharge values to all daily discharge values (EGRET boxQtwice output). The sampled dataset is skewed toward higher flows, reflecting targeted storm-event monitoring.



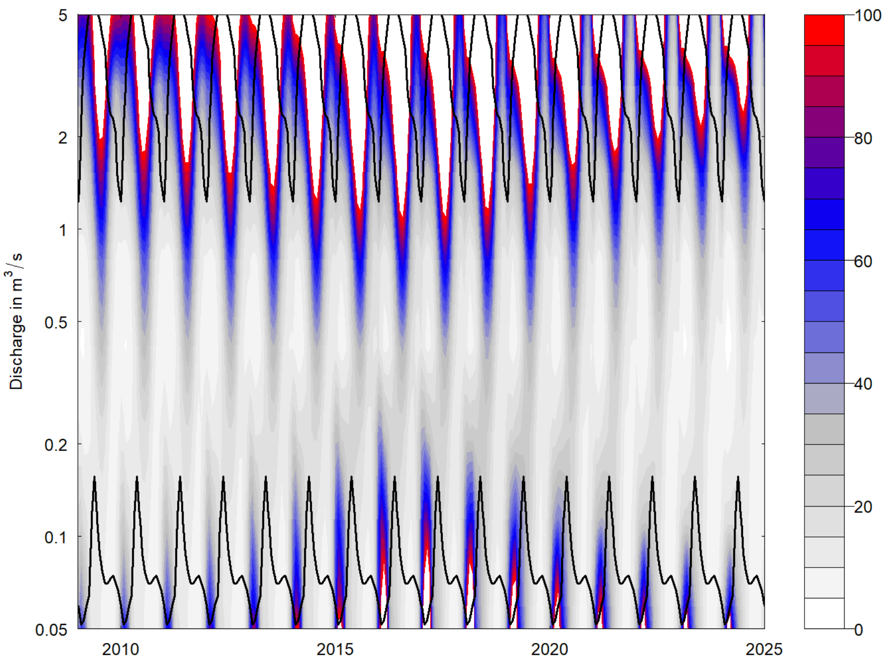
This targeted approach results in overrepresentation of higher flows in the sample dataset; however, WRTDS accounts for this imbalance by estimating concentrations across the full discharge range. As a result, the model provides robust estimates of both typical and high-flow conditions.

Importantly, this sampling design ensures that the conditions responsible for most of the sediment transport are well represented in the dataset.

5. Changes in Sediment Response Across Flow Conditions

Contour analysis provides insight into how sediment concentrations vary across both time and discharge. Contour analysis indicates that the decline in suspended sediment concentrations since approximately 2017 occurred primarily during high discharge conditions (Figure 3). Elevated concentrations associated with storm events were more common prior to 2017 and decreased substantially in subsequent years, suggesting reduced sediment mobilization during runoff events. This demonstrates that improvements are concentrated during storm events, which are responsible for the majority of sediment transport.

Figure 3. WRTDS contour plot (plotContours) showing modeled TSS concentrations across time and discharge. Warmer colors indicate higher concentrations, black lines are the 5 and 95 flow percentiles.



6. Flow-duration Sediment Export

Flow-duration analysis indicates that suspended sediment exports are highly episodic in Dobbins Creek (Figure 4). The highest 1% of flows accounted for approximately 41% of total sediment export, while the highest 5% of flows accounted for approximately 73% of total export. These results help explain the apparent disconnect between concentration and flux trends. While the concentration is improving, the total load remains high because we are seeing more extreme rain events. Table 2 provides a list of the top 10 sediment contributing days. On the single two-day storm event in June 2024, nearly 180 truckloads of sediment were moved, illustrating how a weekend of extreme rain can dominate the watershed's annual footprint (Table 2).

Figure 4. Relationship between flow exceedance probability and cumulative sediment export. High-flow events contribute a disproportionate share of total sediment load.

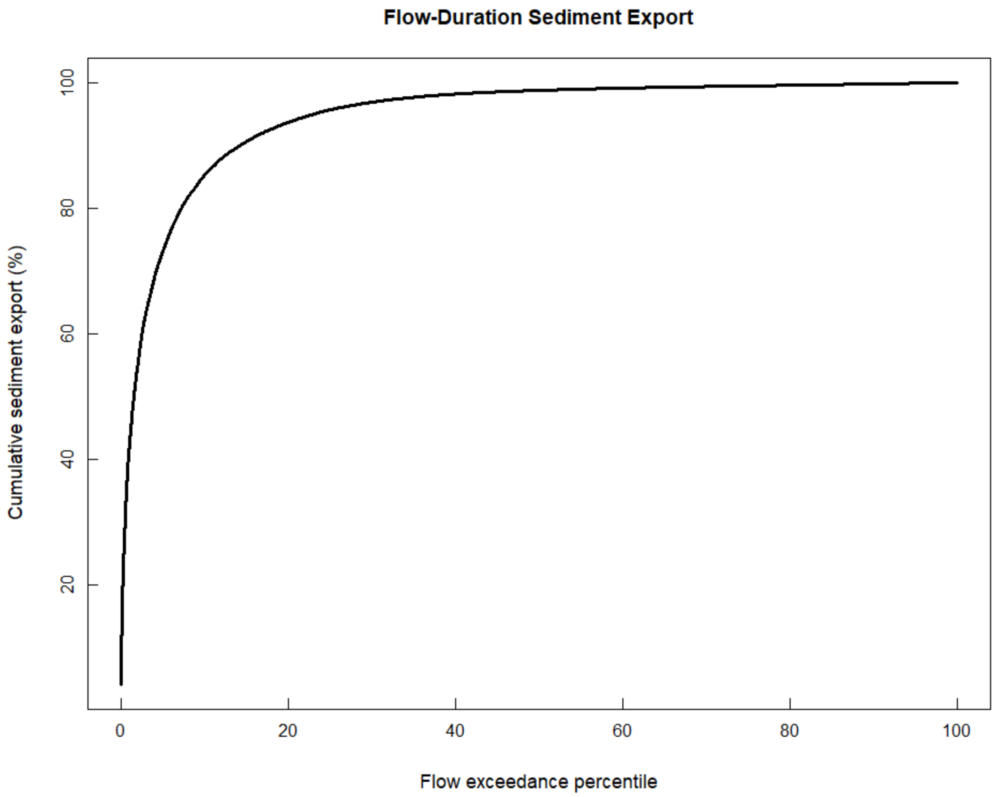
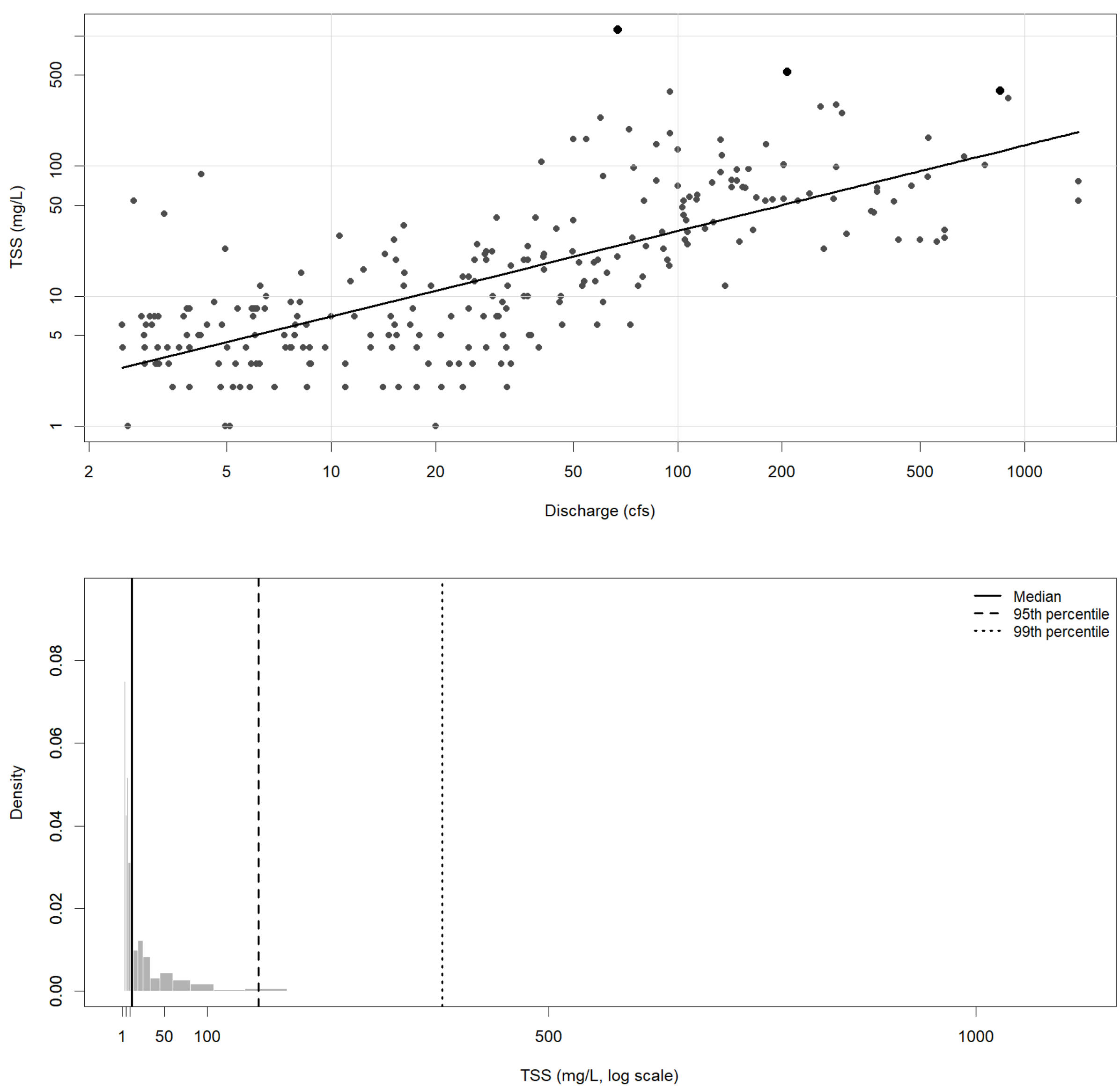


Table 2. Top 10 days of sediment contribution from 2009-2025 in Dobbins Creek. Truck loads/day assumes one dump truck ~ 20 short tons (18,144 kg).

Date	Flow (m^3/s)	Flow (cfs)	kg/day	Truck Loads/day
6/22/2024	71.9	2,540	2630968	145
2/20/2017	51.5	1,816	1917974	106
5/20/2013	35.1	1,239	1001322	55
3/15/2019	26.6	941	1000966	55
3/14/2019	24.7	874	903736	50
6/22/2015	25.5	900	734394	41
9/22/2016	40.5	1,429	717066	40
2/21/2017	24.9	878	694546	38
6/23/2024	23.5	828	590521	33
4/14/2018	19.5	689	581618	32

This patchy transport behavior is also reflected in the distribution of observed sediment concentrations. Suspended sediment concentrations exhibit a strong positive relationship with streamflow, with the highest concentrations occurring during large runoff events. While most samples fall below approximately 160 mg/L (95th percentile), rare high-flow events can produce concentrations exceeding 1,000 mg/L (Figure x). These extreme values, although infrequent, represent important sediment transport conditions and are consistent with a system where a small number of storm events contribute disproportionately to total sediment export. This pattern reinforces the importance of managing runoff and erosion during high-flow conditions to achieve meaningful reductions in sediment loading.

Figure 5. Top: Relationship between streamflow and suspended sediment (TSS) and distribution of concentrations. Bottom: log-scaled distribution of TSS concentrations.



7. Change-Point Interpretation of TSS Trends

Evaluation of flow-normalized TSS concentrations indicates a clear reversal in the trend, characterized by a distinct change point around 2017 (Figure 5a).

Prior to approximately 2017, concentrations increased steadily, suggesting a period of elevated sediment mobilization potentially associated with watershed disturbance, channel instability, and/or hydrologic conditions. Following this period, concentrations declined sharply and consistently through 2025.

This pattern represents a transition from degradation to recovery, rather than a simple linear trend.

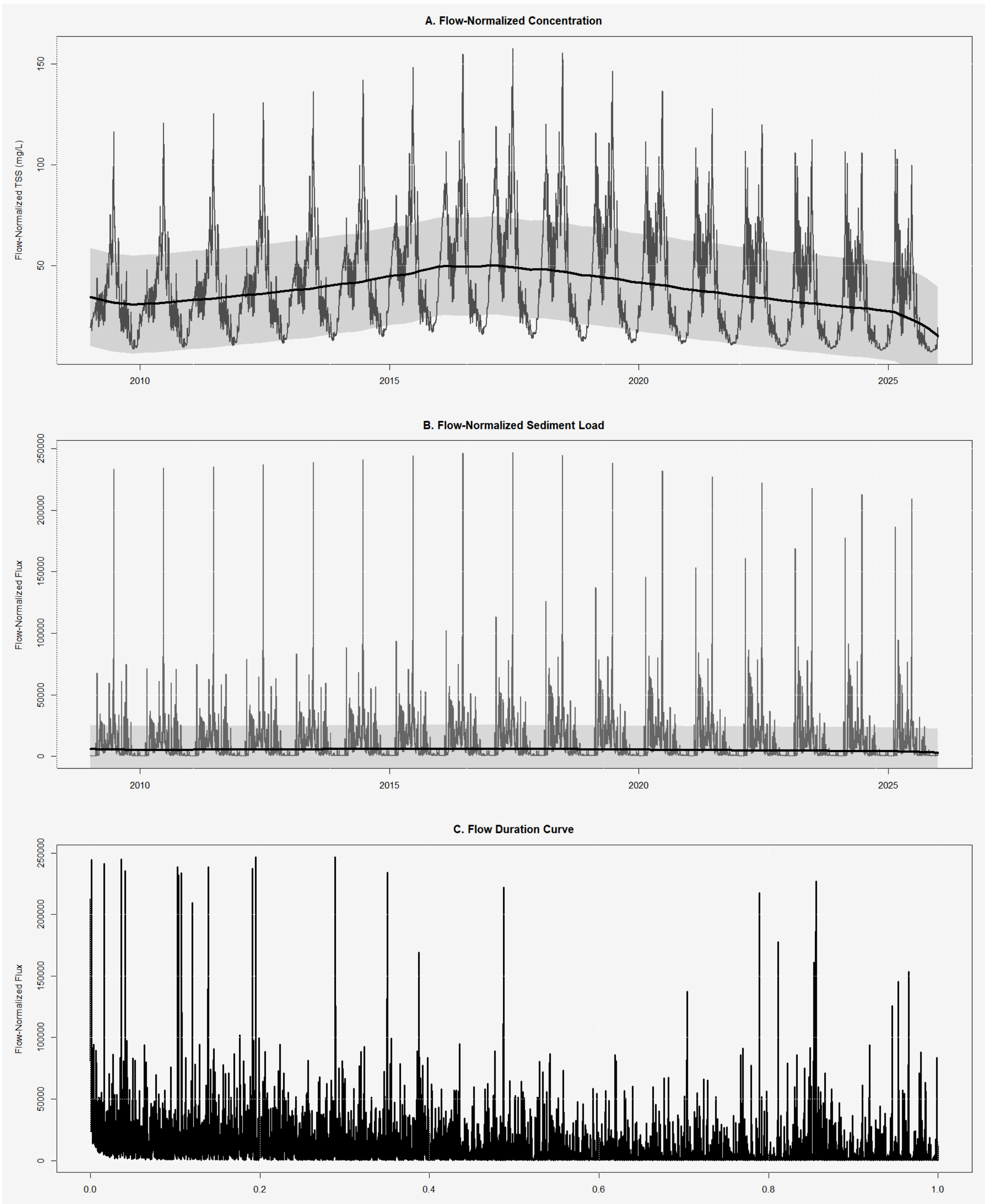
Evidence of a Change Point

- Peak flow-normalized concentrations observed around 2017
- Subsequent sustained decline (~70% reduction by 2025)
- Contour analysis showing reduced concentrations during high-flow events
- Recent trend analysis (2015–2025) indicating a likely downward trajectory

Full-period trend statistics (2009–2025) underestimate recent improvements because early increases in sediment concentrations offset more recent declines (Figure 5b). In contrast, recent-period trend analysis (2015–2025) captures the recovery phase and indicates a likely downward trajectory in sediment concentrations.

This change-point framework provides a more accurate representation of watershed response than a single monotonic trend.

Figure 6. A) Flow-normalized TSS concentrations in Dobbins Creek (2009–2025) with locally weighted regression (LOWESS) smooth and approximate confidence interval. (B) Flow-normalized sediment flux over the same period, having substantial variability and no clear long-term trend. (C) Flow-duration curve illustrates the disproportionate contribution of high-flow events to total sediment transport.



8. Management Implications

The observed trends provide important insight into watershed response and future management priorities.

Effectiveness of BMP Implementation

The reduction in high-flow sediment concentrations suggests that implemented BMPs are effectively reducing erosion and sediment delivery, particularly during runoff events. The presence of a likely downward trend in flow-normalized concentrations further supports the conclusion that these improvements represent real changes in watershed condition rather than hydrologic variability.

Importance of High-Flow Management

Because sediment exports are dominated by storm events, practices that reduce runoff volume, attenuate peak flows, and stabilize channels are likely to provide the greatest water quality benefits. Managing extreme runoff events is still needed to achieve continued measurable load reductions associated with storm events.

Monitoring Strategy

Routine monitoring with consistent storm-event sampling has proven effective in capturing the dominant sediment transport processes and should be maintained as part of ongoing effectiveness monitoring.

Future Evaluation Needs

- Continued monitoring to confirm sustained trends
- Linking trends to BMP implementation timelines
- Expansion to sediment load estimates for reporting and comparison to reduction goals

9. Conclusion

TSS conditions in Dobbins Creek have improved substantially since approximately 2017 following a period of elevated sediment concentrations. The approximately 70% reduction in flow-normalized concentrations indicates meaningful progress in reducing sediment delivery independent of hydrologic variability.

Statistical trend analysis indicates a likely downward trajectory in recent years, although variability associated with high-flow events continues to influence total sediment loads.

These improvements are primarily driven by reduced sediment mobilization during high-flow events, which dominate sediment transport in the watershed. Given the importance of storm-driven processes, continued emphasis on runoff and channel management will be critical to sustaining and building upon these gains.

10. Statistical Interpretation of Trends

Trend significance was evaluated using the EGRET/WRTDS framework, which provides both traditional p-values and likelihood-based metrics describing the probability of increasing or decreasing trends. Given the high natural variability typical of sediment transport systems, results were interpreted using a weight-of-evidence approach. In addition to conventional significance thresholds ($\alpha = 0.05$), trends with p-values ≤ 0.10 were considered statistically meaningful in the context of environmental data. Likelihood estimates (e.g., probability of an increasing or decreasing trend) were used to further characterize trend direction and strength. Trends were therefore classified based on both statistical significance and likelihood, with particular emphasis on consistency between statistical results, observed patterns, and underlying hydrologic processes.

11. References

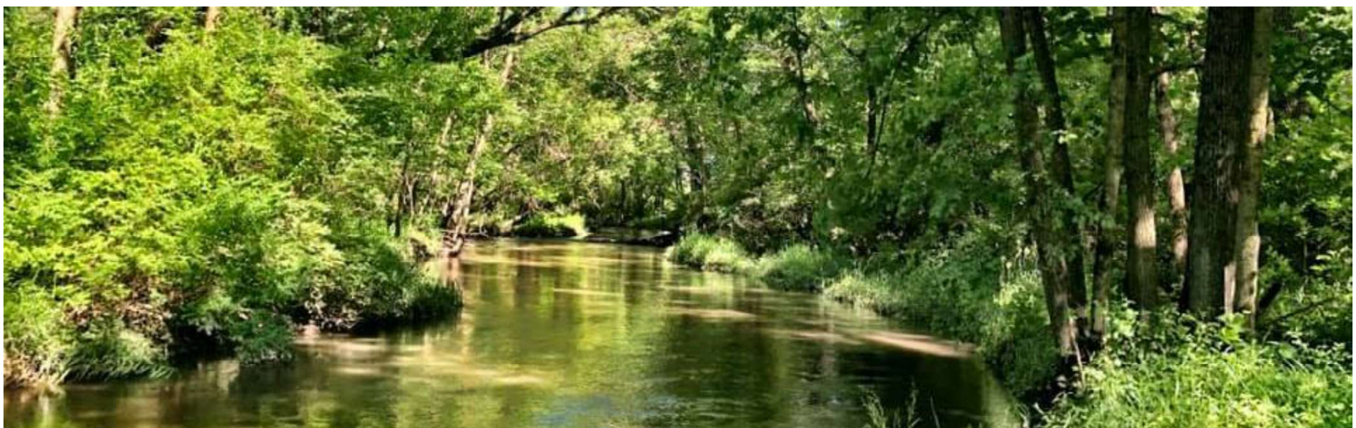
Hirsch, R.M., Moyer, D.L., and Archfield, S.A. (2010). Weighted regressions on time, discharge, and season (WRTDS), with an application to Chesapeake Bay river inputs. *Journal of the American Water Resources Association*, 46(5), 857–880.

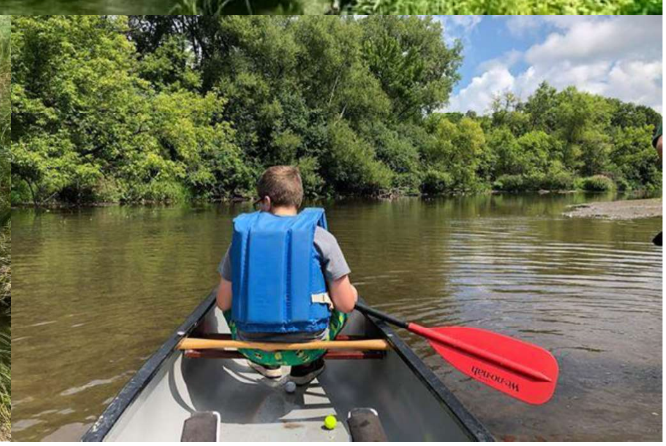
Hirsch, R.M., De Cicco, L.A., Archfield, S.A., and others. 2023. *EGRET: Exploration and Graphics for RivEr Trends (R package)*. U.S. Geological Survey. Available at: https://cran.r-project.org/package=EGRET

Appendix D: *E. coli* enhanced source assessment for the Dobbins Creek Subwatershed

E. coli Enhanced Source Assessment for the Dobbins Creek Subwatershed

A detailed report of *E. coli* sources in the Dobbins Creek subwatershed; Cedar River Watershed.





MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Abbreviations

1W1P	One Watershed, One Plan
AQR	aquatic recreation
AU	animal unit
BMP	best management practice
CAFO	concentrated animal feeding operation
CAR	community assessment report
CDC	concentration duration curve
CRW	Cedar River Watershed
CWF	Clean Water Fund
E. coli	*Escherichia coli*
EPA	U.S. Environmental Protection Agency
ESA	Enhanced source assessment
FDC	flow duration curve
HUC	Hydrologic Unit Code
IQR	interquartile interval
ISTS	individual sewage treatment system
LDC	load duration curve
MS4	municipal separate storm sewer system
MST	microbial source tracking
NLCD	National Land Cover Dataset
NPDES	National Pollutant Discharge Elimination System
org/100 mL	organism per 100 milliliter
SDS	State Disposal System
SSTS	subsurface sewage treatment system
SWCD	Soil and Water Conservation District
WBIF	Watershed based implementation funds (One Watershed, One Plan)
WRAPS	Watershed Restoration and Protection Strategy

1. Introduction

As part of Minnesota's Watershed Management Framework, state and local partners develop restoration and protection strategies for HUC8 watersheds across the state. The Cedar River Watershed (CRW) began strategy development through WRAPS Update scope development. This effort followed intensive watershed monitoring (2019 - 2020), water quality assessment (2021), and stressor identification (2022 - 2023). As part of WRAPS Update scope development, local partners advocated for a detailed assessment of *E. coli* sources in the Dobbins Creek subwatershed (070802010205). The Dobbins Creek *E. coli* Enhanced Source Assessment (ESA) is a result of that request.

ESAs are studies designed to better understand and/or identify the sources of pollutants to priority waters to better inform implementation efforts. This report summarizes all *E. coli* sources and places emphasis on those places and sources most likely contributing to the *E. coli* impairments noted for the Dobbins Creek subwatershed. Recommendations for future consideration are also included to assist local watershed partners in prioritizing *E. coli* reduction efforts through local implementation programs.

1.1 Dobbins Creek subwatershed (070802010205)

The Dobbins Creek subwatershed is located in east central CRW. Portions of Red Rock, Windom, Dexter and Marshall townships lie within the subwatershed including the small community of Nicolville. Most of the Dobbins Creek subwatershed is rural in nature, however, the lower portion of the subwatershed is within the city of Austin.

The surface water of Dobbins Creek subwatershed includes the mainstem Dobbins Creek and the unnamed southern branch of Dobbins Creek. Multiple unnamed tributaries flow into both the mainstem and the south branch. Dobbins Creek eventually flows into East Side Lake (50-0002-00).

Landcover (NLCD 2019) in the subwatershed is predominantly cultivated cropland. Developed landcover is the second highest landcover but only applies to 9% of the subwatershed (Table 1 and Figure 2).

Table 1. Landcover in the Dobbins Creek subwatershed (NLCD 2019).

Landcover	Area (acres)	Area (%)
Water and Wetlands	495.20	2.01%
Forest	288.31	1.17%
Developed	2,229.02	9.06%
Cultivated Crops	20,056.31	81.51%
Hay/Pasture	1,035.02	4.21%
Grassland and Shrubland	500.88	2.04%
Totals	**24,604.74**	**100%**

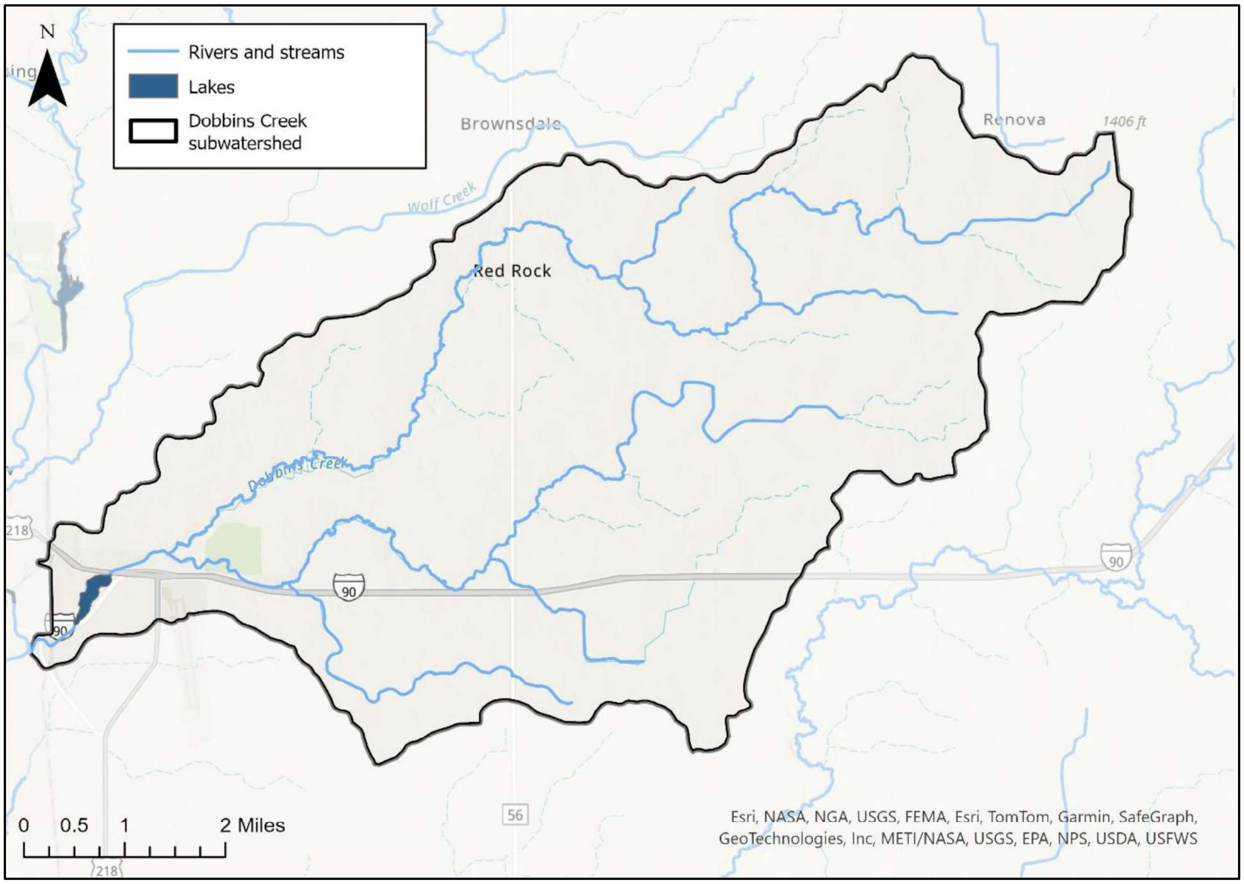

Figure 1. Dobbins Creek subwatershed

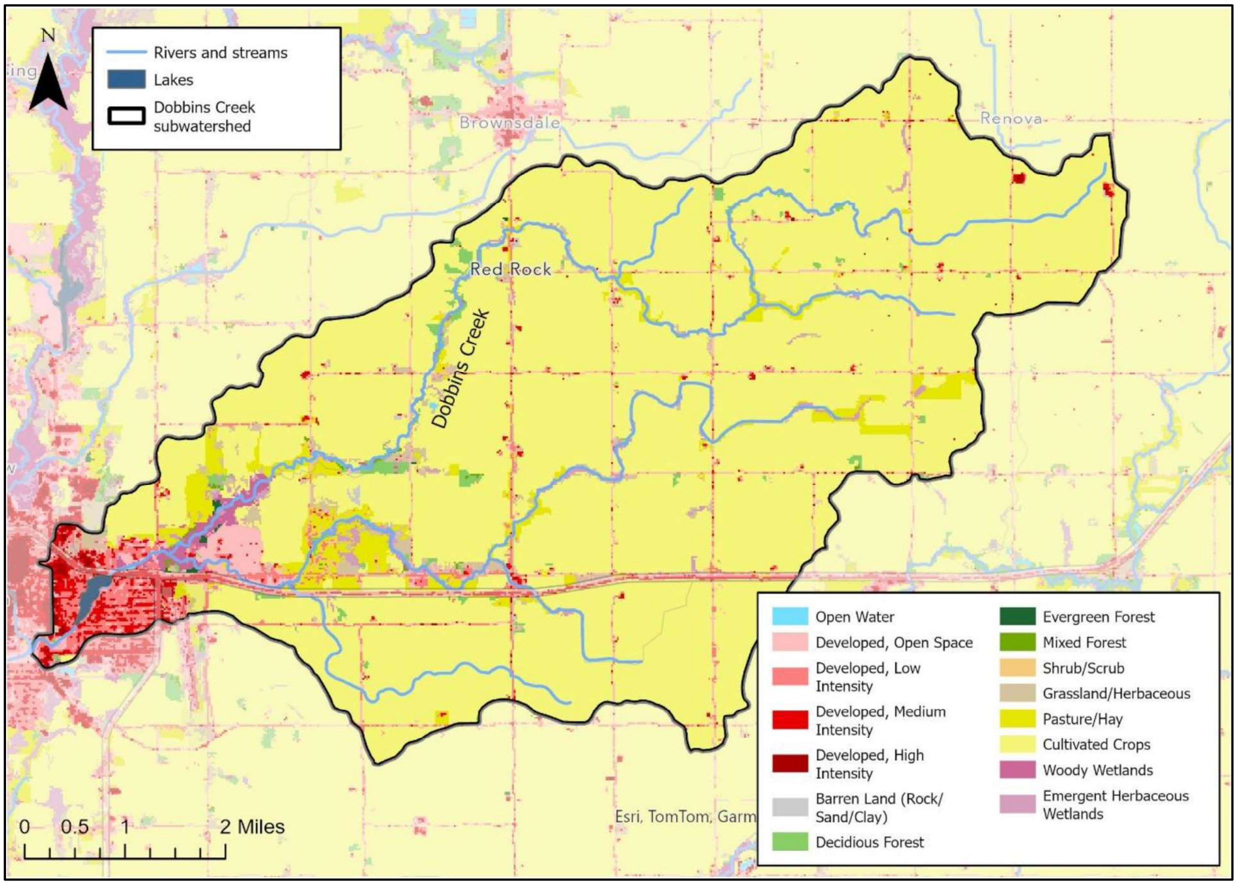

Figure 2. NLCD land cover in the Dobbins Creek Subwatershed.

1.2 Streams impaired due to *E. coli*

MPCA uses *E. coli* bacteria, which are commonly found in fecal waste and are easy to measure, as an indicator species of potential waterborne pathogens. Using indicator bacteria to assess the presence of pathogens is not a perfect process though it is the best available currently. There are two *E. coli* standards for the impaired waters in Dobbins Creek (Table 2). One is applied to monthly *E. coli* geometric mean concentrations, and the other is applied to individual samples. Exceedances of either *E. coli* standard indicates that a water body does not meet the applicable designated use. These standards apply from April through October.

Table 2. *E. coli* water quality standard (Minn. R. 7050.0222).

Parameter	Stream class (River Nutrient Region)	Water quality standard	Numeric standard/target
E. coli	Class 2A and 2B	Not to exceed 126 organisms per 100 milliliters (org/100 mL) as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than 10% of all samples taken during any calendar month individually exceed 1,260 org/100 mL. The standard applies April 1–October 31.	≤ 126 organisms/ 100 mL water (monthly geometric mean) ≤ 1,260 organisms/ 100 mL water (individual sample)

The Dobbins Creek subwatershed has been extensively monitored by MPCA and Cedar River Watershed District/Mower Soil and Water Conservation District staff. Through this monitoring, many stream segments of the Dobbins Creek subwatershed have been assessed for aquatic recreation. Table 3 summarizes the segments of Dobbins Creek that are not meeting aquatic recreation standards and are listed as impaired due to *E. coli*. These streams are shown in Figure 3.

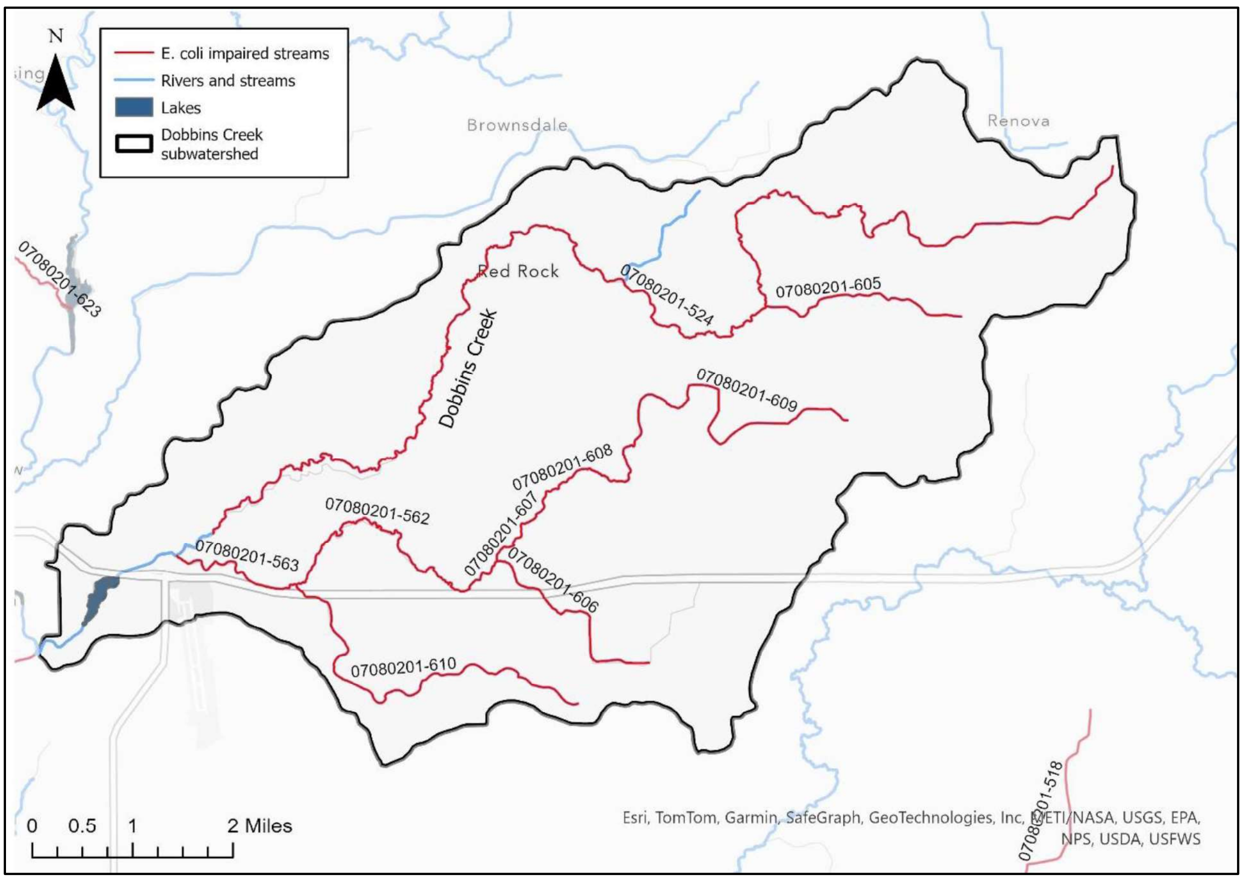

Figure 3. Streams impaired due to aquatic recreation/*E. coli* in the Dobbins Creek subwatershed.

Table 3. Impaired water segments in the Dobbins Creek subwatershed (aquatic recreation/*E. coli*).

AUID	Water body name	Water body description	Use class	Listing year	Affected designated use [a]	Listing Parameter
07080201-524	Dobbins Creek	Headwaters to T103 R17W S31, west line	2Bg	2022	AQR	*E. coli*
07080201-605	Unnamed creek	Headwaters to Dobbins Cr	2Bg	2022	AQR	*E. coli*
07080201-609	Unnamed creek	Unnamed cr to Unnamed cr	2Bg	2022	AQR	*E. coli*
07080201-608	Unnamed creek	Unnamed cr to Unnamed cr	2Bg	2022	AQR	*E. coli*
07080201-606	Unnamed creek	Unnamed cr to Unnamed cr	2Bg	2022	AQR	*E. coli*
07080201-610	Unnamed creek	Headwaters to Unnamed cr	2Bg	2022	AQR	*E. coli*
07080201-562	Unnamed creek	Unnamed cr to Unnamed cr	2Bg	2022	AQR	*E. coli*
07080201-563	Unnamed creek	Unnamed cr to Dobbins Cr	2Bg	2022	AQR	*E. coli*
07080201-535	Dobbins Creek	T103 R18W S36, east line to East Side Lk	2Bg	2006	AQR	*E. coli*
07080201-537	Dobbins Creek	East Side Lk to Cedar R	2Bg	2006	AQR	*E. coli*

a. AQR: aquatic recreation

2. *E. coli* water quality analysis

Recent available *E. coli* data (2015-2022) were used in the water quality analysis for the Dobbins Creek ESA. Monitoring station locations and station IDs were confirmed with Mower SWCD staff and are provided in Figure 4 and Table 4.

Table 4. Monitoring locations used in the Dobbins Creek subwatershed *E. coli* ESA. Corrected station IDs provided by Mower SWCD staff and used in this ESA.

<table>
<tr><th>AUID</th><th>Waterbody name</th><th>Station ID (EQuIS)</th><th>Corrected station ID (used in ESA)</th></tr>
<tr><td>07080201-537</td><td>Dobbins Creek</td><td>S003-066</td><td>S003-066</td></tr>
<tr><td rowspan="3">07080201-535</td><td rowspan="3">Dobbins Creek</td><td>S003-065</td><td rowspan="2">S003-065</td></tr>
<tr><td>S008-963</td></tr>
<tr><td>S008-951</td><td>S008-951</td></tr>
<tr><td rowspan="5">07080201-524</td><td rowspan="5">Dobbins Creek</td><td>S007-236</td><td>S007-236</td></tr>
<tr><td>S008-953</td><td>S008-953</td></tr>
<tr><td>S008-958</td><td rowspan="2">S008-958</td></tr>
<tr><td>S008-961</td></tr>
<tr><td>S008-960</td><td>S008-960</td></tr>
<tr><td rowspan="2">07080201-563</td><td rowspan="2">Unnamed creek</td><td>S008-955</td><td>S008-955</td></tr>
<tr><td>S009-281</td><td>S009-281</td></tr>
<tr><td>07080201-563</td><td>Unnamed creek</td><td>S008-956</td><td>S008-956</td></tr>
<tr><td>07080201-562</td><td>Unnamed creek</td><td>S008-954</td><td>S008-954</td></tr>
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<tr><td>07080201-609</td><td>Unnamed creek</td><td>S008-959</td><td>S008-959</td></tr>
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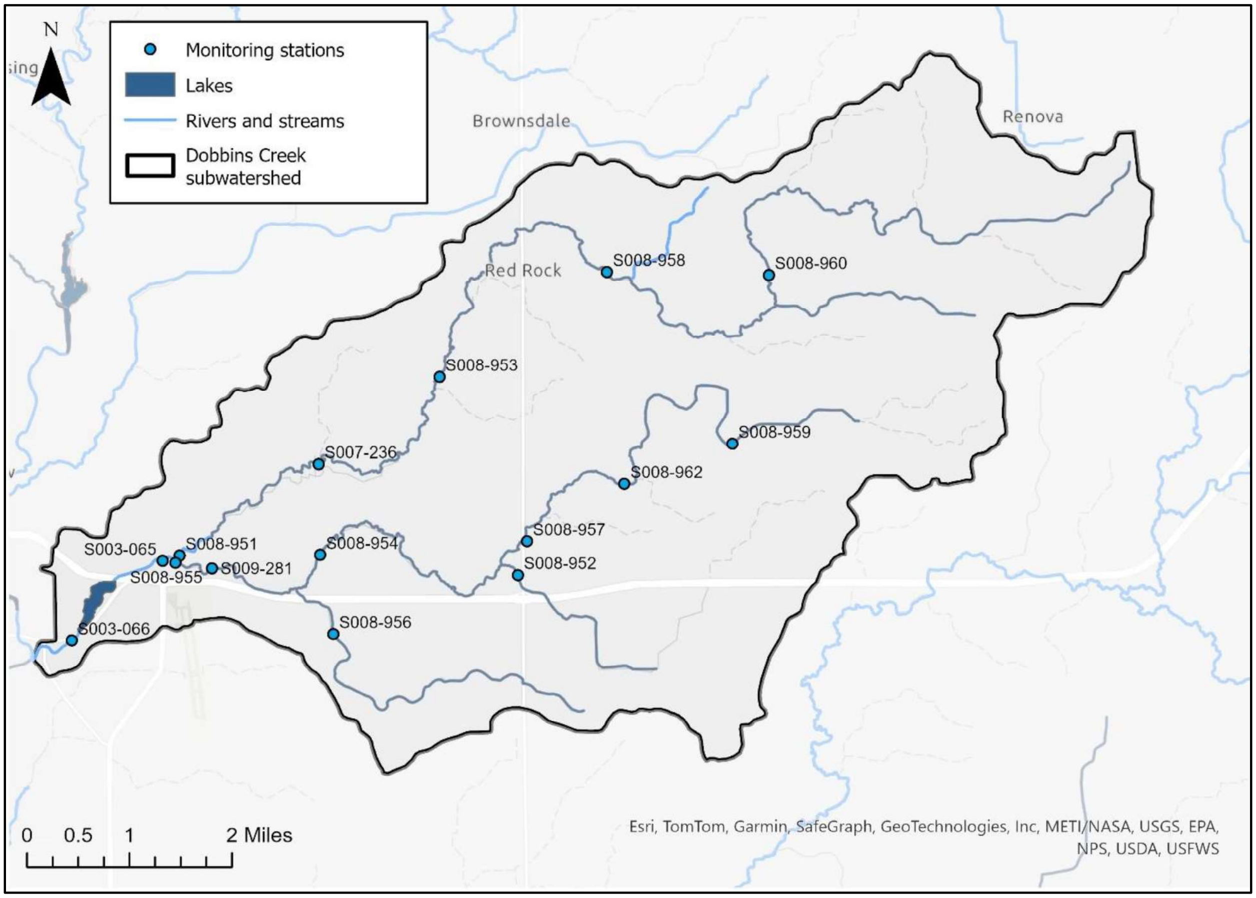

Figure 4. Monitoring stations in Dobbins Creek subwatershed.

2.1 Data summary

Individual sample *E. coli* concentrations ranged from 10 to over 24,000 org/100 mL. The largest number of *E. coli* samples were taken in the 2015 (n=262), 2021 (n=63) and 2022 (n=63).

When summarizing all data from 2015-2022 at the annual scale, frequencies of exceedance of the individual sample standard range from 0 to 71%. The highest frequency of exceedance occurred in 2016 (n=7) and the lowest occurred in 2017 (n=6) (Table 5).

The majority of *E. coli* sampling from 2015-2022 occurred during the months June through September; however, data were collected during the entire standard applicability period of April-Oct. When summarizing all data from 2015-2022 at the monthly scale, monthly geometric means are exceeded every month. The frequencies of exceedance of the individual sample standard range from 14 to 24%. The highest frequency of exceedance occurred in data collected during the month of June (n=78) (Table 6). Monthly geometric means and the maximum individual samples concentrations increase in the months of June to September. Sample counts are also higher during these months (Table 6).

Table 5. Annual summary of *E. coli* data in Dobbins Creek subwatershed (all monitoring stations, April-Oct, 2015-2022).

E. coli concentrations not to exceed 126 org/100 mL as a geometric mean nor shall more than 10% of all samples taken during any calendar month individually exceed 1,260 org/100 mL. The standard applies April 1–October 31.

Year	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL) [a]	Number of individual standard exceedances	Frequency of individual standard exceedance
2015	262	606	10	24,196	58	22%
2016	7	2,956	648.8	15,531	5	71%
2017	6	262	121	650	0	0%
2018	6	999	20	3,282	4	67%
2019	6	384	36.4	3,873	1	17%
2020	7	422	162	2,420	2	29%
2021	63	198	10	1,850	1	1.6%
2022	63	333	10.4	4,839.2	13	20%

a. The maximum recordable value for *E. coli* concentration depends on the extent of sample dilution and is often 2,420 org/100 mL. Concentrations that are noted as 2,420 org/100 mL are likely higher, and the magnitude of the exceedances is not known.

Table 6. Monthly summary of *E. coli* data for Dobbins Creek subwatershed. (all monitoring stations, April-Oct, 2015-2022)

Values with asterisks indicate months in which the monthly geometric mean standard of 126 org/100 mL was exceeded or the individual standard of 1,260 org/100 mL was exceeded in greater than 10% of the samples.

Month	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of individual standard exceedance
April	5	113	10.4	1,450	1	20%
May	29	201	10	3,873	5	17%
June	78	568	15	19,863	19	24%
July	106	599	10.4	24,196	22	20%
Aug	75	531	51.2	12,033	16	21%
Sept	92	488	52	24,196	16	17%
Oct	35	273	10	5,475	5	14%

2.2 Concentration duration curve

A flow duration curve (FDC) was developed using mean daily flows calculated from flow data just upstream of Eastside Lake (EQuIS ID: S003-065; WISKI ID: H48005001). FDCs relate mean daily flow to the percent of time those values have been met or exceeded. For example, an average daily flow at the 50% exceedance value is the midpoint or median flow value; average daily flow in the reach equals the 50% exceedance value 50% of the time. The curve is divided into flow zones, including very high flows (0% to 10%), high flows (10% to 40%), mid-range flows (40% to 60%), low flows (60% to 90%), and very low flows (90% to 100%).

The FDC was used to develop both a concentration duration curve (CDC) for the subwatershed. A CDC provides the concentration of a pollutant and plots those concentrations by flow condition (Figure 5). A CDC can be useful in assessing the flow conditions under which *E. coli* levels are high.

There is not a strong relationship between *E. coli* concentration and flow zone in the Dobbins Creek subwatershed. Monitoring data points above individual sample water quality standard and flow zone geomeans above the monthly geomean water quality standard are seen across all flow conditions in the Dobbins Creek subwatershed. The most individual WQ exceedances occur under mid flow conditions.

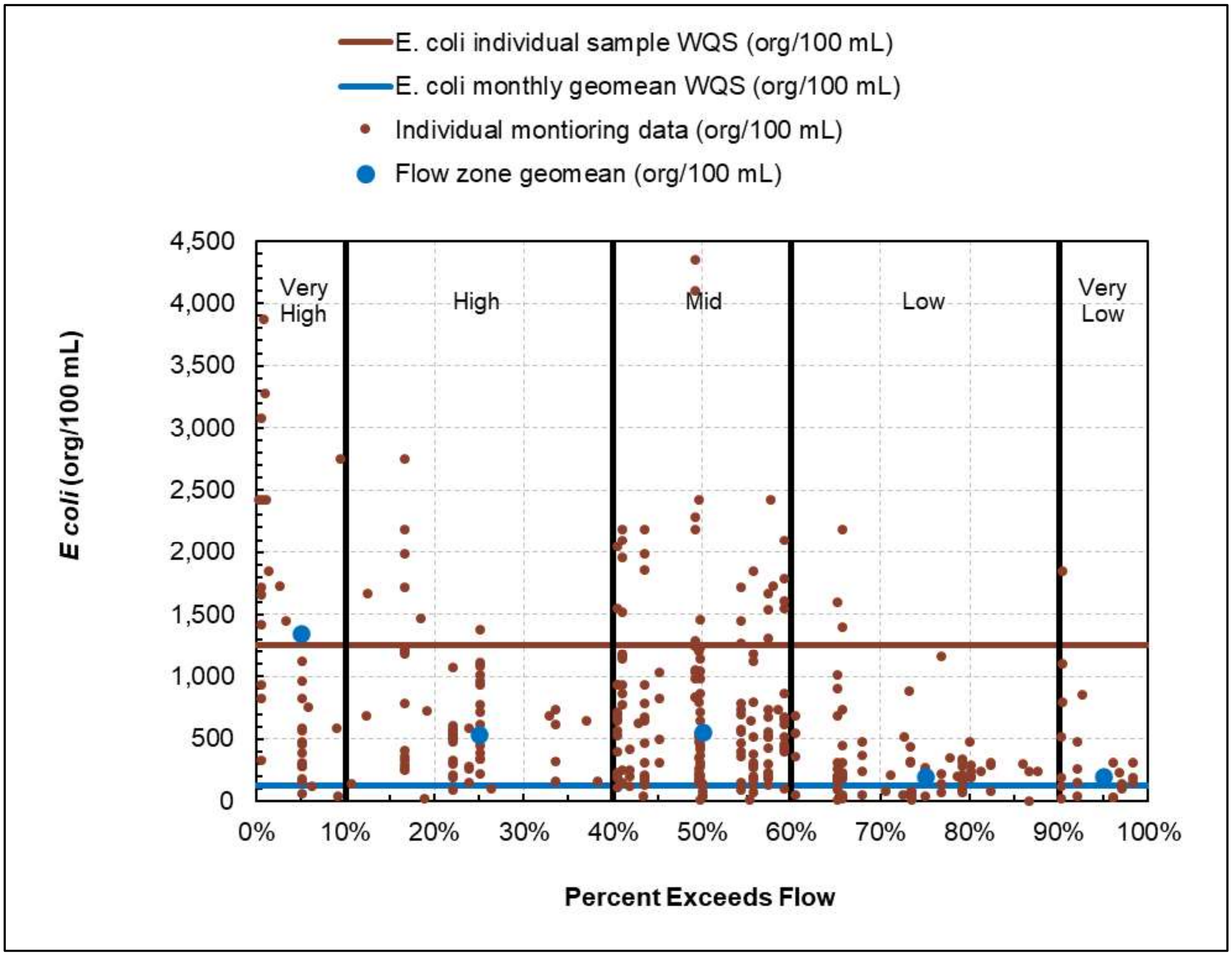

Figure 5. ***E. coli*** **concentration duration curve for Dobbins Creek subwatershed (all monitoring stations, April–Oct, 2015-2022).**

2.3 Longitudinal analysis

E. coli concentrations were evaluated longitudinally along the main stem of Dobbins Creek (Figure 7) and along the main southern tributary, Unnamed Creek (Figure 8) using a box and whisker plot. Box and whisker plots provide a summary of several aspects of a data set in one plot (Figure 6). The box portion or interquartile interval (IQR) represents where 50% of the data lie. The lower end of the IQR is the first quartile or 25th percentile, and the upper end is the third quartile or 75th percentile of the dataset. The median of the dataset is show with a horizontal line. The mean of the dataset is shown with the “x”. The upper and lower bars represent the maximum and minimum values of the dataset, not considering outliers, or data that are more than 1.5 times the IQR. Outliers were removed from the plots for ease of reading.

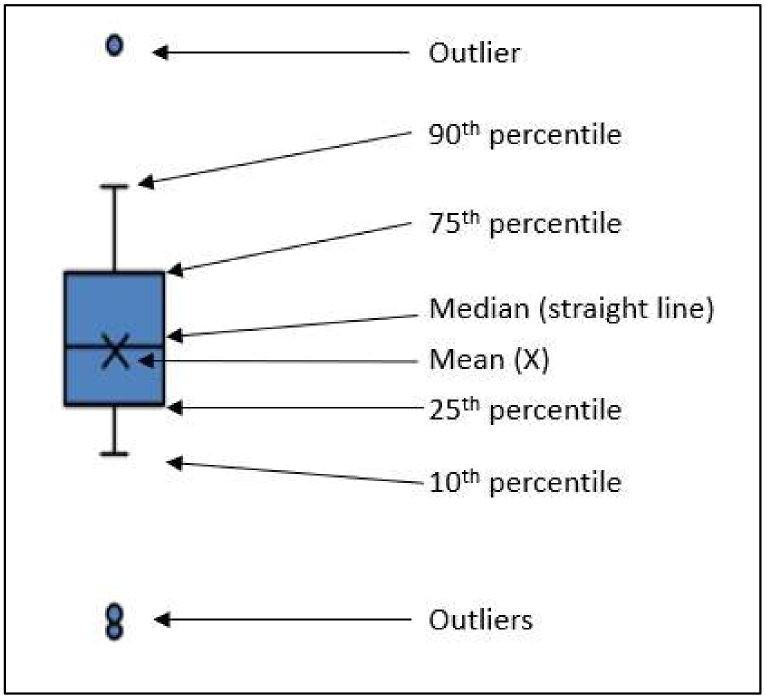

Figure 6. Box and whisker plot description.

In general, *E. coli* concentrations increase from upstream to downstream along the mainstem Dobbins Creek with a few exceptions (Figure 7).

- *E. coli* data concentrations upstream and downstream of Eastside Lake suggest that overall Eastside Lake acts as a sink for *E. coli.*
- *E. coli* concentrations drop after the confluence of Unnamed Creek (-563) with Dobbins Creek, suggesting that Unnamed Creek may have a dilution effect on the *E. coli* concentration in the mainstem Dobbins Creek.
- Data suggest that tributaries Unnamed Creek (-605) and Unnamed Creek (-624) further upstream on the mainstem Dobbins Creek may increase *E. coli* concentrations in the mainstem Dobbins Creek at certain times, as the IQR for monitoring station downstream of the tributaries (S008-958) has a higher range than the IQR upstream of them (S008-960). There is little change between the median values of both stations.

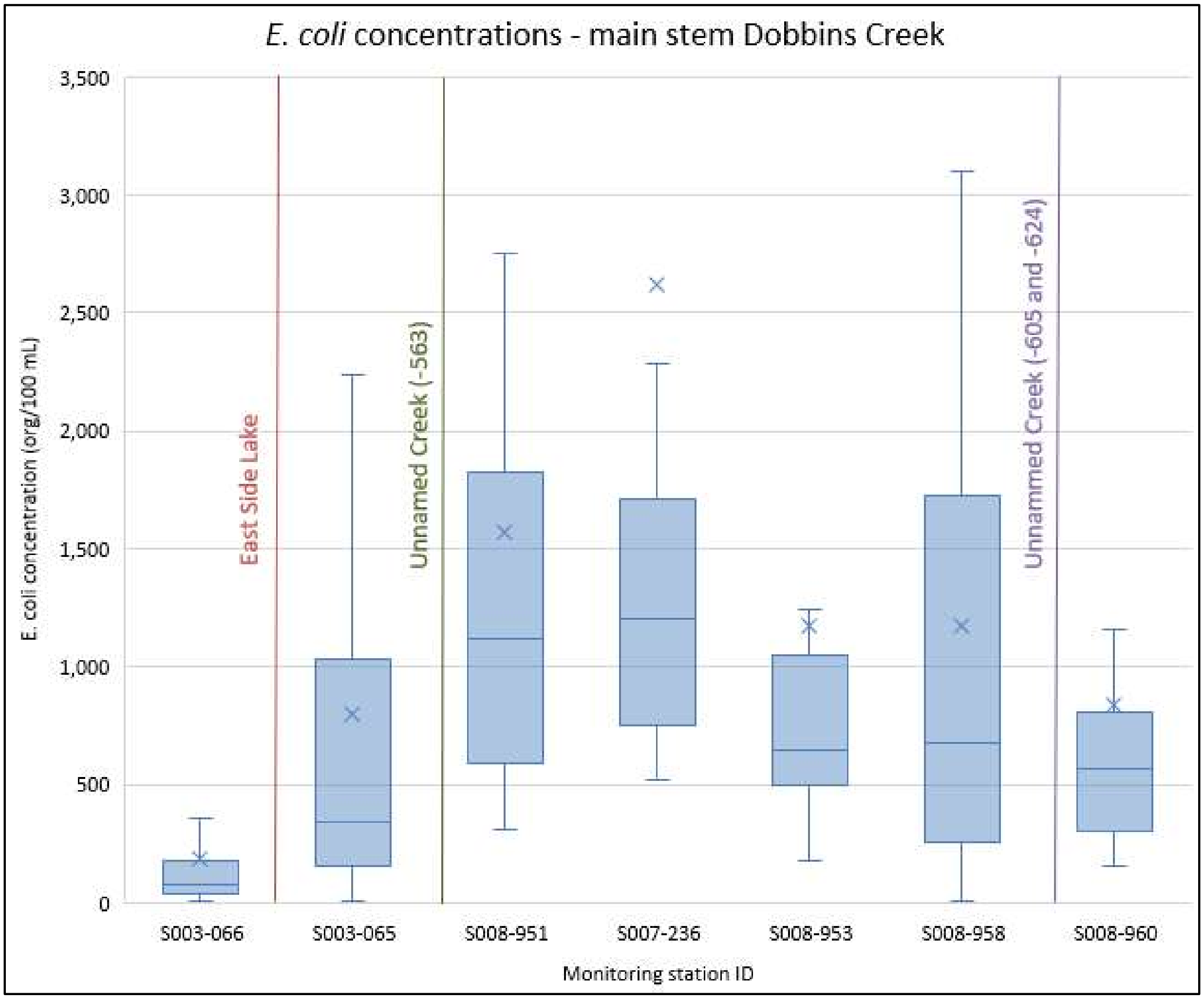

Figure 7. Box plot analysis of *E. coli* monitoring data along the main stem of Dobbins Creek. Monitoring stations arranged from downstream to upstream (left to right). Outliers not shown. (April - Oct, 2015-2022).

Overall *E. coli* concentrations along the main tributary to Dobbins Creek, Unnamed Creek (-563), are lower than *E. coli* concentrations along the mainstem Dobbins Creek (-524) (Figure 8). Unlike along the mainstem Dobbins Creek, smaller tributaries to Unnamed Creek (-563) do not seem to be major contributors of *E. coli* to the system as *E. coli* concentrations are lower and flow from these tributaries is also likely lower than flow on Unnamed Creek (-563).

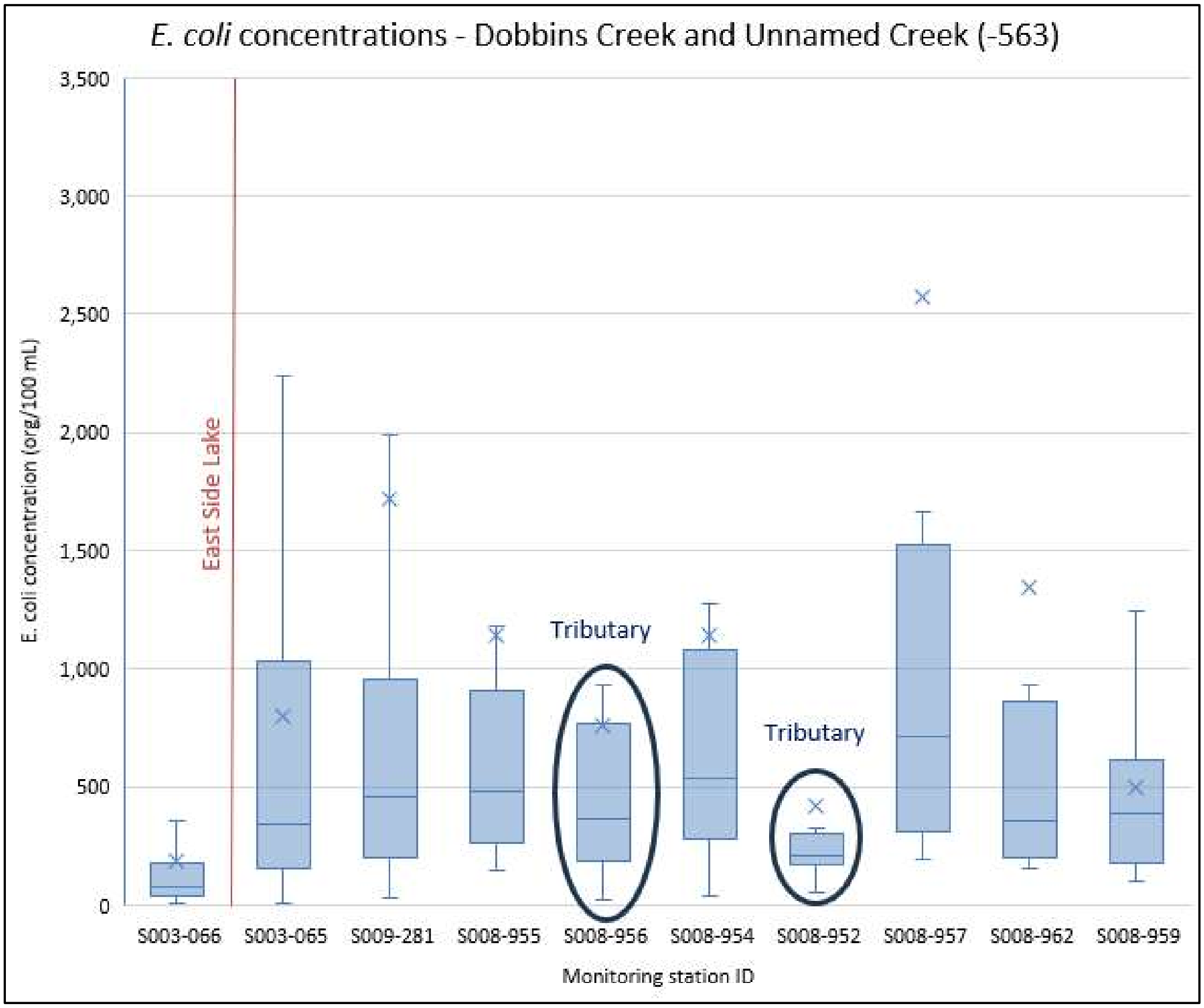

Figure 8. Box plot analysis of *E. coli* monitoring data along the main stem of Dobbins Creek and the Unnamed Creek southern tributary (-563). Monitoring stations arranged from downstream to upstream (left to right). (April – Oct, 2015-2022).

Median *E. coli* concentrations were mapped by monitoring station to illustrate these observations in a different way in Figure 5. Larger and warmer colored markers indicate high median *E. coli* concentrations during the months of April-Oct 2015-2022.

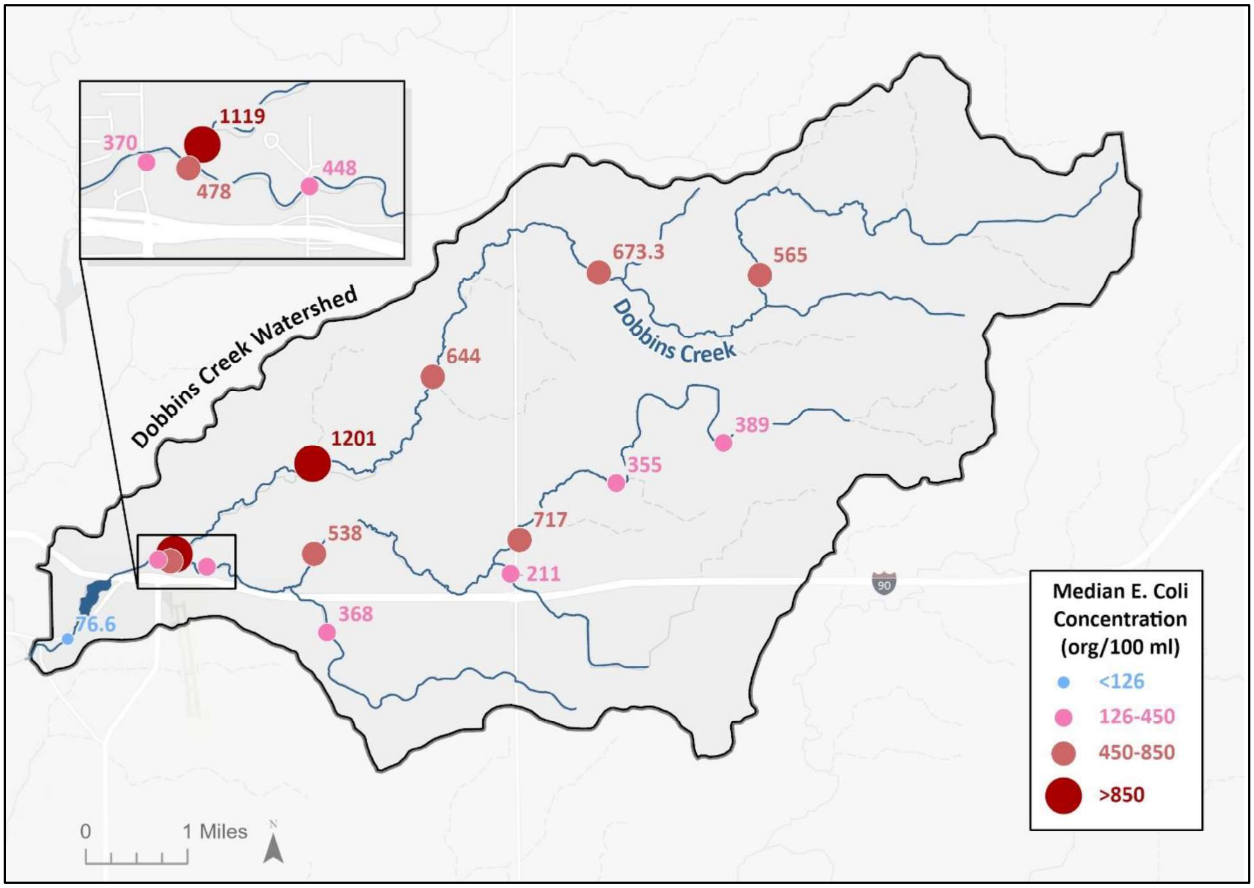

Figure 9. Median E. coli concentrations by monitoring station (April – Oct, 2015-2022).

2.4 Statistical Analysis of Dobbins Creek Effectiveness Monitoring Protocol

A water quality study was conducted by the University of Minnesota (Van Kirk 2017) in Dobbins Creek subwatershed in 2015 to better understand *E. coli* in the watershed. Fourteen monitoring sites were sampled weekly for *E. coli* and a suite of other parameters including water temperature, pH, dissolved oxygen, specific conductivity, turbidity, and nitrate . Statistical analysis was then performed on the data to determine if the main stem Dobbins Creek samples statistically differed from the samples along the main southern tributary. E. coli concentrations on both stems were compared to one another by using a Wilcoxon rank-sum test. Box plots were used to visualize the branch comparison. None of the tests returned p-values less than 0.05. While *E. coli* came very close (0.072) to a p-value less than 0.05, the branches were not found to be statistically different from each other with regard to *E. coli* concentration in the 2015 sampling season.

2.5 Summary of *E. coli* water quality analysis:

- Recent available *E. coli* data (2015-2022) were used in the water quality analysis from months within the standard applicability period (April-Oct)

- The majority of *E. coli* sampling from 2015-2022 occurred during the months June through September; however, data were collected the entire standard applicability period of April-October.
- Individual sample *E. coli* concentrations ranged from 10 to over 24,000 org/100 mL. The largest number of *E. coli* samples were taken in 2015 (n=262), 2021 (n=63) and 2022 (n=63).
- When summarizing all data from 2015-2022 at the **annual** scale, samples exceeded the 1,260 orgs/100 ml standard at a frequency of 0% in 2016 (n=7) to 71% in 2017 (n=6) (Table 5).
- When summarizing all data from 2015-2022 at the **monthly** scale, the monthly geometric mean standard (126 org/100mL) is exceeded every month besides Apri (May-Oct). The frequencies of exceedance of the individual sample standard range from 14% in October (n=24) to 24% in June (n=78). Monthly geometric mean and maximum individual sample concentrations increase in the months of June to September. Sample counts are also higher during these months (Table 6).
- There is not a strong relationship between *E. coli* concentration and flow zone in the Dobbins Creek subwatershed. Exceedances of the monthly geomean standard are seen across all flow conditions with the most exceedances occurring under mid flow conditions (Figure 5).
- In general, *E. coli* concentrations increase from upstream to downstream along the mainstem Dobbins Creek (Figure 7). In addition:
    - *E. coli* data concentrations upstream and downstream of Eastside Lake suggest that overall Eastside Lake acts as a sink for *E. coli.*
    - *E. coli* concentrations drop after the confluence of Unnamed Creek (-563) with Dobbins Creek, suggesting that Unnamed Creek may have a dilution effect on the *E. coli* concentration in the mainstem Dobbins Creek.
    - Data suggest that tributaries Unnamed Creek (-605) and Unnamed Creek (-624) further upstream on the mainstem Dobbins Creek may increase *E. coli* concentrations in the mainstem Dobbins Creek at certain times.
- Overall *E. coli* concentrations along Unnamed Creek (-563) are lower than *E. coli* concentrations along the mainstem Dobbins Creek (-524). Tributaries to Unnamed Creek (-563) do not seem to be major contributors of *E. coli* to the system as *E. coli* concentrations are lower and flow from these tributaries is also likely lower than flow on Unnamed Creek (-563) (Figure 8).
- A 2015 study by the U of M (Van Kirk 2017) did not find Dobbins Creek and the main southern tributary to be statistically different from one another. The p-value for *E. coli*, however, was 0.072, very close to what is needed for statistical difference (p value <0.05).

3. *E. coli* source assessment

Potential sources of *E. coli* in the Dobbins Creek subwatershed include livestock sources (feedlot facilities, pastured areas, land applied manure), stormwater runoff, and individual subsurface sewage treatment systems. There is no evidence at this time to suggest that natural background *E. coli* and naturalized *E. coli* are major drivers of impairment and/or affect the water bodies' ability to meet state water quality standards.

3.1 Livestock

Livestock are housed in feedlots and/or pastured areas. Feedlots and manure storage areas can be a source of *E. coli* due to runoff from the animal holding areas or the manure storage areas. Pastures can be sources of *E. coli* if livestock have access to surface water and if the pastureland does not have adequate vegetation to "trap" livestock manure from entering surface waters during times of runoff. This is dependent on the proximity of the pasture to a surface water. The land application of all manure, regardless of whether the source of the manure originated from permitted or nonpermitted feedlots, is considered a potential source of *E. coli*. The timing, placement, application method and volume of land applied manure are factors that influence the likelihood of *E. coli* from manure entering surface waters.

Feedlots

This ESA provides information on two types of feedlots within the Dobbins Creek subwatershed: concentrated animal feeding operations (CAFOs) and non CAFO registered feedlots.

CAFO is a federal definition that implies not only a certain number of animals but also specific animal types. The MPCA uses the federal definition of a CAFO in its permit requirements of animal feedlots along with the state definition of an animal unit (AU). In Minnesota, the following types of livestock facilities are issued, and must operate under, an NPDES or SDS permit as follows:

a) All federally defined CAFOs as required by federal law, some of which are under 1,000 AUs in size, must operate under an NPDES permit.

b) All CAFOs and non-CAFOs that have 1,000 or more AUs must operate under an NPDES or SDS permit.

CAFOs with fewer than 1,000 AUs and that are not required by federal law to maintain NPDES permit coverage may choose to operate without an NPDES permit. A current manure management plan that complies with Minn. R. 7020.2225 and the respective permit is required for all CAFOs and feedlots with 1,000 or more AUs.

CAFOs and feedlots with 1,000 or more AUs must be designed to contain all manure, manure contaminated runoff, process wastewater, and the precipitation from a 25-year, 24-hour storm event. CAFOs are inspected by the MPCA in accordance with the MPCA NPDES Compliance Monitoring Strategy approved by the EPA. All CAFOs are inspected by the MPCA on a routine basis with an appropriate mix of field inspections, offsite monitoring, and compliance assistance.

Of the approximately 28 registered animal feedlots in the Dobbins Creek subwatershed, there is one CAFO with a NPDES permit.

Table 7. Permitted CAFOs in the Dobbins Creek subwatershed.

Permittee name	Feedlot registration	Animal units	Primary animal type
Holden Farms - Dobbins Creek	099-100193	1,333.4	Swine

Feedlots under 1,000 AUs and those that are not federally defined as CAFOs do not operate with NPDES permits. In Minnesota, feedlots with greater than 50 AUs, or greater than 10 AUs in shoreland areas, are required to register with the county feedlot officer if the county is delegated, or with the MPCA if the county is nondelegated. Facilities with fewer AUs are not required to register. Shoreland is defined by Minn. R. 7020.0300 as land within 1,000 feet from the normal high water mark of a lake, pond, or flowage, and land within 300 feet of a river or stream.

All non-CAFO feedlots in the Dobbins Creek subwatershed are inspected by the Mower County feedlot officer on a routine basis in accordance with the delegated county’s Delegation Agreement and Work Plan, which is prepared with and approved by MPCA every other year.

The 27 registered non-CAFO feedlots in the Dobbins Creek subwatershed are mapped in Figure 10. Both active and inactive feedlots are listed. While inactive feedlots no longer have livestock, they have the potential to be a source of historical *E. coli* loading to surface waters.

Special attention should be paid to feedlots that are located within Shoreland and within 1,000 feet of surface water. These facilities have a higher chance of *E. coli* contaminated runoff making it to Dobbins Creek if certain measures are not in place. Are mapped in Figure 11.

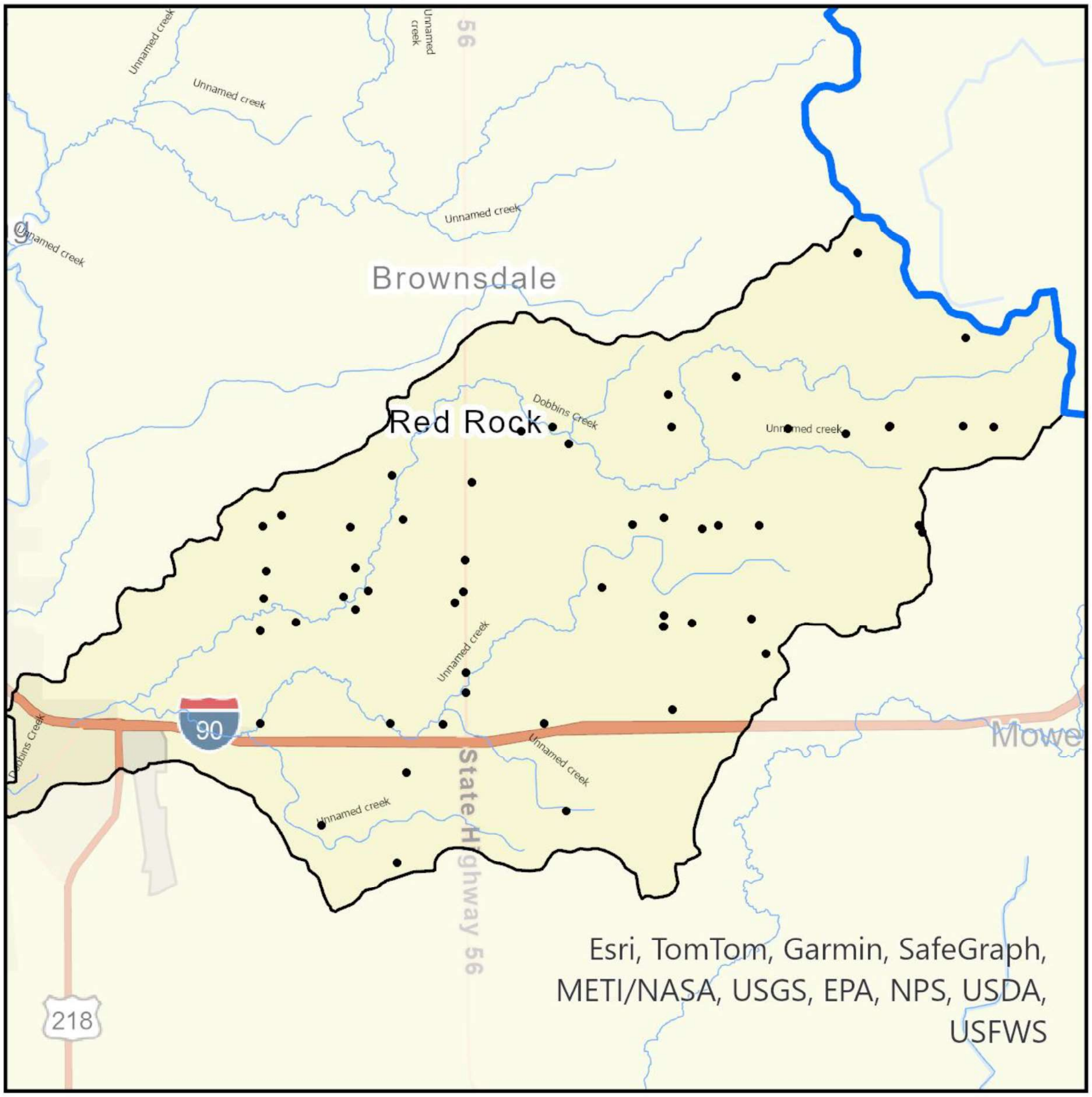

Figure 10. Registered feedlots in the Dobbins Creek subwatershed (December 2023).

Pasture

Pastures can be sources of *E. coli* under certain circumstances. The first is if livestock have constant access to the surface water that may flow through the pastureland. Livestock can loaf and defecate in the water. This results in the introduction of *E. coli*. Secondly, pastures that are not well managed may not have adequate vegetation to "trap" livestock manure from entering surface waters during times of runoff. This is dependent on the proximity of the pasture to a surface water. Pasture is a component of 22 of the 28 registered feedlots in the Dobbins Creek subwatershed. Approximately 1,035 acres or 4.2% of the Dobbins Creek subwatershed is classified as "Hay/Pasture" landcover (NLCD 2019). Locations of pastures that pose high risk of *E. coli* introductions are identified in Table 8 and Figure 11..

Table 8. Feedlots with pasture component and potential livestock water access.

Feedlot registration number	Animal type	Nearest MPCA monitoring site	Compliance history
099-83213	Beef	S008-968	None
099-83440	Horse	S007-236	None
099-83594	Swine	S007-236	Compliant (8/11/22)
099-93966	Beef	S008-958	Compliant (6/23/15)
099-83447	Beef/goat/duck/chicken	S008-953	None
Not registered (56788 220th St)	Beef	None	None
099-83664	None	S008-962	None (ponds)

Land application of manure

Manure that is generated on feedlots is usually stockpiled on site or on crop fields, or stored in pits, tanks, or earthen basins on site until field conditions and the crop rotation allow for applying the manure as fertilizer. Manure can be delivered to surface waters from failure of manure containment, runoff from the feedlot itself, or runoff from nearby fields where the manure is applied.

While a full accounting of the fate and transport of manure was not conducted for this project, a large portion of it is ultimately applied to the land surface and, therefore, this source is of possible concern. Minn. R. 7020.2225 contains several requirements for land application of manure; however, there are no explicit requirements for *E. coli* treatment prior to land application.

Farmland under row crop production can be source of *E. coli* to surface waters under various conditions. The first condition is that the field receives animal manure. The timing of manure spreading, as well as the application rate and method, affects the likelihood of *E. coli* loading to nearby water bodies. The spreading of manure on frozen soil in the late winter is likely to result in surface runoff with precipitation and snowmelt runoff events. Deferring manure application until snow has melted and soils have thawed decreases overland runoff associated with large precipitation events. Land applying manure when rain is forecasted also increases the chances of manure runoff. Injecting or incorporating manure is a preferred best management practice (BMP) to reduce the runoff of waste and associated pollutants. Incorporating manure into the soil reduces the risk of surface runoff associated with large precipitation events. More research is needed to understand if and how injected manure in a drain tiled farm field impacts the transport of *E. coli*.

Aerial imagery of farmland within the Dobbins Creek subwatershed allowed the detection of farm fields that may have areas of concentrated flow. Areas of concentrated flow are fast pathways for *E. coli* to enter surface waters because there are little to no barriers (vegetation, berms) to intercept runoff. Table 9 identifies farm fields in close proximity to streams in the Dobbins Creek subwatershed with areas of concentrated flow; these areas are also mapped in Figure 11. It is not yet known if the locations identified land apply manure. This is essential information needed to properly understand these locations' *E. coli* loading potential.

Table 9. Cropped farm fields with high potential for runoff to surface waters.

Closest receiving water	Parcel ID
Headwaters of Dobbins Creek (-605)	05.020.0060
Headwaters of Dobbins Creek (-605)	05.019.0010
Main Branch Dobbins (-524)	16.021.0025
Main Branch Dobbins (-524)	16.021.0040
Southern Tributary to Dobbins (-609)	16.025.0010

Priority areas for livestock-related sources of *E. coli*

Figure 11 provides an overview of the known priority areas for livestock related sources of *E. coli.* These areas are most likely to contribute livestock related sources of *E. coli*.

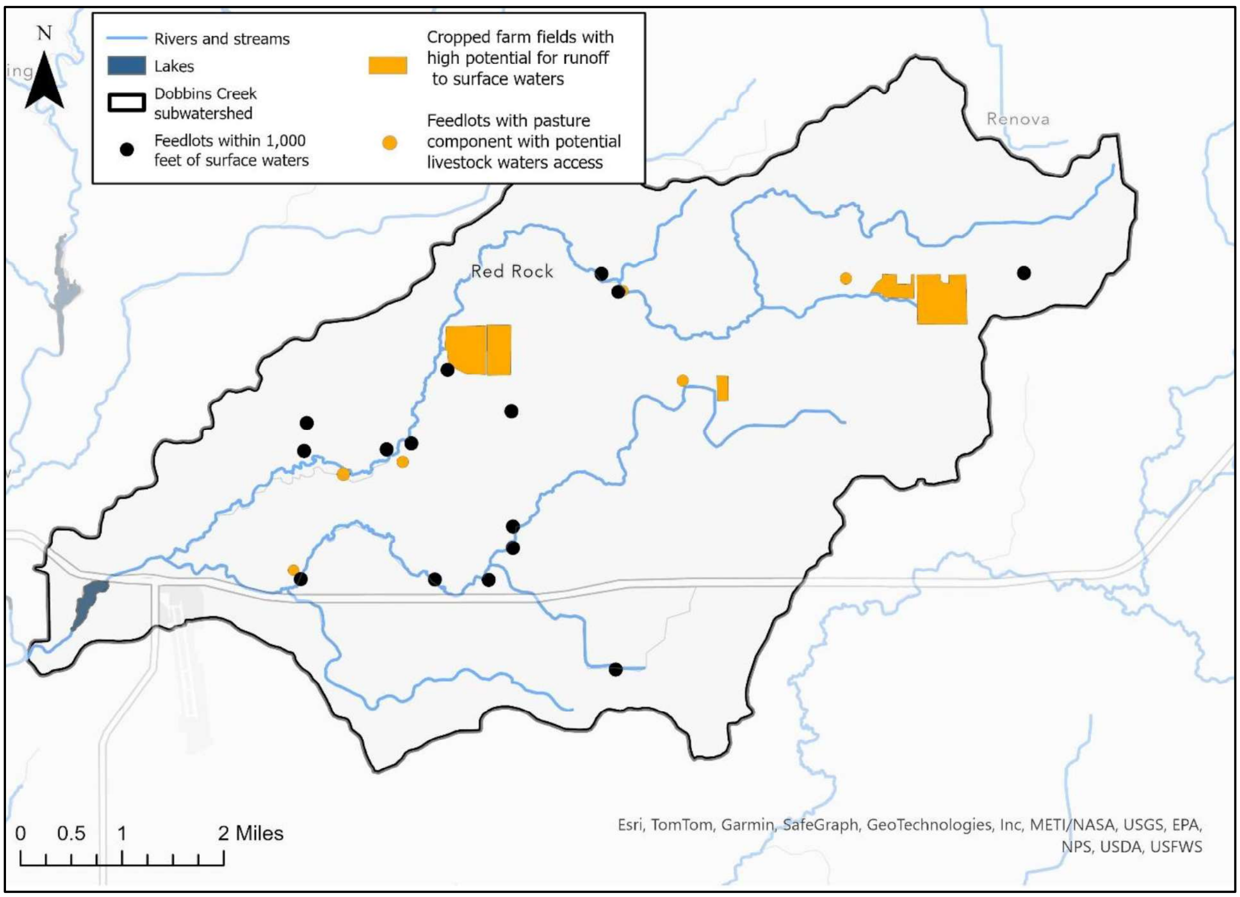

Figure 11. Priority areas for livestock sources of *E. coli.*

3.2 Stormwater runoff

Both permitted (Municipal Separate Storm Sewer System, or MS4) and non permitted stormwater can be a transport mechanism for loading *E. coli* into rivers and streams. Stormwater runoff acts as an important delivery mechanism of multiple *E. coli* sources. Stormwater runoff from impervious surfaces, such as roads and parking lots, can directly connect the location where *E. coli* is deposited on the landscape to surface waters.

Permitted MS4 area within the Dobbins Creek subwatershed is provided in Figure 12. All developed (permitted and non permitted) areas cover approximately 9% or 2,229 acres and are provided in Figure 2.

While stormwater may be impacting *E. coli* concentrations in the Dobbins Creek watershed, water quality data from stations within the MS4 (S008-955, S009-281, S003-065) show generally lower *E. coli* concentrations compared to upstream water quality monitoring stations. In addition, developed areas make up a much smaller amount of the total land cover than cropland areas. This indicates that, stormwater from developed areas is not likely contributing relatively significant *E. coli* loads to the Dobbins Creek subwatershed.

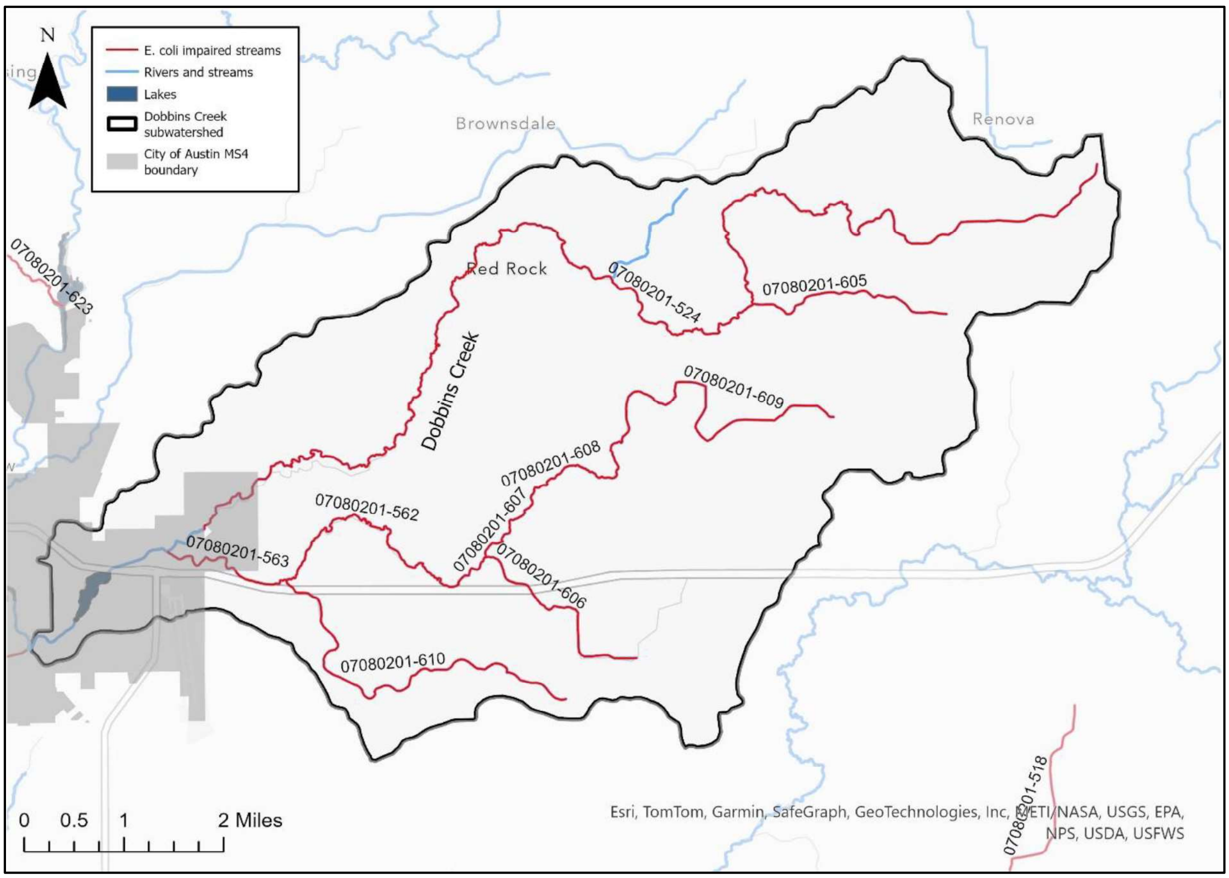

Figure 12. City of Austin permitted stormwater (MS4) boundary.

3.3 Individual subsurface sewage treatment systems

Adequate wastewater treatment is vital to protecting the health, safety, and environment in Minnesota. Approximately 30% of Minnesotans rely on subsurface sewage treatment systems (SSTSs).

SSTSs that fail to treat wastewater adequately threaten groundwater used for drinking water and surface water used for recreation. Inadequate treatment of wastewater/sewage, which contains bacteria, viruses, parasites, nutrients, and chemicals, can result in contamination of drinking water sources. Additionally, straight-pipe wastewater "systems," which route raw wastewater to the ground or nearby waters, can directly impact lakes, streams, and wetlands.

SSTSs can fail for a variety of reasons, including excessive water use, poor design, physical damage, and lack of maintenance. Common limitations that contribute to failure include seasonal high water table, fine-grained soils, bedrock, and fragipan (i.e., altered subsurface soil layer that restricts water flow and root penetration). Septic systems can fail hydraulically through surface breakouts or hydrogeologically from inadequate soil filtration. Failure potentially results in higher levels of pollutant loading to nearby surface waters.

Other sources of wastewater in the watershed may include straight pipe discharges, earthen pit outhouses, and land application of septage. Straight pipe systems are unpermitted and illegal sewage disposal systems that transport raw or partially treated sewage directly to a lake, stream, drainage system, or the ground surface. Straight pipe systems are required to be addressed 10 months after discovery (Minn. Stat. § 15.55, subdiv. 11). Outhouses, or privies, are legal disposal systems and are regulated under Minn. R. 7080.2150, subp. 2F and Minn. R. 7080.2280.

In 2023, Mower County conducted a community assessment report (CAR) on the existing compliance status of SSTS in Windom and Red Rock townships. The CAR identified that of the 76 properties with individual subsurface sewage treatment systems (ISTS) in the Dobbins Creek study area, 49% are compliant while the other 51% are not (Table 10).

Table 10. Compliance status of ISTS in Windom and Red Rock townships (Stantec, 2023).

Status of ISTS	Number	Percentage
Compliant	37	49%
Noncompliant (imminent threat to public health and safety)	2	2%
Noncompliant (failure to protect groundwater)	37%	49%

The CAR also identifies the feasibility and cost of all septic treatment options (ISTS, shared community system or wastewater treatment plant connection). Recommendations for future septic treatment are:

- If stakeholders want the lowest cost, continue using private ISTS;
- If stakeholders desire a community solution, conveying septage to Austin wastewater treatment plant should be pursued;
- If stakeholders don't want City of Austin annexation, community cluster large subsurface sewage treatment system should be pursued.

The next step for Mower County is identifying which option above is the preference of property owners in this area.

3.4 Industrial by-product

While there are no permitted discharge sites for Hormel Food Corp that discharge within the Dobbins Creek subwatershed, activities related to the plant, such as land application of industrial by-product to cropland and livestock truck washing could be potential sources of *E. coli* to Dobbins Creek if permit requirements and guidance are not met.

Land application of industrial by-product

The MPCA assumes that industrial by-products contain pathogens if waste streams are known or likely to comingle with blood, animal feces, or raw meats. Industrial by-products from Hormel Food Corp are assumed to contain pathogens as they include waste such as blood, animal feces, and raw meat (Minn. R. 7001 2.2.50). However, if permit requirements are met, land application of industrial by-product is not assumed to be a source of *E. coli* to streams.

Hormel Food Corp's NPDES/SDS Permit (permit MN0050911) authorizes the land application of industrial by-product from production processes. The industrial by-product covered under this permit includes two waste streams that consist primarily of water and animal residue. The first waste stream (97% of the total by-product) is sludge that is captured through a dewatering process at the onsite wastewater pretreatment plant. The other waste stream (3% of the by-product) consists of paunch material captured from the hogs' stomachs and intestines. This waste is primarily undigested or partially digested corn.

According to the Industrial By-Product General SDS permit (Permit #MNG960000), the site used for land application shall have a growing crop, which is harvested and removed during the cropping year that the by-product is land applied. If the by-product contains pathogens:

- The soil texture at the zone of industrial by-product application shall be fine sand, loamy sand, sandy loan, silt, silt loam, sandy clay loan, clay loam, sand clay, silty clay loam, silty clay or clay
- The depth to bedrock shall be at least 3 feet, unless the soil is classified as a highly permeable soil, in which case the minimum depth is increased up to 5 feet
- The depth to the seasonal high water table shall be at least 3 feet, unless the soil is classified as a highly permeable soil, in which case the minimum depth is increased to 5 feet. On sites installed with tile drainage, the depth to tile lines is the depth to the seasonal high water table.

Required minimum separation distances from the industrial by-product land application site are provided in Figure 13. Additional required minimum separation distances from application sites when the industrial by-product contains pathogens are provided in Figure 14.

Table 5. Minimum separation distances from the land application site.

Feature		Separation Distances (feet) Surface Applied	Incorporated within 48 hours	Injected
Private drinking water supply wells		200 feet	200 feet	200 feet
Public drinking water supply wells		1000 feet	1000 feet	1000 feet
Down gradient lakes, rivers, streams, type 3, 4, and 5 wetlands, intermittent streams, or tile inlets connected to these surface water features,[1] and sinkholes	Slope 0 % to 6 %	200 feet	50 feet	50 feet
	Slope 6 % to 12 %	Not Allowed	100 feet	100 feet
	Winter (0 % to 2 %)	600 feet	Not Applicable	Not Applicable
Grassed Water Ways[2]	Slope 0 % to 6 %	100 feet	33 feet	33 feet
	Slope 6 % to 12 %	Not Allowed	33 feet	33 feet

[1]Intermittent stream means a drainage channel with definable banks that provides for runoff flow to any of the surface waters listed in the above table during snow melt or rainfall events.

[2]Grassed waterways are natural or constructed and seeded to grass as protection against erosion. Separation distances are from the centerline of grassed waterways. For a grassed waterway, which is wider than the separation distances required, application is allowed to the edge of the grass strip.

Figure 13. Minimum separation distances from the land application site (Industrial By-Product General Permit #MNG960000).

Table 6. Additional minimum separation distances from application sites when the industrial by-product contains pathogens.

Separation Distances (feet)			
Feature	**Surface Applied**	**Incorporated within 48 hours**	**Injected**
Residences	200[1] feet	200[1] feet	100 feet
Residential development	600[1] feet	600[1] feet	300 feet
Public contact site	600 feet	600 feet	300 feet
Depth to Bedrock	5[2] feet	5[2] feet	5[2] feet
Depth to Seasonal High Water Table or drain tile[3]	5[2] feet	5[2] feet	5[2] feet
Private Supply Wells	200 feet	200 feet	200 feet
Public Supply Wells	1000 feet	1000 feet	1000 feet
Irrigation Wells	50 feet	25 feet	25 feet

[1]This distance may be reduced with written permission from all persons responsible for residential developments, places of recreation, and all persons inhabiting residence within the designated separation distance.

[2]The separation distance may be decreased to 3 feet if the soil is not classified as a "highly permeable soil," as defined by this permit.

[3]The depth to subsurface drainage tiles shall be considered the depth to the seasonal high water table for sites that are designed according to Natural Resources Conservation Services engineering standards and criteria.

Figure 14. Additional minimum separation distances from application sites when the industrial by-product contains pathogens (Industrial By-Product General Permit #MNG960000).

Land application sites of Hormel Food Corps' industrial by-product are provided in Figure 15.

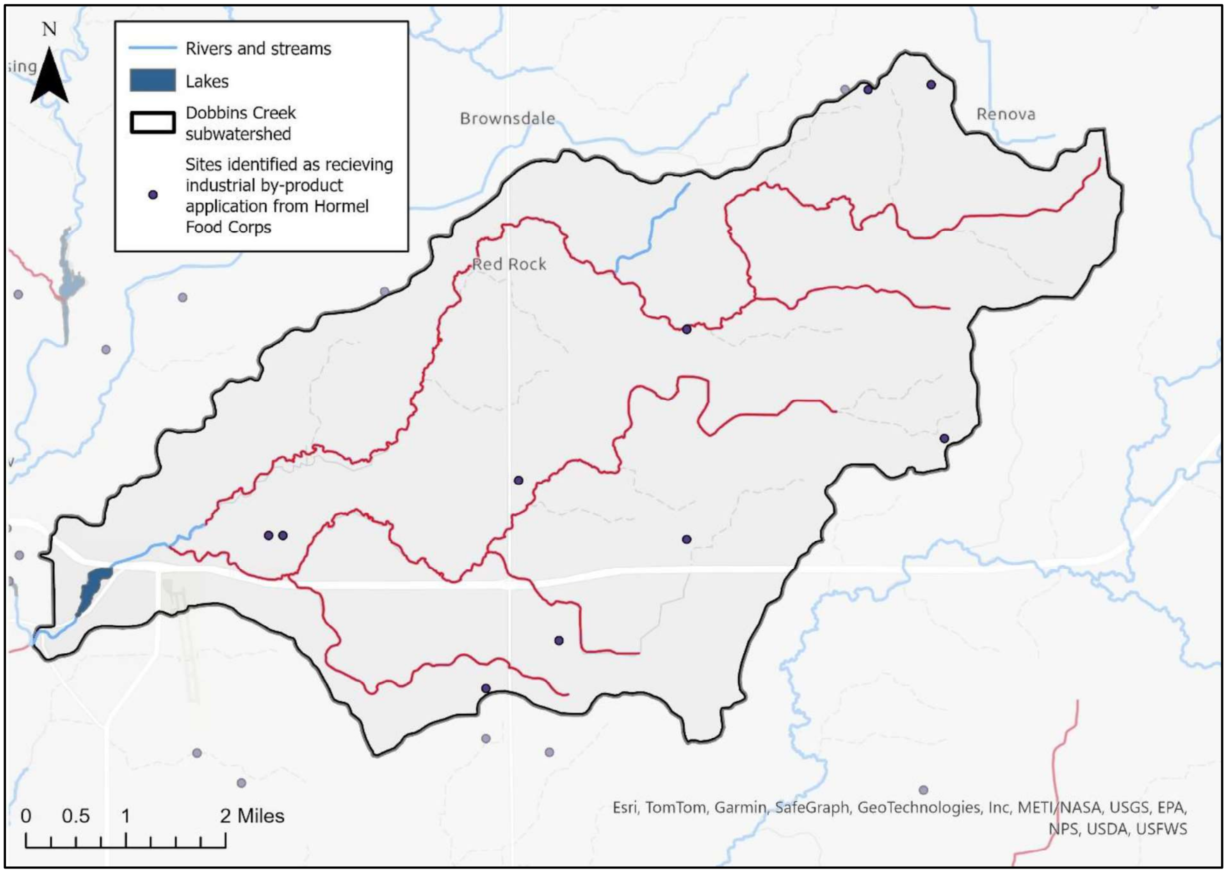

Figure 15. Sites identified as receiving land application of industrial by-product from Hormel Food Corps (MPCA Tempo database.

Animal truck washing

Trucks that carry hogs to the Hormel Food Corps plant are washed after delivery at truck washes. Livestock truck washes are regulated by either the MPCA's feedlot or industrial by-product program based on whether the truck wash is a private or public wash and whether it's located at a feedlot. There are two known truck washing stations in the Dobbins Creek subwatershed with the potential to be used by trucks delivering to Hormel Food Corps, both are privately owned and therefore regulated through the MPCA's industrial by-product program. Waste from truck washing stations may be land applied under certain circumstances. Additional private livestock truck washing stations may also be present in the subwatershed. More information on land application of truck washing wastewater can be found here: https://www.pca.state.mn.us/sites/default/files/wq-lndapp2-08.pdf. If permit and/or guidance requirements are met, truck washing stations are not assumed to be a source of *E. coli* to streams.

3.5 Natural background sources

"Natural background" is defined in both Minnesota statute and rule. The Clean Water Legacy Act (Minn. Stat. § 114D.15, subd. 10) defines natural background as "characteristics of the water body resulting from the multiplicity of factors in nature, including climate and ecosystem dynamics, that affect the physical, chemical, or biological conditions in a water body, but does not include measurable and distinguishable pollution that is attributable to human activity or influence." Minn. R. 7050.0150, subp. 4 states, "'Natural causes' means the multiplicity of factors that determine the physical, chemical, or biological conditions that would exist in a water body in the absence of measurable impacts from human activity or influence."

Natural background sources are inputs that would be expected under natural, undisturbed conditions. Natural background sources can include inputs from natural geologic processes such as soil loss from upland erosion and stream development, atmospheric deposition, and loading from forested land, wildlife, etc. However, for each impairment, natural background levels are implicitly incorporated in the water quality standards used by the MPCA to determine/assess impairment, and therefore natural background is accounted for and addressed through the MPCA's water body assessment process. Natural background conditions were evaluated within the source assessment portion of this study. These source assessment exercises indicate that natural background inputs are generally low compared to livestock, cropland, streambank, failing SSTSs, and other anthropogenic sources.

Based on this enhanced source assessment, there is no evidence at this time to suggest that natural background sources are a major driver of any of the impairments and/or affect the water bodies' ability to meet state water quality standards.

3.6 Naturalized *E. coli*

The adaptation and evolution of naturalized *E*. *coli* that allow it to survive and reproduce in the environment make it physically and genetically distinct from *E*. *coli* that cannot survive outside of a warm-blooded host. This naturalized *E. coli* may be a source of *E. coli* to the impairments.

The relationship between *E. coli* sources and *E. coli* concentrations found in streams is complex, involving precipitation and flow, temperature, sunlight and shading, livestock management practices, wildlife contributions, *E. coli* survival rates, land use practices, and other environmental factors. Research in the last 15 years has found the persistence of *E. coli* in soil, beach sand, and sediments throughout the year in the north central United States without the continuous presence of sewage or mammalian sources. This *E. coli* that persists in the environment outside of a warm-blooded host is referred to as naturalized *E. coli* (Jang et al. 2017). Naturalized *E. coli* can originate from different types of *E. coli* sources, including 1) natural background sources such as wildlife and 2) human attributed sources such as pets, livestock, and human wastewater. Therefore, whereas naturalized *E. coli* can be related to natural background sources, naturalized *E. coli* is not always from a natural background source.

An Alaskan study (Adhikari et al. 2007) found that total coliform bacteria in soil were able to survive for six months in subfreezing conditions. Two studies near Duluth, Minnesota found that *E. coli* were able to grow in agricultural field soil (Ishii et al. 2010) and temperate soils (Ishii et al. 2006). A study by Chandrasekaran et al. (2015) of ditch sediment in the Seven Mile Creek Watershed in southern Minnesota found that strains of *E. coli* had become naturalized to the water−sediment ecosystem. Survival and growth of fecal coliform has been documented in storm sewer sediment in Michigan (Marino and Gannon 1991), and *E. coli* regrowth was documented on concrete and stone habitat within an urban Minnesota watershed (Burns & McDonnell Engineering Company, Inc. 2017). This ability of *E. coli* to survive and persist naturally in watercourse sediment can increase *E. coli* counts in the water column, especially after resuspension of sediment (e.g., Jamieson et al. 2005).

Although naturalized *E. coli* likely exist in the watershed, non-naturalized sources of *E. coli* were also noted in the source assessment. This suggests that naturalized *E. coli* are not the sole driver of impairment and/or the only source affecting the water bodies' ability to meet state water quality standards.

3.7 The Cedar River Project Izaak Walton League's Upper Mississippi River Initiative

In 2017 and 2018, volunteer stream monitors for the Isaak Walton League monitored throughout the Cedar River watershed, which contains the Dobbins Creek subwatershed. Microbial Source Tracking was conducted using markers for swine, cattle, and human related sources of pathogens. In Dobbins Creek, Rose Creek and other locations both in Mower and Dodge County, 13/15 tested positive for human e-coli contamination. Swine DNA was found in the majority of water samples. Cattle was found in approximately half (Izaak Walton League 2018).

3.8 *E. coli* source assessment summary

- Livestock are likely contributing *E. coli* to the Dobbins Creek subwatershed through the following sources:
    - Manure runoff from feedlots within 1,000 feet of surface waters (Figure 11 and Table 8)
    - Manure runoff from pastures or direct fecal input from cattle in streams (Figure 11 and Table 9)
    - Manure runoff from cropped fields with high potential for runoff to surface waters (concentration flow paths to streams) (Figure 11 and Table 10)
- ISTS are likely contributing *E. coli* in certain areas of the Dobbins Creek subwatershed:
    - 50% of ISTS in the Windom and Rock townships are non-compliant
- Stormwater runoff, land application of industrial by-product, natural background, and naturalized *E. coli* are not likely major drivers of *E. coli* impairments the Dobbins Creek subwatershed.

4. Future recommendations

This section provides future recommendations to better understand and address likely sources of *E. coli* to the Dobbins Creek subwatershed. A summary of these recommendations and potential funding sources are outlined in Table 11; additional details are provided below.

Table 11. Summary of recommendations from *E. coli* enhance source assessment.

***E. coli* source/initiative**	**Recommendation**	**Potential funding sources**	**Recommended location**
Septic systems	Expand CAR to include remaining townships in Dobbins Creek subwatershed (Dexter & Marshall)	319 grant, WBIF	Throughout subwatershed
	Conduct property owner outreach to determine preference of future septic treatment	319 grant, WBIF	
	Incentivize septic compliance (inspection), maintenance, upgrades and/or replacement	WBIF, CWP Low interest loan (MPCA)	
	Work with local applicators to locate areas with septage land application and ensure proper treatment and runoff management	319 grant	
Feedlot	Engage with Mower County feedlot officer to ensure pasture compliance and potential recommendations to reduce livestock from accessing streams.	Feedlot program, 319 grant (in-kind)	Figure 11
	Conduct feedlot owner outreach on advantages of vegetative buffers, livestock water restriction structures and/or alternative livestock watering solutions.	319 grant, WBIF	
Cropland	Conduct assessment of which farm fields land apply manure. Consultation with Mower County feedlot officer may be helpful.	319 grant, WBIF	Figure 11
	Prioritize outreach to farm fields in close proximity to streams and with areas of concentrated flow.	319 grant, WBIF	
	Promote grassed waterways, incorporating land applied manure, increasing setbacks of land applied manure, or verifying compliance of manure application.	319 grant, WBIF	
Monitoring	Consider whether future *E. coli* monitoring would be beneficial to study *E. coli* concentrations following targeted implementation.	319 grant, Public university	Throughout subwatershed
	Consider the possibility of microbial source tracking (MST) to identify specific species sources.	Public university, WBIF	
	Boron testing for detergents to determine influence of septic systems.		

WBIF: watershed based implementation funding from One Watershed, One Plan program.

CWP: Clean Water Program

ISTS outreach and cost share

As identified in the Community Assessment Report (CAR), there is expected to be about 51% of ISTS in Windom & Red Rock townships with noncompliant septic systems. These noncompliant systems may be contributing *E. coli* to Dobbins Creek surface water; particularly those in close proximity to surface waters. It is recommended that watershed decision makers expand the CAR to include the remaining townships in Dobbins Creek subwatershed (Dexter and Marshall). Watershed decision makers should implement the next steps in the CAR by determining the future septic treatment preference of property owners identified in this study. Watershed decision makers should carefully consider which funding opportunities are available to incentivize septic inspections, upgrades and outreach.

Feedlot inspections and technical assistance

Feedlots located within 1,000 feet of surface water and feedlots with pasture operations that allow livestock constant access to surface waters (Figure 11) pose the highest risk of introducing *E. coli* to the Dobbins Creek subwatershed. Special attention should be paid to these select facilities to identify potential improvements. The Mower County feedlot officer should be consulted to assess pasture compliance and potential recommendations. These may include installing buffers between pasture and surface water, livestock restriction structures, and alternative watering solutions.

Conservation practices on farmland

Cropland that receives animal manure can be a source of *E. coli* to Dobbins Creek surface waters. Especially those farm fields in close proximity to streams and with high potential for runoff to surface waters (cropland with areas of concentrated flow) (Figure 11). Watershed decision makers should first assess which farm fields in the Dobbins Creek subwatershed land apply manure. Of those fields, property owner outreach should be prioritized to those in close proximity to surface waters and with areas of concentrated flow. Practices to minimize *E. coli* loading from cropland could include installing grassed waterways, incorporating land applied manure, increasing setbacks of land applied manure, or verifying compliance of manure application.

Future monitoring

Continued monitoring of *E. coli* may be useful for watershed decision makers. It is recommended that before establishing a future monitoring program, watershed partners carefully assess what they hope to learn from monitoring. If decreases in *E. coli* concentration are of interest, watershed partners should focus monitoring on locations where targeted implementation is planned or underway. To learn more about the origin of *E. coli*, watershed partners may want to consider microbial source tracking (MST). Because of the expense of MST, it is recommended that focus be on one or two source species (human, bovine, swine, etc.) and sample locations of MST carefully considered. Boron tests for detergents can also be used if stakeholders are interested in determining the influence of septic systems on water ways.

5. References

Adhikari, H., D. L. Barnes, S. Schiewer, and D. M. White. 2007. Total Coliform Survival Characteristics in Frozen Soils. Journal of Environmental Engineering 133(12):1098–1105. doi: 10.1061/(ASCE)0733-9372(2007)133:12(1098)

Burns & McDonnell Engineering Company, Inc. 2017. Minnehaha Creek Bacterial Source Identification Study Draft Report. Prepared for City of Minneapolis, Department of Public Works. Project No. 92897. May 26, 2017.

Chandrasekaran, R., M. J. Hamilton, P. Wang, C. Staley, S. Matteson, A. Birr, and M. J. Sadowsky. 2015. Geographic Isolation of *Escherichia coli* Genotypes in Sediments and Water of the Seven Mile Creek — A Constructed Riverine Watershed. Science of the Total Environment 538:78–85. https://doi.org/10.1016/j.scitotenv.2015.08.013

Ishii, S., W.B. Ksoll, R.E. Hicks, and M. Sadowsky. 2006. Presence and Growth of Naturalized *Escherichia Coli* in Temperate Soils from Lake Superior Watersheds. Applied and Environmental Microbiology 72: 612–21. doi:10.1128/AEM.72.1.612–621.2006

Ishii, S., T. Yan, H. Vu, D. L. Hansen, R. E. Hicks, and M. J. Sadowsky. 2010. Factors Controlling Long-Term Survival and Growth of Naturalized *Escherichia coli* Populations in Temperate Field Soils. Microbes and Environments 25(1):8−14. doi: 10.1264/jsme2.me09172

Izaak Walton League. 2018. The Cedar River Project Izaak Walton League’s Upper Mississippi River Initiative 2018 Summary.

Jamieson, R. C., D. M. Joy, H. Lee, R. Kostaschuk, and R. J. Gordon. 2005. Resuspension of Sediment-Associated *Escherichia coli* in a Natural Stream. Journal of Environmental Quality 34(2):581-589.

Marino, R. P., and J. J. Gannon. 1991. Survival of Fecal Coliforms and Fecal Streptococci in Storm Drain Sediments. Water Research 25(9):1089–1098.

Van Kirk, A. 2017. Statistical Analysis of Dobbins Creek Effectiveness Monitoring Protocol. University of Minnesota Department of Bioproducts and Biosystems Engineering. July 26, 2017

Appendix E: Fact sheet translations

MINNESOTA POLLUTION CONTROL AGENCY

www.pca.state.mn.us

Septic systems 101

Facts about subsurface sewage treatment systems

Subsurface sewage treatment systems (SSTS), commonly known as septic systems, are soil-based treatment systems used by homes and businesses that are not connected to municipal sewers. The systems treat and dispose of wastewater generated on-site. More than 500,000 septic systems are in use in Minnesota, which includes 30% of the state's households. Septic systems treat approximately 25% of wastewater generated in the state.

Wastewater contains sewage, which includes bacteria, viruses, parasites, nutrients, and some chemicals. Correctly treating and disposing of wastewater is critical to protecting public health and the environment. More than two-thirds of Minnesotans get their drinking water from groundwater, and poorly built or ill-functioning septic systems can contaminate groundwater and other water resources. When constructed and maintained properly, septic systems are highly effective at treating sewage and keeping Minnesota's groundwater, lakes, and rivers safe and clean.

MINNESOTA POLLUTION CONTROL AGENCY

www.pca.state.mn.us

Cov txheej txheem lim kho dej 101

Qhov tseeb txog cov txheej txheem kev lim kho dej qias neeg saum npoo av

Cov txheej txheem kev lim kho dej qias neeg saum npoo av (SSTS), feem ntau hu ua cov txheej txheem kev lim kho dej, yog cov txheej txheem siv av lim kho dej qias neeg los ntawm cov tsev neeg thiab cov chaw lag luam uas tsis txuas nrog cov kav dej qias neeg hauv nroog. Cov txheej txheem no yuav lim kho thiab pov tseg tej dej khib nyiab tsim tawm ntawm lub chaw. Muaj kev siv ntau dua 500,000 cov txheej txheem lim kho dej qias neeg hauv xeev Minnesota, uas duav tag nrho 30% ntawm cov tsev neeg hauv lub xeev. Cov txheej txheem lim kho dej no kho khwv yees li 25% ntawm cov dej khib nyiab uas tau tsim nyob hauv lub xeev.

Cov dej khib nyiab muaj cov dej qias, uas suav nrog cov kab mob npev this lias, kab mob vais lav, kab mob paslaxij, cov as-ham, thiab qee yam tshuaj khes mis. Kev lim kho thiab pov tseg cov dej khib nyiab kom raug yog qhov tseem ceeb rau kev tiv thaiv pej xeem txoj kev noj qab haus huv thiab ib puag ncig. Ntau tshaj li ob feem peb ntawm cov pej xeem Minnesota tau txais lawv cov dej haus los ntawm cov dej hauv av, yog li cov txheej txheem lim kho dej uas tsim los tsis zoo lossis ua haujlwm tsis zoo tuaj yeem ua rau cov dej hauv av thiab lwm yam dej tsis huv tau. Thaum tsim thiab tswj cov txheej txheem lim kho dej kom zoo yuav muaj txiaj ntsig zoo hauv kev kho cov dej qias neeg no kom huv thiab pab ceev kom xeev Minnesota cov dej hauv av, pas dej, thiab cov dej ntws nyob nyab xeeb thiab huv si.