Watershed health

August 2021

Blue Earth River Watershed Stressor Identification Report

A study of local stressors limiting the biotic communities in the Blue Earth River Watershed.

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Key terms & abbreviations

AUID	Assessment Unit ID
BMP	best management practice
CADDIS	Causal Analysis/Diagnosis Decision Information System
CBI	coldwater biotic index
CL	confidence limits
cm	centimeter
DELT	Deformities, Eroded fins, Lesions, and Tumors
DO	dissolved oxygen
DNR	Minnesota Department of Natural Resources
EPA	U.S. Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, and Trichoptera
FIBI	Fish Index of Biological Integrity
FWMC	Flow-weighted mean concentration
GP	Glide/Pool
HUC	Hydrologic Unit Code
IBI	Index of Biotic Integrity
IWM	intensive watershed monitoring
MDA	Minnesota Department of Agriculture
MDH	Minnesota Department of Health
MIBI	Macroinvertebrate Index of Biological integrity
mg/L	milligrams per liter
MPCA	Minnesota Pollution Control Agency
MSHA	MPCA Stream Habitat Assessment
N	Nitrate
RR	Riffle Run
SID	Stressor Identification
SOE	Strength of Evidence
TIV	Tolerance Indicator Value
TMDL	total maximum daily load
TP	total phosphorus
TSS	total suspended solids
TSVS	Total Suspended Volatile Solids
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WPLMN	Watershed Pollutant Load Monitoring Network
WRAPS	Watershed Restoration and Protection Strategies
WWTP	wastewater treatment plant

Executive summary

Over the past few years, the Minnesota Pollution Control Agency (MPCA) has substantially increased the use of biological monitoring and assessment as a means to determine and report the condition of the state's rivers and streams. This basic approach is to examine fish and aquatic macroinvertebrate communities and related habitat conditions at multiple sites throughout a major watershed. From these data, an Index of Biological Integrity (IBI) score can be developed, which provides a measure of overall community health. If biological impairments are found, stressors to the aquatic community must be identified.

Stressor identification (SID) is a formal and rigorous process that identifies stressors causing biological impairment of aquatic ecosystems and provides a structure for organizing the scientific evidence supporting the conclusions (Cormier et al. 2000). In simpler terms, it is the process of identifying the major factors causing harm to aquatic life. SID is a key component of the major watershed restoration and protection projects being carried out under Minnesota's Clean Water Legacy Act.

This report summarizes SID work in the Blue Earth River Watershed, along with the monitoring efforts within the assessment period. In total there were 69 stream reaches monitored for biology, roughly half failed to meet support for fish. Only five reached passed for fish assemblage at the highest threshold of the general use standard. Macroinvertebrate communities scored better overall, compared to fish. Out of 66 assessed sites, 43 of these sites passed for macroinvertebrate assemblage.

After examining many candidate causes for the biological impairments, the following stressors were identified as probable causes of stress to aquatic life:

- Dissolved oxygen (DO)
- Eutrophication
- Nitrate
- Total suspended solids (TSS)
- Habitat
- Connectivity
- Altered hydrology

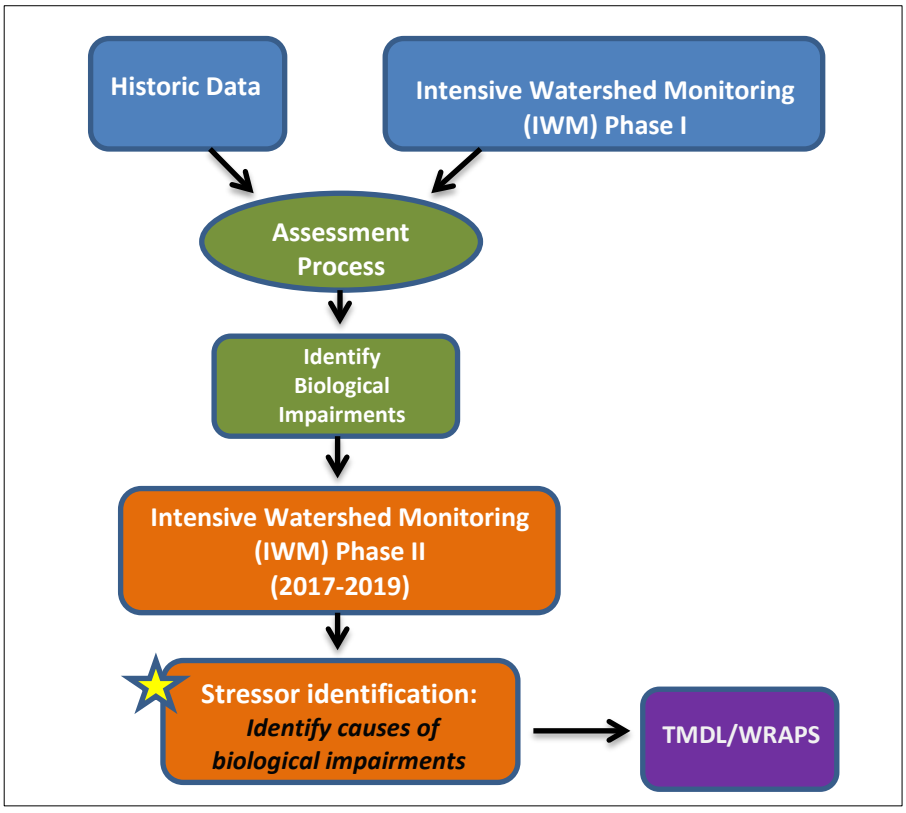
1. Introduction

1.1 Monitoring and assessment

Water quality and biological monitoring in the Blue Earth River Watershed have been ongoing. As part of the MPCA's Intensive Watershed Monitoring (IWM) approach, monitoring activities increased in rigor and intensity during the years of 2017-2019, and focused more on biological monitoring (fish and macroinvertebrates) as a means of assessing stream health. The data collected during this period, as well as historic data obtained prior to 2017, were used to identify stream reaches that were not supporting healthy fish and macroinvertebrate assemblages (Figure 1).

Once a biological impairment is discovered, the next step is to identify the source(s) of stress on the biological community. A SID analysis is a step-by-step approach for identifying probable causes of impairment in a particular system. Completion of the SID process does not result in a finished total maximum daily load (TMDL) study. The product of the SID process is the identification of the stressor(s) for which the TMDL may be developed. In other words, the SID process may help investigators nail down excess fine sediment as the cause of biological impairment, but a separate effort is then required to determine the TMDL and implementation goals needed to restore the impaired condition.

Figure 1. Process map of IWM, Assessment, SID and TMDL processes.

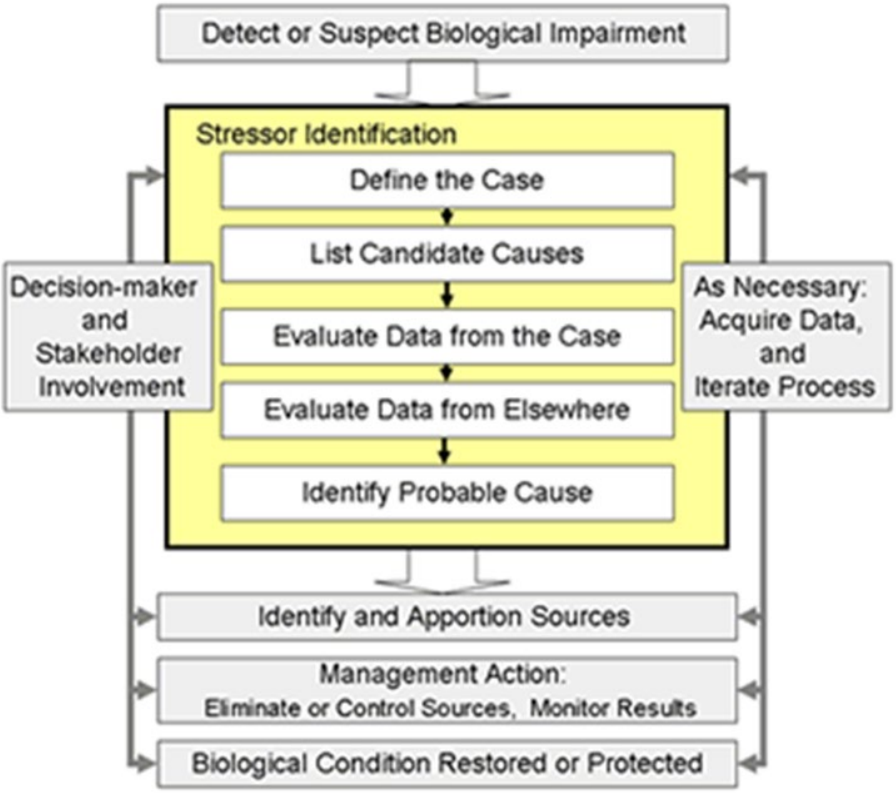


1.2 Stressor identification process

The MPCA follows the U.S. Environmental Protection Agency's (EPA's) process of identifying stressors that cause biological impairment, which has been used to develop the MPCA's guidance to SID (Cormier et al. 2000; MPCA 2008). The EPA has also developed an updated, interactive web-based tool, the Causal Analysis/Diagnosis Decision Information System (CADDIS; EPA 2010). This system provides an enormous amount of information designed to guide and assist investigators through the process of SID. Additional information on the SID process using CADDIS can be found here: http://www.epa.gov/caddis/

SID is a key component of the major watershed restoration and protection projects being carried out under Minnesota's Clean Water Legacy Act. SID draws upon a broad variety of disciplines and applications, such as aquatic ecology, geology, geomorphology, chemistry, land-use analysis, and toxicology. A conceptual model showing the steps in the SID process is shown in Figure 2. Through a review of available data, stressor scenarios are developed that aim to characterize the biological impairment, the cause, and the sources/pathways of the various stressors.

Figure 2. Conceptual model of SID process (Cormier et al. 2000).



Strength of evidence (SOE) analysis is used to evaluate the data for candidate causes of stress to biological communities. The relationship between stressor and biological response are evaluated by considering the degree to which the available evidence supports or weakens the case for a candidate cause. Typically, much of the information used in the SOE analysis is from the study watershed (i.e., data from the case). However, evidence from other case studies and the scientific literature is also used in the SID process (i.e., data from elsewhere).

The existence of multiple lines of evidence that support or weaken the case for a candidate cause generally increases confidence in the decision for a candidate cause. Additionally, confidence in the results depends on the quantity and quality of data available to the SID process. In some cases, additional data collection may be necessary to accurately identify the stressor(s) causing impairment. Additional detail on the various types of evidence and interpretation of findings can be found here: https://www.epa.gov/caddis-vol1/caddis-volume-1-stressor-identification-summary-tables-types-evidence.

1.3 Common stream stressors

The five major elements of a healthy stream system are stream connections, hydrology, stream channel assessment, water chemistry and stream biology. If one or more of the components are unbalanced, the stream ecosystem may fail to function properly and is listed as an impaired water body. Table 1 lists the common stream stressors to biology relative to each of the major stream health categories.

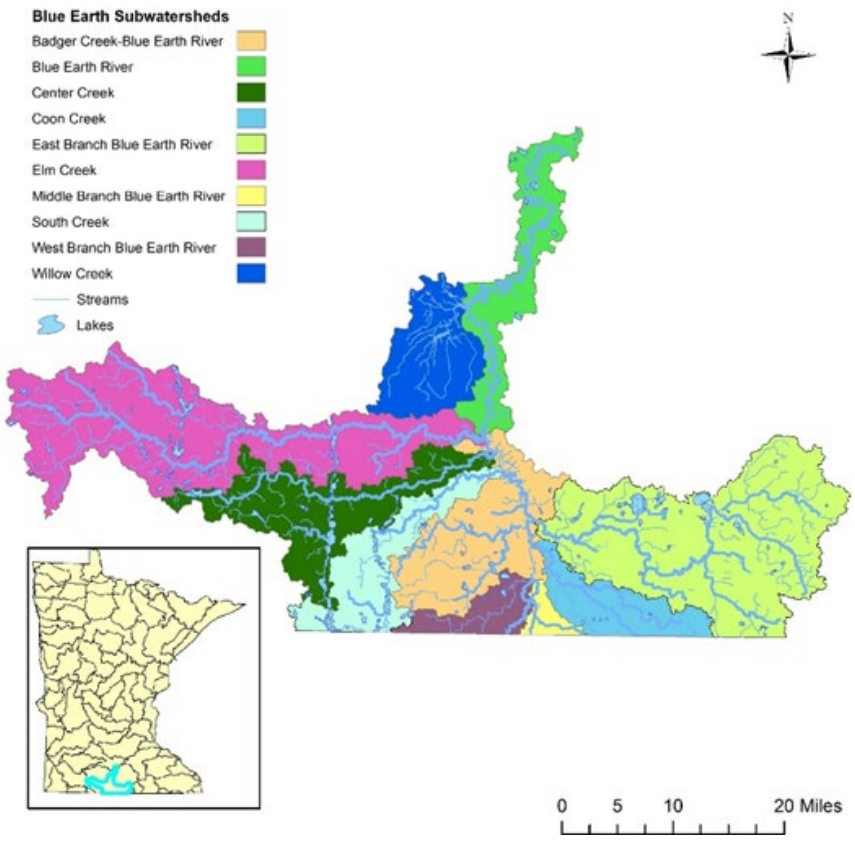
Table 1. Common streams stressors to biology (i.e., fish and macroinvertebrates).

Stream health	Stressor(s)	Link to biology
Stream connections	**Loss of connectivity** • Dams and culverts • Lack of wooded riparian cover • Lack of naturally connected habitats/ causing fragmented habitats	Fish and macroinvertebrates cannot freely move throughout system or complete their lifecycle. Loss of refuge areas (lakes and wetlands) during times of lost stream connectivity damage fish communities.
Hydrology	**Altered hydrology** **Loss of habitat due to channelization** **elevated levels of TSS** • Channelization • Peak discharge (flashy) • Transport of chemicals	Unstable flow regime within the stream can cause a lack of habitat, unstable stream banks, filling of pools and riffle habitat, and affect the fate and transport of chemicals. Stream temperatures also become elevated due to lack of shade from compromised riparian.
Stream channel assessment	**Loss of habitat due to stream modifications** Loss of dimension/pattern/profile • Bank erosion from instability • Loss of riffles due to accumulation of fine sediment • Increased turbidity and or TSS	Habitat is degraded due to excess sediment moving through system. There is a loss of clean rock substrate from embeddedness of fine material and a loss of intolerant species. Habitat diversity becomes less abundant.
Water chemistry	**Low dissolved oxygen concentrations** **elevated levels of nutrients** • Increased nutrients from human influence • Widely variable DO levels during the daily cycle • Increased algal and or periphyton growth in stream • Increased nonpoint pollution from urban and agricultural practices • Increased point source pollution from urban treatment facilities	There is a loss of intolerant species and a loss of diversity of species, which tends to favor species that can breathe air or survive under low DO conditions. Biology tends to be dominated by a few tolerant species.
Stream biology	Fish and macroinvertebrate communities are affected by all of the above listed stressors	If one or more of the above stressors are affecting the fish and macroinvertebrate community, the IBI scores will not meet expectations and the stream will be listed as impaired.

1.4 Report format

This stressor identification report format will first summarize candidate causes of stress to the biological communities at the 8 -digit HUC scale. The analysis of sample sites will be looked at and discussed at the 10 -digit HUC scale, shown in Figure 3.

Figure 3. Map showing management units (HUC 10 Subwatersheds) in the Blue Earth River Watershed.

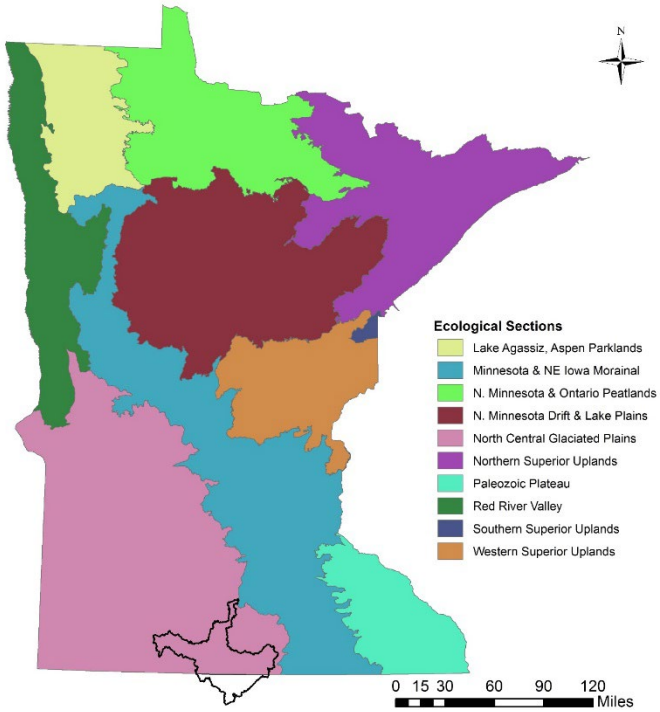


2. Overview of the Blue Earth River Watershed

2.1 Background

The Blue Earth River Subwatershed (07020009 HUC 10) is in the south-central portion of Minnesota and boarders Iowa. The 1,500 square miles of watershed primarily falls into Martin, Faribault, and Blue Earth Counties. The Blue Earth Watershed primarily falls within the North Central Glaciated Plains, a sub section of the Prairie Parkland Province.

Figure 4. Map of ecological zones within the Blue Earth River Watershed.



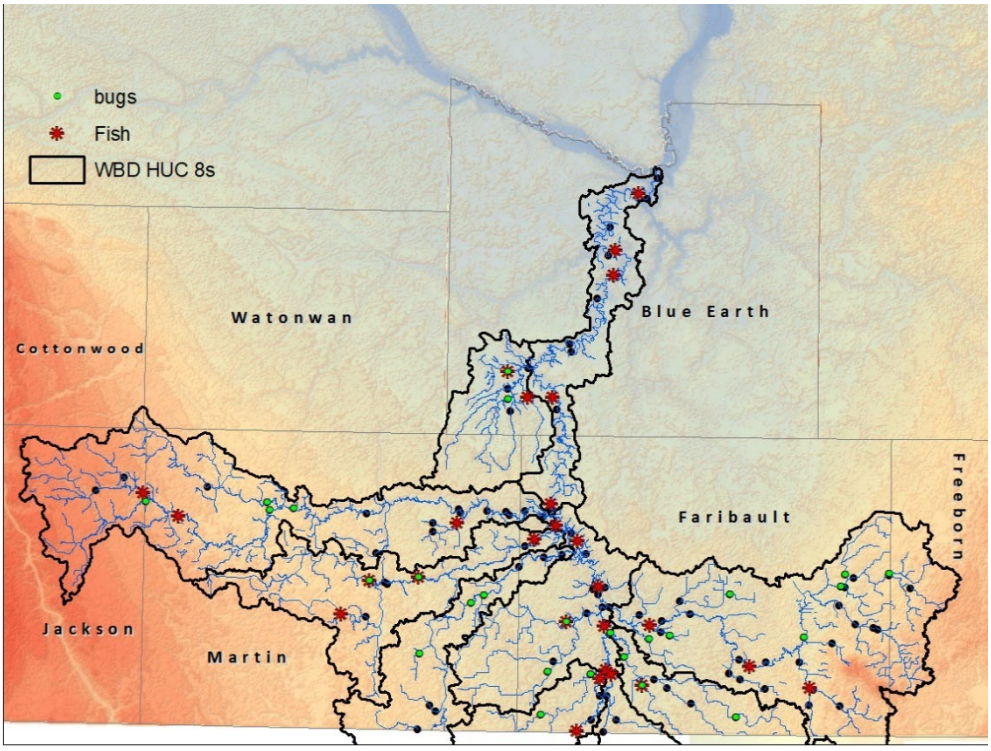
Historically the majority of the landscape was converted from prairie to agricultural fields. These changes to the land resulted in loss of water retention area (wetlands) and modifications to the stream systems within the watershed. Historical and current land use will be discussed in further detail in Section 3.1.7 Altered hydrology portion of this report.

2.2 Summary of biological impairments

The approach used to identify biological impairments includes assessment of fish and aquatic macroinvertebrates communities and related habitat conditions at sites throughout a watershed. The resulting information is used to develop an IBI. The IBI scores can then be compared to range of thresholds.

The fish and macroinvertebrates within each Assessment Unit Identification (AUID)/WID were compared to a regionally developed threshold and confidence interval and utilized a weight of evidence approach. The water quality standards call for the maintenance of a healthy community of aquatic life. IBI scores provide a measurement tool to assess the health of the aquatic communities. IBI scores higher than the impairment threshold indicate that the stream reach supports aquatic life. Conversely, scores below the impairment threshold indicate that the stream reach does not support aquatic life. Confidence limits around the impairment threshold help to ascertain where additional information may be considered to help inform the impairment decision. When IBI scores fall within the confidence interval, interpretation and assessment of the waterbody condition involves consideration of potential stressors, and draws upon additional information regarding water chemistry, physical habitat, and land use, etc. Figure 5 below highlights assessment sites with impairments.

Figure 5. Map of monitoring stations in the Blue Earth River Watershed.



In the Blue Earth River Watershed, 44 are currently impaired for a lack of biological assemblage and addressed within this report (Table 2).

Table 2. Biological impairments by AUID and stations.

AUID	**Blue Earth Watershed** Stream Name (Grouped by HUC10)	Biological Stations	Impairment
	East Branch		
623	Judicial Ditch 14	17MN368	M-IBI
622	Thisius Brach	17MN365	F-IBI and M-IBI
556	Foster Creek	92MN076	M-IBI
652	Blue Earth River, East Branch	17MN301	M-IBI
654	Brush Creel	01MN022, 17MN374	F-IBI
553	Blue Earth River, East Branch	15EM120, 17MN362, 17MN359, 17MN314	F-IBI
603	County Ditch 25	17MN360	F-IBI and M-IBI
669	County Ditch 8	17MN354	M-IBI
628	County Ditch 26	17MN357	M-IBI
	Coon Creek		
665	Judicial Ditch 13	10EM156	M-IBI
612	County Ditch 31	17MN353	F-IBI and M-IBI
648	Coon Creek	92MN074, 17MN313	F-IBI and M-IBI
	Middle Branch		
646	Blue Earth River, Middle Branch	17MN310	F-IBI
	West Branch		
611	Judicial Ditch 7	17MN344, 17MN372	F-IBI and M-IBI
643	Blue Earth River, West Branch	17MN312	F-IBI
644	Blue Earth River, West Branch	10EM028	F-IBI
	Badger Creek		
658	Judicial Ditch 14 (Badger Creek)	17MN345	M-IBI
642	Little Badger Creek	17MN347	F-IBI and M-IBI
504	Blue Earth River	00MN001	F-IBI
518	Blue Earth River	10EM163, 92MN088	F-IBI
565	Blue Earth River	17MN349	F-IBI
508	Blue Earth River	17MN316	F-IBI
516	Blue Earth River	17MN348	F-IBI
514	Blue Earth River	17MN308	F-IBI
	South Creek		
660	Judicial Ditch 38	17MN334	F-IBI
610	Judicial Ditch 98	17MN332	M-IBI
639	South Creek	17MN338, 15EM040	M-IBI
	Center Creek		
636	Dutch Creek	17MN328	F-IBI
633	Lily Creek	17MN329, 92MN083,	F-IBI, M-IBI
503	Center Creek	92MN084, 17MN304	F-IBI, M-IBI
	Elm Creek		
631	Elm Creek	17MN320	F-IBI
561	Elm Creek, South Fork	17MN323	F-IBI, M-IBI
522	Elm Creek	17MN325 17MN306	F-IBI, M-IBI
521	Cedar Run Creek	17MN301	F-IBI
502	Elm Creek	03MN063, 17MN327, 17MN172	M-IBI
627	Judicial Ditch 38	17MN336	F-IBI
	Willow Creek		
620	County Ditch 89	17MN343	F-IBI
566	Unnamed Creek	17MN341	M-IBI
625	Unnamed Creek	17MN339	F-IBI, M-IBI
577	Willow Creek	17MN309	F-IBI
	Blue Earth		
515	Blue Earth River	00MN003, 00MN004	F-IBI
507	Blue Earth River	10EM051, 00MN005	F-IBI
509	Blue Earth River	17MN315	F-IBI
501	Blue Earth River	17MN317	F-IBI

3. Possible stressors to biological communities

A candidate cause is defined as a "hypothesized cause of an environmental impairment that is sufficiently credible to be analyzed" (USEPA, 2012). Identification of a set of candidate causes is an important early step in the SID process and provides the framework for gathering key data for causal analysis. A more detailed description of possible candidate causes or stressors specific to Minnesota is provided in the document Stressors to Biological Communities in Minnesota's Rivers and Streams (MPCA, 2017). This information provides an overview of the pathway and effects of each candidate stressor considered in the biological stressor identification process with relevant data and water quality standards specific to Minnesota. The U.S. Environmental Protection Agency (EPA) has additional information, conceptual diagrams of sources and causal pathways, and publication references for numerous stressors on its CADDIS website. A list community metrics used throughout this report can be referenced in Appendix A1.

3.1 Summary of candidate causes in the Blue Earth River Watershed

Candidate causes were selected as possible drivers of biological impairments in the Blue Earth River Watershed:

- Dissolved oxygen (DO)
- Eutrophication
- Nitrate
- Total suspended solids (TSS)
- Habitat
- Connectivity
- Altered hydrology

3.1.1 Candidate cause: Low dissolved oxygen

Overview of dissolved oxygen in the Blue Earth River Watershed

In the Blue Earth River Watershed, WIDs with low dissolved oxygen often correlated with eutrophic conditions within the headwater regions of the watershed. Dissolved oxygen (DO) is critical for aquatic life. Signs of low dissolved oxygen stress within a biological community often is seen in loss of diversity, as well as interruption of species life cycle. When evaluating low dissolved oxygen as a biological stressor, streams that fall below 5 mg/L for DO are found to limit aquatic life.

To evaluate for dissolved oxygen, several different collection methods were conducted for analysis, those included:

Point measurements

Instantaneous DO data is available throughout the watershed and can be used as an initial screening for low DO. These measurements represent discrete point samples, usually conducted in conjunction with surface water sample collection utilizing a sonde.

Diurnal (Continuous)

Where warranted, Yellow Springs Instruments (YSI) sondes were deployed for numerous days throughout the watershed in late summer to capture diurnal fluctuations over the course of a number of diurnal patterns and measure the amount of 24 hour dissolved oxygen fluctuation (diurnal flux).

For additional information on low DO in stream systems, as well as the drivers refer to EPA's CADDIS Dissolved Oxygen webpage.

3.1.2 Candidate cause: Eutrophication

Overview of eutrophication in the Blue Earth River Watershed

Eutrophic conditions were identified in the headwater areas of stream systems. Here, phosphorus loading is high due to agricultural contributions, paired with the stream modifications that led to losing natural riparian shading, as well as more water surface area within the stream. These upland portions of the watershed are also low gradient, which provides for increased residence time for pollutant loading and growing time for both sestonic and benthos algal growth.

River eutrophication is harmful to aquatic life in a number of ways, with the primary impacts in this watershed being noted as loss of dissolved oxygen, as well as reduced transparency. In some cases, eutrophication streams will lead to habitat impairments as organic matter begins to settle and smother the streambed. For additional information on eutrophic streams and biologic impacts, refer to the EPA's CADDIS Nutrients webpage.

There are several standards that are evaluated when determining eutrophic conditions. The newly adopted river eutrophication standard for the South River Nutrient Region is a maximum total phosphorus (TP) concentration of 150 µg/L (Or .15 mg/L), for the Central River Nutrient Region the maximum total TP concentration is 100 µg/L (Or .1 mg/L). Total phosphorus is the causative variable involved with this standard. Also at least one response-variable must be above a threshold value, or out of a desired range. The appropriate response variables for the South and River Nutrient Region are listed below:

Table 3. River eutrophication standards used within the Blue Earth River Watershed.

Parameter	Southern Nutrient Region	
Chlorophyll a	35 µg/L	
Dissolved oxygen flux	≤4.5 mg/L	
Biochemical oxygen demand	≤3.0 mg/L	
Periphyton density	150 mg chlorophyll a / sq. meter	

Ecoregion data are available to show if specific data from the Blue Earth River Watershed are within the expected norms (http://www.pca.state.mn.us/index.php/view-document.html?gid=14947).

3.1.3 Candidate cause: Nitrate

Overview of nitrate in the Blue Earth River Watershed

Nitrate was one of the more common stressors within the Blue Earth River Watershed, in regards to macroinvertebrate stressors. In addition of measuring for a biological community response related to nitrate, chemistry concentrations are also evaluated to determine this parameter as a stressor. Currently there is not a final nitrate limit in regards to aquatic life that is officially adopted. However, there is a strong correlation seen in drop in nitrate sensitive macroinvertebrate populations as nitrate concentrations increase, particularly after 4.9 mg/L. In 2013, the MPCA proposed a 4.9 mg/L nitrate standard for aquatic life, found in the Aquatic Life Water Quality Standards Technical Support Document for Nitrate. Included within this support document is a list of specific macroinvertebrate species and their respected thresholds for nitrate. For the purposes of this stressor identification report, the established drinking water standard of 10 mg/L is also used in addition to the proposed 4.9 mg/L as the impairment concentration threshold.

For additional information on nitrate related to biology, reference the EPA's CADDIS nutrient website.

Nitrogen is commonly applied as a crop fertilizer. Eighty-five percent of the Blue Earth River Watershed consists of cultivated cropland, and is likely that various forms of nitrogen including nitrate and anhydrous ammonia are being applied throughout the watershed. The specific timing and rate of nitrogen fertilizer application is unknown, but nitrogen isotopes could assist in the source identification of excess nitrate in future monitoring. When water moves quickly through the soil profile (as in the case of heavily tiled watersheds) nitrate transport can become large.

Figure 6. Statewide nitrogen pathways to surface waters pie chart, taken from statewide nitrogen study (MPC 2013).

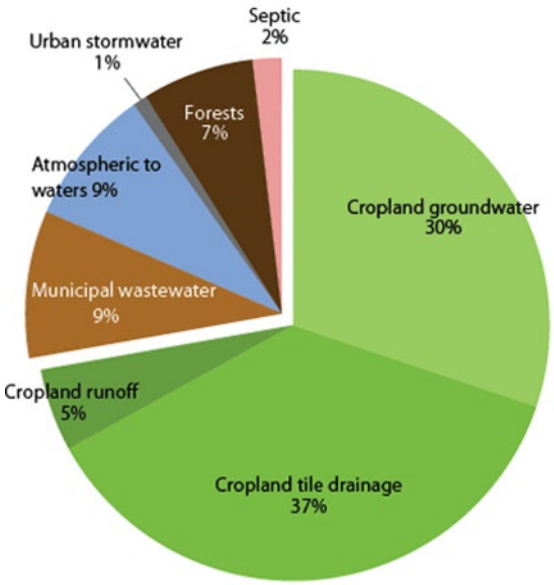
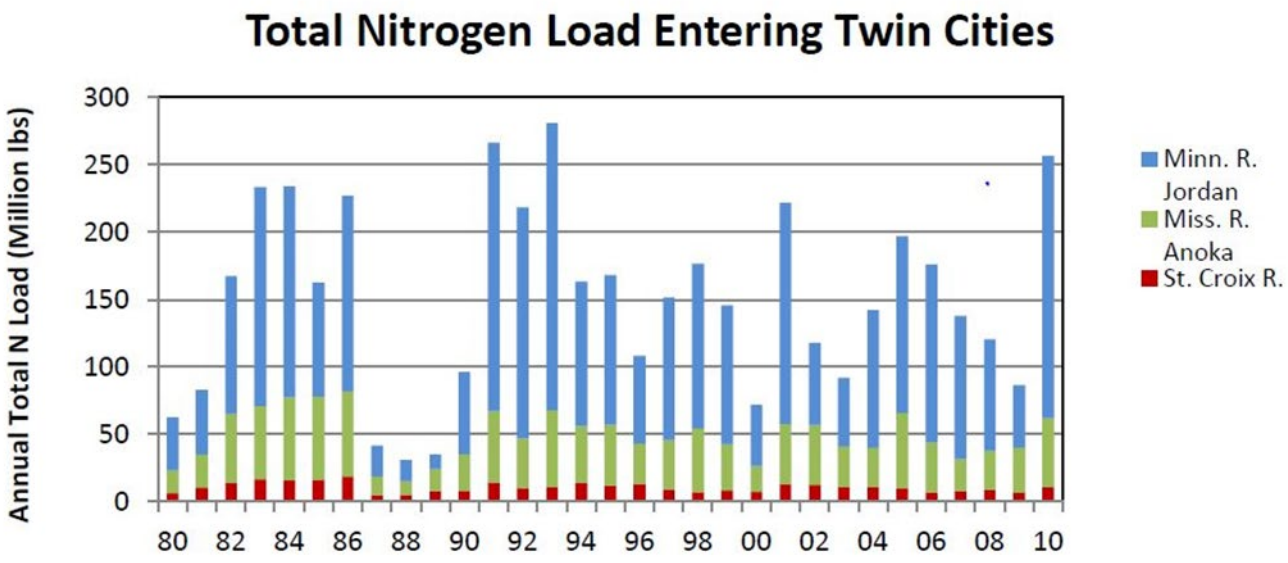


Figure 6 is reference to a statewide nitrogen study that found cropland commercial fertilizers make up 47% of nitrogen added to the landscape, 21% occurs through cropland legume fixation, 16% from manure application, and 15% from atmospheric deposition (MPCA, 2013). Nitrogen can reach waterways through surface runoff, tile drainage, and leaching to groundwater, with tile drainage being the largest pathway (MPCA, 2013).

Figure 7. Annual combined total N loads from the three-mainstem rivers entering the Twin Cities Area: the Mississippi River in Anoka, the St. Croix River in Stillwater, and the Minnesota River in Jordan. Time period 1980 to 2010.



The greater Blue Earth Watershed and the Minnesota River Basin has some of the highest stream nitrogen loading in the state. Out of all the major watershed basins, the Minnesota River contributes 69% of the nitrate load that enters into the Twin Cities monitoring station, before converging with the Mississippi River, shown in Figure 7 (MPCA, 2013).

3.1.4 Candidate cause: Total suspended solids

Overview of TSS in the Blue Earth River Watershed

Total suspended solids (TSS) within this subwatershed is seen primarily in the form of sediment as well as total suspended volatile solids (TSVS), often as suspended algae. Streams impaired by TSS will often have direct impacts on the streams biology both directly (such as damaging fish gills, or smothering eggs) as well as indirectly (as seen in loss of habitat features as well as changes to the natural dissolved oxygen regime). The TSS criteria are stratified by geographic region and stream class due to differences in natural background conditions resulting from the varied geology of the state and biological sensitivity. The TSS standard for the southern region of the state has been set at 65 mg/L.

In stable streams, sediment loads created by erosion from a meandering stream channel will be balanced out by deposition. However, anthropogenic changes to the landscape and direct channel modifications are thought to have thrown off the balance between erosion and deposition abilities (Leopold et al 1964).

Table 4. Blue Earth River Watershed WIDs impaired for turbidity.

WID	Stream Name
07020009-501	Blue Earth River
07020009-502	Elm Creek
07020009-503	Center Creek
07020009-507	Blue Earth River
07020009-509	Blue Earth River
07020009-514	Blue Earth River
07020009-518	Blue Earth River
07020009-521	Cedar Creek (Cedar Run Creek)
07020009-522	Elm Creek
07020009-565	Blue Earth River
07020009-631	Elm Creek
07020009-633	Lily Creek
07020009-636	Dutch Creek
07020009-652	Blue Earth River

Another source of TSS data that was included for evaluation during this study was collected by the MPCA's Watershed Pollutant Load Monitoring Network, which calculates flow-weighted mean concentration (FWMC) and pollutant loads at specific river monitoring sites.

Table 5. MPCA's Watershed Pollutant and Load Monitoring network data, displaying location of sampling and catchment size.

Average values for all measured parameters							
Station name	Station number	Parameter	Average range	AvgFWMC (mg/L)	AvgMass (kg)	AvgVol (acre-ft)	AvgYield (lbs/acre)
Blue Earth River at Blue Earth, CR6	H30021003	Total suspended solids	2013 - 2018	53.5	12,174,794	209,566	96.20
Blue Earth River nr Rapidan, MN	E30092001	Total suspended solids	2007 - 2018	161	245,822,480	1,232,329	352.00
Blue Earth River nr Winnebago, CSAH12	H30025001	Total suspended solids	2013 - 2019	82	72,460,605	755,268	180.00
East Branch Blue Earth River at Blue Eart..	H30046002	Total suspended solids	2013 - 2019	53.4	11,100,100	181,392	131.00

3.1.5 Candidate cause: Habitat

Overview of Habitat in the Blue Earth Watershed

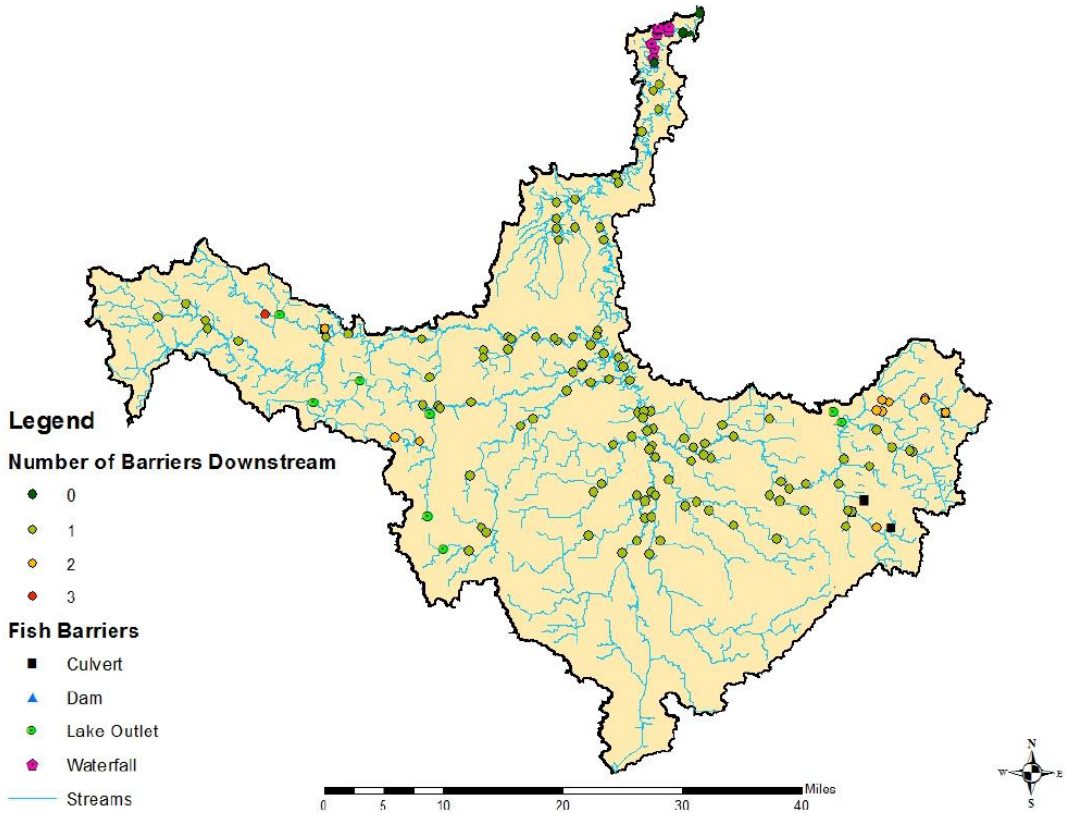
Loss of habitat was a common identified stressor throughout the Blue Earth River Watershed. Habitat is often degraded in modified streams where ditching and channelization is evident as habitat diversity is eliminated and the natural stability of the stream becomes compromised; erosive banks, poor substrate, and lack of vegetative cover are often found at and downstream of these modified waterways. Areas with acceptable habitat conditions were often located downstream of headwater locations. This is contributed to the land use on these steep gradients being highly vegetative, providing both stream stability (mitigating erosion) as well as shade and refuge. These steep gradients also allowed the fine sediments to wash through, allowing for diverse and clean riverbed substrate. For additional narrative and the habitat conceptual model, reference the EPA's CADDIS habitat webpage.

Lack of habitat is strongly connected to stream modifications (such as ditching) that eliminate physical habitat diversity; replaced by homogenous features throughout the stream. Additional to physical modification, excess fine sediment deposition on benthic habitat has been proven to adversely impact fish and macroinvertebrate species that depend on clean, coarse stream substrates for feeding, refugia, and/or reproduction (Newcombe et al., 1991). Aquatic macroinvertebrates are generally affected in several ways: (1) loss of certain taxa due to changes in substrate composition (Erman and Ligon, 1988); (2) increase in drift (avoidance by movement with current) due to sediment deposition or substrate instability (Rosenberg and Wiens 1978); and (3) changes in the quality and abundance of food sources such as periphyton and other prey items (Pekarsky 1984). Fish communities are typically influenced through: (1) a reduction in spawning habitat or egg survival (Chapman, 1988) and (2) a reduction in prey items as a result of decreases in primary production and benthic productivity (Bruton, 1985; Gray and Ward, 1982). Fish species that are simple lithophilic spawners require clean, coarse substrate for reproduction. These fish do not construct nests for depositing eggs, but rather broadcast them over the substrate. Eggs often find their way into interstitial spaces among gravel and other coarse particles in the streambed. Increased sedimentation can reduce reproductive success for simple lithophilic spawning fish, as eggs become smothered by sediment and become oxygen deprived. The sediments primarily responsible for causing an embedded condition in southern Minnesota streams are sand and silt particles, which can be transported in the water column under higher flows, or as a bedload component. When stream velocities and gradient decrease, these sediments can "settle out" into a coarser bottom substrate area, thus causing an embedded condition.

3.1.6 Candidate cause: Connectivity

Overview of connectivity in the Blue Earth River Watershed

Figure 8. Blue Earth River Watershed with identified barriers.



Throughout the Blue Earth River Watershed, connectivity is identified as a barrier and stressor in all but two WIDs (The furthest downstream on the outlet of the Blue Earth Watershed). The DNR conducted a comprehensive geomorphology study of this watershed, where further information can be found that covers both longitudinal and lateral morphology of many of the subwatershed systems found in the Blue Earth River Watershed.

Connectivity in river ecosystems refers to how waterbodies and waterways are linked to each other on the landscape and how matter, energy, and organisms move throughout the system (Pringle, 2003). While the tendency is to consider this generally in a longitudinal manner (up-stream to downstream), there are also vertical, horizontal and subsurface connections that are important to the overall ecology of the system.

Impoundment structures (dams) on river systems alter streamflow, water temperature regime, and sediment transport processes-each of which can cause changes in fish and macroinvertebrate assemblages (Cummins, 1979; Waters, 1995). Dams also have a history of blocking fish migrations and can greatly reduce or even extirpate local populations (Brooker, 1981; Tiemann et al., 2004). In Minnesota, there are more than 800 dams on streams and rivers for a variety of purposes, including flood control, wildlife habitat, and hydroelectric power generation. Beavers build dams to create impoundments with adequate water depth for a winter food cache. Beaver dams, even though natural, can also be barriers to fish migration.

Dams, both human-made and natural, can cause changes in flow, sediment, habitat and chemical characteristics of a waterbody. They can alter the hydrologic connectivity, which may obstruct the movement of migratory fish causing a change in the population and community structure. The stream environment is also altered upstream of a dam to a predominately lentic (lake or “still water”) condition (Mitchell and Cunjak, 2007).

3.1.7 Candidate cause: Altered hydrology

Altered hydrology is the change of the stream flow regime caused by human sources. These sources can include channel alteration, water withdrawals, land cover alteration, agricultural tile drainage, and impoundments or dams, to name a few. Hydrology within the Blue Earth River Watershed is complex and there are a number of factors that drive dramatic changes in stream hydrology and morphology. Due to the dominant land use of agriculture, most of the water storage as well as waterways in this watershed have been significantly altered to eliminate water off the landscape. One of the most dramatic impacts of this is stream flow and water volume, which in turn will lead to negative direct and indirect effects on multiple biological stressors. As such, the hydrology is increasingly viewed as the key driver of the ecology. The alteration of flow regimes affects ecosystem structure and function, which may shift the dominance in native community assemblages and facilitate the invasion and success of exotic and introduced species (Bunn, 2002). Altered hydrology influences several stressors and is the primary driving force to the impaired biological communities in the Blue Earth River Watershed.

Channelization/ditching

Ditching is defined as the digging of a trench to divert water where no channel previously existed. Channelization is the process of straightening a preexisting natural channel. Drainage ditches and channelized streams are a common features in Minnesota Mankato Watershed as altered streams. Channelization and or ditching changes the physical structure of a stream, but will also change the flow regime for a waterway. The result is often increased peak discharges and reduced baseflow (blann et al,

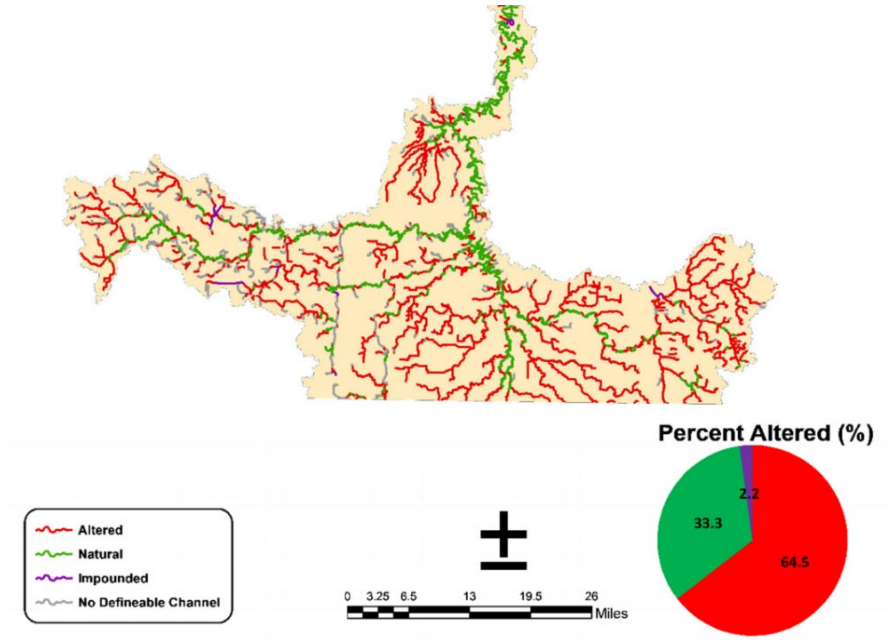
2009). As water is diverted from the landscape and routed through manmade or altered channels, there is a loss of habitat features. The habitat features that are commonly affected include loss of pool depth, increased embeddedness of gravel and cobble in riffles, loss of floodplain connectivity, and loss of woody material in the channel. Additionally, high flows can scour organisms and substrate from streambeds, while low flows can reduce habitat area and volume.

Figure 9. Example of a channelized stream on the Middle Branch, (17MN311) in the Blue Earth River Watershed

Overview of altered hydrology in the Blue Earth River Watershed

Currently 65% of the Blue Earth River Watershed's tributaries are altered as a result of ditching for agricultural practices. A majority of the alterations are in the headwater portion of streams (as seen in Figure 10), where both direct and indirect impacts to the stream occur at the altered location as well as downstream.

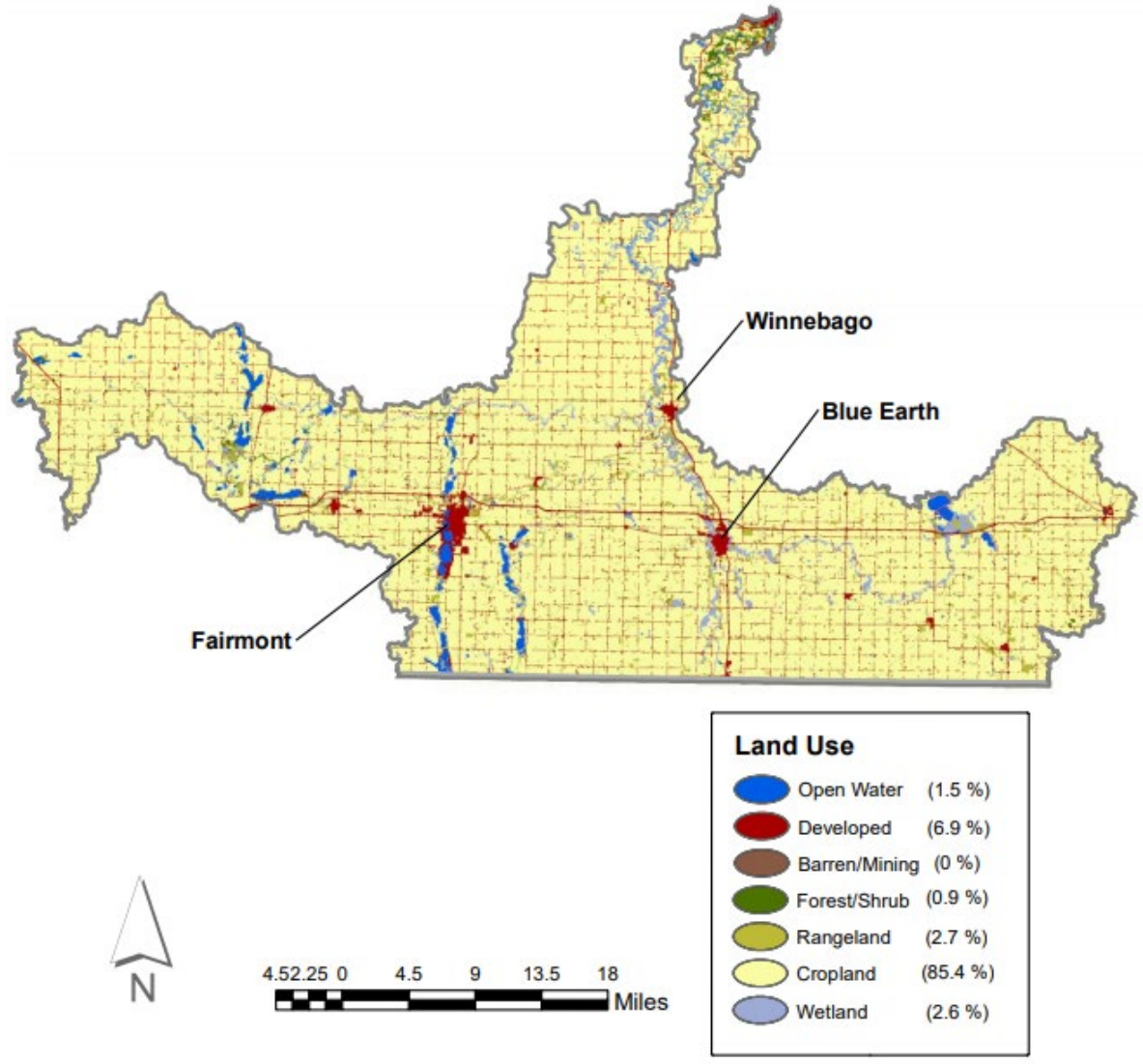
Figure 10. All streams within the Blue Earth River Watershed with alterations.



Land use and drainage

The peak flows in this watershed are a response of overland flow and shallow subsurface pathways. In urban or developed areas (which makes up about 7% of the land) runoff can occur rapidly due to impervious surfaces, and peak flows can occur quickly. Cropland and the associated practice of subsurface drainage (tile drainage) is the dominating hydrologic influence on this stream system, as it applies to 86% of the watershed.

Figure 11: Land use within the Blue Earth River Watershed.



Agricultural tile drainage systems are used to intentionally reduce soil moisture by moving precipitation or irrigation waters from subsurface soils, through pipe, and eventually into ditches or streams and thereby altering timing and magnitude of flows. As shown in Figure 12, historical wetlands that have now been eliminated through drainage is significant. Although tile drainage can increase agricultural productivity, it has negative impacts on hydrology (e.g. increasing peak flows and reducing base flows) and water quality (e.g. increasing nitrogen loading and sediment transport). A recent study comparing changes in hydrology for 21 Minnesota watersheds, which included the Blue Earth, found that "artificial drainage is a major driver of increased river flow, exceeding the effects of precipitation and crop conversion" (Schottler et al. 2013). It also noted that "twentieth century crop conversions and the attendant decreases in ET from depressional areas due to artificial drainage have combined to significantly alter watershed hydrology on a very large scale, resulting in more erosive rivers. (MPCA 2015).

Figure 12. DNR Restorable wetland map from DNR Blue Earth River characterization report; Lore 2021.

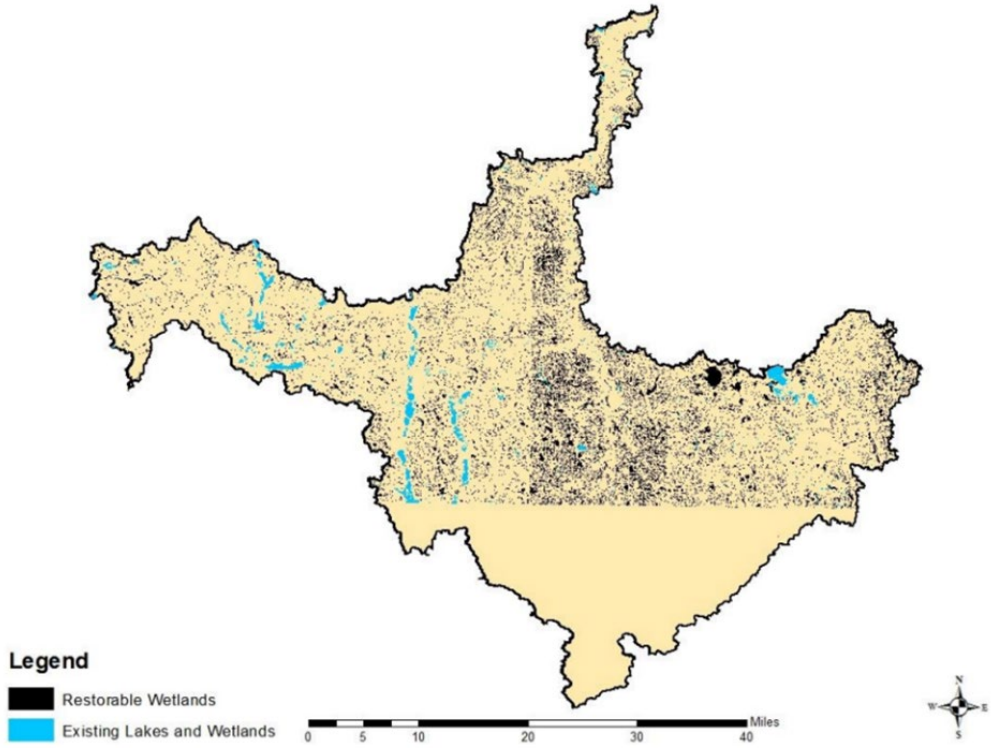


Figure 13. Diagram illustrating subsurface water transport via tile lines to surface water (Typically a ditch/channelized stream).

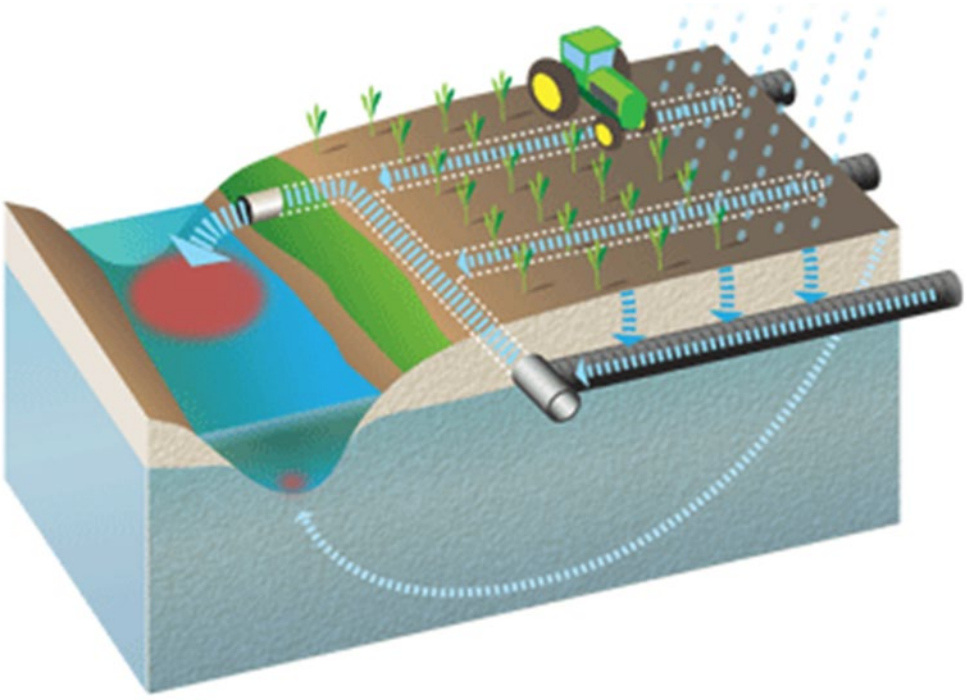


Figure 14. Example of a drain tile outlet to Little Badger Creek (17MN345) flowing into a ditched system within the Blue Earth River Watershed.

The inverse effect to an increase of stream flow with artificial subsurface drainage is seen in the reduction of base flow conditions. Within this watershed, there are times where base flow within these tributaries drastically drop, or will dry up later in the year. This is largely due to the fact that drainage within the Minnesota River Valley, can potentially lower groundwater tables and therefore reduce the near channel storage that otherwise sustains lateral drainage during dry periods (Blann; et al 2009). In spring to mid-summer, the river system within this watershed is seen to be flashier, as water is quickly transported from land to streams via subsurface tile lines before crops are established. In mid-summer to fall months the river system in significantly less flashy and is even noted have some of the tributary streams completely dry out, as the lateral water cycle cannot sustain base flow conditions.

Geomorphology and soils

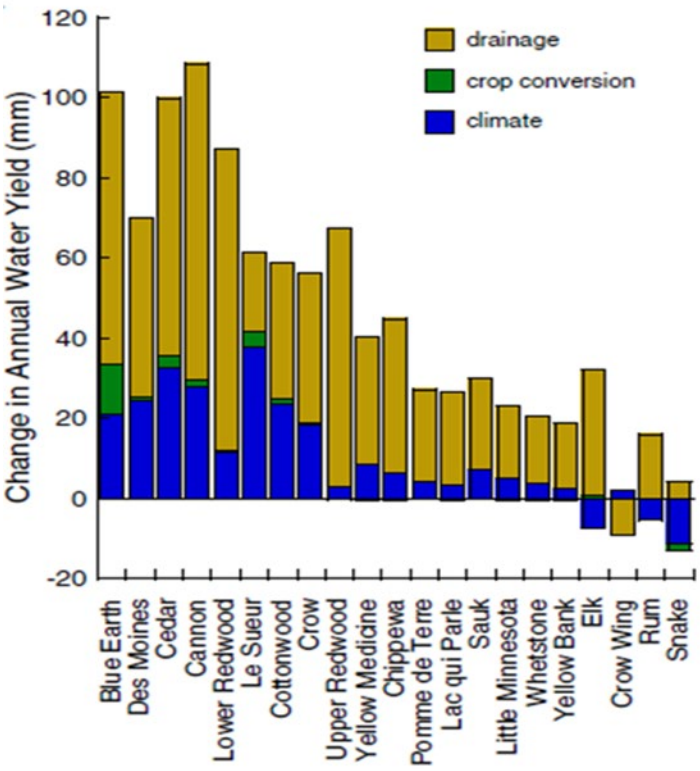
Soil types are an influencing factor when interpreting stream morphology and hydrology. Sediments delivered to the Minnesota River from upland areas such as the Blue Earth Watershed are generally fine-grained and derived from lacustrine or glacial till sources (Lore 2016). Soils that now reside in the flat upland portions of the Blue Earth Watershed are typically high in organic matter and naturally are poorly drained, as many of the soils found today are remains of wetlands from pre European settlement and prior to tile drainage. These wetland soil types allowed for land and stream equilibrium. One of the ways in achieving this was the ability of the wetland to exhibit long retention times during high flow periods. This would be particularly true in wetland class types with bi-directional and isolated hydrology. In general, these wetland types would be expected to have high pollutant assimilative and flood storage capacities, which benefit downstream waters and land. It is estimated that approximately 97,941 acres of wetlands have been lost since European settlement. It is estimated that only 2.2% of the pre-existing water storage remains today. Wetlands that remain are likely to be degraded due to invasive species, altered hydrology, as well as nutrient enrichment. For additional information on wetland functional classes and history, refer to the 2021 Blue Earth River Monitoring and Assessment report.

Climate and precipitation

Climate and precipitation change is another possible contributor to altered hydrology in the watershed. In a 2013 study, done by Shawn Schottler et al, the relationship of river morphology and change in precipitation and land use was examined. It was found that while the Minnesota statewide spatial average of precipitation has significantly increased, in South Central Minnesota there has not been a statistically significant rise in yearly total rainfall over the last 20 years. One regional study focused on the precipitation trends in this watershed as well as surrounding watersheds and found a shift in precipitation over two 35-year periods. These findings concluded that increased precipitation is occurring at greater amounts during the September through October months, whereas precipitation trends are staying the same or decreasing during May and June months (Schottler 2013).

While precipitation plays an important role in hydrology, the driving force on how the Blue Earth River Watershed is responding and changing is due to land use, primarily intense row crops and associated tile drainage, and ditching for expedited water transport off the land. In the vast majority of watersheds studied, drainage made up the biggest portion of change in annual water yield. In this same study, stream flashiness (a rapid increase in stream water volume) was found to be occurring more rapidly and at greater intensities during the months where little to no change in precipitation had been found. It is also important to note this is occurring well after thaw-out and snowmelt occurs, thus concluding that the seasonal hydrological changes observed are not the result of precipitation alone (Schottler 2013).

Figure 15. Apportionment of changes in mean annual water yield for each watershed. In rivers with significant changes in flow, climate and crop conversions account for less than half of the total change in water yield. Excess water yield is the portion that cannot be attributed to changes in crop ET and climate and is hypothesized to result from artificial drainage. The above figure was taken from the journal article titled "Twentieth century agricultural drainage creates more erosive rivers" (Schottler et al. 2013).



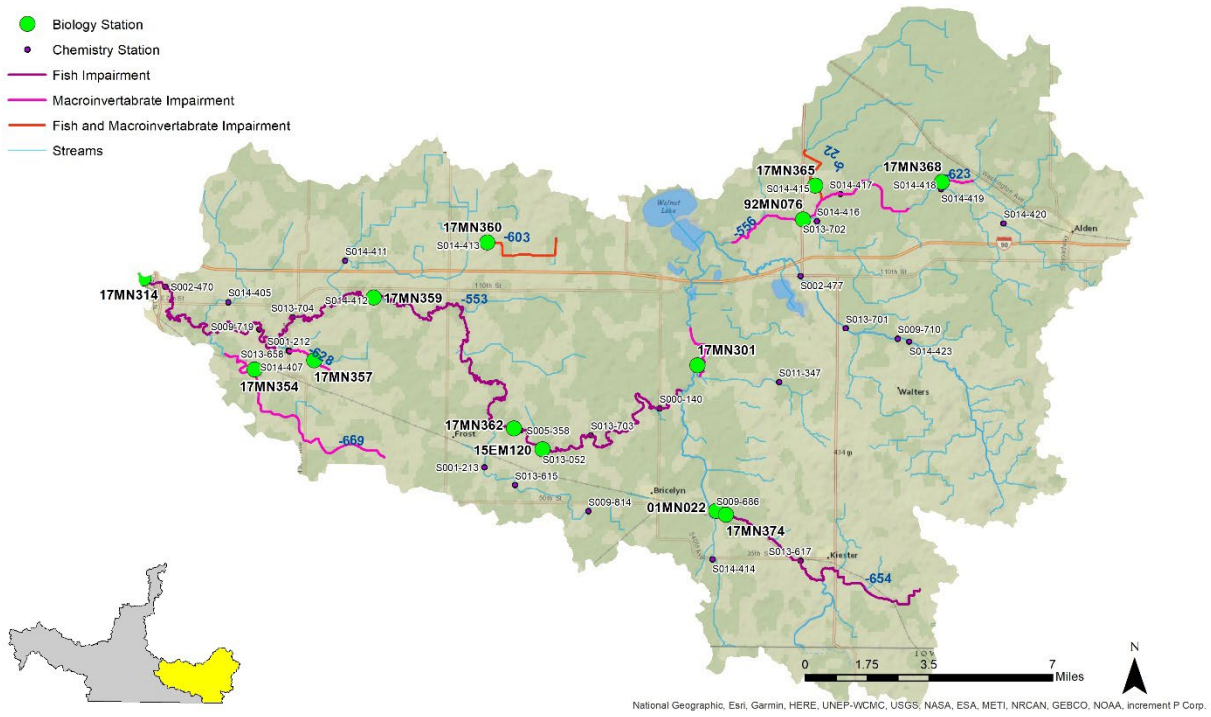
Altered hydrology (directly and/or indirectly) is negatively influencing the biology in the Blue Earth River Watershed, and contributing to most of the biological stressors. Some examples include pollutant loading via tile lines (subsurface drainage) as well as impervious surfaces, loss of habitat via channelization, increased sedimentation, and changes in stream velocity and water availability.

4. Evaluation of candidate causes

4.1 East Branch (10 Digit HUC)

The HUC 10 East Branch portion of the Blue Earth River Watershed is the largest of the subwatersheds, with a drainage area of 188,695 acres. While the primary land use within this subwatershed is for agricultural land use, within the area are six towns; the largest being Blue Earth. This western section of the Blue Earth Watershed has nine biological impairments. AUIDs with biologic impairments are highlighted in Figure 16 below. AUID -650 sense the time of biological assessment has become delisted for a fish impairment. In conjunction with biological impairments, there are two turbidity impairments (-652, and -553). There are also two impaired AUIDs for *Escherichia coli* (-652 and –553) that will not be addressed within this report.

Figure 16. Map of the East Branch Subwatershed of the Blue Earth Watershed.



4.1.1 Biological communities

Biological fish and macroinvertebrate communities will be broken down and displayed according to their designated stream class (See stream class details in appendix Table A 1).

East Branch fish samples

Within the East Branch Subwatershed, the fish communitys were assessed in two stream catagories. Shown below in Figure 17.

Figure 17. Condition of monitoring locations for the Southern Headwaters fish impairments within the East Branch Subwatershed.

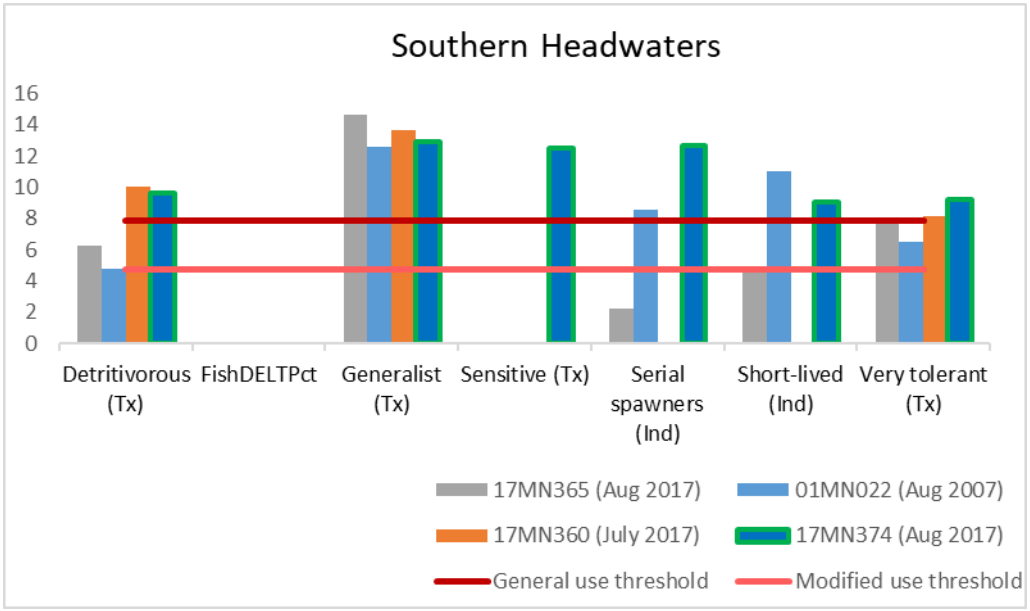
The southern headwaters portion encompases a majority of the impaired streams. The farthest upstream monitoring station of 17MN365 on WID - 622 was found to be modified use, as it was ditched and channalized. A strong majority of the fish sampled were fathead minnows, due to the abundance of them the metics and composistion of the site are skewed. Fathead minnows are a very pollutant tolerant and generalist specie. The second most abundant fish sampled were creek chubs with similar characteristics as the fatheadminnow, and Johnny Darters. Johnny darters are less tollerant, yet are considered a pioneering native. This could be an indication that the fish communty may be starting to recover. There was a complete lack of sensitive taxon in this sample.

To the west is the tributary of County Ditch 25 (WID-603). This is another modified use class stream, by way of ditching and channalization. Monitoring station 17MN360's sampling event resulted in a small sample size with fish types that all fell in the single digets for count. Creek Chubs were the most prominent with a count of 6 indivuals in the sample. In total there were 10 different taxa found. There were a few species present that would be what you would expect to see in a southern headwaters

stream, such as the tadpole madtom, yellow perch, and northern pike. However, with such a small overall sample size it is difficult to determin how well this stream section could support these species long term.

The last southern headwaters reach to have a fish impairment within the East Branch Subwatershed is the brush creek site WID -654. Despite this reach being used as an agricultural ditch, this site was catagorized as general use due to the exceptional habitat features within the stream. There were two assessable monitoring stations that will be evaluated for this report. The first site of 01MN022 was originally sampled in 2001, that scored poory for fish and was the reason this reach was listed for a fish impairment at that time. Within this monitoring cycle it was assessed again in 2007. That sample was found to have 10 different taxa types for fish, with the dominant species being the fathead minnow. The counts for the tolerant fathead minnow were 146. Bigmouth shiner (70) and blacknose dace (60) were found to be the other two prevelant species of the sample. Fathead minnows and bigmouth shinners are generally tolerant secies, blacknose dace is healthy for a stream of this type. While there were a fair number of other taxa types that would be expected to be found in a non stressed stream of this type, they were few individual fish within those taxa types. In 2017 another monitoring station (17MN374) was placed on -654, a little over 500 yards from the original site of 01MN022. This station scored well with nearly 20 different taxa types present and the most dominant being the black nose dace, and several sensitive taxa found. Site 17MN374 scored well with an IBI of 66, 10 points above the general use threshold of 55. There are several reasons why this site scored better than its sister site of 01MN022. There is the possibility of the population recovering in the last decade, as the brush creek ditch has not been cleaned out of dredged. This has allowed the ditch to redevelop southern headwaters habitat properties. Upstream of these stations there also is a a fish barrier just upstream of the site that could be leading to the high numbers of fish that where found at 17MN374. However, it is important to note that even if a barrier is impacting the number of fish in the assembalage there is still a balanced relationship of tolerant and sensive species found.

Figure 18. Fish community metrics for Southern headwaters streams in the East Branch subwatershed.



The other stream type found to have a fish impairment within the East Branch Subwatershed was AUID - 553 classified as a Southern Stream. This section of stream was also catagorized as general use. Within this nearly 40 mile long streatch of stream there were four assessable biological stations for fish. The fish sample and IBI results varied. Upstream station 15EM120 was sampled earlier (2015) than all the other sites (2017). This could be a potential reason why it scored significantly lower. The next dowstream site of 17MN362 was sampled in July of 2017 and scored right at the IBI threshold of 50 yet fell within the confidence interval (CL) of 9. In July of 2017 the next downstream station of 17MN359 fell slightly under the threshold of 50, scoring an IBI of 43 and also falling withing the CL. The last monitoring station of 17MN314 was sampled in August of 2017, resulting in another score of 50 and within the CL.

Figure 19. Condition of monitoring locations for the Southern Stream fish impairments within the East Branch subwatershed.

East Branch macroinvertebrate sample

All macroinvertebrate streams were placed in the modified use category, due to extensive ditching and channelization throughout this watershed. All macroinvertebrate streams were also found in Prairie streams with glide pool features, assigned a passing IBI of 22 (CL of 13.1) for macroinvertebrates.

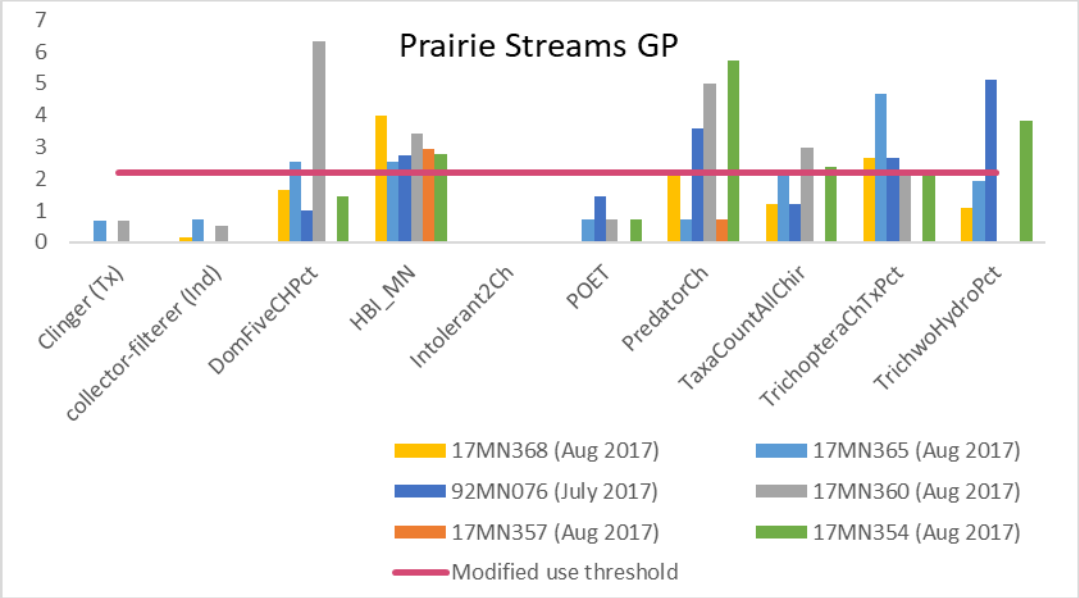
Figure 20. Condition of monitoring locations for the macroinvertebrate impaired streams within the East Branch.

Going upstream to downstream, WID -623 has one biological monitoring site of 17MN362 sampled in 2017. The macroinvertebrate sample scored poorly at 12.9. *Physella* (left handed snail) overwhelmingly dominated the sample. While there were 24 other taxa types, most had few individual counts that led to poor community balance score (DomFiveCHPct), this is also the reason for the acceptable HBI_MN community score, PredatorCh, as well as the Trichopetra as it indicates tolerance values based on taxon percentage, rather than individual. Overall, all functional and intolerant species were lacking, if not missing altogether.

The next adjoining WID of -622 had station 17MN365, sampled in 2017 with a score of 16.6. While this section scored slightly better than the upstream 17MN368, there are similar patterns that can be seen within the macroinvertebrate community. The primary difference is noted in the slightly higher diversity of macroinvertebrates, as noted in the DomFiveCHPct and over all taxa count. Most abundant were mayflies, *Hyalella* (scuds), non-biting midges, and left handed snails. Tolerant species were higher than what they should be, yet there was found to be some slightly sensitive taxa noted in POET and non-net spinning Trichoptera.

The two previous discussed WIDs converge into WID -556 of Foster Creek. Two biological monitoring stations were used to determine the impairment status within this section. Station 17MN365 sampled in August of 2017 receiving a macroinvertebrate score of 16.6 and the just downstream station 92MN076 sampled in July of 2017 having a similar score of 17.7.

Figure 21. Macroinvertebrate community metrics for Prairie streams in the East Branch Subwatershed.



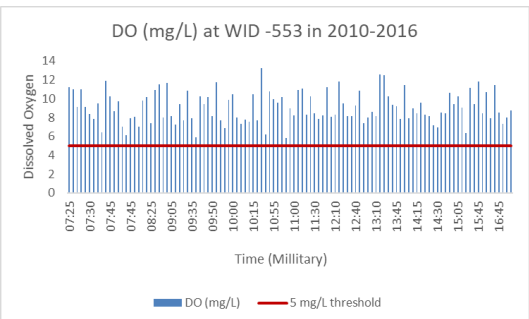
4.1.2 Dissolved oxygen and eutrophication

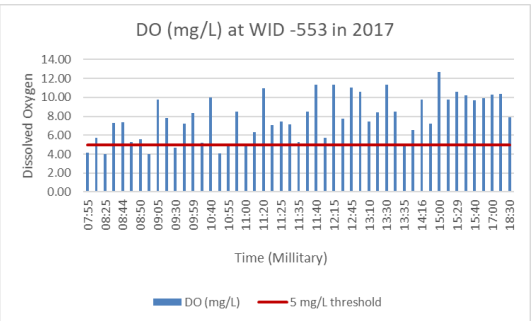
Chemistry

Throughout this report, eutrophication and low dissolved oxygen (DO) will be evaluated together, as a majority of these impairments are correlated together. Often chronic low DO is a direct byproduct of a eutrophic or nutrient rich stream. This is due to the respiration of dense populations of autotrophic organisms (such as phytoplankton and algae). These freshwater organisms become overabundant due to high phosphorus input, as well as other physical conditions around the stream that will be discuses in the summary below.

DO was evaluated throughout the East Branch stream system. Most of the data was collected the form of “instantaneous” or point data; That is a single sample that is collected and analyzed in the field at the time of collection. The farthest upstream stations of WID -622 and WID -623 DO was limited to

Figure 22. DO readings recorded by time taken.



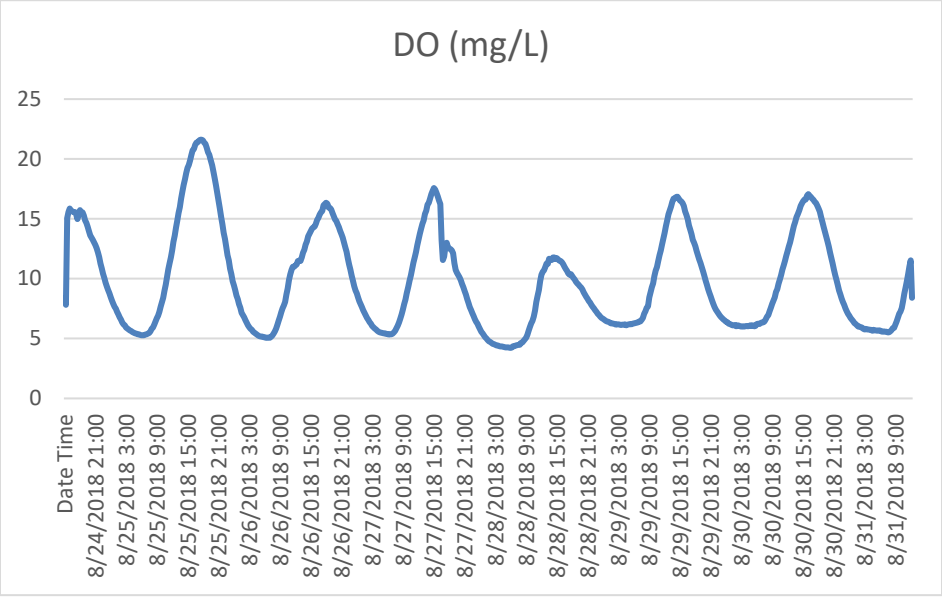


three readings at each site that were collected mid-day, all within normal range. WID -625 DO point data also had fairly normal readings, with the exception of some high afternoon spikes (ranging around 17 mg/L). At the time of monitoring WID -652 had one low reading of 4.83 mg/L taken at 9:00 a.m. There was also continuous monitoring conducted at this location. WID -654 was limited to samples collected at the time of monitoring, all fell within normal range. The mainstem of the Blue Earth River, East Branch has an extensive DO data set on WID -553, shown in Figure 22. DO data is organized by time of collection to analyze for extreme low values in early morning with high values are occurring to indicate DO flux. The 2017 data is stand alone, while 2010-2015 are combined as low DO was not as prevalent in these years.

The last three WIDs assessed are tributaries that coverage with the East Branch mainstem towards the outlet. DO at WID -603 was limited to what was collected at the time of monitoring, with one early morning low DO reading of 3.16 mg/L. During this sample conditions were noted to be excessive in filamentous algae. Around the same time, WID -669 showed a similar trend in low DO with a reading of 3.55 mg/L. In addition, the fish sample was collected in the early afternoon that collected a DO reading if 15.81 mg/L. This is indicative of eutrophic driven DO flux. Again there was noted to be an overabundance of macrophytes as well as floating algae mats. The final WID of -628 showed low DO during both the fish and macroinvertebrate sample (5.11 and 5.2 mg/L respectively). Floating mats were also noted at the time of the biological sample.

YSI Sondes were deployed at multiple locations to collect continuous data over a period of several days. This form of data collection is important to better understand both the DO levels at single points of time as well fluctuation (flux) of DO throughout a 24 hour period. Sondes were places at 4 locations throughout the East Branch Subwatershed. The furthest upstream station on WID -556 had DO readings collected at station 92MN076, as shown in Figure 23.

Figure 23. Farthest upstream station of the East Branch river stream, located at 92MN076.



Data collected displays DO on most nights hovering around or under 5 mg/L, the aquatic life standard for warmwater streams. What is clearly discernable in this data set if that DO Flux is occurring in drastic increments. When DO fluctuation changes more than 5 mg/L within a 24 hour period this adds stress to

aquatic life. Across the course of five days, DO Flux consistently crossed the 5 mg/l flux threshold at 92MN076. Figure 24 displays the sonde that was used to collect this DO data. As shown, within the time of deployment there was a fair amount of detritus build up on the equipment. There also was a large amount of Elodea throughout the stream.

Figure 24. Photo of deployed sonde at 92MN076 at the time of pick up, showing detritus build up from a seven-day deployment.

Further downstream after the connection of Walnut Lake, WID -656 also had collected continuous DO Readings at biological monitoring station 17MN301 (Figure 26). Over the course of 5 days in 2019 DO did hover slightly above the threshold of 5 mg/L. The DO flux had daily swings of the 5 mg/L difference in the beginning portion of September of 2019 under base conditions (Figure 27). Later on an additional deployment was done during rain events in the same month. As shown in Figure 25 below, the DO responds in a different way with the introduction of precipitation. Following rain events DO responds by being driven down after a momentary spike, by the biological or sediment oxygen demand from run off.

Figure 26 DO readings for station 17MN301.

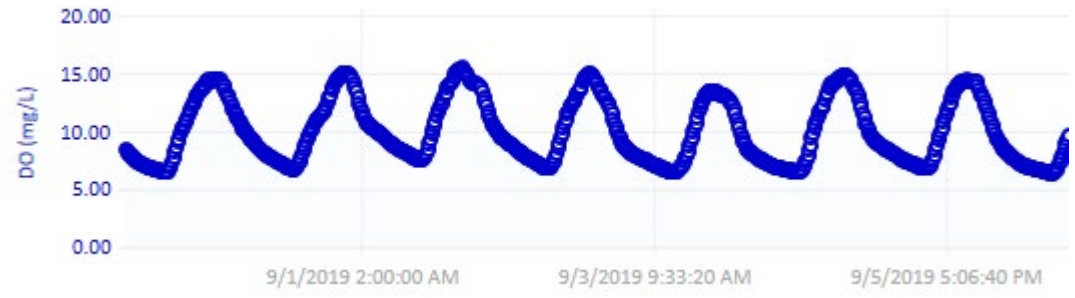
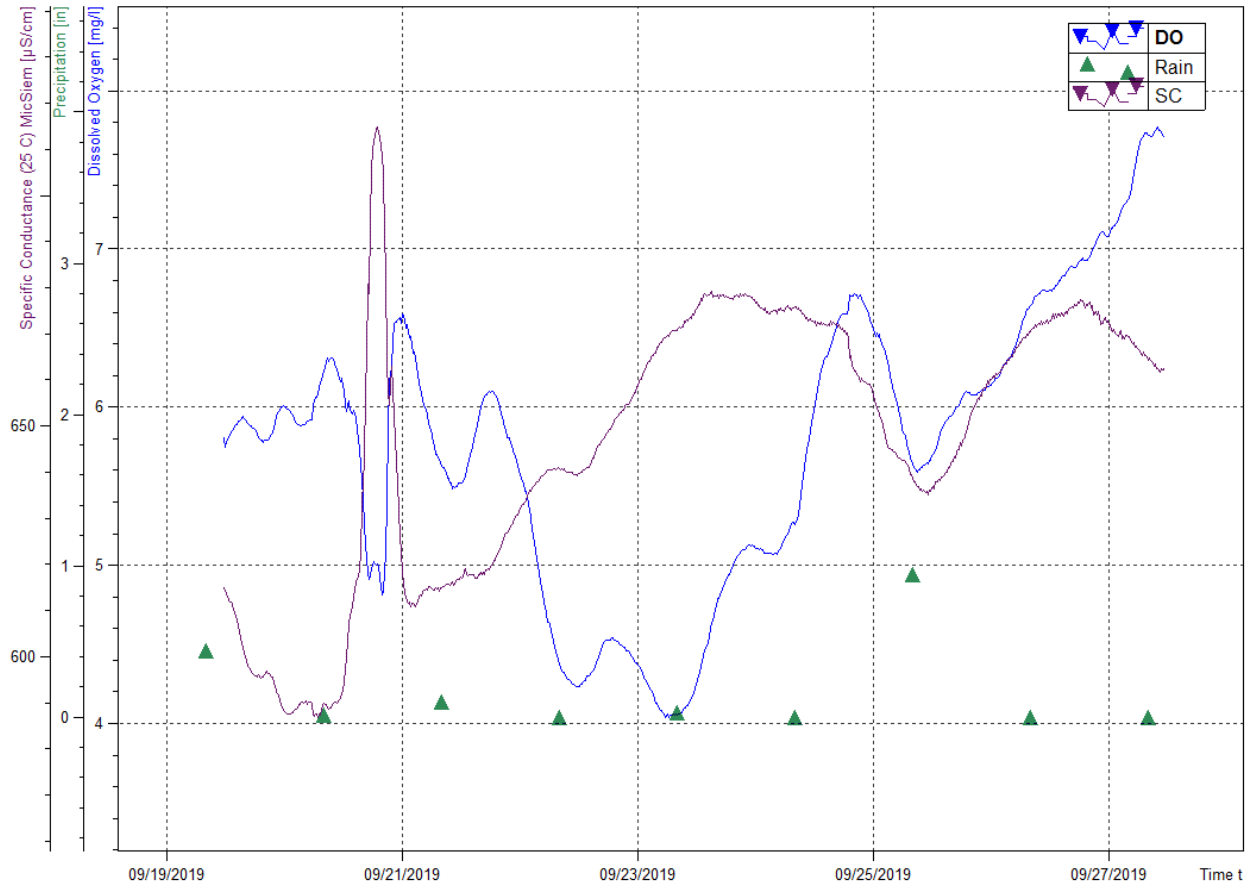


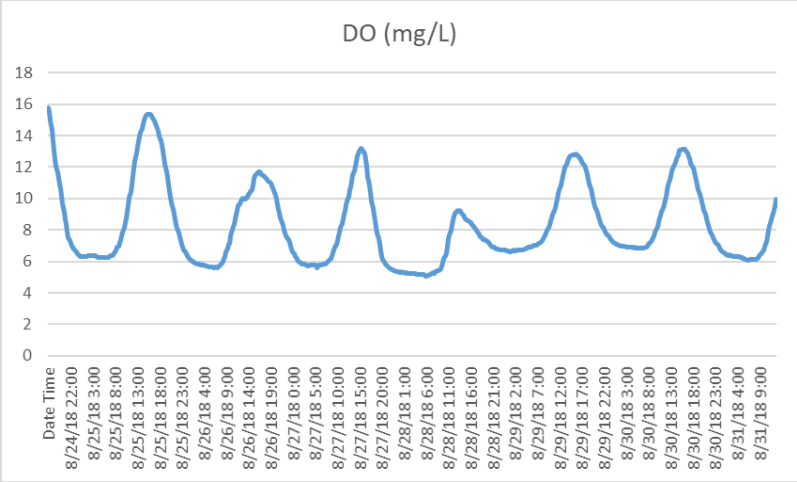
Figure 25. Continuous DO recorded with precipitation, and specific conductance at 17MN301.



The spike in specific conductance during these times especially highlight this land to stream relationship.

The other two locations where sondes were deployed are in relation to Brush Creek (slightly before the confluence into the mainstem of the East Branch), as well as County Ditch 8 (17MN354). As shown in Figure 27 below, Brush Creeks DO did stay slightly above the low DO threshold. However, the dynamics do indicate DO flux intensity from an overabundance of autotrophic activity throughout this system as a whole.

Figure 27. DO readings for Brush Creek near confluence into the East Branch.



Station 17MN354 also had a sonde deployed. Upon pick up there was a large amount of stream debris covering the sensor (Figure 28), resulting in the DO results having to be thrown out.

Figure 28. Sonde with fowling at the time of pick up at 17MN354.

Phosphorus

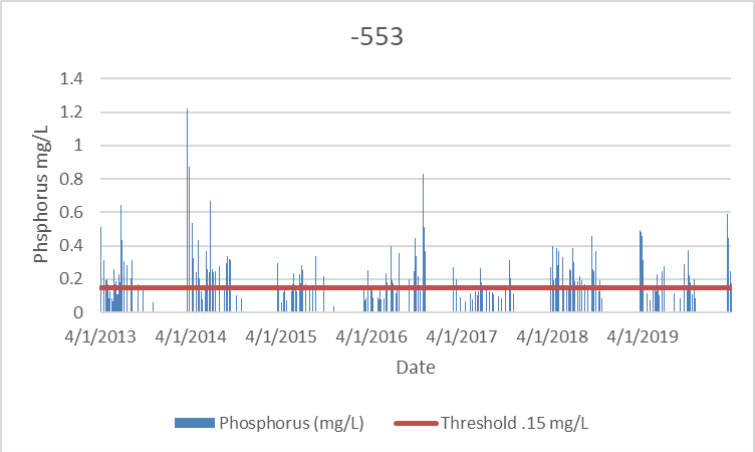
Phosphorus collections were taken during summer months, primarily in 2017 and 2019 and during the original fish sample. For additional comprehensive information of data collection (including exact location, times, and concentration) refer to the MPCA's Surface Water Data, that's located on the MPCAs webpage.

Table 6. Condensed findings for total phosphorus per WID within the East Branch Subwatershed.

AUID	Stream Name	Biological Stations		Impairment	Number of samples	Range of TP (mg/L)	Average of TP (mg/L	# of exceedances .15 mg/L
	East Branch							
623	Judicial Ditch 14	17MN368		M-IBI	5	.04-.09	0.06	0
622	Thisius Brach	17MN365		F-IBI M-IBI	5	.02-.22	0.08	1
556	Foster Creek	92MN076		M-IBI	5	.04-0.08	0.06	0
652	Blue Earth River, East Branch	17MN301		M-IBI	15	.05-.22	0.11	2
654	Brush Creek	01MN022	17MN374	F-IBI	4	.09-.2	0.13	1
553	Blue Earth River, East Branch	15EM120 17MN362	17MN359 17MN314	F-IBI	390	.04-1.22	0.21	246
603	County Ditch 25	17MN360		F-IBI M-IBI	5	.06-.22	0.13	1
669	County Ditch 8	17MN354		M-IBI	1		0.05	
628	County Ditch 26	17MN357		M-IBI	7	.04-.18	0.1	1

Table 6 highlights the quantities of TP samples collected, range, as well as averages from sampling events. Sites are listed from upstream to downstream until WID 553, where the smaller WIDS (603, 669, and 628) conjoin along sections of the downstream mainstem -553 East Branch, Blue Earth River. As Shown, few had little Phosphorus exceedances found. Seen in Figure 29 below, this catchment does have a high TP concentration draining from this subwatershed. The upper reaches are likely transporting high levels of phosphorus due to the land use being dominantly agricultural. Chlorophyll-a samples were also limited to WID-553. None of the 17 samples was found to be above the 40 ug/L. The East Branch river system does have one lake chain that intersects after Foster Creek (-652), Walnut Lake. However, this lake has been assessed and was found to not have a eutrophic impairment. For further details, refer to the Blue Earth River Watershed Monitoring and Assessment Report 2021.

Figure 29. Phosphorous concentrations at primary WID -553 of the East Branch River, Blue Earth River Watershed.



Chemistry data does indicate eutrophic conditions are occurring within the East Branch Subwatershed. Due to the limitations of TP data in the small order streams, eutrophication noted in phosphorus data as well as DO fluctuation is found to be highlighted in the mainstem of the east branch of -652 and -553. Total phosphorus concentrations in general are of concern by itself, based on the chronically high level of TP the East Branch is conveying into the Blue Earth Watershed.

Fish community

Fish monitoring took place primarily in the year 2017. Impaired fish stations are listed from upstream to downstream and divided by stream type, as shown in Table 7. Each station was found to have an adequate number of fish taxa types collected at each biological monitoring site. It is important to note that thresholds for fish community metrics differ for streams that are considered general use (typically an unaltered stream) versus a modified stream (often via ditching or channelization).

Table 7. Fish Metrics listed by WID, listed from upstream to downstream. Failing fish community metrics are highlighted in red.

East Branch Headwaters	Station (Year sampled)	DarterPct	OmnivorePct	SLithopPct	SensitivePct	TolPct	CountofTaxa	DO TIV
622	17MN365 (2017)	9.27	65.15	11.00	0.00	89.49	16	8.46
654	17MN374 (2017	15.97	8.11	42.99	2.21	81.08	19	
	01MN022 (2007)	2.89	31.24	50.42	3.06	77.93	25	8.67
603	17MN360 (2017)	9.09	18.18	13.64	0.00	68.18	10	8.45
Passing Streams Average	**Southern Headwaters General use**	11.5	16.9	31.5	7.9	72.8	12	*8.44*
	Southern Headwaters Modified use	*8.5*	*20.16*	*27.9*	*4.5*	*79.9*	*10*	*8.25*
	Expected response to stress	↓	↑	↓	↓	↑	↓	↓

East Branch Southern Streams	Station (Year sampled)	DarterPct	OmnivorePct	SLithopPct	SensitivePct	TolPct	CountofTaxa	DO TIV
553	15EM120 (2015)	4.14	44.44	18.08	1.13	81.54	20	8.60
	17MN359 (2017)	1.43	17.62	11.43	0.95	65.24	20	8.91
Passing Streams Average	**Southern Streams General use**	*11.9*	*17.7*	*37*	*16.9*	*44.9*	*19*	*8.56*
	Southern Streams Modified use	*9.9*	*20.6*	*31.7*	*10.3*	*57.4*	*18*	*8.41*
	Expected response to stress	↓	↑	↓	↓	↑	↓	↓

Eutrophic conditions place limitations on a variety of fish feeding habits and habitat needs. Some of the primary community groups that can be observed to have direct impacts by stream eutrophication are listed within Table 7. Across all stations sensitive species were lacking, replaced by a generally tolerant

fish community as a whole. Darter species that depend on both fair substrate as well as good water visibility are in fair condition within the headwater portions. The one exception being an older fish monitoring location that failed in 2007. This stream was resampled at a nearby downstream station of 17MN374 (that passed for fish IBI) and displayed improvement as a whole for fish in -654. As for the other headwater WIDS in relation to eutrophic metrics, it is fairly mixed with some indication of Eutrophic stress being a limiting factor. Although it is not likely the primary stressor.

The mainstem of the East Branch seems to indicate a clear stressor that is shifting habitat quality (noted in the lack of lithophilic spawners that needs clean substrate) and well as feeder types that are more generalist (omnivore abundance). Darters are extremely low in these sections. However, this WID is impaired for Turbidity/TSS and could be what is impeding visibility as well as substrate needs.

Chemistry data indicates Eutrophic conditions are contributing to the impairment.it is likely not the primary stressor for fish. Low DO does not clearly present itself as a stressor based on the fish metrics alone.

Macroinvertebrate community

Due to the inability to migrate as readily as fish within the stream, macroinvertebrates can be a strong indicator of chronic water quality issues, especially due to their long lifecycle needs within one given area. The East Branch Subwatershed had five additional WIDs assessed based on macroinvertebrate impairments. The mainstem (WID -553) was found to have a healthy community of macroinvertebrates, therefore is left out of the comprehensive table of invert metrics. Table 8 below highlights metric response in relation to DO limitations to the macroinvertebrate community, while Macroinvertebrate metrics that can indicate DO driven displacement (Table 7) are noted by looking at taxa abundance, sensitive orders that require clean water quality (EPT), removing tolerant algae filtering Trichoptera (primarily noted as the Net Spinning Caddisfly), and observing the calculated DO index values that have been calculated using a number of different species and counts from the original raw data. As the table shows taxa counts in most WIDs were poor. The exception being Brush Creek WID -654 (a site that passed for invertebrates yet is listed for an old fish impairment). In all other categories -654 appears to support a variety of macroinvertebrate taxa types with a healthy range of sensitive species and an appropriate amount of generalist species. The data for this station both serves as an example of how metrics in a healthy stream may appear, as well as indicates that Brush Creek's water quality has improved from the original biological impaired listing. This site will have additional follow up to determine if the existing impairment can be delisted. Unfortunately, all other WIDs indicate some degree of DO levels restricting the macroinvertebrate communities. In addition to sensitive taxa types of the EPT class lacking, the DO index is either below the threshold or very near. Where EPT seemed to be at decent levels, the additional evaluation of tolerant Trichoptera making up a majority of the population discounted that metric alone. However, while the macroinvertebrate community is primarily made up of tolerant species, it is not all comprised of specifically the DO tolerant.

Table 8 displays response to eutrophic conditions. WIDs are listed from upstream to downstream within the East Branch Subwatershed.

Table 8. Macroinvertebrate metrics for low DO in impaired prairie streams within the East Branch Subwatershed.

East Branch Prarie Streams	Station (Year sampled)	Taxa Count	EPT	Trichoptra	sensitive Tricoptra	HBI_MN	DO Index	% DO tolerant	% DO Intolerant
623	17MN368 (2017)	23	0.31	4.35	0.31	7.80	5.89	3.11	0.62
622	17MN365 (2017)	26	37.96	7.69	0.62	8.09	6.02	54.46	1.54
556	92MN076 (2017)	23	5.40	4.35	2.54	8.05	6.80346056	9.84	0.32
652	17MN301 (2017)	macroinvertebrate habitat not available to sample							
654	01MN022 (2001)	39	18.62	10.26	2.07	9.11	6.62	14.19	1.01
	17MN374 (2017)	38	61.00	15.80	0.00	7.40	7.581900592	3.03	43.33
603	17MN360 (2017)	29	0.97	3.45	0.00	7.832915783	5.39	14.29	0.00
669	17MN354 (2017)	27	1.58	3.70	1.58	8.03	5.91	56.21	0.00
628	17MN357 (2017)	12	0.00	0.00	0.00	7.97	6.747661338	4.62	0.00
Passing Streams Average	**Prarie Streams General use**	37	38.45	10	5.5	7.55	7.04	25.1	5
	Prarie Streams Modified use	*34*	*20.58*	*5.71*	*4.76*	*8*	*6.19*	*31.37*	*2*
	Expected response to stress	↓	↓	↓	↓	↑	↓	↑	↓

Macroinvertebrate metrics that can indicate DO driven displacement (Table 8) are noted by looking at taxa abundance, sensitive orders that require clean water quality (EPT), removing tolerant algae filtering Trichoptera (primarily noted as the Net Spinning Caddisfly), and observing the calculated DO index values that have been calculated using a number of different species and counts from the original raw data. As the table shows taxa counts in most WIDs were poor. The exception being Brush Creek WID - 654 (a site that passed for invertebrates yet is listed for an old fish impairment). In all other categories - 654 appears to support a variety of macroinvertebrate taxa types with a healthy range of sensitive species and an appropriate amount of generalist species. The data for this station both serves as an example of how metrics in a healthy stream may appear, as well as indicates that Brush Creek's water quality has improved from the original biological impaired listing. This site will have additional follow up to determine if the existing impairment can be delisted. Unfortunately, all other WIDs indicate some degree of DO levels restricting the macroinvertebrate communities. In addition to sensitive taxa types of the EPT class lacking, the DO index is either below the threshold or very near. Where EPT seemed to be at decent levels, the additional evaluation of tolerant Trichoptera making up a majority of the population discounted that metric alone. However, while the macroinvertebrate community is primarily made up of tolerant species, it is not all comprised of specifically the DO tolerant.

Table 9. Macroinvertebrate metrics for eutrophication in impaired prairie streams within the East Branch Subwatershed.

East Branch Prarie Streams	Station (Year sampled)	% Scraper	CrustMollPct	TanytarsiniPct	Phos Index	% Tolerant	% Intolerant	%Gen Tolerant
623	17MN368 (2017)	61.06	61.37	14.08	0.12	5.15	1.52	95.92
622	17MN365 (2017)	17.28	37.35	20.00	0.12	19.81	0.00	89.29
556	92MN076 (2017)	77.14	79.37	3.03	0.17	52.48	0.00	95.27
652	17MN301 (2017)	macroinvertebrate habitat not available to sample						
654	17MN374 (2017)	7.27	7.88	5.48	0.12	5.15	1.52	78.90
603	17MN360 (2017)	25.65	28.57	6.35	0.12	19.81	0.00	89.29
669	17MN354 (2017)	63.09	74.13	5.13	0.17	52.48	0.00	88.89
628	17MN357 (2017)	85.85	85.85	13.79	0.15	4.00	0.00	91.67
Passing Streams Average	**Prarie Streams General use**	*16.11*	*11.78*	*18.46*	*0.13*	*30.6*	*3.8*	*61.78*
	Prarie Streams Modified use	17.73	*23.21*	*22.11*	*0.14*	45.87	*1.79*	*73.64*
	Expected response to stress	↑	↑	↑	↑	↑	↓	↑

Macroinvertebrate metrics that can indicate eutrophic driven displacement are further evaluated in Table 9. This table displays the additional feeder types present, as well as specific eutrophic tolerance metrics. When evaluating macroinvertebrate response for eutrophication, one of the primary ways this can be achieved is by measuring the abundance of species that are filter feeders as well as benthic algae

eaters (such as “scraper” feeding groups that feed on benthic and filamentous algae). In Table 8 the order Trichoptera is typically a sensitive order with the exception of hydropsychidae. This is a tolerant algae filtering Net Spinning Caddisfly that is common in this area of Minnesota, particularly is waters with high amounts of suspended algae. All impaired sites indicate that if Trichoptera taxa were present they were primarily that of the tolerant net spinning caddisfly. Other filter feeders that can indicate high suspended algae are Crustaceans and Mollusks, as well as Tanytarsini (non-biting midge). Tanytarsini can also be an indicator of poor or organic rich substrate, as they spend most of their time in this section of the stream. Across all sections, *Tanytarsini* did not seem to be in overabundance. However, substrate (especially mucky) alone is usually not considered at targeted habitat when sampling, therefor this can lead to some misleading *Tanytarsini* metrics.

Once again, all streams with the exception of the already passing WID -654 show some indication of eutrophic stress. WID 669 (17MN354) gave the strongest indications of eutrophic stress within the macroinvertebrate community, but lacks TP data to confirm. Unfortunately this is the case with most headwater stations. The data set paired with some response noted in the fish at the outlet (-553) of the East Branch Watershed, does indicate phosphorus loading fueling eutrophication is prevalent throughout the stream system.

4.1.3 East Branch DO/Eutrophication summary

The farthest upstream WID of -623 were limited in both DO and TP data. What was available fell within normal values. Monitoring station 17MN368 metrics were consistently poor. However, this is likely due to the 96% generally tolerant make-up of the community. At the time of sampling little algae growth was noted in stream. With the poor data set in conjunction of a generally tolerant community it is difficult to see indication of low DO and eutrophication. For these reason these two parameters are listed as inconclusive.

Figure 30. Station 17MN368 on August 22, 2017.

The next WID down of -622 also had poor data with slight indication that there may be DO flux occurring. Phosphorus does have the potential to be high with a reading of .22 mg/L. There were some algae mats at the time of the sample. The fish community was generally tolerant, making it difficult to clearly see low do or eutrophic displacement in the community. In addition the metrics were mixed. Macroinvertebrate metrics did add some clarity, the community was largely made up of specifically low DO tolerant species, with a lack of low DO sensitive. In addition filter feeders as well as scrapers were in

abundance. There are still some inconsistencies within the metrics (such as there not being a high amount of eutrophic tolerant species), as well as question in the tolerance values as once again this was a community that was made up of nearly 90% generally tolerant individuals. Once again this creates findings that are inconclusive.

Foster Creek (-556) is the receiving stream of the other two WIDs above. This stream was noted to have algal growth at the time of sampling as well as high density macrophytes. There also was clear low DO as well as DO fluctuation occurring. Furthermore the macroinvertebrate metrics are indicative of a eutrophic stream, particularly noted in the high amounts of filter feeders and scrapers. Low DO and eutrophication are considered a stressor.

After Walnut Lake, -652 was found to have DO flux occurring. While TP samples were limited, the exceedances were found to be well over the phosphorus threshold. This is a unique macroinvertebrate impairment, as this site was not sampled, but listed as an impairment due to lack of habitat (discussed further on). Therefore the low DO issues here cannot be correlated to a community sample. Low DO and eutrophication occurring within in this WID is therefore inconclusive. However, there are concerning indications of potential nearby land use impacts to the stream that were highlighted in the continuous DO monitoring efforts.

Brush Creek (654) is slated to be resampled to see if the fish community has made a well enough comeback from the original 2001 assessment for Fish. For now this site is listed as a place holder within the table and findings as this preexisting fish impairment is currently being reevaluated for delisting.

The mainstem of the East Branch (-553) had the most robust data set for DO and TP. Both indicate some chronic issues, particularly in 2017. In 2019 DO Flux was apparent in the upstream site, as well as the outlet of the Brush Creek tributary. A competing stressor is also noted in the preexisting impairment for Turbidity/TSS, at times this makes algae and other autotrophic growth difficult. However, the abundance of some fish taxa (omnivores) in conjunction with other shifts do indicate some degree of algae growth. There is some level of eutrophication occurring as well as low DO susceptibility. It's important to note that mitigation efforts put in place would be most beneficial upstream in controlling the pollutant loading and stream chemistry dynamics occurring within this reach.

WID 603 is one of the smallest headwater streams. This small order stream has been modified into a low gradient ditch, with little to no canopy cover. This site also shows phosphorus levels as high as .22 mg/L. These three factors create prime conditions for autotrophic growth to occur, as shown in Figure 20 above at Station 17MN360. While DO was limited, the early morning reading shows that high plant/autotrophic respiration is occurring here. Fish metrics as well as macroinvertebrate metrics show some low DO and eutrophic displacement. Low DO and eutrophication are a stressor to biology within this stream.

WID-669 was limited in chemistry data. However, there was one early morning DO sample well below the standard, as well as one high afternoon sample that is indicative of eutrophic driven DO response. While continuous data had to be thrown out, the reason was for a buildup of macrophytes and filamentous algae covering the sensors. Invertebrate metrics for both low DO as well as eutrophication measured a consistent response for these two parameters playing a large role in limiting the population.

Figure 31. 17MN354 on August 8, 2017

The final WID of -628 was noted to have algal mats at the time of biological monitoring. There was also a large amount of detritus build up on the stream bed, in conjunction with low flow. While data was limited, low DO was a constant find throughout monitoring visits. TP also indicated potential for high phosphorus loading to occur. In addition, the metrics for macroinvertebrates reviled algae eaters to be dominant here, with additional metrics signaling both low DO and eutrophic stress. Eutrophication is a stressor here, as is low DO. Low DO is likely occurring from both eutrophication as well as low flow conditions/susceptibility at this station.

Figure 32. Dissolved oxygen and eutrophication stressor summary table for the East Branch Subwatershed. Red indicates a stressor, blue indicates inconclusive findings.

				Dissolved Oxygen				Eutrophication		
WID	**Stream Name**	**Biological Stations**	**Impairment**	Dissolved Oxygen	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland/Lake influcence	Excess Phosphorus	Unidentified
	East Branch									
623	Judicial Ditch 14	17MN368	M-IBI	•					•	
622	Thisius Brach	17MN365	F-IBI M-IBI	•					•	
556	Foster Creek	92MN076	M-IBI	•					•	
652	Blue Earth River, East Branch	17MN301	M-IBI*	•	•		•		•	
654	Brush Creek	01MN022 17MN374	F-IBI							
553	Blue Earth River, East Branch	15EM120 17MN359 17MN362 17MN314	F-IBI	•			•		•	
603	County Ditch 25	17MN360	F-IBI M-IBI	•					•	
669	County Ditch 8	17MN354	M-IBI	•					•	
628	County Ditch 26	17MN357	M-IBI	•					•	

4.1.4 Nitrate

Nitrate concentrations throughout the East Branch Subwatershed were of concern. The mainstem of the subwatershed (WID -533) especially highlight how nitrate is a chronic issue. While not all of the tributary reaches had a large dataset, concentrations were often at high levels. As shown in Table 10 below, nitrate often exceeded the proposed biological threshold of 4.9 mg/L and nearly just as many times nitrate exceeded the drinking water standard of 10 mg/L.

Table 10. Nitrate concentrations shown by WID; highlighting number of samples, range, average, exceedances at East Branch Subwatershed.

WID	Stream Name	Biological Stations	Impairment	Number of samples.	Range of Nitrate (mg/L)	Average of Nitrate (mg/L)	# of exceedances 4.9 mg/L	# of exceedances 10 mg/L
East Branch								
623	Judicial Ditch 14	17MN368	M-IBI	7	1.7-15	10.11	6	5
622	Thisius Brach	17MN365	F-IBI M-IBI	6	1.3-14	9.18	4	4
556	Foster Creek	92MN076	M-IBI	8	.38-13	7.5	6	4
652	East Branch	17MN301	M-IBI	7	1.7-15	10.11	6	5
654	Brush Creek	01MN022 17MN374	F-IBI	3	3.4-11	8.13	2	2
553	Blue Earth River, East Branch	15EM120 17MN359 17MN362 17MN314	F-IBI	367	.05-25.2	11.62	319	222
603	County Ditch 25	17MN360	F-IBI M-IBI	4	5.7-16	11.9	4	3
669	County Ditch 8	17MN354	M-IBI	2	11	11	2	2
628	County Ditch 26	17MN357	M-IBI	5	7.4-13	10.68	5	5

For the evaluation of nitrate within the East Branch HUC 10 Subwatershed, the macroinvertebrates will be the only biologic community assessed. Fish metrics (aside from DELTS) are poor indicators of nitrate displacement. Macroinvertebrates typically display a stronger signal of nitrate toxicity prevalent within the community.

Figure 33. Macroinvertebrate biotic metrics in relation to nitrate within the East Branch Subwatershed. Metrics in pink indicate a poor response.

East Branch	Station (Year sampled)	Taxa Count	EPT#	Nitrate Index	% Nitrate tolerant	% Nitrate Intolerant
623	17MN368 (2017)	23	1	6.70	75.16	0
622	17MN365 (2017)	26	3	4.14	71.08	0
556	92MN076 (2017)	23	3	8.13	92.38	0
652	17MN301 (2017)	macroinvertabrate habitat not available to sample				
654	17MN374 (2017)	30	4	3.58	54.24	0
553	15EM120 (2015)	40	9	3.68	74.19	0
	17MN359 (2017)	23	12	3.65	66.99	0
	17MN362 (2017)	33	12	3.97	66.66	0
	17MN314 (2017)	31	17	3.86	71.9	0.65
603	17MN360 (2017)	29	2	4.43	62.01	0.00
669	17MN354 (2017)	27	1	4.62	44.41	0
628	17MN357 (2017)	12	0	8.62	94.15	0
Passing Streams Average	**Prarie Streams General use**	37	11.5	3.23	54.86	3.18
	Prarie Streams Modified use	24	7.6	3.32	59.41	1.95
	Expected response to stress	↓	↓	↑	↑	↓

The above Figure 33 highlights nitrate influenced macroinvertebrate communities noted in nearly every sample collected. One of the primary communities looked at to determine if nitrate toxicity has occurred is ETP. Previously this metric was assessed as dominance within the total sample (as a percentage), where individual taxa types are looked at in assessing for nitrate toxicity. The nitrate index, as well as weighing the nitrate specific tolerant and intolerant dominance highlight shifts within the sample. As shown, nearly all stations fell below the passing average for EPT taxon diversity. The stations within the mainstem that did pass were hovering just above the threshold with a fair amount of tolerant species (such as *Intercalaris*, in the Ephemeroptera order). The nitrate index is extremely high in every location, with a complete lack of nitrate sensitive species. WID -654 and -669 were the only two sites that did not have an over dominance of specific nitrate tolerant species, where all other locations had extremely high dominance of nitrate tolerant species.

While many of these tributaries have poor datasets for nitrate samples, what is available does show high concentrations occurring with nearly every sample. In addition the macroinvertebrate community consistently displayed high nitrate index with nitrate tolerant being dominant at nearly every site. Where nitrate tolerant did not technically go over the threshold at two locations, the percentage fell just below. Nitrate is considered to be a stressor at nearly every location with the exception of two sites. 17MN374 due to impairment status (consideration for delisting) and 17MN301 due to the absence of macroinvertebrate sampling. However, the high concentrations of nitrate at both locations should be noted, especially as there are notable impacts both upstream and downstream of this reach.

Nitrate summary

Figure 34. Nitrate stressor summary table for the East Branch Subwatershed.

				Nitrate			
AUID	**Stream Name**	**Biological Stations**	**Impairment**	Land Use (application)	Upstream waterbody	Point Souce	Unidentified
	East Branch						
623	Judicial Ditch 14	17MN368	M-IBI	●			
622	Thisius Brach	17MN365	F-IBI M-IBI	●			
556	Foster Creek	92MN076	M-IBI	●			
652	Blue Earth River, East Branch	17MN301	M-IBI*	●			
654	Brush Creek	01MN022 17MN374	F-IBI	●	●		
553	Blue Earth River, East Branch	15EM120 17MN359 17MN362 17MN314	F-IBI	●	●		
603	County Ditch 25	17MN360	F-IBI M-IBI	●			
669	County Ditch 8	17MN354	M-IBI	●			
628	County Ditch 26	17MN357	M-IBI	●			

4.1.5 Total suspended solids

Total suspended solids (TSS) in addition to total suspended volatile solids (TSVS/TVS) are evaluated together when applicable. This is in effort to understand organic contributions in addition to sediment to the overall TSS load within the assessed sites. The mainstem of this subwatershed has existing turbidity impairments assigned to them (WID -652 and -553). The samples taken during this assessment window varied in quantity of data throughout the sites. Many of the small order tributaries within this subwatershed did not exceed the TSS threshold of 45 mg/L. The organic composition also (TVS) also was relatively low in most of the small order streams. Although TSVS does appear to make up a significant amount of the overall TSS make up, the TSS concentrations are low as a whole. Streams with a strong data set do show some indication that TSS overloading is occurring, in particular on the East Branch (-652), Brush Creek (-654), and along the Blue Earth (-553). County Ditch 26 (-628) does have one exceedance of TSS that just fell over the 45 mg/L threshold.

Table 11. TSS concentrations within the East Branch Subwatershed.

WID	Stream Name	Biological Stations	Impairment	# of TSS samples	# of TVS samples	Range of TSS (mg/L)	Range of TVS (mg/L)	Average of TSS (mg/L)	% TSVS made up TSS (Average)	# of exceedances 45 mg/L
East Branch										
623	Judicial Ditch 14	17MN368	M-IBI	5	5	2-20	1-4.8	9.6	37.93	0
622	Thisius Brach	17MN365	F-IBI M-IBI	5	5	4.8-12	1.6-2.8	7.12	36.9	0
556	Foster Creek	92MN076	M-IBI	5	5	4.8-28	2-5.6	13.28	38.2	0
652	East Branch	17MN301	M-IBI	14	4	5.6-75	2-8.2	32.72	31.76	2
654	Brush Creek	01MN022 17MN374	F-IBI	3	3	18-110	4-14	49.3	18.98	1
553	Blue Earth River, East Branch	15EM120 17MN359 17MN362 17MN314	F-IBI	224	95	2-560	2-100	65.89	27.04	127
603	County Ditch 25	17MN360	F-IBI M-IBI	4	4	3.2-28	2-6.4	18.05	32.55	0
669	County Ditch 8	17MN354	M-IBI	1	1	22	4	22	18.18	0
628	County Ditch 26	17MN357	M-IBI	7	7	2.4-51	1.6-8.4	18.94	39.1	1

The Minnesota Department of Natural Resources conducted an in-depth watershed characterization report for the Blue Earth Watershed. Within this study, several locations within the East Branch were assessed. One of those was Foster Creek, concluding this small tributary as being a moderate sediment contributor. Foster Creek currently calculates 4.43 tons of sediment leaving this WID annually. The aerial image below (recorded in the DNR Characterization report), highlights a recently altered and widened channel (Lore, 2020)

Figure 35. Aerial imagery comparing Foster Creeks change within 4 years, from the DNR Watershed Characterization report.

Near the outlet of Walnut Lake (above site 17MN301) is another location that underwent a geomorphic study. This site was ranked as being fairly stable, with an annual contribution of .035 tons of sediment from the East Branch. Further downstream, the lower East Branch mainstem is rated to be less stable, with very high stream bank erosion and a very high sediment supply at 6.78 tons of sediment annually (Lore, 2020).

Fish TSS metrics

TSS as a stressor can present itself in a variety of ways within the fish community's composition. One community response is noted in habitat degradation from sedimentation related to TSS. The lack of benthic feeders that depend on a diverse and clean substrate for their feeding purposes, lack of riffle dwelling species, and an absence of lithophilic spawners are used as metric indicators. A lack of herbivores also can indicate poor visibility/turbid conditions that block sunlight into the streams water column, impairing macrophyte growth. There are also specific families of fish such as Perciforms and the subfamily Centrarchidae (sunfish) that are especially sensitive to high TSS or turbid conditions; impacting respiration, predatory, and reproductive habits. In addition, a lack of long lived species, TSS tolerant, intolerant, and TSS tolerance index value all help highlight TSS stress on the community.

Table 12. Fish metrics for TSS within the East Branch Subwatershed; Southern headwaters class on top with Southern streams class on bottom. Red indicates metric value over the threshold.

East Branch	Station (Year sampled)	Benthic Feeders Pct	Sensitive Centrarchidae Pct	Herbivores Pct	Intolerant Pct	Long Lived Pct	Sensitive Perciformes Pct	Riffle Pct	Sensitive Pct	Lithophilic Spawners Pct	TSS TIV
622	17MN365 (2017)	17.08	0.00	9.82	0.00	1.11	10.37	9.82	0.00	6.36	20.75
654	17MN374 (2017)	17.44	0.00	12.78	0.00	2.21	17.69	12.78	2.21	4.67	16.34
	01MN022 (2007)	21.82	0.00	9.75	0.00	0.21	17.37	9.75	0.00	4.24	16.33
603	17MN360 (2017)	31.82	0.00	13.64	0.00	13.64	18.18	13.64	0.00	13.64	18.20
Passing Streams Average	**Southern Headwaters General use**	34.97	0.99	22.40	1.61	4.51	13.61	26.18	7.87	14.63	15.09
	Southern Headwaters Modified use	27.34	0.67	17.80	0.81	4.28	10.30	19.86	4.53	12.03	15.49
	Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

East Branch	Station (Year sampled)	Benthic Feeders Pct	Sensitive Centrarchidae Pct	Herbivores Pct	Intolerant Pct	Long Lived Pct	Sensitive Perciformes Pct	Riffle Pct	Sensitive Pct	Lithophilic Spawners Pct	TSS TIV
553	15EM120 (2015)	13.37	0.00	12.24	0.00	2.45	4.71	12.99	1.13	12.62	24.65
	17MN359 (2017)	11.43	0.00	9.05	0.00	3.81	1.90	10.48	0.95	10.95	29.20
Passing Streams Average	**Southern Streams General use**	36.02	5.37	25.68	4.24	13.58	20.09	30.18	16.89	19.11	17.59
	Southern Streams Modified use	29.70	3.12	21.65	2.07	10.30	15.39	24.42	10.30	15.02	19.19
	Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

As shown in the table above, nearly all sites had strong indication of TSS creating some displacement within the fish community in the southern headwaters portion of this subwatershed. The less impacted WID of -603 had community indications of good benthic habitat, in conjunction with a good amount of long lived species as well as sensitive Perciformes. While there were other fields within this WID that scored poorly for TSS metrics, there is enough to show at a minimum TSS is not likely the primary stressor. It is important to note that these headwater sections all converge into the mainstem of the East Branch, which has a known TSS/turbidity issues, and appears to be a stressor to the fish populations. This could be impairing migration to these upstream locations. On the inverse, it is likely alterations that are occurring at the headwater locations throughout this subwatershed are the driving force of the downstream turbidity impairment.

Macroinvertebrate TSS metrics

The metrics used for the assessment of TSS in the macroinvertebrate community are similar to what group types are assessed within the fish community. The specific metrics include the abundance of Plecoptera (stonefly). Plecoptera are great indicators due to their long life stage (one to two years) in the stream. They particularly rely in the habitat of the stream bed, typically clinging to the underside of rocks. Plecoptera are also known to be sensitive to low DO and pollutants. Ephemeroptera (mayflies) is another specific species evaluated for TSS. Eggs for Ephemeroptera are especially sensitive to the presents of TSS, resulting to low hatch rate. Ephemeroptera also share the same habitat needs as Plecoptera. Both of these species are also susceptible to physical abrasions and internal clogging from excess sediment. The overall taxa count as well as abundance of long lived species help determine if there is frequent or significant disruptions in the habitat (often being some form of TSS related degradation). Other metrics highlight specific TSS sensitive abundance, along with specific TSS tolerant, and the TSS index value calculated from the collection.

Reviewing the table below, stations are listed from upstream to downstream. WID 623 indicates a clear pattern of TSS as a stressor. WID 622 had already showed TSS stress in the fish community. The macroinvertebrates show less of a response, yet still show that TSS sensitive inverts were completely absence (the single Ephemeroptera was the tolerant Caenis, diminuta). WID -654 showed some improvement in diversity and overall index value from the 2001 sample to the 2017. The remaining WIDs showed clear indications of some degree of TSS stress (with the exception of WID -603).

Table 13. Macroinvertebrate metrics for TSS within the East Branch Subwatershed. Red indicates metric value over the threshold.

East Branch	Station (Year sampled)	Taxa Count	%Long Lived	%Plecoptera	Ephemeroptera Count	TSS Index	% Tolerant	% Intolerant
623	17MN368 (2017)	23	0.31	0.00	0.00	18.35	58.39	0.00
622	17MN365 (2017)	26	7.10	0.00	1.00	16.61	22.46	0.00
556	92MN076 (2017)	23	0.63	0.00	2.00	22.57	78.41	0.00
652	17MN301 (2017)	Not Sampled due to lack of habitat						
654	01MN022 (2001)	39	8.27	0.00	9.00	18.52	65.54	0.34
	17MN374 (2017)	83	6.97	0.00	0.00	16.34	30.91	0.00
603	17MN360 (2017)	29	3.90	0.00	1.00	14.29	30.52	0.00
669	17MN354 (2017)	27	0.00	0.00	0.00	16.64	38.20	0.00
628	17MN357 (2017)	12	0.00	0.00	0.00	22.91	83.69	0.00
Passing Streams Average	**Prarie Stream general use**	37	7.5	0.2	6.7	17.35	48.28	2.67
	Prarie Stream modified use	*24*	*6.0*	*0.1*	*4.8*	*16.02*	*35.60*	*1.27*
	Expected response to stress	↓	↓	↓	↓	↑	↑	↓

Summary

The mainstem to where all the assessed tributaries drain into is WID -553. This area has been long established for monitoring efforts and recognized for its turbidity and TSS loading issues. The upstream tributaries (WID -623, 622, 556, 669, 628) that feed into the Blue Earth River, East Branch all showed indications of TSS stress within the biology. While the chemistry data that was collected during this assessment period was scarce for these sites specifically, stream instability and TSS issues were evident. Two stations were listed as inconclusive. The upper portion of the East Branch (WID -652) was inconclusive as there was not any available biology to be assessed. However, had there had been an assessment it is likely that TSS would be been found to be a limiting factor to the biological communities here. County Ditch 25 (WID -603) was the other station that was inconclusive, due to a lack of data in addition to mixed metric response. Brush Creek is currently being reconsidered as a delisted impairment.

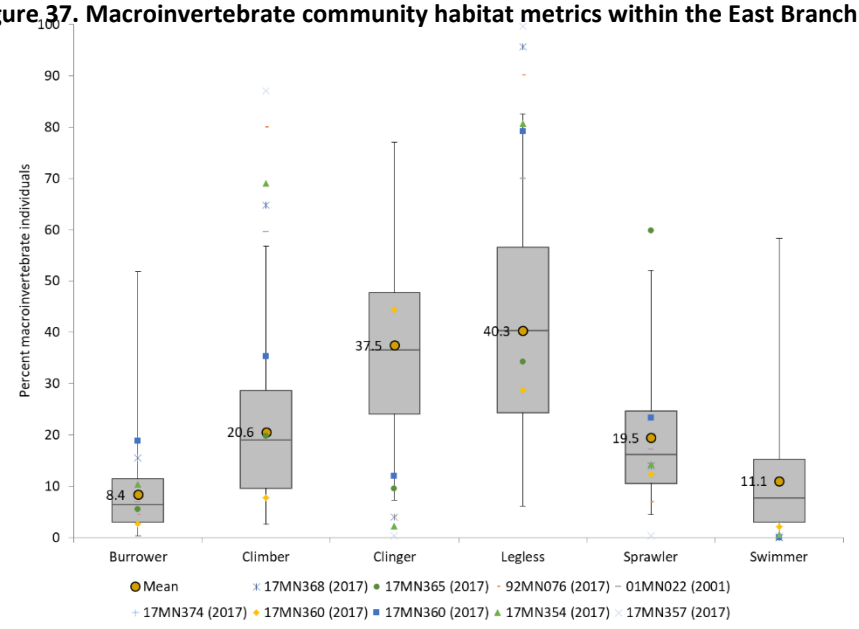
Figure 36. Total suspended solids stressor summary table for the East Branch Subwatershed.

WID	Stream Name	Biological Stations	Impairment	TSS			
				Suspended Algae	Flow Alterations	Stream Bank Erosion	Pasture
	East Branch						
623	Judicial Ditch 14	17MN368	M-IBI		●	●	
622	Thisius Branch	17MN365	F-IBI M-IBI		●	●	
556	Foster Creek	92MN076	M-IBI		●	●	
652	Blue Earth River, East Branch	17MN301	M-IBI*		●		●
654	Brush Creek	01MN022 17MN374	F-IBI				
553	Blue Earth River, East Branch	15EM120 17MN359 17MN362 17MN314	F-IBI		●	●	
603	County Ditch 25	17MN360	F-IBI M-IBI		●	●	
669	County Ditch 8	17MN354	M-IBI	●	●	●	
628	County Ditch 26	17MN357	M-IBI	●	●		

4.1.6 Habitat

Judicial Ditch 14 (WID -623), Thisius Branch (WID -622), and Foster Creek (WID -556) upstream of Walnut Lake all had similar stream habitat characteristics and land use features. These streams in addition to the upstream sites of County Ditch 25 (WID -603), County Ditch 26 (WID -628), and County

Figure 37. Macroinvertebrate community habitat metrics within the East Branch Subwatershed.



Ditch 8 (WID -628) are all headwater sections that have been altered by way of ditching and channelizing for agricultural purposes. As noted in Figure 20 in the above conditions of sites during the macroinvertebrate sample, these sites were largely homogenous in stream features. Additional habitat assessments show all sites scored poorly in regards to stream stability, in particularly from bank instability. In addition, there was a lack in diversity in stream substrate types. Within the mainstem of the East Branch, WID -652 showed similar characteristics as the headwater streams. Here, habitat was the only identifiable macroinvertebrate stressor as habitat conditions were so poor there could be no sample taken. Further downstream, stream instability contributes to high TSS values and conditions. The macroinvertebrate communities throughout this subwatershed show strong indication of habitat displacement in the benthic zone of the stream. This is often noted in an increase of burrowing species as well as legless. Lack of clingers are indicative of an embedded stream.

The fish community (reflected in Table 12 in the above TSS section) also consistently reflects habitat displacement, noted in the lack of benthic feeders, lithophilic spawners, and riffle dwellers.

Summary

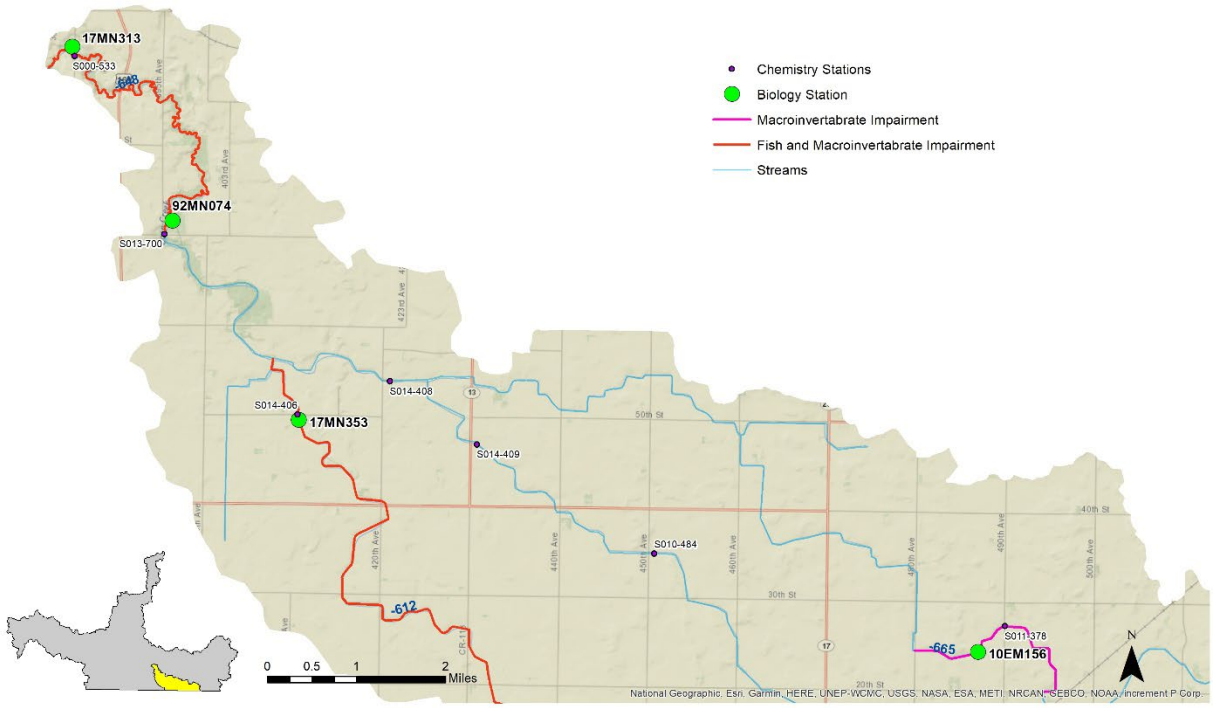
Habitat is one of the dominant stressors throughout the East Branch Subwatershed. The primary driver to these impacts and loss of habitat is from altered hydrology. For additional information on how altered hydrology is a primary stressor within the Blue Earth River Watershed see Section 3.1.7 within this report.

Table 14. Habitat stressor summary table.

				Habitat				
WID	**Stream Name**	**Biological Stations**	**Impairment**	Channalized	Riparian	Streambed	Habitat diversity	Trampeling
East Branch								
623	Judicial Ditch 14	17MN368	M-IBI	•	•	•	•	
622	Thisius Branch	17MN365	F-IBI M-IBI	•	•	•	•	
556	Foster Creek	92MN076	M-IBI	•	•	•	•	
652	Blue Earth River, East Branch	17MN301	M-IBI*	•	•	•	•	
654	Brush Creek	01MN022 17MN374	F-IBI					
553	Blue Earth River, East Branch	15EM120 17MN359 17MN362 17MN314	F-IBI			•	•	
603	County Ditch 25	17MN360	F-IBI M-IBI	•	•	•	•	
669	County Ditch 8	17MN354	M-IBI	•	•	•	•	
628	County Ditch 26	17MN357	M-IBI	•	•	•	•	

4.2 Coon Creek

Figure 38. Coon Creek HUC 10 Subwatershed indicating biological impairments along with monitoring stations and AUIDs.



The Coon Creek Subwatershed is unique as only a portion of the 70,670 area/acre drainage area is assessed, due to a majority of the headwaters of this system beginning in Iowa. Streams that fall in the state of Minnesota will only be assessed for the purposes of this report. Land use within the Iowa portion as well as what is assessed in the Minnesota area of the watershed are agricultural dominant. Near the headwaters of the Coon Creek Watershed is the small town of Buffalo Center, with a population under 1,000. This is the only developed area throughout the watershed. Three stream AUIDs were found to have biological impairments, as shown in Figure 38. An additional impairment for *Escherichia coli* on AUID -648 that will not be addressed in this report. The furthest upstream AUIDs of -665 (10EM156) and -612 (17MN353) are assessed as modified streams due to the extensive channelization within this section of the Coon Creek Watershed, while the downstream AUID -648 (17MN313 and 92MN074) is assessed as general use.

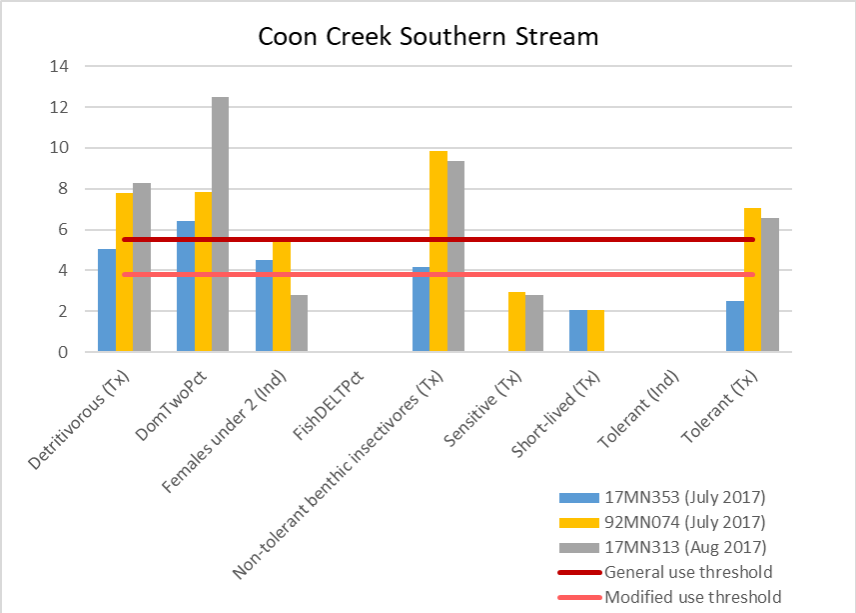
Figure 39. Condition of streams within the Cook Creek Subwatershed taken at the time on biological monitoring.

4.2.1 Biological communities

Coon Creek fish sample

Biological monitoring for fish occurred in summer of 2017. This resulted in the three fish impairments. All stations with fish impairments were categorized as warm-water southern streams. The upstream (headwaters) were assessed as modified use, due to ditching and channelizing, while the downstream WID of -648 is considered general use, due to the natural stream riparian and in channel features.

Figure 40. Fish community metrics for southern streams in the Coon Creek Subwatershed.



As shown in

Figure 40, there is a noticeable trend moving upstream to downstream in the fish assemblage, were there is a positive response throughout the community metrics. The only exceptions being found in female maturity and short lived species (highlighting reproduction and life cycle capabilities are slightly limited at 17MN313). All stations were classified as southern streams.

Macroinvertebrate sample

Figure 42. Impaired macroinvertebrate community within Coon Creek prairie streams with glide/pool features.

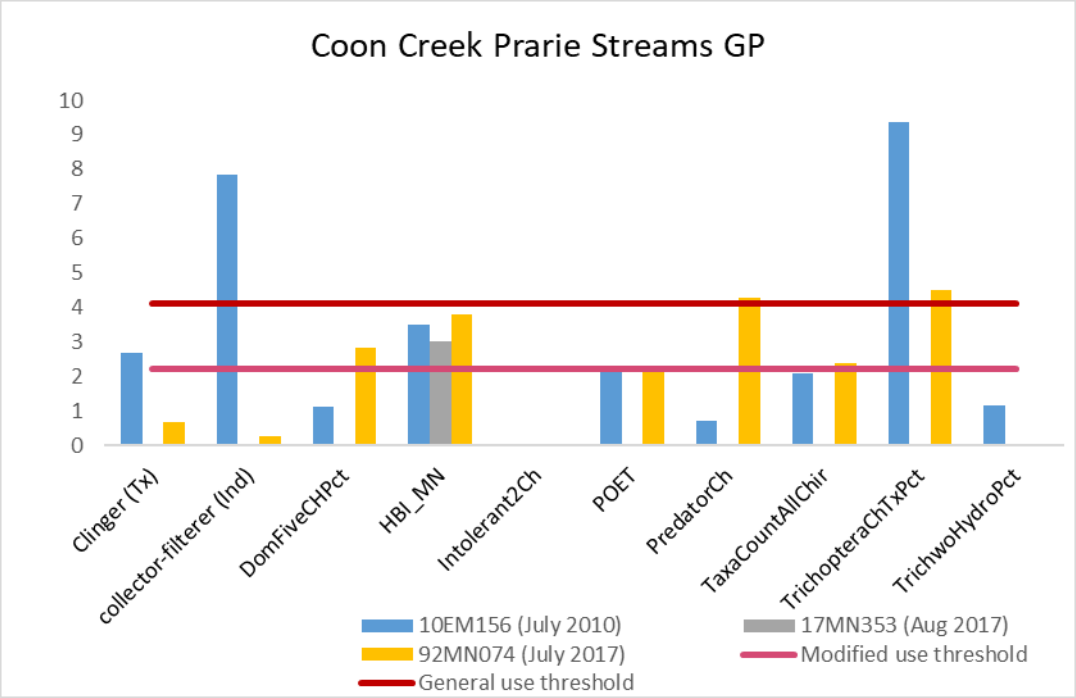
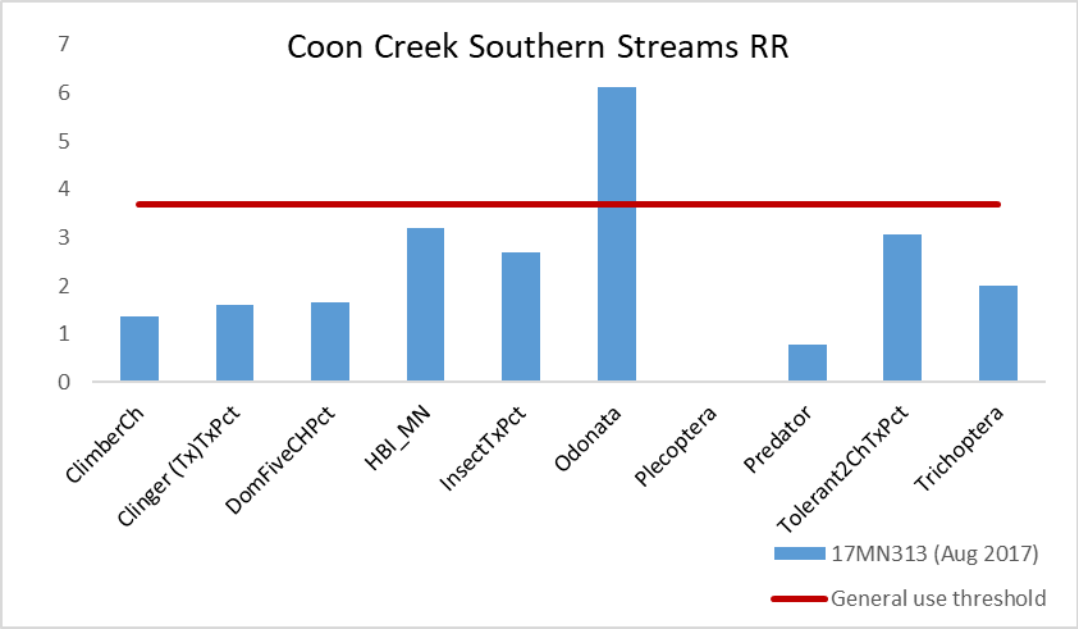


Figure 41. Impaired macroinvertebrate community within Coon Creek southern streams with riffle run features.



Coon Creek Subwatershed has three WIDs impaired for poor macroinvertebrate assemblage. Most biological monitoring stations fell into the prairie stream G/P class (Figure 42) the exception being

17MN313 at WID -648 designated as a southern stream R/R (Figure 41). While WID -648 is unique by having two biological stations on the same reach. These differences are accounted for by station 92MN074 being in the farthest upland area of the reach, before the gradient of the stream significantly changes. Whereas 17MN313 is the furthest downstream monitoring station, that is located at the outlet of the Coon Creek Subwatershed. As WID -648's gradient increased, so did the habitat features within the stream, allowing for the stream to be designated as both general use, and 17MN313 being places in an area of Coon Creek where riffle and run features were prevalent.

4.2.2 Dissolved oxygen and eutrophication

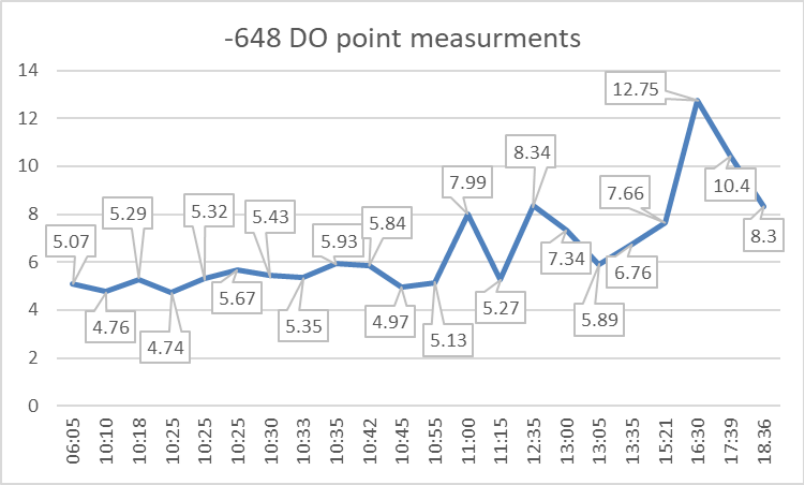
Throughout this report, eutrophication and low dissolved oxygen (DO) will be evaluated together; as a majority of these impairments are correlated together. Often chronically low DO is a direct byproduct of a eutrophic stream, or another upstream water source that discharges into the stream. This is due to the respiration of dense populations of autotrophic organisms (such as phytoplankton and algae). These freshwater organisms become overabundant due to high phosphorus input, as well as other physical conditions around the stream that will be discuses in the summary below.

At WID -665 (10EM156) Three dissolved oxygen readings in total were taken at this site during this monitoring cycle. Two were taken at the time of biological sampling (one at the time for fish and one other during the macroinvertebrate collection). Between the three samples, DO ranged from 7.3 mg/L to 12.4.

WID -612 (17MN353) DO was also limited to three readings. 6.88 – 13.89 mg/L. The highest reading could be an indication of high DO from an abundance of photosynthetic activity occurring during the day time.

At WID -648 Station 92MN074 and 17MN313 out of 20 samples between the two sides on this WID only 2 exceeded the .05 mg/L threshold for Phosphorus. DO at this WID strongly indicates chronic low DO issues. All samples shown in Figure 43 below, were taken all taken in the summer months of 2017 and 2018. The highest DO reading fell in spring months of April and May. There are not many early am readings, if there were it would likely display DO levels below 5mg/L on a regular basis.

Figure 43. Dissolved oxygen point measurements collected on WID -648.



Phosphorus

Table 15 displays a compilation of total phosphorus (TP) by stream WID within Coon Creek Subwatershed. Phosphorus collections were taken during summer months in 2017 (At the time of biological monitoring), 2018, and 2019. For additional comprehensive information of data collection (including exact location, times, and concentration) can be delivered upon request or by referring to the MPCA's "Surface Water Data" that's located on the MPCAs webpage.

Table 15. Condensed findings for total phosphorus per WID within the Coon Creek Subwatershed.

AUID	Stream Name	Biological Stations	Impairment	Number of samples.	Range of TP (mg/L)	Average of TP (mg/L	# of exceedances .15 mg/L
Coon Creek							
665	Judicial Ditch 13	10EM156	M-IBI	5	.06-.5	0.16	2
612	County Ditch 31	17MN353	F-IBI M-IBI	6	.03-.49	0.18	2
648	Coon Creek	92MN074 17MN313	F-IBI M-IBI	20	.03-.38	0.11	2

Data is listed from upstream to downstream. While samples are limited in the headwater portions, TP was found to be significantly higher than the threshold of .15 mg/L. It is important to point one that one sample from June 20, 2019 was taken after a rain fall, leading to extremely high phosphorus levels found at all three sites. These high levels may not be a chronic issue in the stream, it does show how vulnerable the system here is after a rain event. While this may not be indicative of base flow conditions, it does show the vulnerability of these streams to phosphorus loading from nearby land use practices and potential upstream instabilities.

Figure 44 below displays strong evidence of eutrophic conditions at the headwater streams of WID -655 and -612. This is particularly evident in the filamentous benthic and floating algae. While the monitoring locations at WID -648 did not show as much filamentous algae, it was still noted during the time of biological monitoring. There is a fair amount of detritus build up within this reach. In addition to filamentous algae noted during every biological monitoring event.

Figure 44. Condition of Coon Creek monitoring sites in order of upstream to downstream.

Table 16. Impaired fish communities within the Coon Creek Subwatershed displaying metrics for Eutrophication and low DO stress.

Coon Creek Southern Streams	Station (Year sampled)	DarterPct	OmnivorePct	SLithopPct	SensitivePct	TolPct	CountofTaxa	DO TIV
07020009-612	17MN353 (2017)	6.03	28.06	53.92	0.00	91.38	15	8.61
07020009-648	92MN074 (2017)	5.72	29.04	45.40	1.35	91.70	19	8.53
	17MN313 (2017)	10.97	26.88	26.76	1.79	85.11	20	8.60
Passing Streams Average	**Southern Streams General use**	11.9	17.7	37	16.9	44.9	19	8.56
	Southern Streams Modified use	*9.9*	*20.6*	*31.7*	*10.3*	*57.4*	*18*	*8.41*
	Expected response to stress	↓	↑	↓	↓	↑	↓	↓

Shown in Table 16, WID -612 does indicate some eutrophic/DO displacement within the fish community, however overall this community is primarily made up of tolerant species. The presence of lithophilic spawners is encouraging to see and indicate some degree of good streambed substrate. The overabundance of omnivores are the strongest indicator of eutrophic conditions influencing the fish community.

Going further downstream to WID -648 there is a slightly higher signal of Eutrophic and DO stress at station 17MN313. This is primarily noted in habitat degradation and loss in darters as well as lipophilic spawners. Based on metrics alone within the fish community it is difficult to determine of eutrophic conditions are impacting habitat needs, or if it's another stressor such as TSS. Between the two sites that represent this reach, there were three metrics that technically did not go past the threshold. However, it is important to note that these three metrics were just at the thresholds.

Table 17. Macroinvertebrate metrics for low DO in impaired prairie streams with glide/pool features on top; Southern Streams on bottom within the Coon Creek Subwatershed. Metrics over the threshold are highlighted in red.

Coon Creek	Station (Year sampled)	Taxa Count	EPT	Trichoptra	Sensitive Tricoptra	HBI_MN	DO Index	% DO tolerant	% DO Intolerant
07020009-665	10EM156 2017)	26	30.42	15.38	0.32	7.80	6.88	1.29	2.27
07020009-612	17MN353 (2017)	8	0.00	0.00	0.00	7.95	6.90	0.62	0.00
07020009-648	92MN074 (2017)	27	33.44	7.41	0.00	7.66	5.99	0.63	1.26
Passing Streams Average	**Prarie Streams General use**	36.8	38.45	10	5.5	7.55	7.04	25.1	5
	Prarie Streams Modified use	*33.59*	*20.58*	*5.71*	*4.76*	*8*	*6.19*	*31.37*	*2*
	Expected response to stress	↓	↓	↓	↓	↑	↓	↑	↓
Coon Creek	Station (Year sampled)	Taxa Count	EPT	Trichoptra	Sensitive Tricoptra	HBI_MN	DO Index	% DO tolerant	% DO Intolerant
07020009-648	17MN313 (2017)	29	55.25	13.79	6.48	7.25	7.30	0.62	22.46
Passing Streams Average	**Southern Streams General use**	31	42.6	18.72	5.48	7.09	7.04	9.06	24.01
	Expected response to stress	↓	↓	↓	↓	↑	↓	↑	↓

Similar to the fish metrics that correlate with DO, the headwater section of Coon Creek did not signal a strong correlation of stress within the macroinvertebrate community in comparison to the furthest downstream locations (Table 17). Site 17MN353 had very few taxa, leaving inaccurate metrics due to the low population size. Once again monitoring station 92MN074 consistently showed a tolerant community, with an excess of filter feeders paired with a decrease of intolerant species. Station 17MN313 (Table 17) yielded a better score in regards to DO. While the overall Trichoptera group was slightly down, the intolerant species were at a sufficient level. Sensitive Ephemeroptera as well as Plecoptera are at expected levels here. The DO intolerant make-up by percentage in the sample did fall below the threshold of 24%, missing the threshold by just 1.55%.

Out of all the macroinvertebrate metrics related to DO, station 92MN074 displayed the strongest negative correlation. In both fish and macroinvertebrates.

Table 18. Macroinvertebrate metrics for Eutrophic impaired prairie streams with glide/pool features on top, and southern streams on the bottom within the Coon Creek Subwatershed. Metrics over the threshold are highlighted in red.

Coon Creek	Station (Year sampled)	% Scraper	CrustMollPct	Tanytarsini Pct	Phos Index	% Tolerant	% Intolerant	%Gen Tolerant
07020009-665	10EM156 2017)	26	30.42	15.38	0.32	7.80	6.88	1.29
07020009-612	17MN353 (2017)	95	95.38	0.00	0.15	0.30	0.00	100.00
07020009-648	92MN074 (2017)	31	35.64	2.32	0.12	6.94	0.32	59.30
Passing Streams Average	**Prarie Streams General use**	*16.1 1*	*11.78*	*18.46*	*0.13*	*30.6*	*3.8*	*61.78*
	Prarie Streams Modified use	17.73	*23.21*	*22.11*	*0.14*	45.87	*1.79*	*73.64*
	Expected response to stress	↑	↑	↑	↑	↑	↓	↑

Coon Creek	Station (Year sampled)	% Scraper	CrustMollPct	Tanytarsini Pct	Phos Index	% Tolerant	% Intolerant	%Gen Tolerant
07020009-648	17MN313 (2017)	9	21.60	28.02	0.13	1.54	0.00	48.45
Passing Streams Average	**Southern Streams General use**	15	9.64	28.02	0.12	19.12	5.82	49.64
	Expected response to stress	↑	↑	↑	↑	↑	↓	↑

The macroinvertebrate community indicated some level of eutrophic stress at all monitoring locations. -612 is difficult to evaluated for this parameter as the sample size was limited to 8 taxa types and was made solely of general tolerant macroinvertebrate. However, based on the density if scrapers and filtering species, eutrophication does seem to be influencing the community. The strongest signals being noted at the beginning of the WID 92MN074 (Table 18). The furthest downstream site of 17MN313 showed some signals of suspended algae influencing the community in the high filter feeder population. Tanytarsini was right at the threshold, indicating some degree of detritus build up. There were not any specific eutrophic intolerant, nor tolerant. In addition, the general tolerant population was at an acceptable level. Given the location of the site, it is more than likely being influenced from the upstream sources that were shown to be eutrophic in photo documentation (

Figure 39 and Figure 44).

4.2.3 Coon Creek DO/Eutrophication summary

WID -665 is an isolated impairment for macroinvertebrate on at the headwaters of JD 13 at station 10EM156. Throughout the monitoring season, there was clear overgrowth of filamentous algae throughout the stream. In addition, phosphorus level were extremely high throughout the Coon Creek Subwatershed, including at this monitoring location with phosphorus levels as high as .5mg/L. There was little DO data to show how low DO levels can go or how they respond to the eutrophic conditions, although further downstream there are clear issues with DO, that logically points to this WID playing some role into that. However, the macroinvertebrate community did show a community that is being driven by eutrophic conditions.

On the secondary branch within Coon Creek is WID -612 on County Ditch 31 that had both a fish and macroinvertebrate impairment. This station had similar characteristics to the previous discussed WID. There was some buildup of detritus as well as filamentous algae. At both monitoring events, algae mats were noted throughout the stream. While there was not any low DO observed within the small sample set, there was a high value that could be reflecting an overabundance of photosynthetic activity happening in the early afternoon. As is this case with WID -665, shortly upstream from this site there are clear low DO values found in a more robust data set. It is reasonable to assume that this section if stream is playing a role into those low DO values. While phosphorus was limited, there was clear indications of TP overloading with values as high as .49 mg/L (well above the .15 mg/L threshold). Fish metrics indicated some degree of eutrophic displacement. The macroinvertebrates were extremely poor with a taxa count of eight, the majority of which are algae eaters. It is clear that eutrophication is playing a role in the decline of the biological communities. It is also likely that the downstream station of -648 is representative in DO of what is also occurring here.

The furthest downstream WID of -648 on Coon Creek is located at the outlet of the HUC 10 subwatershed, with two monitoring stations. One station is positioned at the start of this WID (92MN074), as well as one at the outlet (17MN313). The stream features change significantly from modified to a more natural channel moving towards the outlet. This station was impaired for both fish and macroinvertebrates. There were physical characteristics noted throughout the monitoring period that noted eutrophic conditions. Low DO was clearly a problem, as previously discussed as was evidence of TP over loading showing a response within both the fish and macroinvertebrate community of low DO and eutrophic stress.

Table 19. Dissolved oxygen and eutrophication stressor summary table for the Coon Creek Subwatershed.

				gs. Dissolved Oxygen				Eutrophication		
WID	**Stream Name**	**Biological Stations**	**Impairment**	Dissolved Oxygen	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland/Lake influcence	Excess Phosphorus	Unidentified
	Coon Creek									
665	Judicial Ditch 13	10EM156	M-IBI	•			•		•	
612	County Ditch 31	17MN353	F-IBI M-IBI	•					•	
648	Coon Creek	92MN074 17MN313	F-IBI M-IBI	•					•	

4.2.4 Nitrate

Nitrate concentrations in Coon Creek are shown to reach concerning levels. While the overall sample set is not large, yet roughly half of what was collected exceeded the proposed aquatic life standard in addition to the drinking water threshold. As shown in Table 20, the average concentrations fell around 8 mg/L throughout all reaches in the subwatershed.

Table 20. Nitrate concentrations within the Coon Creek Subwatershed.

WID	Stream Name	Biological Stations	Impairment	Number of samples.	Range of Nitrate (mg/L)	Average of Nitrate (mg/L)	# of exceedances 4.9 mg/L	# of exceedances 10 mg/L
	Coon Creek							
665	Judicial Ditch 13	10EM156	M-IBI	6	3.2-14	8.71	4	3
612	County Ditch 31	17MN353	F-IBI M-IBI	7	2.4-12	7.38	4	3
648	Coon Creek	92MN074 17MN313	F-IBI M-IBI	12	1.8-13	8.1	7	6

Biology

When evaluating nitrate impacts to biology, fish response (beyond physical alterations of DELTs) are poorly understood. The macroinvertebrate community response provides a stronger line of evidence to nitrate toxicity within the stream. One of the primary communities looked at to determine if nitrate toxicity has occurred is the sensitive orders of Ephemeroptera, Plecoptera & Trichoptera (ETP). Previously (under eutrophic/low DO) this metric was assessed as dominance within the total samples population (as a percentage), here individual taxa counts are evaluated in assessing for nitrate toxicity. The nitrate index, as well as weighing the nitrate specific tolerant and intolerant dominance highlight shifts within the sample. As shown, all stations fell below the passing average for EPT taxon diversity. There was a clear nitrate dominant community at both WID -665 as well as -648. WID -612 had an inadequate taxa count, making a specific determination of nitrate toxicity impossible.

Table 21. Macroinvertebrate metrics within the Blue Earth River Subwatershed, with Prairie Streams on top and southern streams on the bottom. Red highlighted metrics indicate over the threshold.

Coon Creek	Station (Year sampled)	Taxa Count	EPT#	Nitrate Index	% Nitrate tolerant	% Nitrate Intolerant
07020009-665	10EM156 (2017)	26	5.00	3.98	92.56	0.00
07020009-612	17MN353 (2017)	8	0.00	9.33	0.62	0.00
07020009-648	92MN074 (2017)	27	4.00	4.56	0.63	0.00
Passing Streams Average	**Prarie Streams General use**	37	*11.5*	*3.23*	*54.86*	*3.18*
	Prarie Streams Modified use	24	*7.6*	*3.32*	*59.41*	*1.95*
	Expected response to stress	↓	↓	↑	↑	↓
Coon Creek	Station (Year sampled)	Taxa Count	EPT#	Nitrate Index	% Nitrate tolerant	% Nitrate Intolerant
07020009-648	17MN313 (2017)	29	6.00	4.30	51.08	0.31
Passing Streams Average	**Southern Streams General Use**	31	*6.9*	*2.95*	*47.6*	*2.92*
	Expected response to stress	↓	↓	↑	↑	↓

Concentrations throughout the Coon Creek Subwatershed show high concentrations in all locations sampled. The macroinvertebrate metrics show a clear negative response of nitrate within the community at both the furthest upstream tributary of WID -665 and the mainstem of Coon Creek at WID -648. However, due to the low number of total taxa at station 17MN353 at WID -612 nitrate was listed as inconclusive as the biological metrics are not reliable with a small sample set. Additional monitoring at this location is recommended to verify nitrate stress.

Table 22. Nitrate stressors throughout Coon Creek Subwatershed; red highlights nitrate stressor, blue marks inconclusive.

				Nitrate			
AUID	**Stream Name**	**Biological Stations**	**Impairment**	Land Use (application)	Upstream waterbody	Point Souce	Unidentified
	Coon Creek						
665	Judicial Ditch 13	10EM156	M-IBI	●			
612	County Ditch 31	17MN353	F-IBI M-IBI	●			
648	Coon Creek	92MN074 17MN313	F-IBI M-IBI	●			

4.2.5 Total suspended solids

Total suspended solids (TSS) was analyzed along with total suspended volatile solids (TSVS), in effort to evaluate organic contributions along with sediment. The furthest upstream WID -665 had relatively low TSS concentrations out of the modest data set, with organic contributions falling within the expected level. The next tributary of County Ditch 31 also had a small data set on WID -612, TSS concentrations did exceed the standard of 45 mg/L twice out of the five samples. This signals that this stream likely is vulnerable to TSS overloading. The mainstem of Coon Creek had a strong data set, with 20 samples. Only three of those exceeded the 45 mg/L standard. While there were not many exceedances out of the total sample set, the concentrations that did reached concerning levels with the highest at 97 mg/L.

Table 23. TSS concentrations within the Coon Creek Subwatershed.

WID	Stream Name	Biological Stations	Impairment	# of TSS samples	# of TVS samples	Range of TSS (mg/L)	Range of TVS (mg/L)	Average of TSS (mg/L)	% TSVS made up TSS (Average)	# of exceedances 45 mg/L
	Coon Creek									
665	Judicial Ditch 13	10EM156	M-IBI	5	5	4.4-31	2.4-9.56	54.88	25.28	0
612	County Ditch 31	17MN353	F-IBI M-IBI	5	5	3.2-75	2-12	42.64	25.5	2
648	Coon Creek	92MN074 17MN313	F-IBI M-IBI	20	10	4.8-97	1.6-15	27.36	20.79	3

Fish TSS metrics

The mainstem of Coon Creek (WID -648) in addition to CD 31 (WID -612) were both impaired for fish assemblage. Metrics that show TSS displacement were slightly mixed between the two streams. WID -612 on station 17MN353 scored adequately with metrics that often highlight TSS driven habitat stress; benthic feeders, herbivores, riffle dwellers, and lithophilic spawners were within acceptable ranges. Coon Creek's mainstem on the other hand scored poorly across all parameters, in particularly the furthest downstream site if 17MN313. Centrarchidae and Perciforms are two orders that do not thrive well in high TSS conditions. In addition the overall specific TSS intolerant and sensitive species were missing from both streams.

Table 24. Fish metrics for TSS in the Coon Creek Subwatershed. Red highlighted metrics indicate over the threshold.

Coon Creek	Station (Year sampled)	Benthic Feeders Pct	Sensitive Centrarchidae Pct	Herbivores Pct	Intolerant Pct	Long Lived Pct	Sensitive Perciformes Pct	Riffle Pct	Sensitive Pct	Lithophilic Spawners Pct	TSS TIV
07020009-612	17MN353 (2017)	34.56	0.00	26.57	0.00	0.00	6.03	26.49	0.00	25.39	15.66
07020009-648	92MN074 (2017)	34.64	0.00	31.05	0.00	2.13	5.94	31.61	1.35	26.23	8.53
	17MN313 (2017)	23.07	0.22	15.45	0.00	2.80	11.31	16.69	1.79	15.57	8.62
Passing Streams Average	**Southern Stream General Use**	36.02	5.37	25.68	4.24	13.58	20.09	30.18	16.89	19.11	17.59
	Southern Stream Modified Use	29.70	3.12	21.65	2.07	10.30	15.39	24.42	10.30	15.02	19.19
	Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

Nearly all the metrics that identify TSS stress within the macroinvertebrate community are highlighted across all monitoring locations. The exception being the overall TSS index that scored just below the threshold. Due to the poor taxa count at WID -512, community metrics are not useful here. The lack of long lived species can be an indication of frequent disturbance, just as high TSS following rain events. Both orders of Plecoptera as well as Ephemeroptera were lacking. Overall there was a complete lack of TSS intolerant species with TSS tolerant slightly dominating the population.

The furthest upstream monitoring site showed a higher response to TSS stress, this is likely from the streams erodibility as the gradient picks up, in addition to taking on higher velocity's from upstream drainage practices. While there is potential for TSS to cause some stress at the upstream locations, the results were slightly mixed in addition to a small data set, leading to inconclusive findings.

4.2.6 Habitat

Station 10EM156 on WID -665 of Judicial Ditch 13 has been physically altered by way of channelizing and ditching. With this process many features of the stream have been lost. However, as a modified stream this site scored well during the site assessment. The riparian around this section of stream is extensive, helping provide more stability. As a result bank erosion was minimal at this location. Within the stream there was diverse habitat features that are noted in the ruffle, runs, and pools with heavy shade from canopy cover. While there was some embeddedness in areas of the stream bed, there was clean substrate noted. The fish community did well here as they community was not found to be impaired. The macroinvertebrate habitat type groups do show a slight skew is distribution in legless and sprawlers.

Table 26. Macroinvertebrate metrics within the Coon Creek Subwatershed; Prairie stream class on top with the Southern Stream class on bottom. Red highlighted metrics indicate over the threshold.

Coon Creek	Station (Year sampled)	Taxa Count	%Long Lived	%Plecoptera	Ephemeroptera Count	TSS Index	% Tolerant	% Intolerant
665	10EM156 (2017)	26	0.00	0.00	1.00	15.98	50.49	0.00
612	17MN353 (2017)	8	0.31	0.00	0.00	24.32	94.77	0.00
648	92MN074 (2017)	27	1.26	0.00	2.00	16.62	58.36	0.00
Passing Streams Average	**Prarie Stream general use**	37	7.5	0.2	6.7	17.35	48.28	2.67
	Prarie Stream modified use	24	6.0	0.1	4.8	16.02	35.60	1.27
	Expected response to stress	↓	↓	↓	↓	↑	↑	↓
Coon Creek	Station (Year sampled)	Taxa Count	%Long Lived	%Plecoptera	Ephemeroptera Count	TSS Index	% Tolerant	% Intolerant
648	17MN313 (2017)	29	0.62	0.00	2.00	17.37	47.69	0
Passing Streams Average	**Southern Stream RR general use**	31	8.99	0.54	6.04	15.87	35.22	5.06
	Expected response to stress	↓	↓	↓	↓	↑	↑	↓

Table 25. TSS findings within the Coon Creek Subwatershed; red indicates TSS as a stressor, blue is inconclusive.

WID	Stream Name	Biological Stations	Impairment	TSS			
				Suspended Algae	Flow Alterations	Stream Bank Erosion	Pasture
Coon Creek							
665	Judicial Ditch 13	10EM156	M-IBI		•		
612	County Ditch 31	17MN353	F-IBI M-IBI		•		
648	Coon Creek	92MN074 17MN313	F-IBI M-IBI		•	•	

While there are some indication of habitat displacement in the community (leading to inconclusive findings as a stressor), this station could improve and potentially upgrade to the general use class in time if left undisturbed.

WID -612 on County Ditch 31 in another modified stream as a result of channelization for agricultural purposes. Two separate habitat assessment at this location confirmed degraded habitat features. Stream features here homogenous, with very little pool areas for refuge. In addition to lack of pool features, there was little noted for overhanging canopy. Neither site visit noted any visible course substrate and high siltation. Overall stability and bank erosion was not rated as being a primary habitat concern. As shown previously in Table 24 that evaluated for potential habitat displacement from TSS and sediment build up, the fish community that dependent on clean substrate did not seem to be impacted within the sample. However, they all fell just about the threshold for the low modified threshold. The downstream reached that appear to have more diversity in habitat could be influencing the fish community that was sampled here. Looking at the macroinvertebrate habitat group metrics, there was a clear imbalance in habitat diversity as nearly the entire population fell into the “climber” or “legless” groups. This further highlights this sites inability to support habitat diversity needs. Habitat is considered a stressor at this location.

The mainstem of Coon Creek (WID – 648) two monitoring stations fell under separate stream classifications in assessing macroinvertebrates due to the staggering differences between the sites. The furthest upstream site that is at the start of this WID is 92MN074 categorized as a prairie stream. Habitat conditions are greatly influenced here for the upstream locations. Here, the stream begins to form its natural stream features as the riparian widens and the stream meanders trying to establish energy equilibrium. Erosion and siltation and fine sediments are noted here. Moving downstream along this WID conditions improve significantly. The outlet site of 17MN313 has strong habitat availability. Diversity is noted in the riffle, run, and pool features that are made up of a variety of substrate types. The cover is also noted as substantial providing additional refuge. The TSS section of this assessment found that benthic feeders were just below the threshold at both locations while herbivores, riffle dwellers, and lithophilic spawners varied between the two locations within this WID, but were not absent at either location. The macroinvertebrate metrics in Figure 45 show that overall both communities fell within the expected compilation and distribution. Due to the large variation between the upstream and downstream station that represent WID -648, habitat is listed as inconclusive.

County Ditch 31 is the only site where there was conclusive evidence to show that habitat is limiting biology, with the primary driver being altered hydrology.

Figure 45. Macroinvertebrate Habitat group metrics; Prairie stream class on left with Southern Stream on the right.

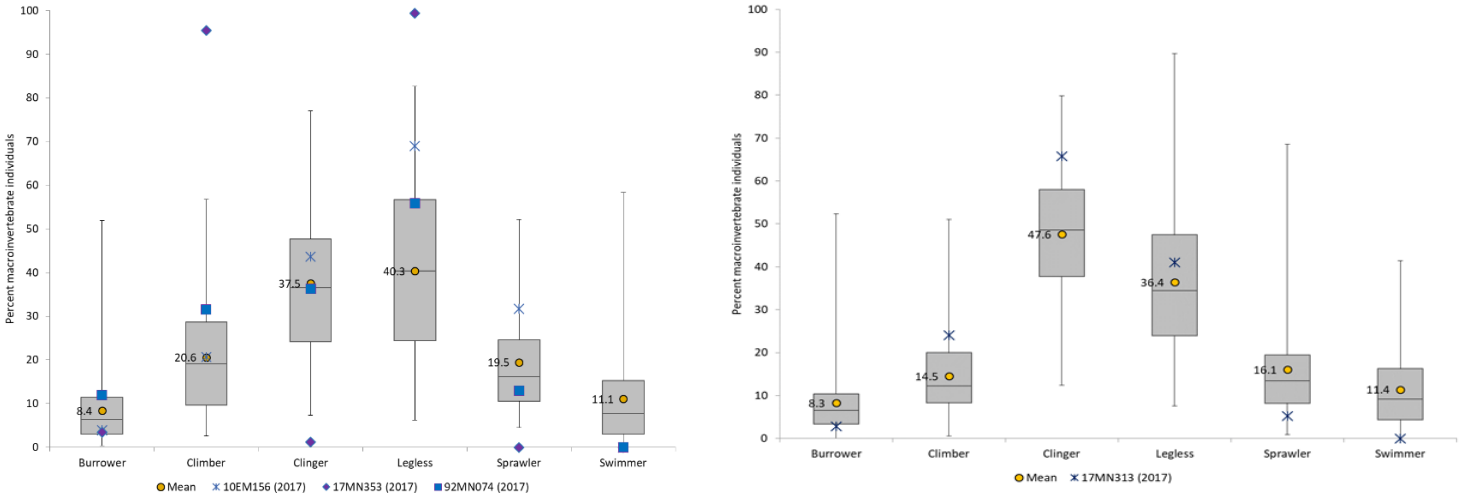
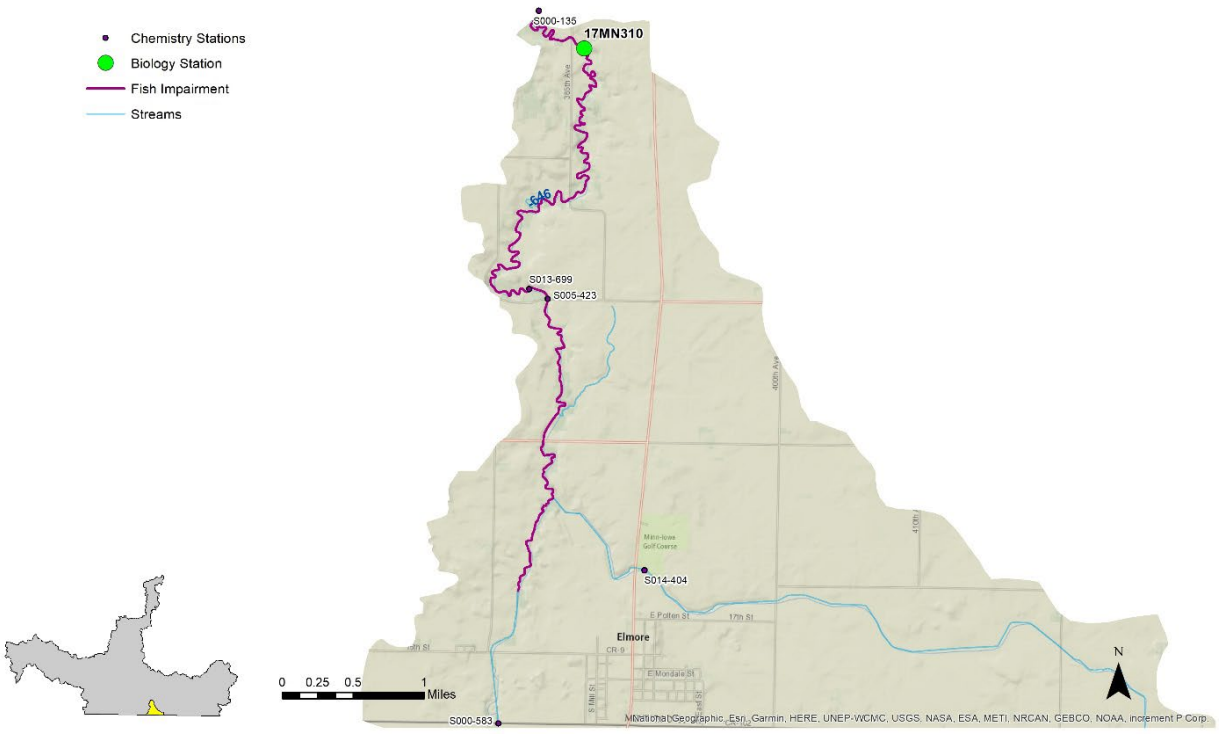


Table 27. Habitat stressors throughout the Coon Creek Subwatershed; red indicates stressor, blue marks inconclusive.

				Habitat				
WID	**Stream Name**	**Biological Stations**	**Impairment**	Channalized	Riparian	Streambed	Habitat diversity	Trampeling
	Coon Creek							
665	Judicial Ditch 13	10EM156	M-IBI					
612	County Ditch 31	17MN353	F-IBI M-IBI	●	●	●	●	
648	Coon Creek	92MN074 17MN313	F-IBI M-IBI					

4.3 Middle Branch

Figure 46. Map outlining Middle Branch Blue Earth River with stream WIDS and monitoring sited identified.



The Middle Branch Subwatershed is located in Southern Minnesota, with the two headwater streams beginning in Northern Iowa (Figure 46). The majority of Middle Branch is in Iowa, with less than a quarter of the entire 110 square mile HUC 10 subwatershed falling within Minnesota. Monitoring only occurred within the Minnesota boundaries. There were four sites sampled for both fish and inverts, with only one resulting in a biological impairment for fish at the farthest downstream 17MN310, collected on August 2, 2017. The majority of the stream system is natural channel. There is one small town (Elmore) upstream on the impaired biological site.

4.3.1 Biological communities

Middle Branch fish sample

Monitoring station 17MN310's fish community failed to meet the threshold for general use. White suckers dominated the sample. The average taxa had about 20 individuals collected, where white suckers was made up of 377 individuals. As shown in Figure 47, there was found to be an imbalance of sensitive and tolerant individuals.

Figure 47. Fish community metrics for southern streams in the Middle Branch Subwatershed.

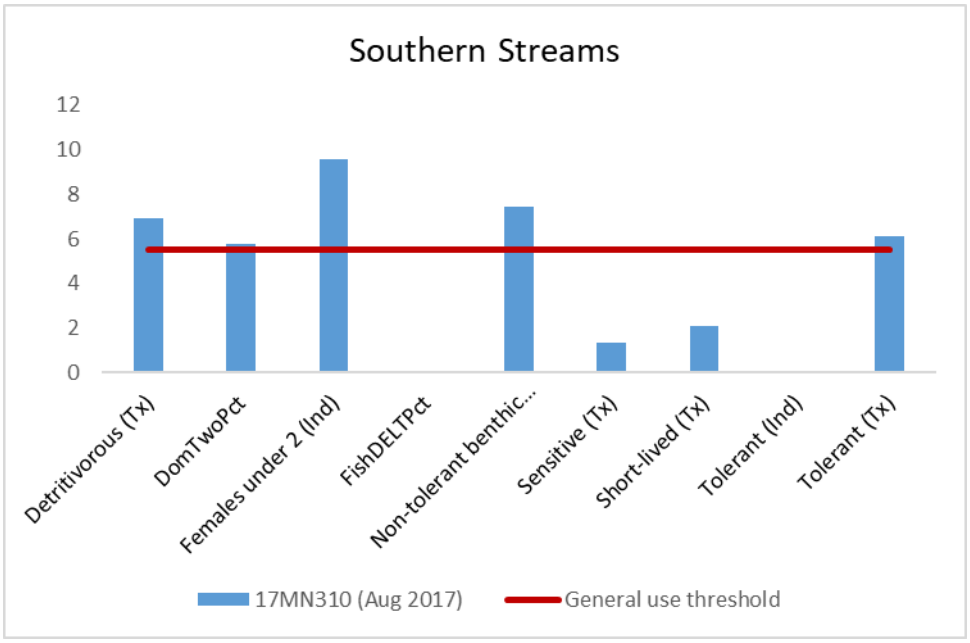


Figure 48. Condition of station 17MN310, taken during the fish sample on August 2, 2017

Macroinvertebrate communities will not be fully annualized as none of the samples within this subwatershed resulted in a macroinvertebrate impairment. In some cases the macroinvertebrate metrics of station 17MN310 may be used to see if there is some signal of displacement from a specific parameter.

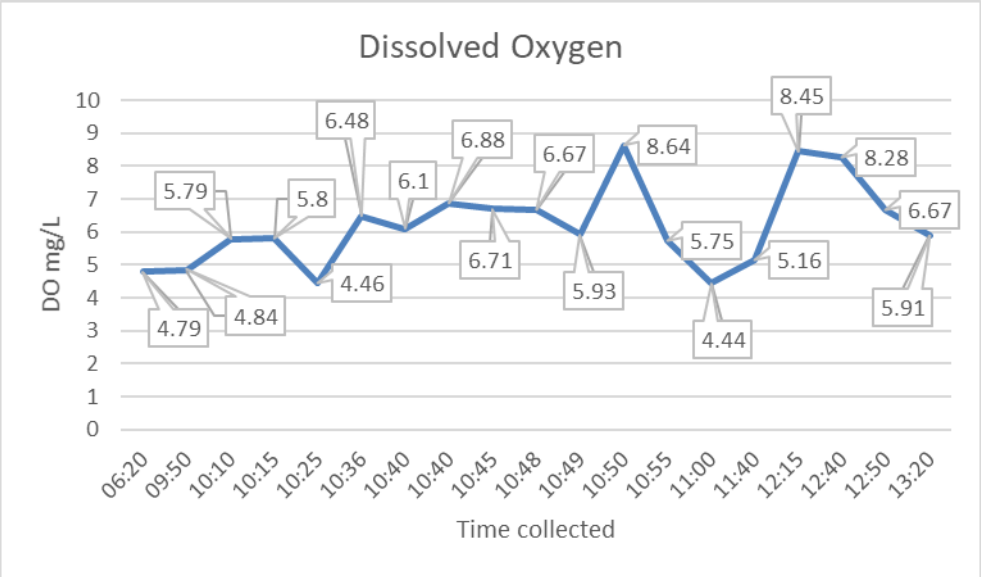
4.3.2 Dissolved oxygen and eutrophication

Chemistry

Dissolved oxygen (DO) data was limited to just grab samples. Continuous DO data was not collected during this monitoring cycle.

WID -646 had a large enough single point DO data set to observe that low DO is likely a chronic issue. Out of the 19 DO samples, 4 fell below the DO standard of 5 mg/L, while a majority of the others fell just above the standard. Based on single grab samples such as these, it is difficult to determine if extreme DO fluctuation is frequently occurring. In addition to the DO levels noted in Figure 49, DO was measured at the time of the fish sample was high with a reading of 15.42 mg/L taken at 14:47. This higher reading taken in mid-afternoon does indicate that DO flux is feasible.

Figure 49. Grab samples for DO taken at station 17MN310 to correlate DO with the time of day (in military time).



Phosphorus

Table 28 shows samples for total phosphorus were collected in the summer of 2017 and 2019. Three of the 16 samples analyzed for TP exceeded the southern stream standard of TP of .15 mg/L. Each exceedance was associated with a rain event. Most samples fell close to 1 mg/L.

Table 28. Findings for total phosphorus on WID -646 in the Middle Branch Subwatershed.

AUID	Stream Name	Biological Stations	Impairment	Number of samples	Range of TP (mg/L)	Average of TP (mg/L	# of exceedances .15 mg/L
Middle Branch							
646	Blue Earth River, Middle Branch	17MN310	F-IBI	16	.05-.44	0.13	3

At the time of the biological sample, it was documented that there was deteriorating floating algae as well as benthic algae throughout the stream. The low DO levels in early mornings through early afternoon, paired with the susceptibility of phosphorus overloading (particularly after rain events) indicate eutrophic conditions. Other physical conditions to note that leave this stream vulnerable is the poor riparian coverage on this modified low gradient stream.

Fish sample

As shown in Table 29 most of the fish community was made up of general tolerant species, even with a healthy distribution of taxa types. Omnivores (that are opportunistic in their eating habits relying on some degree of vegetation) made up nearly half of the sample. Darters depend on clear water quality, as well as some rock substrate for habitat needs. The lack of darters found in this reach is of concern. With what is known about the chemistry data, as well as documentation at the time of sample, DO and eutrophication are playing some role in limiting the biology within this reach.

Table 29. Impaired fish WID -646 within the Middle Branch Subwatershed displaying metrics for eutrophication and low DO stress.

Coon Creek Southern Streams	Station (Year sampled)	DarterPct	OmnivorePct	SLithopPct	SensitivePct	TolPct	CountofTaxa	DO TIV
07020009-646	17MN310 (2017)	4.33	49.94	59.58	0.99	91.97	21	8.53
Passing Streams Average	**Southern Streams General use**	11.90	17.70	37.00	16.90	44.90	19	8.56
	Expected response to stress	↓	↑	↓	↓	↑	↓	↓

Summary

At the time of monitoring, algae mats and benthic algae were noted throughout the WID. In addition low DO levels are believed to be driven by eutrophic conditions to some degree. However, as low DO was noted at later times in the day as well there could be other low DO drivers as well that went undetected during the time of assessment. Phosphorus loading can occur in significant concentrations here, particularly after rain events. In addition to the physical and chemical indications, the fish community did show some degree of eutrophic stress as well as low DO tolerance. With the macroinvertebrates not being impaired, and especially not showing signaling of any displacement that can occur in feeder types and habitat needs, it's not likely that these stressors are a primary or even a large obstacle for the fish. However, with physical conditions, chemistry, and the community makeup showing what it did at this assessment low DO and eutrophication are driving the fish community to some level.

Table 30. Summary of dissolved oxygen and eutrophic stress in the Middle Branch Subwatershed, red cells indicate a stressor.

				Dissolved Oxygen				Eutrophication		
WID	**Stream Name**	**Biological Stations**	**Impairment**	Dissolved Oxygen	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland/Lake influcence	Excess Phosphorus	Unidentified
	Middle Branch									
646	Blue Earth River, Middle Branch	17MN310	F-IBI	•					•	

4.3.3 Nitrate

Nitrate values are of concern in this reach. Table 31 shows values frequently exceeded concentrations of 4.9 mg/L (the proposed aquatic life threshold). Regardless of the small sample size for nitrate, it is of concern that half of the time nitrate levels exceeded 10 mg/L (human health standard), leaving an average of 9.26 mg/L.

Table 31. Nitrate concentrations in the Middle Branch.

AUID	Stream Name	Biological Stations	Impairment	Number of samples.	Range of Nitrate (mg/L)	Average of Nitrate (mg/L)	# of exceedances 4.9mg/L	# of exceedances 10mg/L
	Middle Branch							
646	Blue Earth River, Middle Branch	I7MN310	F-IBI	6	1.2-19	9.26	4	3

Biological

Fish metrics are not yet developed to identify a community nitrate response, therefore macroinvertebrate metrics are the only biological indicator used here (Table 32). There is high diversity noted in the macroinvertebrate types at this location. There was a fair number of nitrate sensitive Ephemeroptera, Plecoptera & Trichoptera (ETP). However, further evaluation shows that this count is brought up by a series of net spinning caddisfly's that are generally tolerant, often found to withstand higher nitrate concentrations.

Table 32. Macroinvertebrate metrics for the Middle Branch, red highlighted metrics indicate over the threshold.

Middle Creek Southern Streams	Station (Year sampled)	Taxa Count	EPT#	Nitrate Index	% Nitrate tolerant	% Nitrate Intolerant
07020009-646	17MN310 (2017)	39	11.00	3.50	62.66	0.00
Passing Streams Average	*Prarie Streams Modified use*	24	*7.6*	*3.32*	*59.41*	*1.95*
	Expected response to stress	↓	↓	↑	↑	↓

The overall community is shown to be nitrate tolerant with a complete lack of nitrate sensitive species. The biologic indicators along with nitrate levels nearing 20 mg/L indicate nitrate toxicity is a stressor. Upstream there are two WWTP from two different small towns that discharge into the headwaters. (This is not to indicate that these permitted facilities are not in compliance, merely the potential for nitrate contribution).

Table 33. Summary of nitrate stress in the Middle Branch Subwatershed

AUID	Stream Name	Biological Stations	Impairment	Nitrate			
				Land Use (application)	Upstream waterbody	Point Souce	Unidentified
Middle Branch							
646	Blue Earth River, Middle Branch	17MN310	F-IBI	•		•	

4.3.4 Total suspended solids

Total suspended solids (TSS) was evaluated along with total suspended volatile solids (TSVS) to evaluate for organic contributions in addition to sediment (Table 34). Overall there is not a high response. TSS as a whole was of concern as readings reached 120 mg/L. This largest measured concentration was collected shortly after a rain event. The three other exceedances remained in the double digits, slightly hovering above the threshold (46mg/L, 65mg/L, and 70 mg/L).

Table 34. TSS concentrations within the Middle Branch Subwatershed.

WID	Stream Name	Biological Stations	Impairment	# of TSS samples	# of TVS samples	Range of TSS (mg/L)	Range of TVS (mg/L)	Average of TSS (mg/L)	% TSVS made up TSS (Average)	# of exceedances 45 mg/L
Middle Branch										
646	Blue Earth River, Middle Branch	17MN310	F-IBI	16	6	8-120	2.8-10	33.2	24.37	4

Fish TSS metrics

Fish metrics to evaluate for total suspended solids (TSS) is slightly mixed. Fish groups that are used to evaluate TSS impacts to habitat are often noted in lack of benthic feeders, herbivores, riffle dwellers, and lithophilic spawners. Across all of these habitat groups (noted in

Table 35) there is not an indication that sediment is prohibitive to habitat needs. Despite these findings within the habitat groups, there were some other metrics that highlighted some concern. TSS sensitive sunfish (Centrarchidae) as well as Perciformes where lacking. Long lived species were sparse. This is important to highlight as this can point to a disruptive event within the stream that would limit the populations (typically from significant TSS loading rapidly going through after a strong rain event). There are hardly any TSS sensitive species present. The overall community tolerance index value scored just above the threshold.

Table 35. TSS metrics within the Middle Branch Subwatershed. Red highlights metric over the threshold.

Middle Branch	Station (Year sampled)	Benthic Feeders Pct	Sensitive Centrarchidae Pct	Herbivores Pct	Intolerant Pct	Long Lived Pct	Sensitive Perciformes Pct	Riffle Pct	Sensitive Pct	Lithophilic Spawners Pct	TSS TIV
07020009-646	17MN310 (2017)	55.38	0.00	52.41	0.00	2.22	4.45	53.40	0.99	48.58	17.77
Passing Streams Average	**Southern Stream General Use**	36.02	5.37	25.68	4.24	13.58	20.09	30.18	16.89	19.11	17.59
	Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

Macroinvertebrate TSS metrics

The macroinvertebrate community did not show a strong response to indicate TSS displacement. The taxa count is acceptable. Long lived species are of particular importance as they can be good indicators of life cycle disruption. Sensitive orders of Plecoptera and Ephemeroptera were both accounted for in the community. While the TSS index score is just above the threshold and there is not any TSS intolerant individuals, there is not much indication that TSS is limiting the macroinvertebrates.

Table 36. TSS Macroinvertebrate metrics within the Middle Branch Subwatershed. Red highlighted metrics over threshold.

Middle Creek	Station (Year sampled)	Taxa Count	%Long Lived	%Plecoptera	Ephemeroptera Count	TSS Index	% Tolerant	% Intolerant
646	17MN310 (2017)	39	10.13	0.63	7.00	16.52	30.70	0
Passing Streams Average	*Prarie Stream modified use*	24	6.0	0.1	4.8	16.02	35.60	1.27
	Expected response to stress	↓	↓	↓	↓	↑	↑	↓

Summary

While TSS concentrations did show this stream is susceptible to high TSS loading (especially after rain events), there was very little evidence to show TSS is limiting either the fish or the macroinvertebrate. As a result of the conflicting biological data with the chemistry, TSS is inconclusive.

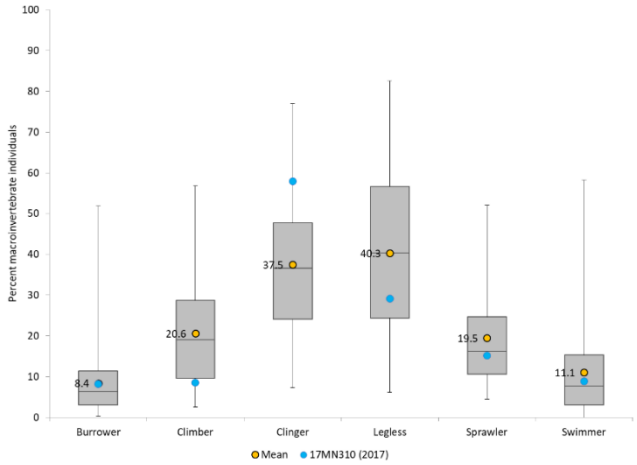
Table 37. TSS findings for Middle Branch; Blue cells represents inconclusive findings.

				TSS			
AUID	**Stream Name**	**Biological Stations**	**Impairment**	Suspended Algae	Flow Alterations	Stream Bank Erosion	Pasture
Middle Branch							
646	Blue Earth River, Middle Branch	17MN310	F-IBI		•	•	

4.3.5 Habitat

Physical conditions of the Middle Branch where rated as poor during two separate site assessments. The stream was largely homogenous in feature types, lacking diversity. Substrate material was primarily fine sands and sediment, with bank erosion prominent. Vegetative cover (was limited to woody debris and undercut banks. Algae in the form of floating mats and benthic were the only form of vegetation noted. Macroinvertebrates appear to fall within the expected normal ranges (Figure 50), with the exception of the high amount of clingers. This group's abundance is due to the overabundance of the tolerant net spinning caddisfly. There is also a high amount of tolerant mayfly *diminuta* contributing to the clinger category. While the taxa count was high many of them fell within single digits for individual counts. Had the Clinger category not had been so skewed, the Burrower category would have fallen above the normal range. Fish did not show a significant negative response. Based on physical conditions and macroinvertebrate total composition, habitat is considered a stressor.

Figure 50. Middle Branch macroinvertebrate community make up Prairie stream class.



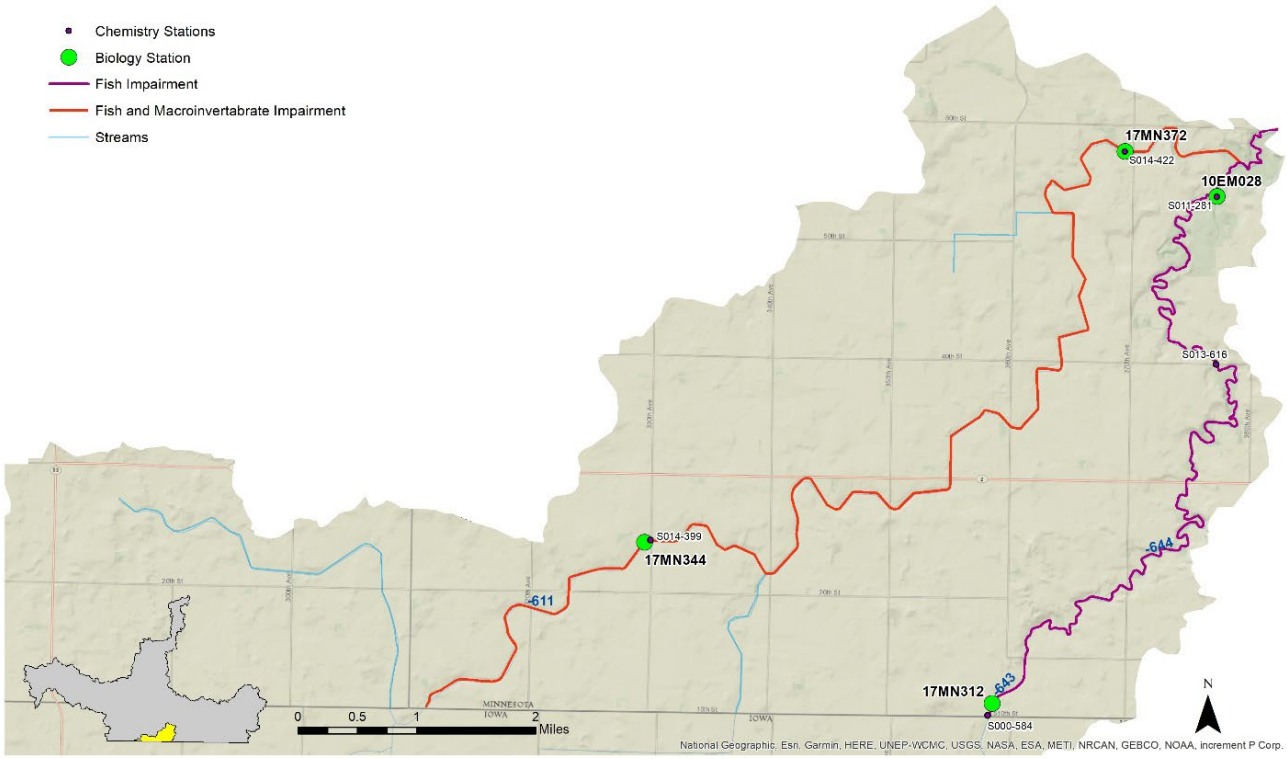
While the majority of the Middle Branch is categorized as general use, the headwaters portion of this stream is largely channelized for the purpose of agricultural drainage. These alterations are the primary driver to these downstream habitat impacts. See above Section 3.1.8 on how altered hydrology is the primary driver of stressors within the Blue Earth River Watershed.

Table 38. Habitat stressor for the Middle Branch Subwatershed; red highlights nitrate stressor.

				Habitat				
WID	**Stream Name**	**Biological Stations**	**Impairment**	Channalized	Riparian	Streambed	Habitat diversity	Trampeling
Middle Branch								
646	Blue Earth River, Middle Branch	17MN310	F-IBI	•	•	•	•	

4.4 West Branch

Figure 51. West Branch HUC 10 Subwatershed indicating biological impairments along with monitoring stations.



The West Branch HUC 10 Subwatershed is another section of the Blue Earth River Watershed that has a significant portion of the 10,669 area/acres that begins in Iowa. Due to the state boundaries, only three reaches that fall within Minnesota will be assessed. In addition to the biological impairments, there is an impairment for *Escherichia coli* on WID -643 that will not be addressed in this report. Biological monitoring within the West Branch included three WIDs. WID -644 was the only stream that was assessed as general use, with one biological monitoring station (10EM028). WID -643 (17MN312) as well as -611 (17MN344 and 17MN372) were assessed as modified use, due to extensive channelization of the stream. WID -643 begins well into Iowa, were at least one town (Lakota) appears to have a point source discharger (wastewater) upstream. The dominant land use within the subwatershed is designated as agricultural us. Images that display conditions of the monitoring stations at the time of biological monitoring can be seen below in Figure 52.

Figure 52. Condition of streams within the West Branch Subwatershed, taken at the time on biological monitoring. Left shows -611 with upstream to downstream going from bottom to top. Right shows -643 and -644 stations bottom to top.

4.4.1 Biological communities

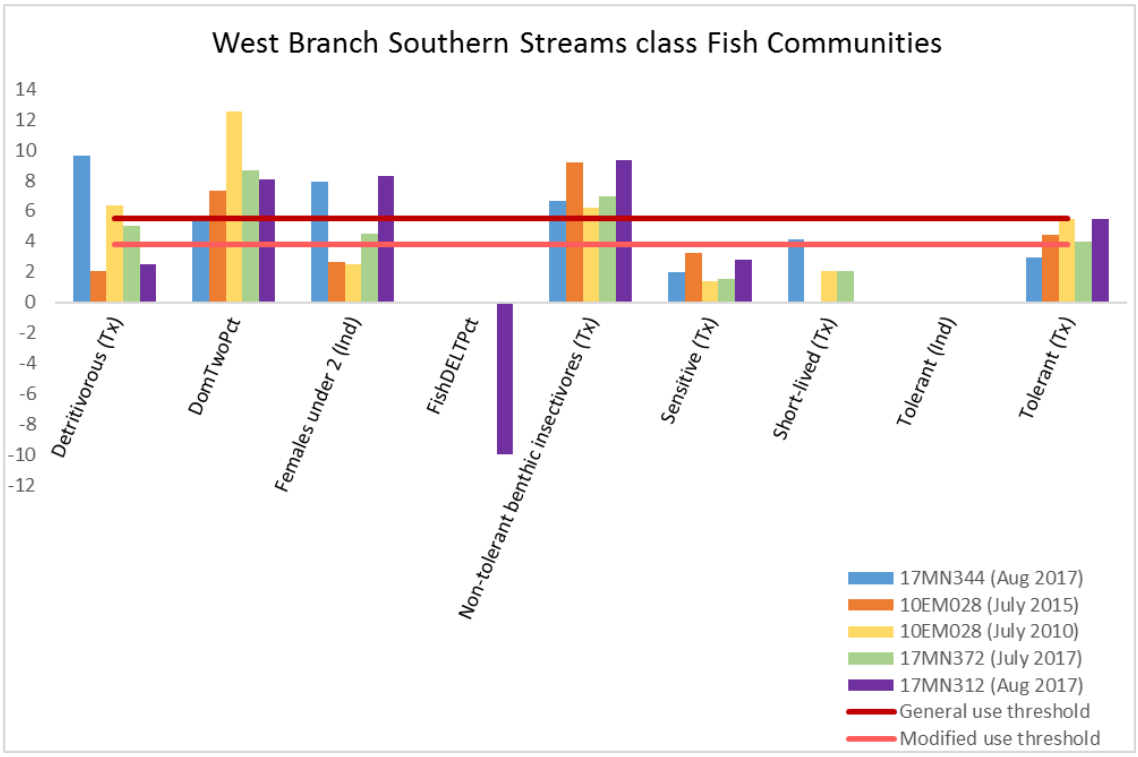
Fish community

The fish assessment across all sites within the West Branch displayed similar community types that make up the overall IBI, as shown in Figure 53. On WID -611 station 17MN344 had a score of 38.9, falling slightly above (yet within the confidence limit) the modified use threshold for southern streams of 35. Missing within the community are the sensitive taxa groups, replaced with tolerant groups. Downstream on the same WID station 17MN372's sample was similar with an IBI of 32.8, also falling within the confidence limit of 35 for a modified southern stream. The dominate fish species collected at both locations were blacknose dace and well as central stonerollers.

Within the other tributary in the Coon Creek Watershed is station 10EM028, located on WID -644. This station was sampled in two different years. In 2010 the IBI scored 36.6 and in 2015 the score dropped to 28.9. Both years scored well below the general use threshold hold of 50. Both sample years showed similar community composition, with an absence of sensitive species as well as an abundance of young female fish. This could be contributed to the high numbers of creek chubs that greatly dominated the sample in both years.

At the upstream site of 17MN312 (On WID 643) the IBI score was 26.5, below the modified use threshold of 35. Like the other stations, the primary concern to the community is the abundance of tolerant species. This station does stand apart from others as it is of special concern due to the occurrence of deformities, erosion, lesion, and tumor (DELT) anomalies within the sample. It total there were 33 individual fish with abnormalities. Thirty white suckers were noted to have lesions that appeared to look like a sore, possible fungus or disease may be the culprit as so many from the same species were inflicted. However, in addition to the lesions found on the white suckers there was a case of eroded gills and another deformity detected in the common carp that were collected. There was also a single spotfin shiner that was noted to have a lesion as well. There were no other spotfin shiners in the sample.

Figure 53. West Branch Fish community composition for all biomonitoring sites.

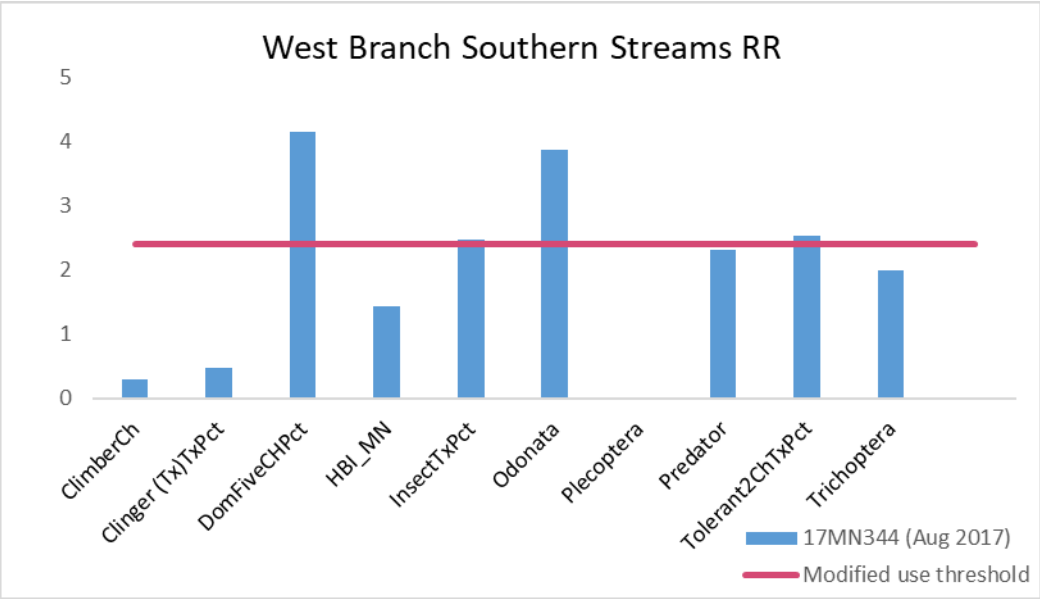


4.4.2 Macroinvertebrate community

The macroinvertebrate assessments led to two separate stream classifications on the only impaired WID (-611) for macroinvertebrates. Station 17MN344 being classified as a southern stream with riffle/run features, while the upstream station 17MN372 is classified as a Prairie Stream with glide/pool features (Figure 55). As shown in Figure 54, station 17MN344 had a macroinvertebrate community that was lacking in some of the functional groups (Climbers and Clingers), also noted is a higher than average amount of pollutant tolerant taxa types (HBI_MN), yet did not disproportionately dominate the overall sample of tolerant from intolerant taxa types. What is of most concern is the lack of sensitive Trichoptera and Plecoptera. Odonata is well within the expected numbers. The number of Odonata is the primary driver of the predator types that just fall short of meeting the threshold. However, the

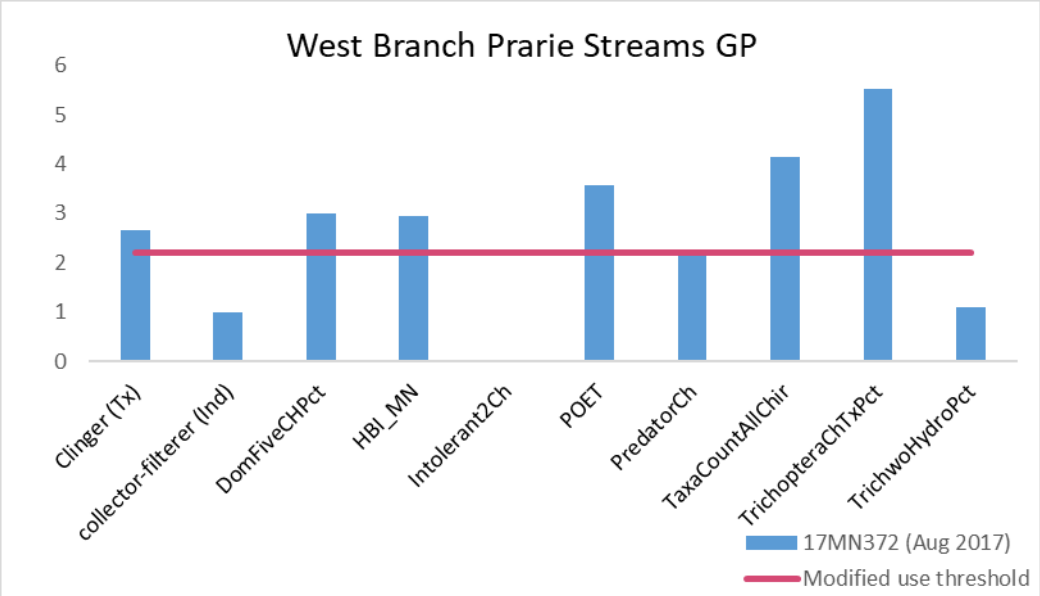
overall Odonata score is likely driven from the high number of the tolerant mayfly *Coenagrionidae* in the sample.

Figure 54. Southern Stream with riffle and run features at site 17MN344 on WID -611.



Downstream conditions on WID -611 change class types from a modified southern stream to a modified prairie stream. Station 17MN372 is the second biological station, found to be impaired for macroinvertebrates, as shown in Figure 55. This sample resulted in a finding of a slightly tolerant community. While there was a presents of sensitive groups of Plecoptera, Odonata, Ephemeroptera & Trichoptera individuals in the sample, most of those groups were composed of tolerant types such as *Canis* and *Cheumatopsyche* that overwhelmingly dominated the sample. In addition, *Physella* and *Thienemannimyia Gr.* (snails and non-biting midge) also made up a large number of the sample size.

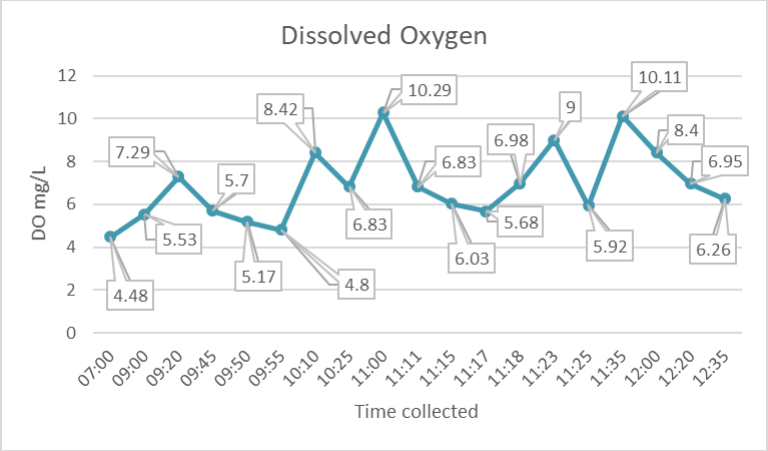
Figure 55. Prairie Stream with glide pool features at site 17MN372 on WID -611.



4.4.3 Dissolved oxygen and eutrophication

Dissolved oxygen (DO) data was limited to samples taken at the time of biological monitoring for WIDs -644 and -611. DO from WID -611 did indicate some instability. This is noted in an afternoon reading reaching 15.39 mg/L for DO, indicative of a eutrophic stream with excess autotrophic growth (with the inverse being low DO after sundown when respiration is high). At the beginning of the other branch is WID -643. At the time of the biological sample this station had an unusually high reading of 21 mg/L (300% Do saturation) collected at 6:30 pm. In addition there were 19 point measurements collected during the summer months of 2017. These concentrations (shown in Figure 56 below) highlight chronic issues of low DO. There are many dynamics occurring within this stream system that could be driving the do levels found, varying from land use practices, upstream point sources, as well as eutrophication.

Figure 56. Dissolved oxygen point measurements collected on WID -643.



The next downstream WID of -644 had 4 DO readings taken at the time of biological monitoring, all fell within normal range.

Phosphorus

Nearly every station had indications of phosphorus (TP) overloading within the West Branch Subwatershed. As shown in Table 39, TP often exceeded the .15mg/L. WID -644 was limited in data, yet every sample that was collected exceeded the TP limit of .15 mg/L. Other documentation taken during

Table 39. Summary of Total phosphorus findings within the West Branch Subwatershed.

AUID	Stream Name	Biological Stations	Impairment	Number of samples.	Range of TP (mg/L)	Average of TP (mg/L	# of exceedances .15 mg/L
West Branch							
611	Judicial Ditch 7	17MN344 17MN372	F-IBI and M-IBI	14	.1-.57	0.26	11
643	West Branch	17MN312	F-IBI	15	.06-.29	0.14	6
644	West Branch	10EM028	F-IBI	3	.16-.28	0.2	3

sampling noted concerning findings within this subwatershed. Figure 57 highlights the high autotrophic abundance, particularly noted in WID -643 and the receiving WID of -644. In addition, at the time of

Figure 57. Station 17MN312 (Left) taken September 6, 2019; Station 10EM028 (right) taken September 20, 2019 on WID -643 Bottom shows station 17MN372 taken September 6, 2019 (right); 17MN344 taken September 20, 2019 (left).




monitoring an aquatic vegetation/algae survey was taken. At WID -611 Benthic and filamentous algae (floating mats) were observed, particular at the furthest headwaters section of -611. WID -643 suspended algae was present and benthic algae was noted to be in overabundance. Eutrophication is especially apparent in WID -643. The receiving WID of -644 did not have a recent survey taken with the last one collected in 2015. However, at that time there was not any vegetation or algae present. This

could indicate turbid conditions are beginning to block out autotrophic growth.

Fish metrics for eutrophication

Fish metrics at WID 611 had a generally low taxa count at both monitoring locations of 17MN344 and 17MN372. The majority of fish species were generally tolerant within each reach with hardly any noted sensitive species. Darters that need good water quality were lacking in all but one station (10EM028) in the 2015 sample. Omnivorous that are generalist eaters that typically indicate organic matter such as alga. Omnivores were the dominant feeder types in only WID -643. Throughout each WID there was some degree of lithophilic spawners, this indicates some clean substrate for spawning. Habitat and feeding needs that are evaluated for eutrophication are mixed regarding the fish assemblage. Using these fish metrics alone, it is difficult to see if low DO/eutrophication are limiting factors to the biology.

Table 40. Fish metrics in response to low DO and eutrophic conditions within the West Branch Subwatershed, red indicates metric over the threshold.

West Branch Southern Streams	Station (Year sampled)	DarterPct	OmnivorePct	SLithopPct	SensitivePct	TolPct	CountofTaxa	DO TIV
611	17MN344 (2017)	5.74	11.06	28.57	0.14	93.70	14	8.59
	17MN372 (2017)	3.44	8.29	35.20	1.51	92.14	18	8.75
643	17MN312 (2017)	4.13	36.85	43.73	4.13	87.92	20	8.69
644	10EM028 (2010)	6.90	15.66	19.83	0.72	83.91	20	8.64
	10EM028 (2015)	14.08	15.14	29.58	1.76	82.39	17	8.49
Passing Streams Average	**Southern Streams General use**	11.9	17.7	37	16.9	44.9	19	8.56
	Southern Streams Modified use	*9.9*	*20.6*	*31.7*	*10.3*	*57.4*	*18*	*8.41*
	Expected response to stress	↓	↑	↓	↓	↑	↓	↓

Macroinvertebrates low DO

Table 41. Macroinvertebrate metrics to assess low DO within West Branch Subwatershed with southern streams on top and the prairie stream class on the bottom. Red highlighted metrics indicate over the

West Branch Southern Streams	Station (Year sampled)	Taxa Count	EPT	Trichoptra	sensitive Tricoptrapct	HBI_MN	DO Index	% DO tolerant	% DO Intolerant
611	17MN344 (2017)	33	32.81	12.12	2.19	7.89	6.58	16.20	1.56
Passing Streams Average	*Southern Streams Modified use*	31	42.6	18.72	5.48	7.09	7.04	9.06	24.01
	Expected response to stress	↓	↓	↓	↓	↑	↓	↑	↓

West Branch Southern Streams	Station (Year sampled)	Taxa Count	EPT	Trichoptra	sensitive Tricoptrapct	HBI_MN	DO Index	% DO tolerant	% DO Intolerant
611	17MN372 (2017)	33	36.36	9.09	0.31	7.99	6.68	18.81	1.25
643	17MN312 (2017)	22	61.20	13.64	4.10	8.62	6.27	63.52	0.63
644	10EM028 (2010)	31	49.09	12.90	4.85	7.68	7.04	4.85	12.12
	10EM028 (2015)	43	47.65	9.30	2.51	7.76	6.36	9.09	8.15
Passing Streams Average	**Prarie Streams General use**	37	38.45	10	5.5	7.55	7.04	25.1	5
	Prarie Streams Modified use	*34*	*20.58*	*5.71*	*4.76*	*8*	*6.19*	*31.37*	*2*
	Expected response to stress	↓	↓	↓	↓	↑	↓	↑	↓

WID -611 had two monitoring stations (17MN344 and 17MN372) both falling into different stream classes for macroinvertebrates. Station 17MN344 is the farthest upstream site of this WID. There are some indications of DO impacting the biology at this location. Sensitive EPT species fell below the threshold, what was present was largely made up of the tolerant net spinning caddisfly. Both locations on WID -611 also show a clear dominance of DO tolerant with a lack of species that are specifically sensitive to low DO. Station 17MN372 scored slightly better, especially in the overall DO index and tolerance metrics. There is still a poor amount of EPT, with a strong majority being made up of the tolerant net-spinning caddisfly. The other two WIDS are not as clearly impacted by low DO within this stream system. Metrics at WID -643 were mixed, with the largest indication of low DO stress noted in the amount of specific low DO tolerant species. WID -644 scored poorly for low DO index. However, there is a high percentage of EPT, an adequate amount if low DO sensitive, in addition to a low

percentage of specific DO tolerant make up. This does cast some doubt on if low DO is playing a limiting role.

As the case with the low DO metrics shown previously, WID -611 does show some response in the metrics in regards to eutrophic displacement in the community (Table 42). Particularly noted in the amount of individuals who need organic matter to thrive, such as scrapers that have a diet of benthic algae and mollusks that thrive on suspended organic matter. Nearly all other locations were lacking in generally sensitive individuals. It was only station 17MN344 that was dominated by generally tolerant species. Due to what is present (algae eaters) it is plausible that eutrophication is playing a limiting role in -611. WID -643 had mixed results. The phosphorus index as well as the percentage of eutrophic tolerant indicate some potential to signal eutrophic stress. However, as the overall population was made up of general tolerant species this discredits the ratings slightly. WID -644 didn't display as clear of signals in the macroinvertebrate metrics. Indicating that eutrophication is playing a minimal role as a stressor to the inverts at this site.

Table 42. Macroinvertebrate metrics to assess low DO within West Branch Subwatershed with southern streams on top and the prairie stream class on the bottom. Red highlighted metrics indicate over the

West Branch Southern Streams	Station (Year sampled)	% Scraper	CrustMollPct	Tanytarsini Pct	Phos Index	% Tolerant	% Intolerant	%Gen Tolerant
611	17MN344 (2017)	33	32.81	12.12	2.19	7.89	6.58	16.20
Passing Streams Average	*Southern Streams Modified use*	*9.9*	*20.6*	*31.7*	*10.3*	*57.4*	*18*	*8.41*
	Expected response to stress	↑	↑	↑	↑	↑	↓	↑
West Branch	Station (Year sampled)	% Scraper	CrustMollPct	Tanytarsini Pct	Phos Index	% Tolerant	% Intolerant	%Gen Tolerant
611	17MN372 (2017)	20.06	21.94	14.71	0.14	19.44	0.31	65.83
643	17MN312 (2017)	9.78	10.09	17.07	0.16	64.78	0.00	92.74
644	10EM028 (2010)	10.00	6.36	10.87	0.13	30.00	1.52	50.91
	10EM028 (2015)	10.03	7.52	12.31	0.12	15.99	3.13	33.23
Passing Streams Average	**Prarie Streams General use**	*16.1 1*	*11.78*	*18.46*	*0.13*	*30.6*	*3.8*	*61.78*
	Prarie Streams Modified use	17.73	*23.21*	*22.11*	*0.14*	45.87	*1.79*	*73.64*
	Expected response to stress	↑	↑	↑	↑	↑	↓	↑

WID -611 makes up the west tributary of the West Branch (two tributary) Subwatershed. In the minimal DO dataset, there was some indication of high DO saturation, due to an abundance of autotrophic growth. Phosphorus loading is a chronic issue, noted in the TP chemistry. There was also some benthic algae noted and documented within this stream WID. Fish metrics indicated some degree of DO and eutrophic stress, although it was slightly mixed. The invertebrate metrics highlighted these parameters stressing the biological community, with impacts lessoning between the upstream site of 17MN344 and the downstream location of 17MN372. Between the documented chemistry, physical conditions, and noted in the biology, low DO as well as eutrophication is considered a stressor to some degree to the biological community, particularly within the macroinvertebrates.

The next WID of -643 on the east tributary is primarily in Iowa, with the monitoring station near the end of the assessed stream, near the state boundary. This is another modified ditch, with poor riparian cover, as well as a waste water pond that discharges into this system further upstream. Low DO, in addition to some extremely high DO spikes in the afternoon (21 mg/L with 300% saturation) is clearly a problem and documented. In addition, phosphorus concentrations are of concern, indicating chronic overloading issues. Fish here did indicate that there is some degree of eutrophic stress. While these parameters are considered stressors, the fish community.

The downstream WID of -644 makes up a large portion of the east tributary that is located within the West Branch tributary, directly before the convergence of the other west tributary. Physical attributes along this WID are that of a more natural system, with better coverage and well as riparian. While DO was here was also limited to what was collected during the assessment, all values fell within normal range. Phosphorus reading were limited to three samples at this location, all of which did exceed the .15 mg/L threshold. Even though there are some indications of DO tolerance in the community and phosphorus overloading, overall the data is lacking to positively identify the limitations these parameters could be placing on the community. Even though macroinvertebrates were not impaired, metrics were still assessed at this location and did not see indication of DO or eutrophic displacement.

Table 43. Summary of dissolved oxygen and eutrophication stressors within the West Branch subwatershed; Red indicates stressor while blue indicates inconclusive findings.

								Dissolved Oxygen				Eutrophication			
AUID	Stream Name	Biological Stations	Impairment	Number of samples	Range of TP (mg/L)	Average of TP (mg/L	# of exceedances .15 mg/L	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified
West Branch															
611	Judicial Ditch 7	17MN344 17MN372	F-IBI M-IBI	14	.1-.57	0.26	11	●					●		
643	West Branch	17MN312	F-IBI	15	.06-.29	0.14	6	●					●		
644	West Branch	10EM028	F-IBI	3	.16-.28	0.2	3	●					●		

4.4.5 Nitrate

Chemistry

Nitrate samples were collected at the time of the biological sample as well as the following year. As shown in Figure 58, nitrate often exceeded the proposed biological nitrate standard of 4.9 mg/L. Nearly half the time nitrates exceeded the higher threshold of 10 mg/L. The average concentrations falling just short of this threshold. All stream sections showed similar trends in high nitrate loading.

Figure 58. Nitrate samples within the West Branch Subwatershed.

AUID	Stream Name	Biological Stations	Impairment	Number of samples.	Range of Nitrate (mg/L)	Average of Nitrate (mg/L	# of exceedances 4.9 mg/L	# of exceedances 10 mg/L
West Branch								
611	Judicial Ditch 7	17MN344 17MN372	F-IBI M-IBI	14	.37-14	8.28	9	7
643	West Branch	17MN312	F-IBI	5	.11-13	9.06	4	3
644	West Branch	10EM028	F-IBI	5	.05-13	8.55	4	2

Biology

Fish metrics are not yet established to evaluate for nitrate, therefore macroinvertebrate specific metrics will be primarily used in this assessment. It is worth noting however, Station 17MN312 on WID -643 had potential indications of nitrate toxicity that was noted in the DELTs found in the fish sample. Eroded gills

were found, as was a large number of lesions from what may have been an intraspecific species virus. Nitrate can be especially harmful in the form on Ammonia. It is difficult to say with any degree of certainty that nitrate is the culprit behind the high amount of DELTs found across this site, be in directly through burns and toxicity or indirectly by lowing the community's immune response making them more susceptible to infection.

The macroinvertebrate community showed variation in response of nitrate. The first stream WID of -611 is unique as it is categorized under two classifications from the first station of 17MN372 (rated as a modified prairie stream) to the upstream 17MN344 (rated of a modified southern stream). While the thresholds are different the composition was very similar between the two locations as shown in Figure 59. The overall macroinvertebrate diversity is acceptable with 33 different taxa types at both locations. There was an overall lack of sensitive Ephemeroptera, Plecoptera & Trichoptera (ETP), high nitrate index score, in conjunction with a population specifically nitrate tolerant with a complete lack of nitrate intolerant. The next WID of -643 shows a similar community composition.

WID -644 is the only site within this subwatershed that is not a modified stream. This station has two sample years to assess, one in 2010 and again in 2015 at 10EM028. As shown below, the macroinvertebrate community scored similarly in both years. There was a slight increase in taxa diversity. Along with that there was an increase in ETP as well. However, the abundance of nitrate tolerant species also increased slightly. Overall, the station is just above all nitrate metric thresholds (with the exception of percent nitrate intolerant).

Figure 59. Macroinvertebrate response to nitrate within the West Branch Subwatershed; Prairie Stream class on top with Southern Stream class on the bottom. Values highlighted in red indicate over the threshold.

West Branch Southern Streams	Station (Year sampled)	Taxa Count	EPT#	Nitrate Index	% Nitrate tolerant	% Nitrate Intolerant
611	17MN372 (2017)	33	6.00	4.79	83.70	0.00
643	17MN312 (2017)	22	6.00	3.96	89.94	0.00
644	10EM028 (2010)	31	10.00	3.25	52.12	0.00
	10EM028 (2015)	43	11.00	3.30	58.62	0.00
Passing Streams Average	**Prarie Streams General use**	37	*11.5*	*3.23*	*54.86*	*3.18*
	Prarie Streams Modified use	24	*7.6*	*3.32*	*59.41*	*1.95*
	Expected response to stress	↓	↓	↑	↑	↓

West Branch Southern Streams	Station (Year sampled)	Taxa Count	EPT#	Nitrate Index	% Nitrate tolerant	% Nitrate Intolerant
611	17MN344 (2017)	33	6.00	3.84	80.37	0.00
Passing Streams Average	*Southern Streams Modified use*	31	*6.9*	*2.95*	*47.6*	*2.92*
	Expected response to stress	↓	↓	↑	↑	↓

Summary

Nitrate is considered to be a stressor within a majority of this small subwatershed. These small headwater streams are especially vulnerable to nitrate overloading as these streams are receiving tile drainage in an agriculturally dominated environment. In addition there are a number of feedlots within the region. Station 17MN344 is in close proximity to a site where poor manure management was identified during this assessment period. Land use is likely playing an influence to nitrate stress that is within WID -611. This streams chemistry as well as macroinvertebrate population at both locations reflect nitrate is impacting the biology.

The next WID -643 on West Branch is on the Iowa boarder. There are clear issues impacting biology with nitrate being one of them. As is the case with the other branch (WID-611), land use is playing a role. There is a high potential of some degree of point source contribution within Iowa, as the headwaters of the West Branch begin before a town where there is at least one municipal contributor.

Further downstream on the West Branch the nitrate response was not as evident within the macroinvertebrates. Nitrate concentrations between the upstream and downstream locations could be being mitigated through natural stream processes and uptake as this section naturally meanders and has strong riparian support.

Table 44. Nitrate stressors within the West Branch Subwatershed; Red indicates impairment with blue indicating inconclusive findings.

				Nitrate			
AUID	Stream Name	Biological Stations	Impairment	Land Use (application)	Upstream waterbody	Point Souce	Unidentified
West Branch							
611	Judicial Ditch 7	17MN344 17MN372	F-IBI M-IBI	●			
643	West Branch	17MN312	F-IBI	●		●	
644	West Branch	10EM028	F-IBI	●			

4.4.6 Total suspended solids

Total suspended solids (TSS) was assessed with total volatile suspended solids (TSVS) to evaluate sediment against organic matter. Throughout all locations organic matter did not seem to make up a significant portion of the total TSS contribution within the assessed streams. TSS overall showed potential to be of concern, with each site having at least one sample that exceeded the 45 mg/L threshold. Within the West Branch itself the sites 17MN312 and 10EM028 showed a slight difference in sampled concentrations, with the furthest downstream location showing higher concentrations compared to 17MN312.

Figure 60. TSS and TSVS concentrations within the West Branch Subwatershed.

WID	Stream Name	Biological Stations	Impairment	# of TSS samples	# of TVS samples	Range of TSS (mg/L)	Range of TVS (mg/L)	Average of TSS (mg/L)	% TSVS made up TSS (Average)	# of exceedances 45 mg/L
West Branch										
611	Judicial Ditch 7	17MN344 17MN372	F-IBI M-IBI	12	12	8-90	3.2-12	39.75	24.06	4
643	West Branch	17MN312	F-IBI	15	2	3-48	5.2-6.8	24.11	24.91	1
644	West Branch	10EM028	F-IBI	3	3	15-67	4-12	38.6	20.74	1

Fish TSS metrics

WID -611 on Judicial Ditch 7 showed a fish community that did not seem heavily influenced by sediment (Table 45). One of the most dominant species within the sample were central stonerollers that depend on substrate availability to build nesting habitat. Metrics show both within this stream, as well as the beginning reach of the West Branch on WID -643, there is little indication of TSS degrading the stream ben enough to limit fish species that thrive within this section. All stations have an absence of Centrarchidae, as well as specific TSS intolerant species. However, the overall community composition yielded an acceptable TSS tolerance index score.

The furthest downstream WID -644 showed a significant difference in comparison to previous sites. As scores across all TSS parameters were poor.

Table 45. Fish metrics for TSS within the West Branch Subwatershed, red highlighted values indicate exceedance of the threshold.

West Branch	Station (Year sampled)	Benthic Feeders Pct	Sensitive Centrarchidae Pct	Herbivores Pct	Intolerant Pct	Long Lived Pct	Sensitive Perciformes Pct	Riffle Pct	Sensitive Pct	Lithophilic Spawners Pct	TSS TIV
611	17MN344 (2017)	50.56	0.00	45.10	0.00	0.14	5.74	45.10	0.14	10.64	15.63
	17MN372 (2017)	29.82	0.00	26.16	0.00	1.51	3.44	26.16	1.51	6.57	17.65
643	17MN312 (2017)	52.14	0.00	45.26	0.00	6.88	4.13	47.40	4.13	40.83	19.67
644	10EM028 (2010)	18.25	0.57	14.22	0.00	4.74	7.90	15.37	0.72	12.93	17.40
	10EM028 (2015)	22.18	0.00	15.14	0.00	4.23	14.08	16.90	1.76	13.03	21.89
Passing Streams Average	**Southern Streams General use**	36.02	5.37	25.68	4.24	13.58	20.09	30.18	16.89	19.11	17.59
	Southern Streams Modified use	29.70	3.12	21.65	2.07	10.30	15.39	24.42	10.30	15.02	19.19
	Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

Macroinvertebrate TSS metrics

Macroinvertebrates were found to also be mixed in showing a response across metric parameters. All sites but -611 (17MN344) scored poorly for the overall TSS Index score. Across all sites there was also an absence of specific TSS intolerant species. Both Ephemeroptera as well as Plecoptera orders scored poorly at nearly all stations, the exception being noted in the 2015 sample at WID -644. The most TSS specific tolerant were found at WID -644, although there was some improvement from 2010 to 2015 for this population composition.

Table 46. Macroinvertebrate metrics for TSS within the West Branch Subwatershed; Prairie stream class on top with Southern stream on bottom. Red highlighted values indicate exceedance of the threshold.

West Branch	Station (Year sampled)	Taxa Count	%Long Lived	%Plecoptera	Ephemeroptera Count	TSS Index	% Tolerant	% Intolerant
611	17MN372 (2017)	33	4.08	0.00	2.00	18.00	51.41	0
643	17MN312 (2017)	22	9.46	0.00	3.00	17.30	21.38	0
644	10EM028 (2010)	31	5.45	0.00	6.00	18.60	54.24	0
	10EM028 (2015)	43	11.29	2.19	7.00	16.74	47.65	0
Passing Streams Average	**Prairie Stream general use**	37	7.5	0.2	6.7	17.35	48.28	2.67
	Prairie Stream modified use	*24*	*6.0*	*0.1*	*4.8*	*16.02*	*35.60*	*1.27*
	Expected response to stress	↓	↓	↓	↓	↑	↑	↓
West Branch	Station (Year sampled)	Taxa Count	%Long Lived	%Plecoptera	Ephemeroptera Count	TSS Index	% Tolerant	% Intolerant
611	17MN344 (2017)	33	3.75	0.00	2.00	15.87	36.76	0.00
Passing Streams Average	*Southern Stream modified use*	24	16.9	31.5	7.9	15.99	73.8	2.21
	Expected response to stress	↓	↓	↓	↓	↑	↑	↓

Summary

Out of all three sites assessed within the West Branch Subwatershed, the furthest upstream WID of -644 showed the strongest response to biological stress, in particular within the fish community. While the chemistry dataset for this site is not as robust as the others, TSS loading is higher here in comparison to the upstream location of -643. Between these two locations there are significant changes to the stream (as noted in the images that were taken during sampling Figure 52). Discussed further on, there is evidence that erosion and stream stability issues within this stretch of the West Branch is sever. While the macroinvertebrate response was slightly mixed the fish metrics signaled clear TSS displacement to the community, leaving -644 the only site with TSS as a stressor within this subwatershed. The other sites are inconclusive at this time due to mixed biological response.

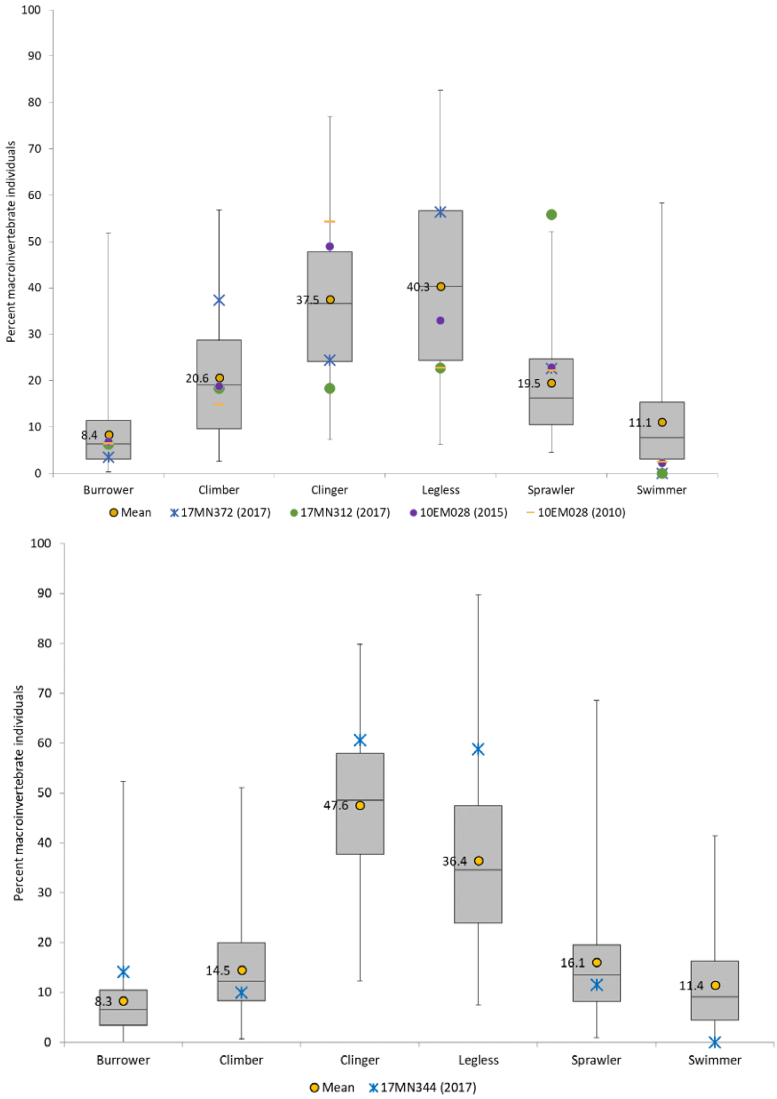
Table 47. Summary of TSS stressors within West Branch. Red indicates stressor while blue is inconclusive.

				TSS			
AUID	**Stream Name**	**Biological Stations**	**Impairment**	Suspended Algae	Flow Alterations	Stream Bank Erosion	Pasture
	West Branch						
611	Judicial Ditch 7	17MN344 17MN372	F-IBI M-IBI		●		
643	West Branch	17MN312	F-IBI		●		
644	West Branch	10EM028	F-IBI	●		●	

4.4.7 Habitat

As noted throughout the West Branch section of this report, Judicial Ditch 7 (WID -611) has two separate class stations. The furthest upstream station is near the beginning of this ditch system on station 17MN344. This narrow section of stream was assessed as having little to no bank erosion, with adequate substrate diversity. There are some areas were light embeddedness is noted. Habitat was the strongest here due to moderate channel stability as well as physical diversity. However, moving further downstream this WID, towards the other monitoring location of 17MN372, this diversity does decrease as embeddedness and siltation increase. Bank erosion also begins to escalate within this zone. While degraded, the benthic metrics assessed for fish in Table 45 did not show significant habitat displacement by this as a WID as a whole. As shown below in Figure 61, the macroinvertebrate community based on habitat composition was slightly skewed do to the high count of legless species. However, further downstream the composition switches to climbers slightly skewing results. The habitat assessment shows some indication of limitations, yet it's not clear if it's a dominant stressor given what is physically present and with the fish response. For these reason WID 611 is inconclusive as a stressor.

Figure 61. West Branch macroinvertebrate community make up within the Southern Streams class (top) and Prairie streams class (bottom).



The West Branch as a whole is a much more dynamic stream in terms of flow, as the headwaters leading up to the first monitoring point is significantly longer than the other branch of JD7. On WID -643 station 17MN312 was noted as having some erosion with a degraded streambed where fine sediment dominated as there was not any course substrate noted. There was lack in overall habitat features as there were not any riffle or pool features located within this reach. In addition to poor instream habitat, channel riparian was also poorly rates, with space cover, making any forms of refuse and cover difficult to find throughout this section of the West Branch. Wood was the dominant available macroinvertebrate habitat. This is reflected in the macroinvertebrate habitat groups below, “sprawlers” making up the majority of the overall sample. This is due to the dominance of *diminuta.* This is a fairly hardy form of mayfly that are one of the more common and tolerant forms (Taylor 2001). If these were

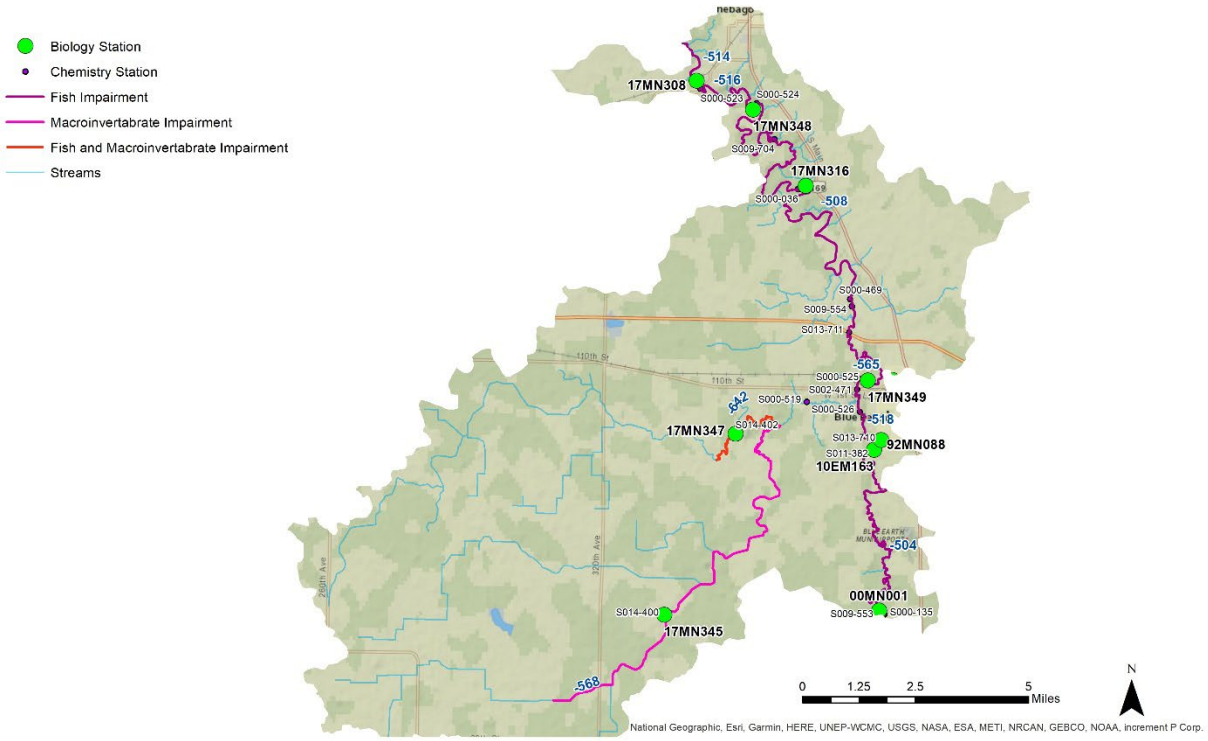
to be eliminated from the distribution, burrower groups would be highlighted as one of the more dominant. As previously discussed, fish metrics that evaluated for benthic dweller displacement (Table 45) did not show a response. Based on the physical habitat conditions, and elimination thereof by way of channeling and ditching, habitat is considered a biological stressor.

Going further downstream the West Branch the highly altered and channelized stream begins to form meanders and the natural widening riparian, surrounding the stream with forestland. Despite the near channel habitat improvements on land, instream habitat shows signs of degradation. Several habitat assessments have been done at this location from 2010 to 2015. Some degree of stream embeddedness was consistently noted, with the overall channel stability being rated as low. As discussed in the prior TSS section of this subwatershed, the fish species showed consistent response to lack of benthic habitat in both years. The macroinvertebrates community showed a habitat group that was primarily of the clinger variety. This is likely a result of the dominant habitat sampled being wood and the high populations of net spinning caddisfly. Habitat is a stressor at this location.

Table 48. Habitat stressors within the West Branch Subwatershed, red indicates stressor with blue indicating inconclusive findings.

				Habitat				
WID	**Stream Name**	**Biological Stations**	**Impairment**	Channalized	Riparian	Streambed	Habitat diversity	Trampeling
West Branch								
611	Judicial Ditch 7	17MN344 17MN372	F-IBI M-IBI			●		
643	West Branch	17MN312	F-IBI	●	●	●	●	
644	West Branch	10EM028	F-IBI	●	●	●	●	

4.5 Badger Creek



The Badger Creek HUC 10 Subwatershed is made up of a long stretch of the Blue Earth River headwaters as three other HUC 10 systems drain into it. Those being the Middle Branch and West Branch that form the furthest upstream sections of the Blue Earth River. Coon Creek and the East Branch join the Blue Earth River within Bader Creek Subwatershed, near the town of Blue Earth. Blue Earth is the largest town within this subwatershed. The majority of land is designated as agricultural in the form of row crops. The furthest head water stream found to have an impairment is AUID -568 that has a macroinvertebrate impairment. An additional biological impairment for both fish and macroinvertebrate communities is on AUID -642. The Blue Earth mainstem within the Badger Creek subwatershed is impaired for fish in each on the AUIDs (-504, -518, -565, -508, -516, -514). In addition to fish impairments, all but -516 are impaired for turbidity as well. The furthest upstream site of -504 also has an impairment for *Escherichia coli* that will not be addressed within this report, additional information on this can be found in the MPCA's Monitoring and Assessment report.

4.5.1 Biological communities

Stream conditions at the time of biological sampling are shown below in Figure 62.

Figure 62. Conditions of monitoring sites taken at the time of the biological sample.

Fish

All fish impaired streams that are classified as Southern Rivers are categorized as general use, due to the natural riparian surrounding the mainstem of the Blue Earth streams are not directly altered by anthropogenic causes. Community metrics are listed in order of upstream to downstream sites, as shown in the legend in Figure 63 below.

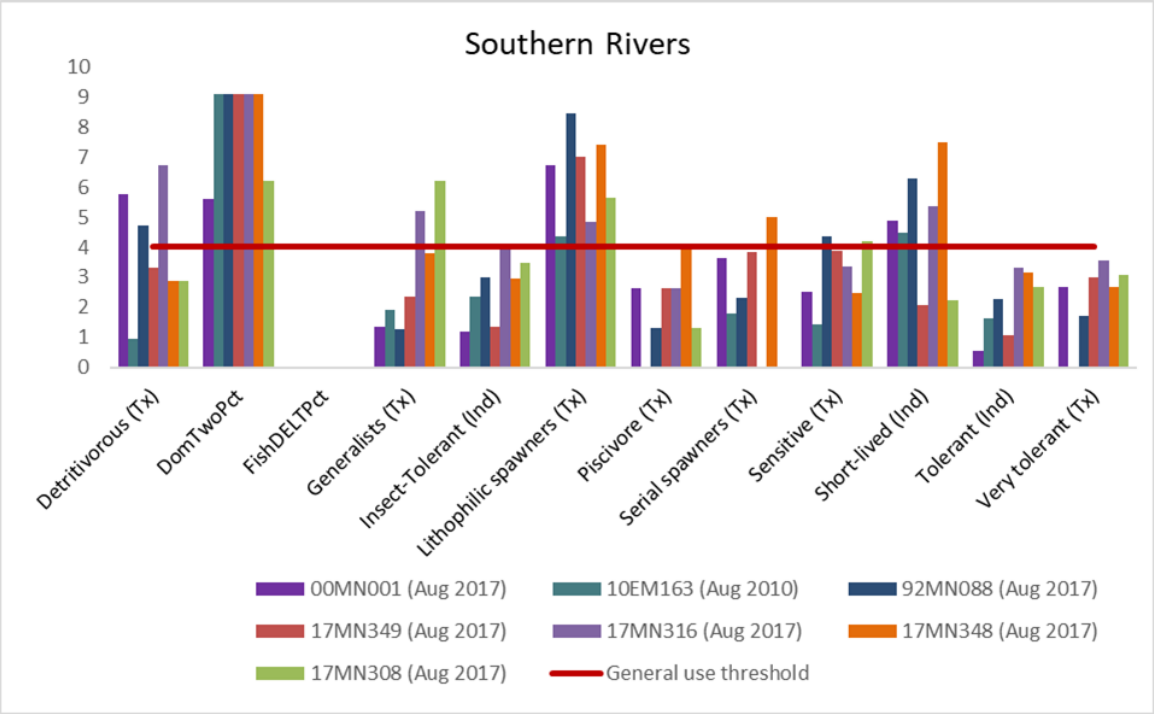
The farthest upstream WID of -504 is listed impaired for fish based off of station 00MN001 results. This site has an IBI score of 35.3, below the threshold of 49 and outside the CL of 11. There were 24 different taxa types surveyed here, with white sucker, bluntnose minnows, redhorse, and sand shiner being the most dominant. As shown in the community metrics, there is a disproportionate amount of generalist. In place, there was found to be a lack of insectivores as well as piscivors. This indicates an imbalance of trophic types seen in the sample. Highlighting the distribution of lithophilic spawners (that have specific habitat needs) in proportion to serial spawners, suggests that spawning conditions are adequate. There is a clear stressor occurring that is displacing sensitive species and allowing very tolerant species to thrive.

The furthest downstream WID -518 with station of 10EM163 is the only assessable station that was sampled in 2010 rather than 2017 within the Badger Creek Subwatershed. From that sample this station scored an IBI of 28, well below the threshold of 49 and outside the CL of 11. There were 18 taxa types noted, with tolerant species such as Creek Chubs and the Bluntnose Minnow being the most dominant in the population. As shown in Figure 63, the community types that were the most skewed were those that reflect the trophic balance. This is seen in the abundance of detritivorous taxa, lack of intolerant insectivores, and absence of piscivores. In general there was noted to be a lack of individual sensitive fish and a higher than normal of tolerant taxa. Of less concern are the metrics that indicate reproduction and habitat needs, as the lithophilic spawner population was where it would be in a healthy stream system, in addition to not an overly dominant population of serial spawners (although they are slightly higher than they should be). On the same WID, slightly farther downstream is monitoring station 92MN088, with the assessable sample being taken in 2017. This station scored an IBI of 44.8, just slightly under the threshold of 49 and within the CL of 11. There were 25 different taxa types collected, with the dominant fish species samples fairly well distributed in 7 species; white suckers, green sunfish, blunt nose minnow, short head redhorse, common carp, blackside darter, and the spotfin shiner. The fish community is similar to the sister stream of 10EM163. With the primary difference being a slightly less skewed populations within the trophic categories, as well as a higher taxa count of fish types that depend on clean substrate (noted in lithophilic spawners).

Further downstream station WID -514 on station 17MN308 had an IBI score of 38, falling below the general use threshold of 49 and just outside of the CL of 11. Making up a little under half of the fish population was golden shiners. In all there were 21 different taxa types surveyed. As shown in Figure 63, there was a slightly skewed distribution of detritivorous fish as well as a lack of piscivors. However, insectivores and generalist were at their expected proportion. This provides mixed results of the trophic conditions at this location. There is not an excess of serial spawners while lithophilic spawners are thriving in the community, showing reproductive needs are being met. There was a higher than average amount of short lived fish taxa, indicating this area may not be favored for bigger game fish. There was found a higher than average amount of very tolerant taxa types in the sample, yet the abundance of sensitive individual fish was at an acceptable level.

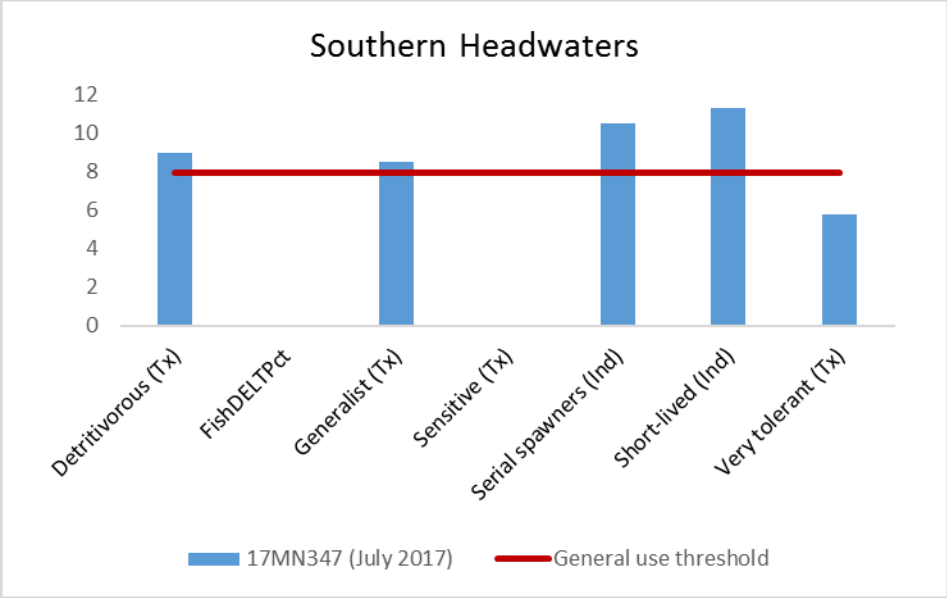
WID -508 and WID -516 have monitoring stations 17MN316 and 17MN348 respectively. 17MN316 IBI fell at 48, one point below the threshold of 49 and within the CL of 11. Station 17MN348 scored 50.9, with the same threshold and CL. These stations scored better than all other sites within this HUC 10 during the 2017 sample. However, both AUIDs have pre-existing fish impairments from samples taken in 2000 and 2001. There are also fish impairments on the reaches directly upstream as well as downstream of these WIDs. As shown in Figure 63, the fish community at both sites are similar as well as fairly balanced. With the exception of the high number of serial spawners at 17MN316 and slightly higher than average of composition of tolerant species.

Figure 63. Southern Rivers stations found to have fish impairment within the Badger Creek Subwatershed.



There was only one WID that was classified as a southern headwater, that being WID -642. This stream is also categorized as general use due to the abundance of a healthy riparian zone. The only biological monitoring station is 17MN347, as shown in Figure 64. With a score of 45 this site falls 5 points under the general use threshold of 55 yet is within the CL. The dominant fish group were creek chubs, with one individual of that group noted to have eroded gills. There is also high numbers of central stonerollers and bluntnose minnows. It is likely the abundance of the bluntnose minnows drove up the very tolerant and the serial spawner community scores. There were a total of 13 different taxa types, most in low numbers.

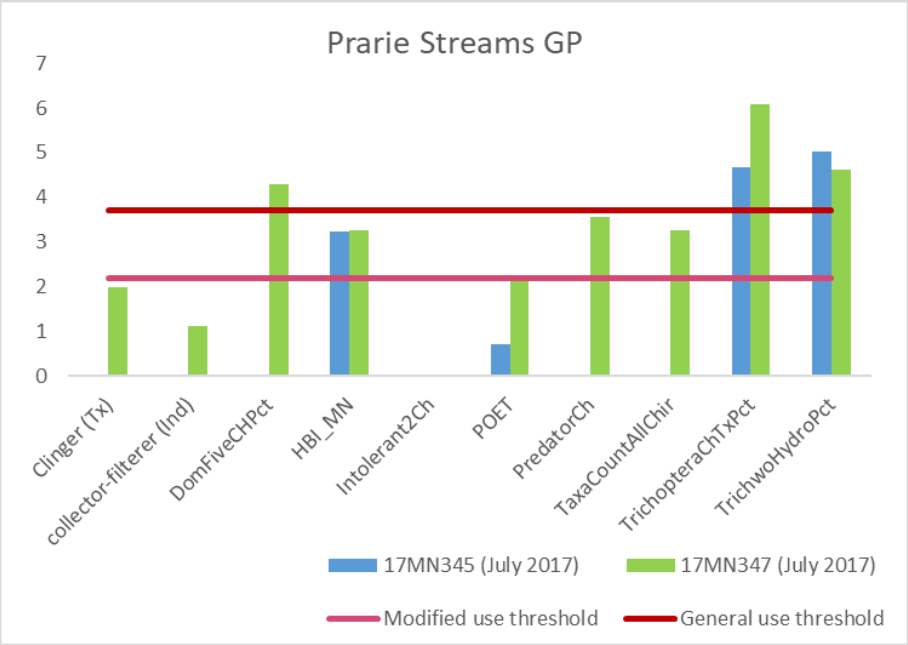
Figure 64. Southern headwater stream fish impaired community within the Badger Creek Subwatershed.



Macroinvertebrates

Both of the macroinvertebrate impaired streams in Badger Creek are rated as Prairie Streams with glide pool features. Monitoring station 17MN345 on WID -568 is scored as a modified use stream with an IBI of 33.3. The macroinvertebrate community was dominated by two snail species (*Physella* and *gyraulus*) as well as a tolerant amphipod (*hyalella*). Station 17MN357 on WID -642 is scored as a general use stream with an IBI of 19.8, well below the threshold of 47. This sample is dominated by snail Physella, a tolerant genus and only four EPT taxa were present.

Figure 65. Macroinvertebrate community for Prairie Streams GP class within the Badger Creek Subwatershed.



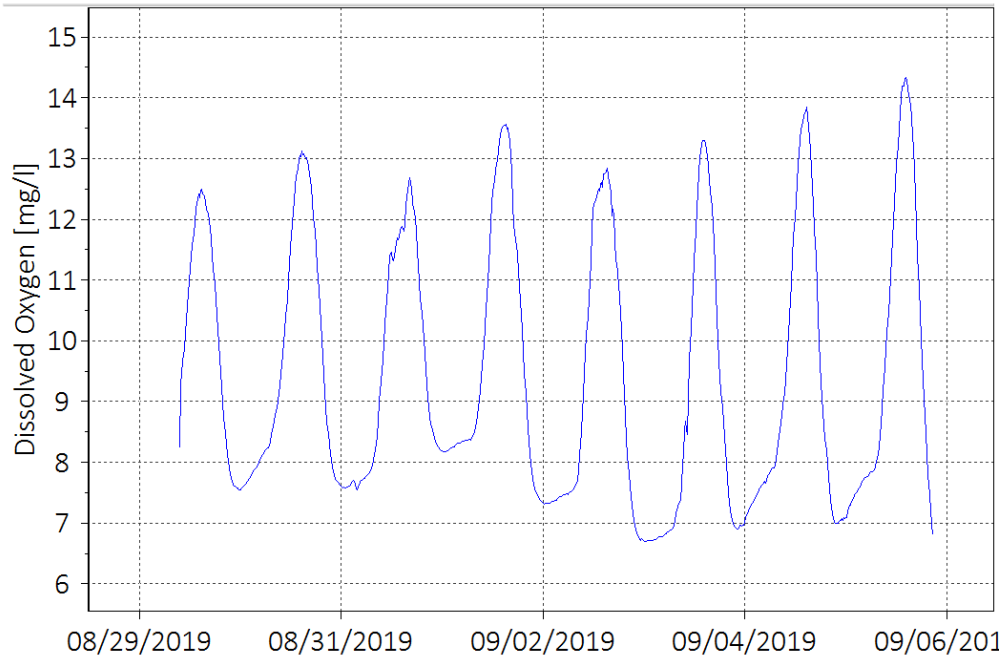
4.5.3 Dissolved oxygen and eutrophication

Chemistry

Dissolved oxygen (DO) data varied in quantity throughout the Badger Creek Subwatershed. The furthest upstream site of WID -642 had limited DO data that was collected at the time of biological sampling. A morning reading of 6.07 mg/L in July and an early afternoon reading of 2.26 mg/L in August 2017.

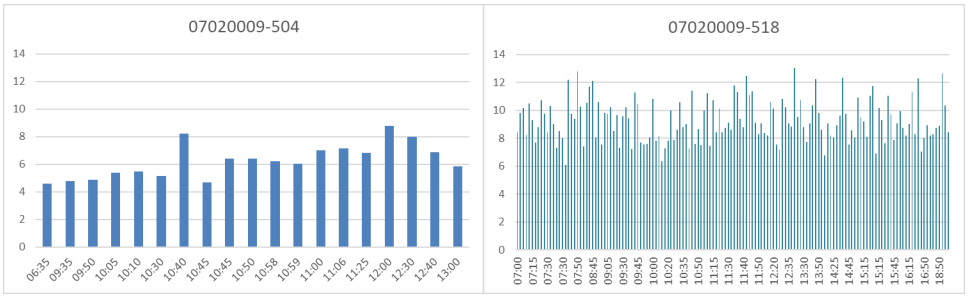
Continuous data collected on the other WID -658 from August 29, 2019 to September 6, 2019. As shown in Figure 66, DO did not fall below the 5 mg/L threshold. However, DO fluctuation with a change above 5 mg/L within a 24 hour period was observed to occur daily.

Figure 66. Continuous DO readings from 17MN345.



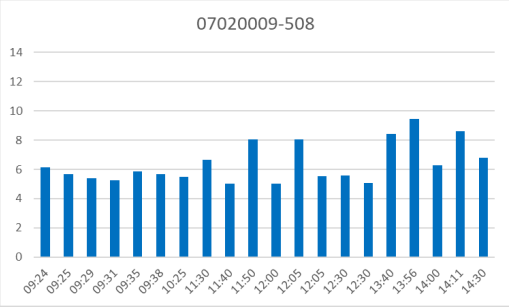
The following graphs display point measurements for DO, categorized by time of the sample in military time to highlight photosynthetic dynamics throughout the day. Sample dates omitted from the chart and available on request. All samples were collected during summer months in the assessment period. WID -504 and -518 did have a few morning low DO readings with one below 5 mg/L.

Figure 68. Instantaneous DO samples collected at 00MN001 left, and 92MN088 in the Blue Earth River.



The next downstream station WID -508 had an adequate sample set with 20 readings throughout the assessment period, shown in Figure 69. Morning readings for low DO were often low, yet above the 5 mg/L threshold.

Figure 69. DO samples collected throughout the assessment period for 17MN316.



WID-656 with station 17MN349 was limited to three samples, collected over 2013, 2014, and 2016. 2016 was a later sample in the month of August yielding a sample of 4.9 mg/L. the other two DO reading were 7.13 mg/L and 6.19 mg/L respectively. WID-516 was limited to what was collected at the time of biological sampling, both within normal range of 8.72 mg/L and 7.6 mg/L taken in morning hours in the month of August.

Phosphorus

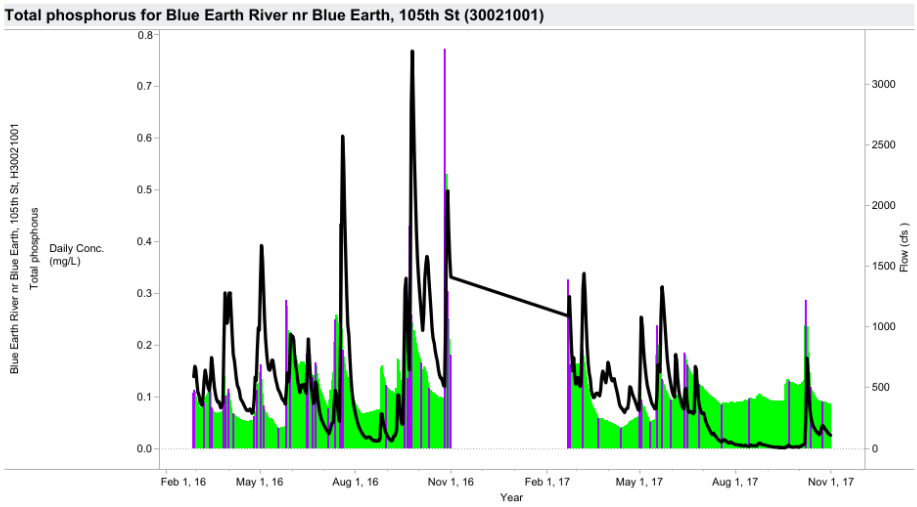
Total phosphorus (TP) was collected at both Little Badger and the mainstem of Badger Creek, other sites were limited. Phosphorus did exceed the .15 mg/L standard of TP a third of the time. The mainstem of the Blue Earth River portion of this branch within this subwatershed had frequent TP exceedances (Table 49).

Table 49. Phosphorus samples within the Badger Creek Subwatershed.

AUID	Stream Name	Biological Stations	Impairment	Number of samples	Range of TP (mg/L)	Average of TP (mg/L	# of exceedances
	Badger Creek						
658	Badger Creek	17MN345	M-IBI	11	.03-.22	0.12	4
642	Little Badger Creek	17MN347	F-IBI M-IBI	6	.08-.22	0.12	2
504	Blue Earth River	00MN001	F-IBI	11	.06-.2	0.11	3
518	Blue Earth River	10EM163 92MN088	F-IBI	198	.04-1.1	0.2	112
565	Blue Earth River	17MN349	F-IBI	3	.26-.33	0.29	3
508	Blue Earth River	17MN316	F-IBI	3	.2-.21	0.21	3
516	Blue Earth River	17MN348	F-IBI	2	.11-.31	0.2	1
514	Blue Earth River	17MN308	F-IBI	11	.07-.13	0.11	0

The monitoring site south of the town of Blue Earth had the most samples, over half are above the standard. This one of MPCA's Watershed Pollutant Load Monitoring Network (WPLMN) sites. Figure 70 below shows phosphorus trends throughout a two year period around the time of biological sampling. Additional years of data is available to review by request or by utilizing the MPCA's Surface water data webpage. The phosphorus trends for the watershed display that phosphorus concentrations were high during low flow conditions and particularly high following rain events.

Figure 70. WPLMN station within the Badger Creek Subwatershed showing TP concentrations throughout 2016 and 2017. Purple represents actual sample taken, green indicates modeled sample, and black represents the stream flow.



4.5.4 Biological metrics

Fish metrics

The headwater WID -642 does indicate potential eutrophic stress (Table 50) in some of the assessed fish samples, noted in the complete lack if the lack of darters and simple lithophilic spawners show physical issues in water quality. The community was largely made up of generally tolerant fish species. The tolerance index value was not below the threshold to indicate DO displacement.

Table 50. DO and eutrophication fish metrics within Badger Creek, red highlighted cells indicate values above threshold.

Badger Creek	Station (Year sampled)	DarterPct	OmnivorePct	SLithopPct	SensitivePct	TolPct	CountofTaxa	DO TIV
504	00MN001 (2017)	2.89	31.24	50.42	3.06	77.93	25	8.69
518	10EM163 (2010)	9.43	23.27	28.93	0.00	68.55	18	8.65
	92MN088 (2017)	12.47	30.08	40.65	4.88	62.87	25	8.64
565	17MN349 (2017)	2.87	28.34	31.53	4.46	73.25	25	8.73
508	17MN316 (2017)	16.88	13.21	36.51	22.02	54.31	27	8.91
516	17MN348 (2017)	2.35	31.37	28.63	1.18	55.69	24	8.92
514	17MN308 (2017)	10.90	11.53	33.64	14.64	59.50	21	8.93
Passing Streams Average	**Southern Streams General use**	11.90	17.70	37.00	16.90	44.90	19	8.56
	Expected response to stress	↓	↑	↓	↓	↑	↓	↓
Badger Creek	Station (Year sampled)	DarterPct	OmnivorePct	SLithopPct	SensitivePct	TolPct	CountofTaxa	DO TIV
642	17MN347 (2017)	6.43	16.37	15.79	0.00	90.64	13	8.57
Passing Streams Average	**Southern Headwaters General use**	11.50	16.90	31.50	7.90	72.80	11.50	8.44
	Expected response to stress	↓	↑	↓	↓	↑	↓	↓

Throughout the mainstem of the Blue Earth River there was a similar mixed pattern in the metrics compared to that of the headwater WID of -642. Out of all the WIDS on the mainstem of this subwatershed, WID -508 showed the least amount of potential impact from low DO or eutrophication. This site had the most amount of darters (that depend on good water quality), the least amount of opportunistic feeders (meaning a prevalence of specialized species), and had the fewest generally tolerant species. In turn WID -508 has the highest overall percentage of sensitive fish species. While this site scored the best in these categories the outlet WID -514 also had near acceptable scores. With the TSS problems known within this subwatershed it is difficult to see a distinguishable indication that eutrophication could be limiting the fish population, as the community that is responding negatively will also show a similar pattern with TSS displacement.

Macroinvertebrate metrics

Both WIDs found to be impaired for macroinvertebrate assemblage do indicate low DO stress that is likely driven by eutrophic conditions. As shown in Table 51 the taxa diversity was slightly poor, with little DO sensitive species present. This is especially highlighted with the lack of EPT. What made up the Trichoptera order was primarily the tolerant net-spinning caddisfly family. Both locations were found to not be overly dominated by "general tolerant" taxa, allowing for better discernment between specific parameter tolerance that is present. In the case of DO there was not an overabundance of DO tolerant, yet there were not any specific DO sensitive species present. WID -658 had poor DO and Phosphorus index scores, while WID -642 just passed the threshold. In addition to the overall make-up of the community's, the species types present do indicate some degree of eutrophication stress based on feeding habits noted in the abundance of scrapers as well as filter feeders (Mollusks).

The headwater stream system of WID -642 and -568 does indicate eutrophication stress to some degree between the chemistry collected as well as the metric response. Due to the lack of chemistry data at 642 paired with some mixtures within the metrics for both DO and eutrophication stress this station is considered to be inconclusive. While -658 has similar gaps in metrics related to eutrophication, the continuous data that shows daily DO flux is telling of eutrophic conditions as well as potential for low DO conditions.

WID -504 often had low DO reading during early morning. This in conjunction with the poor phosphorus levels and fish metrics point to these parameters placing some restrictions on the community. Although it may not be the primary stressor. WID -518 in noted to have significantly improved fish community from the sample in 2010 (10EM163) to the 2017 sample at (92MN088). The most recent score does show some promise in the diversity of species as well as darters and lithophilic spawners that typically decrease in eutrophic conditions.

Table 51. DO and eutrophication macroinvertebrate metrics for the Badger Creek Subwatershed, red cells indicate values above threshold.

Badger Creek Southern Streams	Station (Year sampled)	Taxa Count	EPT	Trichoptra	Sensitive Tricoptrapct	HBI_MN	DO Index	% DO tolerant	% DO Intolerant
642	17MN347 (2017)	30	12.80	10.00	2.13	7.89	6.78	11.85	0.00
568	17MN345 (2017)	27	1.58	3.70	1.58	8.03	5.91	56.21	0.00
Passing Streams Average	**Prarie Streams General use**	37	38.45	10	5.5	7.55	7.04	25.1	5
	Prarie Streams modified use	*34*	*20.58*	*5.71*	*4.76*	*8*	*6.19*	*31.37*	*2*

Badger Creek Southern Streams	Station (Year sampled)	% Scraper	CrustMollPct	Tanytarsini Pct	Phos Index	% Tolerant	% Intolerant	%Gen Tolerant
642	17MN347 (2017)	53.66	55.18	19.10	0.13	15.12	4	73.17
568	17MN345 (2017)	63.09	74.13	5.13	0.13	20.50	8	36.74
Passing Streams Average	**Prarie Stream General use**	*16.1 1*	*11.78*	*18.46*	*0.13*	*30.6*	*3.8*	*61.78*
	Prarie Streams modified use	17.73	*23.21*	*22.11*	*0.14*	45.87	*1.79*	*73.64*
	Expected response to stress	↑	↑	↑	↑	↑	↓	↑

The furthest upstream WID -658 is the headwaters portion of Badger Creek. As noted in the images above this is a small order stream, with a lack of a good headwater canopy, allowing for more instream UV penetration. There was also a note of this being a slow velocity stream, further allowing for autotrophic growth within this WID. This paired with the potential for phosphorus loading creates prime conditions for Eutrophication to occur. In the summer of 2019 continuous DO was measures from late August to early September. While DO did stay slightly above the 5 mg/L threshold for aquatic life, there was chronic DO fluctuation of above 5 mg/L. Furthermore there was clear indication in the macroinvertebrate community of eutrophication impacting the community to some degree. Eutrophication and DO instability is considered a stressor at this location.

The tributary of Little Badger Creek (WID -642) was assessed on biological monitoring station 17MN347. At the time of monitoring there was noted to be decent overhanging vegetation for cover. There was some filamentous algae present during the sample. DO data was limited, yet was available was poor (value as low as 2.26 mg/L). Phosphorus has a few exceedances, similar to WID 658. Fish were generally tolerant, making the fish metrics difficult to see a response by parameter. It is worth noting that the fish sample here had a large number of DELTs (eroded gills). Indicating an additional stressor that will be explored further on in this report. Unlike the fish sample, the macroinvertebrate sample shows some indication of eutrophic stress. While not likely the primary stressor to the biology, there are enough indicators within the macroinvertebrates, the fish community, and chemistry to list DO as well as eutrophication as a stressor.

The mainstem of the Blue Earth River makes up a majority of the impaired sites within the Badger Creek subwatershed. From upstream to the furthest downstream site, some degree of benthic algae was noted. However, what was present was rated as sparse to moderate with none of the sites having an overabundance of benthic or suspended algae. DO levels throughout the mainstem showed the most concern at the furthest upstream WID of 504 showing an early morning trend constant with eutrophic driven low DO. All the WIDS on the mainstem but -518 had at least one low DO reading. This may be due to low flow as well as sediment oxygen demand as the entire mainstem is listed to have a preexisting turbidity impairment. The one exception to a turbidity/TSS impairment is WID -516 that is not listed due to insufficient data. Sediment issues within this portion of the Blue Earth River may also be playing a role in phosphorus overloading. However, the headwaters portions to the mainstem have chronically high TP concentrations. This is particularly noted at -518 where a watershed pollutant loading monitoring station is established, allowing for a large dataset to assess. Closer to the outlet of this subwatershed TP concentrations are slightly less concentrated, likely from a dilution factor as South Creek and Center Creek converge in before these locations. There is also an increase of riparian as well and gradient change moving towards the outlet, allowing for more natural DO aeration as well as let retention time for eutrophic conditions to grow. Physical conditions at the time of sampling also indicate extremely muddy/turbid waters, particularly closer to the outlet. Making eutrophication less likely at sites, yet still potentially causing low DO issue due to sediment oxygen demand. Another potential cause of some of the low DO reading could also be from lack of flow, as noted in some of the photos. DO as a stressor is inconclusive at all locations, with the exception of WID -518 were it is considered not to be a stressor based on metrics as well as a robust dataset. Eutrophication is considered to be inconclusive at WID -

504, with the upstream WIDs (- 518, 565, 508, 516, 514) being less likely to have eutrophic growth within those sites due to the turbid environment, although they are still indicated as to having high TP.

Table 52. Summary of dissolved oxygen and eutrophication stressors within the Badger Creek Subwatershed; Red indicates stressor while blue indicates inconclusive findings.

				Dissolved Oxygen				Eutrophication		
WID	Stream Name	Biological Stations	Impairment	Dissolved Oxygen	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland/Lake influcence	Excess Phosphorus	Unidentified
	Badger Creek									
568	Badger Creek	17MN345	M-IBI	•					•	
642	Little Badger Creek	17MN347	F-IBI M-IBI	•					•	
504	Blue Earth River	00MN001	F-IBI	•					•	
518	Blue Earth River	10EM163 92MN088	F-IBI						•	
565	Blue Earth River	17MN349	F-IBI		•		•		•	
508	Blue Earth River	17MN316	F-IBI				•		•	
516	Blue Earth River	17MN348	F-IBI				•		•	
514	Blue Earth River	17MN308	F-IBI				•		•	

4.5.5 Nitrate

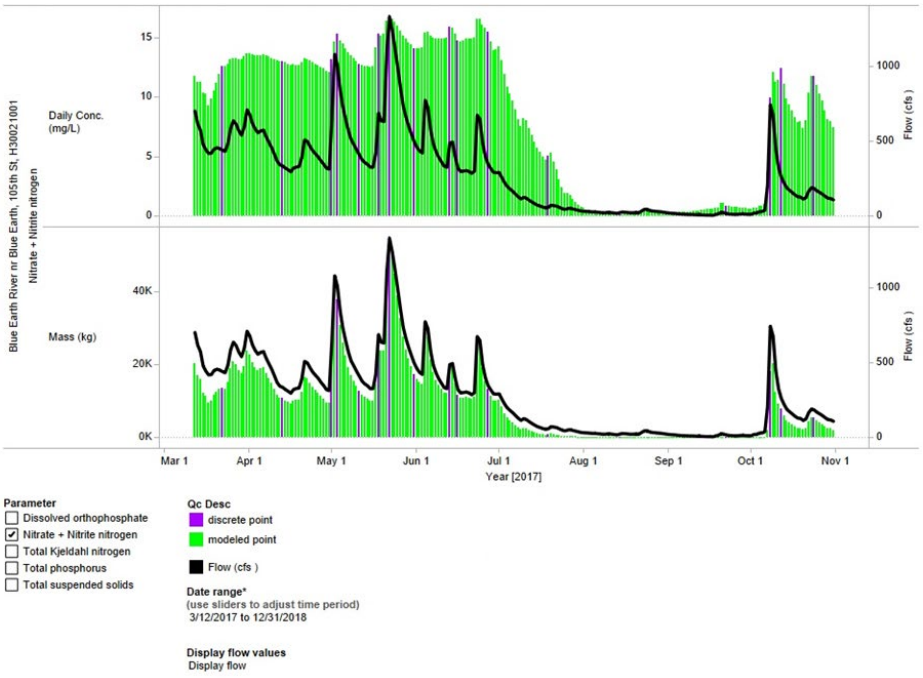
Nitrate data greatly varied throughout the Badger Creek subwatershed. Most headwater streams were limited to what was collected at the time of biological monitoring. There are a few locations within the mainstem of the Blue Earth that indicates chronic nitrate overloading, particularly at WID 518 and 565 as concentrations fell over 20 mg/L. Nitrate levels are of biological concern around 4.9 mg/L and a hazard to human health at 10 mg/L. All streams with the exception of -658 recorded findings that fell above these parameters.

Figure 71. Nitrate concentrations within the Badger Creek Subwatershed.

AUID	Stream Name	Biological Stations	Impairment	Number of samples.	Range of Nitrate (mg/L)	Average of Nitrate (mg/L	# of exceedances 4.9 mg/L	# of exceedances 10 mg/L
	Badger Creek							
658	Badger Creek	17MN345	M-IBI	1	4.1	4.1	0	0
642	Little Badger Creek	17MN347	F-IBI M-IBI	7	.61-14	8.19	5	0
504	Blue Earth River	00MN001	F-IBI	1	13	13	1	1
518	Blue Earth River	10EM163 92MN088	F-IBI	211	.09-25.2	12.79	181	147
565	Blue Earth River	17MN349	F-IBI	9	.048-17.2	9.03	6	5
508	Blue Earth River	17MN316	F-IBI	3	1.7-13	7.9	2	1
516	Blue Earth River	17MN348	F-IBI	3	.05-7.7	2.95	1	0
514	Blue Earth River	17MN308	F-IBI	2	1.1-8.3	4.7	1	0

In addition to the samples in Figure 71 this subwatershed has an intense monitoring location through the Watershed Pollutant Monitoring program. As shown in Figure 72, this monitoring effort highlighted the streams high nitrate response following higher flows.

Figure 72. Nitrate concentrations with flow in the Blue Earth River at WPLMN site near the town of Blue Earth. Purple shows measured concentrations while green is modeled, black line indicates flow.



Macroinvertebrate

Macroinvertebrate community response to nitrate is the strongest biological indicator to determine nitrate stress. Fish community metrics are yet to be established in determining nitrate stress. Within the Badger Creek subwatershed, nitrate response varied, as shown in (

Figure 73). The overall taxa count was either above or close to the average amount found in passing streams at all locations. Ephemeroptera, Plecoptera & Trichoptera (EPT) are three insect orders that are particularly sensitive to Nitrate. There were a few sites that scored within the acceptable range, those being on the mainstem of the Blue Earth River at WIDs 504, 518 (for 2010 also isolated good ratings for Nitrate Index and tolerant), and 514. WID -642 had one of the worst ratings as far as nitrate displacement. While the taxa count was adequate, sensitive ETP species lacked, where specific nitrate tolerant as well as the nitrate index score was well past the threshold. All sites were severely lacking in nitrate intolerant species.

Figure 73. Nitrate metrics for macroinvertebrate assemblage in the Badger Creek Subwatershed, red cells indicate value over the threshold.

Badger Creek	Station (Year sampled)	Taxa Count	EPT#	Nitrate Index	% Nitrate tolerant	% Nitrate Intolerant
508	17MN316 (2017)	28	11.00	3.28	62.81	0.00
516	17MN348 (2017)	46	12.00	3.37	62.35	0.00
514	17MN308 (2017)	50	15.00	3.20	50.31	0.31
Passing Streams Average	**Prarie Forest River General Use**	35	13.77	2.86	46.79	4.36
	Expected response to stress	↓	↓	↑	↑	↓

Badger Creek	Station (Year sampled)	Taxa Count	EPT#	Nitrate Index	% Nitrate tolerant	% Nitrate Intolerant
642	17MN347 (2017)	30	4.00	6.50	82.67	0.00
568	17MN354 (2017)	27	1.00	4.62	44.41	0.00
504	00MN001 (2017)	42	12.00	3.35	56.46	0.00
518	10EM163 (2010)	43	13.00	3.02	51.76	1.28
	92MN088 (2017)	46	11.00	3.40	58.31	0.00
565	17MN349 (2017)	27	8.00	3.57	69.42	0.00
Passing Streams Average	**Prarie Stream general use**	37	*11.5*	*3.23*	*54.86*	*3.18*
	Prarie Stream modified use	24	*7.6*	*3.32*	*59.41*	*1.95*
	Expected response to stress	↓	↓	↑	↑	↓

Summary

About half of the WIDs within Badger Creek Subwatershed are inconclusive due to a lack of data or mixed data results (WID 568, 504, 516, and 514). Little Badger Creek at WID-642 had some of the poorest nitrate biological metrics. In addition the nitrate concentrations often exceeded the proposed biological nitrate standard of 4.9mg/L, reaching up to 14 mg/L. There are strong indications that nitrate is stressing the community. Further down on WID -518 on the mainstem of the blue Earth there were two years of biological data. There was a clear decline in the community between 2010 and 2017 sampling. While the 2010 sample scored ok, the 2017 macroinvertebrate sample resembled a community negatively impacted by high nitrates. In addition, the robust data set shows that nitrate concentrations are a chronic issue with a majority of all samples not just exceeding the proposed biological standard of 49 mg/L but also the drinking water standard of 10 mg/L, reaching concentrations of 25 mg/L at times. The direct downstream WIDs of -565 and -508 do not have as robust of a chemistry data set as -518, yet shows similar trends. Both chemistry and the macroinvertebrate assemblage at these three WIDS show nitrate as a stressor.

The final two WIDs of -516 and -514 are inconclusive. There is a poor data set to assess at these locations, although they both show there is some evidence for high nitrate concentrations in the few samples collected. The biological metrics were below the high standards for a natural Forest Prairie Stream standard, yet better than other streams metrics. Additional nitrate sampling would help understand chemistry dynamics within these two WIDs and determine if nitrate is a chronic issue. The dilution of nitrate from other subwatersheds that converge before these locations is a possibility.

Contributors of nitrate are predominantly a result of nearby land use practices. Row crops in conjunction with subsurface tile drainage is a direct introduction of nitrate into the stream system. In addition there are multiple lagoons, back waters, as well as a municipality that could potentially deliver some levels of nitrate to the Badger Creek Subwatershed.

Figure 74. Nitrate identified as a stressor within the Badger Creek Subwatershed by WID; Red indicates nitrate stress in that community while blue is inconclusive.

					Nitrate		
AUID	Stream Name	Biological Stations	Impairment	Land Use (application)	Upstream waterbody	Point Souce	Unidentified
	Badger Creek						
568	Badger Creek	17MN345	M-IBI	●			
642	Little Badger Creek	17MN347	F-IBI M-IBI	●			
504	Blue Earth River	00MN001	F-IBI	●			
518	Blue Earth River	10EM163 92MN088	F-IBI	●		●	
565	Blue Earth River	17MN349	F-IBI	●		●	
508	Blue Earth River	17MN316	F-IBI	●		●	
516	Blue Earth River	17MN348	F-IBI	●			
514	Blue Earth River	17MN308	F-IBI	●			

4.5.6 Total suspended solids

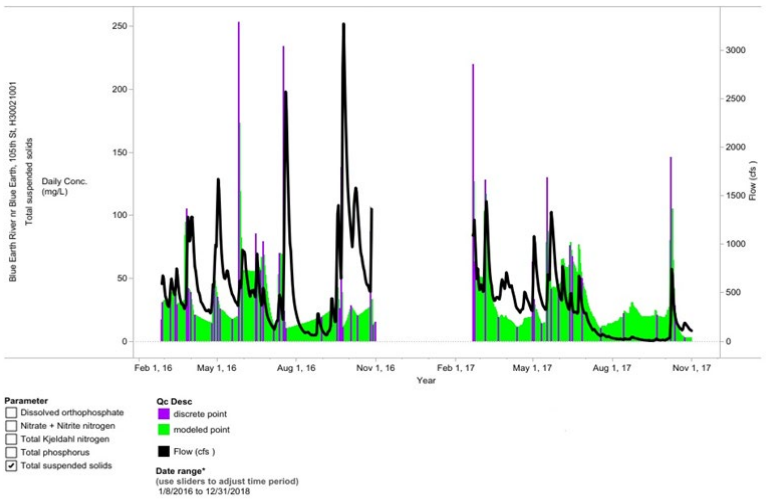
The amount of total suspended solids (TSS) data varies from site to site throughout the Badger Creek Subwatershed, yet all sites show at least one exceedance of the 45 mg/L standard (Figure 75). Total suspended volatile solids (TSVS) were sampled alongside with TSS to evaluate organic contributions, typically in form of suspended algae. Most sites had an organic composition of 20-30% of the total sample. As with other parameters, WID -518 had the strongest data set, with 206 samples. Eighty-four of the sampled within this WID exceeded the standard, reaching concentrations as high as 524 mg/L (following a severe rain event).

Figure 75. TSS and TSVS concentrations within the Badger Creek Subwatershed.

WID	Stream Name	Biological Stations	Impairment	# of TSS samples	# of TVS samples	Range of TSS (mg/L)	Range of TVS (mg/L)	Average of TSS (mg/L)	% TSVS made up TSS (Average)	# of exceedances 45 mg/L
	Badger Creek									
658	Badger Creek	17MN345	M-IBI	10		14-56		28.35		3
642	Little Badger Creek	17MN347	F-IBI M-IBI	4	5	9.6-95	2.8-14	36.92	23.86	2
504	Blue Earth River	00MN001	F-IBI	11	1	12.5-47	6.8	26.22	18.89	1
518	Blue Earth River	10EM163 92MN088	F-IBI	206	92	3-524	2-100	52.95	31.6	84
565	Blue Earth River	17MN349	F-IBI	7	3	11-72	6-16	39.57	29.18	2
508	Blue Earth River	17MN316	F-IBI	13	3	10-68	3.2-10	34.31	22.84	2
516	Blue Earth River	17MN348	F-IBI	2	2	36-83	12-14	59.5	25.1	1
514	Blue Earth River	17MN308	F-IBI	12	2	33-78	14(2)	48.13	24.4	5

There was one site near the town of Blue Earth within the Blue Earth River where data was collected from 2016 to 2018 for TSS through the MPCAs Watershed Pollutant Load Monitoring Network. As shown in Figure 76, TSS concentrations are extremely responsive to rain events, often reaching concentrations into the 100's. More often than not the mainstem that falls within the Badger Creek Subwatershed was above the threshold of 45 mg/L.

Figure 76. Nitrate concentrations with flow in the Blue Earth River at WPLMN site near the town of Blue Earth. Purple shows measured concentrations while green is modeled, black line indicates flow.



Fish TSS metrics

All WIDs show in the below Figure 77 show that the tolerance index value for TSS exceeded the threshold. In addition there is a complete absence of TSS sensitive species, including Centrarchidae. All but WID -504 had a lack of benthic feeding fish this shows there is a high likelihood of an embedded or smothered streambed from channel instability and sediment delivery. Herbivores were lacking in all but WID -504 and -542 on Badger Creek. Lack of herbivores can be an indication that turbidity may be inhibiting in stream plant growth.

Fish that were maintaining the long lived and lithophilic spawner were made up of tolerant species such as common carp, white suckers, and creek chubs.

Figure 77. Fish TSS metrics within the Badger Creek Subwatershed, with Southern Streams class on the top and Southern Headwaters on the bottom.

Badger Creek	Station (Year sampled)	Benthic Feeders Pct	Sensitive Centrarchidae Pct	Herbivores Pct	Intolerant Pct	Long Lived Pct	Sensitive Perciformes Pct	Riffle Pct	Sensitive Pct	Lithophilic Spawners Pct	TSS TIV
504	00MN001 (2017)	38.54	0.00	34.80	0.00	5.43	3.23	35.99	3.06	34.63	20.33
518	10EM163 (2010)	23.27	0.00	11.32	0.00	22.64	11.32	20.75	0.00	21.38	23.63
	92MN088 (2017)	32.25	0.00	17.89	0.00	21.95	12.74	27.64	4.88	31.44	23.50
565	17MN349 (2017)	23.25	0.64	11.78	0.00	27.71	4.78	23.25	4.46	21.34	24.73
508	17MN316 (2017)	22.20	0.37	9.91	0.00	15.41	18.35	34.68	22.02	20.18	26.73
642	17MN347 (2017)	32.75	0.00	27.49	0.00	0.00	6.43	27.49	0.00	8.19	17.32
Passing Streams Average	Expected response to **Southern Headwaters General use**	34.97	0.99	22.40	1.61	4.51	13.61	26.18	7.87	14.63	15.09
	Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

Macroinvertebrate TSS metrics

The macroinvertebrate community failed to show sites with strong consistent response to TSS (Figure 78). All locations lacked TSS intolerants, while those specifically tolerant to TSS often fell at acceptable ranges throughout the system. Most stations had acceptable diversity that is noted in the taxa count. Long lived species also were present at lost locations, with the exception of those on the tributary of Little Badger (WID -642 and -658). Long lived metrics are used in interpreting potential of potential disruption (such as high sediment loads) creating a mass elimination to macroinvertebrates. Sensitive Plecoptera and Ephemeroptera were diminished at all but the furthest downstream station and WID -518. These orders could also be diminished from another pollutant or disturbance factor as well.

Figure 78. Macroinvertebrate TSS metrics within the Badger Creek Subwatershed; Prairie Streams class on top with Prairie Forest Streams on Bottom.

Badger Creek	Station (Year sampled)	Taxa Count	%Long Lived	%Plecoptera	Ephemeroptera Count	TSS Index	% Tolerant	% Intolerant
642	17MN347 (2017)	30	0.61	0.00	1.00	20.30	61.40	0.00
568	17MN354 (2017)	27	0.00	0.00	0.00	16.64	38.20	0.00
504	00MN001 (2017)	42	9.76	0.00	5.00	16.02	23.42	0.00
518	10EM163 (2010)	43	18.21	0.32	9.00	19.23	59.42	0.32
	92MN088 (2017)	46	13.17	0.31	10.00	17.61	33.23	0.00
565	17MN349 (2017)	27	7.67	0.00	5.00	17.40	42.51	0.31
Passing Streams Average	**Prarie Stream general use**	37	7.5	0.2	6.7	17.35	48.28	2.67
	Prarie Stream modified use	24	6.0	0.1	4.8	16.02	35.60	1.27
	Expected response to stress	↓	↓	↓	↓	↑	↑	↓
Badger Creek	Station (Year sampled)	Taxa Count	%Long Lived	%Plecoptera	Ephemeroptera Count	TSS Index	% Tolerant	% Intolerant
508	17MN316 (2017)	28	2.50	0.63	5.00	17.17	46.88	0.00
516	17MN348 (2017)	46	13.93	1.86	9.00	18.48	49.69	0.00
514	17MN308 (2017)	50	26.79	3.12	9.00	20.01	57.76	0.62
Passing Streams Average	**Prarie Forest River General Use**	35	6.64	0.58	7.11	18.37	49.06	3.91
	Expected response to stress	↓	↓	↓	↓	↑	↑	↓

TSS summary

TSS is playing a limiting factor to some extent throughout the mainstem of the Blue Earth River in this subwatershed. Macroinvertebrates are able to thrive to some extent without showing strong indications of TSS limitations to the community, however TSS impacts are still noted and clearly limiting the habitat (discussed further down) as well as the fish community. The chemistry data shows that this stream system as a whole is sensitive to rain events. The DNR reported that the Badger Creek subwatershed is one of the most altered subwatersheds with also a lack of water holding areas (Lore 2021). There is also a turbidity impairment along the branch of the Blue Earth River within the Badger Creek Subwatershed.

Table 53. Summary of TSS stressors within Badger Creek Subwatershed, red indicates stressor while blue is inconclusive.

				TSS			
AUID	**Stream Name**	**Biological Stations**	**Impairment**	Suspended Algae	Flow Alterations	Stream Bank Erosion	Pasture
	Badger Creek						
568	Badger Creek	17MN345	M-IBI		●		
642	Little Badger Creek	17MN347	F-IBI M-IBI		●		
504	Blue Earth River	00MN001	F-IBI		●	●	
518	Blue Earth River	10EM163 92MN088	F-IBI		●	●	
565	Blue Earth River	17MN349	F-IBI		●	●	
508	Blue Earth River	17MN316	F-IBI		●	●	
516	Blue Earth River	17MN348	F-IBI		●	●	
514	Blue Earth River	17MN308	F-IBI		●	●	

4.5.7 Habitat

During site inspections in Badger Creek the habitat was found to more degraded the further upstream the monitoring sites were. Station 17MN345 on WID -568 on the headwaters of Badger Creek and Station 17MN347 on WID -642 in Little Banger Creek are both completely altered by way of channelization and ditching. This has led to poor habitat diversity as well as habitat quality. The streambed features were found to have a lack of substrate diversity with a dominance of fines. There also was some channel instability noted in streambank erosion. The dominant forms of habitat sampled was Pond Weed, submerged Reed Canary Grass, and occasional woody debris. These forms of habitat can often drive up the climber score, noted in the high amount of snail species that were dominant in the sample at both sites. Both locations also had an overabundance of legless species that don't require specific clean substrate or habitat. Station 17MN347 scored poorly for fish assemblage, with benthic feeders and lithophilic spawners low. This further increases the likelihood that poor benthic habitat is causing limitations on biology.

The other stations are all on the Blue Earth River that are within the boundaries of the Badger Creek Subwatershed. The furthest upstream station of 00MN001 had several habitat assessments done with all showing erosion as a reoccurring issue. Siltation and embeddedness also is noted at times. Macroinvertebrates fell within the expected distribution based on habitat needs. The fish composition at station 00MN001 had adequate about on herbivores, benthic eaters, and lithophilic spawners. There are some habitat concerns yet it is not evident that there are strong limitations to biology, therefore inconclusive. The next downstream WID of -518 was the only other WID that had a clear habitat impairment. The two stations of 10EM163 and 92MN088 were particularly lacking in streambed diversity. As discussed previously in the TSS section for Badger Creek, TSS concentrations come through here in alarming amounts that directly limit habitat. While macroinvertebrates were not significantly impacted by habitat conditions, the lack of herbivores, benthic feeders, and riffle dwellers strongly indicate habitat is degraded and limiting the fish community here. WID-565 was the last the Prairie Stream with station 17MN349. As shown below, the macroinvertebrate habitat was slightly skewed due

to the high abundance of “clingers.” Regardless of these high percentages, there were not a concerning level of other habitat groups that signal major habitat displacement. In the fish community there also a fair amount of lithophilic spawners. The habitat scores varied between the two visits. While there was moderate embeddedness and high amount of fine sediments, there was some gravel also noted. Bank erosion was not surprisingly noted within area as well. However, overall habitat diversity was adequate, yet varied in degree of degradation. Habitat is inconclusive at this location.

Figure 79. Prairie Stream macroinvertebrate habitat metrics within Badger Creek.

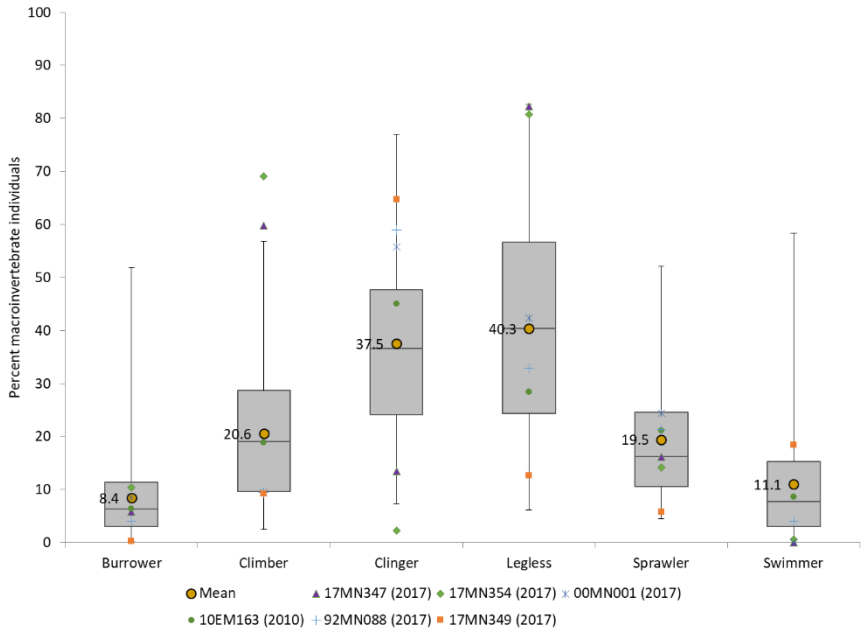
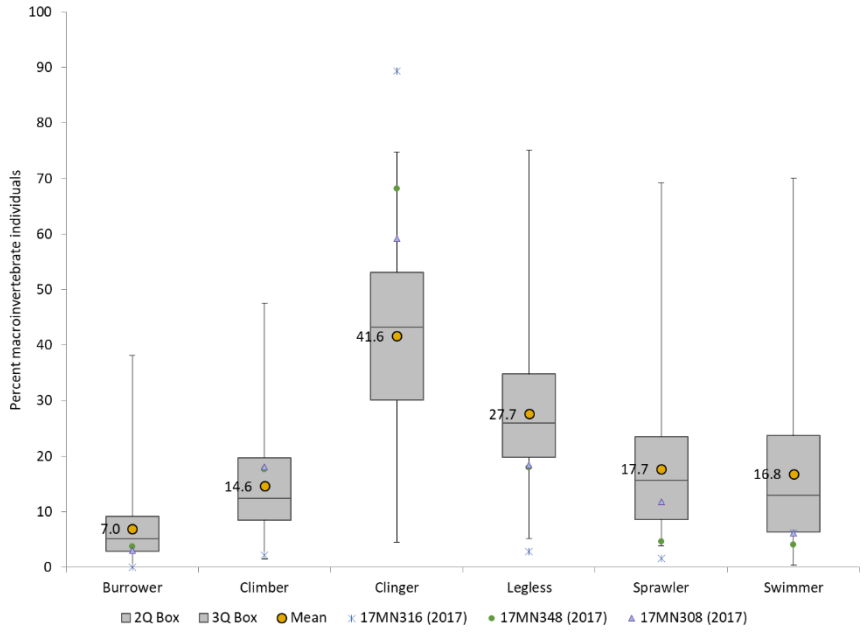


Figure 80. Prarie Forest River macroinvertabrate habitat metrics within Badger Creek.

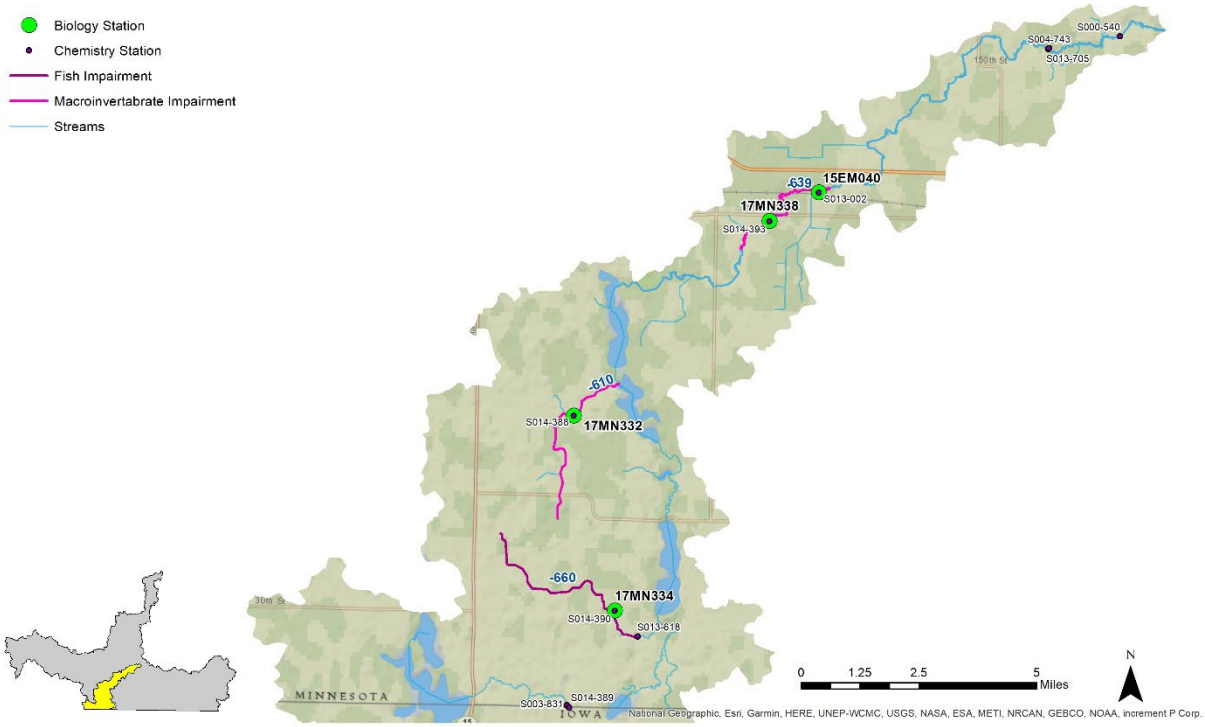


The final stretch of the Blue Earth River that falls within the Badger Creek Subwatersheds is categorized as a Forest Prairie Stream for evaluating the composition of macroinvertebrates (Figure 79). The final three WIDs of -508, 516, and 514 (monitoring stations 17MN316, 17MN348, and 17MN308 respectively). Figure 79 above, highlights that while those who dwell in habitats where currents can increase, there were not any concerning distributions of burrowers or legless individuals. In addition to the makeup of the macroinvertebrates, fish did not signal a strong response of habitat displacement when they were evaluated under TSS. These final three WIDs were rated as having some of the better habitat out of the entire Blue Earth River Watershed. This is likely due to the wider areas of riparian that allows for some mitigation of altered flows. Substrate diversity increased a great deal within this final stretch. As the gradient increase this does leave more opportunity for a variety of stone movement.

Table 54. Summary of habitat stressors within the Badger Creek Subwatershed, red indicates a stressor while blue indicates inconclusive findings.

				Habitat				
WID	**Stream Name**	**Biological Stations**	**Impairment**	Channalized	Riparian	Streambed	Habitat diversity	Trampeling
	Badger Creek							
568	Badger Creek	17MN345	M-IBI	●	●	●	●	
642	Little Badger Creek	17MN347	F-IBI M-IBI	●	●	●	●	●
504	Blue Earth River	00MN001	F-IBI		●			
518	Blue Earth River	10EM163 92MN088	F-IBI		●	●	●	
565	Blue Earth River	17MN349	F-IBI		●			
508	Blue Earth River	17MN316	F-IBI		●			
516	Blue Earth River	17MN348	F-IBI		●	●	●	
514	Blue Earth River	17MN308	F-IBI		●			

4.6 South Creek



The South Creek Subwatershed was found to have three separate WIDs impaired for biological assemblage. Judicial Ditch 38 on WID -660 had one monitoring location (17MN334), impaired for fish. Judicial Ditch 98 on WID -610 (17MN332) and South Creek's WID -639 (17MN338 and 15EM040) are impaired for macroinvertebrate assemblage. This HUC 10 watershed is located within Martin County intersecting the Iowa border. Only sections that fell within Minnesota is assessed. This area of the watershed is roughly 112 square miles. Here, there is the chain lakes of East Chain, South Silver, and Iowa Lake. South Silver is currently impaired for aquatic life use, while other two are impaired for aquatic recreation. For additional information refer to the MPCAs Blue Earth River Monitoring and Assessment Report or the DNR's Lake Stressor Identification findings.

4.6.1 Biological communities

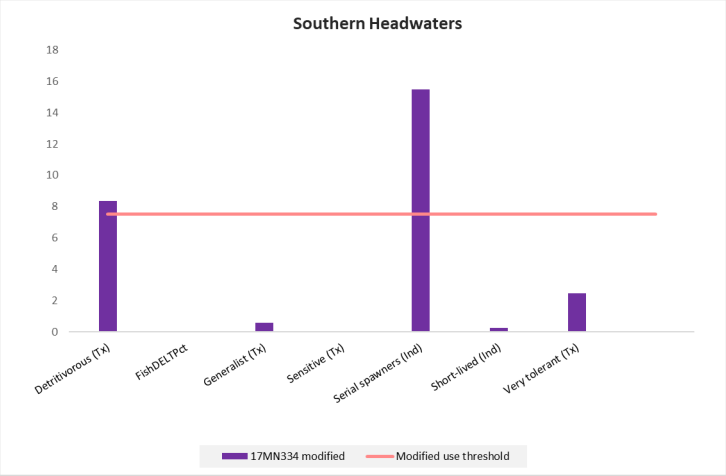
The image in Figure 81 below show the conditions of the monitoring locations at the time of the biological sample.

Figure 81. Conditions of the monitoring locations within the South Creek Subwatershed.

Fish assemblage

The South Creek Subwatershed was found to only have one WID impaired for fish assemblage (WID-660). The fish sample collected on June 19, 2017. This station is located in the far upper headwaters, feeding into the East Chain lakes system. This lake was monitored and found to have excess phosphorus, chlorophyll-a, and Secchi tube readings. The FIBI score was 27.1, below the southern streams modified use threshold of 33. Taxa diversity was extremely poor with only four taxa types present. Brook Stickleback made up a strong majority with 30 individuals. Blacknose Dace, Fathead Minnow, and a Green Sunfish were all found to be in the single digits. Due to the low diversity and poor overall small sample size, fish metrics will not be helpful in determining specific stressors by parameter using metrics.

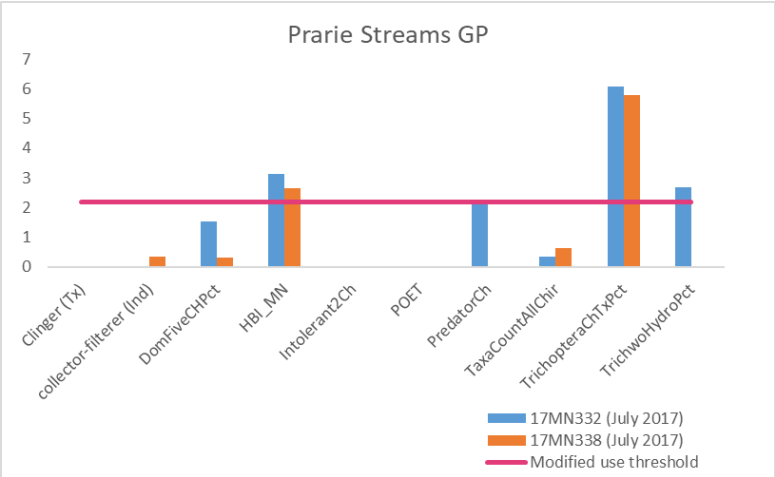
Figure 82. Fish community metrics for southern headwater streams in the Badger Creek Subwatershed.

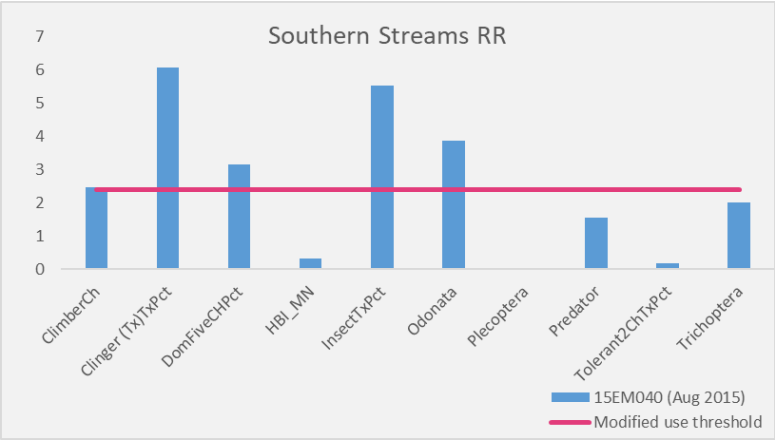


Macroinvertebrates

There were two WIDs that were impaired for macroinvertebrate assemblage within the South Creek Subwatershed. WID -660 that was impaired for fish was not able to be assessed for macroinvertebrates due to low water levels. The furthest upstream WID -610 that is located on Judicial Ditch 98 drains into the East Chain lakes system. Station 17MN332 scored an IBI of 15.9, below the modified use threshold of 22 (±13.6). Multiple non-biting midges and snails dominated the sample. Overhanging vegetation was the primary habitat available to collect the macroinvertebrate samples from. The next WID -639 runs along the mainstem of South Creek, with two monitoring stations. The first (17MN338) fell into the Prairie Streams GP modified use class, scoring well below the threshold at 9.7. There was a fair amount of diverse habitat types to collect macroinvertebrates from, however the overall taxa count was low. Net-spinning caddisfly's were the most abundant species. Further downstream was station 15EM040, that was last sampled in 2015. This stream is classified as a Southern Stream with riffle run features having the modified use threshold of 24 (±12.6). This station scored slightly above at 25.1, but within the CL.

Figure 83. Macroinvertebrate community metrics, prairie streams on top with southern streams on bottom.





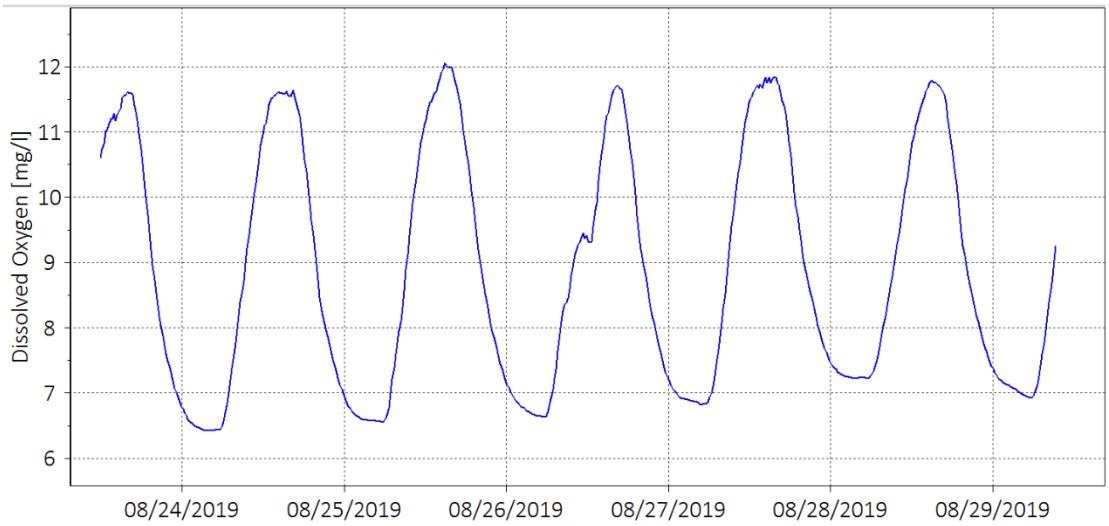
4.6.2 Dissolved oxygen and eutrophication

Dissolved oxygen (DO) data at WID -660 was limited to what was collected at the time of biological monitoring. During the fish sample, the DO reading was 14.46 mg/L at 5:00 p.m. on July 19, 2017, on the inverse an early morning reading at the time of the invertebrate visit during 8:46 a.m. was 5.47 mg/L. While data quantity is limited, this snapshot dynamic between early morning and afternoon readings does reflect intense DO fluctuation.

WID -610 was also limited in DO readings to just what was collected at the time of biological sampling. During the invert sample on August 8, 2017 DO was below the standard of 5mg/L at 4.27 mg/L during a 9:00 a.m. reading. The fish sample on July 18, 2017, was 7.65 mg/L during a 6:00 p.m. reading. The low morning reading in the later part of the summer does correlate to hotter stream temperatures and high organic respiration.

WID -639 only had four samples. None of the four fell out of the normal range. Station 17MN338 was slightly farther upstream, this station did have a stronger data set, as continuous DO data was collected from August 22 through August 29th 2019, displayed in Figure 84 below. Nightly concentrations often fell around the 5 mg/L threshold.

Figure 84. Continuous DO data on site 17MN338.



Phosphorus

Phosphorus data was sparse, however, the data collected showed clear potential for high loading potential. This is especially evident at Judicial Ditch 98 and the site within South Creek as there were values well above the .15 mg/L phosphorus threshold for Minnesota Southern Rivers.

Table 55. Phosphorus values within South Creek Subwatershed.

AUID	Stream Name	Biological Stations	Impairment	Number of samples.	Range of TP (mg/L)	Average of TP (mg/L	# of exceedances .15 mg/L
South Creek							
660	Judicial Ditch 38	17MN334	F-IBI	1	-	0.041	0
610	Judicial Ditch 98	17MN332	M-IBI	4	.05-.31	0.16	2
639	South Creek	17MN338 15EM040	M-IBI	4	.17-.21	0.19	4

Macroinvertebrates

Macroinvertebrate metrics for low DO did show indication of displacement in the southern stream portion of WID -639 (15EM040), shown in Table 56. While the taxa count fell just above the threshold, the EPT community is largely shown to be made up of the tolerant Trichoptera (net spinning caddisfly). In addition, there is a complete absence of DO intolerant species with an overabundance of specifically tolerant low DO individuals. Overall the taxon sampled are of the generally tolerant variety.

Table 56. Macroinvertebrate low DO metrics within the South Creek Subwatershed, red indicates value over the threshold.

South Creek	Station (Year sampled)	Taxa Count	EPT	Trichoptra	Sensitive Tricoptrapct	HBI_MN	DO Index	% DO tolerant	% DO Intolerant
639	15EM040 (2015)	28	14.51	14.29	1.89	8.24	6.66	30.19	2.20
Passing Streams Average	*Southern Rivers RR Modified use*	27	40.3	18.5	4.3	7.57	6.75	18.23	12.71
	Expected response to stress	↓	↓	↓	↓	↑	↓	↑	↓
South Creek	Station (Year sampled)	Taxa Count	EPT	Trichoptra	Sensitive Tricoptrapct	HBI_MN	DO Index	% DO tolerant	% DO Intolerant
639	17MN338 (2017)	21	57.91	9.52	0.00	8.06	6.73	1.89	0.63
East Chain Lake Impaired for fish and Chlorophill-a, TP, and Secchi readings.									
610	17MN332 (2017)	20	2.81	10.00	0.94	7.96	6.68	1.25	0.00
Passing Streams Average	*Prarie Streams Modified use*	*24*	*25.90*	*5.80*	*2.40*	*7.92*	*6.19*	*31.36*	*3.08*
	Expected response to stress	↓	↓	↓	↓	↑	↓	↑	↓

The eutrophic metric response at 15EM040 was not as prominent as LOW DO (Table 57), yet still some indications of stress within the community. Primarily noted in the overall abundance of taxa that are specifically tolerant to eutrophication paired with the complete absence of those that are sensitive. Station 17MN338 that is also located on WID -639 showed a similar metric response to the downstream station of 15EM040. The exception being there were slightly fewer taxa types collected for the average of a stream of this type, and there was not as prevalent of an over dominant tolerant community for either low DO or eutrophication.

Further upstream are the East Chain Lakes system. This chain lake is noted to have a proposed impairment for fish assemblage as well as eutrophication (noted in Chl-*a* and TP). This lake is likely playing some role to the downstream conditions found on South Creek's WID -639. Lakes like this are also telling of what is being contributed from upstream sources.

Judicial Ditch 98's WID -610 (17MN332) scored poorly for both low DO (Table 56) and eutrophic (Table 57) metric response. There was a low amount of taxa present in conjunction of a complete lack of sensitive species. The feeding types that were sampled are particularly telling of a high autotrophic stream system as there was an overabundance of the three primary algae feeder types (scrapers, filterers, and filters).

The furthest upstream station in the South Creek Subwatershed is Judicial Ditch 38 (WID -660) on station 17MN344. This system feeds into the impaired East Chain Lake. At the time of monitoring this station was noted as having excess filamentous algae in additions to sever embeddedness. The macroinvertebrate sample was not able to be carried out due to low water levels. The fish sample was poor with only four taxa types, all but brook stickle backs being in the single digits. With this low of diversity metrics are unhelpful. Chemistry was limited, however there is some indication of DO flux based on the two point measurement's, in correlation with the times taken. Phosphors trends in this WID is unknown as there was only one reading. While low DO and eutrophication is possibly play a role in limiting biology, there is not enough in biological data or chemistry data to make a determination. Based on the site condition it would be likely that if there is, the alterations to the stream and the riparian are the primary drivers in influencing these parameters.

Table 57. Eutrophication metrics within the South Creek Subwatershed, red indicates value over the threshold.

South Creek	Station (Year sampled)	% Scraper	CrustMollPct	TanytarsiniPct	Phos Index	% Tolerant	% Intolerant	%Gen Tolerant
639	15EM040 (2015)	3.47	3.47	0.83	0.16	29.25	0.00	80.13
Passing Streams Average	*Southern Rivers RR Modified use*	13.5	10.7	25.63	0.14	27.87	3.27	54.6
	Expected response to stress	↑	↑	↑	↑	↑	↓	↑
South Creek	Station (Year sampled)	% Scraper	CrustMollPct	TanytarsiniPct	Phos Index	% Tolerant	% Intolerant	%Gen Tolerant
639	17MN338 (2017)	1.58	0.95	0.00	0.14	4.10	0.00	30.38
East Chain Lake Impaired for fish and Chlorophill-a, TP, and Secchi readings.								
610	17MN332 (2017)	24.69	25.31	42.18	0.13	1.88	0.00	84.06
Passing Streams Average	*Prarie Streams Modified use*	17.2	18.9	20.7	0.15	45.87	1.43	73.6
	Expected response to stress	↑	↑	↑	↑	↑	↓	↑

Judicial Ditch 38 is a small stream system that also feeds into the chain lakes. At the time of monitoring there was noted to be an extensive amount if aquatic vegetation (primarily Elodea) as shown in Figure 81. There was a moderate amount of filamentous algae. The site pictures above show overgrowth within the stream. While DO data is limited, there does show some indication of low DO issues. Phosphorus data is also limited, yet had a sample value of .31 mg/L with an average concentration of .06 mg/L. The macroinvertebrates did show some indication of eutrophic displacement, with a complete lack of eutrophic sensitive or low DO species. However, the lack of data and inconstancy's within the overall DO metrics require additional monitoring to verify these parameters as a stressor, leaving them inconclusive for now.

The mainstem of South Creek had one impaired WID (-639) with two monitoring stations assessed, 17MN338 and 15EM040 respectively. This site is located downstream in the impaired chain lakes. Other than the photo documentation that was taken at the time of sampling (Figure 85), follow up site visits showed frequent green water at station 17MN338 like the one shown below.

Figure 85. Station 17MN338

Continuous DO data was collected at this site that did show the DO flux was a problem. During this deployment DO did not fall below 5 mg/L but was close. There was an additional low DO instantaneous measurement that fell below 5mg/L. The downstream station of 15EM040 had limited DO data, where none of the samples showed low DO. Phosphorus samples are limited on this WID, although the samples did show high potential for TP overloading. The macroinvertebrate metrics indicated that the downstream station was made up of generally tolerant species, scoring poorly in both the phosphorus index and low DO index in comparison to the upstream station of 17MN338. Both locations had a high population of the tolerant form of Trichoptera, the net-spinning caddisfly *Cheumatopsyche.* These species depend on high suspended algae content to thrive. Based on what chemistry data is available, field observations, the sources feeding this WID, and the metrics there is some indication of low DO and eutrophication displacement in the macro inverts.

Table 58. Summary table for DO and eutrophication stress within the South Creek Subwatershed, red cells show stressor where blue shows inconclusive findings.

				Dissolved Oxygen				Eutrophication		
AUID	Stream Name	Biological Stations	Impairment	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland/Lake influcence	Excess Phosphorus	Unidentified
	South Creek									
660	Judicial Ditch 38	17MN334	F-IBI		●					
610	Judicial Ditch 98	17MN332	M-IBI	●					●	
639	South Creek	17MN338 15EM040	M-IBI	●		●		●	●	

4.6.3 Nitrate

Nitrate data collection was sparse throughout the South Creek Subwatershed. Out of the few samples collected, nitrate concentration levels reached concerning levels. The highest were noted in Judicial Ditch 38 (WID -660) and Judicial 98 (WID -610) reaching levels around 20 mg/L, as shown in Figure 86. In addition to noting the extreme high concentrations, there were also consistently high concentrations at JD 98.

Figure 86. Nitrate concentrations within the South Creek Subwatershed, categorized by WID.

AUID	Stream Name	Biological Stations	Impairment	Number of samples.	Range of Nitrate (mg/L)	Average of Nitrate (mg/	# of exceedances 4.9 mg/L	# of exceedances 10 mg/L
	South Creek							
660	Judicial Ditch 38	17MN334	F-IBI	1	23	23	1	1
610	Judicial Ditch 98	17MN332	M-IBI	4	10.0-19.0	14.75	4	4
639	South Creek	17MN338 15EM040	M-IBI	5	.16-5.0	2.46	1	0

Macroinvertebrate

Fish metrics to evaluate for nitrate displacement are still under development, leaving the macroinvertebrate community to be the only biological response measured across all sites. As shown in Figure 87, across all stations nitrate metrics indicated some degree of nitrate impacting the community composition. There were not any nitrate intolerant species, in place was an overabundance of nitrate tolerant making up a majority of the total population at all locations. In addition the overall taxa count was below average and nitrate sensitive Ephemeroptera, Plecoptera & Trichoptera (ETP) were also lacking.

Figure 87. Macroinvertebrate response to nitrate within the South Creek Subwatershed; Prairie Stream class on top and Southern stream class on the bottom.

South Creek	Station (Year sampled)	Taxa Count	EPT#	Nitrate Index	% Nitrate tolerant	% Nitrate Intolerant
639	17MN338 (2017)	21	2	3.89	88.33	0
EAST CHAIN LAKE Impaired for fish and Chlorophill-a, TP, and Secchi readings.						
610	17MN332 (2017)	20	2	5.49	91.88	0
Passing Streams Average	*Prairie Streams GP Modified use*	24	*7.6*	*3.32*	*59.41*	*1.95*
	Expected response to stress	↓	↓	↑	↑	↓

South Creek	Station (Year sampled)	Taxa Count	EPT#	Nitrate Index	% Nitrate tolerant	% Nitrate Intolerant
639	15EM040 (2015)	28	6	3.84	62.58	0
Passing Streams Average	*Southern Rivers RR Modified use*	31	*6.9*	*2.95*	*47.6*	*2.92*
	Expected response to stress	↓	↓	↑	↑	↓

Summary

Nitrate is considered a significant biological stressor at all impaired WIDs in in the South Creek subwatershed. Macroinvertebrate metrics consistently indicated significant stress at all locations, with WID 660 as the exception due to lack of macroinvertebrates to assess. However, with the nitrate reading of 23 mg/L, and the trends noted by similar nearby reaches, it's reasonable to make the correlation that Nitrate is likely a factor. While the chemistry data set was modest, concentrations reached upwards of 20 mg/L.

Table 59. Summary of Nitrate stressors within the South Creek Subwatershed, red cells indicate a stressor.

				Nitrate			
AUID	**Stream Name**	**Biological Stations**	**Impairment**	Land Use (application)	Upstream waterbody	Point Souce	Unidentified
	South Creek						
660	Judicial Ditch 38	17MN334	F-IBI	●			
610	Judicial Ditch 98	17MN332	M-IBI	●			
639	South Creek	17MN338 15EM040	M-IBI	●	●		

One of the primary contributors to nitrate loading is due to the surrounding land use being agriculturally dominated in conjunction with tile drainage networks transporting field drainage to the stream. The mainstem of South Creek is also a receiving stream of the Chain lakes, this in addition to other near land water storage can at times deliver high amounts of nitrate to receiving streams.

4.6.4 Total suspended solids

Total suspended solids (TSS) were evaluated with total suspended volatile solids to evaluate both sediment and organics within the stream column. As shown in Figure 88, chemistry data was lacking across all sites. Judicial Ditch 38 and 98 were limited on Chemistry. However, JD 98 showed that the potential of exceedances is likely as one of the two samples was over the threshold. Without additional chemistry it is difficult to determine trends here.

Fish TSS metrics

Figure 88. TSS and TSVS concentrations within the South Creek Subwatershed.

WID	Stream Name	Biological Stations	Impairment	# of TSS samples	# of TVS samples	Range of TSS (mg/L)	Range of TVS (mg/L)	Average of TSS (mg/L)	% TSVS made up TSS (Average)	# of exceedances 45 mg/L
	South Creek									
660	Judicial Ditch 38	17MN334	F-IBI							
610	Judicial Ditch 98	17MN332	M-IBI	2	2	4.8-49	2.8-9.6	26.9	38.96	1
639	South Creek	17MN338 15EM040	M-IBI	4	4	35-86	16-29	53.5	30.98	3

WID -660 was the only station to have a fish impairment in the South Creek Subwatershed. The fish sample only found a total of 5 tolerant taxa types and total individual count of 36 (all but one were minnows). With a community this limited, biological metrics are not a useful tool.

Macroinvertebrate TSS metrics

Macroinvertebrate communities throughout the impaired sections of South Creek did show potential stress response to TSS. In particular WID -639 on the mainstem at sites 17MN338 and 15EM040, as all parameters were poor. The dominance of WID -610 on station 17MN332 did not show a correlation to TSS stress (noted in the lack of specific TSS tolerant species).

Table 60. Macroinvertebrate metrics within the South Creek Subwatershed, red highlighting values over the threshold.

South Creek	Station (Year sampled)	Taxa Count	%Long Lived	%Plecoptera	Ephemeroptera Count	TSS Index	% Tolerant	% Intolerant
639	15EM040 (2015)	28	0.00	0.00	2.00	20.82	52.83	0.00
Passing Streams Average	*Southern Rivers RR Modified use*	24	16.9	31.5	7.9	15.99	45.25	2.21
	Expected response to stress	↓	↓	↓	↓	↑	↑	↓
South Creek	Station (Year sampled)	Taxa Count	%Long Lived	%Plecoptera	Ephemeroptera Count	TSS Index	% Tolerant	% Intolerant
639	17MN338 (2017)	21	1.58	0	0	18.14	82.02	0
EASST CHAIN LAKE Impaired for fish and Chlorophill-a, TP, and Secchi readings.								
610	17MN332 (2017)	20	1.25	0	0	15.60	26.25	0
Passing Streams Average	*Prarie Stream modified use*	24	6.0	0.1	4.8	16.02	35.60	1.27
	Expected response to stress	↓	↓	↓	↓	↑	↑	↓

While there are some areas of notable erosion (discussed more in the habitat section below), the geomorphic study carried out by the DNR indicated that near the outlet of South Creek, conditions are relatively stable. Also finding in this study that South Creek is one of the lowest contributor of TSS within the Blue Earth River Watershed. This is largely due to areas of the stream and landscape remaining natural (Lore, 2020). The areas where water is still able to be maintain does help store and mitigate some of the hydrologic response from climate chance and stream alterations that increase flow. For more information on the geomorphic properties of this subwatershed see the DNRs Blue Earth River Watershed Characterization Report.

Table 61. Summary of TSS stressors within the South Creek Subwatershed, blue cells indicate inconclusive findings.

				TSS			
AUID	**Stream Name**	**Biological Stations**	**Impairment**	Suspended Algae	Flow Alterations	Stream Bank Erosion	Pasture
	South Creek						
660	Judicial Ditch 38	17MN334	F-IBI		●		
610	Judicial Ditch 98	17MN332	M-IBI	●	●		●
639	South Creek	17MN338 15EM040	M-IBI	●	●		

4.6.5 Habitat

South Creek is one of the three unique subwatersheds within the Blue Earth River Watershed that contain rare species and specialized habitat. Within this subwatershed there is a higher percentage of wetlands and other water storage features compared to the majority if the Blue Earth Watershed as a whole. For the streams that were found to have biologic impairments within this subwatershed, there are some concerns with habitat. The furthest upstream site of 17MN334 on WID -660 there are some significant instream impacts to habitat and hydrology. Invertebrates were unable to be sampled due to water levels. Regardless, the physical habitat that would have been available was severely embedded. During the habitat survey at the time of the fish sample, nearly all categories assessed for habitat scored very poorly (Land use, riparian, substrate, cover, and morphology). The largest limitation is the physical alteration of the stream channel by way of ditching and channelizing. This stream has no course substrate with a completely embedded stream. There also was a complete absence of pools. The lack of fish assemblage is also telling of a hostile habitat.

Judicial Ditch 98's WID -610 had similar issues to physical habitat that were noted in -660. The exception being that there was some forms of gravel and sand in areas of the channel. This stream is also slightly more erosive, possibly contributing to the different substrate types noted. Figure 89 highlights the poor habitat conditions in the overabundance in legless individuals, as these species do not have specialized habitat needs. The amount of tolerant snails also lead to a higher than usual amount of clingers.

The final impaired section of South Creek (WID -503) also showed habitat stress at both monitoring locations. The furthest upstream location of 17MN338 scored slightly better that 15EM040, although the two sited were sampled in separate years. Station 17MN338 had some of the strongest habitat

features out of the other sites evaluated in this system. While this site was categorized and a prairie stream with glide pool features, there were also riffles present. However, erosion and siltation are clearly noted. “Clinger” species made up over half of the total sample, overwhelming made up of Cheumatopysche, a tolerant form of net spinning caddisfly. The eutrophic conditions of this channel are likely driving up this population. Station 15EM040 was dominated by various genus of non-biting midges, noted in the high “legless” category in the chart below. Physical features for a southern streams with expected riffle run features were scored poorly. Erosive conditions have made this section unstable, also leading to an embedded stream.

Figure 89. Macroinvertebrate habitat metrics within the in the South Creek Subwatershed; prairie streams class on the left with southern streams class on the right.

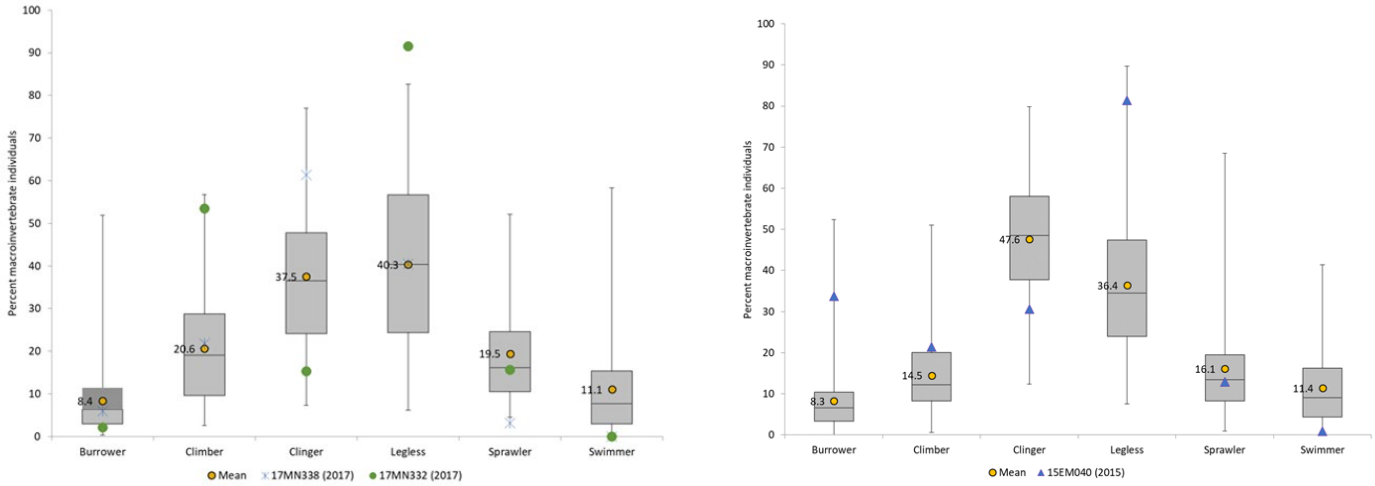
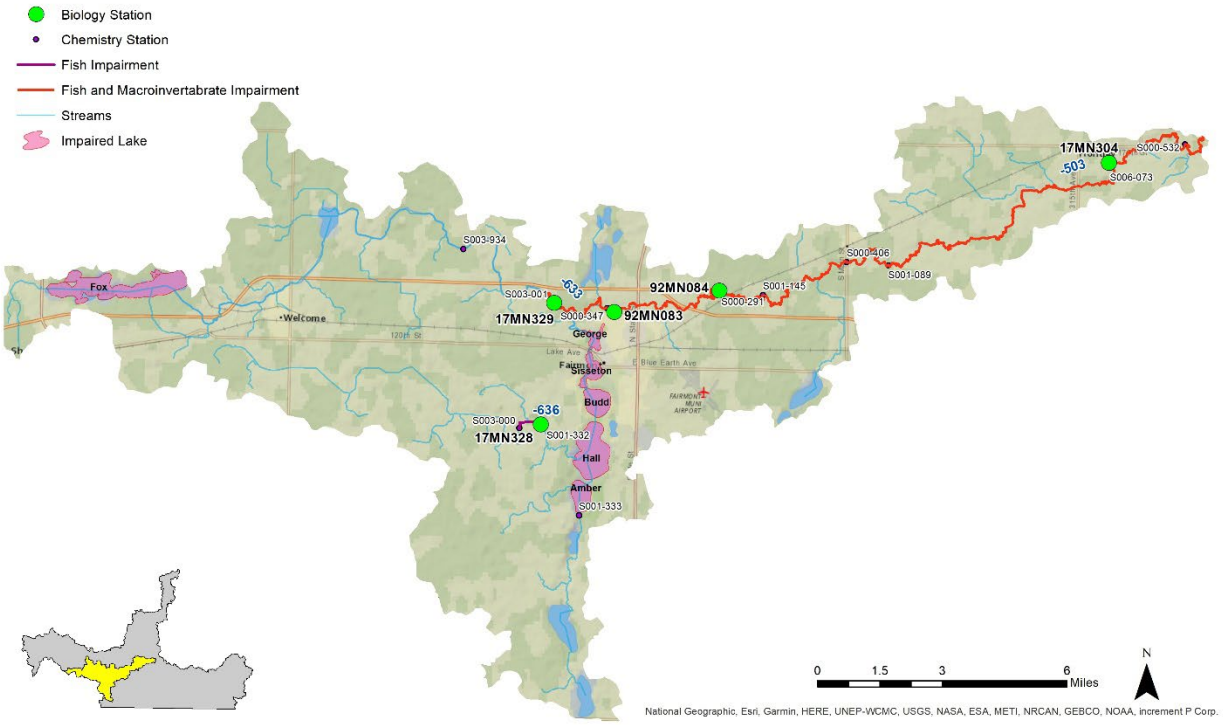


Table 62. Summary of habitat stressors within the South Creek Subwatershed, with red cells indicating a stressor.

WID	Stream Name	Biological Stations	Impairment	Habitat				
				Channalized	Riparian	Streambed	Habitat diversity	Trampeling
South Creek								
660	Judicial Ditch 38	17MN334	F-IBI	•	•	•	•	
610	Judicial Ditch 98	17MN332	M-IBI	•	•	•	•	
639	South Creek	17MN338 15EM040	M-IBI		•	•		

4.7 Center Creek



Center Creek subwatershed covers approximately 140 square miles, the city of Fairmont falls in the middle of this watershed. In addition to the three impaired WIDs, there are several impaired lakes that feed into the Center Creek stream system. Dutch Creek (WID -636) is impaired for lack of fish assemblage and is a small order tributary that comes in from the north of center Creek's mainstem, and flows into Hall Lake. Fox Lake feeds into the headwaters of Lilly Creek's WID -633 (impaired for fish assemblage) and Center Creeks large WID -503, impaired for both fish and macroinvertebrate assemblage. In addition to biological impairments, Center Creek has preexisting impairments for Turbidity, fecal coliform, and ammonia. Outside of turbidity, other impairments will not be addressed within this report. For additional information refer to the MPCA's monitoring and assessment report as well as the DNR's Lake Stressor Identification report.

4.7.1 Biological communities

Figure 90 below shows monitoring locations at the time of biological sampling. Station 92MN083 monitoring site was last sampled in 2010, while the biological metrics from that time are being evaluated there is not a recent photo to review.

Figure 90. Conditions of the monitoring locations within the Center Creek Subwatershed, taken at the time of the biological sample.

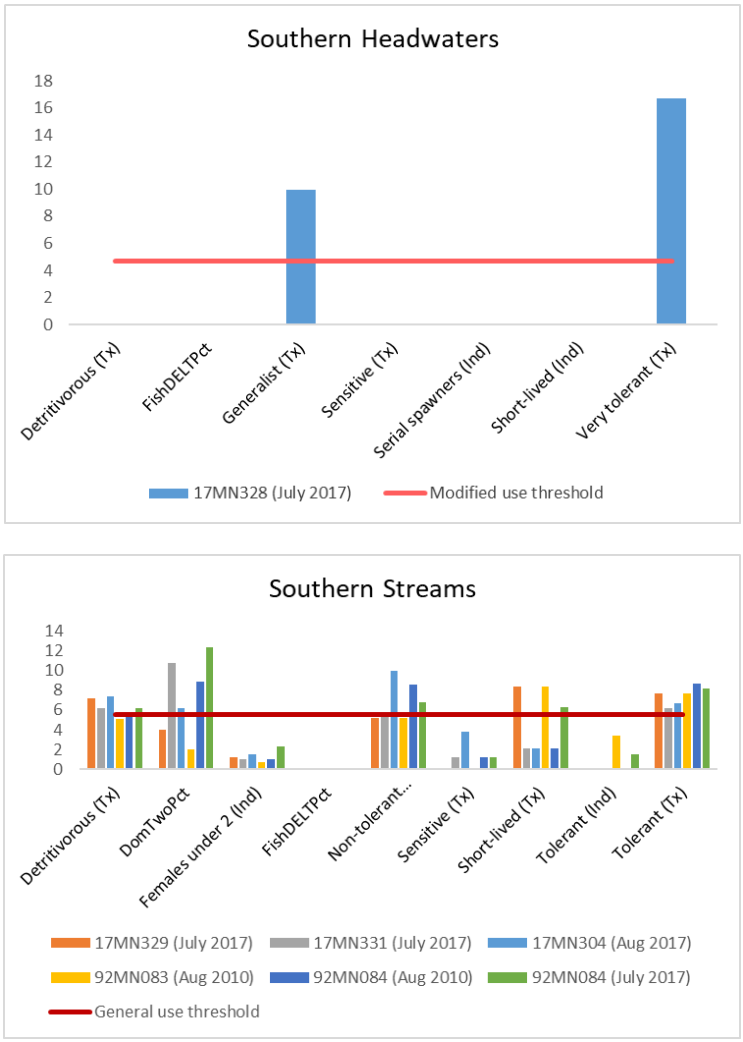
Fish

There are three separate WIDs within the Center Creek Subwatershed that were found to have biological impairments. The furthest upstream WID (-636) is located on the tributary of Dutch Creek, before entering the chain lakes system (North Silver, Wilmert, Amber, Hall, Budd, Sisseton, and George Lakes). The monitoring station of 17MN328 scored poorly for fish, with an IBI score of 26.6, below the Southern headwaters-modified use threshold of 33 (±7). There were 4 taxa types sampled in all; they were 2 white suckers, 1 spotfin shiner, 1 freshwater drum, and 1 creek chub. This station passed for macroinvertebrates.

The other two WIDs fall on the mainstem of Center Creek, impaired for both fish and macroinvertebrates. The furthest upstream WID -633 with the biological monitoring station 17MN329 is before the outlet of the chain lakes system. This site had an IBI score of 33.7, below the general use

threshold of 50 (±9) for a Southern stream. There were a total on 18 fish species at this location, with the majority of the species being tolerant (Figure 91). The next WID -503 starts after the convergence of the impaired chain lakes system, making up the remainder of Center Creek. The multiple stations throughout this WID are shown in the bottom of Figure 91 under Southern streams. The upstream sites of 92MN083 and 92MN084 were sampled multiple times throughout the years. Both show some increase in taxa diversity within the last 10 years. Station 92MN083 last fish sample was in 2010 and

Figure 91. Fish community metrics that make up the IBI. Southern Headwater stream class shown on top, with Southern streams class on bottom.



resulted in an IBI of 32.4. There were 15 different species. Station 92MN084 was sampled in the same time frame in 2010 had an IBI of 36 and had slightly more taxa types at 22. In 2017 the score increased to 44.7 with23 taxa types. The furthest downstream station of 17MN304 was limited to the single biological sample in 2017 that resulted in an IBI score of 37.6 and 22 taxa types.

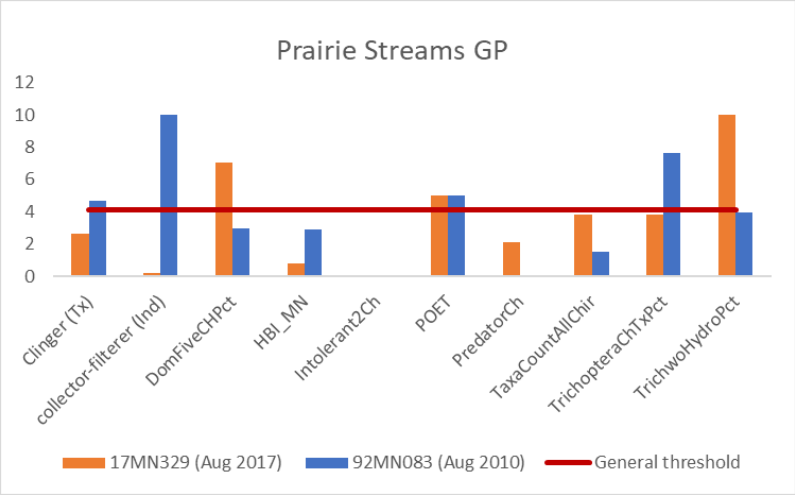
Macroinvertebrates

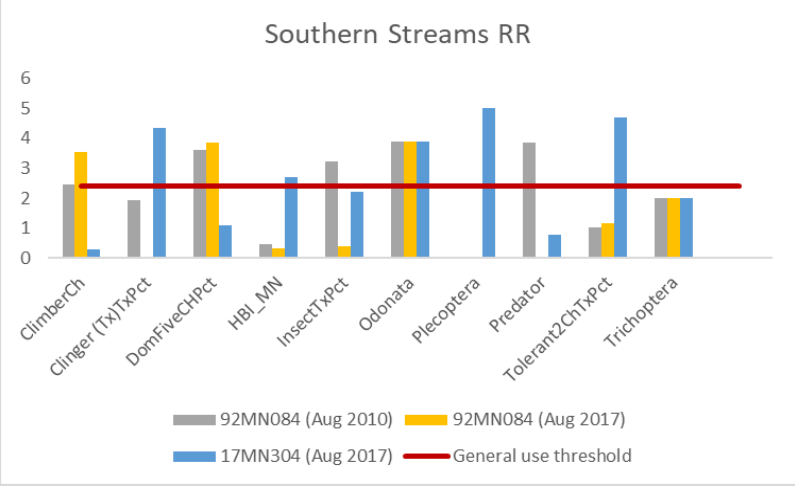
Sites that were found to be impaired for macroinvertebrate assemblage all were on the mainstem of Center Creek and fell into two different class categories (Figure 92). The upstream sites of 17MN329 on WID -633 and 92MN083 on -503 are categorized as being Prairie Streams with glide and pool features, having an IBI threshold of 31 (±13.6). Stations 92MN084 and 17MN329 on -503 are categorized as being

Southern Streams with riffle run features, with a general use threshold IBI if 37 (±12.6). The furthest upstream WID -633 of 17MN329 scored an IBI of 35.5. *Nectopsyche* (long-horned Caddisfly) where the dominant species in the sample. While there were a number of other taxa types, many were in the single digits for count. Overhanging vegetation and wood debris was the majority of available habitat. The next station within this class is 92MN083 on WID -503 with a score of 38.6. The dominant species were non-biting midge and tolerant forms of caddisfly's.

The Southern streams portion of Center Creek had two samples from different years at 92MN084, 22.4 in 2010 and degreased significantly in 2017 to a score of 15.1. Sampled macroinvertebrate habitat quality was noted to have decreased over the years from trampling and sever erosion issues.

Figure 92. Macroinvertebrate community metrics that make up the IBI. Prairie stream GP class shown on top, with Southern streams RR class on bottom.

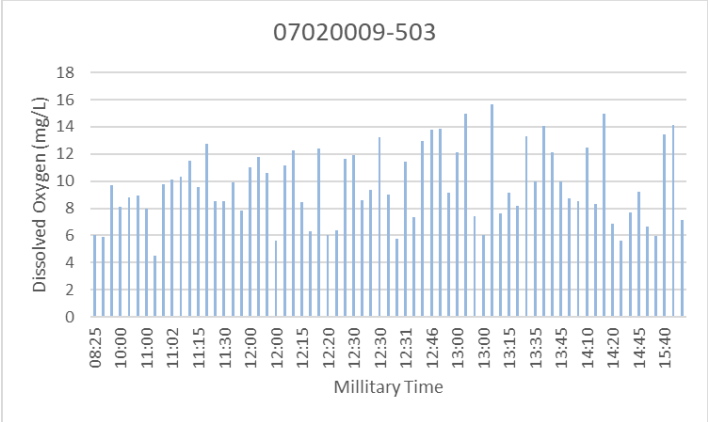




4.7.2 Dissolved oxygen and eutrophication

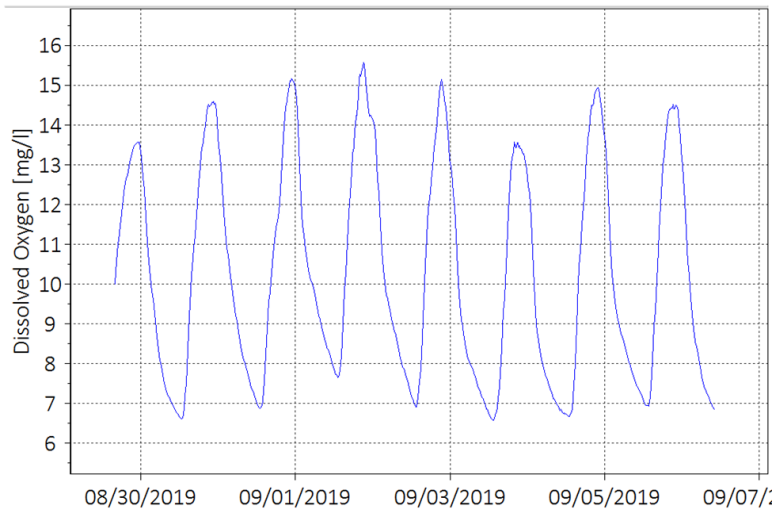
The strongest dissolved oxygen (DO) data set within this watershed is from the mainstem of Center Creek on WID -503 (Figure 93). DO was found to be in normal range for the year 2007 out of the 37 samples taken during those summer months. There were only a few early morning readings. However, mid-day hours did not show abnormally high DO either. Year 2008 was a similar trend with 33 samples and again in 2009 (12 samples). In 2017 there was some indication of DO instability. There were 13 samples collected over the summer. Nearly half of those were around 5mg/L. 2018 was consistently around 5 mg/L +-1mg/L. However, a majority of these were early morning readings.

Figure 93. DO samples collected throughout the assessment period for Center Creek.



In addition to point measurements, continuous DO was collected at 92MN084 from August 29th to September 7th 2019, as shown in Figure 94. During this time DO fluctuation was extreme, showing daily swings greater than a 5mg/L difference.

Figure 94. Continuous DO monitoring at station 92MN084.



WID -633 was limited to DO taken at the time of the biological sample – 8:00 a.m. reading of 5.81 on July 25, 2017 and 4.37 at 9:00 a.m. on August 9, 2017. WID -636 also was limited to DO reads taken at the time of biological sampling, July 26, 2017 taken at 6:19 p.m. was 8.26 mg/L, and 7.76 mg/L at 8:04 a.m. on August 9, 2017.

Total phosphorus

The mainstem WID -503 of Center Creek had the most total phosphorus (TP) data, as shown in Figure 95. While the upstream WIDs are low on TP data, having a robust data set on the mainstem section of the subwatershed is a fair representation of the subwatersheds contributions of TP as a whole. This data shows that phosphorus overloading occurs frequently within this system, with potential to exceed the 1.5 mg/L standard by 6 times as much.

Fish metrics

Figure 95. Total phosphorus samples within the Center Creek Subwatershed.

AUID	Stream Name	Biological Stations	Impairment	Number of samples.	Range of TP (mg/L)	Average of TP (mg/L	# of exceedances .15 mg/L
	Center Creek						
636	Dutch Creek	17MN328	F-IBI	1		0.08	0
633	Lily Creek	17MN329	F-IBI M-IBI	4	.09-.22	0.19	2
503	Center Creek	92MN083 92MN084 17MN304	F-IBI M-IBI	218	.02-.58	0.18	147

Fish communities within the Center Creek subwatershed often showed some degree of low DO and eutrophic stress, as highlighted in Table 63. Dutch Creek (WID -636) was made of generalist species without any sensitive species present. However, with only four taxa types, metrics of any types provide little value.

Prior to the chain lakes draining into the mainstem of Center Creek, Lilly Creek (WID -633) show poor metrics across all parameters. This far up the stream system the taxa is diminished, in comparison to the further downstream locations. However, there is still a reliable enough population to note that the community is likely being displaced noted in the DO tolerance index value (DO TIV). In addition to the generally tolerant population dominating, there was a complete absence if sensitive species. Darter and

Table 63. DO and eutrophication fish metrics within Center Creek, red highlighted cells indicate values above threshold.

Center Creek	Station (Year sampled)	DarterPct	OmnivorePct	SLithopPct	SensitivePct	TolPct	CountofTaxa	DO TIV
633	17MN329 (2017)	1.03	21.57	3.36	0.00	79.18	18	8.55
Impaired Chain Lakes Amber, Hall, Budd, Sisseton, George								
503	92MN083 (2010)	0.82	57.94	0.98	0.00	62.19	18	8.33
	92MN084 (2010)	0.72	30.03	2.68	0.21	77.40	22	8.69
	92MN084 (2017)	3.18	27.53	11.80	0.37	69.10	23	8.54
	17MN304 (2017)	1.30	7.95	12.82	2.44	80.52	22	8.90
Passing Streams Average	**Southern Streams General use**	*11.9*	*17.7*	*37*	*16.9*	*44.9*	*19.3*	8.56
	Expected response to stress	↓	↑	↓	↓	↑	↓	↓

simple lithophilic spawners were lacking while omnivore (generalist) thrived. After the chain lakes is the longest assessed section on Center Creek of WID -503. The earlier assessed sites of 92MN083 and 92MN084 in 2010 scored significantly worse than the more recent 2017 samples. Nearly all parameters failed to meet the expected thresholds.

Macroinvertebrate metrics

Macroinvertebrate metrics to assess for low DO displacement were mixed. Lily Creek's WID -633 scored well in the overall make up of sensitive Trichoptera, however there was a low count in general. The DO index scored just below the threshold. The inverse of this was found at the mainstem of Center Creek's prairie stream section for the Trichoptera populations. Both stations did not have an overly dominant DO tolerant community, nor was there any intolerant. The southern streams portion of Center Creek was similarly mixed across all parameters and years.

Table 64. DO macroinvertebrate metrics within the Center Creek Subwatershed, Prairie streams on top with southern streams on bottom. Red highlights exceedance of the threshold.

Center Creek	Station (Year sampled)	Taxa Count	EPT	Trichoptra	Sensitive Tricoptrapct	HBI_MN	DO Index	% DO tolerant	% DO Intolerant
Impaired Fox Lake feeds stream system									
633	17MN329 (2017)	32	41.10	6.25	19.63	8.66	7.03	13.46	3.98
Impaired Chain Lakes (Amber, Hall, Budd, Sisseton, George)									
503	92MN083 (2010)	24	40.98	12.50	1.64	7.99	7.26	8.79	3.91
Passing Streams Average	**Prarie Streams General use**	37	38.45	10	5.5	7.55	7.04	25.1	5
	Expected response to stress	↓	↓	↓	↓	↑	↓	↑	↓
Center Creek	Station (Year sampled)	Taxa Count	EPT	Trichoptra	Sensitive Tricoptrapct	HBI_MN	DO Index	% DO tolerant	% DO Intolerant
503	17MN331 (2017)	28	74.35	14.29	1.30	7.90	7.35	3.25	16.88
	92MN084 (2010)	26	29.84	11.54	8.25	8.50	6.98	14.51	2.52
	92MN084 (2017)	34	18.15	11.76	6.77	8.26	6.62	27.08	2.15
	17MN304 (2017)	32	61.28	12.50	0.91	7.47	7.39	5.47	34.04
Passing Streams Average	**Southern Streams General use**	31	42.6	18.72	5.48	7.09	7.04	9.06	24.01
	Expected response to stress	↓	↓	↓	↓	↑	↓	↑	↓

As shown in Table 65, throughout this subwatershed there was not a consistent overabundance of feeder types that thrive on algae, noted in "scrapers", filter feeding mollusks, or the Tanytarsini order. The phosphorus index exceed the threshold in all samples, in addition to there being a lack of specific eutrophic intolerant samples.

Table 65. Eutrophication macroinvertebrate metrics within the Center Creek Subwatershed, Prairie streams on top with southern streams on bottom. Red highlights exceedance of the threshold.

Center Creek	Station (Year sampled)	% Scraper	CrustMollPct	Tanytarsini Pct	Phos Index	% Tolerant	% Intolerant	%Gen Tolerant
Impaired Fox Lake feeds stream system								
633	17MN329 (2017)	11.35	8.59	9.76	0.15	34.25	0.31	53.99
Impaired Chain Lakes (Amber, Hall, Budd, Sisseton, George)								
503	92MN083 (2010)	4.92	6.89	16.10	0.15	18.24	0.00	60.00
Passing Streams Average	**Prarie Streams General use**	*16.1 1*	*11.78*	*18.46*	*0.13*	*30.6*	*3.8*	*61.78*
	Expected response to stress	↑	↑	↑	↑	↑	↓	↑
Station (Year sampled)		% Scraper	CrustMollPct	Tanytarsini Pct	Phos Index	% Tolerant	% Intolerant	%Gen Tolerant
503	17MN331 (2017)	5.52	5.84	2.17	0.14	8.44	0.00	26.62
	92MN084 (2010)	25.89	3.81	24.49	0.17	31.23	0.00	67.62
	92MN084 (2017)	4.44	5.54	7.65	0.14	14.15	0.00	71.69
	17MN304 (2017)	14.94	9.15	13.51	0.13	6.08	0.30	31.40
Passing Streams Average	**Southern Streams General use**	15	9.64	28.02	0.12	19.12	5.82	49.64
	Expected response to stress	↑	↑	↑	↑	↑	↓	↑

The first WID to be evaluated in the Center Creek Subwatershed is Dutch on station 17MN328. This creek is upstream from Hall Hal Lake, an impaired lake. At the time of sampling the stream there was not any instream vegetation noted. The limited DO and phosphorus samples did not provide enough information to make a determination of chemistry influences. While the metrics were evaluated, they were of no value as the sample size was made up of only five individual fish. From four taxa types. This results in both parameters being inconclusive as a fish stressor.

WID -633 on Lilly Creek was sampled at monitoring station 17MN329. This WID on Lily Creek is located directly before the convergence into Center Creek and the outlet of where the impaired chain lakes meet. While there was not any physical evidence of plant or algae overgrowth in stream, the bed was fully embedded with detritus. DO measurements were limited to two samples, one hovering right above the 5 mg/L standard and the other below. Phosphorus samples were also limited. However, two of the four exceeded the standard. The fish community was predominantly made up of generally tolerant species, with very little species that depend on some degree of clean substrate present. The macroinvertebrate diversity was slightly better, as there were fewer tolerant species. All functional groups that typically increase in eutrophic conditions (filter feeders/algae eaters) were not found to be overabundant. However, both the fish and invert DO and Eutrophic index values did score the community as a whole showing some degree of displacement from these two parameters. Due to the lack of chemistry data as well as conflicting biological data, these parameters are considered inconclusive until follow up monitoring can be carried out.

WID -503 in Center Creek is the longest reach to be assessed within the subwatershed, starting from the confluence of Lily Creek and the chain lakes ending at the outlet of Center Creek that merges into the Blue Earth River. Site 92MN084 was noted as having high manure content at the time of sampling. As shown in the monitoring photo, there was also excessive trampling of the banks. Site 17MN304 near the outlet showed a slightly better riparian. The stream bed is noted as having a variety of healthy habitat features, however duck wee d and benthic algae was present. At location 92MN084 continuous data for DO was collected, showing DO Flux of around 10 mg/L daily with lows around the threshold. In addition to this the instantaneous DO samples indicate low DO is an issue here. Phosphorus loading is also clearly a chronic issue in this location. Within the fish community there is come improvement seen in the overall community from 2010 to 2017. However, there are still indications of low DO and eutrophic conditions negatively impacting the environment at this WID. The macroinvertebrate metrics varied in response, showing a higher degree of impact at the upstream locations. This correlates with the Chemistry and observational data found. Low DO as well as eutrophication are clear stressors within this WID, particularly in the upstream station of 92MN084. It is likely that the impaired lakes, as well as the large pasture this WID flows through are contributors to these impairments.

Table 66. Summary table for DO and eutrophication stress within the Center Creek Subwatershed, red cells show stressor where blue shows inconclusive findings.

								Dissolved Oxygen				Eutrophication		
AUID	Stream Name	Biological Stations	Impairment	Number of samples.	Range of TP (mg/L)	Average of TP (mg/L	# of exceedances .15 mg/L	Plant Reseperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland/Lake influcence	Excess Phosphorus	Unidentified
Center Creek														
636	Dutch Creek	17MN328	F-IBI	1		0.08	0	•					•	
633	Lily Creek	17MN329 92MN083	F-IBI M-IBI	4	.09-.22	0.19	2	•	•				•	
503	Center Creek	92MN083 92MN084 17MN304	F-IBI M-IBI	218	.02-.58	0.18	147			•	•	•	•	

4.7.3 Nitrate

Nitrate data was primarily collected at the mainstem WID -503 on Center Creek, highlighted in Table 67. From this data set it is clear that nitrate overloading is a chronic issue in the Center Creek Subwatershed. With more than half of the 186 samples exceeding 4.9 mg/L, the proposed aquatic life threshold. Exceedances of the drinking water standard (10 mg/L) were not frequently found.

Table 67. Nitrate samples within the Center Creek Subwatershed.

AUID	Stream Name	Biological Stations	Impairment	Number of samples.	Range of Nitrate (mg/L)	Average of Nitrate (mg/L)	# of exceedances 4.9 mg/L	# of exceedances 10 mg/L
Center Creek								
636	Dutch Creek	17MN328	F-IBI	4	.88-9.8	4.07	1	0
633	Lily Creek	17MN329 92MN083	F-IBI M-IBI	4	.88-9.8	3.92	1	0
503	Center Creek	92MN084 17MN304	F-IBI M-IBI	186	.05-12	5.32	109	11

Macroinvertebrate

Taxa counts hovered around acceptable ranges throughout the subwatershed, with WID-636 and -633 dipping just below the average number found in non-impaired streams of the respective types. Nitrate sensitive taxa types of ETP counts varied between sites as well as years, with the mainstem showing the strongest diversity in these types. The nitrate index score fell above the threshold at all locations, with specific nitrate tolerant species absent at all sites. Lilly Creeks WID -633 had the highest concentration of nitrate tolerant species with over 93% of the sample classified as that.

Table 68. Macroinvertebrate response to nitrate within the Center Creek Subwatershed; Prairie Stream class on top and Southern stream class on the bottom.

Center Creek	Station (Year sampled)	Taxa Count	EPT#	Nitrate Index	% Nitrate tolerant	% Nitrate Intolerant
636	17MN328 (2017)	28	7.00	3.61	43.93	0.00
Impaired Fox Lake feeds stream system						
633	17MN329 (2017)	32	7.00	4.51	93.58	0.00
Impaired Chain Lakes (Amber, Hall, Budd, Sisseton, George						
503	92MN083 (2010)	24	8.00	3.70	62.87	0.00
Passing Streams Average	**Prarie Streams General use**	37	*11.5*	*3.23*	*54.86*	*3.18*
	Prarie Streams Modified use	24	*7.6*	*3.32*	*59.41*	*1.95*
	Expected response to stress	↓	↓	↑	↑	↓

Center Creek	Station (Year sampled)	Taxa Count	EPT#	Nitrate Index	% Nitrate tolerant	% Nitrate Intolerant
503	92MN084 (2010)	26	0	3.61	70.35	0
	92MN084 (2017)	34	11	3.90	79.69	0
	17MN304 (2017)	32	8	3.56	45.59	0
Passing Streams Average	**Southern Streams General use**	31	*6.9*	*2.95*	*47.6*	*2.92*
	Expected response to stress	↓	↓	↑	↑	↓

Summary

Nitrate concentrations that were found at the mainstem of -503 were of concern at the proposed aquatic life threshold of 4.5mg/L. However, the macroinvertebrate community seem to be showing less of a response with this stressor in comparison to the others. WID 636 had little data, in addition this community specific nitrate tolerant make up fell within an acceptable range. While the inverts are clearly limited, it's difficult to make a clear correlation to nitrate. Lily Creek also lacked a robust nitrate data set, yet the macroinvertebrate metrics clearly signaled a community impacted by nitrate toxicity. Lily Creek is the only WID where nitrate is considered a stressor, while Dutch Creek and Center Creek are inconclusive as to Nitrate playing a significant role in limiting biology at this time.

4.7.4 Total suspended solids

Chemistry

Total suspended solids (TSS) was analyzed along with total volatile solids (TSVS) in effort to determine if TSS is predominantly sediment driven or organic. Overall there was not enough TSVS data to make a clear correlation. Where TSVS was available organics made up around 30% of the samples. However, during these sample events the TSS concentrations were generally low, making the percentage easily skewed. Looking at the mainstem robust TSS data set at WID -503, it is clear that TSS concentrations often exceed the 45 mg/L threshold.

Figure 96. TSS and TSVS concentrations within the Center Creek Subwatershed.

WID	Stream Name	Biological Stations	Impairment	# of TSS samples	# of TVS samples	Range of TSS (mg/L)	Range of TVS (mg/L)	Average of TSS (mg/L)	% TSVS made up TSS (Average)	# of exceedances 45 mg/L
	Center Creek									
636	Dutch Creek	17MN328	F-IBI	7		10-63		29.29		2
633	Lily Creek	17MN329 92MN083	F-IBI M-IBI	7	4	22-60	6.4-10	36.6	30.23	2
503	Center Creek	92MN084 17MN304	F-IBI M-IBI	104	13	8.8-73	2.2-15	55.4	30.5	53

Fish

The fish community at -636 was composed of only four taxa types and had a total count of five fish, leading to unreliable metric data and left out of Table 69. Therefore TSS metrics are inconclusive. The four that were sampled were all tolerant. The fish metrics at 633 as well and 503 do indicate some TSS stress. Metrics that were meeting the threshold were often the result of a tolerant speciese presents that falls into that catagors, such as Creek Chubs and Common Carp.

Table 69. Fish metrics for TSS in the Center Creek Subwatershed

Center Creek	Station (Year sampled)	Benthic Feeders Pct	Sensitive Centrarchidae Pct	Herbivores Pct	Intolerant Pct	Long Lived Pct	Sensitive Perciformes Pct	Riffle Pct	Sensitive Pct	Lithophilic Spawners Pct	TSS TIV
633	17MN329 (2017)	2.99	5.23	2.33	0.00	5.98	6.63	2.33	0.00	2.33	25.62
503	92MN083 (2010)	2.29	16.04	0.49	0.00	19.80	18.66	0.49	0.00	0.49	23.43
	92MN084 (2010)	2.89	6.19	2.06	0.00	7.53	7.64	2.27	0.21	2.37	24.43
	92MN084 (2017)	10.86	14.79	7.68	0.00	20.79	19.85	9.55	0.37	9.55	23.74
	17MN304 (2017)	10.06	2.92	7.47	0.00	4.22	4.22	10.06	2.44	8.12	26.54
Passing Streams Average	**Southern Streams General use**	36.02	5.37	25.68	4.24	13.58	20.09	30.18	16.89	19.11	17.59
	Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

Macroinvertebrates

Within the prairie streams (WID -633 and upper portion of -503) TSS response was noted across all parameters, with the exception of percent long lived species at -633. The long lived are from the tolerant genus Dubiraphia, otherwise known as the riffle beetle.

The mainstem of Center Creek at WID -503 showed some degradation to the macroinvertebrate community from 2010 to now, however it narrowly passed before. Taxa counts did increase slightly, although the majority are tolerant. The long lived percentage is misleading as it is Dubiraphia, a TSS tolerant riffle beetle that made up this percentage in the samples.

Figure 97. Macroinvertebrate metrics for TSS in the Center Creek Subwatershed; Prairie Stream class on top and Southern Stream on bottom.

Center Creek	Station (Year sampled)	Taxa Count	%Long Lived	%Plecoptera	Ephemeroptera Count	TSS Index	% Tolerant	% Intolerant
Impaired Fox Lake feeds stream system								
633	17MN329 (2017)	32	11.66	0	5	20.56	53.52	0
Impaired Chain Lakes (Amber, Hall, Budd, Sisseton, George								
503	92MN083 (2010)	24	0.33	0	5	19.06	73.62	0
Passing Streams Average	**Prairie Stream general use**	37	7.5	0.2	6.7	17.35	48.28	2.67
	Expected response to stress	↓	↓	↓	↓	↑	↑	↓
Center Creek	Station (Year sampled)	Taxa Count	%Long Lived	%Plecoptera	Ephemeroptera Count	TSS Index	% Tolerant	% Intolerant
503	92MN084 (2010)	26	9.52	0	3	19.89	78.55	0
	92MN084 (2017)	34	14.77	0	2	17.43	36.62	0
	17MN304 (2017)	32	7.93	0	5	17.46	45.29	0
Passing Streams Average	**Southern Stream RR general use**	*31*	*8.99*	*0.54*	*6.04*	*15.87*	*35.22*	*5.06*
	Expected response to stress	↓	↓	↓	↓	↑	↑	↓

As fish metrics were not able to be of use, metrics for the macroinvertebrates at -636 will be the only biological indicator. Macroinvertebrates at this WID do indicate some degree of TSS placing limitations on the community. In addition there are clear physical indications that TSS loading is impacting the habitat at this location (Discussed further on in the habitat section.) This location has both sediment deposition as well as sediment loss occurring. Macroinvertebrate metrics at WID -633 and -503 both indicate TSS stress. The one metric that was above the threshold was 633's long lived. This is due to the presents of *Dubiraphia*, a tolerant species of Riffle Beatle.

The streams geomorphology was assessed on Lily Creek (WID -633) and Center Creek (WID -503) by the DNR. Lily Creed was shown to have approximately 4.64 tons of annual sediment loss, with notable channel loss (that exceeded modeled predictions). Further downstream closer to WID -503 was the second studied location. This site was found to be the largest sediment contributor in all of the assessed Blue Earth River Watershed Streams at a sediment contribution of 552.64 tons annually (Lore, 2020).

Table 70. Summary of TSS stressors within the Center Creek Subwatershed, blue cells indicate inconclusive findings.

				TSS			
AUID	Stream Name	Biological Stations	Impairment	Suspended Algae	Flow Alterations	Stream Bank Erosion	Pasture
	Center Creek						
636	Dutch Creek	17MN328	F-IBI		●	●	●
633	Lily Creek/Center	17MN329 92MN083	F-IBI M-IBI	●	●	●	●
503	Center Creek	92MN084 17MN304	F-IBI M-IBI		●	●	●

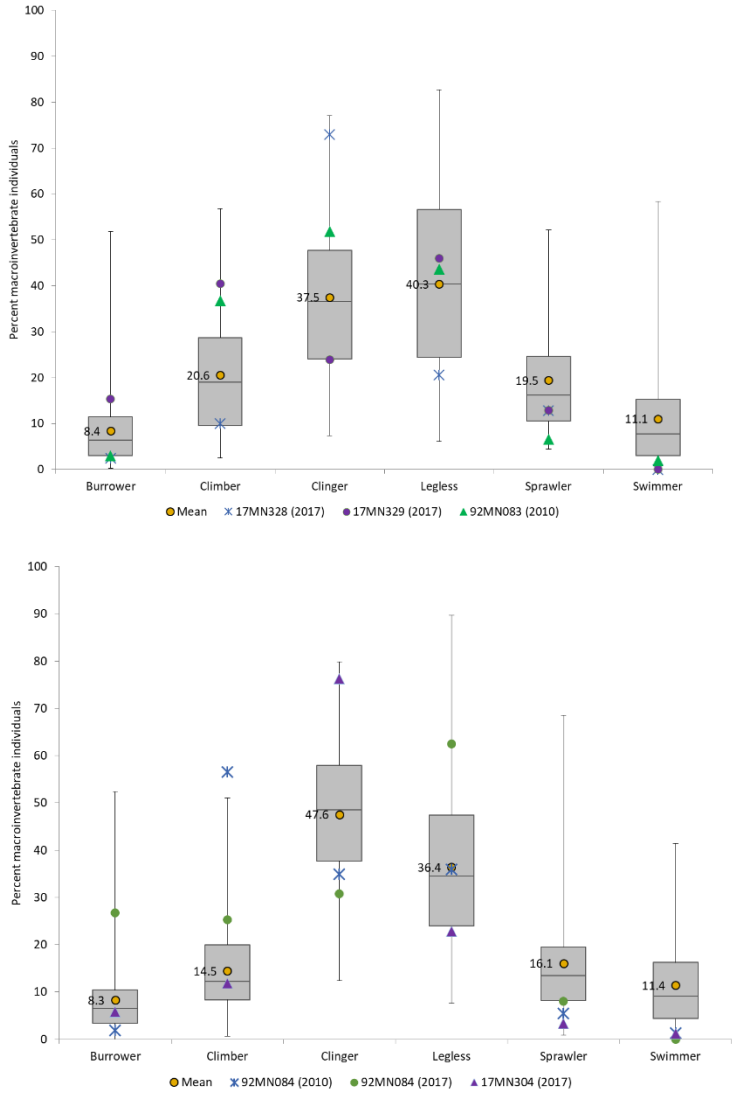
4.7.5 Habitat

Dutch Creek's WID -636 physical habitat conditions of the stream bed was found to be severely degraded by sedimentation and trampling. While there were notable pools, riffles, and runs there was poor substrate diversity. This channel was also rated as having poor stability. As this stream section is positioned in an open pasture trampling is prevalent. Macroinvertebrates were primarily sampled on available wood debris as well as overhanging vegetation on the bank, resulting in the habitat composition that is charted below for 17MN328 high numbers of clingers (Figure 98). This is from the over dominance of Hydropsyche, the tolerant net-spinning caddisfly that often dwells in woody material.

Lilly Creek's WID -633 habitat scores were also overall poorly rated with the worst features noted within the stream bed and lack of substrate diversity. Station 17MN329 is noted as being severely embedded, leading to a higher than typical amount of burrower species. Similar to Dutch Creek, overhanging vegetation and woody debris was the dominant macroinvertebrate habitat to sample. Erosion was also extensive within this reach.

On the upper portion of Center Creek on WID -503 is the final site (92MN083) categorized as being within a southern prairie stream GP. This station was last surveyed in 2010 and noted as having some of the strongest habitat features within the subwatershed. As shown in Figure 98, the habitat type distribution is within acceptable ranges.

Figure 98. Habitat community metrics within the Center Creek Subwatershed; Southern Prairie Streams GP on top with Southern Streams RR Features on bottom.



The macroinvertebrate Southern Streams class with riffle and run features is correlated to the downstream site of -503, the mainstem of Center Creek. The station of 92MN084 has greatly declined from the first habitat survey that took place in 2001. Throughout the years, streambank erosion and livestock trampling have impaired the streams habitat features. The community composition shows the dramatic shifts between the two site visits in the six years. The 2017 sample had an abnormally high concentration of burrowers and legless individuals. The downstream site of 17MN304 near the outlet of Center Creek, has similar habitat features as the latest survey from 92MN084. It's worth noting that the macroinvertebrate composition was greatly skewed by the high climber counts due to net-spinning caddisfly's dominating the overall sample. In addition to the habitat survey scores and the macroinvertebrate composition, the fish metrics that were observed in the TSS analyses (Table 69)

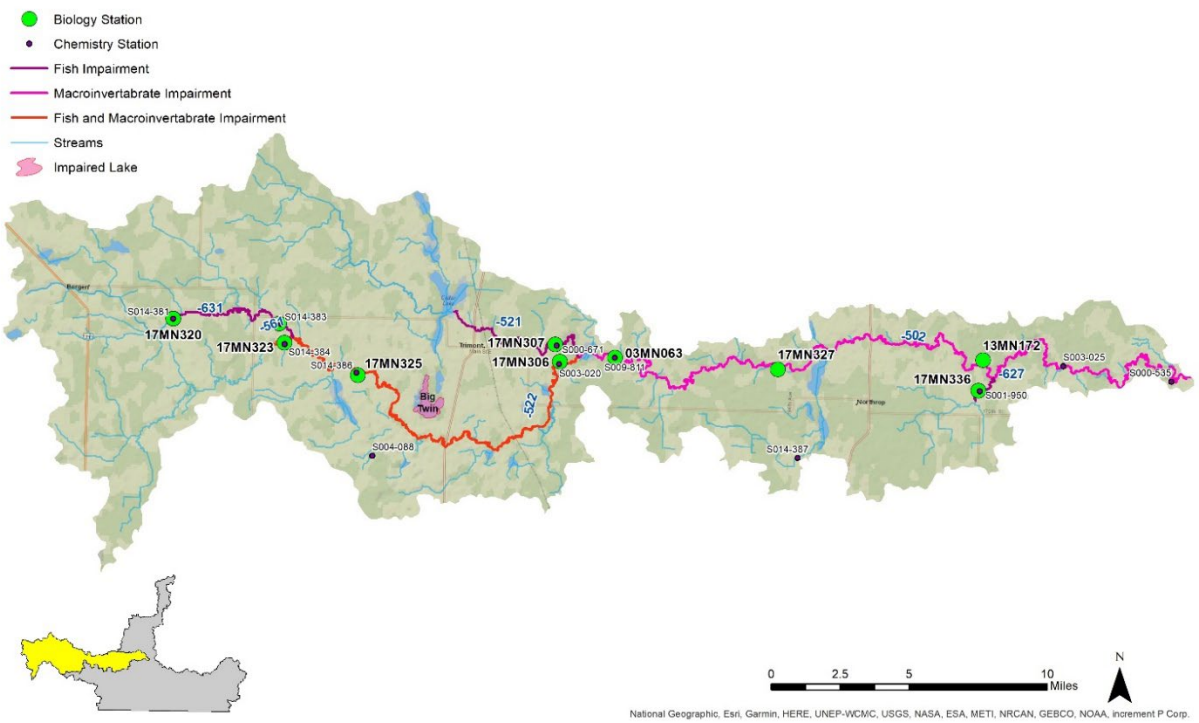
consistently showed habitat displacement from sedimentation and habitat loss. This is primarily noted in the lack of riffle dwellers, benthic feeders, as well as lithophilic spawners.

Habitat plays a large role in limiting biological assemblage throughout all the impaired reaches in the Center Creek Subwatershed. Dutch Creek has a history of being channelized, leaving homogenous feature without diversity. In addition, all locations have nearby land use that are influencing the streams riparian cover, erosion rates, and morphology.

Table 71. Summary of habitat stressors within the Center Creek Subwatershed, with red cells indicating a stressor.

				Habitat				
WID	**Stream Name**	**Biological Stations**	**Impairment**	Channalized	Riparian	Streambed	Habitat diversity	Trampeling
	Center Creek							
636	Dutch Creek	17MN328	F-IBI	●	●	●	●	●
633	Lily Creek	17MN329 92MN083	F-IBI M-IBI		●	●	●	
503	Center Creek	92MN083 92MN084 17MN304	F-IBI M-IBI		●	●	●	●

4.8 Elm Creek

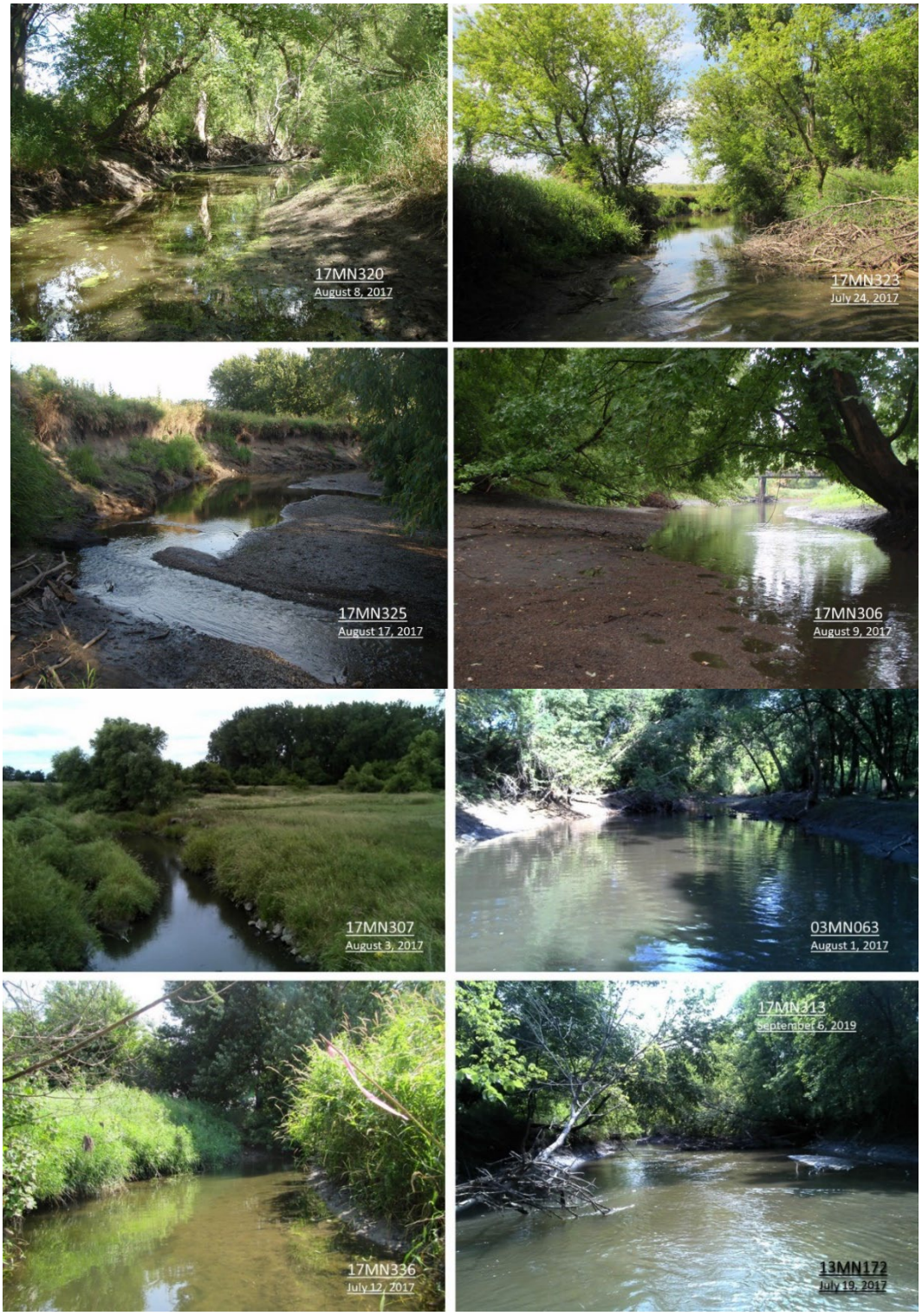


The Elm Creek Subwatershed is just over 280 square acres within Martin County. Six stream WIDs were found to be impaired for biology. In addition there are three shallow water lakes (Fish, Cedar, and Big Twin) that are impaired for nutrients. All impaired WIDs failed for fish assemblage, with the exception of the mainstem of Elm Creek -502. Macroinvertebrates were found to initially be impaired at the mainstem of WID -502. However, the data had to be thrown out as result of a database error after the assessment occurred. Other sites that failed based on lack of macroinvertebrate assemblage was WID -522 further upstream on Elm Creek and the South Fork tributary WID -561. In addition to the biological impairments, there is a turbidity impairment throughout the Elm Creek system, as well as historical DO impairments at WID -627 on Judicial Ditch 38 and WID -521 on Cedar Run Creek. Fecal Coliform is also an impairment at all sites, yet will not be discussed within this report as this parameter does not directly stress biology. For additional information related to chemical assessments refer to the MPCA Blue Earth River Monitoring and Assessment Report.

4.8.1 Biological communities

Stream conditions at the time of the biological sample are shown in Figure 99. Station 17MN327 did not have photos taken at the time of biological monitoring.

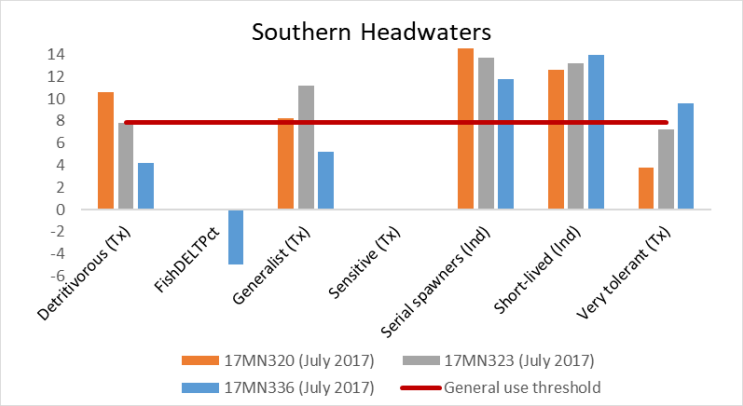
Figure 99. Biological monitoring stations within the Elm Creek Subwatershed at the time of the biological sample.



Fish biological community

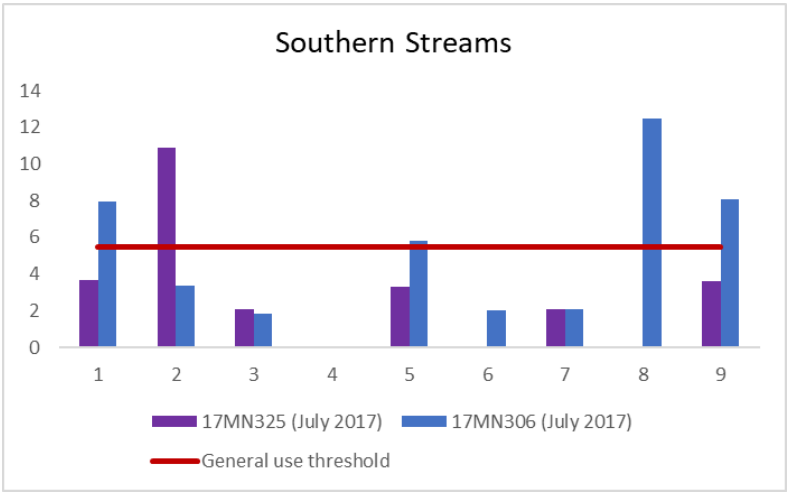
Four of the WIDs impaired for fish assemblage fell into the southern headwaters general use classification (Figure 100). An IBI needs a score of 55 or higher to be considered as passing. WID -631 on the upper branch of Elm Creek was found to be impaired for poor fish assemblage, scoring 49.7 at station 17MN320 with 11 taxa types that were generally tolerant. In addition to the fish impairment, there is a turbidity impairment. The South Fork of Elm Creek is impaired for both fish and macroinvertebrates on WID -561. Station 17MN323 scored 53.1 based on the 12 taxa types collected. Further downstream the tributary of Judicial Ditch 3 in WID of -627 on station 17MN336 scored poorly at 39.8 and only 8 taxa types. This WID has an existing DO impairment, as well as DELTs in the form of black spots and lesions. All DELTs were found in Creek Chubs.

Figure 100. Impaired fish communities in Southern Headwaters within Elm Creek Subwatershed.



WID -522 on the upstream portion of Elm Creek impaired for fish assemblage fell into the Southern Streams general use class (Figure 101). The furthest upstream station on this WID of 17MN325 with an IBI of 25.6 fell greatly below the expected threshold. The furthest downstream monitoring station of 17MN306 scored significantly better at 43.6. Both sites on the WID had a fair number of taxa types. This WID has a preexisting impairment for turbidity.

Figure 101. Impaired fish communities in southern streams within the Elm Creek Subwatershed.



Macroinvertebrate biological community

Three WIDs were found to be impaired for macroinvertebrate assemblage in the Elm Creek stream system under the prairie Stream with glide and pools class. This stream type has an IBI threshold of 41 (±13). The furthest upstream tributary of WID -561 is on the South Fork of Elm Creek with 17MN323 being the only monitoring location. This site scored 27.7, far below the IBI threshold. WID -521 is the single southern stream with riffle run features. This WID is a part of Cedar Run Creek, a tributary the feeds into Elm Creek. There is one biological station of 17MN307 that is impaired for macroinvertebrates, with an IBI of 16.8. Well below the general use threshold of 37 (±12.6) for this stream type. While WID -627 of Judicial Ditch 38 was not impaired for macroinvertebrates, the community at 17MN336 was still evaluated in some cases (such as DO) to determine if the historical impairment is still valid and causing any degree is displacement.

Figure 102. Macroinvertebrate impaired communities within the Elm Creek Subwatershed in Prairie Streams with glide pool features.

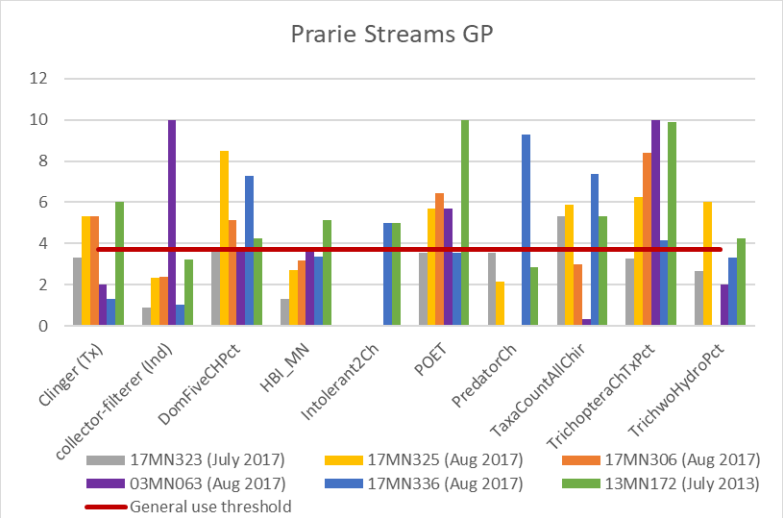
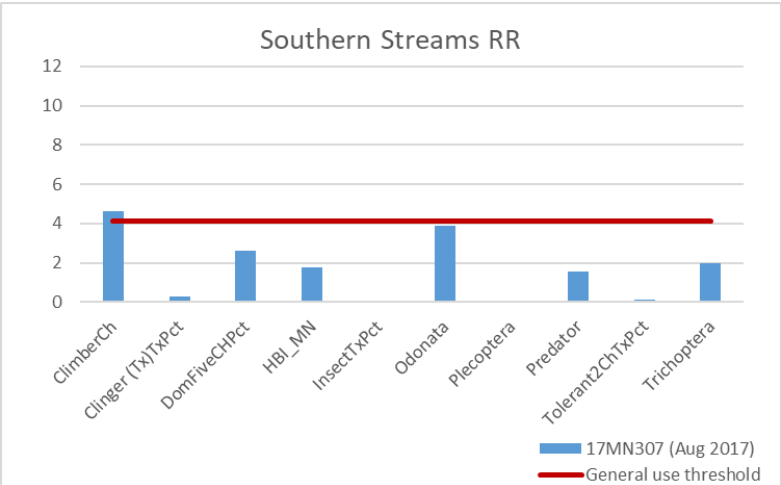


Figure 103. Macroinvertebrate impaired community within the Elm Creek Subwatershed in a Southern Streams class with riffle run features.



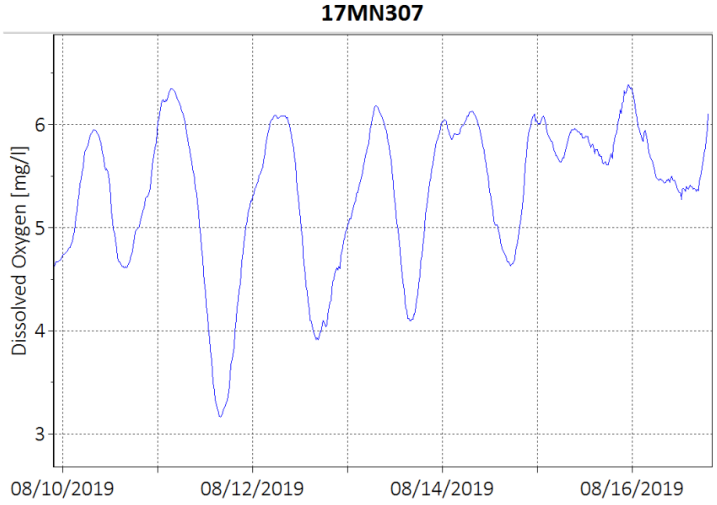
4.8.2 Dissolved oxygen and eutrophication

The furthest upstream WID -631 was limited to what was collected at the time of biological monitoring. DO from these visits were within a normal range during the macroinvertebrate sample. However, during the fish sample at 9:00 a.m. DO fell under the 5 mg/L threshold at 4.96 mg/L. WID -561 was also limited to samples that were collected at the time of sampling. Both reading were around 9 mg/L during afternoon hours, collected in late July and early August.

WID -522 had a total of 17 point measurements for DO in 2017. Values did not indicate too much of a concern, with a range of 4.67 mg/L (afternoon reading) to 11.21 mg/L. Apart from the single low value (that was collected on July 12), all other values fell within acceptable ranges.

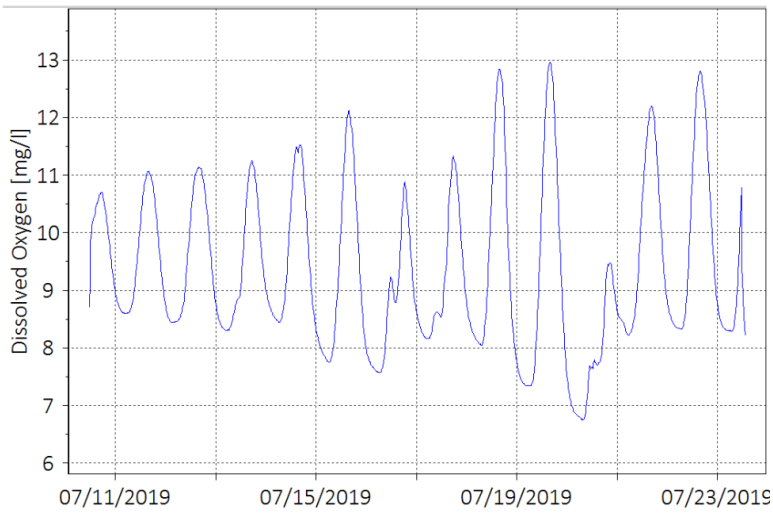
There are two tributaries within the Elm Creek Subwatershed with historical DO impairments, those being Cedar Creek's WID-521 (17MN307) and Judicial Ditch 38's WID -672 (17MN336). A continuous monitoring probe was deployed at both locations to collect DO mg/L every 15 minutes over a period of multiple days. As shown in Figure 104, Cedar Creek DO concentrations fell consistently below the threshold, it's important to note that the DO does not fluctuate in correlation to photosynthesis and respiration. Rather the low DO is constant. This points to potential sediment oxygen demand, or possibly another undetected source.

Figure 104. Continuous DO monitoring at station 17MN307.



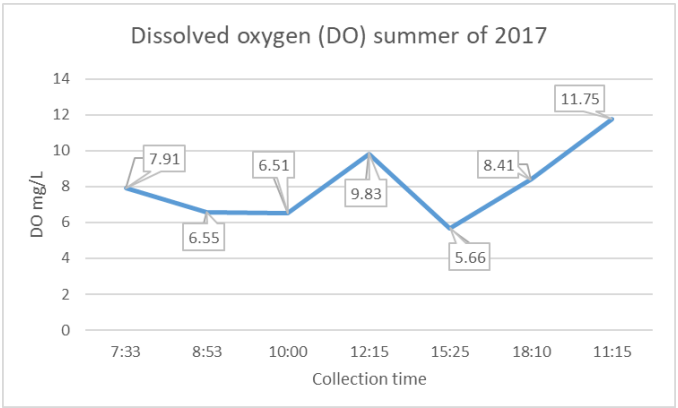
The other tributary of Judicial Ditch 38, station 17MN336 did not show chronic low DO. As shown in Figure 105, sample collection from September 10th through September 24th showed concentrations consistently falling above the threshold of 5 mg/L. In addition to acceptable levels there was fairly stable daily DO fluctuation.

Figure 105. Continuous DO monitoring at station 17MN336.



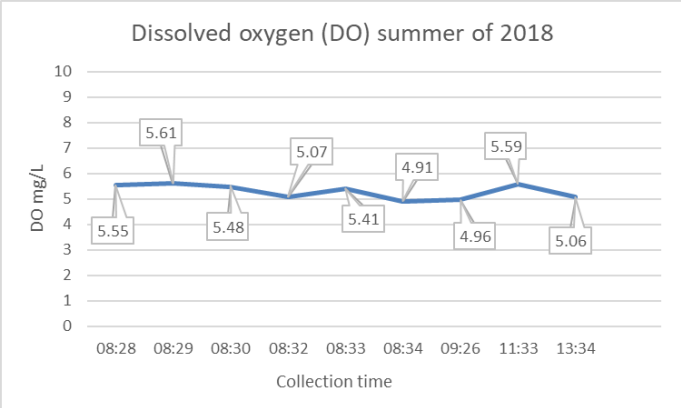
The mainstem, and longest WID (-502) on Elm Creek had a total of 74 point measurements collected in 2007 and 2008 and all in normal range. However, there were only a couple early pre-9:00 a.m. readings. This leaves some question into how DO responds to night respiration activity within the stream. In 2017 (Figure 106) and 2018 (Figure 107). Year 2018 data did show lower values throughout the year. DO at the time of the biological sample at all three stations in 2017 were found to be at an acceptable DO range.

Figure 106. Point measurements at WID -502 at the outlet of Elm Creek in 2017, samples correlate to time of say collected.



In 2018 DO monitoring took place at the outlet of Elm Creek (17MN327). Samples were of concern as all measurements collected fell close to the 5 mg/L threshold.

Figure 107. Point measurements at WID -502 at the outlet of Elm Creek in 2018, samples correlate to time of say collected.



Total phosphorus

All streams showed high potential for phosphorus loading, as shown in Table 72 below. Every stream exceeded the standard at least once. Streams that had a few exceedances of the standard .15 mg/L, typically fell well above. Other stations with a robust data set showed not only high concentrations but frequent as well. WID -627 on station 17MN336 has the fewest exceedances in combination with the lowest concentration with the only exceedance falling .01 mg/L above the standard.

Table 72. Total phosphorus samples within the Elm Creek Subwatershed.

AUID	Stream Name	Biological Stations		Impairment	Number of samples	Range of TP (mg/L)	Average of TP (mg/L	# of exceedances .15 mg/L
Elm Creek								
631	Elm Creek	17MN320		F-IBI	22	.07-.33	0.17	11
561	South Fork	17MN323		F-IBI M-IBI	5	.04-.3	0.11	1
522	Elm Creek	17MN325		F-IBI M-IBI	16	.05-.35	0.13	3
521	Cedar Run Creek	17MN307		F-IBI	15	.08-.38	0.16	8
502	Elm Creek	03MN063 17MN327	13MN172	M-IBI	16	.06-.24	0.15	9
627	Judicial Ditch 38	17MN336		F-IBI	6	.09-.16	0.12	1

Fish metrics

The southern headwater stream WIDs of Elm Creek were slightly mixed in showing indications of the fish community being displaced from low DO or eutrophic conditions (Table 73). Darters were hovering around the threshold for a headwater stream, showing that water quality or transparency may not be a limiting habitat factor. Generalist feeders (omnivores) were slightly up at WID -627, while the other WIDs fell into an acceptable range. What is of some concern is the low number of total taxa types at -631 and -627. Also, the total population of each sample was primarily made up of generally tolerant fish species with a complete absence of any sensitive species. While this highlights there are significant stressors to the community, there is not enough on fish data alone to conclusively say low DO and Eutrophication is stressor.

Table 73. DO and eutrophication fish metrics within Elm Creek Subwatershed, Southern headwater streams on top with Southern streams on bottom. Red highlighted cells indicate values above threshold.

Elm Creek Headwaters	Station (Year sampled)	DarterPct	OmnivorePct	SLithopPct	SensitivePct	TolPct	Taxa Count	DO TIV
631	17MN320 (2017)	11.11	12.22	22.22	0.00	87.78	11	8.55
561	17MN323 (2017)	20.96	12.31	24.81	0.00	77.12	15	8.48
627	17MN336 (2017)	16.13	22.58	25.81	0.00	77.42	8	8.48
Passing Streams Average	**Southern Headwaters General Use**	11.50	16.90	31.50	7.90	72.80	12	*8.44*
	Expected response to stress	↓	↑	↓	↓	↑	↓	↓

Elm Creek Southern Streams	Station (Year sampled)	DarterPct	OmnivorePct	SLithopPct	SensitivePct	TolPct	Taxa Count	DO TIV
522	17MN325 (2017)	8.7	12.9	16.4	0.0	87.1	19	8.70
	17MN306 (2017)	3.2	11.1	5.2	0.5	27.5	27	8.49
521	17MN307 (2017)	9.6	30.4	21.4	0.7	64.3	22	8.52
Passing Streams Average	**Southern Streams General use**	*11.9*	*17.7*	*37*	*16.9*	*44.9*	*19*	8.56
	Southern Streams Modified use	*9.9*	*20.6*	*31.7*	*10.3*	*57.4*	*18*	8.41
	Expected response to stress	↓	↑	↓	↓	↑	↓	↓

In the southern stream WIDs of Elm Creek, there is a slight indication that low DO and eutrophication could be limiting the fish communities. Unlike the headwater streams, the southern stream darter population along with lithophilic spawners was significantly diminished. This suggests diminished water quality and transparency along with excess of potential organic matter impairing local habitat. Generalist eaters were at a reasonable level in all but WID -521. Overall, all but one of the stations (17MN306) had an overabundance of generally tolerant species and a lack of sensitive species. While 17MN306 was not dominated by generally tolerant, the overall fish sample scored poorly for species that were specifically tolerant to low DO levels. Due to this the metrics for fish on these parameters at 17MN306 show there is reasonable evidence that -522 may be stressed for low DO and Eutrophication.

Cedar Run Creek's station (17MN307) barley passed the DO tolerance index score as well as the Taxa diversity threshold. This site scored poorly in all the fish metric categories. In particular there was very limited darters and lithophilic spawners paired with high values for Omnivores that are generalists and typically able to withstand a lower DO threshold. As is the case with a majority of the fish samples, there was a high percentage of tolerant individuals, with a lack of sensitive species.

Macroinvertebrate metrics

Community metrics for the Elm Creek Subwatershed (Table 74) she WIDs that fell into the prairie stream class had somewhat mixed results as the stream went from upstream to downstream of Elm Creek. WID -631 was impaired for fish only, yet had an incomplete IBI assessment, therefore there are not any macroinvertebrate metrics to evaluate at this furthest upstream site on Elm Creek. One trend that was clear from the upstream to downstream was a richer abundance of taxa types with a decreasing population of sensitive EPT species. At all stations, what made up the Trichoptera family was primarily from the abundance of the tolerant net-spinning caddisfly (known to thrive best in environments with high suspended organic material). Looking at the samples as a whole, all but 17MN306 showed communities that were primarily made up of specific low DO tolerant individuals with little to no low DO sensitive present.

Table 74. Macroinvertebrate metrics for DO within the Elm Creek Subwatershed, Prairie streams on top with Southern Streams on bottom. Red highlighted cells indicate values above threshold.

Elm Creek	Station (Year sampled)	Taxa Count	EPT	Trichoptra	Sensitive Tricoptrapct	HBI_MN	DO Index	% DO tolerant	% DO Intolerant
561	17MN323 (2017)	37	50.77	5.41	0.93	8.66	6.80	30.96	2.79
522	17MN325 (2017)	39	30.94	10.26	3.44	8.14	6.92	11.53	5.92
	17MN306 (2017)	29	78.03	13.79	0.00	7.88	7.44	0.32	16.88
627	17MN336 (2017)	44	11.54	6.82	1.28	7.95	6.26	22.76	0.96
Passing Streams Average	**Prarie Stream General Use**	31	42.6	18.72	5.48	7.09	7.04	25.1	5
	Expected response to stress	↓	↓	↓	↓	↑	↓	↑	↓
Elm Creek Southern Streams	Station (Year sampled)	Taxa Count	EPT	Trichoptra	Sensitive Tricoptrapct	HBI_MN	DO Index	% DO tolerant	% DO Intolerant
521	17MN307 (2017)	29	37.15	13.79	5.88	7.73	6.90	22.29	29.72
502	13MN172 (2017)	37	82.66	16.22	1.86	7.30	7.53	1.23	55.56
Passing Streams Average	**Southern Streams General use**	31	42.6	18.72	5.48	7.09	7.04	9.06	24.01
	Southern Streams Modified use	27	40.3	18.5	4.3	7.57	6.75	18.23	12.71
	Expected response to stress	↓	↓	↓	↓	↑	↑	↑	↓

Evaluating for eutrophication by feeding types showed the most probability in a downstream station on WID -627, where both benthic and suspended algae eaters where found in abundance (noted in scrapers and crustacean/mollusks). Curiously there is not an overabundance of specific eutrophic tolerant individuals, indicating that eutrophication is likely not limiting the population. This is consistent with the findings of the macroinvertebrate community not being impaired. All stations lacked the eutrophic sensitive Tanytarsini class while also scoring high on the phosphorus index scale. Station 17MN323 had a specific high population of eutrophic tolerant individuals, however there is some overlap in eutrophic tolerant and those categorized as generally tolerant. All stations were lacking in eutrophic sensitive species.

The southern stream class WIDs in Elm Creek were fairly mixed in a response to low DO. The diversity of macroinvertebrates was adequate at both locations. WID –521 was able to support some species that are categorized as low DO intolerant yet scored poorly in bot DO index value as well as the HBI index. While Trichoptera and overall ETP were in decline, what was present was considered sensitive. Where there is typically an overabundance of net-spinning caddisfly's in eutrophic conditions, they were lacking at this site. This is significant as this could indicate that turbidity was not organically driven and possibly from sediment.

The farthest downstream WID of -502 had a high percentage of the sample rated as being sensitive to eutrophic conditions, with very few eutrophic tolerant species noted. In addition, there was a high percentage of EPT indicating that WID -502 is able to support a variety of sensitive species. However, there are some tolerant species as noted in the abundance of the net spinning caddisfly, indicating that the habitat is good for filter feeders.

Table 75. Macroinvertebrate metrics for Eutrophication within the Elm Creek Subwatershed, Prairie streams on top with Southern Streams on bottom. Red highlighted cells indicate values above threshold.

Elm Creek	Station (Year sampled)	% Scraper	CrustMollPct	TanytarsiniPct	Phos Index	% Tolerant	% Intolerant	%Gen Tolerant
561	17MN323 (2017)	8.36	10.84	5.88	0.15	55.11	0.31	69.66
522	17MN325 (2017)	7.81	8.44	9.47	0.14	21.50	0.00	56.56
	17MN306 (2017)	26.75	0.96	3.77	0.14	27.71	0.64	19.43
627	17MN336 (2017)	17.63	35.26	10.75	0.15	28.85	0.00	72.44
Passing Streams Average	**Prarie Stream General Use**	16	11.78	18.46	0.13	30.6	3.80	61.78
	Expected response to stress	↑	↑	↓	↑	↑	↓	↑
Elm Creek Southern Streams	Station (Year sampled)	% Scraper	CrustMollPct	Tanytarsini Pct	Phos Index	% Tolerant	% Intolerant	%Gen Tolerant
521	17MN307 (2017)	13.62	25.39	1.10	0.14	31.58	0.00	65.02
502	13MN172 (2017)	26.93	0.31	17.14	0.12	13.58	1.23	43.34
Passing Streams Average	**Southern Streams General use**	15	9.64	28.02	0.12	19.12	5.82	49.64
	Southern Streams Modified use	18.17	10.7	25.63	0.14	27.87	3.27	54.6
	Expected response to stress	↑	↑	↓	↑	↑	↓	↑

At the furthest upstream station of Elm Creek, photo documentation taken at the time of sampling (Figure 99) on WID 631 at station 17MN320 indicate a highly degraded stream with high levels of organic matter embedding on the bottom of the stream. In addition there is visible evidence of algae/plant growth. Chemistry samples show that phosphorus is chronically high, with half of the 22 TP samples collected over the .15 mg/L with reaching levels as high as .33 mg/L. However, the fish community did not seem to be specifically displaced by eutrophic conditions. DO data was limited to one reading taken at the time of sampling, with a result of 12.12 mg/L. The fish tolerance DO index score regarding was within an acceptable range, leading to DO to be inconclusive.

The South Fork of Elm Creek was assessed as WID 561 at site 17MN323. There was some degree of embeddedness noted from the photo taken at the time of the fish sample. However, due to the streams turbidity it was undetermined in having excess suspended of benthic algae. Chemistry is limited to five TP samples. Only one of the five samples exceeding the standard, yet that sample was very high at .3 mg/L (well over the .15 mg/L standard). DO was limited to 1 reading, 9.14 mg/L taken at the time of sampling. Fish metrics did not show a direct indication that eutrophic conditions could be placing limitations on the community. However, the macroinvertebrate community did signal some small degree of eutrophic stress but not a dominant limiting factor. These reasons have led to this WID being inconclusive as a biological stressor for both DO and eutrophication. At this time, it does not look like these parameters alone would be limiting the biology.

WID -522 on Elm Creek at stations 17MN325 and 17MN306 showed slightly improved stream beds, with less organic build up and more areas of clean substrate. Stream visibility was slightly improved during this visit. Follow up monitoring also noted fair visibility with not documentation of algae or excess plant blooms. Out of the 16 samples for TP only three exceeded. However, concentrations are of concern as they reached .38 mg/L. DO was limited to three samples that were all within normal range. The biology did indicate eutrophic displacement. For fish there was stronger diversity at the downstream site, yet scored worse when evaluated for both eutrophication and DO. Conversely, the macroinvertebrates showed a slight increase the scores for these two parameters. These are some indications that there is

an additional parameter that is negatively impacting this community (such as TSS), leading to mixed results. Additional information (such as continuous DO measurements) is needed to make a call for both DO and eutrophication as a stressor to the community.

The station on Cedar Run Creek's WID 521 (17MN307) has a previous DO impairment. This station had multiple site visits for evaluation following biological sampling. Water clarity was always turbid from excess sediment, with the stream bed also being fully embedded. Physically, there were not any indications of plant overgrowth occurring within the stream during these visits. In fact there was little growth if any at all. Yet, phosphorus levels were the highest here compared to all other sites within Elm Creek. DO levels also were found to be chronically low, indicating that the existing DO impairment still stands. Biologically speaking, the fish scored poorly across all metrics. Macroinvertebrates were looked at in hopes to add some strength to the evidence, even though they are not listed as impaired for this site. This led to inconstant results for both parameters, pushing the findings more towards another stressor limiting the community rather than eutrophication. DO is clearly placing limitations within this reach as it was found to be chronically low, therefore will be listed as a biological stressor. Eutrophication is not likely despite high phosphorus loading. It is more likely that phosphorus is coming from nearby land application, or other sediment sources. During assessment the stream bed was extremely embedded and turbid, providing a poor environment for any autotrophic growth to occur. However, phosphorus should still be managed for downstream impacts.

Judicial Ditch 38 on WID 627 (station 17MN336) was the other tributary that drains into Elm Creek. This location also has an old impairment for DO. Due to this, there was continuous DO monitoring following the biological sample in 2017. Current data suggests that this WID no longer has chronic DO issues. During site visits this stream was observed to have fair water clarity, with a lack evidence of overgrowth for plants or algae occurring within this WID. The only phosphorus sample to exceeded the standard only fell .01 mg/L over. Regardless of sample size, samples throughout Elm Creek were collected within the same timeframe showing a significant different trend occurring at this side tributary. The fish community did not show consistent signals that low DO or eutrophication is placing limits on the community's diversity. Even though macroinvertebrates were not impaired at this site, metrics were still evaluated to see if there was some indication of a eutrophic tolerant community. It was found to not be. This evaluated with the chemistry data suggests that low DO or eutrophication is not a significant contributor to the community's impairment. Both parameters are considered to not be a biological stressor. As there is still an existing DO impairment on this WID, it is recommended further assessment to de-list.

The mainstem of Elm Creek is the largest WID (502) of Elm Creek. Three biological monitoring stations were evaluated for this reach (03MN063, 13MN172, 17MN327). During site visits water clarity within this section of Elm Creek was found to be extremely turbid from excess sediment. DO measurements were primarily assessed in 2017 and 2018. Year 2017 DO data fell within range, conversely 2018 was consistently low coming out of the outlet of Elm Creek. Phosphorus also was high within the WID,

consistent with the upstream WID trends. At this time the biology is being differed as there was error found within the raw data. The current fish assessment found fish to be passing.

Table 76. Summary of DO and eutrophication stressors within Elm Creek Subwatershed. Red indicates stressor while blue shows inconclusive findings.

				Dissolved Oxygen				Eutrophication		
WID	**Stream Name**	**Biological Stations**	**Impairment**	Dissolved Oxygen	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland/Lake influcence	Excess Phosphorus	Unidentified
	Elm Creek									
631	Elm Creek	17MN320	F-IBI	●					●	
561	South Fork	17MN323	F-IBI M-IBI	●					●	
522	Elm Creek	17MN325 17MN306	F-IBI M-IBI						●	
521	Cedar Run Creek	17MN307	F-IBI				●			
502	Elm Creek	03MN063 17MN327 13MN172	M-IBI							
627	Judicial Ditch 38	17MN336	F-IBI							

4.8.3 Nitrate

Nitrate often fell above the proposed aquatic life threshold of 4.9 mg/L across most WIDs within the Elm Creek Subwatershed. The mainstem of Elm Creek had the highest concentrations recorded, with the highest at 28.7 mg/L. While this is the only WID with a strong number of samples, this is the most representative location of what nitrate loads look like throughout the system.

Figure 108. Nitrate levels by WID within the Elm Creek Subwatershed.

AUID	**Stream Name**	**Biological Stations**	**Impairment**	**Number of samples**	**Range of Nitrate (mg/L)**	**Average of Nitrate (mg/L)**	**# of exceedances** 4.9 mg/L	**# of exceedances** 10 mg/L
	Elm Creek							
631	Elm Creek	17MN320	F-IBI	7	.54-8.8	4.6	4	0
561	South Fork	17MN323	F-IBI M-IBI	5	1.1-10	5.86	4	1
522	Elm Creek	17MN325	F-IBI M-IBI	11	.36-7.9	4.69	7	0
521	Cedar Run Creek	17MN307	M-IBI	5	.79-6.7	2.92	1	0
502	Elm Creek	03MN063 17MN327 17MN172	M-IBI	344	.05-28.7	8.05	241	118
627	Judicial Ditch 38	17MN336	F-IBI	6	3.4-17	11.15	5	4

The furthest upstream location of WID -631 on Elm Creek did not have a macroinvertebrate sample to analyze, automatically leading to inconclusive findings as fish metric response to nitrate toxicity is still under development and not as well understood.

All other stations with the exception of WID 502 and 521, do show fairly strong indications of communities that have been impacted by nitrate toxicity. This is especially apparent in the dominance of specific nitrate tolerant species making up a majority of the population at some locations. WID -627 is unique within the Elm Creek Subwatershed as this was one of the few locations throughout the greater Blue Earth River Watershed that had a sample fish population where there was found to be DELTs within the community. Nitrate toxicity may directly cause physical impairments or indirectly by leaving them susceptible to fungal or pathogens (Camargo 2006). While the data set for total nitrogen is limited, there was strong indication that nitrogen loading is a chronic issue here. Throughout the system, nitrate intolerant species were nearly absent at all stations and overrun with nitrate tolerant species. Two WIDs (-502 and -521) did marginally fall at the threshold, especially Cedar Run Creek -521. For this reason -521 is inconclusive due to the mixed metric results that indicate nitrate is likely not the primary limitation, yet it could still be playing some role. Additional monitoring for this parameter and response in future is recommended.

Table 77. Nitrate metrics for Prairie Streams (top) and Southern Streams (bottom) within the Elm Creek Subwatershed. Red highlighted cells show exceedance of the threshold.

Elm Creek	Station (Year sampled)	Taxa Count	EPT#	Nitrate Index	% Nitrate tolerant	% Nitrate Intolerant
561	17MN323 (2017)	37	7	4.37	88.24	0.00
522	17MN325 (2017)	39	10	4.18	78.82	0.00
	17MN306 (2017)	29	11	3.47	63.06	0.00
502	13MN172 (2017)	37	15	2.77	51.85	0.00
627	17MN336 (2017)	44	4	4.36	68.91	0.32
Passing Streams Average	**Prairie Streams General use**	37	*11.5*	*3.23*	*54.86*	*3.18*
	Prairie Streams Modified use	24	*7.6*	*3.32*	*59.41*	*1.95*
	Expected response to stress	↓	↓	↑	↑	↓
Elm Creek	Station (Year sampled)	Taxa Count	EPT#	Nitrate Index	% Nitrate tolerant	% Nitrate Intolerant
521	17MN307 (2017)	29	8	3.51	44.58	0.00
Passing Streams Average	*Southern Streams Modified use*	*31*	*6.7*	*3.22*	*56.71*	*1.88*
	Expected response to stress	↓	↓	↑	↑	↓

The chemistry data set showed high potential for nitrate overloading throughout the Elm Creek stream systems, with the exception of WID -521. The lack of data that shows high nitrate concentrations lead to inconclusive findings at this WID. The mixed results within the macroinvertebrate community at 521 lead to inconclusive findings as well. All other WIDs showed nitrate driven displacement within the macroinvertebrate community, in addition to nitrate loading issues within the chemistry data set.

Land use in conjunction with altered hydrology is thought to be the primary drivers to nitrate overloading within this subwatershed. WID -522 on the upstream tributary of Elm Creek and Cedar Run Creek do have wetland waterbodies that are also potential contributors to total nitrate under the right conditions.

Table 78. Summary of nitrate impairments within Elm Creek. Red indicates a stressor while blue represents inconclusive findings.

WID	Stream Name	Biological Stations	Impairment	Land Use (application)	Upstream waterbody	Point Souce	Unidentified
Elm Creek							
631	Elm Creek	17MN320	F-IBI	•			
561	South Fork	17MN323	F-IBI M-IBI	•			
522	Elm Creek	17MN325 17MN306	F-IBI M-IBI	•	•		
521	Cedar Run Creek	17MN307	F-IBI	•	•		
502	Elm Creek	03MN063 13MN172 17MN327	M-IBI				
627	Judicial Ditch 38	17MN336	F-IBI	•			•

4.8.4 Total suspended solids

In effort to better understand overall total suspended solids (TSS) composition, Total suspended volatile solids (TSVS) were assessed as well to identify organic contributions, summarized in Table 79. Nearly all stations show potential for chronic total suspended solids for TSS loading. Even with the small sample sets at some locations, each station showed susceptibility to high rates. The only exception being WID 627, where the highest concentration just fell under the threshold. At the mainstem, over half of the large sample set was over the threshold of 45 mg/L. Organic contributions typically made up 25% of the overall TSS concentrations, fairly typical for streams within this region of Minnesota.

Table 79. TSS and TSVS concentrations within the Elm Creek Subwatershed.

WID	Stream Name	Biological Stations	Impairment	Number of TSS samples.	Number of TVS samples.	Range of TSS (mg/L)	Range of TVS	Average of TSS (mg/L)	% TSVS made up TSS (Average)	# of exceedances 45 mg/L
Elm Creek										
631	Elm Creek	17MN320	F-IBI	6	6	8.8-71	2.2-13	27.13	25.03	1
561	South Fork	17MN323	F-IBI M-IBI	4	4	11-130	3.2-23	44.75	26.22	1
522	Elm Creek	17MN325	F-IBI M-IBI	20	9	12-160	3.2-24	43.8	22.59	5
521	Cedar Run Creek	17MN301	F-IBI	16	5	17-86	10-21	42.38	24.26	6
502	Elm Creek	03MN063 17MN172 17MN327	M-IBI	209		2-218		56.42		115
627	Judicial Ditch 38	17MN336	F-IBI	6	6	12-36	2.4-8	23.5	22.19	0

In partnership with Martin County, turbidity readings were conducted using t-tubes. Once a month samples were collected on the same day, to determine the Elm Creek's Subwatershed Turbidity trends. All but one location had poor readings, that being station 17MN336 on WID 627.

Fish TSS metrics

The fish communities TSS metrics at the southern headwater sections of Elm Creek were marginal. WID -627 metrics did show that TSS is not completely impacting habitat, whereas the furthest upstream WID --631 shows habitat is the most impacted by sedimentation, with the downstream WID -561 not improving by much. Both of these WIDs run through pastures, where trampling in the bank as well as in stream are noted. WID -627 metrics did show that TSS is not impact habitat, reproductive, or feeding needs. Within the Southern streams class the mainstem of WID -522 and the tributary WID -521 of Cedar Run Creek show similar patterns in their lack of benthic dwellers and spawners. In addition, herbivores were greatly diminished. The TSS tolerance index values were the highest within these sections of assessed WIDS. Like the other class section of WIDs, TSS intolerant fish species were completely absent.

Table 80. Fish metrics for TSS in the Elm Creek Subwatershed, Southern Headwaters on top and Southern Streams on bottom. Red highlighted cells show values over the threshold.

Elm Creek	Station (Year sampled)	Benthic Feeders Pct	Sensitive Centrarchidae Pct	Herbivores Pct	Intolerant Pct	Long Lived Pct	Sensitive Perciformes Pct	Riffle Pct	Sensitive Pct	Lithophilic Spawners Pct	TSS TIV
631	17MN320 (2017)	12.22	1.11	3.33	0.00	0.00	12.22	3.33	0.00	3.33	19.93
561	17MN323 (2017)	26.73	0.00	11.35	0.00	0.96	21.92	11.35	0.00	10.77	15.78
627	17MN336 (2017)	35.48	0.00	25.81	0.00	0.00	16.13	22.58	0.00	22.58	18.88
Passing Streams Average	**Southern Headwaters General use**	34.97	0.99	22.40	1.61	4.51	13.61	26.18	7.87	14.63	15.09
	Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑
Elm Creek	Station (Year sampled)	Benthic Feeders Pct	Sensitive Centrarchidae Pct	Herbivores Pct	Intolerant Pct	Long Lived Pct	Sensitive Perciformes Pct	Riffle Pct	Sensitive Pct	Lithophilic Spawners Pct	TSS TIV
522	17MN325 (2017)	14.86	0.00	9.07	0.00	4.63	12.16	8.88	0.00	7.53	19.22
	17MN306 (2017)	3.51	11.84	2.41	0.00	12.34	15.45	3.11	0.50	2.71	28.90
521	17MN307 (2017)	15.42	11.08	13.01	0.00	18.07	20.96	13.49	0.72	13.01	23.22
Passing Streams Average	**Southern Streams General use**	36.02	5.37	25.68	4.24	13.58	20.09	30.18	16.89	19.11	17.59
	Southern Streams Modified use	29.70	3.12	21.65	2.07	10.30	15.39	24.42	10.30	15.02	19.19
	Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

Macroinvertebrate TSS metrics

Macroinvertebrate metrics for TSS did indicate some potential for TSS stress to the community, shown in Table 81 below. One of the most alarming indicators is noted in that across all stream types and stations, long lived species greatly lacked. This can indicate a hostile environment that has potential to eliminate communities within the system. High TSS loading after land disturbance or heavy erosion near stream is a plausible pathway for this. The order Plecoptera is sensitive to TSS and were completely absent from all samples throughout all stations. Overall TSS macroinvertebrates were greatly lacking. However, not all sites were dominated by specific TSS tolerant. Similarly to the TSS fish metrics, WID -522 of Elm Creek and WID -521 of Cedar Run Creek showed the most consistent metric response of TSS stress. While other sites shows some indication of TSS stress, there was some mixed results that could indicate the communities that are suffering is from other stressors or multiple factors. The dominant form of macroinvertebrates not specific tolerant to TSS could indicate that there are other factors playing a larger role in community displacement.

Upstream portions to the Elm Creek Subwatershed did show some indication of potential TSS stress to aquatic life. Land use of agriculture and altered hydrology through the system is the driver for stream instability and erosion. There is also a fair amount of pasture land with notable in stream and bank trampling.

Table 81. Macroinvertebrate metrics for TSS within the Elm Creek Subwatershed, Prairie streams on top with Southern Rivers on bottom. Red highlighted cells show values over the threshold.

Elm Creek	Station (Year sampled)	Taxa Count	%Long Lived	%Plecoptera	Ephemeroptera Count	TSS Index	% Tolerant	% Intolerant
561	17MN323 (2017)	37	4.33	0.00	5.00	20.03	35.60	0.31
522	17MN325 (2017)	39	4.06	0.00	6.00	19.38	53.58	0.31
	17MN306 (2017)	29	0.64	0.00	9.00	22.78	76.75	0.00
502	13MN172 (2017)	37	1.86	0.00	11.00	17.75	33.02	0.00
627	17MN336 (2017)	44	9.94	0.00	1.00	16.91	36.22	0.00
522	17MN325 (2017)	39	4.06	0.00	6.00	19.38	53.58	0.31
Passing Streams Average	**Prarie Stream general use**	37	7.5	0.2	6.7	17.35	48.28	2.67
	Expected response to stress	↓	↓	↓	↓	↑	↑	↓
Elm Creek	Station (Year sampled)	Taxa Count	%Long Lived	%Plecoptera	Ephemeroptera Count	TSS Index	% Tolerant	% Intolerant
521	17MN307 (2017)	29	0.62	0.00	4.00	18.62	43.34	0
Passing Streams Average	*Southern Rivers RR Modified use*	24	16.9	31.5	7.9	72.8	35.25	2.21
	Expected response to stress	↓	↓	↓	↓	↑	↑	↓

Both WID -521 and -522 are impaired for turbidity. Current data and fish metrics still indicated this to be a problem within this subwatershed. Both WIDS had consistent indications that TSS is a stressor. Sediment appears to be the dominant form of suspended solids here. However, with the contributing Cedar Lake to WID -521, there is some potential for high organic matter being flushed through at times from this lake, as it is listed as eutrophic. It is likely similar trends in chemistry would have been noted in the mainstem (WID -502). This large section of the mainstem to Elm Creek is impaired for turbidity, with current data trends showing this is still an issue. However, the sample data was unusable leaving this station unable to be evaluated as the current state of the biologic community is unknown.

Table 82. Summary table for TSS within Elm Creek Subwatershed. Red indicates a stressor while blue shows inconclusive findings.

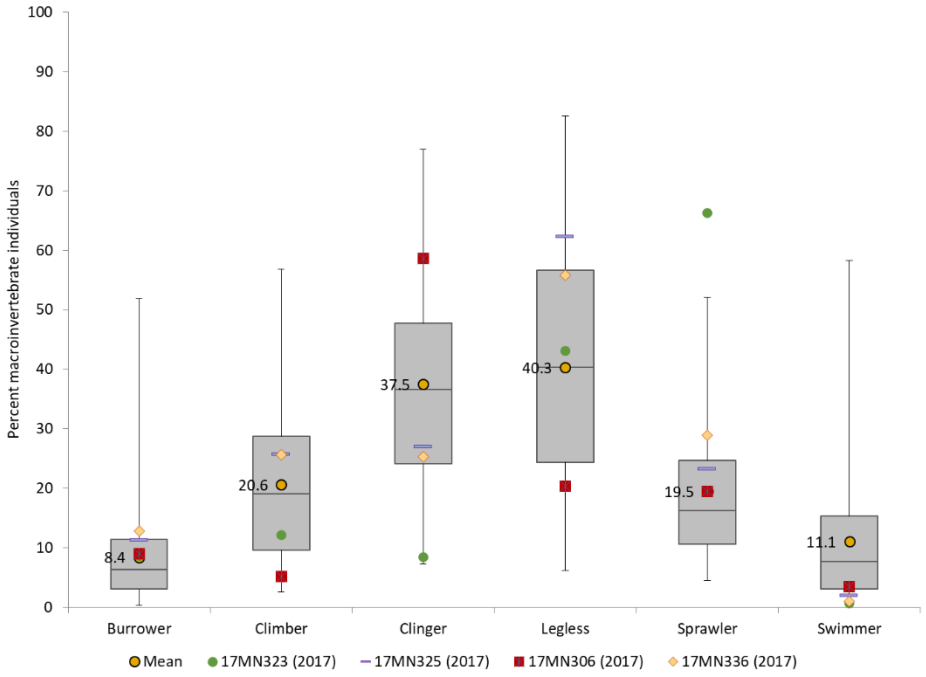
				TSS			
WID	**Stream Name**	**Biological Stations**	**Impairment**	Suspended Algae	Flow Alterations	Stream Bank Erosion	Pasture
	Elm Creek						
631	Elm Creek	17MN320	F-IBI				•
561	South Fork	17MN323	F-IBI M-IBI		•	•	•
522	Elm Creek	17MN325 17MN306	F-IBI M-IBI		•	•	•
521	Cedar Run Creek	17MN307	F-IBI			•	
502	Elm Creek	03MN063 17MN327 13MN172	M-IBI				
627	Judicial Ditch 38	17MN336	F-IBI				

4.8.5 Habitat

Habitat availability is sparse throughout the Elm Creek Subwatershed. The furthest upstream WID of -631 on station 17MN320 did not have macroinvertebrate community metrics to analyze, like other sites that are shown below in **Error! Reference source not found.**. The MSHA score for this station scored poorly for land use (surrounded by row crops) and poor substrate. While overall stream stability was fair, the poor conditions of the riverbed leave enough displacement for riffle dwelling and spawning needs. WID -561 on upper Elm Creek scored poorly at station 17MN323 in all possible categories (land use, riparian, substrate, cover, and morphology of the stream). This section of stream has extensive bank erosion, in hand with a heavy embedded stream. These habitat conditions do fall in line with the macroinvertebrate community types found here. As Figure 109 below highlights, station 17MN323 shows there is a lack of climber and clingers, with a slight increase of legless, sprawlers, and burrowers. Habitat degradation is thought to be one of the primary stressors within this WID. The next two stations of 17MN325 and 17MN306 on WID -522 show a slight difference in community types between the two locations, with the furthest upstream station scoring higher in legless and burrowers. However, both sites scored poorly in habitat ratings across all features. The final WID in the Prairie Stream class is WID -627 at station 17MN336. This station had some of the strongest habitat diversity within the watershed, and shows the ability to support a diverse macroinvertebrate community. Yet there are still areas of some concern noted in stream instability and some embeddedness in some sections. In follow up stream visits, there was noted to be a diverse arrangement of rocky substrate types.

Site 17MN307 primary habitat type that was sampled was riffle features, with the majority of the stream being embedded. With this being the dominant form of habitat, the below composition is of concern. In a stream with riffles being the most available feature, there typically would be a large percentage of clingers. However, this stream is largely composed of legless species that thrive in embedded environments. The higher than average burrower types also confirm this.

Figure 109. Habitat macroinvertebrate metrics for the Elm Creek Subwatershed Prairie streams (top) and Southern stream (bottom).



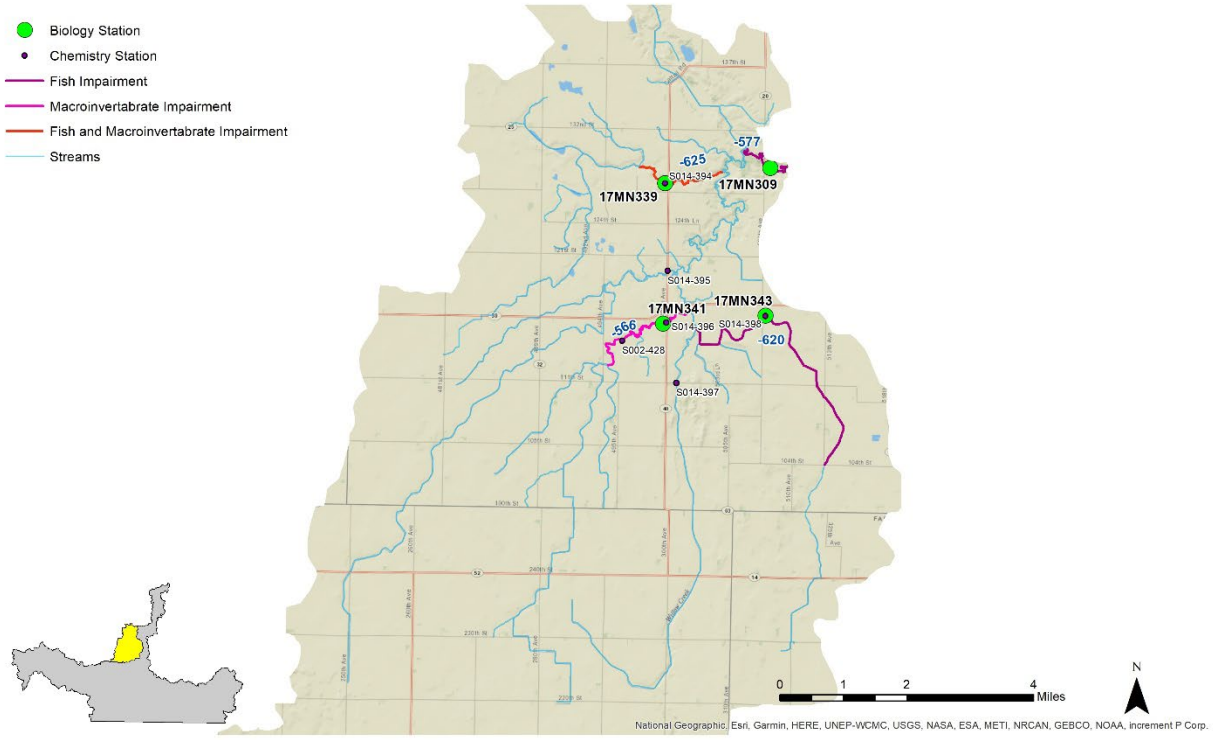
Nearly all locations scored poorly in regards to physical habitat diversity and quality. In addition to physical characteristics of the assessed channels, macroinvertebrate community habitat types were often found to be skewed. Another factor that was considered during the time of this decision was Fish community types that are found within the TSS section of this report (Table 80), as many of the TSS assessed are evaluating habitat needs (such as benthic feeders or lithophilic spawners). It's clear that limited habitat is impacting a majority of the biological communities within this subwatershed. The exception being WID -627 of Judicial Ditch 38. This station has seen significant recovery in comparison to findings in prior years outside of this assessment window. There are a few beaver damns that may be contributing to overall changes of the stream morphology, as they mitigate altered hydrology's flows to an extent.

Table 83. Summary of habitat stressors within the Elm Creek Subwatershed. Red indicates a stressor while blue shows inconclusive findings.

				Habitat				
WID	**Stream Name**	**Biological Stations**	**Impairment**	Channalized	Riparian	Streambed	Habitat diversity	Trampeling
	Elm Creek							
631	Elm Creek	17MN320	F-IBI	●	●	●		
561	South Fork	17MN323	F-IBI M-IBI	●	●	●		
522	Elm Creek	17MN325 17MN306	F-IBI M-IBI		●	●		
521	Cedar Run Creek	17MN307	F-IBI			●	●	
502	Elm Creek	03MN063 17MN327 13MN172	M-IBI					
627	Judicial Ditch 38	17MN336	F-IBI			●		

4.9 Willow Creek

Figure 110. Willow Creek Subwatershed highlighting biological impairments.



The Willow Creek Subwatershed is the last stream system that contributes to the Blue Earth Watershed before meeting the confluence of the Minnesota River. This is an 84 square mile subwatershed with more than 80% of them modified streams by way of channelization. There were four WIDs found to have biological impairments (Figure 110). In addition to biological impairments, WID -577 has an Escherichia coli impairment that will not be addressed within this report as this does not significantly impact biology.

4.9.1 Biological communities

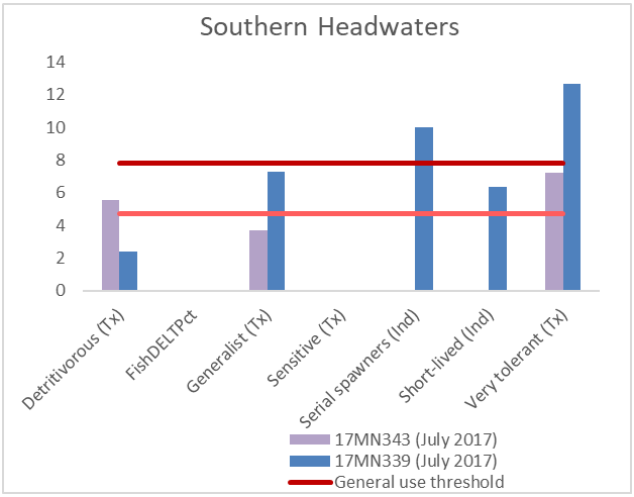
Shown in Figure 111 are conditions of the monitoring locations, taken at the time of sampling.

Figure 111. Condition of stations within Willow Creek at the time of the biological sample.

Fish community

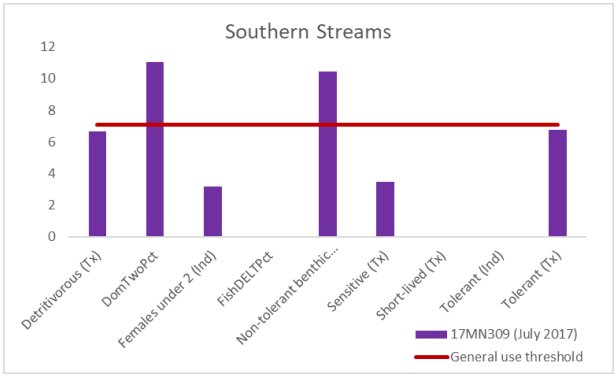
Two sites that are classified as Southern Headwaters had poor fish assemblage in the Willow Creek Subwatershed, shown in Figure 112. Station 17MN343 on WID -620 scored poorly with an IBI of 16.5, falling far below the modified use threshold of 33. This is primarily due to the lack of taxa present (6), as well as poor individual count (21). Blacknose dace were the highest abundance at 13 individuals, all other species fell in the single digits. While the macroinvertebrates did pass for this site, the score was barley passing the low standard of the modified use threshold. Station 17MN339 located on WID -625 was scored as a headwater stream under general use classification. Due to the higher threshold of 55, the IBI score of 38.6 fell short. This site also had limited taxa (7 types), while the individual count was higher to the previous site. Fathead minnows as well as creek chubs mad up about half of the total sample size.

Figure 112. Fish community metrics for Southern headwater streams within Willow Creek Subwatershed.



Station 17MN309 on WID -577 was another station that was found to be impaired for fish assemblage. Scoring an IBI of 41.5 falling short of the threshold of 50 that would be expected for a southern stream under the general use class. Taxa diversity was more abundant at this locations for fish, with 24 taxa types recorded. Bluntnose minnows and Sand shiners had the highest individual numbers. Sensitive fantail darters and northern hogsuckers were found, although not in high numbers. At the time of monitoring a log jam was noted to be impounding the stream shortly upstream from the monitoring site.

Figure 113. Fish community metrics for Southern stream in Willow Creek Subwatershed.

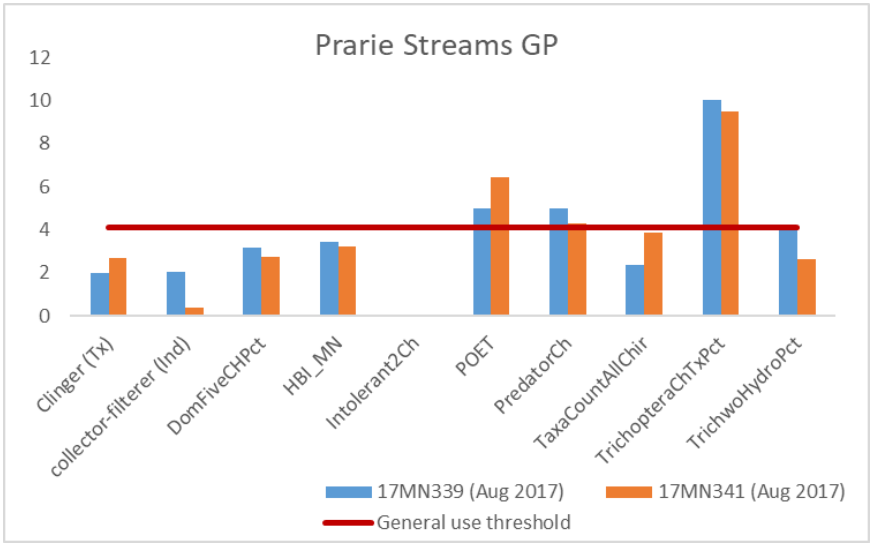


Macroinvertabrate community

Two sites within the Willow Creek Subwatershed were found to be impaired for macroinvertabrate assebelage, both under the Prairie Streams class (Figure 114). At the time of the macroinvertabrate sample for station 17MN339 (WID -625), the water level was recorded as being very low. This potentially could have had a direct impact on the sample. The IBI score was within the confidence interval of the general use threshold of 41, receiving a score of 46.5. However, the overal taxa size was poor with a total of 27 types collected. In addition the sample was dominated by a tolerant netspinning caddisfly taxa, *Cheumatopsyche*.

WID -566 was also listed for a macroinvertabrate impairment. Similar to station 17MN339, the IBI score of 40.5 fell within the confidence interval to the threshold of 41 for deneral use in a prarie stream. Invert taxa was non diverse, with an over abundance of tolerant species in place of sensitiva taxa. Flow was noted as very low at the time of sampling.

Figure 114. Macroinvertebrate community metrics for Prairie Streams within Willow Creek Subwatershed.



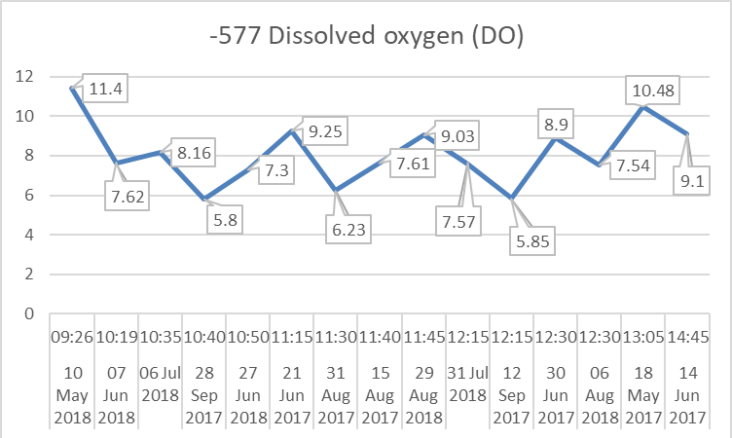
4.9.2 Dissolved oxygen and eutrophication

Dissolved oxygen (DO) and eutrophication data will be analyzed together, as southern Minnesota streams DO issues are often a direct result of plant respiration in eutrophic settings.

All but one station was limited in DO data. What is available is that was collected at the time of the biological sample. All but one fell in normal ranges. The exception being 17MN341 on WID on 566, scoring extremely high with levels at 14.06 mg/L at 11:30 a.m. This is likely a response to high autotrophic photosynthetic activity.

Willow Creek -577 was the one WID were multiple DO data was collected. As shown in Figure 115, the DO levels fell within an acceptable level for the biology, regardless of the time the sample was collected.

Figure 115. Dissolved oxygen point measurements recorded in mg/L, collected throughout 2017 and 2018; Points are correlated to the time of day they were collected.



Phosphorus

All stations showed high phosphorus loading potential (Table 84). The headwaters of Willow Creek had multiple exceedances of the .15 mg/L TP threshold. The furthest downstream section of Willow Creek (-577) showed the lowest potential of chronic TP loading compared to the upstream tributaries.

Table 84. Willow Creek Subwatershed's total phosphorus values shown by WID.

AUID	Stream Name	Biological Stations	Impairment	Number of samples	Range of TP (mg/L)	Average of TP (mg/L	# of exceedances .15 mg/L
	Willow Creek						
620	County Ditch 89	17MN343	F-IBI	8	.06-.47	0.19	4
566	Unnamed Creek	17MN341	M-IBI	9	.03-.41	0.11	3
625	Unnamed Creek	17MN339	F-IBI M-IBI	7	.05-.31	0.187	4
577	Willow Creek	17MN309	F-IBI	10	.06-.26	0.12	2

Fish

The southern headwater streams of WID -620 and -625 both had a general tolerant dominant fish community, with less than 10% falling outside of that category. The southern stream WID -577 had stronger diversity in the amount of taxa with a slightly less percentage of generally tolerant species representing the overall community. All sites showed a decrease of darters, that typically indicates poor water visibility or substrate. While WID -620 did not go over the modified use threshold, the other two sites had higher than usual populations of generalist eaters that are noted in the omnivore metrics. With the exception of -625, the simple lithophilic populations were also indicating habitat degradation to the sediment. All sites lacked sensitive species. While the community specific metrics can highlight indication of eutrophic displacement to the habitat, the DO tolerant index values (derived by a total

calculation of specific low DO tolerant species within the sample) do not indicate a direct correlation. WID -625 was the only site that scored poorly for DO TIV, by slightly going past the threshold.

Table 85. Fish metrics for DO and eutrophication within the Willow Creek Subwatershed. Southern headwaters on top with southern streams class on bottom. Red highlighted values show over the threshold.

Willow Creek Southern Streams	Station (Year sampled)	DarterPct	OmnivorePct	SLithopPct	SensitivePct	TolPct	CountofTaxa	DO TIV
577	17MN309 (2017)	6.21	21.41	25.27	2.14	79.23	24	8.76
Passing Streams Average	**Southern Streams General use**	*11.90*	*17.70*	*37.00*	*16.90*	*44.90*	*19*	8.56
	Expected response to stress	↓	↑	↓	↓	↑	↓	↓
Willow Creek Southern Headwaters	Station (Year sampled)	DarterPct	OmnivorePct	SLithopPct	SensitivePct	TolPct	CountofTaxa	DO TIV
620	17MN347 (2017)	6.43	16.37	15.79	0.00	90.64	13	8.76
625	17MN339 (2017)	2.16	37.41	29.50	0.00	97.84	7	8.35
Passing Streams Average	**Headwaters General use**	*11.50*	*16.90*	*31.50*	*7.90*	*72.80*	*12*	8.44
	Headwaters Modified use	*8.50*	*20.16*	*27.90*	*4.50*	*79.90*	*10*	8.25
	Expected response to stress	↓	↑	↓	↓	↑	↓	↓

Macroinvertebrates

Nearly all three stations that were found to be impaired for macroinvertebrates showed some degree of low DO displacement within the community (Table 87). The total taxa collected were slightly limited for general class use streams. Sensitive species of the Order Ephemeroptera, Plecoptera, and Trichoptera (EPT) are low at all stations. Upon first glance it appears as if WID -625 had a sufficient population within this group. However, with further review in the lack of sensitive Trichoptera, this family is primarily made up of the tolerant Net-Spinning Caddisflies. While there was not an overabundance of DO tolerant individuals, there were little to no low DO sensitive individuals. The overall community make up scored poorly for the low DO index, as well as the calculated HBI index across all locations.

Table 87. Macroinvertebrate metrics for eutrophication within the Willow Creek subwatershed. Red cells indicate value over the threshold. Macroinvertebrate metrics for DO within the Willow Creek subwatershed.

Willow Creek Prarie Stream	Station (Year sampled)	% Scraper	CrustMollPct	TanytarsiniPct	Phos Index	% Tolerant	% Intolerant	%Gen Tolerant
620	17MN343 (2017)	37.46	36.53	9.64	0.15	25.54	0.00	92.88
566	17MN341 (2017)	57.85	57.85	7.79	0.14	8.62	0.00	82.46
625	17MN339 (2017)	8.54	7.62	0.00	0.14	12.73	0.30	24.39
Passing Streams Average	**Prarie Streams General use**	*16.11*	*11.78*	*18.46*	*0.13*	*30.6*	*3.8*	61.78
	Prarie Streams Modified use	*17.73*	*23.21*	*22.11*	*0.14*	*45.87*	*1.79*	73.64
	Expected response to stress	↑	↑	↓	↑	↑	↓	↑

Table 86. Macroinvertebrate metrics for DO within the Willow Creek Subwatershed. Red cells indicate value over the threshold.

Willow Creek Prarie Stream	Station (Year sampled)	Taxa Count	EPT	Trichoptra	Sensitive Tricoptrapct	HBI_MN	DO Index	% DO tolerant	% DO Intolerant
620	17MN343 (2017)	31	4.02	3.23	3.41	8.28	5.95	22.77	0.92
566	17MN341 (2017)	30	12.80	10.00	2.13	7.89	6.78	11.85	0.00
625	17MN339 (2017)	27	67.38	18.52	1.83	7.83	6.85	8.79	3.64
Passing Streams Average	**Prarie Streams General use**	37	38.45	10	5.5	7.55	7.04	25.1	5
	Prarie Streams Modified use	*24*	*25.9*	*5.8*	*2.4*	*8*	*6.19*	*31.37*	*3*
	Expected response to stress	↓	↓	↓	↓	↑	↓	↑	↓

Eutrophic conditions can typically be noted by the abundance of algae feeders, along with the community's overall tolerance values. There were high numbers of algae scrapers as well as algae filterers at WIDs -620 and -566. However, WID -625 did not have as much of a dominate community of algae eaters. This is in part due to the high number of net-spinning caddisflies that dominated the overall sample. In addition to the high community of algae eaters, there was also a lack of the eutrophic

Table 88. Summary of DO and eutrophic stressors within Willow Creek Subwatershed.

				Dissolved Oxygen				Eutrophication		
AUID	Stream Name	Biological Stations	Impairment	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland/Lake influcence	Excess Phosphorus	Unidentified
	Willow Creek									
620	County Ditch 89	17MN343	F-IBI	●					●	
566	Unnamed Creek	17MN341	M-IBI	●					●	
625	Unnamed Creek	17MN339	F-IBI M-IBI	●					●	
577	Willow Creek	17MN309	F-IBI	●					●	

sensitive class of Tanytarsini at all locations. The phosphorus index scored poorly in terms of the total sample indicating eutrophication displacement. While there was not an overabundance of generally tolerant individuals, there was also not an overabundance of individuals specifically tolerant to eutrophic conditions. However, there was a complete lack of individuals that are sensitive to those conditions. The only exception being WID -625.

The detection of low DO was not apparent in the samples collected at these locations. However, it is worth noting that there was a poor Chemistry set to assess from. Detection of low DO in particular needs early morning reading or continuous measurements to better understand the dynamics occurring here. Total phosphorus clearly presented itself as an issue, given the high detection levels that were noted in the modest sample set. There was some indication of both low DO and eutrophication limiting the fish population at -620, -625, and -577, yet the dominance of generally tolerant makes it difficult to clearly distinguish. For these reasons, in conjunction with mixed low DO metrics all stations in willow creek were found to be inconclusive for low DO as a stressor to the fish communities.

Macroinvertebrate metrics were slightly clearer in showing a response to eutrophication. Station -620 and -566 displayed consistent signals that there is some degree of eutrophication limiting the population of macroinvertebrates. These stations also showed the highest range to TP samples. WID -625 showed some indication, yet there is not clear metric indication that eutrophication specifically is a limiting factor leading to -625 being inconclusive for identifying low DO and eutrophication as a limitation to the macroinvertebrate community. All four of the assessed WIDs are inconclusive.

4.9.3 Nitrate

Nitrate samples were evaluated for all WIDs with the exception of WID -577. However, WID -577 was analyzed for ammonia, were out of the eight collected samples there were not any exceedances of the standard. Nitrate at the other locations that are summarized in Table 89 evaluated against both the proposed biological standard of 4.9 mg/L and the drinking water standard of 10 mg/L. At least half of the samples collected exceeded the aquatic life standard, while WID -566 often surpassed the 10 mg/L threshold.

Table 89. Nitrate concentrations by WID within the Willow Creek Subwatershed.

AUID	Stream Name	Biological Stations	Impairment	Number of samples.	Range of Nitrate (mg/L)	Average of Nitrate (mg/L	# of exceedances 4.9mg/L	# of exceedances 10mg/L
	Willow Creek							
620	County Ditch 89	17MN343	F-IBI	9	4.3-14	9.4	4	3
566	Unnamed Creek	17MN341	M-IBI	10	5.5-14	10.98	8	7
625	Unnamed Creek	17MN339	F-IBI M-IBI	8	34-9.2	5.59	3	0
577	Willow Creek	17MN309	F-IBI	-	-	-	-	-

Macroinvertebrate metrics

As fish metrics are still under development, macroinvertebrate metrics are used in place to assess all monitoring locations. Table 90 shows the upstream tributary of 620 and the furthest downstream WID of 577 was found to have marginally adequate taxa types and numbers, unlick the other two WIDS if 566 and 625. All locations had a dominance of nitrate tolerant individuals with a complete lack of intolerant species, driving up the nitrate tolerance index value across all locations.

Table 90. Nitrate macroinvertebrate metrics for prairie streams (top) and southern streams (bottom) within the Willow Creek Subwatershed.

Willow Creek	Station (Year sampled)	Taxa Count	EPT#	Nitrate Index	% Nitrate tolerant	% Nitrate Intolerant
620	17MN343 (2017)	31	3	5.445	64.923	0.000
566	17MN341 (2017)	32	9	7.18	87.38	0.00
625	17MN339 (2017)	27	8	3.89	80.30	0.00
Passing Streams Average	**Prairie Streams General use**	37	*11.5*	*3.23*	*54.86*	*3.18*
	Prairie Streams Modified use	24	*7.6*	*3.32*	*59.41*	*1.95*
	Expected response to stress	↓	↓	↑	↑	↓

Willow Creek	Station (Year sampled)	Taxa Count	EPT#	Nitrate Index	% Nitrate tolerant	% Nitrate Intolerant
577	17MN309 (2017)	42	12	3.53	62.86	0.00
Passing Streams Average	**Southern Streams General use**	31	*6.9*	*2.95*	*47.6*	*2.92*
	Expected response to stress	↓	↓	↑	↑	↓

The three WIDs of -620, 566, and 625 do show a consistent response of nitrate displacement within the community, in conjunction to nitrate readings being high across all sampled locations with data. Nitrate contributions are thought to be primarily due to surrounding land use being row crop production in addition to tiling to streams. There is a small wetland upstream of WID -625 and -577 that is also a potential nitrate contributor at times.

Table 91. Summary of Nitrate stressors within the Willow Creek Subwatershed.

				Nitrate			
WID	**Stream Name**	**Biological Stations**	**Impairment**	Land Use (application)	Upstream waterbody	Point Souce	Unidentified
Willow Creek							
620	County Ditch 89	17MN343	F-IBI	•			
566	Unnamed Creek	17MN341	M-IBI	•			
625	Unnamed Creek	17MN339	F-IBI M-IBI	•	•		
577	Willow Creek	17MN309	F-IBI	•	•		

4.9.4 Total suspended solids

Total suspended solids (TSS) and organics particulate measured in total suspended volatile solids (TSVS) are evaluated against each other where applicable. Overall, sediment made up the majority of suspended particulate in the streams, as shown in Table 92. While some sites had a poor total sample set, every location did capture the potential for high TSS concentrations with at least one sample from each site exceeding the 45 mg/L threshold.

Table 92. TSS and TSVS by with within the Willow Creek Subwatershed.

WID	**Stream Name**	**Biological Stations**	**Impairment**	**# of TSS samples**	**# of TVS samples**	**Range of TSS (mg/L)**	**Range of TVS (mg/L)**	**Average of TSS (mg/L)**	**% TSVS made up TSS (Average)**	**# of exceedances** 45 mg/L
Willow Creek										
620	County Ditch 89	17MN343	F-IBI	7	7	3.2-68	1.6-8.8	68	27.75	2
566	Unnamed Creek	17MN341	M-IBI	8	8	11-140	3.2-16	58.5	18.8	3
625	Unnamed Creek	17MN339	F-IBI M-IBI	6	6	16-83	2.8-14	37.83	17.67	2
577	Willow Creek	17MN309	F-IBI	7		10-52		29.28		1

Fish TSS metrics

WID -620 did not show a strong indication that TSS could be leading to sedimentation driven displacement in the fish metrics (Table 93). Often this is noted in the absence of benthic feeders, riffle dwellers, and well as lithophilic spawners. Other metrics were mixed, such as the complete lack of TSS intolerant species yet the overall acceptable tolerance index values. While WID -625 scored poorly across all TSS metric parameters, previous assessment of this site revealed that the fish sample size was limited to 7 tolerant taxa types. This low sample size will give inaccurate parameter led distribution. The final fish impaired WID -577 also scored poorly across all TSS parameters.

Table 93. Fish Metrics for TSS within the Willow Creek Subwatershed for southern headwater streams (top) and southern streams (bottom).

Willow Creek	Station (Year sampled)	Benthic Feeders Pct	Sensitive Centrarchidae Pct	Herbivores Pct	Intolerant Pct	Long Lived Pct	Sensitive Perciformes Pct	Riffle Pct	Sensitive Pct	Lithophilic Spawners Pct	TSS TIV
620	17MN347 (2017)	32.75	0.00	27.49	0.00	0.00	6.43	27.49	0.00	8.19	15.30
625	17MN339 (2017)	8.63	0.00	6.47	0.00	0.00	2.16	6.47	0.00	6.47	17.30
Passing Streams Average	**Southern Headwaters General use**	34.97	0.99	22.40	1.61	4.51	13.61	26.18	7.87	14.63	15.09
	Southern Headwaters Modified use	27.34	0.67	17.80	0.81	4.28	10.30	19.86	4.53	12.03	15.49
	Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

Willow Creek	Station (Year sampled)	Benthic Feeders Pct	Sensitive Centrarchidae Pct	Herbivores Pct	Intolerant Pct	Long Lived Pct	Sensitive Perciformes Pct	Riffle Pct	Sensitive Pct	Lithophilic Spawners Pct	TSS TIV
577	17MN309 (2017)	22.70	0.64	12.63	0.00	6.42	6.85	17.77	2.14	16.92	23.34
Passing Streams Average	**Southern Streams General use**	*36.02*	*5.37*	*25.68*	*4.24*	*13.58*	*20.09*	*30.18*	*16.89*	*19.11*	*17.59*
	Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

Macroinvertebrate TSS metrics

The macroinvertebrate community scored poorly across all prairie streams WIDs that can be related to TSS displacement, shown in Table 94. The complete lack of long lived species can indicate sporadic hostile environment, potentially from high concentrations of sediment periodically running through the stream system. The Plecoptera and Ephemeroptera orders are particularly sensitive to TSS, which lacked in all but WID – 577. TSS specific tolerant species on average made up 70% of the total population. The TSS index was also consistently high across all WIDs in the prairie stream class. WID -577 is the only macroinvertebrate impairment that falls under the southern streams riffle-run class. This WID did not strongly indicate TSS displacement within the macroinvertebrate metrics.

Table 94. Macroinvertebrate metrics for TSS within the Willow Creek Subwatershed for prairie streams (top) and southern streams with riffle run features (bottom).

Willow Creek	Station (Year sampled)	Taxa Count	%Long Lived	%Plecoptera	Ephemeroptera Count	TSS Index	% Tolerant	% Intolerant
577	17MN309 (2017)	42	12.38	0.00	7.00	16.85	36.19	0.00
Passing Streams Average	**Southern Stream RR general use**	*31*	*8.99*	*0.54*	*6.04*	*15.87*	*35.22*	*5.06*
	Expected response to stress	↓	↓	↓	↓	↑	↑	↓

Flow alteration within this region of Minnesota is often the primary driver of TSS, particularly when there are dramatic changes to gradient. The only WID that showed consistent evidence of TSS stress is noted in 566. This site was also one of the few that was noted to have heavy bank erosion. The other WIDs either contradicted each other in the biological metrics or had weak overall evidence, leaving them as inconclusive.

WID -577 is inconclusive for TSS as a stressor. The macroinvertebrate did not indicate TSS was a primary stressor. However, the fish community is consistent to what would be seen in a high TSS stream. It is important to highlight that this station is the closest to the Blue Earth River that has an existing turbidity impairment. With the site this close, there is a possibility the fish species here may be reflective of those downstream conditions.

Table 95. TSS stressors within the Willow Creek Subwatershed. Red indicated stressor while blue indicates inconclusive findings.

				TSS			
AUID	**Stream Name**	**Biological Stations**	**Impairment**	Suspended Algae	Flow Alterations	Stream Bank Erosion	Pasture
Willow Creek							
620	County Ditch 89	17MN343	F-IBI		●		
566	Unnamed Creek	17MN341	M-IBI		●	●	
625	Unnamed Creek	17MN339	F-IBI M-IBI		●		
577	Willow Creek	17MN309	F-IBI		●		

Willow Creek	Station (Year sampled)	Taxa Count	%Long Lived	%Plecoptera	Ephemeroptera Count	TSS Index	% Tolerant	% Intolerant
620	17MN343 (2017)	31	0.00	0.00	2.00	18.53	64.62	0.00
566	17MN341 (2017)	32	1.54	0.00	4.00	21.00	69.54	0.00
625	17MN339 (2017)	27	0.30	0.00	4.00	17.97	66.36	0.00
Passing Streams Average	**Prarie Stream general use**	37	7.5	0.2	6.7	17.35	48.28	2.67
	Prarie Stream modified use	24	6.0	0.1	4.8	16.02	35.60	1.27
	Expected response to stress	↓	↓	↓	↓	↑	↑	↓

4.9.5 Habitat

Physical habitat was assessed during each of the biological assessments. Physically all of the upland prairie stream WIDs scored poorly for habitat availability and diversity. The surrounding land use agriculturally dominant by row cropping. Due to this these channels have been physically altered by way of channelizing as well as the introduction of subsurface drainage by way of tile. These modifications create a more homogenous stream bed, taking away from the streams natural diversity. Increased flows also can contribute to instability of the stream channels. This is especially apparent in WID -566, where bank erosion is leading to sediment contributions within the stream. In addition to the physical alterations to the stream, fish and macroinvertebrate assemblage can highlight habitat disparities. As shown in the above Table 93 for TSS, Benthic and riffle dwellers were mixed. However, lithophilic spawners were consistently below the benchmark. Headwater sites such as these play a critical role as spawning grounds for some species. The lack of spawners is of concern. In addition to the fish population, the macroinvertebrate habitat groups (Figure 116) is also indicative of poor habitat that are noted in the skewed distributions.

The only station with inconclusive habitat findings (17MN309) on WID 577 was not as clear in displaying habitat limitations. As discussed in the above TSS section, fish species that depend on specific habitat needs were lacking yet not completely absent. The macroinvertebrate community fell within the expected distributions, with the exception of a slight increase in clingers (Figure 117).

Figure 116. Habitat invertebrate metrics within the Willow Creek Subwatershed, scored to the prairie stream standard.

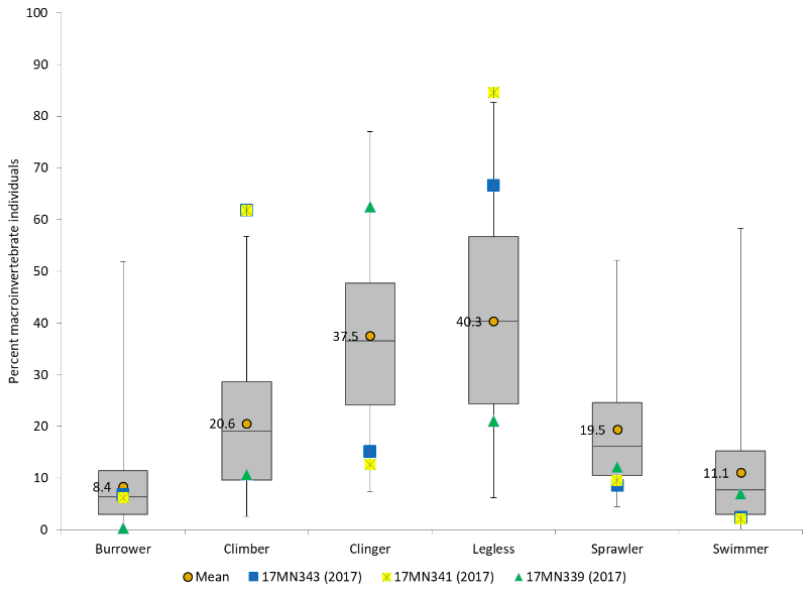
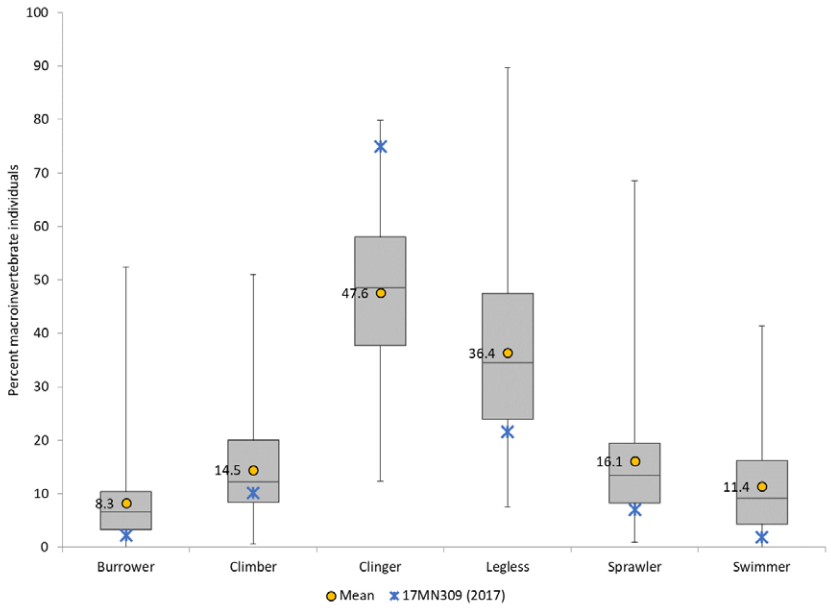


Figure 117. Habitat invertebrate metrics within the Blue Earth Watershed, scored to the southern stream standard.

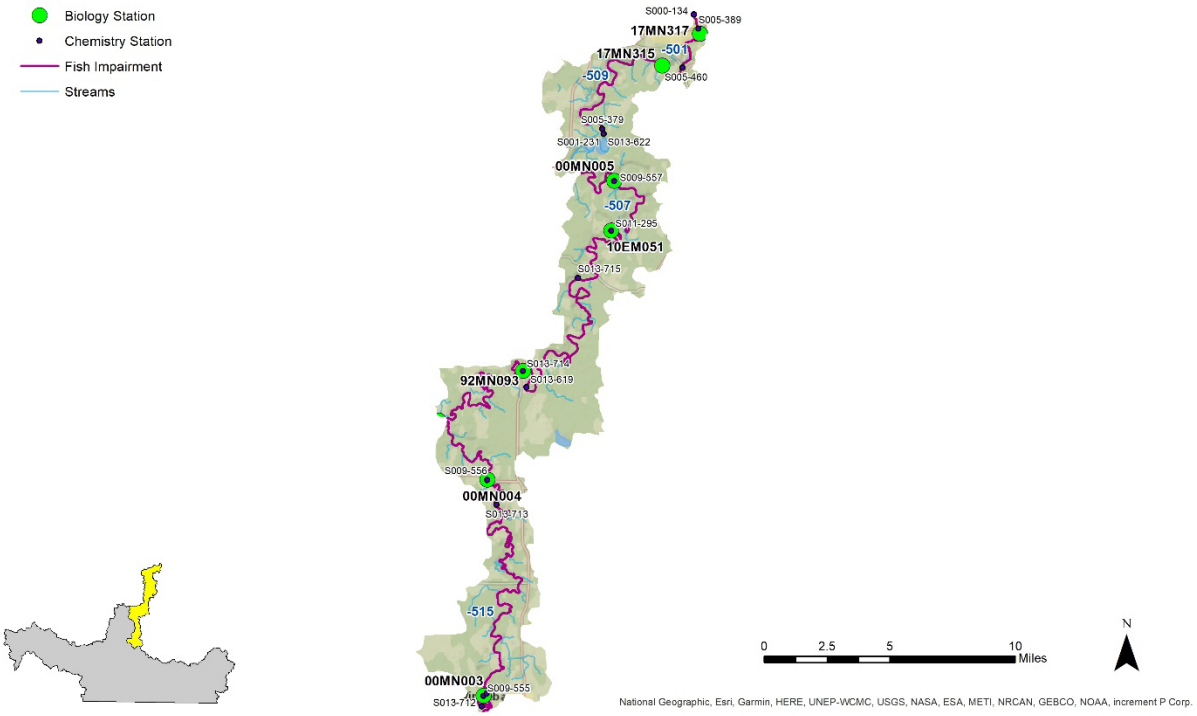


Habitat is limiting biology in the upstream headwaters of the Willow Creek Subwatershed. All of these sites are physically altered onto channelized streams for agricultural purposes. This significantly reduces habitat diversity as well as quality. The mainstem of Willow Creek WID -577 has slightly improved habitat features, with mixed metrics that led to inconclusive findings as a biological stressor.

Table 96. Summary of habitat stressors within the Willow Creek Subwatershed. Red indicates stressor while blue is inconclusive.

				Habitat				
WID	**Stream Name**	**Biological Stations**	**Impairment**	Channalized	Riparian	Streambed	Habitat diversity	Trampeling
	Willow Creek							
620	County Ditch 89	17MN343	F-IBI	•	•	•	•	
566	Unnamed Creek	17MN341	M-IBI	•	•	•	•	
625	Unnamed Creek	17MN339	F-IBI M-IBI			•	•	
577	Willow Creek	17MN309	F-IBI			•		

4.10 Blue Earth River



This section of the Blue Earth Subwatershed contains the mainstem and outlet of the Blue Earth River Watershed in its entirety. There are three towns along this final stretch of River. Starting at the furthest upstream station is the town of Winnebago, where the Blue Earth then goes through the town of Rapidan, until it converges with the Minnesota River at Mankato. Rapidan has a water Dam that creates an obvious fish barrier as well as changes to the streams hydrology. In addition, following the Rapidan dam are a series of waterfalls leading up to the outlet of the Blue Earth where it converges into the Minnesota River, near Mankato. Along this HUC 10 of the Blue Erath River, there is a total of seven monitoring stations. All locations were found to be impaired for Fish assemblage. The macroinvertebrate communities that were assessed were found to be passing. This entire section of the Blue Earth River is impairments for Turbidity. Closer to the outlet, WID -509 has an existing nutrient impairment, current data still suggests there is still nutrient overloading occurring. WIDs -509 and 501 also have a preexisting E.coli impairment that will not be discussed in the report.

4.10.1 Biological communities

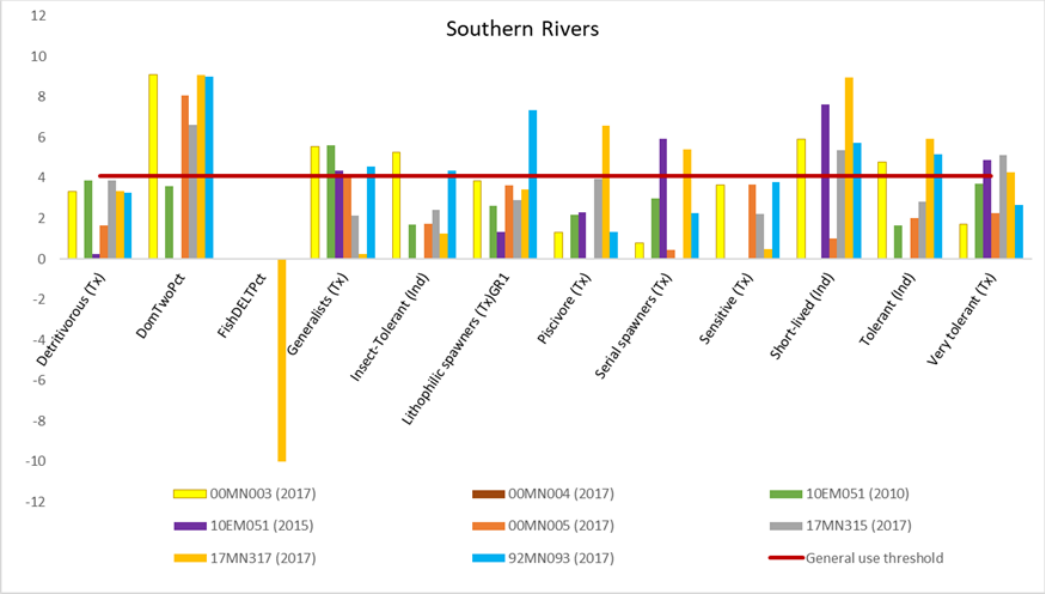
Below shown in Figure 118 are the assessed sites, taken at the time of biological monitoring.

Figure 118. Stream conditions of biomonitoring stations within the Blue Earth River Subwatershed, taken at the time of the fish sample.

Fish community

All streams on the Blue Earth River fish stations were assessed as southern rivers under the general use class, resulting in an IBI threshold of 49. Station 00MN003 had an IBI score of 45.2. This subwatershed was one of the few where DELTs impacted the fish IBI. DELTs in this case were found within the bigmouth buffalo (L and E), and Carp (L), Channel Catfish (F,L, and N) populations. Station 10EM051 scored 26.6 in 2015 with sand shiners making up a majority of the population. Station or Site 17MN317 with an IBI score of 39 was overwhelmingly made up of emerald shiners. This location is also where the DELTs within the population were recorded. Station 00MN004 was primarily fathead minnows with an IBI score of 37.5. Station 00MN005 fell at 28.7 with sand shiners being the most prevalent. Station 92MN093 did not have a single species that significantly overtook the population. However, for each specie type present there were very few individuals that made up the taxa count. The highest number was seen in Shorthead redhorse, with a count of 31 and common carp with a count of 28. Most other individual counts per specie type fall into single digits. The IBI score for this site fell 37.1. The next downstream station of 10EM051 had the poorest score in 2010 of 26.6, sandshiners and bluntnose minnows made up a bulk of the sample. The furthest downstream station of 17MN315 had an IBI of 45 with gizzard shad and green sunfish.

Figure 119. Impaired fish communities in Southern Rivers within the Blue Earth River Subwatershed.



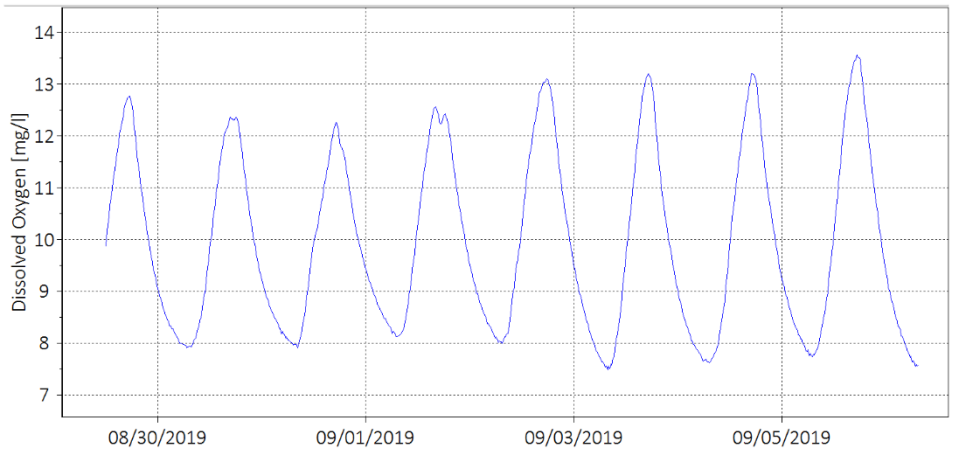
4.10.2 Dissolved oxygen and eutrophication

Within this region of Minnesota, dissolved oxygen (DO) typically holds a close relationship to eutrophication within lakes and streams. For this reason, these two perameters will be assessed together.

The furthest upstream WID of -515 had a large data set of DO point measurments through the summer months in the years of 2013-2019. Out of 149 samples, DO did not fall below the 5 mg/L threshold. Concintrations ranged from a minimum of 5.63 mg/L and a maximum of 13.47. Further upstream WID -507 and -501 showed similar readings over a span of 10 years. Out of 202 instuntainious readings the minimum was 5.43 mg/L with a maximum of 15.2 mg/L.

In 2019 a YSI EXO sond was deployed on WID -515 to better understand dirunal oxygen levels. As shown in Figure 120

Figure 120. Continuous dissolved oxygen measurements taken at 00MN003 from August 31st to September 5th of 2019.



Dissolved oxygen was recorded closely together over the months of Late August and Septemer. The Fist continuous DO reading did not result in any reading below the 5 mg/L threshold for aquatic life. However, there was some extreeme 24 hour DO flucuation. Typically the 24 hour DO change ranged from 4 mg/L – 7 mg/L.

Phosphorus

The phosphorus samples collected at all but WID -507 displayed high and potential chronic phosphorus loading issues, summarized in Table 97 below. With the exception of WID -507, phosphorus concentrations were shown to exceed the .15mg/L standard roughly half of the time throughout the Blue Earth River where there was strong data set to analyze.

Table 97. Blue Earth summary of total phosphorus values.

AUID	River Name	Biological Stations	Impairment	Number of samples	Range of TP (mg/L)	Average of TP (mg/L	# of exceedances .15 mg/L
Blue Earth							
515	Blue Earth	00MN003 00MN004	F-IBI	209	.03-1.67	0.25	151
507	Blue Earth	10EM051 00MN005	F-IBI	4	.06-.12	0.1	0
509	Blue Earth	17MN315	F-IBI	509	.01-1.36	0.23	346
501	Blue Earth	17MN317	F-IBI	26	.03-.93	0.18	9

Within the HUC 10 outlet of the Blue Earth River there are two different Watershed Pollutant Load Monitoring Network stations (WPLMN), providing long term data in relationship to flow. The first station is located at the farthest upstream station on the Blue Earth River near Winnebago, displayed in Figure 121. The second station is located closer to the outlet of the Blue Earth River near Rapidan, seen in Figure 122. In addition to the significant correlation of phosphorus levels during rain events (noted in the rise of stream flow in black), there is also an increase in overall phosphorus loading from the upstream portion to the mouth of the Blue Earth River. In addition to minor tributaries that flow in between these intensive monitoring stations, the Watonwan River converges into the Blue Earth River shortly before the Rapidan station.

Figure 122. Total phosphorus loading with flow of the Blue Earth River, taken at Winnebago.

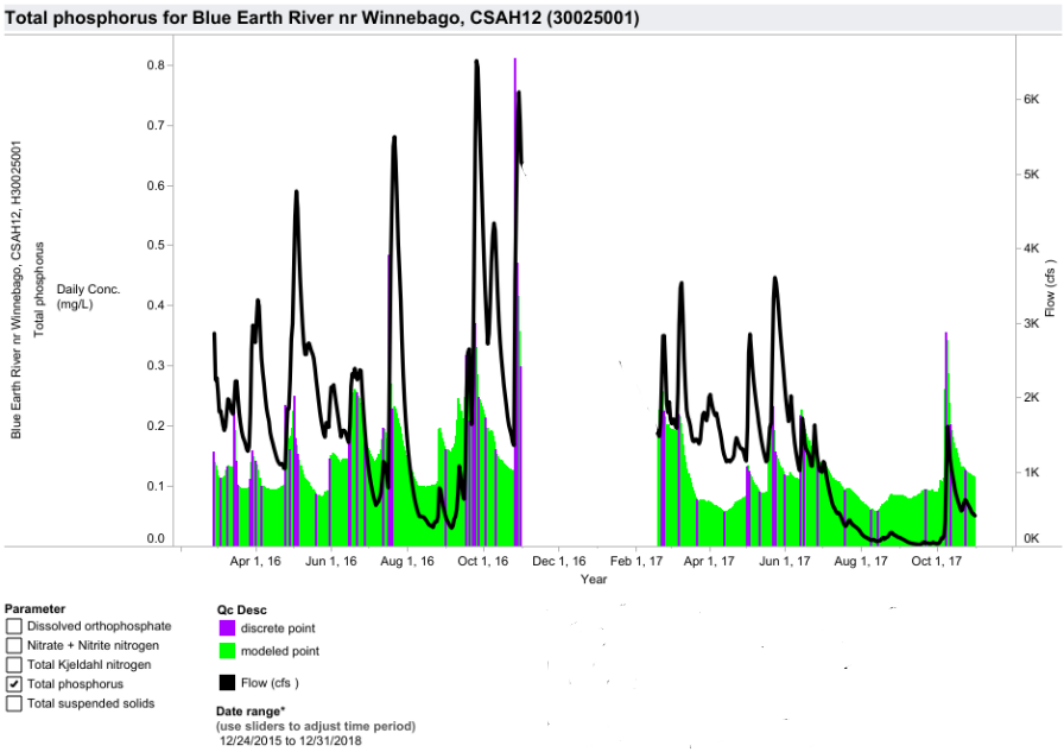
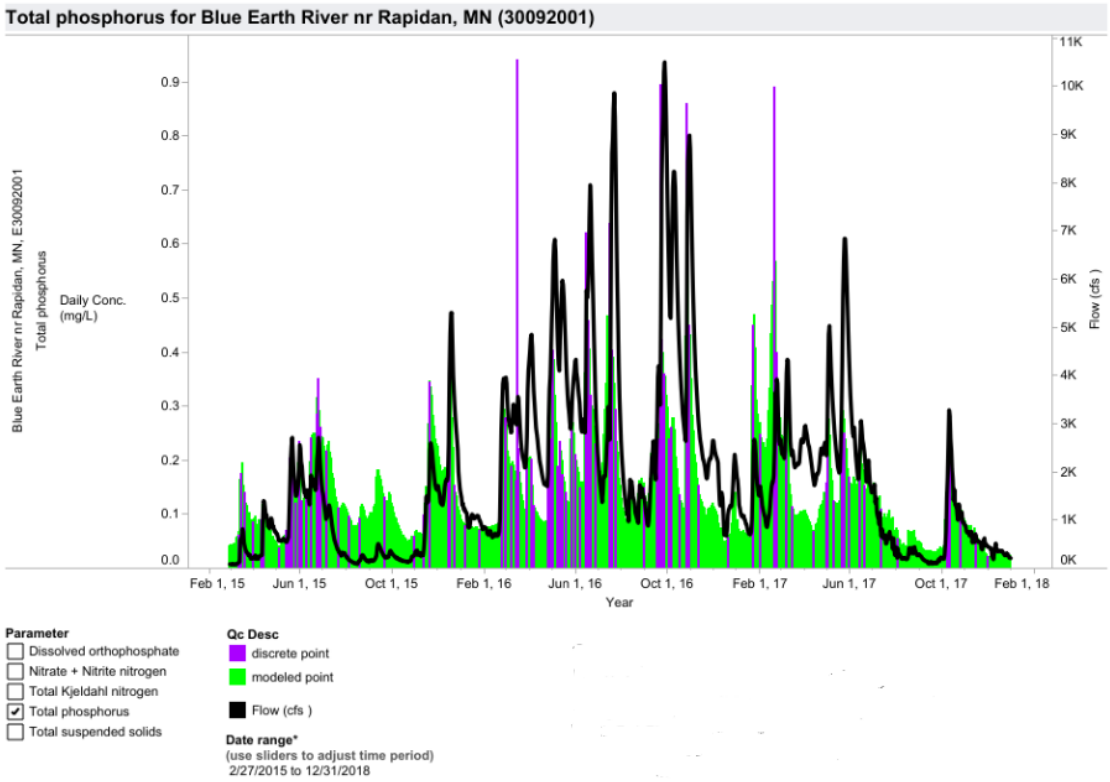


Figure 121. Total phosphorus loading with flow of the Blue Earth River, taken at Rapidan.



The fish communities sampled throughout the Blue Earth Watershed did signal some degree of stress throughout the communities related to eutrophic impaired habitat and DO stress (Table 98). While the dissolved oxygen tolerance index values are not tripped, the fish community's composition shows a lack of darters and lithophilic spawners that you would expect to see in a southern river. Omnivore species were in mixed abundance throughout the Blue Earth mainstem. As with a majority of the streams assessed throughout the watershed, sensitive species lacked, while generally tolerant fish species thrived in place. Evaluating the fish data alone does not conclusively highlight that eutrophication and dissolved oxygen are limiters to the community.

Table 98. Fish metrics to evaluate DO and eutrophic stress within the Blue Earth River Subwatershed.

Blue Earth Southern Rivers	Station (Year sampled)	DarterPct	OmnivorePct	SLithopPct	SensitivePct	TolPct	CountofTaxa	DO TIV
515	00MN003 (2017)	9.67	17.10	34.94	14.50	42.01	25	8.86
	00MN004 (2017)	0.19	30.00	22.69	3.08	45.96	24	8.86
507	10EM051 (2010)	0.83	8.31	15.79	6.65	68.14	23	9.00
	10EM051 (2015)	0.26	4.35	1.92	1.28	87.26	22	9.07
	00MN005 (2017)	3.64	17.62	14.94	7.09	65.13	19	8.83
	92MN093 (2017)	4.32	28.11	28.65	9.73	38.65	28	8.85
509	17MN315 (2017)	10.53	7.89	16.67	12.28	58.33	23	8.84
501	17MN317 (2017)	0.80	47.20	15.20	4.00	32.00	25	8.86
Passing Streams Average for Southern Rivers	**Southern Rivers General use**	4.46	15.72	24.97	13.53	22.05	22	8.76
	Expected response to stress	↓	↑	↓	↓	↑	↓	↓

Chemistry data indicates clear phosphorus overloading within the stream in addition to concerning DO dynamics. In particular station 00MN003 where the continuous data for DO was recorded in the late summer months highlighted a eutrophic response in both 24 hour FLUX and chronically low DO in the later monitoring period that would correlate with organic breakdown and respiration. However, in evaluating the fish data there is not a lot to highlight that eutrophication and dissolved oxygen are limiters to the community. It is particularly difficult to isolate these two parameters as this river is listed for a turbidity impairment and can show a similar signal in the fish communities' assessed in the table above. Along with the turbidity impairment there is also a nutrient impairment found at the outlet of this HUC. This is consistent to the high levels of phosphorus noted in the samples. While DO and eutrophication may not be the primary stressor, there may be some degree of limitation to the biology given what is noted in the stream chemistry. Therefore eutrophication and low DO will be listed as inconclusive. It is likely that most reduction or practiced to reduce phosphorus and by extension low DO would be from upstream targeting from the feeding tributaries.

Table 99. Summary of DO and eutrophic stressors within the Blue Earth River Watershed. Blue cells highlight inconclusive findings.

				Dissolved Oxygen				Eutrophication		
AUID	**River Name**	**Biological Stations**	**Impairment**	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland/Lake influcence	Excess Phosphorus	Unidentified
Blue Earth										
515	Blue Earth	00MN003 00MN004	F-IBI	●					●	
507	Blue Earth	10EM051 00MN005	F-IBI	●					●	
509	Blue Earth	17MN315	F-IBI	●					●	
501	Blue Earth	17MN317	F-IBI	●					●	

4.10.3 Nitrate

In addition to this, there was multiple point sampling events (Table 100) collected throughout the last 10 year monitoring cycle. As shown below, nitrate concentrations frequently exceed the proposed biological nitrate standard of 4.9 mg/L.

Table 100. Nitrate sample concentrations within the Blue Earth River Subwatershed.

AUID	River Name	Biological Stations	Impairment	Number of samples.	Range of Nitrate (mg/L)	Average of Nitrate (mg/L)	# of exceedances 4.9mg/L	# of exceedances 10mg/L
Blue Earth								
515	Blue Earth	00MN003 00MN004	F-IBI	360	.05-22.1	11.4	293	225
507	Blue Earth	10EM051 00MN005	F-IBI	3	.4-8.8	3.5	1	-
509	Blue Earth	17MN315	F-IBI	491	.07-23	8.4	356	159
501	Blue Earth	17MN317	F-IBI	124	.13-14.3	6.98	93	17

There are two WPLMN stations that capture and model pollutant loads for nitrate in conjunction with flow. The first station is located near the furthest upstream station of 00MN003 near the town of Winnebago (Figure 123). The second station located closer to the outlet of the Blue Earth River near Rapidan dam (Figure 124).

Figure 123. WPLMN station near Winnebago, showing measured nitrate in relation to flow within the Blue Earth Subwatershed.

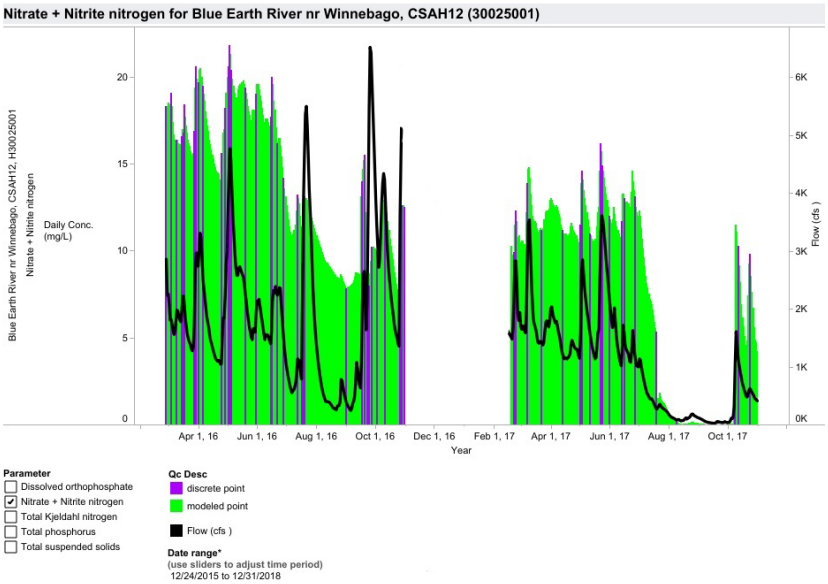
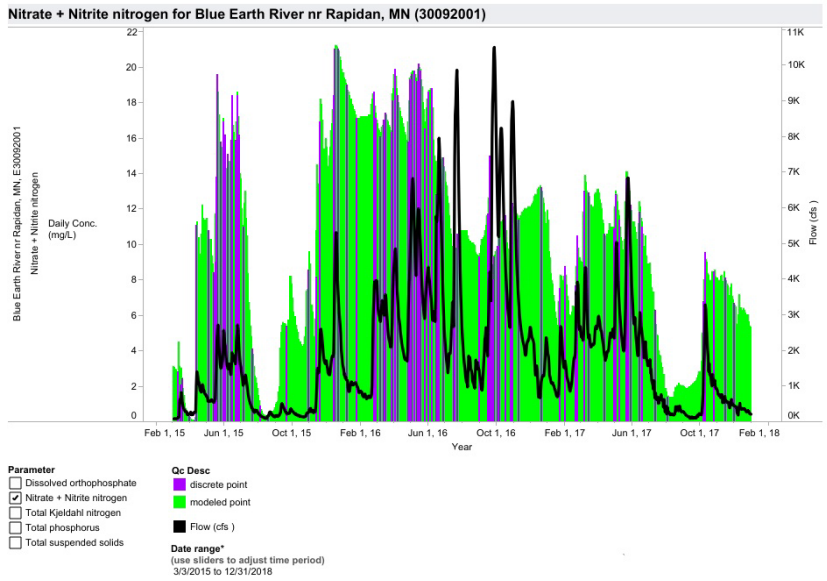


Figure 124. WPLMN station near Blue Earth, showing measured nitrate in relation to flow within the Blue Earth Subwatershed.



The macroinvertebrate community showed only a slight nitrate response, noted in Table 101. While all sites showed a lack of nitrate intolerant species, the strongest indicator was in the poor nitrate index score of WID -515 and the 2010 sample in WID -507. The 2010 sample was the only site to score poorly across all nitrate metrics. Overall, a majority of this subwatershed did not indicate nitrate displacement to the macroinvertebrate communities.

Table 101. Macroinvertebrate metrics for nitrate within the Blue Earth Subwatershed. Red highlighted cells indicate values over the threshold.

Blue Earth Southern Rivers	Station (Year sampled)	Taxa Count	EPT#	Nitrate Index	% Nitrate tolerant	% Nitrate Intolerant
515	00MN003 (2017)	37	17	2.88	44.69	0.32
	00MN004 (2017)	32	14	2.06	22.88	0.00
507	10EM051 (2010)	25	10	3.35	58.33	0.62
	10EM051 (2015)	35	15	2.41	30.16	0.30
	00MN005 (2017)	40	17	2.47	38.46	0.62
	92MN093 (2017)	37	13	2.21	28.13	0.31
509	17MN315 (2017)	29	15	2.81	32.52	0.61
Passing Streams Average for Southern Rivers	**Prarie Forest Rivers**	35	13.77	2.86	46.79	4.36
	Expected response to stress	↓	↓	↑	↑	↓

While the recent macroinvertebrate communities did not signal a strong nitrate stress signal, nitrate concentrations are concerning with levels frequenting above 20 mg/L. There also is a concerning level of fish DELTs found at the furthest downstream station of 509, showing potential of fish stress from some forms of nitrates. While WID- 509 has a historical nutrient impairment, there is some indication within the macroinvertebrates that the community is slightly improving. Overall the sites showed conflicting information to determine if nitrate concentrations are significantly influencing biology within this subwatershed. Potential nitrate concentrations are primarily in relationship to the upstream land use of agriculture (row cropping). There is some potential of point source contributions from the towns with industrial, municipal, and MS4s dischargers.

Table 102. Nitrate stressors within the Blue Earth Subwatershed. Blue cells indicate inconclusive findings.

				Nitrate			
AUID	River Name	Biological Stations	Impairment	Land Use (application)	Upstream waterbody	Point Souce	Unidentified
Blue Earth							
515	Blue Earth	00MN003 00MN004	F-IBI	●		●	
507	Blue Earth	10EM051 00MN005	F-IBI	●			
509	Blue Earth	17MN315	F-IBI	●		●	
501	Blue Earth	17MN317	F-IBI	●		●	

4.10.4 Total suspended solids

Total suspended solids (TSS) has a robust data set to evaluate with two Watershed Pollutant Load Monitoring Network (WPLMN) locations within this subwatershed (Figure 125 and Figure 126 below). In addition there is a strong data set of single sample grabs collected throughout this assessment period, as shown below in Table 103. While not all TSS data was able to have the distinction of organic vs sediment made, there were similar trends of the organic make up percentage (around 20%) in the furthest upstream WIDS. The organic percentage and TSS concentration overall declined after the Rapidan dam.

Table 103. TSS and TSVS sample concentrations by WID within the Blue Earth River Subwatershed.

WID	Stream Name	Biological Stations	Impairment	# of TSS samples	# of TVS samples	Range of TSS (mg/L)	Range of TVS (mg/L)	Average of TSS (mg/L)	% TSVS made up TSS (Average)	# of exceedances 45 mg/L
Blue Earth										
515	Blue Earth	00MN003 00MN004	F-IBI	216	64	3-3212	2-287	101.02	24.5	161
507	Blue Earth	10EM051 00MN005	F-IBI							
509	Blue Earth	17MN315	F-IBI	491	210	1-1380	1-136	151.84	21.84	350
501	Blue Earth	17MN317	F-IBI	64	47	4.4-1600	4-1536	256.62	13.36	53

Figure 126. WPLMN station near Winnebago, showing measured TSS in relation to flow within the Blue Earth.

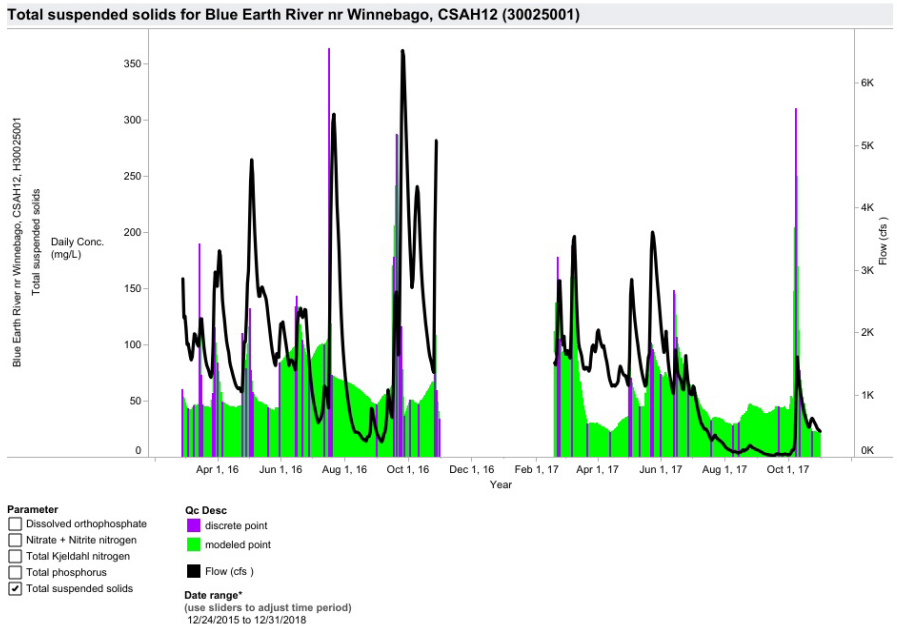
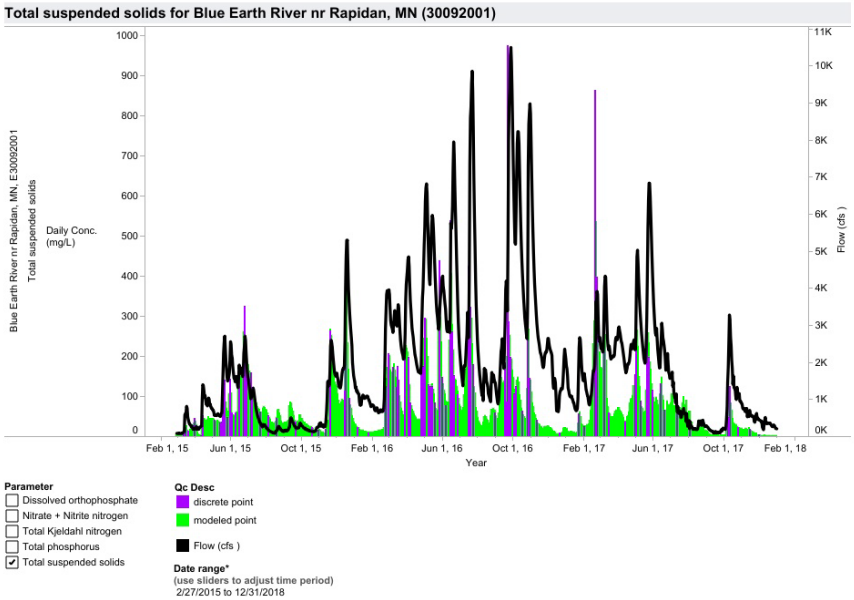


Figure 125. WPLMN station near Rapidan, showing measured TSS in relation to flow within the Blue Earth.



As shown in the hydrographs, TSS within the Blue Earth River has a close relationship to flow. In addition this watershed's geologic location, precipitation change, and land conversion have all led to intense erosion events and changed within the channel. The DNR's Watershed Characterization Report goes into detail explaining how these dynamics have directly impacted the stream. The most recent stream surveys have shown that accelerated stream bank erosion has led to a 30% increase in overall channel width over the last 30 years along the Blue Earth's mainstem (lore, 2020).

Fish metrics for TSS

Fish TSS stress was indicated throughout all biological sites within the Blue Earth River Subwatershed (Table 104). TSS tolerant species thrived. There were not any TSS sensitive species at any of the sites throughout the mainstem. Feeding types such as benthic feeders and herbivores were lacking in many areas, typically a result of poor substrate and turbid water quality. This is consistent with the historic findings of the turbidity impairments. TSS is playing a role in limiting the fish communities.

Table 104. TSS Fish metrics within the Blue Earth Subwatershed

Blue Earth	Station (Year sampled)	Benthic Feeders Pct	Sensitive Centrarchidae Pct	Herbivores Pct	Intolerant Pct	Long Lived Pct	Sensitive Perciformes Pct	Riffle Pct	Sensitive Pct	Lithophilic Spawners Pct	TSS TIV
	00MN003 (2017)	23.05	0.37	8.55	0.00	30.48	12.64	25.65	14.50	22.68	28.95
515	00MN004 (2017)	40.77	0.96	7.31	0.00	37.12	1.73	16.73	3.08	22.69	30.08
	10EM051 (2010)	18.84	0.28	5.82	0.00	19.39	1.66	9.42	6.65	15.51	28.49
	10EM051 (2015)	4.61	0.00	1.28	0.00	3.78	0.32	1.54	1.28	2.43	29.79
507	00MN005 (2017)	15.13	0.00	3.83	0.00	13.41	4.02	15.52	7.09	13.03	27.19
509	17MN315 (2017)	11.31	0.40	4.37	0.00	5.75	8.13	9.72	4.56	7.54	27.94
501	17MN317 (2017)	40.00	0.80	4.80	0.00	64.80	8.00	8.00	4.00	17.60	39.20
Passing Streams Average	Southern Streams General use	21.36	4.12	6.19	4.24	43.61	20.09	13.92	13.53	24.97	17.59
	Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓	↑

TSS within this subwatershed is primarily made up of sediment from stream bank erosion as well as headwater contributions from the other subwatersheds. TSS is found to be a stressor to the fish community from the impacts to both water quality and habitat, especially before reach the Rapidan Dam.

Table 105. Summary of TSS findings.

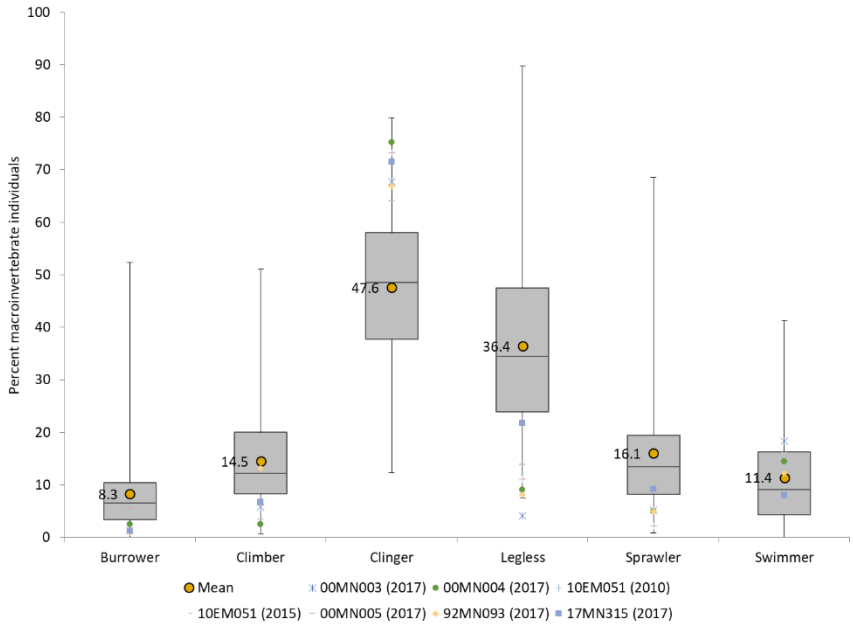
				TSS			
AUID	River Name	Biological Stations	Impairment	Suspended Algae	Flow Alterations	Stream Bank Erosion	Pasture
Blue Earth							
515	Blue Earth	00MN003 00MN004	F-IBI		●	●	
507	Blue Earth	10EM051 00MN005	F-IBI		●	●	
509	Blue Earth	17MN315	F-IBI		●	●	
501	Blue Earth	17MN317	F-IBI		●	●	

4.10.5 Habitat

Habitat diversity is different within this subwatershed as the stream magnitude is the greatest here. In addition there is several drastic gradient changes, as well as changed to flow. This section of the watershed has high erosion rates and sedimentation. Figure 127 highlights areas where extreme bluff erosion is occurring. This leads to areas where habitat can be smothered (sedimentation) and loss of overall habitat diversity. However, habitat assessment scores show that the stream bed still has a fair amount of diversity that it noted in riffle, runs, and pools In addition there are some areas with adequate untouched riparian. As shown in the above fish metrics for TSS (Table 104), metrics that highlight fish habitat needs show mixed results in regards to benthic dwellers, riffle dwelling, and spawning needs (lithophilic spawners). While the macroinvertebrates are not impaired, the distribution of habit groups is used to determine any irregularities. Figure 128 below, shows the macroinvertebrate community is not skewed from distressed habitat.

Figure 127. 2020 Google imagery of the Blue Earth mainstem, highlighting stream bank erosion and sediment transport.

Figure 128. Habitat invertebrate metrics within the Blue Earth Watershed, scored to the southern river general use standard.



Habitat is inconclusive throughout the Blue Earth mainstem. While there is evidence of stream instability and rapid changes, there is still some degree of diversity of habitat. The biological metrics specific to habitat displacement is slightly mixed throughout the mainstem. There are other biological stressors that also could be masking a response in the habitat metrics, such as fish barriers and TSS/Turbidity issues.

Table 106. Summary of habitat stressors within the Blue Earth River Subwatershed. Blue indicates inconclusive findings.

				Habitat				
WID	**Stream Name**	**Biological Stations**	**Impairment**	Channalized	Riparian	Streambed	Habitat diversity	Trampeling
Blue Earth								
515	Blue Earth	00MN003 00MN004	F-IBI			•		
507	Blue Earth	10EM051 00MN005	F-IBI			•		
509	Blue Earth	17MN315	F-IBI			•		
501	Blue Earth	17MN317	F-IBI			•		

5. Conclusions and recommendations

5.1. Summary of probable stressors

Below

Table 107 displays the summary table of stressors for the Blue Earth Watershed, listed by subwatershed. Red indicates stressor while blue cells represent inconclusive findings.

Table 107. Summary of probable stressors in the Blue Earth River Watershed.

				Dissolved Oxygen				Eutrophication			Nitrate				TSS				Habitat					Connectivity	
WID	Stream Name	Biological Stations	Impairment	Dissolved Oxygen	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland/Lake influcence	Excess Phosphorus	Unidentified	Land Use (application)	Upstream waterbody	Point Souce	Unidentified	Suspended Algae	Flow Alterations	Stream Bank Erosion	Pasture	Channalized	Riparian	Streambed	Habitat diversity	Trampeling	natural	Man Made
	East Branch																								
623	Judicial Ditch 14	17MN368	M-IBI	●					●		●					●	●		●	●	●	●			●
622	Thisius Brach	17MN365	F-IBI M-IBI	●					●		●					●	●		●	●	●	●			●
556	Foster Creek	92MN076	M-IBI	●					●		●					●	●		●	●	●	●			●
652	Blue Earth River, East Branch	17MN301	M-IBI*	●	●		●		●		●					●		●	●	●	●	●			●
654	Brush Creek	01MN022 17MN374	F-IBI																						
553	Blue Earth River, East Branch	15EM120 17MN359 17MN362 17MN314	F-IBI	●			●		●		●	●				●	●				●	●			●
603	County Ditch 25	17MN360	F-IBI M-IBI	●					●		●					●	●		●	●	●	●			●
669	County Ditch 8	17MN354	M-IBI	●					●		●				●	●	●		●	●	●	●			●
628	County Ditch 26	17MN357	M-IBI	●					●		●				●	●			●	●	●	●			●
	Coon Creek																								
665	Judicial Ditch 13	10EM156	M-IBI	●			●		●		●					●									●
612	County Ditch 31	17MN353	F-IBI M-IBI	●					●		●					●			●	●	●	●			●
648	Coon Creek	92MN074 17MN313	F-IBI M-IBI	●					●		●					●	●								●
	Middle Branch																								
646	Blue Earth River, Middle Branch	17MN310	F-IBI	●					●		●		●			●	●		●	●	●	●		●	●
	West Branch																								
611	Judicial Ditch 7	17MN344 17MN372	F-IBI M-IBI	●			●		●		●					●					●			●	●
643	West Branch	17MN312	F-IBI	●					●		●		●			●			●	●	●	●		●	●
644	West Branch	10EM028	F-IBI	●					●		●				●		●		●	●	●	●		●	●
	Badger Creek																								
568	Badger Creek	17MN345	M-IBI	●					●		●					●			●	●	●	●			●
642	Little Badger Creek	17MN347	F-IBI M-IBI	●					●		●					●			●	●	●	●	●		●
504	Blue Earth River	00MN001	F-IBI	●					●		●					●	●			●					●
518	Blue Earth River	10EM163 92MN088	F-IBI						●		●		●			●	●			●	●	●			●
565	Blue Earth River	17MN349	F-IBI		●		●		●		●		●			●	●			●					●
508	Blue Earth River	17MN316	F-IBI				●		●		●		●			●	●			●					●
516	Blue Earth River	17MN348	F-IBI				●		●		●					●	●			●	●	●			●
514	Blue Earth River	17MN308	F-IBI				●		●		●					●	●			●					●
	South Creek																								
660	Judicial Ditch 38	17MN334	F-IBI		●						●					●			●	●	●	●		●	●
610	Judicial Ditch 98	17MN332	M-IBI	●					●		●				●	●		●	●	●	●	●			●
639	South Creek	17MN338 15EM040	M-IBI	●		●		●	●		●	●			●	●				●	●				●
	Center Creek																								
636	Dutch Creek	17MN328	F-IBI	●					●		●		●			●	●	●	●	●	●	●	●		●
633	Lily Creek	17MN329	F-IBI M-IBI	●	●				●		●	●	●		●	●	●	●		●	●	●			●
503	Center Creek	92MN083 92MN084 17MN304	F-IBI M-IBI			●	●	●	●		●	●	●			●	●	●		●	●	●	●		●
	Elm Creek																								
631	Elm Creek	17MN320	F-IBI	●					●		●							●	●	●	●				●
22	South Fork	17MN323	F-IBI M-IBI	●					●		●					●	●	●	●	●	●				●
522	Elm Creek	17MN325 17MN306	F-IBI M-IBI						●		●	●				●	●	●		●	●				●
521	Cedar Run Creek	17MN307	F-IBI				●				●	●					●				●	●			●
502	Elm Creek	03MN063 13MN172 17MN327	M-IBI																						
627	Judicial Ditch 38	17MN336	F-IBI								●			●							●			●	●
	Willow Creek																								
620	County Ditch 89	17MN343	F-IBI	●					●		●					●			●	●	●	●		●	●
566	Unnamed Creek	17MN341	M-IBI	●					●		●					●	●		●	●	●	●		●	●
625	Unnamed Creek	17MN339	F-IBI M-IBI	●					●		●	●				●					●	●		●	●
577	Willow Creek	17MN309	F-IBI	●					●		●	●				●					●			●	●
	Blue Earth																								
515	Blue Earth	00MN003 00MN004	F-IBI	●					●		●		●			●	●				●			●	●
507	Blue Earth	10EM051 00MN005	F-IBI	●					●		●					●	●				●			●	●
509	Blue Earth	17MN315	F-IBI	●					●		●		●			●	●				●				
501	Blue Earth	17MN317	F-IBI	●					●		●		●			●	●				●				

● = probable stressor pathway

5.2. Recommendations

As discussed throughout this report, altered hydrology within this watershed is the driving force of biological impairments. Aside from educating and implementing best management practices (BMPs) on the landscape, focus needs to be spent on the headwaters of these impaired systems for downstream improvements to occur. One of the more cost effective and practical restoration practices can be seen in the elimination/reduction of ditch clean outs. One of the largest barriers in implementing this is the lack of education in stream morphology, storage, and energy dissipation.

Allowing a ditch that is shallow, wide, and homogenous to (whether naturally or via construction) develop a two stage sinuous channel that is deeper, narrower, and diverse is going to carry the same or similar volume of water; the dissipation of the streams energy will be mitigated by the banks curvature. (Rhoads et al 2010).

While this is not a “fix all”, it is a better compromise. The main goal is to maintain current field drainage rates while:

- Dissipate stream energy
- Reduce stream fragmentation
- Increase habitat availability
- Increases denitrification rates
- Reduce eutrophic growth

Other BMPs found the Department of Agriculture’s BMP Handbook are also encouraged to improve overall stream health.

Reference the Blue Earth River WRAPS report for additional information, as well as specific targeting.

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7. Appendix

Table A 1. Stream classifications with corresponding threshold per stream type. Fish classifications on top with macroinvertebrate classifications on the bottom.

Class #	Class Name	Use Class	Exceptional Use Threshold	General Use Threshold	Modified Use Threshold	Confidence Limit
Fish						
1	Southern Rivers	2B, 2C	71	49	NA	±11
2	Southern Streams	2B, 2C	66	50	35	±9
3	Southern Headwaters	2B, 2C	74	55	33	±7
10	Southern Coldwater	2A	82	50	NA	±9
4	Northern Rivers	2B, 2C	67	38	NA	±9
5	Northern Streams	2B, 2C	61	47	35	±9
6	Northern Headwaters	2B, 2C	68	42	23	±16
7	Low Gradient	2B, 2C	70	42	15	±10
11	Northern Coldwater	2A	60	35	NA	±10
Invertebrates						
1	Northern Forest Rivers	2B, 2C	77	49	NA	±10.8
2	Prairie Forest Rivers	2B, 2C	63	31	NA	±10.8
3	Northern Forest Streams RR	2B, 2C	82	53	NA	±12.6
4	Northern Forest Streams GP	2B, 2C	76	51	37	±13.6
5	Southern Streams RR	2B, 2C	62	37	24	±12.6
6	Southern Forest Streams GP	2B, 2C	66	43	30	±13.6
7	Prairie Streams GP	2B, 2C	69	41	22	±13.6
8	Northern Coldwater	2A	52	32	NA	±12.4
9	Southern Coldwater	2A	72	43	NA	±13.8

Table A 2. Biological metrics included in the SID process.

Metric name	Type	Metric description	Use in report
MA>3Pct	Fish	Relative abundance of individuals with a female mature age >=3 (Frimpong)	DO
Sensitive	Fish	Taxa richness of sensitive species	DO, FIBI
SSpnPct	Fish	Relative abundance (%) of individuals that are serial spawning species	DO, FIBI
DetNWQTXPct	Fish	Relative abundance (%) of taxa that are detritivorous (NAWQA database)	FIBI
GeneralPct	Fish	Relative abundance (%) of individuals that are generalist species	FIBI
Insect-TolPct	Fish	Relative abundance (%) of individuals that are insectivore species (excludes tolerant species)	FIBI
Piscivore	Fish	Taxa richness of piscivore species	FIBI
SLvdPct	Fish	Relative abundance (%) of individuals that are short-lived	FIBI
SSpnTXPct	Fish	Relative abundance (%) of taxa that are serial spawners	FIBI
VtolTXPct	Fish	Relative abundance (%) of taxa that are very tolerant species	FIBI
SensitiveTXPct	Fish	Relative abundance (%) of taxa that are sensitive	FIBI
SLithop	Fish	Taxa richness of simple lithophilic spawning species	FIBI
FishDELTPct	Fish	Relative abundance (%) of individuals with DELT anomalies (deformities, eroded fins, lesions, or tumors)	FIBI
BenInsect-TolTXPct	Fish	Relative abundance (%) of taxa that are non-tolerant benthic insectivores	FIBI
MA<2Pct	Fish	relative abundance (%) of individuals with a female mature age <=2 (Frimpong)	FIBI
SLvd	Fish	Taxa richness of short-lived species	FIBI
TolTXPct	Fish	Relative abundance (%) of taxa that are tolerant species	FIBI
GeneralTXPct	Fish	Relative abundance (%) of taxa that are generalists	FIBI
CWSensitivePct_10DrgArea	Fish	Relative abundance (%) of individuals that are considered Sensitive in coldwater streams, adjusted for Drainage Area using the residuals	FIBI
CWTol_10DrgArea	Fish	Number of taxa that are considered Tolerant in coldwater streams, adjusted for Drainage Area	FIBI
NativeColdTXPct_10DrgArea	Fish	Relative abundance (%) of taxa that are native and prefer coldwater, adjusted for Drainage Area	FIBI

Metric name	Type	Metric description	Use in report
NativeColdPct	Fish	Relative abundance (%) of individuals that are native coldwater species	FIBI
HerbvPct	Fish	Relative abundance (%) of individuals that are herbivore species	FIBI
SdetTXPct_10DrgArea	Fish	Relative abundance (%) of taxa that are detritivorous, adjusted for Drainage Area using the residuals	FIBI
DomTwoPct	Fish	Relative abundance (%) of individuals of the dominant two species	FIBI, Habitat
TolPct	Fish	Relative abundance (%) of individuals that are tolerant species	FIBI, Eutrophic, DO, Habitat
BenInsectPct	Fish	Relative abundance (%) of individuals that are benthic insectivore species	Habitat
LithFrimPct	Fish	Relative abundance (%) of individuals that are lithophilic spawners	Habitat
DarterSculpSucPct	Fish	Relative abundance (%) of individuals that are darter, sculpin, and round bodied sucker species	Habitat
BenInsect-TolPct	Fish	Relative abundance (%) of individuals that are non-tolerant benthic insectivore species	Habitat
PiscivorePct	Fish	Relative abundance (%) of individuals that are piscivore species	Habitat
PioneerPct	Fish	Relative abundance (%) of individuals that are pioneer species	Habitat, FIBI
DarterPct	Fish	Relative abundance (%) of individuals that are darter species	Eutrophic
TaxaCount	Fish	Total taxa richness of fish species (hybrids and exotics often excluded)	Eutrophic, DO
SLithopPct	Fish	Relative abundance (%) of individuals that are simple lithophilic spawners	Eutrophic, Habitat
SensitivePct	Fish	Relative abundance (%) of individuals that are sensitive species	Eutrophic, TSS
ColdPct	Fish	Relative abundance (%) of individuals that are coldwater species	Temperature
ColdCoolPct	Fish	Relative abundance (%) of individuals that are coldwater and coolwater species	Temperature
BenFdFrimPct	Fish	Relative abundance (%) of individuals that are exclusively benthic feeders (Frimpong)	TSS
Centr-TolPct	Fish	Relative abundance (%) of individuals that are non-tolerant Centrarchidae	TSS

Metric name	Type	Metric description	Use in report
HrbNWQPct	Fish	Relative abundance (%) of individuals that are herbivore species (NAWQA database)	TSS
IntolerantPct	Fish	Relative abundance (%) of individuals that are tolerant species	TSS
LLvdPct	Fish	Relative abundance (%) of individuals that are long-lived (Frimpong)	TSS
Percfm-TolPct	Fish	Relative abundance (%) of individuals of the Order Perciformes (excluding tolerant)	TSS
SLithFrimPct	Fish	Relative abundance (%) of individuals that are simple lithophilic spawners, as per Frimpong database	TSS
TSS Index Score (RA)	Fish	TSS index score	TSS
RifflePct	Fish	Relative abundance (%) of individuals that are riffle-dwelling species	TSS, Habitat
Low DO Index Score	Macroinvertebrates	Low DO index score	DO
Low DO Intolerant Taxa	Macroinvertebrates	Number of taxa with tolerance values in the lower 25th percentile of stressor tolerance scores	DO
Low DO Very Intolerant Taxa	Macroinvertebrates	Number of taxa with tolerance values in the lower 15th percentile of stressor tolerance scores	DO
Low DO Tolerant Taxa	Macroinvertebrates	Number of taxa with tolerance values in the upper 25th percentile of stressor tolerance scores	DO
Low DO Very Tolerant Taxa	Macroinvertebrates	Number of taxa with tolerance values in the upper 15th percentile of stressor tolerance scores	DO
Low DO Tolerant Pct	Macroinvertebrates	Relative Abundance of taxa with tolerance values in the upper 25th percentile of stressor tolerance scores	DO
Low DO Very Tolerant Pct	Macroinvertebrates	Relative Abundance of taxa with tolerance values in the upper 15th percentile of stressor tolerance scores	DO
HBI_MN	Macroinvertebrates	A measure of pollution based on tolerance values assigned to each individual taxon developed by Chirhart	DO, Nitrate, MIBI
Burrower	Macroinvertebrates	Taxa richness of burrowers (excluding chironomid burrower taxa)	Habitat
Climber	Macroinvertebrates	Taxa richness of climbers (excluding chironomid climber taxa)	Habitat
Clinger	Macroinvertebrates	Taxa richness of clingers (excluding chironomid clinger taxa)	Habitat
Legless	Macroinvertebrates	Taxa richness of legless macroinvertebrates (chironomid taxa treated as one taxon)	Habitat

Metric name	Type	Metric description	Use in report
Sprawler	Macroinvertebrates	Taxa richness of sprawlers (excluding chironomid and baetid sprawler taxa)	Habitat
Swimmer	Macroinvertebrates	Taxa richness of swimmers (excluding chironomid, baetid taxa treated as one taxon)	Habitat
ClimberCh	Macroinvertebrates	Taxa richness of climbers	MIBI
ClingerChTxPct	Macroinvertebrates	Relative percentage of taxa adapted to cling to substrate in swift flowing water	MIBI
DomFiveCHPct	Macroinvertebrates	Relative abundance (%) of dominant five taxa in subsample (chironomid genera treated individually)	MIBI
InsectTxPct	Macroinvertebrates	Relative percentage of insect taxa	MIBI
Odonata	Macroinvertebrates	Taxa richness of Odonata	MIBI
Plecoptera	Macroinvertebrates	Taxa richness of Plecoptera	MIBI
PredatorCh	Macroinvertebrates	Taxa richness of predators	MIBI
Trichoptera	Macroinvertebrates	Taxa richness of Trichoptera	MIBI
ClingerCh	Macroinvertebrates	Taxa richness of clingers	MIBI
POET	Macroinvertebrates	Taxa richness of Plecoptera, Odonata, Ephemeroptera, & Trichoptera (baetid taxa treated as one taxon)	MIBI
ChiroDip	Macroinvertebrates	Ratio of chironomid abundance to total dipteran abundance	MIBI
VeryTolerant2Pct	Macroinvertebrates	Relative abundance (%) of macroinvertebrate individuals in subsample with tolerance values equal to or greater than 8, Using MN TVs	MIBI
TrichopteraCh	Macroinvertebrates	Taxa richness of Trichoptera	Nitrate
Nitrate Index Score	Macroinvertebrates	Nitrate index score	Nitrate
Nitrate Intolerant Taxa	Macroinvertebrates	Number of taxa with tolerance values in the lower 25th percentile of stressor tolerance scores	Nitrate
Nitrate Very Intolerant Taxa	Macroinvertebrates	Number of taxa with tolerance values in the lower 15th percentile of stressor tolerance scores	Nitrate
Nitrate Tolerant Taxa	Macroinvertebrates	Number of taxa with tolerance values in the upper 25th percentile of stressor tolerance scores	Nitrate
Nitrate Very Tolerant Taxa	Macroinvertebrates	Number of taxa with tolerance values in the upper 15th percentile of stressor tolerance scores	Nitrate
Nitrate Tolerant Pct	Macroinvertebrates	Relative Abundance of taxa with tolerance values in the upper 25th percentile of stressor tolerance scores	Nitrate
Nitrate Very Tolerant Pct	Macroinvertebrates	Relative Abundance of taxa with tolerance values in the upper 15th percentile of stressor tolerance scores	Nitrate

Metric name	Type	Metric description	Use in report
TrichwoHydroPct	Macroinvertebrates	Relative abundance (%) of non-hydropsychid Trichoptera individuals in subsample	Nitrate, MIBI
TrichopteraChTxPct	Macroinvertebrates	Relative percentage of taxa belonging to Trichoptera	Nitrate, MIBI
Intolerant2Ch	Macroinvertebrates	Taxa richness of macroinvertebrates with tolerance values less than or equal to 2, using MN TVs	Nitrate, Eutrophic, MIBI
EPT	Macroinvertebrates	Taxa richness of Ephemeroptera, Plecoptera & Trichoptera (baetid taxa treated as one taxon)	Eutrophic, DO
TaxaCountAllChir	Macroinvertebrates	Total taxa richness of macroinvertebrates	Eutrophic, DO, MIBI
Tolerant2ChTxPct	Macroinvertebrates	Relative percentage of taxa with tolerance values equal to or greater than 6, using MN TVs	Eutrophic, DO, MIBI
CBI	Macroinvertebrates	Coldwater Biotic Index score based on coldwater tolerance values derived from Minnesota taxa/temperature data	Temperature
Collector-filtererCh	Macroinvertebrates	Taxa richness of collector-filterers	TSS
Collector-gathererCh	Macroinvertebrates	Taxa richness of collector-gatherers	TSS
TSS Intolerant Taxa	Macroinvertebrates	Number of taxa with tolerance values in the lower 25th percentile of stressor tolerance scores	TSS
TSS Very Intolerant Taxa	Macroinvertebrates	Number of taxa with tolerance values in the lower 15th percentile of stressor tolerance scores	TSS
TSS Tolerant Taxa	Macroinvertebrates	Number of taxa with tolerance values in the upper 25th percentile of stressor tolerance scores	TSS
TSS Very Tolerant Taxa	Macroinvertebrates	Number of taxa with tolerance values in the upper 15th percentile of stressor tolerance scores	TSS
TSS Tolerant Pct	Macroinvertebrates	Relative Abundance of taxa with tolerance values in the upper 25th percentile of stressor tolerance scores	TSS
TSS Very Tolerant Pct	Macroinvertebrates	Relative Abundance of taxa with tolerance values in the upper 15th percentile of stressor tolerance scores	TSS
IntolerantPct	Macroinvertebrates	Relative abundance (%) of macroinvertebrate individuals in subsample with tolerance values less than or equal to 2	TSS
LongLivedPct	Macroinvertebrates	Relative abundance (%) of longlived individuals in subsample	TSS
Collector-filtererPct	Macroinvertebrates	Relative abundance (%) of collector-filterer individuals in subsample	TSS, MIBI