Stressor Identification

January 2019

Minnesota River Mankato Watershed Stressor Identification Report

A study of local stressors limiting the biotic communities in the Minnesota River – Mankato Watershed.

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Key Terms & Abbreviations

AUID Assessment Unit ID
BEHI Bank Erosion Hazard Index
BHR Bank Height Ratio
BMP Best Management Practice
BOD biological oxygen demand
CADDIS Causal Analysis/Diagnosis Decision Information System
CBI coldwater biotic index
CCSI channel condition stability index
CL confidence limits
cm centimeter
DELT Deformities, Eroded fins, Lesions, and Tumors
DO Dissolved Oxygen
DNR Minnesota Department of Natural Resources
EDA Environmental Data Access
EPA Environmental Protection Agency
EPT Ephemeroptera, Plecoptera, and Trichoptera
FIBI Fish Index of Biological Integrity
FWC Flow weighted 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
NBS near bank stress
NTU Nephelometric Turbidity Units
RR Riffle Run
SID Stressor Identification
SOE Strength of Evidence
SSURGO Soil Survey Geographic Database
TIV Tolerance Indicator Value
TMDL Total Maximum Daily Load
TP Total Phosphorus
TSS Total Suspended Solids
VSS Volatile Suspended Solids
USDA United States Department of Agriculture
USGS United States Geological Survey
W/D width to depth ratio
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 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. Stressor identification 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 stressor identification work in the Minnesota River – Mankato Watershed.

In 2013, 86 different stream reaches within this watershed were assessed to their Assessment Unit Identification Determinations (AUID's). Out of those 86 assessed AUIDs, 54 were found to be impaired for biology with only 14 found to be supporting. Impaired reaches will be individually evaluated under Chapter 4 of this report.

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

- Temperature
- Dissolved Oxygen (DO)
- Eutrophication
- Nitrate
- TSS (Total Suspended Solids)
- Habitat
- Connectivity
- Altered Hydrology

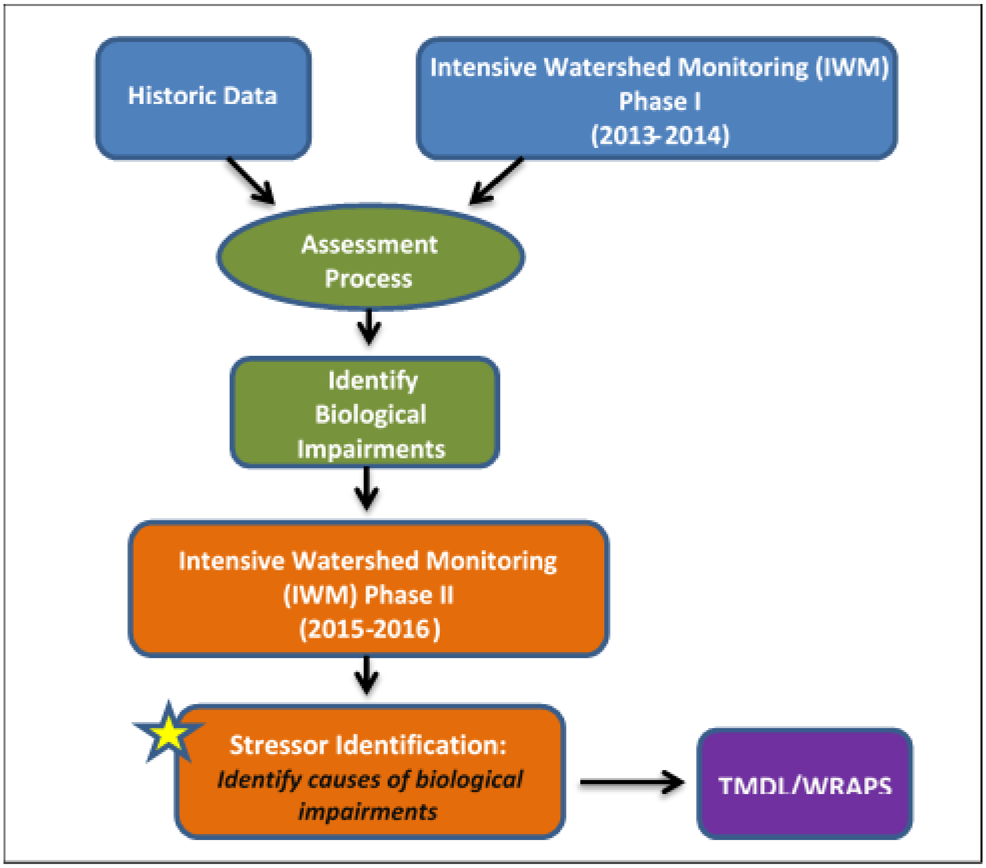
A summary of recommendations for the entire Minnesota River, Mankato Watershed, are found at the end of this document in Chapter 5.

1. Introduction

1.1 Monitoring and Assessment

Water quality and biological monitoring in the Minnesota River - Mankato 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 2013-2014, 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 2013, were used to identify stream (Figure 1.) Once a biological impairment is discovered, the next step is to identify the source(s) of stress on the biological community. A Stressor Identification (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 highlight excess fine sediment as the cause of biological impairment, but typically, a separate effort is then required to determine the TMDL and implementation goals needed to restore the impaired condition.

Figure 1. Process map of Intensive Watershed Monitoring, Assessment, Stressor Identification and TMDL processes.

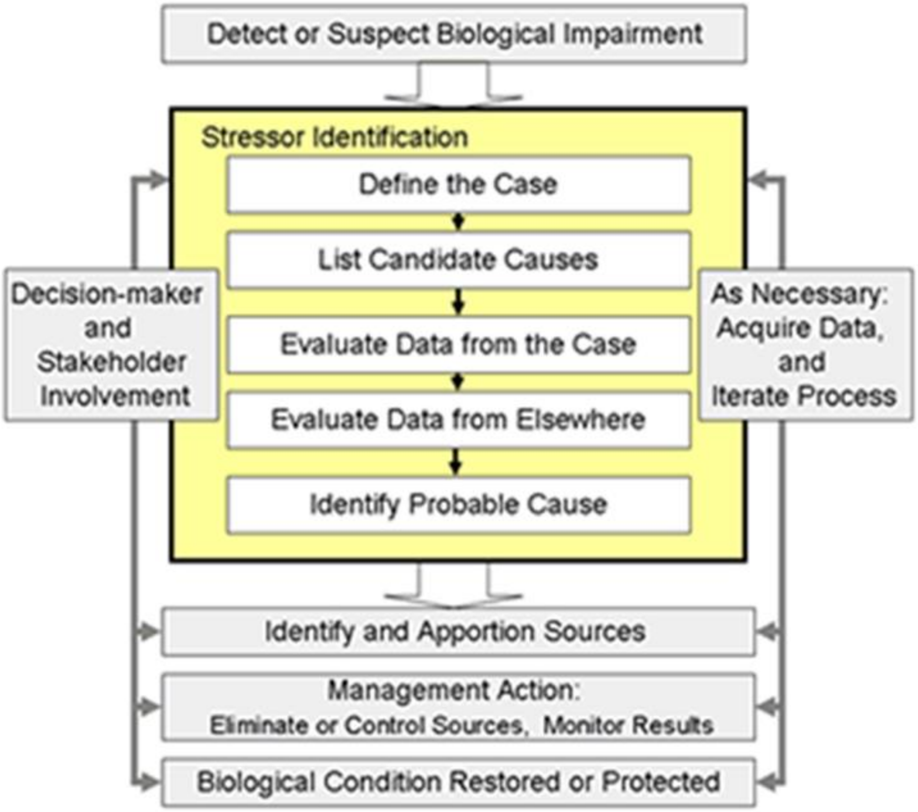


1.2 Stressor Identification Process

The MPCA follows the EPA's process of identifying stressors that cause biological impairment, which has been used to develop the MPCA's guidance to stressor identification (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 Stressor Identification. Additional information on the Stressor Identification process using CADDIS can be found here: http://www.epa.gov/caddis/

Stressor Identification 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 Stressor Identification 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).

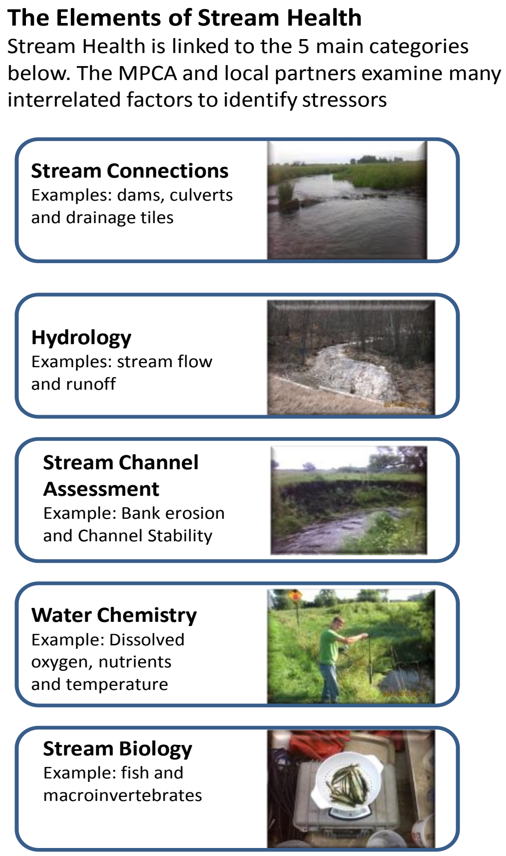
Developed by the EPA, a standard scoring system is used to tabulate the results of the SOE analysis for the available evidence. The SOE table allows for organization of all of the evidence, provides a checklist to ensure each type has been carefully evaluated and offers transparency to the determination process.

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 Elements of Stream Health

The elements of a healthy stream consist of five main components (Figure 3): stream connections, hydrology, stream channel assessment, water chemistry, and stream biology. The following flowchart shows the five components of a healthy stream. If one or more of the components are unbalanced, the stream ecosystem fails to function properly and is listed as an impaired waterbody. These dynamics are important to understand when going through SID evaluation.

Figure 3. The five components of stream health and conditions that stress streams



1.4 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 waterbody. Table 1 lists examples as well as some of the direct and indirect impacts that will impair a biological community.

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

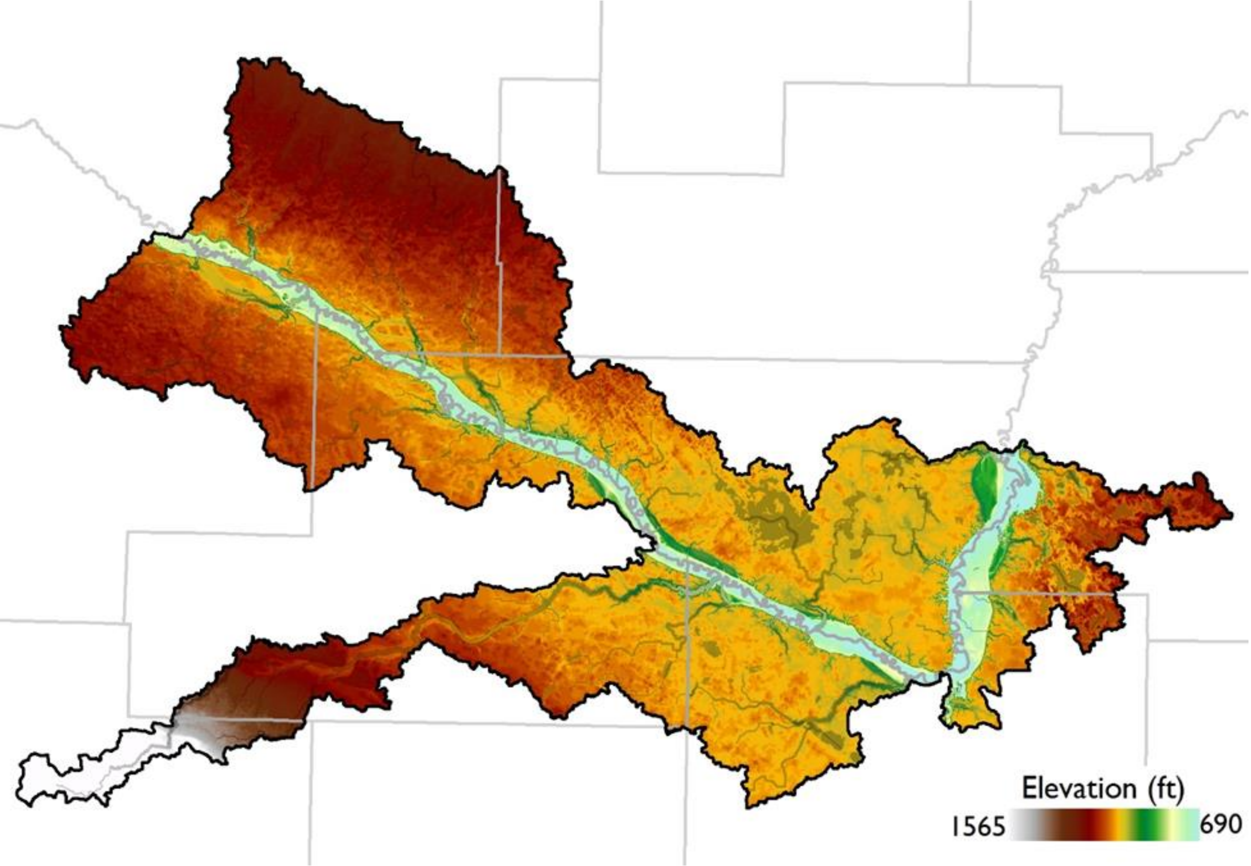
Stream health	Stressor(s)	Link to biology
Stream connections	**Loss of connectivity** • Dams and culverts • Lack of wooded riparian cover • Lack of naturally connected habitats/ causing fragmented habitats	Fish and macroinvertebrates cannot freely move throughout system or complete their lifecycle. Loss 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.

2. Overview of Minnesota River – Mankato Watershed

2.1 Background

The Minnesota River – Mankato (07020007 8-HUC) major watershed in South Central Minnesota follows the Minnesota River from approximately Redwood Falls at the Western boundary of the watershed, Southeast to Mankato, and turns Northeast around St Peter. The watershed is bisected by its main feature, the Minnesota River and its substantial valley, which was created by the Glacial River Warren. The watershed contains 1,564 stream miles (NRCS 2009). Within the Minnesota River basin, the watershed is the second to the last major watershed (HUC 8) before the Minnesota River's confluence with the Mississippi River (Figure 4). Due to this geography of the landscape, this watershed goes through dramatic changes in elevation, as the tributaries to the Minnesota River down cut through the Minnesota River Valley to converge with the Minnesota River (shown in Figure 4).

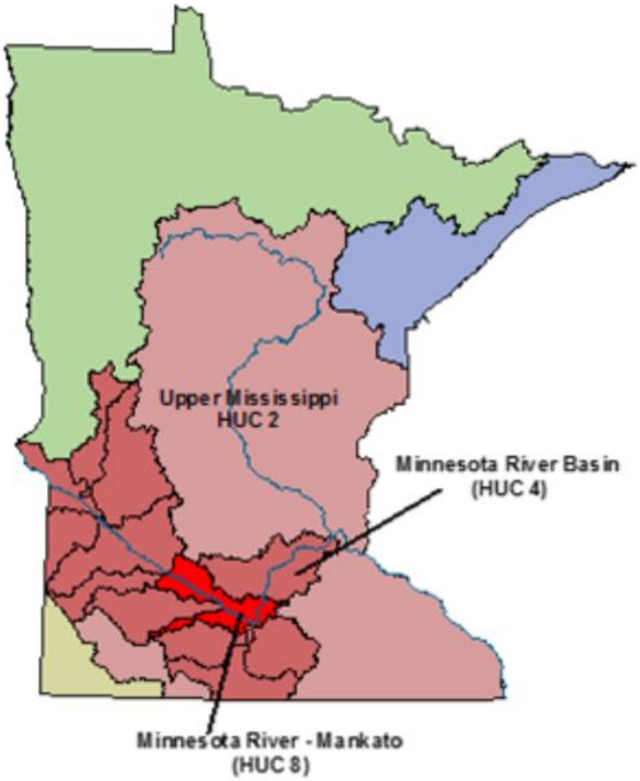
Figure 4. Elevation of the Minnesota River – Mankato Watershed.



The watershed encompasses an area of 1347 square miles, or 861,882 acres (DNR 2015). The watershed includes portions of nine Minnesota Counties, in order from the largest percentage of the watershed to the smallest: Nicollet (24.2%), Brown (21.6%), Renville (18.4%), Blue Earth (13.2%), Redwood (10.5%), Le Sueur (6.5%), Cottonwood (2.8%), Sibley (2.7%), and a very small portion of Watonwan (0.0%) (NRCS 2009). The largest cities in the watershed include Mankato, New Ulm, St. Peter, and Lake Crystal. Notable towns on the north side of the river include Morton, Franklin, Fairfax, Courtland, and Nicollet.

Other notable towns on the south side of the river include part of Redwood Falls, Morgan, Comfrey, Hanska, Judson, Kasota, and Cleveland.

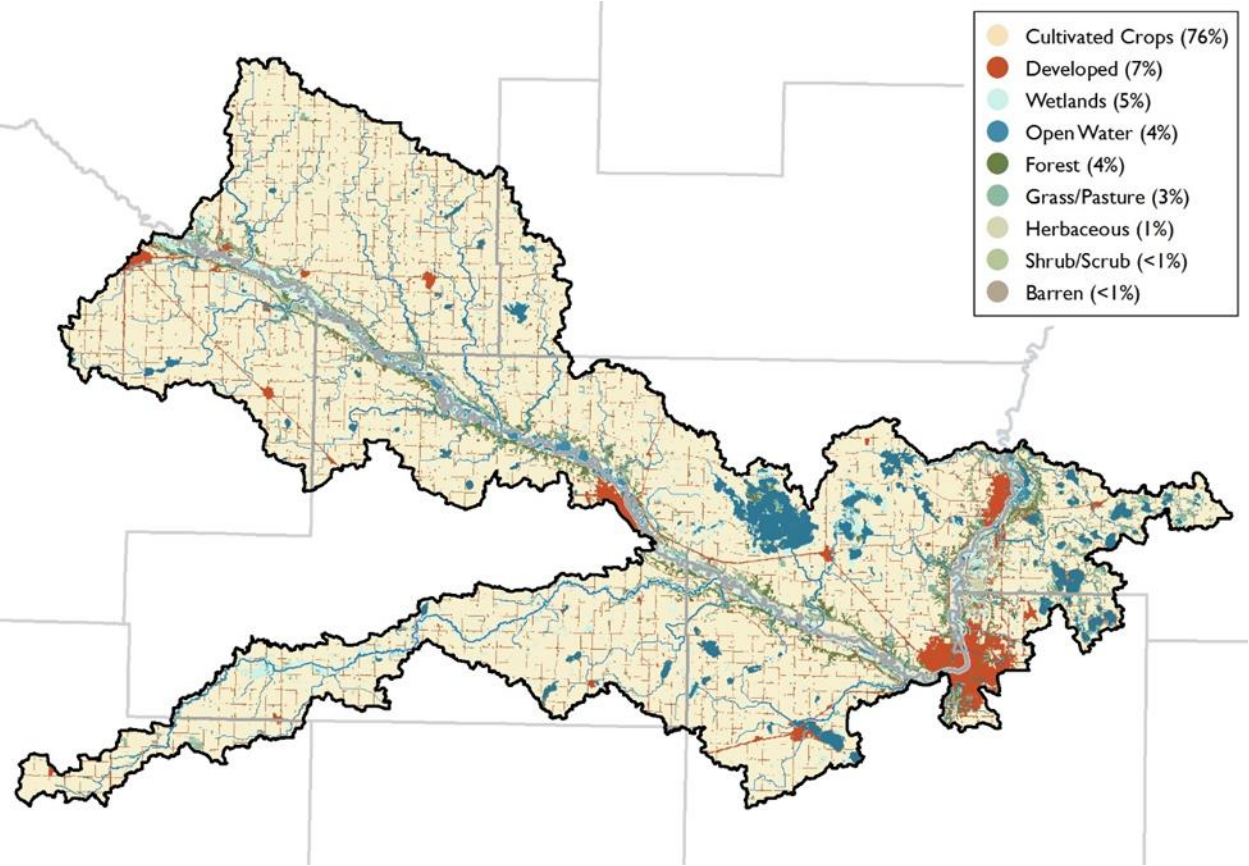
Figure 5. Location of the Minnesota River – Mankato Watershed (highlighted in red) within the Minnesota River Basin and the upper Mississippi River HUC 2.



The majority of the Minnesota River-Mankato Watershed lies in the Western Corn Belt Plains Level III Ecoregion (Figure 5) from the Environmental Protection Agency (EPA) (Omernik and Gallant 1988). The Western Corn Belt Plains consists of gently rolling glaciated till plains and hilly loess plains that were once tallgrass prairie, with some small areas of bur oak and oak-hickory woodlands (Wiken et. al. 2011). During the last glaciation, the area was once covered by the Des Moines Lobe so the area consists of thick loess and glacial till deposits overlying Mesozoic and Paleozoic shale, sandstone, and limestone bedrock (Wiken et. al. 2011). For soils, Mollisols and Alfisols are dominant with mesic soil temperatures and udic soil moisture (Wiken et. al. 2011).

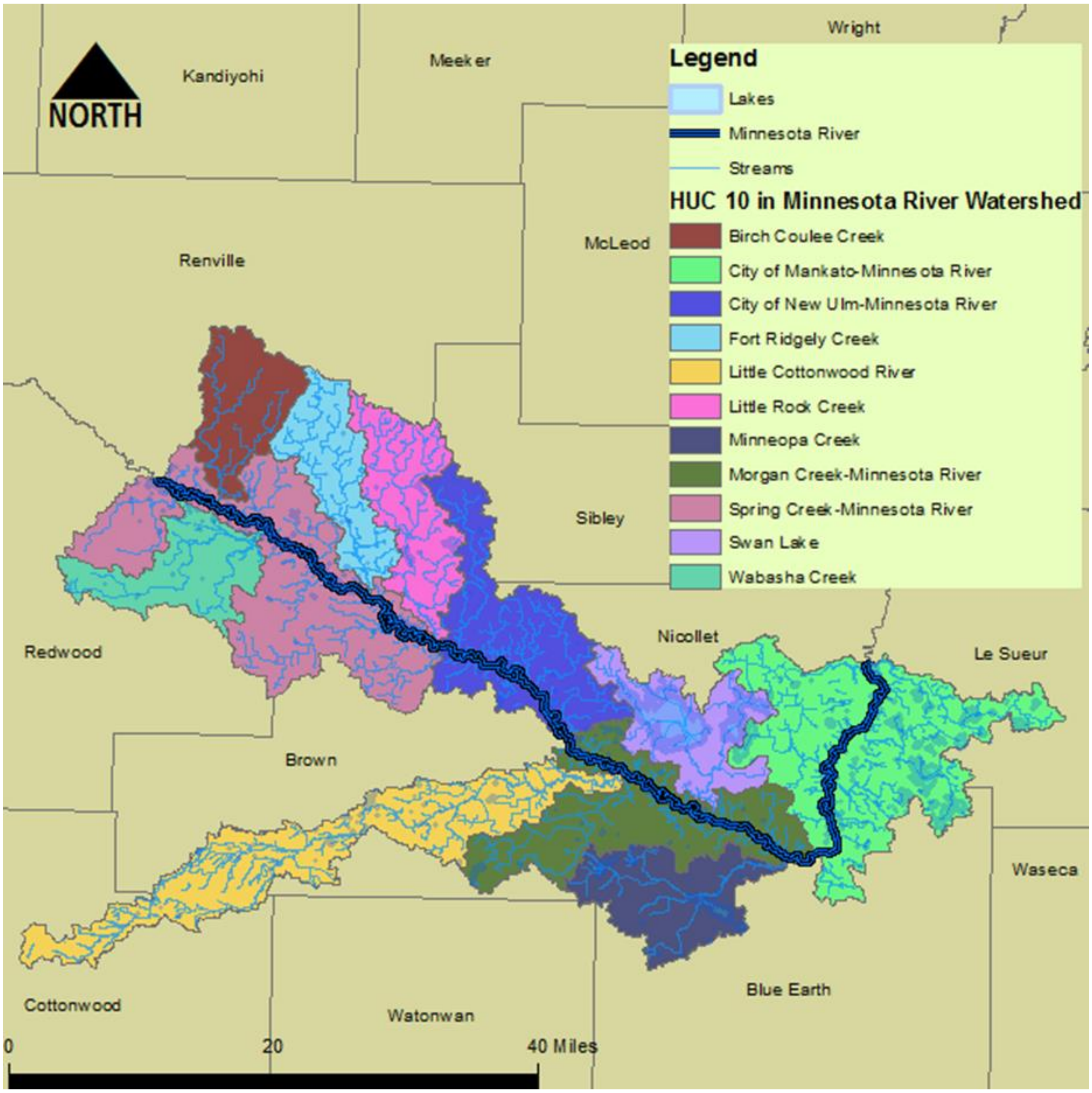
A smaller portion of the watershed from approximately St Peter and to the east lies in the North Central Hardwood Forest Level III Ecoregion (Figure 5) (Omernik and Gallant 1988). This ecoregion is primarily a transition between the forested ecoregions in the north and the predominately agricultural ecoregions to the south (Wiken et. al. 2011). Terrain consists of nearly level to rolling till plains, lacustrine basins, outwash plains, and rolling to hilly moraines dominated by oak savanna, oak-hickory forests, and maple-basswood forests (Wiken et. al. 2011). Within this portion of the watershed (south of St Peter) begins an active karst section. This area is found as it fallows the Minnesota River north, were the karst features dissipate near the Blue Earth area (Adams et al, 2016). After European settlement, the ecoregion is now a mosaic of forestland, cropland, and pasture (Wiken et. al. 2011). At 76%, this watershed is agricultural dominant within the upland portion of the watershed (Figure 6).

Figure 6. Land use of the Minnesota River –Mankato Watershed.



The Minnesota River – Mankato can be further broken down into 10 subwatersheds as shown in Figure 7. Due to the county boundaries, subwatershed conclusions throughout this report have been divided by north and south sections, with the Minnesota River acting as the division line.

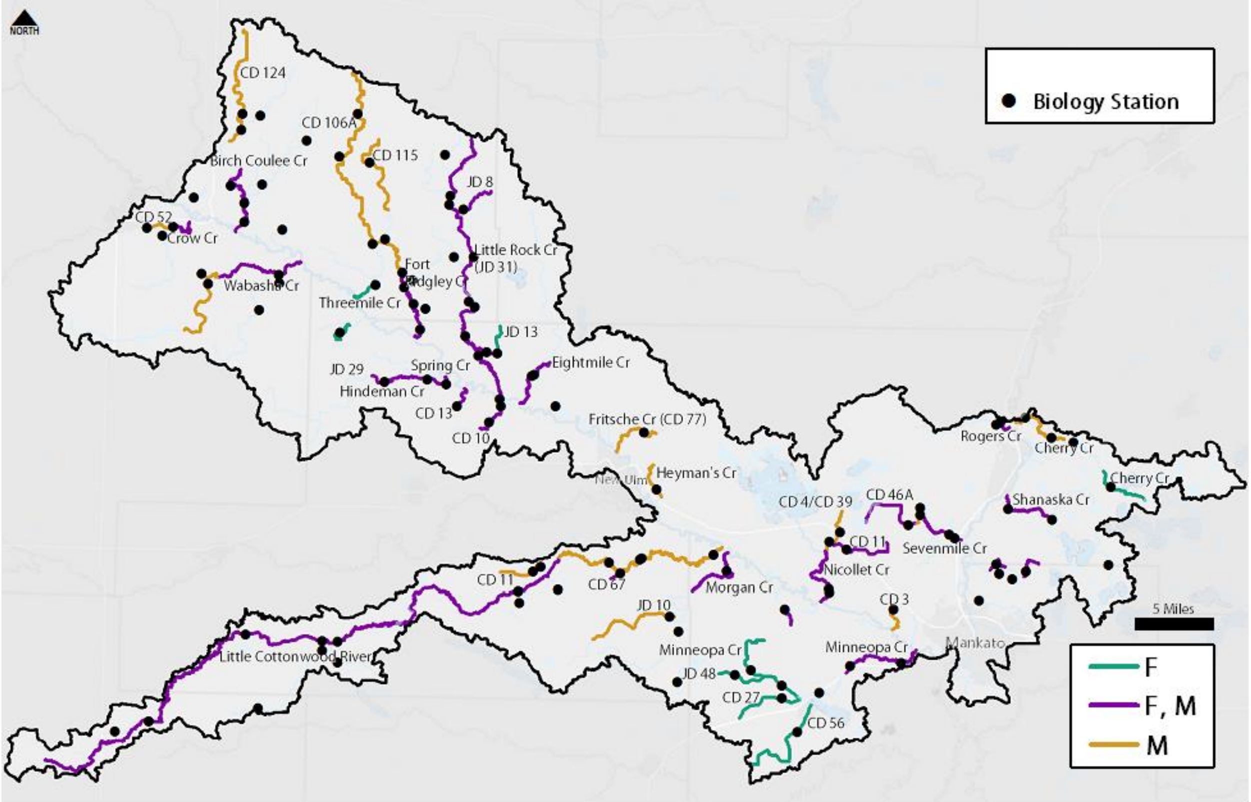
Figure 7. Minnesota River – Mankato Watershed including subwatershed at the HUC 10 scale.



2.2 Monitoring Overview

The biological monitoring stations that led to aquatic life listings that are included in this report are mapped below in Figure 8. Additional information can be found in subsequent sections of this report, in addition to the comprehensive assessment report for the Minnesota River- Mankato Watershed. Other details and reports related to this watershed can be found here.

Figure 8. Map of monitoring stations in the MNR Mankato Watershed, biological impairments and stations.



Data management

It is MPCA policy to use all credible and relevant monitoring data to assess surface waters. The MPCA relies on data it collects along with data from other sources, such as sister agencies, local governments and volunteers. The data must meet rigorous quality assurance protocols before being used. All monitoring data required or paid for by MPCA are entered into EQuIS (Environmental Quality Information System), MPCA's data system and are also uploaded to the US Environmental Protection Agency's data warehouse. Data for monitoring projects with federal or state funding are required to be stored in EQuIS (e.g., Clean Water Partnership, CWLA Surface Water Assessment Grants and TMDL program). Many local projects not funded by MPCA also choose to submit their data to the MPCA in an EQuIS-ready format so that the monitoring data may be utilized in the assessment process. Prior to each assessment cycle, the MPCA sends out a request for monitoring data to local entities and partner organizations. Data can be publicly accessed through MPCA's Environmental Data Application.

Period of record

The MPCA uses data collected over the most recent 10-year period for all water quality assessments. This time frame provides a reasonable assurance that data will have been collected over a range of weather and flow conditions and that all seasons will be adequately represented; however, data for the entire period is not required to make an assessment. The goal is to use data that best represents current water quality conditions. Therefore, recent data for pollutant categories such as toxics, lake eutrophication and fish contaminants may be given more weight during assessment.

2.3 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 index of biological integrity (IBI). The IBI scores can then be compared to a range of thresholds.

The fish and macroinvertebrates within each Assessment Unit Identification (AUID) 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. In the Minnesota River – Mankato Watershed, 54 AUIDs are currently impaired for a lack of biological assemblage (Table 2).

Table 2. All biological impaired AUIDs in the Minnesota River – Mankato Watershed, separated by the north and south side of the Minnesota River.

AUID	**MNR-Mankato North Section Stream Name**	**Biological Stations**	**Impairment**
	SPRING CREEK		
704	Threemile Creek	13MN014	F-IBI
	BIRCH COULEE CREEK		
670	County Ditch 124	13MN004	M-IBI
711	County Ditch 124	07MN080	M-IBI
588	Birch Coulee Creek	90MN053	F-IBI, M-IBI
587	Birch Coulee Creek	14MN210, 13MN008	F-IBI, M-IBI
	FORT RIDGLEY		
673	County Ditch 115	13MN018	M-IBI
688	County Ditch 106A	13MN017, 91MN054	M-IBI
689	Fort Ridgley Creek	13MN021, 05MN014, 05MN013, 05MN015	F-IBI, M-IBI
	LITTLE ROCK CREEK		
666	Judicial Ditch 8	13MN028	F-IBI, M-IBI
686	Little Rock Creek (Judicial Ditch 31)	13MN027, 13MN029	F-IBI, M-IBI
687	Little Rock Creek (Judicial Ditch 31)	13MN032, 03MN019, 03MN020	F-IBI, M-IBI
716	Judicial Ditch 13	13MN031	F-IBI
717	Judicial Ditch 13	10EM083	F-IBI, M-IBI

	CITY OF NEW ULM				
684	Eightmile Creek	13MN087, 13MN033	13MN087, 13MN033	13MN087, 13MN033	F-IBI, M-IBI
709	Fritsche Creek (CD 77)	05MN012	05MN012	05MN012	M-IBI
675	Heyman's Creek	13MN040	13MN040	13MN040	M-IBI
	SWAN LAKE				
545	County Ditch 4/County Ditch 39	13MN056, 13MN057	13MN056, 13MN057	13MN056, 13MN057	M-IBI
661	County Ditch 11	13MN058			M-IBI
683	Swan Lake Outlet (Nicollet Creek)	13MN086, 03MN069	13MN086, 03MN069	13MN086, 03MN069	M-IBI
	MORGAN CREEK				
660	County Ditch 3	13MN067			M-IBI
	CITY OF MANKATO				
678	County Ditch 46A	91MN059	91MN059	91MN059	F-IBI, M-IBI
679	County Ditch 46A	13MN069	13MN069	13MN069	M-IBI
562	Seven Mile Creek	09MN090	09MN090	09MN090	F-IBI, M-IBI
703	Seven Mile Creek	13MN068	13MN068	13MN068	M-IBI
547	Rogers Creek	91MN061, 13MN094			F-IBI, M-IBI

AUID	**MNR-Mankato South Section Stream Name**	**Biological Stations**			**Impairment**
	City of Mankato				
541	Cherry Creek	13MN088			F-IBI
543	Cherry Creek	13MN083, 13MN081			M-IBI
693	Shanaska Creek	13MN079			F-IBI, M-IBI
696	Unnamed Creek	01MN020			F-IBI, M-IBI
550	Unnamed Creek	03MN072			F-IBI, M-IBI
	Minneopa Creek				
593	Judicial Ditch 48	13MN059			F-IBI
531	Minneopa Creek	13MN061, 13MN060			F-IBI
535	County Ditch 27	13MN062			F-IBI
557	Lake Crystal Inlet(County Ditch 56)	13MN063			F-IBI
534	Minneopa Creek	13MN066, 13MN065			F-IBI, M-IBI
	Morgan Creek				
577	Unnamed Creek	09MN094			F-IBI, M-IBI
701	Judicial Ditch 10	13MN053			M-IBI
691	Morgan Creek	13MN055			F-IBI, M-IBI
	Little Cottonwood				
657	County Ditch 11	13MN049			M-IBI

658	County Ditch 67	13MN051			F-IBI, M-IBI
676	Little Cottonwood River	13MN048, 13MN044, 13MN041, 91MN056			M-IBI
677	Little Cottonwood River	13MN052, 90MN058, 97MN009, 13MN050			M-IBI
	Spring Creek				
571	County Ditch 10 (John's Creek)	09MN080, 05MN011			F-IBI, M-IBI
712	County Ditch 13	13MN025			F-IBI, M-IBI
622	Spring Creek (Judicial Ditch 29)	13MN024			F-IBI, M-IBI
574	Spring Creek (Hindeman Creek)	91MN055			F-IBI, M-IBI
573	Spring Creek	13MN090			F-IBI, M-IBI
715	Unnamed Creek	13MN013			F-IBI
636	County Ditch 52	07MN074			M-IBI
569	Crow Creek	13MN002			F-IBI, M-IBI
	Wabasha Creek				
527	Wabasha Creek	13MN012			F-IBI, M-IBI
699	Wabasha Creek	13MN010			M-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 Minnesota River-Mankato Watershed

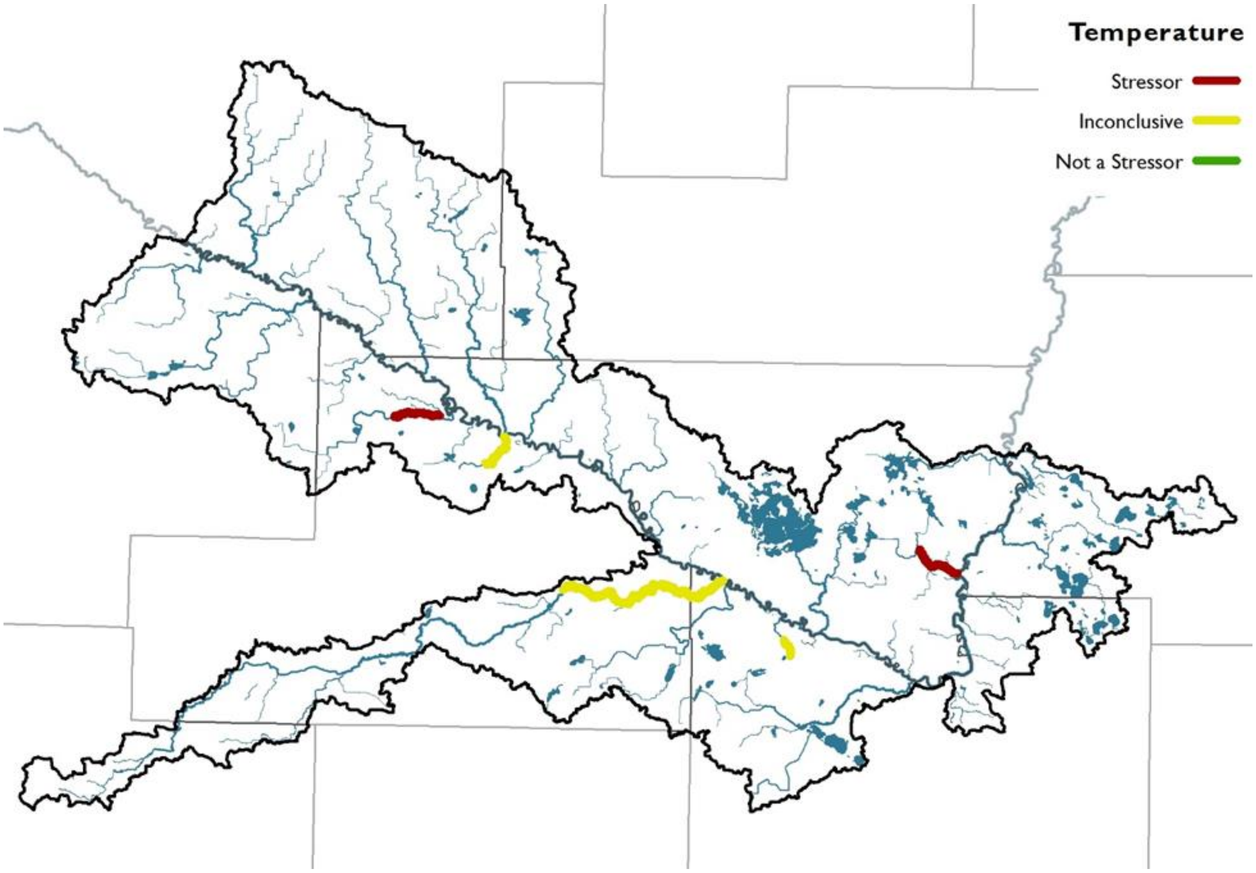
Eight candidate causes were selected as possible drivers of biological impairments in the Minnesota River - Mankato watershed:

- Dissolved Oxygen (DO)
- Temperature
- Eutrophication
- Nitrate
- TSS (Total Suspended Solids)
- Habitat
- Connectivity
- Altered Hydrology

3.1.1 Candidate Cause Temperature

Water temperature regime alteration

Figure 9. Overview of temperature in the Minnesota River - Mankato Watershed.



Temperature was evaluated primarily for the coldwater streams. Temperature impairments within this watershed typically tie back to upstream modifications that eliminate shade as well. Riparian land cover alteration and increasing channel width are both occurring in the Minnesota River – Mankato watershed, contributing to higher water temperatures. Increased temperatures can influence predator-prey dynamics, but this is hard to quantify. The causes and potential sources for excess temperature are modeled at [EPA's CADDIS Temperature webpage.]

Thresholds viewed between warmwater and coldwater streams:

Warmwater: The standard for Class 2B (warmwater) waters of the state is not to exceed five degrees Fahrenheit (°F) above natural (Minn. Stat. 7050.0222 subp. 4), based on monthly average of maximum daily temperature. In no case shall it exceed the daily average temperature of 86 degrees Fahrenheit (30 degrees Celsius).

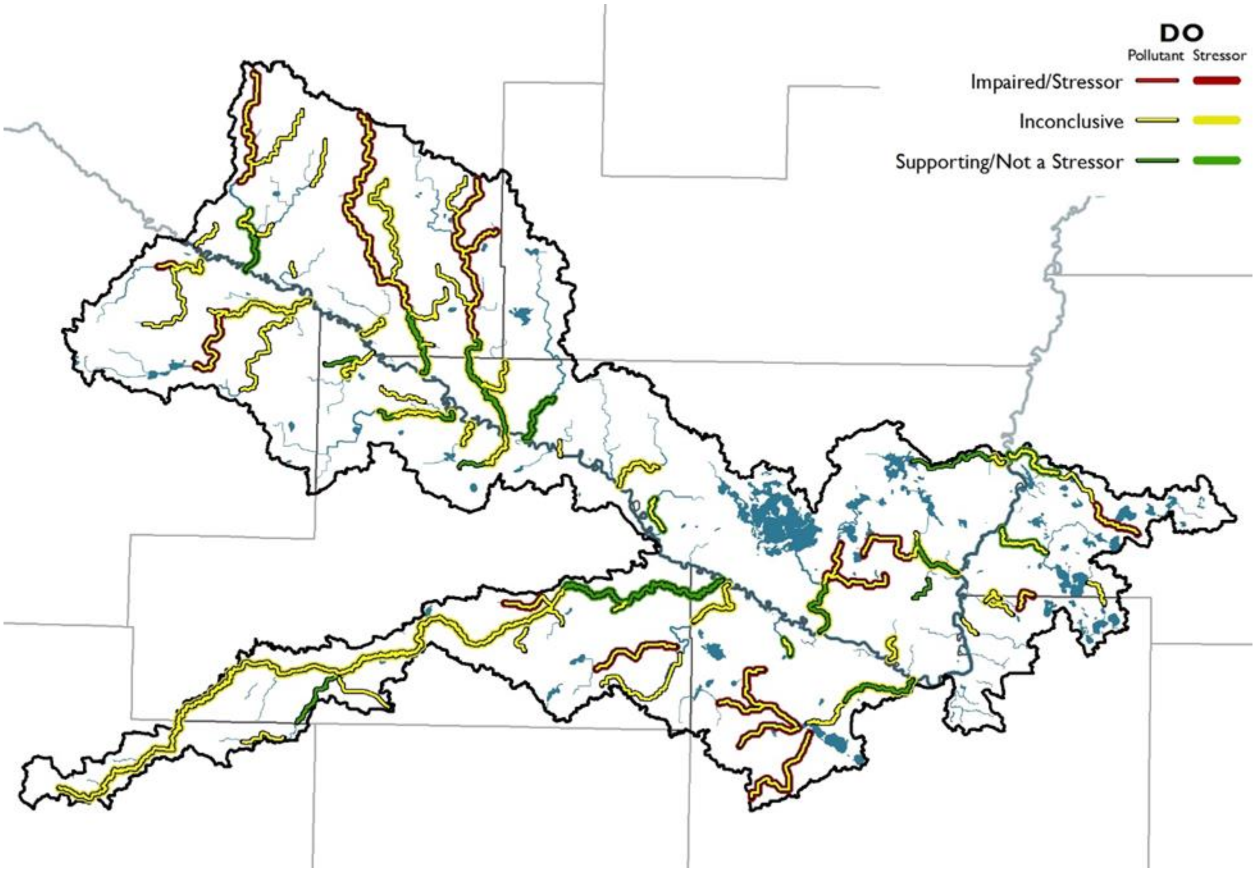
Coldwater: The state standard for temperature in Class 2A streams is "no material increase" (7050.0222 Specific Water Quality Standards for Class 2 Waters of the State; Aquatic Life and Recreation).

The highest temperature found in the biological impaired reaches was 29.4 degrees Celsius. With the available data, temperature is not a stressor to the biological community at this time.

3.1.2 Candidate cause: Low Dissolved Oxygen

Overview of dissolved oxygen in the Minnesota River-Mankato Watershed

Figure 10. Minnesota River – Mankato AUID's with low dissolved oxygen listed as a biological stressor.



In the Minnesota River Watershed, reaches with low dissolved oxygen often correlated with eutrophic conditions within the headwater regions of the watershed. Dissolved oxygen 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. There are several springs along the Minnesota River Valley that mitigate against upstream oxygen depletion. The gradient of these stream systems also greatly increase as they converge with the Minnesota River mainstem, allowing for natural aeration of the stream as turbulence increases.

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.

Longitudinal (Synoptic)

A series of longitudinal synoptic DO surveys were conducted in some subwatershed systems within the Minnesota River - Mankato watershed. A synoptic monitoring approach aims to gather data across a large spatial scale and minimal temporal scale. In terms of DO, the objective was to sample a large number of sites from upstream to downstream under comparable ambient conditions.

Diurnal (Continuous)

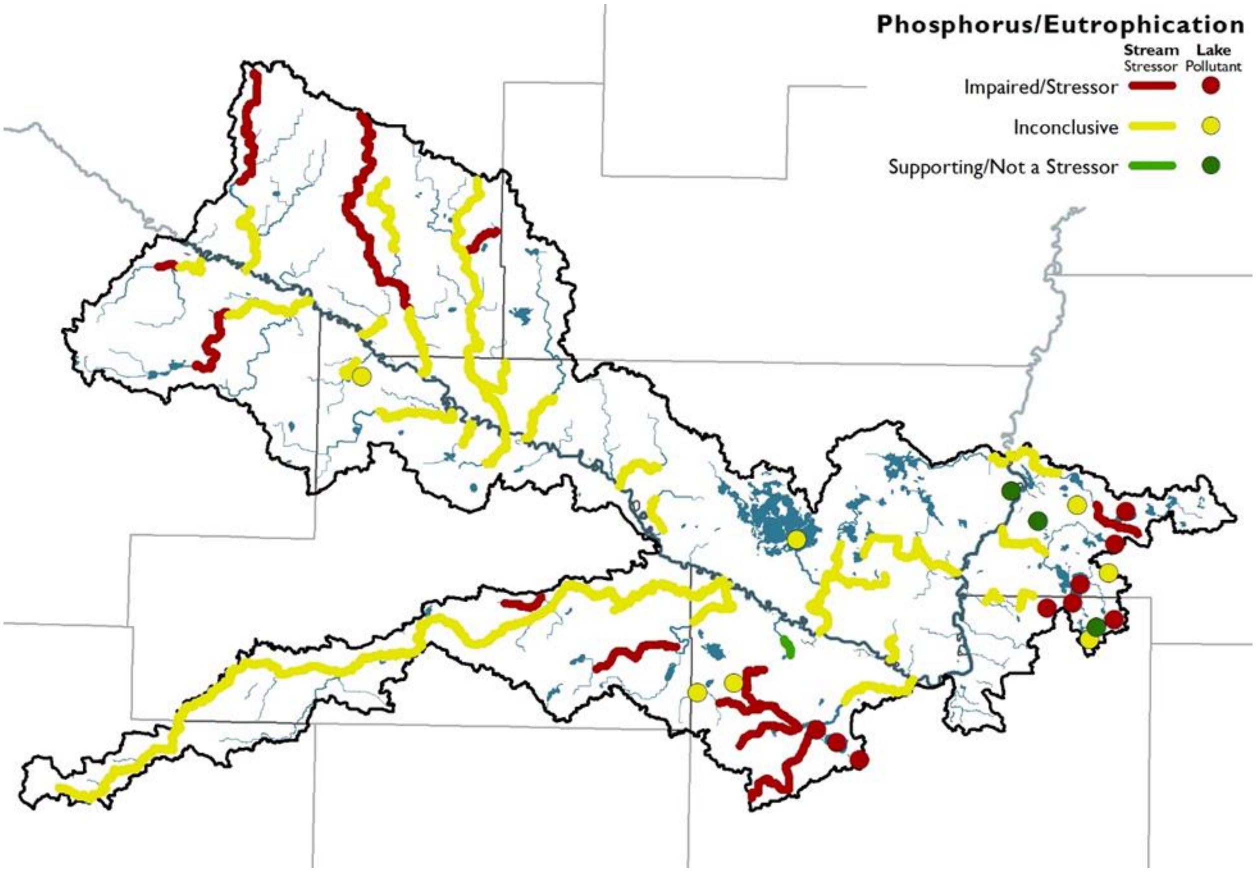
Where warranted, Yellow Springs Instruments (YSI) sondes were deployed for numerous days throughout the watershed in late summer to capture diurnal fluctuations over the course of a number of diurnal patterns and measure the amount of 24 hour dissolved oxygen fluctuation (diurnal flux).

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

3.1.3 Candidate Cause: Eutrophication

Overview of eutrophication in the Minnesota River-Mankato Watershed

Figure 11. Minnesota River – Mankato AUID's with eutrophic conditions listed as a biological stressor.



Within the Minnesota River – Mankato Watershed, eutrophic conditions were identified in the headwater areas of stream systems, as shown in Figure 11. 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 Minnesota River – Mankato Watershed.

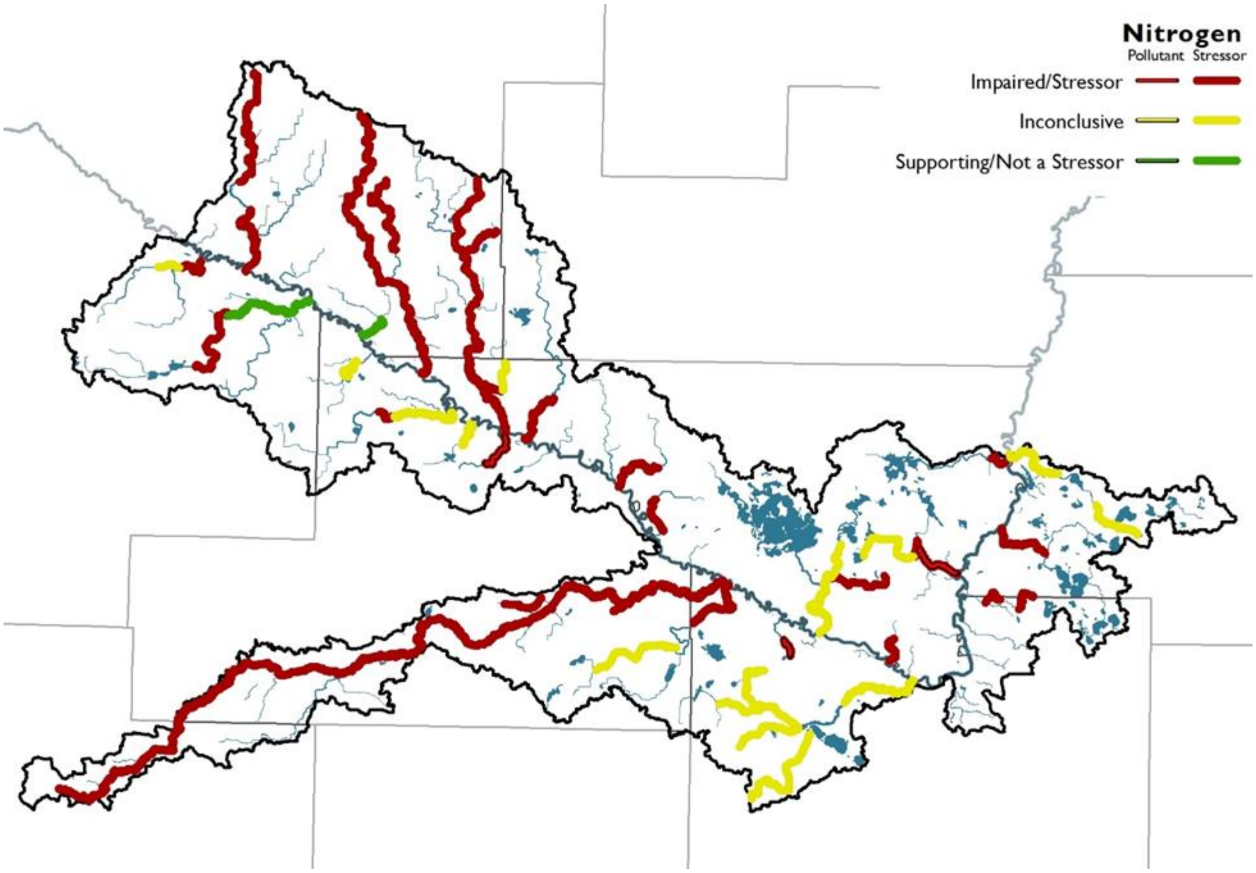
Parameter	Southern Nutrient Region	
Chlorophyll a	35 µg/L	
Dissolved oxygen flux	≤4.5 mg/L	
Biochemical oxygen demand	≤3.0 mg/L	
Periphyton density	150 mg chlorophyll a / sq. meter	

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

3.1.4 Candidate Cause: Nitrate

Overview of nitrate in the Minnesota River-Mankato Watershed

Figure 12. Reaches were nitrate is identified as a biological stressor (In red) within the Minnesota River – Mankato Watershed.

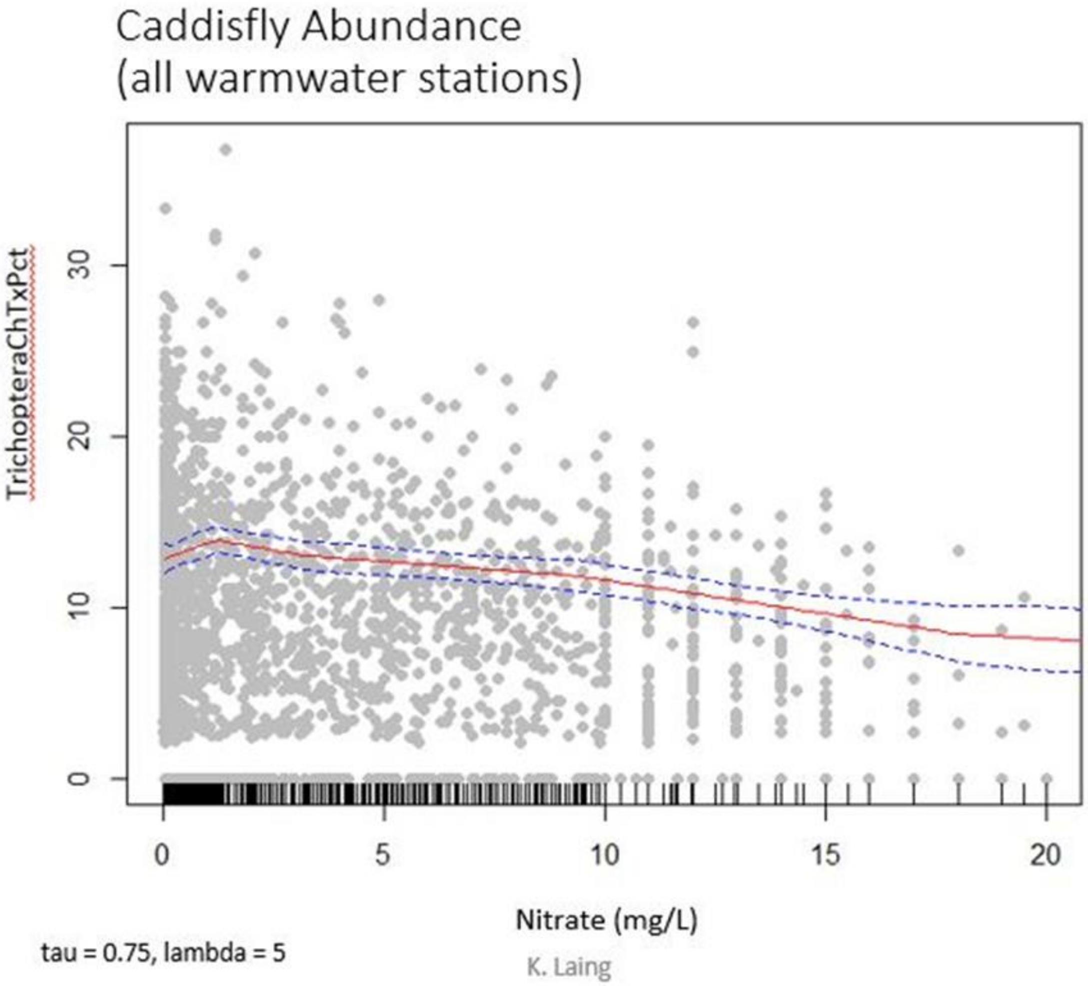


Nitrate was one of the more common stressors within the Minnesota River – Mankato watershed (Figure 12). In addition, of measuring for a biological community response related to nitrate, chemistry concentrations are also evaluated to determine this parameter as a stressor. Currently there is not a final nitrate limit in regards to aquatic life. However, there is a strong correlation seen in drop in nitrate sensitive macroinvertebrate populations as nitrate concentrations increase, particularly after 10 mg/L (Figure 13). 10 mg/L is also the standard for drinking water. 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 used as the impairment concentration threshold.

Within the Minnesota River- Mankato Watershed nitrogen, samples were typically high in spring and early summer months, with concentrations well above 10 mg/L; 47% of the total samples collected were above 10 mg/L as shown in Figure 16.

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

Figure 13. Correlation of nitrate sensitive caddisfly abundance, with nitrate concentrations from the time of sampling.



Nitrogen is commonly applied as a crop fertilizer. Seventy-six percent of the Minnesota River – Mankato 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 14. Statewide nitrogen pathways to surface waters pie chart, taken from statewide nitrogen study (MPC 2013).

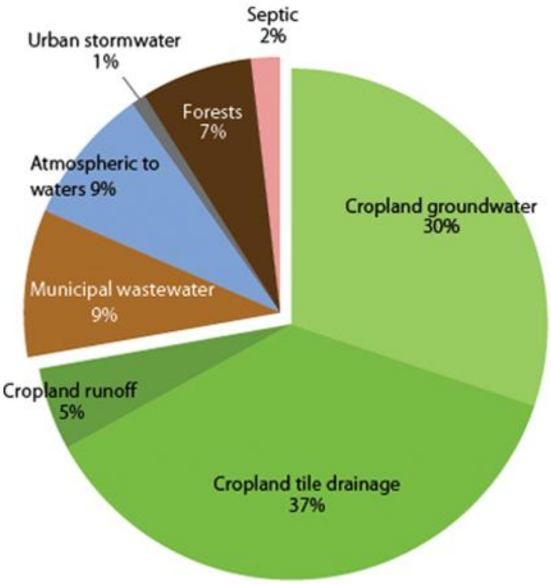
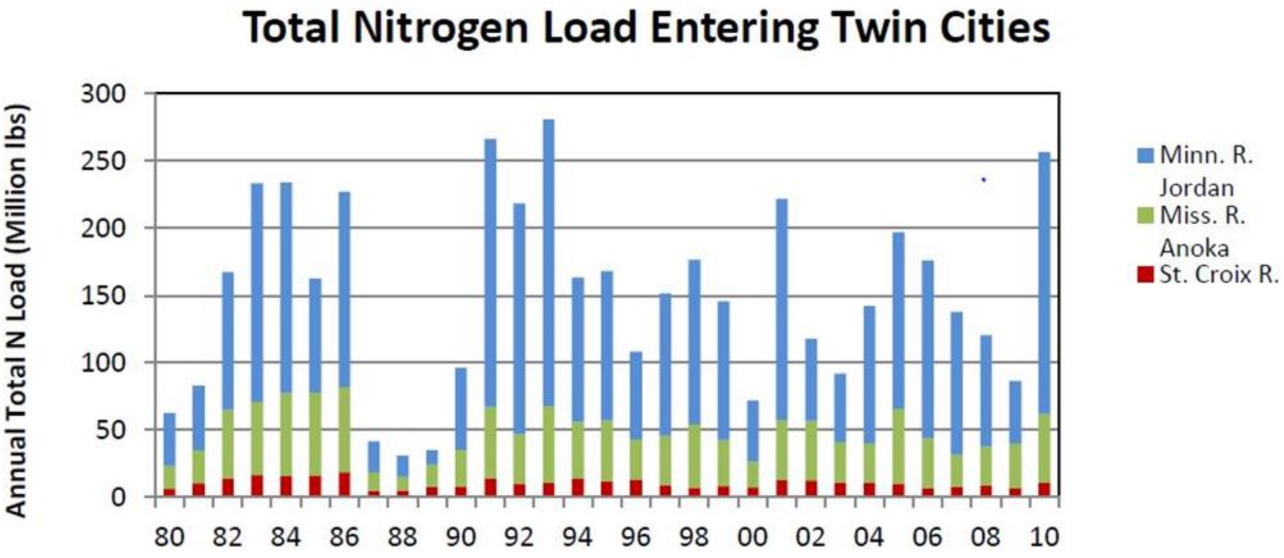


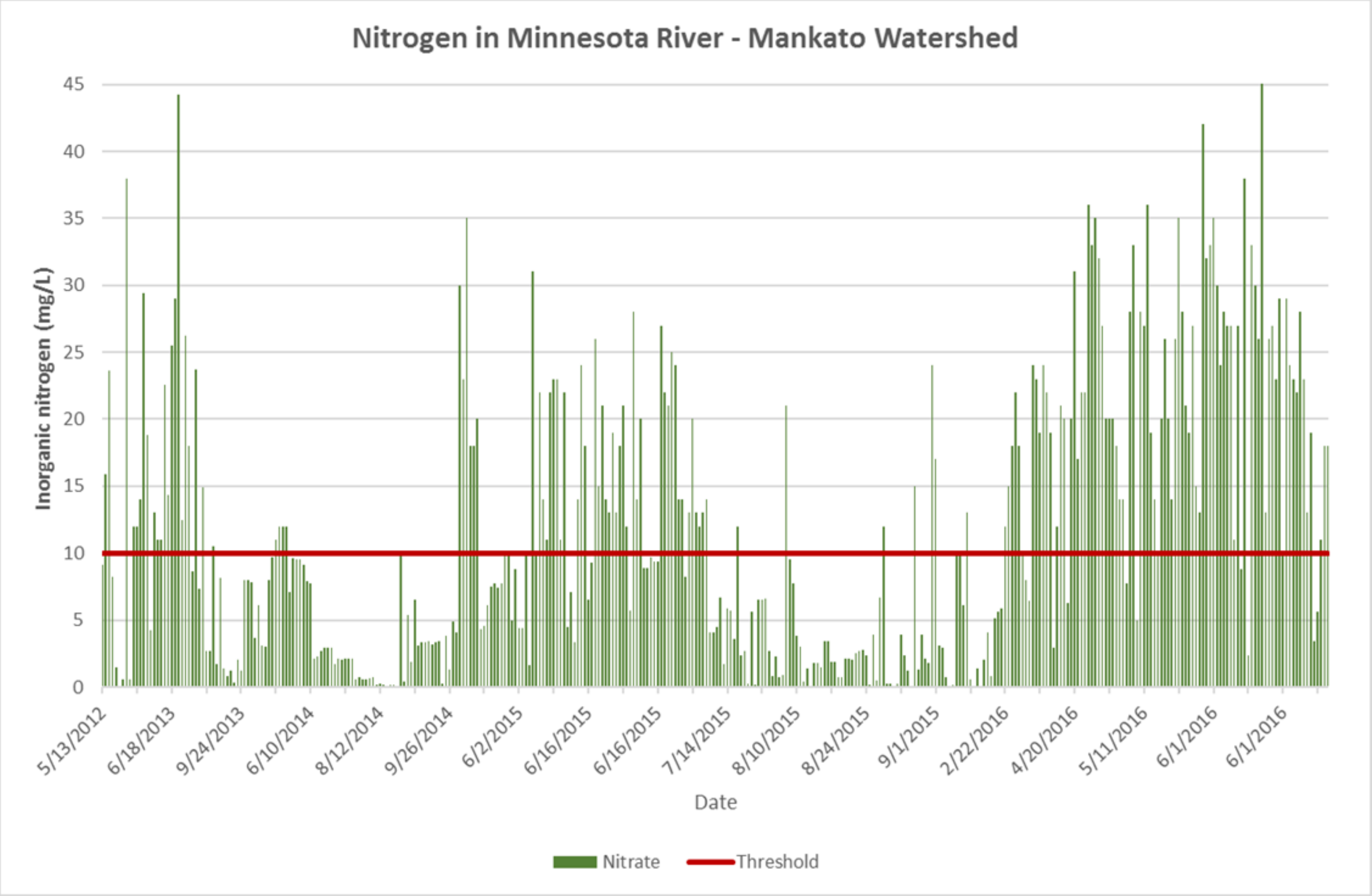
Figure 14 is reference to a statewide nitrogen study that found cropland commercial fertilizers make up 47% of nitrogen added to the landscape, 21% occurs through cropland legume fixation, 16% from manure application, and 15% from atmospheric deposition (MPCA, 2013). Nitrogen can reach waterways through surface runoff, tile drainage, and leaching to groundwater, with tile drainage being the largest pathway (MPCA, 2013).

Figure 15. 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 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 15 (MPCA, 2013). As reflected in Figure 16, sampled collected within the Minnesota River-Mankato watershed were often above the 10 mg/L threshold.

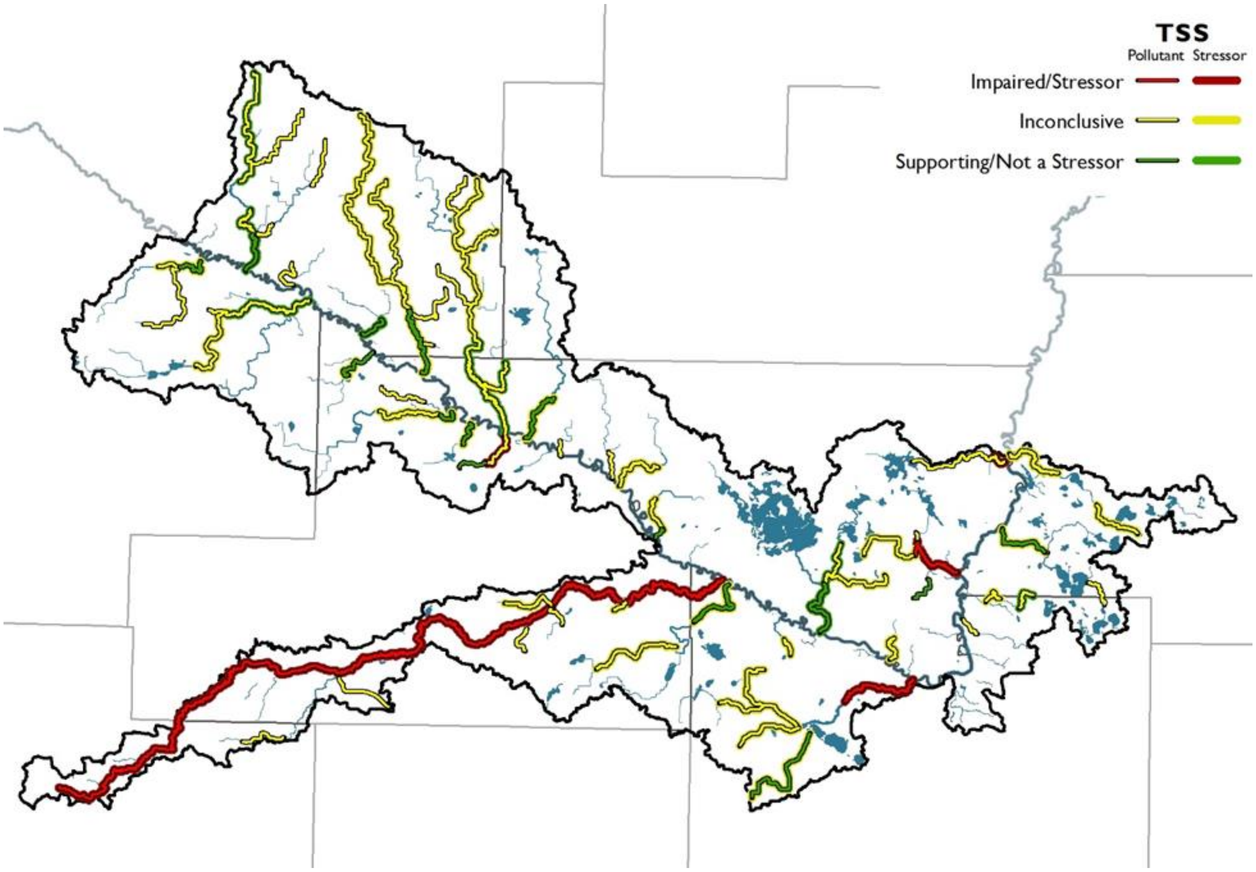
Figure 16. Inorganic nitrogen samples collected at biologically impaired reaches within the Minnesota River – Mankato Watershed.



3.1.5 Candidate cause: Total suspended solids

Overview of TSS in the Minnesota River-Mankato Watershed

Figure 17. Minnesota River – Mankato Watershed with TSS impairments to biology (in red).



Total suspended solids (TSS) within this subwatershed is seen primarily in the form of sediment as well as volatile suspended solids (VSS), 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. There were only three subwatersheds with TSS listed as a stressor (Figure 17). Minneopa Creek was listed as impaired for TSS. Unlike the other systems where TSS was largely contributed to sediment and stream instability, Minneopa Creek TSS was largely composed of VSS, driven by upstream eutrophic headwaters as well as the hyper-eutrophic Lake Crystal.

Currently, there are 11 AUIDs in the Minnesota River – Mankato Watershed that are listed with water quality impairments for turbidity (Table 4). Of those, five have listings for biological impairments (denoted with an asterisk after Assessment Unit description). 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). It is estimated that the Minnesota River – Mankato Watershed undergoes 3252 tons of sediment erosion and transportation a year from ravines, bluffs, and streambanks (MPCA 2010).

Table 4. Minnesota River – Mankato Watershed reaches impaired for turbidity.

Assessment Unit	ID	Added to Inventory
County Ditch 46A: Headwaters to Seven Mile Cr*	07020007-678 (516)	2006
Beaver Cr to Birch Coulee	07020007-514	2002
Cottonwood River to Little Cottonwood River	07020007-503	2002
Shanaska Cr to Rogers Cr	07020007-501	2002
Little Cottonwood Cr headwaters to Minnesota River*	07020007-676 (515)	2006
Seven Mile Cr T109 R27W S4, north line to Minnesota R*	07020007-562	2006
Blue Earth River to Shanaska Cr	07020007-502	2002
Seven Mile Cr CD 13A to CD 46A*	07020007-703 (564)	2006
Minneopa Cr T108 R28W S23, South line to Minnesota R*	07020007-534	2006
Minneopa Creek to Blue Earth River	07020007-504	2010
Swan Lake outlet to Minneopa Cr	07020007-505	2010

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 list five stations within the Minnesota River – Mankato Watershed, where the Minnesota River at St. Peter monitoring location (close to the outlet of the large watershed) highlights the mass (calculated by tons) of TSS that is transported through the Minnesota River – Mankato watershed. This table also displays that the highest TSS concentrations that were found, is within the Little Cottonwood River site.

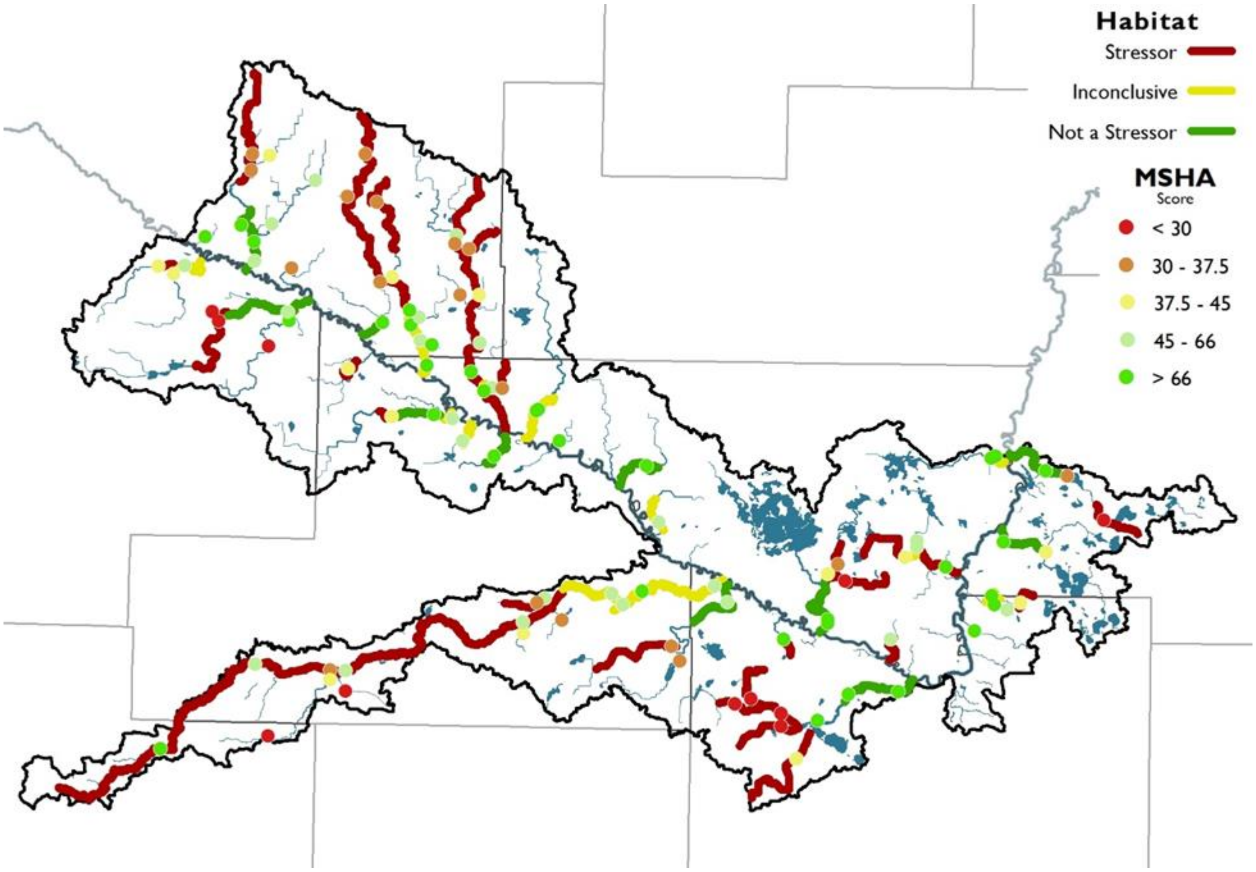
Table 5. MPCA's Watershed Pollutant and Load Monitoring network data, displaying location of sampling and catchment size. Data was based off samples collected from 2007-2014.

Site Name	Hydstra ID	Station Catchment area (Acres)	TSS FWMC (mg/L)	TSS Mass (Tons)
Minnesota River at Morton, MN	E28012001	5,740,800	73	208,389
Minnesota River at St. Peter, MN	H28038002	9,661,384	127	765,599
Little Cottonwood R near Courtland, MN	E28057001	108,800	225	15,020
Minnesota River at Judson, MN	H28054001	7,216,237	88	334,002
Seven Mile Creek near St. Peter, MN	H28063001	23,173	186	4,399

3.1.6 Candidate cause: Lack of Habitat

Overview of Habitat in the Minnesota River-Mankato Watershed

Figure 18. Minnesota River – Mankato Watershed with habitat impairments to biology (in red).



Loss of habitat was a common identified stressor throughout the Minnesota River – Mankato Watershed, as shown in Figure 18. Habitat was 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. As shown in Figure 18, as the stream systems would downcut through the Minnesota River Valley, habitat was generally found to improve. 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.

3.17. Candidate cause: Connectivity

Overview of connectivity in the Minnesota River-Mankato Watershed

Figure 19. The Minnesota River - Mankato Watershed with identified barriers (DNR 2015), below identified AUIDs (in red) with connectivity identified as a stressor.

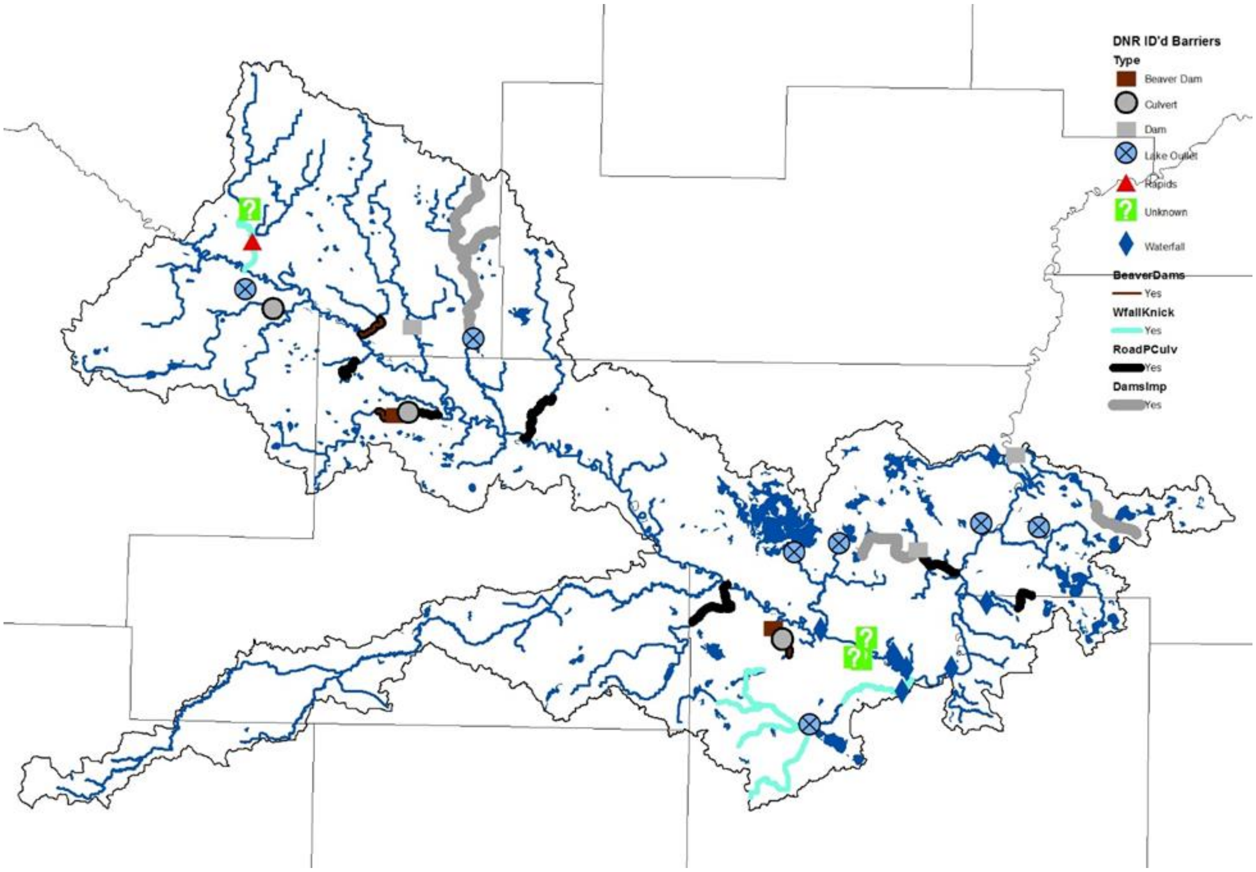
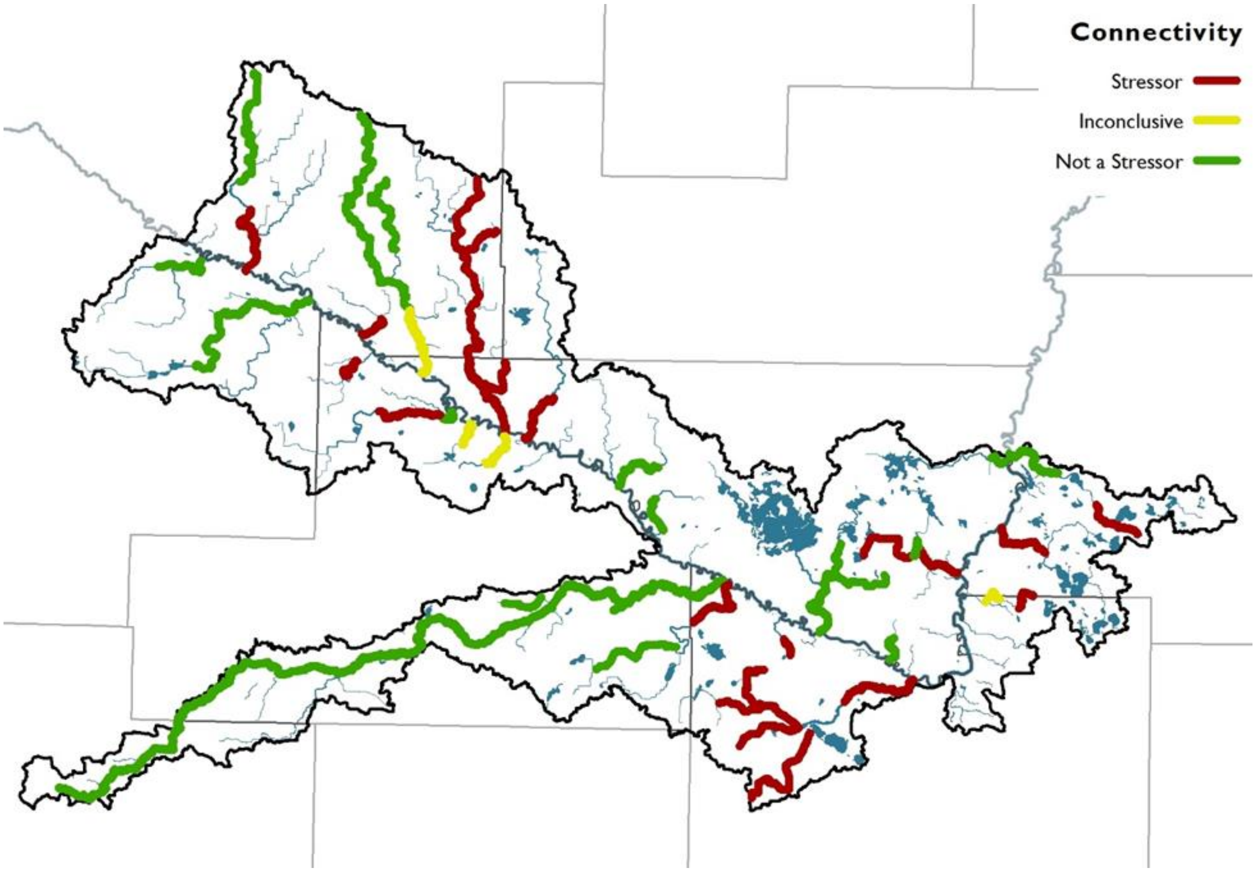


Figure 20. Minnesota River – Mankato Watershed with connectivity impairments to biology (in red).



Within the Minnesota River – Mankato Watershed, connectivity impairments were only considered for monitoring sites that assessed the fish community as impaired. As shown in Figure 19 longitudinal barriers consisted of both anthropogenic and natural features. Natural features (waterfalls) were only considered when upstream refuge areas (lakes and wetlands) were impaired or depleted. A lake stressor identification was conducted by the Minnesota Department of Natural Resources (DNR), producing a draft report that can be referenced in appendix A2 for lake-associated impairments that will be discussed throughout this report where applicable.

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 Minnesota River –Mankato 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.

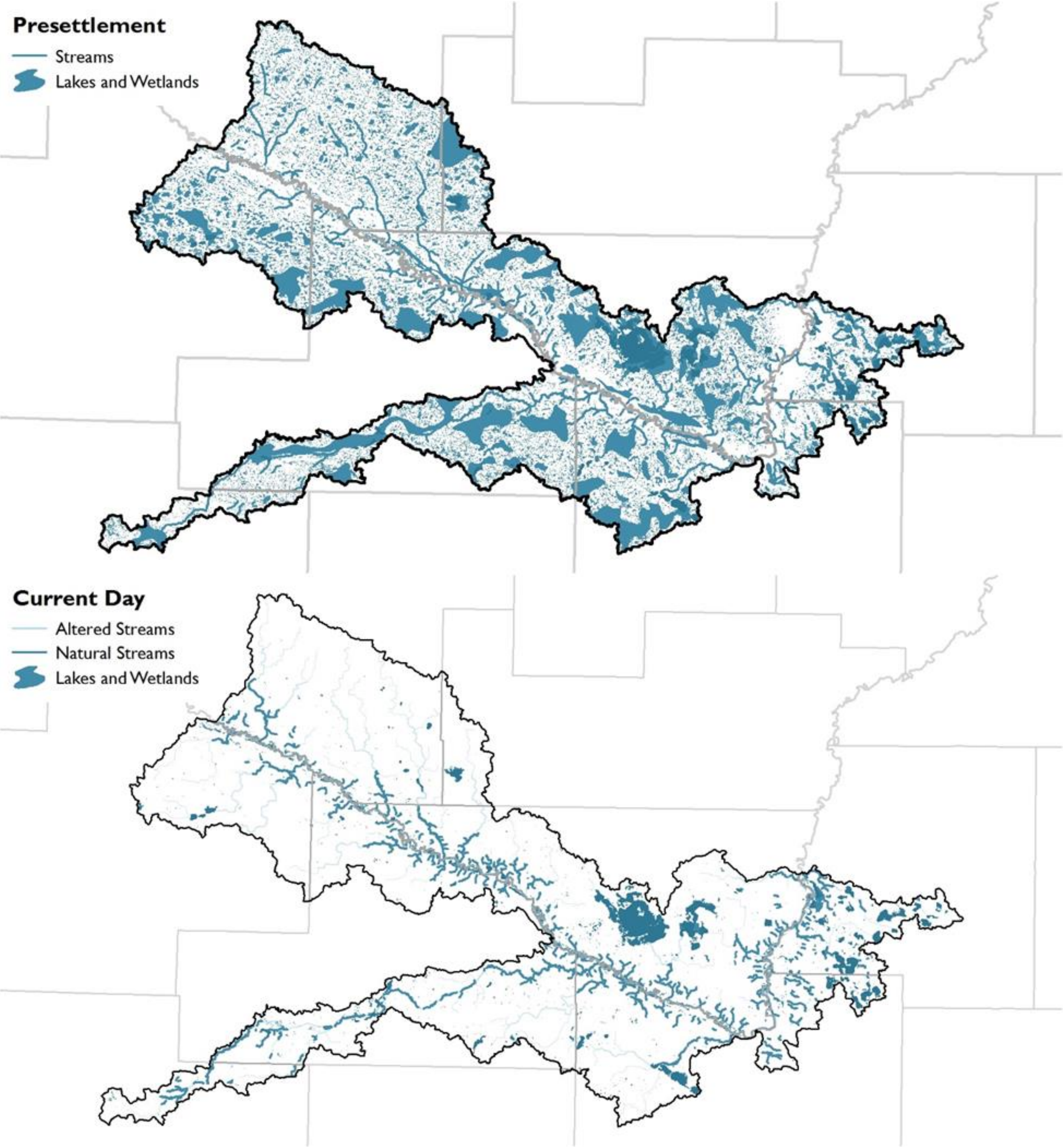
Impoundment structures (dams) on river systems alter streamflow, water temperature regime, and sediment transport processes-each of which can cause changes in fish and macroinvertebrate assemblages (Cummins, 1979; Waters, 1995). Dams also have a history of blocking fish migrations and can greatly reduce 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).

3.1.8 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 Minnesota River Mankato 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, as shown in Figure 21. 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 a primary driving force to the impaired biological communities in the Minnesota River Mankato Watershed.

Figure 21. Minnesota River –Mankato displaying changing in surface waters pre and post settlement.



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 22. Example of a channelized stream Wabasha Creek, (13MN010) in the Minnesota River – Mankato Watershed.

Overview of altered hydrology in the Minnesota River-Mankato Watershed

Currently 64.5% of the Minnesota River Mankato 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, where both direct and indirect impacts to the stream occur at the altered location as well as downstream. While the Little Cottonwood subwatershed has the most feet of altered streams, it also has a significant amount of natural channel as well. On the other hand, watersheds like Little Rock Creek has a disproportionate amount of alterations compared to natural channels, and Swan Lake Watershed has a significant amount of impounded reaches comparatively (Figure 22 and Figure 23).

Figure 23. AUIDs within the Minnesota River – Mankato Watershed that have biological impairments with alteration status. Bar chart displays portions of streams in feet that have been altered, natural, impounded, or are listed as "no definable channel." (N) or (S) stands of the North or South sections of the Minnesota River Mankato.

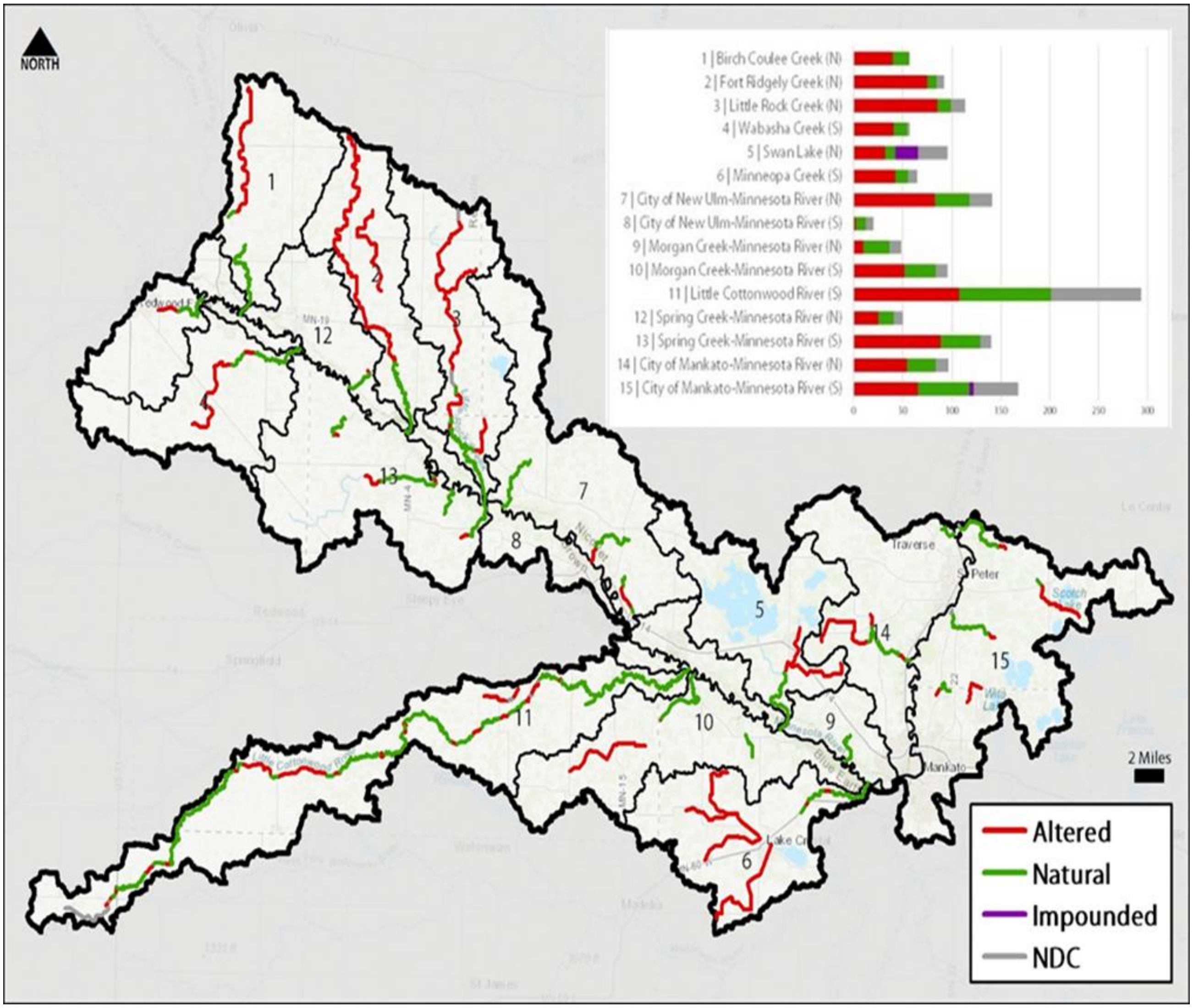
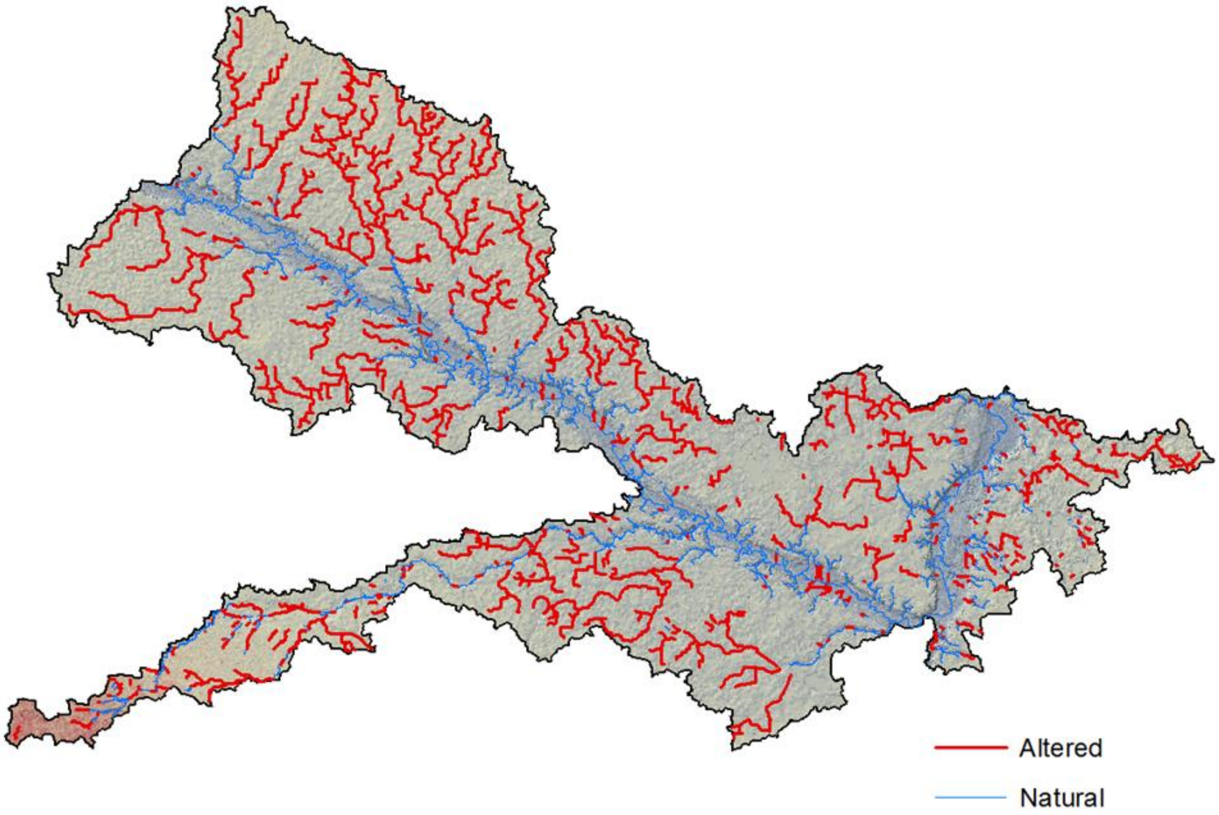


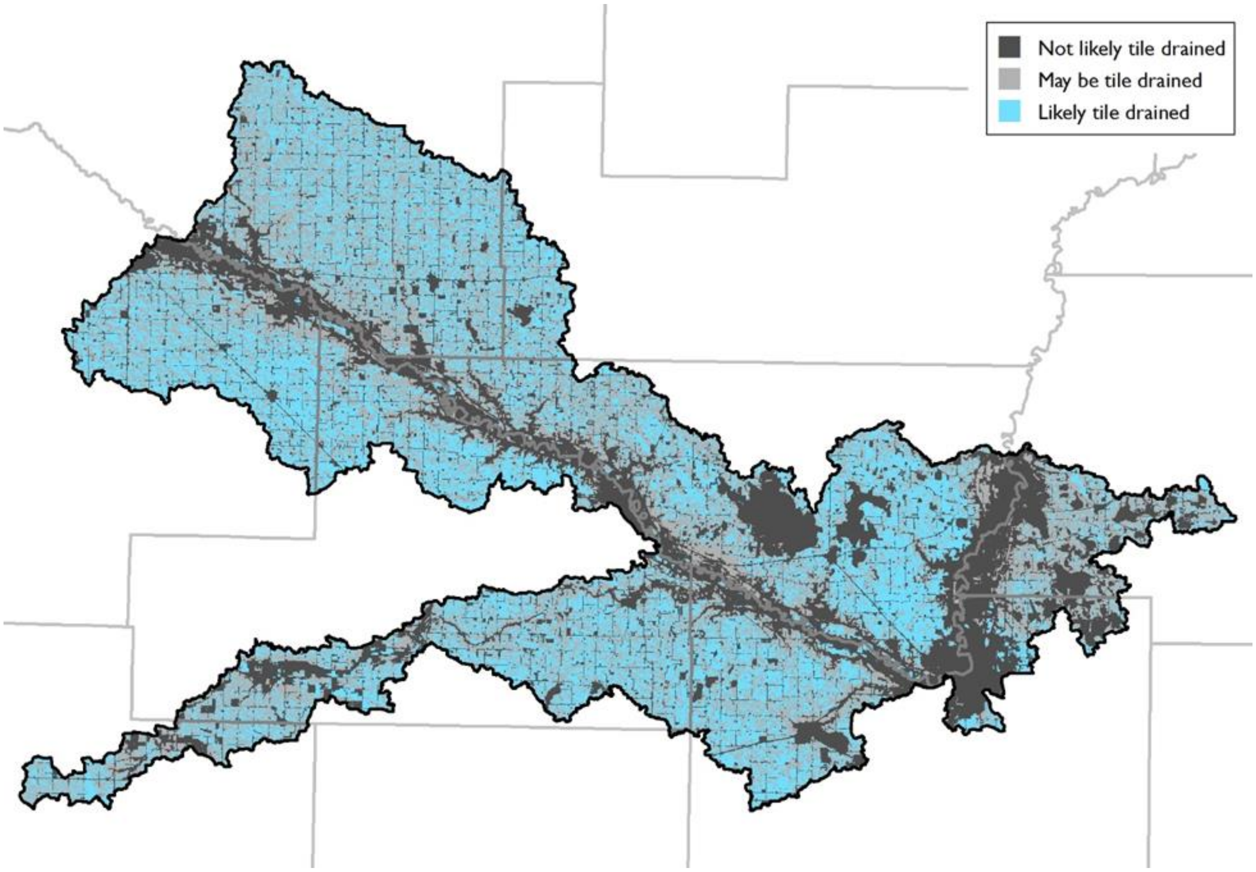
Figure 24. All streams in the Minnesota River – Mankato Watershed showing natural (blue) and altered (red) watercourses.



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 76% of the watershed (Figure 25).

Figure 25. Minnesota River – Mankato Watershed displaying modeled tiled land (light blue), possivle tiled land (light gray), and not likely tiled land (dark gray).



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 (Figure 26 and Figure 27). 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 several watersheds (e.g. Blue Earth, Cedar, and Le Sueur) near the Minnesota River Mankato, 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. This is exactly the case of the Minnesota River, which is the largest source of sediment to the South Metro Mississippi River, as discussed previously. (MPCA 2015).

Figure 26. Diagram illustrating subsurface water transport via tile lines to surface water (Typically a ditch/channelized stream).

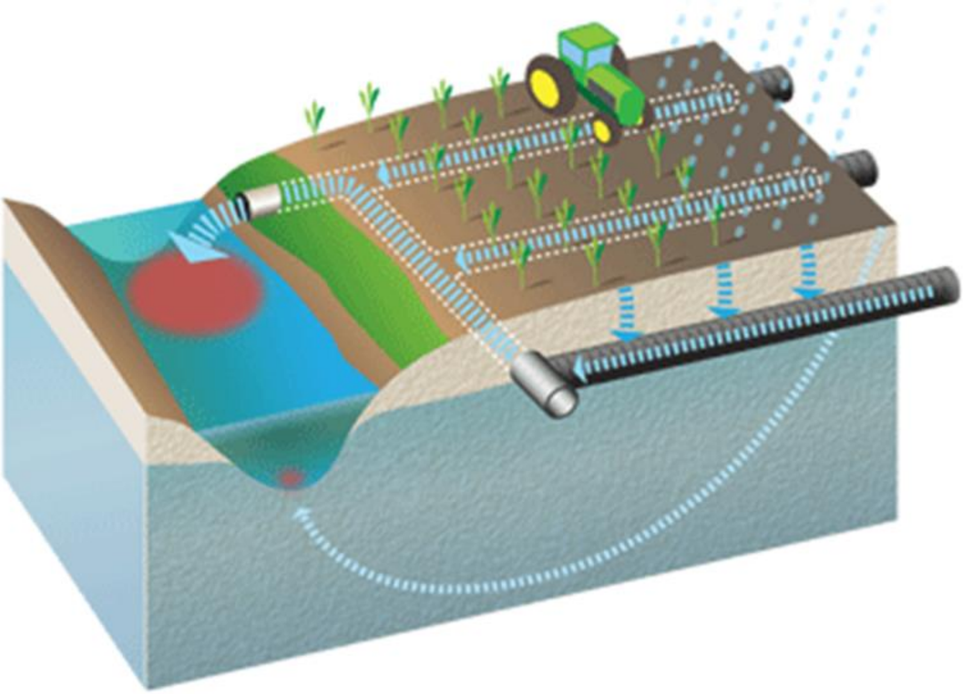


Figure 27. Example of a drain tile outlet to Little Rock Creek, Fairfax Minnesota (13MN026) flowing into a ditched system within the Minnesota River - Mankato Watershed.

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

Understanding the general geology and natural background of the Minnesota Mankato Watershed is an important layer in interpreting the morphology that is taking place within these stream systems. This watershed lies within an area that was created by the glacial River Warren, which carved the Minnesota River Valley. As a result of glacial carving, tributaries that start out in the flat headwater areas have a dramatic change in elevation by the time they reach the mainstem of the Minnesota River. Elevation changes of up to 250 feet have been noted within this watershed (Waters 1977). Many tributaries have formed steep walled ravines in the higher gradient portions of the valley, before they join the Minnesota River. Because of the steep terrain along these ravines, these areas are not suitable for cropland and typically the only locations where natural channels have been identified within this watershed, since all upland areas (headwaters) are partially or completely channelized.

Bedrock types vary within this watershed. Throughout the upper, middle, and eastern regions of the watershed, bedrock typically is composed of erosion resistant rock types such as gneiss, durable forms of sandstone, or quartzite. This can create natural stream barriers seen in nick points or waterfalls such as Minneopa Falls. In other areas, this bedrock can make up the foundation of rapid environments, as seen in the Birch Coulee outcrops (Lore 2016). To the Southeastern, portion of the watershed lies the karst landscape made up of primarily sandstone, shale, and carbonate. Karst terrain, due to the dominance of soluble rocks, is typically characterized my features such as sinkholes, caves, springs, and underground drainage. Karst regions by nature allow direct and rapid exchange between surface and groundwater (Adams, Barry, and Green 2016). For a comprehensive analysis of this watersheds geomorphology by sub-watershed region, please see the DNR's 2016 Minnesota River, Mankato Characterization Report

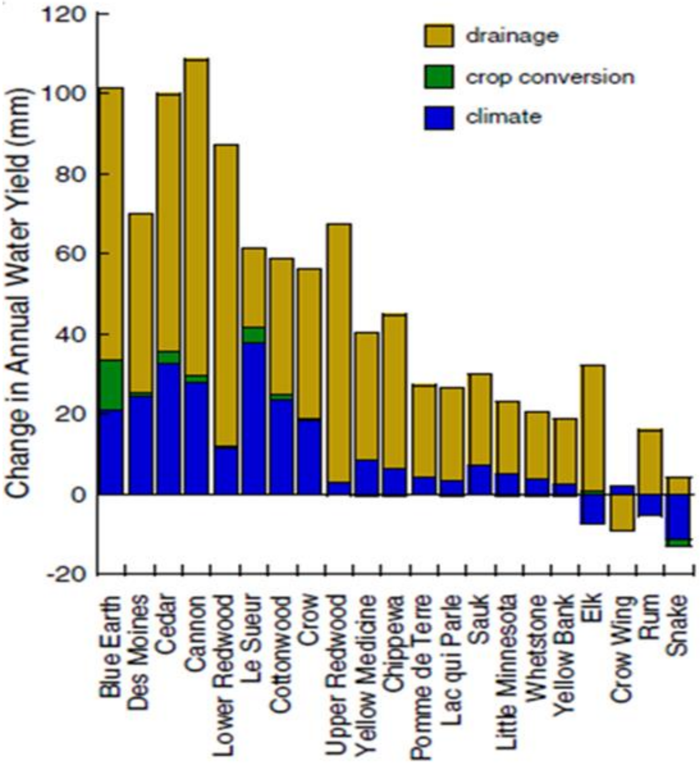
Soil types are another influencing factor when interpreting stream morphology and hydrology. Sediments delivered to the Minnesota River are generally fine-grained and derived from lacustrine or glacial till sources (Lore 2016). Soils that now reside in the flat upland portions of the watershed are typically 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 382,940 acres of wetlands have been lost since European settlement. Subwatersheds within the Minnesota River-Mankato Watershed have lost between 30-65% of the historical wetlands, depending on the location of the watershed. Many of the current wetlands are found in the floodplain of the Minnesota River, making the river valley a significant natural corridor. 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 2016 Minnesota River – Mankato Watershed 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 Minnesota River – Mankato 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. (Figure 28). 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 28. 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 Minnesota River Mankato Watershed, and contributing to most of the stressors in the watershed. 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.

3.2 Inconclusive Causes in the Minnesota River-Mankato Watershed

Pesticides

The Minnesota Department of Agriculture primarily oversees and conducts pesticide sampling. They have conducted 491 samples at nine established monitoring locations for pesticides within the Minnesota River-Mankato Watershed.

Seven Mile Creek (WID 07020007-562) was listed in 2012 for Chloryrifos. However, it is under consideration for delisting, as it has not been detected since 2010. In that same year, the pesticide tebupirimfo fell above the EPA Chronic Value Aquatic Life Benchmark. Both these samples exceeded the state and federal limits only once. Additional sampling information can be found within the Department of Agriculture's Pesticide Monitoring in the Minnesota River – Mankato Watershed, attached to this report as Appendix A3.

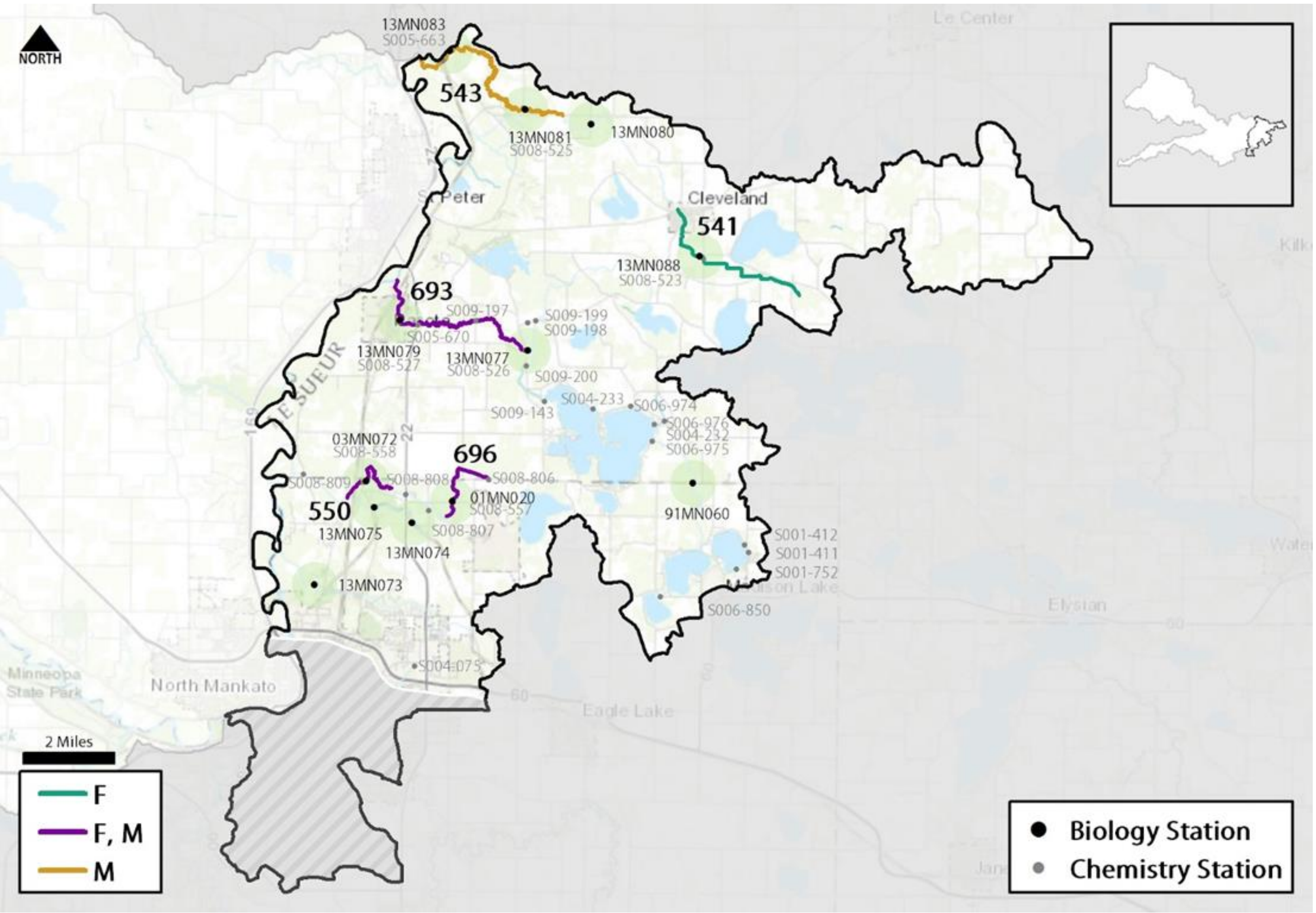
With limited data available, the effects of pesticides on the biological community within this reach are inconclusive. Currently, the additive effect of pesticides on aquatic organisms at levels below state or federal standards is unknown. Research is currently being done to better characterize the potential effect. Given the current gaps in understanding of the additive effects, it is difficult to rule out pesticide toxicity as a possible stressor or conclude that it may be a stressor at this time.

For additional information on general biological impacts associated to the stressors listed above, please reference the 2017 Stressors to Biological Communities in Minnesota's Rivers and Streams.

4. Evaluation of Candidate Causes South of Minnesota River City of Mankato-MNR Mankato South

This section encompasses biotic impaired reaches in the City of Mankato – Minnesota River 10 digit HUC (0702000711). There are five reaches impaired for biology in this 10 digit HUC that are located on the south side of the Minnesota River. One site is impaired for macroinvertebrates only (Cherry Creek – 543), one site is impaired for fish only (Cherry Creek – 541), three were impaired for both macroinvertebrates and fish (Shanaska Creek – 693, Unnamed Creek – 550, Unnamed Creek – 696). All of the reaches within this subwatershed are fed by eutrophic lakes. Scotch Lake and Wita Lake have been assessed and listed as impaired for nutrients; these are the headwaters for Cherry Creek and Unnamed Creek respectively.

Figure 29. Map of the City of Mankato watershed with biological impairments and monitoring stations. Impairments are described as F=Fish, F, M=Fish and Macroinvertebrates, and M=Macroinvertebrates.



4.1 Cherry Creek (07020007-541)

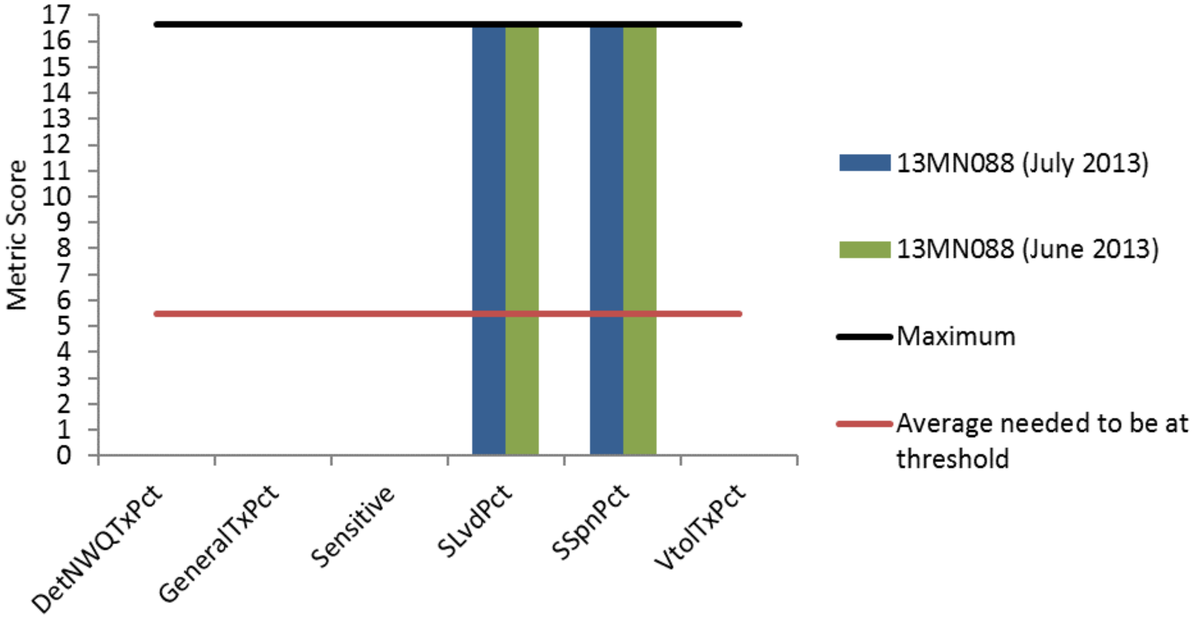
Cherry Creek (07020007-541) is the upstream reach of Cherry Creek, southwest of Cleveland, Minnesota. The reach is warmwater modified use Class 2B. The reach extends from the headwaters of Huoy Lake (Mud Lake) and Scotch Lake to downstream of MN-99 in Cleveland. The reach is impaired for lack of fish assemblage.

4.1.1 Biological Communities

Station 13MN088 was sampled in 2013 for fish and macroinvertebrates. The macroinvertebrate community had an IBI of 47.3; above the Southern Forest Streams GP threshold for modified use of

43. The fish community was surveyed twice in 2013. Station 13MN088 FIBI's score was 23.4 on June 10, 2013, and 33.4 on July 23, 2013. The southern headwaters class threshold for modified use FIBI is 33. The entire fish community consisted of black bullheads. The June sample was 10 points lower due to a DELT deduction. DELT anomalies are fish with deformities, eroded fins, lesions, or tumors and often signal severe degradation. The metric scored groups were the same for each visit, with metric scores of zero for four of six metrics (detritivorous, generalists, sensitive, and very tolerant groups scoring poorly (Figure 30). Short-lived (SLvdPct) and serial spawners (SSpnPct).

Figure 30 Fish metrics of the Southern Headwaters IBI modified use for station 13MN088, Cherry Creek.



4.1.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

At the time of biological monitoring, dissolved oxygen (DO) was recorded at 10.96 mg/L on June 10, 2013 and at 7.5 mg/L on July 23, 2013. Station S008-523 had five additional samples with DO concentrations ranging from 3.97 mg/L to 12.88 mg/L, with an average concentration of 6.90 mg/L. One sample fell below the DO standard of 5 mg/L. In 2015, an YSI sonde was deployed at station 13MN088 from August 10 – 17 (Figure 31). The DO ranged from 1.79 to 9.1 mg/L, with daily violations of the DO standard of 5 mg/L. The 24 hour dissolved oxygen fluxuation (DO flux) was elevated, ranging from 3.7 to 6.6 mg/L, averaging 5.2 mg/L (Figure 32).

Figure 31. Diurnal dissolved oxygen for station 13MN088, August 10 - 17, 2015.

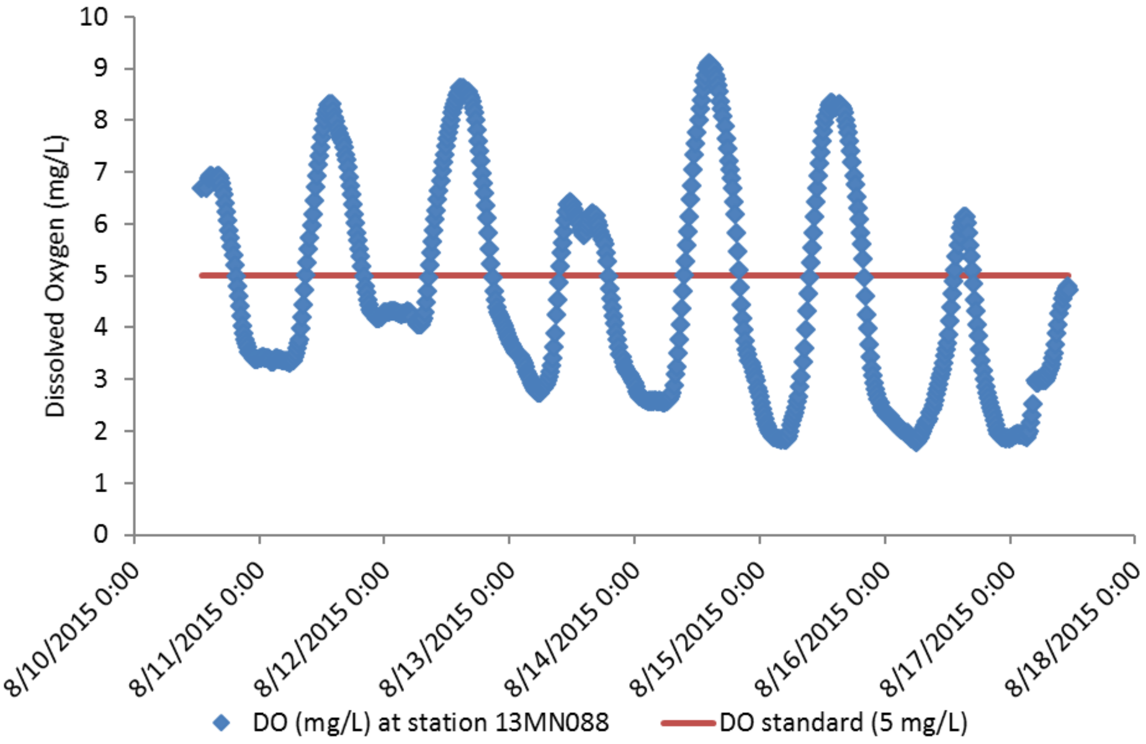
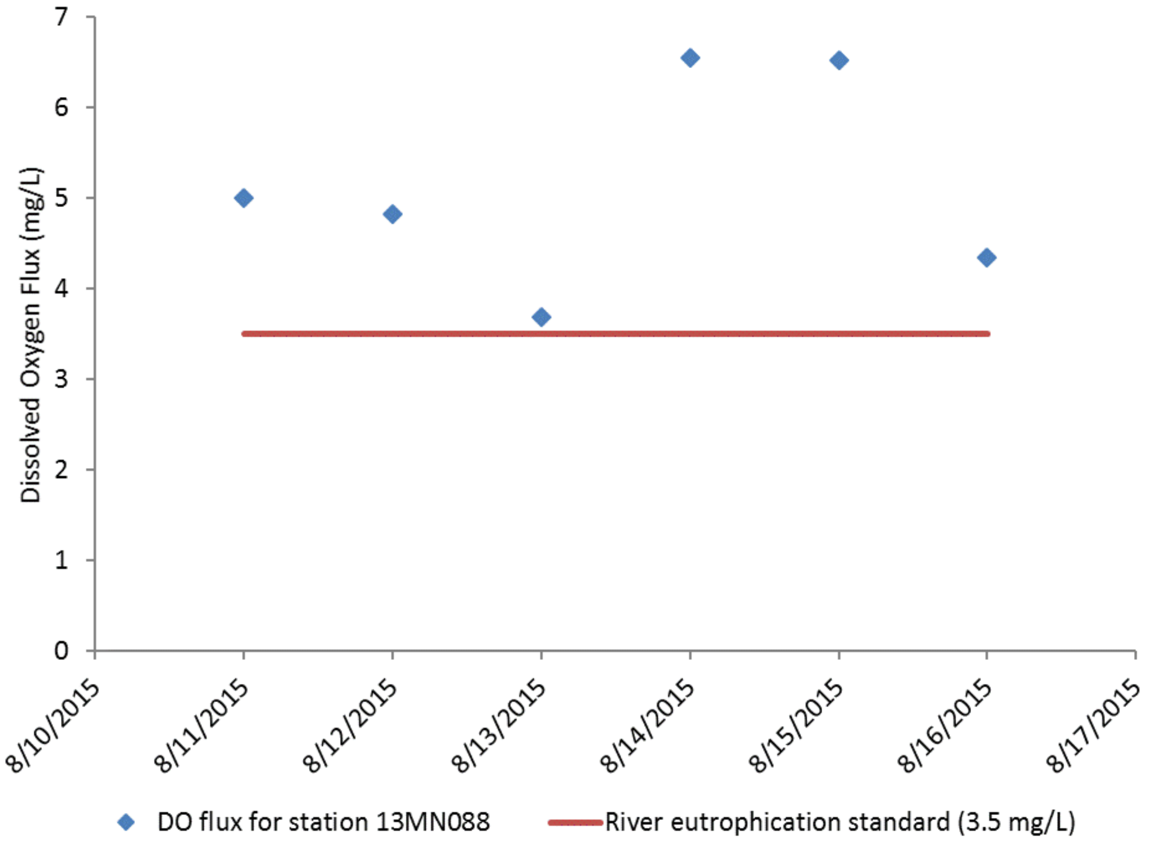


Figure 32. Dissolved oxygen flux at station 13MN088, August 11 - 16, 2015.



The entire fish community was composed of black bullheads. Biological metrics can be helpful at identifying community stressors; however, with only one fish taxon the metric percentages are skewed. Black bullheads are quite tolerant of low dissolved oxygen. Utilizing Minnesota derived tolerance values, they have been found to be very tolerant to low DO (the most tolerant 15% of species using early morning DO data) this explains the poor DO Index score and high DO tolerant individuals (Table 6).

Table 6. Fish metrics that respond to low DO stress in Cherry Creek (-541) compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
13MN088 (2013)	**0**	**0**	**100**	**5.4**	**0**	**0**	1	**100**
Southern Streams Average	*16.9*	*24.6*	*44.9*	*7.2*	*1.7*	*6.1*	*4.7*	*18.5*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Although not impaired, the macroinvertebrate community metrics where evaluated to see if there were signals of low DO stress within the community. The macroinvertebrate metrics did indicate the community is being impacted by low DO (Table 7). The DO index score was at six; Falling below the average for visits meeting the general use southern streams average of 7.04 (Table 7). There was also a slightly elevated number of tolerant taxa and a moderate percent of individuals tolerant to low DO (22.7%). There were some intolerant species present, but still fell far below what is expected for this stream type. Sensitive taxa Ephemeroptera, Plecoptera, and Trichoptera (EPTCh) were far below the expected abundance for this stream type. The macroinvertebrate community is suggestive of low DO stress, even though it is not impaired at this time.

Table 7. Macroinvertebrate metrics that respond to low DO stress in Cherry Creek (-541) compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN088 (2013)	**31**	**4**	**7.48**	**6**	**1**	**.3**	**5**	**22.7**
Southern Streams Average	*45.8*	*14.2*	*7.08*	*7.04*	*9.0*	*24.0*	*4.8*	*9.9*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is considered a biological stressor within this reach of Cherry Creek. Black bullheads dominate the impaired fish community and are very tolerant of low DO. In addition, a sonde deployment in 2015 showed multiple days of DO exceeding the 5 mg/L standard. The macroinvertebrate community, while not impaired, is also showing signs of stress due to low DO.

Eutrophication

At the time of biological monitoring, total phosphorus (TP) was recorded at .088 mg/L on June 10, 2013 and at .094 mg/L on July 23, 2013. Additional chemistry monitoring at this site found that TP concentrations in 2015 and 2016 ranged from .076 mg/L - .208 mg/L, with an average of .141 mg/L. Five out of the seven samples collected were below the river eutrophication standard for the Central Region (0.1 mg/L). Phosphorus concentrations peaked in the late summer months of July. Samples were collected from station S008-523. Chlorophyll- a (chl-a) samples were limited to two samples, with both well above the standard (18 µg/L), 101 µg/L on September 2, 2015 and 108 µg/L on August 17, 2015 at station S005-523.

At the time of biological monitoring, the total suspended solids (TSS) sample was on the higher range at 62 mg/L. Further evaluation found volatile suspended solids (VSS) at 30 mg/L, approximately half of the TSS sample was composed of organic matter; this concludes there was a high level of suspended algae within the reach. This also falls in line with the photo documentation that was taken along with the chemistry samples during monitoring. Water clarity was observed to be low, and there was a visible green hue noted in Figure 33, pointing to a high amount of suspended algae.

Figure 33. Photograph of monitoring station 13MN088, taken June 10, 2013.

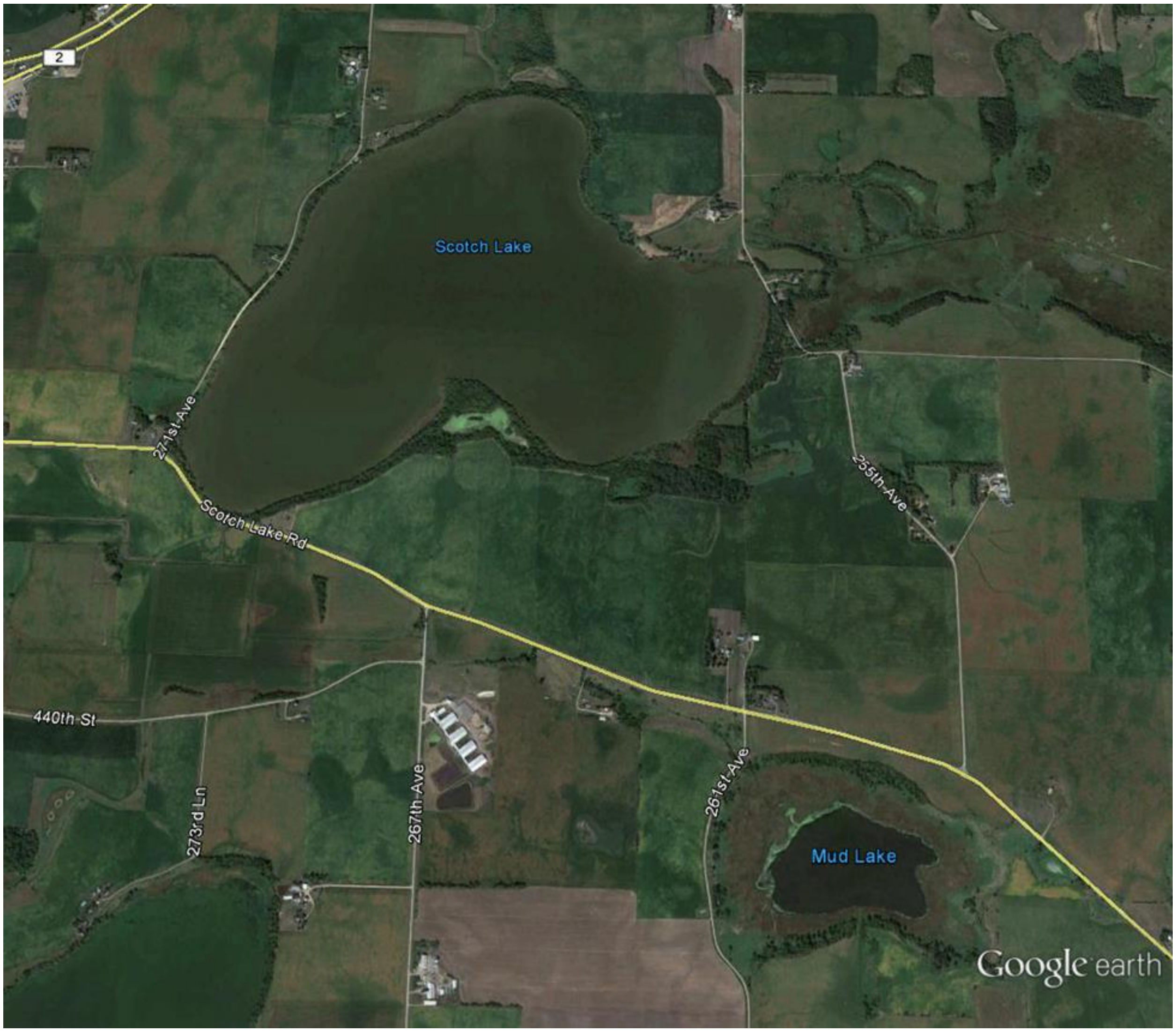
Additional site recon on April 27, 2015 also displayed high overgrowth potential, as filamentous algae was also observed at a separate site visit, seen in Figure 34.

Figure 34. Monitoring station 13MN088 on April 27, 2015.

In 2015, an YSI sonde was deployed at station 13MN088 from August 10 - 17. The DO ranged from 1.79 mg/L to 9.1 mg/L, with daily violations of the DO standard of 5 mg/L. The DO flux was elevated, ranging from 3.7 mg/L to 6.6 mg/L, averaging 5.2 mg/L in daily DO concentration swing. Daily exceedances of the 3.5 mg/L flux occurred the entire sonde deployment. The daily dramatic shifts in DO is being driven by an overproduction of algae (in the forms of both suspended and filamentous) within this stream. During the day, when photosynthetic activity is at its peak, the stream is highly saturated with DO. In contrast, at night when plant respiration occurs, this segment of stream is depleted of oxygen.

The additional upstream influence of Scotch Lake is likely contributing to the eutrophic conditions of this reach, as this waterbody is listed as a hypereutrophic lake. Scotch Lake fits into the shallow lake criteria (11 feet maximum depth and 100% littoral zone), with a total phosphorus loading average of .14 mg/L, and chlorophyll-a average of 184.5 µg/L. Data from 2013 and 2014 grossly exceed lake standards. Algae blooms were apparent in both years; TP data was noticeably higher in 2014 possibly reflecting an increased inflow during that summer or more frequent internal loading. Secchi data was right at the standard (0.7 m), with a long-term trend indicating water clarity is decreasing. Mud Lake has no data available but shows green in aerial photographs (Figure 35).

Figure 35. Arial image of Scotch and Mud Lake from August 28, 2012.



Eutrophication is a stressor in Cherry Creek. Elevated TP, chl-a, and DO flux have been documented, as well as low DO and associated daily DO fluxuation. The fish community is entirely dominated by black bullheads, a highly tolerant species. In addition to the nutrient concentrations and stream conditions that create eutrophication, this stream system is likely receiving an abundance of algae from the eutrophic lakes that feed Cherry Creek.

Nitrate

During biological monitoring, the nitrate concentration at 13MN088 was recorded at 2.3 mg/L on June 10, 2013 and .53 mg/L on July 23, 2013. There were nine additional samples taken on this reach in 2015 and 2016 from April through September. The nitrate concentration ranged from .55 mg/L up to 23 mg/L, with an average concentration of 6.33 mg/L. Two of the nine samples were at or above 20 mg/L, taken in the months of May and July.

Fish often do not show a strong response to increased nitrate concentrations. Macroinvertebrate communities are often more affected by nitrate toxicity. The macroinvertebrates in this reach are not impaired, and also do not show strong indication they are stressed by the elevated nitrate concentrations (Table 8). The nitrate specific metrics show better than average Trichoptera taxa, and fewer than average tolerant individuals. The nitrate index score was 2.5, while the average for Southern

Forest Streams meeting impairment threshold is 3.0. This suggests that overall the community present is not overly tolerant to high nitrate concentrations. Increasing nitrate concentrations also correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct). While intolerant taxa and non-hydropsychid individuals are not in abundance here, they are not significantly impaired or lacking as a community.

Table 8. Macroinvertebrate metrics that respond to nitrate stress in Cheery Creek (-541) compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN088 (2013)	**3**	5.6	2.5	**1**	17	30.0
Southern Forest Streams Average ***(MU)***	*3.4*	*2.7*	*3.0*	*1.8*	*18.8*	*53.5*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate concentrations are elevated, and should be reduced, but at this time. It is not clear if high concentrations are a chronic issue within this stream, with only a two exceedances noted. There is little response noted in the macroinvertebrate community metrics. It is inconclusive if nitrate is what is stressing the fish community.

Total Suspended Solids

Total suspended solids (TSS) concentrations collected in 2015 and 2016 ranged from 2.4 mg/L – 52 mg/L, with an average concentration of 26.9 mg/L. None of the eight samples collected in the two years exceeded the standard of 65 mg/L. Samples were collected from April through September with the highest concentrations occurring in June 2016 and August of 2015. Two additional TSS samples were collected at the time of biological monitoring; TSS concentration at 13MN088 was 51 mg/L on June 10, 2013 and 62 mg/L on July 23, 2013. Volatile suspended solids (VSS) typically accounted for 33-70% of these samples, indicating a high percentage of organic matter in for form of suspended algal growth influencing TSS samples. Scotch Lake, just upstream is a likely source (as discussed in the above eutrophic section).

As the fish community sampled were all black bullheads, and neither tolerant or intolerant of high TSS levels, the fish community metrics should not be used for evaluation of TSS as stressor.

TSS is inconclusive due to the lack of chemistry data, as well as lack of fish community to help identify if TSS is causing a community shift.

Habitat

At station 13MN088, the habitat was poor with MSHA scores of 26 and 30. The subcategories that scored the lowest were land use, channel morphology, and substrate (>75%) (Figure 36). The surrounding land use is row crop. There was moderate riparian width with little bank erosion and light (5-25%) shade available (25%). The reach was 100% run feature with sand and silt substrates. The embeddedness was variable from light in June to severe in July. There was sparse to moderate cover with undercut banks, overhanging vegetation, and macrophytes. There was little depth variability in the reach. The station had poor to fair sinuosity, moderate channel stability and poor channel development.

Figure 36. Percentage of MSHA subcategory scores for station 13MN088, Cherry Creek.

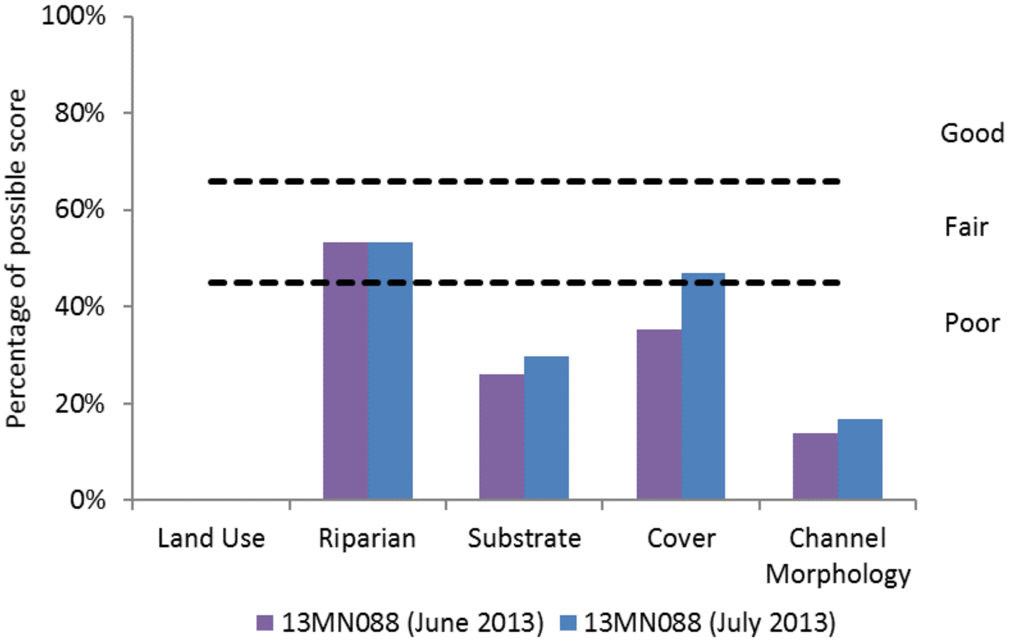


Figure 37. Station 13MN088 on June 10, 2013.

Habitat is considered a stressor to the fish community within this AUID of Cherry Creek. The fish community suggests habitat may be an issue with a complete lack of benthic insectivores, riffle dwelling species, and simple lithophilic spawners. However, only black bullheads were present which creates bias in metric response. This reach is considered modified, and habitat has already been determined to be limited due to this designation. That coupled with a poor MSHA score, and limited fish diversity, indicates that lack of habitat is a stressor in this AUID. As clearly observed in Figure 37, there is a lack of habitat diversity as well as stream cover.

Altered Hydrology and Longitudinal Connectivity

All biological stations on Cherry Creek are influenced by a dam downstream of county road 23. Additionally, at 321st Ave there is a misplaced shallow culvert. Both of these structures have an impact on longitudinal connectivity for fish passage and stream stability. For more information on the barriers and hydrological impacts to this area, please see page 59 of the DNR's Minnesota River, Mankato Watershed Characterization Report (DNR 2015).

Of four stations upstream of the dam, only two fish species were surveyed (black bullhead and creek chub). At station 13MN088, only black bullheads were surveyed. Both of these species are lake species, likely from the upstream lakes and wetlands that may provide fish replenishment. The fish that are present are tolerant species. The headwaters of Cherry Creek is partly fed by Scotch Lake, where predatory fish are stocked by the DNR. Northern Pike were last stocked in 2012. A 2013 Lake fish survey showed low abundance in Northern Pike, yet growth size of individuals captured ranged into larger than the average size of 30.0 inches in length. Walleye fry were stocked in 2013 and in the same year surveyed. Past surveys show a stable population of this predatory fish in Scotch Lake (Rounds DNR).

With the fish, population is managed by the DNR, due to the lake outlet these fish are blocked from migrating into Cherry Creek. Additional to the physical barriers that are present within this system, altered hydrology is also impacting longitudinal connectivity.

During a September 2012 survey, this reach was recorded as being dry at station 13MN088. With 70% of this reach ditched, hydrology is altered in its stability to retain base flow as well as impacts on stream morphology and loss of habitat types. On April 27, 2015 there was a recorded level of 0.5-1ft of standing water, similar to baseflow at this location of Cherry Creek; downstream however was recorded as being dry, as shown in Figure 38 below. The photograph was taken off Highway 23 before Cherry Creek reaches the dam and downstream of perched culvert.

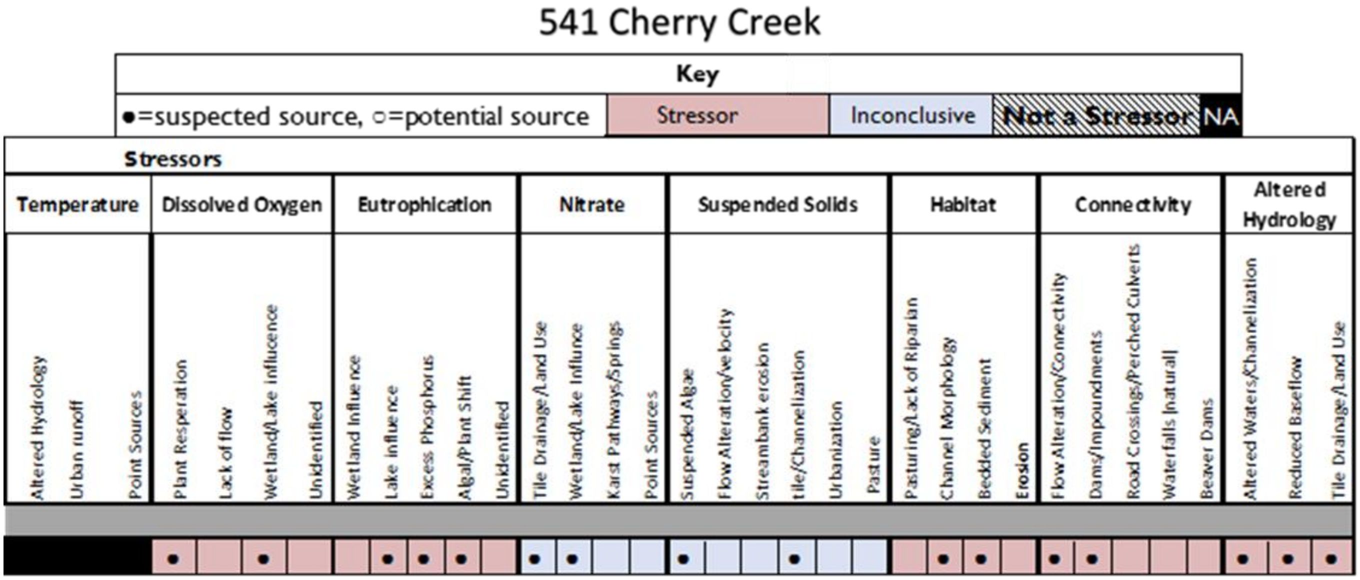
Figure 38. Cherry Creek off County Highway 23 on April 27, 2015.

This reach of Cherry Creek has been modified via channelizing and ditching as an agricultural drainage practice, this homogenizes the stream and greatly impacts stream velocity that further impacts the streams stability and biological habitat. Additional to diching and channelizing, the introduction of subsurface tile drainage change the soils longitudinal stream recharge ability during low precipitation, and greatly increases it during precipitation events, as well as pulls in chemicals or excess nutrients from land application. Both of these practices change the streams morphology, hydrologic capacity, and profile. For more information regarding altered hydrology within this region and the impacts, reference Chapter 3.1.8 of this report.

Altered hydrology and connectivity is found to be the primary stressor to the fish community, as they are directly contributing to the other stressors identified within this reach.

Summary Table

Table 9. Identified stressors with suspected sources for reach 541 of Cherry Creek.



541 Cherry Creek

Key

●=suspected source, ○=potential source | 🟥 Stressor | 🟦 Inconclusive | ▨ Not a Stressor | ■ NA

Stressors

Temperature			Dissolved Oxygen				Eutrophication				
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified
■	■	■	🟥 ●	🟥	🟥 ●	🟥	🟥	🟥 ●	🟥 ●	🟥 ●	🟥

Nitrate				Suspended Solids					
Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture
🟦 ●	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦

Habitat				Connectivity					Altered Hydrology		
Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
🟥	🟥 ●	🟥 ●	🟥	🟥 ●	🟥 ●	🟥	🟥	🟥	🟥 ●	🟥 ●	🟥 ●

4.2 Cherry Creek (07020007-543)

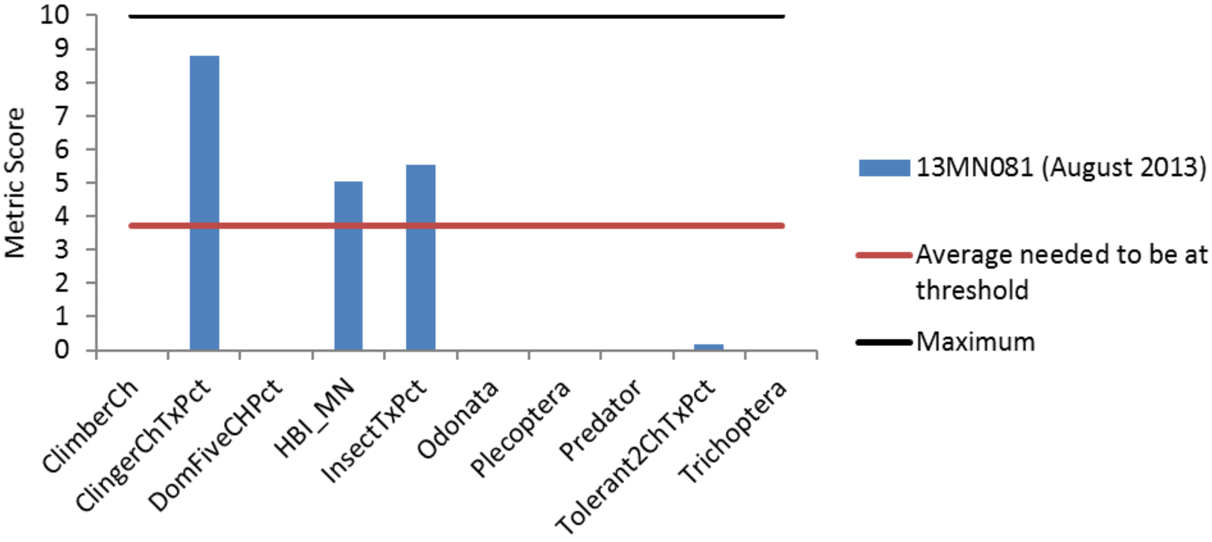
Cherry Creek (07020007-543) is the downstream reach of Cherry Creek (07020007-541), northeast of St. Peter, Minnesota. The reach is a warmwater general use Class 2B. The reach extends from 410th St. to the Minnesota River. The reach is impaired for lack of macroinvertebrate assemblage.

4.2.1 Biological Communities

Station 13MN081 was sampled for fish and macroinvertebrates in 2013. The downstream station 13MN083 was not assessable due to dry conditions. For more information, visit the Minnesota River, Mankato Monitoring and Assessment Report.

The macroinvertebrate community scored a low at 18.8 on the Southern Streams RR class IBI. The threshold for this class is 37. The reach is characterized by low taxonomic diversity, no intolerant taxa, and dominated by few, tolerant taxa. Seven of the 10 metric scores in the IBI were zero or nearly zero (Figure 39). The community was dominated by black fly larva (Simulium).

Figure 39. Macroinvertebrate metrics of the Southern Streams RR class for station 13MN081, Cherry Creek.



4.2.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

At the time of the fish sample on July 22, 2013, dissolved oxygen (DO) was recorded at 8.06 mg/L. Eight additional samples were taken throughout this reach of Cherry Creek during the monitoring period. Station S008-525 had two samples with DO concentrations at 11.27 mg/L on May 19, 2015 and 7.37 mg/L on August 17, 2015. Station S005-663 had six samples taken in the months of May to September in 2015. These values ranged from 8.42 - 11.59 mg/L, with an average of 9.30 mg/L. DO concentrations started high in spring months and gradually dropped throughout the year. All values fell above the DO standard of 5 mg/L. In 2015, YSI sondes were deployed at station 13MN081 and station 13MN083 from August 10 - 17. The DO ranged from 6.8 mg/L to 8.0 mg/L at station 13MN081 and from 7.7mg/L to 9.1 mg/L at station 13MN083, with no violations of the DO standard. DO flux was low, less than a 2 mg/L in DO concentration daily variation for each station.

The macroinvertebrate metrics that are known to respond to low DO stress were inconsistent (Table 10). The total taxa richness sampled (TaxaCountAllChir) was below the average for a Minnesotan southern stream. There was a decrease in Ephemeroptera, Plecoptera, as well as Trichoptera (EPTCh). The HBI_MN is a measure of pollution based on tolerance values assigned to each individual taxon, and was found to be lower than the state average for this stream class of 7.08. There was also a lack of abundance from low DO intolerant individuals. However, there was not an overabundance of Low DO tolerant species. The corresponding metric response is likely due to another stressor and not due to low DO stress.

Table 10. Macroinvertebrate metrics that respond to low DO stress in Cherry Creek (-543) compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN081 (2013)	**14**	**6**	6.63	7.62	**3**	**4.4**	1	2.5
Southern Streams Average	*45.8*	*14.2*	*7.08*	*7.04*	*9.0*	*24.0*	*4.8*	*9.9*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is not considered a biological stressor within this AUID of Cherry Creek. Chemistry samples did not show any indication of low DO occurring, and the biological community metrics did not indicate low DO to be limiting the macroinvertebrate community, although it did show as a whole, the macroinvertebrate are lacking. While low DO is identified as a stressor in the headwaters of Cherry Creek, this downstream reach likely is getting enough DO as the streams gradient changes, with it increasing the streams aeration ability.

Eutrophication

At the time of biological monitoring, total phosphorus (TP) was recorded .107 mg/L. Additional samples for TP concentrations were collected in 2009, 2015, and 2016 and ranged from .027 mg/L - .762 mg/L, providing an average of .202 mg/L. Nine of the 12 samples exceeded the river eutrophication TP standard for the Central Region (0.1 mg/L). Sample values that did not exceed the standard were collected in April and May of 2009 and 2016. TP concentrations reached the highest during the months of June and July.

There were three samples of Chlorophyll-a (chl-a) in the reach in 2015. One sample was greatly above the standard at 58.5 µg/L on September 2, 2015 (station S005-663). On August 17, 2015, samples at station S005-663 and S008-525 were just above the standard (18.1 and 18.9 µg/L respectively).

In 2015, YSI sondes were deployed at station 13MN081 and station 13MN083 from August 10 - 17. The DO ranged from 6.8 to 8.0 mg/L at station 13MN081 and from 7.7 to 9.1 mg/L at station 13MN083, with no violations of the DO standard. The DO flux was low, less than 2 mg/L variation swing for each station.

The macroinvertebrate metrics that respond to eutrophication stress do correlate to eutrophic stress Table 11. There was a lack of collector filterer species. The taxa sample for macroinvertebrates that depend on conditions for filtering and gathering (Collector-filtererCh and Collector-gathererCh) typically were found to be just under the average. Ephemeroptera, Plecoptera & Trichoptera, (EPT) were just under the average in years the taxa counts fell under the average for this stream type. These taxa types will typically display the strongest metric signal for eutrophication; overall, generally tolerant individuals dominated, while there were not any intolerant species recorded.

Table 11. Macroinvertebrate metrics that respond to eutrophication stress in Cherry Creek (-543) compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN081 (2013)	**14**	**2**	**7**	**5**	**0**	**92.9**
Southern Streams Average	*45.8*	*7.3*	*15.9*	*12.2*	*0.8*	*72.6*
Expected response to stress	↓	↓	↓	↓	↓	↑

The biological metrics strongly suggest eutrophic stress is affecting the macroinvertebrate community, while the chemical analysis is not as straight forward. Being a limiting nutrient, the high TP concentrations found within this reach, are typically telling of potential or actual eutrophic conditions. However, dissolved oxygen is almost always going to be imbalanced in chronic eutrophic conditions, as high macrophyte production results in high levels of DO during active photosynthesis and will fall dramatically during respiration. This pattern was not observed at the time of continuous monitoring that took place in 2015 with the sondes, or during instantaneous DO sampling. Even with the increase of stream aeration, if overproduction was actively occurring there likely would have been a drastic increase in DO during the day. Chlorophyll-a samples did suggest high amounts of suspended algae are coming through this reach. It is possible that the high levels recorded for chl-a are related to a storm event and were flushing through the system. This is especially possible as the headwaters of this stream are Eutrophic. Eutrophication is inconclusive as a stressor in this AUID. As there does not to be an overabundance of growth actively occurring within this reach, eutrophication from this reach cannot be concluded as a stressor. However, it is likely that the upstream eutrophic conditions are having on impact to biology here.

Nitrate

During biological monitoring, the nitrate concentration at 13MN081 was 6.2 mg/L on June 10, 2013 and at 3.2 mg/L on July 22, 2013. Station 13MN083 was recorded at 3.3 mg/L on July 22, 2013. There were 16 additional samples taken within the two monitoring stations in 2009, 2015 and 2016 in the months of April through September. The nitrate concentrations ranged from 1.5 mg/L - 30 mg/L. The average concentration was 9.56 mg/L. 6 of the sixteen samples were above 10 mg/L and 2 of the sixteen samples were above 20 mg/L, both taken on May 19, 2015 at the two monitoring locations.

The biological metrics are slightly mixed but not strongly suggestive of nitrate stress (Table 12). The nitrate index score was 2.8, just below the average for Southern Streams meeting impairment threshold (2.9). Increasing nitrate concentrations also correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct) and decreased intolerant taxa, both which are lacking in this reach in number, but make up more than the threshold of 5.5 percentage wise. Additionally, the number of nitrate tolerant taxa was also sparse scoring just eight, and did not fall above the threshold of 18.8 for this stream type. These metrics are likely due to lower than average taxa counts.

Table 12. Macroinvertebrate metrics that respond to nitrate stress in Cherry Creek (-543) compared to the statewide average of visits meeting the warmwater use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN081 (2013)	**1**	9.0	2.8	**0**	8	16.8
Southern Streams Average	*6.3*	*5.5*	*2.9*	*2.4*	*18.8*	*47.2*
Expected response to stress	↓	↓	↑	↓	↑	↑

Elevated nitrate concentrations have been documented in this reach. At a glance, the macroinvertebrate community do not appear to be directly limited by nitrate. However, the macroinvertebrate metrics may be misleading as the community was dominated by Simulium, skewing the invert community metrics. Nitrate is inconclusive as a stressor due to the combination of high nitrate findings, and a skewed macroinvertebrate community.

Total Suspended Solids

Three total suspended solids (TSS) concentrations were collected at the time of biological monitoring. The TSS concentration at 13MN081 was 28 mg/L on June 10, 2013 and 47 mg/L on July 22, 2013. Station 13MN083 sample exceeded the standard at 86 mg/L on July 22, 2013. Additional water chemistry sampling occurred in 2009, 2015, and 2016 from April through September. Data from these collections ranged from 2.0 mg/L – 75 mg/L, with an average concentration of 29.97 mg/L. Two of the 14 samples collected exceeded the southern rivers standard of 65 mg/L. TSS concentrations that exceeded the standard were collected in summer months. Additional water chemistry data associated with this AUID was limited to one EQUIS station (S005-663), located downstream of the biomonitoring stations. All data collected would meet the respective standard, with the exception of one total suspended solid measurement of 86 mg/L.

Volatile suspended solids (VSS) was also analyzed within this reach to better understand the organics reflected in the TSS samples. It was found that organics on average accounted for 22% of what was found in the TSS samples. This is important to note, as it indicates that nearly a quarter of the TSS is made up of organics, likely as suspended algae.

The macroinvertebrate community is missing stoneflies (PlecopteraPct) and TSS intolerant taxa types and individuals. However, the other metrics known to respond to elevated TSS stress do not indicate stress (Table 13). The percentage of collector-filterers were quite high for this stream type, specifically reflected in the unusually high amount of black flies (simulium) that were sampled, skewing the metric scores. This filtering species is likely thriving from the high amount of organics that are being delivered to this section of stream, from the identified upstream eutrophic areas.

Table 13. Macroinvertebrate metrics that respond to high TSS stress in Cherry Creek (-543) compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

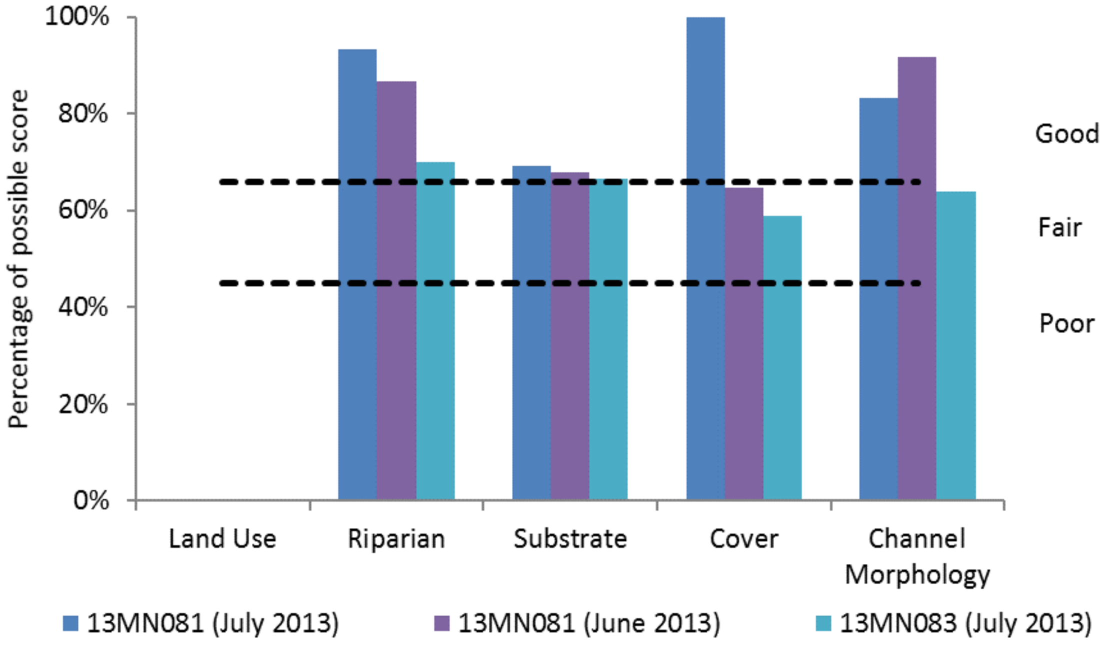
Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN081 (2013)	81.6	**0**	14.18	**0**	**0**	4	9.3
Southern Streams Average	*25.4*	*0.7*	*15.63*	*2.9*	*4.7*	*12.2*	*34.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

At this time, TSS is listed as an inconclusive biological stressor, yet should be mitigated wherever possible. While the biological metrics do not clearly reflect a TSS related impact to the community, the water chemistry samples do indicate some potential for TSS overloading issues. As there was only one biological collection site (13MN081) that was found to be assessable, the community from 13MN083 has an unknown community impact related to TSS.

Habitat

Station 13MN081 had good habitat scores on the MSHA of 79.9 and 75.3 (Figure 40). Station 13MN083 had a fair score of 61.45. Both stations are surrounded by row crop. Station 13MN081 had an extensive riparian width with little to moderate bank erosion. There was also a fair amount of diverse riverbed substrate. Good canopy was noted, providing both cover for habitat and shade. Aside from surrounding land use scores, physical habitat availability was consistently found at both monitoring locations within this reach of Cherry Creek.

Figure 40. Percentage of MSHA subcategory scores for stations 13MN081 and 13MN083, Cherry Creek.



As mentioned before, 80% of the macroinvertebrate community that was sampled at 13MN081 was black flies (Simulium), contributing to a higher than usual “clinger” score (Figure 41). The community from this site did fall below the average in each of the other habitat type groups. However, this is due from the dramatic skew in population of high “clingers”. It is also likely that this community was diminished from the low flow conditions. The streams full habitat abundance to be reflected in the community types was restricted by low flow conditions for this assessment.

Figure 41. Macroinvertebrate metrics that respond to habitat for station 13MN081, Cherry Creek, compared to the range of values for Southern Streams RR visits meeting the general use biocriteria.

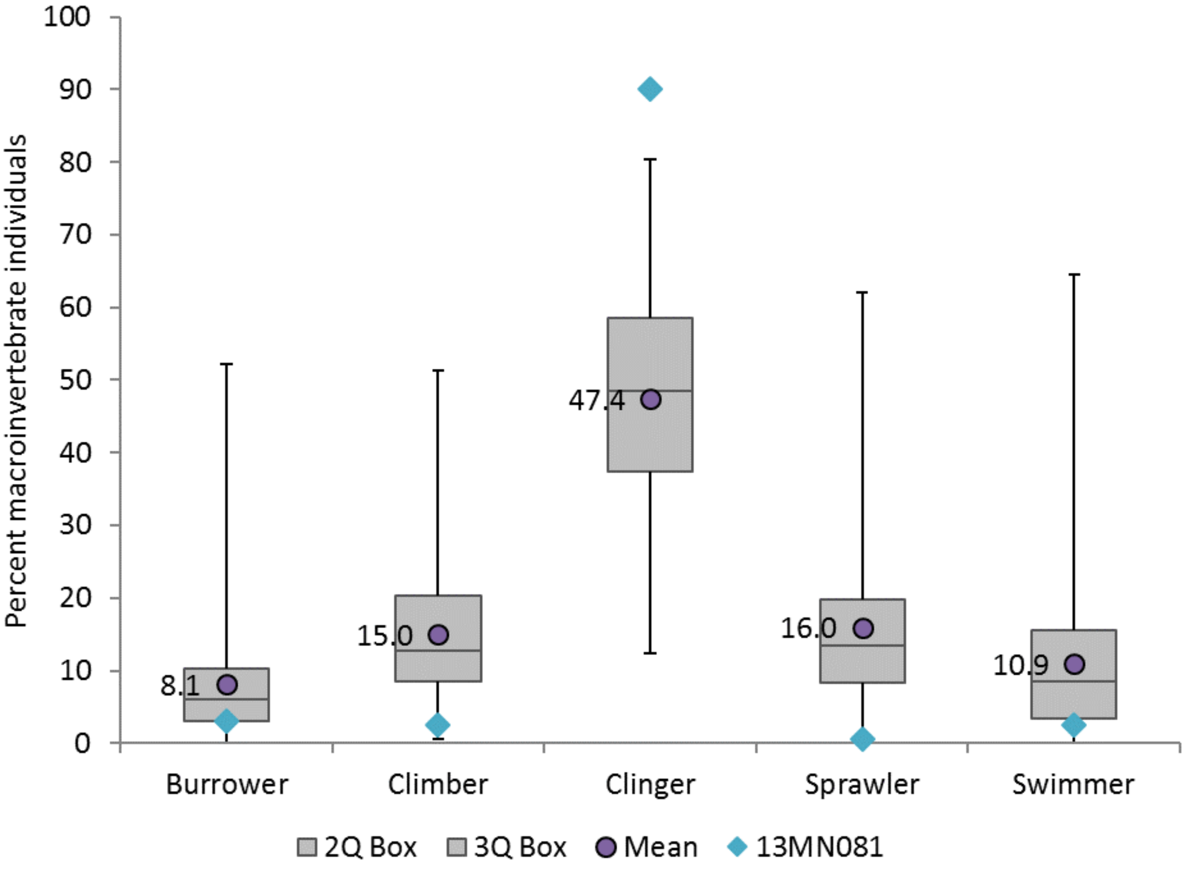


Figure 42. Station 13MN081 on June 10, 2013.

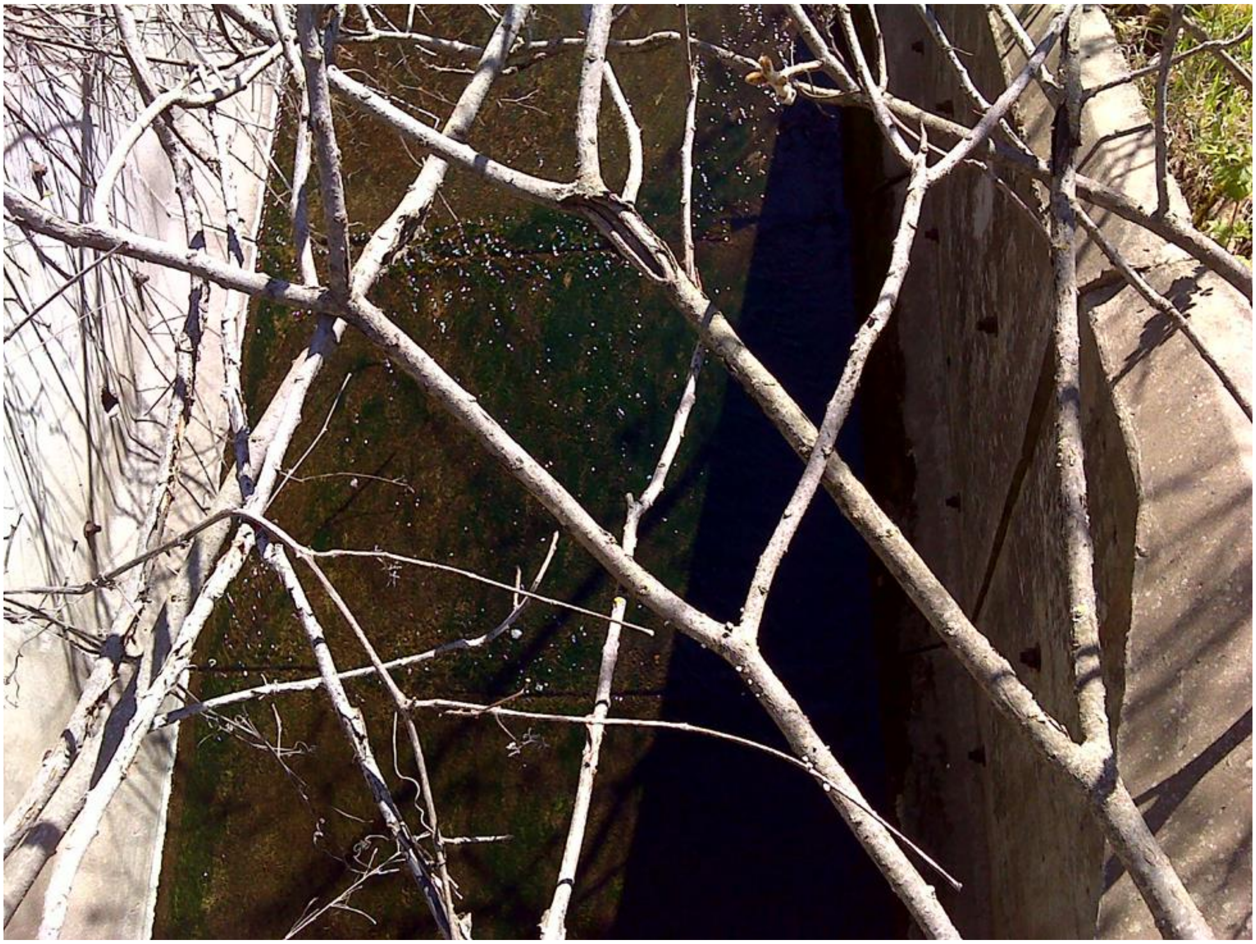
Habitat is not considered a biological stressor at this site. There was a wide variety of physical habitat to meet diverse biological needs. The substrate consisted of a mix of cobble and gravel in the riffle portions of the stream, with cobble and sand making up the runs, silt and cobble made up the pools in this reach. There was a healthy diversity of cover types to provide strong canopy cover refuge and shade (Figure 42), as well as rooted bank stability. The channel itself is fairly stable; the only problematic component is slight instability due to erosive potential.

Longitudinal Connectivity and Altered Hydrology

Longitudinal connectivity is not listed as a stressor in this reach. Longitudinal connectivity does not directly affect macroinvertebrate communities that are assessed by the MPCA (although they will hinder mussel migration, which are not assessed in the macroinvertebrate IBI score). Fish are the most impacted communities in regards to barriers. However, as the fish sample was not assessable within this reach, they are not factored into being a biological stressor. If the fish sample had been assessable, it is worth noting that all biological stations on Cherry Creek would have been found to be impacted by a dam downstream of Hwy 23. Additionally, at 321st Ave., where the culvert is misplaced and shallow (Figure 43). Both of these structures would limit longitudinal passage for fish and impact stream stability, along with hydrologic conditions (DNR 2015). For more information on the barriers and hydrological impacts to this subwatershed, please see DNR's Minnesota River, Mankato Watershed Characterization Report.

All four stations upstream of the dam, only two fish species observed (black bullhead and creek chub). Both of these species are Lake Species, from the upstream lakes and wetlands that provide fish replenishment.

Figure 43. Road culvert at 321st Ave. (April 27, 2015).



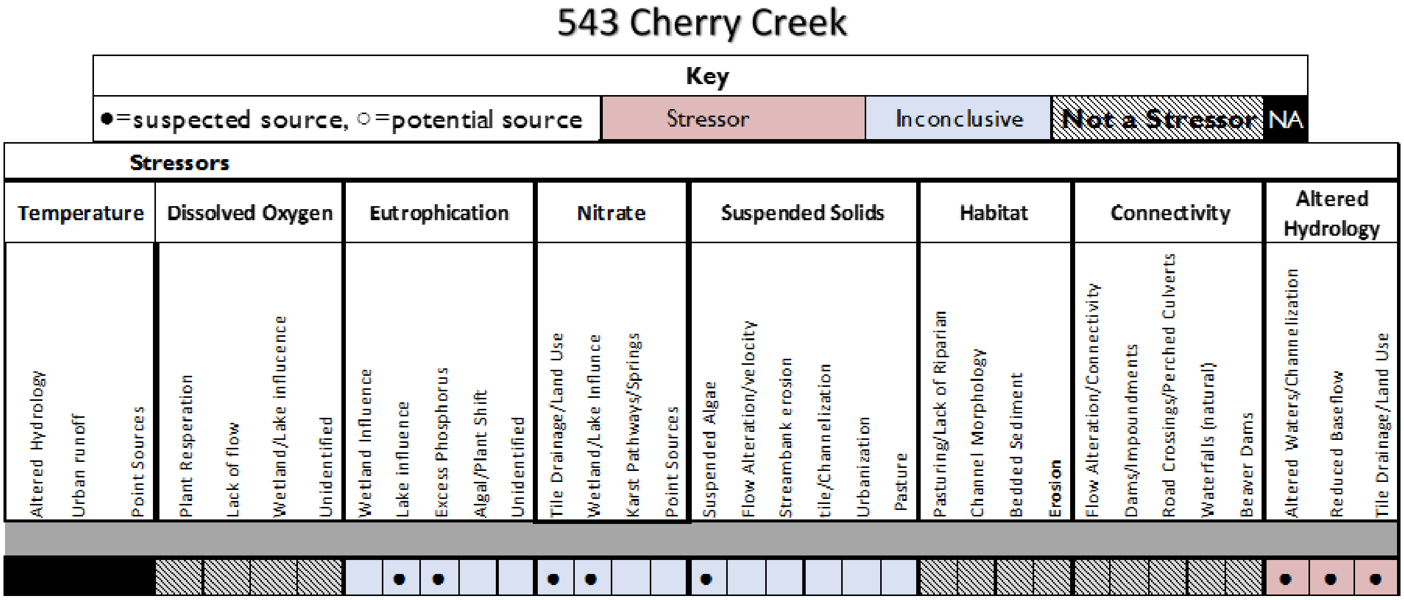
Altered Hydrology is thought to be the primary stressor within this reach, as it is directly or indirectly influencing the other parameters. The majority of the headwaters to this stream are altered by way of ditching and channelizing, as well as introduction of subsurface tile drainage. These modifications create dynamic alterations to the streams hydrology, creating changes to the geomorphology, as well as increases in pollutant loading. Altered hydrology is a foundational issue, and a contributor to all the impaired biological communities in the Minnesota River Mankato Watershed. For additional information on how these changes are occurring, refer to Chapter 3.1.8 of this report.

The location may be a naturally losing reach. At the time of macroinvertebrate sampling at station 13MN083 on July 22, 2013, the station was dry and could not be sampled. Again, on April 27, 2015 downstream at Hwy 23 the streambed was dry while upstream still had some flow (Figure 44). Cherry Creek would benefit from a hydrologic study to further understand the natural and anthropogenic factors affecting the hydrologic conditions within this system. Both fish and aquatic macroinvertebrates require water. The dry conditions that exist within this reach are stressing the biological communities within this lower portion of Cherry Creek.

Figure 44. Upstream of Hwy 23 (April 27, 2015).

Summary Table

Table 14. Identified stressors with suspected sources for reach 543 of Cherry Creek.



543 Cherry Creek

Key				
●=suspected source, ○=potential source	Stressor	Inconclusive	Not a Stressor	NA

Stressors																																		
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	**Erosion**	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls (natural)	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
■	■	■	▨	▨	▨	▨		●	●			●	●			●						▨	▨	▨	▨	▨	▨	▨	▨	▨	●	●	●

4.3 Shanaska Creek (07020007-693)

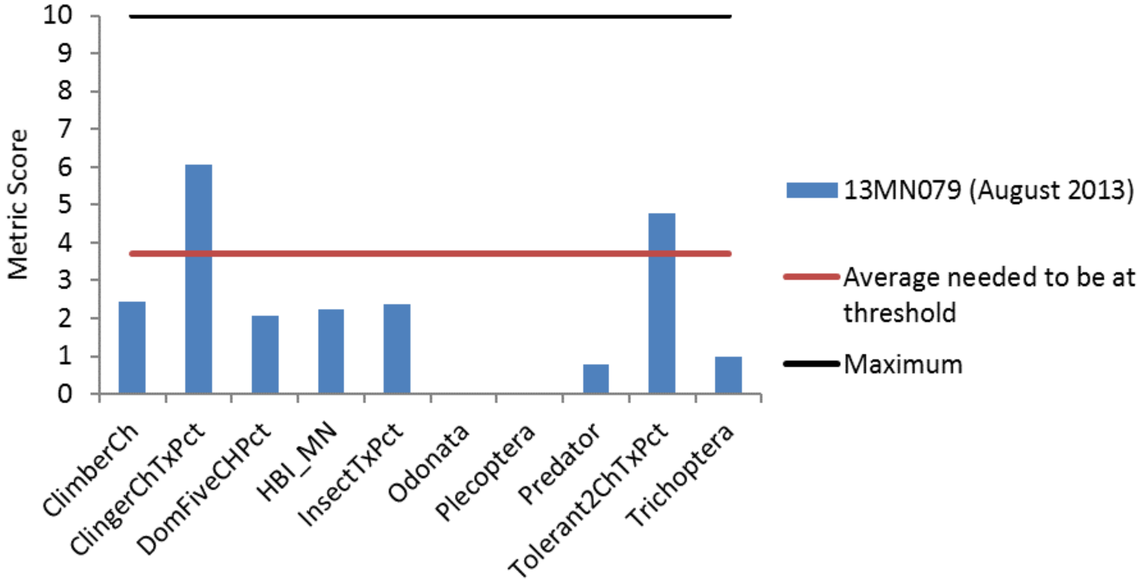
Shanaska Creek (07020007-693) is a tributary to the Minnesota River, near Kasota, Minnesota. This reach is warmwater general use Class 2B. The reach extends from Shanaska Cr. Rd. to the Minnesota River. The reach is impaired for lack of macroinvertebrate assemblage and lack of fish assemblage. This reach is also impaired for *E. coli*, which will not be addressed in this report.

4.3.1 Biological Communities

Station 13MN079 was sampled in 2013, for fish and macroinvertebrates. The fish IBI was zero in 2013, on the Southern Streams FIBI that has a threshold score of 37. The only fish found at this station were five common carp.

The macroinvertebrate IBI score of 22.7 was below the threshold of 37 for the Southern Streams RR class. The macroinvertebrate community was sparse and non-diverse. The most abundance taxa were non-biting midges (Polypedilum) and black fly larva (Simulium), and are responsible for driving up the percentage of "clinger" species (ClingerChTxPct) seen below in the metric table. Most of the IBI metrics were below the average metric score needed to have an IBI score at the threshold (Figure 45).

Figure 45. Macroinvertebrate metrics of the Southern Streams RR class for station 13MN079, Shanaska Creek.

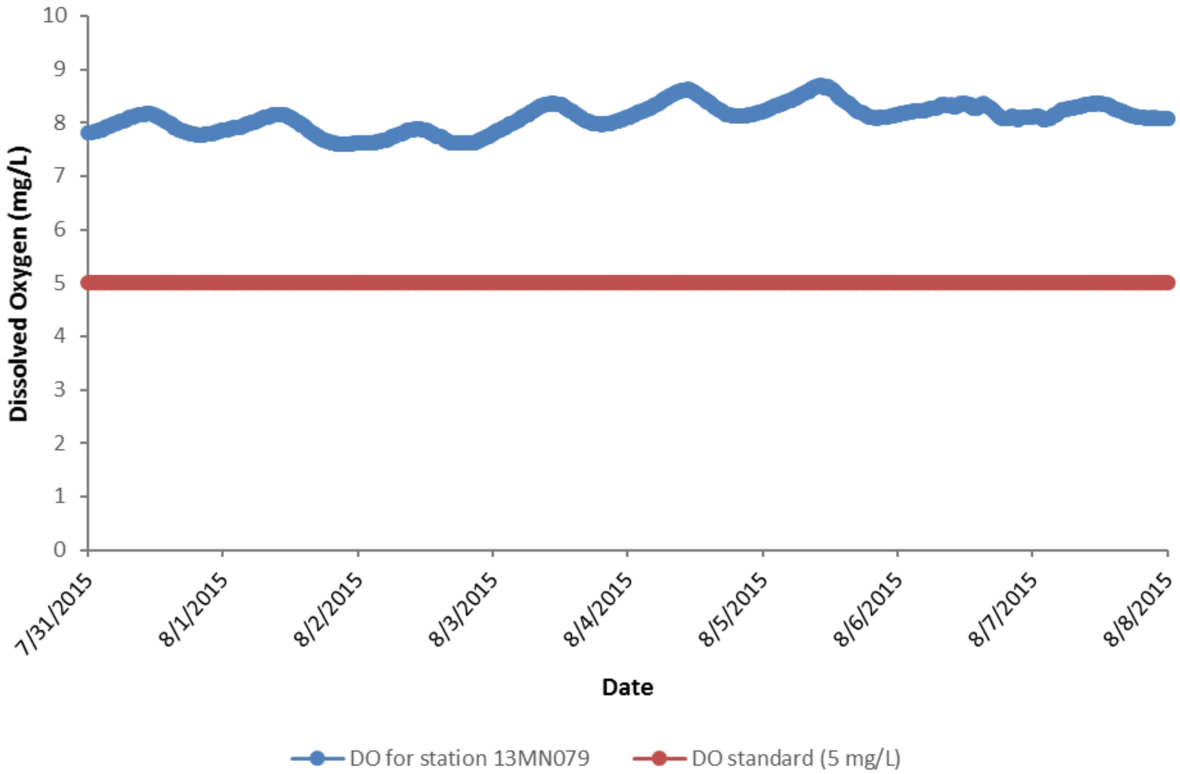


4.3.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

At the time of biological monitoring, station 13MN079 had a dissolved oxygen (DO) value of 8.61 taken on July 18, 2013. Only two additional instantaneous readings for DO concentrations were taken, one at 9 mg/L on June 23, 2015 and the other at 8.32 mg/L taken August 10, 2015. In 2015, a sonde was deployed at station 13MN079 from July 30 to August 10 (Figure 48). This displays continuous DO monitoring from July 31 through August 8 The DO ranged from 7.59mg/L to 8.69 mg/L, with DO 24 hour variation (flux) less than 1 mg/L, indicating DO stability within the stream. Values also were found to consistently stay above the DO standard of 5 mg/L.

Figure 46. Diurnal dissolved oxygen for station 13MN079.



The macroinvertebrate community had a low index score for low DO, as well as a low percentage of low DO intolerant individuals. There were also a low number of low DO tolerant taxa (Table 15). This is likely due to the low sample size of individuals present. The metrics that appear to respond to potential low DO stress are likely due to other stressors.

Table 15. Macroinvertebrate metrics that respond to low DO stress in Shanaska Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN079 (2013)	**28**	**6**	**7.59**	**6.77**	**6**	**9.3**	3	6.3
Southern Streams Average	*45.8*	*14.2*	*7.08*	*7.04*	*9.0*	*24.0*	*4.8*	*9.9*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

As the fish sample only consisted of five common carp, a species that is overall tolerant of a wide variety of parameters, metric response is not assessable on this reach.

DO is not considered to be a stressor at this time. Low DO is not reflected in the sonde data or within the other instantaneous DO readings. Chemistry data alone in this finding, as the community for fish and macroinvertebrates were skewed in there metric response. What was present, did display there is a presents of some low DO sensitive species; therefore the community is likely being limited by a different biological stressor.

Eutrophication

At the time of biological monitoring, station 13MN079 had a total phosphorus (TP) concentration of .131 mg/L, taken on July 18, 2013. Additional water chemistry samples were taken in 2009, 2010, and 2015. TP concentrations from these samples ranged from .031 mg/L - .302 mg/L providing an average concentration of .120 mg/L. 11 of the 22 samples (50%) exceeded the river eutrophication TP standard for the Central Region (0.1 mg/L). All but one of the 2009 samples fell below the standard of .1 mg/L. In all three years data analysis shows the highest concentrations occurring June through August. On August 10, 2015 chlorophyll-a (chl-a) was elevated at downstream station S008-527 (25.6 µg/L) and upstream station S008-526 (24.8 µg/L).

In 2015, a sonde was deployed at station 13MN079 from July 30 to August 10. DO ranged from 7.59 to 8.69 mg/L, with 24-hour DO fluxuation (DO flux) varying less than 1 mg/L. DO never fell below the standard of 5 mg/L.

The macroinvertebrate community was suggestive of possible eutrophication stress (Table 16). Nearly all of the metrics that respond to possible eutrophication were less than the average of similar stations meeting the biocriteria. Species' richness (TaxaCountAllChir) was almost half of what would be expected for a stream of this type. Relative abundance of Ephemeroptera, Plecoptera & Trichoptera individuals was also lacking, but not completely absent. Collector filter-gatherer species also were diminished, but not completely missing, as some of the more tolerant filtering and gathering species can thrive in eutrophic settings. The percentage of tolerant taxa was very close to the average of similar stations meeting the biocriteria, while there were not any intolerant species noted in the sample.

Table 16. Macroinvertebrate metrics that respond to eutrophication stress in Shanaska Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN079 (2013)	**28**	**5**	**9**	**6**	**0**	71.4
Southern Streams Average	*45.8*	*7.3*	*15.9*	*12.2*	*0.8*	*72.6*
Expected response to stress	↓	↓	↓	↓	↓	↑

There were only five common carp surveyed at the time of biological sampling at 13MN079. It is difficult to use metrics to analyze potential stress when only one taxon was found. Common carp are tolerant and live in conditions with elevated eutrophication.

Eutrophication is inconclusive as a stressor in this AUID. Phosphorus in this stream is high, and with it carries potential for eutrophic conditions. However, the DO data is limited and what was captured did not display a strong response of over production of autotrophic density. There was one high sample of chl-a and one that fell below the threshold, with these being the only chl-a samples and without any BOD sampling it cannot be identified one way or another if the eutrophic signals that are present are occurring within this reach, or if high concentrations of organic matter are being flushed through from an upstream source.

Nitrate

During biological monitoring, the nitrate concentration at 13MN079 was 6.8 mg/L on July 18, 2013. There were 22 additional samples taken within this reach over the years of 2009, 2010 and 2015 from the months of April through September. The nitrate concentration ranged from .28 mg/L – 27.9 mg/L. The average concentration was 6.40 mg/L, with four of the 22 samples above 10 mg/L. High nitrate loading occurrences peaked in June in all three years.

Fish often do not show a strong response to increased nitrate concentrations. Macroinvertebrate communities are often more affected by nitrate. The macroinvertebrates in this reach show they are stressed by the elevated nitrate concentrations. The macroinvertebrates in this reach had a nitrate index score that was at 3.2, this is higher than the southern streams average of 2.9 (Table 17). The nitrate specific metrics show lower than average Trichoptera taxa (TrichopteraCh), in non-hydropsychid Trichoptera individual percentages (sensitive caddisflies that do not spin nets; TrichwoHydroPct). This reveals that the population of Trichoptera are made up of nitrate tolerant net-spinning caddisfly's. Nitrate intolerant species were absent, while nitrate tolerant species dominated the sample. The only parameter that did not go over the threshold was the individual nitrate tolerant count; this is likely due to the low sample size.

Table 17. Macroinvertebrate metrics that respond to nitrate stress in Shanaska Creek compared to the statewide average of visits meeting the warmwater general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN079 (2013)	**3**	**0**	**3.2**	**0**	16	**62.0**
Southern Streams Average	6.3	5.5	2.9	2.4	18.8	47.2
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is considered a biological stressor to this reach. The chemistry data shows frequent exceedances of nitrate, paired with a macroinvertebrate community that lacks in nitrate sensitive taxa; in place made up of nitrate tolerant species. High nitrate concentrations are correlated to land application of nutrients and rain events flushing them through the system. With a number of wetland and lakes near the headwaters, some mitigation of nitrate is noted in the data and the low concentrations throughout most of the year.

Total Suspended Solids

Total Suspended Solids (TSS) had the largest data collection available for this reach, with 24 samples. Of those, four samples (collected in June 2010) exceeded the regional south standard of 65 mg/L. While a majority of the chemistry data had samples that fell far below the standard, there was some indication that high TSS loading does occur throughout this reach. Volatile suspended solids (VSS) were limited. However, there were a few taken at the time TSS was high, and displayed about a quarter of the total TSS concentration. High TSS and VSS were both correlated to rain events. It is likely that organics and sediment are being flushed through the system from an upstream source. Erosion is minimal within this portion of the stream system, due to the healthy riparian and stream stability found within this reach.

Chronic TSS often is associated to loss of habitat, primarily within the streambed. This reach was noted to have clean and diverse substrate with no embeddedness. TSS that is coming through this reach is not settling out here in abnormal rates.

The macroinvertebrate community exhibited mixed response to TSS stress (Table 18). There was an abundance of collector-filterer individuals than what is typically seen in this stream type. Often times this community type will be hit the hardest by chronic TSS, as it inhibits filtering. Plecoptera (PlecopteraPct) was found to be completely absent. This species is sensitive to a number of pollutants so is not a strong indicator for TSS alone, and is likely abolished from the high presents of nitrates. The macroinvertebrate TSS index score was lower than the average TSS Index for this stream type; as this score increases, it reflects the tolerance of TSS noted in the community. Both TSS intolerant and tolerant species were found to be below the average for this stream type. TSS tolerant species did make up a higher percentage of the total sample; this is likely due to the overall low sample size.

Table 18. Macroinvertebrate metrics that respond to high TSS stress in Shanaska Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN079 (2013)	26.3	**0**	14.23	**1**	**0.7**	7	**42.7**
Southern Streams Average	*25.4*	*0.7*	*15.63*	*2.9*	*4.7*	*12.2*	*34.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

The fish metrics are not helpful for analyzing impacts on the fish community, due to the poor sample size and lack of diversity. There were only five fish sampled, all being Common Carp (a general tolerant fish).

TSS as a biological stressor is inconclusive. Elevated TSS has been documented, but the macroinvertebrate community did not indicate that TSS is limiting the community. The fish community is exceptionally limited, as there was only five fish sampled, all of a generally tolerant species; due to this, it is difficult to determine what parameter(s) may be limiting the fish population.

Habitat

At station 13MN079, habitat was good with a MSHA score of 82.5 (Figure 47). The station is situated in an urban park type area with the left side having a wide riparian width; the right side is fairly narrow. There was no bank erosion and heavy shade provided by the strong canopy cover in this reach (Figure 48). The stream was predominantly comprised of riffle features with cobble and boulder substrate dominating. There was no embeddedness noted. This portion of stream, was found to have high channel stability.

Figure 47. Percentage of MSHA subcategory scores for station 13MN079, Shanaska Creek.

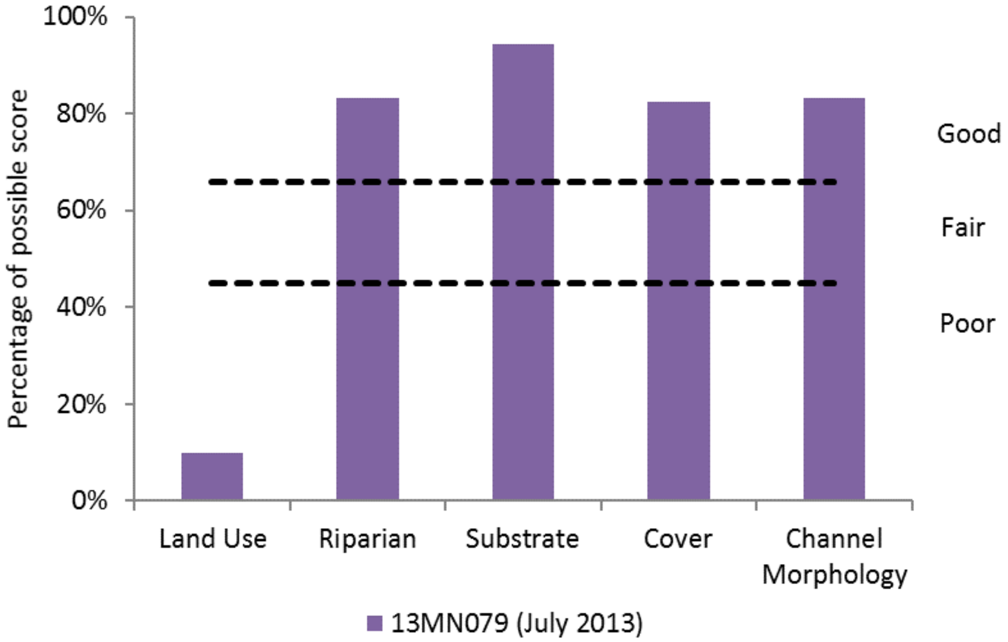


Figure 48. Macroinvertebrate metrics that respond to habitat for station 13MN079, Shanaska Creek, compared to the range of values for Southern Streams RR visits meeting the general use biocriteria.

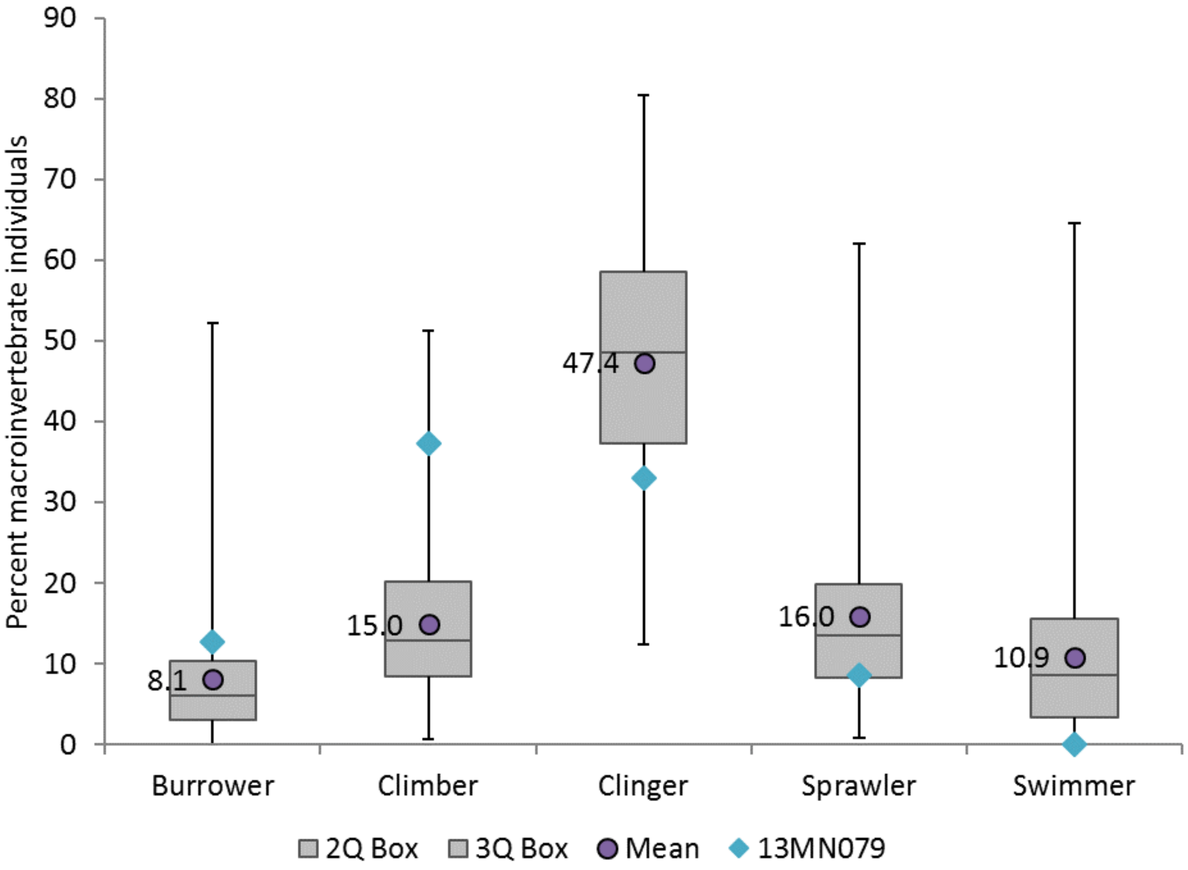


Figure 49. Station 13MN079, July 18, 2013.

Adequate habitat is present in this reach. This section of stream was found to have extensive cover, minimal bank erosion, and coarse substrate. These stream features support both habitat quality as well as diversity. Habitat is not a biological stressor in this portion of Shanaska Creek.

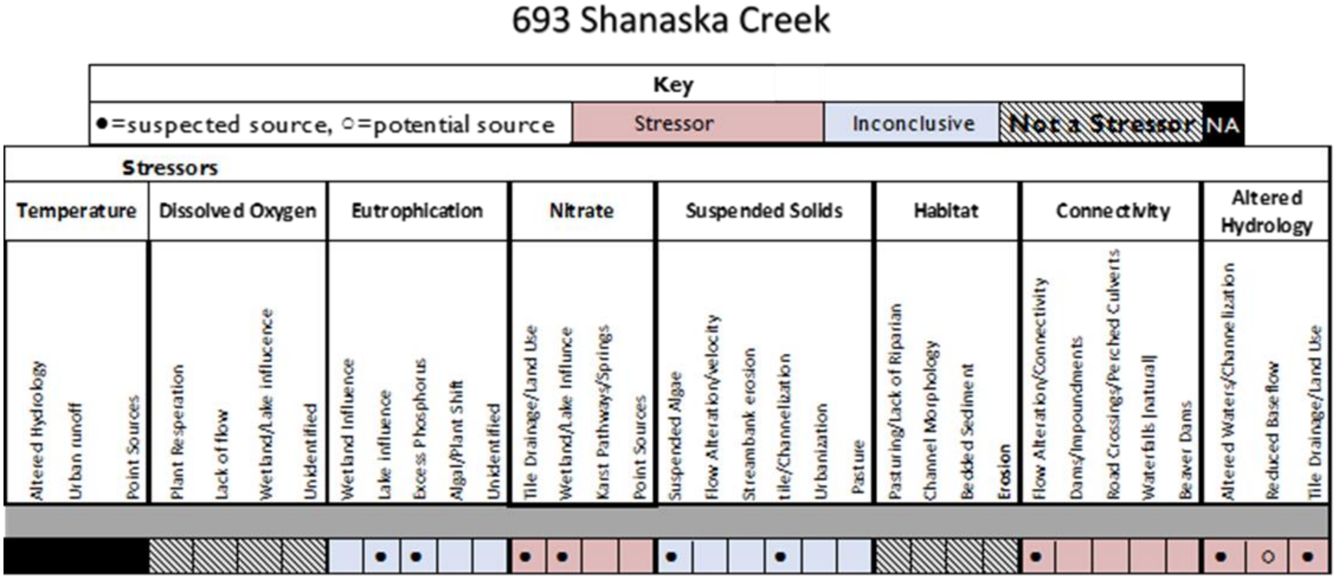
Longitudinal Connectivity and Altered Hydrology

Longitudinal connectivity is a stressor within this reach. One barrier that is limiting the fish population is a manmade structure with an approximate 5-foot drop, located less than a mile from the confluence of the Minnesota River. This barrier restricts migration ability. For more information on the barrier, please see DNR's Minnesota River, Mankato Watershed Characterization Report (2015). There are two stations upstream of the barrier and no comparison stations downstream. There were nine fish species at the upstream biological monitoring station 13MN077, but only one at station 13MN079. There are a number of impaired lakes and small wetlands that do drain into this reach. Lake Washington is one of the primary waterbody's, yet is impaired for nutrients. Due to the degraded water quality of lakes, refuge is limited to tolerant taxa types.

Altered hydrology is the primary stressor contributing to the biological impairment. According to the DNR's watershed report, this area is classified as channelization being less prevalent in the watershed with 24 - 35% identified as channelized. While there are more natural channels found in this subwatershed compared to most in the greater watershed area, this section of stream is still being impacted by upstream altered hydrology. Most of the headwaters that drain into this reach are altered by way of ditching, channelizing, as well as the incorporation of subsurface tile drainage. Paired with the dominant land use of agriculture, these alterations of the flow influence the streams hydrology, geomorphology, and pollutant loading capacity. For this reach, the strong stream riparian supports the stability of the channel; protecting it from increased velocities from these forms of drainage practices. Over time, this could change if the streams riparian becomes compromised. The primary impact in this reach from altered hydrology is seen from the pollutant overloading of TP and nitrate, and also TSS (following intense rain events). With 22 lakes and wetlands within this subwatershed, there is also a strong lake to stream influence that contribute to water quality. However, it is important to note the lakes in this area also degraded as they are also being influenced from the surrounding agricultural practices and contributions of subsurface tile drainage.

Summary Table

Table 19. Identified stressors with suspected sources for reach 693 of Shanaska Creek.



693 Shanaska Creek

Key				
●=suspected source, ○=potential source	🟥 Stressor	🟦 Inconclusive	▨ Not a Stressor	■ NA

Stressors																																			
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
■	■	■	▨	▨	▨	▨	🟦	🟦 ●	🟦 ●	🟦	🟦	🟥 ●	🟥 ●	🟥	🟥	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	▨	▨	▨	▨	🟥 ●	🟥	🟥	🟥	🟥	🟥 ●	🟥 ○	🟥 ●

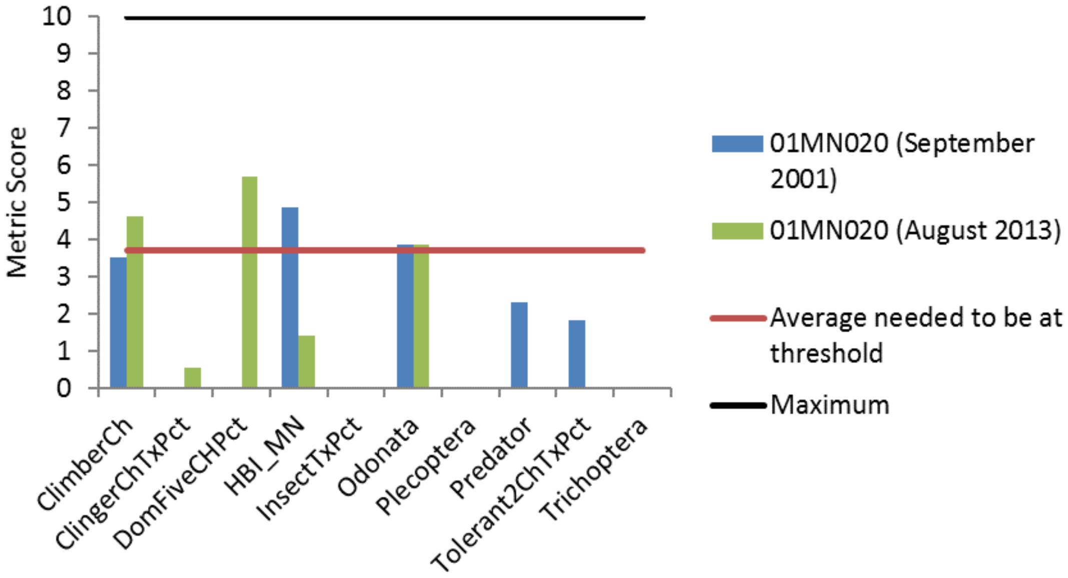
4.4 Unnamed Creek (07020007-696)

Unnamed Creek (07020007-696) is a small tributary northwest of the Mankato Regional Airport. The small stream drains from Wita Lake. The reach is warmwater modified use Class 2B. The reach extends from approximately 243rd St. to 0.4 mi. downstream of 240th St. The reach is impaired for lack of macroinvertebrate assemblage and lack of fish assemblage.

4.4.1 Biological Communities

Station 01MN020 was sampled for fish and macroinvertebrates in 2001 and 2013. Both years the fish community scored a zero FIBI on the Southern Headwaters class IBI. In 2001, the fish community consisted of green sunfish (4), golden shiner (2), and black bullhead (1). In 2013, the only fish surveyed was one creek chub. The macroinvertebrate community scored low both years on the Southern Streams RR class IBI. In 2001, the MIBI was 16.5 and in 2013, it was 16.1. The modified use threshold for this Class is 24. In 2001, the dominant taxon was worms (Oligochaeta). In 2013, non-biting midges (Polypedilum) and mayflies (Baetis) were the most abundant in the sample. Many of the metrics were below the average metric score needed for the IBI to be at the modified use threshold. Those that scored zero both visits were relative percentage of insect taxa (InsectTxPct), taxa richness of Plecoptera (Plecoptera), and taxa richness of Trichoptera (Trichoptera) (Figure 50).

Figure 50. Macroinvertebrate metrics of the Southern Streams RR class for station 01MN020, Unnamed Creek.



4.4.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

At the time of biological monitoring DO data was recorded at 6.6 mg/L (July 10, 2001), 7.71 mg/L (August 8, 2013), and 12.78 mg/L on July 13, 2013. Station 01MN020 had six instantaneous samples taken in 2015 with DO concentrations ranging from 4.76 mg/L – 10.95 mg/L. The average from this sample set of 6.64 mg/l reflects most of the samples collected fell close to the threshold of 5 mg/L. In 2015, a sonde was deployed at station 01MN020 from July 30 to August 10 (Figure 51). The DO ranged from 0.02 to 8.13 mg/L. DO flux was generally low with an average of 2.24 mg/L (Figure 52). The only days above 4.5 mg/L DO flux were the days that transitioned to that very low DO period. At the time of limited DO, it is likely there was not any flow within this reach, until it spiked on August 7, where there was a rain event that gave this reach flow.

Figure 51. Diurnal dissolved oxygen for station 01MN020, July 30 – August 10, 2015.

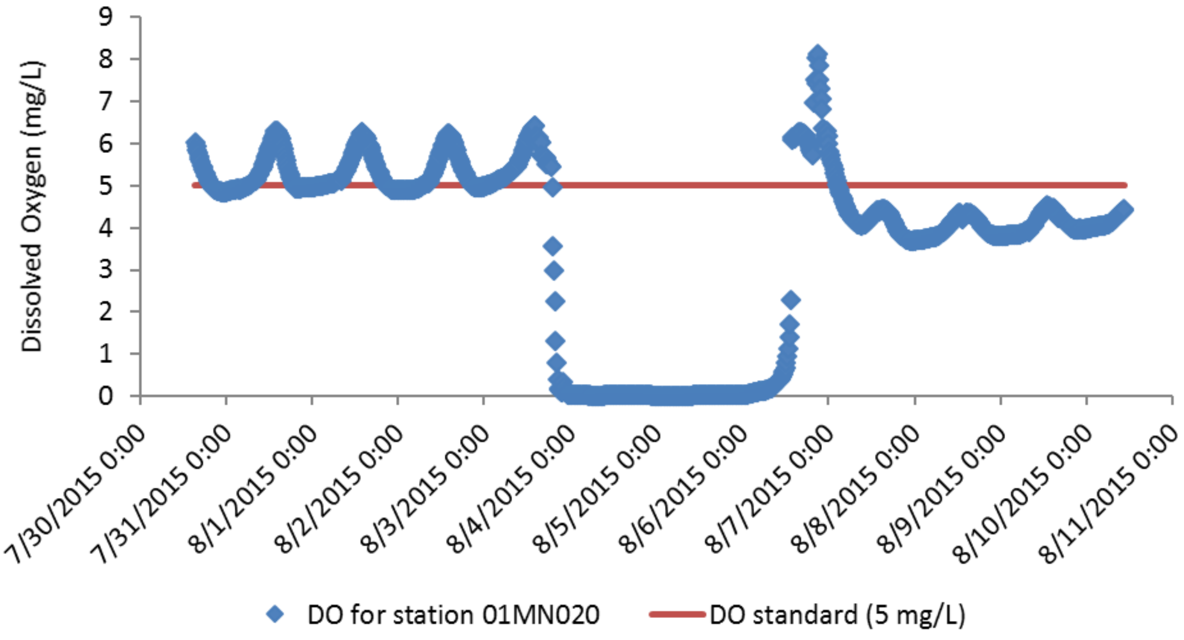
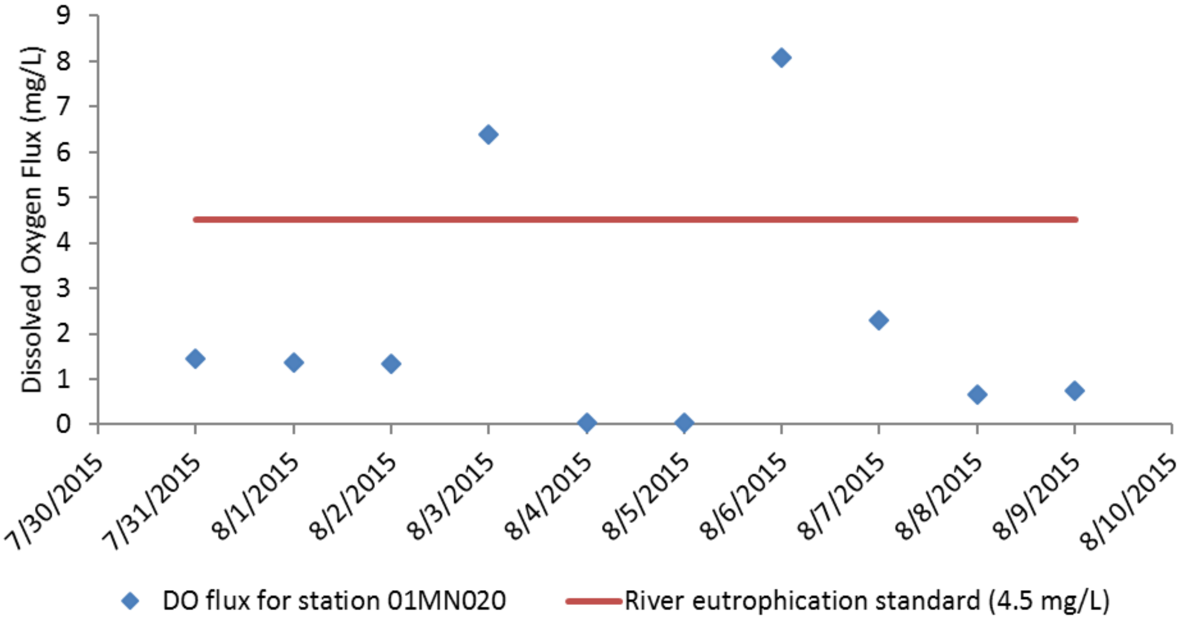


Figure 52. Dissolved oxygen flux at station 01MN020, July 31- August 9, 2015.



The macroinvertebrate community in Unnamed Creek was suggestive of possible low DO stress both in 2001 and in 2013. Both visits had lower than average DO intolerant taxa and elevated presence of low DO tolerant taxa (Table 20). In both years the low DO index score was below the threshold of 6.97, the state average score for modified southern streams.

Table 20. Macroinvertebrate metrics that respond to low DO stress in Unnamed Creek compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
01MN020 (2001)	**26**	**4**	6.70	**2.94**	**2**	**1.2**	**8**	**22.1**
01MN020 (2013)	**28**	**1**	**7.87**	**6.61**	**2**	**19.3**	**8**	**14.4**
Southern Streams Average	*41.5*	*12.1*	*7.31*	*6.97*	*7.0*	*20.3*	*5.0*	*11.3*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

The fish metrics within this reach are not very telling, as there was a low sample size of fish and they were all generally tolerant species. There was a lack of sensitive species and specifically tolerant to low DO species. There was also an absence of mature fish over the age of three sampled (.MA>3Pct) as shown in Table 21.

Table 21. Fish metrics that respond to low DO stress in Unnamed Creek compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
01MN020 (2001)	**0**	**0**	**71.43**	6.26	**0**	**0**	3	1
01MN020 (2013)	**0**	**0**	**100**	7.25	**0**	**0**	0	0
Southern Streams Average	*16.9*	*24.6*	*44.9*	*7.2*	*1.7*	*6.1*	*4.7*	*18.5*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is considered a biological stressor. Chemistry data displays recurrent low DO within this reach. Likely correlated to upstream and potential instream eutrophic conditions, as well as low flow conditions during late summer months. Biological metrics indicate that low DO is likely limiting the macroinvertebrate community. As the fish sample was limited to a few general tolerant species, parameter metrics will not be helpful in clearly identifying if it is a limiting factor.

Eutrophication

During biological monitoring three total phosphorus (TP), samples were collected. Station 01MN020 had a TP concentration of .186 mg/L on July 10, 2001, at .19 mg/L on August 8, 2013, and .038 mg/L on June 13, 2013. Nine additional water chemistry samples were taken in 2015 and 2016. TP concentrations ranged from .03 mg/L - .278 mg/L giving an average of .121 mg/L. Three of the nine additional samples exceeded the river eutrophication TP standard for the South Region of 0.15 mg/L.

There were also two chlorophyll-a (chl-a) samples collected within this reach. On September 2, 2015 chl-a at station S008-557 was 16.4 µg/L and on August 10, 2015 a chl-a sample of 2.18 µg/L was collected. This suggests suspended algae is not in excess within this reach at the times sampled. However, the volatile suspended solids (VSS) to total suspended solids (TSS) ratio does indicate that organic matter accounts for nearly 40% of what is found in TSS samples. This could be from high inputs of suspended algae from upstream sources.

Wita Lake feeds into this location and listed as Hypereutrophic. Wita Lake was assessed on the shallow lake standard using data from 2013 and 2014; all three-lake eutrophication parameters severely exceed standards across both years revealing a persistent pattern of high TP concentrations and frequent heavy algae blooms, which will result in a new aquatic recreation use impairment listing. For more information on Wita Lake assessment, see the 2016 Minnesota River – Mankato Watershed Monitoring and Assessment Report.

The macroinvertebrates are suggestive of possible elevated eutrophication stress. There were fewer collector-filterer and collector-gatherer taxa, with a high percentage of tolerant taxa in the samples (Table 22).

Table 22. Macroinvertebrate metrics that respond to eutrophication stress in Unnamed Creek compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
01MN020 (2001)	**27**	**5**	**11**	**4**	**0**	**85.2**
01MN020 (2013)	**28**	**2**	**9**	**1**	**0**	**96.4**
Southern Streams Average	*41.5*	*6.7*	*14.8*	*10.4*	*0.5*	*77.7*
Expected response to stress	↓	↓	↓	↓	↓	↑

The fish community could be interpreted as being limited to eutrophic stress, particularly noted in the absents of darters (DarterPct) and simple lithophilic spawners SlLithopPct). There were very few fish present and what was found was tolerant. As mentioned in previous sections, the low fish sample was made up of generally tolerant fish. (Table 23).

Table 23. Fish metrics that respond to eutrophication stress in Unnamed Creek compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
01MN020 (2001)	**0**	**0**	**0**	71.4	**3**	**0**
01MN020 (2013)	**0**	**0**	**0**	**100**	**1**	**0**
Southern Headwaters Average	*4.5*	*8.5*	*27.9*	*79.9*	*10.4*	*0.8*
Expected response to stress	↓	↓	↓	↑	↓	↓

Eutrophication is inconclusive as a biological stressor. The chemical data available does show eutrophic signals, such as frequent high numbers of phosphorus and low DO. However, 24 hour DO fluxuation and consistent high concentrations of chl-a are lacking to determine chronic eutrophic conditions. Furthermore, it is likely that the biology is being impacted from the eutrophic Wita Lake, and mitigation efforts should be focused there to decrease impacts to this downstream community. Additional monitoring is needed to rule out or confirm if eutrophic growth is occurring within this reach.

Nitrate

During biological sampling, the nitrate concentration at 01MN020 was .54 mg/L on July 11, 2001, 10 mg/L on June 13, 2013, and 2.1 mg/L on August 8, 2013. There were nine additional water quality samples taken in 2015 and 2016 from April through September. The nitrate concentrations ranged from 7.7 mg/L – 25 mg/L. The average concentration was 13.28 mg/L.

The macroinvertebrate nitrate metrics vary between the two sampling years (Table 24). In 2001 the nitrate index score fell far below the modified use southern streams average of 3.0, while in 2013 the score was 3.9; The higher the nitrate index score the more suggestive the nitrate impairment is for the macroinvertebrate community. 2001 did not display a dominance of tolerant species and had one intolerant taxa present. Whereas the 2013 sample was, dominate of nitrogen tolerant species and completely lacking in any intolerant taxa. These metrics also display a clear correlation with the chemistry taken at the time of biological sampling as the 2001-nitrate sample was at .54 mg/L and 2013 was significantly higher at 10 mg/L. Both years had a lack of caddisflies (TrichopteraCh) particularly noted in specific nitrate sensitive non-hydropsychidae Trichoptera, these are sensitive caddisflies that do not spin nets (TrichwoHydroPct).

Table 24. Macroinvertebrate metrics that respond to nitrate stress in the unnamed creek compared to the statewide average of visits meeting the warmwater modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
01MN020 (2001)	**1**	**0**	1.3	**1**	9	19.1
01MN020 (2013)	**0**	**0**	**3.9**	**0**	**21**	**80.7**
*Southern Streams Average **(MU)***	*5.4*	*4.3*	*3.0*	*1.6*	*18.5*	*52.7*
Expected response to stress	↓	↓	↑	↓	↑	↑

Fish communities often do not show strong response to increased nitrate concentrations, therefore, there is not a metric table to measure the fish community's response to nitrate in this report.

Nitrate is considered a biological stressor. While there are two separate monitoring years reflecting different community impacts of nitrate, the overall chemistry data does show frequent nitrate overloading. The 2001 sampling was not suggestive of this being a primary stressor; yet 2013 biological monitoring did show a direct response.

Total Suspended Solids

Three total suspended solids (TSS) concentrations were collected at the time of biological monitoring. The TSS concentration at 01MN020 was 22 mg/L on July 10, 2001, 11 mg/L on June 13, 2013, and 9.6 mg/L on August 8, 2013. Ten additional water chemistry samples were collected in 2015 and 2016 from April through September; these concentrations ranged from 2.8 mg/L – 99 mg/L, with an average of 31.54 mg/L. Only one of the ten samples collected exceeded the standard of 65 mg/L. The TSS sample of 99 mg/L was correlated to a nearly 2-inch rain event.

The macroinvertebrate metric scores were not strongly reflective of TSS driven community displacement, rather it is reflecting a generally tolerant community (Table 25). Both years the TSS index score was below the threshold of 15.89, scoring only 7.21 in 2001, and 14.66 in 2013; as this score increases, so does the tolerance of TSS noted in the community. Both years had a poor collector filtering community, and there was an absents of pollutant sensitive stonefly's (PlecopteraPct). These groups could be limited from another stressor such as nitrate within this reach. There was a lack of both TSS tolerant and intolerant species, which indicates another stressor is limiting the community.

Table 25. Macroinvertebrate metrics that respond to high TSS stress in Unnamed Creek compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
01MN020 (2001)	**7.6**	**0**	7.21	**1**	4.2	9	12.5
01MN020 (2013)	**10.5**	**0**	14.66	**0**	**0**	7	31.5
Southern Streams Average	*26.4*	*0.4*	*15.89*	*1.8*	*2.9*	*11.3*	*36.9*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

Due to the small fish sample size and lack of diversity of taxa collected at this site, metrics are not going to be useful in identifying specific stressors at this site. These measurements are still available to review in Table 26 and Table 27.

Table 26. Fish metrics that respond to high TSS stress in Unnamed Creek compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
01MN020 (2001)	**0**	**0**	28.6	**0**	**0**	**0**	**0**	**0**	**0**
01MN020 (2013)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Southern Headwaters Average	*27.3*	*0.7*	*17.8*	*0.8*	*4.3*	*10.3*	*19.9*	*4.5*	*12.0*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 27. Fish metrics that respond to high TSS stress in Unnamed Creek compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TSS Index Score	TSS Sensitive Taxa	TSS Sensitive Pct	TSS Tolerant Taxa	TSS Tolerant Pct
01MN020 (2001)	**22.2**	**0**	**0**	0	0
01MN020 (2013)	**16.3**	**0**	**0**	0	0
Southern Headwaters Average	*16.2*	*0.5*	*2.9*	*0.5*	*2.5*
Expected response to stress	↑	↓	↓	↑	↑

TSS is not considered to be a stressor. There was one moderately high TSS reading that was measured after a significant rain event. Considering the rain intensity that correlates to the high TSS reading, it would appear this is not an unusual amount; even in the most stable of systems there would be a similar response. Within the biological metrics, there was little indication to show the TSS was limiting the macroinvertebrates. Due to the limited diversity and sample size in the fish sample metrics are not a reliable indicator for TSS stress limiting the fish community.

Habitat

Station 01MN020 had poor habitat each of the three visits that the MSHA was conducted, 39.2 on July 2001, 36.75 in June 2013, and 42 in August of 2013 (Figure 53). The riparian width was narrow to very narrow during the visits (Figure 54). Generally, there was little to no bank erosion, except in 2001, the right bank had severe erosion. The shade was moderate to substantial. Run features dominated the reach. There was the presence of riffle features in 2001, but none in 2013. Similarly, in 2001, there was greater than four substrate types available, which was not the case in 2013. Throughout there was moderate embeddedness, with moderate to sparse cover available. Channel stability as low with poor sinuosity in 2001. By 2013, there was moderate-high stability although similar characteristics to the 2001 visit for the other metrics of channel morphology.

Figure 53. Percentage of MSHA subcategory scores for station 01MN020, Unnamed Creek.

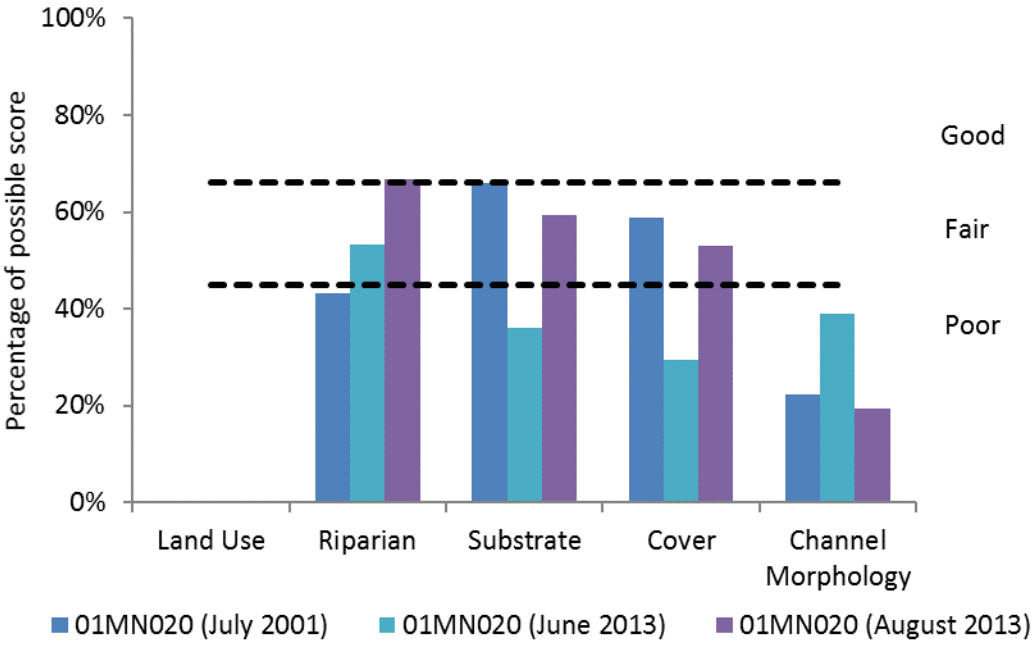
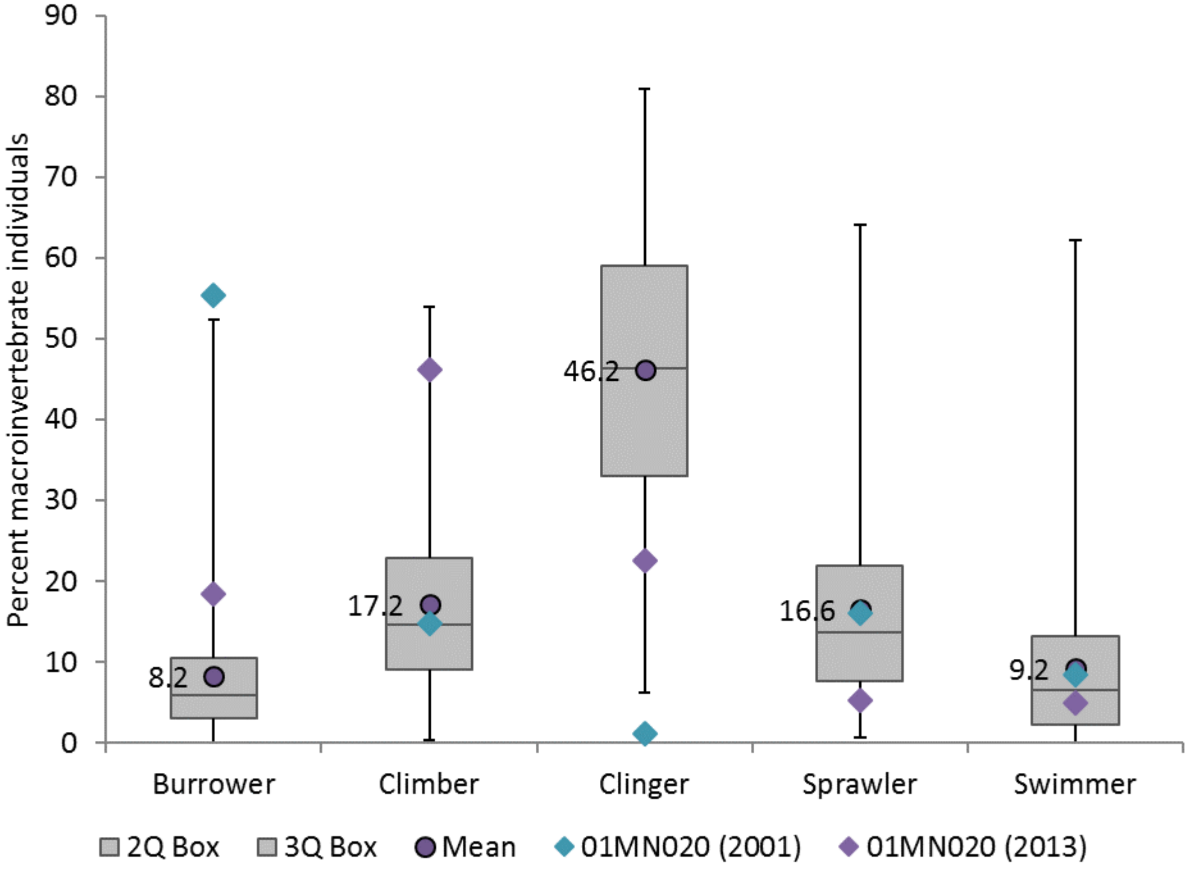


Figure 54. Station 01MN020, May 19, 2015.

In Figure 55, the macroinvertebrate community found within this reach exhibited clear habitat displacement in 2001; in this year, burrowers dominated the sample. High percentage of burrowers indicate a homogenous streambed that is embedded. This also coincides with MSHA findings for habitat in 2001. In 2013, the population was slightly more distributed between the habitat group types, yet still indicated some community imbalance, as there were slightly more burrower types in the place of clingers. In both years, the macroinvertebrate habitat types indicate a streambed issue.

Figure 55. Macroinvertebrate metrics that respond to habitat for station 01MN020, Unnamed Creek compared to the range of values for Southern Streams RR visits meeting the general use biocriteria.



Habitat is considered a stressor. The MSHA scored poor with physical habitat within and around the stream being altered and limited to support species diversity. The macroinvertebrate groups are also suggestive of habitat displacement within the streambed with a high percentage of burrows, who prefer soft sediments, and a lack of clinger species likely reduced due to the lack of riffles.

Longitudinal Connectivity and Altered Hydrology

From this site, to the confluence into the Minnesota River, there are at least two perched culverts that are influencing longitudinal connectivity and migration for fish. There was also an observed absence of migration species, whereas they had been present at the downstream station of 03MN072 (Table 28).

Table 28. Migration Metrics downstream to the upstream station of 01MN020. MgrTxPct is the abundance of migratory taxa within the fish sample; MgrPct is the abundance of migratory species within the fish sample.

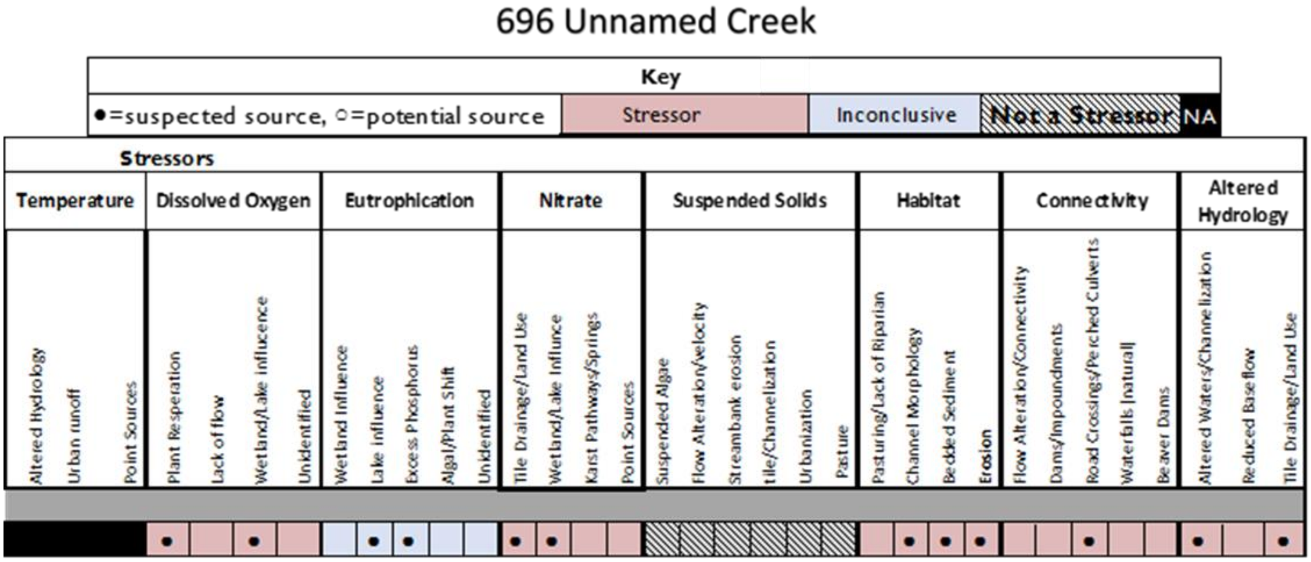
Station (Year Sampled)	MgrTxPct	MgrPct
03MN072 (2003)	12.5	1.3
03MN072 (2013)	15.38	25.23
01MN020 (2003)	0	0
01MN020 (2013)	0	0

Longitudinal connectivity is limiting the fish population within this reach from the perched culverts. Removing these downstream barriers by culvert replacement would increase the fish population at the upstream location.

Altered hydrology is also prevalent here and is considered one of the primary stressor to the biology. A large majority of this reach has been modified through channelization with over half of this AUID being ditched. Primary land use around the reach is agricultural row crops. Part of the agricultural practice within this area is the addition of subsurface tile drainage. These two land to stream changes, impact both the morphology of the stream, as well as pollutant loading, and stream velocity. For further information on how these practices influence water quality, stream stability, and habitat reference Chapter 3.1.8 of this report.

Summary Table

Table 29. Identified stressors with suspected sources for reach 696 of Unnamed Creek.



696 Unnamed Creek

Key				
●=suspected source, ○=potential source	Stressor	Inconclusive	Not a Stressor	NA

Stressors											
Temperature			Dissolved Oxygen				Eutrophication				
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified
NA	NA	NA	●		●			●	●		

Stressors									
Nitrate				Suspended Solids					
Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture
●	●			▨	▨	▨	▨	▨	▨

Stressors											
Habitat				Connectivity					Altered Hydrology		
Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
	●	●	●			●			●		●

4.5 Unnamed Creek (07020007-550)

Unnamed Creek (07020007-550) is a small tributary north of Mankato and downstream of Unnamed Creek (07020007-696). The reach is warmwater general use Class 2B. The reach extends from Unnamed Creek to Unnamed ditch, upstream and downstream of Hwy 21. The reach is impaired for lack of macroinvertebrate assemblage and lack of fish assemblage.

4.5.1 Biological Communities

Station 03MN072 was surveyed for fish and macroinvertebrates in 2003 and 2013 (Figure 56 and Figure 57). In 2003, the fish community scored 31.4 on the Southern Headwaters IBI, below the threshold of 55, with green sunfish and fathead minnows being the most abundant is survey. In 2013, the FIBI score was 41.4. In 2013, blacknose dace and central stonerollers were the most abundant in the survey.

In 2003 and 2013, the macroinvertebrate community scored 23.3 and 19.6 on the Southern Streams RR IBI. Both scores were below the general use threshold of 37. In 2003, non-biting midges (Rheotanytarsus) and mayflies (Baetis) were the most abundant. In 2013, the most abundant taxon was snails (Physa).

Figure 56. Fish metrics of the Southern Headwaters IBI for station 03MN072, Unnamed Creek.

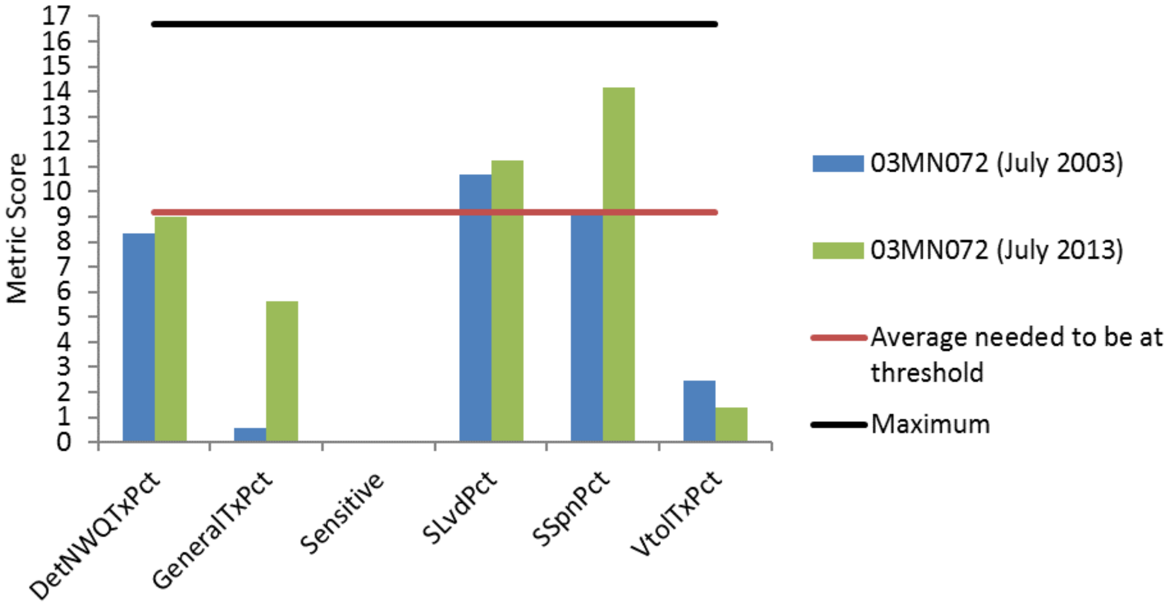
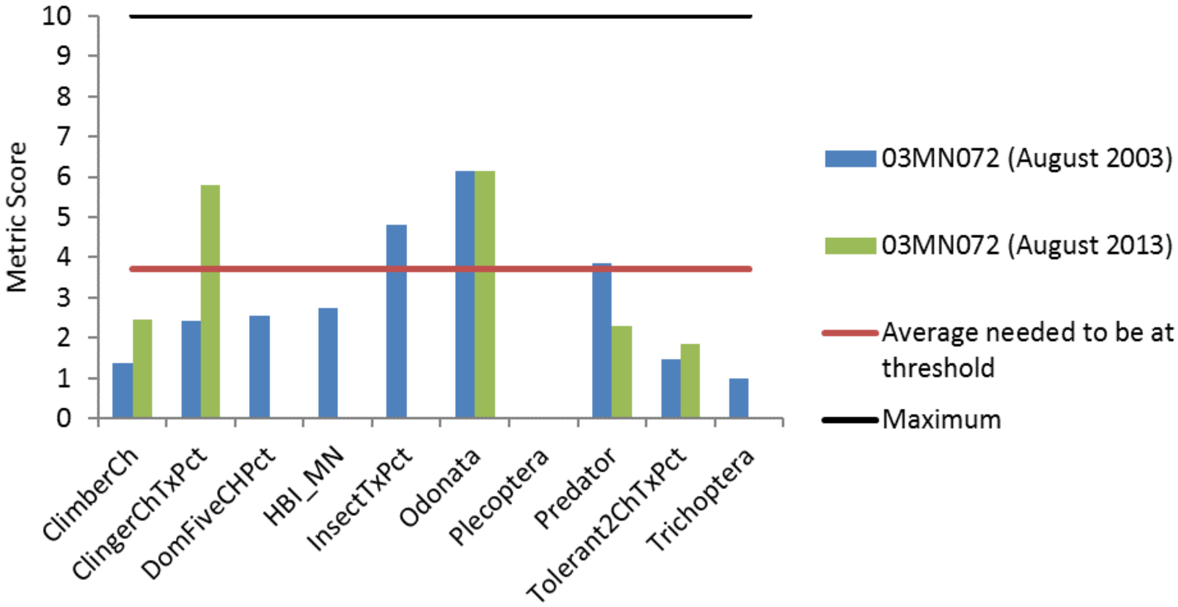


Figure 57. Macroinvertebrate metrics of the Southern Streams RR class for station 03MN072, Unnamed Creek



4.5.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

At the time of biological monitoring three-dissolved oxygen (DO), samples were taken at 03MN072. On July 21, 2003 DO was recorded at 8.5 mg/L, on July 18, 2013 the DO was at 7.99mg/L, and on August 6, 2013 it was at 7.56 mg/L. Station S008-558 had five additional DO samples with concentrations ranging from 8.65 mg/L – 10.85 mg/L in 2015. All values fell above the DO standard of 5 mg/L.

The macroinvertebrate community does show some indication that low DO could be stressing the community (Table 30). The abundance of taxa sampled was below the southern stream average.

Sensitive Ephemeroptera, Plecoptera & Trichoptera taxa (EPTCh) were greatly below average in both years. The HBI_MN (A measure of pollution based on tolerance values assigned to each individual taxon) was elevated for both sample years. The Low DO index score was slightly above the threshold in 2003 and shortly below in 2013. There was a lack of intolerant macroinvertebrates collected, as well as percentage that made up the sample size. However, there was not an overabundance of specifically low DO tolerant species either, as this score fell below the average for what is expected in a southern stream in Minnesota. This indicates that there could be something else stressing this community. Without additional chemistry data, it is unclear if it is another parameter limiting macroinvertebrate community, or a combination of additional stressors to low DO.

Table 30. Macroinvertebrate metrics that respond to low DO stress in Unnamed Creek compared to the 03statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
03MN072 (2003)	**38**	**6**	**7.41**	7.18	**5**	**22.5**	**5**	4.1
03MN072 (2013)	**20**	**3**	**9.02**	**6.81**	**2**	**14.0**	1	0.3
Southern Streams Average	*45.8*	*14.2*	*7.08*	*7.04*	*9.0*	*24.0*	*4.8*	*9.9*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Both fish samples reflected an overall tolerant fish community, noted in the Table 31 below. In both years, there was not any sensitive fish species found. There was also a lack mature female fish species (MA>3Pct); indicating an environmental limitation to the lifecycle of the fish community. In both years, the population was dominated by general tolerant fish species (TolPct). Looking at specific low DO tolerance within the community displays a complete absence of sensitive species in the population. However, species that are specifically tolerant to low DO conditions were not overly abundant.

Table 31. Fish metrics that respond to low DO stress in Unnamed Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
03MN072 (2003)	**0**	**1.30**	**100**	**6.41**	**0**	**0**	**5**	.9
03MN072 (2013)	**0**	**13.51**	**86.49**	**7.03**	**0**	**0**	**6**	.4
Southern Streams Average	*16.9*	*24.6*	*44.9*	*7.2*	*1.7*	*6.1*	*4.7*	*18.5*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is inclusive as a stressor. There was limited chemistry samples collected, although what was there did not display low DO values. 24 hour DO fluxuation (DO Flux) is unknown, as most of the samples occurred well into the afternoon when photosynthetic activity would be at its highest. This reach also has a fair amount of riffles and turbulent areas, which in the right flow conditions could offset low DO caused by plant respiration. Again, due to low sample numbers it is not clear what the overall DO dynamics of this stream are. In the future additional DO testing is recommended.

In both the macroinvertebrate and fish metrics, the population was made up of a generally tolerant community. In both communities, specific low DO tolerant species were present, however, were not overabundant. Based on the community composition it would not appear that low DO is the primary stressor to the community. Although it could be playing a role in conjunction with additional stressors.

Eutrophication

During biological monitoring two total phosphorus (TP), samples were collected. Station 03MN072 had a TP concentration of 0.11 mg/L on July 21, 2003 and 0.156 mg/L on July 18, 2013. Seven additional water chemistry samples were taken in 2015 and 2016. TP concentrations ranged from 0.086 mg/L - 0.612 mg/L (average of 0.22 mg/L). Seventy-eight percent of the total TP samples exceeded the river eutrophication TP standard for the Central Region of 0.1 mg/L. Phosphorus reached peak levels in mid-summer months. On September 2, 2015 chl-a at station S008-558 was 9.94 µg/L, and did not exceed the standard of 18 µg/L. While there is a lack of chemistry data, there were numerous site visits that noted abundant algal growth within the stream in forms of suspended and filamentous algal, seen in Figure 58.

Figure 58. April 27, 2015 algal bloom in Unnamed Creek (0702007-550)

The macroinvertebrate community did display consistent signals of eutrophic stress (Table 32). The community primarily was made up of tolerant taxa and completely lacking in intolerant species. As algal blooms settle to the bottom of the riverbed, it often times will impact macroinvertebrate habitat. This could explain the low number of "collector" macroinvertebrate groups observed in both sampling years.

Table 32. Macroinvertebrate metrics that respond to eutrophication stress in Unnamed Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
03MN072 (2003)	**38**	**6**	**14**	**6**	**0**	**86.8**
03MN072 (2013)	**20**	**4**	**5**	**3**	**0**	**85**
Southern Streams Average	*45.8*	*7.3*	*15.9*	*12.2*	*0.8*	*72.6*
Expected response to stress	↓	↓	↓	↓	↓	↑

The fish community also displayed consistent signals of eutrophic stress response (Table 33). Nearly the entire population was considered tolerant, with a complete lack of sensitive (SensitivePct) or intolerant species (Intolerant Pct) noted in both years. There were hardly any species present that are lithophilic spawners (SlithopPct) in 2003. A slight increase was observed in 2013, yet still fell short of the average for southern headwater streams. There was also an absence of darters (DarterPct) in both samples. As darters depend on decent water transparency, this metric is particularly telling of potential eutrophic conditions stressing the fish community.

Table 33. Fish metrics that respond to eutrophication stress in Unnamed Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
03MN072 (2003)	**0**	**0**	**1.9**	**100**	**8**	**0**
03MN072 (2013)	**0**	**0**	**27.0**	**86.5**	13	**0**
Southern Headwaters Average	*7.9*	*11.5*	*31.5*	*72.8*	*11.5*	*1.6*
Expected response to stress	↓	↓	↓	↑	↓	↓

Eutrophication is inconclusive. While the biometrics in both macroinvertebrates and fish suggest eutrophic stress, the secondary responses are lacking. Therefore, eutrophication cannot be identified. There were a number of high phosphorus samples, efforts should be made on reducing this as it is a limiting nutrient, and therefore carries the potential of creating eutrophic conditions.

Nitrate

During fish sampling, the nitrate concentration at 03MN072 was high during both samples, recorded at 12 mg/L on July 21, 2003 and at 11 mg/L on June 18, 2013. There were seven additional water quality samples taken in 2015 and 2016 from April through September. The nitrate concentration ranged from 6.1 mg/L – 24 mg/L. The average concentration was 14.44 mg/L. Six of the seven nitrate samples exceeded 10 mg/L.

Fish often do not show strong metric signals for nitrate, therefore only the macroinvertebrate nitrate metrics were reviewed for this assessment. The macroinvertebrates in this reach display a response to elevated nitrate concentrations (Table 34). The nitrate index score ranged from 3.1 to 4.7, while the average for Southern Streams meeting impairment threshold is 2.9. The index score, in addition to the percentage of nitrate tolerant individuals indicates a community dominated by nitrate tolerant taxa, particularly in the 2003 sample. Increasing nitrate concentrations also correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct) and decreased intolerant taxa, both which are lacking in this reach.

Table 34. Macroinvertebrate metrics that respond to nitrate stress in the unnamed creek compared to the statewide average of visits meeting the warmwater general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
03MN072 (2003)	**3**	**0**	**3.1**	**0**	**22**	**60.4**
03MN072 (2013)	**2**	**1.2**	**4.7**	**0**	9	**93.3**
Southern Streams Average	*6.3*	*5.5*	*2.9*	*2.4*	*18.8*	*47.2*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is a biological stressor within this reach. There was a consistent response seen in both the chemistry analysis as well as the macroinvertebrate metrics.

Total Suspended Solids

Two total suspended solids (TSS) concentrations were collected at the time of biological monitoring. The TSS concentration at 03MN072 was 2.8 mg/L on July 21, 2003 and 30 mg/L on June 18, 2013. Six additional water chemistry samples were collected in 2015 and 2016 from May through September. Data from these collections ranged from 6.8 mg/L – 150 mg/L, with an average of 70.13 mg/L. Outlier data of 710 mg/L (July 6, 2015) was excluded from the average calculation, but important to factor in for the streams TSS potential, particular after a large rain event (as this was the main driving force that flushed the TSS through the system. Four of the six samples collected exceeded the south standard of 65 mg/L. In addition to the analysis of TSS concentrations, transparency tube readings were evaluated. As seen in Table 35, there are multiple instances of increased turbidity (decreased transparency) throughout the year.

Table 35. Transparency tube readings recorded in cm, taken throughout 2015.

Date	Parameter	Depth(cm)
5/19/2015	Transparency, tube with disk	73
6/11/2015	Transparency, tube with disk	66
6/23/2015	Transparency, tube with disk	12
7/6/2015	Transparency, tube with disk	5
9/2/2015	Transparency, tube with disk	7

The macroinvertebrate within this community displayed a mixed response on TSS metric scores (Table 36); with the major differences being see in the different sampling years. In 2003, *Rheotanytarsus* dominated the sample, a non-biting midge that depends on filter feeding. In systems that are turbid from sediment, all filter feeders will be negatively impacted. However, in systems where there is an overabundance of suspended organic material, the more tolerant collector filter groups can greatly increase. This is likely what drives up the score for the 2003 sample. In both years, there was an absence of sensitive or intolerant species. In 2013 there was a consistent response in the measurements that did indicate TSS community stress, with the only parameter not being tripped being an abundance of TSS tolerant taxa. In the year 2013 Species that depend on clear water quality habitat for filtering, were in great decline, where TSS intolerant taxa were completely absent from the community. The TSS index score was 17.76; this is above the southern streams average for the state of 15.63.

Table 36. Macroinvertebrate metrics that respond to high TSS stress in Unnamed Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
03MN072 (2003)	34.9	**0**	14.25	**0**	**0**	11	31.0
03MN072 (2013)	**5.8**	**0**	**17.76**	**0**	**0**	4	**74.7**
Southern Streams Average	*25.4*	*0.7*	*15.63*	*2.9*	*4.7*	*12.2*	*34.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

As with the macroinvertebrate metrics, the fish metrics vary from year to year (Table 37 and Table 38), leading to mixed results. What is interesting to note is that TSS stress is more prominent is 2003 versus 2013, the opposite findings seen in the macroinvertebrate metrics. Abundance of exclusive benthic feeders (BenFdFrimPct) was low in both years. Centrarchidae (Centr-TolPct), rated as being a TSS intolerant species, was only lacking in their dominance in 2003. Herbivores (HrbNWQPct) were not as abundant in 2003 falling well below the threshold of what is expected. However, in 2013 they were above the expected average. There was found to not be any sensitive species in both the years sampled. While 2003 did not find any long-lived species, 2013 found well over the average expected amount for long lived species. Perciforms (Percfm-TolPct) were not found in the 2003 sample; when resampled in 2013 they fell slightly below the threshold, but were present. The same increasing trend from 2003 to 2013 can be seen in the abundance of species that depend on clean riverbed substrate, noted in riffle-dwelling species and simple lithophilic spawners. Both groups were present but fell far below the expected averages for a southern headwater stream. The TSS index score was elevated in both years, indicating a strong measure of a TSS tolerant community. There was also a complete lack of specific TSS intolerant species in both years. However, there was only a slight indication of TSS tolerant domination of the community noted in 2013; as TSS tolerant were complexly lacking from the 2003 sample.

Table 37. Fish metrics that respond to high TSS stress in Unnamed Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
03MN072 (2003)	**1.3**	**0**	**1.3**	**0**	**0**	**0**	**1.3**	**0**	**1.3**
03MN072 (2013)	**25.2**	12.6	25.2	**0**	19.8	**13.5**	**25.2**	**0**	**6.3**
Southern Headwaters Average	*35.0*	*1.0*	*22.4*	*1.6*	*4.5*	*13.6*	*26.2*	*7.9*	*14.6*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 38. Fish metrics that respond to high TSS stress in Unnamed Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TSS Index Score	TSS Sensitive Taxa	TSS Sensitive Pct	TSS Tolerant Taxa	TSS Tolerant Pct
03MN072 (2003)	**23.8**	**0**	**0**	0	0
03MN072 (2013)	**18.5**	**0**	**0**	**1**	**6.3**
Southern Headwaters Average	*15.4*	*0.9*	*4.1*	*0.4*	*2.0*
Expected response to stress	↑	↓	↓	↑	↑

TSS is inconclusive as a biological stressor to the biological community within this reach. The data available for TSS did indicate high TSS overloading potential. However, both the fish and macroinvertebrate community displayed too much variation in metrics between the years to determine if TSS is a limiting factor.

Habitat

In 2003, the habitat score was good with a 70 on the MSHA (Figure 59). Similarly, in 2013, the MSHA score was 75.5. The riparian width was extensive with heavy shade and little to moderate bank erosion. In 2003, riffle features comprised 40% of the reach with gravel and cobble predominantly. There was also 40% pool and 20% run, with more than four substrate types available. In 2013, riffle features dominated the reach at 60%, with 15% pool and 25% run. Gravel and cobble were the predominate substrate in all of the features; can be seen in Figure 60 and Figure 61. There was light embeddedness noted both years. Although there were many types of cover available, there was a moderate cover amount in 2003 and sparse in 2013. In 2003, there was moderate channel stability, with fair sinuosity and good depth variability. In 2013, the channel morphology score was a bit better with moderately high channel stability and good sinuosity.

Figure 59. Percentage of MSHA subcategory scores for station 03MN072, Unnamed Creek

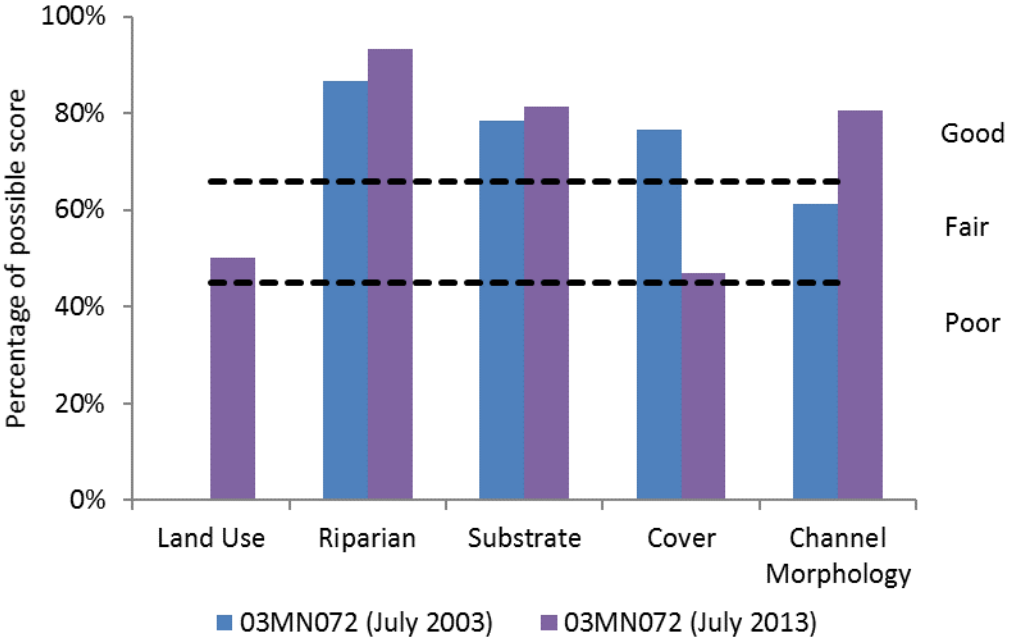


Figure 60. Station 03MN072, July 21, 2003

Figure 61. Station 03MN072, July 18, 2013

The graph below (Figure 62) shows the abundance of each habitat group within the macroinvertebrate sample, in comparison to the state average for southern headwater streams that was found to support the biological community. The 2003 sample found all the habitat groups meeting the expected thresholds for community make up. At first glance, the 2013 sample does looked displaced. However, this is due to the high amount of Rheotanytarsus (non-biting midge) that drove up the climber groups, thus creating a decreased shift of abundance seen in the other groups.

Figure 62. Macroinvertebrate metrics that respond to habitat for station 03MN072, Unnamed Creek compared to the range of values for Southern Streams RR visits meeting the general use biocriteria.

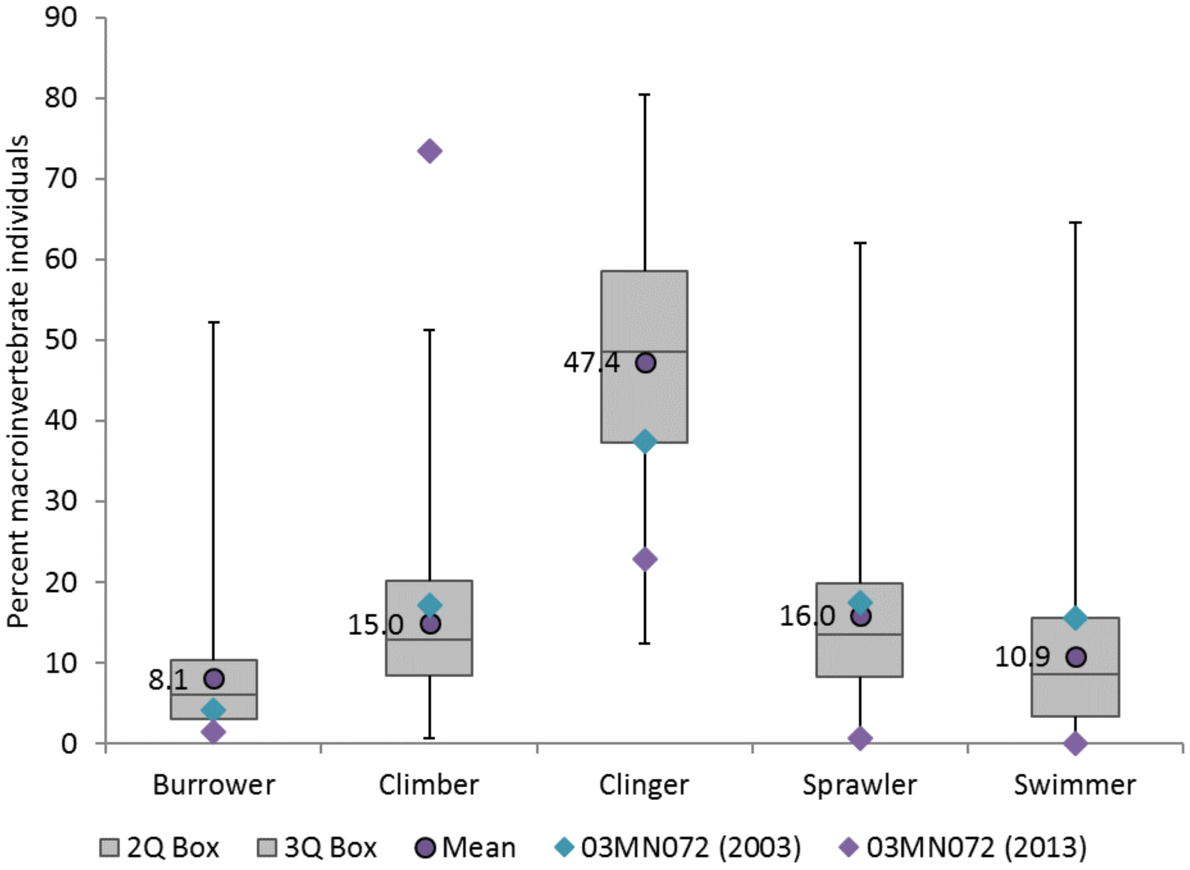


Table 39 and Table 40 was previously described within the TSS analyses section above. TSS plays a strong role in degrading fish habitat and often can be seen within the metrics. Exclusive benthic feeders were low in both years. Herbivores varied between years as they were not abundant in 2003, yet in 2013, they were above the expected average. The same increasing trend from 2003 to 2013 is seen in riffle-dwelling species and simple lithophilic spawners. While these four different groups were present, all but herbivores (2013) fell far below the expected averages for a southern headwater stream. These fish species depend on clean riverbed substrate for both their lifecycle and feeding needs.

Table 39. Fish metrics that respond to high TSS stress in Unnamed Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
03MN072 (2003)	**1.3**	**0**	**1.3**	**0**	**0**	**0**	**1.3**	**0**	**1.3**
03MN072 (2013)	**25.2**	12.6	25.2	**0**	19.8	**13.5**	**25.2**	**0**	**6.3**
Southern Headwaters Average	*35.0*	*1.0*	*22.4*	*1.6*	*4.5*	*13.6*	*26.2*	*7.9*	*14.6*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 40. Fish metrics that respond to high TSS stress in Unnamed Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TSS Index Score	TSS Sensitive Taxa	TSS Sensitive Pct	TSS Tolerant Taxa	TSS Tolerant Pct
03MN072 (2003)	**23.8**	**0**	**0**	0	0
03MN072 (2013)	**18.5**	**0**	**0**	**1**	**6.3**
Southern Headwaters Average	*15.4*	*0.9*	*4.1*	*0.4*	*2.0*
Expected response to stress	↑	↓	↓	↑	↑

Habitat is inconclusive as being considered a stressor to the biological communities within this reach. While the fish habitat groups are limited, it is difficult to say if it is from habitat displacement to the community, as the MSHA scores do not indicate this. There could be another external stressor limiting species richness and diversity, or another pollutant stressor that is limiting the community composition. Furthermore, there was not any indication of habitat displacing one type from another within the macroinvertebrate sample.

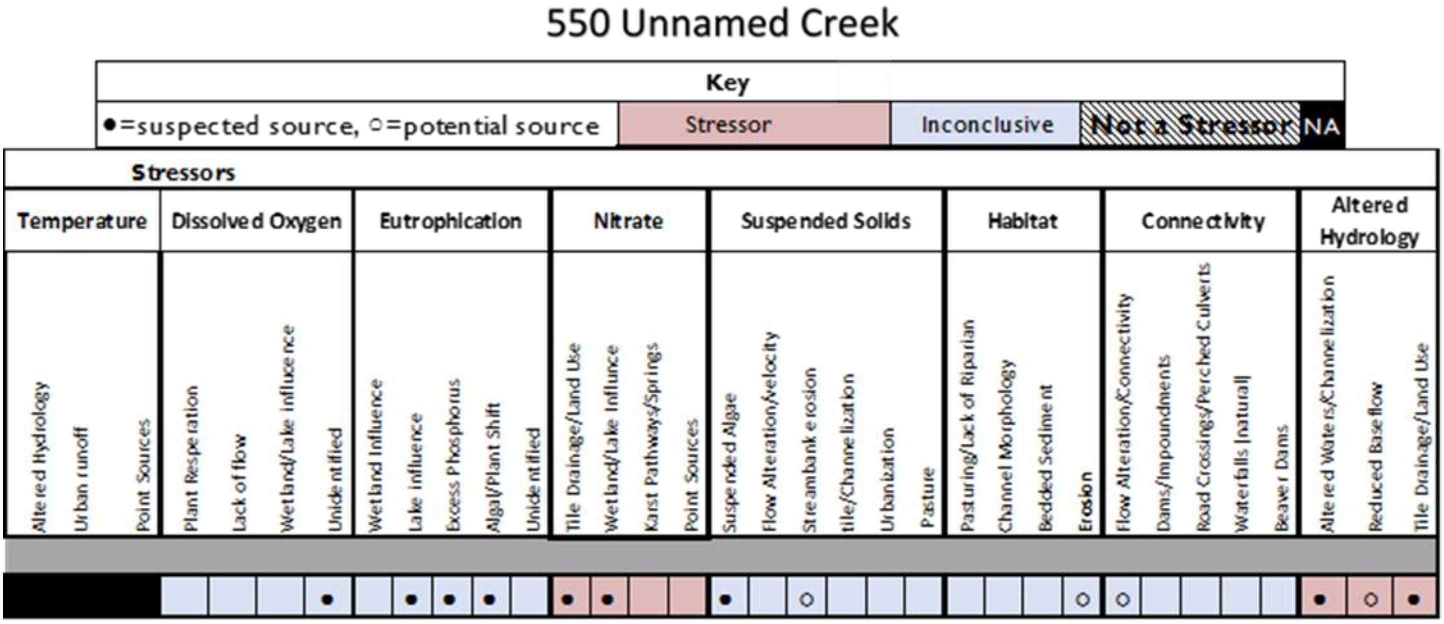
Longitudinal Connectivity and altered hydrology

Longitudinal connectivity is inconclusive for this reach. Downstream from the location of the biological monitoring station the reach has been altered. Sometime before the early 1990,'s the stream was redirected and straightened to go around a quarry site. The reach was rechanneled to run directly south and into a wetland area. It is unclear if these changes have been had an impact to migration abilities for this fish community. Without a biological monitoring site downstream of this site, there is, no way to compare is this could be a contributing factor into the lack of fish diversity. As noted in the longitudinal connectivity section for the branch of Unnamed Creek (07020007-696), there are migratory fish species present within this section so they are not completely hindered by downstream alterations.

Further stream alterations have been made upstream, as the headwaters into this reach have been modified for agricultural drainage practices. These alterations are primarily seen in ditching the stream channel, along with the introduction of subsurface drainage. The practice of these two practices greatly impact and change the streams geomorphology, pollutant loading capacity, and stream velocity. For further information on how these practices directly contribute to other biological stressors, reference the altered hydrology section above that is found in Chapter 3.1.8 of this report. Altered hydrology is thought to be the primary stressor for this reach.

Summary Table

Table 41. Identified stressors with suspected sources for reach 550 of Unnamed Creek.



550 Unnamed Creek

Key				
●=suspected source, ○=potential source	🟥 Stressor	🟦 Inconclusive	▨ Not a Stressor	■ NA

Stressors																																	
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
■	■	■	🟦	🟦	🟦	🟦 ●	🟦	🟦 ●	🟦 ●	🟦 ●	🟦	🟥 ●	🟥 ●	🟥	🟥	🟦 ●	🟦	🟦 ○	🟦	🟦	🟦	🟦	🟦	🟦	🟦 ○	🟦 ○	🟦	🟦	🟦	🟦	🟥 ●	🟥 ○	🟥 ●

Mankato (South) Subwatershed Conclusion

Five stream reaches were found to be impaired for biology in the south section of the Mankato Subwatershed. This includes Cherry Creek (-531) a reach near the headwaters and was assessed as modified use, impaired for fish assemblage. The other section of Cherry Creek (-543) was assessed as general use and impaired for macroinvertebrate assemblage. Note that fish were not assessed at this location due to drought. Shanaska Creek (-693), assessed as general use, was found to be impaired for both invertebrates and fish. There are two unnamed tributaries that flow to the Minnesota River. The upstream reach (-696) was assessed as a modified stream and reach (-550) as general use. Both of the Unnamed Creek reaches were impaired for macroinvertebrate and fish**.** All streams there were assessed as warmwater streams**.**

Altered hydrology is the primary stressor in these streams as it is directly contributing to the other stressors. Altered hydrology is occurring two ways within this subwatershed. The first is through subsurface tile drainage and the second is stream channel alteration by ditching and channelizing. Alterations in this region are from agricultural practices in attempt to expedite water off the land to optimize growing conditions. Both of these practices result in altered hydrology. As a result, the streams are taking on volumes of water greater than what they are naturally designed to carry. This results in accelerated flow velocity and significantly changes the morphology of the stream at the receiving location as well as downstream areas. Stream banks erode and streambeds are scoured out or filled in with sediment. Habitat degradation within this watershed directly ties back to altered hydrology. As displayed in the above table, reaches that have been ditched result in poor habitat quality and a lack of habitat diversity from being ditched. Two streams were found to have strong habitat features; these differ from the upland streams as they have a large riparian area and limited altered land use due to their steep gradient. However, the two streams that are supporting for habitat are still impacted by poor water chemistry from upland altered hydrology.

The Mankato Subwatershed has a pronounced lake to stream relationship that is influencing the biologic communities and water chemistry of the streams. A majority of these streams did show a negative biological response to eutrophic conditions. Stream reaches marked as inconclusive are due to lack of secondary data (chlorophyll-a, BOD, DO fluctuation). These parameters indicate over production of algae growth was occurring in these stream reaches. Suspended algae in hyper eutrophic lakes (Scotch Lake, Lake Wita, Huoy Lake) is likely impacting the biology in these stream reaches they feed into. Reaches found on the flat, upland agricultural dominant area of this subwatershed are subject to becoming eutrophic. These areas typically are high in phosphorus loading, lack riparian cover that limits sunlight, and have slow stream velocities; these yield prime conditions for autotrophic activity. All but one stream had clear signals and chemistry data to confirm eutrophication was limiting biology. Suspended algae is the prominent indicator that eutrophication is occurring, and the main source of suspended solids within some of these reaches.

Eutrophication is closely associated with low dissolved oxygen (DO) within the watershed. Stream reaches where low DO is limiting biology are found in the upland reaches; here they are the most influenced by plant (algae) respiration from stream and eutrophic lake contributions. Low DO was not a stressor in two streams. Stable DO levels within these streams were likely due to increased water turbulence from the steep gradient of the stream.

Nitrates is another parameter that shares a lake to stream interaction. At certain times of the year, some reaches were found to have lower than expected nitrate concentrations. These lower nitrate levels were likely occurring when natural denitrifying rates within the lakes were at their highest. However, this is not occurring at a rate that completely mitigates the overloading of nitrates from upland sources. The largest contributor of nitrate is from tile lines and agricultural drainage.

There are several fish barriers in this area inhibiting migration within this subwatershed. There are at least two perched culverts from the mainstem of the Minnesota River to Lake Wita that are hindering migration abilities for fish species. All biological stations on Cherry Creek are influenced by a dam downstream of County Road 23 and at 321st Avenue.

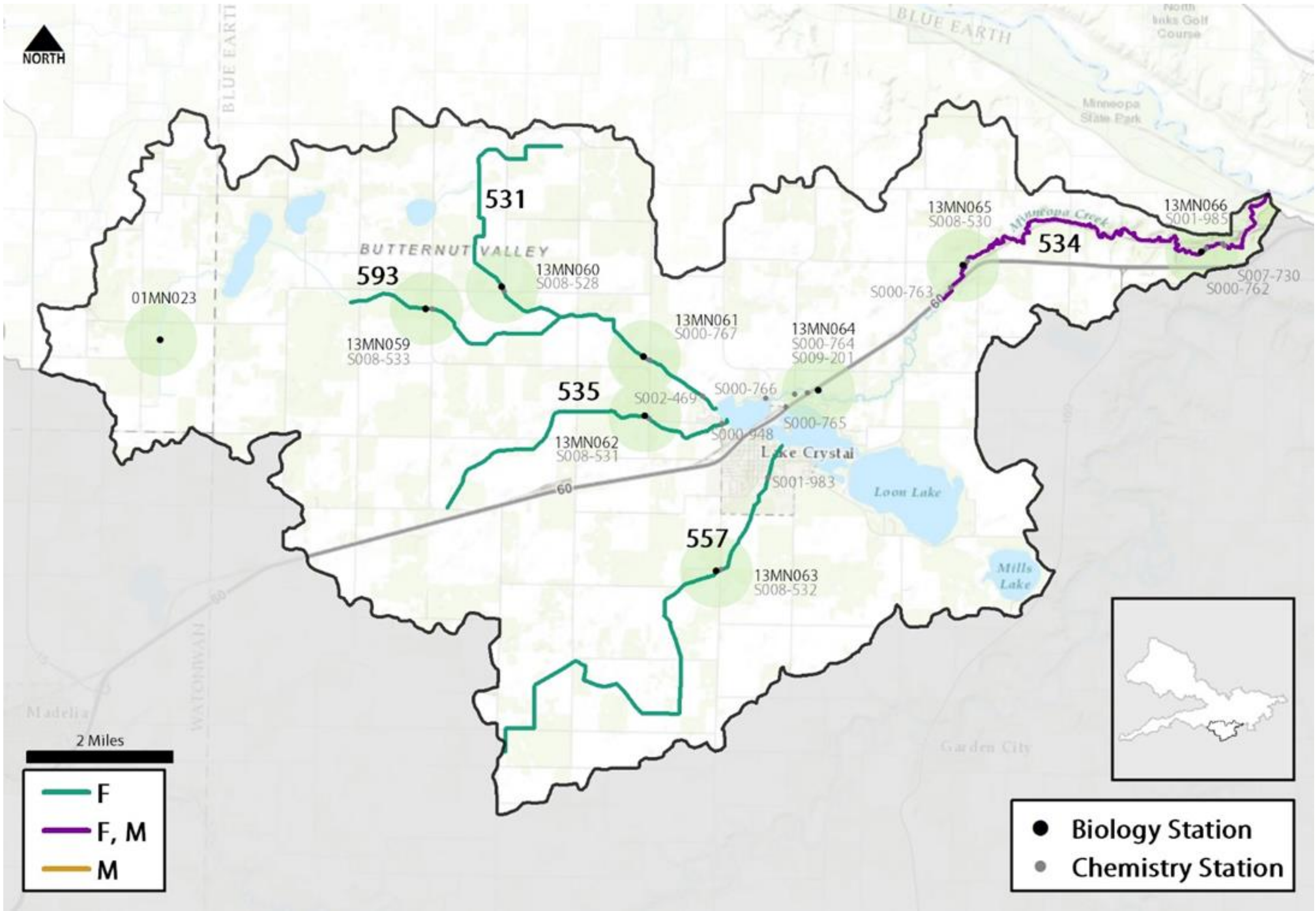
One of the largest questions that was left after this investigation is if Cherry Creek is a losing reach, based on the observed differences of base flow from upstream to downstream.

Minneopa Creek-MNR Mankato South

This section encompasses biotic impaired reaches in the Minneopa Creek 10 digit HUC (0702000709). There are five reaches impaired for biology in this 10 digit HUC. Four of the reaches are upstream of Lake Crystal and one is downstream. All four upstream reaches (Judicial Ditch 48 (593), Minneopa Creek (531), County Ditch 27 (535), and County Ditch 56 (557) are all impaired for lack of fish assemblage. The downstream most reach of Minneopa Creek (534) is impaired for fish and macroinvertebrates.

Channelization is extensive in the watershed, accounting for 66% of the streams. Natural stream channels account for only 20% of the streams, and primarily consists of Minneopa Creek from Lake Crystal downstream to the confluence. The highest (~52 feet) natural waterfall in the Minnesota River – Mankato Watershed occurs where Minneopa Creek is undercutting a layer of Jordan Sandstone in Minneopa State Park (DNR 2015).

Figure 63. Map of the Minneopa Creek Watershed with biological impairments and monitoring stations. Impairments are described as F=Fish, F, M=Fish and Macroinvertebrates, and M=Macroinvertebrates



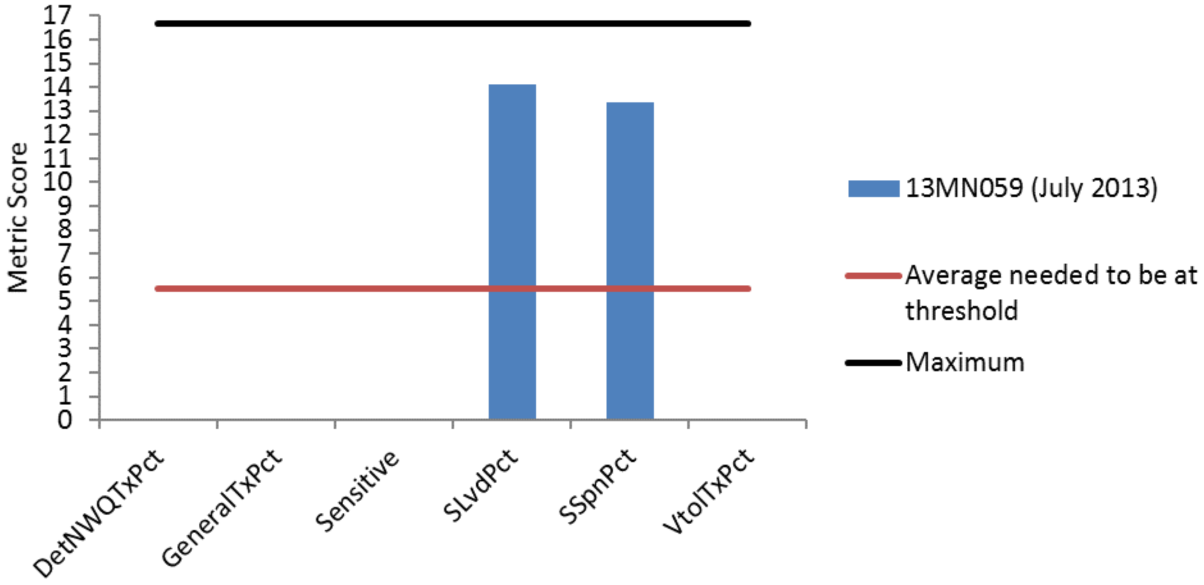
4.6 Judicial Ditch 48 (07020007-593)

Judicial Ditch 48 (07020007-593) is a small tributary west of Lake Crystal, Minnesota. The reach is warmwater modified use Class 2B and extends from unnamed ditch to Minneopa Creek. The reach is impaired for lack of fish assemblage.

4.6.1 Biological Communities

Station 13MN059 was sampled in 2013 for fish and macroinvertebrates. The macroinvertebrate community scored (34.5) above the modified use threshold (22) for the Prairie Streams GP class. The fish community scored (27.5) below the modified use threshold (33) for the Southern Headwaters class. The fish present were common carp, fathead minnows, and black bullheads. Four of the six FIBI metrics scored zero (Figure 64).

Figure 64. Fish metrics of the Southern Headwaters class for 13MN059, JD 48



4.6.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

At the time of biological monitoring DO was 10.2 mg/L. Only two additional samples were collected with concentrations of 9.33 mg/L on June 12, 2015 and 10.48 mg/L on September 1, 2015. All of these DO samples were collected in mid to later day periods, when dissolved oxygen will be at its highest.

Table 42 displays results of a 2015 longitudinal DO survey conducted within the Minneopa Creek Subwatershed. Highlighted in yellow displays the 24-hour DO fluxuation potential. In Eutrophic conditions, algal respiration (occurs when photosynthetic production stops) will deplete DO levels. Within this reach early morning DO was far below 5 mg/L with a reading of .92 mg/L; The inverse is during times of peak photosynthesis from overabundant algal growth, DO will rise well above the threshold of 5 mg/L, this accounts for the higher DO levels found in the afternoon within this DO survey for the subwatershed.

Table 42. Longitudinal YSI sonde readings taken on August 4-5, 2015 showing a daily flux in DO. Station 13MN059 for JD 48 is highlighted on yellow.

Sonde deployments		PM pt measures				AM pt measures			
Station	Waterbody name	Date	Time	Temp	DO mg/L	Date	Time	Temp	DO mg/L
13MN060	Minneopa Creek	8/4/2015	15:22	18.9	4.38	8/5/2015	7:20	15.29	1.43
13MN059	Judicial Ditch 48-Minneopa Trib	8/4/2015	15:35	27.95	10.86	8/5/2015	7:30	16.79	0.92
13MN061	Minneopa Creek	8/4/2015	15:45	25.02	13.22	8/5/2015	7:04	19.02	0.69
13MN062	Minneopa Creek	8/4/2015	15:51	25.03	11.88	8/5/2015	6:55	16.69	1.57
13MN063	County Ditch 56-Minneopa Trib	8/4/2015	16:00	21.17	1.4	8/5/2015	6:40	16.88	0.43
13MN064	Minneopa Creek	8/4/2015	16:30	27.01	15.03	8/5/2015	6:32	20.13	2.34
13MN065	Minneopa Creek	8/4/2015	16:41	25.3	14.45	8/5/2015	6:22	19.08	5.71
13MN066	Minneopa Creek	8/4/2015	17:00	23.65	12.02	8/5/2015	6:07	19.17	7.5

With the only taxa sampled being common carp, fathead minnows, and black bullheads, metric calculations are not going to be telling of what parameter are limiting intolerant fish, as the population sampled was completely made up of tolerant species (Table 43).

Table 43. Fish metrics that respond to low DO stress in Judicial Ditch 48 compared to the statewide average of visits meeting the modified use warmwater biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
13MN059 (2013)	**0**	**0**	**100**	**6.33**	**0**	**0**	3	**100**
Southern Headwaters (Modified) Average	*4.5*	*11.7*	*79.9*	*7.00*	*0.4*	*2.2*	*3.5*	*28.4*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

While the macroinvertebrates were not listed as impaired within this reach, it is worth noting that the community was reflective of a generally tolerant composition and similar to what would be found in wetlands, primarily being *Physa* (snails) and *Paratanytarsus* and *Cricotopus* (non-biting midges). These are low DO tolerant taxa (Table 44). The macroinvertebrate table below displays signs suggestive of low DO stress; the overall individual taxa abundance fell below average. Taxa richness of the low DO sensitive Ephemeroptera, Plecoptera and Trichoptera (EPTCh) fell below expected values. Overall species sensitive to low DO were completely lacking, while tolerant species were abundant.

Table 44. Macroinvertebrate metrics that respond to low DO stress in Judicial Ditch 48 compared to the statewide average of visits meeting the modified use warmwater biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN059 (2013)	41	**4**	**8.64**	**6.05**	**0**	**0**	**20**	**56.54**
Prairie Streams Average	36.8	7.6	7.92	6.42	2.4	4.5	8.4	25.1
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Figure 65 below displays high algae productivity within this reach. This photo was taken at the time of biological monitoring. Given what this photo shows, it would not be unreasonable to assume that the trends displayed from the longitudinal survey are representative with the standard conditions of this reach, and would support the finding of non-aquatic life supporting levels of low DO to high swings of high levels in peak production.

Figure 65. Monitoring station 13MN059, taken on July 11, 2013, displaying high algae and macrophyte growth.

Low DO is a biological stressor in this reach. While there is not a large data set of instantaneous DO sample grabs, the longitudinal survey was able to validate what the photos and metrics display; being extremely low daily dips of DO followed by high DO concentrations in the day is led by the high abundance of algal and macrophyte growth.

Eutrophication

During the fish sample on July 11, 2013, one total phosphorus (TP) sample was collected at station 13MN059 with a concentration of 0.075 mg/L. Five additional water chemistry samples were taken in 2015 and 2016. TP concentrations ranged from 0.050 mg/L - 0.600 mg/L; giving an average of 0.177 mg/L. One of the five samples exceeded the river eutrophication standard for the South Region of 0.150 mg/L. Given the state of the stream during times of recon and biological monitoring, it is possible that phosphorus samples could have been low due to TP being bound in vegetation, limiting the available TP in the water column. There was only one chlorophyll a (chl-a) sample taken on September 1, 2015 at station S008-533, which was 25.3 µg/L; however, photographic documentation of this reach does indicate chl-a can much higher.

One of the most telling indications of a eutrophic stream is the daily fluctuation of DO levels in the stream. As noted above in the DO section write up of this reach, daily variation of DO was found and identified as being eutrophic driven.

The fish community at station 13MN059 is consistent with eutrophication stress (Table 45). None of the fish species are considered sensitive, darters, simple lithophilic spawners, or intolerant. There were only three taxa, and they are all considered tolerant.

Table 45. Fish metrics that respond to eutrophication stress in Judicial Ditch 48 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
13MN059 (2013)	**0**	**0**	**0**	**100**	**3**	**0**
Southern Headwaters Average	***4.5***	***8.5***	***27.9***	***79.9***	***10.4***	***0.8***
Expected response to stress	↓	↓	↓	↑	↓	↓

One of the strongest indicators of a eutrophic stream is seen by the physical appearance. Multiple site visits noted and/or documented overgrowth of plants and algal, as referenced in Figure 65 in the above DO section, as well as Figure 66.

Figure 66. Judicial Ditch 48 (07020007-593) displaying abundant autotrophic growth within the stream, taken on September 1, 2015.

Eutrophication is a stressor within this reach. While grab samples are scarce, the longitudinal DO table (Table 42) does display a daily DO swing that is indicative of one that would be driven by an over-productive system. The biological metrics are also constant with communities that are limited by eutrophic conditions. The largest piece of evidence to a eutrophic stream is noted in the physical condition; large colonies of filamentous algae can be noted throughout this stream.

Nitrate

During fish sampling, the nitrate concentration at 03MN072 was 4.7 mg/L on July 11, 2013. There were five additional water quality samples taken in 2015 and 2016 from April through September. The nitrate concentration ranged from .75 mg/L – 23 mg/L, with all but one of the samples falling above 10 mg/L. The average concentration was 14.55 mg/L.

Fish metrics have not yet been developed to indicate a nitrate stressed community. Macroinvertebrate communities respond in a much more predictable way when being limited by nitrate concentrations. The macroinvertebrate community's composition did display nitrate tolerant displacement (Table 46). Sensitives Trichoptera species were not in abundance, falling below the threshold, as well as other nitrate sensitive taxa. Nitrate tolerant species were in abundance. The nitrate index score also fell well above the state average for modified southern streams of 3.0 as the score ranged from 3.1-4.7.

Table 46. Macroinvertebrate metrics that respond to nitrate stress in Judicial Ditch 48 compared to the statewide average of visits meeting the warmwater modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
03MN072 (2003)	**3**	**0.0**	**3.1**	**0**	**22**	**60.4**
03MN072 (2013)	**2**	**1.2**	**4.7**	**0**	**9**	**93.3**
Southern Streams Average ***(MU)***	*5.4*	*4.3*	*3.0*	*1.6*	*18.5*	*52.7*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is inconclusive as a stressor at this time. While there is not a large number of water chemistry samples for nitrate, what is available was sporadic (random) enough that the consistent high values that were found are likely telling of the overall nitrate dynamics within this reach. Furthermore, the metrics in both 2003 and 2013 suggest nitrate is effecting the macroinvertebrate community. However, macroinvertebrates are not impaired within this reach so can only be used as an indicator if nitrate is creating a community shift. While it was found that nitrates are shifting the community for macroinvertebrates to an extent, the community as a whole is not impaired and therefore nitrate is not limiting them to unsustainable levels.

Total Suspended Solids

One total suspended solids (TSS) sample was collected at the time of biological monitoring on July 11, 2013, with a concentration of 25 mg/L. Six additional water chemistry samples were collected in 2015 and 2016 from May through September. Data from these samples ranged from 1.6 mg/L – 13 mg/L, with an average of 7.23 mg/L.

The fish community was limited to only three fish species. As is the case with any limited taxa sample, metrics will not be a strong indicator alone in determining if TSS is shifting the community to more TSS tolerant individuals. Table 47 will still be discussed to highlight the fish types that are absent from the community. Exclusive benthic feeders (BenFdFrimPct), Centrarchidae (Centr-TolPct), Herbivores (HerbNWQpct), Perciforms (Percfm –TolPct), Riffle Dwelling species, Simple Lithophilic spawners (SLithFrimPct), intolerant, and sensitive species were completely absent. The average expected amount for long lived species (LlvdPct) was unusually high in this reach. However, this is due to the overabundance of common carp in the sample. Table 47 does indicate that TSS is stressing the community, as the TSS Index score is over double the score of the southern headwaters average paired with TSS tolerant dominance within the community. Again, these metrics should be taken lightly as these metric calculations are thrown off due to the three taxa sampled being generally tolerant and hearty fish.

Table 47. Fish metrics that respond to high TSS stress in Judicial Ditch 48 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
13MN059 (2013)	**0**	**0**	**0**	**0**	81.9	**0**	**0**	**0**	**0**
Southern Headwaters Average	*27.3*	*0.7*	*17.8*	*0.8*	*4.3*	*10.3*	*19.9*	*4.5*	*12.0*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 48. Fish metrics that respond to high TSS stress in Judicial Ditch 48 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TSS Index Score	TSS Sensitive Taxa	TSS Sensitive Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN059 (2013)	**36.5**	**0**	**0**	**1**	**81.9**
Southern Headwaters Average	*16.2*	*0.5*	*2.9*	*0.5*	*2.5*
Expected response to stress	↑	↓	↓	↑	↑

TSS is inconclusive as a stressor. The biological metrics indicate TSS could be displacing the fish community, it is important to factor in the host of other parameters that could be shifting the community. Metrics alone are not going to be useful in isolating a single parameter due to the lack of diversity in the sample size. Chemistry data can only add little clarity to the question if TSS is a problematic, as there are only seven points of analyses and all of which are low. By doing further analysis and evaluating volatile suspended solids (VSS), organics such as suspended algae accounted for half of the TSS sample, in a few cases up to 75% of the sample. Given the above analysis on eutrophication within this reach, it is likely that the diving force of suspended solids is the result of overproduction and not sediment.

Habitat

The MSHA scored poorly at 17.5. The limiting factors (Figure 67) was poor stream features as there were not any riffles or pools, and silt being the dominate substrate. There was a complete lack of diverse habitat types, as well as poor riverbed substrate. This limits both refuge and spawning ability's for the fish community. The lack of vegetate cover not only degrades refuge ability, it also exposes the stream to an overabundance of sunlight that is contributing to the eutrophic conditions found within this reach.

Figure 67. Percentage of MSHA subcategory scores for station 13MN059, Judicial Ditch 48

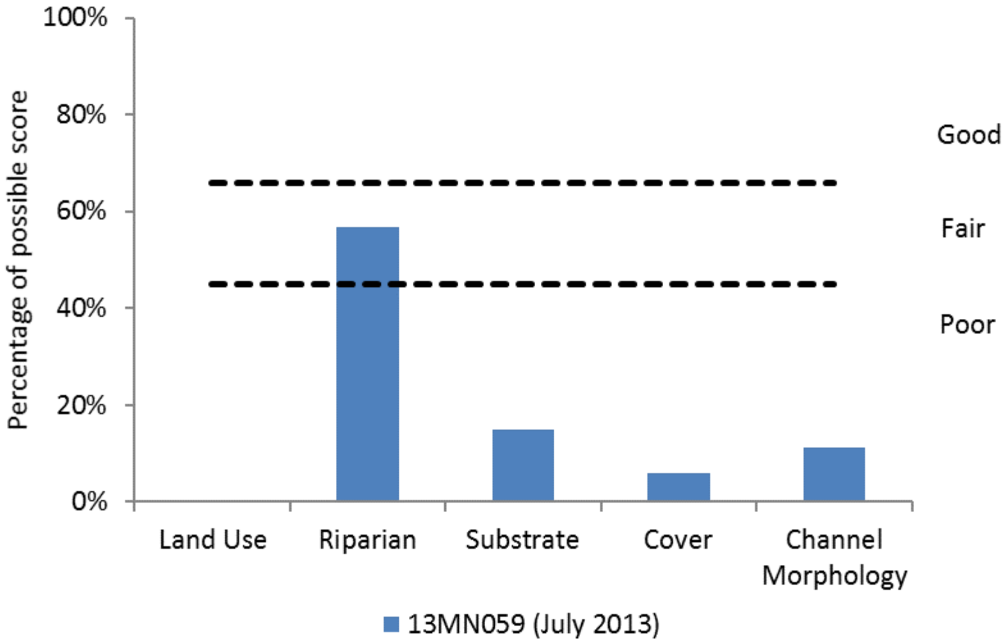


Figure 68 shows the reach at the time of biological monitoring. As shown in the photograph, this stream channel has been modified into an agricultural ditch. Through this modification, the channel was straightened and the features of the stream became homogenous.

Figure 68. Station 13MN059, July 11, 2013

Poor habitat was also reflected in the fish community, as noted above in the TSS section (Table 47) Absent from the stream were exclusive benthic feeders, Centrarchidae (rated as being an intolerant species), herbivores, riffle-dwelling species, and simple lithophilic spawners. The average for long-lived species was greatly exceeded in this reach; however, this is due to the overabundance of common carp in the sample, who are not specialized spawners.

Habitat is a stressor within this reach as there is a lack of diversity within the stream. The lack of habitat refuge from cover are also directly contributing to the eutrophic conditions noted in this reach.

Longitudinal Connectivity and Altered Hydrology

On Minneopa Creek, there is a waterfall approximately 1.4 miles upstream of the confluence with the Minnesota River. The waterfall is a barrier for fish migration, with an approximate 52-foot drop in the longitudinal profile of the stream. For more information on the barrier, please see the DNR's Minnesota River, Mankato Watershed Characterization Report (DNR 2015). All of the biological stations are located upstream of the waterfall, so there is not a downstream comparison site available to better understand what fish migrate in the downstream portions of the subwatershed. The waterfall limits migration fish replenishment to Judicial Ditch 48 in combination of the stressors present with the stream (low DO and Eutrophic), and impaired refuge areas (lakes and wetlands), that are driving the diversity down.

This reach in particular is limited in the diversity of fish, as noted in Table 49. This station (13MN059) as well as 13MN063 are the furthest monitoring station from wetland and lake refuge areas and also have the poorest fish diversity.

Table 49. Fish species present at stations in Minneopa Creek Watershed upstream from downstream.

	13MN059	13MN060	13MN061	13MN062	13MN063	13MN065	13MN066
	2013	2013	2013	2013	2013	2013	2013
black bullhead	x		x		x	x	
black crappie					x		
brook stickleback			x	x		x	
channel catfish							
common carp	x	x	x	x	x	x	x
creek chub		x		x		x	x
fathead minnow	x	x	x	x		x	x
golden shiner				x			
green sunfish		x		x		x	
johnny darter		x	x			x	x
northern pike		x				x	
white sucker		x	x	x		x	x
yellow bullhead					x		

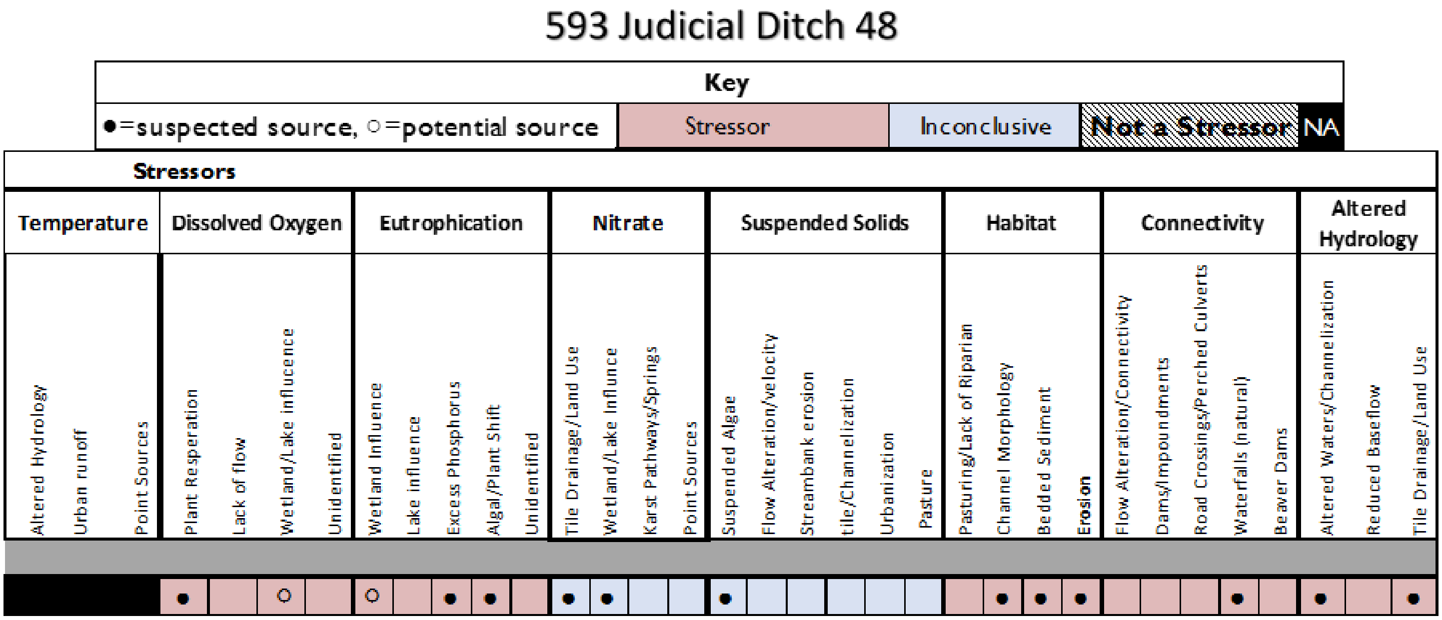
While this subwatershed has more upland water storage area than a majority of the others within the Minnesota, Mankato River Watershed, it is in the form of hypereutrophic lakes and wetlands that have been negatively impacted by surrounding land use inputs. As the only refuge areas are impaired, fish utilizing these areas must be tolerant to thrive. For more information on the lake impairments within the Minneopa Creek Subwatershed, reference the Minnesota River – Mankato Watershed Report.

While the macroinvertebrate community was not impaired, it was indicative of a wetland community, rather than a prairie stream.

The primary stressor for this reach, as well as the subwatershed as a whole is altered hydrology. This stream has been modified by ditching and channelization. There is also the introduction of subsurface tile drainage that contributes to nutrient overloading of the stream (primarily seen in the high amounts of TP that have led to eutrophic conditions). Subsurface tile drainage also created a lateral disconnection of soil water to stream recharge. As water is expedited off the land, the stream's volume will erratically increase, creating further issues in downstream geomorphology and stability. The inverse to this is seen during the dry season, where there is a lack of ground recharge to the stream that creates low to stagnant conditions. For additional information on how these alterations affect the streams stability, as well as pollutant overloading, reference the above section on Altered Hydrology found in Chapter 3.1.8.

Summary Table

Table 50. Identified stressors with suspected sources for reach 593 of Judicial Ditch 48.



593 Judicial Ditch 48

Key				
●=suspected source, ○=potential source	Stressor	Inconclusive	Not a Stressor	NA

Stressors																																	
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls (natural)	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
			●		○		○		●	●		●	●			●							●	●	●				●		●		●

4.7 Minneopa Creek (07020007-531)

Minneopa Creek (07020007-531) is a small tributary west of Lake Crystal, Minnesota. The reach is warmwater modified use Class 2B. The reach extends from the headwaters to Lily Lake. The reach is impaired for lack of fish assemblage.

4.7.1 Biological Communities

Stations 13MN060 and 13MN061 were sampled for fish and macroinvertebrates in 2013. The macroinvertebrate community scored above the modified use threshold of 22 on the Prairie Streams GP class IBI. With Scores at station 13MN060, scored 23.8 and station 13MN061 scored 29.3. For fish, station 13MN060 scored 38.5 on the Southern Headwaters class IBI, above the modified use threshold of 33. Station 13MN061 scored 15.9, below the modified use threshold of 35 for Southern Streams class for fish, reflected in Figure 69 and Figure 70. Common carp dominated both station visits.

Figure 69. Fish metrics of the Southern Headwaters class for station 13MN060, Minneopa Creek

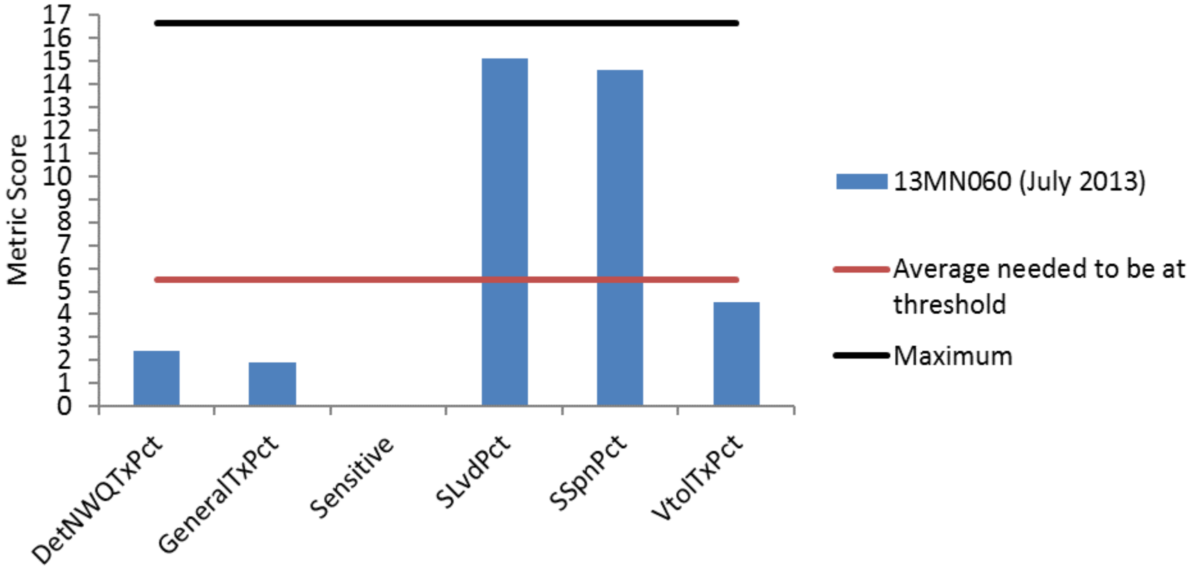
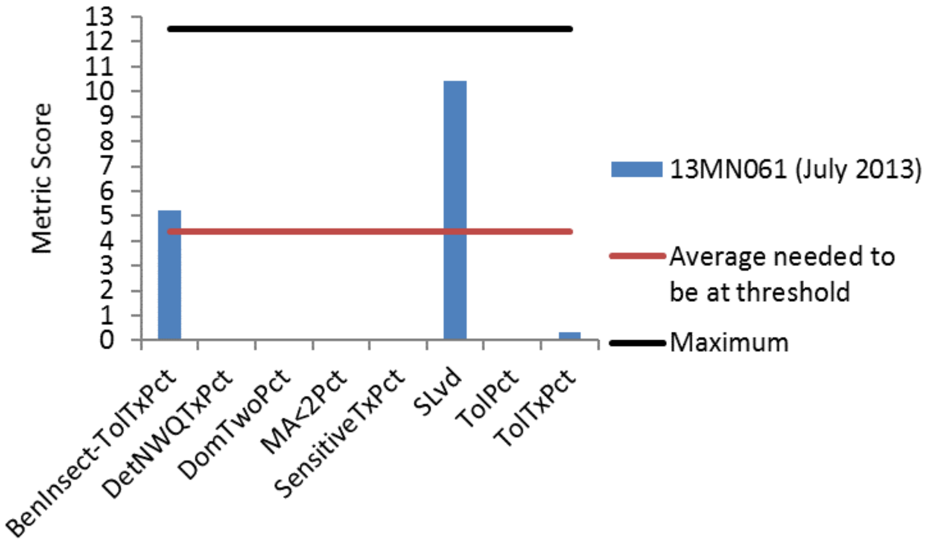


Figure 70. Fish metrics of the Southern Streams class for station 13MN061, Minneopa Creek



4.7.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

At the time of biological monitoring for station 13MN061, dissolved oxygen (DO) was low at 5.3 mg/L, recorded at 8:00am the morning of July 11, 2013. By 10:00am DO had significantly increased to 14.4 mg/L, when taken at station 13MN060. There were four additional samples collected, which had DO readings of 1.07 mg/L to 7 mg/L. All but one fell under the standard of 5 mg/L for warmwater.

Table 51 displays results of a 2015 longitudinal DO survey conducted within the Minneopa Creek Subwatershed. Highlighted in yellow displays the high variability of the daily DO swing at the two monitoring locations within this reach. At night autotrophic respiration occurs, driving the DO levels down. This process becomes exacerbated in stream systems where there is abundant algal growth. Early morning readings recorded critically low levels of DO at 1.43 mg/L and 0.69 mg/L. The inverse of abundant autotrophic growth, times active photosynthesis will increase DO levels in a stream. This accounts for the rise in DO levels found in the afternoon of 4.38 mg/L and 13.22 mg/L respectively.

Table 51. Longitudinal YSI sonde readings taken on August 4-5, 2015 showing a daily flux in DO from night to day.

Sonde deployments		PM pt measures				AM pt measures			
Station	**Waterbody name**	**Date**	**Time**	**Temp**	**DO mg/L**	**Date**	**Time**	**Temp**	**DO**
13MN060	Minneopa Creek	8/4/2015	15:22	18.9	4.38	8/5/2015	7:20	15.29	1.43
13MN059	Judicial Ditch 48-Minneopa Trib	8/4/2015	15:35	27.95	10.86	8/5/2015	7:30	16.79	0.92
13MN061	Minneopa Creek	8/4/2015	15:45	25.02	13.22	8/5/2015	7:04	19.02	0.69
13MN062	Minneopa Creek	8/4/2015	15:51	25.03	11.88	8/5/2015	6:55	16.69	1.57
13MN063	County Ditch 56-Minneopa Trib	8/4/2015	16:00	21.17	1.4	8/5/2015	6:40	16.88	0.43
13MN064	Minneopa Creek	8/4/2015	16:30	27.01	15.03	8/5/2015	6:32	20.13	2.34
13MN065	Minneopa Creek	8/4/2015	16:41	25.3	14.45	8/5/2015	6:22	19.08	5.71
13MN066	Minneopa Creek	8/4/2015	17:00	23.65	12.02	8/5/2015	6:07	19.17	7.5

Figure 71 displays overabundant algal and macrophyte productivity within this reach. This photo was taken at the time of biological monitoring. This photo illustrates it would not be unreasonable to correlate trends displayed from the longitudinal survey as being algae driven.

Figure 71. Monitoring location 13MN061 taken on July 11, 2013 displaying high algae/macrophyte production.

The biometrics for the fish community are suggestive of low DO stress (Table 52). Species that are sensitive to low DO were completely lacking in both locations. At the upstream location of 13MN060, there was an abundance in mature female species (MA>3Pct), found within the population of white suckers collected at this site. Station 13MN061 had a significant decrease in mature females, falling far below the average for a modified prairie stream. Both stations had low DO tolerant species (TolPct) as the dominant taxa present in both samples. This is also reflected in the fact that 80 – 90% of all individuals sampled were categorized as being tolerant specifically to low DO. The DO index score also fell below 7.00, the state average for a modified prairie stream, scoring at 6.54 and 6.38. There were not any low DO intolerant species in either sample.

Table 52. Fish metrics that respond to low DO stress in Judicial Ditch 48 compared to the statewide average of visits meeting the modified use warmwater biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
13MN060 (2013)	**0**	13.57	**95.98**	**6.54**	**0**	**0**	**4**	**98.9**
13MN061 (2013)	**0**	**0.98**	**99.78**	**6.38**	**0**	**0**	**4**	**80.0**
Prairie Streams MU average	*8.7*	*12.7*	*69.6*	*7.00*	*0.4*	*2.2*	*3.5*	*28.4*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

DO is a stressor within this reach, as it is reflected in the DO chemistry data and the subwatershed longitudinal DO survey. The stream dynamics are indicative of the low DO conditions being driven by eutrophication, which will be discussed in more detail below.

Eutrophication

During biological monitoring, the total phosphorus (TP) concentration at 13MN060 was 0.061 mg/L and at 13MN061 recorded at 0.044 mg/L on July 11, 2013. Four additional water chemistry samples with an average of .124 mg/L were taken in 2015 and 2016. TP concentrations ranged from 0.014 mg/L in May and reached up to 0.331 mg/L in September. There was one sample of chl-a in this reach of 12.6 mg/L (September 1, 2015). 24 hour DO fluxuation (DO flux) data is limited to what was found at the time of the longitudinal survey (refer to the above DO parameter for further information). DO flux would appear to be occurring within this stream.

While chemistry data is limited, almost every photo that was taken at the time of monitoring or from additional site visits displayed clear evidence of stream eutrophication, seen primarily in the form of filamentous algae blooms (Figure 72).

Figure 72. Minneopa Creek (07020007-531) taken on September 14, 2014 during an algal bloom.

Eutrophication metrics are suggestive of limiting the fish community, as shown in Table 53; neither location provided a sensitive or intolerant individual in the sample. There were a few darter species present, as well as simple lithophilic spawners. However, these groups both fell well below the average for what would be expected in this type of stream. The number of taxa (TaxaCount) collected fell just short of the average, and almost entirely found to be tolerant individuals (TolPct).

Table 53. Fish metrics that respond to eutrophication stress in Minneopa Creek compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
13MN060 (2013)	**0**	**3.0**	**13.6**	**96.0**	**7**	**0**
13MN061 (2013)	**0**	**0.2**	**0.89**	**99.8**	**6**	**0**
Southern Headwaters Average	*4.5*	*8.5*	*27.9*	*79.9*	*10.4*	*0.8*
Expected response to stress	↓	↓	↓	↑	↓	↓

Eutrophication does appear to stressing the fish community within this reach. While chemistry data is limited, what is available strongly indicates eutrophic conditions, as do the metrics. The largest piece of evidence is within the photo documentation.

Nitrate

During the fish sample, the nitrate concentration at 13MN060 was 9.6mg/L and at 13MN061 was 7.5 mg/L both taken on July 11, 2013. There were four additional samples taken in 2015 and 2016. The nitrate concentration ranged from 0.05 mg/L in September and up to 23 mg/L in June. The average concentration was 16.01 mg/L. All but one of the four samples was greatly above 10 mg/L.

The macroinvertebrate response was mixed between the two monitoring locations (Table 54). Sensitive Trichoptera species were not in abundance, and found to be completely lacking in the upstream station. Nitrate metrics show a lack of nitrate sensitive taxa, and abundant nitrate tolerant taxa and individuals. In both years, the nitrate index score was well above the state average for modified southern streams of 3.2. Station 13MN060 yielded a score of 3.8, while the downstream station fell just under the threshold at 3.1. The higher the Nitrate Index Score, the higher the nitrate tolerance shift is detected within the sample.

Table 54. Macroinvertebrate metrics that respond to nitrate stress in Minneopa Creek compared to the statewide average of visits meeting the warmwater modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN060 (2013)	**1**	**0.0**	**3.8**	**0**	**24**	**80.3**
13MN061 (2013)	**0**	**0.3**	3.1	**1**	17	59.4
Prairie Streams Average ***(MU)***	*2.6*	*2.4*	*3.2*	*1.1*	*18.0*	*59.7*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate as a stressor to the fish community is inconclusive within this reach. It is possible that there is a chronic nitrate problem stressing the community, based on the limited samples. The metrics do reflect possible displacement as there is a higher than average amount of nitrate tolerant species, while the sensitive groups are lacking. However, fish are impaired in this reach, and it is not clear if they are being impacted by excess nitrate. Nitrate is considered inconclusive at this time due to the lack on nitrate data available, as well as an inconclusive community metric response.

Total Suspended Solids

During the fish sample, the Total Suspended Solids (TSS) concentration at 13MN060 was 14 mg/L and at 13MN061 11 mg/L (July 11, 2013). TSS had four additional water quality samples taken in June and September of 2015 and in May and June of 2016. Data from collections ranged from 2.8 mg/L to 4.4 mg/L. A pattern of exceedance does not exist in the TSS dataset.

Fish TSS metrics did indicate stress within the fish community (Table 55 and Table 56). Exclusive benthic feeders were not as abundant as what typically would be seen in this type of stream. Centrarchidae, rated as being an intolerant species was also not to be found in either sample. Herbivores and sensitive species were lacking in the sample. The average expected amount for long-lived species was greatly exceeded in this reach; however, this is due to the overabundance of common carp in the sample. Perciformes as well as riffle-dwelling species were not in abundance at either location. Simple lithophilic spawners, who depend on gravel or course substrate for spawning, showed a mixed response.

Table 55. Fish metrics that respond to high TSS stress in Minneopa Creek compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
13MN060 (2013)	**16.6**	**0**	**13.6**	**0**	70.9	**3.0**	**13.6**	**0**	13.6
13MN061 (2013)	**1.11**	**0**	**0.9**	**0**	94.4	**0.2**	**0.89**	**0**	**0.89**
Southern Headwaters Average	*27.3*	*0.7*	*17.8*	*0.8*	*4.3*	*10.3*	*19.9*	*4.5*	*12.0*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

The TSS index score was significantly worse than the average of 16.2 that is scored for modified southern headwater streams, with scored nearly doubling that at 32.7-37.9. The fish community was overwhelmingly TSS tolerant dominant, complexly lacking is TSS sensitive species. This is likely due to the overwhelming abundance of carp in the fish sample.

Table 56. Fish metrics that respond to high TSS stress in Minneopa Creek compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

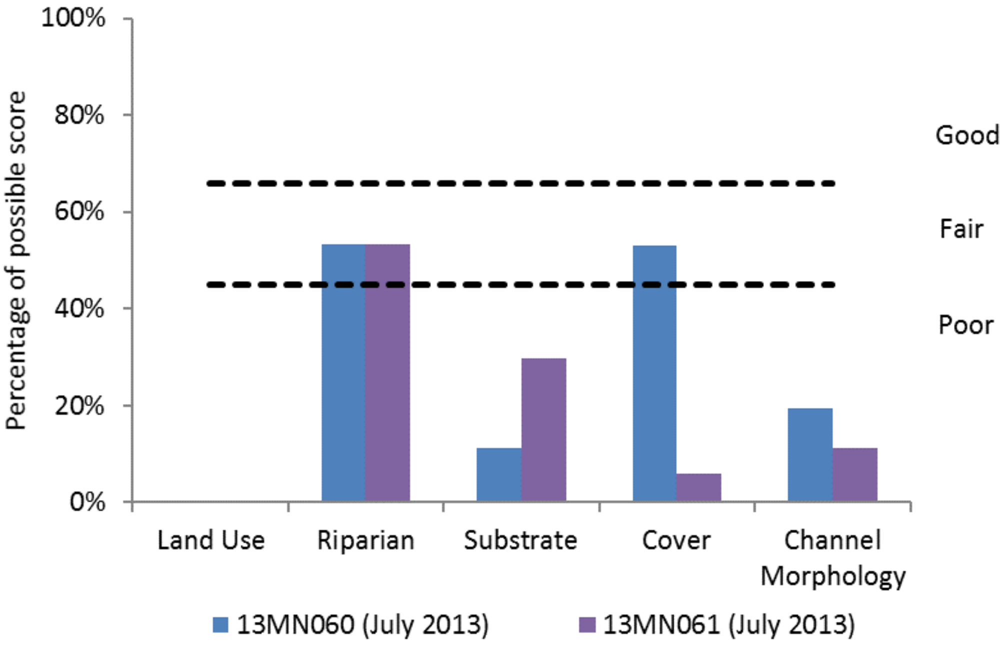
Station (Year sampled)	TSS Index Score	TSS Sensitive Taxa	TSS Sensitive Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN060 (2013)	**32.7**	**0**	**0**	**1**	**69.8**
13MN061 (2013)	**37.9**	**0**	**0**	**1**	**94.4**
Southern Headwaters Average	*16.2*	*0.5*	*2.9*	*0.5*	*2.5*
Expected response to stress	↑	↓	↓	↑	↑

TSS is inconclusive within this reach. While the metrics do indicate TSS as a possible stressor, another stressor such as eutrophic conditions could send similar signals. Lack of chemistry data is limiting the evidence to find the community impaired by TSS. In the future TSS, along with volatile suspended solids (VSS) should be collected to assess if this stream does have a TSS impairment.

Habitat

At station 13MN060 and 13MN061, the MSHA score was low at 27 and 21 respectively, falling far below the total of 100. Land use at both locations was composed of row crops, resulting in a score of zero. The land use directly influenced the narrow riparian width at the two locations as well; allowing for only some forms of prairie grass to provide shade (cover). At both locations, substrate and morphology scored the lowest scores (Figure 73). Substrate was primarily silt, with and absents of riffle and pools.

Figure 73. Percentage of MSHA subcategory scores for stations 13MN060 and 13MN061, Minneopa Creek.



The fish species measured in Table 55 support the habitat poor ratings at the monitoring locations. The streambeds at these locations were rated as having poor variation within the streambed, as it was severely embedded with silt. This could be part of the reason why benthic feeders and riffle dwellers were not abundant and the communities were dominated by carp. Overall, this reach had poor variation in habitat availability. Historically this stream was modified to a ditch to fit agricultural needs. Habitat is a stressor as it is reflected in MSHA scores, as well and the absence of fish groups that have specific habitat needs.

Longitudinal Connectivity and Altered Hydrology

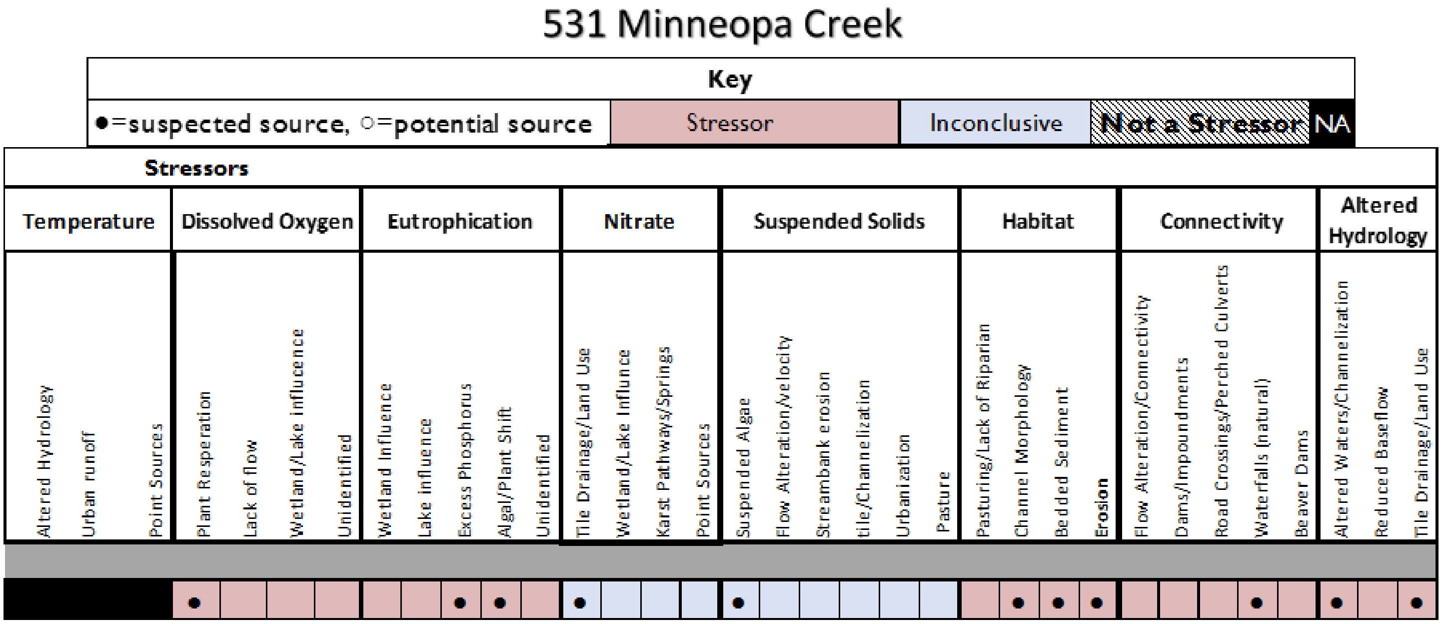
On Minneopa Creek, there is a waterfall approximately 1.4 miles upstream of the confluence with the Minnesota River. The waterfall is a barrier to migration with an approximate 52-foot drop. For more information on the barrier, please see DNR's Minnesota River, Mankato Watershed Characterization Report (2015). All of the biological stations are located upstream of the waterfall. There are not any downstream comparison sites available. Along with other stressors, the waterfall limits fish replenishment to Judicial Ditch 48.

While this subwatershed has more storage area than a majority of the others within the Minnesota River - Mankato Watershed, it is in the form of hypereutrophic lakes and wetlands. As this is the only refuge area, fish utilizing these areas must be tolerant to thrive.

Outside of the storage areas of wetlands and lakes upstream and downstream of this site, the remainder of this reach is being impacted by ditching, channelizing, as well as subsurface tile from agricultural practices. See Section 3.1.8 of this report for further information on the dynamics of altered hydrology on this landscape. Altered hydrology is thought to be the primary stressor within this reach, as it is driving the other stressors found in this reach. While altered hydrology is not playing a role to the natural barrier it is limiting refuge area's water quality, allowing only tolerant species to thrive.

Summary Table

Table 57. Identified stressors with suspected sources for reach 531 of Minneopa Creek.



531 Minneopa Creek

Key

●=suspected source, ○=potential source | Stressor | Inconclusive | Not a Stressor | NA

Stressors																																	
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls (natural)	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
			●						●	●		●				●							●	●	●				●		●		●

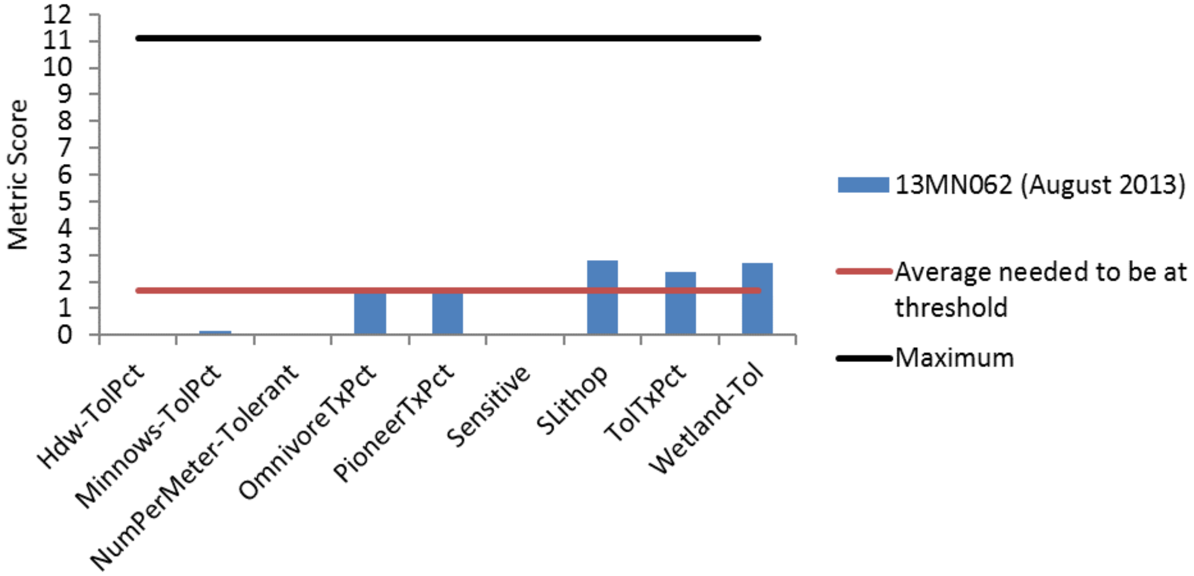
4.8 County Ditch 27 (07020007-535)

County Ditch 27 (07020007-535) is a small tributary west of Lake Crystal, Minnesota. The reach is warmwater modified use Class 2B. The reach extends from the headwaters to Lily Lake. The reach is impaired for lack of fish assemblage.

4.8.1 Biological Communities

Fish and macroinvertebrates were surveyed in 2013 at station 13MN062. The macroinvertebrate community scored 26.9, above the modified use threshold (22) for the Prairie Streams GP class. The fish community scored 11.2, which is below the modified use threshold (15) for the low gradient class. The fish community was dominated by common carp. Four metrics scored below the average metric score needed to have the IBI at the threshold (Figure 74). The relative abundance of non-tolerant individuals that are headwater species (Hdw-TolPct), relative abundance of non-tolerant individuals that are Cyprinidae species (Minnows-TolPct), number of non-tolerant individuals per meter of stream sampled (NumPerMeter-Tolerant), and taxa richness of sensitive species (Sensitive).

Figure 74. Fish metrics of the low gradient class for station 13MN062, County Ditch 27.



4.8.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

At the time of biological monitoring, dissolved oxygen (DO) was recorded at 11.11 mg/L around noon on August 12, 2013 and 19.94 mg/L taken in the afternoon on June 12, 2013 at station 13MN062. Only two additional DO readings were taken, with results of 11.15 mg/L on June 12, 2015 and significantly dropping to 4.4 mg/L in September 1, 2015; falling below the minimum level of 5 mg/L required to sustain aquatic life for warmwater reaches.

Table 58 displays results of a 2015 longitudinal DO survey conducted within the Minneopa Creek subwatershed. Highlighted in yellow displays the high variability in DO within a 24-hour period for station 13MN062. Throughout the night (during times of plant respiration) DO will go down, in this case significantly with a reading of 1.57 mg/L; The inverse is during daylight hours (during photosynthesis) DO will rise, this accounts for the rise in DO levels found in the afternoon reading of 11.88 mg/L. The more abundant the algal bloom, the more dramatic the 24 hour DO fluctuation.

Table 58. Longitudinal YSI sonde readings taken on August 4-5, 2015 showing a daily flux in DO from night to day.

Sonde deployments		PM pt measures				AM pt measures			
Station	**Waterbody name**	**Date**	**Time**	**Temp**	**DO mg/L**	**Date**	**Time**	**Temp**	**DO mg/L**
13MN060	Minneopa Creek	8/4/2015	15:22	18.9	4.38	8/5/2015	7:20	15.29	1.43
13MN059	Judicial Ditch 48-Minneopa Trib	8/4/2015	15:35	27.95	10.86	8/5/2015	7:30	16.79	0.92
13MN061	Minneopa Creek	8/4/2015	15:45	25.02	13.22	8/5/2015	7:04	19.02	0.69
13MN062	Minneopa Creek	8/4/2015	15:51	25.03	11.88	8/5/2015	6:55	16.69	1.57
13MN063	County Ditch 56-Minneopa Trib	8/4/2015	16:00	21.17	1.4	8/5/2015	6:40	16.88	0.43
13MN064	Minneopa Creek	8/4/2015	16:30	27.01	15.03	8/5/2015	6:32	20.13	2.34
13MN065	Minneopa Creek	8/4/2015	16:41	25.3	14.45	8/5/2015	6:22	19.08	5.71
13MN066	Minneopa Creek	8/4/2015	17:00	23.65	12.02	8/5/2015	6:07	19.17	7.5

Figure 75 supports the findings of an over-productive autotrophic stream, as there is an abundance of both algae and macrophytes. Given the density of algae matts shown paired with the shallow conditions of this low gradient prairie stream, it is likely that eutrophication within this stream was chronically depleting DO.

Figure 75. Biological monitoring station 13MN062, taken on August 12, 2013.

The fish metrics are suggestive of low DO stress. Species that are sensitive to low DO were completely lacking in this reach, as were mature female species (MA>3Pct) over the age of three years old. Species and dominant taxa were found in place of sensitive species, as reflected in the fact that 99% of all individuals sampled were categorized as being tolerant to low DO. The DO index score also fell below 7.00 (the average for a stream of this type) scoring at 6.2.

Table 59. Fish metrics that respond to low DO stress in Judicial Ditch 48 compared to the statewide average of visits meeting the modified use warmwater biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
13MN062 (2013)	**0**	**0.7**	**99.3**	**6.2**	**0**	**0**	5	**96.5**
Low Gradient Average	*18.7*	*16.1*	*49.2*	*6.4*	*0.1*	*0.6*	*6.8*	*59.7*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

DO is considered a biological stressor within this reach of County Ditch 27. The minimal DO data that exists on this reach is suggestive of low DO as a stressor. Additionally, the stream has visual indications of excessive autotrophic production. Fish metrics are also displaying a response to low DO.

Eutrophication

During the fish sample, the total phosphorus (TP) concentration at 13MN062 was 0.141 mg/L on June 12, 2013 and 0.390 mg/L on August 12, 2013. Five additional water chemistry samples were taken in 2015 and 2016 with results ranging from 0.078 mg/L - 0.310 mg/L at an average concentration of 0.135 mg/L. In both years TP samples would exceed the 0.150 mg/L standard in mid-summer and fall months. There was one sample of chlorophyll-a (chl-a) in the reach taken September 1, 2015 with a concentration of 11.5 µg/L. Dissolved oxygen fluxuation (DO flux) was likely a chronic issue, while there is only one set of daily DO fluxuation, the isolated DO reading displayed dramatic highs and lows of DO levels that correlate with eutrophic response.

Eutrophication metrics are suggestive of this stressing the fish community (Table 60). There was a lack of sensitive or intolerant individuals in the fish sample. There were not any darter species present, and only one simple lithophilic spawner (SLithopPct). Taxa abundance at this location was below the average collected in this stream type.

Table 60. Fish metrics that respond to eutrophication stress in County Ditch 27 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
13MN062 (2013)	**0**	**0**	**0.7**	**99.3**	**7**	**0**
Low Gradient Average	*18.7*	*6.5*	*23.1*	*49.2*	*12*	*4.4*
Expected response to stress	↓	↓	↓	↑	↓	↓

Figure 76. County Ditch 27, taken on September 1, 2015.

Eutrophication is a biological stressor. Total phosphorus does fall just under the average threshold of .15 mg/L. This is due to a number of factors, low sample numbers being one of them. The clear abundance of filamentous algae and aquatic macrophytes likely have TP bound. Chl-a was also low in the one sample that was collected. However, it is important to highlight that this sample was a water column grab sample, where only suspended algae would have resulted in an elevated chl-a reading. The extreme DO swing recorded at this reach paired with the obvious overgrowth during multiple sites visits (as seen in Figure 75 and Figure 76) point to a eutrophic stream. The fish metrics also indicate eutrophication is limiting the fish community.

Nitrate

During the fish sample, nitrate concentrations at 13MN062 was 16 mg/L on June 12, 2013 and 0.06 mg/L on August 12, 2013. Five additional water chemistry samples were taken in 2015 and 2016 with concentrations ranging from 0.12 mg/L (September 1, 2015) – 28 mg/L (June 1, 2016), having on average concentration of 19.82 mg/L. Sampling was done in the months of April, May, June, and September with all but one sample exceeding 20 mg/L. This reach displayed chronic overloading of nitrates.

Fish often do not show a strong response to increased nitrate concentrations. Macroinvertebrate communities are often more affected by nitrate. The macroinvertebrates in this reach indicated a response to elevated nitrate concentrations (Table 61). Sensitive Trichoptera species were not in abundance. Increased nitrate concentrations also correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct) and decreased intolerant taxa, both which are lacking in this reach. Intolerant species were found to be replaced by nitrate tolerant species. The nitrate index score also fell right at the threshold for modified prairie streams with a score of 3.2.

Table 61. Macroinvertebrate metrics that respond to nitrate stress in County Ditch 27 compared to the statewide average of visits meeting the warmwater modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN062 (2013)	**1**	**0.3**	**3.2**	**0**	**21**	**63.6**
Prairie Streams Average ***(MU)***	*2.6*	*2.4*	*3.2*	*1.1*	*18.0*	*59.7*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate readings were high throughout the year, and the macroinvertebrate community displayed a strong metric response to being displaced by nitrates. However, as it is only the fish community that is listed as impaired, macroinvertebrate metrics can only be used as an indicator of nitrate impacts rather than a direct correlation to a fish impairment. Therefore, nitrate is inconclusive but clearly should be targeted for reduction within this reach.

Total Suspended Solids

During the fish sample, the total suspended solids (TSS) concentration at 13MN062 was 2.8 mg/L for both the July 29, 2013 and August 12, 2013 sample. Five additional water chemistry samples were taken in 2015 and 2016 with concentrations ranging from 1.2 mg/L – 14 mg/L, with an average concentration of 5.36 mg/L.

The sampled fish community did indicate some TSS stress, seen in Table 62 and Table 63. Excess TSS in a stream often will correlate to an embedded or buried streambed. Fish groups that depend on clean river ben substrate, such as exclusive benthic feeders (BenFdFrimPct), herbivores (HrbNWQPct), riffle dwelling species, and simple lithophilic spawners (SLithFrimPct) were greatly lacking within this reach. Centrarchidae (Centr-TolPct) and Perciforms (Percfm-TolPct), both rated as being TSS intolerant were absent from the community; whereas in a supporting stream these species should make up approximately a combined 20% of the community. In general, intolerant species were lacking.

The average expected amount for long-lived species (LlvdPct) was exceeded in this reach; however, this is due to the overabundance of common carp in the sample.

Table 62. Fish metrics that respond to high TSS stress in County Ditch 27 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
13MN062 (2013)	**0.7**	**0**	**1.4**	**0**	69.9	**0**	**0.7**	**0**	**0.7**
Low Gradient Average	*16.4*	*4.9*	*14.5*	*2.7*	*12.0*	*15.2*	*10.6*	*11.2*	*12.3*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

The TSS index score was significantly worse than the average of 14.8 that is scored for modified low gradient streams, with this site scoring over double that at 31.7. Specific TSS intolerant or sensitive species were replaced by TSS tolerant species.

Table 63. Fish metrics that respond to high TSS stress in County Ditch 27 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

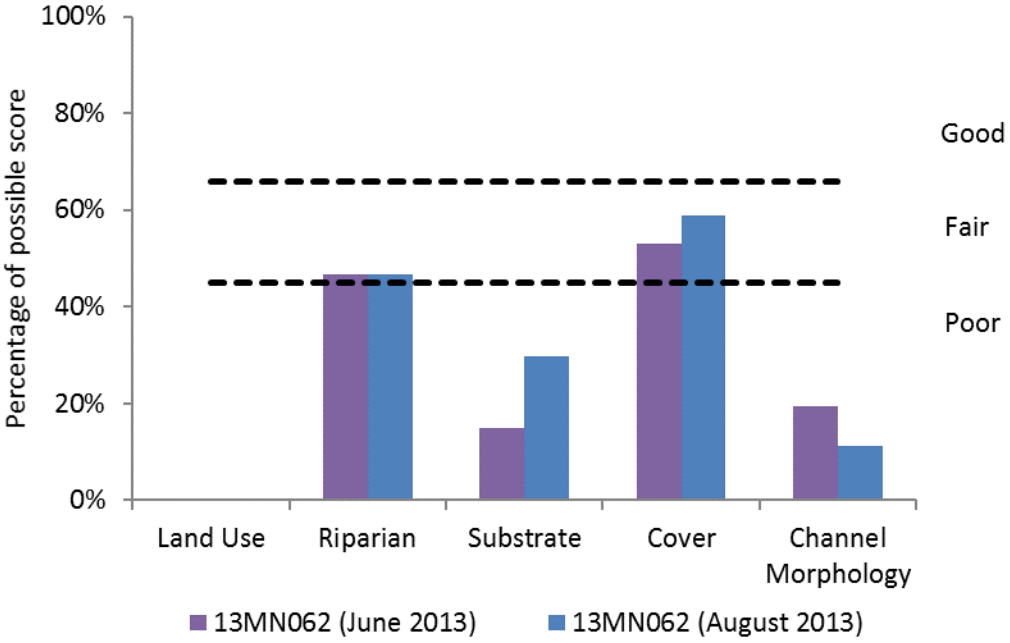
Station (Year sampled)	TSS Index Score	TSS Sensitive Taxa	TSS Sensitive Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN062 (2013)	**31.7**	**0**	**0**	**1**	**69.9**
Low Gradient Average	*13.8*	*1.6*	*10*	*0.1*	*0.4*
Expected response to stress	↑	↓	↓	↑	↑

TSS is inconclusive as a stressor to the fish community. While metrics do show a clear response to TSS being a stressor on the fish community, there is not any chemistry data to indicate that TSS is a problem in this stream. Therefore, it is difficult to conclude if the community composition is skewed for TSS or from another stressor (such as habitat conditions). Additional TSS monitoring is recommended in the future.

Habitat

MSHA scores for the two months sampled in 2013 were both poor, with scores of 29 in June and 27 in August of 2013. Several poor habitat features are contributing to the low MSHA, as shown in Figure 77, surrounding agricultural land use paired with poor riparian greatly drove down the overall score. The stability of the channel was one of the worst scoring categories. The channel is characterized as homogenous and shallow, with no noted riffles. The substrate consisted of sand and silt, noted as being severely embedded. Some light bank erosion was noted. Stream velocity was noted as slow on a low gradient. There was little overhanging vegetation.

Figure 77. Percentage of MSHA subcategory scores for station 13MN062, County Ditch 27



The fish species measured in the previous TSS section indicate habitat issues, particularly reflected in the streambed. Rated as having poor substrate, as it was severely embedded with silt and sand it is likely the primary reason why benthic feeders, simple lithophilic spawners, and riffle dwellers were completely absent (Table 62). Overall, this reach had poor variation in habitat availability. Historically this stream was modified to a ditch to fit agricultural needs. Figure 78 below highlights the homogenous features of this stream, providing poor habitat diversity for the fish community.

Figure 78. Station 13MN062, August 12, 2013

Habitat is considered a stressor to the fish community. Clear limitations and degradation on the streambed have taken away both habitat diversity as well as habitat quality. There is also a lack of refuge area and cover, as the riparian is compromised. The fish metrics also display a community that can thrive is degraded conditions, with very few fish present that require specific habitat needs.

Longitudinal Connectivity and altered hydrology

Downstream from this site, on Minneopa Creek there is a waterfall approximately 1.4 miles upstream from the confluence with the Minnesota River. The waterfall is a barrier to migration with an approximate 52-foot drop. For more information on the barrier, please see DNR's Minnesota River, Mankato Watershed Characterization Report (2015). All of the biological stations are located upstream of the waterfall, with no downstream comparison sites available. Along with other stressors, the waterfall limits fish replenishment to Judicial Ditch 48. It is a combination of factors including stressors present in the existing lakes and wetlands upstream of the wetlands with the waterfall that limits the fish community.

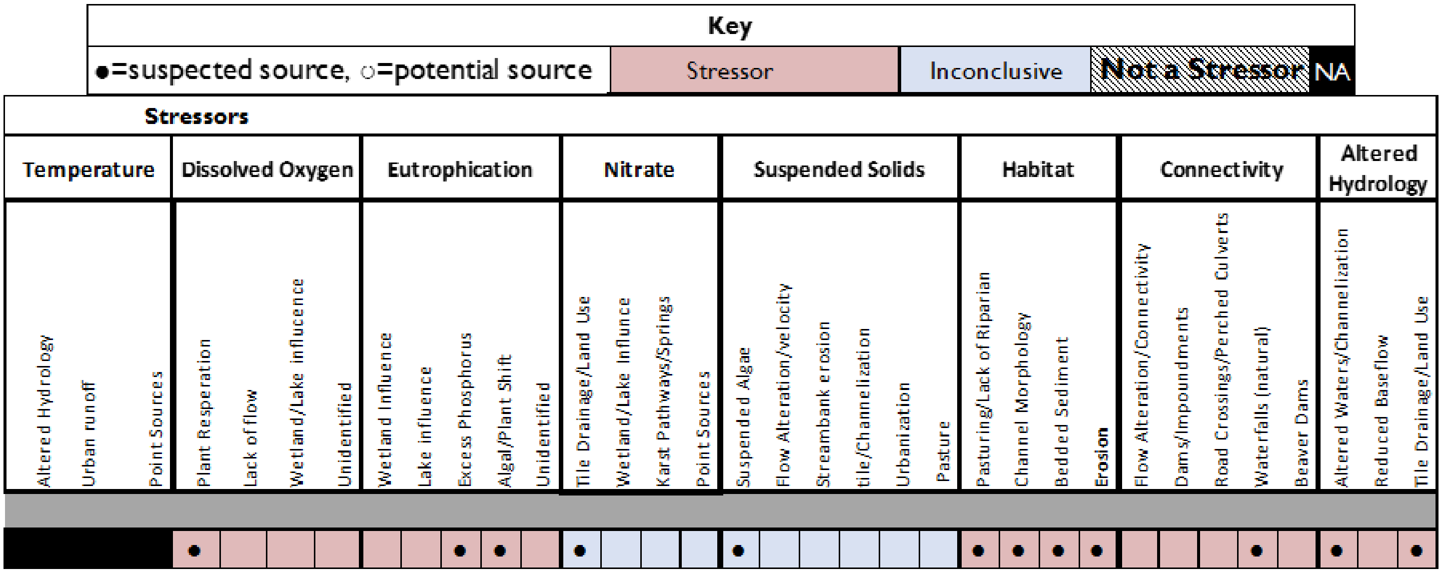
While this subwatershed has more storage area than a majority of the others within the Minnesota, Mankato River Watershed, it is in the form of hypereutrophic lakes and wetlands. As this is the only refuge area, fish utilizing these areas must be tolerant to thrive.

While the macroinvertebrate community was not listed, the invertebrate community was indicative of tolerant wetland species. Outside of the storage areas of wetlands and lakes upstream and downstream of this site, the remainder of this reach is being impacted by ditching and channelizing, as well as tile imputes from subsurface tile drainage from agricultural practices. See Chapter 3.1.8 of this report for further information on the dynamics of altered hydrology on this landscape.

Summary Table

Table 64. Identified stressors with suspected sources for reach 535 County Ditch 27.

535 County Ditch 27



Key				
●=suspected source, ○=potential source	Stressor	Inconclusive	Not a Stressor	NA

Stressors																																	
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls (natural)	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
			●						●	●		●				●						●	●	●	●				●		●		●

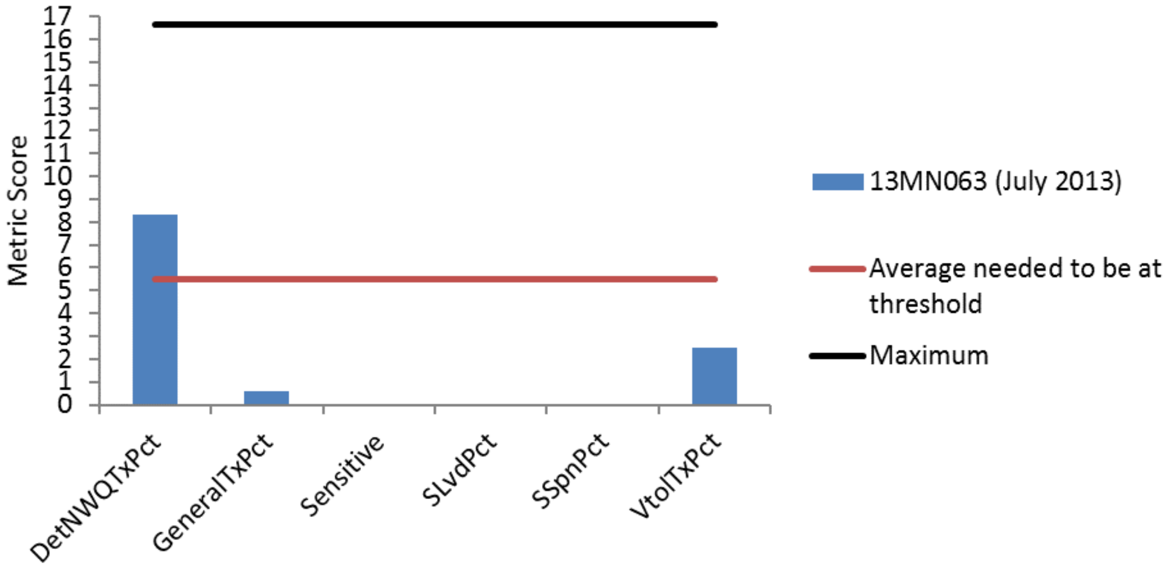
4.9 County Ditch 56 (Lake Crystal Inlet) (07020007-557)

County Ditch 56 (07020007-557) is a small tributary south of Lake Crystal, Minnesota. The reach is warmwater modified use Class 2B. The reach extends from the headwaters to Lake Crystal. The reach is impaired for lack of fish assemblage. The reach is also impaired for *E. coli*, which will not be addressed in this report.

4.9.1 Biological Communities

Station 13MN063 was sampled for fish and macroinvertebrates in 2013. The macroinvertebrate community scored 34.8, above the modified use threshold of 22 for the Prairie Streams GP class. The fish community scored 11.4, below the modified use threshold (33) for the Southern Headwaters class. There were fewer than 25 fish when surveyed. The fish present were black crappie (4), common carp (4), black bullhead (2), and yellow bullhead (2). Nearly all of the metrics were below the average metric scored needed to obtain an IBI at the threshold (Figure 79), with the only one passing was the relative abundance of detritivorous (DetNWQTxPct).

Figure 79. Fish metrics of the Southern Headwaters class for station 13MN063, County Ditch 56



4.9.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

At the time of biological monitoring, dissolved oxygen (DO) was recorded at 11.78 mg/L in the afternoon on August 6, 2013 and at 11 mg/L around noon on August 12, 2013. One other site visit resulted in a high value of 19.94 mg/L taken in the afternoon on June 12, 2013.

Table 65 below displays results of a 2015 longitudinal DO survey conducted within the Minneopa Creek Subwatershed. Highlighted in yellow displays the high variability in DO levels at 13MN062. In early morning hours, this station was significantly below the standard at 0.43 mg/L, correlating with the time of plant respiration where DO will go down as plants are using up oxygen in the stream. The afternoon reading at this station was still below the standard, at 1.4 mg/L. Afternoon reading are typically when DO is often thought to be the highest within a stream as plants and other autotrophs are releasing oxygen. Based on the longitudinal readings, it would appear this stream is vulnerable to chronically low of DO levels.

Table 65. Longitudinal YSI sonde readings taken on August 4-5, 2015 showing a daily flux in DO from night to day.

Sonde deployments		PM pt measures				AM pt measures			
Station	**Waterbody name**	**Date**	**Time**	**Temp**	**DO mg/L**	**Date**	**Time**	**Temp**	**DO mg/L**
13MN060	Minneopa Creek	8/4/2015	15:22	18.9	4.38	8/5/2015	7:20	15.29	1.43
13MN059	Judicial Ditch 48-Minneopa Trib	8/4/2015	15:35	27.95	10.86	8/5/2015	7:30	16.79	0.92
13MN061	Minneopa Creek	8/4/2015	15:45	25.02	13.22	8/5/2015	7:04	19.02	0.69
13MN062	Minneopa Creek	8/4/2015	15:51	25.03	11.88	8/5/2015	6:55	16.69	1.57
13MN063	County Ditch 56-Minneopa Trib	8/4/2015	16:00	21.17	1.4	8/5/2015	6:40	16.88	0.43
13MN064	Minneopa Creek	8/4/2015	16:30	27.01	15.03	8/5/2015	6:32	20.13	2.34
13MN065	Minneopa Creek	8/4/2015	16:41	25.3	14.45	8/5/2015	6:22	19.08	5.71
13MN066	Minneopa Creek	8/4/2015	17:00	23.65	12.02	8/5/2015	6:07	19.17	7.5

The fish metrics are all suggestive of low DO stress (Table 66). Species that are sensitive to low DO were absent. There was also a complete lack of mature female species (MA>3Pct), indicating a disruption to the lifecycle of this fish community. Overall, dominant taxa were found in place of sensitive species, as reflected in the fact that 66.7% of all individuals sampled were categorized as being tolerant to DO. The DO index score was 6.1, far below the state average of 7.13 for a modified southern stream.

Table 66. Fish metrics that respond to low DO stress in the Lake Crystal inlet compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
13MN063 (2013)	**0**	**0**	**50**	**6.1**	**0**	**0.0**	3	**66.7**
Southern Headwaters Average	*7.9*	*13.9*	*72.8*	*7.13*	*0.7*	*4.1*	*3.4*	*21.2*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

DO is likely a biological stressor. While DO readings were high at the time of biological monitoring, it is important to note that sampling occurred in the afternoon, yielding extremely high values that would be indicative of high photosynthetic production. During the longitudinal sample, both the morning and afternoon values were low, this could be due to low flow or stagnant conditions, or high rates of algae decomposition within this small stream. The fish metrics were also suggestive of a community that is being limited by low DO.

Eutrophication

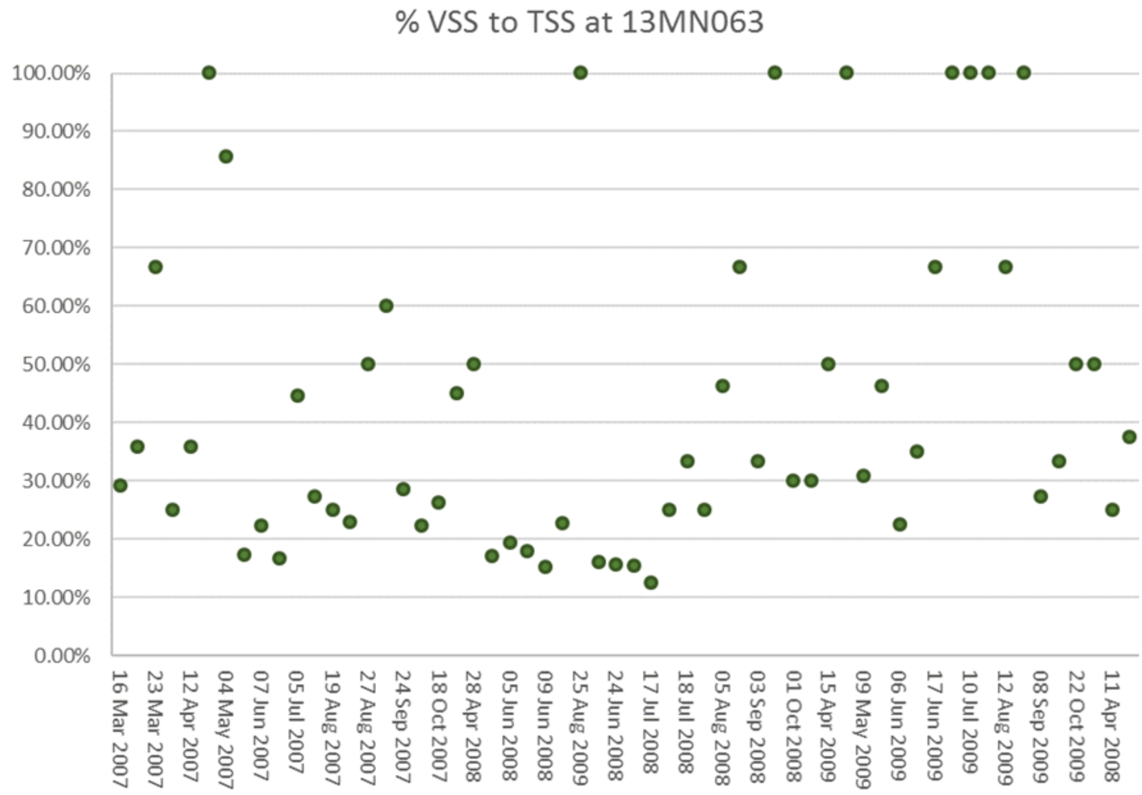
At the time of biological monitoring total phosphorus (TP) was recorded at 0.167 mg/L on July 11, 2013. Phosphorus data for this reach has the largest number of data within this subwatershed, with 63 samples from 2007 to 2008. Sixty two percent exceeded the 0.15 mg/L standard for TP. Samples ranged from 0.049 mg/L to 0.827 mg/L with an overall average of 0.218 mg/L. Chl-a was not analyzed at this site.

Total phosphorus data does exceed the river eutrophication level. There has been evidence of abundant algal growth seen in the form of filamentous algae mats, seen in Figure 80.

Figure 80. 13MN063 September 14, 2012 Algae bloom.

One other indicator of eutrophic conditions is noted in the amount of organics during sampling. Analysis was done to compare the percent of volatile suspended solids (VSS) with associated total suspended solids sample. As shown in Figure 81, VSS made up an average of 40% of the TSS load. This shows this stream has high organic matter, indicating eutrophic conditions.

Figure 81. Ratio of VSS to TSS at station 13MN063, at County Ditch 27 (Lake Crystal Inlet).



The fish community was lacking species that are sensitive to eutrophic conditions (Table 67), such as darters (DarterPct) and simple lithophilic spawners (SlithopPct) that depend on water clarity to thrive. This community is limited in other ways, such as the natural barrier of the waterfall downstream, paired with poor refuge, yielding a low taxa count.

Table 67. Fish metrics that respond to eutrophication stress in County Ditch 56 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
13MN063 (2013)	**0**	**0**	**0**	50	**4**	**0**
Southern Headwaters Average	*4.5*	*8.5*	*27.9*	*79.9*	*10.4*	*0.8*
Expected response to stress	↓	↓	↓	↑	↓	↓

Eutrophication is a stressor within this reach. Phosphorus is abundant enough to sustain overgrowth of algae, which is also reflected in the chronically low DO profile of this stream. TSS will be discussed in greater detail below; it is significant to the case of eutrophication that organic matter (VSS) made up a large percentage of TSS concentrations.

Nitrate

During the fish sample, the nitrate concentration at 13MN063 was 8.9 mg/L on July 11, 2013. Sixty-three additional water chemistry samples were taken in 2007 through 2009 with concentrations ranging from

0.49 mg/L – 16.4 mg/L, with an average concentration of 7.74 mg/L. Sampling was done in the months of March through August and October of 2007 and 2008. Spring months typically yielded the highest concentrations for nitrate.

Fish often do not show a strong response to increased nitrate concentrations. Macroinvertebrate communities are often more affected by nitrate. The macroinvertebrates in this reach did show a negative response to nitrate (Table 68). The nitrate index score that was at 3.4, this is higher than the modified southern streams average of 2.9. The nitrate specific metrics show lower than average Trichoptera taxa, as well as a decrease in non-hydropsychid Trichoptera individual percentages (sensitive caddisflies that do not spin nets; TrichwoHydroPct). Intolerant taxa received the lowest possible score, in the absence of intolerant species, tolerant and species were found in place of sensitive species.

Table 68. Macroinvertebrate metrics that respond to nitrate stress in County Ditch 56 (Lake Crystal Inlet) compared to the statewide average of visits meeting the warmwater modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN063 (2013)	**2**	**0.6**	**3.4**	**0**	**23**	**68.7**
Prairie Streams Average ***(MU)***	*2.6*	*2.4*	*3.2*	*1.1*	*18.0*	*59.7*
Expected response to stress	↓	↓	↑	↓	↑	↑

There was a strong dataset to indicate that high nitrate levels are a chronic issue within this stream, particularly during the spring months. The macroinvertebrate metrics consistently displayed nitrate displacement within the community sampled. However, as fish are impaired and not the macroinvertebrate community nitrate is inconclusive as a stressor. Efforts should still be made to target nitrate reductions within this reach.

Total Suspended Solids

During the fish sample, the total suspended solids (TSS) concentration at 13MN063 was 36 mg/L on July 11, 2013. Sixty-two additional water chemistry samples were taken in 2007 through 2009 with concentrations ranging from 2 mg/L – 392 mg/L, with an average of 28.49 mg/L. This analysis does not include one outlier from July 17, 2008, that had a concentration of 1380 mg/L.

As discussed in the above eutrophic section, VSS values were assessed alongside TSS samples. On average organics were found to make up nearly half of the TSS concentration of each sample. This is not to say TSS in the form of sediment is not high at times, as values fell well into the 100 mg/L and above. However, it was not a chronic issue as only six of the 64 samples fell over the standard of 65 mg/L.

As only 12 individual fish were surveyed in this sample it is important to keep in mind the community metrics and percentages, (Table 69 and Table 70) are skewed due to low sample number. Four individuals of this sample were black crappies, found in the class of Centrarchidae and in the order of Perciforms, therefore the metrics reporting the four made up 33.3% of the entire sample. Long-lived percent was also driven up from four Common Carp that were surveyed. Benthic and herbatious eaters were absent, as were Riffle dwelling and simple lithophilic spawners.

Table 69. Fish metrics that respond to high TSS stress in County Ditch 56 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
13MN063 (2013)	**0**	33.3	**0**	**0**	33.3	33.3	**0**	**0**	**0**
Southern Headwaters Average	*27.3*	*0.7*	*17.8*	*0.8*	*4.3*	*10.3*	*19.9*	*4.5*	*12.0*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

As with the community metrics above, the index, tolerant, and sensitive scores are skewed due to the low sample number.

Table 70. Fish metrics that respond to high TSS stress in County Ditch 56 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

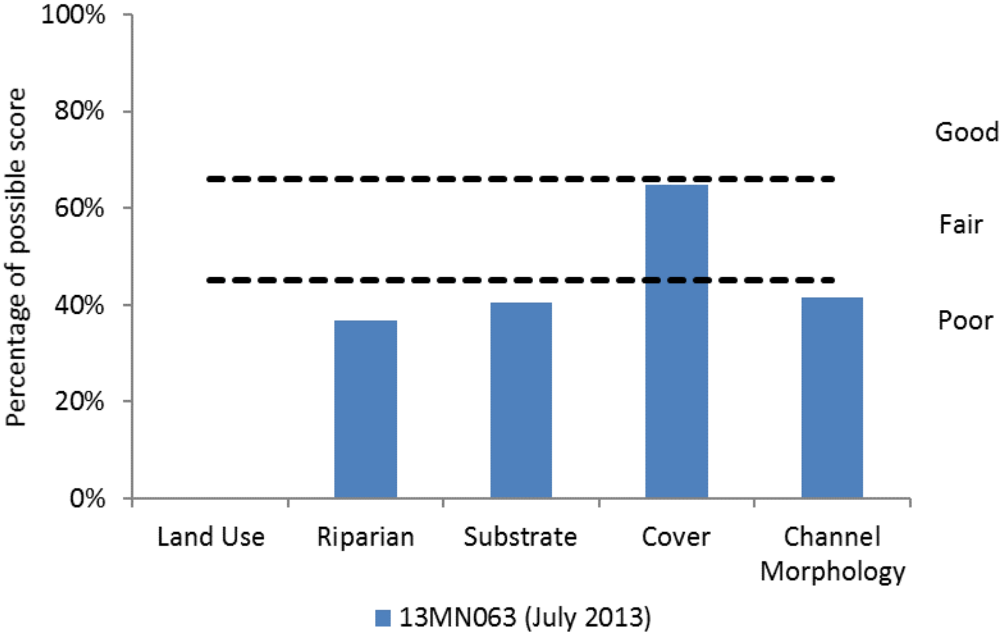
Station (Year sampled)	TSS Index Score	TSS Sensitive Taxa	TSS Sensitive Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN063 (2013)	**25.3**	**0**	**0**	**1**	**33.3**
Southern Headwaters Average	*16.2*	*0.5*	*2.9*	*0.5*	*2.5*
Expected response to stress	↑	↓	↓	↑	↑

TSS is inconclusive as a biological stressor. While the chemistry data displays some potential for high TSS loading within this reach, the number that exceeded the standard fell just under 10% of the extensive data set. The high amount of organics in the data set also leave the question if the population is limited more in the way of eutrophic conditions, or if TSS is also driving the population down. Additional monitoring is recommended to better understand the dynamic occurring within this reach.

Habitat

Station 13MN063 had an MSHA of 42.5, with all stream categories assessed rated as poor (Figure 82) with the exception of "cover" (which was rated as fair). The streambed at this location was described as having poor variation, as well as moderately embedded with silt and sand. Stream stability is also rated as poor, as bank erosion was noted on both sides of the bank. Overall, this reach had poor variation in habitat availability. Historically this stream was modified to a ditch to fit agricultural needs, leaving the stream homogenous. However, over time this stream has redeveloped a few natural features, such as riffles and pools. Cover was found to be adequate, with overhanging vegetation and woody debris acting as the dominate refuge areas.

Figure 82. Percentage of MSHA subcategory scores for station 13MN063, County Ditch 56



The physical modification on this reach has resulted in this stream having a shallower and a less sinuous channel, leaving little habitat variation within the stream. In addition, the poor riparian has left this reach to be vulnerable to chemical and temporal change. Fish metrics found in table in the above TSS section (Table 69) note an absents of riffle dwelling, benthic feeders, simple lithophilic spawners, and herbivores. All of these fish categories depend on a clean riverbed.

Figure 83. Station 13MN063, July 11, 2013

Habitat is a stressor to the fish community. This is primarily noted in the poor streambed substrate that has created a homogenous reach that lacks diversity for specialized fish species. There is also a lack of refuge area that further limits fish diversity.

Longitudinal Connectivity and Altered Hydrology

On Minneopa Creek, there is a waterfall approximately 1.4 miles upstream of the confluence with the Minnesota River. The waterfall is a barrier to migration with an approximate 52-foot drop. For more information on the barrier, please see DNR’s Minnesota River, Mankato Watershed Characterization Report (2015). All of the biological stations are located upstream of the waterfall, so there is no downstream comparison available. Along with other stressors, the waterfall limits fish replenishment to Judicial Ditch 48. It is a combination of factors including stressors present in the existing lakes and wetlands upstream of the wetlands with the waterfall that limits the fish community.

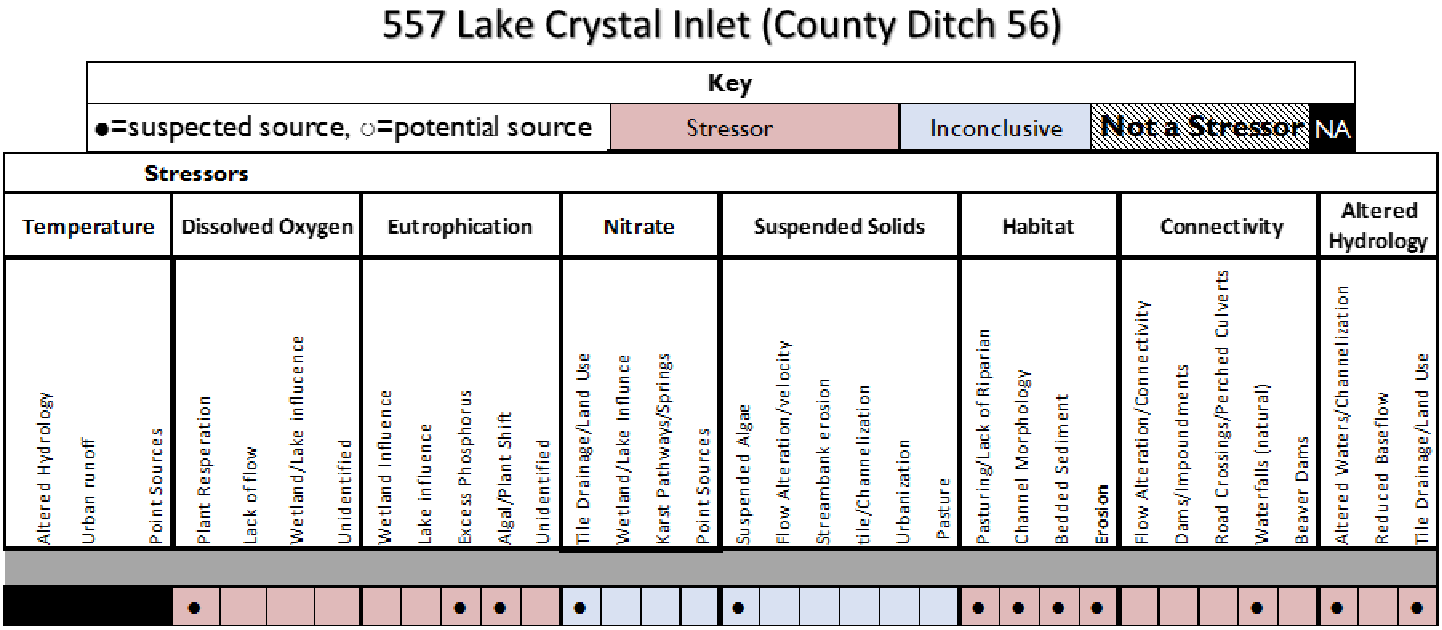
While this subwatershed has more storage area than a majority of the others within the Minnesota, Mankato River Watershed, it is in the form of hypereutrophic lakes and wetlands. As this is the only refuge area, fish utilizing these areas must be tolerant to thrive.

While the macroinvertebrate community was not listed as impaired, the invertebrate sample was indicative of wetland conditions, which is supported by flow conditions at the time of sampling.

Outside of the storage areas of wetlands and lakes upstream and downstream of this site, the remainder of this reach is being impacted by ditching and channelizing, as well as tile imputes from subsurface drainage from agricultural practices. See Section 3.1.8 of this report for further information on the dynamics of altered hydrology on this landscape.

Summary Table

Table 71. Identified stressors with suspected sources for reach 551 County Ditch 56.



557 Lake Crystal Inlet (County Ditch 56)

Key				
●=suspected source, ○=potential source	Stressor	Inconclusive	Not a Stressor	NA

Stressors																																	
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	**Erosion**	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls (natural)	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
			●						●	●		●				●						●	●	●	●				●		●		●

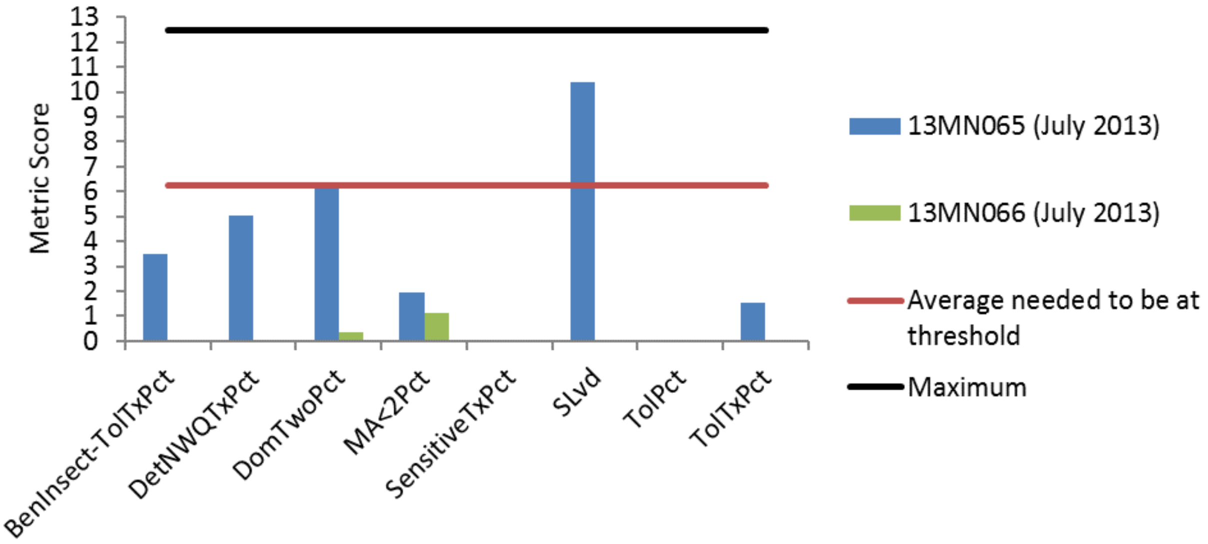
4.10 Minneopa Creek (07020007-534)

Minneopa Creek (07020007-534) is a tributary northeast of Lake Crystal, Minnesota. The reach is warmwater general use Class 2B. The reach extends from upstream of MN 60 to the Minnesota River. The reach is impaired for lack of fish assemblage and lack of macroinvertebrate assemblage. The reach is also impaired for turbidity and *E. coli. E. coli* will not be addressed in this report. Turbidity will be addressed as it relates to the biological communities.

4.10.1 Biological Communities

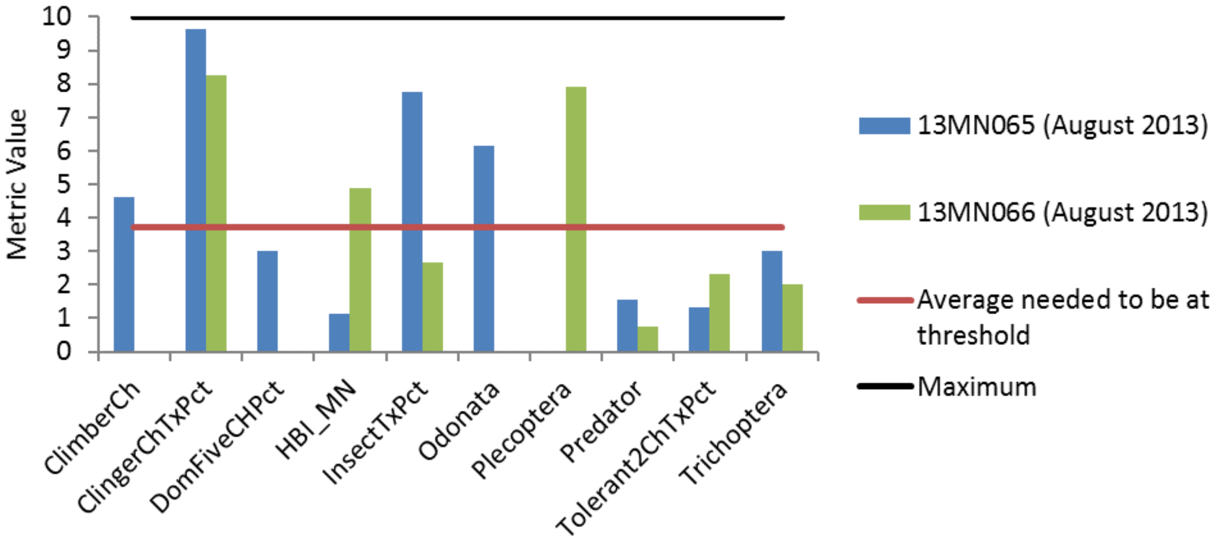
Stations 13MN065 and 13MN066 were sampled for fish and macroinvertebrates in 2013. Station 13MN065 is the upstream station and 13MN066 is the downstream station. The fish community scored below the general use Southern Streams class threshold (50) at both stations (28.5 at station 13MN065 and 1.5 at station 13MN066). Both stations were dominated by common carp. Most of the FIBI metrics were below the average metric score needed to obtain a FIBI at the threshold (Figure 84). Both stations also had a high relative abundance of tolerant individuals as well as tolerant taxa.

Figure 84. Fish metrics of the Southern Streams class for station 13MN065 and 13MN066, Minneopa Creek



At station 13MN065, the MIBI score of 38.6 was just above the general use threshold (37) for the Southern Streams RR class. Station 13MN066 had a worse MIBI of 28.9, below the threshold. As reflected in Figure 85, MIBI metrics that were low in both stations were relative abundance of dominant five taxa in subsample (DomFiveCHPct), taxa richness of predators excluding chironomid predator taxa (Predator), relative percentage of taxa with MN tolerance values equal to or greater than 6 (Tolerant2ChTxPct), and taxa richness of Trichoptera (Trichoptera). At station 13MN065, scuds (Hyalella) were the most abundant taxa. At station 13MN066, black fly larva (Simulium) was the most abundant and dominated the sample.

Figure 85. Macroinvertebrate metrics of the Southern Streams class for stations 13MN065 and 13MN066, Minneopa Creek



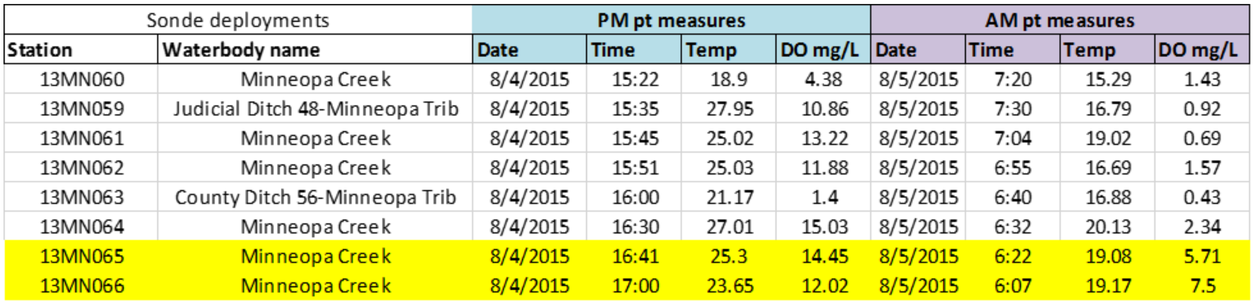
4.10.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

At the time of biological monitoring dissolved oxygen (DO) was recorded at 11.7 mg/L on July 24. 2013, 11.57 on July 29, 2013, 10.9 mg/L, and 9.23 on August 6, 2013. There were 19 additional DO readings taken in 2013 and 2014. These values ranged from 4.56 mg/L-14.8 mg/L. Only one value fell below the standard of 5 mg/L for warmwater. This sample was taken earlier in the day (8:15 am) in comparison to the other samples on September 17, 2013.

A longitudinal DO survey was conducted throughout this subwatershed in 2015, noted in Table 72. While 24-hour DO variation was clearly high and indicated an overabundance of algae and macrophyte productivity, the DO did not fall below the standard of 5 mg/L at either 13MN065 or 13MN066. However, the stations upstream did demonstrate low DO exceeding the standard. The DO flux on August 4 at 13MN065 was 8.7 mg/L while the DO flux at 13MN066 was not quite as high, at 4.5 mg/L. In the future, sonde deployments or long term diurnal DO readings would be helpful with understanding the full DO cycle occurring throughout the stream.

Table 72. Longitudinal YSI sonde readings taken on August 4-5, 2015 showing a daily flux in DO from night to day.



Sonde deployments		PM pt measures				AM pt measures			
Station	**Waterbody name**	**Date**	**Time**	**Temp**	**DO mg/L**	**Date**	**Time**	**Temp**	**DO mg/L**
13MN060	Minneopa Creek	8/4/2015	15:22	18.9	4.38	8/5/2015	7:20	15.29	1.43
13MN059	Judicial Ditch 48-Minneopa Trib	8/4/2015	15:35	27.95	10.86	8/5/2015	7:30	16.79	0.92
13MN061	Minneopa Creek	8/4/2015	15:45	25.02	13.22	8/5/2015	7:04	19.02	0.69
13MN062	Minneopa Creek	8/4/2015	15:51	25.03	11.88	8/5/2015	6:55	16.69	1.57
13MN063	County Ditch 56-Minneopa Trib	8/4/2015	16:00	21.17	1.4	8/5/2015	6:40	16.88	0.43
13MN064	Minneopa Creek	8/4/2015	16:30	27.01	15.03	8/5/2015	6:32	20.13	2.34
13MN065	Minneopa Creek	8/4/2015	16:41	25.3	14.45	8/5/2015	6:22	19.08	5.71
13MN066	Minneopa Creek	8/4/2015	17:00	23.65	12.02	8/5/2015	6:07	19.17	7.5

The macroinvertebrate community displayed a mixed response in regards to low DO stress (Table 73). The overall individual taxa abundance was below the expected amounts for a stream of this type. Taxa richness of the low DO sensitive EPT (Ephemeroptera, Plecoptera and Trichoptera); fell below the expected values at the upstream monitoring station, and just over at 13MN066. While they were not in abundance, low DO intolerant species were found at both sites. Additionally, low DO tolerant taxa and individuals were not overly abundant. Overall there is not a strong indication that DO is influencing to macroinvertebrate community.

Table 73. Macroinvertebrate metrics that respond to low DO stress in Minneopa Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN065 (2013)	**40**	**13**	**7.96**	7.10	**5**	**8.3**	4	**19.5**
13MN066 (2013)	**29**	15	6.68	7.61	**9**	**12.2**	2	2.5
Southern Streams Average	*45.8*	*14.2*	*7.08*	*7.04*	*9.0*	*24.0*	*4.8*	*9.9*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

The fish biometrics are somewhat suggestive of low DO stress. Species that are sensitive to low DO were lacking. Both stations had DO tolerant species reflected in the high percentage of DO tolerant individuals. The DO index score also fell below 7.13 (the state average for a modified southern stream), scoring at 6.73 and 6.61. At both stations, mature females over the age of 3 (MA>3Pct) were lacking, indicating a disruption of the life cycle within these communities.

Table 74. Fish metrics that respond to low DO stress in Minneopa Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
13MN065 (2013)	**0**	**11.98**	**81.25**	**6.73**	**0**	**0**	**6**	**70.6**
13MN066 (2013)	**0**	**8.41**	**85.51**	**6.61**	**0**	**0**	2	**54.9**
Southern Headwaters Average	*7.9*	*13.9*	*72.8*	*7.13*	*0.7*	*4.1*	*3.4*	*21.2*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

It is not clear if low DO is stressing the biology in this reach. There is a lack of conclusive data to show prolonged low DO problems based on the chemical samples. It appears that there are high DO peaks, likely associated with elevated photosynthetic production; paired with drastic drops of DO within a 24 hour period that correlates to autotrophic respiration. If continuous data had been collected within this reach, it is likely the DO flux would have been noted as a chronic issue; although it is not, clear to what extent DO is driven down. Both samples feel just above the 5 mg/L threshold. As the gradient of this reach is significantly stepper than any of the upstream eutrophic counterparts, the additional aeration to the stream could be mitigating low DO. Aside from the chemistry data, the biological metrics are mixed within both the fish and macroinvertebrate communities. Due to these inconsistencies, low DO is listed as an inconclusive biological stressor.

Eutrophication

During the fish sample, on July 24, 2013 the total phosphorus (TP) concentration was 0.159 mg/L (13MN065); on July 29, 2013 was at 1.38 mg/L (13MN066). TP data was limited to these two samples. Secondary chemistry measurements of DO flux are discussed in the above section, with some 24 DO flux noted. There was one reading of chl-a (682 ug/L) taken on July 17, 2013, greatly exceeding the 35 µg/L standard.

This reach does have a better data set for TSS with 13 samples collected. A few results fell above 40 mg/L of total suspended solids with over half of the particulate found to be organic matter, likely in the form of suspended algae. On average VSS made up about 56% of TSS samples. Photo documentation reveals an overload of suspended algae, noted in the green hue in Figure 86.

Figure 86. Photo of Minneopa Creek at biological monitoring site 13MN066, taken on July 29, 2013.

The macroinvertebrate metrics show a mixed response (Table 75), as there was a lower than average number of individuals collected for this sample, especially at 13MN066. There was a lack of both filtering and gathering taxa, even though station 13MN066 was completely dominated by one filtering taxa, simululidae (blackflies). Sensitive taxa like EPT were near averages. Tolerant taxa were dominant within this reach, at both locations.

Table 75. Macroinvertebrate metrics that respond to eutrophication stress in Minneopa Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN065 (2013)	**40**	**5**	16	**12**	**0**	**87.5**
13MN066 (2013)	**29**	**7**	**10**	13	**0**	**82.8**
Southern Streams Average	*45.8*	*7.3*	*15.9*	*12.2*	*0.8*	*72.6*
Expected response to stress	↓	↓	↓	↓	↓	↑

The fish sample was limited of the number of taxa collected noted in Table 76, with 9 taxa types at 13MN065 and 5 at 13MN066, well below the average of 19 for the this type of stream. Both sensitive and intolerant species were lacking in the samples. Simple lithophilic spawners (SlithopPct) were far below what would be expected in this stream type, making up only 12% of the sample at 13MN065 and 8.4 at 13MN066; the low population if this fish type correlates to high TSS (in this case high organics). Darter species did not seem to be in decline, scoring well above the average for this stream type at both sites.

Table 76. Fish metrics that respond to eutrophication stress in Minneopa Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
13MN065 (2013)	**0**	18.5	**12.0**	**81.3**	**9**	**0**
13MN066 (2013)	**0**	14.5	**8.4**	**85.5**	**5**	**0**
Southern Streams Average	*16.9*	*11.9*	*37.0*	*44.9*	*19.3*	*4.2*
Expected response to stress	↓	↓	↓	↑	↓	↓

Eutrophication is inconclusive as a biological stressor. There is a high amount of suspended algae noted to be coming through this section of the stream, fed by the upstream eutrophic reaches as well as Lake Crystal. It is unclear if active eutrophic growth is taking place here. There is not strong metric evidence that eutrophication is limiting the biology. Typically, eutrophic driven low DO will be the primary biological stressor. This was not detected from the DO data collected at this site. Organic matter from upstream, sources could still create habitat and water quality impacts similar to sediment driven TSS impairments.

Nitrate

During the fish sample two nitrate samples were collected, on July 24, 2013 the nitrate, concentration was 2.3 mg/L at 13MN065, on July 29, 2013 nitrate was 2 mg/L at 13MN066. Twelve additional water chemistry samples were taken in 2013 with concentrations ranging from 0.2 mg/L to 14 mg/L giving an average of 3.19 mg/L. Only one sample exceeded 10 mg/L.

The macroinvertebrates in this reach displayed a mix response to nitrate between the two monitoring locations (Table 77). Upstream station 13MN065 had a consistent negative metric response to nitrate, while the downstream station 13MN066 was inconsistent. The nitrate index score at the upstream location fell at 3.2; above the average for modified southern streams of 2.9. The downstream site fell just below at 2.7. The nitrate specific metrics show lower than average Trichoptera taxa, as well as a decrease in non-hydropsychid Trichoptera individual percentages (sensitive caddisflies that do not spin nets; TrichwoHydroPct). Intolerant taxa received the lowest possible score, in the absence of intolerant species, tolerant species were found in abundance at upstream station 13MN065. Again the downstream station did not indicate high nitrate, as nitrate tolerant taxa fell below the expected average in this stream type.

Table 77. Macroinvertebrate metrics that respond to nitrate stress in Minneopa Creek compared to the statewide average of visits meeting the warmwater general use biocriteria. Bold indicates metric value indicative of stress.

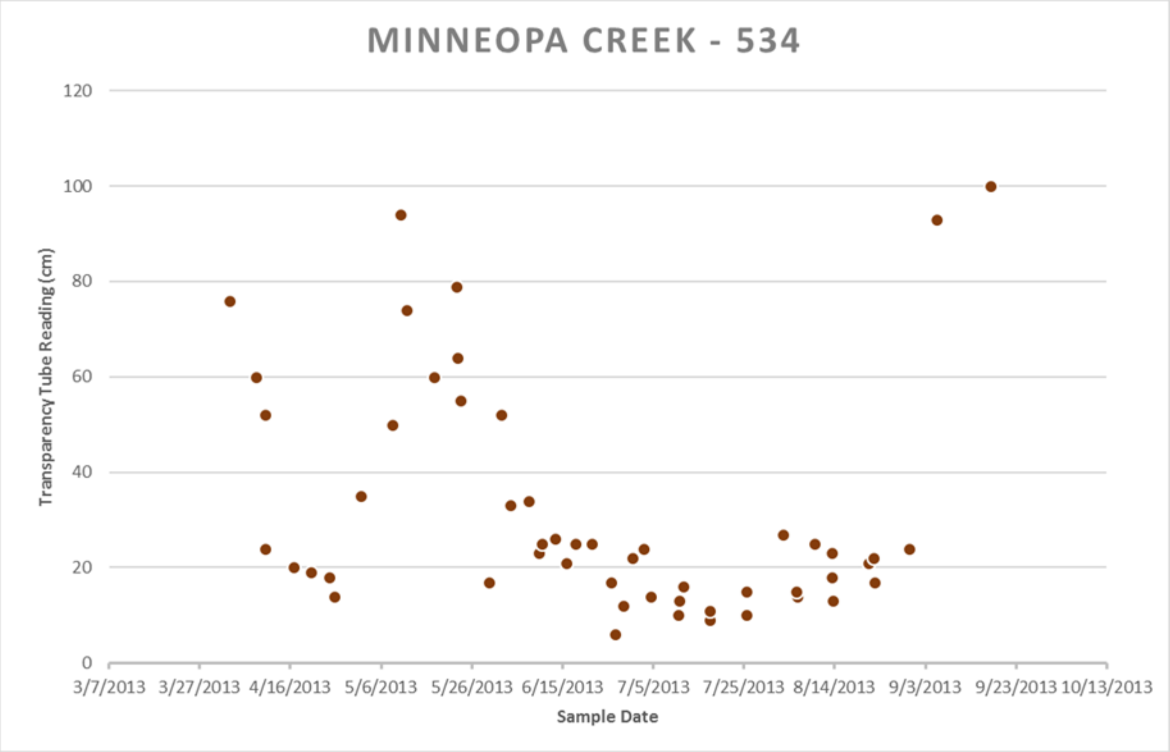
Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN065 (2013)	**5**	**3.3**	**3.2**	**0**	**24**	**54.1**
13MN066 (2013)	**4**	**.06**	2.7	**0**	12	15.9
Southern Streams Average	*6.3*	*5.5*	*2.9*	*2.4*	*18.8*	*47.2*
Expected response to stress	↓	↓	↑	↓	↑	↑

Chemistry data captured readings throughout the sampling period of spring – fall months; there was only one slightly elevated reading of 14 mg/L in the entire set. The biometrics had some indication at the upstream locations, but never greatly exceeded the threshold on any of the parameters. The downstream station did not have a strong indication that the macroinvertebrate community is being impacted by high nitrate. The mixed response and moderate concentrations make nitrate inconclusive as a stressor in this reach.

Total Suspended Solids

During fish sampling TSS, samples were collected. July 24, 2014 had a concentration of 86 mg/L at 13MN065, and on July 29, 2013, TSS was 80 mg/L at 13MN066. Eleven additional water chemistry samples were collected in 2013 May through August. Concentrations ranged from 3.6 mg/L to 520 mg/L with an average of 76.95 mg/L. 5 of the 13 samples analyzed (38%) exceeded the standard of 65 mg/L in June and July of 2013. Historically this reach has had issues with TSS as this reach is listed for turbidity. Turbidity tube readings on this stream show that 40% of the readings fell below 20 cm for transparency. Figure 87 below displays 2013 turbidity tube readings, with higher values indicating better transparency. April and May had better transparency when compared to June, July and August, transparency results are consistently low (poor) during the summer base flow period. In addition to transparency tube reading, volatile suspended solids (VSS) where analyzed in conjunction to the TSS samples. VSS was found to account for approximately 56% with the TSS concentration within this reach. Given the eutrophic status of the upstream reaches, as well as waterbodies, it is likely this is a common relationship of organics making up a large portion of the TSS load.

Figure 87. Transparency tube reading in 2013 at Minneopa Creek; 720007-534.



The two monitoring stations provided different results within the macroinvertebrate community in the same monitoring day (Table 78). The upstream station 13MN065 showed consistent signals that could be indicating TSS stress in the community. The collector filler taxa were not completely absent, but fell below the expected size that would be found in this stream type. Stoneflies (Plecoptra) is an order known to be sensitive to TSS; none were found at this location. The TSS index scored at 20; above the threshold of 15.63; the higher the index score the greater the TSS risks to the community. Intolerant taxa were present, but still below what should be found. TSS tolerant taxa represented 54% of the sample.

The macroinvertebrates at 13MN066 were mixed in regard to showing TSS stress (Table 78). The collector filter community were in abundance here, scoring well above would be expected in this type of stream. This is due to blackflies (Simulium) dominating the sample. These macroinvertebrates filter organic matter out of the water column. Stoneflies a little above the expected range, and the TSS index score was below the threshold at 14.37, again likely due to the dominance of blackflies. While there was not a complete absence of intolerant species, they were not at expected levels. TSS tolerant inverts were not overly abundant and did not dominate the sample size. At this reach, TSS does not seem to be stressing the community, but the response can be explained by blackfly abundance, which drove up the collector filterers, decreased the index score and tolerant percentages. This also could point to water clarity impacts driven by excess algae.

Table 78. Macroinvertebrate metrics that respond to high TSS stress in Minneopa Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN065 (2013)	**16.9**	**0**	**20.0**	**1**	**0.3**	**14**	**53.8**
13MN066 (2013)	75.0	0.9	14.37	**1**	**0.6**	12	11.5
Southern Streams Average	*25.4*	*0.7*	*15.63*	*2.9*	*4.7*	*12.2*	*34.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

The fish community between the two biological monitoring stations displayed similar trends. Table 79 shows that exclusive benthic (bottom) feeders, herbivores, as well as sensitive fish were all lacking within this reach. The average expected amount for long-lived species was greatly exceeded in this reach; however, this is due to the overabundance of common carp in the sample. Perciformes were not in abundance at either location. Riffle-dwelling species were limited as were simple lithophilic spawners, who depend on gravel or course substrate for spawning.

Table 79. Fish metrics that respond to high TSS stress in Minneopa Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
13MN065 (2013)	**30.5**	**0**	**12.0**	**0**	36.7	**18.5**	**12.0**	**0**	**12.0**
13MN066 (2013)	**22.9**	**0**	**8.4**	**0**	59.3	**14.5**	**8.4**	**0**	**8.4**
Southern Streams Average	*36.0*	*5.4*	*25.7*	*4.2*	*13.6*	*20.1*	*30.2*	*16.9*	*19.1*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

The fish metrics did display a negative response in the metrics regarding TSS (Table 80). In both monitoring locations, The TSS index score exceeded the average of 19.2, yielding high scores of 25.3-30. TSS sensitive taxa lacked and seem to have been replaced by tolerant taxa types.

Table 80. Fish metrics that respond to high TSS stress in Minneopa Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

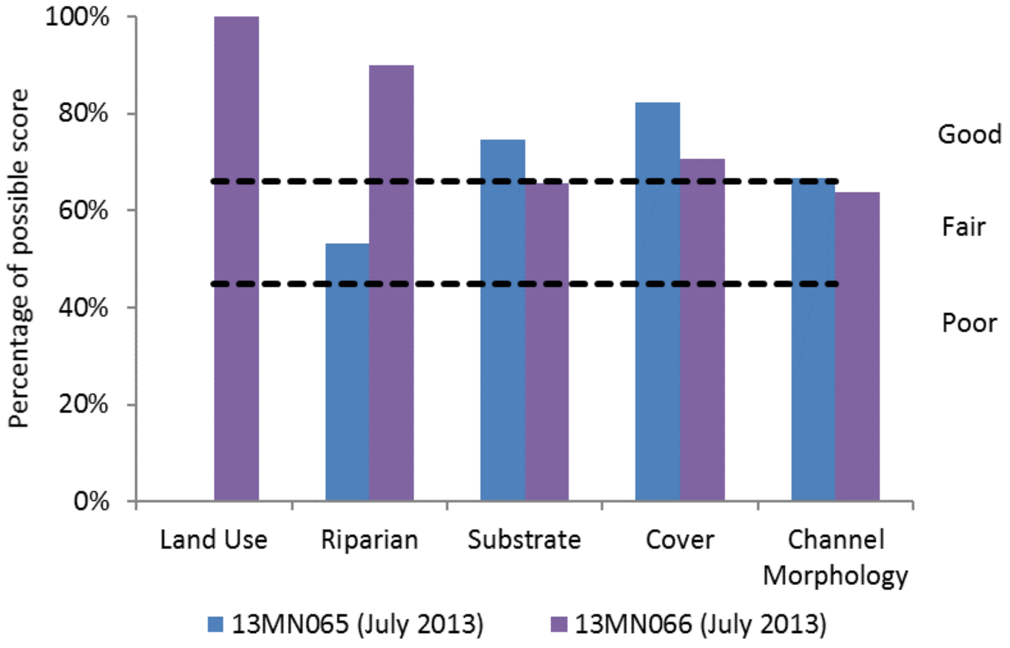
Station (Year sampled)	TSS Index Score	TSS Sensitive Taxa	TSS Sensitive Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN065 (2013)	**25.3**	**0**	**0**	1	**36.5**
13MN066 (2013)	**30.0**	**0**	**0**	1	**59.3**
Southern Streams Average	*19.2*	*1.7*	*5.3*	*2.4*	*12.5*
Expected response to stress	↑	↓	↓	↑	↑

TSS likely is a biological stressor. The chemistry data, historical data, and current stream observations indicate TSS is an issue within this reach. It is important to note that there is a high percentage of the TSS loads made up of organics, such as suspended algae. Upstream management of eutrophic conditions would likely drive down the overall TSS concentrations that are coming through this system.

Habitat

The MSHA scores resulted in similar findings between the two sites (Figure 88). Substrate, cover, and morphology scored between fair to good. Riparian was slightly different, as the riparian width was significantly lower at 13MN065, due to the land use being row crop. 13MN065 had a score of 66.15 while 13MN066 had a score of 71.2. Figure 89 and Figure 90 below, display habitat conditions at the time of biological monitoring.

Figure 88. Percentage of MSHA subcategory scores for stations 13MN065 and 13MN066, Minneopa Creek



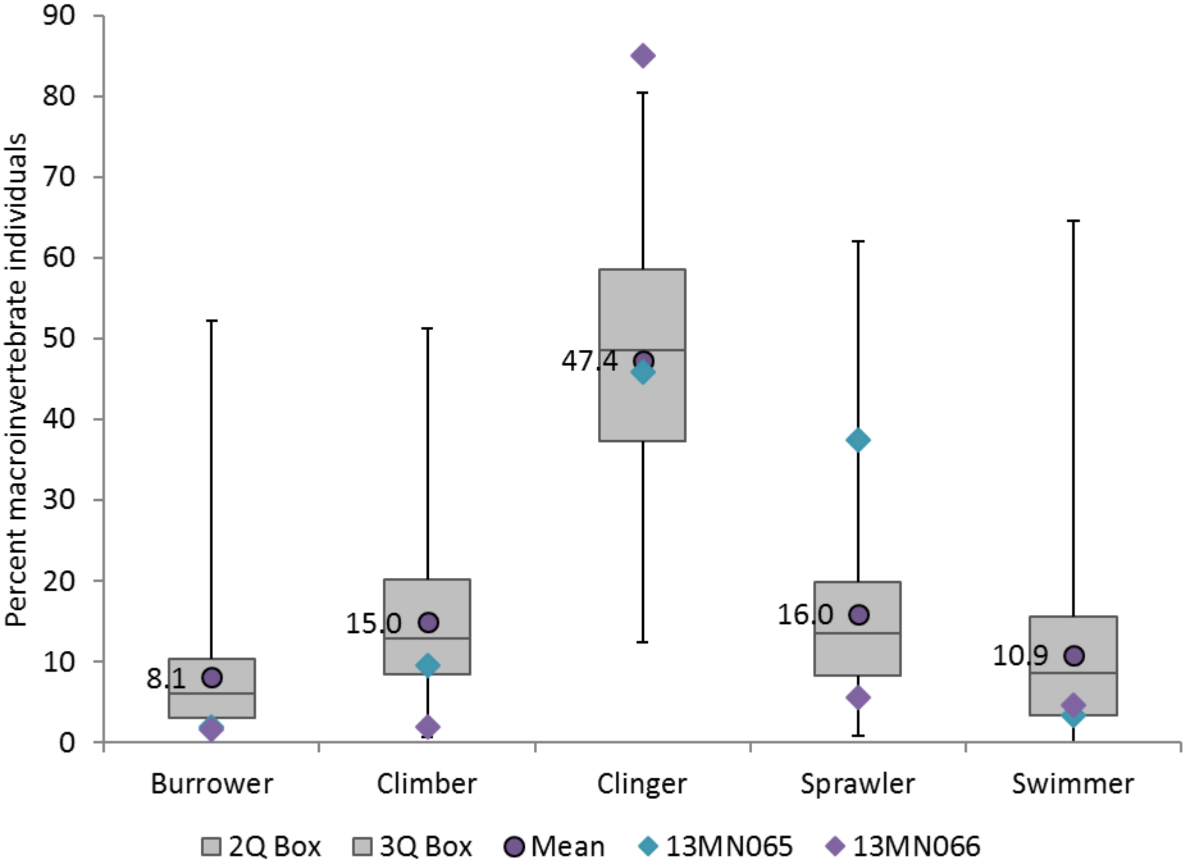
As shown in Figure 89 and Figure 90, this section of Minneopa Creek does exhibit acceptable habitat conditions. There appears to be diverse substrate types, noted in the morphology of the stream in conjunction with multiple gravel and sand types. There are also areas for refuge and shade noted from the healthy growth along a majority of the riparian area, as well as some woody derbies. While water quality is questionable from the green hue in these photos, what is there for physical habitat diversity is adequate.

Figure 89. Station 13MN065, July 24, 2013

Figure 90. Station 13MN066, July 29, 2013

Burrowers, climbers, and swimmers were low at both monitoring locations. Clingers and Sprawlers made up a majority of the population at both locations, with station 13MN066 having a significate higher population of Clingers (Figure 100). This again is due to the overabundance of blackflies in that sample. The elevated clingers can be a sign of a strong habitat as clinger species attach to rock or woody debris need a variation of physical habitat types. Other sensitive taxa at this site also point to decent habitat conditions overall. Stream surveys showed both sites as stable streams, with a wide variation of habitat variability. The increase in sprawlers at 13MN065 may be due to fine sediments, and possibly related to differences in gradient between the two stations, as the gradient is steeper at 13MN066.

Figure 91. Macroinvertebrate metrics that respond to habitat for stations 13MN065 and 13MN066, Minneopa Creek compared to the range of values for Southern Streams RR visits meeting the general use biocriteria.



The fish community that requires specific habitat types is stressed; however, their numbers could be limited from a different stressor. Table 79 displayed in the above TSS section, shows that exclusive benthic (bottom) feeders and herbivores were all lacking, however there were some presents of these groups. Perciformes were not in abundance at either location. Riffle-dwelling species were limited as were simple lithophilic spawners, who depend on gravel or course substrate for spawning, but were not completely absent. Station 13MN065 fish sample was closer at meeting the threshold for these groups when compared to 13MN066.

Habitat not likely a stressor. Physically, there seems to be a diverse habitat types available. In addition, the biologic composition habitat group types are balanced, even though they are decreased in number. If other stressors were addressed related to water quality, it is likely these sensitive groups would thrive in more abundance in the habitat that is currently available within this reach.

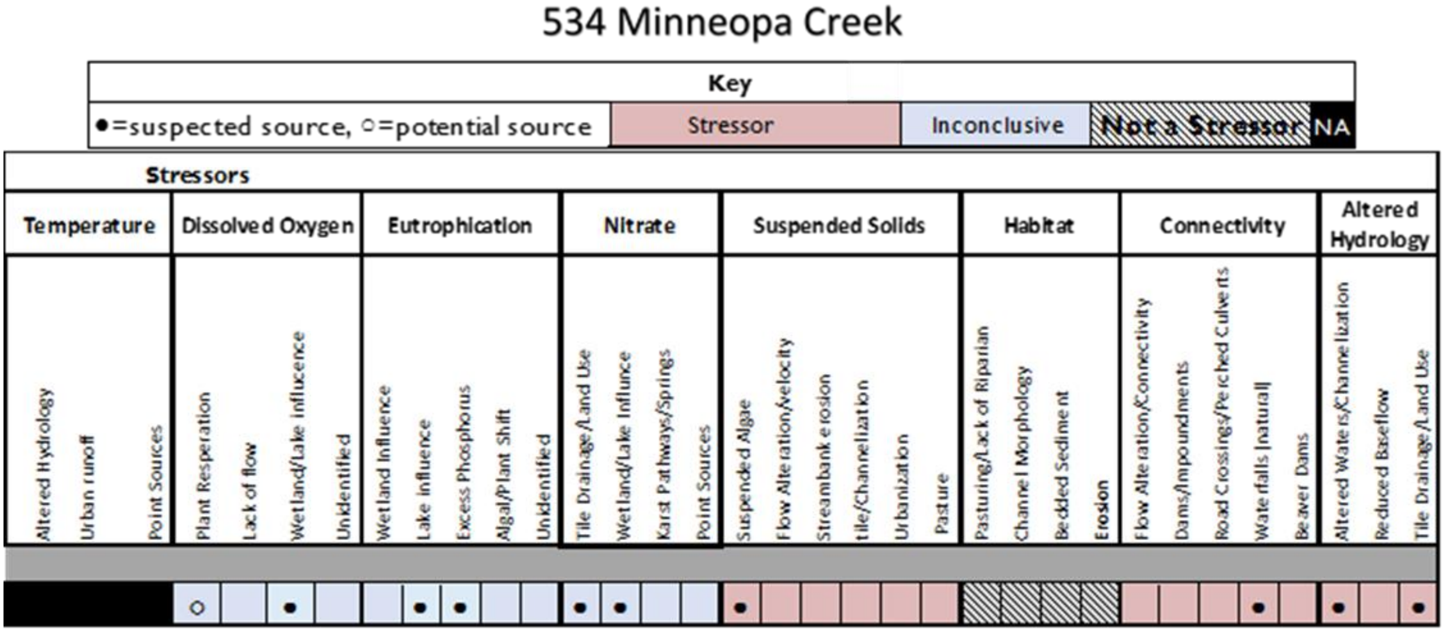
Longitudinal Connectivity and Altered hydrology

The highest (~52 feet) natural waterfall in the Minnesota River – Mankato Watershed occurs where Minneopa Creek is undercutting a layer of Jordan Sandstone in Minneopa State Park (DNR 2015). There is also water quality impacts from Lake Crystal that is contributing to some the biological stressors. For additional information of the Lake Crystal assessment, reference the DNR Lake SID document in the appendix of this report.

Altered hydrology is thought to be the primary stressor within this reach, as it is the driver of all other stressors within this reach. Altered hydrology is occurring in two ways throughout this system. Upstream the channel has been modified by ditching and channelizing, in addition to the practice of subsurface tile drainage. These changes alter the flow regime of the stream system, creating a host of downstream impacts. Tile drainage specifically provides a direct pathway from land to stream for nutrient (as well as other pollutant) overloading. For additional information on altered hydrology within this watershed, reference Chapter 3.1.8 of this report.

Summary Table

Table 81. Identified stressors with suspected sources for reach 534 of Minneopa Creek.



534 Minneopa Creek

Key				
●=suspected source, ○=potential source	🟥 Stressor	🟦 Inconclusive	▨ Not a Stressor	■ NA

Stressors																																							
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
■			🟦 ○	🟦	🟦 ●	🟦	🟦	🟦 ●	🟦 ●	🟦	🟦	🟦 ●	🟦 ●	🟦	🟦	🟥 ●	🟥	🟥	🟥	🟥	🟥	▨	▨	▨	▨	🟥	🟥	🟥	🟥 ●	🟥	🟥 ●	🟥	🟥 ●

Minneopa Creek Subwatershed Conclusion

Five stream reaches were found to be impaired for biology within the Minneopa Creek Subwatershed. Minneopa Creek had two reaches assessed; One upstream reach (-531) was listed impaired for both invertebrates and fish, and the other reach within Minneopa Creek (-534) was downstream of Lake Crystal and impaired for lack of fish. County Ditch 27 (-535) was impaired for fish, Judicial Ditch 48 (-593) feeds into Lake Crystal and was impaired for both fish and macroinvertebrates. County Ditch 56 (-557) feeds into Lake Crystal and is impaired for fish. All streams were assessed as modified use, warmwater; with the exception of Minneopa Creek (-534) that was designated as general use warmwater.

Altered hydrology is the primary stressor in these streams as it is directly contributing to the other stressors. Altered hydrology is occurring two ways within this subwatershed. The first is through subsurface tile drainage and the second is stream channel alteration by ditching and channelizing. Alterations in this region are from agricultural practices in attempt to expedite water off the land to optimize growing conditions. Both of these practices result in altered hydrology. As a result, the streams are taking on volumes of water greater than what they are naturally designed to carry. This accelerates flow velocity and significantly changes the morphology of the stream at the receiving location as well as downstream areas. Stream banks erode and streambeds are scoured out or filled in with sediment. Habitat degradation within this watershed directly ties back to altered hydrology. As displayed in the above table, reaches that have been ditched result in poor habitat quality and lack habitat diversity from being ditched. Minneopa Creek (-534) was found to have strong habitat features; this location differs from the upland streams as this section of stream has a large riparian area and limited altered surrounding land use due to the lands steep gradient. However, this reach is still impacted by poor water chemistry from upland altered hydrology.

Eutrophication is closely associated with low dissolved oxygen (DO) within the watershed. Stream reaches where low DO is limiting biology is the result of plant (algae) respiration from headwater stream and eutrophic lake contributions. Low levels of dissolved oxygen (DO) and eutrophication are clear biological stressors at all but one of the monitoring locations in this subwatershed. Although DO data is limited, the data collected strongly indicates that low DO levels and fluctuation are major stressors throughout the subwatershed. Suspended algae from the eutrophic conditions were found to make up half of the total suspended solids (TSS) impairments within a majority of the reaches in this subwatershed. Eutrophic conditions throughout this region will typically occur in the headwater ditched streams. Here, phosphorus is in abundance, there is a lack of stream covering vegetation that limits sunlight, and there are slower velocities. Minneopa Creek (-534) was found to have high phosphorus loading, However, due to its steep gradient and natural riparian zone it is unlikely that this section is further contributing to the autotrophic (algae) growth. Regardless, the lower section of Minneopa Creek is still being influenced from the high organic material that is coming through from upstream eutrophic streams and Lake Crystal.

Nitrate samples were extremely limited in number. What was sampled often exceeded 20 mg/L (the standard for drinking water is 10 mg/L). It is worth noting that the macroinvertebrate communities in each stream were suggestive of nitrate stress in the community. Due to the lack of chemistry samples, nitrates were found to be inconclusive as a stressor, yet it is highly suspected they are playing a role in limiting the biology.

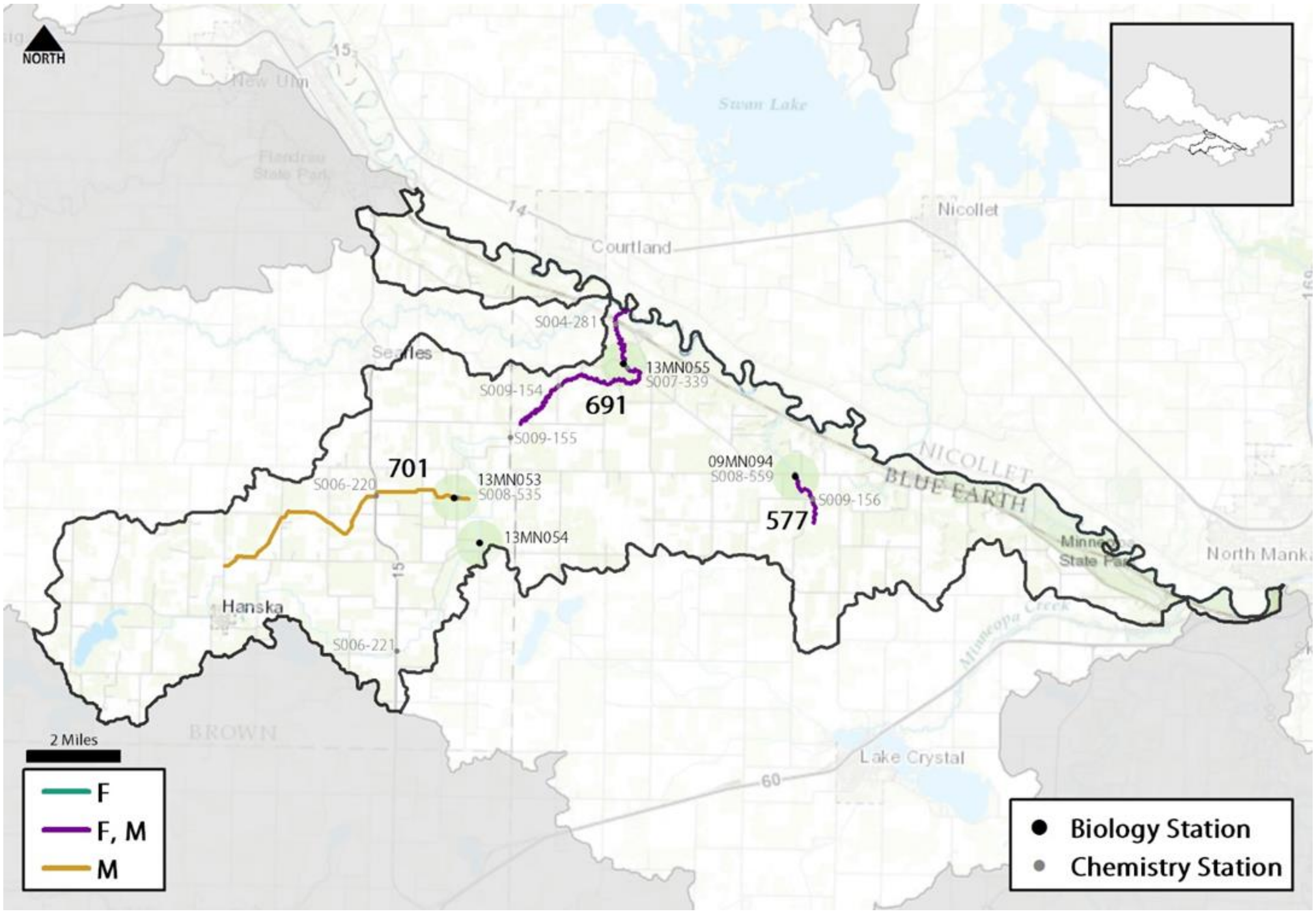
The fish community in the entire subwatershed is limited to tolerant species. This is due to the natural barrier of Minneopa falls that cuts off migration potential from the Minnesota River, paired with the lack of refuge waters where fish would overwinter being highly impaired. Due to these dynamics, only the most tolerant species thrive within the Minneopa Subwatershed.

It is important to stress the need for additional monitoring, as many reaches had limited chemistry samples. This resulted in having to leave many of the parameters inconclusive. More data would particularly be helpful in understanding the sediment load occurring in the upland stream reaches, and nitrates throughout the subwatershed. Restoration efforts should focus on restoring the upland areas that influence refuge areas such as Lake Crystal and Loon Lake.

Morgan Creek – MNR Mankato South

This section encompasses biotic impaired reaches in the Morgan Creek 10 digit HUC. There are three reaches impaired for biology in this 10 digit HUC. Unnamed Creek (577) is a small cold-water tributary to the Minnesota River that is impaired for fish and macroinvertebrates. Judicial Ditch 10 (701) is a tributary to Morgan Creek and is impaired for macroinvertebrates. Morgan Creek (691) is impaired for fish and macroinvertebrates.

Figure 92. Map of the Morgan Creek Watershed with biological impairments and monitoring stations. Impairments are described as F=Fish, F, M=Fish and Macroinvertebrates, and M=Macroinvertebrates



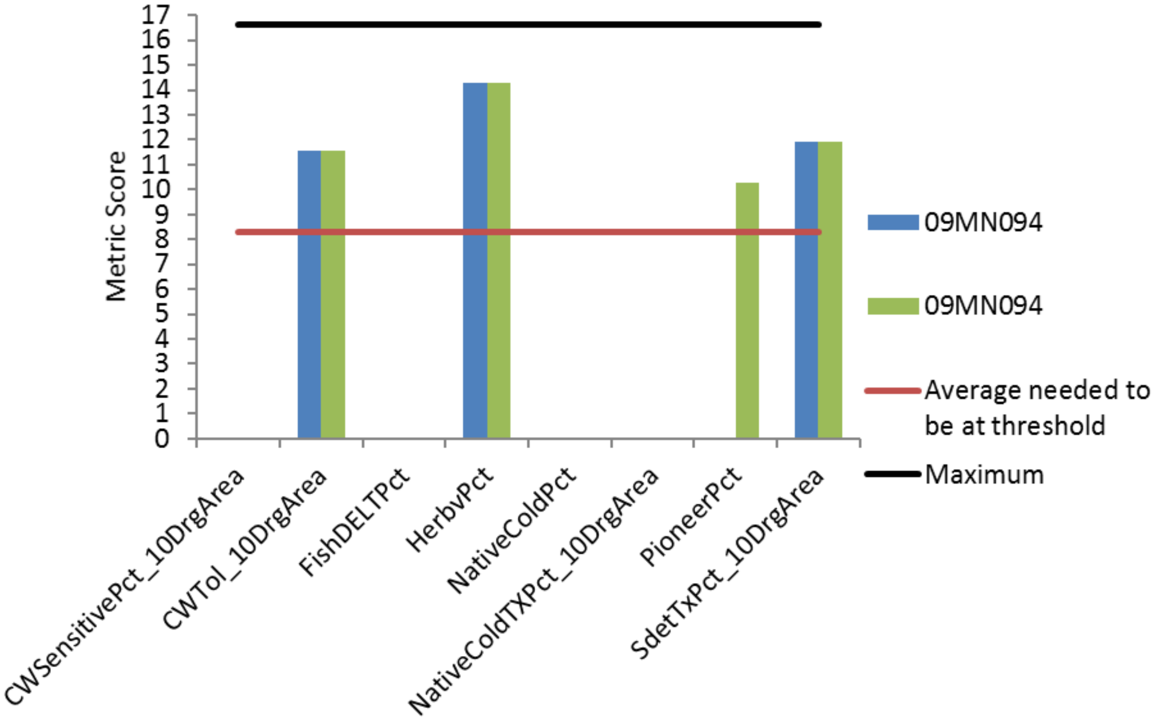
4.11 Unnamed creek (07020007-577)

Unnamed Creek (07020007-577) is a tributary north of Lake Crystal, Minnesota. The reach is cold-water general use Class 2A. The reach extends from upstream of 224th St to MN68. The reach is impaired for lack of fish assemblage and lack of macroinvertebrate assemblage.

4.11.1 Biological Communities

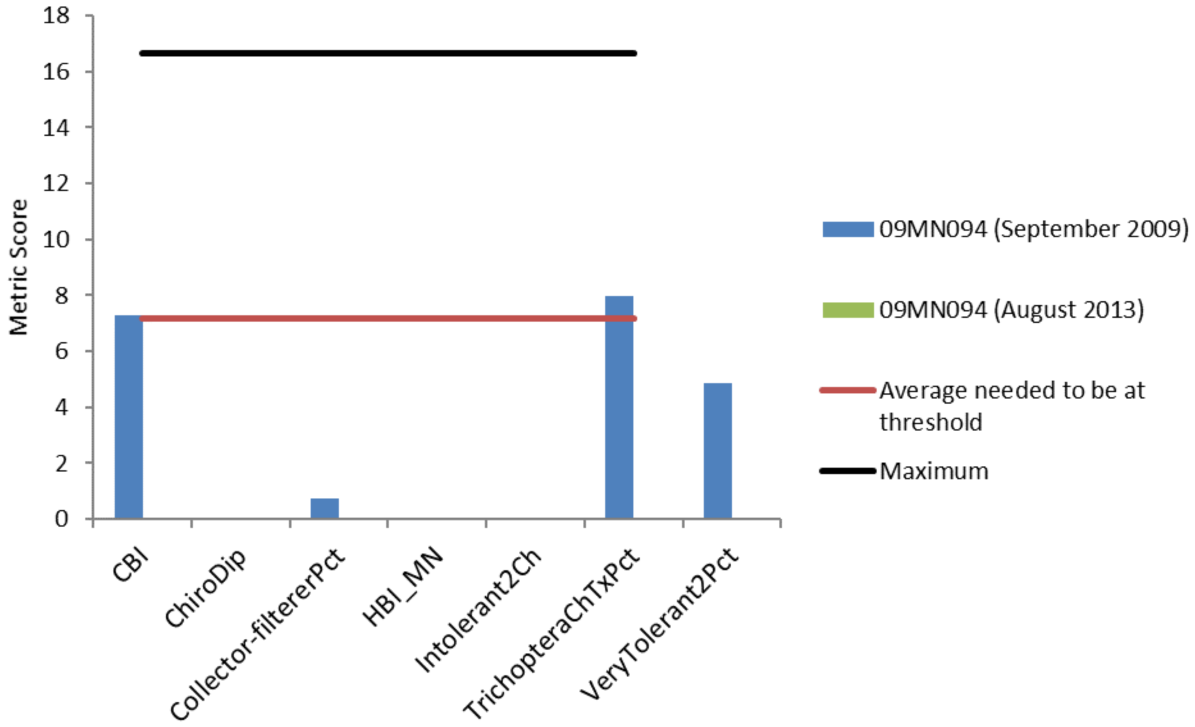
There is fish data from two visits at one station (09MN094) sampled in 2010 and 2013. Both F-IBI scores are below the general use threshold for Southern Coldwater Streams (45) (Figure 93). There were no coldwater or coldwater fish taxa present in either visit.

Figure 93. Fish metrics of the Southern Coldwater Streams class for station 09MN094, Morgan Creek



There are two macroinvertebrate visits on one station (09MN094) sampled in 2009 and 2013 (Figure 94). The sample collected in 2009 scored 13 points below the GU threshold, within the lower confidence interval. The 2013 sample scored 40 points below the GU threshold, well below the lower confidence interval. Comments made at the time of the 2013 data collection suggest that very high flows had recently occurred, based on the presence of deeply eroded banks, and large trees that had been recently moved. There was very low diversity, and a lack of intolerant taxa in the 2013 sample. Abundant phosphorus and nitrogen intolerant taxa were present in the 2013 sample.

Figure 94. Macroinvertebrate metrics of the Southern Coldwater Streams class for station 09MN094, Morgan Creek



4.11.2 Data Evaluation for each Candidate Cause

Temperature

Historically, DNR stream surveys from 1981 and 1995 indicate management for trout in this stream may not be feasible due to lack of sufficient habitat. It was kept on the designated trout waters list for watershed protection, and given current information appears to have coldwater potential.

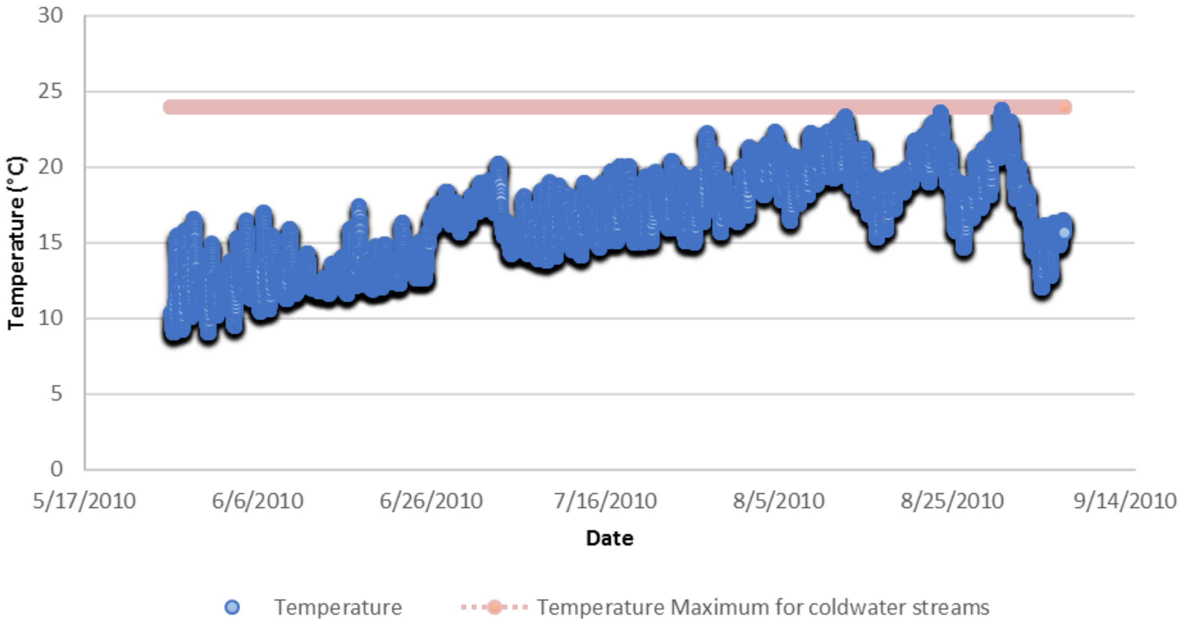
Biologically, coldwater fish species are absent, as shown in Table 82. On the other hand, coldwater macroinvertebrates were fairly abundant in 2010, but absent in 2013. Macroinvertebrate samples have found coldwater taxa including Gammarus and Odontomesa. It is possible the 2013 sample was impacted by a recent high flow event.

Table 82. Biological metrics that respond to temperature compared to the statewide average of visits meeting the Southern Coldwater biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	ColdPct (Fish)	CWSensitivePct (Fish)	NativeColdPct (Fish)	Coldwater Biotic Index (Macroinvertebrates)
09MN094 (2010)	**0**	**0**	**0**	**7.3**
09MN094 (2013)	**0**	**0**	**0**	**0**
Southern Coldwater Average	*66.4*	*70.6*	*30.3*	*7.70*
Expected response to stress	↓	↓	↓	↓

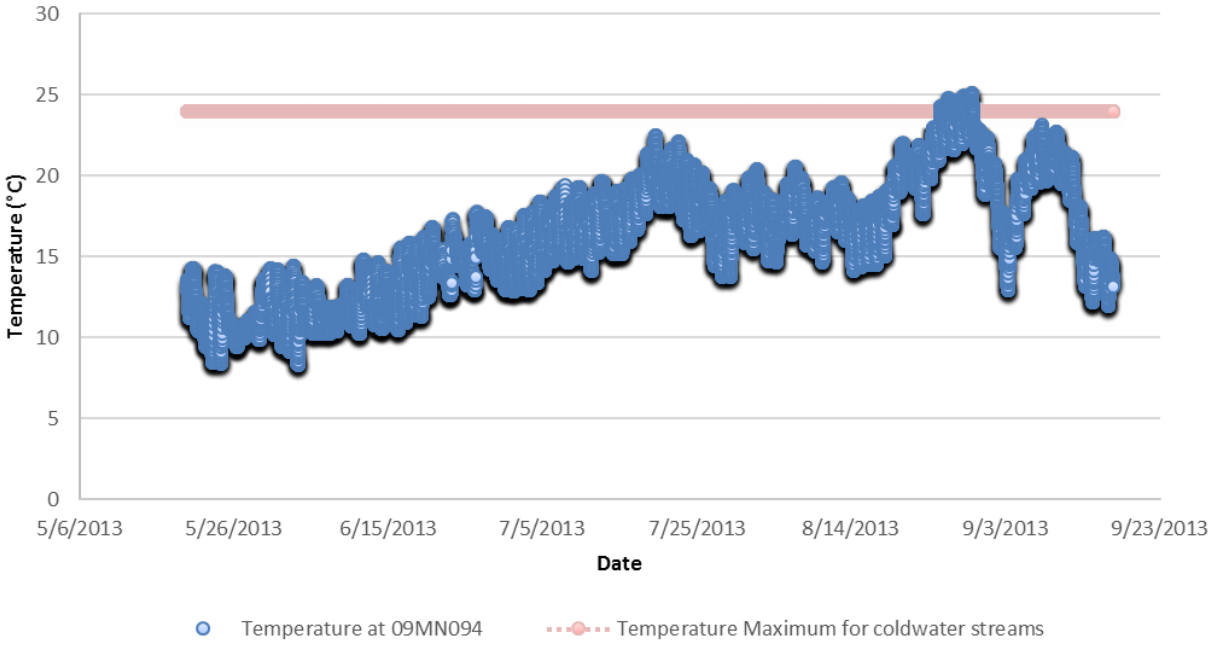
Temperature data has been collected during three different years in Unnamed Creek, displayed in Figure 95, Figure 96, and Figure 98 below. In 2010, temperature data from May through September looks fairly characteristic of a coldwater stream, with a few time periods in August reaching higher temperatures. When temperatures rise near 21°C, other fish can have a competitive advantage over trout for the food supply (Behnke, 1992) and shows some time above this threshold in 2010 and 2013 the threat temperature for brown trout during more critical time periods like July. The most recent deployment of 2016 displayed stable stream temperatures of a coldwater stream.

Figure 95. Temperature data from station 09MN094 in May-September 2010.



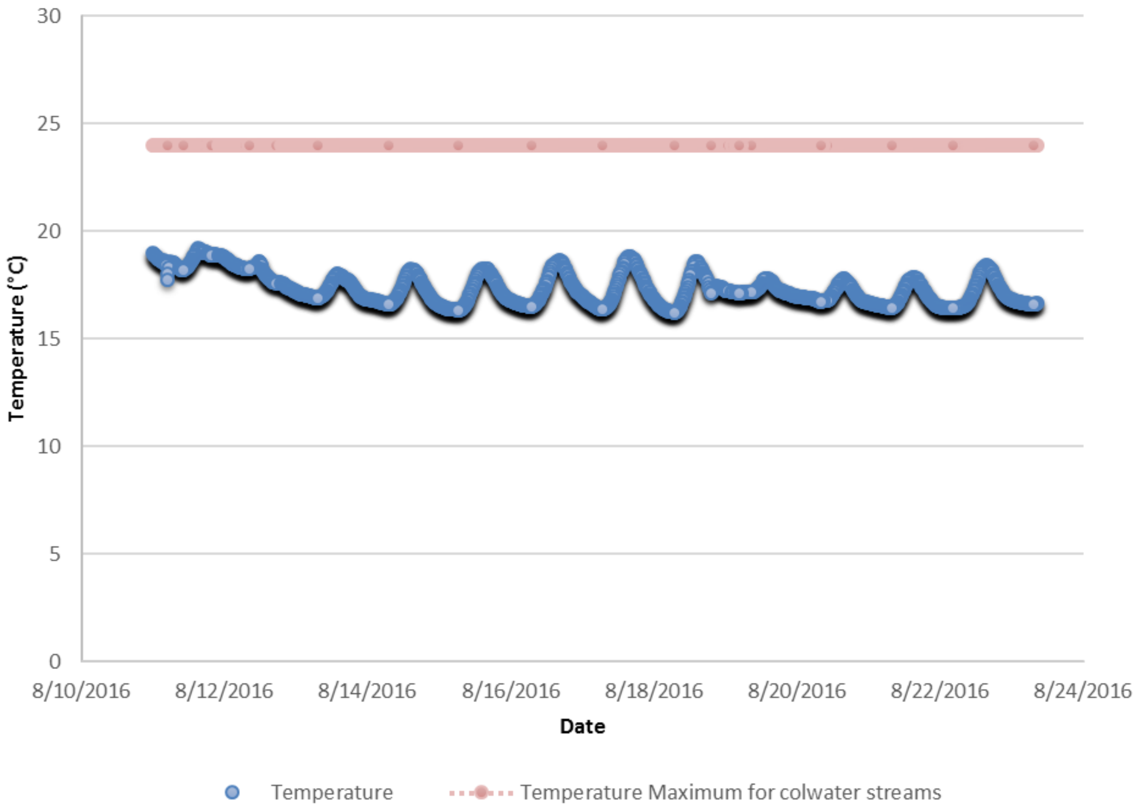
Temperature data in 2013 exceeded the coldwater threshold of 24 degrees Celsius August 25 through August 29 reaching a peak temperature of 25.11 °C. Temperature data in 2010 reached its peak of 23.83 °C in late August.

Figure 96. Temperature data from station 09MN094 in May-September 2013.



During sonde deployment in August 2016, temperatures from this stream appear normal, and very typical of a coldwater stream.

Figure 97. Temperature data from station 09MN094 in August 2016.



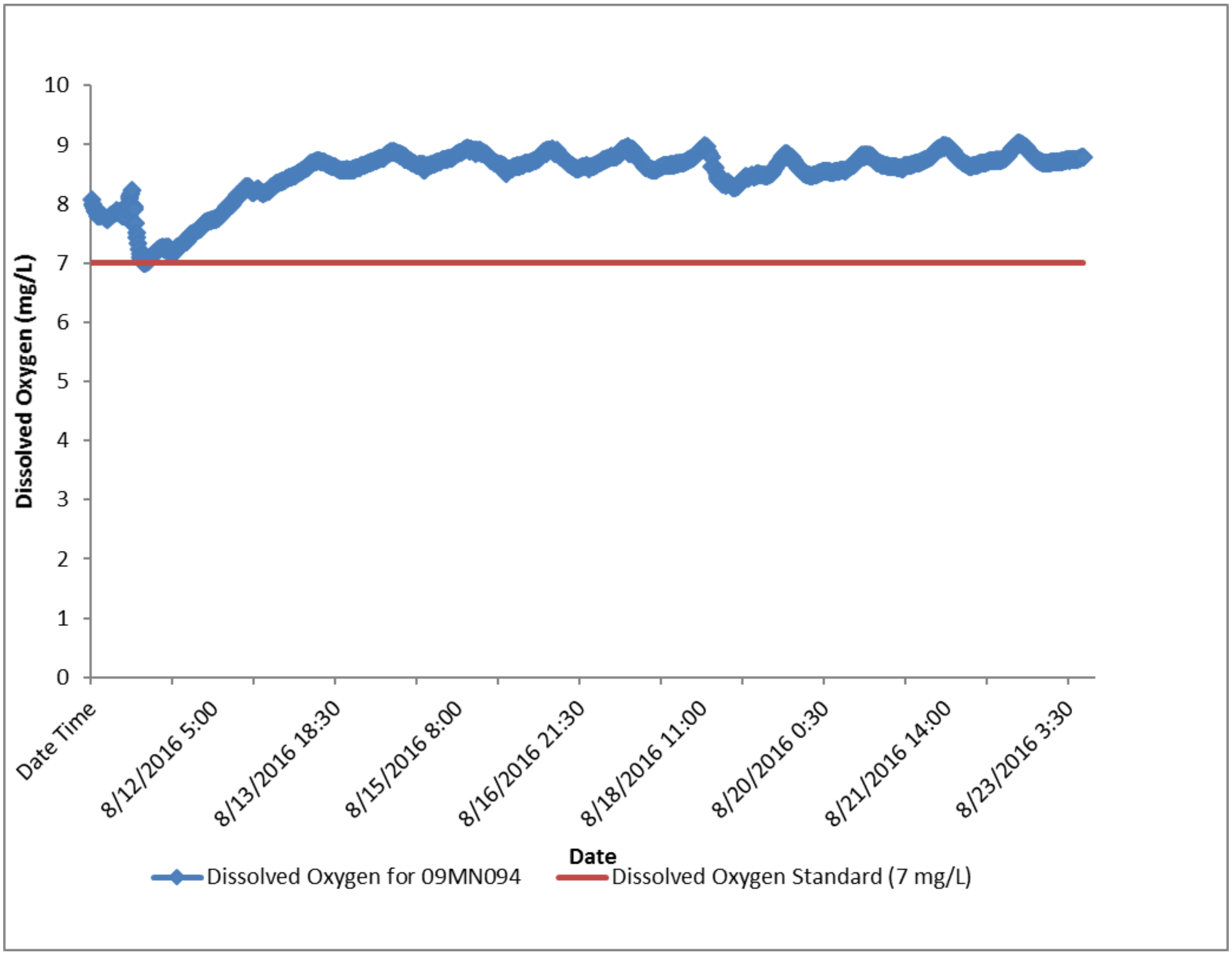
Temperature is inconclusive within this reach. The biological community collected does show the temperature sensitive species are not thriving within this reach. With fish species lacking more so than the macroinvertebrate coldwater species. Additional long-term temperature loggers are recommended to track the coldwater stability of this stream.

Dissolved Oxygen

The dissolved oxygen (DO) concentration during biological sampling on July 21, 2010, September 17, 2013, and August 7, 2013 at station 09MN094 was 8.4 mg/L, 8.7 mg/L, and 7.7 mg/L respectively. Additional samples collected in 2015 and 2016 ranged from 7.7 mg/L – 13.1 mg/L (average of 9.8 mg/L). Only eight samples were collected, and all were above the coldwater standard of 7 mg/L. Samples were collected at stations S008-559 and S009-156.

In 2016, an YSI sonde was deployed from August 10 through August 23. During that period, concentrations ranged from 6.99 mg/L – 9.03 mg/L (Figure 98). DO flux was minimal, and well below the standard for the South Region (4.5 mg/L). There was a brief violation of the coldwater DO standard, but it was just below and overall concentrations were good.

Figure 98. Continuous dissolved oxygen measurements (mg/L) at 09MN094 from August 12, 2016 to August 23, 2016.



A majority of the macroinvertebrate metrics were worse than the statewide average of stations meeting the MIBI threshold (Table 83). The macroinvertebrate DO index score was below average both years; as this score decreases, so does the sensitivity of the community. There were four DO intolerant taxa comprising 2 – 35% of the community, and 3 – 4 DO tolerant taxa comprising 2% of the community. Taxa richness of Ephemeroptera, Plecoptera and Trichoptera (EPTCh) and a measure of pollution based on tolerance values assigned to each individual taxon developed by Chirhart (HBI_MN) were worse than average. Total taxa richness (TaxaCountAllChir) was the only metric to score better than average. Overall, a majority of the macroinvertebrate metrics are suggestive of stress.

Table 83. Macroinvertebrate metrics that respond to low DO stress in Unnamed Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
09MN094 (2009)	25	**5**	**6.9**	**5.1**	**4**	**34.9**	**3**	**1.5**
09MN094 (2013)	22	**0**	**9.6**	**6.6**	**4**	**1.9**	**4**	**1.9**
Southern Coldwater Average	*30.8*	*8.1*	*6.4*	*7.5*	*10.4*	*56.6*	*1.8*	*1.3*
Expected response to stress	↑	↓	↑	↓	↓	↓	↑	↑

A majority of the fish metrics were worse than the statewide average of stations meeting the FIBI threshold (Table 84). Relative abundance of sensitive individuals (SensitivePct) and individuals with a female mature age greater than three years (MA>3Pct) were zero both years, and tolerant individuals (TolPct) comprised 100% of the community. There were zero DO sensitive taxa, and zero DO tolerant taxa. The fish DO index score was below average both years, but the probability of this reach obtaining the DO standard based on the fish community was 88%.

Table 84. Fish metrics that respond to low DO stress in Unnamed Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
09MN094 (2010)	**0**	**0**	**100**	**7.4**	**0**	**0**	0	0
09MN094 (2013)	**0**	**0**	**100**	**7.8**	**0**	**0**	0	0
Southern Coldwater Average	*71.7*	*74.6*	*24.0*	*8.9*	*2.5*	*72.4*	*1.1*	*6.8*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is not considered a stressor within this reach. The chemistry data suggests it would support healthy communities within this reach. Metric scores were suggestive of low DO stress, but it is likely that the poor community scores were due to another stressor.

Eutrophication

The total phosphorus (TP) concentration during biological sampling on July 21, 2010 and July 17, 2013 at station 09MN094 was 0.095 mg/L and 0.099 mg/L respectively. Additional samples collected in 2015 and

2016 ranged from 0.049 mg/L – 0.1 mg/L (average of 0.074 mg/L). Only six samples were collected, and all six samples were below the river eutrophication standard for the South Region (0.150 mg/L). Samples were collected from station S008-559 in April, May, June (two), August, and September.

Chl-a, BOD, and DO flux are also considered when evaluating eutrophication stress. One chl-a sample was collected on September 1, 2015; this sample was well below the 35 µg/L standard at 2.11 µg/L. At this time, there have been zero BOD samples collected. DO flux during sonde deployment in 2016 was minimal, and well below the standard for the South Region of 4.5 mg/L. There was low DO during this deployment, but it was very brief and just below the standard.

All of the macroinvertebrate metrics except for total taxa richness (TaxaCountAllChir) were worse than the statewide average of stations meeting the MIBI threshold (Table 85). There were zero intolerant taxa (Intolerant2Ch), and a high percentage of taxa with tolerance values equal to or greater than six using MN TVs (Tolerant2ChTxPct). There was also a below average score for collector-fillterer species present in both years. However, the collector-gatherer species fell just below the state average for southern coldwater streams.

Table 85. Macroinvertebrate metrics that respond to eutrophication stress in Unnamed Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
09MN094 (2009)	25	**2**	**9**	**5**	**0**	**84**
09MN094 (2013)	22	**2**	**10**	**0**	**0**	**90.9**
Southern Coldwater Average	*30.8*	*6.0*	*12.1*	*7.5*	*1.1*	*66.8*
Expected response to stress	↑	↓	↓	↓	↓	↑

A majority of the fish metrics were worse than the statewide average of stations meeting the FIBI threshold (Table 86). Sensitive individuals (SensitivePct), abundance of darter species (DarterPct), and intolerant individuals (IntolerantPct) were all zero during both visits. Tolerant individuals (TolPct) comprised 100% of the fish community during 2010 and 2013. Abundance of simple lithophilic spawners (SLithopPct) increased substantially from 2010 to 2013.

Table 86. Fish metrics that respond to eutrophication stress in Unnamed Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
09MN094 (2010)	**0**	**0**	**18.2**	**100**	2	**0**
09MN094 (2013)	**0**	**0**	84.6	**100**	2	**0**
Southern Coldwater Average	*71.7*	*3.6*	*20.2*	*24.0*	*5.8*	*26.3*
Expected response to stress	↓	↓	↓	↑	↑	↓

Eutrophication is not likely a stressor within this reach. Chemistry data is not suggestive of nutrient overloading. Secondary chemistry responses, (such as DO flux) also were found to be in acceptable ranges. Visually there were not any eutrophic conditions observed within this reach. It is likely that the biological communities are responding to another stressor.

Nitrate

Nitrate concentration during fish sampling on July 21, 2010 and July 17, 2013 at station 09MN094 was 14 mg/L and 17 mg/L respectively. Additional samples were collected in 2015 and 2016, ranging from 2.9 mg/L – 24 mg/L (average of 18 mg/L). Only six samples were collected, but elevated concentrations were observed. The five highest concentrations ranged from 18 mg/L – 24 mg/L; these samples occurred in April, May, June (2), and August between the two year. Samples were collected from station S008-559.

Taxa richness of Trichoptera (TrichopteraCh) and relative percentage of taxa belonging to Trichoptera (TrichopteraChTxPct) were below the statewide average of stations meeting the MIBI threshold (Table 87). There were 0 – 1 nitrate intolerant taxa, and 14 – 15 nitrate tolerant taxa comprising 52 – 92% of the community. The macroinvertebrate nitrate index score was better than average in 2009, but worse than average in 2013. The macroinvertebrate metrics were indicative of nitrate stress in 2013, but not as much in 2009. The 2013 sample was dominated by snails (Physa).

Table 87. Macroinvertebrate metrics that respond to nitrate stress in Unnamed Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TrichopteraCh	TrichopteraChTxPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
09MN094 (2009)	**4**	**16.0**	2.56	**1**	14	51.82
09MN094 (2013)	**0**	**0.0**	**5.11**	**0**	**15**	**92.24**
Southern Coldwater Average	*5.3*	*17.3*	*3.04*	*1.35*	*14.29*	*60.79*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is considered a biological stressor within this reach. While there was not an abundance of chemistry samples, what was available for analysis showed all but one were high for nitrate. The overall macroinvertebrate response is also suggestive of nitrate stress. Station 09MN094 does appear to be slightly more affected by nitrate, in comparison to 09MN094.

Total Suspended Solids

The total suspended solids (TSS) concentration during fish sampling on July 21, 2010 and July 17, 2013 at station 09MN094 was 24 mg/L and 75 mg/L respectively. Additional samples collected in 2015 and 2016 ranged from 4 mg/L – 39 mg/L (average of 16.1 mg/L). Only seven samples were collected, but four were above the coldwater standard of 10 mg/L. Elevated concentrations were observed in 2016 in February, May, June, and August. Samples were collected at station S008-559.

The relative abundance of collector-filterer individuals (Collector-filtererPct) and relative abundance of Plecoptera individuals (PlecopteraPct) were worse than the statewide average of stations meeting the MIBI threshold (Table 88). The macroinvertebrate TSS index score was below average in 2009, and above average in 2013; as this score increases, so does the tolerance of the community. There were zero TSS intolerant taxa, and 3 – 4 TSS tolerant taxa. The percentage of TSS tolerant individuals was above average both visits, and very high in 2013 (85%). Overall, a majority of the macroinvertebrate metrics are worse than average and suggestive of stress.

Table 88. Macroinvertebrate metrics that respond to high TSS stress in Unnamed Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
09MN094 (2009)	**9.7**	**0**	10.40	**0**	**0**	4	**15.2**
09MN094 (2013)	**2.2**	**0**	**18.18**	**0**	**0**	3	**84.5**
Southern Coldwater Average	*32.7*	*0.4*	*13.34*	*2.3*	*3.5*	*5.2*	*10.8*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

All of the fish metrics with strong relationships to TSS were below the statewide average of stations meeting the FIBI threshold (Table 89). In fact, all metrics had a score of zero. Creek chub and blacknose dace were the only two species collected. Fish TSS index scores were above average both visits (Table 89), suggesting a more tolerant community.

Table 89. Fish metrics that respond to high TSS stress in Unnamed Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
09MN094 (2010)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
09MN094 (2013)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Southern Coldwater Average	*28.3*	*1.0*	*15.1*	*26.3*	*53.9*	*4.7*	*34.2*	*71.7*	*20.2*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 90. Fish metrics that respond to high TSS stress in Unnamed Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

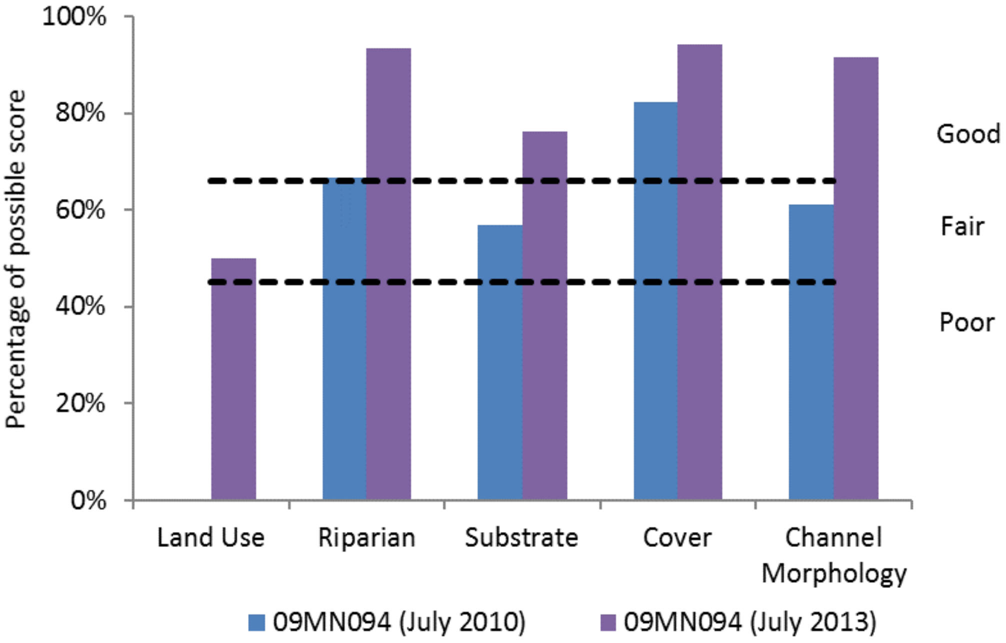
Station (Year sampled)	TSS Index Score	TSS Sensitive Taxa	TSS Sensitive Pct	TSS Tolerant Taxa	TSS Tolerant Pct
09MN094 (2010)	**15.3**	**0**	**0**	0	0
09MN094 (2013)	**11.5**	**0**	**0**	0	0
Southern Coldwater Average	*10.5*	*1.4*	*33.6*	*0.1*	*0.3*
Expected response to stress	↑	↓	↓	↑	↑

TSS is inconclusive as a biological stressor. The macroinvertebrates did indicate some negative response signals within the TSS community metrics, yet specific tolerant to TSS individuals were not abundant. This indicates there is not TSS specific displacement. Fish responded poorly in most parameters for TSS response in the community. As with the macroinvertebrates, TSS tolerant fish groups fell under the expected average, indicating another stressor is limiting this community. Additional to the uncertainty seen in the metrics, there is a lack of chemistry data to conclusively correlate TSS impacts.

Habitat

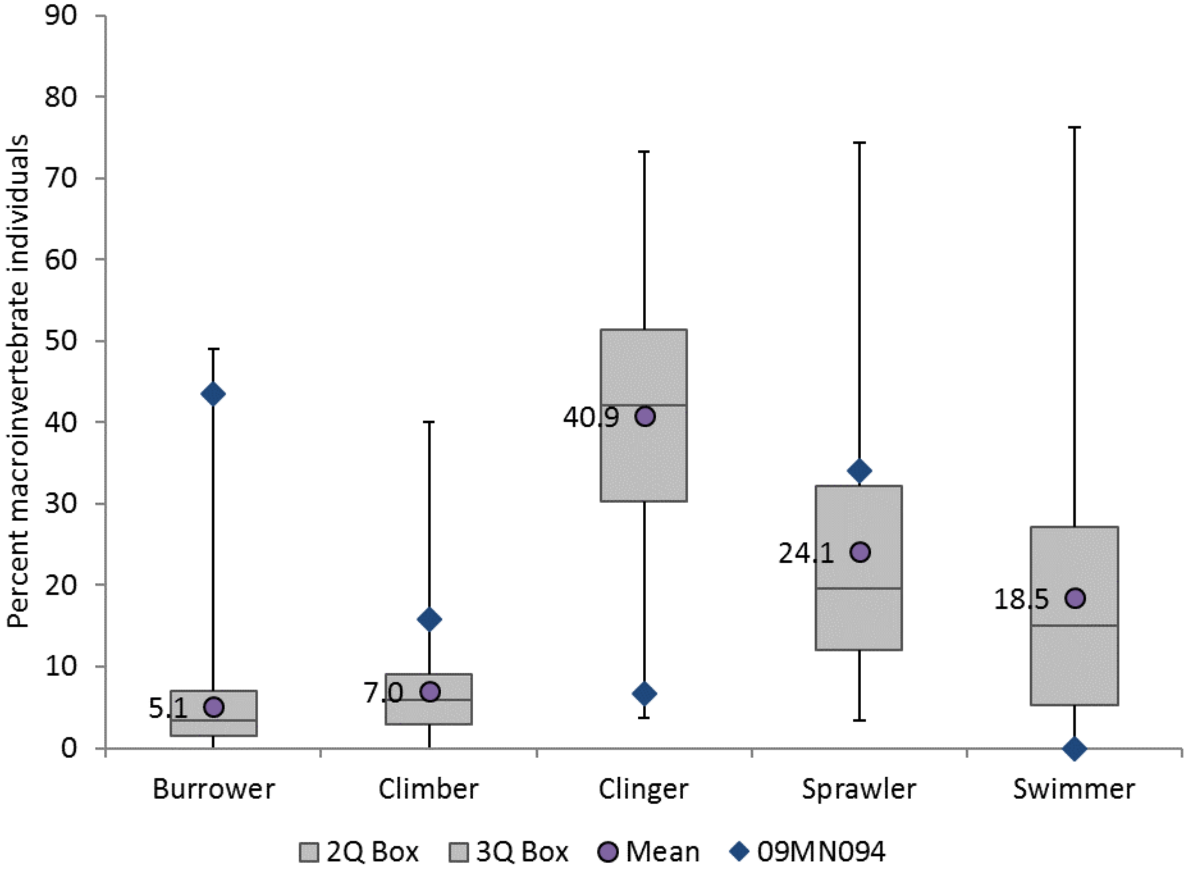
Station 09MN094 MSHA scores display an increasing trend from the 2010 to 2013 survey (Figure 99). In 2010, surrounding land use was the limiting factor out of all the categories assessed. As surrounding land use went from poor to fair, the riparian zone increased; with that yielding stronger shade and cover from the canopy. Channel morphology also improved in correlation to surrounding land use, providing a more stable system that allowed for improvements to the substrate. However, there is embeddedness noted in the form of silt in 2013. The stream ben was also noted to lack diverse substrate types (only three forms present).

Figure 99. Percentage of MSHA subcategory scores for station 09MN094, Unnamed Creek



Burrowers, climbers, and sprawlers were above average, and clingers and swimmers were below average (Figure 100). The elevated burrowers and minimal clingers are symptoms of habitat stress; burrower species "burrow" in fine sediment and clinger species attach to rock or woody debris. Worms (Oligochaeta) and scuds (Gammarus) were the dominant two taxa in 2009. Indicator values for suspended sediment and fine substrates for Gammarus, developed by Carlisle et al (2007), are ten and six respectively. The scoring system is based on a scale from 1 – 10, with ten being the most tolerant. Snails (Physa) dominated the community in 2013. Indicator values for suspended sediment and fine substrates for Physa were five and eight respectively.

Figure 100. Macroinvertebrate metrics that respond to habitat for station 09MN094, Unnamed Creek compared to the range of values for Coldwater Stream visits meeting the modified use biocriteria.



As the fish community was limited two only two taxa types, the metrics are not helpful in identifying if habitat is limiting the community. As displayed in previous TSS section (Table 79), the relative abundance of individuals that are riffle-dwelling species (RifflePct) were zero both years, and abundance of simple lithophilic spawners (SLithopPct) was below average in 2010 but well above average in 2013. These species require clean coarse substrate and riffles, and are expected to decrease with stress. The only two fish species sampled during both visits were blacknose dace and creek chub.

Habitat is considered a stressor as the macroinvertebrates are showing strong signals of habitat stress. The MSHA recon also indicates poor habitat availability as well as unstable stream banks that could be contributing to sedimentation within this channel. The fish sample was limited in being able to call out specific stressors, as there were only two taxa types collected.

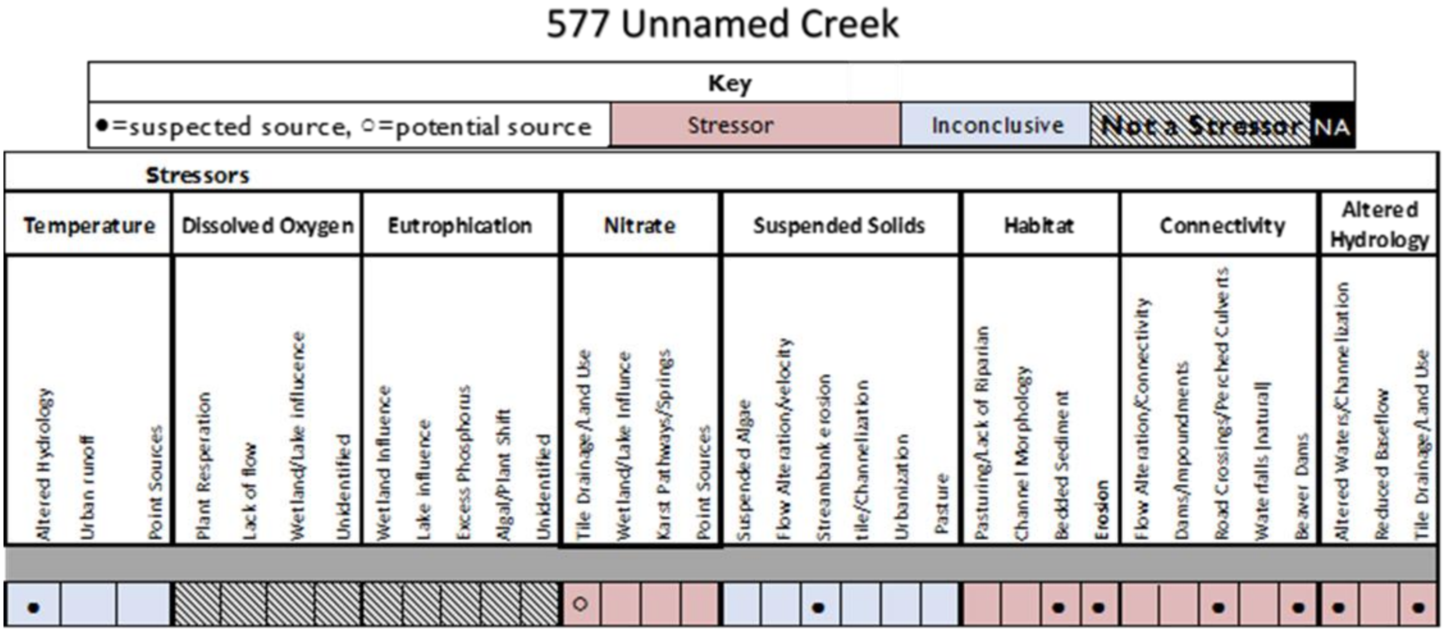
Longitudinal Connectivity and Altered Hydrology

Unnamed Creek has a perched culvert at Hwy 68 and there is also a large beaver dam approximately 1.3 miles from the confluence with the Minnesota River. For more information on the barrier, please see DNR’s Minnesota River, Mankato Watershed Characterization Report (2015). Station 09MN094 is upstream of both the perched culvert and the beaver dam. There are no downstream stations for comparison. Creek chub and blacknose dace were the only fish species surveyed at station 09MN094, in 2010 and 2013. There are no lakes or wetlands that could provide fish replenishment to the creek. These barriers are stressors to the fish community as they disconnect fish from migrating to and from the Minnesota River.

Altered hydrology is thought to be the primary stressor within this reach, as it is the driver of all other stressors within this reach. Altered hydrology is occurring in two ways throughout this system. Upstream the channel has been modified by ditching and channelizing, in addition to the practice of subsurface tile drainage. These changes alter the flow regime of the stream system, creating a host of downstream impacts. Tile drainage specifically provides a direct pathway from land to stream for nutrient (as well as other pollutant) overloading. For additional information on altered hydrology within this watershed, reference Chapter 3.1.8 of this report.

Summary Table

Table 91. Identified stressors with suspected sources for reach 577 of Unnamed Creek.



577 Unnamed Creek

Key

●=suspected source, ○=potential source | 🟥 Stressor | 🟦 Inconclusive | ▨ Not a Stressor | NA

Stressors

Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
🟦 ●	🟦	🟦	▨	▨	▨	▨	▨	▨	▨	▨	▨	🟥 ○	🟥	🟥	🟥	🟦	🟦	🟦 ●	🟦	🟦	🟦	🟥	🟥	🟥 ●	🟥 ●	🟥	🟥	🟥 ●	🟥	🟥 ●	🟥 ●	🟥	🟥 ●

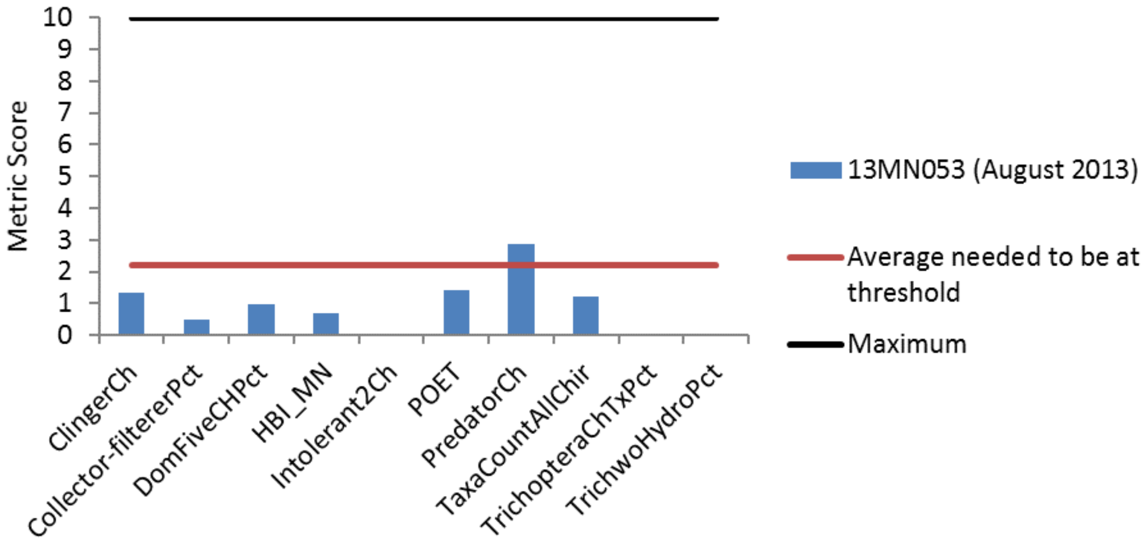
4.12 Judicial Ditch 10 (07020007-701)

Judicial Ditch 10 (07020007-701) is a tributary of Morgan Creek, southeast of Cortland, Minnesota. The reach is warmwater modified use Class 2B. The reach extends from unnamed creek to downstream of 112th Ave. The reach is impaired for lack of macroinvertebrate assemblage.

4.12.1 Biological Communities

Fish and macroinvertebrates were sampled at station 13MN053 in 2013. The fish community scored (47.7) above the modified use threshold (33) for the Southern Headwaters class. The fish community was dominated by brassy minnows and creek chubs. The macroinvertebrate community scored (9.0) below the modified use threshold (22) for the Prairie Streams GP class. The macroinvertebrate community was dominated by snails, Gyraulus and Physa. Nearly all of the MIBI metrics were less than the average metric score needed to obtain an IBI at the threshold (Figure 101).

Figure 101. Macroinvertebrate metrics for the Prairie Streams GP class station 13MN053, Judicial Ditch 10



4.12.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

The only dissolved oxygen (DO) samples collected on this reach occurred during biological sampling on June 12, 2013, August 8, 2013, and August 15, 2013 at station 13MN053. Concentrations were 10.3 mg/L, 2.3 mg/L, and 1.1 mg/L respectively. Two of the samples were well below the warmwater standard (5 mg/L), both collected in early morning. Indicating that the low DO is driven by plant respiration.

A sonde was deployed from July 23 through July 30, 2015 (Figure 102 and Figure 103). During that time DO was low and some days did not reach the standard of 5 mg/L. Yet, there were some days with elevated DO flux, with the DO ranging from 0.4 to 7.5 mg/L within 24 hours. In 2013, elevated DO flux was also noted on August 7 and 8, with DO of 9.6 mg/L at 4:15pm and then 0.90 mg/L at 8 am. DO flux during sonde deployment in 2015 ranged from 2.5 to 7.1 mg/L. Four of the days measured had DO flux greater than 4.5 mg/L, the river eutrophication standard.

Figure 102. Continuous dissolved oxygen measurements (mg/L) at 13MN053 from July 23, 2015 to July 31, 2013.

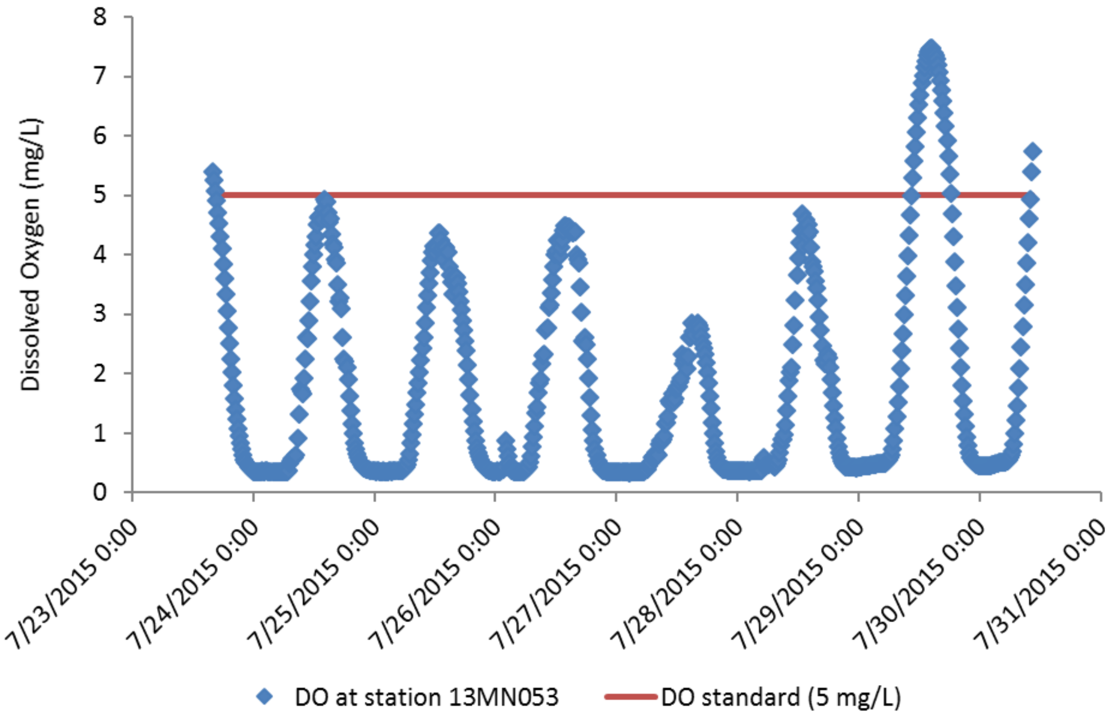
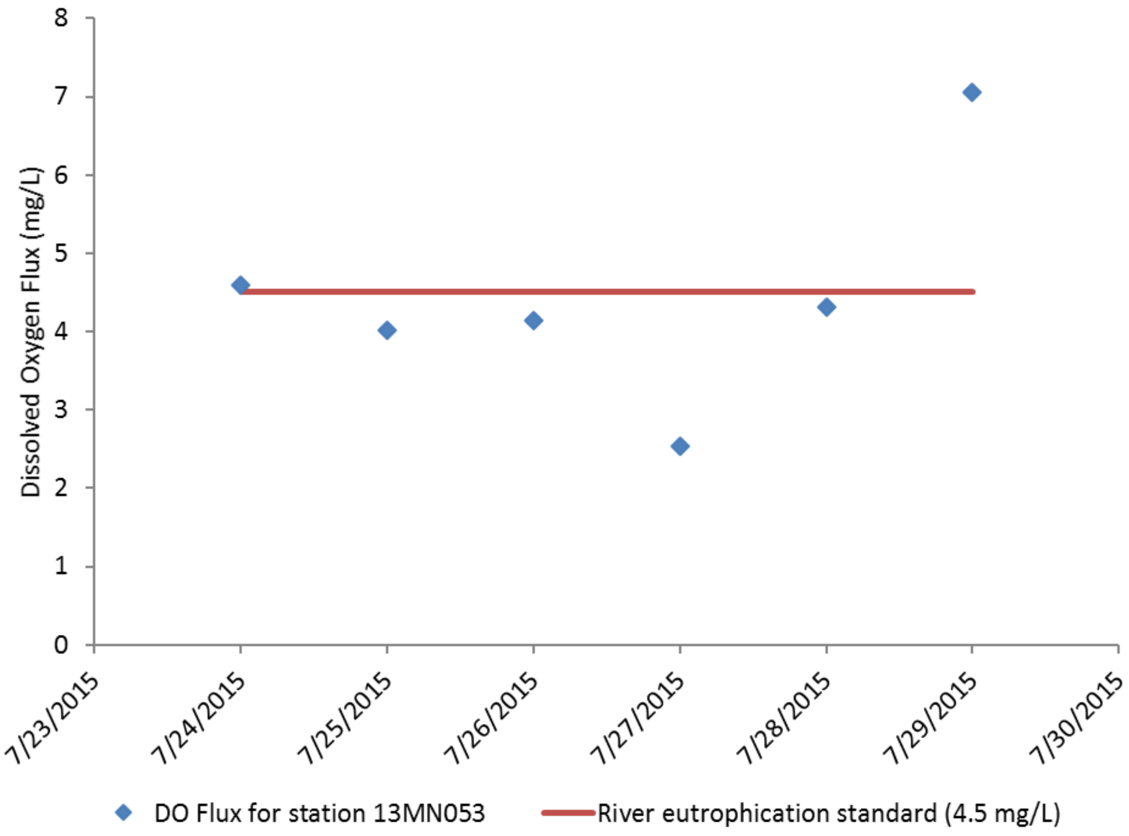


Figure 103. Dissolved oxygen flux measurements (24-hour variation) at 13MN053 from July 23, 2015 to July 31, 2013.



All of the macroinvertebrate metrics were worse than the statewide average of stations meeting the MIBI threshold (Table 92). The macroinvertebrate DO index score was below average; as this score decreases, so does the sensitivity of the community. There were zero DO intolerant taxa, and eleven DO tolerant taxa comprising 59% of the community. Taxa richness of Ephemeroptera, Plecoptera and Trichoptera (EPTCh), a measure of pollution based on tolerance values assigned to each individual taxon developed by Chirhart (HBI_MN), and total taxa richness (TaxaCountAllChir) were worse than average. The macroinvertebrate metrics are suggestive of stress.

Table 92. Macroinvertebrate metrics that respond to low DO stress in Judicial Ditch 10 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN053 (2013)	**23**	**2**	**8.7**	**5.9**	**0**	**0**	**11**	**58.8**
Prairie Streams Average	*36.8*	*7.6*	*7.9*	*6.4*	*2.4*	*4.5*	*8.4*	*25.1*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is a biological stressor within this reach. Chemistry data strongly displayed low levels of DO, during both the grab sample as well as the continuous data during sonde deployment. The macroinvertebrate metrics also showed a consistent negative response to low DO stress.

Eutrophication

The only total phosphorus (TP) samples collected on this reach occurred during fish sampling at station 13MN053 on June 12, 2013 and August 8, 2013. Concentrations were 0.029 mg/L and 0.214 mg/L respectively. The August sample exceeded the river eutrophication standard for the South Region (0.150 mg/L).

Chl-a, BOD, and DO flux are also considered when evaluating eutrophication stress. There have been zero chl-a or BOD samples collected. DO flux during sonde deployment in 2015 ranged from 2.5 to 7.1 mg/L. Only two of the full days of measurements had DO flux greater than 4.5 mg/L, the river eutrophication standard. The two partial days were also greater than 4.5 mg/L, with 5 and 5.3 mg/L flux, on the day of deployment and the day of pick up. Low DO was also documented in this AUID. Abundant autotrophic growth is apparent, seen below in Figure 104 and Figure 105.

All of the macroinvertebrate metrics were worse than the statewide average of stations meeting the MIBI threshold (Table 93**Error! Reference source not found.**). There were zero intolerant taxa (Intolerant2Ch), and a high percentage of tolerant taxa (Tolerant2ChTxPct). Taxa richness of collector-filterers (Collector-filtererCh), collector-gatherers (Collector-gathererCh), and Ephemeroptera, Plecoptera, and Trichoptera (EPT) were below average.

Table 93. Macroinvertebrate metrics that respond to eutrophication stress in Judicial Ditch 10 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN053 (2013)	**23**	**2**	**7**	**2**	**0**	**91.3**
Prairie Streams Average	*36.8*	*3.9*	*12.8*	*6.5*	*0.1*	*85.4*
Expected response to stress	↓	↓	↓	↓	↓	↑

Figure 104. Station 13MN053, August 8, 2013

Figure 105. Station 13MN053, July 23, 2015

Eutrophication is likely a stressor within this reach. While TP data is lacking, what is available is high. DO flux data also is responding in a way indicative of eutrophic conditions. One of the clearest lines of evidence for determining eutrophic conditions is assessment of the physical state of the stream. Each recon visit, excess algal growth is noted. This can be seen in the photo of August 8, 2013 and July 23, 2015. An additional site visit in June of 2013 noted some algal mats.

Nitrate

The only nitrate samples collected on this reach occurred during fish sampling at station 13MN053 on June 12, 2013 and August 8, 2013. Concentrations were 21 mg/L and 0.05 mg/L respectively.

Taxa richness of Trichoptera (TrichopteraCh) and relative abundance of non-hydropsychid Trichoptera individuals (TrichwoHydroPct) were below the statewide average of stations meeting the MIBI threshold (Table 94). There were zero nitrate intolerant taxa, and eleven nitrate tolerant taxa comprising 44% of the community. The macroinvertebrate nitrate index score was worse than average. A majority of the macroinvertebrate metrics were worse than average, but there is not a strong signal of nitrate stress.

Table 94. Macroinvertebrate metrics that respond to nitrate stress in Judicial Ditch 10 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN053 (2013)	**0**	**0.0**	**3.4**	**0**	11	44.4
Prairie Streams Average	*2.6*	*2.4*	*3.2*	*1.1*	*18.0*	*59.7*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is inconclusive as a stressor. There is limited chemistry data, but elevated concentrations have been documented. With the sample of 21 mg/L paired with lack of nitrate sensitive species nitrate is suspected to be a limitation. Additional data is needed to conclusively identify this.

Total Suspended Solids

The only total suspended solids (TSS) samples collected on this reach occurred during fish sampling at station 13MN053 on June 12, 2013 and August 8, 2013. Concentrations were 2 mg/L and 1.6 mg/L respectively. Both samples fell below the warmwater standard for the South Region of 65 mg/L.

The relative abundance of collector-filterer individuals (Collector-filtererPct) and relative abundance of Plecoptera individuals (PlecopteraPct) were worse than the statewide average of stations meeting the MIBI threshold (Table 95). There were zero TSS intolerant taxa, and five TSS tolerant taxa. TSS tolerant individuals comprised 33% of the community. The TSS index score was below average; as this score decreases, so does the tolerance of the community. Overall, the macroinvertebrate metrics display a mixed response to TSS stress.

Table 95. Macroinvertebrate metrics that respond to high TSS stress in Judicial Ditch 10 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN053 (2013)	**2.2**	**0.0**	14.77	**0**	**0**	5	32.8
Prairie Streams Average	*11.7*	*0.1*	*16.68*	*0.8*	*1.4*	*11.8*	*41.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

TSS is inconclusive. As there are limited TSS samples and a mixed biological community response, not able to determine if the negative measured responses is from TSS or from eutrophic conditions, as they will have similar physical impacts of habitat needs for the biology.

Habitat

Both 13MN053 MSHA assessments scored poorly at 30 (June) 35 (August) in 2013. There was noted bank erosion, moderate embeddedness (August 2013) and no coarse substrate (June 2013), and moderate cover. Overhanging vegetation and macrophytes were the available cover types. The reach was 100% run, dominated by sand and silt substrate (Figure 106). Below, Figure 107 captures stream instability, lack of cover, as well as the homogenous features throughout the reach.

Figure 106. Percentage of MSHA subcategory scores for station 13MN053, Judicial Ditch 10

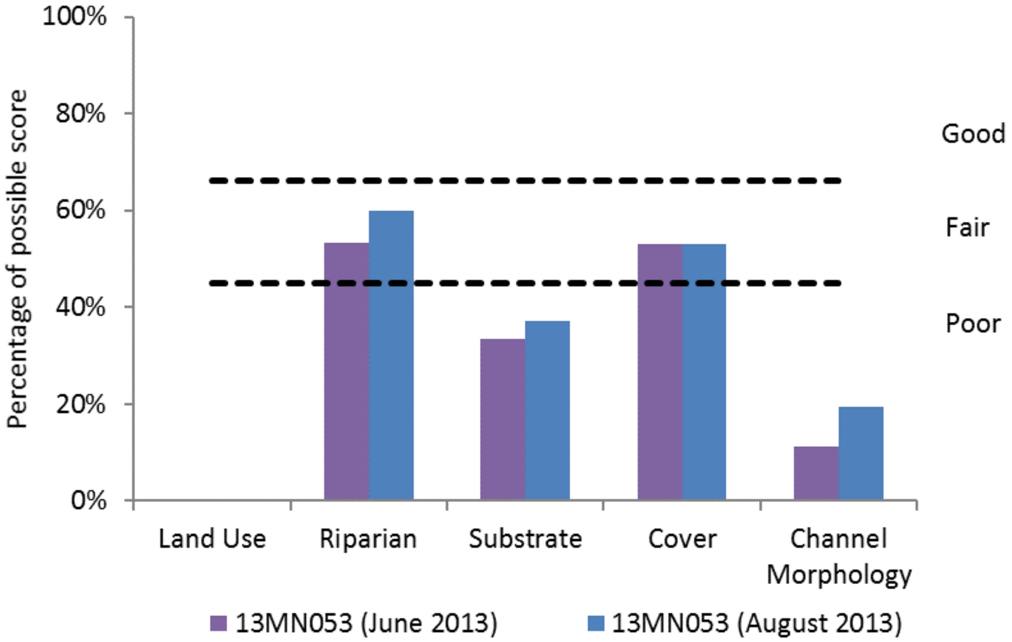
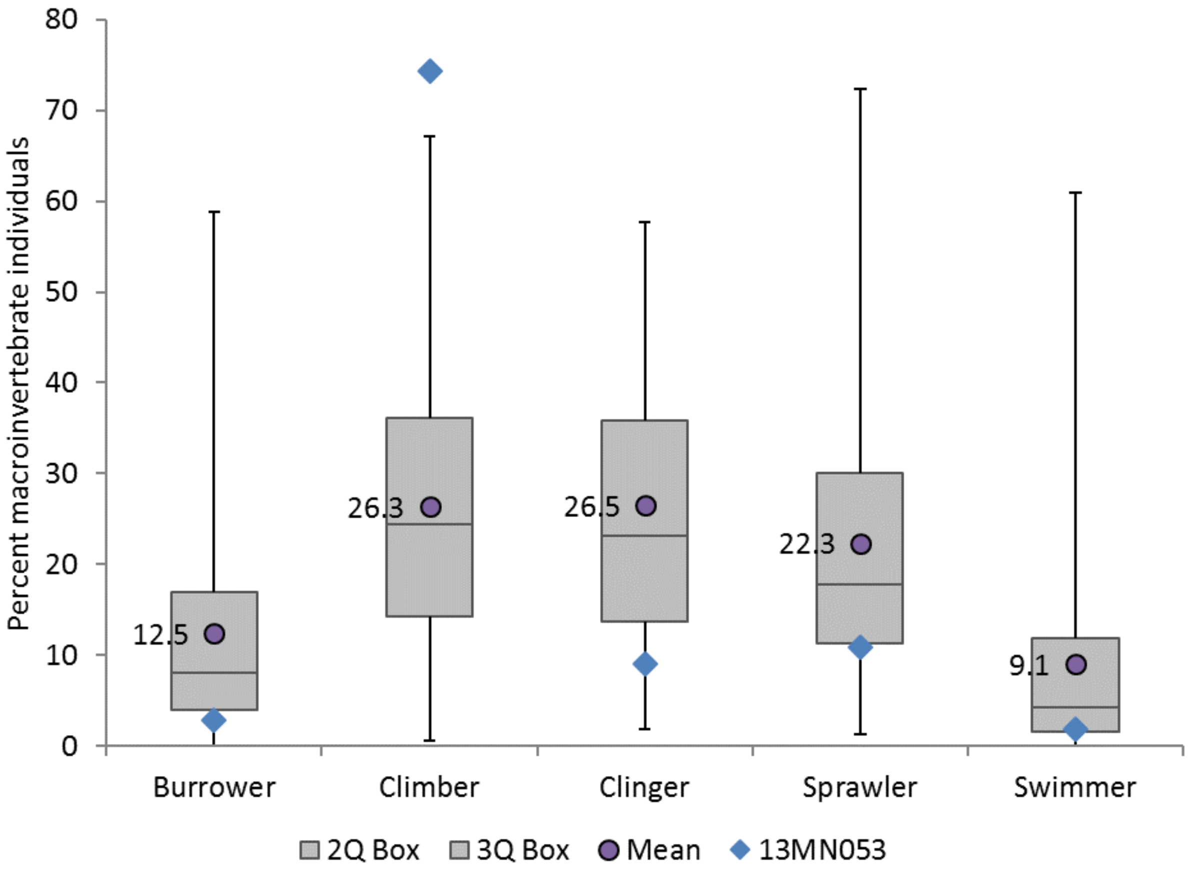


Figure 107. Station 13MN053, August 8, 2013

Burrowers, clingers, sprawlers, and swimmers were below average, and climbers were above average (Figure 108). Climber species use overhanging vegetation or woody debris habitat. Clingers were in the lower quartile, which may be a sign of habitat stress as clingers attach to rock or woody debris. The clinger MIBI metric score was below the average metric score needed to meet the MIBI threshold. Snails (Gyraulus and Physa) dominated the community. Indicator values for suspended sediment and fine substrates for Physa, developed by Carlisle et al (2007), are five and eight respectively. The scoring system is based on a scale from 1 – 10, with ten being the most tolerant.

Figure 108. Macroinvertebrate metrics that respond to habitat for station 13MN053, JD 10 compared to the range of values for Prairie Streams GR visits meeting the modified use biocriteria.



Habitat is a stressor. This reach has poor channel morphology and lack of physical habitat availability, as well as diversity. These features are also reflected in the biological community metrics.

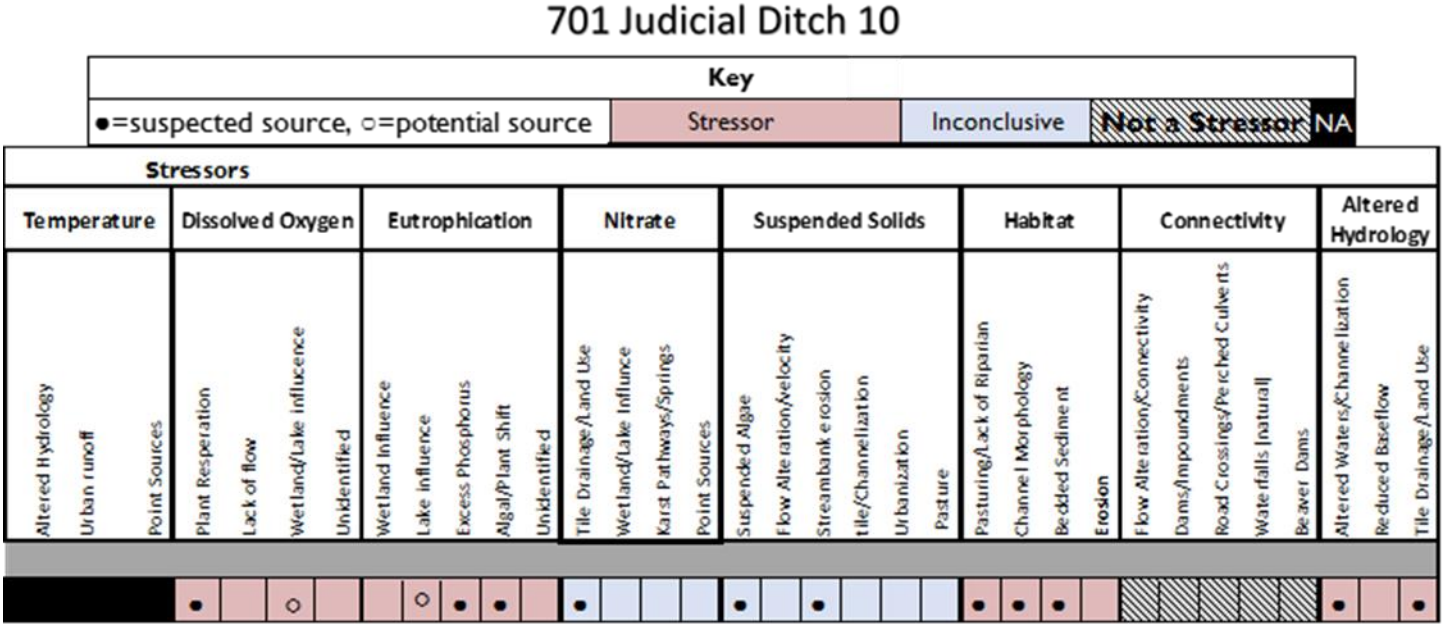
Longitudinal Connectivity and Altered Hydrology

Connectivity was not considered a stressor. There are no identified downstream barriers, or longitudinal connectivity issues that were found to limit migration ability.

Altered hydrology is the primary stressor within this reach, also driving downstream impacts. Judicial ditch 10 is downstream from a significant stretch of altered stream. These channels have been completely altered by way of ditching as well as introduction of subsurface tile drainage for agricultural purposes. For additional information on the impacts of these forms of altered hydrology reference Chapter 3.1.8 of this report.

Summary Table

Table 96. Identified stressors with suspected sources for reach 577 of Unnamed Creek.



701 Judicial Ditch 10

Key

●=suspected source, ○=potential source | Stressor | Inconclusive | Not a Stressor | NA

Stressors

Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channellization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
			●		○			○	●	●		●				●		●				●	●	●							●		●

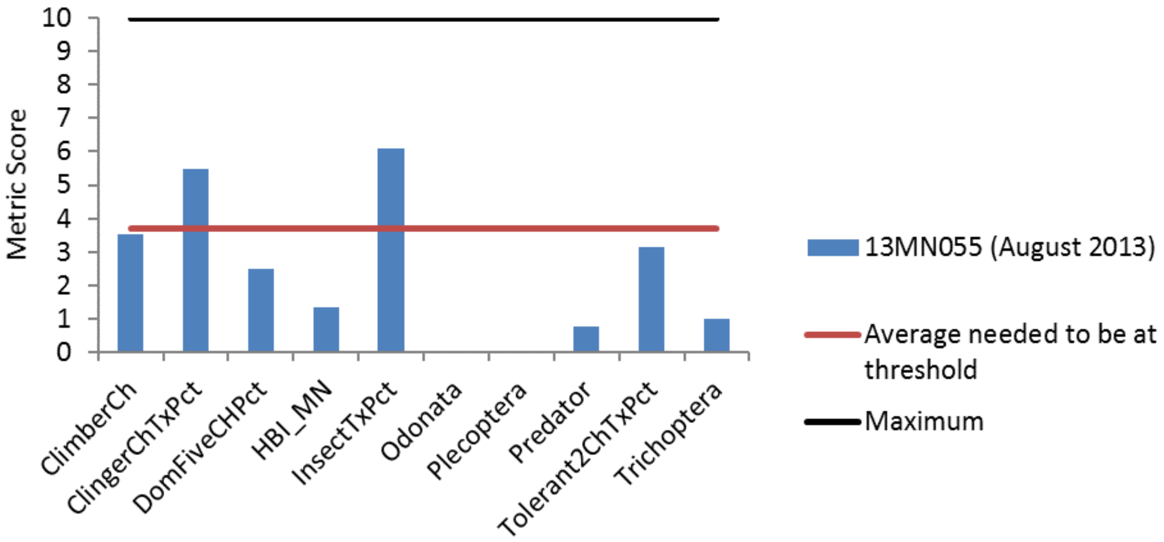
4.13 Morgan Creek (07020007-691)

Morgan Creek (07020007-691) is a tributary south of Cortland, Minnesota. The reach is warmwater general use Class 2B. The reach extends from approximately 232nd St to the Minnesota River. The reach is impaired for lack of fish assemblage and lack of macroinvertebrate assemblage. The reach is also impaired for *E. coli*, but this report will not address that impairment.

4.13.1 Biological Communities

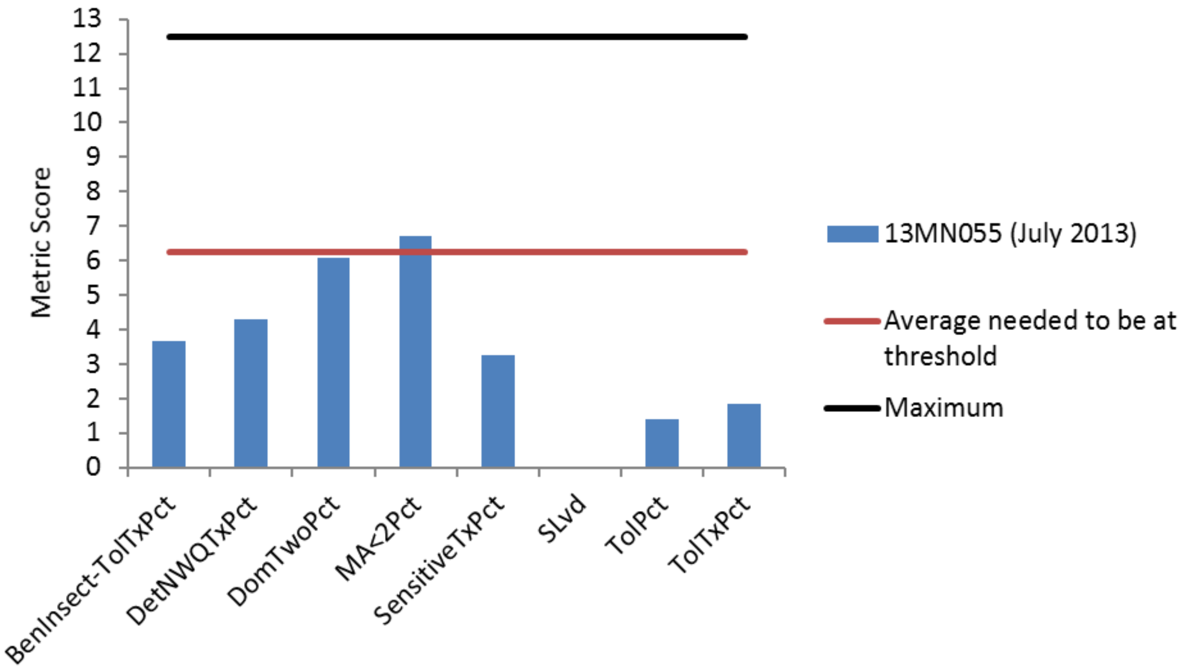
Station 13MN055 was sampled for fish and macroinvertebrates in 2013. The macroinvertebrate community scored 23.8, below the general use threshold of 37 for Southern Streams RR class. The community was dominated by Polypedilum (non-biting midges) and Cheumatopysche (tolerant netspinning caddisflies). Many of the metrics were below the average metric score needed to obtain an IBI at the threshold (Figure 109).

Figure 109. Macroinvertebrate metrics for the Southern Streams RR class station 13MN055, Morgan Creek



The fish community scored (27.3) below the general use threshold (50) for the Southern Streams class. The most abundant fish were central stonerollers, blacknose dace, and common shiners. All but one of the IBI metrics were below the average metric score needed to obtain an IBI at the threshold (Figure 110).

Figure 110. Fish metrics of the Southern Streams class IBI for station 13MN055, Morgan Creek



4.13.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

The dissolved oxygen (DO) concentration during biological sampling on July 29, 2013 and August 7, 2013 at station 13MN055 was 12 mg/L and 11 mg/L respectively. Two additional samples were collected on June 20, 2016 at stations S007-339 and S009-154; concentrations were 8.3 mg/L and 7.2 mg/L respectively. Minimal samples have been collected, but all are above the warmwater standard (5 mg/L).

A majority of the macroinvertebrate metrics were worse than the statewide average of stations meeting the MIBI threshold (Table 97). The macroinvertebrate DO index score was right at the average. There were seven DO intolerant taxa comprising 12% of the community, and four DO tolerant taxa comprising 6% of the community. Taxa richness of Ephemeroptera, Plecoptera and Trichoptera (EPTCh), a measure of pollution based on tolerance values assigned to each individual taxon developed by Chirhart (HBI_MN), and total taxa richness (TaxaCountAllChir) were worse than average.

Table 97. Macroinvertebrate metrics that respond to low DO stress in Morgan Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN055 (2013)	**38**	**7**	**7.9**	7.0	**7**	**12.2**	4	5.8
Southern Streams Average	*45.8*	*14.2*	*7.1*	*7.0*	*9.0*	*24.0*	*4.8*	*9.9*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

A majority of the fish metrics were worse than the statewide average of stations meeting the FIBI threshold (Table 98) Relative abundance of sensitive individuals (SensitivePct) and individuals with a female mature age greater than three years (MA>3Pct) were below average, and tolerant individuals (TolPct) comprised 70% of the community. There was one DO sensitive taxa comprising 0% of the community, and six DO tolerant taxa comprising 4% of the community. The fish DO index score was above average, and the probability of this reach meeting the DO standard based on the fish community was 64%.

Table 98. Fish metrics that respond to low DO stress in Morgan Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
13MN055 (2013)	**4.5**	**3.0**	**69.7**	7.4	**1**	**0.1**	**6**	3.6
Southern Streams Average	*16.9*	*24.6*	*44.9*	*7.2*	*1.7*	*6.1*	*4.7*	*18.5*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

DO is inconclusive as a stressor. This finding is partially due to lack of chemistry data. There are also questionable findings within the biological metrics, as in both cases the DO index score for fish and macroinvertebrates fell at the average score for this stream type. It is plausible the poor metric values within these two groups are related to a different stressor. In the future, continuous sonde data would be helpful in understanding the DO dynamics within this reach, to better interpret the correlation of low DO impacts on the biological community.

Eutrophication

The total phosphorus (TP) concentration during fish sampling on September 29, 2013 at station 13MN055 was 0.068 mg/L. Twenty two additional samples were collected in 2009 and 2010, ranging from 0.02 mg/L – 0.308 mg/L (average of 0.083 mg/L). Of these 22 samples, two exceeded the river eutrophication standard for the South Region (0.150 mg/L). All of these samples were collected near the mouth of Morgan Creek at station S004-281 in April (five), May (four), June (six), July (five) and August (two). Chl-a, BOD, and DO flux are also considered when evaluating eutrophication stress. There have been zero chl-a, BOD, or DO flux samples collected.

All of the macroinvertebrate metrics were worse than the statewide average of stations meeting the MIBI threshold (Table 99). There were zero intolerant taxa (Intolerant2Ch), and an elevated percentage of tolerant taxa (Tolerant2ChTxPct). Taxa richness of collector-filterers (Collector-filtererCh), collector-gatherers (Collector-gathererCh), and Ephemeroptera, Plecoptera, and Trichoptera (EPT) were below average.

Table 99. Macroinvertebrate metrics that respond to eutrophication stress in Morgan Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN055 (2013)	**38**	**5**	**14**	**6**	**0**	**78.9**
Southern Streams Average	*45.8*	*7.3*	*15.9*	*12.2*	*0.8*	*72.6*
Expected response to stress	↓	↓	↓	↓	↓	↑

A majority of the fish metrics were worse than the statewide average of stations meeting the FIBI threshold (Table 100). There were zero intolerant individuals (IntolerantPct), and elevated tolerant individuals (TolPct). Abundance of simple lithophilic spawners (SLithopPct) was the only metric that scored well.

Table 100. Fish metrics that respond to eutrophication stress in Morgan Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
13MN055 (2013)	**4.5**	**7.3**	41.1	**69.7**	**17**	**0**
Southern Streams Average	*16.9*	*11.9*	*37.0*	*44.9*	*19.3*	*4.2*
Expected response to stress	↓	↓	↓	↑	↓	↓

Eutrophication is listed as inconclusive. While there is a fair number of TP collected, there are not any secondary responses to evaluate. Diurnal DO would be especially helpful is identifying a eutrophic signal within this reach. Biological metrics were slightly mixed.

Nitrate

Nitrate concentration during fish sampling on July 29, 2013 at station 13MN055 was 2.2 mg/L. Thirty-two additional samples were collected in 2009, 2010, and 2013, ranging from 0.29 mg/L – 29 mg/L (average of 10 mg/L). Of the entire sample set 50% were above 10 mg/L. Elevated concentrations were observed in all years, in April (three), May (four), June (seven), and July (two). Samples were collected from stations S004-281 and S007-339.

Fish metrics are not yet developed to clearly identify nitrate stress within the fish community. The impacts of nitrate stress to the macroinvertebrate community are a better indicator if nitrate stress. Taxa richness of Trichoptera (TrichopteraCh) was below the statewide average of stations meeting the MIBI threshold (Table 101), and relative abundance of non-hydropsychid Trichoptera individuals (TrichwoHydroPct) was above average. There were zero nitrate intolerant taxa, and twenty-two nitrate tolerant taxa comprising 84% of the community. The macroinvertebrate nitrate index score was worse than average. A majority of the macroinvertebrate metrics are indicative of nitrate stress.

Table 101. Macroinvertebrate metrics that respond to nitrate stress in Morgan Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN055 (2013)	**3**	6.4	**3.8**	**0**	**22**	**84.3**
Southern Streams Average	*6.3*	*5.5*	*2.9*	*2.4*	*18.8*	*47.2*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is likely stressing the biological community within this reach, given the chronically high values in the nitrate dataset. The biological metrics also suggest nitrate is limiting the macroinvertebrate community.

Total Suspended Solids

The total suspended solids (TSS) concentration during fish sampling on July 29, 2013 at station 13MN055 was 3.6 mg/L. Thirty-one additional samples collected in 2009, 2010, and 2013 ranged from 2 mg/L – 290 mg/L with an average of 19.2 mg/L. Only two samples were found to be above the warmwater standard for the South Region of 65 mg/L. The two exceedances were 123 mg/L on June 29, 2010 and 290 mg/L on June 26, 2013. Samples were collected in the lower end of the AUID at stations S004-281 and S007-339; each station had one exceedance.

The relative abundance of collector-filterer individuals (Collector-filtererPct) was above the statewide average of stations meeting the MIBI threshold, while relative abundance of Plecoptera individuals (PlecopteraPct) was below average (Table 102). There was a complete absents of TSS intolerant taxa, and eleven TSS tolerant taxa. TSS tolerant individuals comprised 58% of the community, well above the expected composition of 35% of this stream type. The TSS index score was above average, indicating a more tolerant community. Overall, the macroinvertebrate community is suggestive of stress.

Table 102. Macroinvertebrate metrics that respond to high TSS stress in Morgan Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN055 (2013)	29.8	**0**	**17.02**	**0**	**0**	11	**58.3**
Southern Streams Average	*25.4*	*0.7*	*15.63*	*2.9*	*4.7*	*12.2*	*34.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

Most of the fish metrics with strong relationships to TSS were below the statewide average of stations meeting the FIBI threshold (Table 103). The relative abundance of individuals that are non-tolerant Centrarchidae (Centr-TolPct), relative abundance of individuals that are intolerant species (IntolerantPct), relative abundance of individuals that are long-lived (LLvdPct), relative abundance of individuals of the order Perciformes, excluding tolerant individuals (Percfm-TolPct), relative abundance of individuals that are sensitive species (SensitivePct), and relative abundance of individuals that are simple lithophilic spawners (SLithFrimPct) were all below average. There were zero TSS sensitive taxa, and two TSS tolerant taxa comprising 1% of the community (Table 104). The fish TSS index score was well below average; as this score decreases so does the tolerance of the community.

Table 103. Fish metrics that respond to high TSS stress in Morgan Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
13MN055 (2013)	46.0	**0**	43.1	**0**	**1.1**	**7.3**	43.2	**4.5**	**3.0**
Southern Streams Average	*36.0*	*5.4*	*25.7*	*4.2*	*13.6*	*20.1*	*30.2*	*16.9*	*19.1*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 104. Fish metrics that respond to high TSS stress in Morgan Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

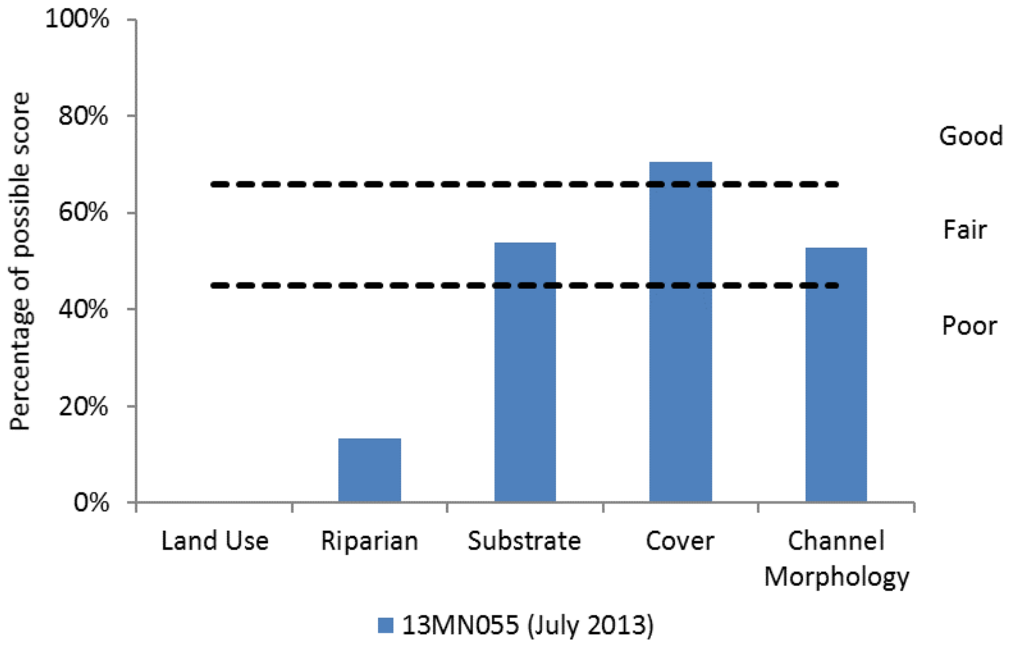
Station (Year sampled)	TSS Index Score	TSS Sensitive Taxa	TSS I Sensitive Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN055 (2013)	14.6	**0**	**0**	2	1.4
Southern Streams Average	*19.2*	*1.7*	*5.3*	*2.4*	*12.5*
Expected response to stress	↑	↓	↓	↑	↑

TSS is listed as inconclusive. While it is not likely the driving stressor on the biological community, there are some indication that it could be placing limitations on the biology. Water chemistry samples did not indicate a chronic TSS issue within this reach. The metrics were mixed, especially in the fish community; however the fish community is likely limited from the connectivity issue of the culvert (discussed in further detail below); this will limit the available fish sample within this reach. What was present within the fish community displayed that there were some species present who cannot thrive in turbid environments, such as benthic feeders and lithophilic spawners. In the macroinvertebrate community there is a higher than usual percentage of TSS tolerant species. However, there was a healthy number of collector filter inverts that depend on non-turbid environments for their habitat.

Habitat

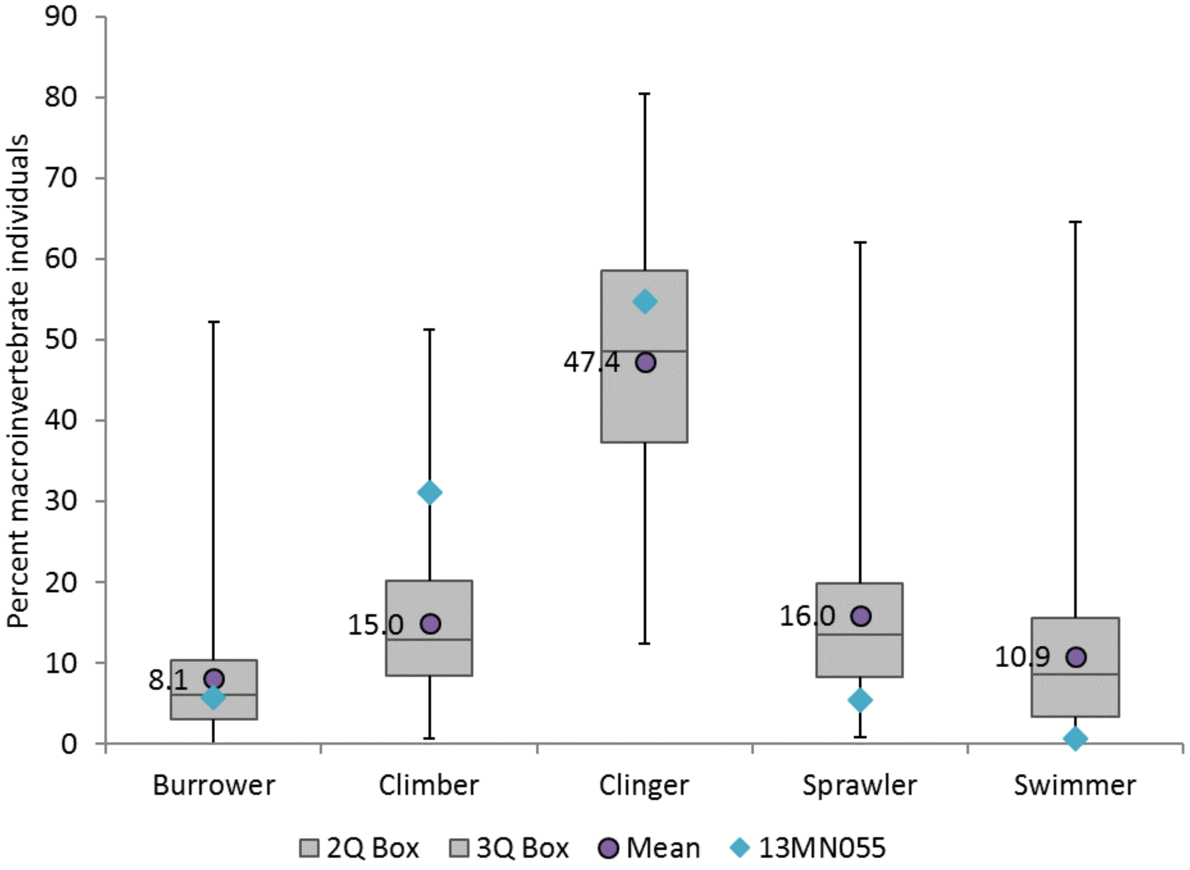
On July 29, 2013 the MSHA score was at 47.55 with the riparian zone being the largest contributor to a low score (Figure 111). There was also heavy bank erosion and moderate embeddedness noted. There were a variety of pool features and substrate types present, as well as a healthy ratio of riffles (25%), runs (55%), and pools (20%). Cover types included deep pools, logs or woody debris, boulders, rootwads, and macrophytes. Overall, there was sufficient physical habitat available.

Figure 111. Percentage of MSHA subcategory scores for station 13MN055, Morgan Creek



Burrowers, sprawlers, and swimmers were below average, and climbers and clingers were above average (Figure 112). There appears to be adequate overhanging vegetation, woody debris, and/or rock substrate, as climbers and clingers were present in good numbers. The climber MIBI metric score was just below the average metric score needed to meet the MIBI threshold, and the clinger MIBI metric score was above average. Overall, the macroinvertebrates do not show strong signs of habitat stress.

Figure 112. Macroinvertebrate metrics that respond to habitat for station 13MN055, Morgan Creek compared to the range of values for Southern Streams RR visits meeting the modified use biocriteria.



As displayed in Table 103 in the TSS section, the relative abundance of individuals that are riffle-dwelling species (RifflePct) as well as benthic feeders were above average. These species require clean coarse substrate and riffles, and are expected to decrease with habitat stress.

Habitat not likely a stressor. Fish and macroinvertebrate community not suggestive and the physical habitat present is diverse and abundant. Poor riparian paired with upstream alterations to flow could change the current habitat findings in the future. While habitat is not thought to be a stressor, it is vulnerable.

Longitudinal Connectivity and Altered hydrology

On August 3, 2016, a perched culvert was found on Morgan Creek at Hwy 68. In June 2016, a flow event that completely filled the two culverts took place, creating stream instability at the mouth of this culvert. It is unknown if the culvert was perched prior to the event. The culvert is perched about a foot under summer baseflow conditions (Figure 113 and Figure 114). Due to this barrier on fish migration, longitudinal connectivity is considered a stressor.

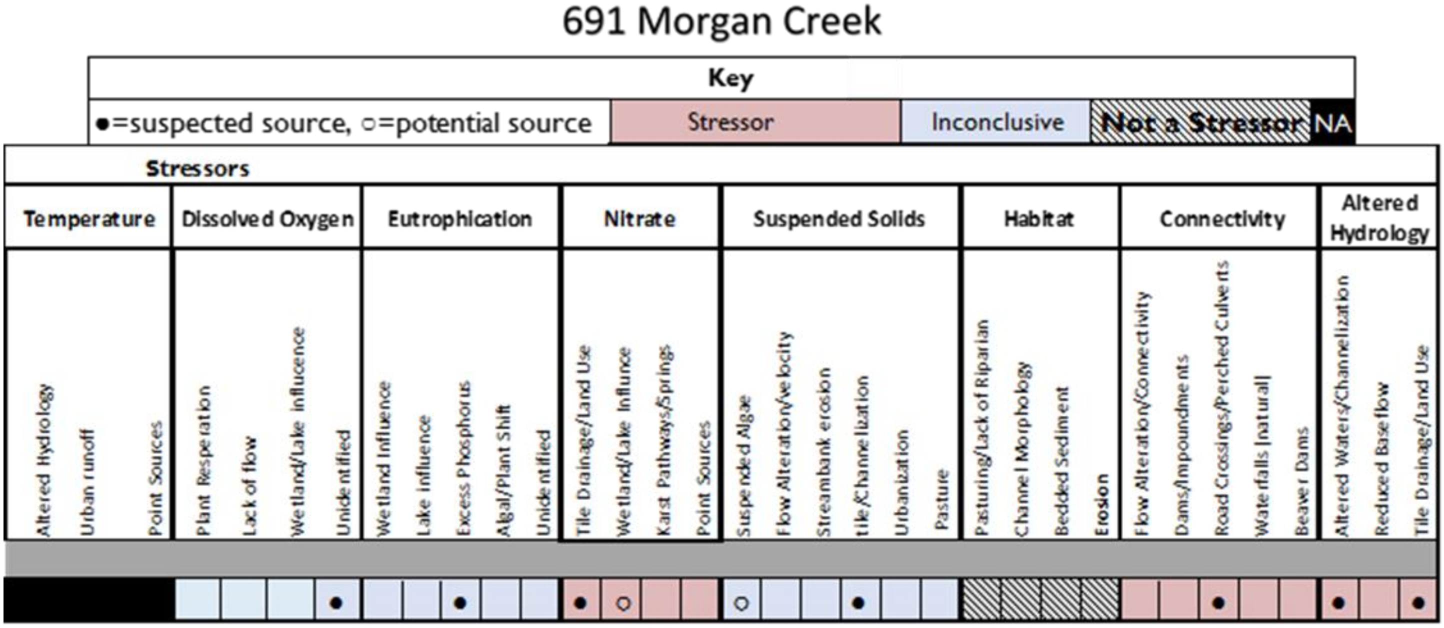
Figure 113. Morgan Creek downstream at Hwy 68, perched approximately 1 foot, August 3, 2016

Figure 114. Morgan Creek, Upstream of Hwy 68, on June 20, 2016, debris resting on culvert from storm event.

This reach is the farthest downstream monitoring station in Morgan Creek. A majority of the upstream locations and tributaries have been completely altered by way of ditching, channelizing, and introduction of subsurface tile drainage for agricultural purposes. This can lead to downstream water quality and geomorphology impacts as this alters the streams flow regime, creating more erosive conditions. Pollutant loading also is enhanced from the direct connection of subsurface tile drainage to the stream. For this reason, altered hydrology is thought to be the primary stressor as it is driving the other identified stressors on this reach. For more information on how altered hydrology impacts streams within this watershed, reference Chapter 3.1.8 of this report.

Summary Table

Table 105. Identified stressors with suspected sources for reach 691 of Morgan Creek.



691 Morgan Creek

Key				
●=suspected source, ○=potential source	🟥 Stressor	🟦 Inconclusive	▨ Not a Stressor	⬛ NA

Stressors

Temperature			Dissolved Oxygen				Eutrophication					Nitrate			
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources
⬛	⬛	⬛	🟦	🟦	🟦	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	🟥 ●	🟥 ○	🟥	🟥

Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
🟦 ○	🟦	🟦	🟦 ●	🟦	🟦	▨	▨	▨	▨	🟥	🟥	🟥 ●	🟥	🟥	🟥 ●	🟥	🟥 ●

Morgan Creek Subwatershed Conclusion

Three stream reaches were found to be impaired for biology in the Morgan Creek Subwatershed and vary in stream type and dynamics. Unnamed Creek (-577) was assessed as a cold-water general use stream, impaired for both macroinvertebrates and fish. Judicial Ditch 10 (-701) was assessed as a modified warmwater stream and only had impairments for macroinvertebrates. Morgan Creek (-691) was assessed as a general warmwater stream, with impairments for both macroinvertebrates and fish.

The Morgan Creek Subwatershed is unique as it has one of the few cold-water reaches contained in the entire Minnesota River- Mankato Watershed.

Unnamed Creek's (Horseshoe creek) temperature was identified as a potential biological stressor, as this reach was found close to exceeding temperatures that are known for limiting cold-water species, but never officially fell over the threshold. Temperatures should continue to be monitored in the future to ensure support for the cold-water biological community. The DNR and MPCA both feel habitat is a limiting factor to the cold-water species in this creek. Biological sampling and geomorphology work indicated severe bank erosion and embeddedness were causing macroinvertebrate and fish displacement. However, a unique attribute of Unnamed Creek is this is the only stream in the entire watershed where altered hydrology as a stressor is not prominent. Erosion occurring in this stream appears to be a natural process in this reach. This stream reach is down cutting and not under altered accelerated forces. There were no cold or cool water fish species sampled during two separate attempts. In 2010, the macroinvertebrate community was right below the expected population for a coldwater stream where in 2013 it was completely lacking. Connectivity is a stressor as fish migration ability is limited due to barriers within this reach, there is an identified community of beavers who have placed a dam between this station and the Minnesota River, and there is also a perched culvert at Hwy 68.

Excluding unnamed creek, the other two streams within this subwatershed are heavily influenced by altered hydrology by way of accelerated ground water input from tile lines related to agriculture. This alteration causes increased input of nutrients such as nitrate and phosphorus. Nitrate alone is toxic to biology and was found to be limiting the biology in two reaches with potential in the other one. High phosphorus loading has led to eutrophic conditions in JD 10. An overabundance of suspended and filamentous algae have made oxygen levels variable and were recorded to reach levels that would not support aquatic life. Suspended algae is also likely contributing to the impairments in biology and made up a significant amount of the total suspended solids.

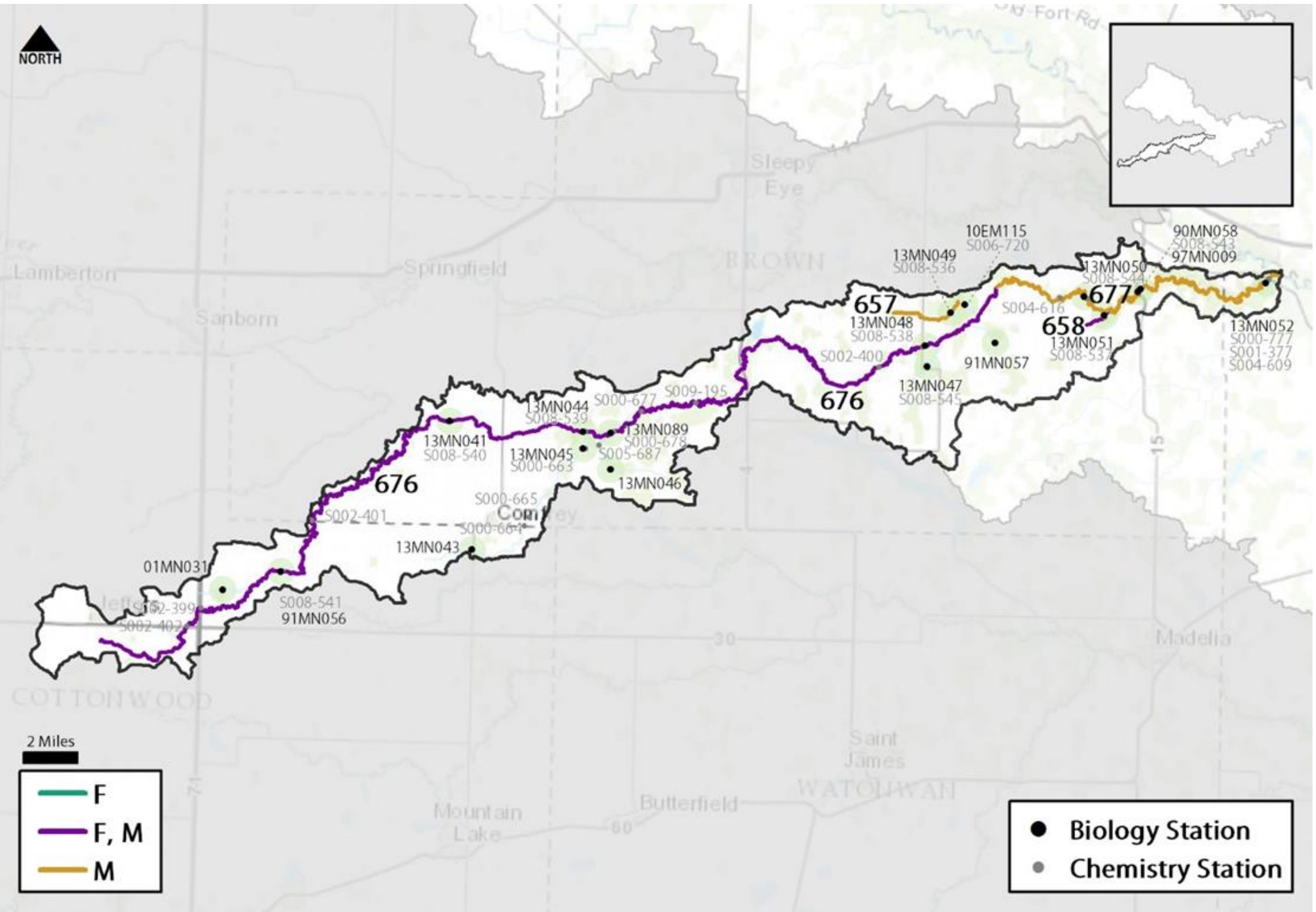
Other than tile line groundwater inputs, the other form of altered hydrology impacts to a stream is seen in ditching and channelizing. This practice of altering the channel increases surface flow and eliminates habitat diversity within the stream. Pasturing land use practices along Judicial Ditch 10 were also found to be limiting habitat.

Little Cottonwood River-MNR Mankato South

This section encompasses biotic impaired reaches in the Little Cottonwood 10 digit HUC. There are four reaches impaired for biology in this 10 digit HUC. County Ditch 11 and County Ditch 67 are tributaries to the Little Cottonwood River. County Ditch 11 is impaired for macroinvertebrates and County Ditch 52 is impaired for both fish and macroinvertebrates. There are two reaches on the Little Cottonwood River. The upstream reach is impaired for fish and macroinvertebrates, while the downstream reach is impaired for macroinvertebrates.

The watershed’s largest tributary, the Little Cottonwood River, is unusual compared to other streams in the watershed because 77% of its 83-mile length is still considered natural channel based on the Altered Watercourse Project. A mere 17% of the Little Cottonwood is considered channelized. Lack of channelization along this stream may be attributed to a portion of the stream occupying lowlands that are more suitable for pasture and hay.

Figure 115. Map of the Little Cottonwood Watershed with biological impairments and monitoring stations. Impairments are described as F=Fish, F, M=Fish and Macroinvertebrates, and M=Macroinvertebrates



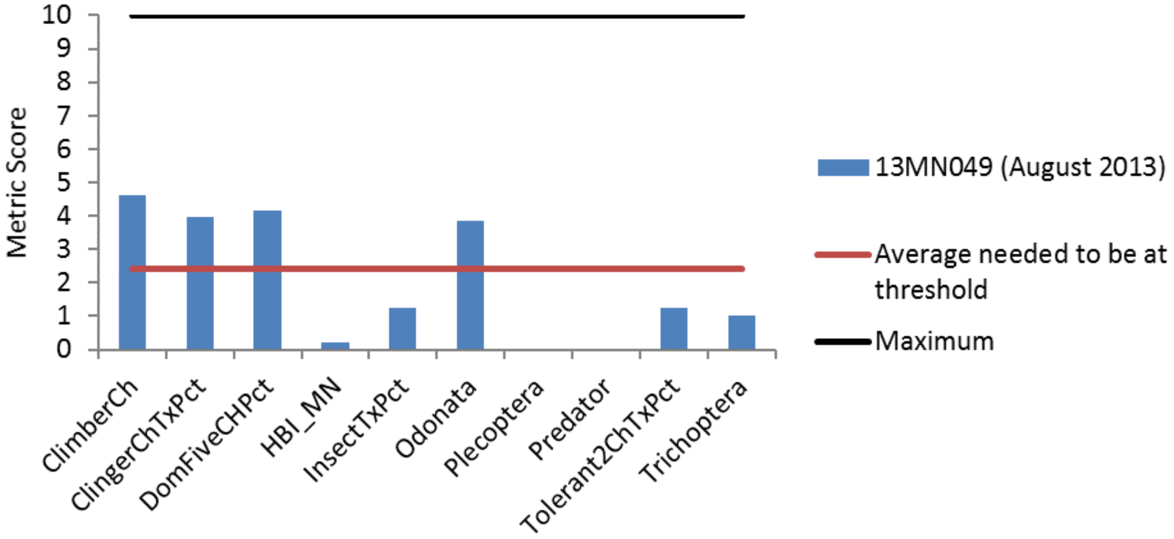
4.14 County Ditch 11 (07020007-657)

County Ditch 11 (07020007-657) is a tributary of the Little Cottonwood River, northwest of Hanska, Minnesota. The reach is warmwater modified use Class 2B. The reach extends from unnamed ditch to Unnamed Creek. The reach is impaired for lack of macroinvertebrate assemblage.

4.14.1 Biological Communities

Fish and macroinvertebrates were surveyed at station 13MN049 in 2013. The fish community scored an IBI of 44.6, above the modified use threshold of 33 for the Southern Headwaters class. Common shiners were the most dominant species present. The macroinvertebrate community had an IBI score of 21.3, below the modified use threshold of 24 for the Southern Streams RR class. The most abundant species were Physa (snails) and Hyalella (scuds). Only four of the 10 metrics in the Southern Streams RR IBI were above the average metric score needed to obtain an IBI score at the threshold (Figure 116).

Figure 116. Macroinvertebrate metrics of the Southern Streams RR IBI class for station 13MN049, County Ditch 11



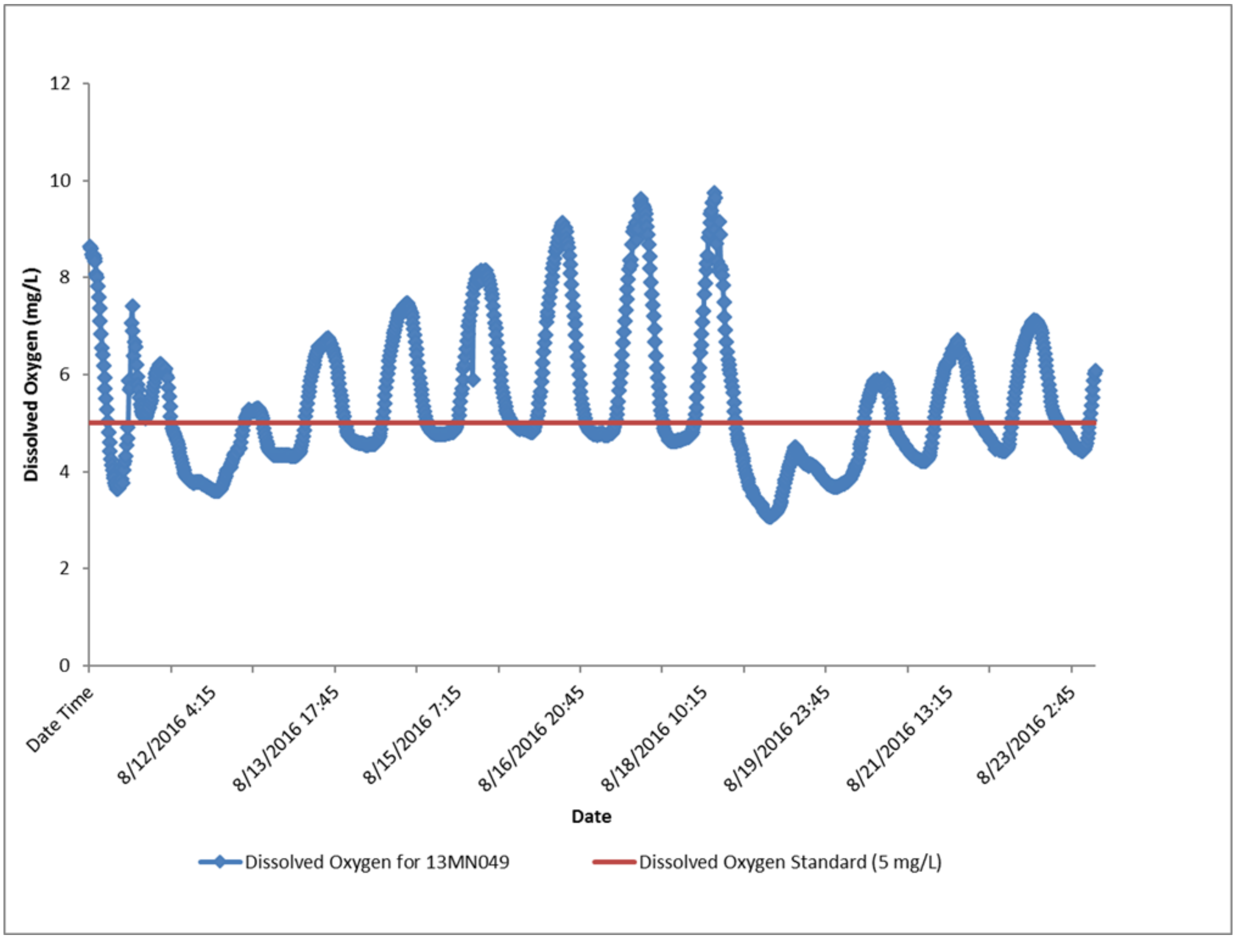
4.14.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

The dissolved oxygen (DO) concentration during biological sampling on July 9, 2013 and August 15, 2013 at station 13MN049 was 11.9 mg/L and 11.7 mg/L respectively. Eight additional instantaneous DO grab samples collected in 2015 and 2016 ranged from 6.4 mg/L – 10.6 mg/L (average of 8.4 mg/L); all were above the warmwater standard (5 mg/L). Samples were collected at station S008-536.

In 2016, a sonde was deployed from August 10 through August 23 at station 13MN049. During that time frame, concentrations ranged from 3.1 mg/L – 9.7 mg/L (Figure 117). Low DO was observed 51% of the deployment. Daily DO flux ranged from 1.4 mg/L – 5.8 mg/L; two days exceeded the 24 hour flux standard for the South Region (4.5 mg/L).

Figure 117. Diurnal dissolved oxygen for station 01MN020, July 30 – August 10, 2015



A majority of the macroinvertebrate metrics were worse than the statewide average of stations meeting the MIBI threshold (Table 107). The macroinvertebrate DO index score was below average; as this score decreases, so does the sensitivity of the community. There were three DO intolerant taxa comprising 8% of the community, and four DO tolerant taxa comprising 30% of the community. Taxa richness of Ephemeroptera, Plecoptera and Trichoptera (EPTCh), a measure of pollution based on tolerance values assigned to each individual taxon developed by Chirhart (HBI_MN), and total taxa richness (TaxaCountAllChir) were worse than average. Overall, the macroinvertebrate metrics are suggestive of stress.

Table 106. Macroinvertebrate metrics that respond to low DO stress in County Ditch 11 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN049 (2013)	**33**	**6**	**8.3**	**6.4**	**3**	**8.0**	4	**29.6**
Southern Streams Average	*41.5*	*12.1*	*7.3*	*7.0*	*7.0*	*20.3*	*5.0*	*11.3*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO appears to be a stressor. There were almost daily violations of the DO standard. It is likely this streams DO dynamics are driven by eutrophication, as there is a clear correlation of high DO levels during peak photosynthesis as well as extreme DO depletion when autotrophic respiration would be at its highest.

Eutrophication

The total phosphorus (TP) concentration during biological sampling on July 9, 2013 at station 13MN049 was 0.064 mg/L. Six additional samples collected in 2015 and 2016 ranged from 0.088 mg/L – 0.757 mg/L (average of 0.271 mg/L). Three of the six samples were above the river eutrophication standard for the South Region (0.150 mg/L). Samples were collected from station S008-536 in February, May, June (two), and August (two); the exceedances occurred in February (0.348 mg/L), May (0.180 mg/L), and August (0.757 mg/L).

Chl-a, BOD, and DO flux are also considered when evaluating eutrophication stress. One chl-a sample was collected on August 27, 2015; this sample was well below the 35 µg/L standard (0.97 µg/L). At this time, there have been zero BOD samples collected. During sonde deployment in 2016, daily DO flux ranged from 1.4 mg/L – 5.8 mg/L; two days exceeded the 24 hour flux standard for the South Region of 4.5 mg/L (Figure 117). Low DO was also observed during the time of this deployment.

Additional to the chemistry data, eutrophic conditions can be seen in the abundance of filamentous algae, in the form of floating algae mats (Figure 118) and benthic algae (Figure 119). As the dominant algae/plant type appears to be filamentous, this could account for the low chl-a, as that sable is usually collecting for the water column; typically limited to picking up suspended algae.

Figure 118. Station 13MN049 on September 13, 2012.

Figure 119. Station 13MN049 on July 9, 2013

The macroinvertebrate community did reflect eutrophic stress in the metrics. All of the macroinvertebrate metrics were worse than the statewide average of stations meeting the MIBI threshold (Table 107). There were zero intolerant taxa (Intolerant2Ch), and a high percentage of tolerant taxa (Tolerant2ChTxPct). Taxa richness of collector-filterers (Collector-filtererCh), collector-gatherers (Collector-gathererCh), and Ephemeroptera, Plecoptera, and Trichoptera (EPT) were below average.

Table 107. Macroinvertebrate metrics that respond to eutrophication stress in County Ditch 11 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN049 (2013)	**33**	**4**	**11**	**6**	**0**	**87.9**
Southern Streams Average	*41.5*	*6.7*	*14.8*	*10.4*	*0.5*	*77.7*
Expected response to stress	↓	↓	↓	↓	↓	↑

Eutrophication is listed as a stressor. While TP and chl-a data is limited, DO flux supports the findings of eutrophic conditions, as does the physical state of the stream over the two biological monitoring years. Phosphorus samples were limited, but what was present was high enough and randomly sampled enough that it strongly indicates a TP overloading problem within this stream.

Nitrate

The nitrate concentration during fish sampling on July 9, 2013 at station 13MN049 was 8.4 mg/L. Six additional samples were collected in 2015 and 2016, ranging from 0.45 mg/L – 27 mg/L (average of 17 mg/L). Four of the six were above 10 mg/L and three above 20 mg/L. The elevated concentrations were observed in February, May, June, and August of 2016. Samples were collected from station S008-536.

Taxa richness of Trichoptera (TrichopteraCh) and relative abundance of non-hydropsychid Trichoptera individuals (TrichwoHydroPct) were below the statewide average of stations meeting the MIBI threshold (Table 108). There were zero nitrate intolerant taxa, and 24 nitrate tolerant taxa comprising 70% of the community. The macroinvertebrate nitrate index score was worse than average. The macroinvertebrate metrics were worse than average and indicative of nitrate stress.

Table 108. Macroinvertebrate metrics that respond to nitrate stress in the Little Cottonwood River, compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN049 (2013)	**3**	**3.5**	**3.4**	**0**	**24**	**70.1**
Southern Streams Average	*5.4*	*4.3*	*3.0*	*1.6*	*18.5*	*52.7*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is a stressor. There is a biological response suggestive of nitrate displacement. While the nitrate samples were limited, they are randomized (in timing) enough that the frequent findings of high concentrations are likely telling of chronic nitrate loading within this stream. With some exceedances as high as 27 mg/L, regardless of frequency, this system demonstrates periods of extremely high nitrate concentrations that would eliminate sensitive taxa.

Total Suspended Solids

The total suspended solids (TSS) concentration during fish sampling on July 9, 2013 at station 13MN049 was 1.6 mg/L. Six additional samples collected in 2015 and 2016 ranged from 1.2 mg/L – 40 mg/L (average of 11.2 mg/L). All were below the warmwater standard for the South Region (65 mg/L). Samples were collected in February, May, June (two), and August (two) at station S008-536.

The relative abundance of collector-filterer individuals (Collector-filtererPct) and relative abundance of Plecoptera individuals (PlecopteraPct) were below the statewide average of stations meeting the MIBI threshold (Table 109). There were zero TSS intolerant taxa, and 10 TSS tolerant taxa comprising 39% of the community. The macroinvertebrate TSS index score was below average; as this score decreases, so does the tolerance of the community. Overall, a majority of the macroinvertebrate metrics were worse than average.

Table 109. Macroinvertebrate metrics that respond to high TSS stress in County Ditch 11 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN049 (2013)	**10.6**	**0**	15.22	**0**	**0**	10	**38.6**
Southern Streams Average	*26.4*	*0.4*	*15.89*	*1.8*	*2.9*	*11.3*	*36.9*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

TSS is inconclusive. Due to the limited data collected, it is not clear what TSS potential this reach has, particularly after a rain event. In addition, there were mixed results in the biological metrics. This makes it difficult to correlate a macroinvertebrate displacement from an overloading of TSS or if the community metrics are responding to a different stressor.

Habitat

During the July 9, 2013 biological sample, the MSHA scored low at 32, scoring “poor” in all categories, with the exception of the substrate category that scored “fair” (Figure 120. There was little bank erosion, moderate embeddedness, and sparse cover. Cover type’s available included overhanging vegetation and macrophytes (Figure 121). This station was 100% run, dominated by gravel and sand. There was a lack of physical habitat variation.

Figure 120. Percentage of MSHA subcategory scores for station 13MN049, County Ditch 11

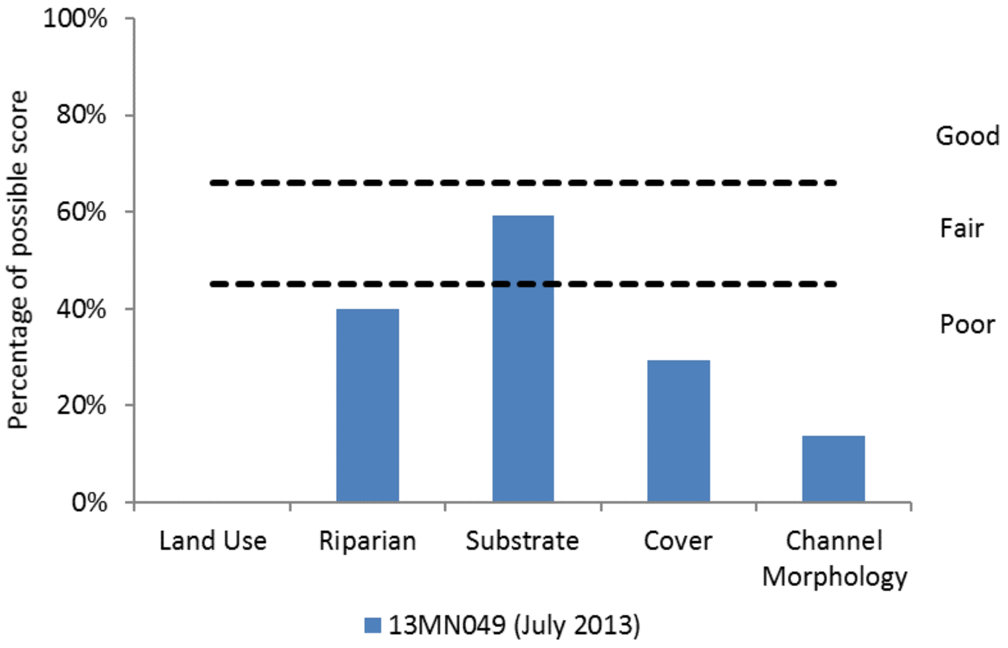
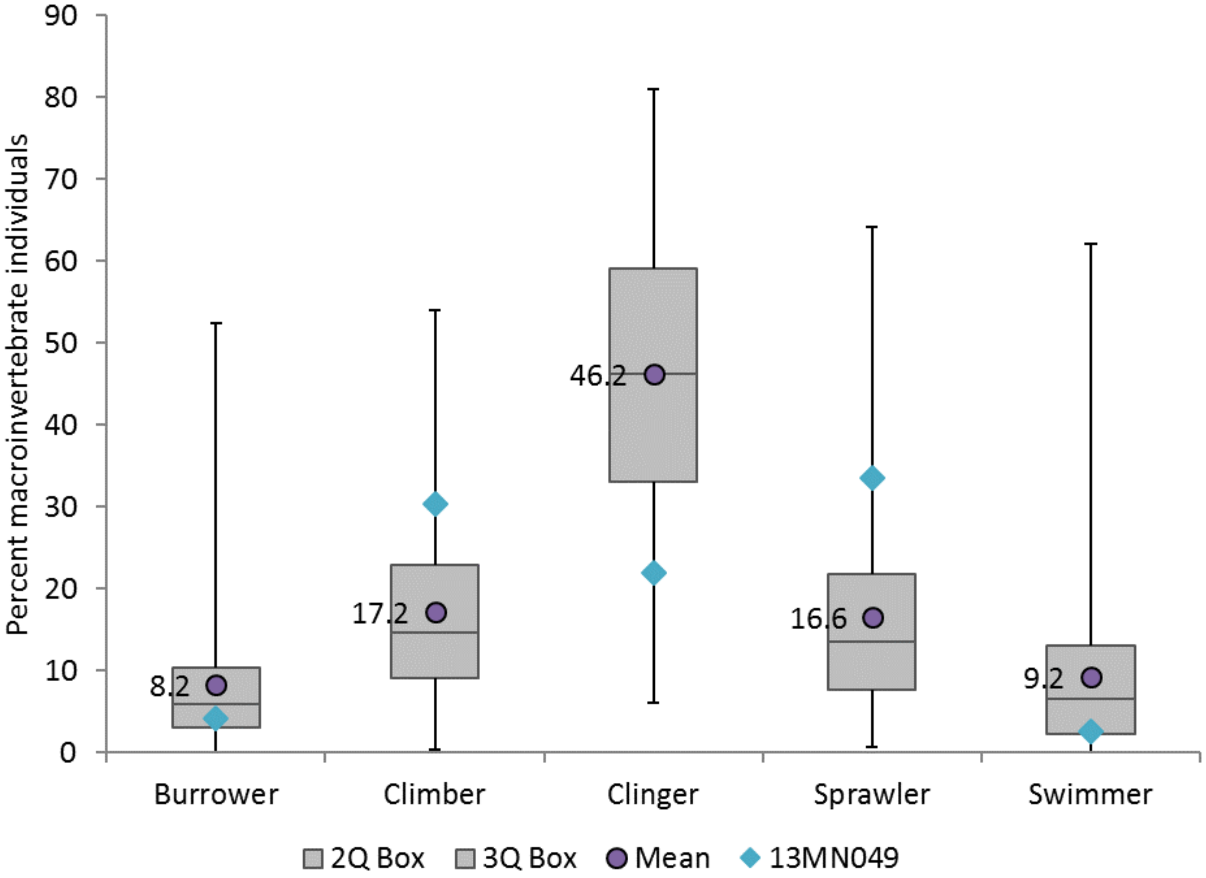


Figure 121. Station 13MN049 on July 9, 2013.

Burrowers, clingers, and swimmers were below average, and climbers and sprawlers were above average (Figure 122). Climbers and sprawlers were in the upper quartile, while clingers were in the lower quartile. The reduced clingers may be a sign of habitat stress, as clingers attach to rock or woody debris. Climber and clinger MIBI metric scores were above the average metric score needed to meet the MIBI threshold. Most of the habitat related macroinvertebrate metrics have values atypical of habitat stress.

Figure 122. Macroinvertebrate metrics that respond to habitat for station 13MN049, CD 11, compared to the range of values for Southern Streams RR visits meeting the modified use biocriteria.



Habitat is considered a biological stressor. There is a clear lack of habitat availability. In addition, stream instability is impairing what habitat is available. While the community group metrics are not completely imbalanced, sensitive species are lacking within this reach, as well as “clingers” that rely on benthic habitat.

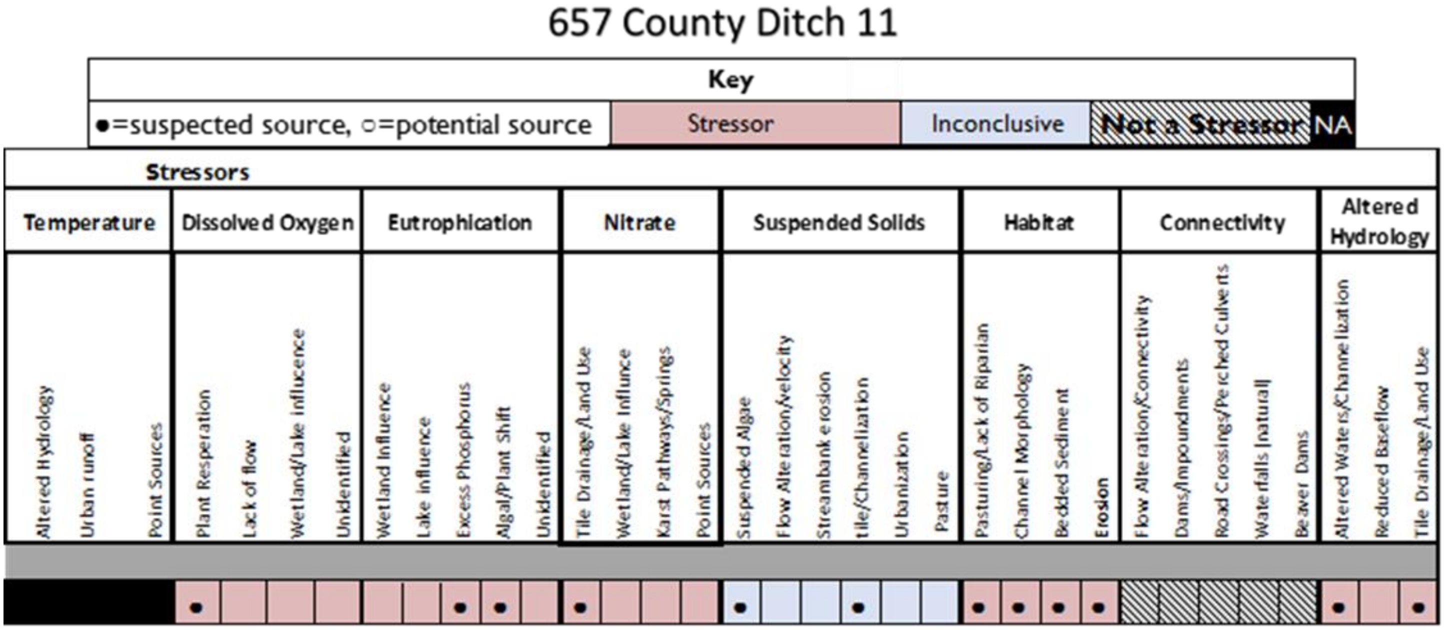
Longitudinal Connectivity and Altered Hydrology

Connectivity will not be evaluated for this reach, as macroinvertebrates were the only community found to be impaired. Fish communities however can be greatly impaired by barriers, as they are not listed as impaired no further evaluation for this stressor is needed. Additionally, there were not any obvious barriers identified downstream of the monitoring site.

Altered hydrology is considered to be the primary stressor as it is the main driver of many of the impairments found within this location. This reach has been completely altered by way of ditching, channelizing, as well as the introduction of subsurface tile drainage for agricultural purposes. These alterations directly affect the systems natural flow regime, nutrient inputs, as stream morphology. For additional information, refer to Chapter 3.1.8 of this report.

Summary Table

Table 110. Identified stressors with suspected sources for reach 567 of County Ditch 11.



657 County Ditch 11

Key				
●=suspected source, ○=potential source	🟥 Stressor	🟦 Inconclusive	▨ Not a Stressor	NA

Stressors																																				
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
NA	NA	NA	🟥 ●	🟥	🟥	🟥	🟥	🟥	🟥 ●	🟥 ●	🟥	🟥 ●	🟥	🟥	🟥	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	🟥 ●	🟥 ●	🟥 ●	🟥 ●	▨	▨	▨	▨	▨	🟥 ●	🟥	🟥 ●

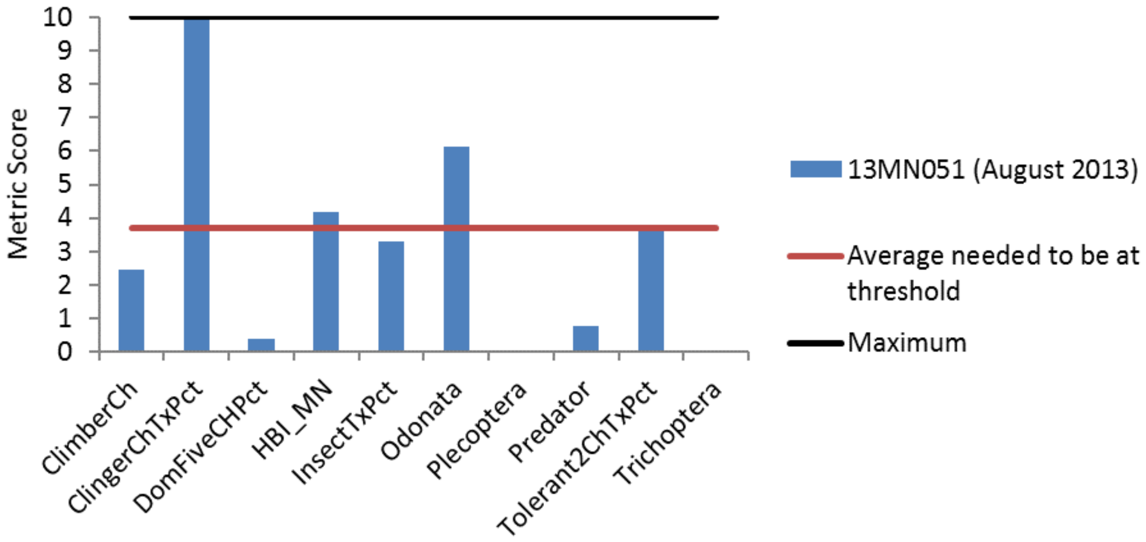
4.15 County Ditch 67 (07020007-658)

County Ditch 67 (07020007-658) is a tributary of the Little Cottonwood River, west of Searles, Minnesota. The reach is warmwater general use Class 2B. The reach extends from CD 58 to Little Cottonwood River. The reach is impaired for lack of macroinvertebrate assemblage and lack of fish assemblage.

4.15.1 Biological Communities

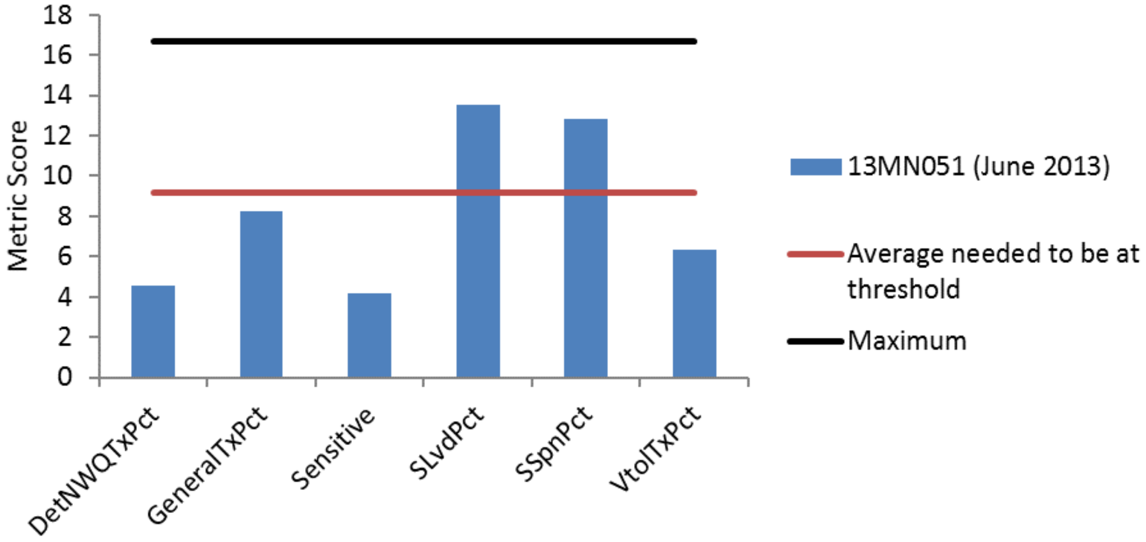
Station 13MN051 was surveyed in 2013 for fish and macroinvertebrates. The macroinvertebrate community scored (31) below the general use threshold (37) for the Southern Streams RR IBI. The sample was dominated by black fly larva, Simulium. Many of the metrics of the IBI were less than the average metric score needed to obtain an IBI score at the threshold (Figure 123). Those that were particularly low were relative abundance of dominant five taxa in subsample (DomFiveChPct), taxa richness of Plecoptera (Plecoptera), taxa richness of predators excluding chironomid predator taxa (Predator), and taxa richness of Trichoptera (Trichoptera).

Figure 123. Macroinvertebrate metrics of the Southern Streams RR IBI for station 13MN051, County Ditch 67



The fish community scored (49.7) below the general use threshold (55) for the Southern Headwaters IBI. The community was dominated by common shiners. Four of six IBI metrics were less than the average metric score needed to obtain an IBI score at the threshold (Figure 124).

Figure 124. Fish metrics of the Southern Headwaters IBI for station 13MN051, County Ditch 67



4.15.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

The dissolved oxygen (DO) concentration during biological sampling on June 12, 2013 and August 7, 2013 at station 13MN051 was 8.6 mg/L and 9.0 mg/L respectively. Five additional samples collected in 2015 and 2016 ranged from 9.0 mg/L – 13.0 mg/L (average of 10.1 mg/L); all were above the warmwater standard (5 mg/L). Samples were collected at station S008-537.

A majority of the macroinvertebrate metrics were better than the statewide average of stations meeting the MIBI threshold (Table 111). The macroinvertebrate DO index score was above average; as this score increases, so does the sensitivity of the community. There were seven DO intolerant taxa comprising 29% of the community, and one DO tolerant taxa comprising 1% of the community. Taxa richness of Ephemeroptera, Plecoptera and Trichoptera (EPTCh) and total taxa richness (TaxaCountAllChir) were worse than average, but a measure of pollution based on tolerance values assigned to each individual taxon developed by Chirhart (HBI_MN) was better than average. The macroinvertebrates do not appear stressed by DO.

Table 111. Macroinvertebrate metrics that respond to low DO stress in County Ditch 67 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN051 (2013)	**26**	**5**	6.9	7.7	**7**	29.3	1	0.9
Southern Streams Average	*45.8*	*14.2*	*7.1*	*7.0*	*9.0*	*24.0*	*4.8*	*9.9*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

The fish metrics were mixed is showing signals of low DO stress; half were better than the statewide average of stations meeting the FIBI threshold, and half were worse (Table 112). Relative abundance of sensitive individuals (SensitivePct) and individuals with a female mature age greater than three years (MA>3Pct) were below average, and tolerant individuals (TolPct) comprised 45% of the community. There were zero DO sensitive taxa, and three DO tolerant taxa comprising 8% of the community. The fish DO index score was above average, and the probability of this reach meeting the DO standard based on the fish community was 54%.

Table 112. Fish metrics that respond to low DO stress in County Ditch 67 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
13MN051 (2013)	**1.8**	**3.1**	44.7	7.2	**0**	**0.0**	3	8.4
Southern Headwaters Average	*7.9*	*13.9*	*72.8*	*7.1*	*0.8*	*4.2*	*3.4*	*20.2*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is not likely a stressor. Both the fish and macroinvertebrate community metrics did not have consistent measurements of low DO stress. In addition, what is available for chemical DO analysis did not indicate low DO.

Eutrophication

The total phosphorus (TP) concentration during biological sampling on June 12, 2013 at station 13MN051 was 0.01 mg/L. Additional samples collected in 2015 and 2016 ranged from 0.130 mg/L – 0.324 mg/L (average of 0.207 mg/L).

Only five samples have been collected, but four of the samples were above the river eutrophication standard for the South Region (0.150 mg/L). Samples were collected from station S008-537 in February, May, June (two), and August; exceedances were observed in all months.

Chl-a, BOD, and DO flux are also considered when evaluating eutrophication stress. One chl-a sample was collected on August 27, 2015; this sample was well below the 35 µg/L standard (1.06 µg/L). At this time, there have been zero BOD or DO flux samples collected.

All of the macroinvertebrate metrics were worse than the statewide average of stations meeting the MIBI threshold (Table 113). There were zero intolerant taxa (Intolerant2Ch), and an elevated percentage of tolerant taxa (Tolerant2ChTxPct). Taxa richness of collector-filterers (Collector-filtererCh), collector-gatherers (Collector-gathererCh), and Ephemeroptera, Plecoptera, and Trichoptera (EPT) were below average.

Table 113. Macroinvertebrate metrics that respond to eutrophication stress in County Ditch 67 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN051 (2013)	**26**	**4**	**8**	**5**	**0**	**76.9**
Southern Streams Average	*45.8*	*7.3*	*15.9*	*12.2*	*0.8*	*72.6*
Expected response to stress	↓	↓	↓	↓	↓	↑

A majority of the fish metrics were worse than the statewide average of stations meeting the FIBI threshold (Table 114). Abundance of darter species (DarterPct) and intolerant individuals (IntolerantPct) were both zero, but percentage of tolerant individuals (TolPct) was low. Abundance of simple lithophilic spawners (SLithopPct) was also better than average.

Table 114. Fish metrics that respond to eutrophication stress in County Ditch 67 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
13MN051 (2013)	**1.8**	**0**	61.1	44.7	**11**	**0**
Southern Headwaters Average	*7.9*	*11.5*	*31.5*	*72.8*	*11.5*	*1.6*
Expected response to stress	↓	↓	↓	↑	↓	↓

Eutrophication is inconclusive. Chemistry analysis at this location was limited in data. Phosphorus was often above the threshold of .15 mg/L. However, there was little secondary chemistry parameters available to determine eutrophic signals. The biological communities are somewhat suggestive of eutrophic stress. With mixed metrics in the fish community, paired with a limited collection in the macroinvertebrates it is difficult to correlate to eutrophication.

Nitrate

Nitrate concentration during fish sampling on June 12, 2013 at station 13MN051 was 12 mg/L. Five additional samples were collected in 2015 and 2016, ranging from 3.9 mg/L – 29 mg/L (average of 20.2 mg/L). Five of the six total samples were above 10 mg/L; three of those above 20 mg/L. Elevated concentrations were observed in both years, in February, May, and June. Samples were collected from station S008-537.

Fish metrics are yet to be developed to identify nitrate stress. Macroinvertebrate metrics provide a stronger line of evidence. Taxa richness of Trichoptera (TrichopteraCh) and relative abundance of non-hydropsychid Trichoptera individuals (TrichwoHydroPct) were below the statewide average of stations meeting the MIBI threshold (Table 115). There were zero nitrate intolerant taxa, and thirteen nitrate tolerant taxa comprising 48% of the community. The macroinvertebrate nitrate index score was worse than average. A majority of the macroinvertebrate metrics were worse than average.

Table 115. Macroinvertebrate metrics that respond to nitrate stress in County Ditch 67, compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN051 (2013)	**2**	**0.0**	**3.2**	**0**	13	**47.8**
Southern Streams Average	*6.3*	*5.5*	*2.9*	*2.4*	*18.8*	*47.2*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is a stressor within CD 67. There is a biological response indicative of nitrate stress. The nitrate samples, are limited; however, they are randomized enough that the frequent findings of high concentrations.

Total Suspended Solids

The total suspended solids (TSS) concentration during fish sampling on June 12, 2013 at station 13MN051 was 23 mg/L. Five additional samples collected in 2015 and 2016 ranged from 12 mg/L – 150 mg/L (average of 52.8 mg/L), one was above the warmwater standard for the South Region (65 mg/L). Samples were collected in February, May, June (two), and August at station S008-537; the exceedance occurred on May 11, 2016.

There were areas of significant TSS contribution potential, due to erosive conditions that are noted within this reach (Figure 125). Unstable banks and the sandy bluffs make this system vulnerable to sediment loading.

Figure 125. Biological monitoring location 13MN051, taken on June 12, 2013.

The relative abundance of collector-filterer individuals (Collector-filtererPct) was well above the statewide average of stations meeting the MIBI threshold, and relative abundance of Plecoptera individuals (PlecopteraPct) was below average (Table 116). There were zero TSS intolerant taxa, and seven TSS tolerant taxa comprising 21% of the community. The macroinvertebrate TSS index score was below average; as this score decreases, so does the tolerance of the community. Overall, the macroinvertebrates do not show a strong indication of TSS stress.

Table 116. Macroinvertebrate metrics that respond to high TSS stress in County Ditch 67 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN051 (2013)	50.8	**0**	15.13	**0**	**0**	7	20.8
Southern Streams Average	*25.4*	*0.7*	*15.63*	*2.9*	*4.7*	*12.2*	*34.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

All of the fish metrics with strong relationships to TSS were below the statewide average of stations meeting the FIBI threshold (Table 117). The relative abundance of individuals that are non-tolerant Centrarchidae (Centr-TolPct), relative abundance of individuals that are intolerant species (IntolerantPct), relative abundance of individuals that are long-lived (LLvdPct), and relative abundance of individuals of the Order Perciformes excluding tolerant individuals (Percfm-TolPct) were all 0% of the fish community. There were zero TSS sensitive taxa, and one TSS tolerant taxa comprising 2% of the community (Table 118). The fish TSS index score was just below average and the probability of the reach meeting the TSS standard based on the fish community was 72%.

Table 117. Fish metrics that respond to high TSS stress in County Ditch 67 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
13MN051 (2013)	**12.4**	**0**	**14.2**	**0**	**0**	**0**	**14.2**	**1.8**	**3.1**
Southern Headwaters Average	*35.0*	*1.0*	*22.4*	*1.6*	*4.5*	*13.6*	*26.2*	*7.9*	*14.6*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 118. Fish metrics that respond to high TSS stress in County Ditch 67 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

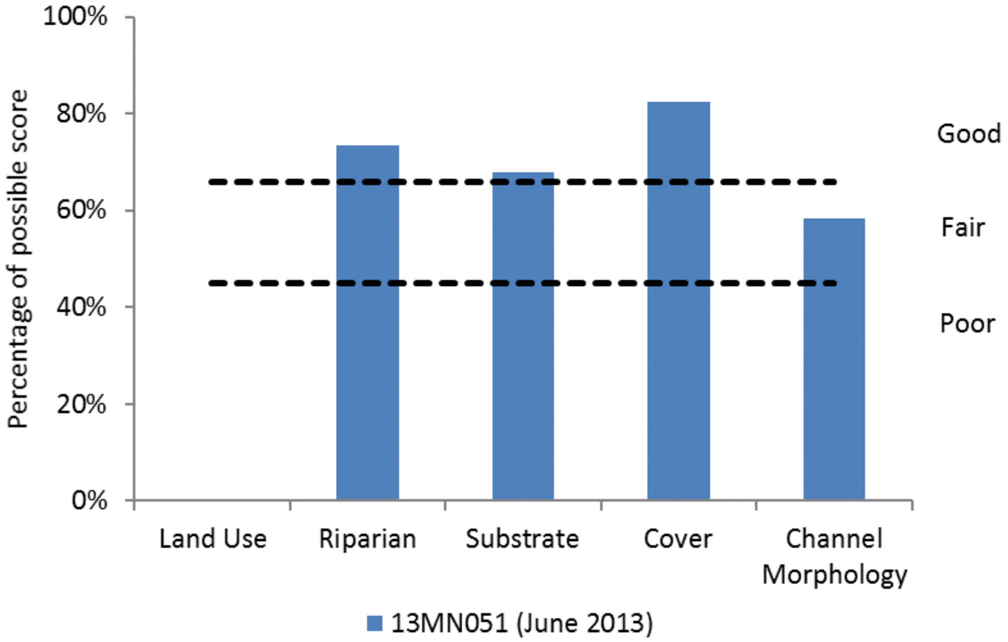
Station (Year sampled)	TSS Index Score	TSS Sensitive Taxa	TSS Sensitive Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN051 (2013)	15.3	**0**	**0**	**1**	1.8
Southern Headwaters Average	*15.4*	*0.9*	*4.1*	*0.4*	*2.0*
Expected response to stress	↑	↓	↓	↑	↑

TSS is inconclusive as a stressor. While biological metrics do not show a conclusive negative response to TSS within the two communities, there are some TSS sensitive species present who depend on good water clarity to thrive. There are few TSS samples to better understand if there is a chronic problem within this reach. Site recon displayed areas of erosion that could be contributing to high TSS loading.

Habitat

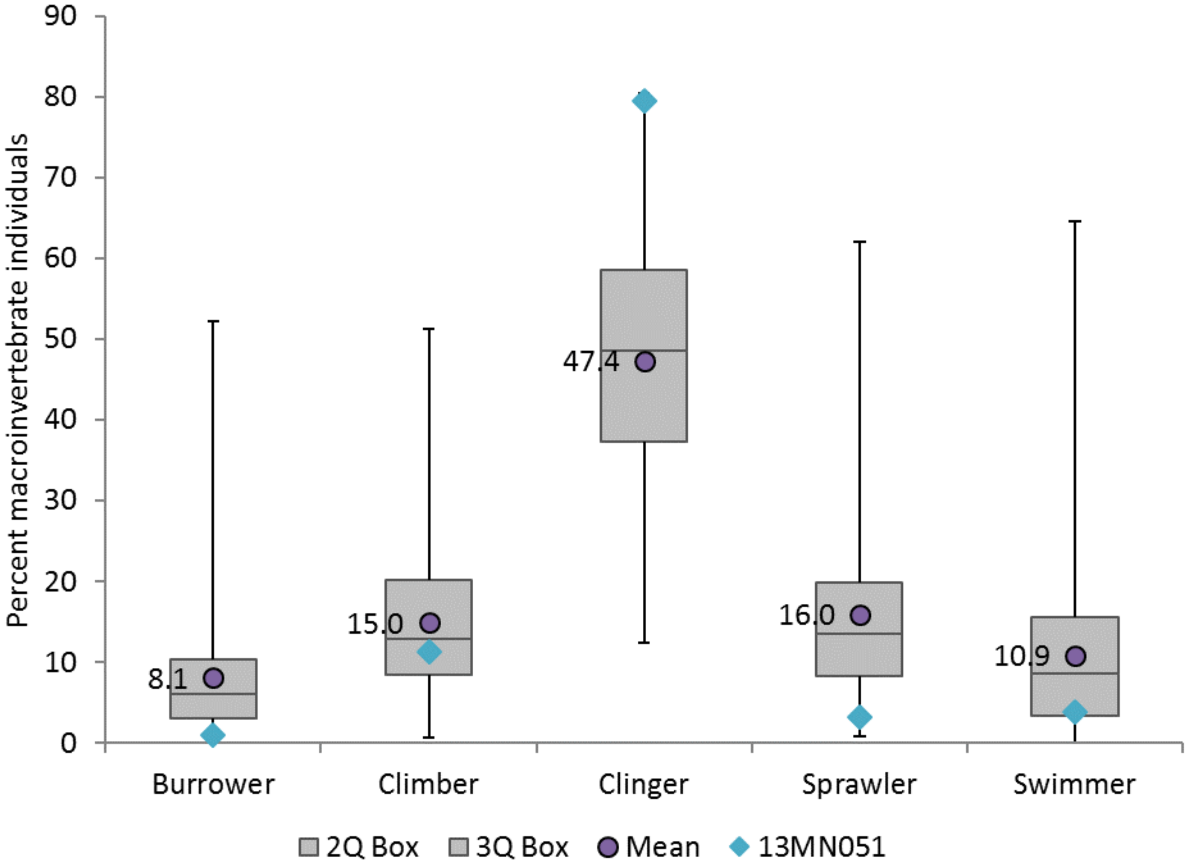
At the time of biological monitoring the MSHA scored fair with a total score of 64.3 (Figure 126). There was noted to be a variety of streambed substrate types as well as strong diversity in cover types and channel morphology. There was heavy bank erosion, moderate embeddedness, and moderate cover. Available cover types included undercut banks, overhanging vegetation, deep pools, logs or woody debris, boulders, root-wads, and macrophytes. The station had a good mix of pools (20%), riffles (25%), and runs (55%).

Figure 126. Percentage of MSHA subcategory scores for station 13MN051, County Ditch 67



Based on the macroinvertebrate habitat groups, there is little to suggest that lack of habitat is limiting the community. Burrowers, climbers, sprawlers, and swimmers were below average due to the abundance of clingers skewing the group composition (Figure 127). Clingers dominated the community; clingers attach to rock or woody debris. The climber MIBI metric score was below the average metric score needed to meet the MIBI threshold, but the clinger MIBI metric score was well above average. Often times in habitat impaired systems, burrowers will dominate as they thrive in embedded streams and are typically composed of generally tolerant species.

Figure 127. Macroinvertebrate metrics that respond to habitat for station 13MN049, CD 67, compared to the range of values for Southern Streams RR visits meeting the general use biocriteria.



As displayed in the TSS section, the relative abundance of individuals that are riffle-dwelling species (RifflePct) fell below average. However, abundance of simple lithophilic spawners (SLithopPct) was above average (Table 117). Both of these fish groups require clean substrate and riffles, and are expected to decrease with stress.

Habitat is inconclusive as a biological stressor. The observed habitat had a combination of good attributes paired with poor. What is of particular concern is the erosive banks as well as some embeddedness of the streambed. The macroinvertebrates did not show a strong indication of habitat stress. The fish community does have some species present that depend on clean riverbed substrate. There were also some sensitive habitat groups missing from the fish sample as well, yielding inconclusive finding in determining habitat impacts to the fish community.

Longitudinal Connectivity and Altered Hydrology

Longitudinal Connectivity is not considered a stressor within this reach. There were not any identified longitudinal connectivity barriers within or downstream of this reach that could be negatively influencing fish migration.

Altered hydrology is identified upstream on this reach, as there are several unassessed reaches that feed into this reach and therefore is likely influenced from the channelized contributing streams. The introduction of subsurface tile drainage is also playing a role in biotic impairments. These practices not just alter the stream systems physical stability as the flow regime is changed, but also the nutrient cycling and loading. For additional information on altered hydrology and impacts to the stream, refer to Chapter 3.1.8 of this report.

Unlike the other tributaries to the Little Cottonwood River that were predominantly channelized, the monitored reach on County Ditch 67 (-658) consists of a mostly natural channel, and showed fair habitat according to MSHA results. This reach is located closer to the Little Cottonwood Rivers confluence with the Minnesota River, and is likely demonstrating the higher gradient, natural channel characteristics that is commonly found as streams near the Minnesota River Valley (as the riparian is left intact, as the surrounding land use is uninhabited).

Summary Table

Table 119. Identified stressors with suspected sources for reach 658 of County Ditch 67.

Stressors																																	
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	**Erosion**	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls (natural)	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
■	■	■	▨	▨	▨	▨			●			●						●	●						●	▨	▨	▨	▨	▨	●		●

Little Cottonwood River (07020007-676)

Little Cottonwood River (07020007-676) is the upstream portion of the Little Cottonwood River system, located north of Comfrey, Minnesota. The reach is warmwater general use Class 2B. The reach extends 63 miles from the headwaters to approximately CR 24. The reach is impaired for lack of macroinvertebrate assemblage and lack of fish assemblage. The reach is also impaired for fecal coliform and turbidity. Fecal coliform will not be addressed in this report. Turbidity will be addressed as it relates to the biological communities.

4.15.3 Biological Communities

In 2001 and 2010, station 91MN056 was surveyed for fish and macroinvertebrates. Stations 13MN041, 13MN044, and 13MN048 were sampled for fish and macroinvertebrates in 2013. At station 91MN056, in 2001 and 2010, the macroinvertebrate community scored (34.9 and 33) just below the Southern Streams RR threshold (37). There were a lack of climbers, stoneflies (Plecoptera) and predator taxa. The community had a large percentage of tolerant taxa as well as a low metric score for a measure of pollution based on tolerance values assigned to each individual taxon developed by Chirhart (HBI_MN). Of the three stations in the Prairie Streams GP MIBI class, only station 13MN044 scored (35.9) below the threshold (41). Station 13MN048 and 13MN041 scored just above the threshold with 41.8 and 45.1 respectively. All three stations had an IBI metrics score for the taxa richness of macroinvertebrates with MN tolerance values less than or equal to two (Intolerant2Ch) less than the average metric score needed to obtain the threshold (Figure 128). Also low was the measure of pollution based on tolerance values assigned to each individual taxon developed by Chirhart (HBI_MN) and the percentage of collector-filterer individuals in subsample (Collector-filtererPct).

Figure 128. Macroinvertebrate metrics of the Southern Streams RR IBI for station 91MN056, Little Cottonwood River

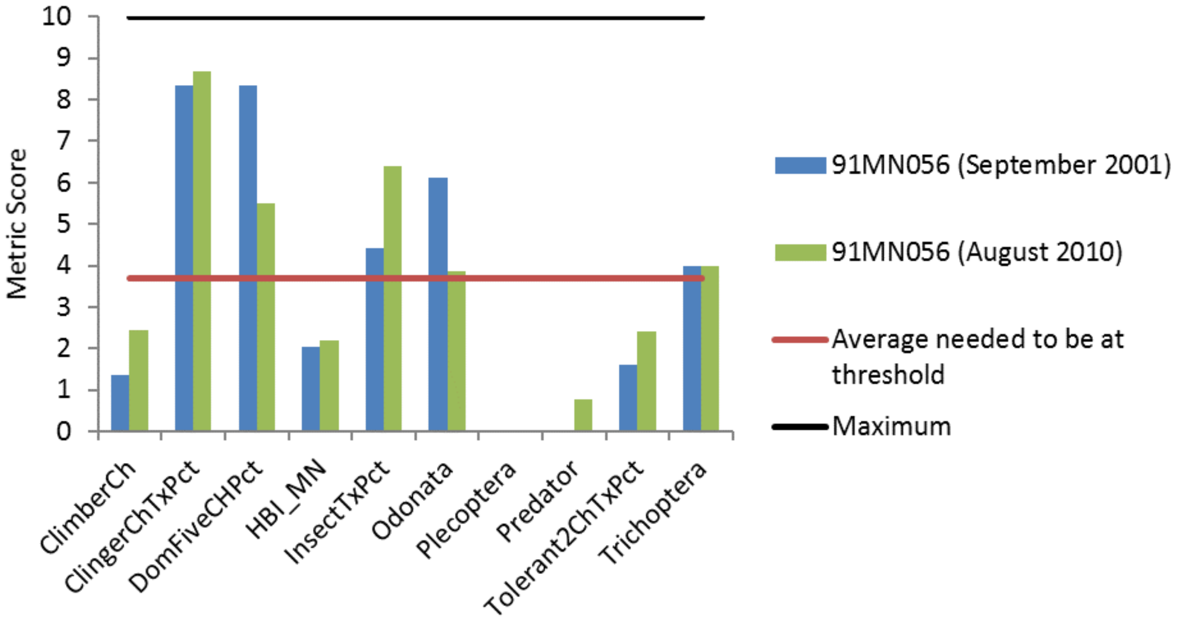
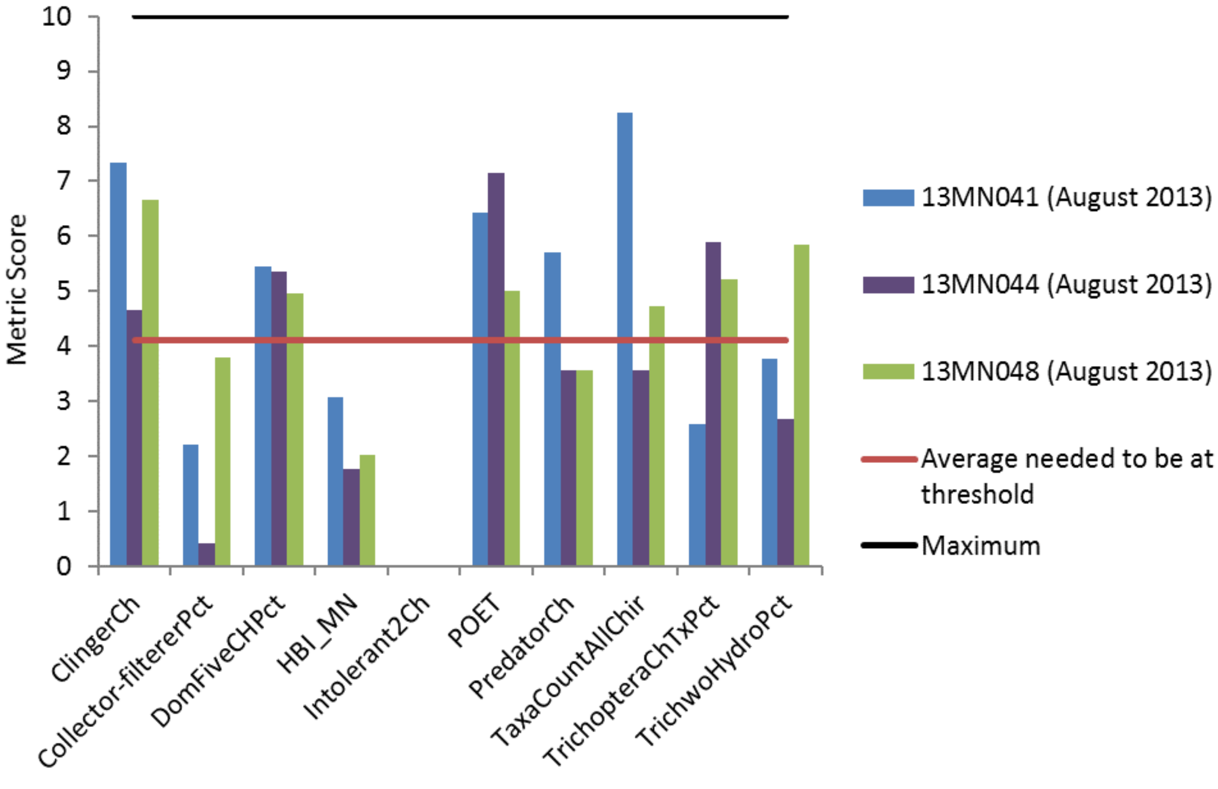


Figure 129. Macroinvertebrate metrics of the Prairie Streams GP IBI for stations 13MN041, 13MN044, and 13MN048, Little Cottonwood River



At station 91MN056, the FIBI scores were 49.9 and 52.8 on the Southern Headwaters class. Both were below the threshold of 55. The most abundant fish were central stonerollers and creek chubs. There was a lack of sensitive fish taxa (Sensitive) as well as a high percentage of generalist taxa (GeneralTxPct) and very tolerant taxa (VtolTxPct; Figure 129). The four visits among the three stations in the Southern Streams class scored worse upstream and improved downstream, but remained below the threshold of

50 (13MN041 = 23.9, 13MN044= 37.7, 13MN048 = 48 & 44.3). The IBI metric scores for these four visits have a similar pattern. All had low scores of the percentage of individuals with a female mature age equal to or less than two (MA<2Pct) and the percentage of taxa that are sensitive (SensitiveTxPct; Figure 130).

Figure 130. Fish metrics of the Southern Headwaters IBI for station 91MN056, Little Cottonwood River

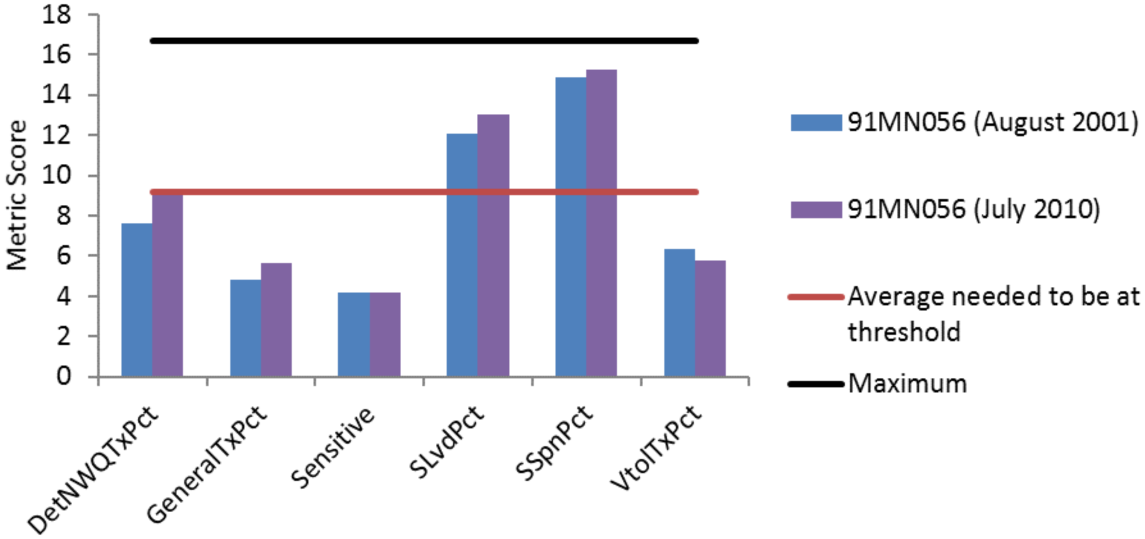
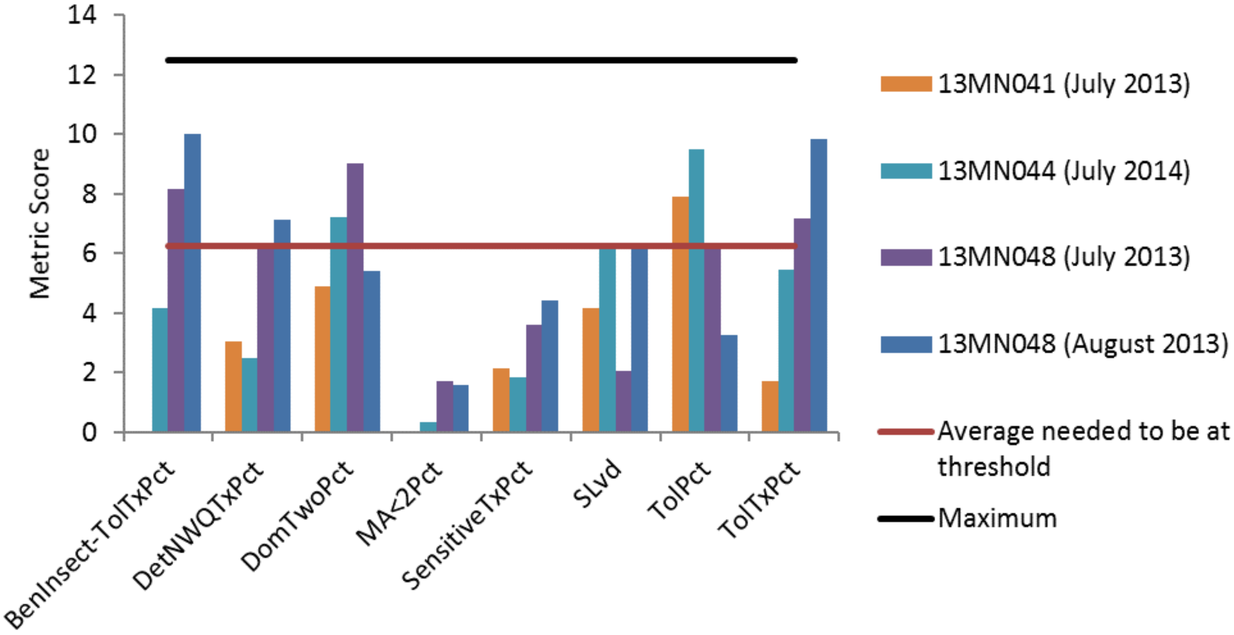


Figure 131. Fish metrics of the Southern Streams IBI for stations 13MN041, 13MN044, and 13MN048, Little Cottonwood River



4.15.4 Data Evaluation for each Candidate Cause

Dissolved Oxygen

The dissolved oxygen (DO) concentration during biological sampling at stations 13MN048, 13MN044, 13MN041, and 91MN056 ranged from 6.5 mg/L – 10.8 mg/L (nine samples). Seventy-nine additional samples collected from 1980 – 2016 ranged from 3.1 mg/L – 13.7 mg/L (average of 8.6 mg/L). Seven (9%) were below the warmwater standard (5 mg/L). There were no recent exceedances; exceedances were documented in 1996 (five), 1999, and 2001. Samples were collected from eight stations.

A majority of the macroinvertebrate metrics were worse than the statewide average of stations meeting the MIBI threshold (Table 120). The macroinvertebrate DO index scores were above average at all stations except 91MN056 (2010); as this score increases, so does the sensitivity of the community. There were 3 – 7 DO intolerant taxa comprising 5 – 16% of the community, and 4 – 6 DO tolerant taxa comprising 2 – 22% of the community. Taxa richness of Ephemeroptera, Plecoptera and Trichoptera (EPTCh) and a measure of pollution based on tolerance values assigned to each individual taxon developed by Chirhart (HBI_MN) were worse than average at all stations. Total taxa richness (TaxaCountAllChir) was worse than average at all stations except 13MN041. Overall, the macroinvertebrate metrics provide a mixed response to low DO stress; station 91MN056 has the greatest potential for stress.

Table 120. Macroinvertebrate metrics that respond to low DO stress in Little Cottonwood River compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
91MN056 (2001)	**36**	**14**	**7.65**	7.07	**4**	**16.0**	4	**12.4**
91MN056 (2010)	**40**	**10**	**7.60**	**6.15**	**4**	**12.5**	4	**21.5**
Southern Streams Average	*45.8*	*14.2*	*7.08*	*7.04*	*9.0*	*24.0*	*4.8*	*9.9*
13MN041 (2013)	47	**11**	**7.93**	7.14	7	**7.1**	6	3.4
13MN044 (2013)	**31**	**10**	**8.33**	7.31	5	**4.7**	6	3.1
13MN048 (2013)	**35**	**7**	**8.25**	7.21	**3**	**7.1**	5	1.9
Prairie Streams Average	*41.6*	*11.5*	*7.59*	*6.79*	*4.1*	*8.5*	*7.0*	*16.6*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

A majority of the fish metrics were worse than the statewide average of stations meeting the FIBI threshold (Table 121). Relative abundance of sensitive individuals (SensitivePct) and individuals with a female mature age greater than three years (MA>3Pct) were below average at all stations, and tolerant individuals (TolPct) comprised 39 – 83% of the community. There were 0 – 1 DO sensitive taxa comprising 0% of the community, and 2 – 8 DO tolerant taxa comprising 4 – 48% of the community. The fish DO index scores were below average at all stations except 91MN056, and the probability of this reach meeting the DO standard based on the fish community ranged from 37 – 62%. The two stations below 50% were 13MN041 and 13MN048; based on fish, these stations have the greatest potential for low DO stress.

Table 121. Macroinvertebrate metrics that respond to low DO stress in Little Cottonwood River compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
91MN056 (2001)	**1.5**	**1.3**	**82.5**	7.3	**0**	**0.0**	2	14.2
91MN056 (2010)	**1.1**	**4.0**	**77.8**	7.3	**0**	**0.0**	3	3.5
Southern Headwaters Average	*7.9*	*13.9*	*72.8*	*7.1*	*0.8*	*4.2*	*3.4*	*20.2*
13MN041 (2013)	**11.0**	**0.0**	**45.2**	**7.0**	**0**	**0.0**	**5**	**26.0**
13MN044 (2013)	**5.8**	**2.6**	39.3	**7.1**	**0**	**0.0**	4	12.0
13MN048 (2013)	**4.3**	**10.4**	**51.1**	**7.1**	**0**	**0.0**	**6**	17.4
13MN048 (2013)	**2.7**	**8.0**	**62.6**	**6.8**	**1**	**0.1**	**8**	**48.0**
Southern Streams Average	*16.9*	*24.6*	*44.9*	*7.2*	*1.7*	*6.1*	*4.7*	*18.5*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

DO is inconclusive. While there is a strong historical dataset, continuous sonde data is needed to fully understand the DO dynamics of this stream. The instantaneous DO measurements do not indicate a chronic low DO issues within this stream. However, continuous DO collection would be helpful in better understanding the DO dynamics of this system. The biological metrics are somewhat suggestive, yet have some inconsistencies within the separate community group measurements.

Eutrophication

The total phosphorus (TP) concentration during biological sampling ranged from 0.054 mg/L – 0.109 mg/L. Additional samples collected from 1980 – 2016 ranged from 0.011 mg/L – 0.858 mg/L (average of 0.184 mg/L). This timeframe includes 162 samples, and 89 exceedances of the river eutrophication standard for the South Region (0.150 mg/L). Samples collected recently (2015 and 2016) ranged from 0.011 mg/L – 0.265 mg/L (average of 0.123 mg/L). Six (40%) of these fifteen samples were above the standard, with exceedances occurring in February, May (two), and June (three). Samples were collected throughout the AUID at stations S000-678, S008-538, S008-540, and S008-541; exceedances were found at all stations.

Chl-a, BOD, and DO flux are also considered when evaluating eutrophication stress. Two chl-a samples were collected on August 27, 2015, one in the upper end of the AUID (S008-541) and one in the lower end (S008-538). Concentrations were 4.64 µg/L and 49.4 µg/L respectively. The sample at station S008-538 was above the 35 µg/L standard. There have been zero recent BOD samples collected. There has been no DO flux information collected.

A majority of the macroinvertebrate metrics were worse than the statewide average of stations meeting the MIBI threshold (Table 122). There were zero intolerant taxa (Intolerant2Ch), and a high percentage of tolerant taxa (Tolerant2ChTxPct) at all stations. Taxa richness of collector-filterers (Collector-filtererCh) was above average at all stations except 13MN044, and taxa richness of collector-gatherers (Collector-gathererCh) was below average at all stations except 13MN041. All stations had at least half of the metrics score worse than average.

Table 122 Macroinvertebrate metrics that respond to eutrophication stress in Little Cottonwood River compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
91MN056 (2001)	**36**	9	**12**	14	**0**	**86.1**
91MN056 (2010)	**40**	8	**13**	**9**	**0**	**82.5**
Southern Streams Average	*45.8*	*7.3*	*15.9*	*12.2*	*0.8*	*72.6*
13MN041 (2013)	47	6	18	**9**	**0**	**87.2**
13MN044 (2013)	**31**	**3**	**9**	10	**0**	**87.1**
13MN048 (2013)	**35**	6	**11**	**7**	**0**	**85.7**
Prairie Streams Average	*41.6*	*5.5*	*14.4*	*9.7*	*0.3*	*80.7*
Expected response to stress	↓	↓	↓	↓	↓	↑

A majority of the fish metrics were worse than the statewide average of stations meeting the FIBI threshold (Table 123). Sensitive individuals (SensitivePct), abundance of darter species (DarterPct), and intolerant individuals (IntolerantPct) were below average at all stations. Tolerant individuals (TolPct) were above average at all stations except 13MN044. Abundance of simple lithophilic spawners (SLithopPct) was below average at all stations except 91MN056 (2001) and 13MN041. At all stations, five out of six metrics were worse than average.

Table 123. Fish metrics that respond to eutrophication stress in Little Cottonwood River compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
91MN056 (2001)	**1.5**	**3.6**	34.5	**82.5**	**11**	**0**
91MN056 (2010)	**1.1**	**10.9**	**30.5**	**77.8**	13	**0**
Southern Headwaters Average	*7.9*	*11.5*	*31.5*	*72.8*	*11.5*	*1.6*
13MN041 (2013)	**11.0**	**0**	42.5	**45.2**	**13**	**0**
13MN044 (2013)	**5.8**	**3.1**	**36.6**	39.3	**15**	**0**
13MN048 (2013)	**4.3**	**5.3**	**34.8**	**51.1**	23	**0**
13MN048 (2013)	**2.7**	**4.8**	**23.8**	**62.6**	25	**0**
Southern Streams Average	*16.9*	*11.9*	*37.0*	*44.9*	*19.3*	*4.2*
Expected response to stress	↓	↓	↓	↑	↓	↓

Eutrophication is inconclusive as a biological stressor. While phosphorus loading within the stream is high, there is a lack of secondary evidence (BOD, chl-a, DO flux) collected or observed to identify eutrophic conditions occurring or directly affecting biology within this reach. Biological metrics are suggestive of eutrophic stress in both the fish and macroinvertebrate communities.

Nitrate

Nitrate concentration during fish sampling on July 15, 2013 and August 7, 2013 at station 13MN048 was 6.8 mg/L and 1.7 mg/L respectively Concentration on July 18, 2013 at station 13MN044 was 9.2 mg/L, and concentration on July 8, 2013 at station 13MN041 was 14 mg/L. Fifteen additional samples collected in 2015 and 2016 ranged from 6.7 mg/L – 19 mg/L (average of 12.8 mg/L). Twelve of the 15 were above 10 mg/L. Elevated concentrations were observed in both years, in February, May (four), June (six), and August. Samples were collected from stations S000-678, S008-538, S008-540, and S008-541; elevated concentrations occurred at all stations.

Nitrate metrics for fish have yet to be developed, therefore the macroinvertebrate metric response is the only community evaluated for nitrate stress. The taxa richness of Trichoptera (TrichopteraCh) and relative abundance of non-hydropsychid Trichoptera individuals (TrichwoHydroPct) were below the statewide average of stations meeting the MIBI threshold at all stations (Table 124). There were 0 – 1 nitrate intolerant taxa, and 16 – 30 nitrate tolerant taxa comprising 55 – 88% of the community. The macroinvertebrate nitrate index scores were worse than average at all stations. A majority of the macroinvertebrate metrics were worse than average and indicative of nitrate stress.

Table 124. Macroinvertebrate metrics that respond to nitrate stress in the Little Cottonwood compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
91MN056 (2001)	**6**	**2.7**	**3.1**	**1**	16	**55.4**
91MN056 (2010)	**6**	**1.6**	**3.0**	**1**	**19**	**58.8**
Southern Streams Average	*6.3*	*5.5*	*2.9*	*2.4*	*18.8*	*47.2*
13MN041 (2013)	**2**	**1.5**	**3.8**	**0**	**30**	**88.3**
13MN044 (2013)	**3**	**0.9**	**3.6**	**1**	18	**60.9**
13MN048 (2013)	**3**	**3.2**	**3.5**	**0**	18	**65.0**
Prairie Streams Average	*4.4*	*4.8*	*3.1*	*2.0*	*18.8*	*55.1*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is a stressor. The chemistry data displayed that nitrate was often over the 10 mg/L threshold. The macroinvertebrate metrics also indicate nitrate stress. This reach has a number of small feedlots and mining operations along it is plausible that these locations are contributing to the high nitrate concentrations.

Total Suspended Solids

The total suspended solids (TSS) concentration during fish sampling on July 8, 2013 (13MN041), July 15, 2013 (13MN048), July 18, 2013 (13MN044), and August 7, 2013 (13MN048) was 35 mg/L, 20 mg/L, 85 mg/L, and 24 mg/L respectively. Fifteen additional samples were collected in 2015 and 2016 ranged from 4.8 mg/L – 160 mg/L (average of 55.3 mg/L), four (27%) were above the warmwater standard for the South Region (65 mg/L). Exceedances occurred in both years, in May and June (three). Samples were collected in February, May (four), June (eight), and August (two) at stations S000-678, S008-538, S008-540, and S008-541. Each station had one exceedance. This AUID is also impaired for turbidity.

A majority of the macroinvertebrate metrics were worse than the statewide average of stations meeting the MIBI threshold (Table 125). TSS intolerant taxa ranged from 0 – 1, comprising 0 – 2% of the community. TSS tolerant taxa ranged from 9 – 18, comprising 34 – 80% of the community. All but one of the macroinvertebrate TSS index scores were above average; as this score increases, so does the tolerance of the community. The macroinvertebrates display signs of TSS stress.

Table 125. Macroinvertebrate metrics that respond to high TSS stress in Little Cottonwood River compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
91MN056 (2001)	27.9	**0**	**16.38**	**1**	**1.5**	**13**	**42.8**
91MN056 (2010)	25.8	**0**	14.67	**0**	**0**	9	33.8
Southern Streams Average	*25.4*	*0.7*	15.63	2.9	4.7	12.2	34.5
13MN041 (2013)	**8.6**	**0**	**20.42**	**0**	**0**	**14**	**73.1**
13MN044 (2013)	**1.9**	1.6	**23.61**	**1**	**0.6**	**18**	**79.4**
13MN048 (2013)	**14.6**	**0**	**22.80**	**0**	**0**	**14**	**80.3**
Prairie Streams Average	*17.7*	*0.2*	*16.96*	*1.5*	*3.1*	*13.2*	*43.1*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

Similar to the macroinvertebrates, most of the fish metrics were worse than the statewide average of stations meeting the FIBI threshold (Table 111). All metrics at all stations in 2013 were worse than average. There were zero TSS sensitive taxa, and 0 – 6 TSS tolerant taxa comprising 0 – 32% of the community (Table 126). Four out of six fish TSS index scores were worse than average, and the probability of the reach meeting the TSS standard based on the fish community ranged from 20 – 73%. Stations 13MN048 and 13MN044 had the lowest probability at 20 and 26% at station 13MN048, and 28% at station 13MN044. The fish community appears to be experiencing TSS stress.

Table 126. Fish metrics that respond to high TSS stress in Little Cottonwood River compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
91MN056 (2001)	**26.2**	**0**	24.1	**0**	**0**	**3.6**	**24.1**	**1.5**	**1.3**
91MN056 (2010)	48.3	**0**	38.7	**0**	**0**	**10.9**	38.7	**1.1**	**4.0**
Southern Headwaters Average	*35.0*	*1.0*	*22.4*	*1.6*	*4.5*	*13.6*	*26.2*	*7.9*	*14.6*
13MN041 (2013)	**1.4**	**0**	**12.3**	**0**	**1.4**	**0**	**12.3**	**11.0**	**0**
13MN044 (2013)	**2.1**	**0**	**7.3**	**0**	**4.7**	**3.1**	**7.3**	**5.8**	**1.6**
13MN048 (2013)	**13.3**	**0.1**	**6.2**	**0**	**3.8**	**5.1**	**7.8**	**2.7**	**6.9**
13MN048 (2013)	**12.5**	**0**	**7.4**	**0**	**4.7**	**6.5**	**8.4**	**4.3**	**7.2**
Southern Streams Average	*36.0*	*5.4*	*25.7*	*4.2*	*13.6*	*20.1*	*30.2*	*16.9*	*19.1*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 127. Fish metrics that respond to high TSS stress in Little Cottonwood River compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

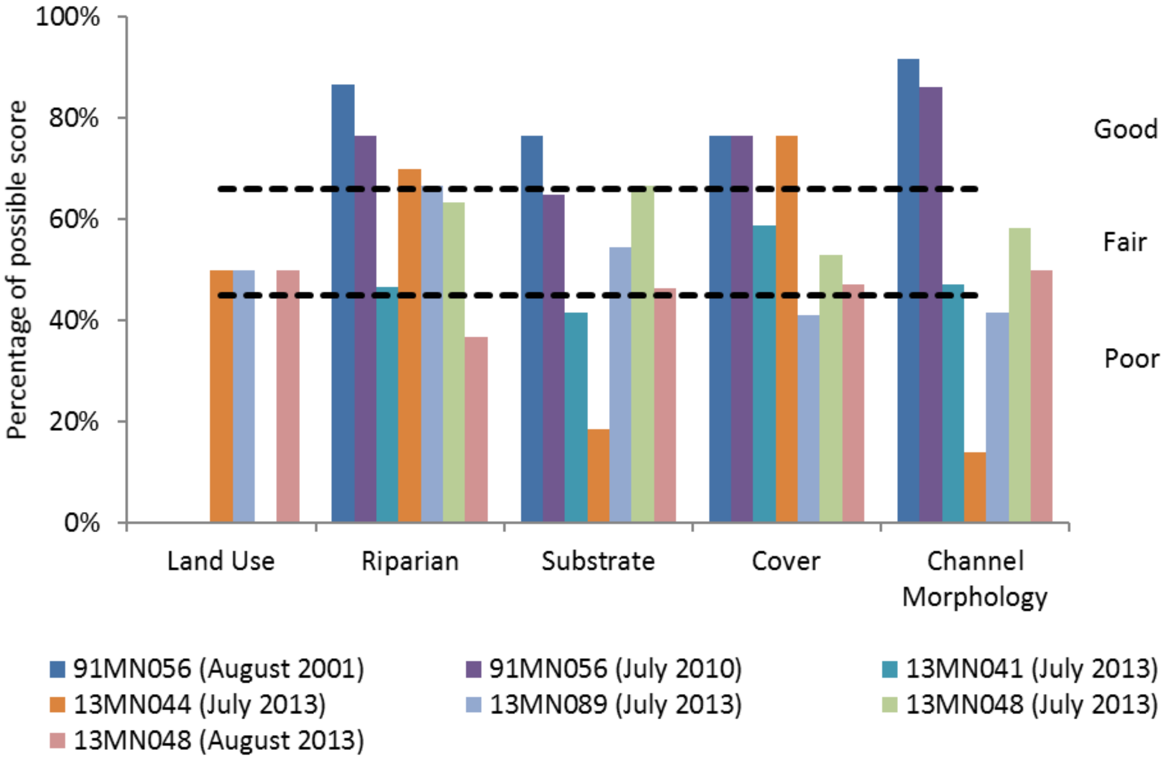
Station (Year sampled)	TSS Index Score	TSS Sensitive Taxa	TSS Sensitive Pct	TSS Tolerant Taxa	TSS Tolerant Pct
91MN056 (2001)	**15.7**	**0**	**0**	0	0
91MN056 (2010)	15.0	**0**	**0**	0	0
Southern Headwaters Average	*15.4*	*0.9*	*4.1*	*0.4*	*2.0*
13MN041 (2013)	17.7	**0**	**0**	**3**	6.8
13MN044 (2013)	**22.3**	**0**	**0**	**4**	**31.9**
13MN048 (2013)	**24.0**	**0**	**0**	**6**	**20.4**
13MN048 (2013)	**22.7**	**0**	**0**	**4**	**31.1**
Southern Streams Average	*19.2*	*1.7*	*5.3*	*2.4*	*12.5*
Expected response to stress	↑	↓	↓	↑	↑

TSS is a stressor. There are strong TSS indications based on the chemistry data as well as historic loading data. Biomonitoring locations 13MN041, 13MN044 and 13MN048 in 2001 had a consistent response to TSS pointing to community decline. Station 91MN056 in the year 2001 had the strongest response to TSS; in 2010, the community still displayed TSS stress with slightly improved scores.

Habitat

This portion of the Little Cottonwood River is continuously changing, by extension so is habitat availability. As the below graph displays (Figure 132), there is high variation through the years regarding riparian, substrate, cover, and the morphology of the stream; land use stayed the same (primary forested and row crops). Across all parameters 2013 as station 13MN044 scored the poorest; noting high readability, lack of substrate diversity and embedded, as well as a complete absence of riffles.

Figure 132. Percentage of MSHA subcategory scores for stations 91MN056, 13MN041, 13MN044, 13MN089, and 13MN048, Little Cottonwood River



In general, the macroinvertebrates do not show strong signs of habitat stress (Figure 133 and Figure 134). For the most part, there were moderate burrowers and climbers; sprawlers and swimmers were present in moderate to slightly elevated numbers. Clingers were a little more variable among stations, ranging from reduced to slightly elevated. The reduced clingers at station 13MN041 are the most likely signal of habitat stress; clingers attach to rock or woody debris and are expected to decrease in areas with poor substrate. The climber MIBI metric scores at station 91MN056 were below the average metric score needed to meet the MIBI threshold, and clinger MIBI metric scores were above average. Clinger MIBI metric scores at stations 13MN041, 13MN044, and 13MN048 were above average.

Figure 133. Macroinvertebrate metrics that respond to habitat for station 91MN056, Little Cottonwood River, compared to the range of values for Southern Streams RR visits meeting the general use biocriteria.

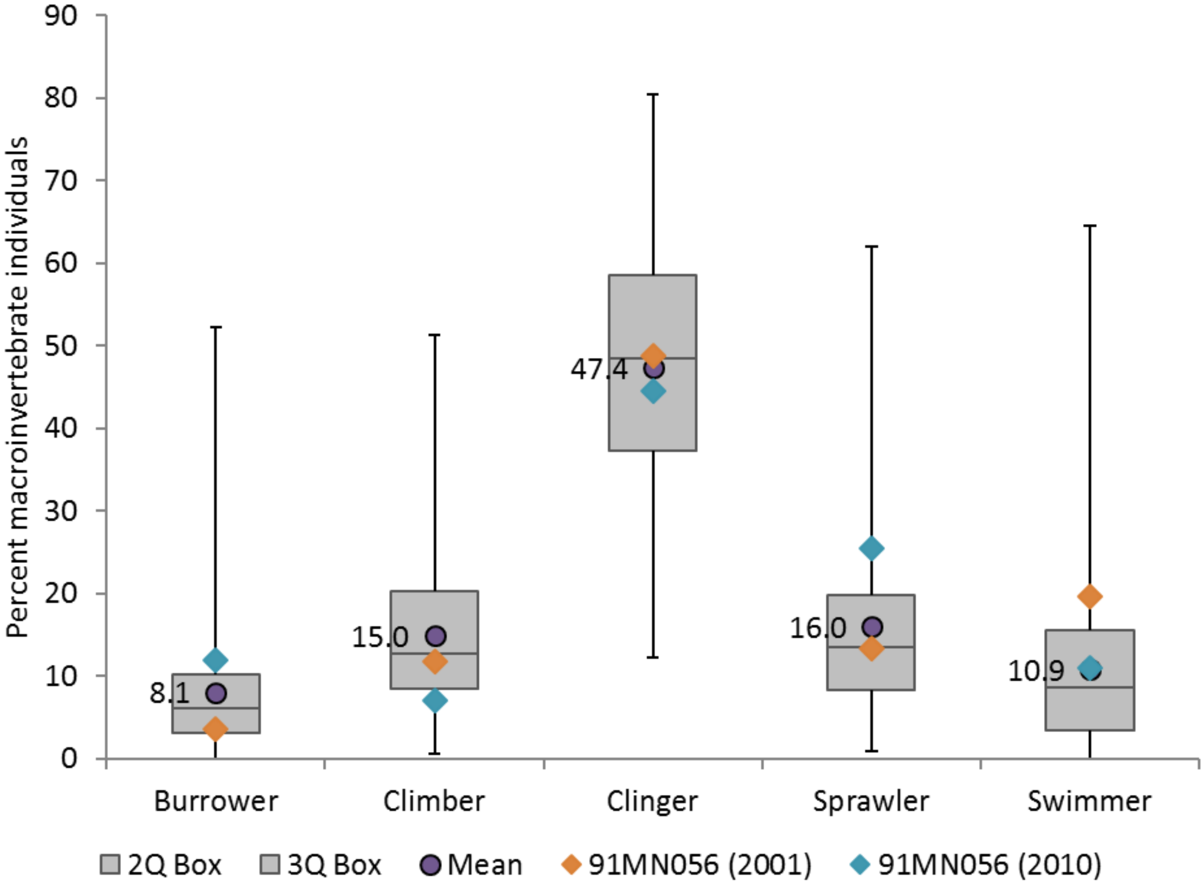
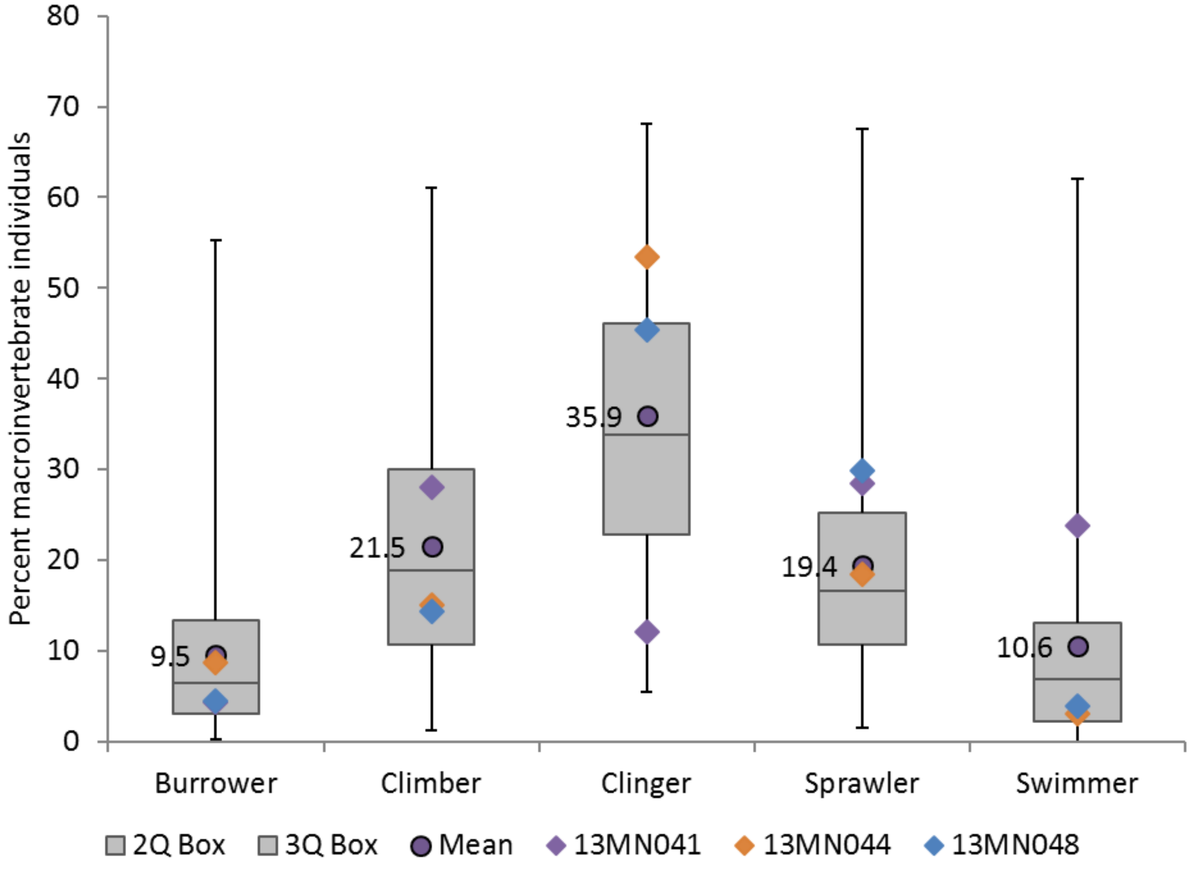


Figure 134. Macroinvertebrate metrics that respond to habitat for station 13MN041, 13MN044, and 13MN048. Little Cottonwood River, compared to the range of values for Prairie Streams GP visits meeting the general use biocriteria.



As displayed in previous sections, the relative abundance of individuals that are riffle-dwelling species (RifflePct) was below average at all stations except 91MN056 in 2010. Abundance of simple lithophilic spawners (SLithopPct) was below average at all stations except 91MN056 in 2001 and 13MN041. These species require clean coarse substrate and riffles, and are expected to decrease with habitat stress.

Much of this reach consists of a natural channel, although some channelized portions exist (Figure 135). Habitat ranged from poor to good, with the majority of the monitoring sites exhibiting fair habitat ratings based on MSHA results. Channel stability for this reach ranged from stable to severely unstable according to CCSI results. One monitoring location (91MN056) exhibited stable conditions, which was located the furthest upstream of all the monitoring locations. Stability at this location may benefit from an outcropping of Sioux Quartzite bedrock at this location, which serves as a durable substrate for the stream channel. Unlike the stability at the uppermost site, the next two monitoring stations downstream exhibit severe channel instability. The lowest two monitoring locations on this reach were rated as moderately unstable.

Figure 135. Monitoring station 13MN044 taken September 13, 2012.

The fall before monitoring began, a site visit was conducted. The conditions seen in the above figure at that time display the steams homogenous habitat features (Figure 135), additional to the degraded streambed. In the photo below (Figure 136), upstream station 13MN041 stream banks are documented as undergoing active erosion. Sediment loss from the channels along the upstream Little Cottonwood contribute both to the turbidity impairment, as well as the loss of habitat at these locations, as well as downstream as sediment fills in pools, and buries the streambed.

Figure 136. Monitoring station 13MN041 taken on July 8, 2013.

Habitat is a stressor. Overall habitat between the multiple monitoring stations varied in the severity of habitat issues. Station 13MN044 has little habitat variation and is unstable, the response is seen more in the fish community and likely ties back to the turbidity impairment on this reach.

Longitudinal Connectivity and Altered Hydrology

Longitudinal Connectivity was not found to be a biological stressor within this section of the little Cottonwood. There were not any noted barriers within this reach, nor downstream leading to the Minnesota River. There was nothing to suggest any limitations on fish migration.

Altered hydrology within this reach is considered the primary stressor to the biological communities, as it is the driving force for TSS, loss of habitat diversity, as well as nitrate overloading. In this region, altered hydrology is driven by the introduction of subsurface tile drains and well and modifications of the streams and landscape as the land was ditched and streams channelized for agricultural drainage. For more information on these drivers of altered hydrology, reference Chapter 3.1.8 of this report.

Altered hydrology impacts within this long reach varies from upstream to downstream, as the landscape and surrounding land use is diverse in comparison to the other subwatershed areas found in the Minnesota River, Mankato Watershed. A comprehensive geomorphology study was conducted throughout the Little Cottonwood River by the DNR to better understand the changing dynamics associated with different stream types and their respective location in the subwatershed.

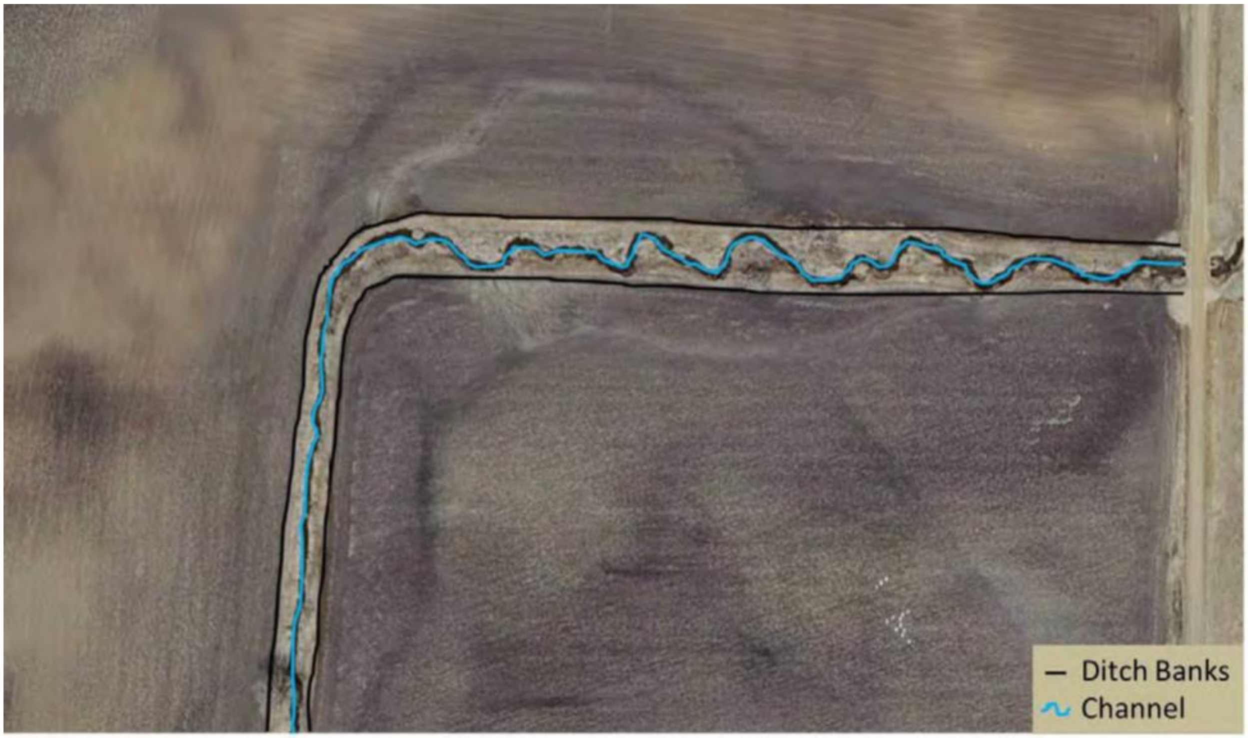
The first area of study falls on the headwaters of the Little Cottonwood River; this site was first established to better understand stream impacts following a ditch network expansion, that was done upstream of this location where 6.5 miles of open ditch was created to flow into the headwaters of the

Little Cottonwood River. The DNR's geomorphology work, paired with historical MPCA cross section measurements found that following the ditch expansion this section in the Little Cottonwood River is changing its dimensions in attempt to reestablish a floodplain within the old channel. Both the MPCA site visit as well as the DNR geomorphology study found this area is especially susceptible to erosion. Confined to the headwater portion of this reach, the BANCS model found that 730' of this section of reach alone contributes 50.44 tons of sediment (DNR 2015). This is a result from the stream losing connection from its floodplain, paired with the increased water contributions from the ditch network have made to increased velocities confined within the channels of the stream.

Further downstream of this reach, another geomorphology site was studied by the DNR. This site is located within a glacial outwash plain, between biological monitoring stations 13MN041 and 13MN044. This section of the reach stands out due to it being non-channelized, as well as preserved within the boundaries of the Terri Wildlife Management Area (although the surrounding drainage area is over 85% agriculture and just under 7% developed). Regardless of being found downstream of severely altered channels, this segment of the reach had maintained its channel stability, as well as its lateral connectivity with its floodplain. However, the streambed is noted as losing some of the natural pool features and substrate due to embeddedness that ties back to upstream erosion. Erosion models that this 518' reach of stream delivers 12.9 tons of sediment annually (DNR 2015).

One additional geomorphology site was studied to better understand the hydrology to stream relationship occurring within this subwatershed. This segment was on the Altermatt Creek tributary that feeds into this reach (AUID 07020007-518). This is a channelized stream that has developed a two-stage ditch and gained back sinuosity naturally over time (Figure 137). Having sinuosity in low-gradient channels, such as this one, allows riffle-pool sequence to form that is needed in order to have a functional aquatic ecosystem with diverse fish and macroinvertebrate assemblages. This ditch is found to have another important role, as two-staged ditches such as this one, naturally create a way for the river to "dissipate energy in high flows, deposit sediment and nutrients onto the floodplain, and store more flood water than most ditches, thus reducing flood stages downstream (Lore)." Sediment erosion from this 507' section was modeled to contribute 7.25 tons of sediment annually (DNR 2015). This is approximately six times less sediment loss from erosion, when compared to the upstream site.

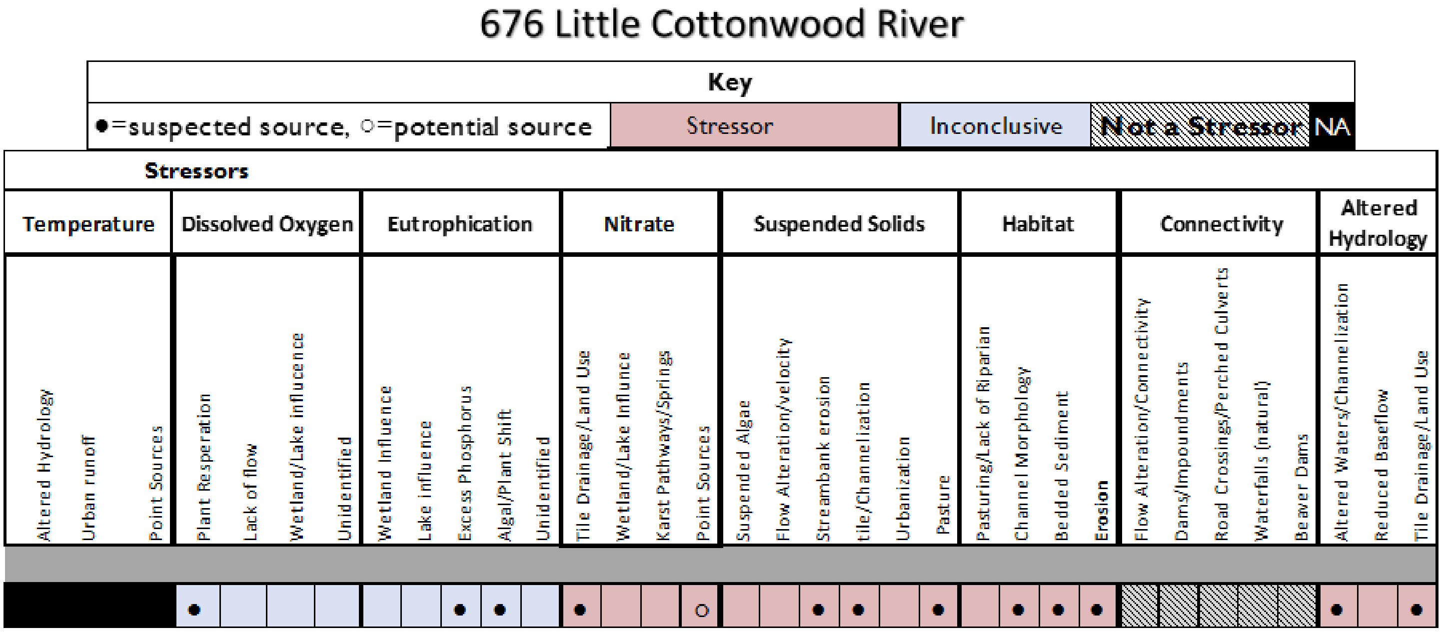
Figure 137. Aerial photo showing two-staged channel within the ditch banks at the Altermatt Creek geomorphology site, from the DNR geomorphology study.



Paired with these alterations, the DNR included a long term precipitation study specifically for this system, that confirmed in this area precipitation has not significantly changed, while flows have increased. This is correlated to the 22% increase in corn and soybean agriculture (since 1921) as an increase of irrigation to accommodate this land use (DNR 2015).

Summary Table

Table 128. Identified stressors with suspected sources for reach 676 of the Little Cottonwood River.



676 Little Cottonwood River

Key				
●=suspected source, ○=potential source	Stressor	Inconclusive	Not a Stressor	NA

Stressors																																		
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls (natural)	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
			●						●	●		●			○			●	●		●		●	●	●						●		●

4.16 Little Cottonwood River (07020007-677)

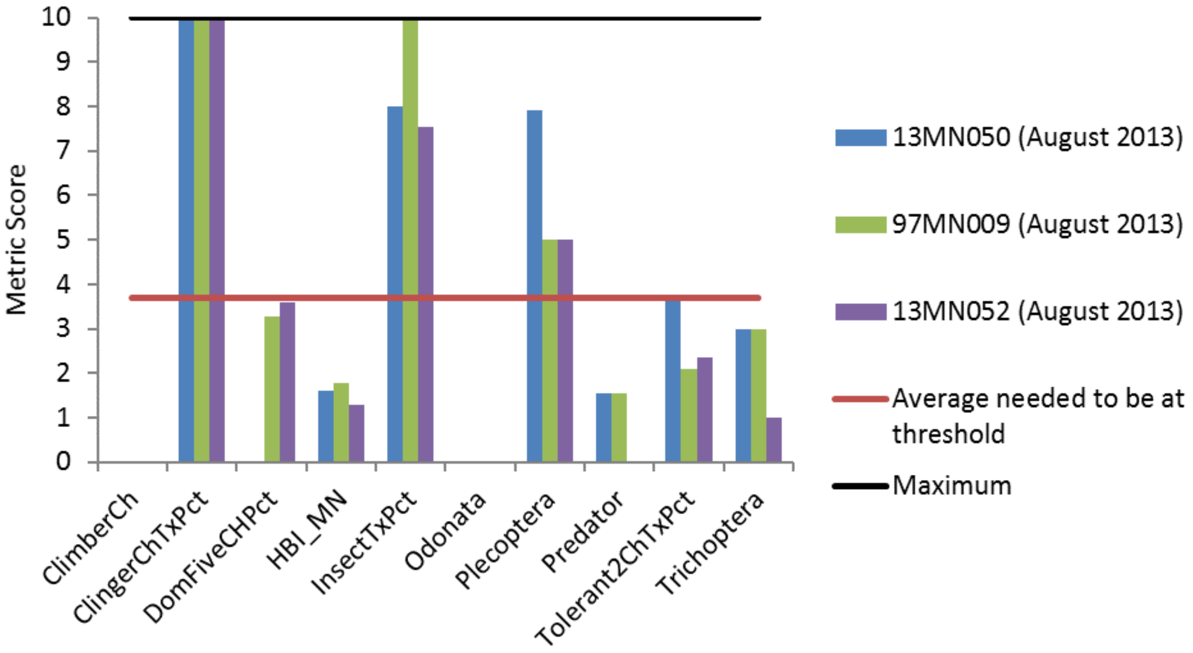
Little Cottonwood River (07020007-677) is the downstream reach of the River, north of Searles, Minnesota. The reach is warmwater general use Class 2B. The reach extends miles from approximately CR 24 to the Minnesota River. The reach is impaired for lack of macroinvertebrate assemblage. The reach is also impaired for fecal coliform and turbidity. Fecal coliform will not be addressed in this report. Turbidity will be addressed as it relates to the biological communities.

4.16.1 Biological Communities

Stations 13MN050, 97MN009, and 13MN052 were sampled for fish and macroinvertebrates in 2013. The fish communities were sampled once at the upstream two stations with scores (64.1 and 61.7) above the Southern Streams class general use threshold (50). Station 13MN052 had two reportable visits. The July 2013 survey resulted in an IBI of 57.8 and the August 2013 survey had an IBI of 46.8. The station was dominated by shiners (sand, common, and spotfin) during each visit. Shiners were also the two most abundant species in the upstream two stations in 2013.

1. Stations 13MN050 and 13MN052 scored (35.8 and 30.8) below the general use Southern Streams RR class threshold (37), and station 97MN009 scored (37.2) just above the threshold. Similar communities present at each station, with subtle differences accounting for the slightly depressed IBI scores. This is exhibited by the similar pattern seen in the IBI metrics scores (Figure 138). A net-spinning caddisfly, Cheumatopsyche, was the most abundant at station 13MN050 and 97MN009. At station 13MN052, the most abundant was tied between Cheumatopsyche and mayflies (Tricorythodes).

Figure 138. Macroinvertebrate metrics of the Southern Streams RR IBI for stations 13MN050, 97MN009, and 13MN052, Little Cottonwood River

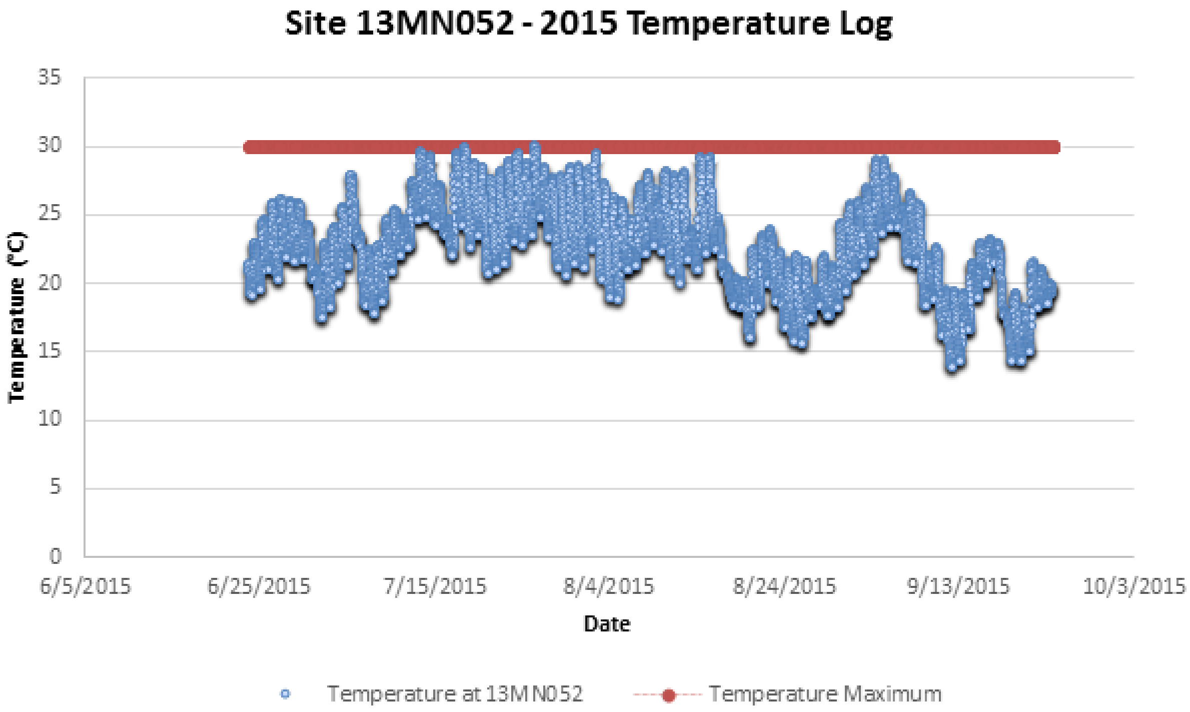


4.16.2 Data Evaluation for each Candidate Cause

Temperature

Of all the warmwater reaches of the entire Minnesota River – Mankato Watershed, this reach showed warmer temperatures comparatively. At the time of biological monitoring, the water temperature was recorded at 30 °C. A temperature logger was placed at 13MN052 from June 6, 2015 to September 23, 2013. The July and August average temperatures were 24 and 22 °C, with a maximum of 29.9 °C. Most of the warmwater streams in the watershed have monthly average temperatures in the summer months near 20 °C, or lower. Looking closely at the data, the periods of high temperatures occurred during periods of low flow.

Figure 139. Temperature log at monitoring station 13MN052, June 25, 2015 to October 3, 2015.



Temperature in this reach in inconclusive. While there was not any recording of temperature to go above the threshold of 30 °C, there were a handful of reading that fell right below or at the threshold. Additional data should be collected to ensure temperatures are not getting higher than what was collected in 2015 and causing stress to aquatic life.

Dissolved Oxygen

The dissolved oxygen (DO) concentration during biological sampling at stations 13MN052, 90MN058, 97MN009, and 13MN050 ranged from 7.9 mg/L – 12.6 mg/L (10 samples). Additional samples collected from 1980 – 2015 ranged from 3.7 mg/L – 21.4 mg/L (average of 9.7 mg/L). Of these 203 samples, four (2%) were below the warmwater standard (5 mg/L). Low values occurred on April 1, 2015 (3.7 mg/L), June 24, 2003 (4.1 mg/L), May 27, 1998 (4.6 mg/L), and May 12, 2003 (4.8 mg/L). Samples were collected at stations S000-677, S000-777, S004-609, S008-543, and S008-544.

The macroinvertebrate metrics were mixed; half were worse than the statewide average of stations meeting the MIBI threshold, and half were better (Table 129). The macroinvertebrate DO index score was below average at station 13MN050, and above average at stations 97MN009 and 13MN052. As this score decreases, so does the sensitivity of the community. There were 7 – 10 DO intolerant taxa comprising 8 – 25% of the community, and 0 – 2 DO tolerant taxa comprising 0 – 1% of the community. Taxa richness of Ephemeroptera, Plecoptera and Trichoptera (EPTCh), total taxa richness (TaxaCountAllChir), and a measure of pollution based on tolerance values assigned to each individual taxon developed by Chirhart (HBI_MN) were worse than average at all stations. Overall, the macroinvertebrate metrics show varying response to low DO stress.

Table 129. Macroinvertebrate metrics that respond to low DO stress in Little Cottonwood River compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN050 (2013)	**21**	**11**	**7.80**	**6.93**	**7**	**7.5**	0	0
97MN009 (2013)	**31**	**14**	**7.74**	7.42	10	24.8	1	0.3
13MN052 (2013)	**29**	**12**	**7.91**	7.56	10	24.3	2	0.6
Southern Streams Average	*45.8*	*14.2*	*7.08*	*7.04*	*9.0*	*24.0*	*4.8*	*9.9*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO was found to not be a biological stressor within this bottom reach of the Little Cottonwood River. The chemical data is no suggestive to chronic low DO issues. The biological metrics are slightly mixed. However, the decrease in these certain groups are likely being driven down from a different stressor.

Eutrophication

Total phosphorus (TP) concentrations from 1980 – 2016 ranged from 0.008 mg/L – 1.27 mg/L (average of 0.228 mg/L). This timeframe includes 327 samples, and 180 exceedances of the river eutrophication standard for the South Region (0.150 mg/L). Samples collected recently (2015 and 2016) ranged from 0.02 mg/L – 1.23 mg/L (average of 0.296 mg/L). Thirty-six (72%) of these fifty samples were above the standard, with exceedances occurring in February (two), March (three), April (two), May (seven), June (fourteen), July (five), and August (three). These samples were collected throughout the AUID at stations S000-777, S008-543, S008-544, and S004-609; exceedances were found at all stations. Chl-a, BOD, and DO flux are also considered when evaluating eutrophication stress. There have been zero recent chl-a, BOD, or DO flux samples collected.

All of the macroinvertebrate metrics were worse than the statewide average of stations meeting the MIBI threshold (Table 130). There were zero intolerant taxa (Intolerant2Ch), and a high percentage of tolerant taxa (Tolerant2ChTxPct). Taxa richness of collector-filterers (Collector-filtererCh), collector-gatherers (Collector-gathererCh), and Ephemeroptera, Plecoptera, and Trichoptera (EPT) were below average.

Table 130. Macroinvertebrate metrics that respond to eutrophication stress in Little Cottonwood River compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN050 (2013)	**21**	**4**	**6**	**10**	**0**	**76.2**
97MN009 (2013)	**31**	**5**	**8**	**12**	**0**	**83.9**
13MN052 (2013)	**29**	**5**	**10**	**10**	**0**	**82.8**
Southern Streams Average	*45.8*	*7.3*	*15.9*	*12.2*	*0.8*	*72.6*
Expected response to stress	↓	↓	↓	↓	↓	↑

Eutrophication is inconclusive. There was some response noted in the metrics. Chemically there was high phosphorus loading within this reach. However, there is a lack of secondary responses (Chl-a, DO flux, BOD), with out those chemical response variables eutrophication cannot be determined.

Nitrate

Nitrate concentrations during fish sampling on July 16, 2013 and August 7, 2013 at station 13MN052 was 5.8 mg/L and 1 mg/L respectively. Concentrations on July 18, 2013 and August 6, 2013 at station 13MN050 was 5 mg/L and 1.8 mg/L respectively; concentrations on the same days at station 97MN009 were 5.1 mg/L and 1.6 mg/L respectively. One hundred and ninety three additional samples were collected in the last decade (2007 – 2016) and ranged from 0.05 mg/L – 18.4 mg/L (average of 6.9 mg/L). Of these 193 samples, 52 (27%) were above 10 mg/L. Elevated concentrations were observed in multiple years and months, and at multiple stations. Samples were collected from stations S000-777, S004-609, S008-543, and S008-544.

Taxa richness of Trichoptera (TrichopteraCh) was below the statewide average of stations meeting the MIBI threshold at all stations (Table 131). Relative abundance of non-hydropsychid Trichoptera individuals (TrichwoHydroPct) were below average at station 13MN052, and above average at stations 13MN050 and 97MN009. There were 0 – 1 nitrate intolerant taxa, and 8 – 15 nitrate tolerant taxa comprising 73 – 77% of the community. The macroinvertebrate nitrate index scores were worse than average at all stations. A majority of the macroinvertebrate metrics were worse than average and indicative of nitrate stress.

Table 131. Macroinvertebrate metrics that respond to nitrate stress in the Little Cottonwood River compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN050 (2013)	**5**	11.3	**3.6**	**1**	8	**75.4**
97MN009 (2013)	**5**	6.9	**3.6**	**0**	13	**73.0**
13MN052 (2013)	**3**	**3.1**	**3.6**	**0**	15	**76.6**
Southern Streams Average	*6.3*	*5.5*	*2.9*	*2.4*	*18.8*	*47.2*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is a stressor. There is a strong data set to indicate chronic nitrate overloading into this stream. In addition to the elevated nitrate concentrations, the majority of the macroinvertebrate metrics suggest nitrate displacement to the community.

Total Suspended Solids

The total suspended solids (TSS) analysis during fish sampling took place on July 16, 2013 (13MN052), July 18, 2013 (13MN050 and 97MN009), August 6, 2013 (13MN050 and 97MN009), and August 7, 2013 (13MN052) was 25 mg/L, 23 mg/L, 18 mg/L, 27 mg/L, 12 mg/L, and 6.4 mg/L respectively. Additional samples collected from 2007 – 2016 ranged from 2 mg/L – 1,520 mg/L (average of 135 mg/L). Of these 193 samples, 94 (49% of all samples) were above the warmwater TSS standard for the South Region of 65 mg/L. Exceedances occurred in various months and years, with at least one exceedance at all stations sampled (S004-609, S008-544, S008-543, and S000-777). Most of the samples (and exceedances) were near the mouth of the Little Cottonwood River at station S004-609. This reach is also impaired for turbidity, as clearly seen in the figure below, were water clarity is poor. Multiple photographic documentation has been taken to capture the clarity of the Little Cottonwood throughout this reach; the photo below (Figure 140) depicts the conditions that are most commonly found.

Figure 140. Monitoring station 13MN050, taken on June 23, 2015.

Additional monitoring has been done by the Pollutant Load Monitoring team at the MPCA. Table 132 highlights the findings on TSS loading within the Little Cottonwood River.

Table 132. MPCA's Watershed Pollutant and Load Monitoring network data, displaying location of sampling and catchment size. Data was based off samples collected from 2007-2014.

Site Name	Hydstra ID	Station Catchment area (Acres)	TSS FWMC (mg/L)	TSS Mass (Tons)
Little Cottonwood R near Courtland, MN	E28057001	108,800	225	15,020

The biological community metrics were suggestive of TSS stress, as shown in Table 133. The relative abundance of collector-filterer individuals (Collector-filtererPct) will typically decrease in streams that has high TSS concentrations in the form of sedimentation. In all three sites, collector filters were above the statewide average of stations meeting the MIBI threshold. This is due to the high numbers of *Cheumatopsyche,* the net spinning caddisfly; this is a tolerant species of caddisfly usually found in abundance in other impaired streams within this watershed. The relative abundance of Plecoptera individuals (PlecopteraPct) was below average at two out of three stations. There were 0 – 1 TSS intolerant taxa comprising 0% of the community, and there were 11 – 13 TSS tolerant taxa comprising 57 – 74% of the community. All macroinvertebrate TSS index scores were well above average; as this score increases, so does the tolerance of the community. Overall, a majority of the macroinvertebrate metrics are suggesting stress.

Table 133. Macroinvertebrate metrics that respond to high TSS stress in Little Cottonwood River compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN050 (2013)	52.3	**0**	**18.36**	**1**	**0.3**	11	**73.8**
97MN009 (2013)	45.5	0.9	**19.04**	**0**	**0**	**13**	**62.7**
13MN052 (2013)	31.3	**0**	**20.19**	**0**	**0**	11	**57.4**
Southern Streams Average	*25.4*	*0.7*	15.63	2.9	4.7	12.2	34.5
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

TSS is a stressor seen in the current and historical data collected. Photo documentation also supports extremely turbid conditions. A majority of the macroinvertebrate metrics displayed a decline, indicating TSS is limiting the community.

Habitat

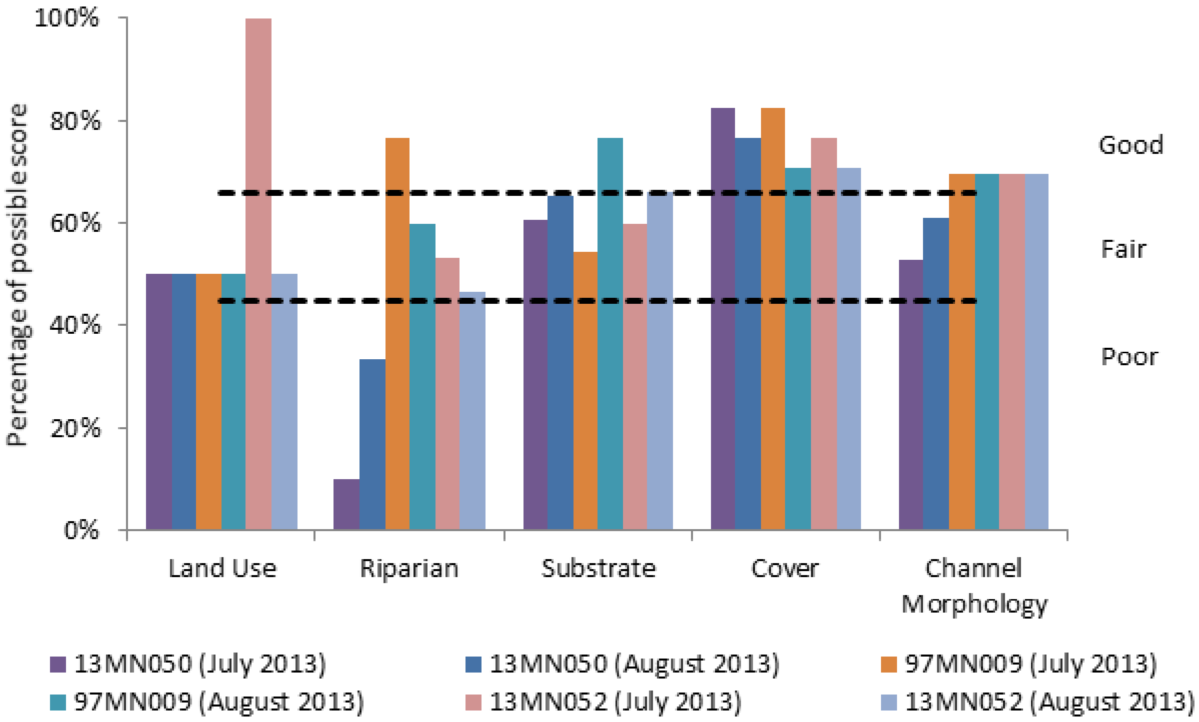
MSHA score at 13MN050 was fair with a total score of 53.4 – 60.1 (Figure 142). Major issues within the stream is channel erosion and embeddedness (Figure 141), however there were other substrate types present. There was also a good proportion of pools (20%), riffles (30%), and runs (50%). Cover type was abundant and diverse.

Figure 141. Bank erosion at station 13MN050 on August 6, 2013.

Station 13MN052 has scored slightly higher with MSHA with scores of 64.3 – 67.2. Bank erosion and embeddedness are marked to the same extent as 13MN050. This station had slightly less substrate type variation but good stream feature variation with a ratio of pools (30%), riffles (15%), and runs (55%). There was a large variation of cover types.

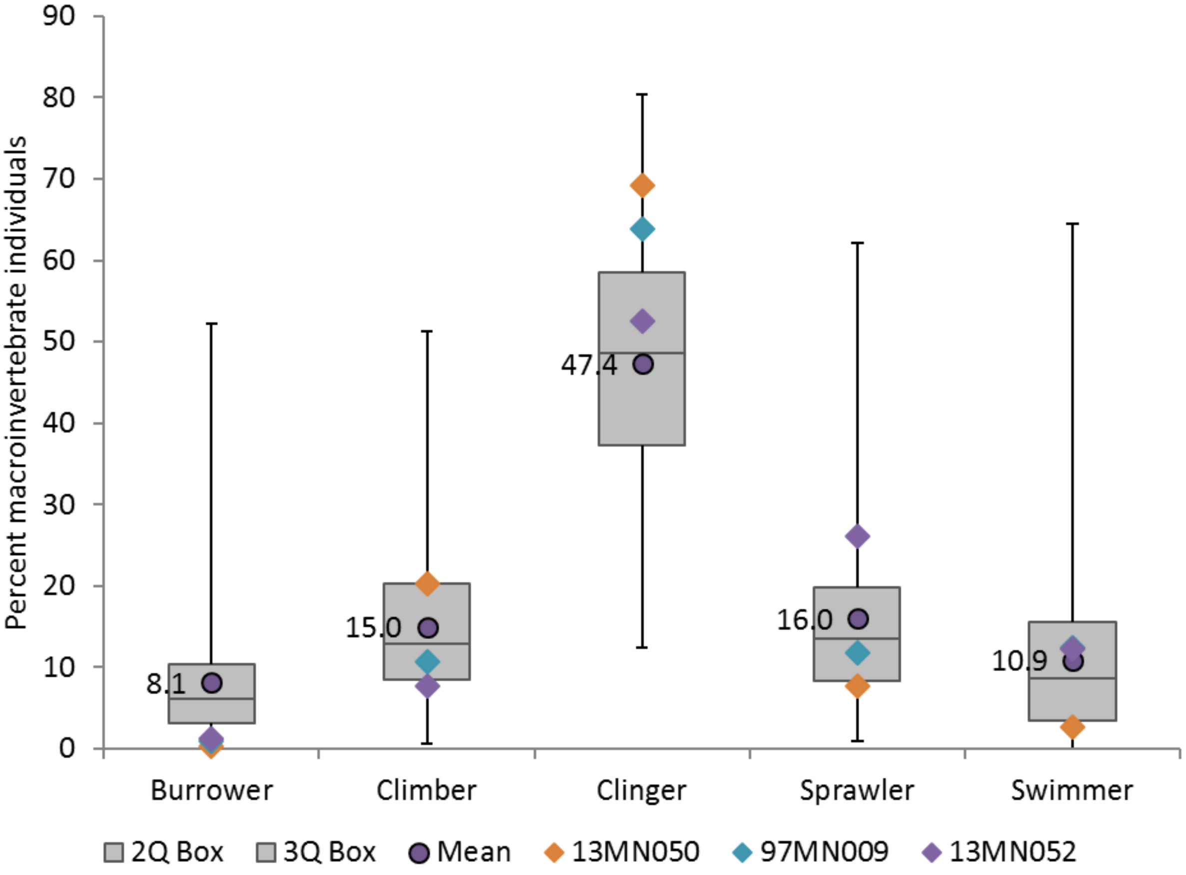
Station 97MN009 had the best MSHA scores of the visits, scoring at 67.65 – 69.2. Bank erosion was noted, but not as prevalent as the other locations. Embeddedness not as much of an issue, and there was a good diversity of substrate types and well as stream feature variation with a ratio of pools (15%), riffles (20%), and runs (65%). Cover types were also marked as diverse and abundant.

Figure 142. Percentage of MSHA subcategory scores for stations 13MN050, 97MN009, and 13MN052, Little Cottonwood River



Burrowers were below average at all stations, and clingers were above average (Figure 143) Climbers, sprawlers, and swimmers were mixed, with some above average and some below. Climber MIBI metric scores at all stations were below the average metric score needed to meet the MIBI threshold, and clinger MIBI metric scores were above average. Overall, the macroinvertebrates do not show strong signs of habitat stress.

Figure 143. Macroinvertebrate metrics that respond to habitat for station 13MN050, 97MN009, and 13MN052, Little Cottonwood River, compared to the range of values for Southern Streams RR visits meeting the general use biocriteria.



While some site visits noted appropriate habitat diversity, the channel is unstable. There are notable unstable habitat conditions, particularly seen in high sedimentation that can lead to impacts to the streambed. The macroinvertebrate habitat group types do not seem displaced by habitat. Due to the strong conflicting lines of evidence, habitat is listed as inconclusive.

Connectivity and Altered Hydrology

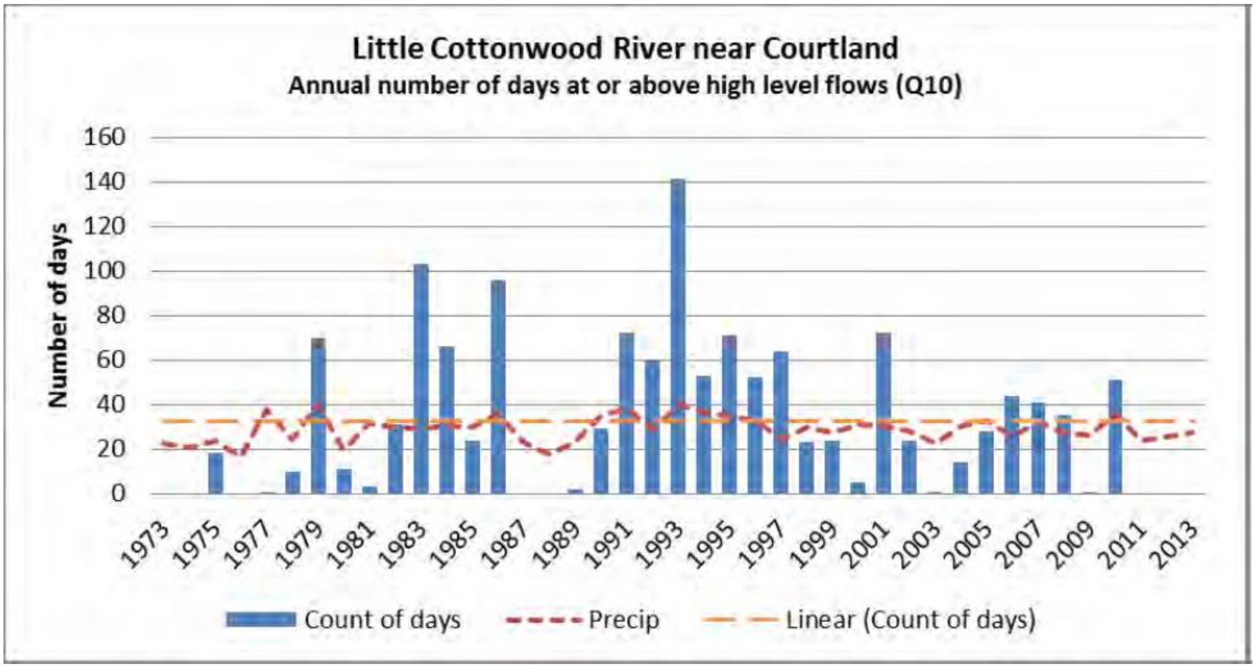
As macroinvertebrates were the only community found to be impaired, and are not impacted by barriers in longitudinal connectivity, this parameter is not considered as a biological stressor.

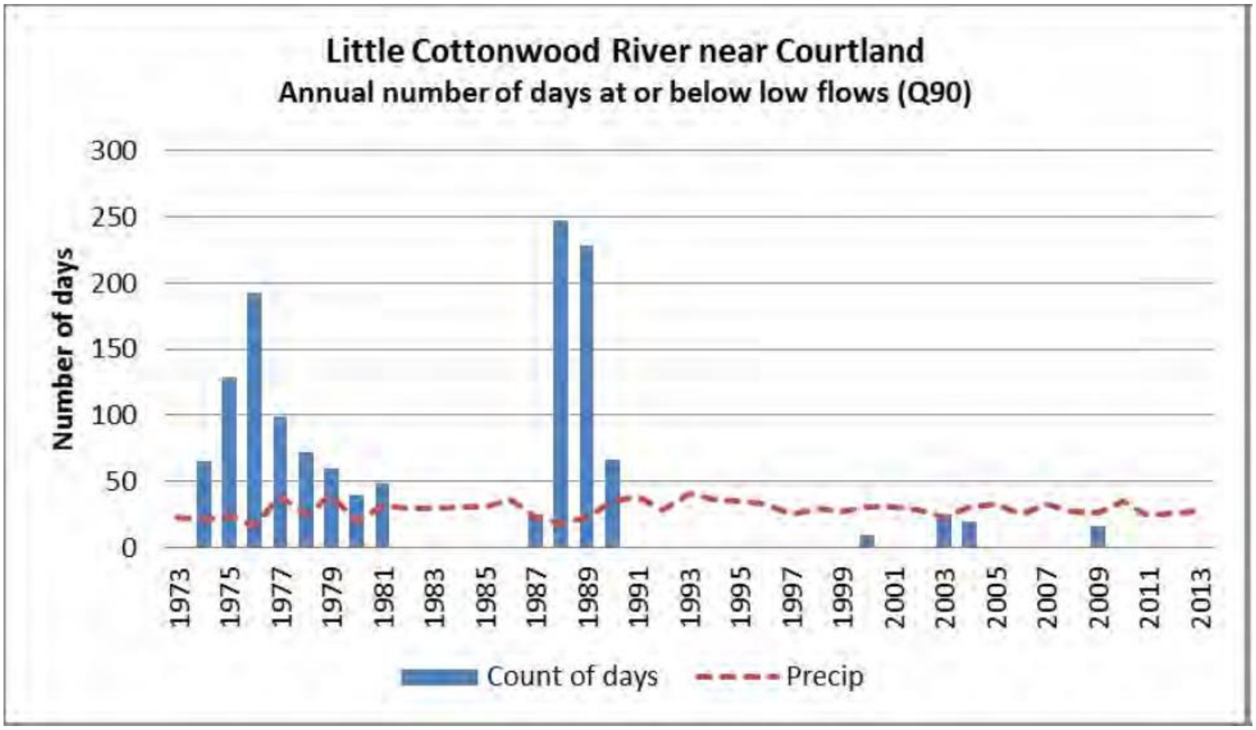
Due to the long-term flow data that has been collected on the outlet of the Little Cottonwood River, near Courtland Minnesota, this reach has been subject to intense analysis by not just the MPCA, but the DNR as well. From this data trend analysis was done to determine changed in the hydrologic regime. For the full report please refer to the DNR's Minnesota River, Mankato report that incorporates full findings of the hydrologic study for this subwatershed.

Discharge analyses showed an increasing trend in the amount of water flowing through the Little Cottonwood River from 1973-2010. The double mass curve showed a break in relationship between precipitation and runoff around 1983; similar to other watersheds in southern Minnesota. Additionally, the Little Cottonwood River has had higher monthly flow averages for every month except November and December when comparing 1973-1982 and 1983-2010. The overall trends do show that precipitation has been staying steady with no significant annual increase of rainfall where runoff volumes and overall discharge volumes of the little cottonwood are increasing (Lore 2016).

The Little Cottonwood River is receiving more water, to the extent that base flows had also increased throughout the year, as shown in Figure 144.

Figure 144. Number of days displaying high flows (top chart) compared to number of days displaying low flows (bottom chart), compiled by the DNR.





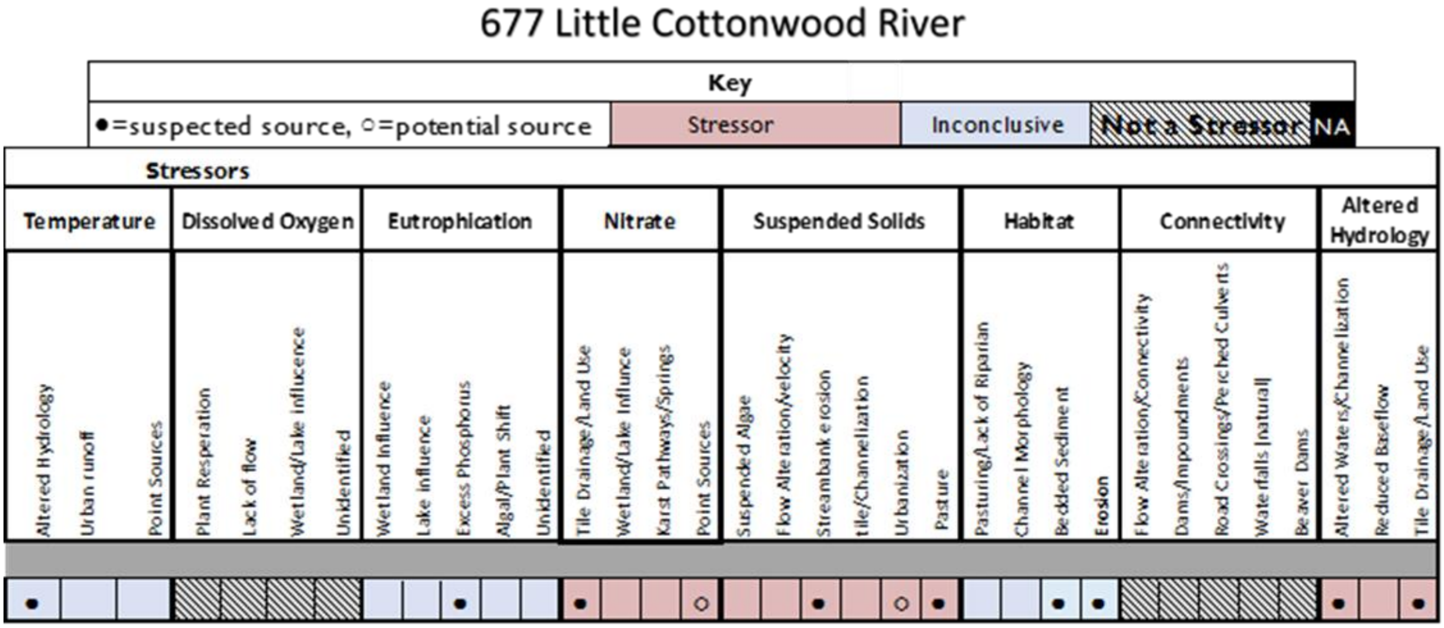
Additional to the hydrologic study, the DNR also conducted cross section measurements to track how this system may be changing at the gage site, reporting, “Upstream land practices, proximity to two road crossings, highly erodible bank material, and fragmented vegetative buffer control all have impacts on the Little Cottonwood River gage survey site. Since 1991, this site has changed its pattern through large amounts of lateral erosion, resulting in high sediment contributions (as shown in Figure 145). Woody debris jams through the reach from previous erosion events leave areas with high shear stress due to flow deflection from the wood, further increasing bank erosion” (DNR 2015).

Figure 145. 2013 Arial imagery with overlay (in red) of the stream channel in 1991 taken from the DNR geomorphology report.

The geomorphic changes, as well as the other stressors within this reach can be tied back to altered hydrology. For this reason, altered hydrology is thought to be the primary stressor within the Little Cottonwood River. As a majority of the surrounding land use that drains into this system, altered hydrology is the result from the practice of subsurface tile drainage, paired with ditching and channelizing the headwater tributaries that feed into the Little Cottonwood River. In this case, the drainage of the agricultural landscape to the stream is creating nitrate overloading as tile drains the soil. Tile drainage and channel alteration is also contributing to peak flows as the landscape is drained and directed to one pour point; primarily influencing erosion rates (that contributes to TSS), stream stability, and loss of habitat. Additional information on altered hydrology can be found in Chapter 3.1.8 of this report.

Summary Table

Table 134. Identified stressors with suspected sources for reach 677 of the Little Cottonwood River.



677 Little Cottonwood River

Key				
●=suspected source, ○=potential source	Stressor	Inconclusive	Not a Stressor	NA

Stressors																																	
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
●			▨	▨	▨	▨			●			●			○			●		○	●			●	●	▨	▨	▨	▨	▨	●		●

Little Cottonwood River Subwatershed Conclusion

There were four reaches with biological impairments within the Little Cottonwood Subwatershed. County Ditch 11 (-657) was the only stream assessed that was classified as modified warmwater, found impaired for macroinvertebrates. All other assessed sites were identified as warmwater general use. County Ditch 67 (-658) and Little Cottonwood (-676) had impairments for both macroinvertebrates and fish. The farthest downstream reach of the Little Cottonwood River (-677) only had impairments of macroinvertebrates.

Altered hydrology is the primary stressor in these streams as it is directly contributing to the other stressors. Altered hydrology is occurring two ways within this subwatershed. The first is through subsurface tile drainage and the second is stream channel alteration by ditching and channelizing. Alterations in this region are from agricultural practices in attempt to expedite water off the land to optimize growing conditions. Both of these practices are the leading source for altered hydrology. Due to these dynamics, these streams are taking on volumes of water greater than what they are naturally designed to carry. This results in accelerated flow velocity and significantly changes the morphology of the stream at the receiving location as well as downstream areas. Stream banks erode and streambeds are scoured out or filled in with sediment. The Little Cottonwood stream is the largest tributary that enters the Minnesota River mainstem within the Minnesota River, Mankato Watershed; for this reason, the Little Cottonwood has been intensely monitored as well studied by the DNR. A comprehensive review of their findings and restoration plan can be found in the DNR's 2016 Minnesota River, Mankato Watershed Characterization Report.

Portions of the Little Cottonwood River have been found to be unnaturally down cutting and losing their natural connection to the floodplain with the presence of increased flows. Downstream on the Little Cottonwood, accelerated erosion is occurring, resulting in high sediment contributions to the stream. The vegetative riparian that was noted throughout the geomorphology reports have been mitigating some of the erosion issues. However, as the stream increases in gradient towards the Minnesota River, other forms of sediment from ravines and bluffs are found to have accelerated erosion rates that further overload the stream. The DNR has recommended that more land water storage efforts be put in place to increase stream stability.

The Little Cottonwood River is listed for a turbidity impairment. Additional to the DNR's work on geomorphology, intense water monitoring efforts have found that the tributary of the Little Cottonwood River has the highest flow-weighted mean concentration in all of the Minnesota River Watershed. As increased erosion rates have already been discussed as a sediment source in this area, it is important to call attention to some of the other likely contributors found within the Little Cottonwood River Subwatershed. There are a few areas where run off from urban development, mining operations, and pasture practices are noted as potential sources.

Total Suspended solids (TSS) is contributing to some of the additional biological stressors in this subwatershed. With high TSS, there is often poor habitat associated. One example of this is seen in the streams with moderate to low gradients, were sediment and silt is settling on the streambed causing embeddedness over time. This reduces habitat diversity as riffles and pools are eliminated from the system.

TSS also can influence temperatures of a stream. As sediment absorbs heat, it can significantly increase water temperatures when introduced at high concentrations. The other influencing driver in increased stream temperatures is typically found in the upland headwaters. Here, there is a lack of overhanging vegetative coverage that allows direct sunlight penetration. The Little Cottonwood River is not a cold-water stream, yet unusually high temperatures at the time of biological monitoring lead to follow up temperature monitoring (typically reserved for cold-water streams). At this time, temperature is listed as inconclusive as it was not found to be consistently at dangerous levels to biology. However, it was borderline on several occasions during deployment. Additional temperature monitoring is recommended.

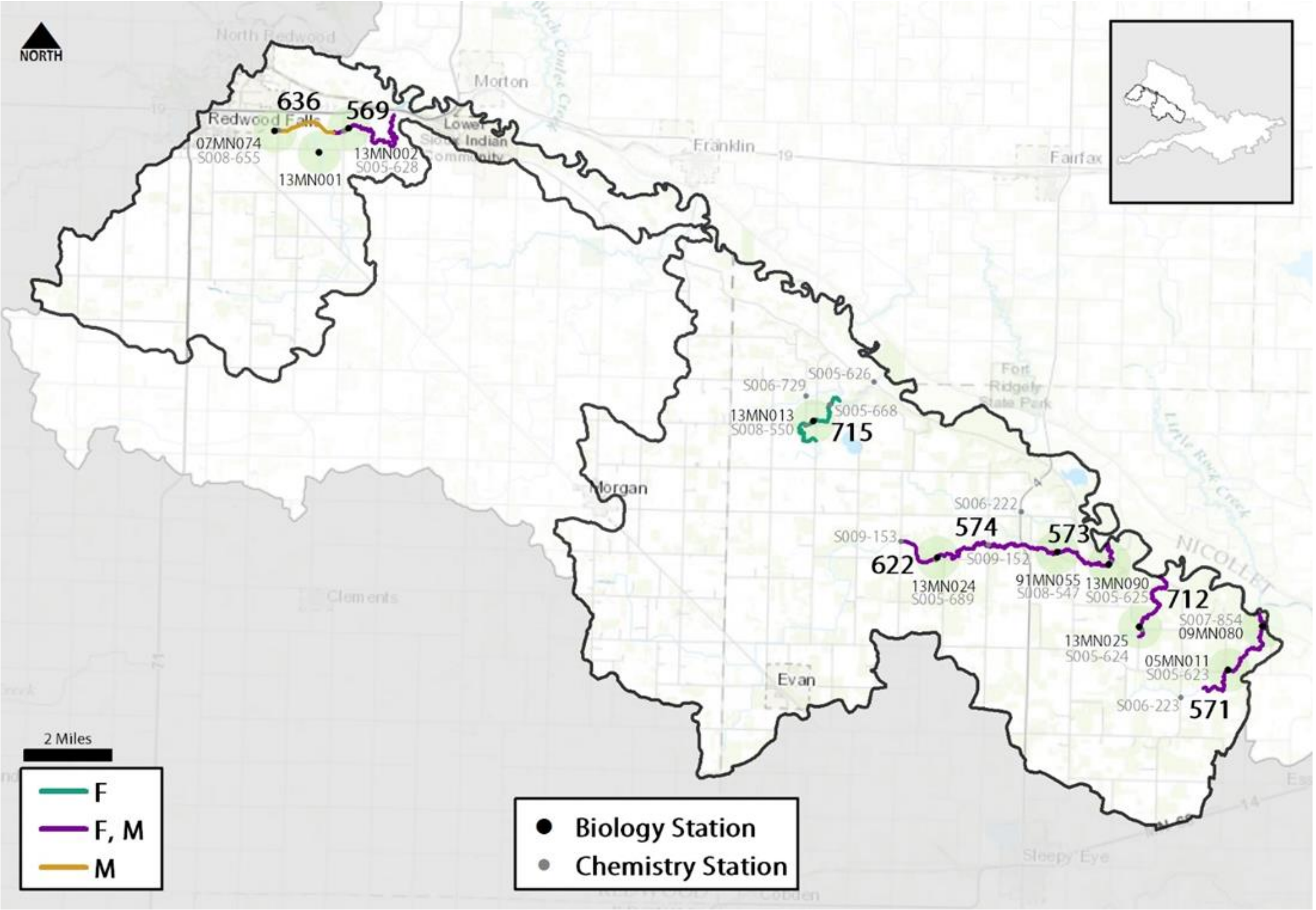
Tile drainage in this watershed is likely the leading input of nutrients, such as nitrates and phosphorus. There are a few potential point source contributors along the Little Cottonwood River as well. Nitrate itself is toxic to biology and was found to be limiting the biological communities at all monitoring locations.

Eutrophication was limiting the biology in County ditch 11. While all the streams had high phosphorus concentrations, CD11 was the only one that had an overabundance of algae growth; likely from the additional combination of poor stream canopy cover and slow flow.

Spring Creek – MNR Mankato South

This section encompasses biotic impaired reaches in the Spring Creek - MNR 10 digit HUC (). There are eight reaches impaired for biology in this 10 digit HUC. They are organized from east to west and upstream to downstream when multiple reaches. There are two coldwater reaches in this group of reaches, John's Creek and the middle reach of Spring Creek. Both are impaired for fish and macroinvertebrates. The two warmwater reaches in Spring Creek are also impaired for fish and macroinvertebrates, same as County Ditch 13 and Crow Creek. Unnamed Creek is impaired for fish only and County Ditch 52 is impaired for macroinvertebrates only.

Figure 146. Map of the Spring Creek Watershed with biological impairments and monitoring stations. Impairments are described as F=Fish, F, M=Fish and Macroinvertebrates, and M=Macroinvertebrates



4.17 County Ditch 10 (John's Creek) (07020007-571)

John’s Creek (07020007-571) is a small tributary, northeast of Sleepy Eye, Minnesota. The reach is cold-water general use Class 2A, and managed as a marginal warmwater trout stream by the DNR. The reach extends miles from approximately T110 R32W S1, west line (between CR 10 and CR 29) to the Minnesota River. The reach is impaired for lack of macroinvertebrate assemblage and lack of fish assemblage. The reach is also impaired for nitrates and *E. coli*. The *E. coli* impairment will not be addressed in this report. The nitrate will be addressed as it pertains to the aquatic life, not drinking water.

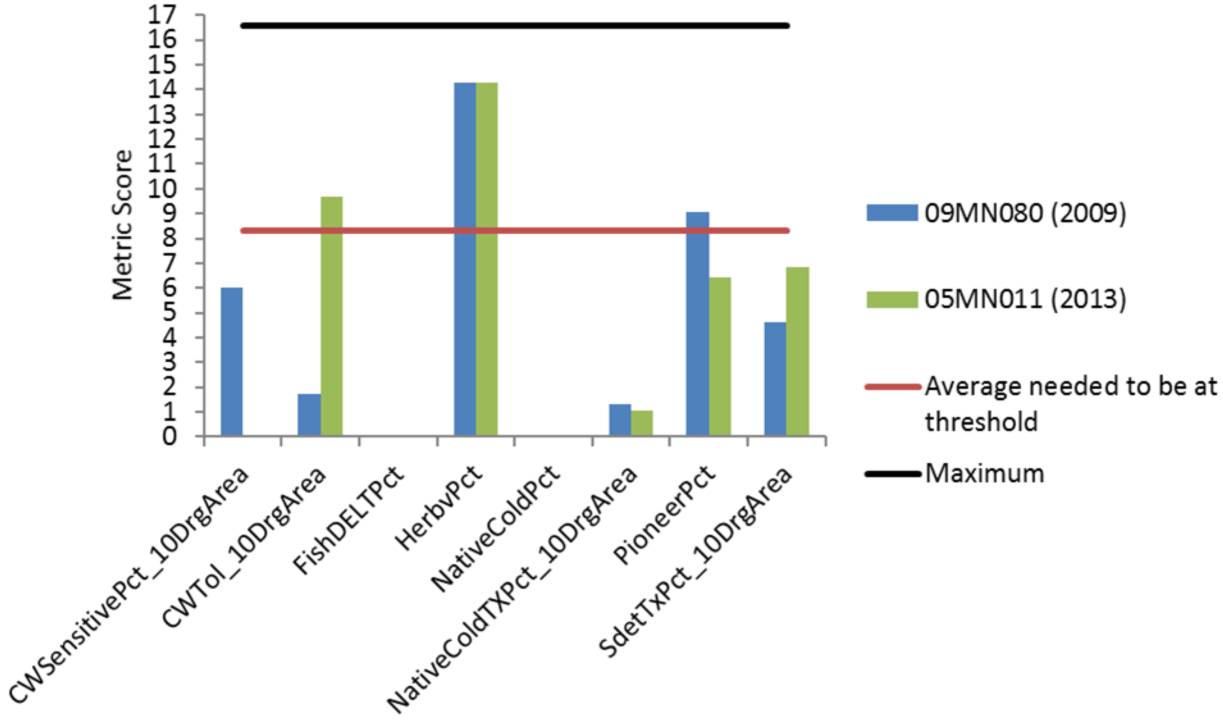
4.17.1 Biological Communities

Fish sampling occurred twice on John’s Creek, once closer to the outlet at 09MN080 in 2009, and upstream at 05MN011 in 2013. Station 09MN080 had a FIBI of 37; station 05MN011 had a score of 38; both falling under the threshold for Southern Coldwater streams of 50. There was a drastic difference in the sampled population between these two samples. In 09MN080, the fish population was primarily made up of 89 brown trout. The sample at this site was of special interest for the DNR for their trout survey on this stream. There has not been cold-water stocking since 1995, and have self-sustained from that time at this station. Also in high abundance were Creek Chubs blacknose dace, and white suckers.

There were 11 types of fish taxa in total. The upstream station 05MN011 was void of trout during the 2013 fish sample, and dominated by blacknose dace with only five taxa types found.

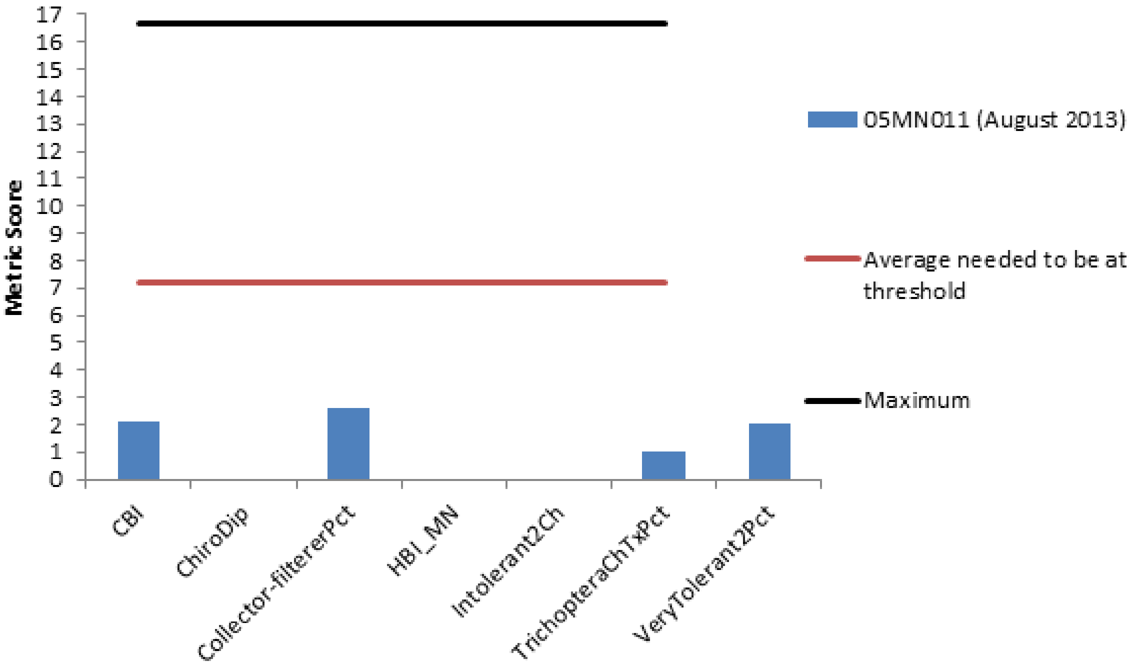
As shown in the figure below, both stations fell short for cold-water sensitive species (CWSensitivePct_10DrgArea), native cold-water species (NativeColdPct), and species that are detritus eaters. Herbivores met the threshold at both sites. Neither sample resulted in a score reduction for DELTS (FishDELTPct).

Figure 147. Fish metrics of the Southern Coldwater Streams class for stations 09MN080 and 05MN011, Spring Creek



Only station 05MN011 was evaluation for macroinvertebrate impairments. The August 11, 2013 sample resulted in an MIBI of 22.6, far below the Southern Coldwater threshold of 43. Polypedilum (non-biting miges) and Baitis (mayflies) were the dominant taxa of the sample. In total, there were 46 taxa types surveyed. There were very few coldwater species (CBI), Chironomidae and Diptera (ChiroDip) were absent as were intolerant taxa (Intolerant2Ch) with very tolerant taxa (veryTolerant2Pct) in place, as noted in Figure 148.

Figure 148. Macroinvertebrate metrics of the Southern Coldwater Streams class for station 05MN011, Spring Creek



4.17.2 Data Evaluation for each Candidate Cause

Temperature

Johns Creek is a designated trout stream and is managed as a marginal warmwater trout stream and extends from the confluence of the Minnesota River to river mile 3.7. According to DNR, from 1961-1995, yearling brown trout and to a lesser extent yearling rainbow trout were stocked to maintain a put-and-take coldwater fishery. Recent assessments in 2009 and 2010 indicate a self-sustaining population of brown trout. In 2009, brown trout ranging from 3.5-19.9 inches were collected representing an estimated minimum of three-year classes. Over 90% were likely from the 2009-year class.

A special assessment in 2005 at approximate river mile 2.5 (05MN077) sampled no brown trout and temperature loggers near this location indicated high summer temperatures that are unsuitable for prolonged trout survival at this location. The 1987 stream survey mentions evidence of over-wintering trout and a subsample of the collected trout were age-two suggesting they were the yearling fish stocked in 1986.

At the time of the fish sample on August 14, 2013, the temperature at station 05MN011 was recorded at 24.1°C.

A temperature logger and sonde were placed at 05MN011 in 2013 and 2016 to record temperature continuously. The temperature data which was collected from May through September of 2013 (Figure 149) showed two days (July 18, 2013 and August 25, 2013) where water temperatures exceeded 24 degrees Celsius. The temperature data shows some regular periods of time where temperature exceeds the critical temperature threshold for brown trout (24°C), but also shows a good amount of time above 18°C, the threat temperature for brown trout. Sonde data that was collected in 2016 does not exceed the 24°C, and does look fairly normal for a coldwater stream, seen in Figure 150.

Figure 149. Temperature data from 05MN011 collected from May to September on Johns Creek, 2013

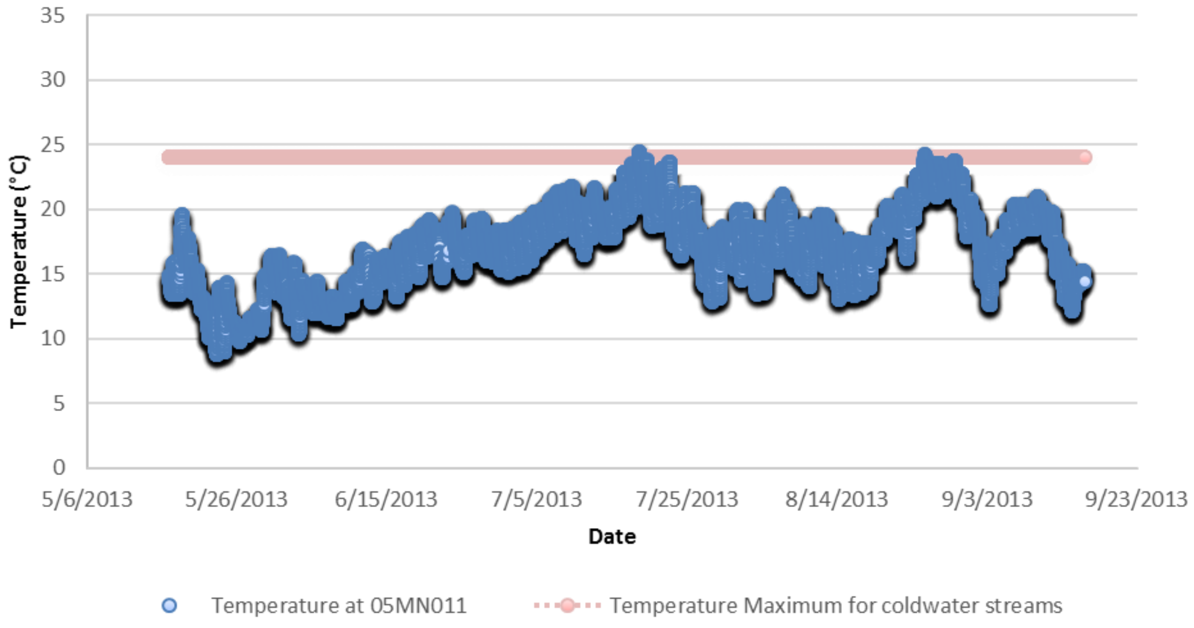
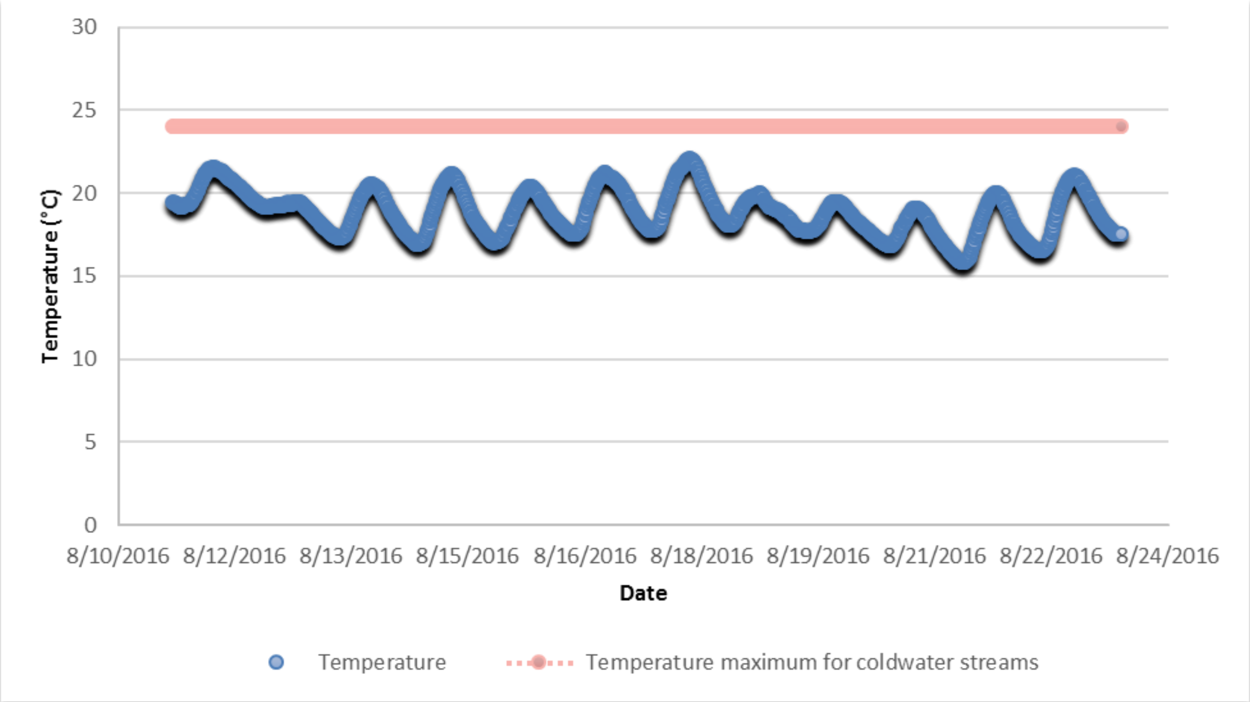


Figure 150. Temperature data from sonde deployment at 05MN011 in August of 2016



Temperature is marginal, while there are not any blatant or consistent violations of the temperature threshold there is not enough data to confidently conclude temperature is not problematic for the coldwater populations.

Biologically, there were some cold-water fish species and cold-water sensitive fish species present, but were not present in high numbers (Table 135). Trout were present in the 2009 sample at 09MN090 but absent in 2013 at 05MN011. Station 09MN090 is on the true cold-water portion of this stream, while

05MN011 exists farther upstream where cold-water is marginal. Coldwater macroinvertebrates were also reduced in numbers at 05MN011 in 2011. No sample was available in 2009 from 09MN080.

Table 135. Biological metrics that respond to temperature compared to the statewide average of visits meeting the Southern Coldwater biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	ColdPct (Fish)	CWSensitivePct (Fish)	NativeColdPct (Fish)	Coldwater Biotic Index (Macroinvertebrates)
05MN011 (2013)	**0**	**0**	**0**	**2.1**
09MN080 (2009)	**46.0**	**47.1**	**0**	na
Southern Coldwater Average	*66.4*	*70.6*	*30.3*	*7.70*
Expected response to stress	↓	↓	↓	↓

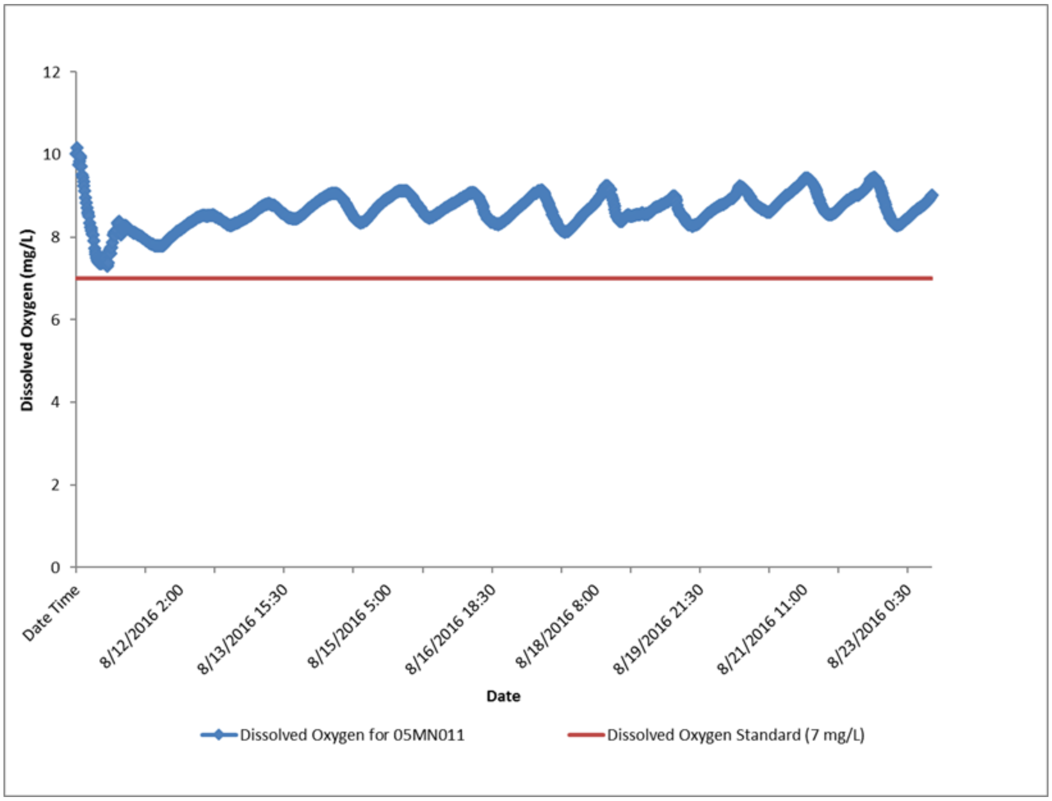
Temperature is inconclusive as a biological stressor. In cold-water streams, temperatures plays a critical role in maintaining the community. While there is a few continuous reading, what is available between two different years, displays different temperature dynamics. Additional temperature monitoring would be beneficial at this reach.

Dissolved Oxygen

The dissolved oxygen (DO) concentration during biological sampling on July 17, 2013 and August 15, 2013 at station 05MN011 was 8.3 mg/L and 7.5 mg/L respectively. Additional samples collected in 2009, 2010, and 2016 ranged from 4.1 mg/L – 18.5 mg/L (average of 10.3 mg/L). Twenty-eight samples were collected, and five (18%) were below the cold-water standard of 7 mg/L. All exceedances occurred in 2009 in August and October. Samples were collected at station S005-623.

In 2016, a sonde was deployed from August 10 through August 23 at station 05MN011. During that period, concentrations ranged from 7.3 mg/L – 10.2 mg/L (Figure 151). All values were above the cold-water standard. Daily DO fluxuation (DO flux) was minimal and below the standard for the South Region of having no more than a 4.5 mg/L swing in DO within 24 hours.

Figure 151. Temperature data from sonde deployment at 05MN011 in August of 2016



The macroinvertebrate metrics are suggestive of stress. All of the macroinvertebrate metrics were worse than the statewide average of stations meeting the MIBI threshold (Table 136). The macroinvertebrate DO index score was below average; as this score decreases, so does the sensitivity of the community. There were five DO intolerant taxa comprising 33% of the community, and seven DO tolerant taxa comprising 6% of the community. Taxa richness of Ephemeroptera, Plecoptera and Trichoptera (EPTCh), a measure of pollution based on tolerance values assigned to each individual taxon developed by Chirhart (HBI_MN), and total taxa richness (TaxaCountAllChir) were worse than average.

Table 136. Macroinvertebrate metrics that respond to low DO stress in John's Creek compared to the statewide average of visits meeting the Coldwater stream biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
05MN011 (2013)	**40**	**4**	**7.1**	**7.0**	**5**	**33.3**	**7**	**5.7**
Coldwater Average	*30.8*	*8.1*	*6.4*	*7.5*	*10.4*	*56.6*	*1.8*	*1.3*
Expected response to stress	↑	↓	↑	↓	↓	↓	↑	↑

All of the fish metrics were worse than the statewide average of stations meeting the FIBI threshold (Table 137). Relative abundance of sensitive individuals (SensitivePct) and individuals with a female mature age greater than three years (MA>3Pct) were below average, and tolerant individuals (TolPct) comprised 51 – 97% of the community. There were 0 – 2 DO sensitive taxa comprising 0 – 47% of the community, and 2 – 3 DO tolerant taxa comprising 11 – 31% of the community. The fish DO index scores were below average, and the probability of this reach meeting the DO standard based on the fish community was 52% (05MN011) and 98% (09MN080).

Table 137. Fish metrics that respond to low DO stress in John's Creek compared to the statewide average of visits meeting the Coldwater stream biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
05MN011 (2013)	**0**	**0.0**	**96.5**	**7.2**	**0**	**0.0**	**2**	**31.0**
09MN080 (2009)	**47.1**	**55.0**	**50.8**	**8.4**	**2**	**47.1**	**3**	**10.6**
Southern Coldwater Average	*71.7*	*74.6*	*24.0*	*8.9*	*2.5*	*72.4*	*1.1*	*6.8*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is inconclusive as a stressor. While the continuous DO monitoring that took place in 2016 looked good, there were a few low DO levels documented, particularly in late summer months when base flow is low. Both the fish and macroinvertebrate community composition is suggestive of low DO stress.

Eutrophication

The total phosphorus (TP) concentration during fish sampling on July 17, 2013 at station 05MN011 was 0.135 mg/L. Thirty additional samples were collected with a majority occurring in 2009 and 2010 ranging from 0.049 mg/L – 0.873 mg/L (average of 0.242 mg/L); one additional sample of .077 mg/L was taken on August 23, 2016. Of these 31 samples, 50% were above the river eutrophication standard for the South Region of 0.150 mg/L. The exceedances occurred in multiple months in 2009 and 2010. All samples were collected in the upper end of the AUID at station S005-623.

Chl-a, BOD, and DO flux are also considered when evaluating eutrophication stress, as they indicate signs of overabundant plant (algae) growth and respiration. There have been zero chl-a or BOD samples collected. During sonde deployment in 2016, daily DO flux was minimal and did not exceed the standard variation for the South Region of 4.5 mg/L. Low DO has been documented in this AUID and future deployments are recommended to better understand the daily DO flux within this system and if it is connected to autotrophic productivity, low base flows, or something else.

All of the macroinvertebrate metrics except taxa richness of collector-filterers (Collector-filtererCh) were worse than the statewide average of stations meeting the MIBI threshold (Table 138). There were zero intolerant taxa (Intolerant2Ch), and a high percentage of tolerant taxa (Tolerant2ChTxPct). Taxa richness of collector-gatherers (Collector-gathererCh) and Ephemeroptera, Plecoptera, and Trichoptera (EPT) were below average. Collector-filterers were right at the average.

Table 138. Macroinvertebrate metrics that respond to eutrophication stress in John's Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
05MN011 (2013)	**40**	6	**12**	**4**	**0**	**80**
Southern Coldwater Average	*30.8*	*6.0*	*12.1*	*7.5*	*1.1*	*66.8*
Expected response to stress	↑	↓	↓	↓	↓	↑

A majority of the fish metrics were worse than the statewide average of stations meeting the FIBI threshold (Table 139). There were zero sensitive individuals (SensitivePct) at station 05MN011, and zero intolerant individuals (IntolerantPct) at stations 05MN011 and 09MN080. Tolerant individuals (TolPct) were elevated at both stations. The only metrics that scored better than average were abundance of simple lithophilic spawners (SLithopPct) and total taxa richness (TaxaCount) at station 05MN011 in 2013.

Table 139. Fish metrics that respond to eutrophication stress in John's Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
05MN011 (2013)	**0**	**3.5**	57.0	**96.5**	5	**0**
09MN080 (2009)	**47.1**	**3.2**	**19.0**	**50.8**	**11**	**0**
Southern Coldwater Average	*71.7*	*3.6*	*20.2*	*24.0*	*5.8*	*26.3*
Expected response to stress	↓	↓	↓	↑	↑	↓

Eutrophication is inconclusive at this time, although phosphorus is high and should be targeted for reduction. The community metrics are suggestive of eutrophic stress, however secondary response (Chl-a, BOD, DO flux) is unavailable for this station. Looking at photo documentation of this reach, there is little to no algae growth present. It is likely that location of this stream is not suitable for high algal growth (due to the velocity of the stream as well as the shade from the healthy canopy cover.

Nitrate

Nitrate concentration during fish sampling on July 17, 2013 at station 05MN011 was 14 mg/L. Thirty additional samples were collected in 2009, 2010, and 2016, ranging from 3.1 mg/L – 26 mg/L (average of 14.7 mg/L). Twenty-five (83%) of those samples were above 10 mg/L. Elevated concentrations were observed in all years and various months. Samples were collected from station S005-623. This AUID is already identified as being impaired for nitrate.

Taxa richness of Trichoptera (TrichopteraCh) and relative percentage of taxa belonging to Trichoptera (TrichopteraChTxPct) were below the statewide average of stations meeting the MIBI threshold (Table 140**Error! Reference source not found.**). There was one nitrate intolerant taxa, and 20 nitrate tolerant taxa comprising 64% of the community. There was a lack of nitrate sensitive Trichoptera, a taxa particularly sensitive to nitrate stress. The macroinvertebrate nitrate index score was worse than average. The macroinvertebrate metrics have values indicative of nitrate stress.

Table 140. Macroinvertebrate metrics that respond to nitrate stress in 05MN011 compared to the statewide average of visits meeting the southern cold-water stream use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TrichopteraCh	TrichopteraChTxPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
05MN011 (2013)	**3**	**7.5**	**3.14**	**1**	**20**	**63.84**
Southern Coldwater Average	*5.3*	*17.3*	*3.04*	*1.35*	*14.29*	*60.79*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is a stressor. Chemistry data, both historic and present are at levels of concern. The macroinvertebrate community also is showing displacement from high nitrate.

Total Suspended Solids

The total suspended solid (TSS) concentration during fish sampling on July 17, 2013 at station 05MN011 was 3.2 mg/L. Thirty additional samples collected in 2009, 2010, and 2016 ranged from 2 mg/L – 182 mg/L, providing an average of 18.7 mg/L, and 9 (30%) were above the cold-water standard of 10 mg/L. Exceedances occurred in 2009 and 2010, in March (two), April, June (two), July, September (two), and October, with higher level noted to follow after rain events. Samples were collected at station S005-623.

The relative abundance of collector-filterer individuals (Collector-filtererPct) and relative abundance of Plecoptera individuals (PlecopteraPct) were below the statewide average of stations meeting the MIBI threshold (Table 141). There were zero TSS intolerant taxa, and seven TSS tolerant taxa comprising 25% of the community. The macroinvertebrate TSS index score was below average; as this score decreases, so does the tolerance of the community. Overall, a majority of the macroinvertebrate metrics are worse than average and suggestive of stress.

Table 141. Macroinvertebrate metrics that respond to high TSS stress in John's Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
05MN011 (2013)	**15.8**	**0**	13.08	**0**	**0**	**7**	**24.8**
Southern Coldwater Average	*32.7*	*0.4*	*13.34*	*2.3*	*3.5*	*5.2*	*10.8*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

All of the fish metrics with strong relationships to TSS were below the statewide average of stations meeting the FIBI threshold (Table 142). The relative abundance of individuals that are non-tolerant Centrarchidae (Centr-TolPct) and relative abundance of individuals that are intolerant species (IntolerantPct) were zero at station 09MN080 in 2009. These metrics, in addition to relative abundance of individuals that are herbivore species (HrbNWQPct), relative abundance of individuals that are long-lived (LLvdPct), relative abundance of individuals that are riffle-dwelling species (RifflePct), relative abundance of individuals that are sensitive species (SensitivePct), and relative abundance of individuals that are simple lithophilic spawners (SLithFrimPct) were also zero at station 05MN011 in 2013. There were zero TSS sensitive taxa at both stations, and one TSS tolerant taxa at station 09MN080 comprising 1% of the community (Table 143). Fish TSS index scores were also worse than average.

Table 142. Fish metrics that respond to high TSS stress in John's Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
05MN011 (2013)	**3.5**	**0**	**0**	**0**	**0**	**3.5**	**0**	**0**	**0**
09MN080 (2009)	**14.3**	**0**	**11.1**	**0**	**46.0**	**3.2**	**12.2**	**47.1**	**9.0**
Southern Coldwater Average	*28.3*	*1.0*	*15.1*	*26.3*	*53.9*	*4.7*	*34.2*	*71.7*	*15.3*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 143. Fish metrics that respond to high TSS stress in John's Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TSS Index Score	TSS Sensitive Taxa	TSS I Sensitive Pct	TSS Tolerant Taxa	TSS Tolerant Pct
05MN011 (2013)	**14.0**	**0**	**0**	0	0
09MN080 (2009)	**12.6**	**0**	**0**	**1**	**1.1**
Southern Coldwater Average	*10.5*	*1.4*	*33.6*	*0.1*	*0.3*
Expected response to stress	↑	↓	↓	↑	↑

Figure 152. Station 05MN011, taken on September 13, 2012 displaying high erosive potential.

TSS is a biological stressor. Both the biological metrics support this, as does the water chemistry collected throughout the monitoring period. Photo documentation (shown in Figure 152), displays erosive conditions within the reach that san contribute to sedimentation.

Habitat

The MSHA for station 05MN011 was good in July 2013 (72.9) (Figure 153). All of the subcategories scored at a minimum in the fair range. The surrounding land use is forest with row crop. The riparian area was wide to extensive with little bank erosion and heavy shade. There were a diverse set of stream features and substrates (Figure 154). Riffle features comprised 50% of the reach with cobble and gravel. There was only 10% pool habitat. There was moderate cover (25-50%). The channel had good depth variability, with moderately high stability.

Figure 153. Percentage of MSHA subcategory scores for station 05MN011, John's Creek

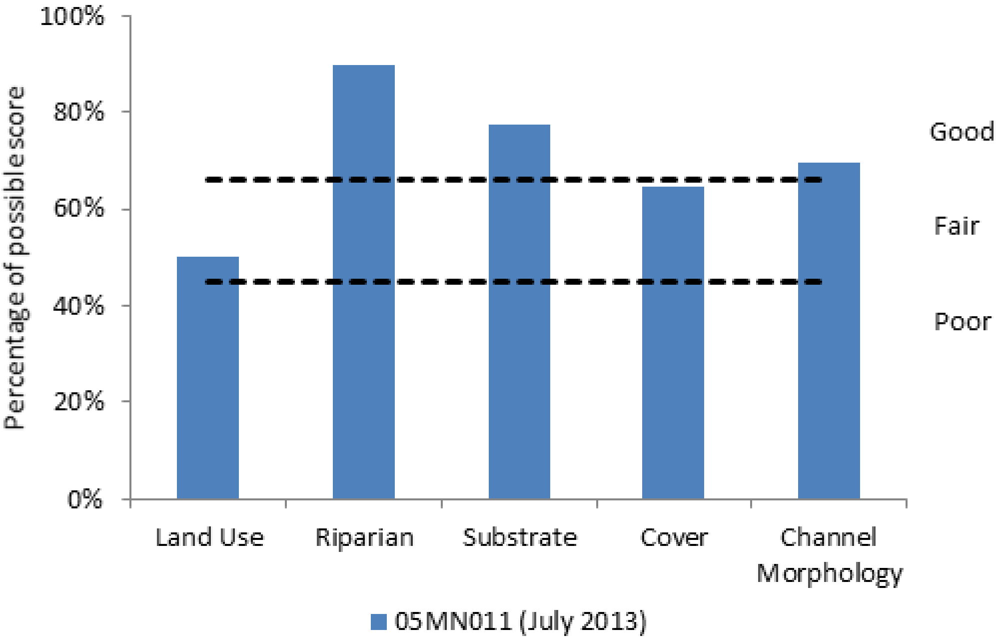
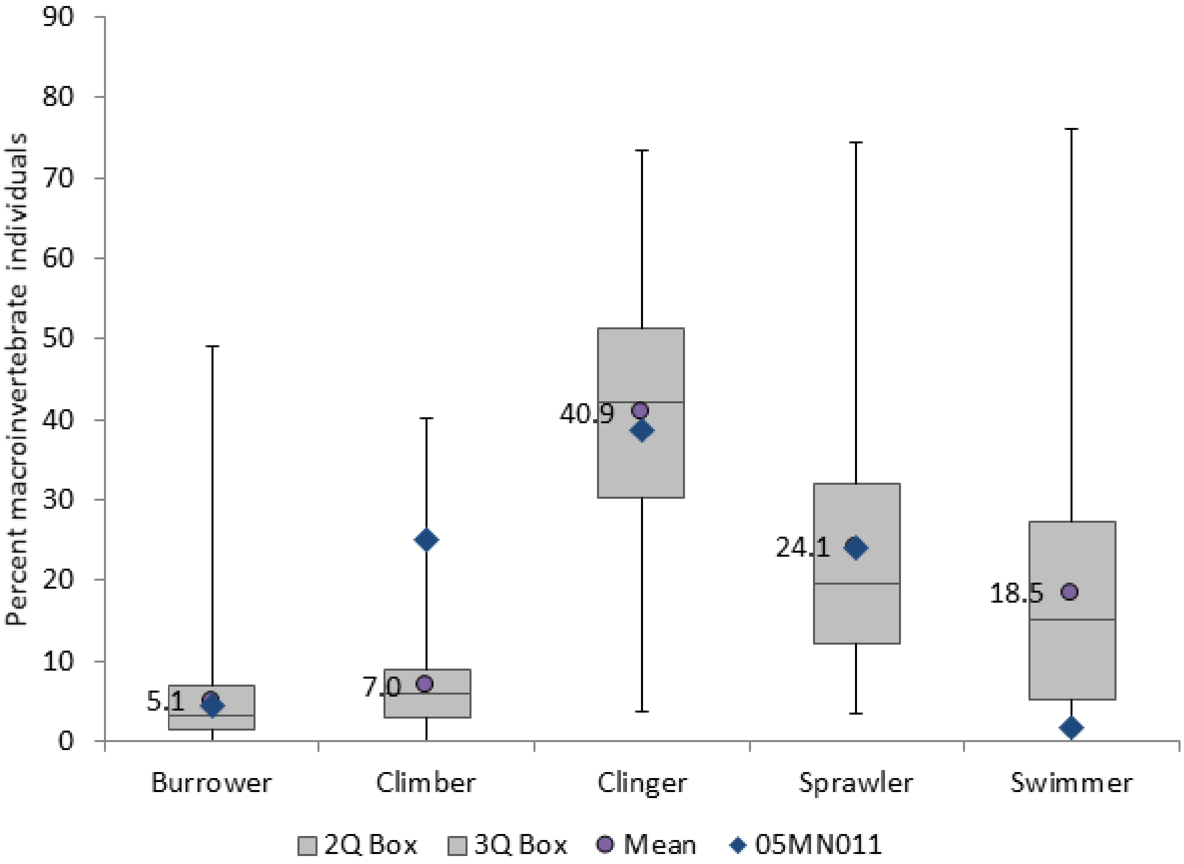


Figure 154. Station 05MN011, July 17, 2013

Burrowers, clingers, and sprawlers were close to average, while climbers were well above average and swimmers were well below average (Figure 155). The elevated climbers are atypical of habitat stress; climbers use overhanging vegetation and woody debris habitat, and are expected to decrease with stress. Most of the habitat related macroinvertebrate metrics had values uncharacteristic of habitat stress.

Figure 155. Macroinvertebrate metrics that respond to habitat for station 09MN094, John's Creek compared to the range of values for Coldwater Stream visits meeting the modified use biocriteria.



As displayed in previous sections, the relative abundance of individuals that are riffle-dwelling species (RifflePct) was below average at both stations. Abundance of simple lithophilic spawners (SLithopPct) was above average at station 05MN011 and just below average at station 09MN080. Both of these species require clean coarse substrate and riffles, and are expected to decrease with stress.

Habitat is not considered a stressor to the macroinvertebrate or fish community. There is diverse and healthy habitat availability noted during site visits. The macroinvertebrate community also does not suggest it is being limited by a habitat impairment.

Longitudinal Connectivity and Altered Hydrology

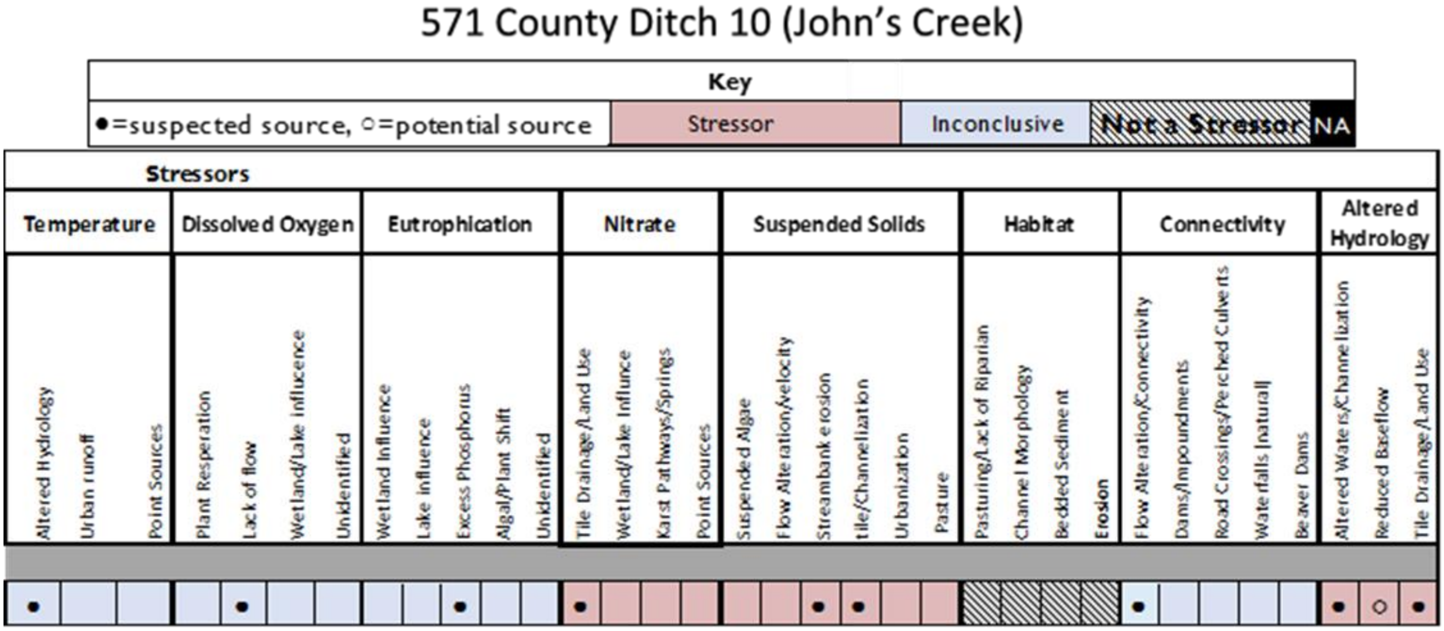
Connectivity is listed as inconclusive as a biological stressor. Longitudinal connectivity could be impaired due to extremely low base flows. It is possible there are connectivity issues associated with flow, particularly at station 09MN080 (Figure 156). In the future, flow monitoring is recommended to confirm if this is a losing reach or not.

Figure 156. Nearly dry creek bed at John's Creek at station 09MN080 taken in July 23, 2015.

Altered Hydrology is viewed as the primary stressor within this reach. While this portion of stream is defined as natural channel, the headwaters that feed into it are completely altered by way of ditching, channelization, as well as subsurface tile drainage for agricultural purposes. These modifications will alter the streams natural flow regime, which can lead stream instability. Tile drainage can directly increase the streams pollutant loading as it transports pollutants from a large land area. More information on the direct and indirect impacts of altered hydrology can be found in Chapter 3.1.8 of this report.

Summary Table

Figure 157. Identified stressors with suspected sources for reach 571 of Johns Creek.



571 County Ditch 10 (John's Creek)

Key				
●=suspected source, ○=potential source	Stressor	Inconclusive	Not a Stressor	NA

Stressors																																			
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls (natural)	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
●				●					●			●						●	●			▨	▨	▨	▨	●					●	○	●

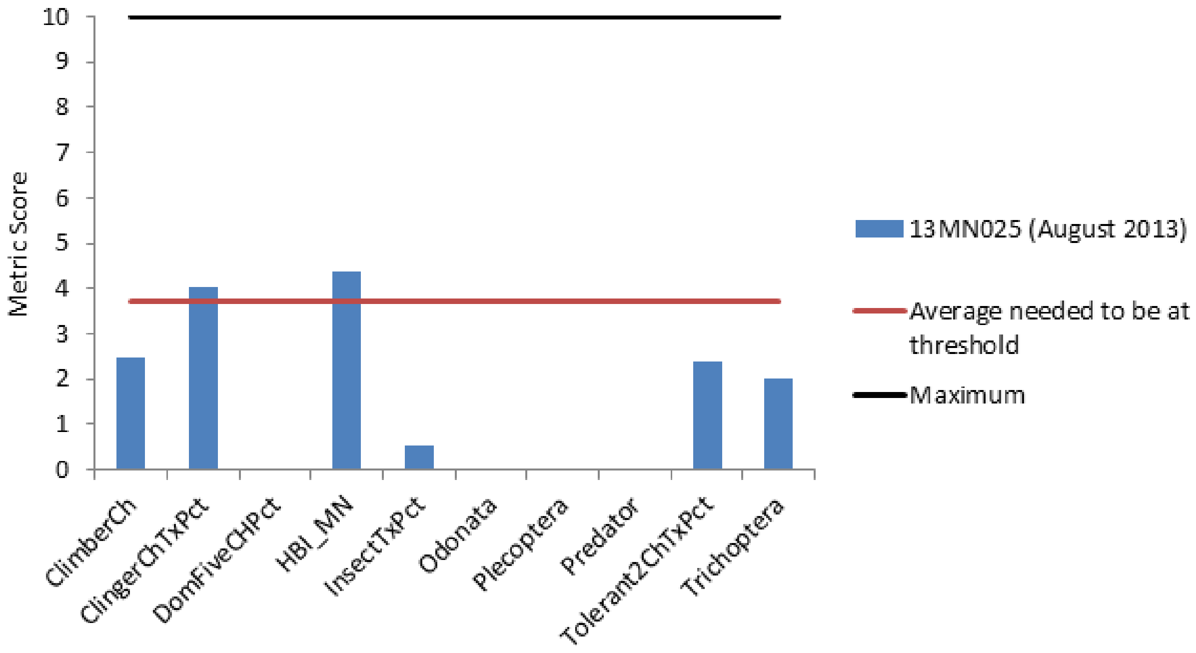
4.18 County Ditch 13 (07020007-712)

County Ditch 13 (07020007-712) is a small tributary northwest of Essig, Minnesota. The reach is general use Class 2B. The reach extends miles from 245th Ave. to the Minnesota River. The reach is impaired for lack of macroinvertebrate assemblage and lack of fish assemblage. The reach is also impaired for *E. coli*. The *E. coli* impairment will not be addressed in this report.

4.18.1 Biological Communities

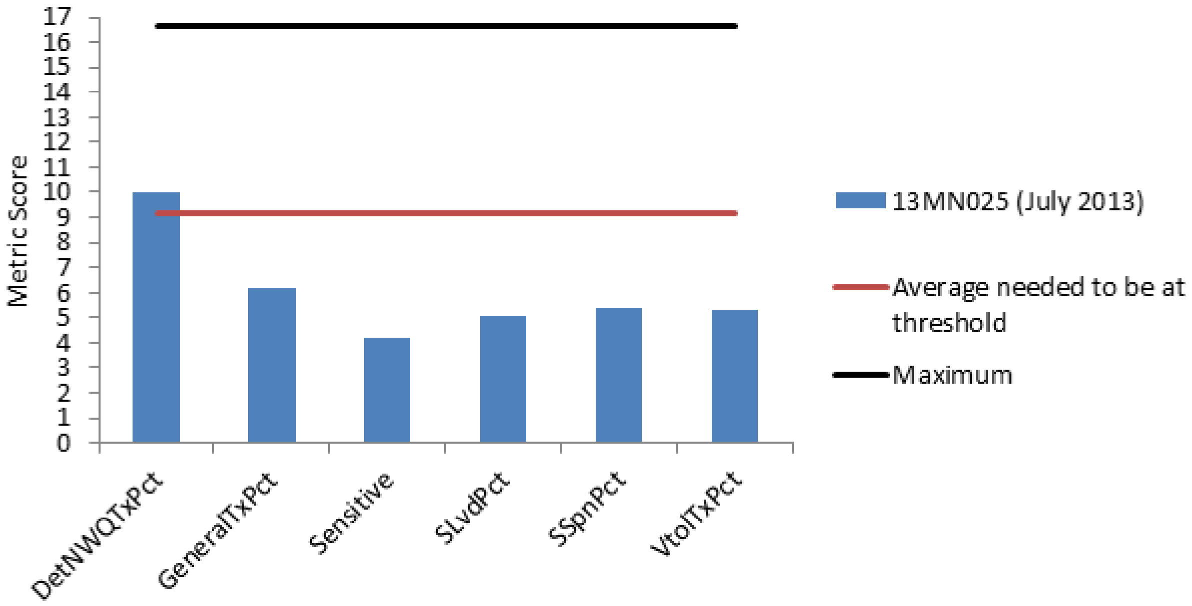
Station 13MN025 was surveyed for fish and macroinvertebrates in 2013. The macroinvertebrate community had an IBI score of 15.7, below the threshold of 37 for the Southern Streams RR class. Nearly all of the macroinvertebrate IBI metrics were below the average metric score to obtain an IBI at the threshold (Figure 158). The community was dominated by black fly larva (Simulium).

Figure 158. Macroinvertebrate metrics of the Southern Streams RR class IBI for station 13MN025, County Ditch 13



The fish community had an IBI score of 36.1, below the threshold of 55 for the Southern Headwaters class. Similar to the macroinvertebrate community, five of six of the FIBI metrics were below the average metric score to obtain an IBI at the threshold (Figure 159). Fathead minnows dominated the survey.

Figure 159. Fish metrics of the Southern Headwaters class IBI for station 13MN025, County Ditch 13



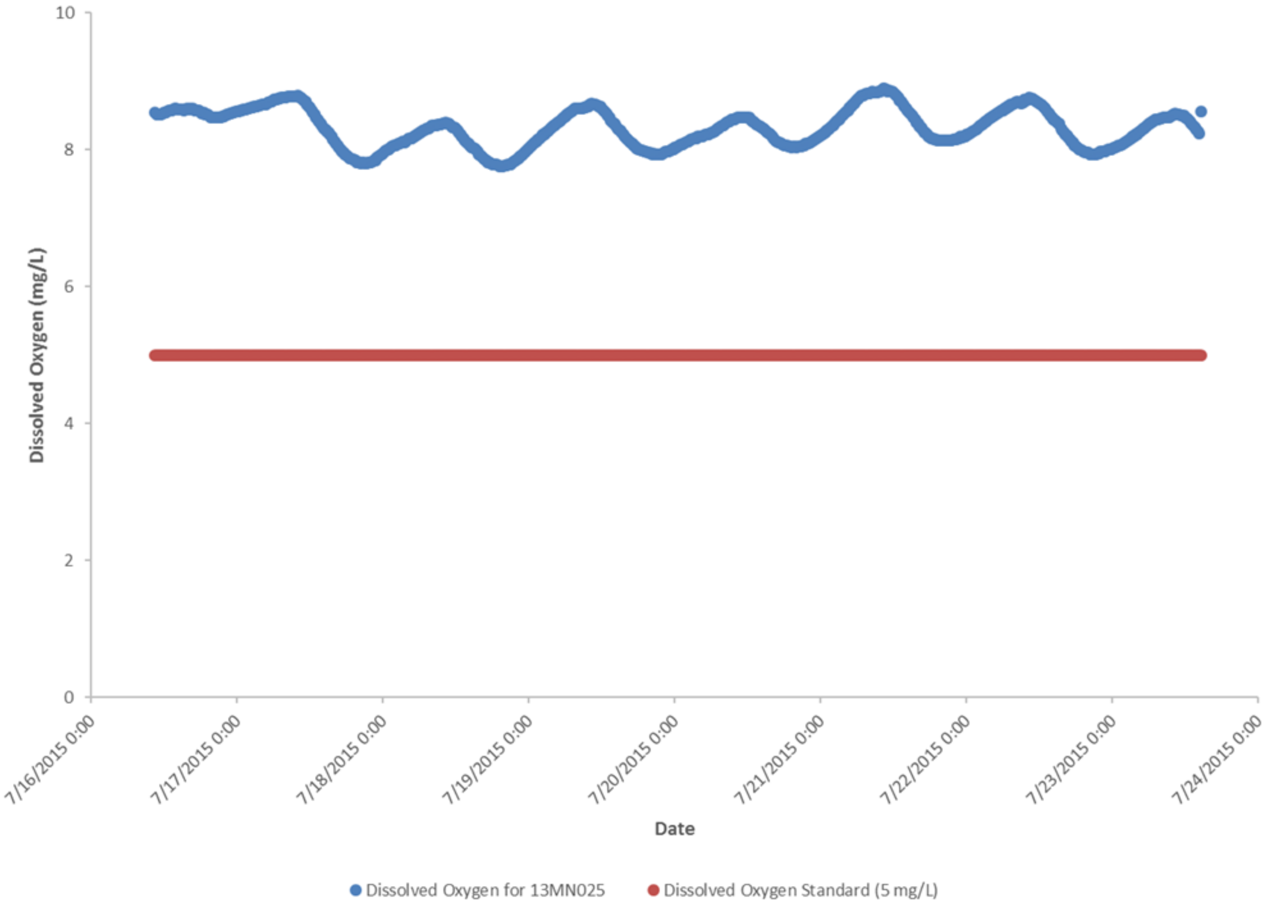
4.18.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

Dissolved oxygen (DO) concentration during biological sampling on July 9, 2013 and August 14, 2013 at station 13MN025 where both at 8.5 mg/L. Additional samples collected in 2009, 2010, and 2015 ranged from 3.8 mg/L – 16.7 mg/L (average of 9.0 mg/L). Twenty-eight samples were collected, and five (18%) were below the warmwater standard (5 mg/L). Exceedances occurred August – October in 2009. Samples were collected at station S005-624.

In 2015, a sonde was deployed from July 16 through July 23 at station 13MN025. During that time frame, concentrations ranged from 7.8 mg/L – 8.9 mg/L (Figure 160) There were zero violations of the standard, and daily 24 hour DO fluxuation (DO flux) was minimal (< 1 mg/L).

Figure 160. 13MN025 Sonde deployment from July 16 through July 23 in 2015.



The macroinvertebrate metrics were mixed (Table 144). The macroinvertebrate DO index score was above average; as this score increases, so does the sensitivity of the community. There were four DO intolerant taxa comprising 10% of the community, and two DO tolerant taxa comprising 3% of the community. Total taxa richness (TaxaCountAllChir) and taxa richness of Ephemeroptera, Plecoptera and Trichoptera (EPTCh) were worse than average, and a measure of pollution based on tolerance values assigned to each individual taxon developed by Chirhart (HBI_MN) was better than average. Overall, the macroinvertebrates are mixed and do not show a strong indication of DO stress.

Table 144. Macroinvertebrate metrics that respond to low DO stress in County Ditch 13 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN025 (2013)	**23**	**6**	6.9	7.5	**4**	**10.3**	2	3.0
Southern Streams Average	*45.8*	*14.2*	*7.1*	*7.0*	*9.0*	*24.0*	*4.8*	*9.9*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

A majority of the fish metrics were worse than the statewide average of stations meeting the FIBI threshold (Table 145). Relative abundance of sensitive individuals (SensitivePct) and individuals with a female mature age greater than three years (MA>3Pct) were below average, and tolerant individuals (TolPct) comprised 84% of the community. There were zero DO sensitive taxa, and three DO tolerant taxa comprising 54% of the community. The fish DO index score was below average, and the probability of this reach meeting the DO standard based on the fish community was 35%. The fish are suggestive of stress.

Table 145. Fish metrics that respond to low DO stress in County Ditch 13 compared to the statewide average of visits meeting the general coldwater use biocritera. Bold indicated metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
13MN025 (2013)	**0.6**	**0.0**	**84.1**	**6.8**	**0**	**0.0**	3	**54.0**
Southern Headwaters Average	*7.9*	*13.9*	*72.8*	*7.1*	*0.8*	*4.2*	*3.4*	*20.2*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

DO is listed as inconclusive. There is a history of random low DO measurements, there has not been any current testing to show low DO is prevalent in this system. Macroinvertebrates are mixed while the fish community was suggestive of low DO stress.

Eutrophication

Total phosphorus (TP) concentration during fish sampling on July 9, 2013 at station 13MN025 was 0.126 mg/L. Forty three additional samples were collected in 2009, 2010, and 2015, ranging from 0.027 mg/L – 0.948 mg/L (average of 0.267 mg/L). Of these 43 samples, 21 (49%) were above the river eutrophication standard for the South Region of 0.150 mg/L. Exceedances occurred in multiple months in 2009 and 2010. All samples were collected in the upper end of the AUID at station S005-624.

Chl-a, BOD, and DO flux are also considered when evaluating eutrophication stress. One chl-a sample was collected on July 23, 2015; this sample was well below the 35 µg/L standard at 3.15 µg/L. At this time, there have been zero BOD samples collected. During sonde deployment in 2015, daily DO flux was minimal low DO has been documented in this AUID.

All of the macroinvertebrate metrics were worse than the statewide average of stations meeting the MIBI threshold (Table 146). There were zero intolerant taxa (Intolerant2Ch), and a high percentage of tolerant taxa (Tolerant2ChTxPct). Taxa richness of collector-filterers (Collector-filtererCh), collector-gatherers (Collector-gathererCh), and Ephemeroptera, Plecoptera, and Trichoptera (EPT) were below average.

Table 146. Macroinvertebrate metrics that respond to eutrophication stress in County Ditch 13 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN025 (2013)	**23**	**4**	**9**	**6**	**0**	**82.6**
Southern Streams Average	*45.8*	*7.3*	*15.9*	*12.2*	*0.8*	*72.6*
Expected response to stress	↓	↓	↓	↓	↓	↑

A majority of the fish metrics were worse than the statewide average of stations meeting the FIBI threshold Table 147). Abundance of darter species (DarterPct) and intolerant individuals (IntolerantPct) were both zero, and tolerant individuals (TolPct) comprised 84% of the fish community. Abundance of simple lithophilic spawners (SLithopPct) was the only metric that scored better than average.

Table 147. Fish metrics that respond to eutrophication stress in County Ditch 13 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
13MN025 (2013)	**0.6**	**0**	32.4	**84.1**	**10**	**0**
Southern Headwaters Average	*7.9*	*11.5*	*31.5*	*72.8*	*11.5*	*1.6*
Expected response to stress	↓	↓	↓	↑	↓	↓

Eutrophication is inconclusive due to the limited secondary response data (Chl-a, BOD, DO Flux). Both biological communities were suggestive of eutrophic stress. However, it is feasible another stressor is displacing these communities. Phosphorus is clearly high within this reach, and should be reduced to reduce downstream impacts.

Nitrate

Nitrate concentration during fish sampling on July 9, 2013 at station 13MN025 was 13 mg/L. Additional samples were collected in 2009, 2010, and 2015, ranging from 0.51 mg/L – 18.1 mg/L (average of 7.4 mg/L). Forty-three samples were collected, and 14 (33%) were above 10 mg/L. Elevated concentrations were observed in all years and various months. Samples were collected from station S005-624.

Taxa richness of Trichoptera (TrichopteraCh) and relative abundance of non-hydropsychid Trichoptera individuals (TrichwoHydroPct) were below the statewide average of stations meeting the MIBI threshold (Table 148). There were zero nitrate intolerant taxa, and thirteen nitrate tolerant taxa comprising 26% of the community. The macroinvertebrate nitrate index score was better than average. The macroinvertebrate metrics provide a mixed response, and there is not a strong signal of nitrate stress.

Table 148. Macroinvertebrate metrics that respond to nitrate stress in County Ditch 13 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN025 (2013)	**4**	**1.3**	2.8	**0**	13	25.5
Southern Streams Average	*6.3*	*5.5*	*2.9*	*2.4*	*18.8*	*47.2*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is inconclusive as a stressor. There was a strong sample set to evaluate nitrate that did show to be a problem. Upon evaluation of the macroinvertebrate community, the sample did not seem to be specifically responding negatively to high nitrate concentrations. There were a high number of Simulium (black fly larva) that are not overly tolerant of nitrate, therefore this cannot explain their dominance of the community and there is likely another stressor limiting this community.

Total Suspended Solids

Total suspended solids (TSS) concentration during fish sampling on July 9, 2013 at station 13MN025 was 4.8 mg/L. Additional samples collected in 2009, 2010, and 2015 ranged from 2 mg/L – 286 mg/L (average of 15.2 mg/L). Out of the 42 samples collected only two (5%) were above the warmwater standard for the South Region of 65 mg/L. Samples were collected at station S005-624; both exceedances were in March 2010.

The relative abundance of collector-filterer individuals (Collector-filtererPct) was well above the statewide average of stations meeting the MIBI threshold, and relative abundance of Plecoptera individuals (PlecopteraPct) was below average (Table 149). There was one TSS intolerant taxa comprising 0% of the community, and eight TSS tolerant taxa comprising 19% of the community. The TSS index score was better than average. Overall, the macroinvertebrate metrics provide a mixed response, but there does not appear to be a strong indication of TSS stress.

Table 149. Macroinvertebrate metrics that respond to high TSS stress in County Ditch 13 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN025 (2013)	67.2	**0**	13.80	**1**	**0.3**	8	18.5
Southern Streams Average	*25.4*	*0.7*	15.63	2.9	4.7	12.2	34.5
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

All of the fish metrics with strong relationships to TSS were below the statewide average of stations meeting the FIBI threshold (Table 150). The relative abundance of individuals that are non-tolerant Centrarchidae (Centr-TolPct), relative abundance of individuals that are intolerant species (IntolerantPct), relative abundance of individuals that are long-lived (LLvdPct), relative abundance of individuals of the Order Perciformes excluding tolerant individuals (Percfm-TolPct), and relative abundance of individuals that are simple lithophilic spawners (SLithFrimPct) were all zero percent of the community. There were zero TSS sensitive taxa, and one TSS tolerant taxa comprising 1% of the community (Table 151). The fish TSS index score was worse than average and the probability of the reach meeting the TSS standard based on the fish community was 42%. A majority of the fish metrics were worse than average and suggestive of stress.

Table 150. Fish metrics that respond to high TSS stress in County Ditch 13 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
13MN025 (2013)	**0.6**	**0**	**1.1**	**0**	**0**	**0**	**1.1**	**0.6**	**0**
Southern Headwaters Average	*35.0*	*1.0*	*22.4*	*1.6*	*4.5*	*13.6*	*26.2*	*7.9*	*14.6*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 151. Fish metrics that respond to high TSS stress in County Ditch 13 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TSS Index Score	TSS Sensitive Taxa	TSS Sensitive Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN025 (2013)	**19.0**	**0**	**0**	**1**	0.6
Southern Headwaters Average	*15.4*	*0.9*	*4.1*	*0.4*	*2.0*
Expected response to stress	↑	↓	↓	↑	↑

TSS is inconclusive. There are few exceedances of TSS during the times of sample. There was a large dataset to assess TSS concentrations, with only a few going above the standard, likely following rain events. There is not much to chemistry wise to suggest TSS is a chronic issue within the stream, although with one of the highest readings reveal that concentrations of that magnitude could temporarily displace the biology. The fish community is indicative of TSS displacement. However, the macroinvertebrates that would be impacted most by chronic TSS conditions are thriving, particularly noted within the filter feeders.

Habitat

The MSHA score notes on July 9, 2013 was fair with a score of 60.9. Driving down the score was poor riparian, due to being row cropped. Stream instability is also suspect as there was heavy bank erosion noted (Figure 161). Available cover types included deep pools, logs or woody debris, boulders, and macrophytes. The station was 15% pool, 20% riffle, and 65% run, providing fair habitat diversity. Figure 162 illustrates some of the streams positive attributes, such as clean substrate as well as overhanging vegetation.

Figure 161. Percentage of MSHA subcategory scores for station 13MN025, County Ditch 13.

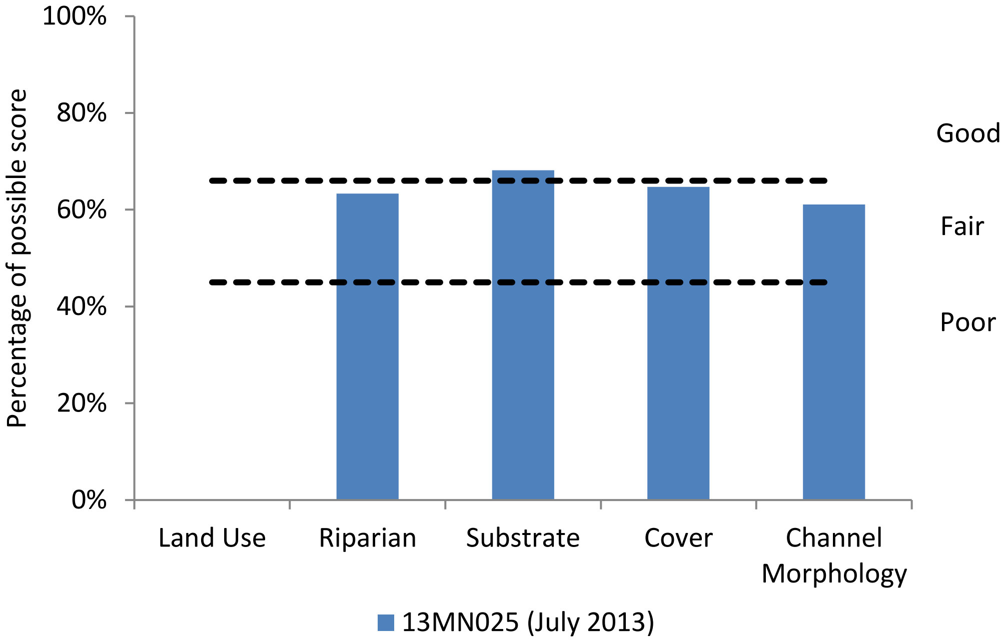
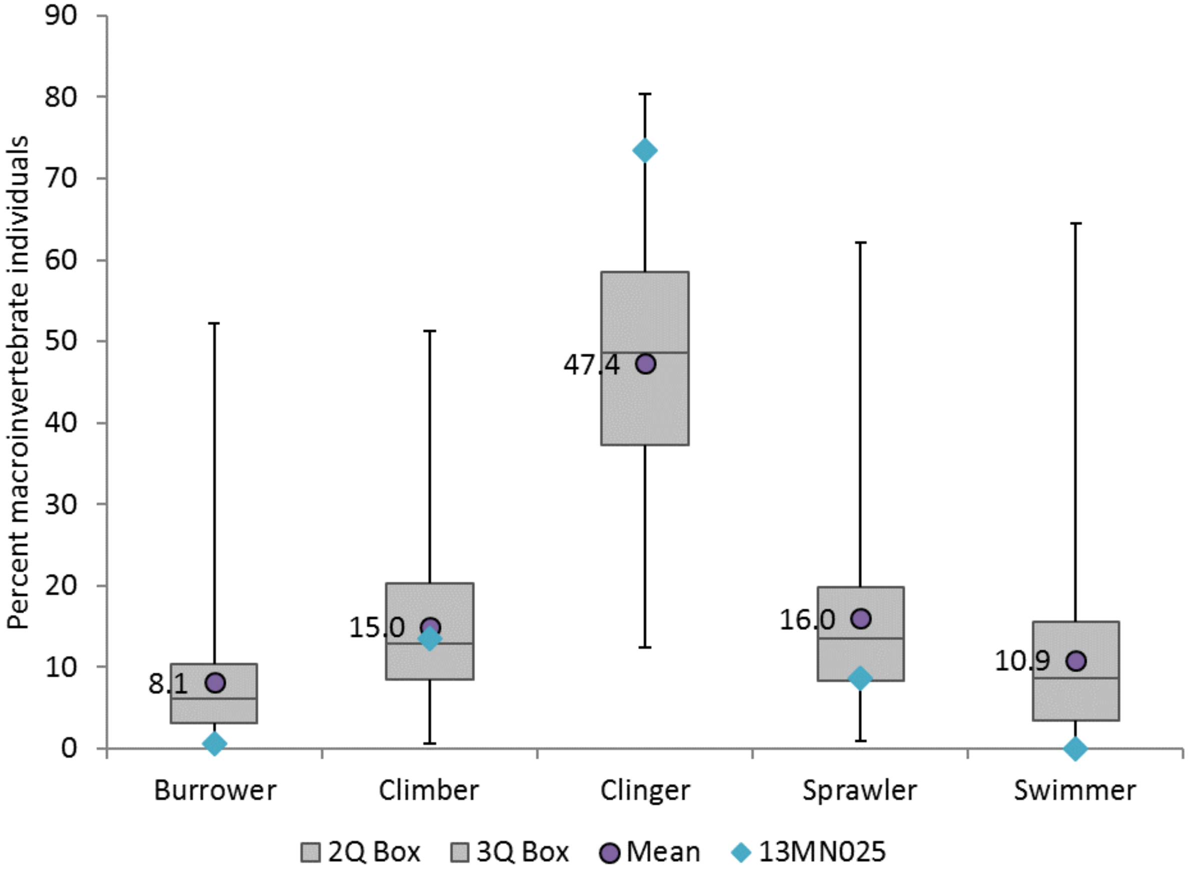


Figure 162. Station 13MN025 on July 9, 2013.

Burrowers and sprawlers, and swimmers were below average, and clingers were above average (Figure 163). The elevated clingers are atypical of habitat stress; clingers attach to rock or woody debris, and are expected to decrease with stress. The climber MIBI metric score was below the average metric score needed to meet the MIBI threshold, and the clinger MIBI metric score was above average. Black flies (Simulium) dominated the community. Indicator values for suspended sediment and fine substrates for Simulium, developed by Carlisle et al (2007), are five and seven respectively. The scoring system is based on a scale from 1 – 10, with ten being the most tolerant. Overall, the macroinvertebrates community did not indicate they are stressed by habitat.

Figure 163. Macroinvertebrate metrics that respond to habitat for station 13MN025, CD 13 compared to the range of values for Southern Streams RR visits meeting the general use biocriteria.



As displayed in previous TSS section, the relative abundance of individuals that are riffle-dwelling species (RifflePct) was below average, and abundance of simple lithophilic spawners (SLithopPct) was just above average. These species require clean coarse substrate and riffles, and are expected to decrease with stress.

At the time of monitoring, the flow conditions were low, and noted to likely impact the riffle dwelling species. Likely, due to low flowing conditions the macroinvertebrate and fish community's potential was not reached and therefor this parameter is listed as inconclusive.

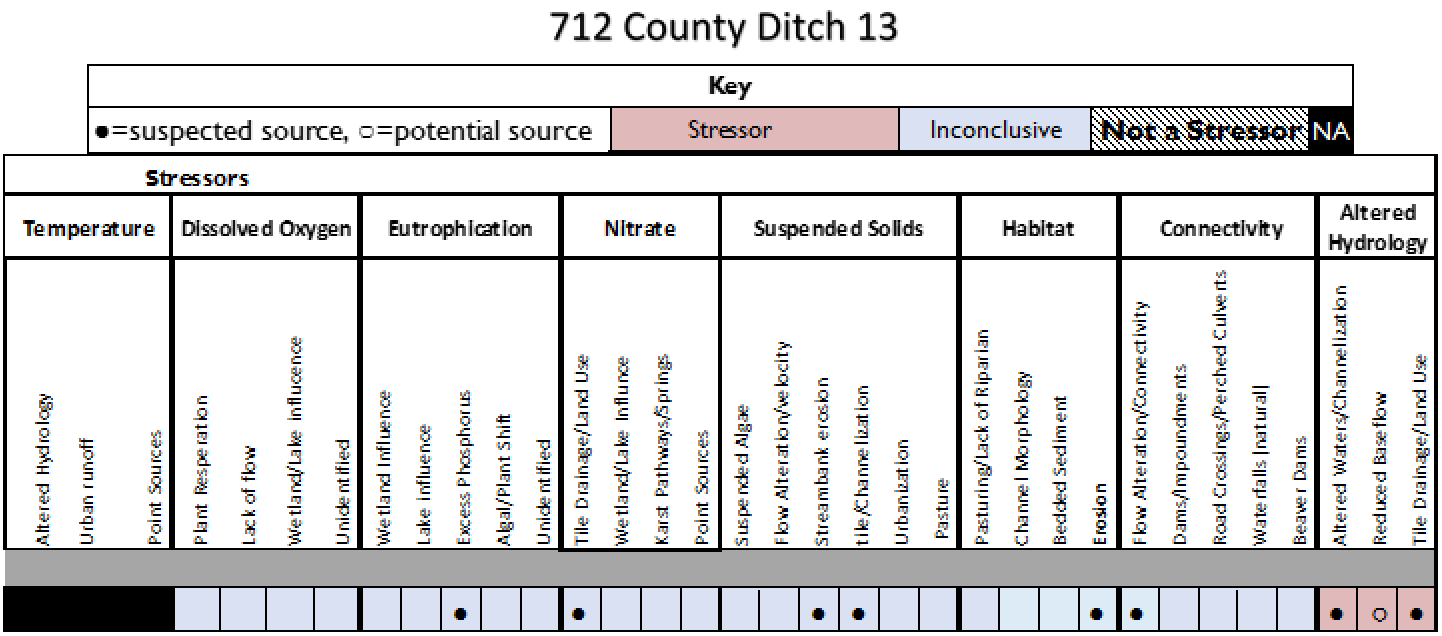
Longitudinal Connectivity and Altered Hydrology

Connectivity is inconclusive as a biological stressor at this time, as there were not any barriers identified at the time of biological monitoring or recon. There is a possibility of altered hydrology within this reach influencing low base flow.

Altered Hydrology is a stressor. While this reach is identified as a natural channel, the headwaters that feed into it are completely altered by way of channelization and subsurface tile drainage for agricultural purposes. For more information on how these land practices lead to altered hydrology, reference Chapter 3.1.8 of this report. While many parameters where listed as inconclusive, the sample size was limited do to erratic flows. The chemistry of the stream does show high potential for nitrates and eutrophication to be likely, however additional biological monitoring would be needed to clearly identify these are limiting the fish and macroinvertebrate community.

Summary Table

Table 152. Identified stressors with suspected sources for reach 712 of County Ditch 13.



712 County Ditch 13

Key				
●=suspected source, ○=potential source	Stressor	Inconclusive	Not a Stressor	NA

Stressors																																	
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake Influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls (natural)	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
									●			●						●	●						●	●					●	○	●

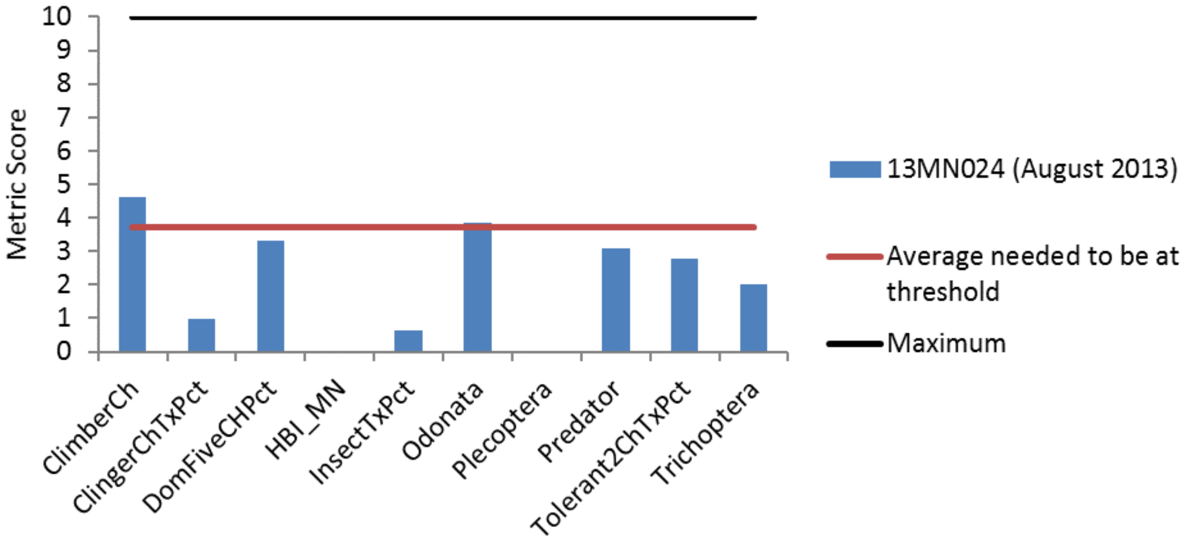
4.19 Spring Creek (Judicial Ditch 29) (07020007-622)

Spring Creek (07020007-622) is the upstream most reach on Spring Creek, northeast of Evan, Minnesota. The reach is general use Class 2B. The reach extends miles from approximately CR 8 to T111 R33W S23, east line (downstream of 300th St). The reach is impaired for lack of macroinvertebrate assemblage and lack of fish assemblage.

4.19.1 Biological Communities

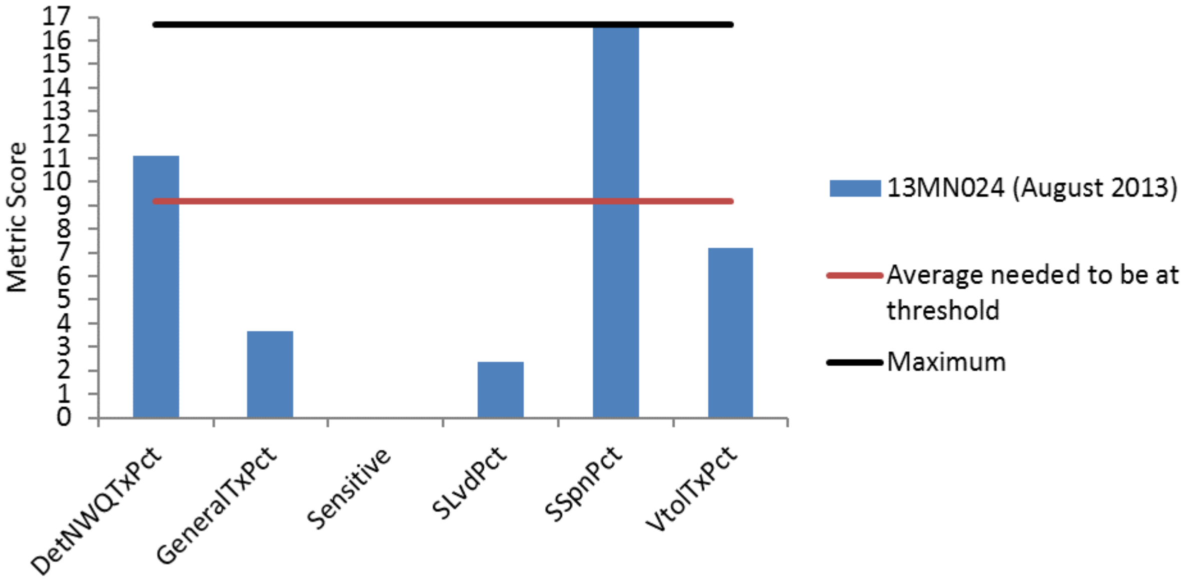
Station 13MN024 was sampled in 2013 for fish and macroinvertebrates. The macroinvertebrate community scored (21.3) below the general use threshold of 37 for the Southern Streams RR class. The community was dominated by snails (Physa). Nearly all the IBI metrics were less than the average metric score needed to obtain an IBI score at the general use threshold (Figure 164).

Figure 164. Macroinvertebrate metrics of the Southern Streams RR class IBI for station 13MN024, Spring Creek.



The fish community had an IBI score (40.9) below the Southern Headwaters class general use threshold of 55. Four of the six IBI metrics were lower than the average metric score needed to obtain an IBI score at the general use threshold (Figure 165). Blacknose dace dominated the community.

Figure 165. Fish metrics of the Southern Headwaters class IBI for station 13Mn024, Spring Creek.



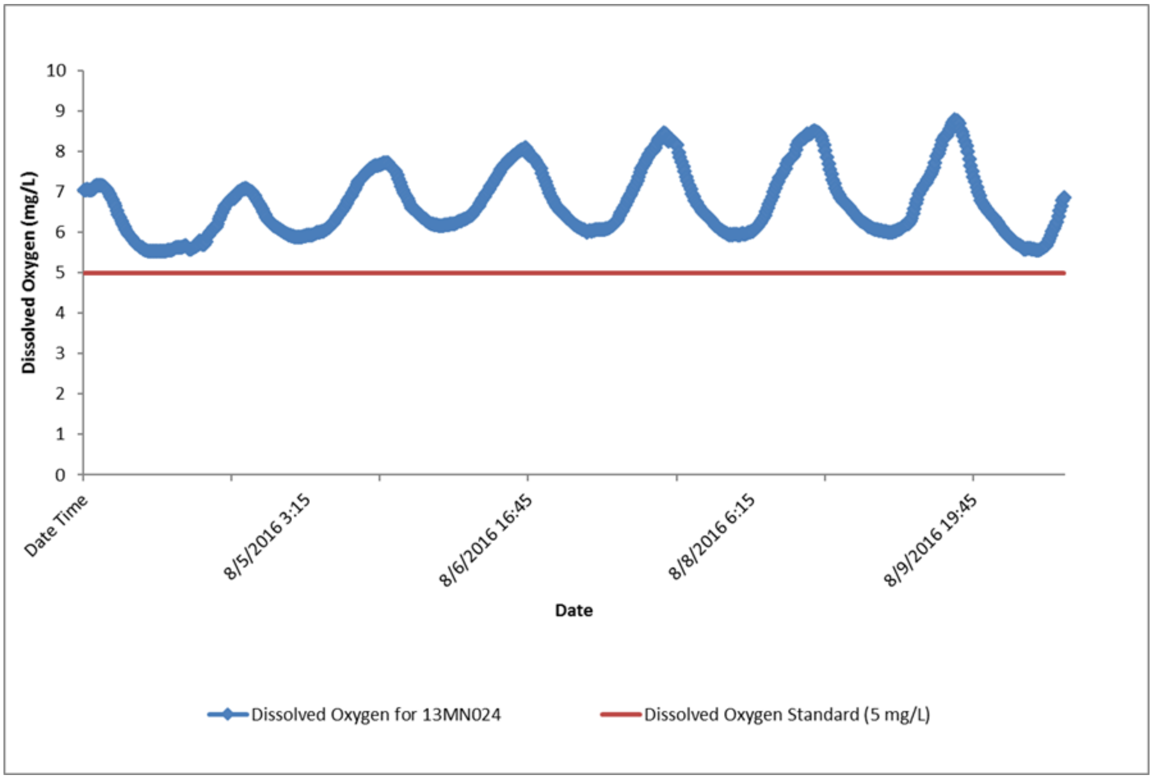
4.19.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

Dissolved oxygen (DO) concentrations during biological sampling on June 12, 2013, August 12, 2013, and August 15, 2013 at station 13MN024 was 3.8 mg/L (Taken at 9:15am), 14.8 mg/L, and 9.2 mg/L respectively. Additional samples collected in 2009, 2010, and 2016 ranged from 4.0 mg/L – 13.5 mg/L (average of 8.8 mg/L). Forty-two samples were collected, with only one below the warmwater standard of 5 mg/L. The low DO reading occurred on the afternoon of September 25,
10; samples were collected at station S005-689. No early morning readings were collected.

In 2016, a sonde was deployed from August 4 through August 9 at station 13MN024. During that time frame, concentrations ranged from 5.53 mg/L – 8.78 mg/L (Figure 166). There were zero violations of the standard, and daily DO flux was minimal with a 2-3 mg/L swing in concentrations.

Figure 166. Continuous DO data at monitoring location 13MN024, from August 4, 2016 to August 10, 2016.



All of the macroinvertebrate metrics were worse than the statewide average of stations meeting the MIBI threshold (Table 153). The macroinvertebrate DO index score was below average; as this score decreases, so does the sensitivity of the community. There was one DO intolerant taxa comprising 1% of the community, and twelve DO tolerant taxa comprising 19% of the community. Taxa richness of Ephemeroptera, Plecoptera and Trichoptera (EPTCh), a measure of pollution based on tolerance values assigned to each individual taxon developed by Chirhart (HBI_MN), and total taxa richness (TaxaCountAllChir) were worse than average. The macroinvertebrate metrics are indicative of low DO stress.

Table 153. Macroinvertebrate metrics that respond to low DO stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN024 (2013)	**31**	**6**	**8.6**	**6.4**	**1**	**0.7**	**12**	**18.7**
Southern Streams Average	*45.8*	*14.2*	*7.1*	*7.0*	*9.0*	*24.0*	*4.8*	*9.9*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

A majority of the fish metrics were worse than the statewide average of stations meeting the FIBI threshold (Table 154). Relative abundance of sensitive individuals (SensitivePct) and individuals with a female mature age greater than three years (MA>3Pct) were zero, and tolerant individuals (TolPct) comprised 99% of the community. There were zero DO sensitive taxa, and one DO tolerant taxa comprising 1% of the community. The fish DO index score was above average.

Table 154. Fish metrics that respond to low DO stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
13MN024 (2013)	**0**	**0.0**	**99.2**	7.8	**0**	**0.0**	1	0.5
Southern Headwaters Average	*7.9*	*13.9*	*72.8*	*7.1*	*0.8*	*4.2*	*3.4*	*20.2*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

DO is inconclusive as a stressor until additional data can be collected. There were minimal DO exceedances and the sonde deployment showed good oxygen values, however this deployment occurred after a large rain event. As discussed under eutrophication (below), there was evidence of algae overgrowth occurring within this stream. In systems like this, low DO is often driven by eutrophication due to excessive plant respiration that will be noted in early morning readings. As monitoring took place after a substantial event that could have flushed the system as well as add aeration to the stream, there is enough uncertainty to withhold a determination on low DO impacts to the biology of this reach. Additionally, the macroinvertebrates were suggesting low DO stress, but the fish were mixed in their response. Low DO is a possibility, future monitoring is recommended.

Eutrophication

Total phosphorus (TP) concentrations during fish sampling on June 12, 2013, August 12, 2013 at station 13MN024 were 0.1 mg/L and 0.344 mg/L respectively. Twenty-two additional samples were collected in 2009, 2010, and 2016, ranging from 0.026 mg/L – 0.541 mg/L (average of 0.240 mg/L). Of these twenty-two samples, thirteen (59%) were above the river eutrophication standard for the South Region (0.150 mg/L). Exceedances occurred in July (three), August (six), and September (four) in 2009, 2010, and 2016. All samples were collected at station S005-689.

Chl-a, BOD, and DO flux are also considered when evaluating eutrophication stress. Twenty-one chl-a samples were collected in 2009 and 2010 at station S005-689, ranging from 1 µg/L – 249 µg/L (average of 18.4 µg/L). There were two exceedances of the standard (35 µg/L) in August 2010 (71.9 µg/L and 249 µg/L). At this time, there have been zero BOD samples collected. Low DO has been documented in this AUID, but there is minimal DO flux (2-3 mg/L) during sonde deployment.

All of the macroinvertebrate metrics were worse than the statewide average of stations meeting the MIBI threshold (Table 155). There were zero intolerant taxa (Intolerant2Ch), and a high percentage of tolerant taxa (Tolerant2ChTxPct). Taxa richness of collector-filterers (Collector-filtererCh), collector-gatherers (Collector-gathererCh), and Ephemeroptera, Plecoptera, and Trichoptera (EPT) were below average.

Table 155. Macroinvertebrate metrics that respond to eutrophication stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN024 (2013)	**31**	**2**	**9**	**6**	**0**	**80.6**
Southern Streams Average	*45.8*	*7.3*	*15.9*	*12.2*	*0.8*	*72.6*
Expected response to stress	↓	↓	↓	↓	↓	↑

A majority of the fish metrics were worse than the statewide average of stations meeting the FIBI threshold (Table 156). Sensitive individuals (SensitivePct), abundance of darter species (DarterPct), and intolerant individuals (IntolerantPct) were all zero. Tolerant individuals (TolPct) comprised 99% of the fish community. Abundance of simple lithophilic spawners (SLithopPct) was well above average, comprising 85% of the community.

Table 156. Fish metrics that respond to eutrophication stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
13MN024 (2013)	**0**	**0**	84.8	**99.2**	**6**	**0**
Southern Headwaters Average	*7.9*	*11.5*	*31.5*	*72.8*	*11.5*	*1.6*
Expected response to stress	↓	↓	↓	↑	↓	↓

Eutrophication is inconclusive. Phosphorus loading is clearly high, and should be reduced. However, secondary responses to validate eutrophic response is lacking. Biological metrics suggest low DO stress in both the fish and macroinvertebrate communities. Most of the site visits resulted in photo documentation of over-growth of algae. However, there was some filamentous floating algae notes at the time of August 12, 2013. The two high chl-a samples also indicate that overgrowth of algae does occur. Additional monitoring should take place to determine how common of an occurrence this is for JD 29.

Nitrate

Nitrate concentration during fish sampling on June 12, 2013, August 12, 2013 at station 13MN024 was 2.8 mg/L and 0.05 mg/L respectively. Additional samples were collected in 2009, 2010, and 2016, ranging from 0.2 mg/L – 17.6 mg/L (average of 6.7 mg/L). Twenty-two samples were collected, and eight (36%) were above 10 mg/L. Elevated concentrations were observed in all years and various months. Samples were collected from station S005-689.

Taxa richness of Trichoptera (TrichopteraCh) and relative abundance of non-hydropsychid Trichoptera individuals (TrichwoHydroPct) were below the statewide average of stations meeting the MIBI threshold (Table 157). There was one nitrate intolerant taxa, and seventeen nitrate tolerant taxa comprising

78% of the community. The macroinvertebrate nitrate index score was worse than average. A majority of the macroinvertebrate metrics were worse than average and indicative of nitrate stress.

Table 157. Macroinvertebrate metrics that respond to nitrate stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN024 (2013)	**4**	**4.9**	**4.5**	**1**	17	**78.0**
Southern Streams Average	*6.3*	*5.5*	*2.9*	*2.4*	*18.8*	*47.2*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is a stressor. Metrics suggest a negative response in the macroinvertebrate community. Nitrate concentrations were also found to be above the threshold of 10 mg/L often.

Total Suspended Solids

The total suspended solids (TSS) concentration during fish sampling on June 12, 2013, August 12, 2013 at station 13MN024 was 2.4 mg/L and 5.2 mg/L respectively. One additional sample was collected on August 10, 2016 (51 mg/L) at station S005-689. There were zero exceedances of the warmwater standard for the South Region of 65 mg/L.

The relative abundance of collector-filterer individuals (Collector-filtererPct) and relative abundance of Plecoptera individuals (PlecopteraPct) were worse than the statewide average of stations meeting the MIBI threshold (Table 158). There were zero TSS intolerant taxa, and nine TSS tolerant taxa comprising 45% of the community. The macroinvertebrate TSS index score was better than average, but overall, a majority of the macroinvertebrate metrics were worse than average.

Table 158. Macroinvertebrate metrics that respond to high TSS stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN024 (2013)	**6.6**	**0**	15.14	**0**	**0**	9	**44.6**
Southern Streams Average	*25.4*	*0.7*	15.63	2.9	4.7	12.2	34.5
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

All of the fish metrics with strong relationships to TSS were below the statewide average of stations meeting the FIBI threshold (Table 141). The relative abundance of individuals that are non-tolerant

Centrarchidae (Centr-TolPct), relative abundance of individuals that are intolerant species (IntolerantPct), relative abundance of individuals that are long-lived (LLvdPct), relative abundance of individuals of the Order Perciformes excluding tolerant individuals (Percfm-TolPct), relative abundance of individuals that are sensitive species (SensitivePct), and relative abundance of individuals that are simple lithophilic spawners (SLithFrimPct) were all zero percent of the community. There were zero TSS sensitive taxa, and zero TSS tolerant taxa (Table 159). The fish TSS index score was better than average. Overall, a majority of the fish metrics were worse than average, but it's possible they are being affected by a different stressor as the TSS index score, TSS tolerant percent, and probability of meeting the TSS standard all scored well.

Table 159. Fish metrics that respond to high TSS stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
13MN024 (2013)	**2.6**	**0**	**2.6**	**0**	**0**	**0**	**2.6**	**0**	**0**
Southern Headwaters Average	*35.0*	*1.0*	*22.4*	*1.6*	*4.5*	*13.6*	*26.2*	*7.9*	*14.6*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 160. Fish metrics that respond to high TSS stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TSS Index Score	TSS Sensitive Taxa	TSS Sensitive Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN024 (2013)	11.6	**0**	**0**	0	0
Southern Headwaters Average	*15.4*	*0.9*	*4.1*	*0.4*	*2.0*
Expected response to stress	↑	↓	↓	↑	↑

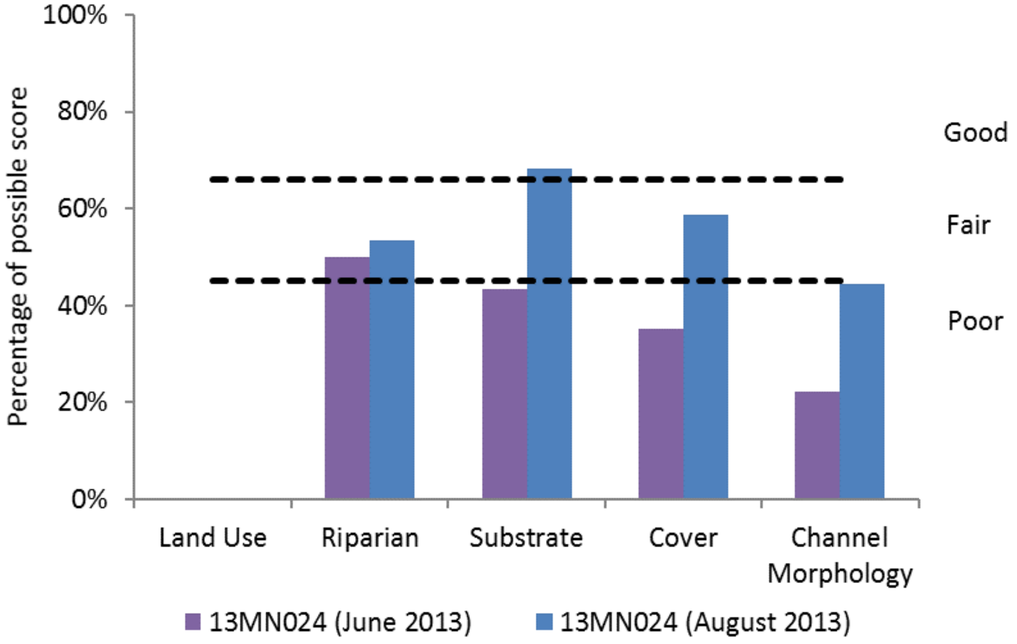
TSS is inconclusive as a stressor. This is largely based on the lack of samples collected to understand TSS loading within this reach. Metrics are suggestive of TSS displacement in both invert and the fish community.

Habitat

As shown in Figure 167, the MSHA categories improved slightly from June to August, yes still followed the same trend regarding habitat degradation. Surrounding land use was the largest negative impact to the overall score, being agricultural row crops. The riparian width of this stream ranges from wide to extensive, yet the canopy cover is moderate and only provides some shade and refuge. The channel morphology of this stream is unstable, with little creating erosive banks and lacking in habitat diversity.

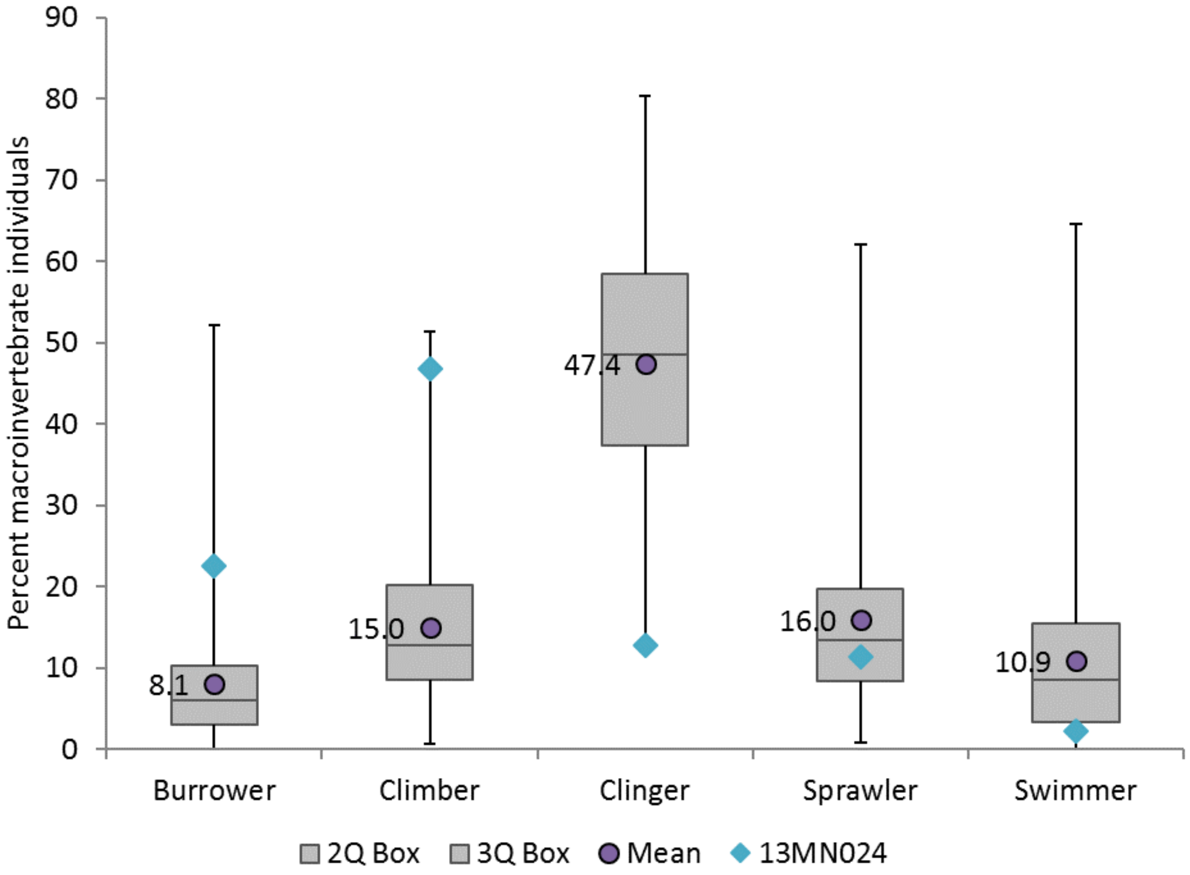
There were no identifiable pool or riffle features in wither assessment. There were multiple substrate types noted, yet there was also some embeddedness noted, ranging from sever to light.

Figure 167. Percentage of MSHA subcategory scores for station 13MN024, Spring Creek



Burrowers and climbers were above average, and clingers, sprawlers, and swimmers were below average (Figure 168). The elevated burrowers and reduced clingers are symptoms of habitat stress, but the elevated climbers are uncharacteristic of habitat stress. The climber MIBI metric score was above the average metric score needed to meet the MIBI threshold, but the clinger MIBI metric score was below average.

Figure 168. Macroinvertebrate metrics that respond to habitat for station 13MN024, Spring Creek compared to the range of values for Southern Streams RR visits meeting the general use biocriteria.



As displayed in Table 161, the relative abundance of individuals that are riffle-dwelling species (RifflePct), simple lithophilic spawners (SLithopPct), Riffle dwellers, stone rollers (Centr-TolPct), and benthic feeders (BenFdFrimPct) were severely depleted if not all together absent from the sample. These species require clean coarse substrate and have specific habitat needs.

Table 161. Fish metrics that respond to high TSS and habitat stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
13MN024 (2013)	**2.6**	**0**	**2.6**	**0**	**0**	**0**	**2.6**	**0**	**0**
Southern Headwaters Average	*35.0*	*1.0*	*22.4*	*1.6*	*4.5*	*13.6*	*26.2*	*7.9*	*14.6*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Figure 169. Station 13MN024 taken on August 12, 2013.

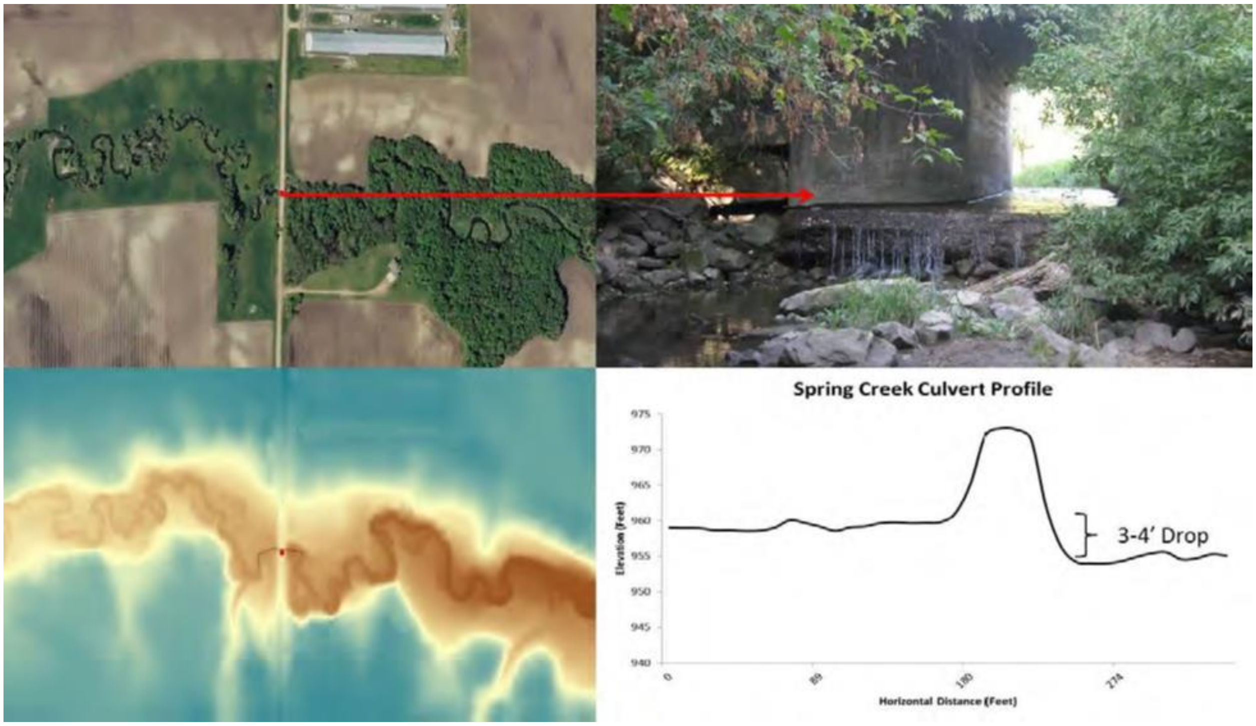
Habitat is a stressor. There is poor habitat diversity noted in the MSHA scores. As is also evident in the above photograph of station 13MN024 (Figure 169), were shade is sparse, and the stream is homogenous. Both the fish and macroinvertebrate community composition displays an absents of groups that have specific habitat needs. Additional information on the stream stability study will be provided in the next section. The instability of this stream is a large contributing factor to the impaired habitat conditions.

Longitudinal Connectivity and Altered Hydrology

Connectivity and altered hydrology are both identified as biological stressors within this reach.

At the time of biological monitoring, downstream on Spring Creek there was a perched culvert as well as beaver dam that has been noted to create impoundment issues. See Figure 170 for the location summary image provided by the DNR on this barrier.

Figure 170. Spatial location of perched culvert on Spring Creek prior to the 2015 restoration project (DNR 2015).



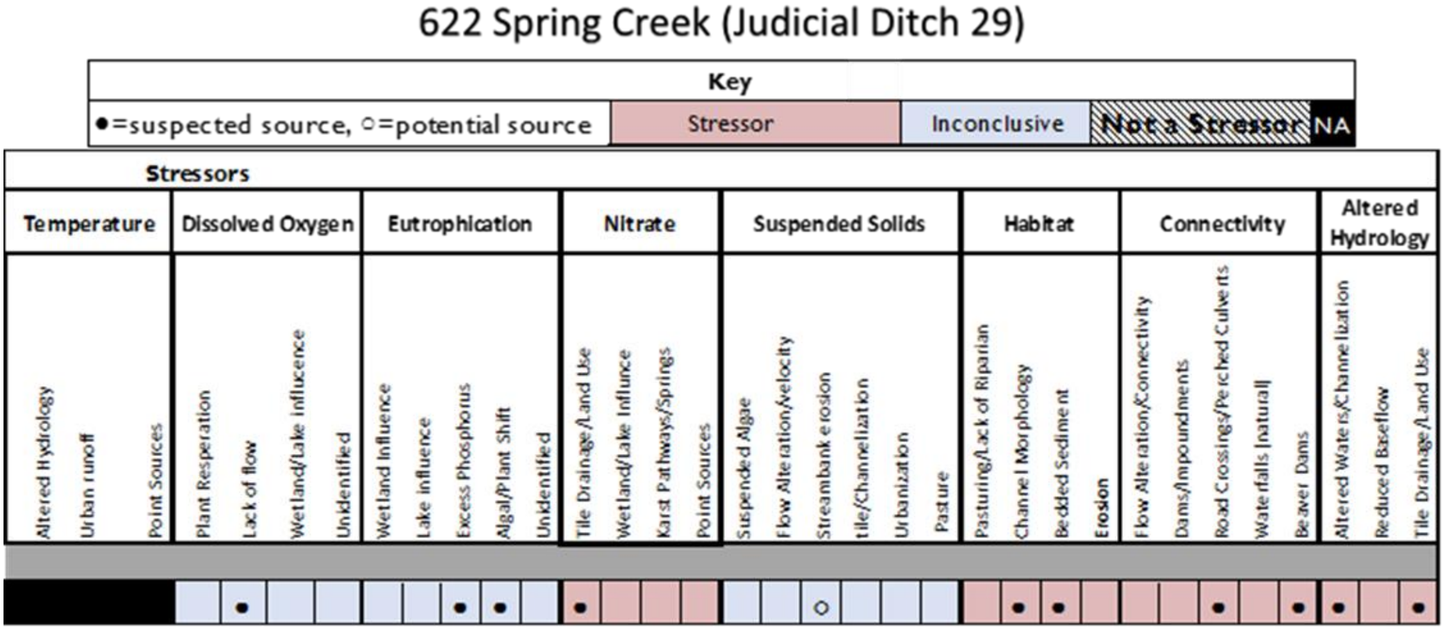
For more information on the perched culvert and beaver dam, please see DNR's Minnesota River, Mankato Watershed Characterization Report (2015). In 2013, station 13MN024 had six species surveyed. Downstream of the culvert and beaver dam, in 2010, station 91MN055 had 13 fish species. At station 13MN090, in 2013, there were 11 fish species surveyed. There are no upstream lakes to replenish this section of Spring Creek. With the reduced fish taxa richness, fish passage due to perched culvert and potentially the beaver dam is a stressor to the fish community. Sense the last fish survey, a respiration projects was conducted to allow for fish passage that may have eliminated this stressor.

This reach is the final stretch of channelized stream. This section and all upstream portions have been completely altered to meet agricultural land use, primarily seen in ditching and channelizing the stream and well and the introduction of subsurface tile drainage to the stream. For more information on how these specific practices influence hydrology in this watershed, reference Chapter 3.1.8 of this report.

This site was established as a geomorphology assessment site by the DNR. The overall findings of this reach found that this reach is not stable, as noted in the erosive bank measurements as well as the stream actively becoming incised, and with that losing connection with its floodplain. Erosions rates in one year of a stream bank measured to be a loss of .638, 'greatly exceeding the predicted erosion rate of .25' a year DNR 2015. The DNR recommends for this historically channelized stream to return to its flood plain and meander pattern by forming a natural two-stage channel (DNR 2015). Withholding from dredging or clean outs is critical for this headwater stream to stabilize and recreate habitat.

Summary Table

Table 162. Identified stressors with suspected sources for reach 622 of Spring Creek.



622 Spring Creek (Judicial Ditch 29)

Key

●=suspected source, ○=potential source | Stressor | Inconclusive | Not a Stressor | NA

Stressors																																			
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
				●					●	●		●						○					●	●				●		●	●		●

4.20 Spring Creek (Hindeman Creek) (07020007-574)

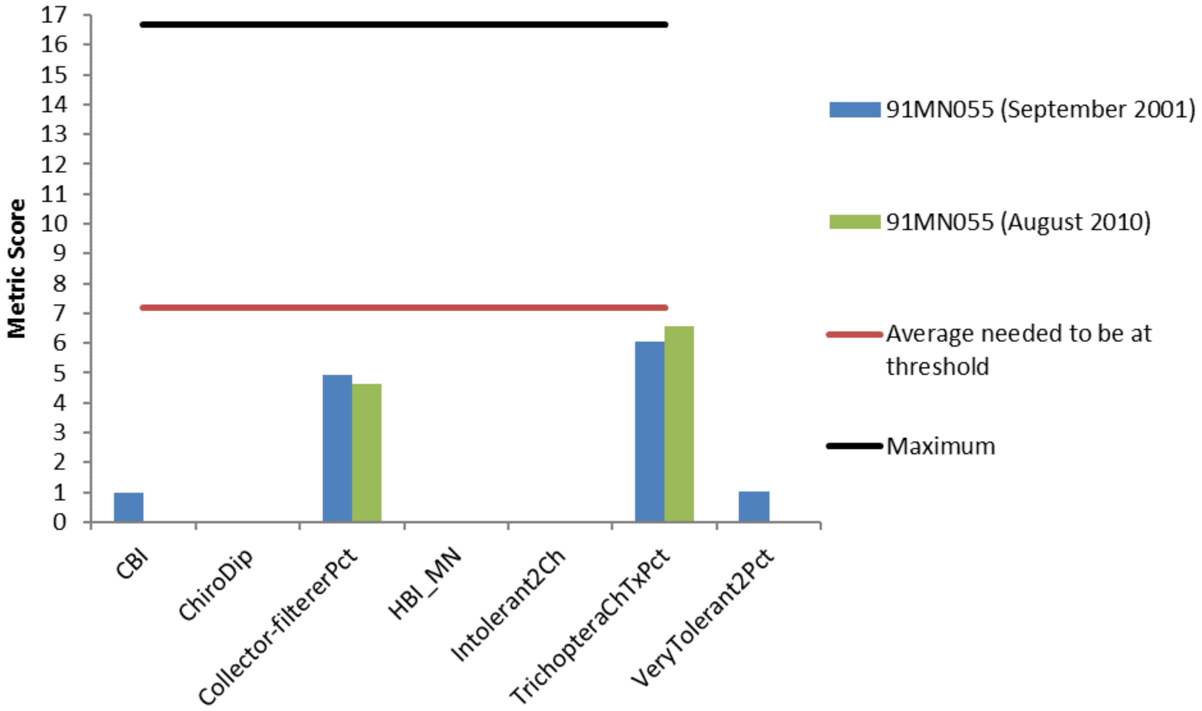
Spring Creek, otherwise known as Hindeman Creek (07020007-574) is the middle reach on Spring Creek, northeast of Evan, Minnesota. The reach is coldwater general use Class 2A. The reach extends miles from approximately T111 R33W S24, west line (downstream of 300th St) to T111 R32W S20, east line (downstream of Golden Gate Rd). The reach is impaired for lack of macroinvertebrate assemblage and lack of fish assemblage.

4.20.1 Biological Communities

Both macroinvertebrate samples at 91MN055 fell significantly below the Southern Coldwater threshold of 43 (Figure 171). The macroinvertebrate sample on September 18, 2001 scored 23.2 with Physa (snails) dominating to population. In the August 16, 2010, the score fell down to 13 out of 43. The dominate taxa was Cricotopus (Non-biting midge). This non-biting midge is known to be extremely tolerant to heavy polluted environments and will thrive in heavily degraded waters; whereas in a balanced system they typically only make up a fraction of the overall community (Boesel 1983).

There were very few coldwater species (CBI), Chironomidae and Diptera (ChiroDip) were absent as were intolerant taxa (Intolerant2Ch) with very tolerant taxa (veryTolerant2Pct) in place, as noted in the figure below.

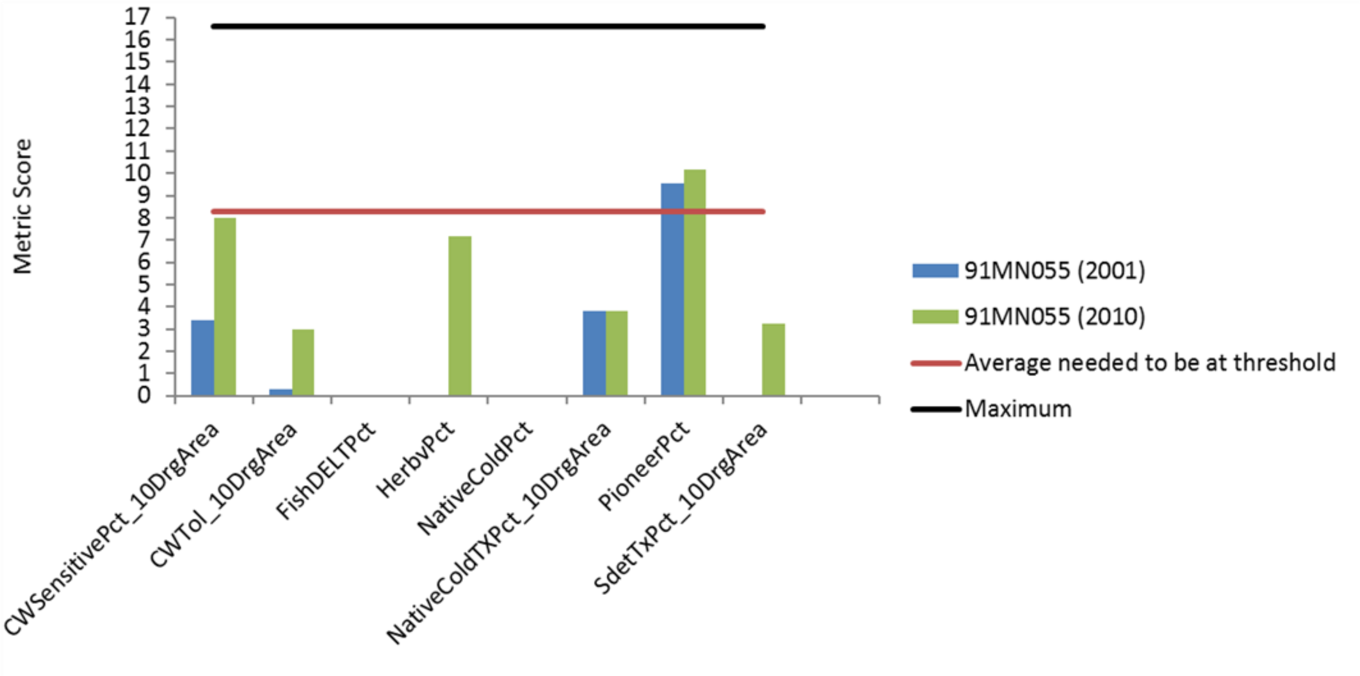
Figure 171. Macroinvertebrate metrics of the Southern Coldwater Streams class for stations 91MN055 (2001) and 91MN055 (2010), Spring Creek (Hindeman Creek).



Fish sampling occurred twice on Hindeman Creek (monitoring station 91MN055). In both years, the fish IBI score was significantly below the southern coldwater streams threshold of 50, scoring 17 in 2001 and 30 in 2010. Spring Creek is currently managed as a put-and-take trout stream, stocked annually for brown and rainbow trout since 2006. It was designated as a trout stream in 1952 and received various numbers of Brown Trout yearlings or occasionally adults, from 1952 to 2005. A separate DNR fisheries fish survey did find one trout in 2003 that was thought to be the product of natural reproduction. There is little else to indicate the trout stocked in Spring Creek thrive, as trout were not found in either MPCA survey for this reach or the downstream reach (-573).

As shown in Figure 172, the fish survey in 2010 was slightly better compared to the 2001 sample. However, both stations fell short for cold-water sensitive species (CWSensitivePct_10DrgArea), native cold-water species (NativeColdPct), and species that are detritus eaters. Herbivores met the threshold at both sites. Neither sample resulted in a score reduction for DELTS (FishDELTPct). Both site had pioneer species (typically slightly tolerant) as the dominate group.

Figure 172. Fish metrics of the Southern Coldwater Streams class for stations 91MN055 (2001) and 91MN055 (2010), Spring Creek (Hindeman Creek).



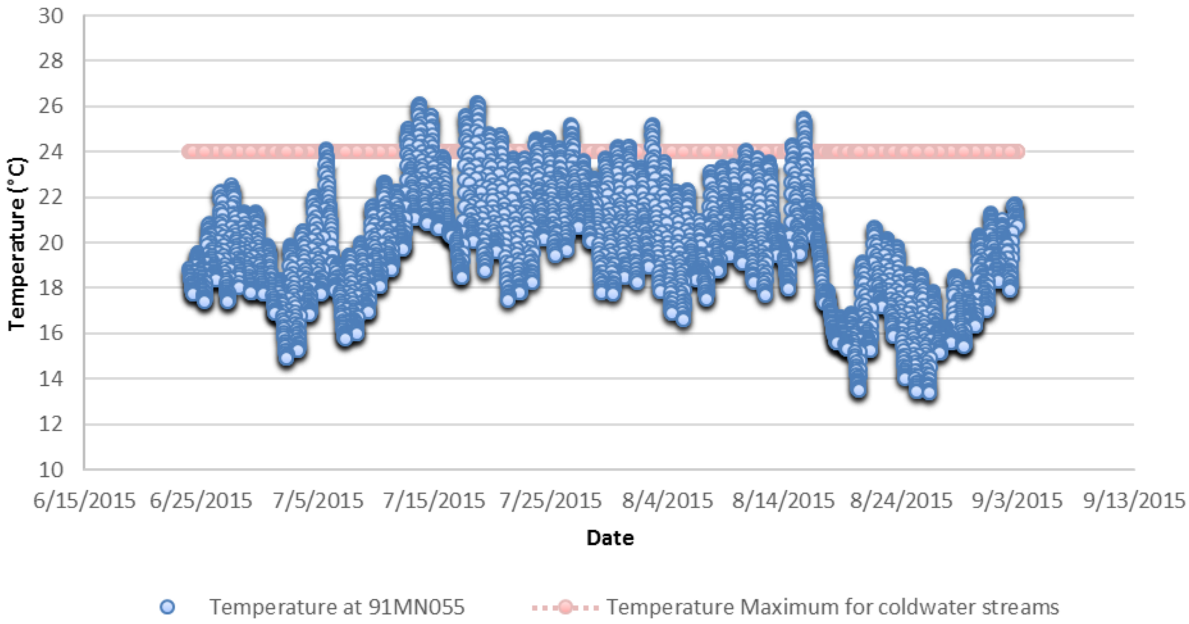
4.20.2 Data Evaluation for each Candidate Cause

During the fish sample, the water temperature was recorded at 23.2°C on July 30, 2001, and 26.2°C on August 9, 2010. There were two other point measurements taken on June 16, 2015 and on September 1, 2015 measuring 18.9°C and 20.19°C respectively.

In 2015, a temperature logger was put at 91MN055 from June through September, displayed in Figure 192. During that time frame, there were 18 days that exceeded 24 degrees for multiple hours at a time. The maximum temperature occurred in July, at 26 degrees. The temperature data shows some regular periods of time where temperature exceeds the critical temperature threshold for brown trout (24°C), but also shows a good amount of time above 18°C, the threat temperature for brown trout.

Temperature

Figure 173. Temperature data from 91MN055 from June through September 2015



There were no trout collected during the fish sample at 91MN055 in either year, which results in a zero score for coldwater fish individuals. There were some fantail darters sampled which are a coldwater sensitive species. However, it is still below the Southern Coldwater average for coldwater sensitive individuals (70.6%). Native coldwater species like Brook Trout were also lacking, resulting in a zero metric score. In addition, coldwater macroinvertebrates were almost absent during both visits (Table 163).

Table 163. Biological metrics that respond to temperature compared to the statewide average of visits meeting the Southern Coldwater biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	ColdPct (Fish)	CWSensitivePct (Fish)	NativeColdPct (Fish)	Coldwater Biotic Index (Macroinvertebrates)
91MN055 (2001)	**0**	**48.0**	**0**	**1.0**
91MN055 (2010)	**0**	**17.6**	**0**	**0**
Southern Coldwater Average	*66.4*	*70.6*	*30.3*	*7.70*
Expected response to stress	↓	↓	↓	↓

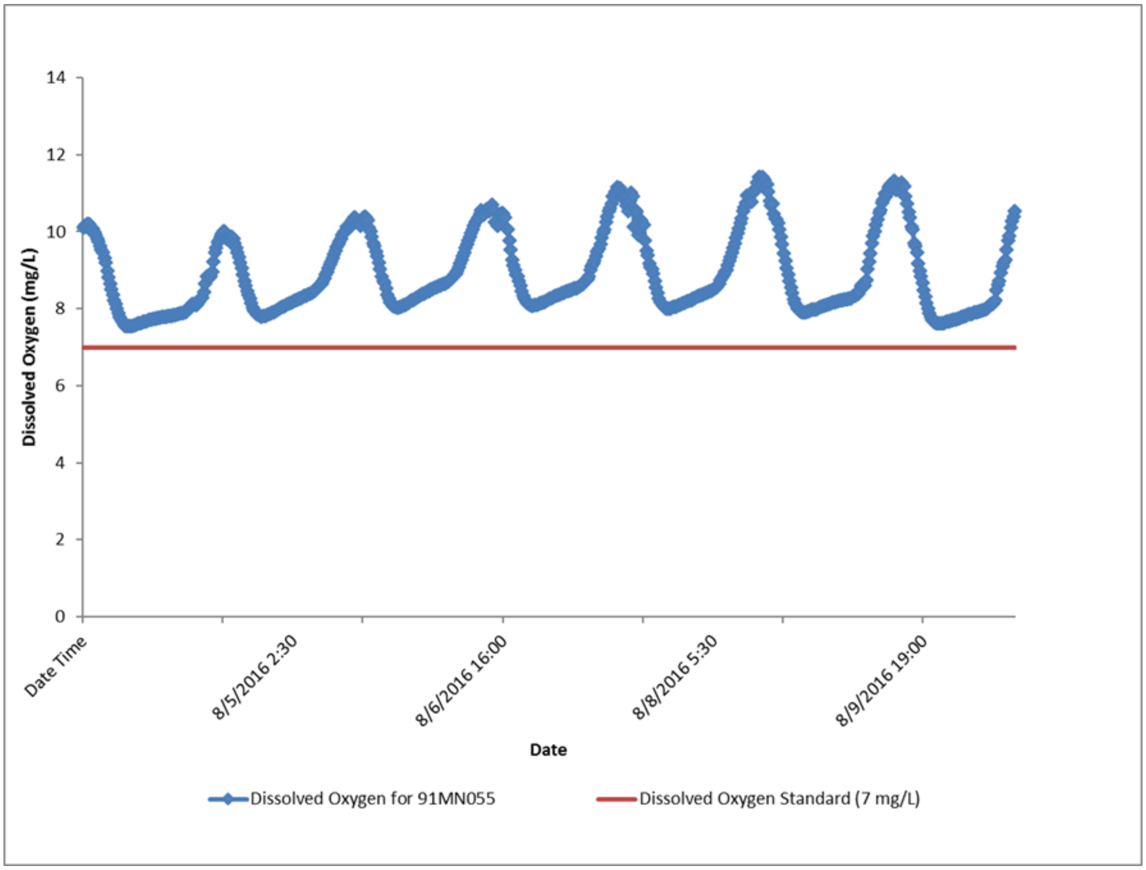
Temperature is considered a stressor on this coldwater community. Temperature reading found that often during summer months the temperature would exceed the coldwater threshold. In addition, that coldwater community metrics show that they are in decline. It is likely the fish metrics would be significantly worse if it was not for the intervention of trout management on this stream.

Dissolved Oxygen

The dissolved oxygen (DO) concentration during biological sampling on August 5, 2009, August 19, 2009, and August 9, 2010 at station 91MN055 was 12.1 mg/L, 9.1 mg/L, and 16.0 mg/L respectively. Additional samples collected in 2015 and 2016 ranged from 6.1 mg/L – 13.9 mg/L (average of 9.9 mg/L). Only 10 samples were collected, but one (10%) was below the cold-water standard of 7 mg/L. The low DO value occurred on June 20, 2016. Samples were collected at stations S008-547 and S009-152.

In 2016, an YSI sonde was deployed from August 3 through August 10 at station 91MN055. During that time frame, concentrations ranged from 7.5 mg/L – 11.4 mg/L (Figure 174). All values were above the cold-water standard, and daily DO flux was below the standard for the South Region of 4.5 mg/L of variation within a 24-hour period.

Figure 174. Continuous DO data at monitoring location 91MN055, from August 4, 2016 to August 10, 2016.



A majority of the macroinvertebrate metrics were worse than the statewide average of stations meeting the MIBI threshold (Table 164). The macroinvertebrate DO index score was below average both years; as this score decreases, so does the sensitivity of the community. There were 6 – 7 DO intolerant taxa comprising 9 – 23% of the community, and 3 – 5 DO tolerant taxa comprising 4 – 8% of the community. Taxa richness of Ephemeroptera, Plecoptera and Trichoptera (EPTCh) was the only metric to score better than average. A measure of pollution based on tolerance values assigned to each individual taxon developed by Chirhart (HBI_MN) and total taxa richness (TaxaCountAllChir) were worse than average. Overall, a majority of the macroinvertebrate metrics are suggestive of stress.

Table 164. Macroinvertebrate metrics that respond to low DO stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
91MN055 (2001)	**44**	11	**7.2**	**6.7**	**7**	**22.5**	**5**	**4.2**
91MN055 (2010)	**42**	10	**7.6**	**6.8**	**6**	**9.4**	**3**	**8.1**
Southern Coldwater Average	*30.8*	*8.1*	*6.4*	*7.5*	*10.4*	*56.6*	*1.8*	*1.3*
Expected response to stress	↑	↓	↑	↓	↓	↓	↑	↑

A majority of the fish metrics were worse than the statewide average of stations meeting the FIBI threshold (Table 165). Relative abundance of sensitive individuals (SensitivePct) and individuals with a female mature age greater than three years (MA>3Pct) were well below average, and tolerant individuals (TolPct) comprised 38 – 69% of the community. There was one DO sensitive taxa comprising 18 – 48% of the community, and 1 – 4 DO tolerant taxa comprising 1 – 3% of the community. The fish DO index scores were below average, and the probability of this reach meeting the DO standard based on the fish community was 72% (2001) and 89% (2010).

Table 165. Fish metrics that respond to low DO stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
91MN055 (2001)	**18.8**	**6.9**	**68.6**	**7.5**	**1**	**17.6**	1	0.8
91MN055 (2010)	**48.5**	**7.4**	**38.1**	**7.8**	**1**	**48.0**	**4**	3.0
Southern Coldwater Average	*71.7*	*74.6*	*24.0*	*8.9*	*2.5*	*72.4*	*1.1*	*6.8*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Due to the mixed results, DO is inconclusive. The continuous DO data was not suggestive that this system has a chronic issue with low DO. However, both invert and fish metrics fell below most of the expected averages, there was still some sensitive and low DO intolerant individuals found.

Eutrophication

Total phosphorus (TP) concentration during fish sampling on August 9, 2010 at station 91MN055 was 0.134 mg/L. Additional samples were collected in 2015 and 2016, ranging from 0.028 mg/L – 0.390 mg/L (average of 0.189 mg/L). Only six samples were collected, but three were above the river eutrophication standard for the South Region (0.150 mg/L). Exceedances occurred in 2016 in February (0.390 mg/L), June (0.364 mg/L), and August (0.160 mg/L). Samples were collected from station S008-547.

Chl-a, BOD, and DO flux are also considered when evaluating eutrophication stress. One chl-a sample was collected on September 1, 2015; this sample was well below the 35 µg/L standard (3.44 µg/L). At this time, there have been zero BOD samples collected. During sonde deployment in 2016, daily DO flux was below the standard for the South Region (4.5 mg/L). Minimal low DO has been documented in this. However, there is little data to correlate a relationship to overproduction of algae.

The macroinvertebrate metrics were mixed; half were worse than the statewide average of stations meeting the MIBI threshold and half were better (Table 166). There were zero intolerant taxa (Intolerant2Ch), and a high percentage of tolerant taxa (Tolerant2ChTxPct). Taxa richness of collector-filterers (Collector-filtererCh), collector-gatherers (Collector-gathererCh), and Ephemeroptera, Plecoptera, and Trichoptera (EPT) were above average. Metric values were similar in 2001 and 2010.

Table 166. Macroinvertebrate metrics that respond to eutrophication stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
91MN055 (2001)	**44**	8	14	11	**0**	**79.5**
91MN055 (2010)	**42**	8	13	9	**0**	**78.6**
Southern Coldwater Average	*30.8*	*6.0*	*12.1*	*7.5*	*1.1*	*66.8*
Expected response to stress	↑	↓	↓	↓	↓	↑

A majority of the fish metrics were worse than the statewide average of stations meeting the FIBI threshold (Table 167). There were zero intolerant individuals (IntolerantPct), and tolerant individuals (TolPct) were elevated during both visits. Abundance of darter species (DarterPct) was above average both years, and abundance of simple lithophilic spawners (SLithopPct) was above average in 2010.

Table 167. Fish metrics that respond to eutrophication stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
91MN055 (2001)	**18.8**	23.0	**19.5**	**68.6**	**13**	**0**
91MN055 (2010)	**48.5**	57.4	27.2	**38.1**	**13**	**0**
Southern Coldwater Average	*71.7*	*3.6*	*20.2*	*24.0*	*5.8*	*26.3*
Expected response to stress	↓	↓	↓	↑	↑	↓

Eutrophication as a stressor is considered inconclusive. There were minimal samples collected for phosphorus, but a few exceeded the standard. There was an overall lack of connecting response data related to eutrophication. The DO data appears sufficient for this reach, but the biological response suggests otherwise. Eutrophication does not appear likely. However, due to conflicting results more data is needed to confirm.

Nitrate

Nitrate concentration during fish sampling on August 9, 2010 at station 91MN055 was 0.61 mg/L. Additional samples were collected in 2015 and 2016, ranging from 2.1 mg/L – 27 mg/L (average of 15 mg/L). Only six samples were collected, but four were above 10 mg/L and two above 20 mg/L. Elevated concentrations were observed in 2016 in February, May, June, and August. Samples were collected at station S008-547.

Taxa richness of Trichoptera (TrichopteraCh) was above the statewide average of stations meeting the MIBI threshold, and relative percentage of taxa belonging to Trichoptera (TrichopteraChTxPct) was below average (Table 168). There was one nitrate intolerant taxa, and 17 – 22 nitrate tolerant taxa comprising 49 – 61% of the community. The macroinvertebrate nitrate index score was better than average in 2001, but worse than average in 2010. The macroinvertebrate metrics were more indicative of nitrate stress in 2010 than 2001.

Table 168. Macroinvertebrate metrics that respond to nitrate stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TrichopteraCh	TrichopteraChTxPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
91MN055 (2001)	6	**13.6**	3.02	**1**	**17**	48.94
91MN055 (2010)	6	**14.3**	**3.27**	**1**	**22**	**61.29**
Southern Coldwater Average	*5.3*	*17.3*	*3.04*	*1.35*	*14.29*	*60.79*
Expected response to stress	↓	↓	↑	↓	↑	↑

At this time, nitrate is inconclusive. There were minimal samples collected, but the concentrations were elevated. However, the biological response within the macroinvertebrate community is mixed and does not strongly indicate stress with moderate to low nitrate tolerant individuals, there was also a decent number of Trichoptera taxa.

Total Suspended Solids

The total suspended solids (TSS) concentration during fish sampling on August 9, 2010 at station 91MN055 was 23 mg/L. Additional samples collected in 2015 and 2016 ranged from 2.8 mg/L – 140 mg/L (average of 48.2 mg/L). Only six samples were collected, but four were above the cold-water standard of 10 mg/L. Exceedances occurred in 2016 in February, May, June, and August. Samples were collected at station S008-547.

The relative abundance of collector-filterer individuals (Collector-filtererPct) and relative abundance of Plecoptera individuals (PlecopteraPct) were worse than the statewide average of stations meeting the MIBI threshold (Table 169). There was one TSS intolerant taxon (2001) comprising 0% of the community, and eleven (2001) and nine (2010) TSS tolerant taxa comprising 29% and 24% of the community respectively. The macroinvertebrate TSS index scores were above average; as this score increases, so does the tolerance of the community. All of the macroinvertebrate metrics are worse than average and suggesting the possibility of stress.

Table 169. Macroinvertebrate metrics that respond to high TSS stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
91MN055 (2001)	**23.2**	**0**	**14.88**	**1**	**0.4**	**11**	**29.2**
91MN055 (2010)	**22.3**	**0**	**14.70**	**0**	**0**	**9**	**23.5**
Southern Coldwater Average	*32.7*	*0.4*	*13.34*	*2.3*	*3.5*	*5.2*	*10.8*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

The fish metrics were mixed, with some above the statewide average of stations meeting the FIBI threshold, and some below (Table 170). The relative abundance of individuals that are non-tolerant Centrarchidae (Centr-TolPct) and relative abundance of individuals that are intolerant species (IntolerantPct) were zero percent of the community during both visits, and relative abundance of individuals that are long-lived (LLvdPct) were well below average. Relative abundance of individuals that are exclusively benthic feeders (BenFdFrimPct) and relative abundance of individuals that are riffle-dwelling species (RifflePct) were well above average both visits. There were zero TSS sensitive taxa, and three (2001) and two (2010) TSS tolerant taxa comprising 2% and 1% of the community respectively (Table 171). Fish TSS index scores were worse than average at 15 and 12.9, with the southern cold-water average being 10.5.

Table 170. Fish metrics that respond to high TSS stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
91MN055 (2001)	71.3	**0**	49.4	**0**	**1.1**	23.4	67.0	**18.8**	**6.9**
91MN055 (2010)	70.8	**0**	**11.9**	**0**	**4.0**	57.4	61.9	**48.5**	**7.4**
Southern Coldwater Average	*28.3*	*1.0*	*15.1*	*26.3*	*53.9*	*4.7*	*34.2*	*71.7*	*15.3*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 171. Fish metrics that respond to high TSS stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TSS Index Score	TSS Sensitive Taxa	TSS I Sensitive Pct	TSS Tolerant Taxa	TSS Tolerant Pct
91MN055 (2001)	**15.0**	**0**	**0**	**3**	**1.5**
91MN055 (2010)	**12.9**	**0**	**0**	**2**	**1.0**
Southern Coldwater Average	*10.5*	*1.4*	*33.6*	*0.1*	*0.3*
Expected response to stress	↑	↓	↓	↑	↑

TSS is considered inconclusive as a stressor. There is limited chemistry data to assess TSS on this reach. Looking at the biological metrics, it is hard to understand if metrics are responding to TSS or other stressors. The macroinvertebrates overall have a more consistent response, but the fish community is a bit mixed. Additional TSS data is needed to make a future determination.

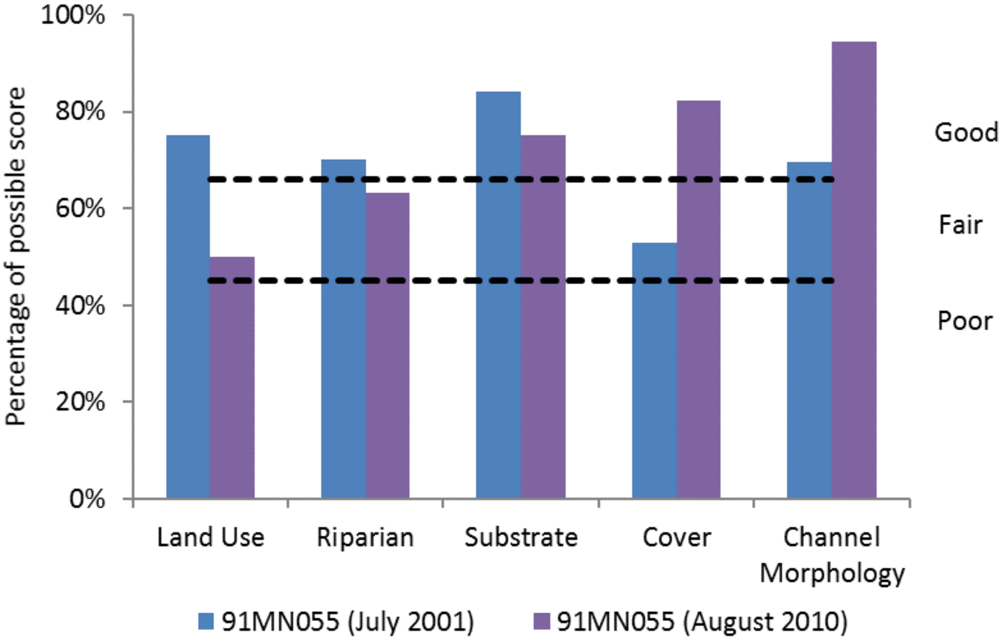
Habitat

At station 91MN055, the MSHA score in 2001 was 70.95 and in 2010 was 80.3, both considered “good”. There was abundant habitat availability observed at those locations, shown in Figure 175.

Surrounding land use drove down the score the most, due to surrounding row crops (Figure 176). However, extensive riparian width paired with rooted vegetation coverage has helped mitigate those land use impacts and created channel stability. With the stable channel, there is also less erosion that allows for cleaner substrate. There was also a good ratio of pools (45%), Riffles (30%), and runs (25%), providing diverse habitat and refuge for the biological communities.

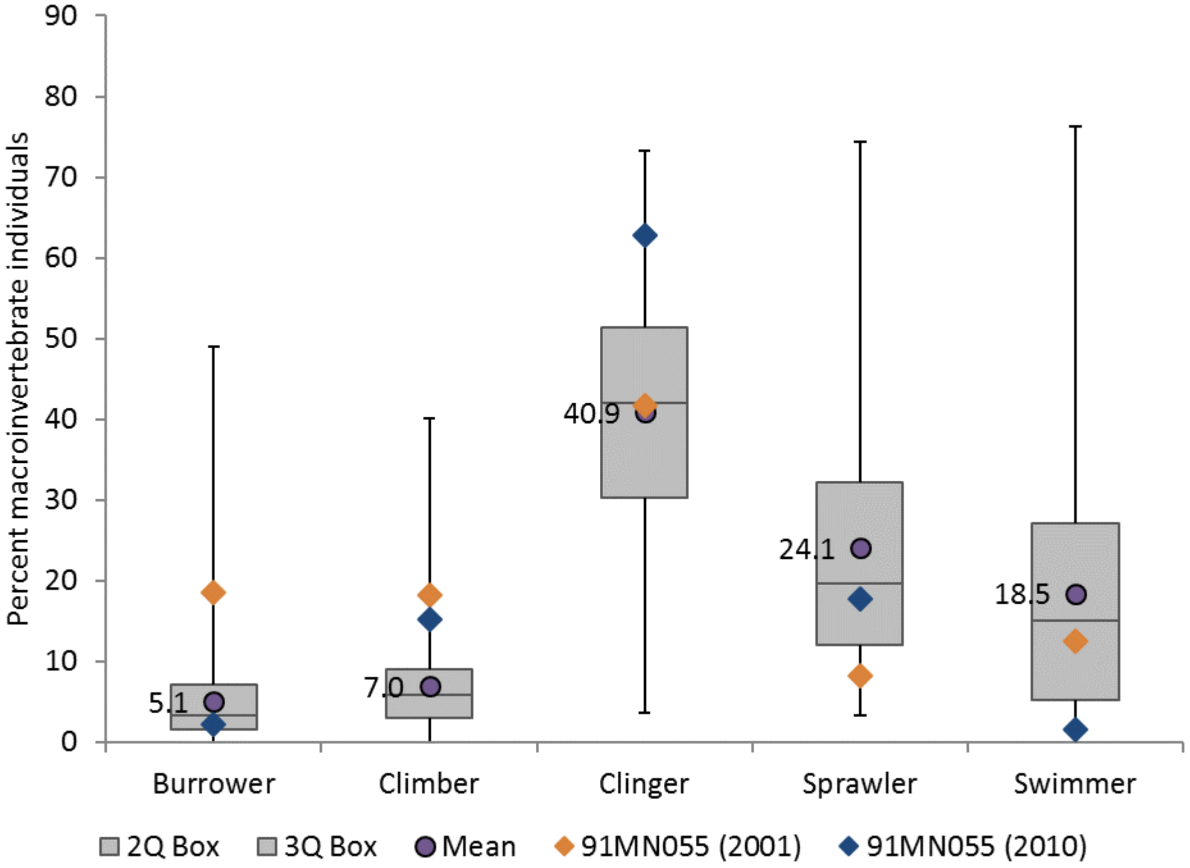
Figure 175. Biological monitoring station 91MN055, taken on July 30, 2001.

Figure 176. Percentage of MSHA subcategory scores for station 91MN055, Spring Creek



Climbers were above average both years, and swimmers and sprawlers were slightly below average (Figure 177). The elevated burrowers (one year) is the only potential symptom of habitat stress or sedimentation of riffle habitats. The percentage of burrowers are expected to increase with stress, while clingers are expected to decrease. There was adequate clingers during both visits, which suggest adequate course substrates or woody debris. The 2001 sample of high burrowers is a result from the Orthocladiinae (non biting midge) within the sample.

Figure 177. Macroinvertebrate metrics that respond to habitat for station 91MN055, Spring Creek (Hindeman) compared to the range of values for Coldwater Stream visits meeting the general use biocriteria.



As displayed in the previous TSS (Table 170), the relative abundance of individuals that are riffle-dwelling species (RifflePct) was above average both years at 91MN055. Abundance of simple lithophilic spawners (SLithopPct) was below average in 2001 and above average in 2010. These species require clean coarse substrate and riffles, and are expected to decrease with stress.

Habitat is not considered to be a stressor. Channel morphology is rated as stable, with excellent development and sinuosity. The substrate of the stream has light embeddedness. There is a healthy variety of substrate as well as cover types. Overall, the available habitat is sufficient for fish and macroinvertebrates in this reach. The 2015 DNR geomorphology report noted some instability in this reach, but concluded for a channel of this type, it is one of the more stable reaches in the entire Minnesota River – Mankato Watershed. A habitat improvement project (with a focus on longitudinal connectivity) was also scheduled to be conducted on this reach in 2015.

Longitudinal Connectivity and Altered Hydrology

Longitudinal connectivity and altered hydrology are both a stressors. Connectivity stressor on this reach would be seen during low base flows that would enable a perched culvert to become a fish barrier (Figure 178).

Figure 178. Photo displays perched culvert downstream of 91MN055, taken April 27, 2015.

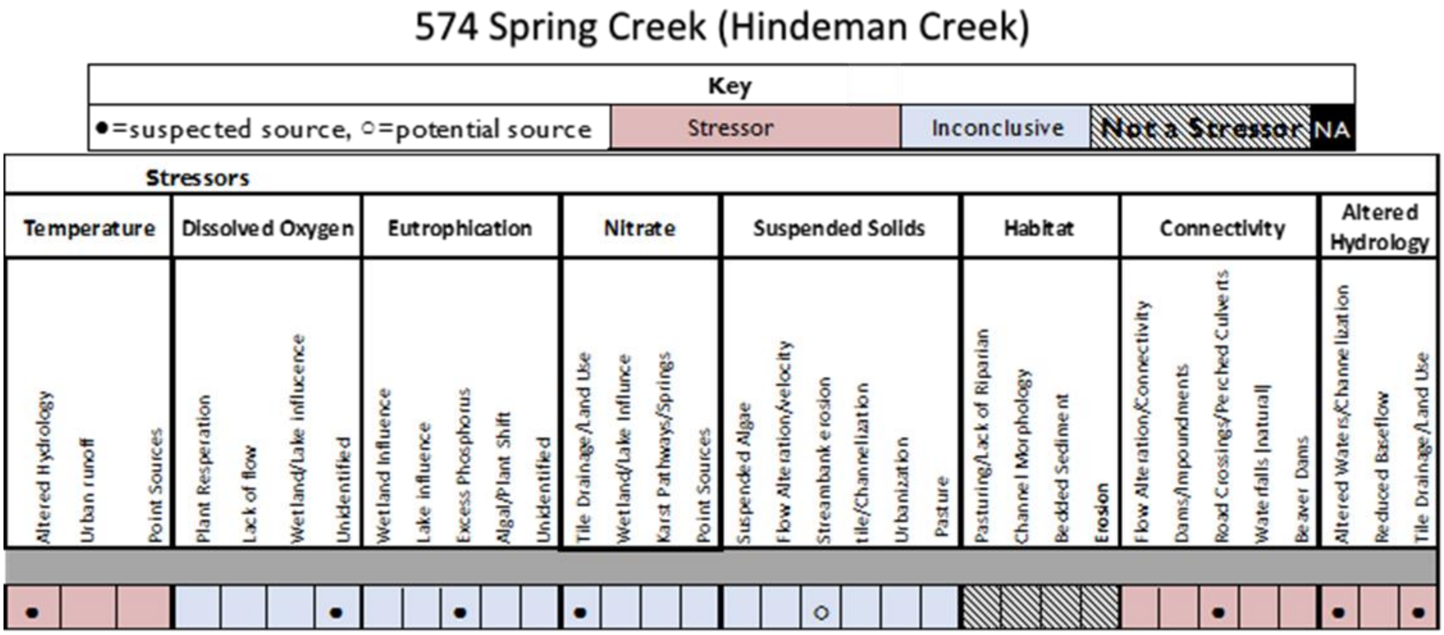
In 2015 there was a stream habitat project scheduled that would allow for further upstream migration, where a perched culvert was identified. The location of this culvert is significantly further upstream than this reach, and would pose as a migration barrier into those headwater areas that were ditched at the time of the biological survey. While the culvert identified in (-622) does not pose as a connectivity threat to this particular reach, improving upstream habitat and connectivity could enhance species richness in this location in the future. There was not any additional barriers identified at this time that could limit fish migration within this reach.

Altered Hydrology is thought to be the primary stressor within this reach. While this portion of Spring Creek is stable, there is a considerable area of ditches and subsurface tile that drains into Spring Creek, creating a host of hydrological issues that typically can be seen in stream instability and diminished water quality. As already stated, the stability of this stream is not as compromised as most streams that have agricultural ditches as headwaters; this is due to the extensive deep-rooted vegetation that has helped stabilize this channel. The flow regime has been significantly altered as natural water storage has been removed; at one point making up 20.3% of the drainage basin. Currently, water storage is reduced to .3% of the drainage basin (DNR 2015).

Water quality within this reach is limiting the biological cold-water communities, notably seen in the high temperatures of this stream. Temperature is likely high from to the upstream low gradient ditches that lack overhanging vegetation that allows for maximum heat absorption from the sun. As upstream water storage has been reduced, paired with subsurface tile drained, there is the possibility of reduced groundwater recharge that would have impacts to temperature. While eutrophic and nitrate toxic conditions were noted as inconclusive, excess phosphorus and nitrates were both found to be overloading this system. All of these deteriorated conditions can be tied back to altered hydrology being the driving force. For additional information on these forms of altered hydrology, refer to Chapter 3.1.8 of this report.

Summary Table

Table 172. Identified stressors with suspected sources for reach 574 of Hindeman Creek.



574 Spring Creek (Hindeman Creek)

Key

● =suspected source, ○ =potential source | 🟥 Stressor | 🟦 Inconclusive | ▨ Not a Stressor | ■ NA

Stressors

Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake Influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls (natural)	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
🟥 ●	🟥	🟥	🟦	🟦	🟦	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	🟦	🟦	🟦	🟦 ○	🟦	🟦	🟦	▨	▨	▨	▨	🟥	🟥	🟥 ●	🟥	🟥	🟥 ●	🟥	🟥 ●

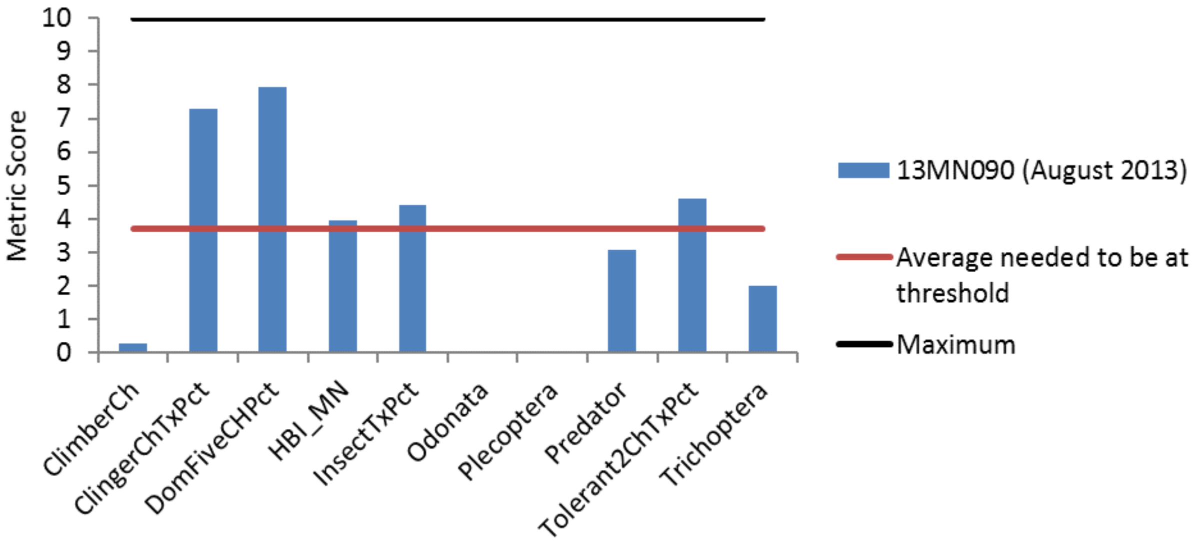
4.21 Spring Creek (07020007-573)

Spring Creek (07020007-573) is the downstream most reach on Spring Creek, northeast of Evan, Minnesota. The reach is warmwater general use Class 2B. The reach extends miles from approximately T111 R32W S21, west line (downstream of Golden Gate Rd.) to the Minnesota River. The reach is impaired for lack of macroinvertebrate assemblage and lack of fish assemblage. This reach is also impaired for *E. coli*. The *E. coli* impairment will not be addressed in this report.

4.21.1 Biological Communities

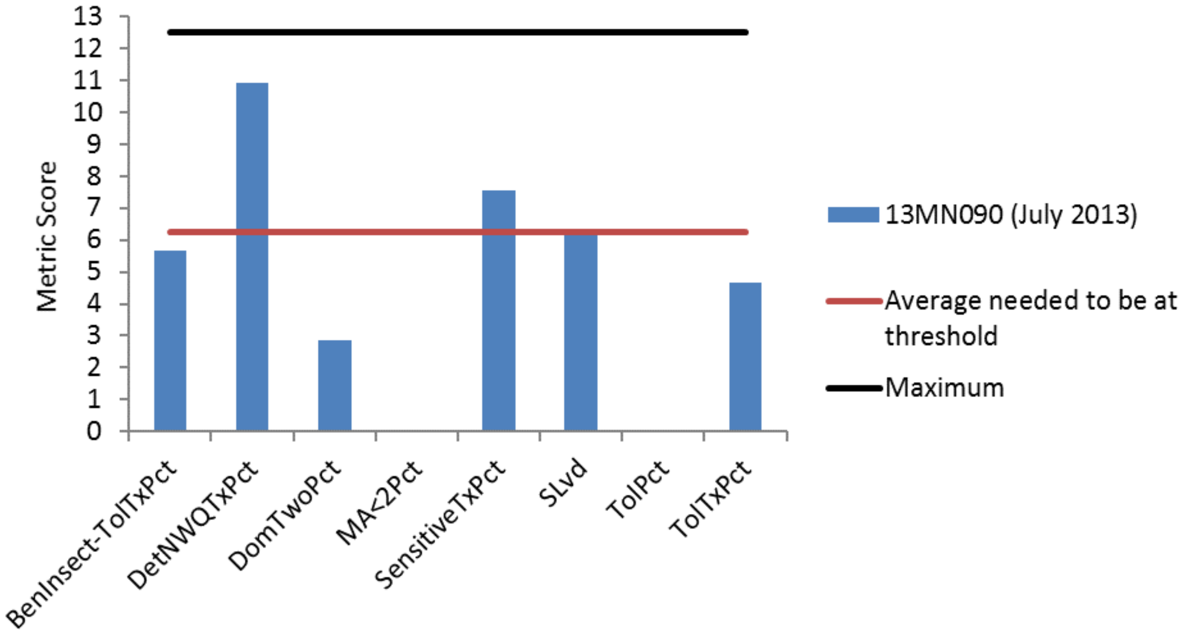
Station 13MN090 was sampled in 2013 for fish and macroinvertebrates. The macroinvertebrate IBI of 34.9 was just below the Southern Streams RR threshold of 37. As shown in Figure 179, the metrics of the IBI were particularly low for (ClimberCh), (Odonata), and (Plecoptera). The sample was dominated by net-spinning caddisflies, Cheumatopsyche.

Figure 179. Macroinvertebrate metrics of the Southern Streams RR class IBI for station 13MN090, Spring Creek.



The fish community scored 37.9, below the Southern Streams IBI threshold of 50. As reflected in Figure 180, sand shiners and blacknose dace dominated the community, resulting in a low metric score for the (DomTwoPct). Other low scoring metrics were abundance of mature female fish species (MA<2Pct) and high presents of tolerant species (TolPct).

Figure 180. Fish metrics of the Southern Streams class IBI for station 13MN090, Spring Creek.



4.21.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

Low dissolved oxygen (DO) concentration during biological sampling on July 8, 2013 and August 15, 2013 at station 13MN090 was 8.5 mg/L and 10.1 mg/L respectively. Additional samples collected from 2009 – 2016 ranged from 4.0 mg/L – 17.5 mg/L (average of 9.6 mg/L). Fifty-five samples were collected, and six (11%) were below the warmwater standard (5 mg/L). Exceedances occurred August – October in 2009; samples were collected at station S005-625.

The macroinvertebrate metrics were mixed in showing low DO stress; half were worse than the statewide average of stations meeting the MIBI threshold, and half were better (Table 173). The macroinvertebrate DO index score was below average; as this score decreases, so does the sensitivity of the community. There were eight DO intolerant taxa comprising 28% of the community, and two DO tolerant taxa comprising 1% of the community. Taxa richness of Ephemeroptera, Plecoptera and Trichoptera (EPTCh) and total taxa richness (TaxaCountAllChir) were worse than average. A measure of pollution based on tolerance values assigned to each individual taxon developed by Chirhart (HBI_MN) was better than average. Overall, the macroinvertebrate metrics are mixed and there does not appear to be a strong indication of DO stress.

Table 173. Macroinvertebrate metrics that respond to low DO stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN090 (2013)	**36**	**7**	7.0	**6.8**	**8**	27.8	2	1.0
Southern Streams Average	*45.8*	*14.2*	*7.1*	*7.0*	*9.0*	*24.0*	*4.8*	*9.9*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

A majority of the fish metrics were better than the statewide average of stations meeting the FIBI threshold (Table 174). Relative abundance of sensitive individuals (SensitivePct) was above average, and relative abundance of individuals with a female mature age greater than three years (MA>3Pct) was below average. Tolerant individuals (TolPct) comprised 75% of the community. There was one DO sensitive taxa comprising 13% of the community, and one DO tolerant taxa comprising 1% of the community. The fish DO index score was above average.

Table 174. Fish metrics that respond to low DO stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
13MN090 (2013)	18.8	**0.0**	**75.0**	7.7	**1**	12.5	1	1.0
Southern Streams Average	*16.9*	*24.6*	*44.9*	*7.2*	*1.7*	*6.1*	*4.7*	*18.5*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is inconclusive. In the future, continuous DO measurements are needed to capture the daily DO relationship. This would be helpful in better understanding the biological response. The low DO values found in 2009 all occurred in the early mornings, suggesting a eutrophic response.

Eutrophication

Total phosphorus (TP) concentration during fish sampling on July 8, 2013 at station 13MN090 was 0.082 mg/L. Additional samples were collected in 2009, 2010, and 2013, ranging from 0.018 mg/L – 1.2 mg/L (average of 0.213 mg/L). Of these 52 samples, 15 (29%) were above the river eutrophication standard for the South Region of 0.150 mg/L. Exceedances occurred in all three years and various months. Four samples were greater than 1 mg/L. All samples were collected at station S005-625.

Chl-a, BOD, and DO flux are also considered when evaluating eutrophication stress. There have been zero chl-a, BOD, or DO flux samples collected. Low DO has been documented in this AUID, and suspected to be related to high respiration rates occurring in the stream.

A majority of the macroinvertebrate metrics were worse than the statewide average of stations meeting the MIBI threshold (Table 175). There was one intolerant taxa (Intolerant2Ch), and a below average percentage of tolerant taxa (Tolerant2ChTxPct). Taxa richness of collector-filterers (Collector-filtererCh), collector-gatherers (Collector-gathererCh), and Ephemeroptera, Plecoptera, and Trichoptera (EPT) were below average.

Table 175. Macroinvertebrate metrics that respond to eutrophication stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN090 (2013)	**36**	**6**	**10**	**7**	1	72.2
Southern Streams Average	*45.8*	*7.3*	*15.9*	*12.2*	*0.8*	*72.6*
Expected response to stress	↓	↓	↓	↓	↓	↑

A majority of the fish metrics were worse than the statewide average of stations meeting the FIBI threshold (Table 176). There were zero intolerant individuals (IntolerantPct), and tolerant individuals (TolPct) comprised 75% of the fish community. Abundance of simple lithophilic spawners (SLithopPct) was below average, as they comprised only 28% of the community. Sensitive individuals (SensitivePct) and abundance of darter species (DarterPct) were the only two metrics better than average.

Table 176. Fish metrics that respond to eutrophication stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
13MN090 (2013)	18.8	13.5	**28.1**	**75.0**	**11**	**0**
Southern Streams Average	*16.9*	*11.9*	*37.0*	*44.9*	*19.3*	*4.2*
Expected response to stress	↓	↓	↓	↑	↓	↓

Eutrophication is inconclusive as there is a lack of response variables. There is some indication that respiration of excess plant growth could be occurring, as there were a few low DO early morning reads.

This data too was limited and not enough to validate that is representative to DO dynamics within this reach. There is some displacement observed in the macroinvertebrate and fish metrics, but not enough to strongly indicate it's a result of eutrophication, or if it's a different parameter causing the limitations.

Nitrate

Nitrate concentration during fish sampling on July 8, 2013 at station 13MN090 was 13 mg/L. Fifty-two Additional samples were collected in 2009, 2010, and 2013, ranging from 0.99 mg/L – 22 mg/L (average of 7.5 mg/L). Fifty-two samples were collected, 16 (31%) were above 10 mg/L. Elevated concentrations were observed in all years and various months. Samples were collected at station S005-625.

Taxa richness of Trichoptera (TrichopteraCh) and relative abundance of non-hydropsychid Trichoptera individuals (TrichwoHydroPct) were below the statewide average of stations meeting the MIBI threshold (Table 177). There were zero nitrate intolerant taxa, and sixteen nitrate tolerant taxa comprising 45% of the community. The macroinvertebrate nitrate index score was better than average. The macroinvertebrate metrics provide a mixed response, and there is not a strong signal of nitrate stress.

Table 177. Macroinvertebrate metrics that respond to nitrate stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN090 (2013)	**4**	**2.8**	2.7	**0**	16	44.5
Southern Streams Average	*6.3*	*5.5*	*2.9*	*2.4*	*18.8*	*47.2*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is inconclusive as a stressor. While there is a good size data set with over 30% exceeding the threshold, the biological response is mixed to having nitrate as a limiting factor. The metrics that did "pass" still fell close the threshold. Nitrate reduction efforts is still recommended within this reach.

Total Suspended Solids

The total suspended solids (TSS) concentration during fish sampling on July 8, 2013 at station 13MN090 was 16 mg/L. Fifty additional samples collected in 2009, 2010, and 2013 ranged from 2 mg/L – 1,380 mg/L (average of 119.3 mg/L). Out of the 50 samples were collected, nine (18%) were above the warmwater standard for the South Region (65 mg/L). Exceedances occurred in 2010 and 2013, in March (three), June (three), and September (three). Samples were collected at station S005-625.

Figure 181 below shows erosive conditions along this reach that could lead to and overloading of TSS conditions, especially during high flow. While these events are intermittent, they can still impact communities, as it will alter habitat conditions.

Figure 181. Monitoring locations 13MN090, taken on July 9, 2013.

The relative abundance of collector-filterer individuals (Collector-filtererPct) was above the statewide average of stations meeting the MIBI threshold, and relative abundance of Plecoptera individuals (PlecopteraPct) was below average (Table 178). There was one TSS intolerant taxa comprising 1% of the community, and seven TSS tolerant taxa comprising 37% of the community. The macroinvertebrate TSS index score was better than average. Overall, the macroinvertebrates display a mixed response to TSS stress.

Table 178. Macroinvertebrate metrics that respond to high TSS stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN090 (2013)	39.1	**0**	14.67	**1**	**0.6**	7	**37.2**
Southern Streams Average	*25.4*	*0.7*	15.63	2.9	4.7	12.2	34.5
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

All but one of the fish metrics with strong relationships to TSS were below the statewide average of stations meeting the FIBI threshold (Table 179). The relative abundance of individuals that are non-tolerant Centrarchidae (Centr-TolPct), relative abundance of individuals that are intolerant species (IntolerantPct), relative abundance of individuals that are long-lived (LLvdPct), and relative abundance of individuals that are simple lithophilic spawners (SLithFrimPct) were all zero. Relative abundance of individuals that are sensitive species (SensitivePct) was the only metric above average. There were zero TSS sensitive taxa, and one TSS tolerant taxa comprising 45% of the community (Table 180). The fish TSS index score was worse than average. Overall, a majority of the fish metrics are worse than average and suggesting stress.

Table 179. Fish metrics that respond to high TSS stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
13MN090 (2013)	**13.5**	**0**	**6.3**	**0**	**0**	**13.5**	**19.8**	18.8	**0**
Southern Streams Average	*36.0*	*5.4*	*25.7*	*4.2*	*13.6*	*20.1*	*30.2*	*16.9*	*19.1*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 180. Fish metrics that respond to high TSS stress in Spring Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

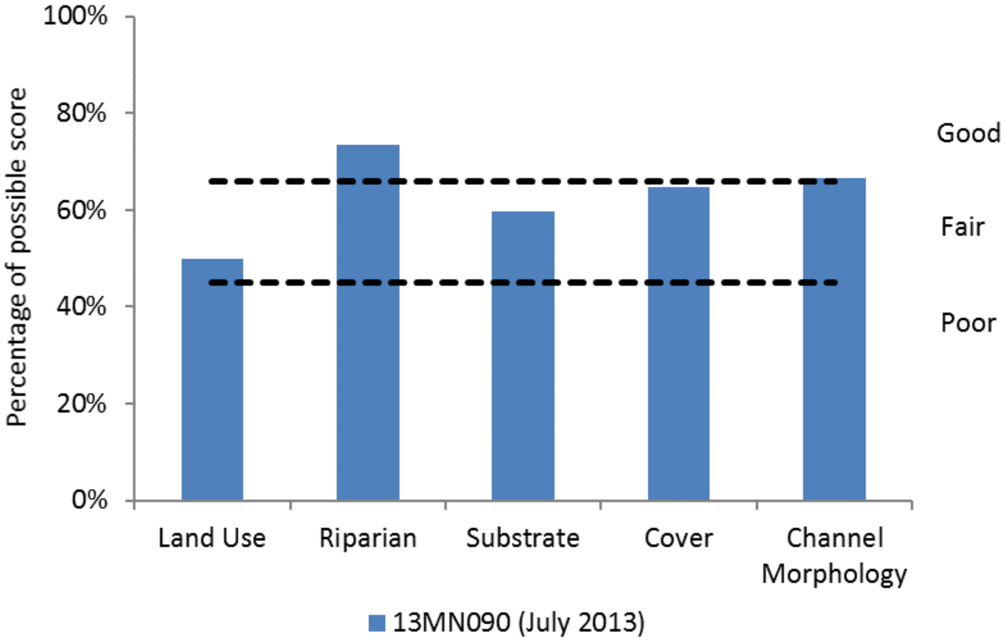
Station (Year sampled)	TSS Index Score	TSS Sensitive Taxa	TSS Sensitive Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN090 (2013)	**21.8**	**0**	**0**	1	**44.8**
Southern Streams Average	*19.2*	*1.7*	*5.3*	*2.4*	*12.5*
Expected response to stress	↑	↓	↓	↑	↑

TSS is inconclusive at this time. Chemistry data as well as noted stream conditions (such as erosion) do indicate a high potential to impact the biology at this reach. Regardless of these findings, the community composition does not appear to be influenced by TSS. One of the greatest indications of this is noted in the abundance of collecter-filler feeders that are well above the threshold.

Habitat

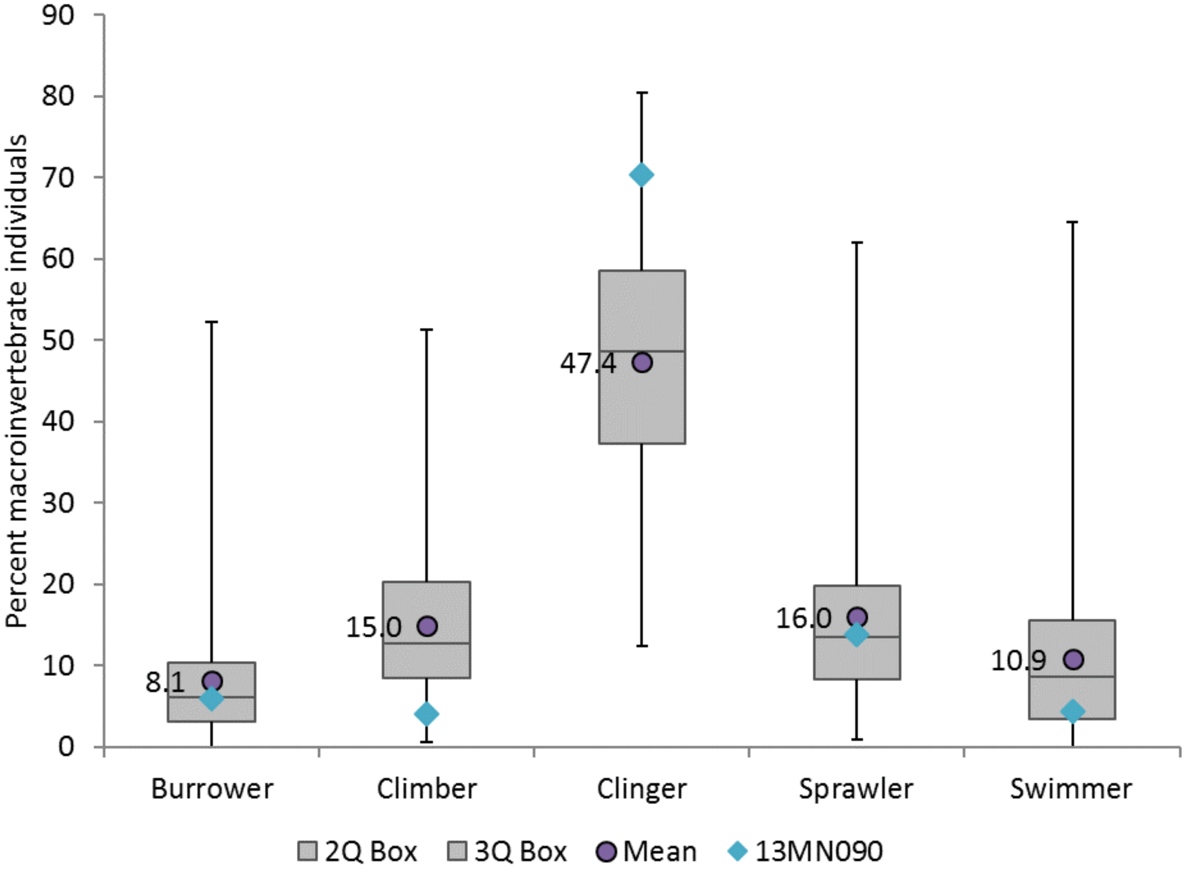
The MSHA score at 13MN090 had a fair score at 64.6, with all the main categories for habitat that were evaluated, scored from fair to good (Figure 182). Stream stability was moderate for this reach, with good physical habitat diversity and availability. However, there was heavy bank erosion, moderate embeddedness, and moderate cover. Substrate diversity was limited to sand and gravel. Available cover types included undercut banks, deep pools, logs or woody debris, and boulders. The station was 30% pool, 10% riffle, and 60% run.

Figure 182. Percentage of MSHA subcategory scores for station 13MN090, Spring Creek.



Burrowers, climbers, sprawlers, and swimmers were below average, and clingers were above average (Figure 183). The reduced climbers may be a symptom of habitat stress, but the elevated clingers are atypical of habitat stress. The climber MIBI metric score was below the average metric score needed to meet the MIBI threshold, and the clinger MIBI metric score was above average.

Figure 183. Macroinvertebrate metrics that respond to habitat for station 13MN090, Spring Creek compared to the range of values for Southern Stream RR visits meeting the general use biocriteria.



The fish community did seem to be displaced from lack of habitat. As displayed in previous TSS section, the relative abundance of individuals that are riffle-dwelling species (RifflePct) and abundance of simple lithophilic spawners (SLithopPct) were below average. These species require clean coarse substrate and riffles, and are expected to decrease with stress. This also correlates with the findings of moderate embeddedness and bank erosion noted during site visits.

While the overall MSHA scored fair- good, the site survey also included a channel condition stability index (CCSI) rating, finding this reach as being severely unstable, stating "this AUID being the lowest in the watershed, all of the accumulated flow moves thru this reach, changes to the hydrology within this watershed would affect this reach the most. Unstable stream channels can negatively impact the fish community." With the MSHA conflicting with the CCSI, additional to the conflict in habitat stress between the fish and the macroinvertebrate communities, habitat is inconclusive.

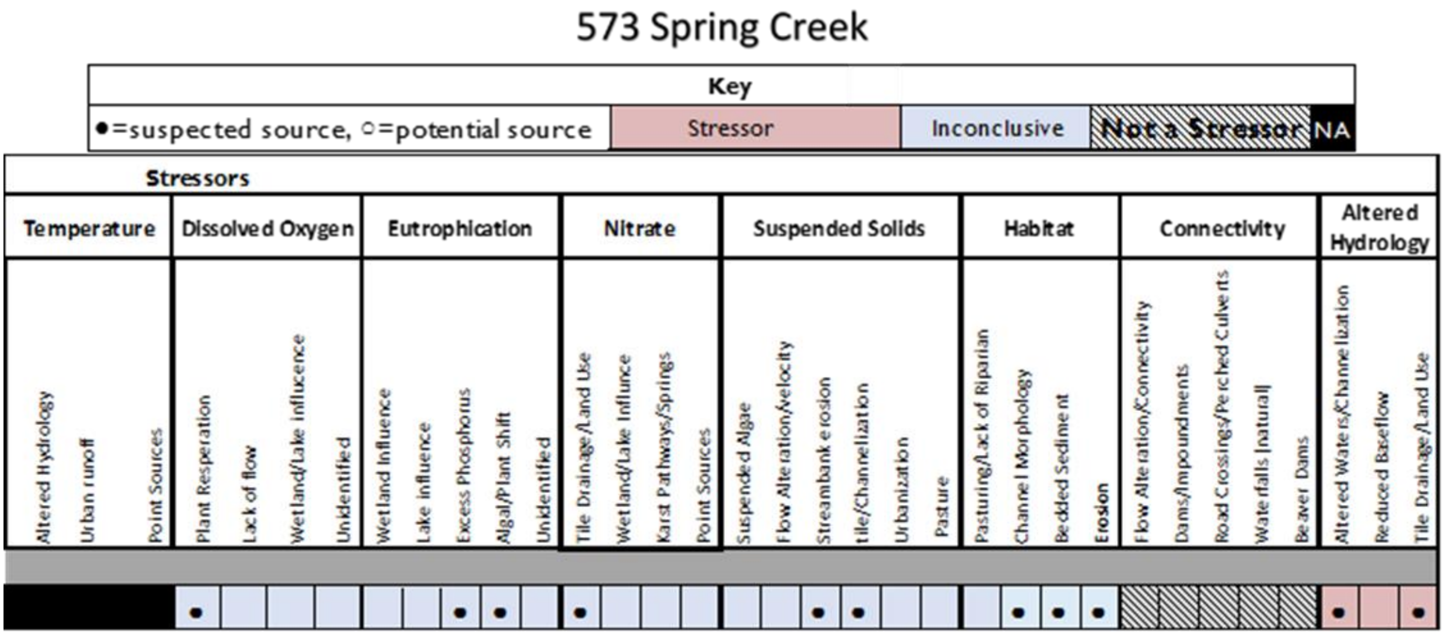
Longitudinal Connectivity and Altered Hydrology

Connectivity does not appear to be a stressor within this reach, there was not any identified areas that would limit fish migration on this lower reach of Spring Creek.

Altered hydrology is considered a biological stressor as this reach has predominantly channelized headwater streams for agricultural use. While the assessment of this reach could not identify definitively the limitations to the community, channel instability and nutrient overloading were identified. These potential limitations to the community tie directly back to the upland altered headwaters of Spring Creek. For better understanding how this form of altered hydrology forms these types of impacts reference Chapter 3.1.8 of this report.

Summary Table

Table 181. Identified stressors with suspected sources for reach 573 of Spring Creek.



573 Spring Creek

Key				
●=suspected source, ○=potential source	Stressor	Inconclusive	Not a Stressor	NA

Stressors																																	
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
■	■	■	●						●	●		●						●	●				●	●	●	▨	▨	▨	▨	▨	●		●

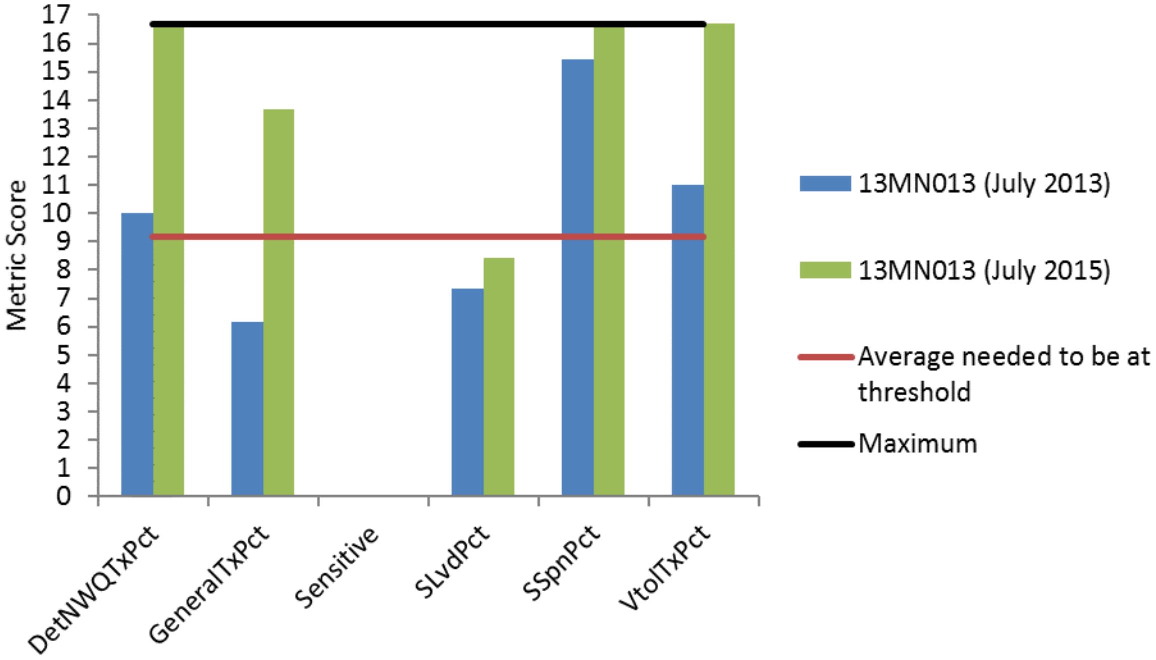
4.22 Unnamed creek (07020007-715)

Unnamed Creek (07020007-715) is a small tributary, northeast of Morgan, Minnesota. The reach is warmwater general use Class 2B. The reach extends miles from approximately T111 R33W S8, east line (CR 8) to Unnamed Creek. The reach is impaired for lack of fish assemblage. The macroinvertebrate community was not sampled in 2013 and was not sampled until after the assessment of the stream in 2015. Station 13MN013 is located upstream of CR 8.

4.22.1 Biological Communities

Station 13MN013 was sampled in July 2013 and July 2015 for fish. The macroinvertebrate community was sampled in August 2015. The fish community IBI scored 50 in 2013 and 72 in 2015, above the Southern Headwaters IBI (threshold of 55). Figure 184 displays that in both years the fish assessment found only five taxa types, primarily made up of creek chubs. The macroinvertebrate community scored below the threshold (37) with a score of 13.8 on the Southern Streams RR IBI; however, macroinvertebrates were not listed yet due to the sample taken after assessment window in 2015.

Figure 184. Fish metrics of the Southern Headwaters class IBI for station 13MN013, Unnamed Creek.



4.22.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

Dissolved oxygen (DO) concentration during biological sampling on July 9, 2013, July 15, 2015, and August 20, 2015 at station 13MN013 was 8.9 mg/L, 8.1 mg/L, and 9.3 mg/L respectively. Additional samples collected in 2015 and 2016 ranged from 9.7 mg/L – 13.0 mg/L (average of 11.1 mg/L). Only five samples were collected, and all were above the warmwater standard (5 mg/L). Samples were collected at station S008-550. There were not any early morning readings of DO.

A majority of the fish metrics were worse than the statewide average of stations meeting the FIBI threshold (Table 182). Relative abundance of sensitive individuals (SensitivePct) and individuals with a female mature age greater than three years (MA>3Pct) were zero both years, and tolerant individuals (TolPct) comprised 99% of the community. There were zero DO sensitive taxa, and 1 – 2 DO tolerant taxa comprising 5 – 42% of the community. The fish DO index score was below average in 2013 and above average in 2015.

Table 182. Fish metrics that respond to low DO stress in Unnamed Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
13MN013 (2013)	**0**	**0**	**98.8**	**6.7**	**0**	**0**	2	**42.4**
13MN013 (2015)	**0**	**0**	**99.0**	7.5	**0**	**0**	1	4.5
Southern Headwaters Average	*7.9*	*13.9*	*72.8*	*7.1*	*0.7*	*4.1*	*3.4*	*21.2*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is inconclusive as a stressor. This is primarily due to the limited data set. Fish metrics were slightly suggestive of low DO; this however could be a misleading measure as taxa types were limited to only five different types within the fish community.

Eutrophication

Total phosphorus (TP) concentration during fish sampling on July 9, 2013 and July 15, 2015 at station 13MN013 was 0.105 mg/L and 0.098 mg/L respectively. Additional samples were collected in 2009, 2015, and 2016, ranging from 0.02 mg/L – 0.271 mg/L (average of 0.09 mg/L). Twelve samples were collected, including three (25%) above the river eutrophication standard for the South Region (0.150 mg/L). Exceedances occurred on July 2, 2009 (0.157 mg/L), June 1, 2016 (0.183 mg/L), and July 16, 2009 (0.271 mg/L). Samples were collected from stations S008-550 and S005-668.

Chl-a, BOD, and DO flux are also considered when evaluating eutrophication stress. One chl-a sample was collected on September 1, 2015; this sample was below the 35 µg/L standard (14.7 µg/L). At this time, there have been zero BOD or DO flux samples collected.

A majority of the fish metrics were worse than the statewide average of stations meeting the FIBI threshold (Table 183). Sensitive individuals (SensitivePct) and intolerant individuals (IntolerantPct) were zero in 2013 and 2015, and tolerant individuals (TolPct) comprised 99% of the fish community both years. Abundance of darter species (DarterPct) and total taxa richness (TaxaCount) were below average. Abundance of simple lithophilic spawners (SLithopPct) in 2015 was the only metric to score better than average.

Table 183. Fish metrics that respond to eutrophication stress in Unnamed Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
13MN013 (2013)	**0**	**1.2**	**12.9**	**98.8**	**5**	**0**
13MN013 (2015)	**0**	**1.0**	44.6	**99.0**	**5**	**0**
Southern Headwaters Average	*7.9*	*11.5*	*31.5*	*72.8*	*11.5*	*1.6*
Expected response to stress	↓	↓	↓	↑	↓	↓

Eutrophication is inconclusive. Although there is high potential seen in phosphorus overloading, from what was collected at this site. What is lacking for analysis is the secondary responses that correlate to eutrophic streams, such as BOD, DO flux, and chl-a. The fish metrics were poor in all groups assessed for eutrophic stress. With such a limited number of taxa sampled, it is difficult to definitively identify eutrophic stress to the poor metrics.

Nitrate

Nitrate concentration during fish sampling on July 9, 2013 and July 15, 2015 at station 13MN013 was 20 mg/L and 22 mg/L respectively. Additional samples were collected in 2009, 2015, and 2016, ranging from 0.38 mg/L – 30 mg/L (average of 11.8 mg/L). Twelve samples were collected, and six (50%) were above 10 mg/L. Elevated concentrations were observed in all years, in May (three) and June (three). Samples were collected at stations S005-668 and S008-550.

Taxa richness of Trichoptera (TrichopteraCh) were below the statewide average of stations meeting the MIBI threshold (Table 184). Relative abundance of non-hydropsychid Trichoptera individuals (TrichwoHydroPct) were in abundance. There was a less than average amount of nitrate intolerant taxa, as well as nitrate tolerant taxa comprising, the tolerant made up 59% of the community. The macroinvertebrate nitrate index score was worse than average. The macroinvertebrate metrics provide a mixed response, and there is not a strong signal of nitrate stress.

Table 184. Macroinvertebrate metrics that respond to nitrate stress in Unnamed Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN013 (2015)	**2**	6.06	**3.4**	**1**	10	**59.34**
Southern Streams Average	*6.3*	*5.5*	*2.9*	*2.4*	*18.8*	*47.2*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is inconclusive at this time. Nitrate concentrations have been noted as being elevated, therefor efforts should be made to make nitrate reductions. There is not a clear indication of the impacts to the biological community at this location. Additional sampling should be done to better understand the Nitrate and biological dynamics within this reach.

Total Suspended Solids

The total suspended solids (TSS) concentration during fish sampling on July 9, 2013 and July 15, 2015 at station 13MN013 was 8.4 mg/L and 3.2 mg/L respectively. Additional samples collected in 2009, 2015, and 2016 ranged from 2 mg/L – 52 mg/L (average of 9.1 mg/L). Twelve samples were collected; none were above the warmwater standard for the South Region (65 mg/L). Samples were collected in April (two), May (three), June (four), July (two), and September at stations S005-668 and S008-550.

Figure 185 displays erosive conditions along this reach that could lead to and overloading of TSS conditions, especially during high flow following rain events or thaw out. While these events are intermittent, they can still impair communities, as it will alter habitat conditions.

Figure 185. Station 13MN013, taken in July 15, 2015.

All of the fish metrics with strong relationships to TSS were below the statewide average of stations meeting the FIBI threshold (Table 185). The relative abundance of individuals of Centrarchidae (Centr-TolPct), relative abundance of individuals that are intolerant species (IntolerantPct), relative abundance of individuals that are long-lived (LLvdPct), relative abundance of individuals that are sensitive species (SensitivePct), and relative abundance of individuals that are simple lithophilic spawners (SLithFrimPct) were all zero during both visits. There were zero TSS sensitive taxa, and zero TSS tolerant taxa (Table 186). Fish TSS index scores were better than average. A majority of the fish metrics are worse than average, but this may be due to another stressor as the TSS index scores, TSS tolerant percentages, and probability of meeting the TSS standard all scored well.

It was also observed that within the macroinvertebrate community, collector filters were lacking, with only a few found. This also could indicate turbid water quality.

Table 185. Fish metrics that respond to high TSS stress in Unnamed Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
13MN013 (2013)	**1.2**	**0**	**0**	**0**	**0**	**1.2**	**0**	**0**	**0**
13MN013 (2015)	**1.5**	**0**	**0.5**	**0**	**0**	**1.0**	**0.5**	**0**	**0**
Southern Headwaters Average	*35.0*	*1.0*	*22.4*	*1.6*	*4.5*	*13.6*	*26.2*	*7.9*	*14.6*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 186. Fish metrics that respond to high TSS stress in Unnamed Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TSS Index Score	TSS Sensitive Taxa	TSS Sensitive Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN013 (2013)	15.2	**0**	**0**	0	0
13MN013 (2015)	13.7	**0**	**0**	0	0
Southern Headwaters Average	*15.4*	*0.9*	*4.1*	*0.4*	*2.0*
Expected response to stress	↑	↓	↓	↑	↑

TSS is inconclusive. Out of 12 samples, none seemed to indicate excessive TSS. However, fish metrics suggest this could be limiting the community. While macroinvertebrates were not listed as impaired yet, it was found that there was a lack inverts that depend on clear water quality for filtering. There are some areas with excessive erosion noted within this reach that could cause an overloading of TSS at times of high flow.

Habitat

In 2015, the habitat assessment noted that much of the overhanging vegetation was grazed off with erosion and sediment present, with banks actively falling in stream. MSHA was completed in July 2013, with a wide range of scores over the five primary habitat categories (Figure 207). Bank erosion was noted as heavy to severe, with light to moderate shading available. In 2013, the cover amount was noted as moderate, and sparse in both 2015 visits. There was moderate embeddedness noted at each visit. The channel stability was noted as low to moderate, with moderate depth variability and fair to good sinuosity and channel development. Figure 186 and Figure 187 below display unstable stream conditions. Additional indication of stream instability is the perched culvert downstream of the station (Figure 188).

Figure 186. Percentage of MSHA subcategory scores for station 13MN013, Unnamed Creek.

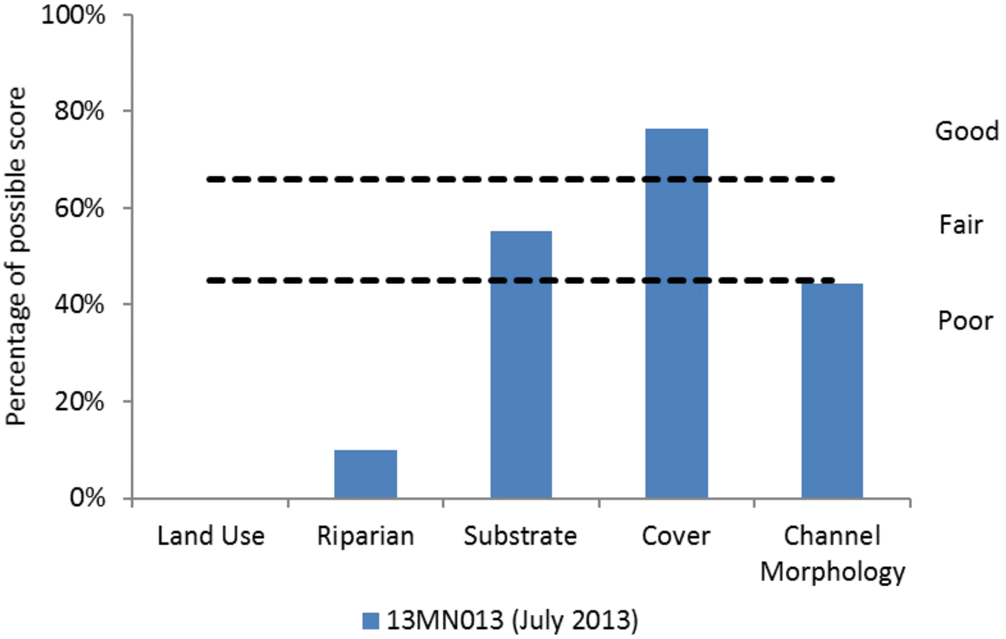


Figure 187. June 16, 2015 – scour pool and erosion, slumping bank.

Figure 188. July 15, 2015 displaying bank erosion at 13MN013.

As the macroinvertebrate metrics were not available for review in this assessment cycle, the fish community was looked at in place to see if there were fish groups that could be being displaced by poor habitat conditions. Station 13MN013 had reduced percentages of fish metrics that can correspond to reduced habitat availability, reflected in Table 187. Simple lithophilic spawners present in both samples were blacknose dace, 11 in 2013, and 90 in 2015. Lack of habitat is a stressor to the fish community at station 13MN013.

Table 187. Fish metrics that respond to habitat stress in Unnamed Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Non-tolerant Benthic Insectivores	Darter, sculpin, & round bodied suckers	Riffle dwellers	Simple Lithophilic spawners
13MN013 (2013)	**1.2**	**1.2**	**0**	**12.9**
13MN013 (2015)	**1.0**	**1.0**	**0.5**	44.6
Southern Headwaters Average	*13.2*	*11.9*	*26.2*	*31.5*
Expected response to stress	↓	↓	↓	↓

Habitat is likely a stressor to the community. The main decline in habitat being the lack of riparian zone, this is enabling channel instability, as the banks are susceptible to erosion; leading to embedded and poor river substrate.

Longitudinal Connectivity and Altered Hydrology.

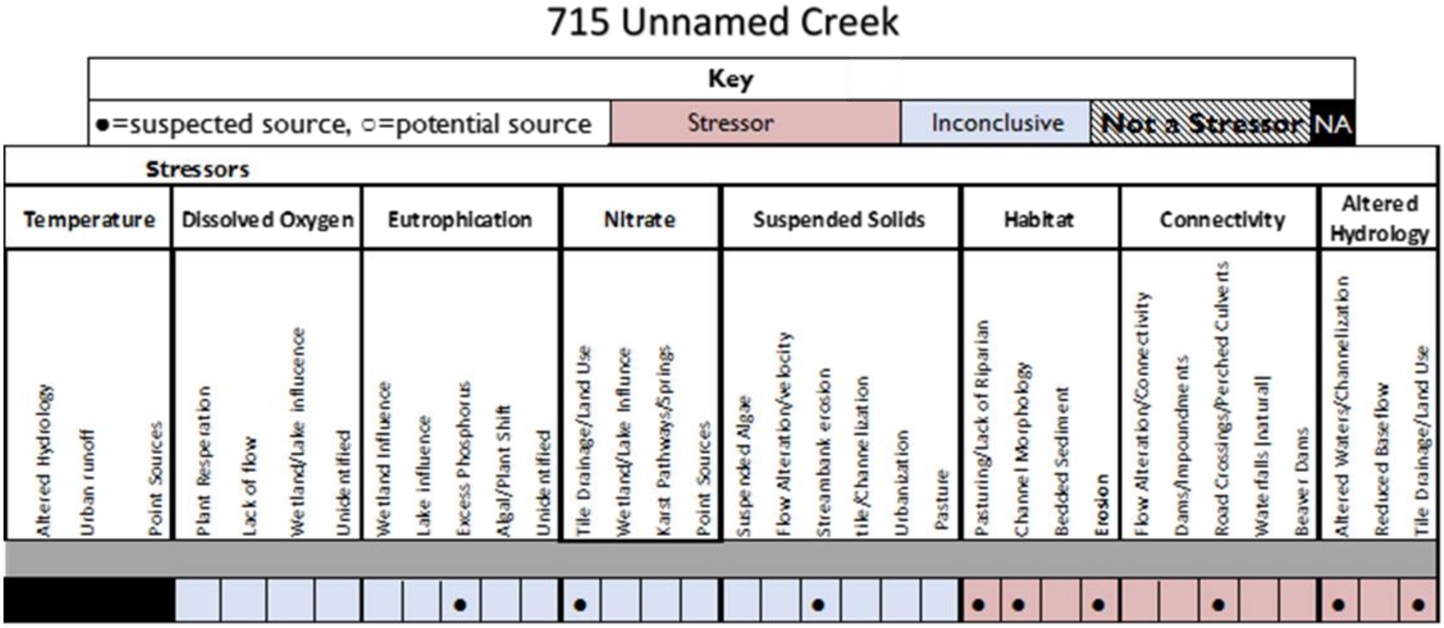
Longitudinal connectivity is a stressor within this reach. On June 16, 2015, a culvert was observed to be perched downstream of the road crossing of CR 8. This culvert created approximately an 8 to 10 inch break in longitudinal connectivity. Station 13MN013 is located upstream of the road crossing. There is not a station currently downstream of the culvert. There were only five fish taxa identified in the sample, with the majority of the fish either creek chub or blacknose dace. Brook stickleback, johnny darter, and central stonerollers made up the remainder taxa types. It is likely that this barrier is impeding fish passage throughout some of the year. It is uncertain the extent due to the lack of information downstream to be able to be used as a comparison site.

Figure 189. June 16, 2015 downstream of 13MN013 perched culvert.

Altered hydrology is considered the primary stressor within this reach, as it is driving the other identified stressor. This reach (as well as the contributing channels upstream of this monitoring location) have been channelized as well as had the introduction of subsurface tile drainage. These practices contribute to the water impairments noted as they directly alter the flow regime that influences channel stability as well as pollutant loading. For more information on these forms of altered hydrology, reference Chapter 3.1.8 of this report.

Summary Table

Table 188. Identified stressors with suspected sources for reach 715 of Unnamed Creek.



715 Unnamed Creek

Key

●=suspected source, ○=potential source | 🟥 Stressor | 🟦 Inconclusive | ▨ Not a Stressor | ⬛ NA

Stressors

Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
⬛	⬛	⬛	🟦	🟦	🟦	🟦	🟦	🟦	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	🟦	🟦	🟦	🟦 ●	🟦	🟦	🟦	🟥 ●	🟥 ●	🟥	🟥 ●	🟥	🟥	🟥 ●	🟥	🟥	🟥 ●	🟥	🟥 ●

4.23 County Ditch 52 (07020007-636)

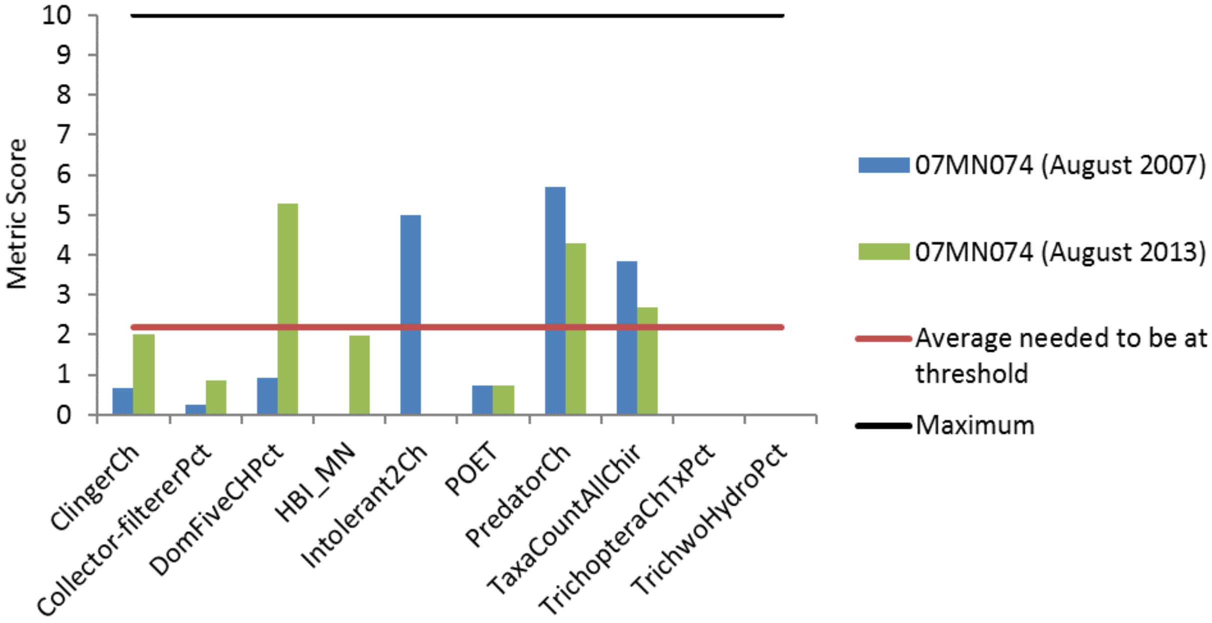
County Ditch 52 (07020007-636) is a tributary to Crow Creek. The reach is a warmwater modified use Class 2B and begins upstream of County Road 1. The reach is impaired for lack of macroinvertebrate assemblage.

4.23.1 Biological Communities

Station 07MN074 was sampled for fish and macroinvertebrates in 2007 and 2013. The fish community scored 55.6 FIBI in 2007, 43.9 and 61 in 2013, all above the modified use threshold of 33 for the Southern Headwaters class. Common shiner, blacknose dace, and creek chub were abundant.

The macroinvertebrate IBI in 2007 was 14.5 and 17.8 in 2013 for the Prairie Streams GP class. Both of the visits resulted in MIBI scores less than the modified use threshold of 22. As displayed in Figure 190.

Figure 190. Macroinvertebrate metrics of the Prairie Streams GP class IBI for station 07MN074, County Ditch 52.



4.23.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

The dissolved oxygen (DO) concentration during biological sampling on June 17, 2013, August 13, 2013, and August 19, 2013 at station 07MN074 was 13.9 mg/L, 14.7 mg/L, and 13.1 mg/L respectively. Additional samples collected in 2015 and 2016 ranged from 8.5 mg/L – 15.6 mg/L (average of 10.8 mg/L). Only six samples were collected, and all were above the warmwater standard (5 mg/L). Samples were collected at station S008-655.

In 2015, an YSI sonde was deployed at station 07MN074 (Figure 191 and 192). The DO ranged from 2.96 to 22.14 mg/L, with violations of the DO standard each day. DO flux was also elevated ranging from 6.52 to 19.05 mg/L, with an average of 13.44 mg/L.

Figure 191. Diurnal dissolved oxygen at station 07MN074, July 16 - 23, 2015.

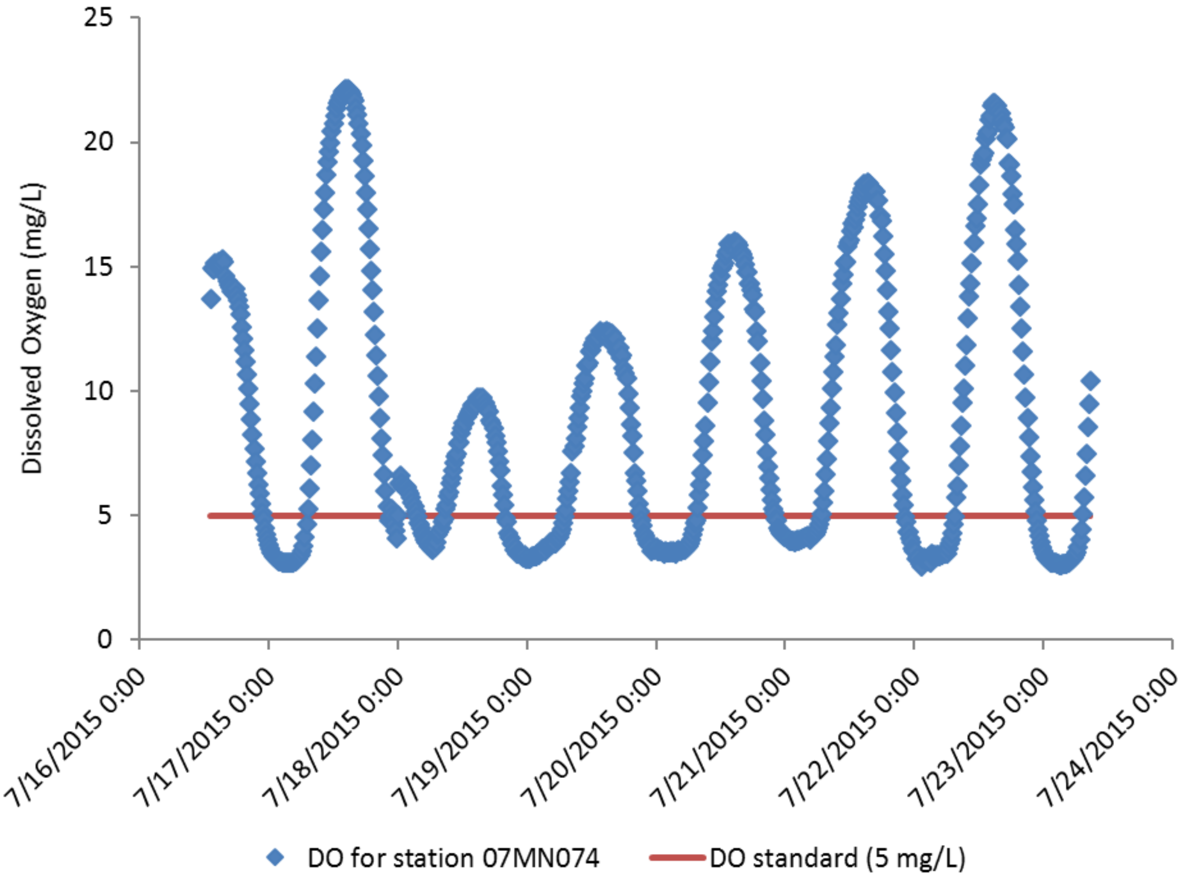
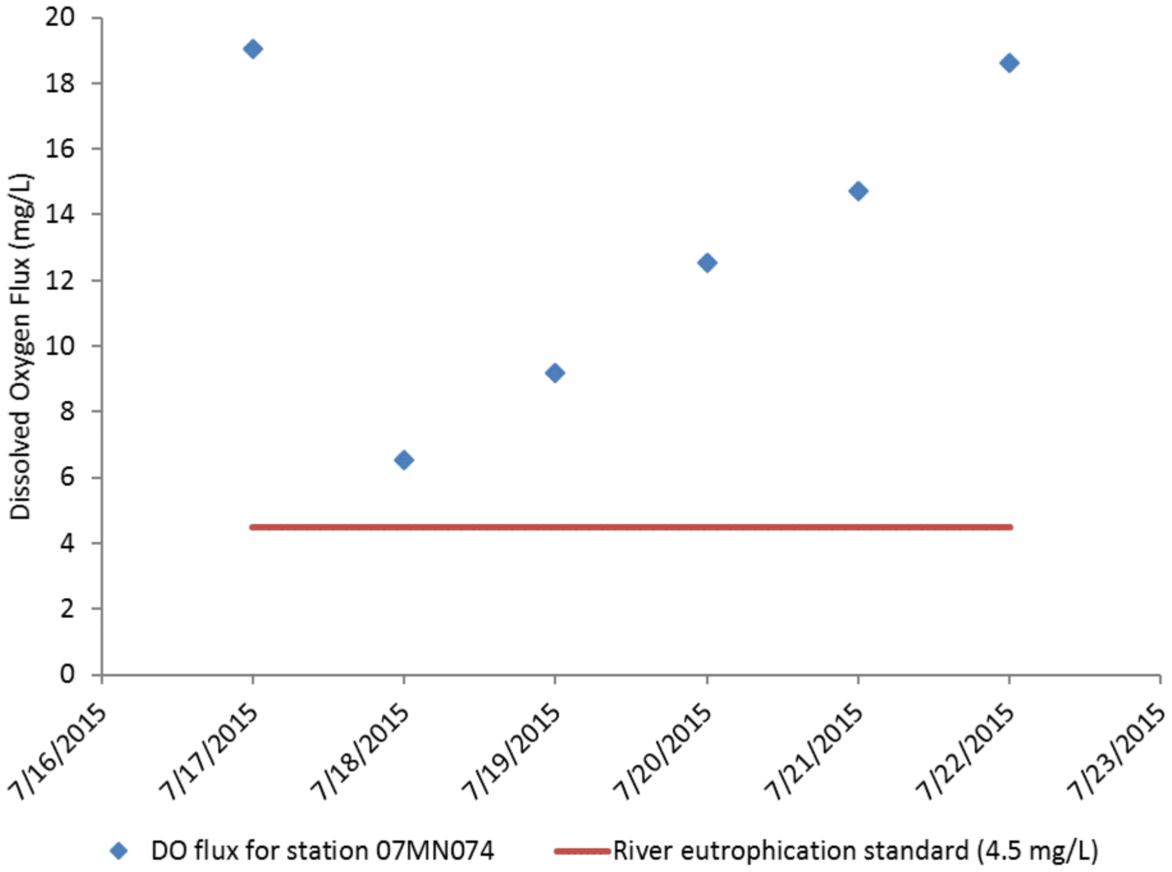


Figure 192. Dissolved oxygen flux at station 07MN074, July 17 - 22, 2015.



The macroinvertebrate community had a response as expected with low dissolved oxygen stress in 2007 and 2013 (Table 189). There was a lack of taxa richness, EPT taxa, and low DO intolerant taxa. There were higher than expected low DO tolerant taxa and individuals.

Table 189. Macroinvertebrate metrics that respond to low DO stress in County Ditch 52 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
07MN074 (2007)	**32**	**0**	**9.2**	**5.7**	**0**	**0**	**10**	**29.9**
07MN074 (2013)	**28**	**1**	**8.3**	**5.9**	**0**	**0**	**10**	**64.8**
Prairie Streams Average	*36.8*	*7.6*	*7.9*	*6.4*	*2.4*	*4.5*	*8.4*	*25.1*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is likely stressing the biological community within this reach. Based on the findings of the deployment that captured daily drops of DO below the standard. The macroinvertebrate metrics consistently indicated low DO stress within the community.

Eutrophication

Total phosphorus (TP) concentration during fish sampling on August 29, 2007, June 17, 2013, August 13, 2013, and August 19, 2013 at station 07MN074 was 0.223 mg/L, 0.049 mg/L, and 0.202 mg/L respectively. Additional samples were collected in 2015 and 2016, ranging from 0.066 mg/L – 0.467 mg/L (average of 0.176 mg/L). Only six samples were collected, but three were above the river eutrophication standard for the South Region of 0.150 mg/L. Exceedances occurred on June 16, 2015 (0.155 mg/L), May 11, 2016 (0.2 mg/L), and February 22, 2016 (0.467 mg/L). Samples were collected from station S008-655.

Chl-a, BOD, and DO flux are also considered when evaluating eutrophication stress. Two chl-a samples were collected in July and September 2015; both samples were below the 35 µg/L standard (11.7 µg/L and 16.2 µg/L respectively). At this time, there have been zero BOD samples collected. During sonde deployment in 2015, daily DO flux was high, ranging from 6.5 to 19.1 mg/L, while Low DO was also documented during this deployment.

At the time of biological monitoring the site was found to have an excess of algal growth, primarily filamentous. An additional site recon visit on June 6, 2015 also noted an overabundance of algae growth (Figure 193).

Figure 193. 07MN074 displaying algae growth on June 6, 2015.

The macroinvertebrate community is overall suggestive of eutrophication stress (Table 190). There was a lack of collector-filterer taxa, collector-gatherer taxa, and EPT taxa. As mentioned previously, there is an overall reduction in taxa richness compared to similar streams meeting the biocriteria. The relative abundance of tolerant taxa is also quite high at both visits. In 2007, there was one taxon considered intolerant.

Table 190. Macroinvertebrate metrics that respond to eutrophication stress in County Ditch 52 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
07MN074 (2007)	**32**	**1**	**9**	**0**	1	**90.6**
07MN074 (2013)	**28**	**3**	**8**	**1**	**0**	**89.3**
Prairie Streams Average	*36.8*	*3.9*	*12.8*	*6.5*	*0.1*	*85.4*
Expected response to stress	↓	↓	↓	↓	↓	↑

Eutrophication is considered a biological stressor within this reach. There are high levels of TP to feed conditions within this stream, as well as a very high daily DO flux as vegetation undergoes photosynthesis and respiration. Chl-a samples were limited, and what was conducted was low. This is likely due to primary from of algae growth being filamentous and not suspended algae. There is also stagnant flow conditions noted during site visits, and lack of shade, which contribute to production of filamentous algae and macrophytes. Biological metrics all consistently respond to eutrophication stress as well.

Nitrate

Nitrate concentration during fish sampling on August 29, 2007, June 17, 2013, August 13, 2013, and August 19 at station 07MN074 was 10 mg/L, 18 mg/L, and 0.05 mg/L respectively. Additional samples were collected in 2015 and 2016, ranging from 0.05 mg/L – 27 mg/L (average of 9 mg/L). Two out of the six samples exceeded 10 mg/L, with one significantly higher with a concentration of 27 mg/L on June 1, 16). Samples were collected at station S008-655 in February, May, June (2), July, and September.

Taxa richness of Trichoptera (TrichopteraCh) and relative abundance of non-hydropsychid Trichoptera individuals (TrichwoHydroPct) were below the statewide average of stations meeting the MIBI threshold (Table 191). There were zero nitrate intolerant taxa, and 9 – 16 nitrate tolerant taxa comprising 52 – 62% of the community. The macroinvertebrate nitrate index scores were worse than average indicating a community tolerant to nitrate. A majority of the macroinvertebrate metrics were worse than average, showing response to high nitrate conditions.

Table 191. Macroinvertebrate metrics that respond to nitrate stress in County Ditch 52 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
07MN074 (2007)	**0**	**0.0**	**3.8**	**0**	9	**62.4**
07MN074 (2013)	**0**	**0.0**	**3.4**	**0**	16	52.4
Prairie Streams Average	*2.6*	*2.4*	*3.2*	*1.1*	*18.0*	*59.7*
Expected response to stress	↓	↓	↑	↓	↑	↑

While there were limited samples at this reach, it is clear high nitrate is contributing to stress in this stream. The biological metrics show some response, but it is not overwhelming. If nitrate were a dominant stressor, we would expect to see higher amounts of nitrate tolerant taxa and individuals. There were limited samples on this reach, and while they show the potential for high nitrate concentrations to occur, it is not clear if the metrics are responding to other stressors or if high nitrate is the cause. Due to this uncertainty, nitrate is inconclusive as a stressor.

Total Suspended Solids

The total suspended solids (TSS) concentration during fish sampling on August 29, 2007, June 17, 2013, August 13, 2013, and August 19 at station 07MN074 was 3.6 mg/L, 2 mg/L, and 7.2 mg/L respectively. Additional samples collected in 2015 and 2016 ranged from 1.2 mg/L – 82 mg/L (average of 24.1 mg/L). Only six samples were collected, but one was above the warmwater standard for the South Region of 65 mg/L. The exceedance occurred on May 11, 2016 (82 mg/L). Samples were collected at station S008-655.

The macroinvertebrate community was suggestive of potential TSS stress in 2007, but not as strongly in 2013 (Table 192). All of the macroinvertebrate metrics that respond to high TSS showed plausible stress in 2007. In 2013, the TSS index score was better as well as fewer TSS tolerant taxa and relative abundance of TSS tolerant individuals.

Table 192. Macroinvertebrate metrics that respond to high TSS stress in County Ditch 52 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
07MN074 (2007)	**1.3**	**0**	**17.65**	**0**	**0**	**12**	**78.5**
07MN074 (2013)	**3.6**	**0**	15.15	**0**	**0**	6	27.0
Prairie Streams Average	*11.7*	*0.1*	*16.68*	*0.8*	*1.4*	*11.8*	*41.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

There is a lack of chemistry data overall to help understand the magnitude and duration of TSS concentrations in this reach. What is available does not strongly indicate chronic high TSS. The metrics are somewhat suggestive; however, it could be a response to other stressors. TSS is inconclusive as a stressor until further information can be collected.

Habitat

MSHA was fair in 2007 (45.5) and poor at both visits in 2013 (40 and 39), reflected in Figure 194. One of the differences between the two visit years was the substrate had light embeddedness in 2007 and moderate to severe in 2013. The cover amount was sparse in 2007 and increased to moderate in 2013. Overhanging vegetation appears more abundant in 2013 in the site photographs. In 2013, there was a small (5%) presence of pool features, which were absent in 2007. Both macroinvertebrate samples were collected on undercut banks and overhanging vegetation.

Figure 194. Percentage of MSHA subcategory scores for station 07MN074, County Ditch 52.

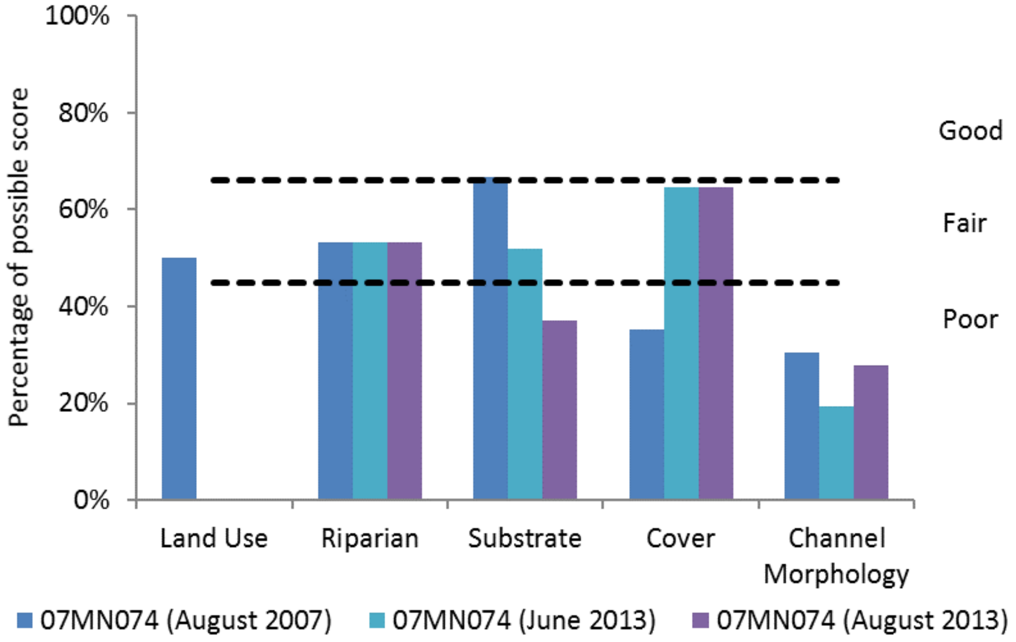
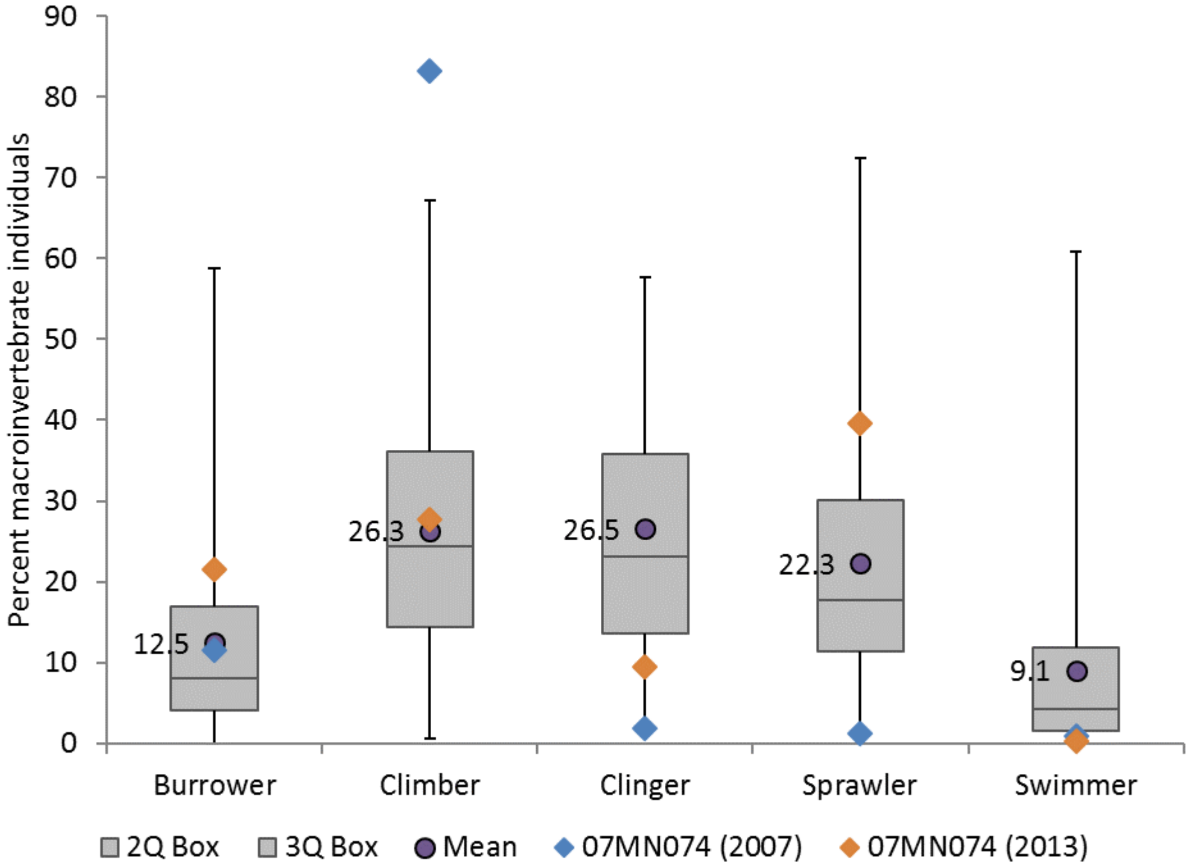


Figure 195. Station 07MN074, August 13, 2013 displaying habitat conditions.

The macroinvertebrate community had mixed results in terms of habitat group metrics (Figure 196). There was an abundance of climbing individuals in 2007 at station 07MN074. There was an elevated percentage of burrowers in 2013, indicating possible excess sediment issues or just a factor of the habitat sampled (banks). Both years there was less than 10% of clinging individuals, and as seen in the IBI there were few clinging taxa. This is likely due to a lack of woody debris or riffle/rock habitat that these types of bugs require.

Figure 196. Macroinvertebrate metrics that respond to habitat for station 07MN074, CD52 compared to the range of values for Southern Prairie Streams GP visits meeting the general use biocriteria.



Habitat is a stressor to the biology in County Ditch 52. There is a lack of physical habitat diversity within the reach. Channel instability and embeddedness are also contributors to the less than ideal habitat conditions. This is also a modified reach, and habitat has been determined to be limiting the biological communities.

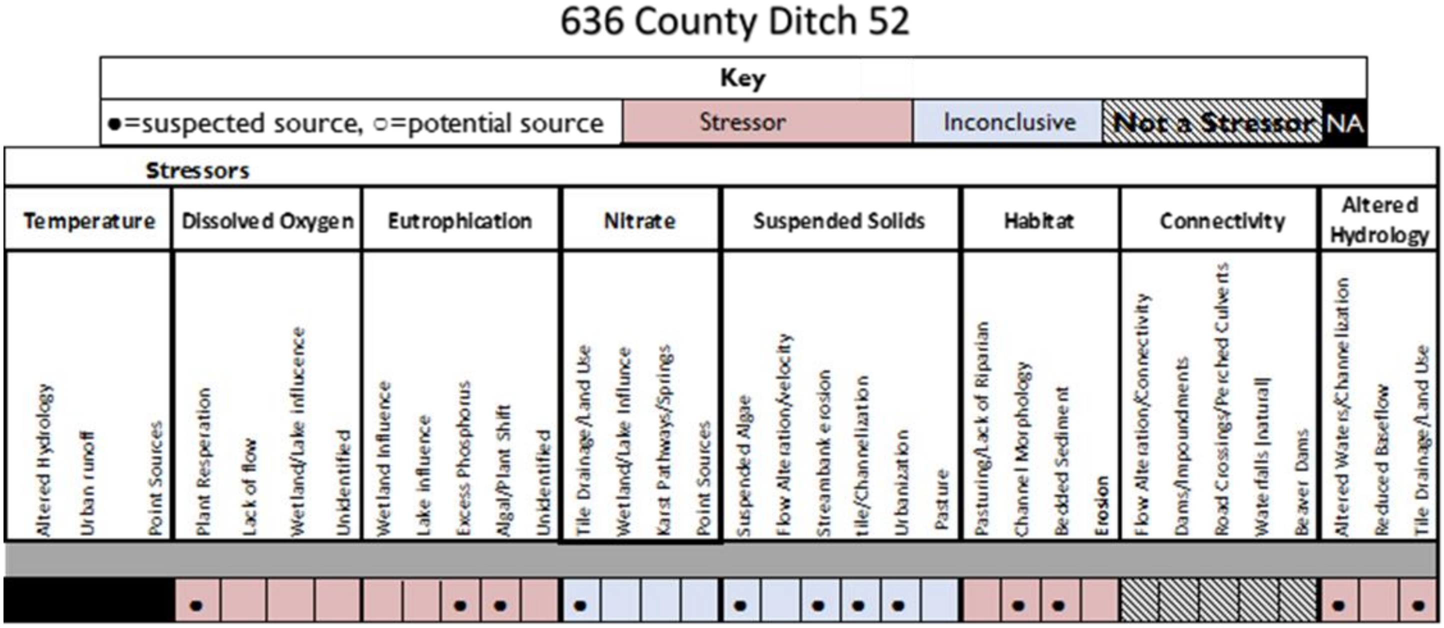
Longitudinal Connectivity and Altered Hydrology

Longitudinal Connectivity is not considered a stressor within this reach, as only the macroinvertebrate community is impaired.

Altered hydrology is influencing the overall stream health and biology at this site, as this section of stream as well as the contributing headers are completely altered by way of ditching, channelizing, as well as introduction of subsurface tile drainage. For additional information on how these forms of altered hydrology influence biology, as well at the other parameters evaluated within this report, reference Chapter 3.1.8.

Summary Table

Table 193. Identified stressors with suspected sources for reach 636 of County Ditch 52.



636 County Ditch 52

Key

●=suspected source, ○=potential source | 🟥 Stressor | 🟦 Inconclusive | ▨ Not a Stressor | ■ NA

Stressors

Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls (natural)	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
■	■	■	🟥 ●	🟥	🟥	🟥	🟥	🟥	🟥 ●	🟥 ●	🟥	🟦 ●	🟦	🟦	🟦	🟦 ●	🟦	🟦 ●	🟦 ●	🟦 ●	🟦	🟥	🟥 ●	🟥 ●	🟥	▨	▨	▨	▨	▨	🟥 ●	🟥	🟥 ●

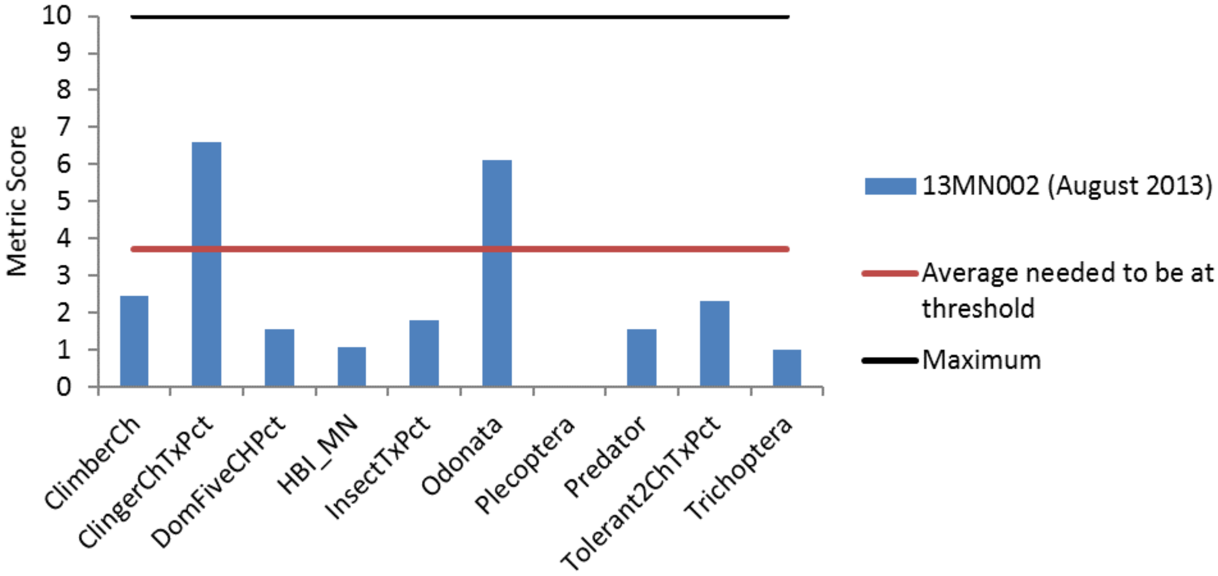
4.24 Crow Creek (07020007-569)

Crow Creek (0702007-569) is a tributary to the Minnesota River, east of Redwood Falls, Minnesota. The reach is warmwater general use Class 2B and begins at County Ditch 140. The reach is impaired for lack of fish assemblage and lack of macroinvertebrate assemblage. The reach is also impaired for *E. coli*, but it will not be covered in this report. Station 13MN002 was sampled for fish and macroinvertebrates in 2013.

4.24.1 Biological Communities

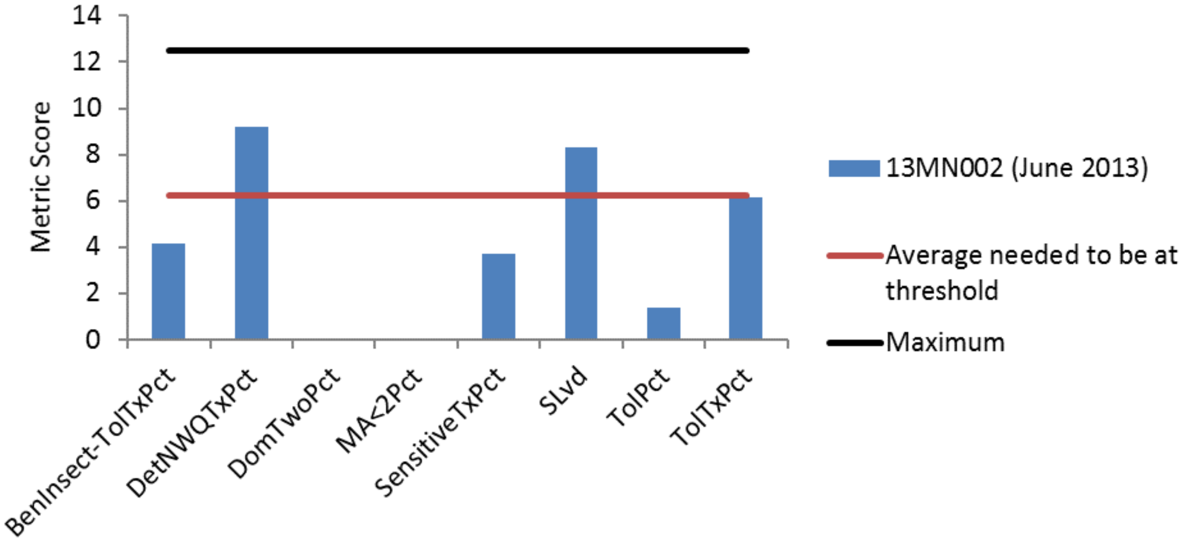
The macroinvertebrate community scored 26.4 MIBI, below the Southern Streams RR class threshold of 37. As shown in Figure 197, most groups that make of the IBI score feel below the threshold. The exception being clinger types as well as species from the order Odonata. Clingers (ClingerChTxPct) made up a large percentage of the community; this is due of the dominance of a relatively tolerant caddisfly, Cheumatopsyche. Odonata was the other category that met the expected threshold. However, roughly half of the species from the order Odonata found were from the lentic dwelling family of Coenagrionidae (Thorp 2010).

Figure 197. Macroinvertebrate metrics of the Southern Streams RR class IBI for station 13MN002, Crow Creek.



The fish community is impaired as well, receiving an FIBI score of 41.2 for the Southern Streams class (threshold of 50). There were six different taxa collected. Reflected in Figure 198, the fish community was dominated by blacknose dace and common shiner on June 18, 2013. Relative abundance of benthic insectivores (BenInsect-TolTXPct) was down, replaced by detritivorous taxa (DetNWQTXPct). There was an absents of mature or long-lived species (MA<2Pct), replaced by short-lived species (SLvd). Taxa types that are tolerant (TolTXPct) were slightly high, but the overall number of individuals rated at tolerant (TolPct) drove down the score.

Figure 198. Fish metrics of the Southern Streams class IBI for station 13MN002, Crow Creek.



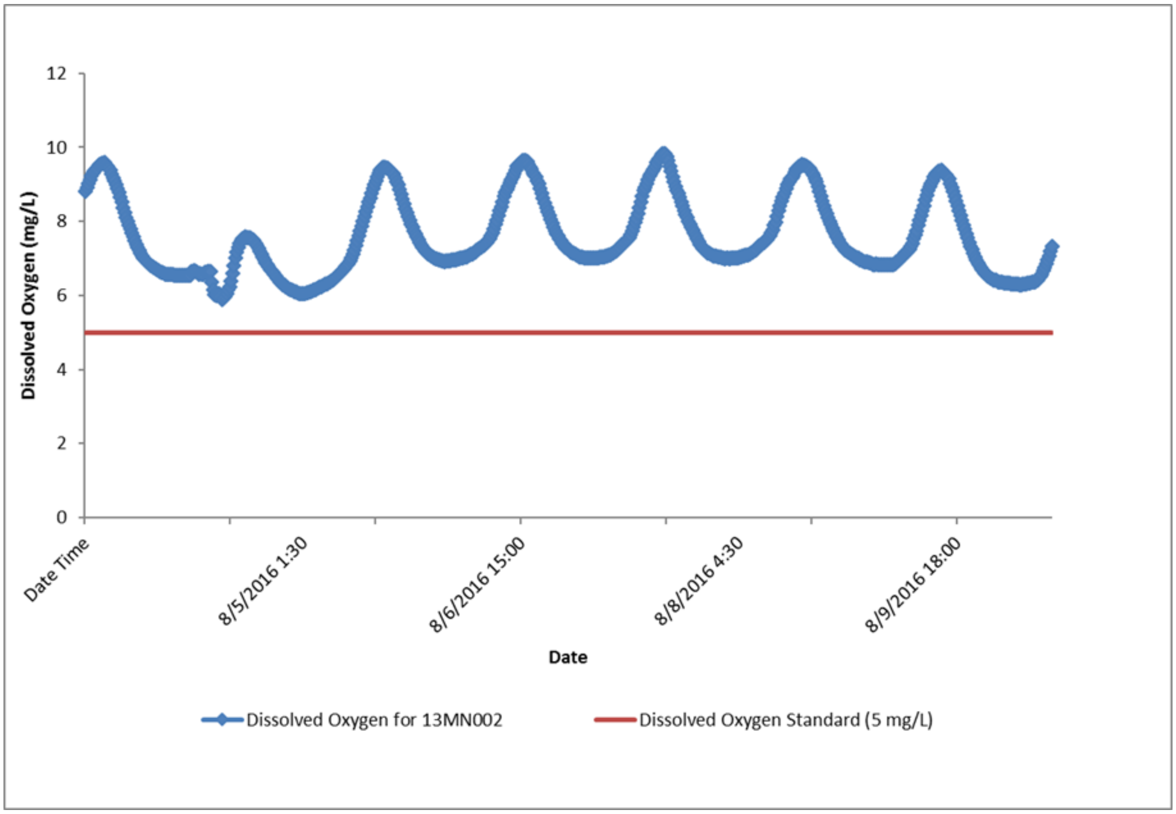
4.24.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

The dissolved oxygen (DO) concentration during biological sampling on June 18, 2013 and August 18, 2013 at station 13MN002 was 6.8 mg/L and 9.4 mg/L respectively. Additional samples collected from 2009 – 2016 ranged from 2.6 mg/L – 15.2 mg/L (average of 8.2 mg/L). Fifty-six samples were collected, and seven (13%) were below the warmwater standard (5 mg/L). All exceedances were found in morning sampling events in late summer months, with all but two of those samples collected in 2009. All samples were collected at station S005-628.

In 2016, an YSI sonde was deployed from August 3 through August 10 at station 13MN002. During that time frame, concentrations ranged from 5.9 mg/L – 9.8 mg/L (Figure 199). All values were above the low DO standard of 5 mg/L and the daily DO flux was 3-4 mg/L, below the standard for the South Region (4.5 mg/L).

Figure 199. YSI sonde deployed from August 3, 2016 through August 10' 2016 at station 13MN002.



The macroinvertebrate community in this reach of Crow Creek has a consistent metric response to a possible low DO stress (Table 194). There are a lack of EPT taxa and elevated Hilsenhoff Biotic Index (HBI_MN). The low DO tolerant taxa and individuals were elevated and the low DO intolerant taxa were not quite as abundant. There were eight low DO intolerant taxa compared to six low DO tolerant taxa.

Table 194. Macroinvertebrate metrics that respond to low DO stress in Crow Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN002 (2013)	**35**	**8**	**8.0**	**6.8**	**8**	**6.6**	**6**	**17.7**
Southern Streams Average	*45.8*	*14.2*	*7.1*	*7.0*	*9.0*	*24.0*	*4.8*	*9.9*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

A majority of the fish metrics were worse than the statewide average of stations meeting the FIBI threshold (Table 195). Relative abundance of sensitive individuals (SensitivePct) and individuals with a female mature age greater than three years (MA>3Pct) were below average, and tolerant individuals (TolPct) comprised 68% of the community. There were zero DO sensitive taxa, and one DO tolerant taxa comprising 2% of the community. The fish DO index score was above average.

Table 195. Fish metrics that respond to low DO stress in Crow Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
13MN002 (2013)	**3.5**	**0.0**	**68.4**	7.6	**0**	**0.0**	1	1.8
Southern Streams Average	*16.9*	*24.6*	*44.9*	*7.2*	*1.7*	*6.1*	*4.7*	*18.5*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

DO is inconclusive as a stressor at this time. The sonde deployment in the week of early August did not pick up low DO reading paired with high DO flux, yet DO concentrations never fell below the critical level of 5 mg/L during that deployment. There were a few instantaneous low DO reading (in 2009). The macroinvertebrates show a consistent response to stress. However, the fish are mixed in biological response. It is not clear if the sonde deployment was representative of the conditions this reach experiences, or if there are other instances of low DO. Additional data needs to be collected in order to confirm or rule out low DO as a stressor.

Eutrophication

The total phosphorus (TP) concentration during fish sampling on June 18, 2013 at station 13MN002 was 0.106 mg/L. Fifty three additional samples were collected from 2009 – 2016, ranging from 0.018 mg/L – 0.904 mg/L (average of 0.205 mg/L). Of these 53 samples, 25 (47%) were above the river eutrophication standard for the South Region (0.150 mg/L). The exceedances occurred in various months in 2009, 2010, and 2013. All samples were collected in the upper end of the AUID at station S005-628. The total phosphorus exceedances also showed multiple time periods when TSS was low, and variable base flow conditions. This is not as common as when samples are taken during storm events, when we would expect to see higher total phosphorus that is tied to sediment.

Chl-a, BOD, and DO flux are also considered when evaluating eutrophication stress. There have been zero chl-a or BOD samples collected. During sonde deployment in 2016, daily DO flux was below the standard for the South Region (4.5 mg/L). Low DO has been documented in this AUID; this was mostly limited in just one year (2009).

The macroinvertebrate community indicates possible stress from eutrophication (Table 196). The number of collector-filterer and collector-gatherer taxa were both slightly reduced at station 13MN002. There were no intolerant taxa, including few EPT, and overall the tolerant taxa comprise a large percentage of the community.

Table 196. Macroinvertebrate metrics that respond to eutrophication stress in Crow Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN002 (2013)	**35**	**5**	**13**	**8**	**0**	**82.9**
Southern Streams Average	*45.8*	*7.3*	*15.9*	*12.2*	*0.8*	*72.6*
Expected response to stress	↓	↓	↓	↓	↓	↑

A majority of the fish metrics were worse than the statewide average of stations meeting the FIBI threshold (Table 197). There were zero intolerant individuals (IntolerantPct), and elevated tolerant individuals (TolPct). Sensitive individuals (SensitivePct) and abundance of darter species (DarterPct) were both below average. Abundance of simple lithophilic spawners (SLithopPct) were well above average, as they comprised 83% of the fish community. This is because the two species that completely dominated the community were blacknose dace and common shiner, both of which are simple lithophilic spawners.

Table 197. Fish metrics that respond to eutrophication stress in Crow Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
13MN002 (2013)	**3.5**	**7.0**	82.5	**68.4**	**6**	**0**
Southern Streams Average	*16.9*	*11.9*	*37.0*	*44.9*	*19.3*	*4.2*
Expected response to stress	↓	↓	↓	↑	↓	↓

Eutrophication is inconclusive as a stressor to this reach. There are high concentrations of TP to feed overgrowth within this stream, during all flow regimes. There is a lack of response variables like chl-a, BOD, or DO flux to confirm eutrophic conditions are occurring in this reach. Biological metrics are slightly mixed, yet suggest eutrophic stress within both the macroinvertebrate and fish community.

Nitrate

Nitrate concentration during fish sampling on June 18, 2013 at station 13MN002 was 13 mg/L. Additional samples collected from 2009 – 2016 ranged from 0.2 mg/L – 21.9 mg/L (average of 9.1 mg/L). Fifty-two samples were collected, and 26 (50%) were above 10 mg/L. Elevated concentrations were observed in most years and various months, with a majority occurring in April – June. Samples were collected at station S005-628.

Taxa richness of Trichoptera (TrichopteraCh) and relative abundance of non-hydropsychid Trichoptera individuals (TrichwoHydroPct) were below the statewide average of stations meeting the MIBI threshold (Table 198). There were zero nitrate intolerant taxa, and 17 nitrate tolerant taxa comprising 78% of the community. The macroinvertebrate nitrate index score was worse (higher) than average, indicating an overall nitrate tolerant community is present. A majority of the macroinvertebrate metrics were worse than average and indicative of nitrate stress.

Table 198. Macroinvertebrate metrics that respond to nitrate stress in Crow Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN002 (2013)	**3**	**0.6**	**3.6**	**0**	17	**78.2**
Southern Streams Average	*6.3*	*5.5*	*2.9*	*2.4*	*18.8*	*47.2*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is a stressor to Crow Creek. The chemistry data displays high nitrate loading to the stream is occurring. The metrics also show consistent response, including lack of sensitive taxa, and high percentages of nitrate tolerant individuals.

Total Suspended Solids

The total suspended solids (TSS) concentration during fish sampling on June 18, 2013 at station 13MN002 was 8 mg/L. Fifty three additional samples collected from 2009 – 2016 ranged from 2 mg/L – 236 mg/L (average of 29.6 mg/L), and 8 (15%) were above the warmwater standard for the South Region (65 mg/L). Exceedances occurred in 2009 and 2010, in March (two), June (three), and September (three). Samples were collected at station S005-628.

Additional to the 53 samples of TSS, volatile suspended solids (VSS) were analyzed side by side with each TSS sample to account for organics within the TSS samples. Overall VSS on average accounted for 52% of what was found in the TSS samples. Analyzing just the TSS samples that exceeded 65 mg/L, found the average of VSS of those samples to be 15%. This points to additional sediment particles in those high samples instead of organics, which is likely related to runoff/storm events in those particular samples. The remaining samples with higher volatiles probably were due to the upstream ditches that feed this reach; as they have documented high algae production (See County Ditch 52 above).

The macroinvertebrate community had a mixed response to high TSS stress (Table 199). There were an abundance of collector-filtering individuals in the community and not a high number of TSS tolerant taxa. However, station 13MN002 had an elevated TSS index score as well as limited TSS intolerant taxa and a high percentage of TSS tolerant individuals in the sample.

Table 199. Macroinvertebrate metrics that respond to high TSS stress in Crow Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN002 (2013)	42.3	**0**	**17.43**	**1**	**0.6**	9	**63.7**
Southern Streams Average	*25.4*	*0.7*	*15.63*	*2.9*	*4.7*	*12.2*	*34.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

The fish community showed response consistent with TSS stress in the general metrics used in the TSS standard, but lacked an elevated TSS index score or presence of TSS tolerant taxa (Table 200 and Table 201). Excess sediment typically leads degraded streambed habitat. Species that depend on clean riverbed substrate were lacking in the sample as noted in the table below. Benthic feeders (BenFdFrimPct), TSS intolerant Perciformes (Percfm-TolPct) and Centrarchidae (Centr-TolPct), herbivores (HrbNWQPct), riffle dwellers (RifflePct), and simple lithophilic spawners (SLithFrimmPct). Both TSS intolerant and tolerant species were below the average for southern streams.

Table 200. Fish metrics that respond to high TSS stress in Crow Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
13MN002 (2013)	**7.0**	**0**	**3.5**	**0**	**0**	**7.0**	**3.5**	**3.5**	**0**
Southern Streams Average	*36.0*	*5.4*	*25.7*	*4.2*	*13.6*	*20.1*	*30.2*	*16.9*	*19.1*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 201. Fish metrics that respond to high TSS stress in Crow Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TSS Index Score	TSS Sensitive Taxa	TSS Sensitive Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN002 (2013)	11.6	**0**	**0**	0	0
Southern Streams Average	*19.2*	*1.7*	*5.3*	*2.4*	*12.5*
Expected response to stress	↑	↓	↓	↑	↑

The metrics are suggestive of TSS stress within the macroinvertebrate community; however, the fish show an overall stunted community, that does not clearly indicate TSS is limiting the community. The dataset shows some exceedances of the standard, but overall these appear to be related to high flow events, and baseflow TSS seems adequate. The mixed response makes TSS as a stressor inconclusive.

Habitat

The MSHA for station 13MN002 was fair 65.2, with four out of the five habitat categories scoring at an acceptable range (Figure 200). The surrounding land use was row crop. The riparian area comprised of moderate width with heavy shade but had moderate to heavy bank erosion. There were diverse substrates available and gravel and cobble in the riffle. Riffle features comprised of 20% of the stream reach, same as pool features, and run features dominated at 60%. There was moderate embeddedness present. Stream cover was rated as moderate with numerous types available. Channel stability was rated as moderate. A site visit on June 18, 2013 (Figure 201) displays erosion on both banks, with quite a bit of woody debris.

Figure 200. Percentage of MSHA subcategory scores for station 13MN002, Crow Creek

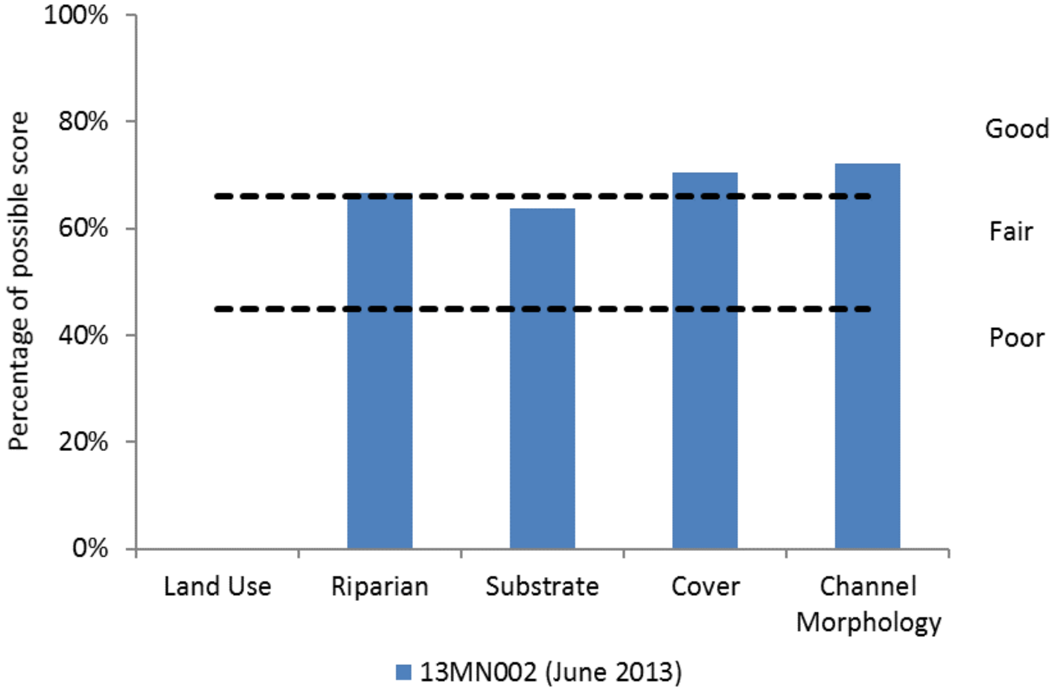
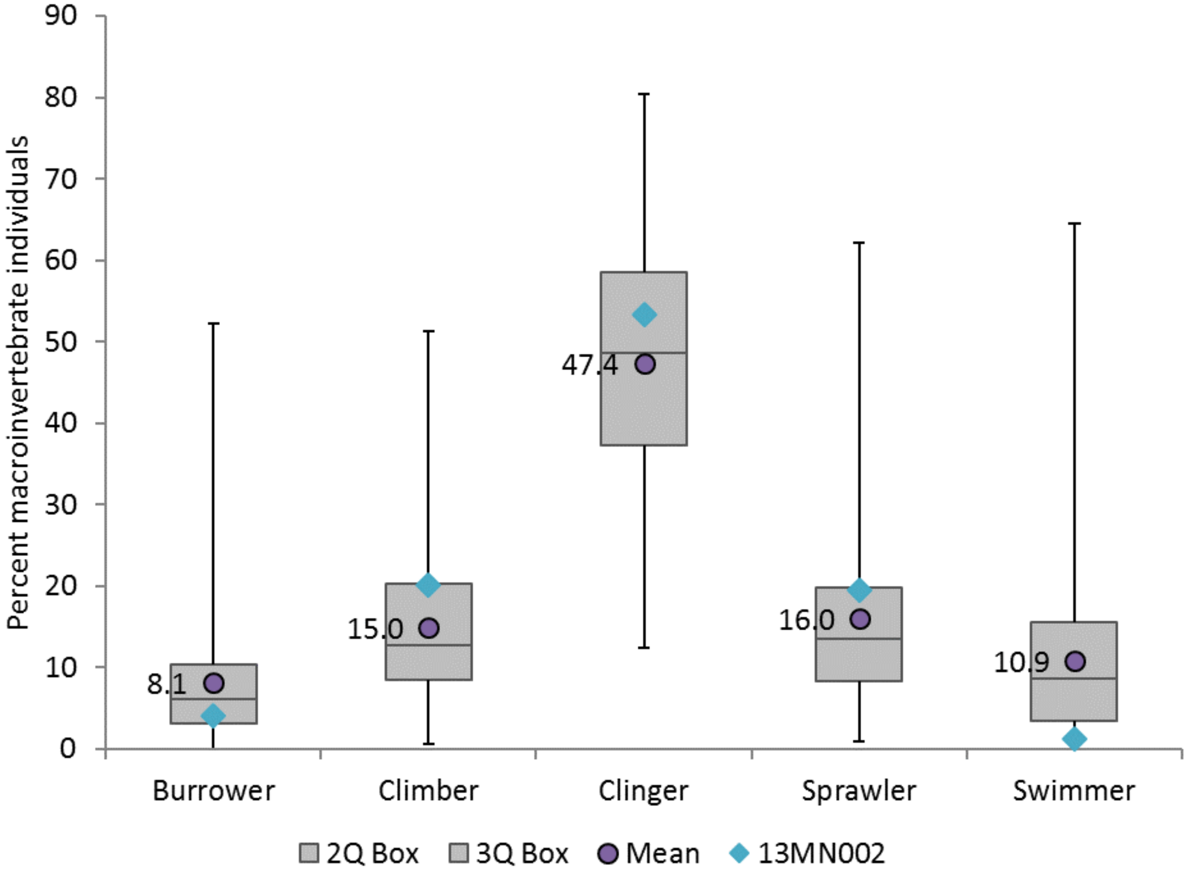


Figure 201. Station 13MN002 on June 18, 2013.

The macroinvertebrate community was sampled on riffle, rock, run and snag, woody debris, and root-wads. The macroinvertebrate community for the most part fell within the expected habitat group types. Burrowers and swimmers were slightly below the average at station 13MN002. The taxa richness of climbers was low as shown in the IBI metrics (Figure 202).

Figure 202. Macroinvertebrate metrics that respond to habitat for station 13MN002, Crow Creek compared to the range of values for Southern Stream RR visits meeting the general use biocriteria.



As discussed in the above TSS section, the relative abundance of individuals that are riffle-dwelling species (RifflePct) was below average, and abundance of simple lithophilic spawners (SLithopPct) was also below average (Table 200). These species require clean coarse substrate and are expected to decrease with habitat stress.

There are some issues of concern noted that could degrade habitat, such as erodible banks and moderate embeddedness in this reach; however, physical habitat availability does not seem to be a driving factor with the macroinvertebrate or fish community metrics. During biological sample, riffles were noted as present, but there was not much flow and the stream was over widened. A lack of riffle dwelling fish species also support this. Certainly, some aspects of habitat could be improved in this reach but mixed information makes habitat inconclusive as a stressor to Crow Creek at this time.

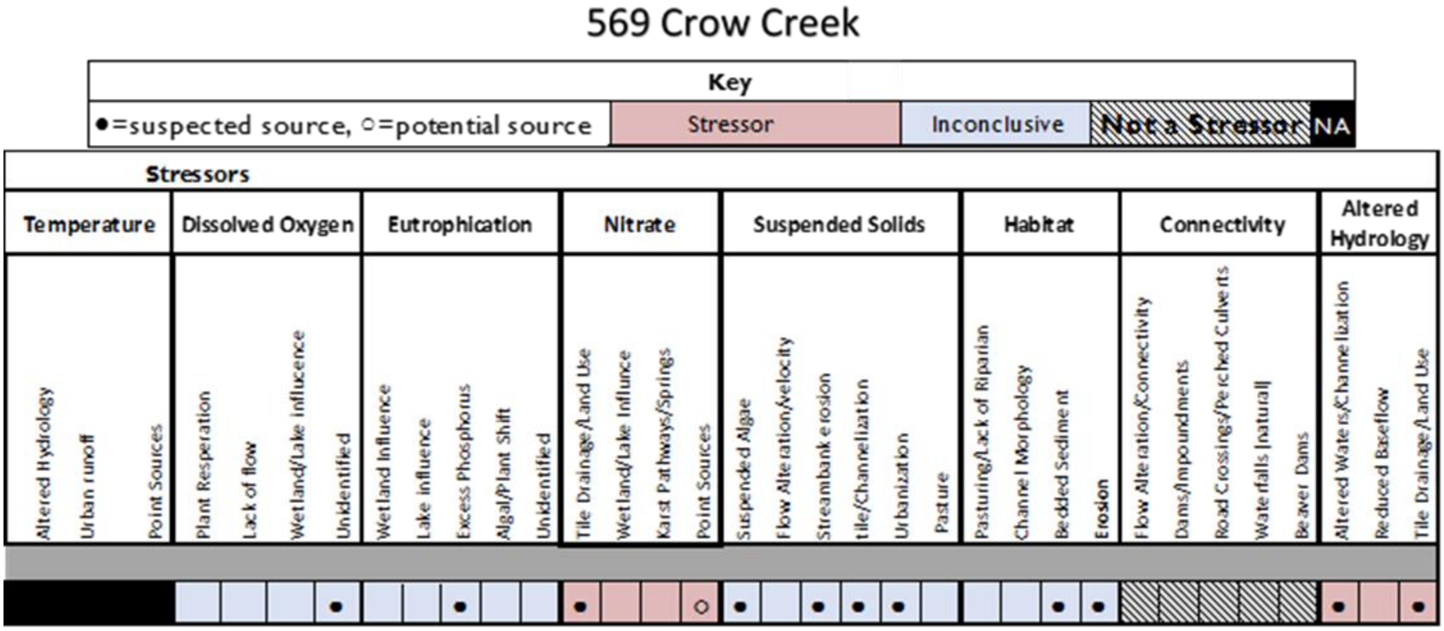
Longitudinal Connectivity and Altered Hydrology

There was not any identified barriers on this reach, or downstream to be influencing the biological community. Longitudinal connectivity is not considered a stressor.

Altered hydrology is considered the primary biological stressor. This reach is a receiving stream for two headwater tributaries that are identified as completely altered via channelization as well as the introduction of subsurface tile drainage. These drivers of altered hydrology create impairment in both channel stability as well as pollutant loading. Reference Chapter 3.1.8 for more information on these forms of altered hydrology.

Summary Table

Table 202. Identified stressors with suspected sources for reach 569 of Crow Creek.



569 Crow Creek

Key				
●=suspected source, ○=potential source	🟥 Stressor	🟦 Inconclusive	▨ Not a Stressor	⬛ NA

Stressors																																				
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls (natural)	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
⬛	⬛	⬛	🟦	🟦	🟦	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	🟥 ●	🟥	🟥	🟥 ○	🟦 ●	🟦	🟦 ●	🟦 ●	🟦 ●	🟦	🟦	🟦	🟦 ●	🟦 ●	▨	▨	▨	▨	▨	🟥 ●	🟥	🟥 ●

Spring Creek Subwatershed Conclusion

There are eight impaired reaches within the Spring Creek Subwatershed. As shown in the above table, they are organized from east to west and upstream to downstream. There are two coldwater reaches in this group of reaches, John's Creek (-571) and the middle reach of Spring Creek, otherwise known as Hindeman Creek (-574). Both are impaired for fish and macroinvertebrates. There are four general use warmwater reaches in Spring Creek that are also impaired for both fish and macroinvertebrates. Unnamed Creek (-715) is classified as a warmwater general use stream, impaired for fish only as the sample for macroinvertebrates was sampled outside of 2015 and therefore was not brought into this assessment period. County Ditch 52 (-636) is impaired for macroinvertebrates only. This was the only modified stream within the list of impaired reaches.

Altered hydrology is the primary stressor in these streams as it is directly contributing to the other stressors. Altered hydrology is occurring two ways within this subwatershed. The first is through subsurface tile drainage and the second is stream channel alteration by ditching and channelizing. Alterations in this region are from agricultural practices in attempt to expedite water off the land to optimize growing conditions. Both of these practices initiate altered hydrology in the system. The streams are taking on volumes of water greater than what they are naturally designed to carry. This results in accelerated flow velocity and significantly changes the morphology of the stream at the receiving location as well as downstream areas. Stream banks erode and streambeds are scoured out or filled in with sediment. All the streams, with the exception of County Ditch 52 and Judicial Ditch 29 are on steep gradients as they make their way down the Minnesota River Valley. Because of this, these sections of stream are not channelized, as farming practices are restricted in the upland flat areas. However, all of these reaches are being influenced from the large upland drainage network that is heavily altered.

Poor habitat was a common stressor that was found to limit the biology in a majority of these streams. Primarily by sedimentation from bank erosion that ties back to altered hydrology. The exception to this source of habitat impairment was found along Unnamed Creek; Here habitat availability is limited from over pasturing and would be improved with introductions of BMPs.

Total suspended solids (TSS) was listed at only one location as a biological stressor. This was at Johns Creek, a cold-water stream. High loading of sediment was recorded within these reaches. In part, some of this erosion is occurring through natural process, as a majority of the streams are naturally down-cutting through bluffs and ravines. However, the force and velocity is often accelerated through upstream altered hydrology, accelerating erosion rates. Another potential source of TSS to the system is urban runoff from the city of Redwood Falls, influencing TSS loading in CD 52 and Crow Creek. At many sites, TSS was listed as inconclusive due to lack of chemistry data.

TSS also can influence temperatures of a stream. As sediment absorbs heat, it can increase water temperatures when introduced at high concentrations. Hindeman Creek (-574) a coldwater stream was found to have a struggling coldwater population. Temperatures at Hindeman Creek are extremely limiting to the community with chronic high temperatures throughout the summer months. John Creek, the other cold-water stream is listed as inconclusive for temperature as more temperature data up stream needs to be collected. Johns Creek is stocked for brown trout that are found to be self-sustaining downstream, but diminish as they go upstream. The other culprit of increased stream temperatures in this region is due to upland headwater contributions. Here, where streambanks have been completely modified for ditching practices, there is a lack of overhanging vegetative coverage that allows direct sunlight penetration. During low baseflow conditions, this upstream source can greatly influence downstream temperatures. Future longitudinal temperature monitoring of Johns Creek is recommended to determine the severity of warmwater contributions to this cold-water reach.

Tile drainage in this watershed is likely the leading input of nutrients, such as nitrates and phosphorus.

Phosphorus was high in all the streams assessed. Only one resulted in eutrophic conditions. This is due to the combination of other factors that require an overproduction of algae growth, in this case slow stream velocity and high sun exposure from lack of vegetative stream cover. Plant respiration in this eutrophic stream results in the low levels of dissolved oxygen (DO) within this reach, also limiting the biology. The overabundance of algae can negatively influence biology in a similar way suspended sediment will. The eutrophic conditions in CD 52 is contributing to TSS loading within this stream as well as the downstream reach of Crow Creek.

Nitrate itself is toxic to biology depending on the concentration levels as well as exposure time. Nitrate was found to be high in most cases but was limited in samples to clearly identify chronic nitrate issues. Three streams had clear biological stress and enough data to determine nitrates are impacting the community.

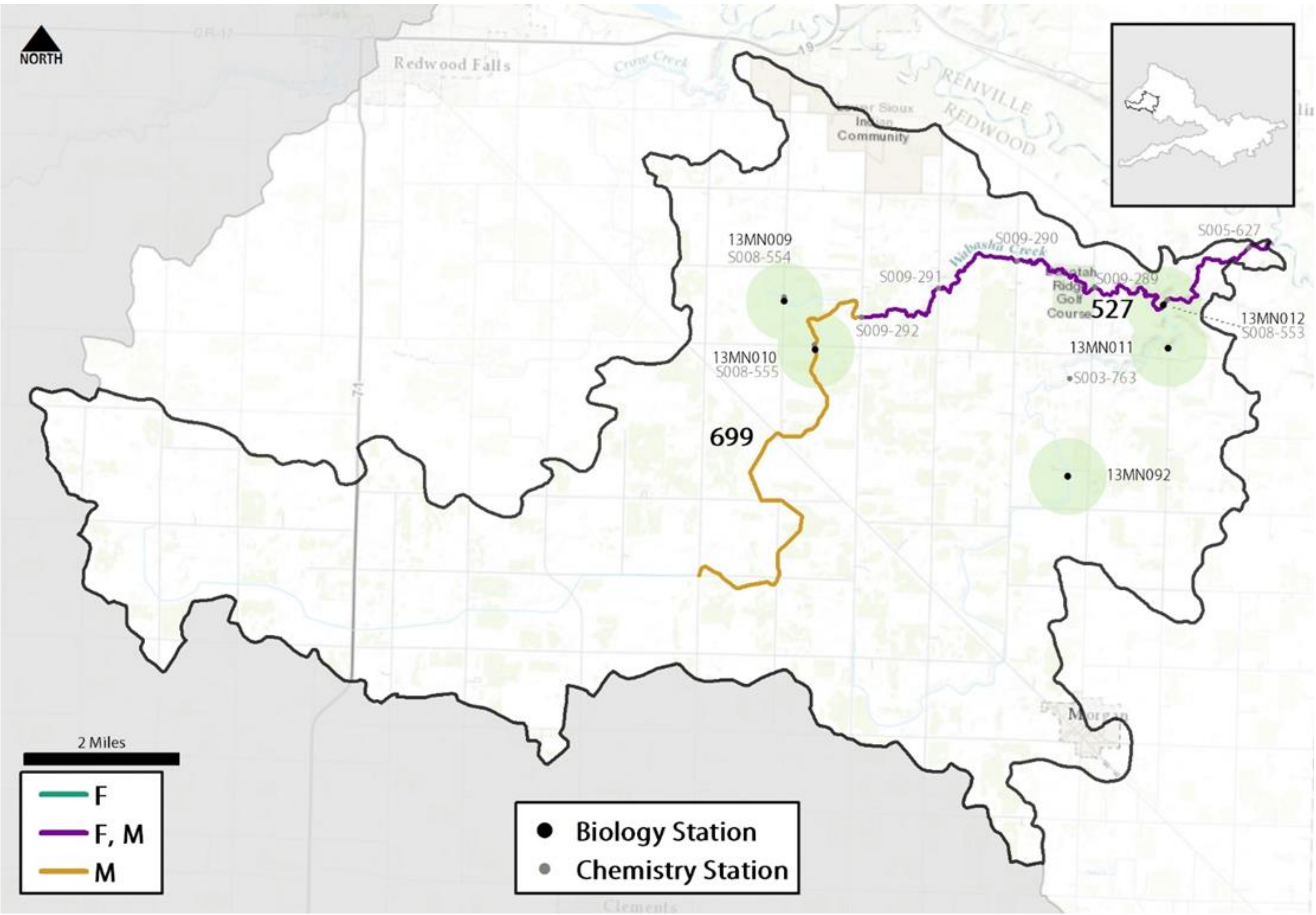
Fish connectivity is of concern within this watershed. Johns Creek and CD 13 are in question for being losing reaches. Additional flow studies are recommended to better understand if this is natural or from local dewatering practices taking place in this system.

Hindeman Creek, JD 29, and unnamed Creek are both identified as having perched culverts that will limit fish migration during low base flow conditions. JD 29 also has a beaver dam noted as a potential barrier.

Wabasha Creek – MNR Mankato South

This section encompasses biotic impaired reaches in the Wabasha Creek 10 digit HUC (). There are two reaches impaired in this 10 digit HUC, an upstream reach on Wabasha Creek and a downstream reach on Wabasha Creek. Both reaches are impaired for lack of macroinvertebrate assemblages and lack of fish assemblages.

Figure 203. Map of the Wabasha Creek Watershed with biological impairments and monitoring stations. Impairments are described as F=Fish, F, M=Fish and Macroinvertebrates, and M=Macroinvertebrates



4.25 Wabasha Creek (07020007-699)

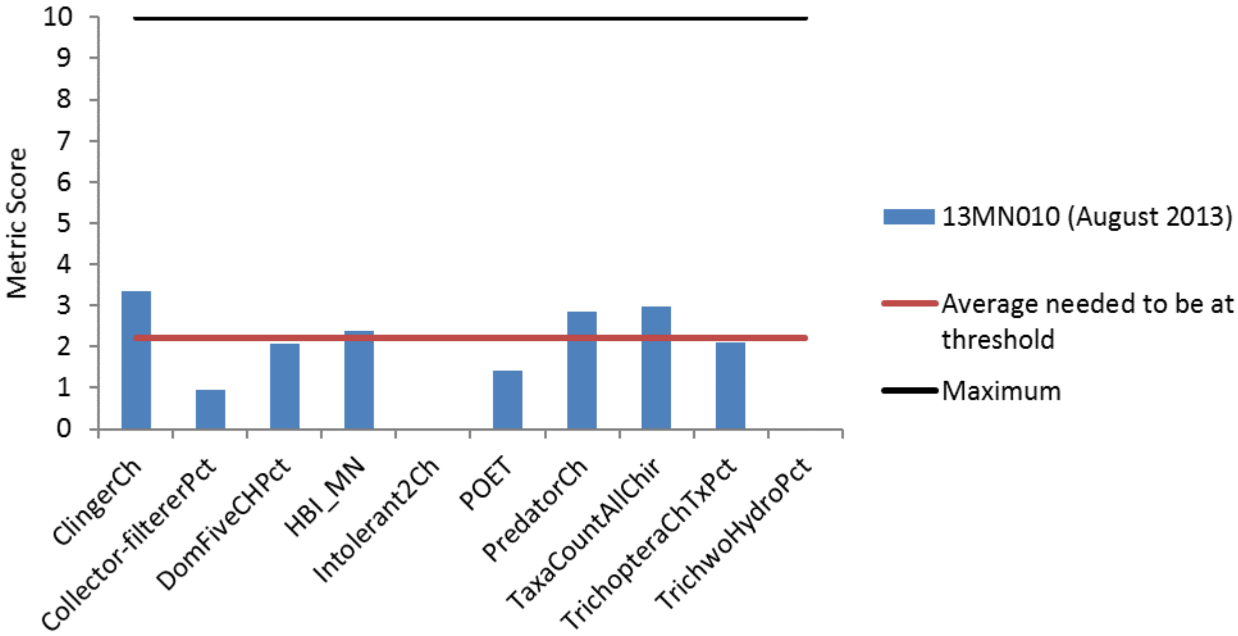
Wabasha Creek (07020007-699) is the upstream AUID on Wabasha Creek. Wabasha Creek is a tributary to the Minnesota River. This reach of Wabasha Creek is from Ocean Ave to County Road 13, southeast of Redwood Falls, Minnesota. The reach is warmwater modified use Class 2B. The reach is impaired for lack of macroinvertebrate assemblage.

4.25.1 Biological Communities

Station 13MN010 was sampled for fish and macroinvertebrates in 2013. The fish community scored 20.1, above the modified use threshold (15) for the low gradient class. Only five fish species were present and the most common was fathead minnows. Fish were not listed as impaired.

The macroinvertebrates were listed as impaired, with a MIBI score of 18.1 in 2013 for the Prairie Streams GP class. The visit resulted in a MIBI score less than the modified use threshold (22). As shown in Figure 204 below, most groups that make of the IBI score feel below the threshold. The exception being clinger types as well as species from the order Odonata. Clingers (ClingerChTxPct) made up a large percentage of the community; this is due of the dominance of a relatively tolerant caddisfly, Cheumatopsyche. Odonata was the other category that met the expected threshold. However, roughly half of the species from the order Odonata found were from the lentic dwelling family of Coenagrionidae.

Figure 204. Macroinvertebrate metrics of the Prairie Streams GP class IBI for 13MN010, Wabasha Creek.



4.25.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

The dissolved oxygen (DO) concentration during biological sampling on June 18, 2013 and August 19, 2013 at station 13MN010 was 9.5 mg/L and 13.8 mg/L respectively. Additional samples collected in 2015 and 2016 ranged from 6.4 mg/L – 14.7 mg/L (average of 10.1 mg/L). Only eight samples were collected, and all were above the warmwater standard (5 mg/L). Samples were collected at stations S008-555 and S009-292.

In 2015, an YSI sonde was deployed at station 13MN010 from July 16 to July 23 (Figure 205 and Figure 206). The DO ranged from 3.04 to 14.99 mg/L; with each day deployed, the DO was below the standard. Daily DO fluxuation DO flux was also elevated, ranging from 6.39 to 10.89 mg/L daily, with an average of 8.49 mg/L.

Figure 205. Diurnal dissolved oxygen for station 13MN010, July 16 - 23, 2015.

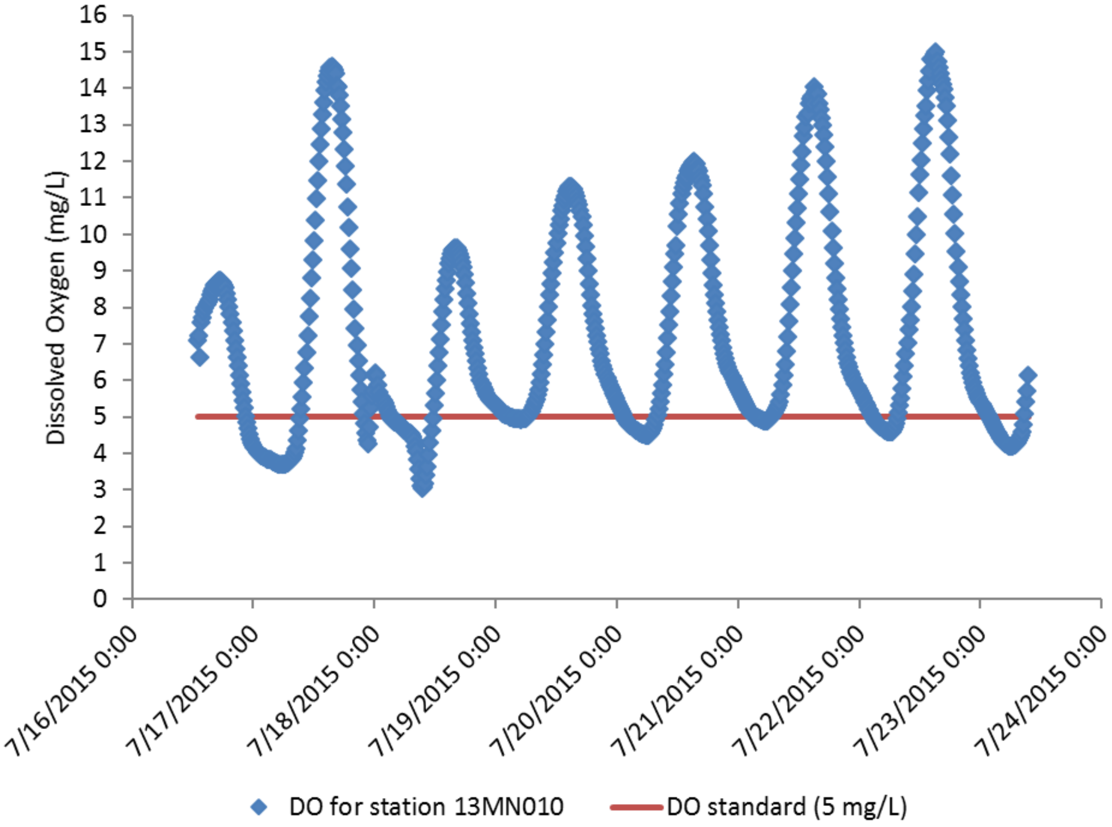
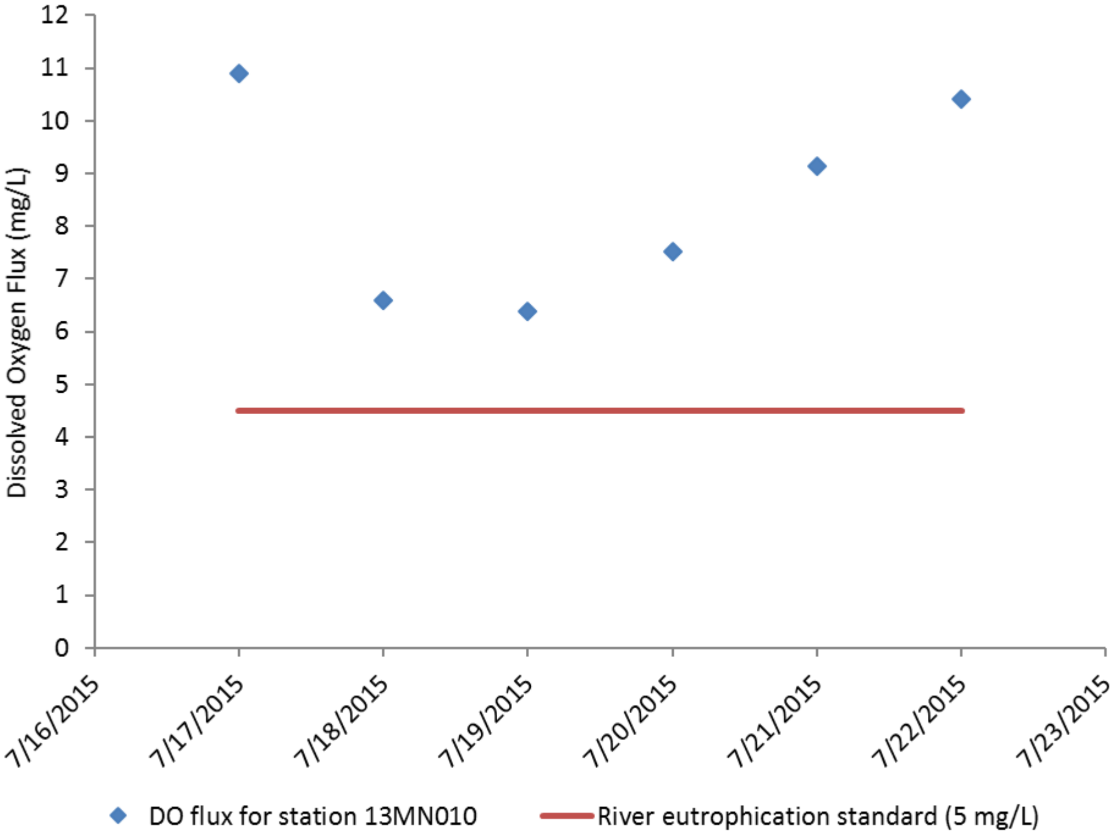


Figure 206. Dissolved oxygen flux for station 13MN010, July 17 – 22, 2015.



The macroinvertebrate community response corresponds to low DO stress (Table 203). There was low EPT taxa and elevated Hilsenhoff Biotic Index for MN. The low DO index score was worse than similar stations meeting the biocriteria. There were no low DO intolerant taxa and elevated DO tolerant taxa and relative abundance of individuals.

Table 203. Macroinvertebrate metrics that respond to low DO stress in Wabasha Creek compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN010 (2013)	**29**	**1**	**8.2**	**6.0**	**0**	**0**	**13**	**61.7**
Prairie Streams Average	*36.8*	*7.6*	*7.9*	*6.4*	*2.4*	*4.5*	*8.4*	*25.1*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

DO is likely stressing the biological community within this reach based on the findings of the deployment that captured daily drops of DO to levels that are not sustainable for most aquatic organisms. The invertebrate metrics are also suggestive of low DO stress within the community.

Eutrophication

The total phosphorus (TP) concentration during fish sampling on June 18, 2013 at station 13MN010 was low, at 0.033 mg/L. Additional samples were collected in 2015 and 2016, ranging from 0.045 mg/L – 0.746 mg/L (average of 0.290 mg/L). Only six samples were collected, but three were above the river eutrophication standard for the South Region of 0.150 mg/L. Exceedances occurred on July 23, 2015 (0.222 mg/L), September 1, 2015 (0.553 mg/L), and February 22, 2016 (0.746 mg/L). Samples were collected from station S008-555.

Chl-a, BOD, and DO flux are also considered when evaluating eutrophication stress. Two chl-a samples were collected in July and September 2015; both samples were below the 35 µg/L standard (2.29 µg/L and 3.01 µg/L respectively). At this time, there have been zero BOD samples collected. During sonde deployment in 2015, daily DO flux was elevated, ranging from 6.39 to 10.89 mg/L. Low DO was also documented daily during this deployment.

Visually, this reach consistently displayed eutrophic conditions, as seen in the abundant algae and macrophyte growth in Figure 207 and Figure 208. On April 27, 2015, a site visit noted that the stream was choked out with algae as well.

Figure 207. Station 13MN010 on June 18, 2013.

Figure 208. Location 13MN010 taken on June 16, 2016.

The macroinvertebrate community at station 13MN010 is consistent with eutrophication stress (Table 204). There were fewer collector-filterer and collector-gatherer taxa than average. The majority of the taxa present were tolerant with no intolerant taxa present. The dominant macroinvertebrate sampled, Hyallela (43% of community), feeds on organic material/detritus and often signals eutrophic conditions may be present.

Table 204. Macroinvertebrate metrics that respond to eutrophication stress in Wabasha Creek compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN010 (2013)	**29**	**3**	**9**	**1**	**0**	**96.6**
Prairie Streams Average	*36.8*	*3.9*	*12.8*	*6.5*	*0.1*	*85.4*
Expected response to stress	↓	↓	↓	↓	↓	↑

Eutrophication is considered a stressor within this reach. There are high levels of nutrients to feed these conditions within this stream, as well as daily high DO flux. Chl-a samples were limited, and sample concentrations were low due to low amounts of suspended algae. However, while suspended algae was not observed in the water column, it was observed in the form of filamentous algae and submerged aquatic macrophytes were abundant. All of the biological, chemical and physical data points to eutrophication as a biological stressor within this reach.

Nitrate

Nitrate concentration during fish sampling on June 18, 2013 at station 13MN010 was 9.7 mg/L. Additional samples collected in 2015 and 2016 ranged from 1.3 mg/L – 33 mg/L (average of 17.7 mg/L). Only six samples were collected, but five were above 10 mg/L (including two above 20 mg/L). Elevated concentrations were observed in both years, in February, May, June (two), and July. Samples were collected at station S008-555.

Taxa richness of Trichoptera (TrichopteraCh) and relative abundance of non-hydropsychid Trichoptera individuals (TrichwoHydroPct) were below the statewide average of stations meeting the MIBI threshold (Table 205). There were zero nitrate intolerant taxa, and 15 nitrate tolerant taxa comprising 45% of the community. The macroinvertebrate nitrate index score was worse than average. A majority of the macroinvertebrate metrics were worse than average.

Table 205. Macroinvertebrate metrics that respond to nitrate stress in Wabasha Creek compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN010 (2013)	**1**	**0.0**	**3.4**	**0**	15	45.0
Prairie Streams Average	*2.6*	*2.4*	*3.2*	*1.1*	*18.0*	*59.7*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is considered a stressor within this reach of Wabasha Creek. While nitrate samples were sparse over the two years samples were collected, what was analyzed was high (in all but one sample). Samples were collected periodically enough that even though the samples were not in abundance, the nitrate concentration found are likely telling of the typical loading within this stream. Invertebrate metrics indicate that nitrate is driving down species that are intolerant or sensitive to high levels of nitrate.

Total Suspended Solids

The total suspended solids (TSS) concentration during fish sampling on June 18, 2013 at station 13MN010 was 2.8 mg/L. Additional samples collected in 2015 and 2016 ranged from 3.2 mg/L – 23 mg/L (average of 8 mg/L). Only six samples were collected, and zero were above the warmwater standard for the South Region (65 mg/L). Samples were collected in February, May, June (two), July, and September at station S008-555.

The macroinvertebrate community had a mixed response to potential high TSS stress (Table 206). The TSS index score was not elevated. Similarly, there was not a high presence of TSS tolerant taxa or individuals. There were some metrics that show community response as expected with TSS stress, but those may be due to other stressors present in the reach. Collector filterers were greatly decreased, while TSS sensitive Plecoptera were all together missing.

Table 206. Macroinvertebrate metrics that respond to high TSS stress in Wabasha Creek compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

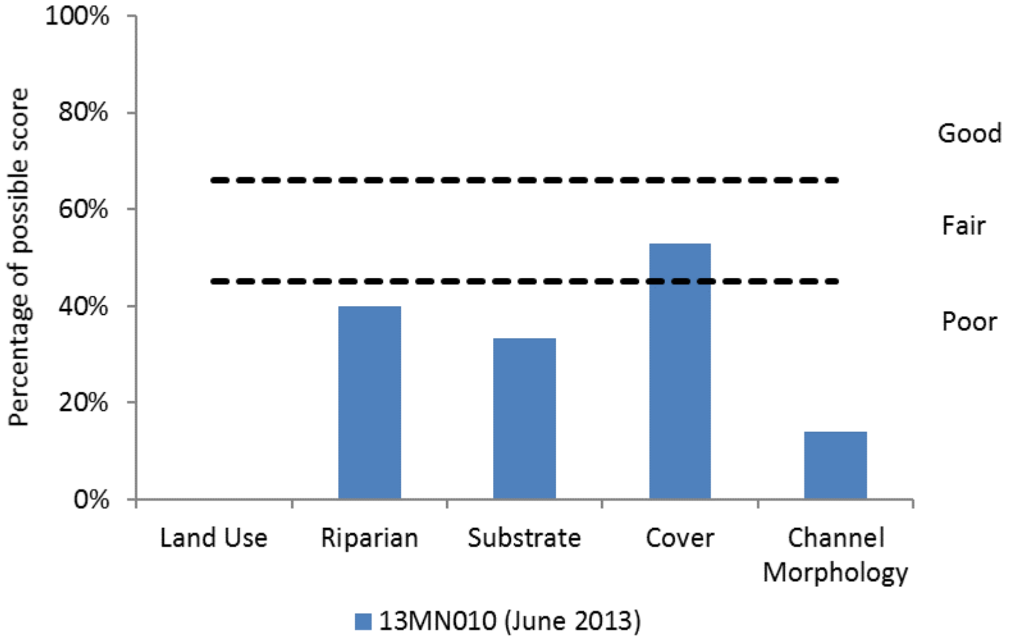
Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN010 (2013)	**3.9**	**0**	15.28	**0**	**0**	8	22.4
Prairie Streams Average	*11.7*	*0.1*	*16.68*	*0.8*	*1.4*	*11.8*	*41.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

There was some indication the TSS could be limiting the macroinvertebrates, but it is not clear if it is an overloading of TSS within the stream, or if it is a response from other stressors. Additional TSS monitoring would help to better understand the dynamics of TSS on this system. There is not enough information to completely rule out TSS as stressor, therefore TSS is inconclusive.

Habitat

In 2013, the MSHA score was poor (29). As shown in Figure 209 below, surrounding land use resulted in the poorest scoring, as land use was row crop. The riparian area was very narrow with light shade and little bank erosion. The reach was comprised of 100% run features with silt and sand (no course substrate available). There was moderate cover provided by overhanging vegetation and submergent macrophytes; however, these forms will vary with the season. There was poor depth variability, a lack of sinuosity, poor channel development, and moderate bank stability.

Figure 209. Percentage of MSHA subcategory scores for station 13MN010, Wabasha Creek

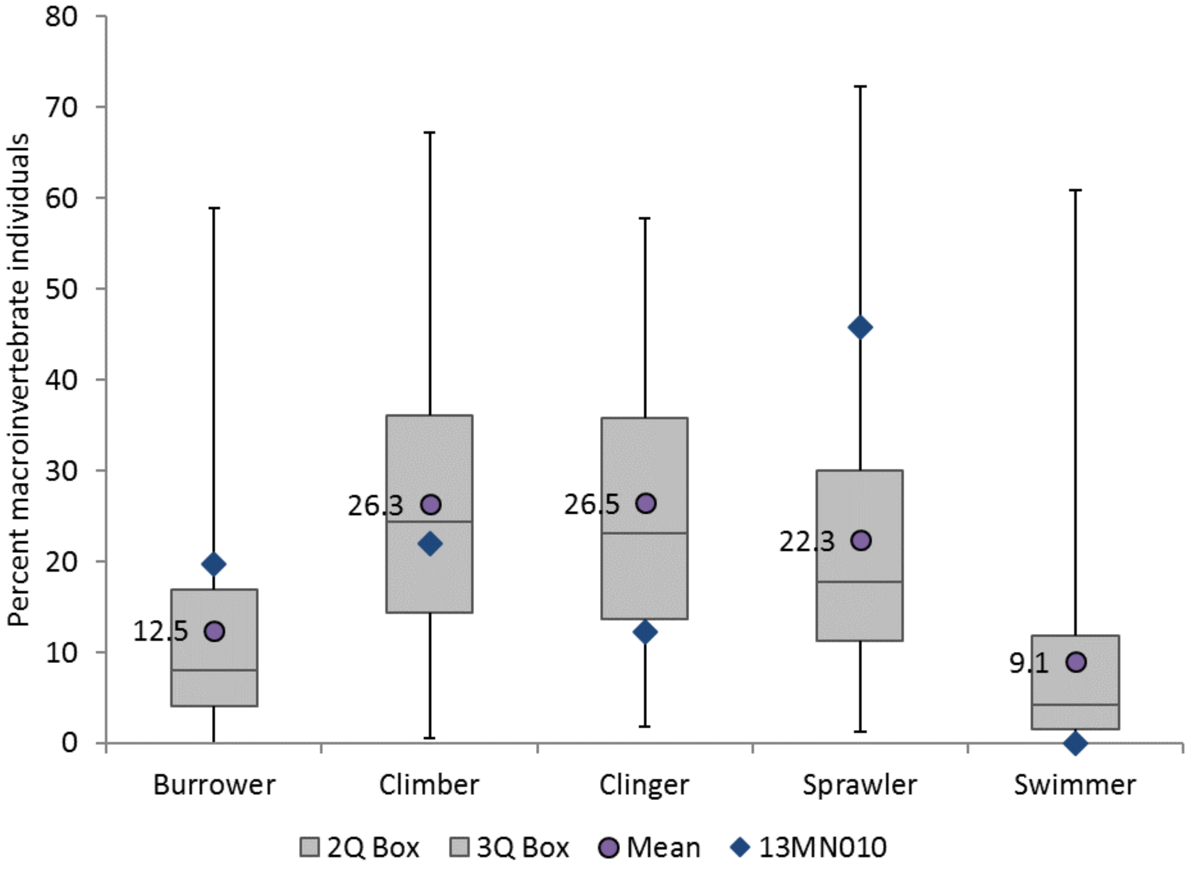


As displayed in Figure 210, this modified reach provides little habitat variation. Vegetation is the primary habitat that could be utilized by select biology.

Figure 210. Station 13MN010 displaying habitat conditions on June 18, 2013

Macroinvertebrates were sampled on undercut banks and overhanging vegetation. The macroinvertebrate community at station 13MN010 responded to the habitat conditions mixed in terms of habitat stress. Figure 211 shows that the burrowers were elevated, along with sprawlers. The excess sprawlers may be due to the thick algal presence in the stream. The clinging macroinvertebrates were reduced and fall within the bottom quarter of stations meeting the biocriteria. A high abundance of burrowers are a strong indication of degraded streambed health.

Figure 211. Macroinvertebrate metrics that respond to habitat for station 13MN010, Wabasha Creek compared to the range of values for Prairie Stream RR visits meeting the modified use biocriteria.



Habitat is a stressor to the macroinvertebrates in this reach. This reach has been modified, greatly limiting the physical habitat diversity. This is reflected in both the MSHA score as well as the macroinvertebrate metrics that habitat conditions are poor. Particularly noted in poor stream substrate, where both embeddedness is noted as well as enhanced numbers of burrower macroinvertebrates.

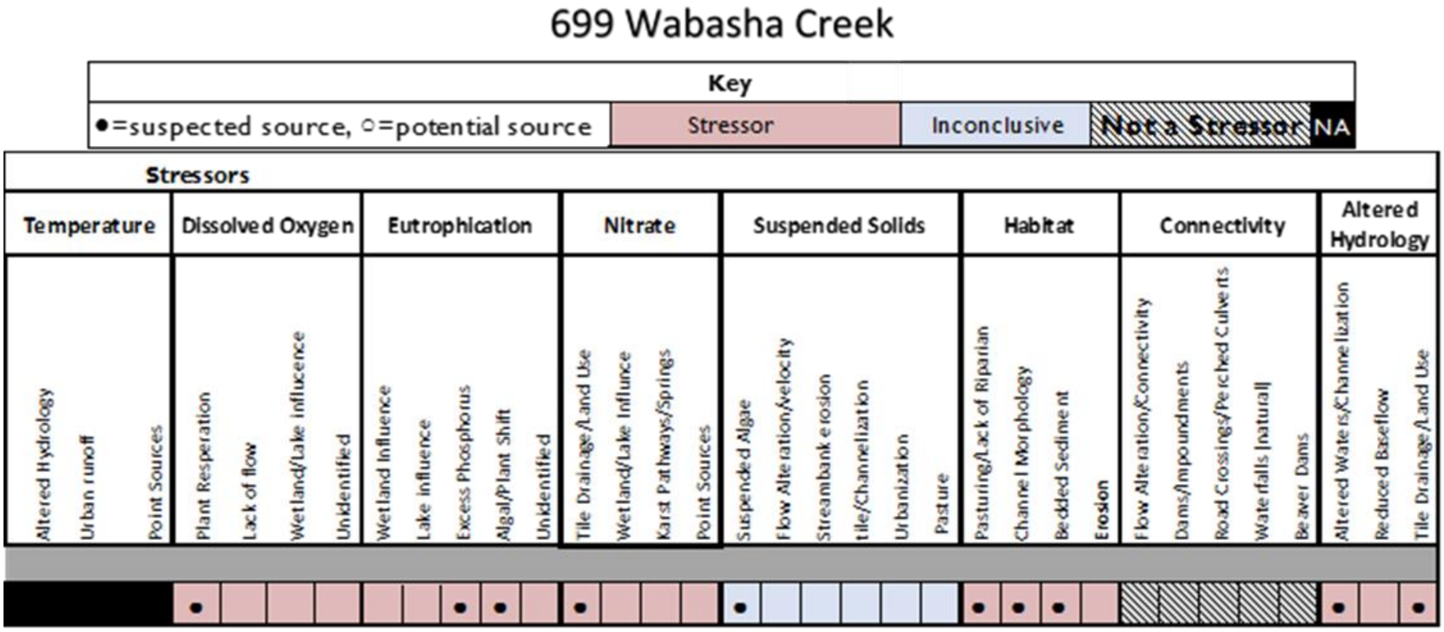
Longitudinal Connectivity and Altered Hydrology

Longitudinal connectivity is not considered a stressor within this reach. Connectivity is evaluated as a stressor when it could act as a barrier for fish migration. As fish on this reach passed the modified threshold technically connectivity cannot be listed as a stressor. On Wabasha Creek (07020007-527), the downstream reach there is a perched culvert at CR 2. For more information on the perched culvert, please see DNR’s Minnesota River, Mankato Watershed Characterization Report (2015). If the fish community declines over time, or becomes impaired, connectivity would need to be reassessed as its likely limiting some fish migration.

Altered hydrology is considered one of the primary biological stressors here. This reach is complete altered by way of ditching and channelizing in addition to the introduction of subsurface tile drainage. These practices have direct impacts to the flow regime that impacts stream stability both here as well as downstream. Paired with the surrounding land practices, tile drainage introduces amounts of nutrients that the system is unable to handle, leading to algal blooms and toxic levels of nitrates. For additional information on the relationship of altered hydrology and water quality within this watershed, reference Chapter 3.1.8 of this report.

Summary Table

Table 207. Identified stressors with suspected sources for reach 699 of Wabasha Creek.



699 Wabasha Creek

Key				
●=suspected source, ○=potential source	🟥 Stressor	🟦 Inconclusive	▨ Not a Stressor	■ NA

Stressors																																	
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
■	■	■	🟥 ●	🟥	🟥	🟥	🟥	🟥	🟥 ●	🟥 ●	🟥	🟥 ●	🟥	🟥	🟥	🟦 ●	🟦	🟦	🟦	🟦	🟦	🟥 ●	🟥 ●	🟥 ●	🟥	▨	▨	▨	▨	▨	🟥 ●	🟥	🟥 ●

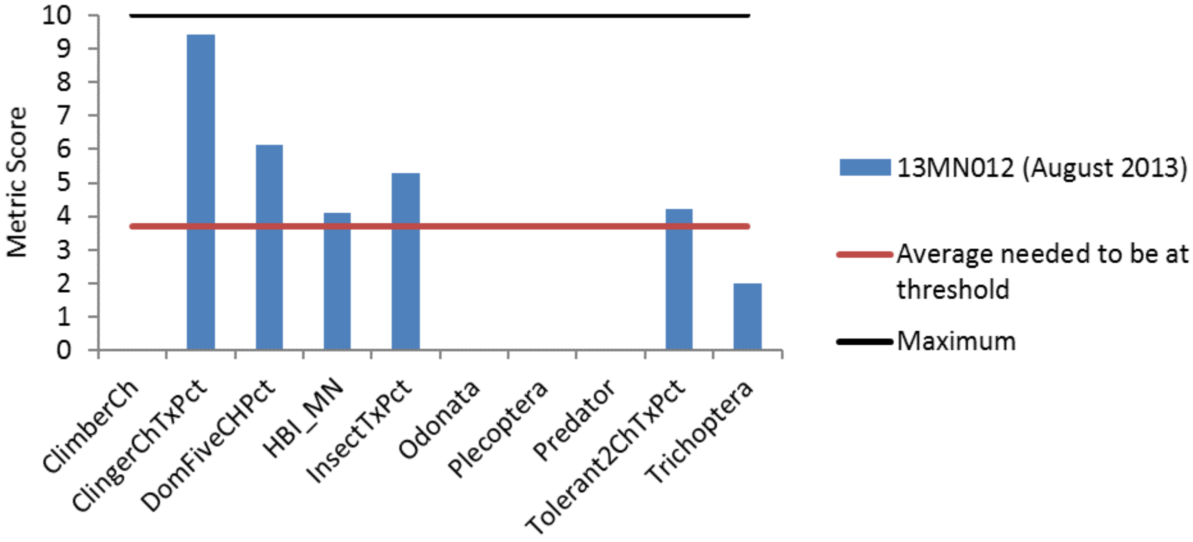
4.26 Wabasha Creek (07020007-527)

Wabasha Creek (07020007-527) is the furthest downstream AUID on Wabasha Creek. This reach of the creek starts at County Road 13 and meets with the Minnesota River. The reach is warmwater general use Class 2B. The reach is impaired for lack of fish assemblage and lack of macroinvertebrate assemblage. The reach is also impaired for *E. coli*, which will not be addressed in this report.

4.26.1 Biological Communities

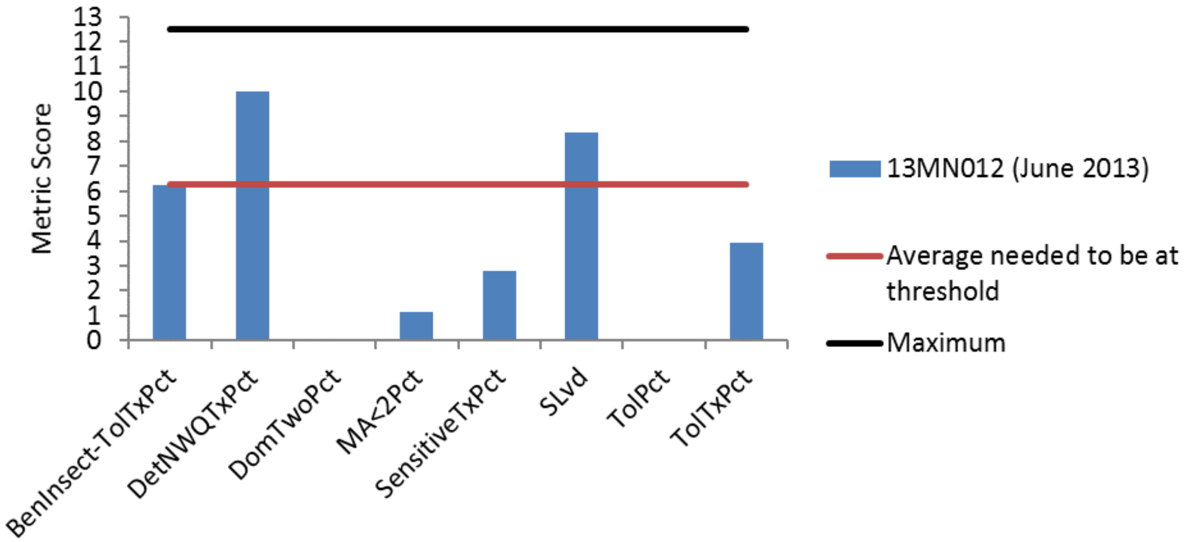
Station 13MN012 was sampled for fish and macroinvertebrates in 2013. The macroinvertebrate IBI was 31.1 in 2013 for the Southern Streams RR class. The visit resulted in a MIBI score less than the general use threshold of 37. As shown in Figure 212 below, the limiting factors of the IBI in this sample is largely due to the absents of species from the order Odonata and Plecoptera. Trichoptera were present but in lower than expected abundance, also primarily made up of tolerant caddisfly’s, such as hydropsychidae. Climbers and predator species were also lacking in the 2013 sample. The sample was dominated by non-biting midge (Polypedilum) as well as non-spinning caddisfly’s (Hydropsychidae).

Figure 212. Macroinvertebrate metrics of the Southern Streams RR class IBI for station 13MN012, Wabasha Creek.



The fish community scored 40.5 in 2013, below the general use threshold of 50 for the Southern Streams class. There were eight different taxa collected. The fish community was dominated by blacknose dace. As shown in Figure 213 below, the population of benthic insectivores (BenInsect-TolTXPct) was barely at the threshold, yet detritivorous taxa (DetNWQTXPct) were more abundant. There was a lack of mature or long lived species (MA<2Pct), replaced by short lived species (SLvd). Taxa types that are tolerant (TolTXPct) were slightly high, but the overall number of individuals rated at tolerant (TolPct) drove down the score.

Figure 213. Fish metrics of the Southern Streams class IBI for station 13MN012, Wabasha Creek.



4.26.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

The dissolved oxygen (DO) concentration during biological sampling on June 11, 2013 at station 13MN012 was 10.4 mg/L. Additional samples collected from 2009 – 2016 ranged from 3.3 mg/L – 14.4 mg/L (average of 8.3 mg/L). Fifty-two samples were collected, and seven (13%) were below the warmwater standard (5 mg/L). Low DO was detected August – October in 2009 at station S005-627. Samples were collected at multiple stations including: S005-627, S008-553, S009-289, S009-290, and S009-291.

The macroinvertebrate community had mixed response to possible low DO stress (Table 208). There were as many low DO intolerant taxa as low DO tolerant taxa; the percent individuals for each was also similar. The low DO index score was just below the average of similar stations meeting the biocriteria. The Hilsenhoff Biotic Index for MN was not elevated, but there were less EPT taxa. The response overall is mixed for low DO stress.

Table 208. Macroinvertebrate metrics that respond to low DO stress in Wabasha Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN012 (2013)	**27**	**6**	7.0	**6.5**	**3**	**1.6**	3	2.9
Southern Streams Average	*45.8*	*14.2*	*7.1*	*7.0*	*9.0*	*24.0*	*4.8*	*9.9*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

A majority of the fish metrics were worse than the statewide average of stations meeting the FIBI threshold (Table 209). Relative abundance of sensitive individuals (SensitivePct) and individuals with a female mature age greater than three years (MA>3Pct) were below average, and tolerant individuals (TolPct) comprised 89.8% of the community. There was one DO sensitive taxa comprising 2% of the community, and one DO tolerant taxa comprising 2% of the community. The fish DO index score was above average.

Table 209. Fish metrics that respond to low DO stress in Wabasha Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
13MN012 (2013)	**1.7**	**6.8**	**89.8**	7.7	**1**	**1.7**	1	1.7
Southern Streams Average	*16.9*	*24.6*	*44.9*	*7.2*	*1.7*	*6.1*	*4.7*	*18.5*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

DO is inconclusive as a stressor at this location. Partly due to questionable data, as 2009 is the stand-alone year with low DO point measurements within this reach. With the upstream eutrophic contributions, it is plausible that low DO could be occurring from excess algae/plant reproduction. In the future, sonde data would help understand the DO dynamics in this stream; this would also help correlate DO to a eutrophic response.

Eutrophication

The total phosphorus (TP) concentration during fish sampling on June 11, 2013 at station 13MN012 was 0.295 mg/L. Additional samples were collected in 2009, 2010, and 2013, ranging from 0.038 mg/L – 1.31 mg/L (average of 0.285 mg/L). Of these 51 samples, 35 (69%) were above the river eutrophication standard for the South Region (0.150 mg/L). Exceedances occurred in various months in all years. All samples were collected near the mouth of Wabasha Creek at station S005-627. Chl-a, BOD, and DO flux are also considered when evaluating eutrophication stress. There have been zero chl-a, BOD, or DO flux samples collected.

The macroinvertebrate community was consistent with possible eutrophication stress (Table 210). Collector-filterer and collector-gatherer taxa were reduced compared to similar stations meeting the biocriteria. There were an abundance of tolerant taxa, but not greatly over the average of similar stations.

Table 210. Macroinvertebrate metrics that respond to eutrophication stress in Wabasha Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN012 (2013)	**27**	**5**	**10**	**6**	**0**	**74.1**
Southern Streams Average	*45.8*	*7.3*	*15.9*	*12.2*	*0.8*	*72.6*
Expected response to stress	↓	↓	↓	↓	↓	↑

The fish community had a similar response to eutrophication stress as the macroinvertebrate community (Table 211). There were a lack of sensitive, darter, and intolerant individuals in the survey. There were an abundance of tolerant individuals. However, the presence of simple lithophilic spawners was quite high. The simple lithophilic spawners present were blacknose dace (36), common shiner (4), and white sucker (4). Blacknose dace dominated the sample.

Table 211. Fish metrics that respond to eutrophication stress in Wabasha Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
13MN012 (2013)	**1.7**	**3.4**	74.6	**89.8**	**8**	**0**
Southern Streams Average	*16.9*	*11.9*	*37.0*	*44.9*	*19.3*	*4.2*
Expected response to stress	↓	↓	↓	↑	↓	↓

Eutrophication is inconclusive. While some abnormally high phosphorus and some low DO was documented, there is a lack of connecting chemistry data (response variables to eutrophication) to show the potential impacts. There was also a lack of documentation to describe or show the physical condition of the stream. Continuous (diurnal) DO data would be helpful in understanding DO flux and potential for algae and macrophytes in this reach. Biological metrics were suggestive of eutrophic stress, but could be responding to other stressors as well. Without the connecting data, eutrophication is considered inconclusive at this time. However, phosphorus reduction should be targeted here.

Nitrate

Nitrate concentration during fish sampling on June 11, 20136 at station 13MN012 was low at 1.2 mg/L. Forty six samples collected in 2009, 2010, and 2013 ranged from 0.2 mg/L – 18.9 mg/L (average of 7.2 mg/L). Out of the 46 samples, 14 (28%) were above 10 mg/L. Elevated concentrations were observed in all years and various months, with a majority occurring in April – June, primarily in 2010. Samples were collected at station S005-627.

Taxa richness of Trichoptera (TrichopteraCh) was below the statewide average of stations meeting the MIBI threshold (Table 212), and relative abundance of non-hydropsychid Trichoptera individuals (TrichwoHydroPct) was above average. There was one-nitrate intolerant taxa, and fourteen nitrate tolerant taxa comprising almost 40% of the community. The macroinvertebrate nitrate index score was better than average compared to similar streams of this type. Overall, the macroinvertebrates do not appear stressed by nitrate.

Table 212. Macroinvertebrate metrics that respond to nitrate stress in Wabasha Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN012 (2013)	**4**	14.7	2.7	**1**	14	39.7
Southern Streams Average	*6.3*	*5.5*	*2.9*	*2.4*	*18.8*	*47.2*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is not stressing the biological community within this reach. While there was a significant amount of the nitrate samples exceeding 10 mg/L, they primarily were found in 2010, there could have been a nearby land use practice or altered hydrology issue (discussed in 3.1.8) that was creating these nitrate loading conditions at that time. In 2013, the year of the biological sample- there was only one exceedance and it was just over 10 mg/L at 10.1 mg/L. The macroinvertebrate metrics are not suggestive of nitrate displacement.

Total Suspended Solids

The total suspended solids (TSS) concentration during fish sampling on June 11, 2013 at station 13MN012 was 2.4 mg/L. Additional samples collected in 2009, 2010, and 2013 ranged from 2 mg/L – 1,040 mg/L (average of 70.1 mg/L). Fifty-one samples were collected, and 10 (20%) were above the warmwater standard for the South Region (65 mg/L). Exceedances occurred exclusively in 2010, in March (two), June (three), and September (five). Samples were collected at station S005-627.

The macroinvertebrate community metrics did not show a strong indication of elevated TSS stress (Table 213). There were some metrics that displayed a slight indication of TSS stress; it is more likely their response could be due to other stressors in the reach. Overall, the TSS index score was better than average, with a good amount of collector-filterers. While the TSS tolerant percentage was just slightly higher than average, it was not significantly higher.

Table 213. Macroinvertebrate metrics that respond to high TSS stress in Wabasha Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN012 (2013)	42.2	**0**	13.87	**1**	5.2	8	**44.6**
Southern Streams Average	*25.4*	*0.7*	*15.63*	*2.9*	*4.7*	*12.2*	*34.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

The fish community was more suggestive of possible TSS stress (Table 214 and Table 215). Many aspects of a healthy community were missing compared to similar stations meeting the biocriteria for this stream type. However, the TSS index score was low and there was neither a presence of TSS sensitive nor TSS tolerant taxa. The taxa that were present in this reach fell in the middle ranges of tolerances to TSS. The probability of the reach meeting the TSS standard based on the fish community was 85%, which means based on the fish community present high TSS is not as likely.

Table 214. Fish metrics that respond to high TSS stress in Wabasha Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
13MN012 (2013)	**13.6**	**0**	**10.2**	**0**	**0**	**3.4**	**11.9**	**1.7**	**6.8**
Southern Streams Average	*36.0*	*5.4*	*25.7*	*4.2*	*13.6*	*20.1*	*30.2*	*16.9*	*19.1*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 215. Fish metrics that respond to high TSS stress in Wabasha Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TSS Index Score	TSS Sensitive Taxa	TSS Sensitive Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN012 (2013)	12.3	**0**	**0**	0	0
Southern Streams Average	*19.2*	*1.7*	*5.3*	*2.4*	*12.5*
Expected response to stress	↑	↓	↓	↑	↑

TSS is not considered a stressor, as with Nitrate the exceedances of TSS occurred in 2010. Looking at the set of data outside of 2010, there are still 30 samples to analyze; within this set, the average concentration for TSS is 7.3 mg/L with no exceedances of the 65 mg/L standard. The high concentration found in 2010 are not representative of the typical stream's TSS loading capacity, and likely reflecting the flood conditions of 2010.

Habitat

At station 13MN012, the MSHA score was 62.4, which is considered fair. As reflected in Figure 214, there was little bank erosion, moderate embeddedness, and moderate cover. The lowest scoring MSHA category was "land use" due to the dominance of row crops. Available cover types included undercut banks, deep pools, logs or woody debris, boulders, and macrophytes. The station had a good mix of pools (30%), riffles (30%), and runs (40%), as shown in Figure 215.

Figure 214. Percentage of MSHA subcategory scores for station 13MN012, Wabasha Creek.

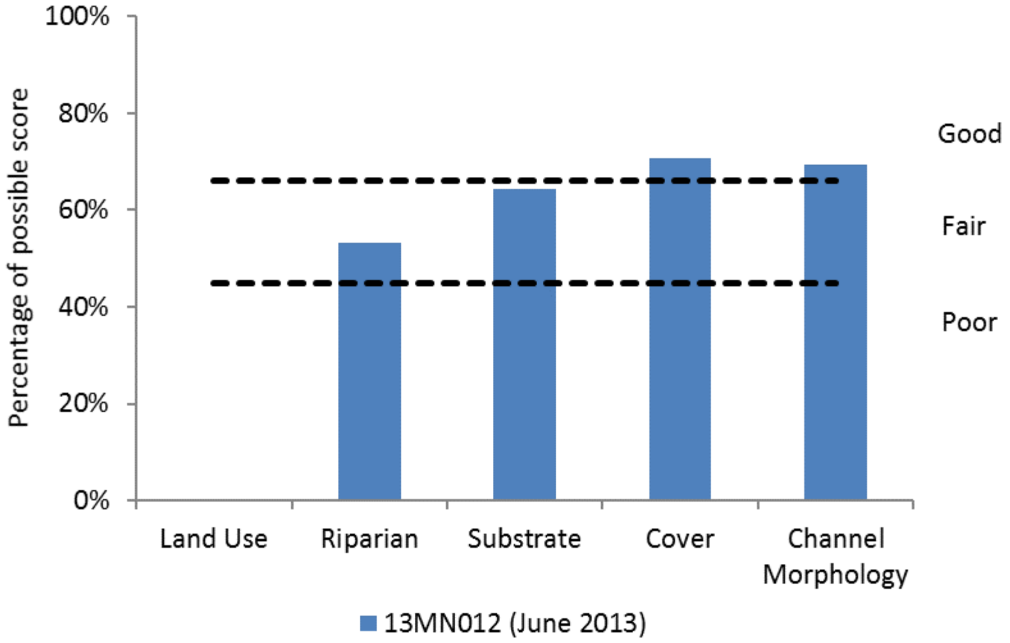
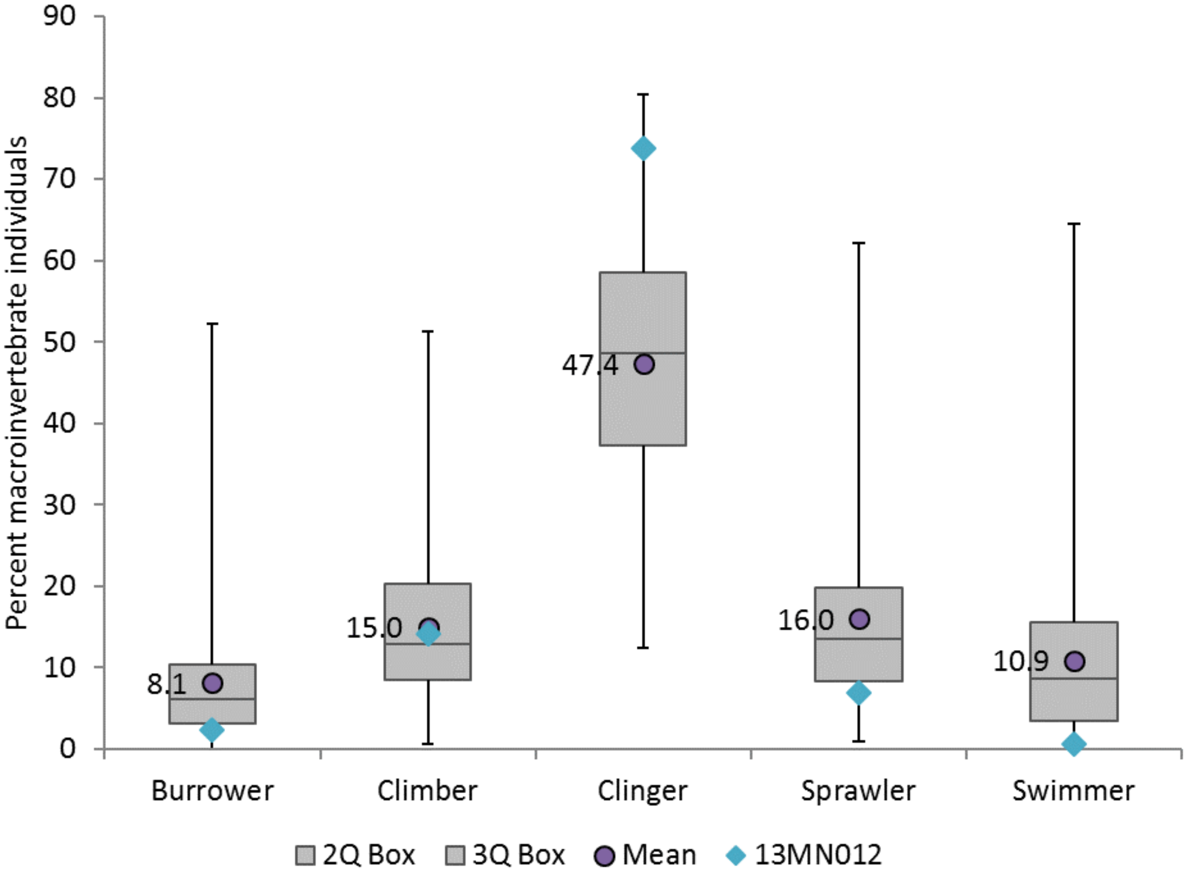


Figure 215. Station 13MN012 displaying habitat conditions on June 11, 2013

The macroinvertebrate community had a low number of burrowers, moderate climbers, high number of clingers and moderate to low sprawlers and swimmers. The climber MIBI metric score was below the average metric score needed to meet the MIBI threshold, and the clinger MIBI metric score was above average. Overall, the macroinvertebrate community was not suggestive of habitat stress. In habitat degraded systems, typically the clinger population will be limited, will burrowers will become more abundant. This is not seen to be the case within this reach.

Figure 216. Macroinvertebrate metrics that respond to habitat for station 13MN012, Wabasha Creek compared to the range of values for Southern Stream RR visits meeting the general use biocriteria.



As displayed in Table 214 in the above TSS section, the relative abundance of individuals that are riffle-dwelling species (RifflePct) was below average, and abundance of simple lithophilic spawners (SLithopPct) was above average. These species require clean coarse substrate and riffles, and are expected to decrease with stress.

Habitat is not considered a stressor at this time. There was a strong diversity of habitat availability noted during the time of site visits. The macroinvertebrate community did not display signals of habitat stress. The fish community was slightly mixed, yet the dominance of lithophilic spawners in conjunction with the other lines of evidence of supporting habitat rule out this being an impairment.

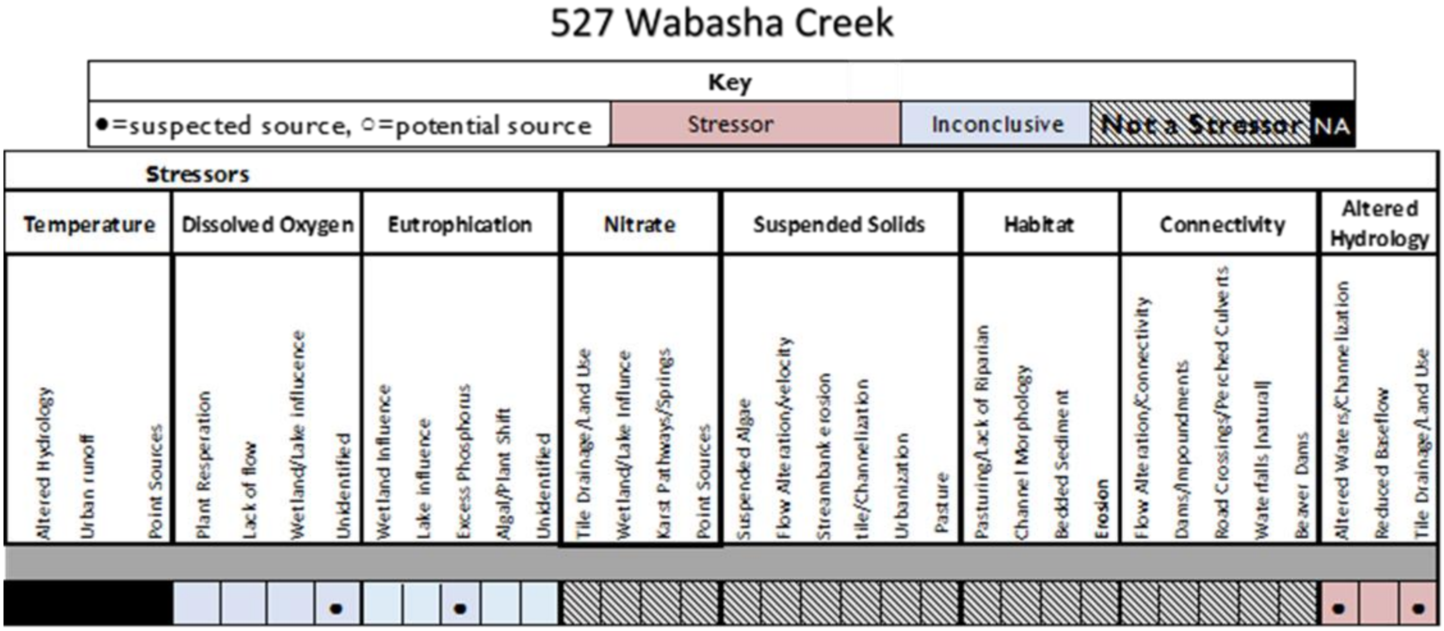
Longitudinal Connectivity and Altered hydrology

Upstream of this monitoring location, there is a perched culvert at CR 2. For more information on this perched culvert, please see DNR's Minnesota River, Mankato Watershed Characterization Report (2015). The perched culvert currently is not a stressor to this fish community at 13MN012. In an unaltered system, this could be a barrier that would inhibit upstream migration for spawning. As the upstream headwaters of Wabasha creek have been modified via channelization, this has made that upstream habitat unsuitable for those needs. Other stressors are responsible for the impaired biological communities in this reach.

The location of 13MN012 monitoring station is at the end of the Wabasha Creek stream system. This reach is not channelized, but a majority of the headstreams that feed into it are, creating an instable flow regime, as well as increased nutrient loading. While eutrophication was listed as inconclusive, phosphorus loading was high. This is likely a result of the upland agricultural land use. For additional information on these forms of altered hydrology, reference Chapter 3.1.8 of this report.

Summary Table

Table 216. Identified stressors with suspected sources for reach 527 of Wabasha Creek.



527 Wabasha Creek

Key: ● =suspected source, ○ =potential source | 🟥 Stressor | 🟦 Inconclusive | ▨ Not a Stressor | NA

Stressors

Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
NA	NA	NA	🟦	🟦	🟦	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	🟥 ●	🟥	🟥 ●

Wabasha Creek Subwatershed Conclusion

Wabasha Creek is one of the smaller subwatersheds. There were only two reaches along Wabasha Creek that were identified as having impaired biological communities. Although they are on the same creek, these two locations are vastly different. 13MN010 of Wabasha Creek is upland on a flat area and has a modified stream via channelization. While station 13MN012 is located within a section of the stream where the channel down cuts towards the Minnesota River Valley giving a significantly steeper slope.

While these two locations are different in geologic location, they both have altered hydrology as the primary driver for impairments. Altered hydrology is occurring two ways in Wabasha Creek. The first is through subsurface tile drainage, and the second is by stream channel alteration by ditching and straightening the stream channel. Both of these alterations are for agricultural practices in effort to expedite water off the land making optimal growing conditions for row crops. Station 13MN010 is the direct recipient of both these forms of alterations, influencing the downstream station 13MN012 water volumes as well as water quality. As channels take on extra water, they change their dimension, pattern, and profile to adjust; resulting in high sediment loads, loss of habitat, and water quality impairments.

One of the direct effects of altered hydrology is noted in available habitat as section 13MN010 has conditions that limit the community. The largest impact is lack of habitat diversity as this channel has been modified, eliminating the natural riffle, run, glides typically seen in this stream type.

As noted above, water quality is impacted through excess nutrients from subsurface tile drainage in this area. Nitrates in particular are toxic to aquatic life. Nitrate overloading was noted at both locations; however, there was only a noticeable response to the biologic community at 13MN010 where 13MN012's community was not displaced by a nitrate tolerant community.

Upland station 13MN010 had clear signs of both eutrophication conditions and biologic stress. High phosphorus loading and an abundance of sunlight from lack of vegetative cover often yields high amounts of plant production. 13MN010 had large amounts of both suspended and filamentous algae. This over production of algae is closely associated with dissolved oxygen impairments as algae respiration occurs at night and temporarily depletes the stream of oxygen. Station 13MN012 was noted as having abnormally high phosphorus loading (one of the highest for the entire Minnesota River, Mankato Watershed) and therefore has some eutrophic potential, although it is less likely to become over productive due to the stream coverage as well as the steep gradient that churns the stream. Low DO was marked as inconclusive only due to lack of data; due to the turbulence of the stream it is not likely this section of stream would experience low DO levels at a chronic level.

The high amount of algae growth also negatively influences the stream much like suspended sediment does. As suspended algae will smother streambed habitat and impact water visibility, and displace feeding type species (often filterer feeders will be dominant in these systems). The traditional form of TSS (sediment) was not found to be affecting biology within Wabasha Creek.

There was one perched culvert noted within Wabasha Creek on County Road 2. The upstream reach may be affected by the perched culvert but the fish community is meeting the modified use threshold. At this time, the perched culvert is not a stressor to the impaired macroinvertebrate community. If the fish community declines over time, or becomes impaired, connectivity would need to be reassessed as its likely limiting fish migration.

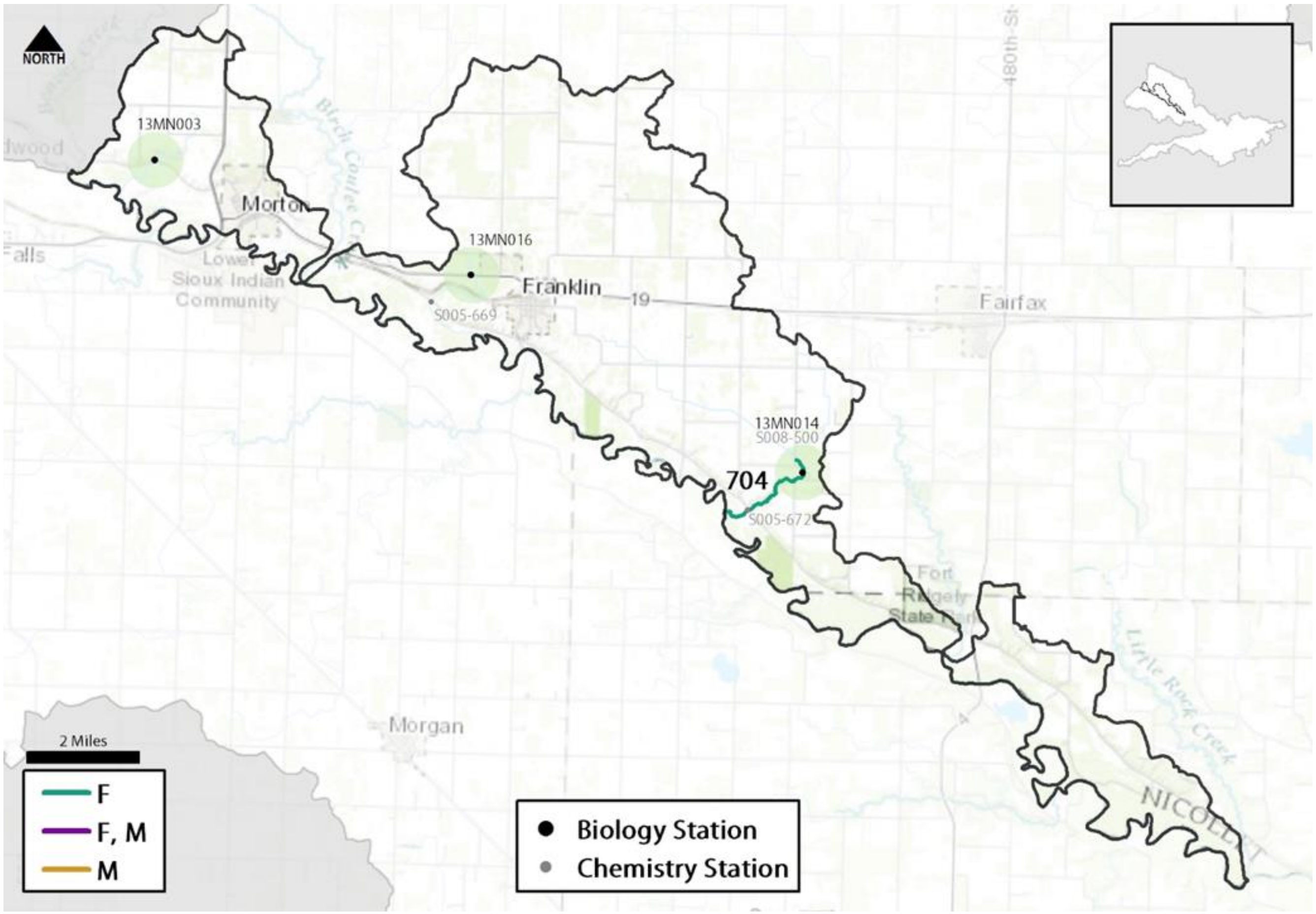
While findings of stressors were sparse within this subwatershed, the early timing of the fish sample, paired with a late ice out may have not provided adequate time for the fish communities to be represented.

North of Minnesota River

Spring Creek – MNR Mankato North

This section encompasses biotic impaired reaches in the Spring Creek – MNR 10 digit HUC. There is one impaired reach for biology in this 10 digit HUC, Threemile Creek. The reach is warmwater, and impaired for lack of fish assemblage.

Figure 217. Map of the Spring Creek Watershed with biological impairments and monitoring stations. Impairments are described as F=Fish, F, M=Fish and Macroinvertebrates, and M=Macroinvertebrates



Threemile Creek (07020007-704)

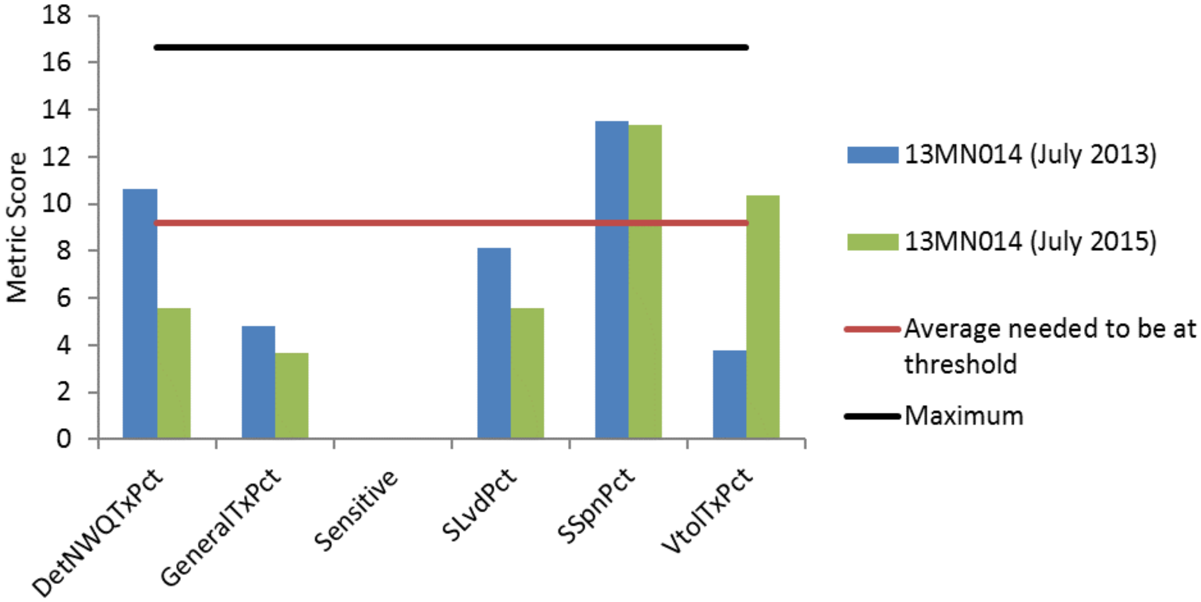
Threemile Creek (07020007-704) is a tributary to the Minnesota River, southwest of Fairfax, Minnesota. The reach is warmwater general use Class 2B and begins at County Ditch 140. The reach is impaired for lack of fish assemblage.

4.26.3 Biological Communities

Station 13MN014 was sampled in 2013 and 2015 for fish and macroinvertebrates. In 2013, the macroinvertebrate community had an IBI right at the threshold (37) and was dominated by Acari (water mites). In 2015, the macroinvertebrate community scored below the threshold with an IBI score of 31, but still within the confidence interval. Due to this, the macroinvertebrate community is not considered impaired.

The fish community is impaired, receiving an FIBI score of 40.9 in 2013 and 39 in 2015 for the Southern Headwaters class (threshold of 55). The fish community was dominated by blacknose dace and creek chub both years. There was a lack of sensitive taxa, as well as a high relative abundance of generalist taxa and short-lived individuals; all which contributed to low FIBI scores (Figure 218).

Figure 218. Fish metrics of the Southern Headwaters class IBI for station 13MN014, Threemile Creek.



4.26.4 Data Evaluation for each Candidate Cause

Dissolved Oxygen

There were two dissolved oxygen (DO) measurements on this reach collected during biological monitoring on July 15, 2013 and July 1, 2015. Both values were in normal range (7.63 mg/L and 7.33 mg/L). In 2016, two additional DO samples were taken on June 20 at two stations, which showed normal values at 7.52 mg/L and 9.18 mg/L.

The fish community does not display a strong indication of DO stress (Table 217). Overall, there are few DO tolerant taxa, however sensitive taxa are lacking. There are generally more tolerant fish taxa, but not an overabundance of those tolerant to low DO (DO Tolerant Pct) which may suggest another stressor is influencing the fish community, and not low DO.

Table 217. Fish metrics that respond to low DO stress in Threemile Creek compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
13MN014 (2013)	**0**	**0**	**88.2**	7.26	**0**	**0**	**5**	17.7
13MN014 (2015)	**0**	**0.2**	**90.1**	7.38	**0**	**0**	2	17.1
Southern Headwaters Average	*7.9*	*13.9*	*72.8*	*7.13*	*0.7*	*4.1*	*3.4*	*21.2*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is inconclusive as a stressor. Given the small chemical dataset, and some biological response, low DO cannot be ruled out as stressor. Collecting additional DO information would be helpful in ensuring DO is not a stressor to this reach.

Eutrophication

At the time of biological monitoring two total phosphorus (TP), samples were collected, with concentrations at 0.22 mg/L on July 15, 2013 and at 0.25 mg/L on July 1, 2015. Additional water quality samples showed concentrations ranging from 0.025 mg/L up to .337 mg/L with an average of 0.085 mg/L. Seven out of the total of 22 samples in this reach were above the river eutrophication standard for the Southern Region for TP (0.15 mg/L). These additional samples were primarily collected in 2009 and 2010. Chl-a, BOD, and DO flux are also considered when evaluating eutrophication stress. However, there was not any data available on those interacting variables for this reach.

The fish metrics that respond to eutrophication stress suggest the potential for stress (Table 218). There was a lack of sensitive and intolerant fish, as well as less than desired abundance of darters (DarterPct). There was a higher percentage of tolerant individuals, but a higher percentage of simple lithophilic spawners (SLithoPct) as well. The mix of response and lack of connecting chemical information make eutrophication inconclusive as a stressor to Threemile Creek.

Table 218. Fish metrics that respond to eutrophication stress in Threemile Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
13MN014 (2013)	**0**	**2.5**	43.9	**88.2**	**11**	**0**
13MN014 (2015)	**0**	**2.1**	56.0	**90.1**	**9**	**0**
Southern Headwaters Average	7.9	11.5	31.5	72.8	11.5	1.6
Expected response to stress	↓	↓	↓	↑	↓	↓

Nitrate

During biological monitoring the nitrate concentration at 13MN014 was recorded at 7.4 mg/L on July 15, 2013 and at 9 mg/L on July 1, 2015. There were 20 additional samples taken on this reach (station S005-672) in 2009 and 2010. The samples were from the months of May through August for both years. The nitrate concentration ranged from 0.55 mg/L in August, up to 15.5 mg/L in June, with an average concentration of 5.26 mg/L. All but one sample fell below 10 mg/L.

Fish often do not show strong response to increased nitrate concentrations. Macroinvertebrate communities often show more of a response to chronic nitrate exposure. The macroinvertebrates in this reach are not impaired, and also do not show strong indication they are stressed by the elevated nitrate concentrations (Table 219). The nitrate specific metrics show better than average Trichoptera taxa, and fewer than average tolerant individuals. The nitrate index score was 2.2, while the average for Southern Streams meeting impairment threshold is 2.9. The higher the number within the nitrate index score, the more higher the likelihood of nitrate displacement within the community. This suggests that overall the community present is not overly tolerant to high nitrate concentrations. Increasing nitrate concentrations also correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct). While intolerant taxa and non-hydropsychid individuals are not in abundance here, their diminished presents could be due to another stressor present.

Table 219. Macroinvertebrate metrics that respond to nitrate stress at 13MN014 compared to the statewide average of visits meeting the biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN014	7	**2.5**	2.2	**1**	**21**	42.1
Southern Streams Average	*6.3*	*5.5*	*2.9*	*2.4*	*18.8*	*47.2*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is not a biological stressor within this reach. The chemical data set does show that nitrate concentrations are elevated, and should be reduced. However, nitrate levels do not seem to be influencing the biology with a nitrate tolerant community.

Total Suspended Solids

Two total suspended solids (TSS) samples were taken at the time of biological monitoring; with TSS concentrations at 13MN014 were measured at 7.4 mg/L on July 15, 2013 and at 9 mg/L on July 1, 2015. There were 22 additional samples taken on this reach at station S005-672) in 2009 and 2010. The samples were from the months of May through August for both years. None of the samples collected exceed the TSS standard for the regional standard of 65 mg/L. The maximum concentration recorded was 57 mg/L from June 29, 2010, with almost all the remaining values (19 samples) below 10 mg/L. The average for water quality samples for TSS was low, at 7.75 mg/L.

The general metrics that relate to TSS show possible stress to the fish community (Table 221), but the responses seen could be due to another stressor. TSS will typically drive down abundance of species that depend on clean riverbed substrate and will be noted in a decrease of benthic feeders (BenFdFrimPct), Riffle dwelling species (RifflePct), and herbivore species (HrbNWQPct). Another concern noted within the sampled community is noted with the lack of long-lived species present, indicating a disruption to life cycle.

The TSS index score is below the statewide average of visits meeting the biocriteria and there was very little relative abundance of TSS tolerant fish (Table 220). These metrics suggest that the community is not overly tolerant to TSS specifically.

Table 220. Fish metrics that respond to high TSS stress in Threemile Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
13MN014 (2013)	**7.0**	**0**	**4.5**	**0**	**0**	**2.5**	**4.5**	**0**	**0**
13MN014 (2015)	**11.3**	**0**	**9.2**	**0**	**0**	**2.1**	**9.2**	**0**	**0.2**
Southern Headwaters Average	*35.0*	*1.0*	*22.4*	*1.6*	*4.5*	*13.6*	*26.2*	*7.9*	*14.6*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 221. Fish metrics that respond to high TSS stress in Threemile Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

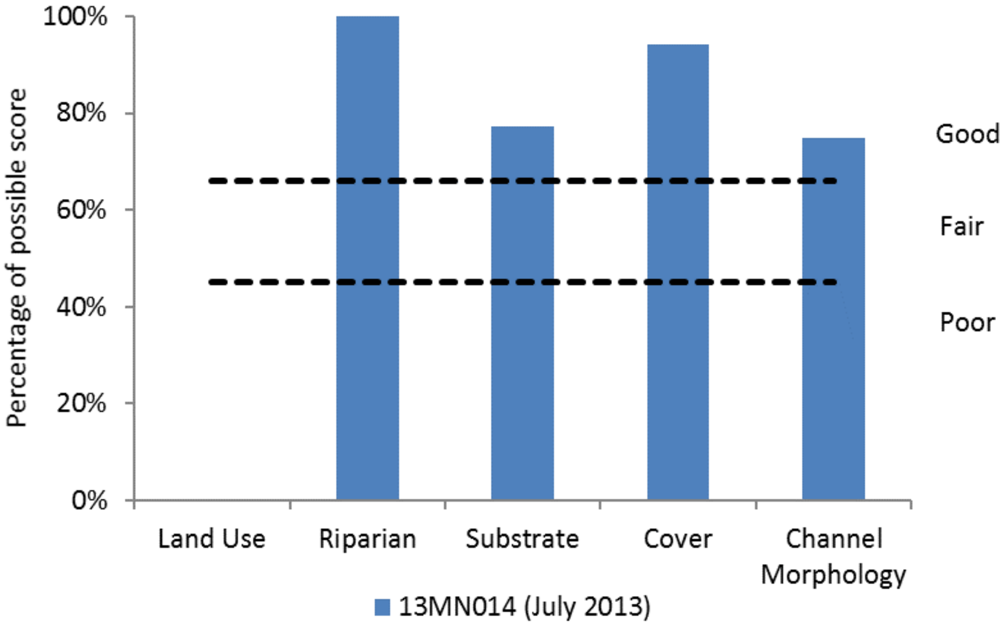
Station (Year sampled)	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN014 (2013)	15.3	**0**	**0**	**1**	0.3
13MN014 (2015)	14.3	**0**	**0**	0	0
Southern Headwaters Average	*15.4*	*0.9*	*4.1*	*0.4*	*2.0*
Expected response to stress	↑	↓	↓	↑	↑

Given the chemical information provided, and metrics responses, TSS is not a likely stressor to the fish community at this time. While the fish community is scoring poorly to the TSS specific metrics, it is likely that TSS sensitive species are lacking as a result from another stressor. There is also a fair amount of TSS samples that do not display TSS overloading within this reach of Spring Creek.

Habitat

The MSHA score for station 13MN014 in Threemile Creek was good at 78.85 taken in 2013, with most aspects of habitat scoring well (Figure 219). Only the subcategory of land use had less than 66% of the possible score. The station is surrounded by row crop, yet the riparian subcategory received all possible points with an extensive riparian width, no bank erosion, and heavy shade. The substrate was diverse with gravel and cobble in the riffle. There was light embeddedness and extensive cover with number of cover types. The channel has moderate/high stability and good development and sinuosity.

Figure 219. Percentage of MSHA subcategory scores for station 13MN014, Threemile Creek



The fish community metrics do suggest habitat may be an issue with reduced numbers of benthic insectivores, riffle dwelling species, and simple lithophilic spawners (as reflected in Table 220 in the above TSS section). These metrics can indicate limitations in fish habitat, among other stressors. However, given there were few fish taxa present, the metric response may be misleading.

Figure 220. Station 13MN014 displaying habitat conditions on July 15, 2013

Overall, the habitat for fish is both diverse and abundant, as evidenced by the photo (Figure 220). The riparian area is sufficient and there seems to be adequate cover. There was also clean riverbed substrate noted during site visits. Fish species that require specific habitat needs (such as riffle dwellers and lithophilic spawners) it seems the available habitat is suitable in this reach, and not the reason fish are impaired. Another stressor is more likely the reason for the responses in the fish community composition.

Altered Hydrology and Longitudinal Connectivity

Connectivity is considered a stressor to the fish community in Threemile Creek. There is an established population of beavers along this reach that have been found to dam the river. During records review it was noted that there have been several historical dams and blow out events in this watershed from beavers. Figure 221 was taken downstream of biological monitoring location. A landowner near 13MN014 said there has not been fish in there in a long time, which is further evidence that beaver dams and connectivity issues may be an issue.

Just upstream of the biological station, Figure 222 shows a perched culvert from August 2015. This appears to be a seasonal barrier to fish movement and may highlighting more of an issue of altered hydrology, given the lack of flow through the culvert. It is possible that beaver dams downstream of the biological monitoring station in combination with culvert and flow issues, could essentially cut off fish migration upstream and downstream at certain times of the year.

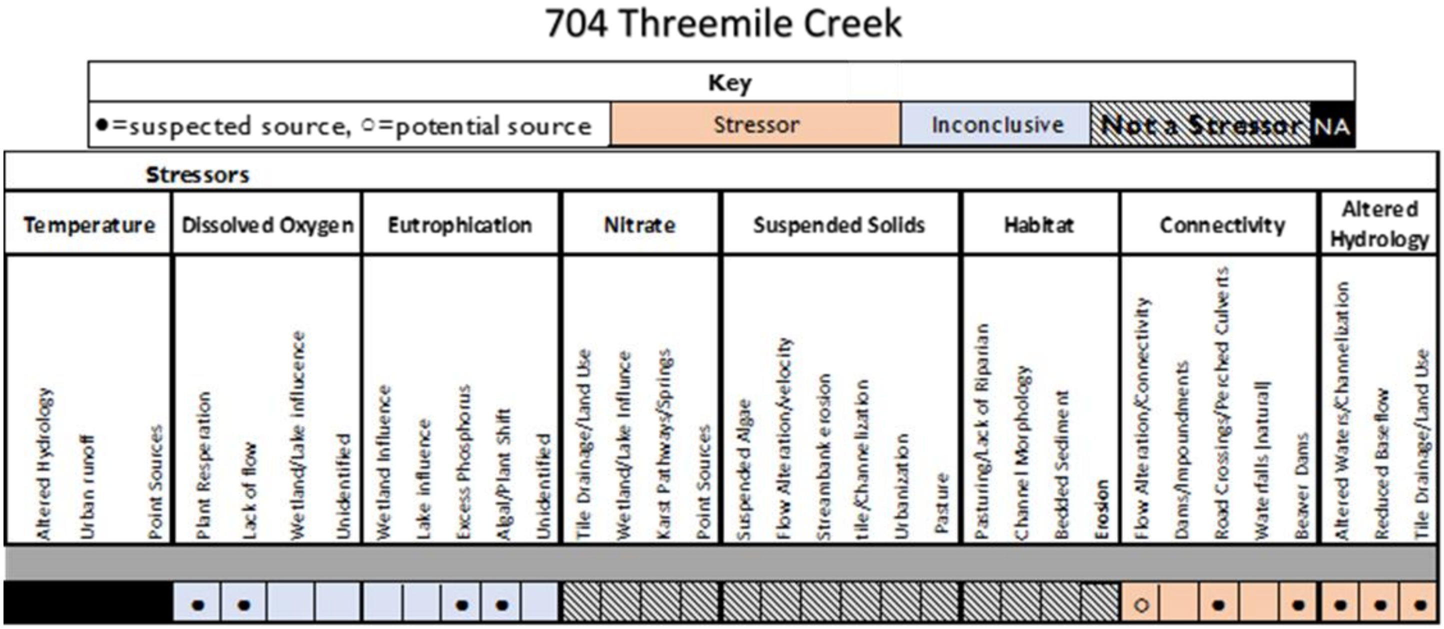
Figure 221. Beaver dam on Threemile Creek taken downstream of biological monitoring location on July 15, 2013.

Figure 222. (Left) June 20 2016 photo; culvert slope visually different from upstream of culvert. (Right) August 6 2015 Photo; Downstream side of same culvert which perched during low flow. Station 13MN014 is downstream of this culvert.

This reach is also being influenced by upstream-altered hydrology. While this section of Threemile Creek is not considered modified, the headwaters that drain into this section are, primarily seen it stream channelizing and subsurface tile drainage. Reference Chapter 3.1.8 for additional information on how these forms of altered hydrology impact stream morphology and water volume.

Summary Table

Table 222. Identified stressors with suspected sources for reach 704 of Threemile Creek.



704 Threemile Creek

Key				
●=suspected source, ○=potential source	🟧 Stressor	🟦 Inconclusive	▨ Not a Stressor	■ NA

Stressors																																	
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls (natural)	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
■	■	■	🟦 ●	🟦 ●	🟦	🟦	🟦	🟦	🟦 ●	🟦 ●	🟦	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	🟧 ○	🟧	🟧 ●	🟧	🟧 ●	🟧 ●	🟧 ●	🟧 ●

Spring Creek Subwatershed Conclusion

Threemile Creek (-704) is a tributary to the Minnesota River, southwest of Fairfax, Minnesota. The reach is designated as warmwater general use and begins at County Ditch 140. There was just one stream in the Spring Creek Subwatershed that has a fish impairment. The macroinvertebrate community was close to impaired. The primary biological stressor to the fish community in Threemile Creek is connectivity and altered hydrology.

The majority of the Spring Creek Subwatershed has been impacted by altered hydrology. Altered hydrology is occurring in two ways. The first is through subsurface tile drainage, and the second is by stream channel alteration via ditching and channelizing the stream channel. Both of these alterations are for agricultural practices in effort to expedite water off the land making in more farmable. As channels take on extra water from these practices, they change their dimension, pattern, and profile to adjust. This reach is suspected to be particularly sensitive to low base flows, an effect of ground tiling that results in poor groundwater to stream recharge. Pollutants such as nitrates and phosphorus within this area are largely introduced from agricultural subsurface tile drainage. The section of Threemile Creek that was assessed is in an area where natural down cutting through the valley is taking place, before it converges with the Minnesota River. Because of the steep gradient of the surrounding land, this section of stream are not channelized, as farming practices are restricted in the upland flat areas. However, it is being influenced from the upland drainage area that is heavily altered.

Along this reach, there are barriers that limit fish movement and migration, including multiple beaver dams and at least one identified perched culvert. There are two other road crossing that are downstream of the monitoring location. The culverts here were not assessed; therefore, it is difficult to say how many barriers there truly are with collecting additional information. Future investigation into these sites will help determine the need for replacements and updates.

Habitat diversity was found to be adequate. This section of stream has a healthy riparian area that has likely been the mitigating factor of upstream flashy stream velocities. There should be additional monitoring to determine how often the low base flows noted in this area are occurring. Flow conditions at any given point in time can influence the available habitat, as well as fish migration.

Dissolved oxygen (DO) is inconclusive as a stressor in this reach. The fish community did not display a strong indication of low DO stress. Overall, there are few low DO tolerant taxa, and sensitive taxa are lacking. However, there are generally more tolerant fish taxa, which may suggest another stressor is influencing the fish community, and not low DO. While macroinvertebrates are not impaired in this reach, the community composition was assessed and metrics within this community did not indicate low DO stress. There is little reason to believe biology is threatened from low DO levels on this reach. DO is listed as inconclusive due to the lack of chemistry samples taken and therefore could not be fully ruled out.

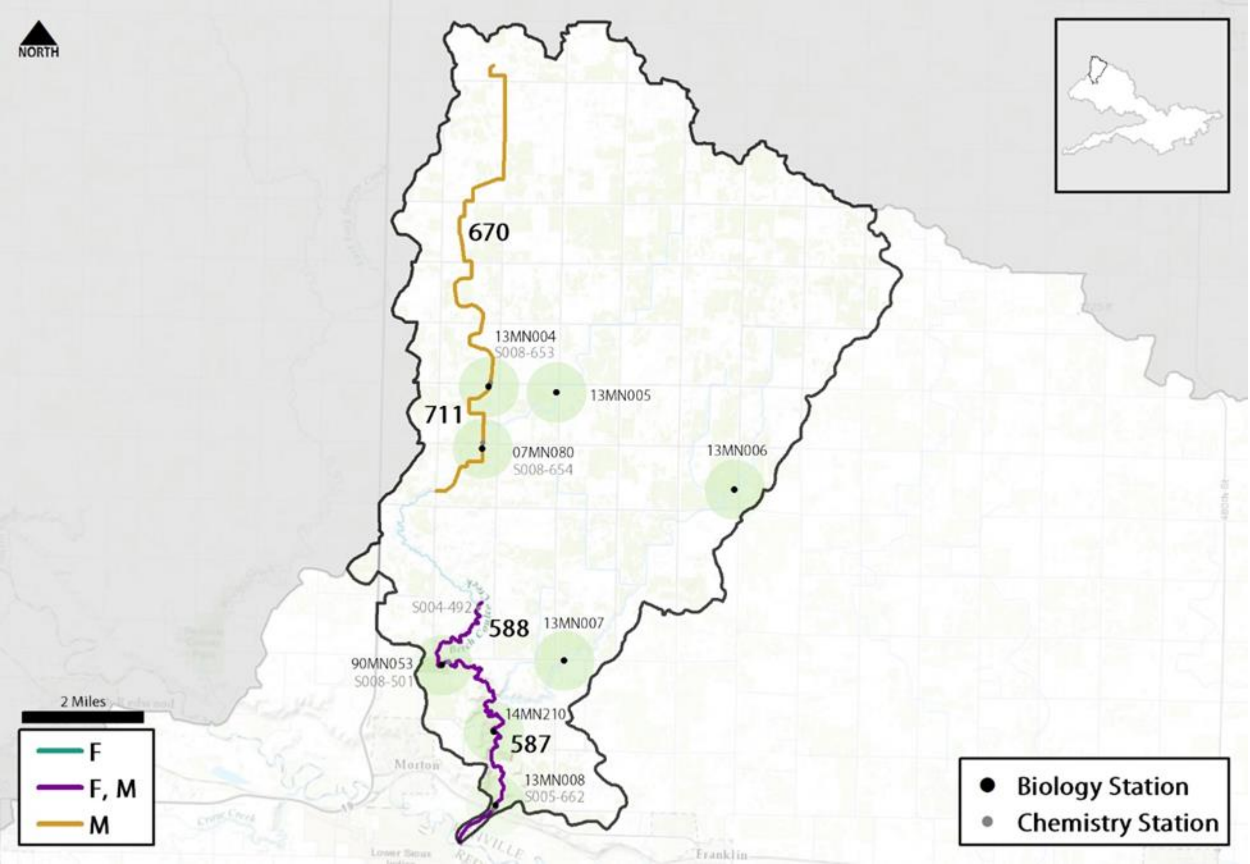
Eutrophication is inconclusive due to lack of corresponding data. Despite a large dataset that did show phosphorus loading is high, there was a lack of secondary chemistry parameters (chlorophyll-a, BOD, DO fluctuation) to show overproduction of algae is occurring within this location. The fish metrics that respond to eutrophic stress were not strong enough to make a strong conclusion on biological impacts, as the fish community was composed of generally tolerant species. Overall, this section of stream is not likely to see a lot of overproduction, due to the steep gradient that creates fast moving streams (not allowing water to pool for long period of time) and due to the strong canopy cover, that creates a natural barrier that limits sunlight that is a contributor to eutrophic conditions. In the future, additional sampling for Chl-a, BOD, or DO flux would help establish a strong conclusion on potential eutrophic stress.

Nitrate, total suspended solids (TSS), and habitat are not driving the biological stress in this reach, given the chemical and biological data. Available habitat can certainly be impacted by beaver activity and connectivity issues during certain times of the year. However, this does not appear to be a chronic migration issue in the reach. The habitat present is suitable for fish at this time and not the driving stressor. The nitrate concentrations were slightly elevated and should be reduced, but they were not typically found to be above the threshold. The stable macroinvertebrate community also reassures that nitrates are not an issue at this time.

Birch Coulee Creek – MNR Mankato North

This section encompasses biotic impaired reaches in the Birch Coulee Creek 10 digit HUC. This subwatershed drains 68 square miles (43,725 acres), and is entirely within Renville County. There are four warmwater reaches impaired for biology in this 10 digit HUC. The two upper reaches in County Ditch 124 will be discussed together and are impaired for macroinvertebrates. Similarly, the two downstream reaches of Birch Coulee Creek will also be discussed together and are impaired for both fish and macroinvertebrates.

Figure 223. Map of the Birch Coulee Creek Watershed with biological impairments and monitoring stations. Impairments are described as F=Fish, F, M=Fish and Macroinvertebrates, and M=Macroinvertebrates.



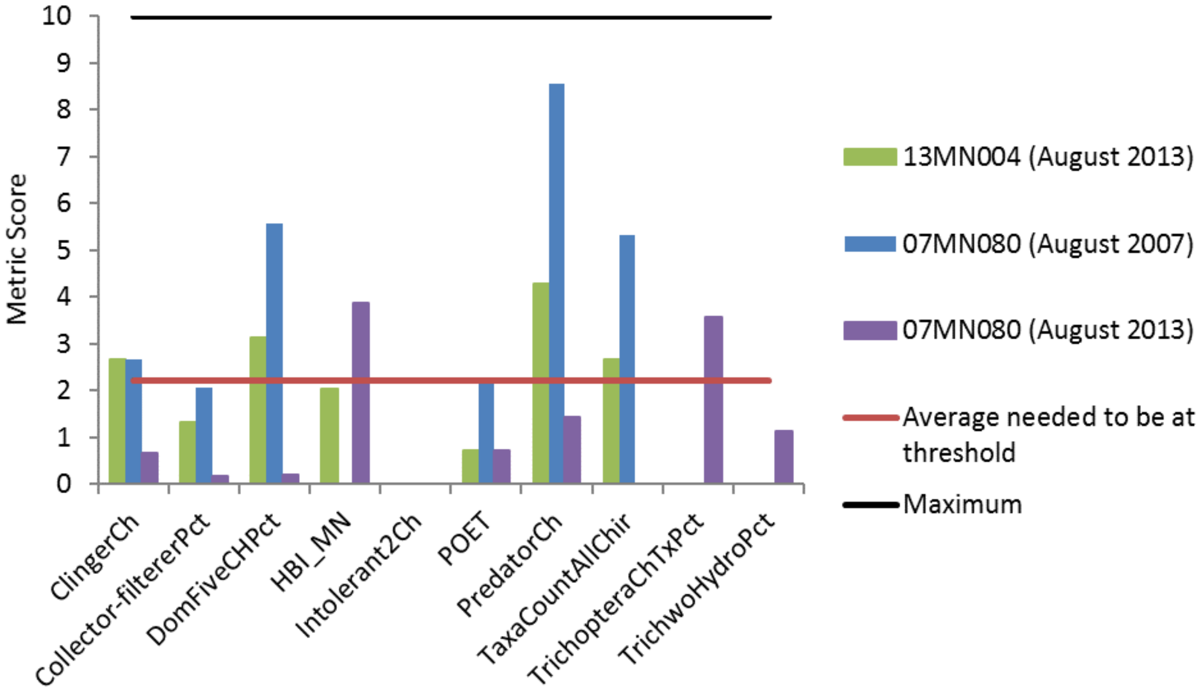
County Ditch 124 (07020007-670) and County Ditch 124 (07020007-711)

County Ditch 124 (07020007-670 and 07020007-711) are the upstream reaches of Birch Coulee Creek, north of Morton, Minnesota. The reaches are both warmwater modified use Class 2B. The upstream reach (-670) is from the headwaters to the confluence with CD 85A. The next reach (-711) is from the confluence with CD 85A to 350th Street. Both reaches are impaired for lack of macroinvertebrate assemblage. Station 13MN004 is on the upstream reach of CD 124 and station 07MN080 is on the downstream reach of CD 124.

4.26.5 Biological Communities

Station 13MN004 was sampled in 2013 for fish and macroinvertebrates. The fish community data was not assessable at this station. The macroinvertebrate community had an IBI score of 16.8. It was below the threshold (22) for the Prairie Streams GP class and was dominated by freshwater amphipods (Hyalella) and snails (Physa). Station 07MN080 was sampled in 2007, 2013, and 2015. The fish community scored 27.3 (in 2007), 20.2 (in 2013), and 26 (in 2015). All visits resulted in IBI scores greater than the threshold (15) for the Low Gradient class. In 2007, the macroinvertebrate community had an IBI of 23.3, in 2013, 11.7 and 15.5. 2013 visits were below the threshold (22) for the Prairie Streams GP class. In 2007, snails and riffle beetles dominated the sample. In 2013, snails and amphipods were the most abundant, similar to the upstream station (Figure 224).

Figure 224. Macroinvertebrate metrics of the Prairie Streams GP class IBI for stations 13MN004 and 07MN080, County Ditch 124.



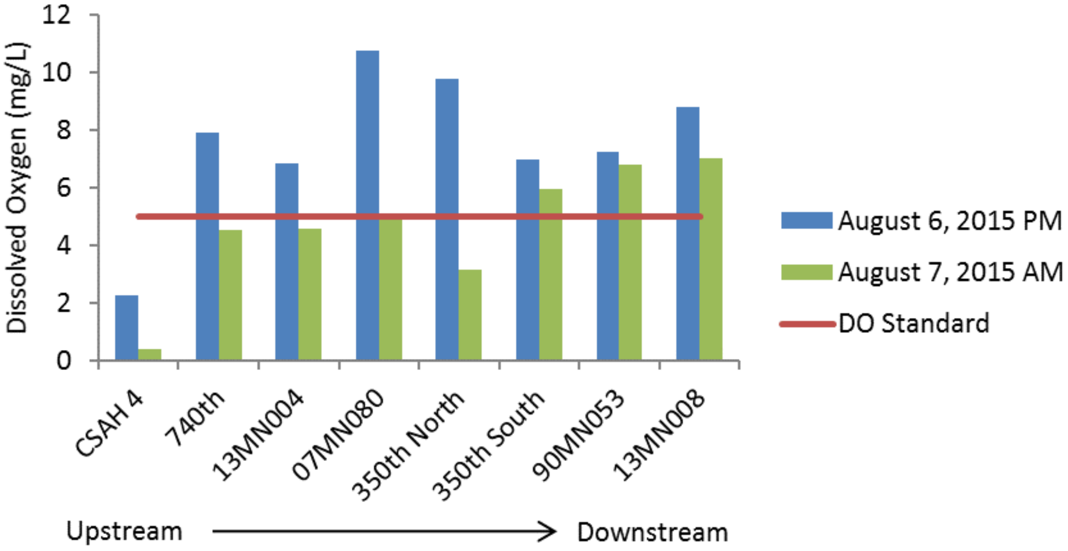
4.26.6 Data Evaluation for each Candidate Cause

Dissolved Oxygen

During biological sampling, a low dissolved oxygen (DO) value was recorded at 13MN004 to be low (3.38 mg/) on August 20, 2013. Additional sampling also took place at two locations (S008-653 and S008-654) on two days in 2015. The June 16 sample was normal at both locations, recording at 9.16 mg/L and 9.94 mg/L. However, on September 1, 2015 station S008-653 had a low DO value at 4.22 mg/L taken at 11:50 am, while S008-654 had a value of 8.38 mg/L at 12:00pm.

Longitudinal DO monitoring also took place August 6 and 7, 2015 (Figure 225). In the afternoon of August 6, only the upstream most station resulted in low DO. In the morning, the first five stations had DO below the standard of 5 mg/L. All morning measurements were taken prior to 9 AM. There were two stations with elevated DO flux, station 07MN080 (5.8) and the upstream crossing at 350th St (6.6).

Figure 225. Longitudinal DO survey in Birch Coulee Creek, August 6 and 7, 2015



The macroinvertebrate community did display a strong negative response to low DO. The total taxa richness sampled (TaxaCountAllChir) was struggling, often falling well below the average for southern streams (Table 223). There was a lack of Ephemeroptera, Plecoptera, as well as Trichoptera (EPTCh) in all three samples. The HBI_MN is a measure of pollution based on tolerance values assigned to each individual taxon, and was found to be lower than the state average of 6.42 during each sample. The low DO index score measures stress response. The lower the index score for low DO, the higher the likelihood is for DO stress. Furthermore, sensitive DO species were completely absent; while tolerant low DO species were overabundant.

Table 223. Macroinvertebrate metrics that respond to low DO stress in County Ditch 124 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN004 (2013)	**28**	**1**	**8.25**	**6.06**	**0**	**0**	**9**	**52.1**
07MN080 (2007)	37	**2**	**8.87**	**5.97**	**0**	**0**	**16**	**30.3**
07MN080 (2013)	**17**	**2**	7.69	**6.04**	**0**	**0**	7	**84.1**
Prairie Streams GP Average	*36.8*	*7.6*	*7.92*	*6.42*	*2.4*	*4.5*	*8.4*	*25.1*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low dissolved oxygen is considered to be stressor within this upland section of Birch Coulee Creek (CD 124). The macroinvertebrate community metrics are consistently suggesting low DO stress. All three visits had lower DO index scores, a lack of low DO intolerant taxa and elevated percentages of low DO tolerant individuals. These metrics show that biologically there is a response to low DO, in addition to the presence of low DO measurements, which further confirm DO is a stressor to this reach.

Eutrophication

Total phosphorus (TP) concentrations from 13 of 16 samples in this reach were above 0.15 mg/L, the river eutrophication standard for the Southern Region. These samples were collected mainly in 2015 and 2016, with 6 occurring during biological sampling in 2007, 2013, and 2015. A total of two chlorophyll-a values were collected in September of 2015, and both were normal at 4.96 ug/L and 10.5 ug/L. As stated above in the DO data, there were a number of low DO concentrations and high DO flux. During biological monitoring on August 29, 2013 and September 22, 2015, it was observed that water had high amounts of algal growth and was almost stagnant in 2013 (Figure 226 and Figure 227). These results indicate a high potential eutrophication stress.

Figure 226. County Ditch 124 at 07MN080 taken on August 28, 2013.

Figure 227. County Ditch 124 at 07MN080 taken on September 29, 2015.

The macroinvertebrate metrics that respond to eutrophication stress show a consistent response (Table 224). There was a lack of collector filterer species, which depend on water quality to support suspended organics to feed on. There was a much higher percentage of tolerant individuals; while there, we not any intolerant species recorded, including Ephemeroptera, Plecoptera & Trichoptera (EPT), which were limited. In 2013, the number of Chironomidae fell below the prairie stream average for the state at both monitoring locations. In 2007, the number was above the average; however, this high population number was largely composed of *Dicrotendipes*, a tolerant genera that is telling of poor water quality. Additionally, the dominating genus sampled was Caenis, which are often found in eutrophic habitats (Menetry et al., 2008).

Table 224. Macroinvertebrate metrics that respond to eutrophication stress in County Ditch 124 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN004 (2013)	**28**	**3**	**10**	**1**	**0**	**96.4**
07MN080 (2007)	37	**2**	**12**	**2**	**0**	**97.3**
07MN080 (2013)	**17**	**1**	**5**	**2**	**0**	**100**
Prairie Streams GP Average	*36.8*	*3.9*	*12.8*	*6.5*	*0.1*	*85.4*
Expected response to stress	↓	↓	↓	↓	↓	↑

Eutrophication is considered a stressor to the macroinvertebrate community. The high phosphorus loading of the stream seems to be a chronic issue, which is a key nutrient to promote overgrowth of algae and macrophytes. There are also clear secondary chemistry variables to concreate these findings, seen in the daily fluctuation of DO driven by intense photosynthesis activity during the day, followed by depletion of oxygen from an overabundance of plant respiration activity.

Nitrate

During the biological sample, the two stations were sampled six different times from 2007, 2013, and 2015. The nitrate concentrations range from 0.2 mg/L to 17 mg/L. There were 11 additional samples taken on this reach in 2015 and 2016. The nitrate concentration ranged from 1.4 mg/L in September, up to 28 mg/L in June. Four of those values were greater than 20 mg/L, all taken in the May or June months.

The macroinvertebrates in this reach show a mixed response to elevated nitrate concentrations (Table 225). The nitrate index score ranged from 2.6 to 3.8, while the average for modified Prairie Streams meeting impairment threshold is 3.2. This shows some differences among sites and years. Increasing nitrate concentrations also correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct) and decreased intolerant taxa, both which are lacking in this reach. Additionally, the number of nitrate tolerant individuals are higher than average at two of the three visits. Interestingly, nitrate tolerant taxa are not as prevalent, which are likely due to lower than average taxa counts.

Table 225. Macroinvertebrate metrics that respond to nitrate stress in County Ditch 124 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN004 (2013)	**0**	**0**	**3.8**	**0**	16	**57.7**
07MN080 (2007)	**0**	**0**	**3.5**	**0**	15	**66.5**
07MN080 (2013)	**1**	**0.3**	2.6	**0**	10	21.0
*Prairie Streams Average **(MU)***	*2.6*	*2.4*	*3.2*	*1.1*	*18.0*	*59.7*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is a stressor within this reach of CD 124. The chemical data shows levels well above the toxic range for aquatic life. The metrics for the macroinvertebrate community also strongly support that the biology is being limited by nitrate concentrations at all locations.

Total Suspended Solids

During the biological sample, the two stations were sampled for total suspended solids (TSS) six different times from 2007, 2013, and 2015. The TSS concentrations were all low, with an average concentration of 6.1 mg/L and a maximum of 17 mg/L, all well below the TSS standard for the central region of 65 mg/L. 11 additional samples were taken in 2015 and 2016, none of which violate the TSS standard. The average concentration was 7.1 mg/L with a maximum of 14 mg/L. Chemistry data does not indicate TSS to be a problem in this reach.

The TSS metrics for macroinvertebrates do not indicate TSS as directly limiting the community. TSS sensitive Plecoptera (PlecopteraPct) were absent in all samples, and collector filterer species were also lacking. However, these groups likely have some other parameter, such as nitrates or low DO, that are driving down there populations.

The macroinvertebrate TSS index score does not raise concern for this site was consistently higher than the average TSS Index for this stream type; as this score increases, it reflects the tolerance of TSS noted in the community. As displayed in Table 226 below, the index score and tolerance values did not consistently indicate TSS stress. In 2007, the metrics that suggest the potential for TSS stress in this reach did consistently score worse than the average for prairie streams. However, the metric responses are just slightly worse than the average of visits meeting the biocriteria. In 2013, the TSS index score was reduced at both locations, as well as noted to have a smaller sample of tolerant to TSS species.

Table 226. Macroinvertebrate metrics that respond to high TSS stress in County Ditch 124 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN004 (2013)	**5.3**	**0**	14.97	**0**	**0**	5	21.0
07MN080 (2007)	**8.1**	**0**	**16.70**	**0**	**0**	**14**	**47.7**
07MN080 (2013)	**1.0**	**0**	15.34	**0**	**0**	4	11.1
Prairie Streams GP Average	*11.7*	*0.1*	*16.68*	*0.8*	*1.4*	*11.8*	*41.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

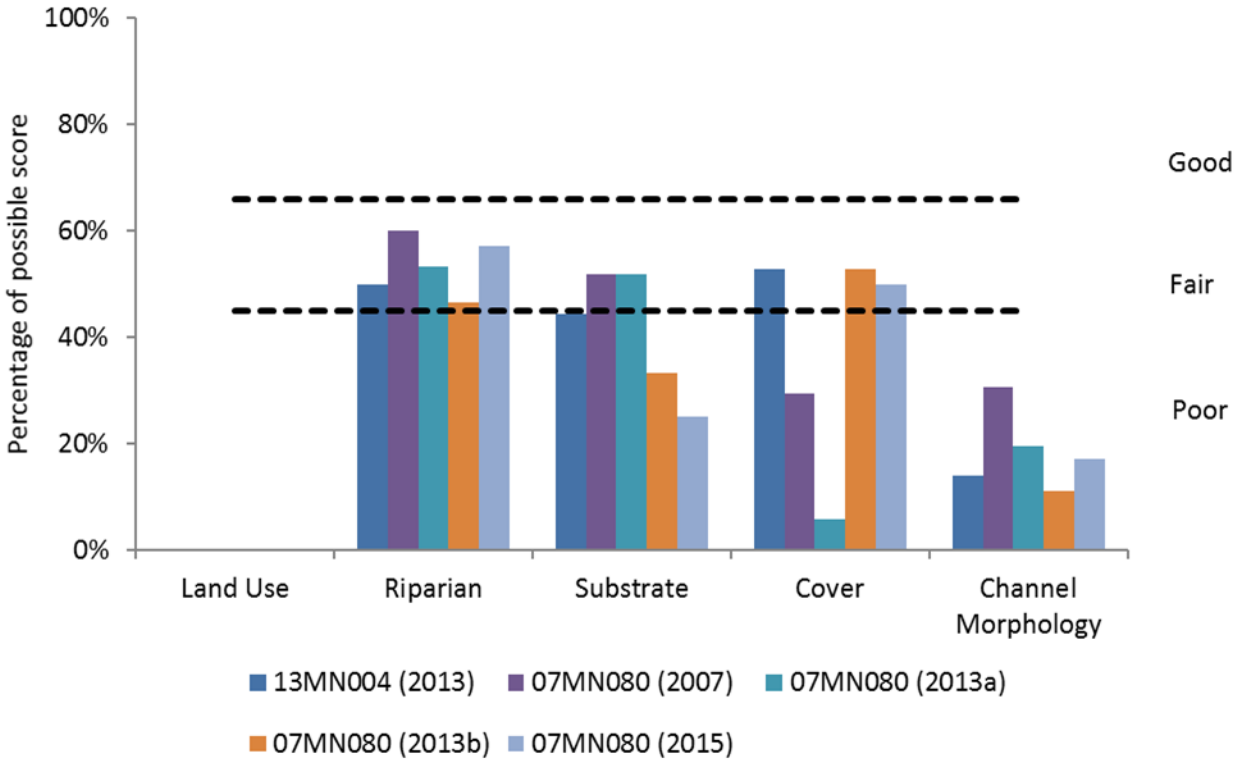
TSS is not stressing the biological community at this site. While some metrics scored poorly in regards to TSS stress, it is likely those particular groups are being limited by another parameter. Chemistry data confirmed that TSS is not of great concern within in this stream segment.

Habitat

Station 13MN004 had a poor MSHA score in 2013 (33.5). This station is surrounded by row crop. The riparian width was very narrow, with little bank erosion and moderate shade. The reach was comprised 100% run, with sand and silt substrate. There was moderate cover with overhanging vegetation and submergent, emergent, and floating leaf macrophytes. The channel morphology was poor with poor sinuosity, poor channel development, a lack of depth variability, with no riffles and moderate channel stability.

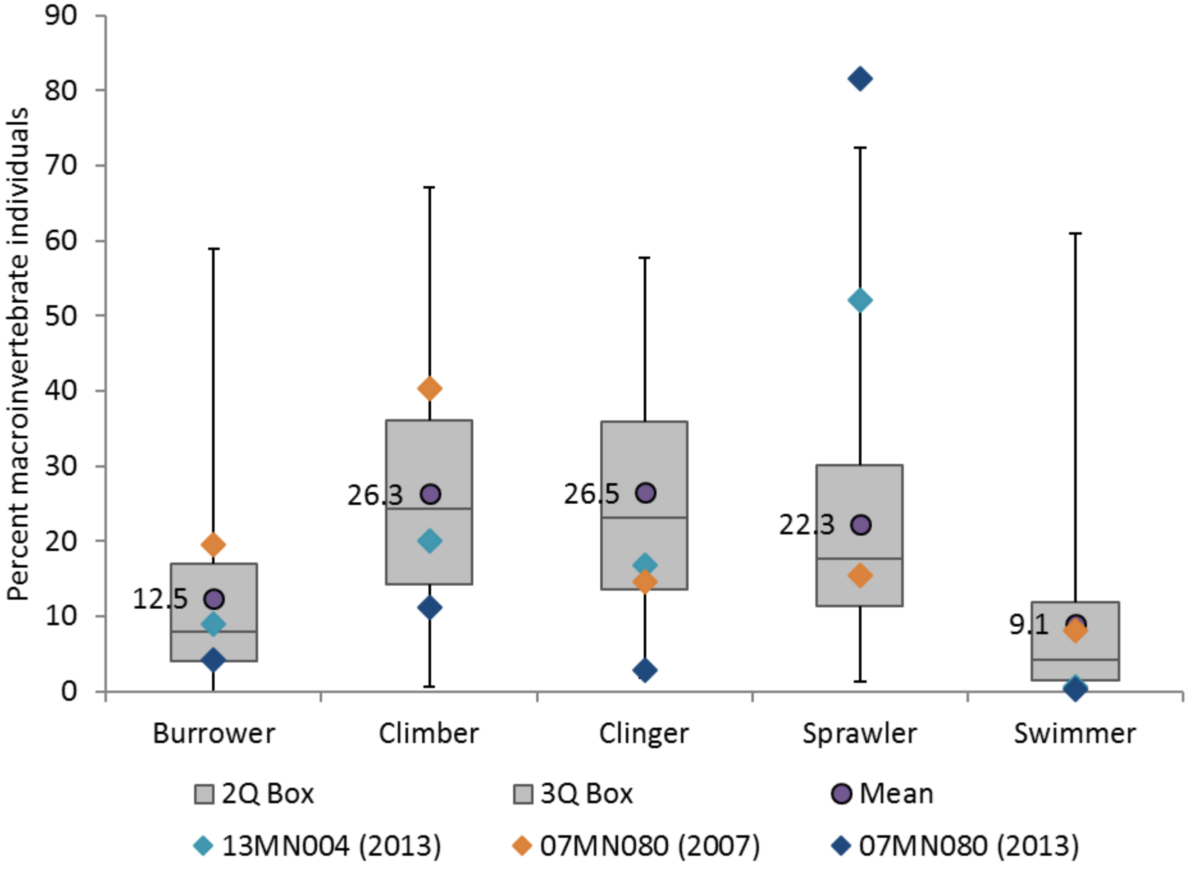
In 2007 2013 and 2015, station 07MN080 had four separate MSHA scores ranging from 29-39 (Figure 228). The surrounding land use is row crop. The riparian width was noted as little as very narrow (1-5m) and up to wide (50-100m). There was little to no bank erosion and light shade during all four visits. Also all four assessments had 100% of the channel type as run features with a complete absence of pools and riffles. The substrate was noted as sand or sand and silt. Cover was generally limited to overhanging vegetation and submergent and emergent macrophytes. The cover amount varied, from sparse in 2007, to moderate in June 2013 and in September 2015, to choking vegetation only in August 2013.

Figure 228. Percentage of MSHA subcategory scores for stations 13MN004 and 07MN080, County Ditch 124.



There was found to be little available habitat, beyond that of overhanging vegetation and macrophytes. Undercut banks and overhanging vegetation was the only habitat that was sampled for macroinvertebrates. Figure 229 shows that the percentage of “sprawlers” was high in 2013 at both stations. The macroinvertebrates that burrow were a bit elevated in 2007 at station 07MN080. Clinging macroinvertebrates were quite low at station 07MN080 in 2013 and below average for the other two visits as well. Clingers require woody debris or course substrate to “cling” to, to their absence reflects the physical observations of the MSHA. There is not a consistent pattern with the metrics related to habitat, but this could be driven by other interacting stressors like flow.

Figure 229. Macroinvertebrate habit metrics with box plot showing range of values from Prairie Streams GP stations meeting the modified use biocriteria, mean of those stations, and metric values from stations 13MN004 and 07MN080.



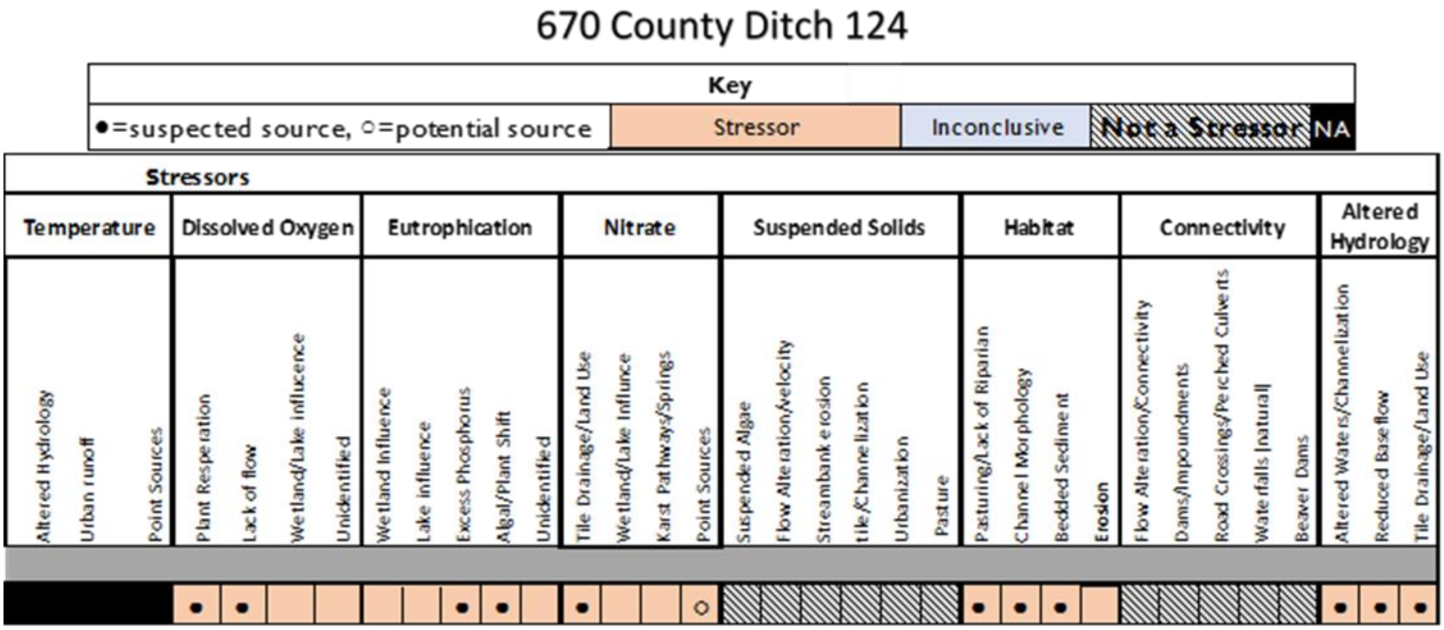
Habitat is considered a stressor. Limitations on habitat are largely due to the homogenous features. Streambed health is also in poor conditions, noted both in the site visits as well as reflected in the high concentration of burrower macroinvertebrates.

Altered Hydrology and Longitudinal Connectivity

The entire reach of -670 and -711 in County Ditch 124 have been modified by way of channelization and ditching. Hydrology is this stream is also being altered by the introduction of subsurface tile lines that changes the soils longitudinal to stream recharge ability, in addition to pollutant loading. These practices change the streams morphology, hydrologic capacity, and profile. Altered hydrology is considered the primary stressor as it is the key driver in the in loss of habitat, as well as pollutant overloading within these reaches. For more information regarding altered hydrology within this region and the impacts, reference Chapter 3.1.8 of this report.

Summary Table

Table 227. Identified stressors with suspected sources for reach 670 of County Ditch 124.



670 County Ditch 124

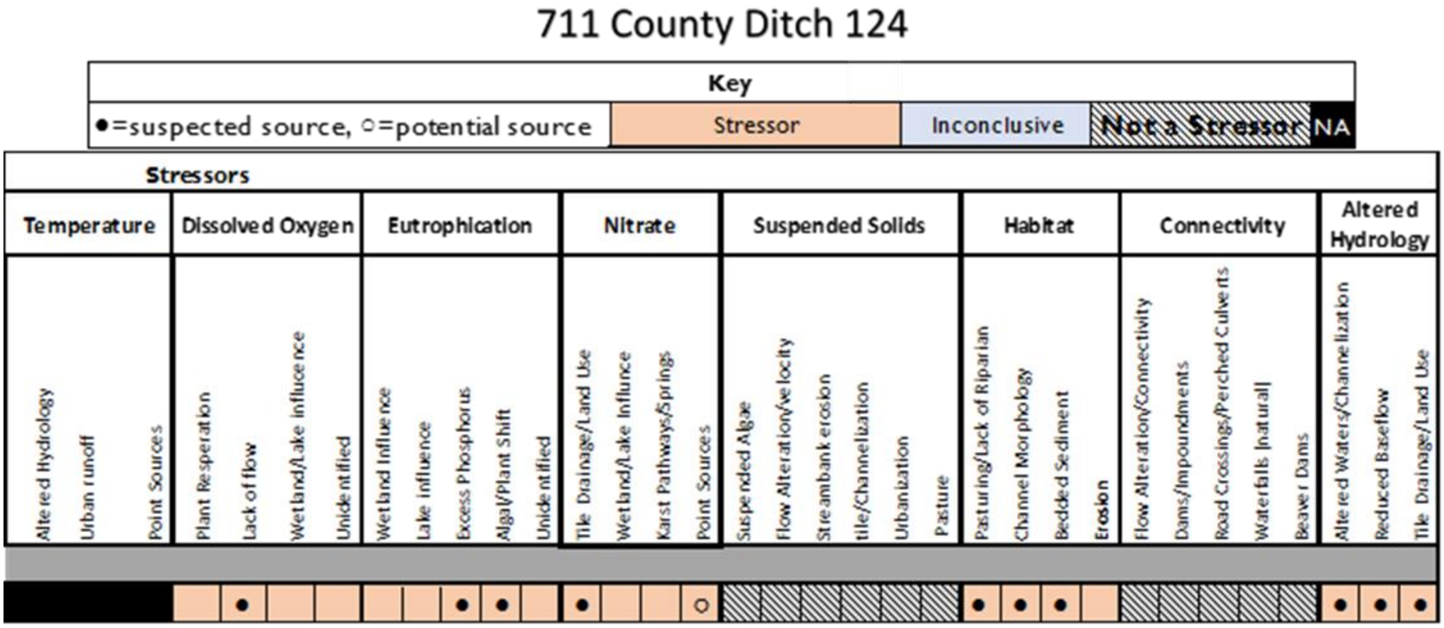
Key

●=suspected source, ○=potential source | Stressor | Inconclusive | Not a Stressor | NA

Stressors

Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Base flow	Tile Drainage/Land Use
■	■	■	●	●					●	●		●			○	▨	▨	▨	▨	▨	▨	●	●	●		▨	▨	▨	▨	▨	●	●	●

Table 228. Identified stressors with suspected sources for reach 711 of County Ditch 124.



711 County Ditch 124

Key

●=suspected source, ○=potential source | Stressor | Inconclusive | Not a Stressor | NA

Stressors

Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
■	■	■		●					●	●		●			○	▨	▨	▨	▨	▨	▨	●	●	●		▨	▨	▨	▨	▨	●	●	●

Birch Coulee Creek (07020007-588 and 07040007-587)

Both reaches of Birch Coulee Creek (07020007-588 and 07020007-587) are impaired for fish and macroinvertebrates. The upstream reach (588) begins at the confluence with Unnamed Ditch and goes to the confluence of Judicial Ditch 12. The downstream reach (587) begins immediately downstream of 588 and extends to the Minnesota River. Both of the reaches are warmwater general use Class 2B. The downstream reach is also impaired for *E. coli*, but that will not be addressed in this report. Station 90MN053 is located on the upstream reach, and stations 14MN210 and 13MN008 are on the downstream reach.

4.26.7 Biological Communities

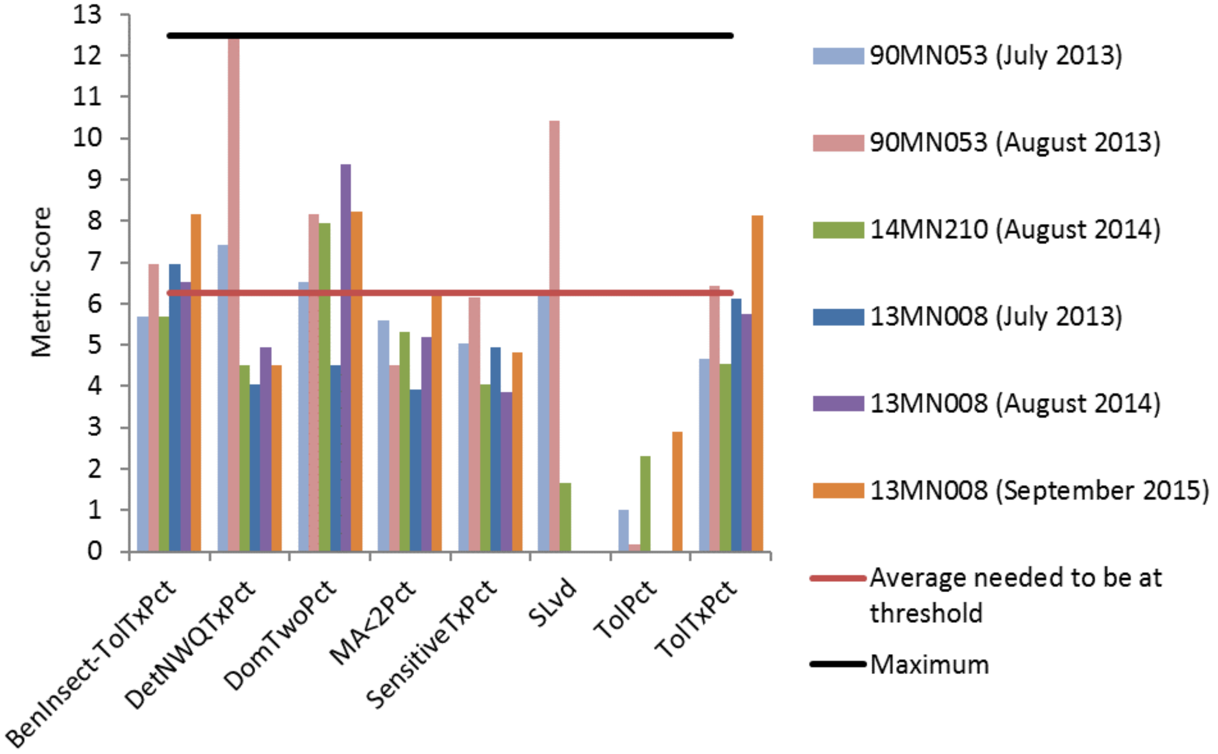
There are multiple biological stations on the two reaches of Birch Coulee Creek. Station 90MN053 was sampled for fish and macroinvertebrates in 2013. Station 13MN008 was also sampled in 2013 for fish and macroinvertebrates. Stations 14MN210 and 13MN008 were sampled in 2014. As displayed in Table 229, the majority of the fish IBI scores were below the threshold for the Southern Streams fish class. Similarly, all but one macroinvertebrate IBI was below the threshold for the Southern Streams RR class.

Table 229. Birch Coulee Creek visits and IBIs for fish and macroinvertebrates compared to the thresholds. Bold indicates IBI below threshold.

Station	Year	Fish IBI	Fish Class (threshold)	Macro-invertebrate IBI	Macro-invertebrate Class (threshold)
90MN053	2013	**42.1**	Southern Streams (50)	**32.8**	Southern Streams RR (37)
		55.3			
14MN210	2014	**44.9**		**30.5**	
13MN008	2013	**38.1**		45.6	
	2014	**45.0**		**26.4**	
	2015	**43.0**		**32.9**	

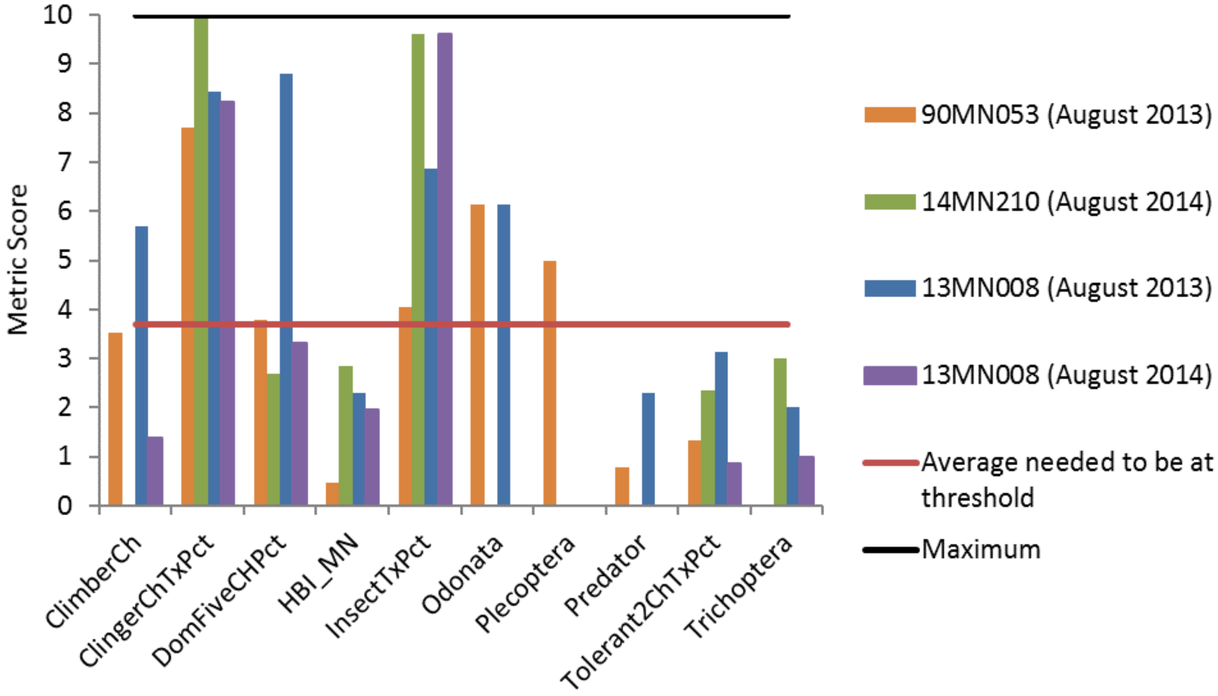
All of the stations show a similar pattern in IBI metric scores throughout these reaches of Birch Coulee (Figure 230). The fish community had an abundance of tolerant individuals, translating to a low percentage of tolerant metric score (TolPct). Stations 14MN210 and 13MN008 had an abundance of short-lived taxa (SLvd). The taxa that comprised of the top two abundant fish at each visit were sand shiner, central stoneroller, white sucker, blacknose dace, creek chub, and common shiner.

Figure 230. Fish metrics of the Southern Streams class IBI for stations 90MN053, 14MN210, and 13MN008, Birch Coulee Creek.



The macroinvertebrate community at the three stations showed similar IBI metric patterns (Figure 231). There also may be some yearly variability present. Macroinvertebrate IBI metrics that scored particularly low were a measure of pollution based on tolerance values assigned to each individual taxon, developed by Chirhart (HBI_MN), the taxa richness of predators (excluding chironomid predator taxa; Predator), relative percentage of taxa with tolerance values equal to or greater than six, using MN TVs (Tolerant2ChTxPct), and taxa richness of caddisflies (Trichoptera). The most abundant macroinvertebrate taxa were net-spinning caddisflies (Cheumatopsyche), midges (Polypedilum), and mayflies (Caenis, Baetis, Stenacron, and Maccaffertium).

Figure 231. Macroinvertebrate metrics of the Southern Streams class IBI for stations 90MN053, 14MN210, and 13MN008, Birch Coulee Creek.



4.26.8 Data Evaluation for each Candidate Cause

Dissolved Oxygen

At the time of biological monitoring, station 90MN053 was sampled for dissolved oxygen (DO) and had ranges that fell just above the 5 mg/L threshold. The sample taken at station 09MN053 on September 22, 2015 is of some concern as DO was recorded at only 6.37 mg/L in the afternoon; this is around a time when DO should be reaching its peak level. However, there was little flow recorded at the time of sampling at this location. Similar flow conditions were noted At 8 am, on August 20, 2013 where another low recording fell just above the threshold, at 5.95 mg/L. Station 13MN008 DO concentrations were at normal levels at the time of biological monitoring. Additional DO values collected on this reach from 2013-2016, also showed normal values. None of the 25 additional values collected violated the DO standard of 5 mg/L. The values ranged from 6.89 mg/L to 14.03 mg/L. Longitudinal DO monitoring took place August 6 and 7 of 2015. Within these reaches of Birch Coulee Creek, DO was at a sufficient level during this sampling as well.

The macroinvertebrate community had some yearly variation in metrics related to indicate low DO response (Table 230). The low DO index score measures stress response. The lower the index score for low DO, the higher the likelihood is for DO stress. The 2013 visits resulted in a lower low DO index scores and higher low DO tolerant percentages. At the same time, these visits had greater number of taxa present than in 2014. There were low DO intolerant taxa present at all visits even though lower than the average of similar stations meeting the biocriteria.

Table 230. Macroinvertebrate metrics that respond to low DO stress in Birch Coulee Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
90MN053 (2013)	**40**	**9**	**8.19**	**6.47**	**5**	**8.7**	**6**	**48.8**
14MN210 (2014)	**29**	**10**	**7.38**	7.43	**6**	**21.9**	4	4.4
13MN008 (2013)	**43**	**10**	**7.57**	**6.93**	**6**	**21.4**	**5**	**15.5**
13MN008 (2014)	**29**	**8**	**7.69**	7.26	**7**	**15.7**	2	1.6
Southern Streams Average	*45.8*	*14.2*	*7.08*	*7.04*	*9.0*	*24.0*	*4.8*	*9.9*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

The fish community has mixed response to low DO stress as well. The DO index score was better than average for all visits and years, and the percentage of DO tolerant taxa appears normal or better than average. Overall, there are a number of tolerant fish, and a lack of sensitive fish, but not an overabundance of DO tolerant fish (Table 231). This perhaps suggests the something other than low DO is influencing the fish community. This in addition to the chemical values observed in the stream, DO is not considered a stressor the biological communities at this time.

Table 231. Fish metrics that respond to low DO stress in Birch Coulee Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
90MN053 (2013)	**7.8**	**1.3**	**71.2**	7.37	**1**	**1.3**	0	0
90MN053 (2013)	**6.3**	**3.2**	**74.3**	7.36	**1**	**1.2**	0	0
14MN210 (2014)	**13.6**	**10.7**	**64.2**	7.23	**1**	**2.0**	**7**	9.5
13MN008 (2013)	**4.3**	**3.2**	**84.6**	7.33	**1**	**1.1**	4	2.2
13MN008 (2014)	**5.8**	**13.1**	**75.8**	7.26	**1**	**1.2**	**6**	7.2
13MN008 (2015)	**10.7**	**3.8**	**64.1**	7.24	**1**	**1.1**	**6**	5.3
Southern Streams Average	*16.9*	*24.6*	*44.9*	*7.20*	*1.71*	*5.94*	*4.69*	*18.54*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is not believed to be a factor that is stressing the biological communities within these two reaches. There were not any low DO reading that fell below the 5 mg/L threshold during the assessment period. Within both the fish and macroinvertebrate communities, the metrics were not suggestive that low DO is what is stressing biology.

Eutrophication

During biological sampling on Birch Coulee Creek, total phosphorus (TP) concentrations varied (seven samples between two different stations). Two of the seven values exceed the phosphorus criteria for the southern river nutrient region (0.150 mg/L). Additional sampling on the reach shows varied concentrations as well. Of the 37 samples collected at two, different chemistry stations on these reaches from 2009-2016, nine violated the standard of the southern region of 0.150 mg/L. The average TP concentration was 0.352 mg/L. Only one chlorophyll-a sample was taken in September 2015, and was low at 19.3 ug/L.

The macroinvertebrate community did indicate a negative response to eutrophic stress (Table 232). The total richness of taxa collected (TaxaCountAllChir) consistently fell below the state average found for non-impaired southern streams. The taxa sample for macroinvertebrates that depend on conditions for filtering and gathering (Collector-filtererCh and Collector-gathererCh) typically were found to be just under the average. Ephemeroptera, Plecoptera & Trichoptera, (EPT) were under the average population sixe within all samples. In general, there was an absence of intolerant species in the sample; the community was abnormally dominated by tolerant taxa.

Table 232. Macroinvertebrate metrics that respond to eutrophication stress in Birch Coulee Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
90MN053 (2013)	**40**	**5**	**14**	**9**	**0**	**87.5**
14MN210 (2014)	**29**	**7**	**9**	**9**	**0**	**82.8**
13MN008 (2013)	**43**	**6**	**15**	**10**	**0**	**79.1**
13MN008 (2014)	**29**	**6**	**8**	**8**	**0**	**89.7**
Southern Streams Average	*45.8*	*7.3*	*15.9*	*12.2*	*0.8*	*72.6*
Expected response to stress	↓	↓	↓	↓	↓	↑

The fish community presented similar results as the macroinvertebrate community, indicating possible eutrophication stress (Table 233). There were low percentages of sensitive species and darter fish (DarterPct) that depend on decent water clarity. Five out of the six fish samples yielded fewer simple lithophilic spawners (SLithoPct) that expected for this stream type, and a complete lack of intolerant fish. Four of the five visits resulted in lower simple lithophilic spawners. In most years to total fish count was acceptable for the site, consistently made up of tolerant species with intolerant species being completely absent.

Table 233. Fish metrics that respond to eutrophication stress in Birch Coulee Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
90MN053 (2013)	**7.8**	**3.9**	41.8	**71.2**	**11**	**0**
90MN053 (2013)	**6.3**	**10.3**	**35.6**	**74.3**	**9**	**0**
14MN210 (2014)	**13.6**	**5.9**	**33.8**	**64.2**	22	**0**
13MN008 (2013)	**4.3**	**3.8**	**22.2**	**84.6**	**18**	**0**
13MN008 (2014)	**5.8**	**4.0**	**31.5**	**75.9**	23	**0**
13MN008 (2015)	**10.7**	**5.4**	**24.8**	**64.1**	23	**0**
Southern Streams Average	*16.9*	*11.9*	*37.0*	*44.9*	*19.3*	*4.2*
Expected response to stress	↓	↓	↓	↑	↓	↓

The biological community does show potential for eutrophication to be a stressor. However, there is a lack of chemical information to support this conclusion. Additional information on DO flux, chlorphyll-a, and phosphorus would help in the understanding of the potential for eutrophication related stress to this reach. Due to lack of connecting information, eutrophication as a stressor is inconclusive for these two reaches.

Nitrate

At the time of biological sampling, the nitrate concentrations were found to be low; with a total of seven samples averaging 2.9 mg/L, and a maximum value of 9.6 mg/L. Five of the values were less than 1 mg/L. However, there were 27 additional samples taken on this reach in 2009-2015. The nitrate concentration ranged from 0.05 mg/L in September and up to 27 mg/L in June of 2015. Fifteen (55%) of the values collected were greater than 10 mg/L, and two were greater than 20 mg/L.

Fish often do not show a strong response to increased nitrate concentrations. Macroinvertebrate communities are often more affected by nitrate. The macroinvertebrates in this reach indicated a response to elevated nitrate concentrations (Table 234). The nitrate index score displayed high ranges for all the sampling years ranging from 3.1 to 3.6, while the average for Southern Streams meeting impairment threshold is 2.9. The index score, in addition to the percentage of nitrate tolerant individuals indicates a community dominated by nitrate tolerant taxa. Increasing nitrate concentrations also correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct) and decreased intolerant taxa, both which are lacking in this reach. Overall, the biological and chemical information point to nitrate a stressor in Birch Coulee Creek.

Table 234. Macroinvertebrate metrics that respond to nitrate stress in Birch Coulee Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
90MN053 (2013)	**2**	**0.3**	**3.3**	**0**	**26**	**72.0**
14MN210 (2014)	**5**	5.6	**3.4**	**0**	15	**67.1**
13MN008 (2013)	**4**	**5.3**	**3.1**	**1**	**23**	**59.6**
13MN008 (2014)	**3**	**4.7**	**3.6**	**0**	**19**	**66.5**
Southern Streams Average	*6.3*	*5.5*	*2.9*	*2.4*	*18.8*	*47.2*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is considered a stressor to the biological community within these two reaches. The macroinvertebrate community consistently displayed nitrate stress. The biological metrics also correlate to with the toxic levels of nitrate found within these reaches.

Total Suspended Solids

During biological sampling on Birch Coulee Creek, total suspended solids (TSS) concentrations were low (seven different samples at two stations all <10 mg/L). Additional sampling on the reach also shows a pattern of low concentrations, with some higher concentrations correlating to storm events. There were 40 samples collected at two different chemistry stations on these reaches throughout 2009-2016. Only two of the 40 samples violate the standard of the southern region for TSS of 65 mg/L; the highest was recorded on June 24, 2013 at 186 mg/L. The remaining samples had an average concentration of 8 mg/L, demonstrating few instances of high TSS with good sampling coverage.

The macroinvertebrate community had somewhat mixed results to possible TSS stress (Table 235). The TSS index score at all visits was greater than that of similar stations meeting the biocriteria of 15.63. There was an absence or low number of TSS intolerant taxa and individuals as well, however the community was not overly dominated by TSS tolerant species, falling below or hovering right about the average. Collector-filter species that depend on low sediment water conditions were lacking in two of the four samples, but well above the average in the other two years.

Table 235. Macroinvertebrate metrics that respond to high TSS stress in Birch Coulee Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
90MN053 (2013)	**9.6**	**0.3**	**16.20**	**0**	**0**	9	24.2
14MN210 (2014)	47.5	**0**	**16.23**	**0**	**0**	5	**42.5**
13MN008 (2013)	**12.8**	**0**	**16.20**	**2**	**0.6**	**14**	30.4
13MN008 (2014)	42.0	**0**	**17.20**	**0**	**0**	8	**59.2**
Southern Streams Average	*25.4*	*0.7*	*15.63*	*2.9*	*4.7*	*12.2*	*34.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

The fish community also had mixed response to TSS stress (Table 236 and Table 237). Overall, there were a wide range of results depending on the station and year. Species that are dependent on clean riverbed substrate such as benthic feeders (BenFdFrimPct), Riffle dwelling species (RifflePct), and herbivore species (HrbNWQPct) were all found to be abundant. Looking at the tolerance TSS metrics in Table 236 and Table 237, the TSS index score for fish was better than average at all but one visit. Intolerant fish are lacking clearly, but TSS tolerant fish do not appear to be dominating the community.

Table 236. Fish metrics that respond to high TSS stress in Birch Coulee Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
90MN053 (2013)	36.6	**0**	39.2	**0**	**0**	**3.9**	40.5	**7.8**	**1.3**
90MN053 (2013)	37.2	**0**	32.0	**0**	**0**	**10.3**	33.2	**6.3**	**3.2**
14MN210 (2014)	38.4	**1.8**	46.3	**0**	**2.3**	**7.7**	49.4	**13.6**	**10.5**
13MN008 (2013)	**30.5**	**0**	30.3	**0**	**0.3**	**4.1**	32.7	**4.3**	**3.0**
13MN008 (2014)	39.8	**0.1**	40.9	**0**	**1.2**	**4.4**	42.5	**5.8**	**13.0**
13MN008 (2015)	41.5	**2.4**	45.5	**0**	**2.6**	**7.7**	46.8	**10.7**	**3.7**
Southern Streams Average	*36.0*	*5.4*	*25.7*	*4.2*	*13.6*	*20.1*	*30.2*	*16.9*	*19.1*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 237. Fish metrics that respond to high TSS stress in Birch Coulee Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
90MN053 (2013)	14.1	**0**	**0**	1	0.7
90MN053 (2013)	14.0	**0**	**0**	0	0
14MN210 (2014)	16.8	**0**	**0**	**4**	5.4
13MN008 (2013)	**21.2**	**0**	**0**	2	**33.5**
13MN008 (2014)	18.2	**0**	**0**	**5**	12.0
13MN008 (2015)	16.3	**0**	**0**	**4**	4.7
Southern Streams Average	*19.2*	*1.7*	*5.3*	*2.4*	*12.5*
Expected response to stress	↑	↓	↓	↑	↑

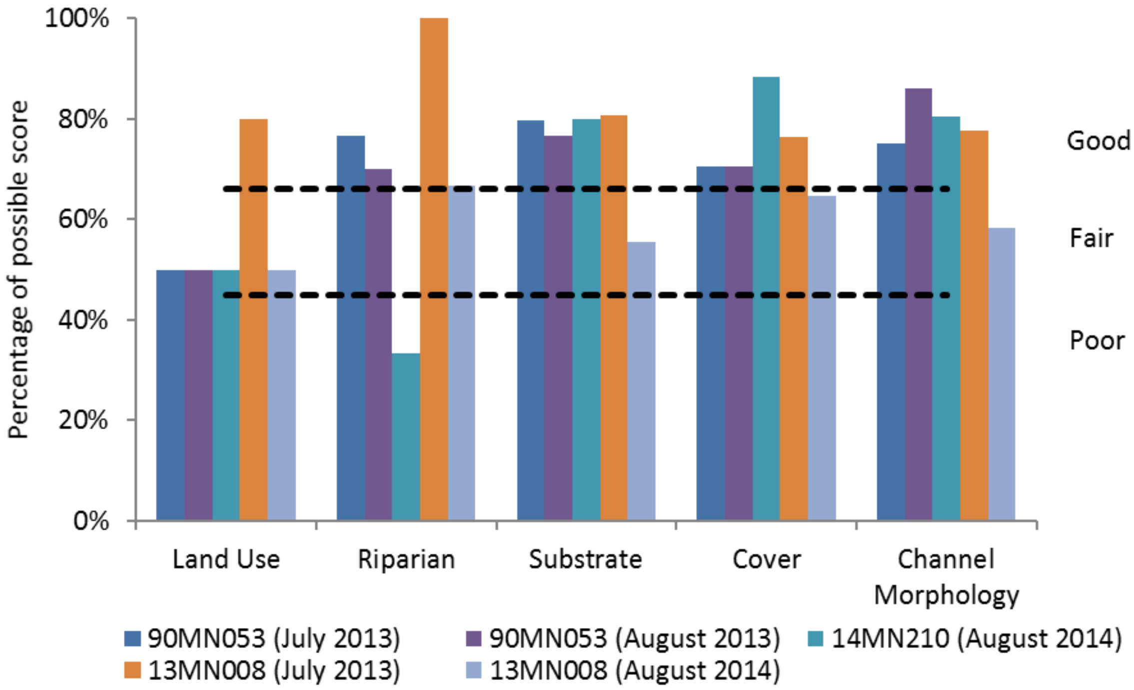
TSS is not a stressor to these two reaches of Birch Coulee Creek at this time. There is not a strong suggestion that TSS is a stressor based on the metrics of the two communities. In addition, chemical data shows relatively low TSS concentrations.

Habitat

The MSHA scores in Birch Coulee were mostly in the good range (73.1 – 81.8) with one score in the fair range (59.5 at station 13MN008 in 2014). There were similarities in subcategory scores among the visits as well (Figure 232). Station 14MN210 scored a little worse for riparian, and station 13MN008 in 2014 scored a little worse than the other visits in substrate, cover, and channel morphology. Station 13MN008 is located within the Minnesota River Valley, where as the other two are located higher in the landscape. Stations 90MN053 and 14MN210 have steeper gradients than station 13MN008. Some of the variation in habitat is due to the natural geologic factors, as it appears material drops out of suspension at station 13MN008 due to the low gradient. There is a great deal more sand at station 13MN008 than the other two stations. Station 13MN008 is over wide, likely due to excess bed material dropping out of suspension. However, deep pools exist in this reach too.

The fish community metrics give a mixed response related to habitat stress (Table 236) Benthic insectivores (BenFdFrimPct) were better than average at all stations. Station 13MN008, having the fewest overall, which was only slightly below average. Similarly, riffle dwelling species (RifflePct) were higher than average at all stations. Yet, simple lithophilic spawners (SLithFrimPct) were reduced at all stations.

Figure 232. Percentage of MSHA subcategory scores for stations 90MN053, 14MN210, and 13MN008, Birch Coulee Creek.



The gradient changes significantly between biological stations. At station 90MN053, the gradient is 4.2. At 14MN210, the gradient is 8.9. At gradient increases, so does the streams ability to move sediment particles and larger particles such as cobble and boulders (Figure 233 and Figure 234). As the stream loses gradient (13MN008 =2.8), often particles drop out of suspension resulting in a loss of diverse streambed features as more fine particles (like silt and sand) are more abundant (Figure 235). Due to this, the downstream reaches have a more homogenous streambed.

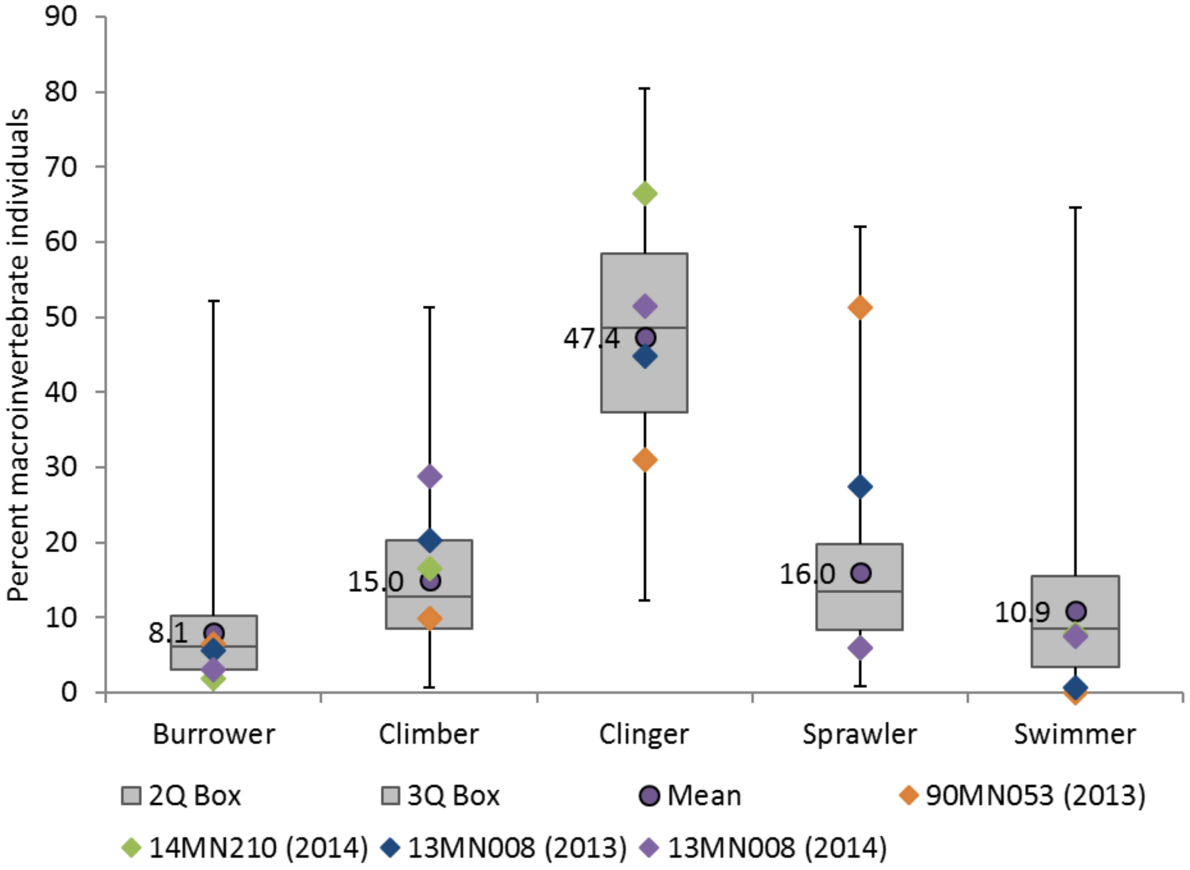
Figure 233. Station 90MN053 displaying diverse substrate features, taken on August 14, 2013.

Figure 234. Station 14MN210 streambed that consists of bedrock with large boulders, taken on August 27, 2014.

Figure 235. Station 13MN008 streambed displaying sedimentation, taken on August 27, 2014.

The macroinvertebrate habit metrics (Figure 236), show mixed results. The majority of metrics are not strongly suggestive of habitat stress. Station 90MN053 shows a lower percentage of clingers in 2013, and abundant sprawlers. This can indicate some issues with sedimentation, among other things. Overall, the habit metrics seem normal for this stream type and do not strongly indicate habitat is not playing a huge role in stressing the macroinvertebrate community.

Figure 236. Macroinvertebrate habit metrics with box plot showing range of values from Southern Streams stations meeting the general use biocriteria mean of those stations, and metric values from stations 90MN053, 14MN210, and 13MN008.



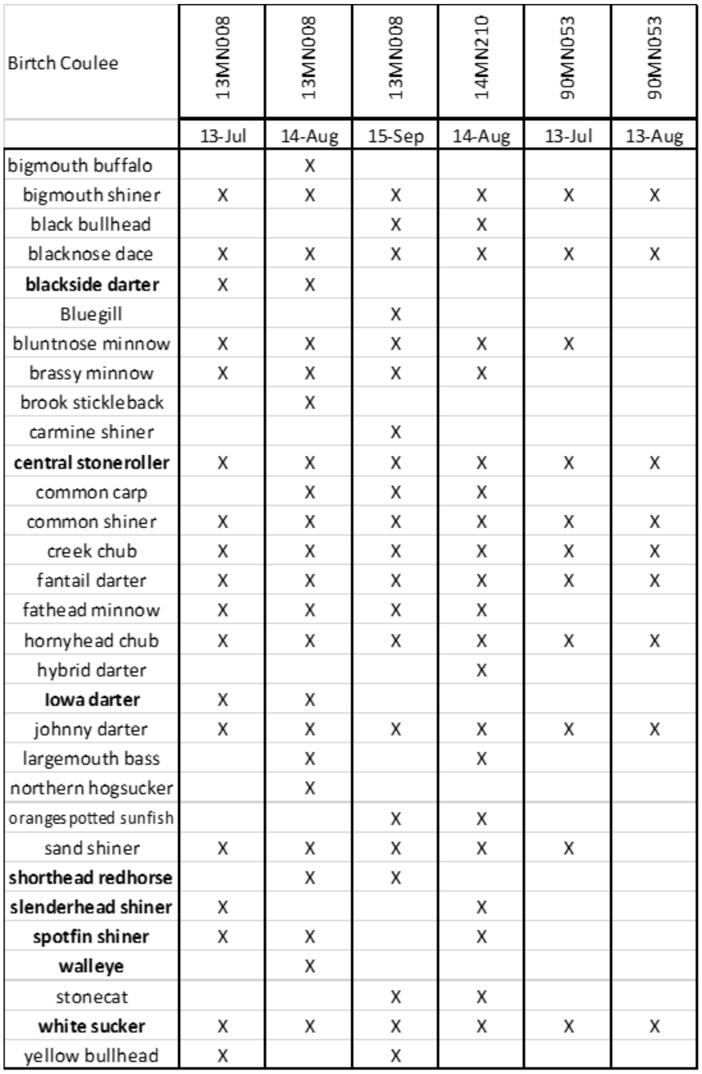
Habitat is not considered to be limiting the biological communities within these two reaches of Birch Coulee Creek. Between the multiple monitoring stations, there is adequate as well as diverse habitat. Furthermore, the macroinvertebrate habitat group types are within the expected makeup at each location (with the exception of 09MN053 where the high abundance of sprawlers skewed the makeup).

Longitudinal Connectivity and Altered Hydrology

Longitudinal connectivity is a factor of stress for the fish population within this portion of Birth Coulee, especially at low flow conditions.

Based on the fish sample taken at these locations in 2013 and 2014, it does suggest certain migratory species types are limited and not able to migrate upstream, as shown in Table 238 below. The biomonitoring station 14MN210 has a significant outcropping of gneiss that has created a steep enough Knick point within the stream that would make migration upstream only possible in moderate to high flow conditions (Figure 237).

Table 238. Displays fish soecies sampled at with an X. Migratory species are highlighted in bold. Stations listed are in order from the downstream to upstream, to better display migration patterns.



Birtch Coulee	13MN008	13MN008	13MN008	14MN210	90MN053	90MN053
	13-Jul	14-Aug	15-Sep	14-Aug	13-Jul	13-Aug
bigmouth buffalo		X				
bigmouth shiner	X	X	X	X	X	X
black bullhead			X	X		
blacknose dace	X	X	X	X	X	X
blackside darter	X	X				
Bluegill			X			
bluntnose minnow	X	X	X	X	X	
brassy minnow	X	X	X	X		
brook stickleback		X				
carmine shiner			X			
central stoneroller	X	X	X	X	X	X
common carp		X	X	X		
common shiner	X	X	X	X	X	X
creek chub	X	X	X	X	X	X
fantail darter	X	X	X	X	X	X
fathead minnow	X	X	X	X		
hornyhead chub	X	X	X	X	X	X
hybrid darter				X		
Iowa darter	X	X				
johnny darter	X	X	X	X	X	X
largemouth bass		X		X		
northern hogsucker		X				
orangespotted sunfish			X	X		
sand shiner	X	X	X	X	X	
shorthead redhorse		X	X			
slenderhead shiner	X			X		
spotfin shiner	X	X		X		
walleye		X				
stonecat			X	X		
white sucker	X	X	X	X	X	X
yellow bullhead	X		X			

Figure 237. Gneiss outcrop at 14MN210 in Birch Coulee Creek. May 19, 2014 recon photo.

Altered Hydrology is prevalent within this subwatershed, as a majority of the headwaters that feed into the assessed monitoring stations are modified by way of channelization, or by subsurface tile line. These practices create changes to the streams flow regime, as shown in Figure 238. This reach does display “flashiness,” or erratic peaks in flow, followed by periods of little to no flow, as shown in Figure 239 Altered flow can lead to changes in the streams stability, often noted in erosive banks and loss of habitat features. As natural water storage is reduced, low flow periods become of greater concern to the biologic communities. Water that previously would recharge the stream through shallow aquafers and upstream water storage areas are depleted in the presents of tile. Currently, changes to the streams morphology are not found to be limiting the biology. What is of greater concern from altered hydrology is the introduction of excess nutrients. Upstream subsurface tile drainage is thought to be the primary contributor of excess phosphorus and nitrates. For more information on how these practices relate to altered hydrology, reference Chapter 3.1.8 of this report.

Figure 238. Hydrograph of stream flow from May 2013 to September 2014.

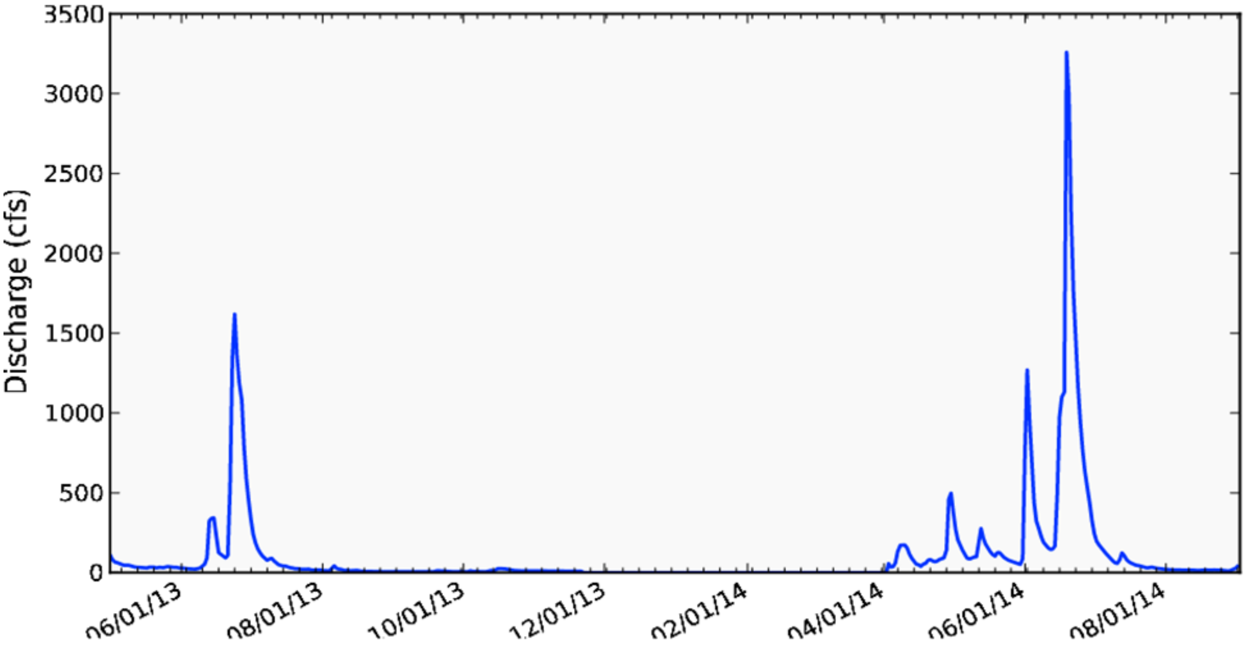
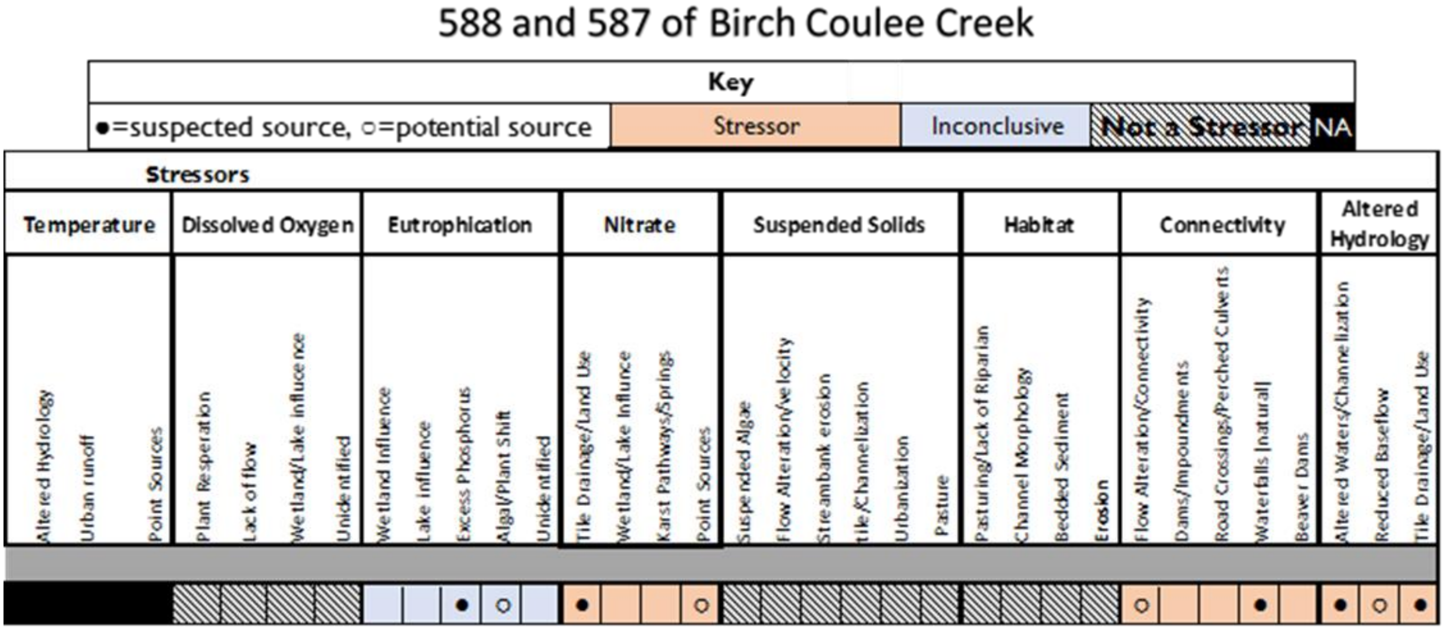


Figure 239. 90MN053 August 20 2013 during low flow.

Summary Table

Table 239. Identified stressors with suspected sources for reaches 588 and 587 of Birch Coulee Creek.



588 and 587 of Birch Coulee Creek

Key				
●=suspected source, ○=potential source	Stressor	Inconclusive	Not a Stressor	NA

Stressors																																	
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls (natural)	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
									●	○		●			○											○			●		●	○	●

Birch Coulee Creek Subwatershed Conclusion

Four stream reaches were found impaired for biology in the Birch Coulee Subwatershed. Two reaches on Birch Coulee Creek were assessed as general use warmwater, and two reaches with County Ditch 124 were assessed as modified use warmwater. County Ditch 124 is located within the upland area of the subwatershed, and has a completely modified stream by way of ditching. CD 124 fish community was not assessed, as sampling was limited to a drought in the area. Downstream portions of this system are on a much steeper gradient then the upland headwaters that drain into Birch Coulee. Due to the spatial and geological placement of these streams, the biological stressors vary.

At all locations, altered hydrology was the primary stressor through direct and indirect impacts. Altered hydrology is occurring in two ways; the first is through subsurface tile drainage, and the second is by stream channel alteration by ditching and channelizing; both of these alterations are heavily practiced within CD 124. Alterations in this region are from agricultural practices in attempt to expedite water off the land to optimize growing conditions. Both of these practices result in altered hydrology. As a result, the streams are taking on volumes of water greater than what they are naturally designed to carry. This results in accelerated flow velocity and significantly changes the morphology of the stream. Stream banks erode and streambeds are scoured out or filled in with sediment. Habitat degradation within this watershed directly ties back to altered hydrology. As displayed in the above table, reaches that have been ditched result in poor habitat quality and a lack of habitat diversity.

At County Ditch 124, habitat availability is limiting the macroinvertebrate community. Within this section of stream habitat diversity is limited or eliminated for some groups, such as those who rely on a healthy streambed or pools to thrive. CD 124 also receives direct subsurface tile drainage, creating erratic base flow conditions as well as increased nutrient inputs.

Nitrates were found to be a stressor to the biologic community. Agricultural drainage is likely the primary contributor of excess nitrate within this subwatershed. At the upstream portion of this system, there is a large feedlot that CD 124 cuts through the middle of. The loading contribution of this point source (if any) is unknown at the time of biologic investigation. Nitrate was consistently found to be high, and is fatal to aquatic life depending on concentrations and duration of exposure. Stream sampling at these locations found frequent high levels of nitrate concentrations.

The other nutrient of excess in this stream system is phosphorus. A combination of high phosphorus loading, lack of stream canopy cover, and slow flowing conditions in CD 124 have created extremely eutrophic conditions. With an overproduction of algae growth in the stream, dissolved oxygen drops to dangerous levels at night when algae respiration is at its peak. Low flows within CD 124 are also thought to be contributing to low levels of DO. Total suspended solids were not found to be limiting the biology in this subwatershed based on the chemical analysis during this monitoring cycle, neither in sediment or organic solids such as suspended algae. While algae was a problem within these streams, it appeared the dominant strands were filamentous. Future efforts in limiting phosphorus inputs, stabilizing the flow regime, and restoring the natural canopy of the stream is recommended eliminate these eutrophic conditions.

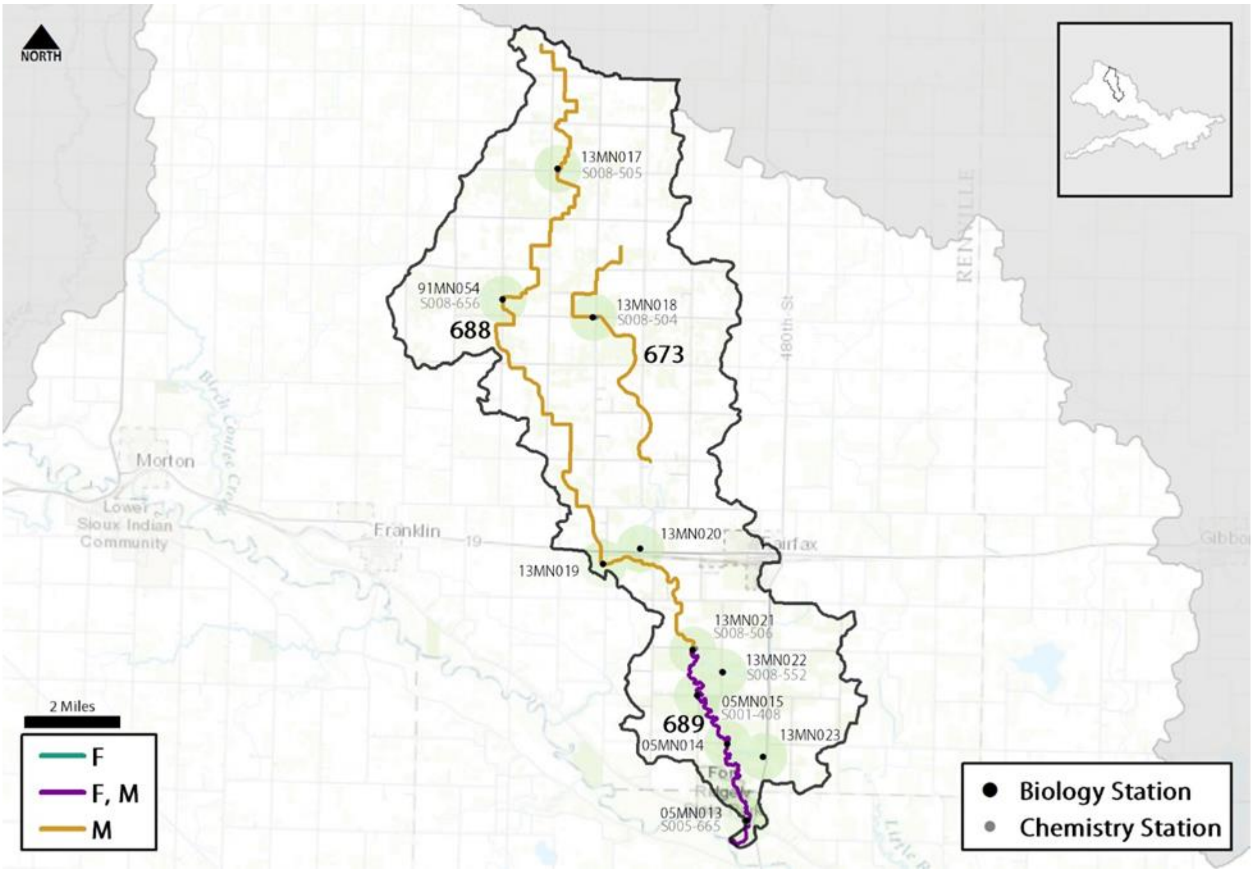
As County Ditch 124 leads into Birch Coulee Creek, water quality and habitat both improve greatly. Habitat diversity and availability is in abundance as the stream takes on a more natural and stable course. Water chemistry is still impacted from the upstream contributions. Nitrates are limiting the community within Birch Coulee Creek. Phosphorus is in excess, but eutrophic conditions are not noted within this reach. This is likely due to the healthy stream cover the limits direct sunlight, and rapid velocity that limits the water from pooling or becoming stagnant.

Connectivity is identified as a stressor as it limits fish migration. It is important to note that the limitation is dependent on the flow conditions. As stated above, this sub watershed’s flow regime is largely dependent to the upstream-altered hydrological responses. Low flow conditions in these systems can occur when ground water recharge to streams is compromised by subsurface tile drainage. This is an area where some of the hardest forms of bedrock are found. There are several areas were outcrops are present within the stream.

Fort Ridgley Creek – MNR Mankato North

This section encompasses biotic impaired reaches in the Fort Ridgley Creek 10 digit HUC. There are three warmwater reaches impaired for biology in this 10 digit HUC. County Ditch 115 is a tributary to Fort Ridgley Creek and impaired for lack of macroinvertebrate assemblage (673). County Ditch 106A is the headwaters reach of Fort Ridgley Creek, and is also impaired for macroinvertebrates (688). The lower reach of Fort Ridgley Creek is impaired for lack of macroinvertebrate assemblage and lack of fish assemblage (689).

Figure 240. Map of the Fort Ridgley Creek Watershed with biological impairments and monitoring stations. Impairments are described as F=Fish, F, M=Fish and Macroinvertebrates, and M=Macroinvertebrates.



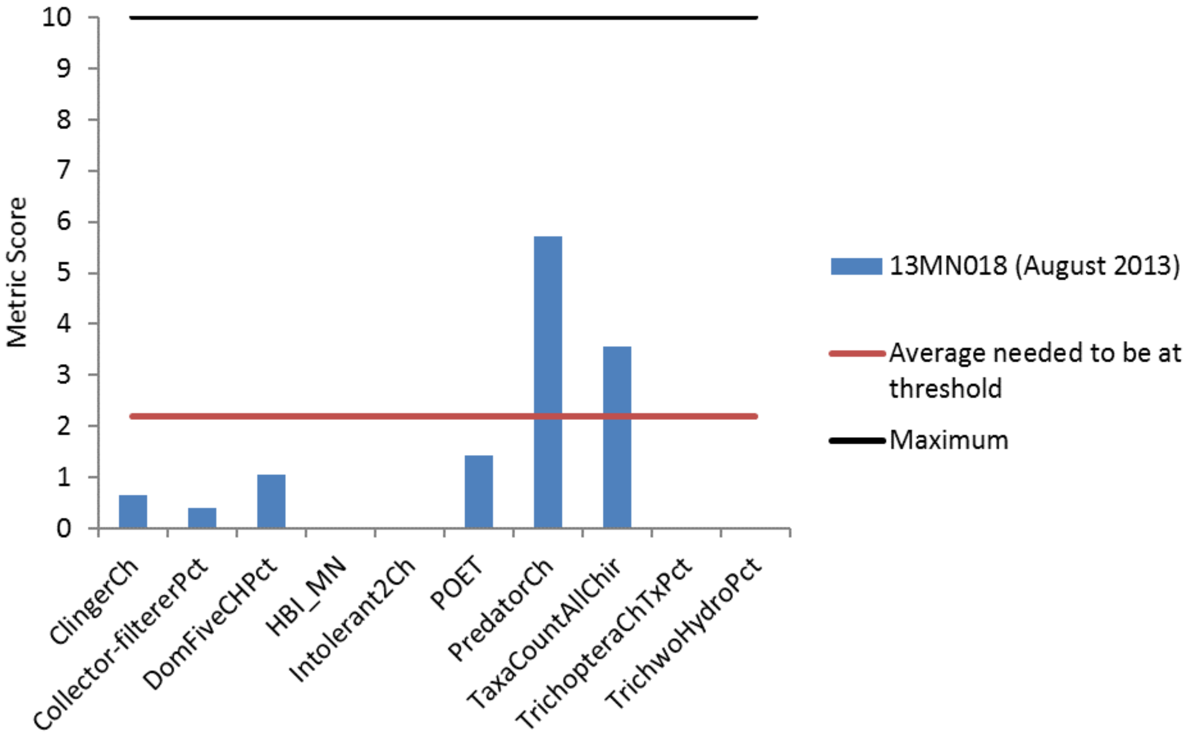
County Ditch 115 (07020007-673)

County Ditch 115 (07020007-673) is a tributary to Fort Ridgley Creek, northwest of Fairfax, Minnesota. The reach is warmwater modified use Class 2B and extends just over seven miles from one unnamed creek to another unnamed creek. County Ditch 115 is impaired for lack of macroinvertebrate assemblage. Station 13MN018 is located upstream of 440th St.

4.26.9 Biological Communities

Station 13MN018 was sampled for fish and macroinvertebrates in 2013. The fish data was not assessable, due to recolonization limited by drought. The macroinvertebrate community scored poorly with 12.8 on the Prairie Streams GP class, with a modified use (MU) threshold of 22. The invertebrate community was dominated by tolerant snails (Physa). Nearly all of the IBI metrics of the Prairie Streams GP class were less than the average needed to be at the threshold, showing a very degraded community (Figure 241).

Figure 241. Macroinvertebrate metrics of the Prairie Streams class IBI for station 13MN018, County Ditch 115.



4.26.10 Data Evaluation for each Candidate Cause

Dissolved Oxygen

There were two dissolved oxygen (DO) measurements on this reach, collected during biological sample on June 20, 2013 and August 19, 2013. Both values were in normal range of 7.33 mg/L and 9.55 mg/L. Four additional DO data points were collected in 2015 and 2016. Five of the six results were normal ranging from 8.04-9.72 mg/L. However, one sample from September 1, 2015, had a very low DO value of 0.43 mg/L. At station 13MN018, an YSI sonde deployment was attempted on August 10, 2015, but due to lack of flow, the data was unable to be collected. This hints that flow is highly variable from year to year, and may be a limiting factor in this reach.

The macroinvertebrate metrics have mixed response to possible low DO stress (Table 240). The low DO index score was very close to the average of similar stations meeting the biocriteria. The Hilsenhoff Biotic Index for Minnesota (HBI_MN) was elevated and there was a lack of low DO intolerant taxa. However, there was a low percentage of low DO tolerant individuals in the sample.

Table 240. Macroinvertebrate metrics that respond to low DO stress in County Ditch 115 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN018 (2013)	**31**	**1**	**9.51**	6.45	**0**	**0**	**13**	23.0
Prairie Streams GP Average	*36.8*	*7.6*	*7.92*	*6.42*	*2.4*	*4.5*	*8.4*	*25.1*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

The macroinvertebrate community shows some potential response to low DO, but the lack of connecting chemical data make it difficult to connect this stressor to the impaired biological condition. More information on DO, specifically continuous measurements, would be helpful in this reach to help confirm this as a potential stressor. DO is considered inconclusive as a stressor.

Eutrophication

During biological sample on June 20, 2013, the phosphorus (TP) concentration was low at 0.028 mg/L. There were four additional samples for TP on this stream taken in 2015 and 2016. One sample from September 1, 2015 had a TP value above 0.150 mg/L, the standard for the southern eutrophication standard. There was one chlorophyll-a sample (18.6 ug/L) also taken on September 1, 2015.

The macroinvertebrate community is suggestive of possible eutrophication stress (Table 241). There were fewer taxa, collector-filterers, EPT, and collector-gatherers than similar Prairie streams. There were no intolerant taxa and a high percentage of tolerant taxa in the sample. While the macroinvertebrates do signal some potential for eutrophication, they could be responding to other stressors as well. Without a lack of connecting chemical data and/or observations to confirm this condition, eutrophication is inconclusive as a stressor.

Table 241. Macroinvertebrate metrics that respond to eutrophication stress in County Ditch 115 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN018 (2013)	**31**	**2**	**9**	**1**	**0**	**96.8**
Prairie Streams Average	*36.8*	*3.9*	*12.8*	*6.5*	*0.1*	*85.4*
Expected response to stress	↓	↓	↓	↓	↓	↑

Nitrate

During the fish sample, the nitrate concentration at 13MN018 was 29 mg/L (June 20, 2013). There were four additional TP samples taken on this reach in 2015 and 2016, ranging from 0.05 mg/L on September 1 2015 to 30 mg/L on June 1, 2016. A sample from May 11, 2016 also was high, at 27 mg/L, in addition to the June 16, 2015 sample that was elevated at 13 mg/L.

The macroinvertebrates in this reach show consistent indication they are stressed by the elevated nitrate concentrations (Table 242). The nitrate index score was 5.3, while the average for modified Prairie Streams meeting impairment threshold is 3.2. This suggests that overall the community present is quite tolerant to high nitrate concentrations. Increasing nitrate concentrations also correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct) and decreased intolerant and Trichoptera taxa, all of which are absent in this reach. Additionally, the number of nitrate tolerant taxa (21) and individuals (94%) are much higher than average. Overall, the chemical and physical data support that nitrate is a stressor to this reach.

Table 242. Macroinvertebrate metrics that respond to nitrate stress in County Ditch 115 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN018	**0**	**0**	**5.3**	**0**	**21.0**	**94.0**
*Prairie Streams Average **(MU)***	*2.6*	*2.4*	*3.2*	*1.1*	*18.0*	*59.7*
Expected response to stress	↓	↓	↑	↓	↑	↑

Total Suspended Solids

During fish sample in 2013, the total suspended solids (TSS) concentration at 13MN018 was low, at 2.4 mg/L. Four Additional samples taken in 2015 and 2016 also showed low values, all 10 mg/L or less. Overall, there is limited TSS information on this reach.

There were a high percentage of TSS tolerant individuals at station 13MN018 (Table 243). Similarly, the TSS index score was elevated indicating a community more adapt to dealing with elevated TSS. The macroinvertebrate community overall indicates plausible stress from elevated TSS, but may be responding to other stressors in the reach as well.

Table 243. Macroinvertebrate metrics that respond to high TSS stress in County Ditch 115 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN018 (2013)	**1.9**	**0**	**18.43**	**0**	**0**	7	**76.1**
Prairie Streams Average	*11.7*	*0.1*	*16.68*	*0.8*	*1.4*	*11.8*	*41.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

TSS is inconclusive as a stressor. Additional information is needed to confirm the chemical conditions of the stream. There is some indication within the biological metrics, particularly noted in the lack of collector-filter individuals. It is difficult to determine if the limitations on the macroinvertebrate community are in relationship to TSS, as there are not any documented exceedances noted out of the few samples that have been collected.

Habitat

The MSHA at station 13MN018 was poor at 32.5. The subcategory metrics are displayed in Figure 242, demonstrating that land use and channel morphology are largely contributing to the poor score. The surrounding land use was row crop. At the time of fish sampling, there was little bank erosion and moderate shade. The riparian width was considered narrow (no wider than 10m). The reach was comprised of 100% run features with sand and silt substrate. There was light embeddedness and less than or equal to four substrate types available. There was moderate cover comprising of overhanging vegetation and macrophytes (submergent and emergent) and seen in Figure 243, below. There was little depth variability, no riffle, poor sinuosity, poor channel development and moderate channel stability.

Figure 242. Percentage of MSHA subcategory scores for station 13MN018, County Ditch 115.

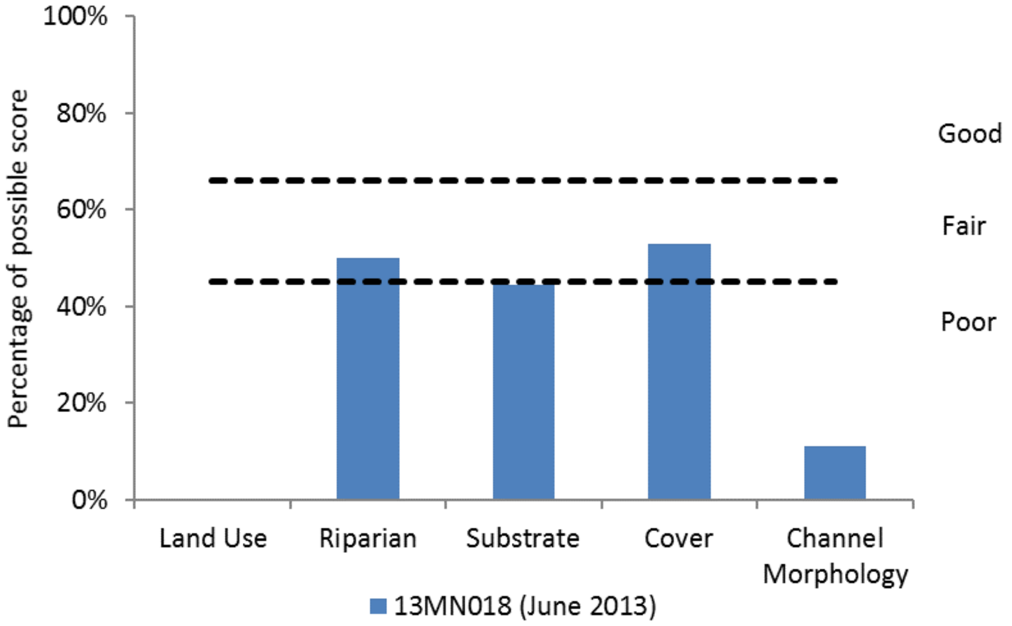
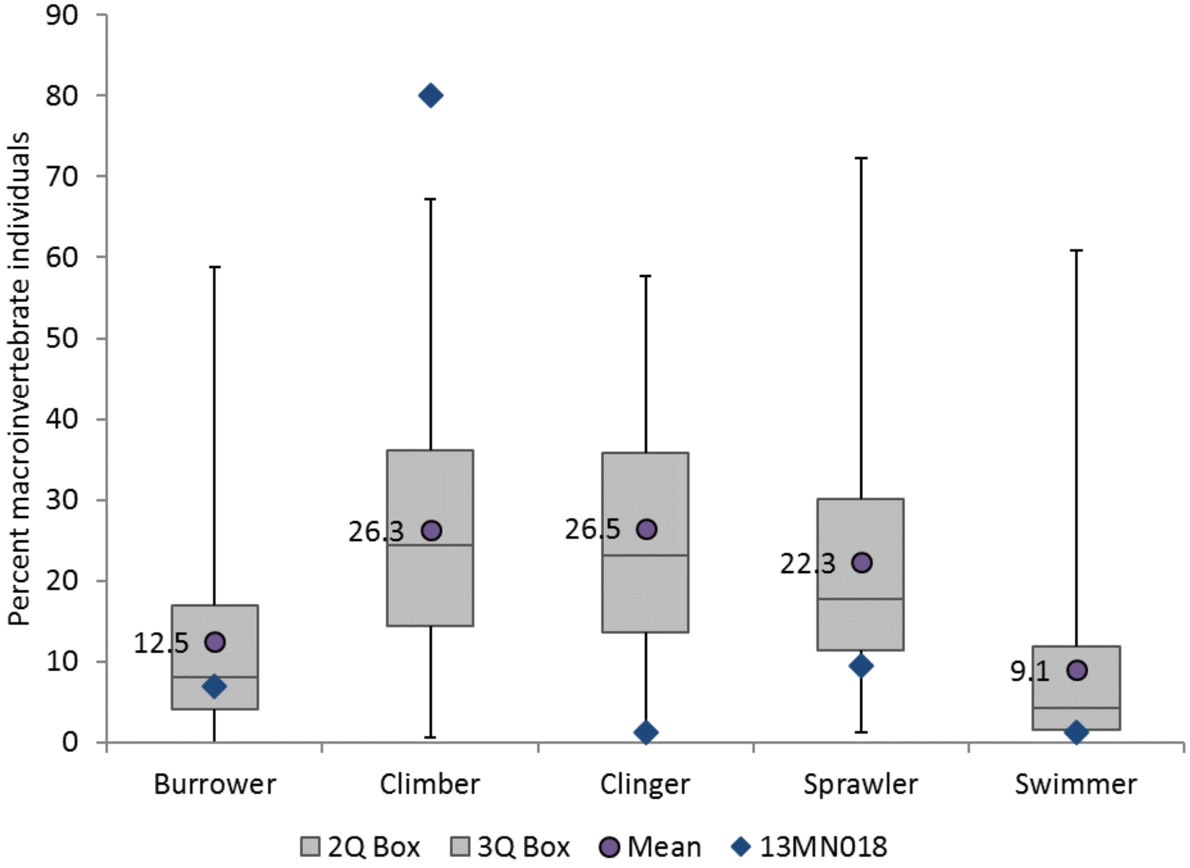


Figure 243. Station 13MN018 displaying habitat conditions on June 20, 2013.

The macroinvertebrate community was sampled on aquatic macrophytes and undercut banks and overhanging vegetation. Over 80% of the macroinvertebrate community was comprised of climbers, which shows an unbalanced community related to potential habitat preferences (Figure 244). There were very few clinger taxa and individuals, which require course substrate or woody debris. The macroinvertebrate community composition in addition to all the physical measurements, and modified use designation all are consistent with stress due to poor habitat conditions and a lack of diverse habitat types.

Figure 244. Macroinvertebrate habit metrics with box plot showing range of values from Prairie Streams stations meeting the modified use biocriteria, mean of those stations, and metric values from station 13MN018.



Habitat is considered a stressor. This is largely due to the homogenous streambed features that limited macroinvertebrate diversity. There is also some disproportionate placement noted within some of the macroinvertebrate habitat groups.

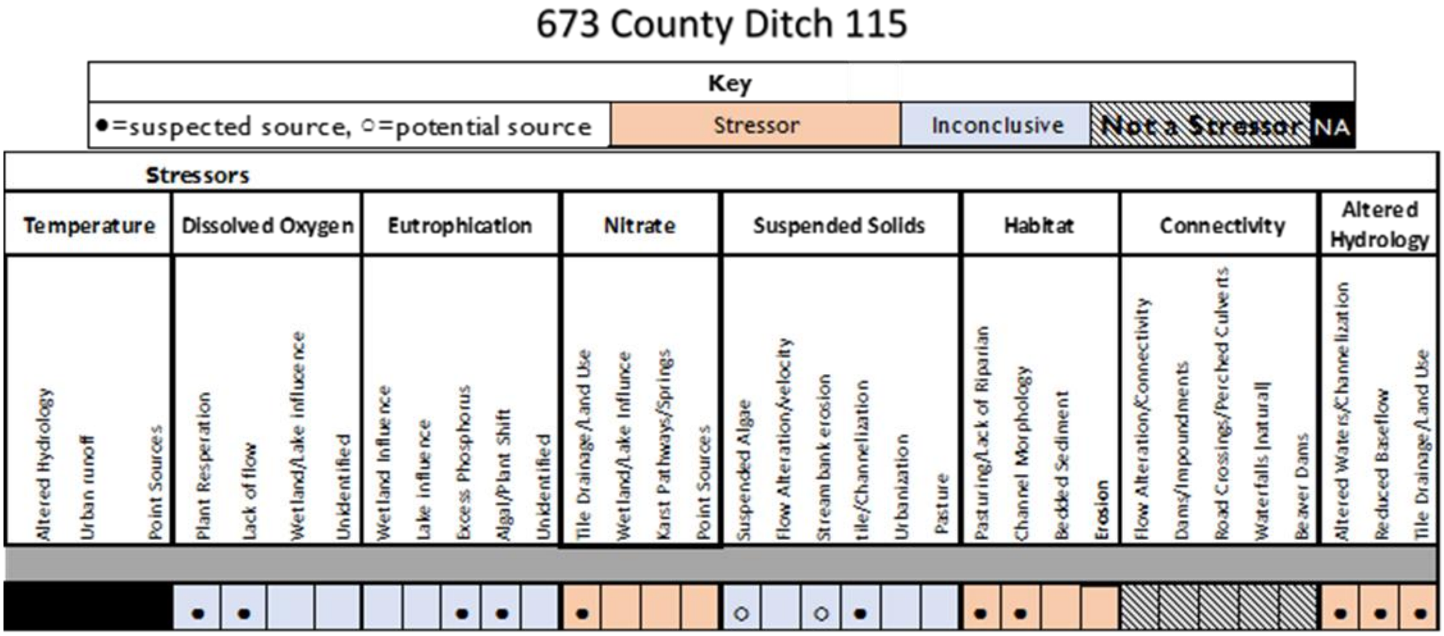
Longitudinal Connectivity and Altered Hydrology

While fish were not assessed within this reach, it is important to note that their presence is likely impacted by a downstream dam that has a six-foot drop. In addition to this barrier, there are not any wetlands or lakes that could provide refuge to the fish population. The DNR has concluded that due to this, it is possible for that in the future there will be less species present in this reach (DNR 2015).

Additional altered hydrology is seen in the impacts of stream channelization and ditching. This subwatershed has the highest percentage of ditched channels when compared to the other subwatersheds of the Minnesota River - Mankato Watershed. Additional to channelized streams, is the introduction of subsurface tile drainage. Both of these hydrologic alterations change the flow regime as well as nutrient inputs. As altered hydrology is the driving force behind the other identified and potential stressors, it is considered the primary stressor. For additional information, see Chapter 3.1.8 of this report.

Summary Table

Table 244. Identified stressors with suspected sources for reach 673 of County Ditch 115.



673 County Ditch 115

Key

●=suspected source, ○=potential source | Stressor | Inconclusive | Not a Stressor | NA

Stressors																																	
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls (natural)	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
			●	●					●	●		●				○		○	●			●	●								●	●	●

County Ditch 106A (Fort Ridgley Creek) (07020007-688)

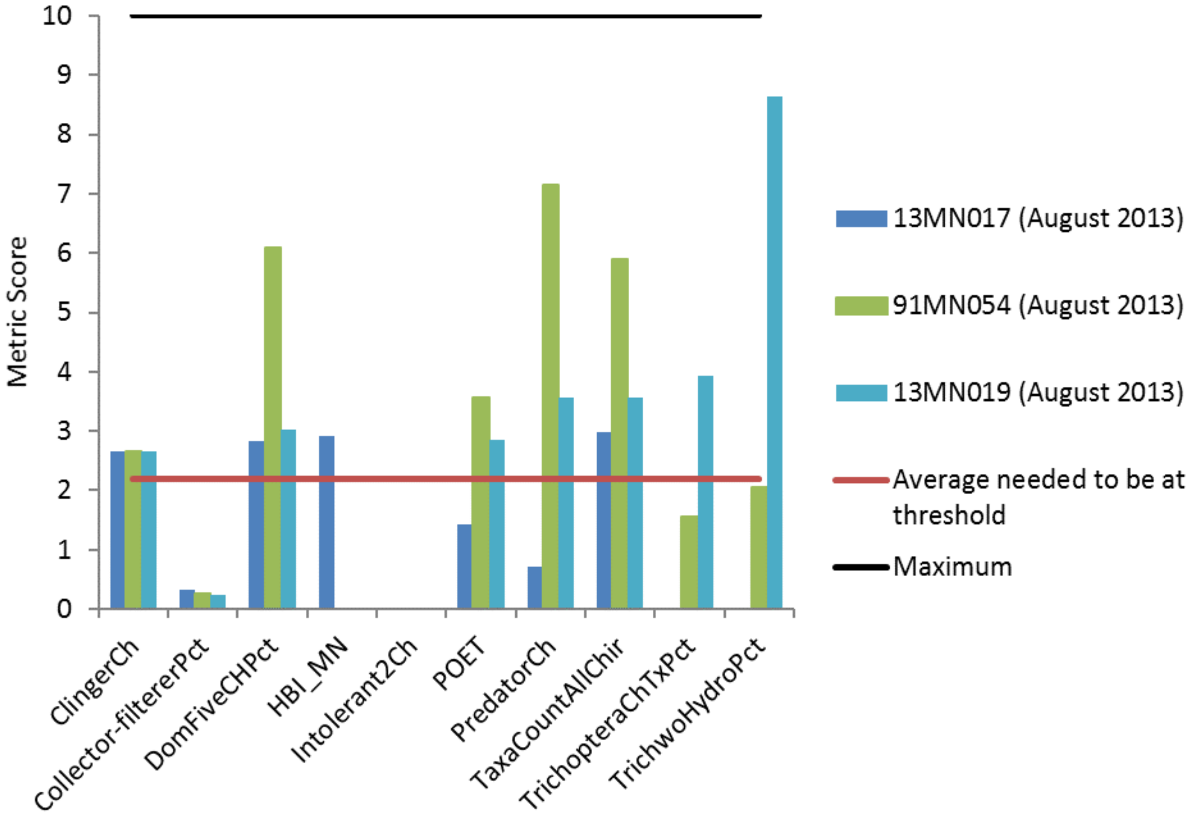
County Ditch 106A (07020007-688) is the start of Fort Ridgley Creek, northwest of Fairfax, Minnesota. The reach is warmwater modified use Class 2B and extends just 20.7 miles from the headwaters to 630th Ave. County Ditch 106A is impaired for lack of macroinvertebrate assemblage. There are three biological stations on this reach, beginning upstream is station 13MN017, then station 91MN054, and furthest downstream on this reach is station 13MN019.

4.26.11 Biological Communities

All three stations were sampled for fish in 2013, but only the visits to stations 13MN017 and 13MN019 were assessable. Both assessable fish visits were above the modified use threshold; 36.6 at station 13MN017 and 47.5 at station 13MN019.

All three stations were sampled for macroinvertebrates in 2013. Station 13MN017 scored 13.9, below the modified use threshold for the Prairie Streams GP class. Stations 91MN054 and 13MN019 scored above the modified use threshold for the Prairie Streams GP class, at 29.2 and 28.5, referenced in Figure 245. Among all stations (Collector-filtererPct) and (Intolerant2Ch) were very low. Station 13MN017 had six of the ten metric scores less than the average score needed to have the IBI at the threshold.

Figure 245. Macroinvertebrate metrics of the Prairie Streams class IBI for stations 13MN017, 91MN054, and 13MN019, County Ditch 106A.



4.26.12 Data Evaluation for each Candidate Cause

Dissolved Oxygen

There were two oxygen measurements at 13MN017, collected during biological sample on August 29 2013 and August 20, 2013. One value from August 29 was very low at 0.57 mg/L (9:00 am), with the other in normal range (6.26 mg/L). At 13MN017, an YSI sonde was attempted to be deployed on August 10, 2015, but due to low/lack of flow, the data was unable to be collected. At station 13MN019 during biological sample the DO level was normal, at 6.87 mg/L. Additional sampling at S008-505 in 2015 and 2016, had three of six measurements less than the DO standard of 5 mg/L. The values ranged from 2.60-6.98 mg/L.

At station, 91MN054 a DO of 20.5 mg/L was collected at noon on August 19, 2013, suggesting the potential for high DO flux and low DO. Therefore, a station 91MN054, an YSI sonde was deployed from July 16 to 23, 2015. Each day the DO was below the 5 mg/L DO standard, with a range of 1.1 to 11.6 mg/L, as seen in Figure 247. The 24-hour DO fluxuation (flux) was also high each day (Figure 246). The flux ranged from 6.4 to 9.8 mg/L with an average of 7.95 mg/L daily flux.

Figure 246. Diurnal dissolved oxygen for station 91MN054, July 16 - 23, 2015.

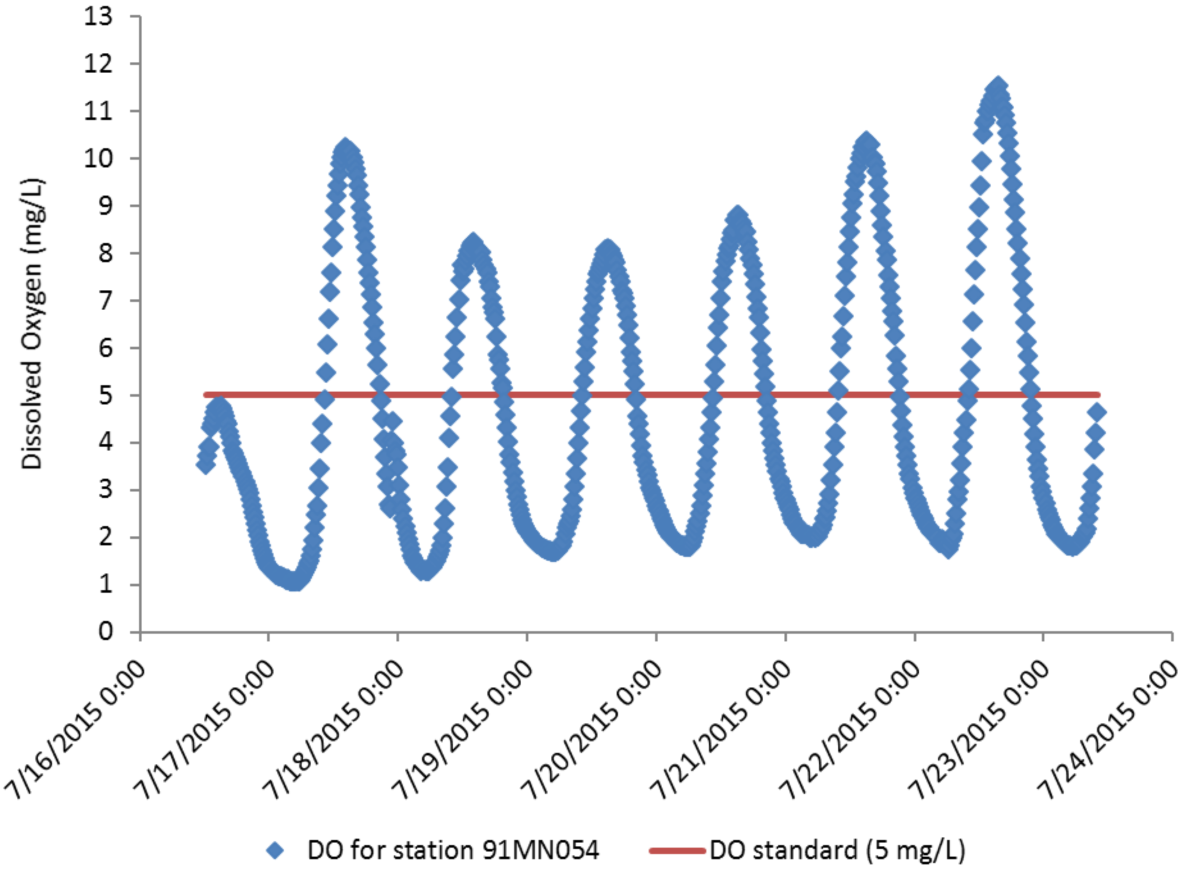
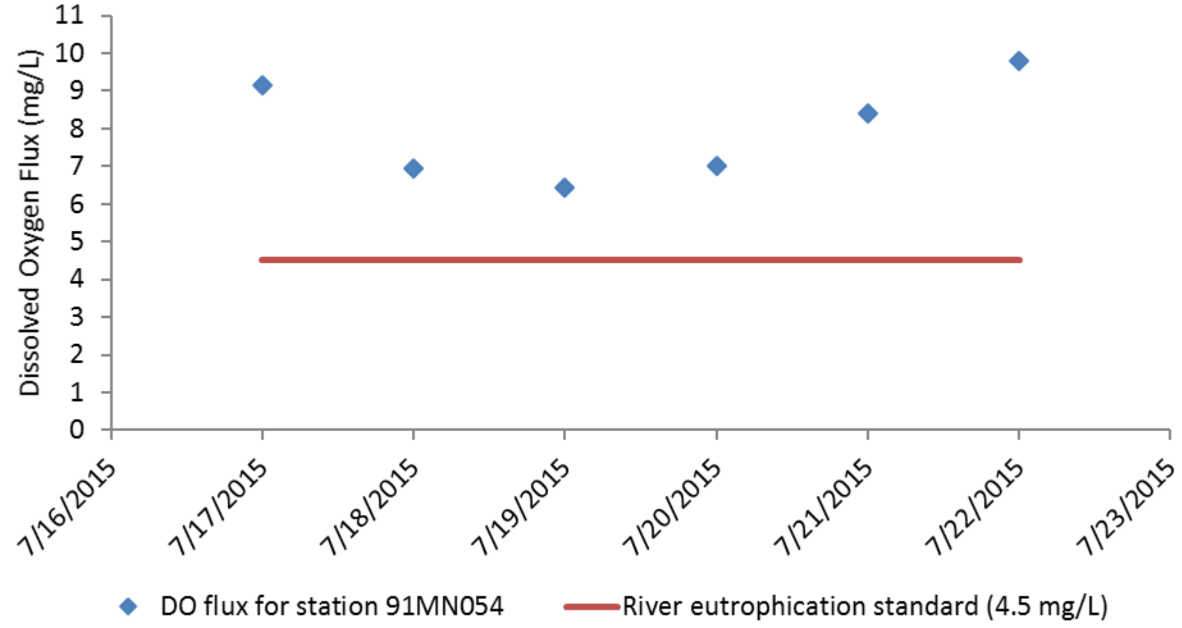


Figure 247. Dissolved oxygen flux at station 91MN054, July 17 - 22, 2015



The macroinvertebrate community in CD 106A was suggestive of low DO stress in 2013 (Table 245). All of the metrics show a response to low DO, with a high percentage of low DO tolerant species, and few intolerant species including EPT. Although all the stations had elevated percentages of low DO tolerant individuals, there was a gradient upstream to downstream, with fewer downstream.

Table 245. Macroinvertebrate metrics that respond to low DO stress in County Ditch 106A compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAll Chir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN017 (2013)	**29**	**2**	**7.98**	**5.56**	**1**	**0.6**	**10**	**64.3**
91MN054 (2013)	**39**	**3**	**8.98**	**6.14**	**0**	**0**	**18**	**41.3**
13MN019 (2013)	**31**	**4**	**9.05**	6.50	**0**	**0**	**12**	**26.9**
Prairie Streams GP Average	*36.8*	*7.6*	*7.92*	*6.42*	*2.4*	*4.5*	*8.4*	*25.1*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Site visits, and photographs (Figure 248) also are reflective of eutrophic conditions that will be discussed within the next section. These conditions often will drive the DO dynamics within a stream, and is thought to be the case within CD 106A.

Figure 248. Station 91MN054, August 19, 2013

Low DO is a biological stressor within County Ditch 106A. The chemistry data displayed a strong line of evidence for low DO. DO was often recorded at levels that would greatly limit the biologic community. The DO data also had significant 24 hour variation that correlates to a eutrophic stream; as photosynthetic protection is at peak time DO would be found extremely high, during respiration DO would almost be depleted from the stream. Additional to the DO flux, documentation of the stream displayed abundant overgrowth of filamentous algae.

Eutrophication

During biological sampling, there were four samples for phosphorus, ranging from 0.015 mg/L to 0.640 mg/L. Two of the four violated the river eutrophication standard for total phosphorus for the southern region (0.150 mg/L). Additional samples collected in 2015 and 2016 at S008-505 showed four of six samples in this reach were above 0.150 mg/L. The maximum concentration collected as 0.901 mg/L. Chlorophyll-a, was limited on this reach to only three samples, including one (38.7 ug/L) that exceeded the southern standard of 35 ug/L.

At station 91MN054, an YSI sonde was deployed from July 16 to 23, 2015. Each day the DO was below the 5 mg/L DO standard, with a range of 1.1 to 11.6 mg/L. The flux was also high each day and ranged from 6.4 to 9.8 mg/L with an average of 7.95 mg/L daily flux (Figure 247). Figure 249 below show the stream condition of algae growth, taken at the end of sonde deployment at 91MN054, on July 23, 2015.

Figure 249. Condition of stream upon sonde retrieval (July 23, 2015).

The macroinvertebrate metrics in CD 106A correspond to eutrophication stress. The collector-filterer and collector-gatherer taxa are low along with an absence of intolerant taxa. The percentage of tolerant taxa was high relative to similar stations meeting the biocriteria (Table 246). The community's at all three stations are dominated by really tolerant taxa, including Physa, which feed on algae, decaying plant matter and detritus. The sonde data, showing high DO flux, and low DO including all the measurements and photos, support that eutrophication is prevalent in this reach and stressing the biological communities.

Table 246. Macroinvertebrate metrics that respond to eutrophication stress in County Ditch 106A compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN017 (2013)	**29**	**3**	14	**2**	**0**	**86.2**
91MN054 (2013)	39	**2**	**12**	**3**	**0**	**92.3**
13MN019 (2013)	**31**	**2**	**10**	**4**	**0**	**96.8**
Prairie Streams GP Average	*36.8*	*3.9*	*12.8*	*6.5*	*0.1*	*85.4*
Expected response to stress	↓	↓	↓	↓	↓	↑

Eutrophication is a biological stressor within this reach. Phosphorus samples displayed high availability for autotrophic growth within this stream. In addition, the DO data demonstrated extreme 24-hour variation that correlates to a eutrophic stream; as photosynthetic protection is at peak time DO would be found extremely high, during respiration DO would almost be depleted from this stream. Additional to high TP and DO flux, there is strong documentation of the streams abundant overgrowth of filamentous algae.

Nitrate

During the biological sample, the nitrate concentration at the stations ranged from 0.05-23 mg/L. There were six additional samples collected on this reach in 2015 and 2016, with an average concentration of 10.39 mg/L and maximum of 24 mg/L. Half of the values were greater than 10 mg/L, all collected in May and June.

The macroinvertebrates in this reach show a mixed response to elevated nitrate concentrations (Table 247). The nitrate index score ranged from 3.1 to 4.3, while the average for modified Prairie Streams meeting impairment threshold is 3.2. The index score, in addition to the percentage of nitrate tolerant individuals indicates a community dominated by nitrate tolerant taxa. Increasing nitrate concentrations also correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct) and decreased intolerant taxa, both which are lacking in all but one visit. Overall, the high chemical concentrations and biological information show nitrate is a stressor to the macroinvertebrates in this reach.

Table 247. Macroinvertebrate metrics that respond to nitrate stress in County Ditch 106A compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN017 (2013)	**0**	**0**	3.1	**0**	17	38.5
13MN019 (2013)	**2**	7.5	**4.4**	**0**	**24**	**76.7**
91MN054 (2013)	**1**	**0.7**	**4.3**	**0**	**23**	**71.4**
*Prairie Streams Average **(MU)***	*2.6*	*2.4*	*3.2*	*1.1*	*18.0*	*59.7*
Expected response to stress	↓	↓	↑	↓	↑	↑

Total Suspended Solids

The total suspended solids (TSS) data during biological sample was available during four visits at two stations in 2013. The TSS values ranged from 3.6-80 mg/L, with only one value exceeding the TSS standard for the southern region of 65 mg/L. Additional data was collected in 2015 and 2016. There were a total of six samples, with only one exceeding the standard (120 mg/L). The remaining samples averaged 7.8 mg/L. Assessing volatile suspended solids to the total suspended solids samples, displayed that organic material (likely suspended algae) make up roughly 40% of what is suspended within this reach. The only water quality sample recorded that was found to exceed the TSS standard was taken on July 23 of 2015. On this same day there was an instantaneous sample of DO sampled that fell at 3.23 mg/L. Prior to this time, DO Flux was in extreme swings, as shown in the sonde data.

The percentage of TSS tolerant macroinvertebrates increased from upstream to downstream. Similarly, the TSS index score had the same gradient. All stations had no TSS intolerant taxa. The macroinvertebrate community is suggestive of possible TSS stress, and more so at the downstream station (Table 248).

Table 248. Macroinvertebrate metrics that respond to high TSS stress in County Ditch 106A compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN017 (2013)	**1.6**	**0**	15.38	**0**	**0**	9	23.0
91MN054 (2013)	**1.3**	**0**	**16.79**	**0**	**0**	**14**	**53.1**
13MN019 (2013)	**1.2**	**0**	**17.82**	**0**	**0**	7	**60.7**
Prairie Streams GP Average	*11.7*	*0.1*	*16.68*	*0.8*	*1.4*	*11.8*	*41.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

TSS is inconclusive. Overall, there is little chemical data to help confirm longitudinal differences in TSS concentration, and to verify the metric responses. Additional data needs to be collected in order to understand these differences, including the impact of algae on suspended material in the water column.

Habitat

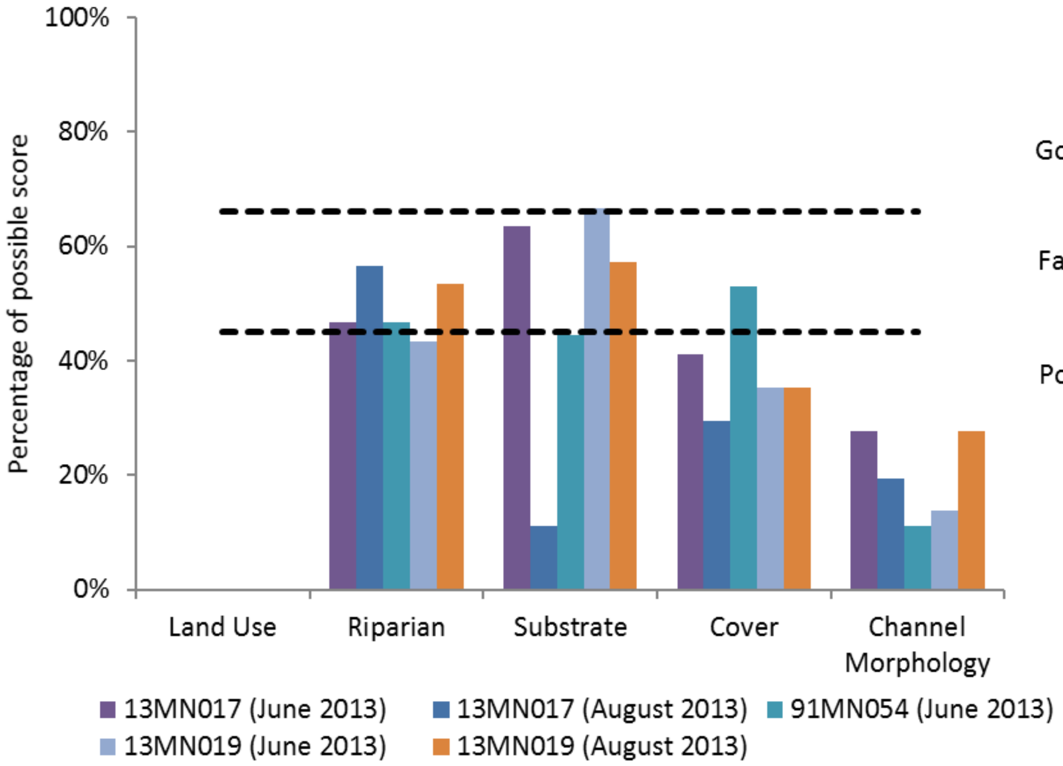
At station 13MN017, the MSHA score was 41.15 in June 2013 and 23.5 in August 2013. Both scores are considered poor. The station is surrounded by row crop, which significantly reduces the MSHA subcategory score for land use (Figure 251). In the 2013 visits, the riparian width was very narrow to narrow, with little to no bank erosion and moderate shade. In June, there was 5% riffle and 5% pool noted in the visit, with some gravel noted in the riffle. The embeddedness was light (25-50%) in June. In August, the only stream feature was run with silt substrate, severe embeddedness. There was moderate depth variability, no riffle in August, poor channel development, poor sinuosity, and moderate channel stability. The stream lacked habitat diversity, as shown in Figure 250.

Figure 250. Station 13MN017, August 29, 2013.

Station 91MN054 also had a poor MSHA score (32). The surrounding land use was row crop. The riparian width was narrow, with little bank erosion, and light shade. The reach was comprised of 100% run feature with sand and silt dominating the substrate. There was light embeddedness, with few substrate types available. There was moderate cover from overhanging vegetation and macrophytes. There was little depth variability. There was also no riffle, poor sinuosity, poor channel development, and moderate channel stability.

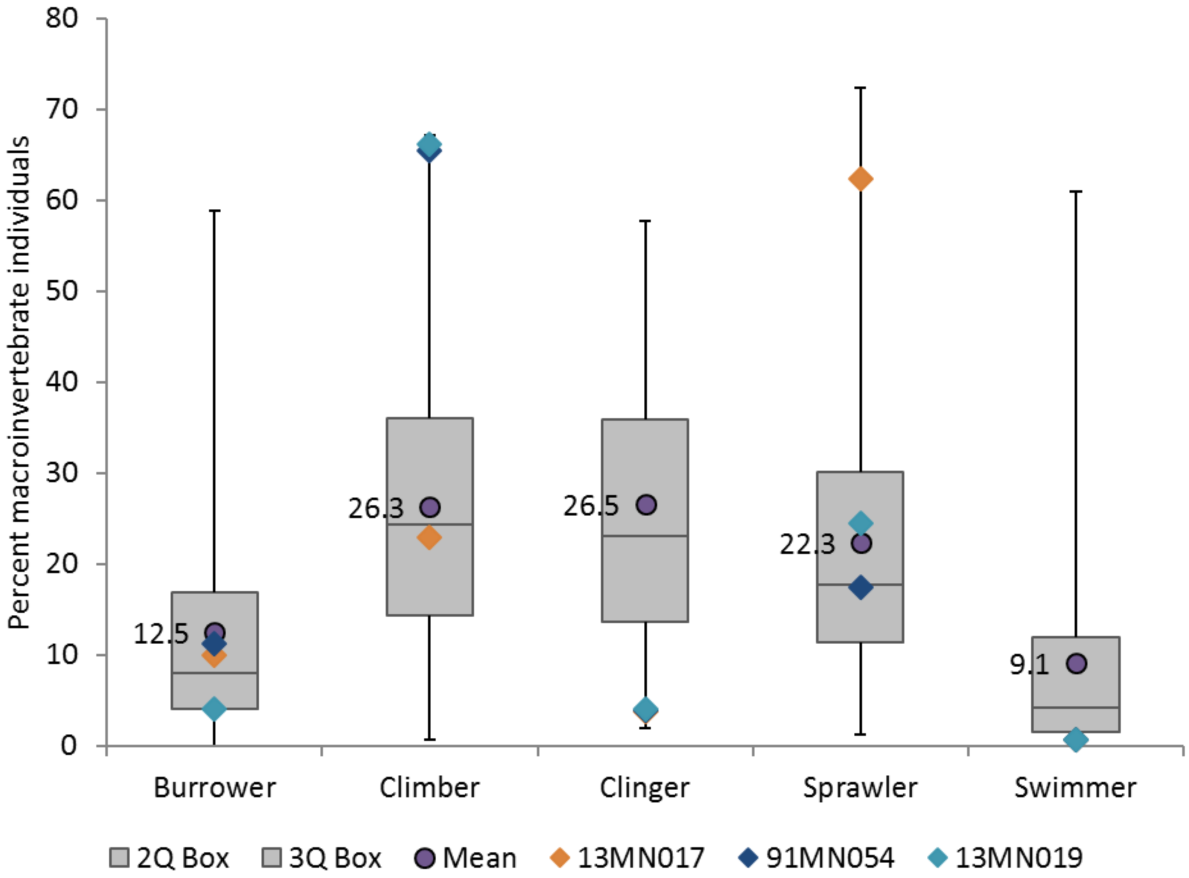
Station 13MN019 scored 35.5 and 39.45 on the MSHA in 2013. Both scores are in the poor category. As with the other stations, the surrounding land use was row crop. The riparian width was very narrow to narrow, with little to no bank erosion, and light shade. The reach was predominantly run, with the August visit noting 5% pool in addition to the run features. Sand and gravel were the predominant substrate in the run features. There was light to moderate embeddedness, with few substrate types available. Cover was sparse (5-25%) with overhanging vegetation, boulders, deep pools, and macrophytes. The depth variability varied between the two visits. There was poor sinuosity, poor channel development, no riffle, and moderate channel stability.

Figure 251. Percentage of MSHA subcategory scores for stations 13MN017, 91MN054, and 13MN019, County Ditch 106A.



At all three stations macroinvertebrates were sampled on undercut banks and overhanging vegetation. As shown in the graph below (Figure 252) Stations 91MN054 and 13MN019 had a large percentage of climbers and station 13MN017 had a large percentage of sprawlers. All three stations had low percentages of macroinvertebrates that cling. There was a moderate number of clinging taxa for the MIBI, but not an abundance. These taxa were likely limited due to a lack of course substrates and woody debris, which are their preferred habitats. Given the lack of various habitat types, homogenous habitat features, and poor riparian area, habitat is considered a stressor to the macroinvertebrate community.

Figure 252. Macroinvertebrate habit metrics with box plot showing range of values from Prairie Streams GP stations meeting the modified use biocriteria, mean of those stations, and metric values from stations 13MN017, 91MN054, and 13MN019.



Habitat is a stressor. There is little diversity seen in available habitat. The limitations on habitat are noted in the skewed macroinvertebrate community.

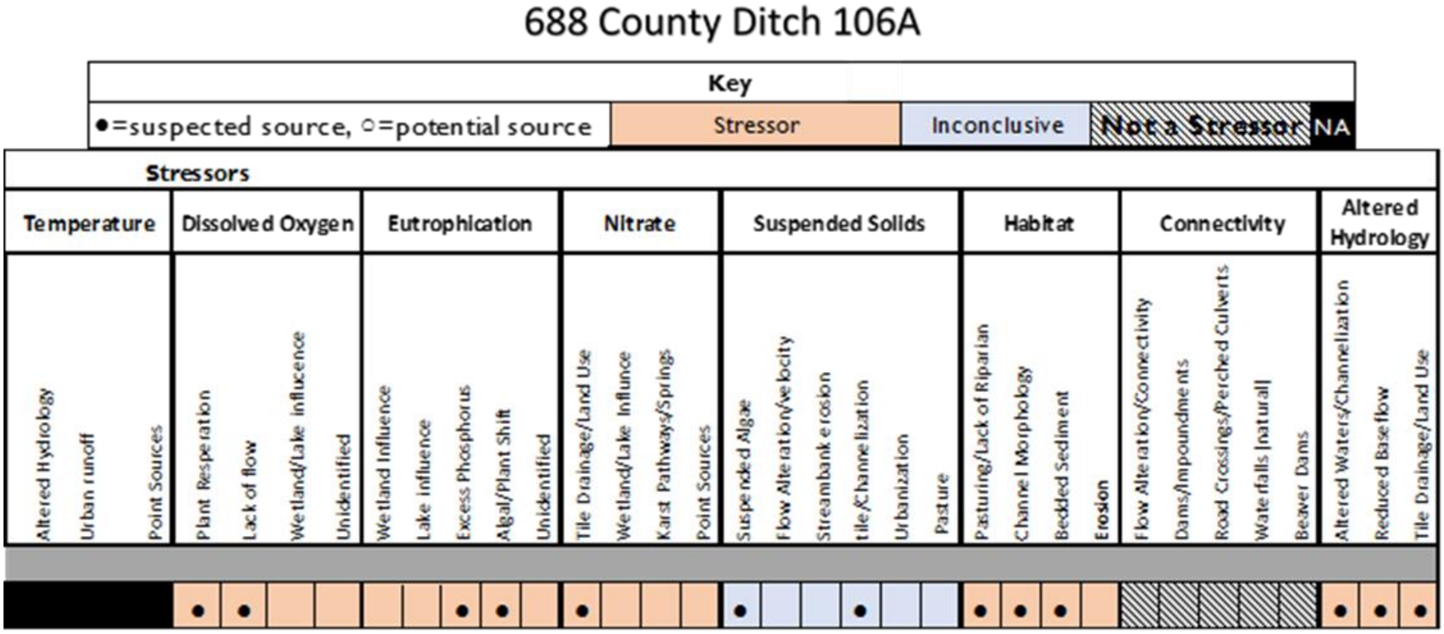
Longitudinal Connectivity and Altered Hydrology

Longitudinal connectivity is not considered to be a stressor within this reach, as the macroinvertebrate community is not typically impaired by downstream barriers.

Altered hydrology is seen in the impacts of stream channelization on ditching. This subwatershed has the highest percentage of ditched channels when compared to the other subwatersheds of the Minnesota River - Mankato Watershed. Additional to this subwatershed's channelized streams, is the introduction of subsurface tile drainage. Both of these hydrologic alterations change the flow regime as well as nutrient inputs. For additional information, see Chapter 3.1.8 of this report. On April 27, 2015 County Ditch 106A underwent a ditch clean out, that is suspected to further change the flow regime.

Fort Ridgley Creek Subwatershed Conclusion

Table 249. Identified stressors with suspected sources for reach 688 of County Ditch 106A.



688 County Ditch 106A

Key

●=suspected source, ○=potential source | Stressor | Inconclusive | ▨ Not a Stressor | ■ NA

Stressors

Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls (natural)	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
■	■	■	●	●					●	●		●				●			●			●	●	●		▨	▨	▨	▨	▨	●	●	●

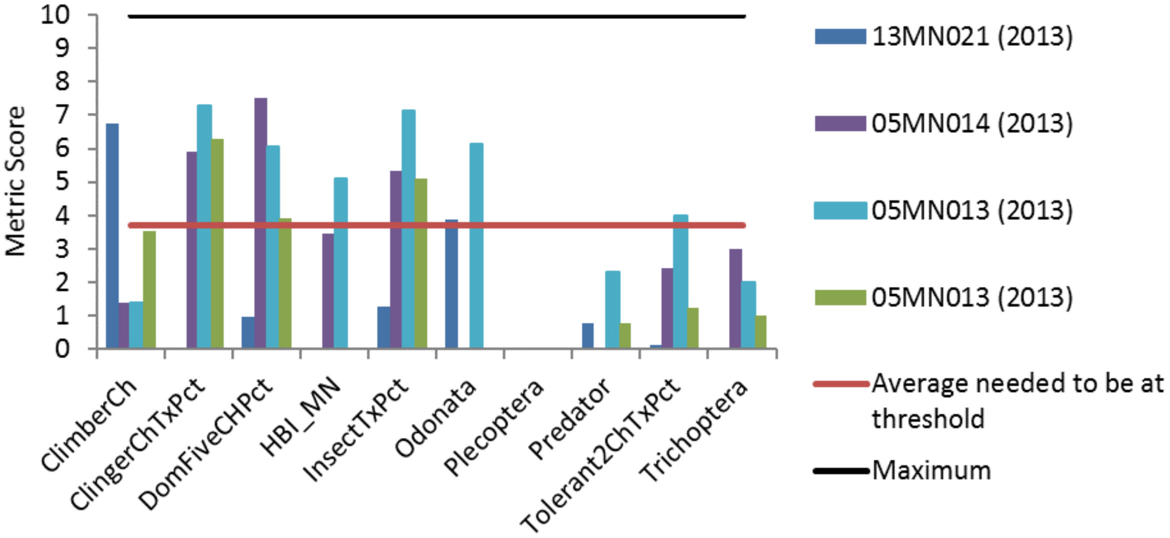
Fort Ridgley Creek (07020007-689)

Fort Ridgley Creek (07020007-689) is a tributary to the Minnesota River, south of Fairfax, Minnesota. It is downstream of County Ditch 106A. The reach is warmwater general use Class 2B and extends just over 7.5 miles from County Ditch 106A. Fort Ridgley Creek is impaired for lack of fish assemblage and lack of macroinvertebrate assemblage. There are four biological stations on this reach, beginning upstream is station 13MN021, followed by stations 05MN015, 05MN014, and 05MN013.

4.26.13 Biological Communities

In 2013, the fish community scored below the threshold (50) for the Southern Streams class in three of four visits to the four stations. Station 05MN015 scored at the threshold. The three downstream stations were sampled in 2005 and scored below the threshold. The majority of fish visits showed a high percentage of tolerant fish species (TolPCt, and TolTxPct), few benthic insectivores (BenInsect-TolTxPct) and sensitive taxa (SensitiveTxPct) as shown in Figure 253.

Figure 253. Fish metrics of the Southern Streams class IBI for stations 13MN021, 05MN015, 05MN014, and 05MN013, Fort Ridgley Creek



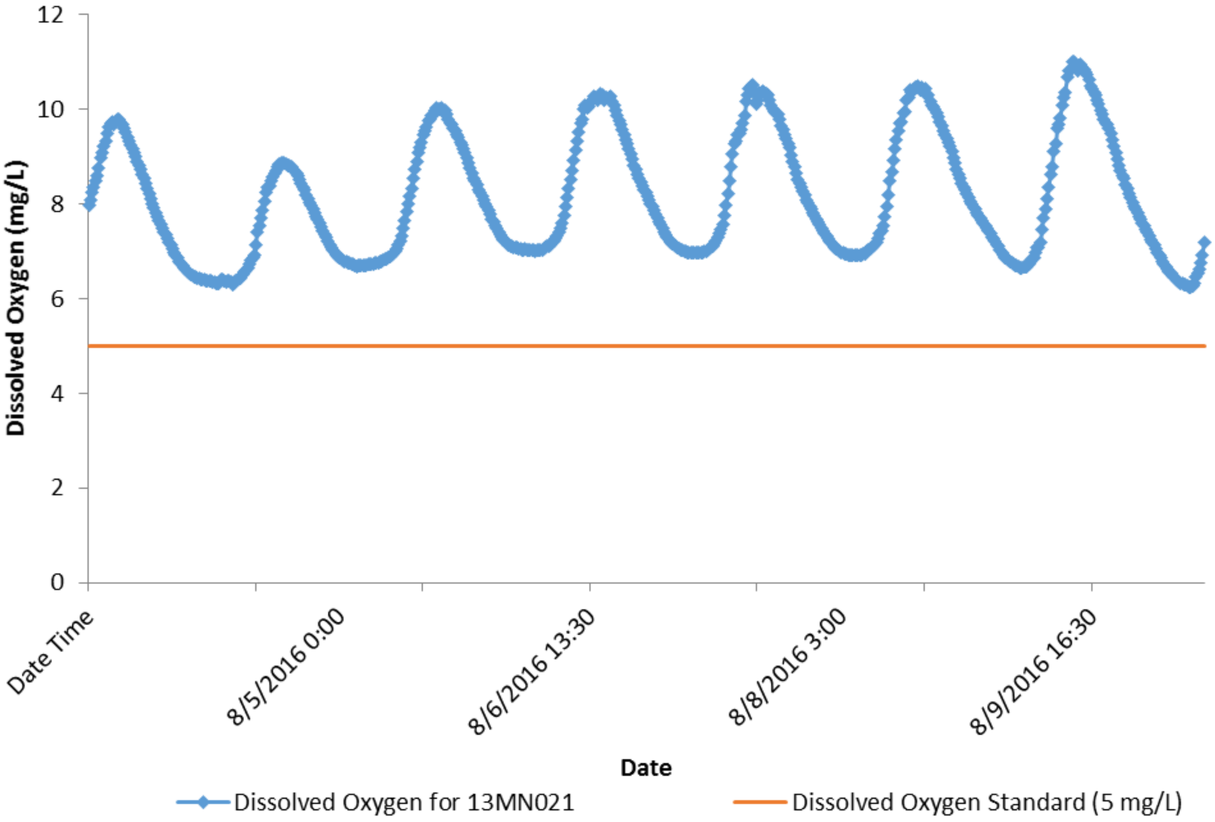
4.26.14 Data Evaluation for each Candidate Cause

Dissolved Oxygen

There were two dissolved oxygen (DO) measurements at the four biological stations, collected during biological sample. They were both in normal range (6.58 and 7.66 mg/L). Additional sampling at S005-665 in 2013 and 2014 had 16 separate DO measurements with an average concentration of 8.3 mg/L. The values ranged from 6.38-14.48 mg/L, none of which violated the low DO standard.

At station 13MN021, an YSI sonde was deployed from August 3 – August 10, 2016. The DO concentrations ranged from 6 to 11 mg/L, with no violations of the dissolved oxygen standard (5 mg/L). The flux was moderate and ranged from 3-4 mg/L each day (Figure 254).

Figure 254. Dissolved oxygen data collected at 13MN021 in 2016.



The macroinvertebrate community shows some potential for low DO stress. The highest percentage of low DO tolerant individuals was at station 13MN021 (Table 250). The station also had the highest Hilsenhoff Biotic Index for Minnesota and the lowest taxa count and EPT taxa. Generally, the taxa counts and EPT taxa were lower than expected, but those can respond to many different stressors, and not just low DO.

Table 250. Macroinvertebrate metrics that respond to low DO stress in Fort Ridgley Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN021 (2013)	**29**	**5**	**9.00**	**6.25**	**0**	**0**	**10**	**32.1**
05MN014 (2013)	**34**	**7**	**7.17**	**6.65**	**3**	**7.8**	**6**	**13.4**
05MN013 (2013)	**33**	**6**	**8.43**	**6.51**	**4**	**19.9**	**7**	4.0
05MN013 (2013)	**36**	**8**	6.61	**6.71**	**1**	**2.9**	**8**	**23.4**
Southern Streams Average	*45.8*	*14.2*	*7.08*	*7.04*	*9.0*	*24.0*	*4.8*	*9.9*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

The fish community metrics have a mixed response to low DO stress (Table 251). The fish community at all visits has few DO tolerant taxa and individuals. The DO index score for all the visits was just above average, not providing strong indication of DO related stress. While there were some DO sensitive fish present at some stations, overall sensitive fish were lacking. There were also few individuals with a female mature age of greater than three years (MA>3Pct). Overall, these metrics do not provide strong indication that the fish community is being impacted by low DO specifically.

Table 251. Fish metrics that respond to low DO stress in Fort Ridgley Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
13MN021 (2013)	**1.32**	**5.26**	**62.37**	7.29	**1**	**0.79**	2	4.74
05MN014 (2013)	**16.50**	**0.51**	**51.52**	7.45	**1**	7.59	2	0.95
05MN014 (2013)	**11.38**	**5.86**	**60.52**	7.48	**1**	12.94	0	0.00
05MN013 (2013)	**3.84**	**1.35**	**81.26**	7.35	**1**	**1.15**	3	0.73
05MN013 (2013)	**8.13**	**0.94**	**50.99**	7.43	**1**	**0.90**	1	0.23
Southern Streams Average	*16.9*	*24.6*	*44.9*	*7.20*	*1.71*	*5.94*	*4.69*	*18.54*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is inconclusive as a stressor. Chemistry data does not indicate a chronic issue, as there were not any low DO measurements. However, there is some indication that low DO is limiting the biology of this reach. Additional DO monitoring is needed to fully rule this parameter out.

Eutrophication

Phosphorus samples were collected in 2009, 2010, 2013, and 2014. The 30 samples ranged from 0.019 to 1.329 mg/L. All but two samples meet the river eutrophication standard set for the southern region, 0.150 mg/L. The two elevated phosphorus samples also had elevated TSS. In this case, the two elevated phosphorus sampled likely tied back to increased flows and phosphorus bound to sediment. There is no chlorophyll-a data or BOD data available for analysis.

At station 13MN021, an YSI sonde was deployed from August 3 – August 10, 2016. The DO concentrations ranged from 6 to 11 mg/L, with no violations of the dissolved oxygen standard (5 mg/L). The flux was moderate and ranged from 3-4 mg/L each day (Figure 286). This information does not provide any strong indication of eutrophication happening at this station.

The macroinvertebrate community had some suggestion of eutrophication stress (Table 252). There was a lack of collector-filterers, and intolerant taxa with a high percentage of tolerant taxa.

Table 252. Macroinvertebrate metrics that respond to eutrophication stress in Fort Ridgley Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN021 (2013)	**29**	**2**	**11**	**5**	**0**	**93.1**
05MN014 (2013)	**34**	**4**	**14**	**7**	**0**	**82.4**
05MN013 (2013)	**36**	**6**	16	**7**	**0**	**75.0**
05MN013 (2013)	**33**	**5**	**11**	**5**	**0**	**87.9**
Southern Streams Average	*45.8*	*7.3*	*15.9*	*12.2*	*0.8*	*72.6*
Expected response to stress	↓	↓	↓	↓	↓	↑

The fish community also had suggestions of eutrophication stress (Table 253). There was some variation in metric response, some near the average of similar stations meeting the biocriteria, although most were worse than the average. There were an elevated percentage of tolerant individuals and no intolerant individuals. However, there were a high percentage of simple lithophilic spawners at four of the five visits.

Table 253. Fish metrics that respond to eutrophication stress in Fort Ridgley Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
13MN021 (2013)	**1.3**	**7.9**	49.2	**62.4**	**12**	**0**
05MN014 (2005)	**11.4**	**10.8**	49.9	**60.5**	**13**	**0**
05MN014 (2013)	**16.5**	15.7	45.9	**51.5**	**11**	**0**
05MN013 (2005)	**8.1**	**4.2**	53.9	**51.0**	**14**	**0**
05MN013 (2013)	**3.8**	**2.9**	**28.7**	**81.3**	**13**	**0**
Southern Streams Average	*16.9*	*11.9*	*37.0*	*44.9*	*19.3*	*4.2*
Expected response to stress	↓	↓	↓	↑	↓	↓

Figure 255. Biomonitoring station 05MN014 taken on July 17, 2013.

There does not appear to be a huge risk of eutrophication occurring here. Most of the samples taken did not indicate a chronic overgrowth in this stream, nor did site recon (Figure 255). The biology had a mixed result in displaying indications of impairment by eutrophic conditions, therefor the biological communities at these sites could be responding to a different stressor. However, this parameter will remain inconclusive as there was a lack of secondary data (such as chlorophyll-a) to ensure this is not a dynamic that is occurring in this stream segment.

Nitrate

Nitrate data in this reach ranged 0.64 – 27 mg/L from 32 samples collected in 2009, 2010, 2013, 2014 and 2015. The average of the data was 8.4 mg/L and had a median of 7.7 mg/L. Twelve of the thirty-two values were greater than 10 mg/L, and one greater than 20 mg/L.

The macroinvertebrates in this reach showed a mixed response to elevated nitrate concentrations (Table 254). The nitrate index score ranged from 2.8 to 4.1, while the average for Southern Streams meeting impairment threshold is 2.9. The index score, in addition to the percentage of nitrate tolerant individuals indicates a community dominated by nitrate tolerant taxa at most visits. Increasing nitrate concentrations also correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct) and decreased intolerant taxa, both which are lacking in this reach, with the exception of 05MN014, which had 10.5% non-hydropsychid Trichoptera. Despite this, the index score and nitrate tolerant percent/taxa were higher than average, demonstrating a nitrate tolerant macroinvertebrate community overall.

Table 254. Macroinvertebrate metrics that respond to nitrate stress in Fort Ridgley Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN021 (2013)	**1**	**0.6**	**4.1**	**0**	18	**77.4**
05MN014 (2013)	**5**	10.5	**3.0**	**0**	**21**	**64.3**
05MN013 (2013)	**4**	**3.7**	2.8	**0**	**19**	**52.8**
05MN013 (2013)	**3**	**5.2**	**3.8**	**0**	**20**	**80.2**
Southern Streams Average	*6.3*	*5.5*	*2.9*	*2.4*	*18.8*	*47.2*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is a stressor within this reach. The chemistry data displayed that this reach will have frequent and high concentrations of nitrate. The macroinvertebrate community is also suggestive if nitrate impacts, as a majority of the population is made up of nitrate tolerant individuals.

Total Suspended Solids

Total Suspended Solids (TSS) ranged from 2 mg/L to 248 mg/L, from 31 samples collected in 2009, 2010, 2013, and 2014. Only two of the samples were elevated above the 65 mg/L standard. Transparency data was collected from 1999-2010 and 2012-2015. Out of the 570 measurements of transparency, only 21 were below the 10 cm surrogate standard (3.6%).

The macroinvertebrate community had mixed response to potential TSS stress (Table 255). There was a mix of percentages of TSS tolerant individuals. There were low amounts of TSS intolerant individuals throughout, but high percentage of collector-filterers at two of the visits. Overall, the macroinvertebrate community does not strongly indicate TSS is a stressor.

Table 255. Macroinvertebrate metrics that respond to high TSS stress in Fort Ridgley Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN021 (2013)	**1.6**	**0**	**17.10**	**0**	**0**	12	**55.2**
05MN014 (2013)	32.0	**0**	13.44	**1**	**2.5**	9	26.1
05MN013 (2013)	34.7	**0**	12.81	**0**	**0**	12	21.9
05MN013 (2013)	**19.5**	**0**	**17.11**	**0**	**0**	9	**47.7**
Southern Streams Average	*25.4*	*0.7*	*15.63*	*2.9*	*4.7*	*12.2*	*34.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

The fish community was slightly more suggestive of TSS stress according to the metrics used in the TSS standard (Table 256), although there were a few exceptions. The Minnesota derived TSS index scores for this reach were all below (better) than that of similar stations meeting the biocriteria. There was a complete lack of TSS intolerant taxa and low numbers of TSS tolerant taxa and individuals (Table 257), indicating there were more in moderate tolerance than in either of the extremes.

Table 256. Fish metrics that respond to high TSS stress in Fort Ridgley Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
13MN021 (2013)	**26.6**	**0**	**19.2**	**0**	**0**	**7.9**	**20.0**	**1.3**	49.2
05MN014 (2005)	**27.1**	**0**	**20.1**	**0**	**0**	**10.8**	**27.7**	**11.4**	**5.9**
05MN014 (2013)	**29.4**	**0**	**17.3**	**0**	**0**	**15.7**	**30.2**	**16.5**	**0.5**
05MN013 (2005)	**10.7**	**0**	**13.6**	**0**	**0**	**4.2**	**14.7**	**8.1**	**0.9**
05MN013 (2013)	49.9	**0.2**	49.9	**0**	**0.2**	**3.2**	50.8	**3.8**	**1.4**
Southern Streams Average	*36.0*	*5.4*	*25.7*	*4.2*	*13.6*	*20.1*	*30.2*	*16.9*	*19.1*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 257. Fish metrics that respond to high TSS stress in Fort Ridgley Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN021 (2013)	14.4	**0**	**0**	0	0
05MN014 (2005)	14.3	**0**	**0**	1	1.9
05MN014 (2013)	15.0	**0**	**0**	1	5.8
05MN013 (2005)	14.5	**0**	**0**	1	5.4
05MN013 (2013)	16.6	**0**	**0**	2	10.8
Southern Streams Average	*19.2*	*1.7*	*5.3*	*2.4*	*12.5*
Expected response to stress	↑	↓	↓	↑	↑

There was a good amount of chemical data, showing TSS or transparency measurements are acceptable in this reach. The macroinvertebrate community and fish community showed mixed responses that can be attributed to other stressors. Elevated suspended sediment is not a stressor in this reach to either macroinvertebrates or fish community.

Habitat

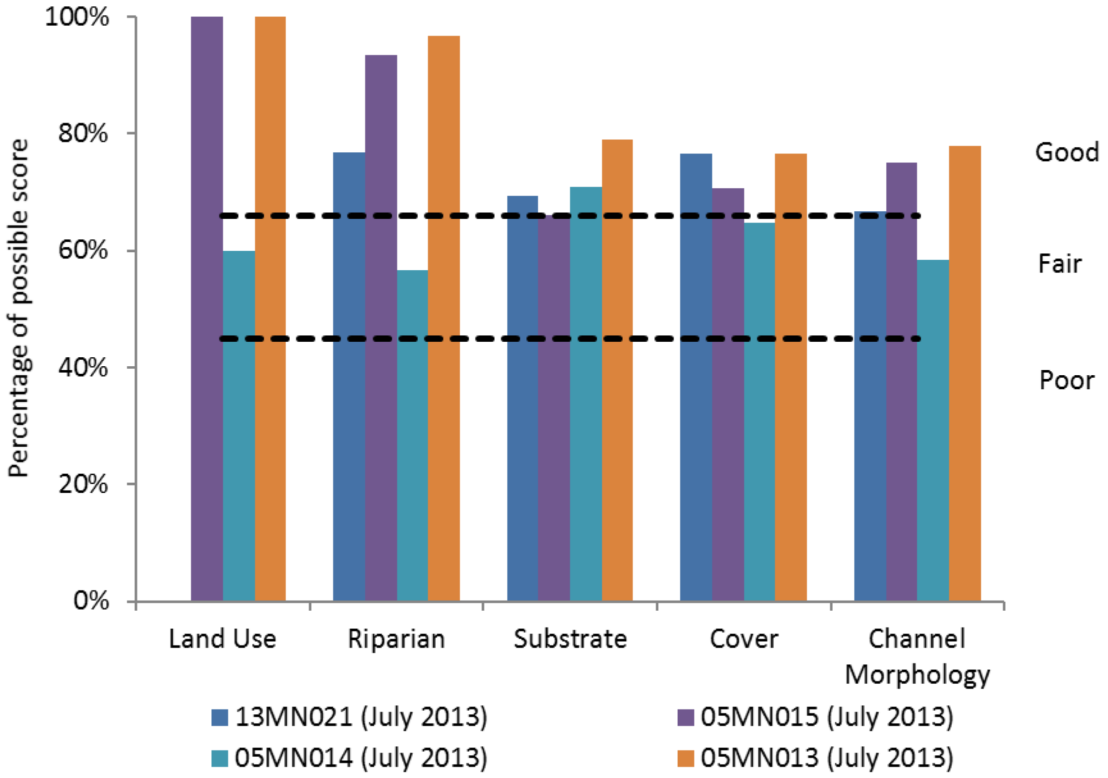
The five main categories evaluated for the MSHA score were fair to good during all visits, as reflected in Figure 288. Station 13MN021 had a good MSHA score (67.2) and was surrounded by row crop. The riparian zone was wide to extensive, with heavy shade, but moderate to heavy bank erosion. The stream features in the reach were 15% pool, 20% riffle, and 65% run. There were substrates of sand, gravel, cobble, and boulder present. There was moderate embeddedness present in 2013. Additionally, there was moderate cover available, comprised of undercut banks, overhanging vegetation, deep pools, logs or woody debris, boulders, and rootwads. There was good depth variability, with good sinuosity and good channel development.

MSHA was good (75.8) at station 05MN015 in 2013 and the surrounding land use was forest, wetland, prairie, or shrub. The riparian width was extensive with heavy shade and little bank erosion. The stream features in the reach were 40% pool, 25% riffle, and 35% run. There were greater than four substrate types ranging from silt to boulders in the pools and riffles. There was moderate embeddedness. There was also moderate cover available in 2013 with overhanging vegetation, deep pools, logs or woody debris, boulders, and rootwads. There was good depth variability, good sinuosity, good channel development, and moderate-high channel stability. Overall, this station exhibited good habitat availability.

Station 05MN014 had a fair MSHA score of 62.6. The surrounding land use was a mix of row crop, residential/park, and forest, wetland, prairie, or shrub. The riparian width was wide to extensive with moderate shade. The right bank had little erosion, but the left bank had severe erosion. Riffle and run features each comprised of 45% of the reach and the pool features were 10% of the reach. Boulders and sand were common in the pools, cobble and gravel in the riffles, and gravel and sand in the runs. There was light embeddedness in 2013. There was also moderate cover (25-50%), with overhanging vegetation, deep pools, logs and woody debris, and boulders. Station 05MN014 had good depth variability, fair sinuosity, good channel development, and moderate stability.

Station 05MN013 had a good MSHA score in 2013 (81.8). At station 05MN013, the surrounding land use was forest, wetland, prairie, or shrub, with an extensive riparian width. There was little to no bank erosion and heavy shade. The reach was comprised of 50% riffle features, 35% run, and 15% pool. There was boulder, cobble, gravel, and sand substrates, ensuring sufficient diversity in substrates. There was light embeddedness present. Cover was considered moderate with undercut banks, over hanging vegetation, deep pools, woody debris, boulders, and root wads. There was good depth variability through the reach. Sinuosity was good, as was the channel development, with moderate-high channel stability.

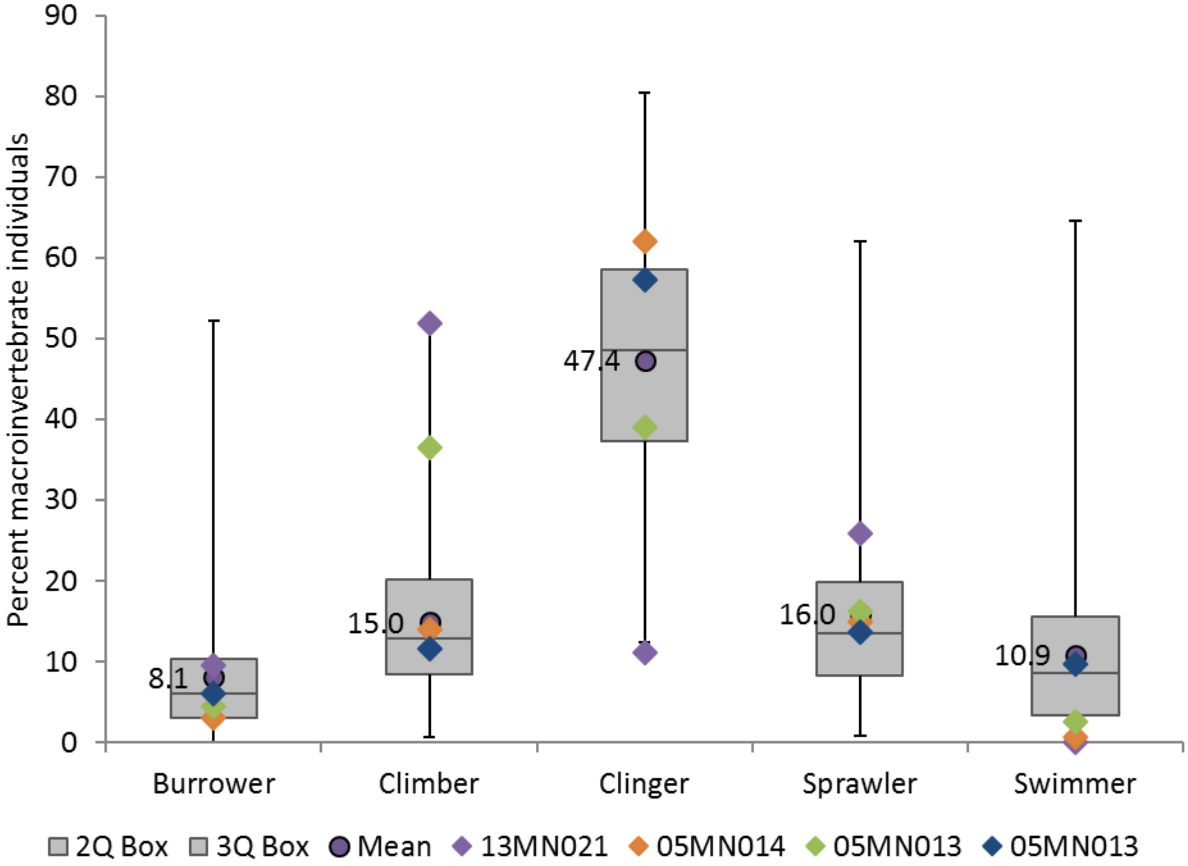
Figure 256. Percentage of MSHA subcategory scores for stations 13MN021, 05MN015, 05MN014, and 05MN013, Fort Ridgley Creek



The fish community metrics give a mixed response related to habitat stress (Table 256) noted from the above TSS section fish metrics. Benthic insectivores (BenFdFrimPct) were mixed among stations, with 05MN013 (2013) having the highest percentage overall. Similarly, riffle dwelling species (RifflePct) were higher than average at this station, but lower than average at the other stations. Simple lithophilic spawners (SLithFrimPct) were fewer than average at all stations except 13MN021.

The macroinvertebrate metrics were variable depending on stations (Figure 257). Station 13MN021 had the greatest variation from similar stations meeting the biocriteria. There were a high percentage of climbers, low percentage of clingers, and slightly elevated percentage of sprawlers. In the MIBI metrics, station 13MN021 had a relative lack of clinging taxa, whereas the other three visits were lacking in climber taxa. Stations 13MN021 and 05MN014 sampled on rock in riffles or runs, and snags, woody debris, or root wads. Station 05MN013 was sampled on rock in riffles or runs, undercut banks and overhanging vegetation, and snags, woody debris, or root wads.

Figure 257. Macroinvertebrate habit metrics with box plot showing range of values from Southern Streams stations meeting the general use biocriteria mean of those stations, and metric values from stations 13MN021, 05MN014, and 05MN013.



It is difficult to say if the macroinvertebrate community is responding to habitat stress, or if it is being solely influenced by upstream communities coming into this reach. The community sampled in 13MN021 displayed the strongest signals of habitat stress. It is important to note that this monitoring station is at the upper most end of this reach, where it is met by the end of a severely channelized ditch system. Due to the mix, response in both the fish and macroinvertebrate community's habitat is considered as an inconclusive stressor.

Longitudinal Connectivity and Altered Hydrology

There is a dam located between stations 05MN014 and 05MN015 on Fort Ridgley Creek. The approximate drop is 6 feet. For more information on the barrier, please see DNR's Minnesota River, Mankato Watershed Characterization Report (2015). The dam has a potential to limit upstream fish species richness. However, the fish species list is not significantly different between the immediate upstream and downstream stations within this AUID (Table 258). Despite the presence of the dam, there is not a difference shortly upstream and downstream of the dam within the fish community. Therefore, connectivity is not a direct stressor at this time. The dam may still be causing instability to the community since it is a barrier. However, it is likely migration of fish species is occurring at times of high flow by way of overtopping the dam, or by way of an undetected side tributary (Figure 258).

Figure 258. Arial image taken from Google Earth, displaying 6 ft. dam and potential connectivity during low flow conditions.

Table 258. Fish species by station in Fort Ridgley Creek (07020007-689) Migratory fish species are highlighted in bold.

	13MN021	05MN015	05MN015	dam	05MN014	05MN014	05MN013	05MN013
	2013	2005	2013		2005	2013	2005	2013
bigmouth shiner	x	x	x		x	x	x	x
blacknose dace	x	x	x		x	x	x	x
bluntnose minnow	x		x		x	x	x	x
brassy minnow		x					x	
brook stickleback	x	x						
brown trout		x						
central stoneroller	x	x	x		x	x	x	x
common shiner	x	x	x		x	x	x	x
creek chub	x	x	x		x	x	x	x
fantail darter	x	x	x		x	x	x	x
fathead minnow	x	x			x		x	
green sunfish					x		x	
hornyhead chub	x	x	x		x	x	x	x
johnny darter	x	x	x		x	x	x	x
largemouth bass								x
sand shiner		x			x	x	x	x
spotfin shiner								x
white sucker	x	x	x		x	x	x	x

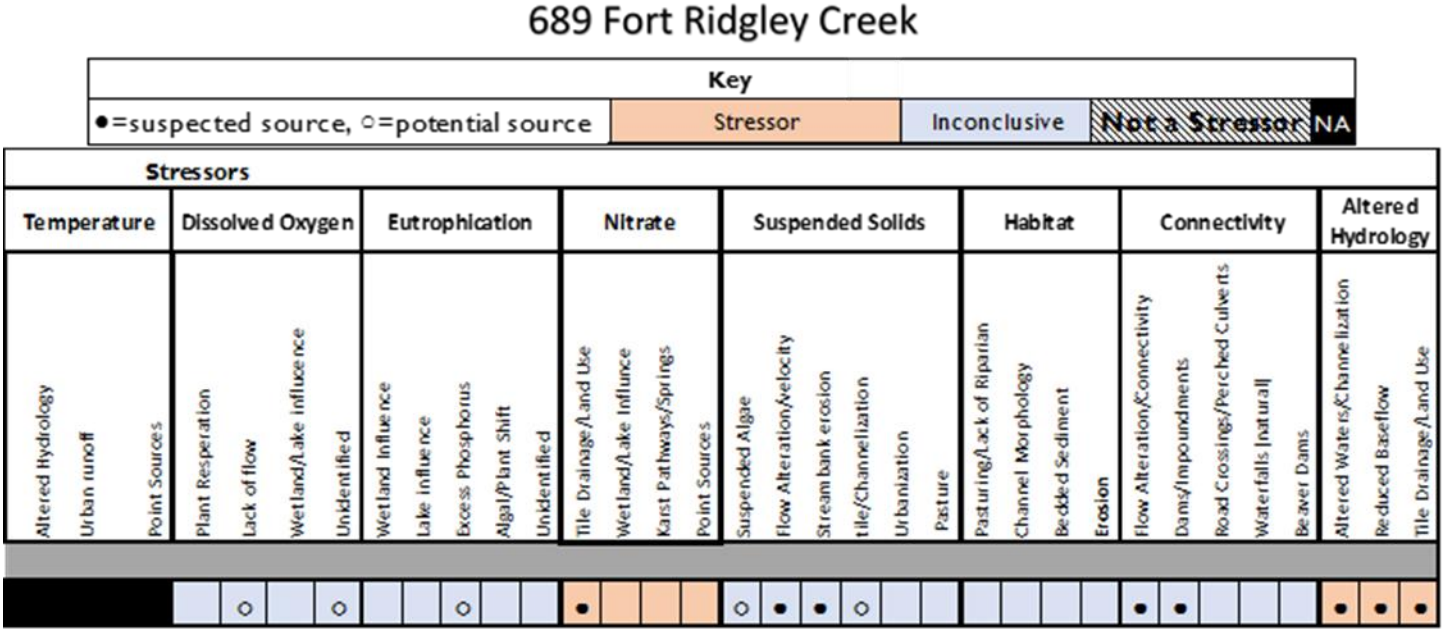
Aside from the dam, this reach has been recorded as going dry, as seen in Figure 259. Additional monitoring is recommended to better understand the hydrologic connectivity of this stream. It is possible the dry periods could be a result of the altered system that drains into this stretch of stream.

Figure 259. Site recon at station 13MN021 on September 14, 2012.

Altered hydrology is seen in the impacts of stream channelization on ditching. This subwatershed has the highest percentage of ditched channels when compared to the other subwatersheds of the Minnesota River - Mankato Watershed. Additional to this subwatershed's channelized streams, is the introduction of subsurface tile drainage is also prevalent. Both of these hydrologic alterations change the flow regime as well as nutrient inputs. For additional information, see Chapter 3.1.8 of this report. On April 27, 2015 County Ditch 106A underwent a ditch clean out, that is suspected to further change the flow regime.

Summary Table

Table 259. Identified stressors with suspected sources for reach 689 of Fort Ridgley Creek.



689 Fort Ridgley Creek

Key

●=suspected source, ○=potential source | Stressor | Inconclusive | Not a Stressor | NA

Stressors																																	
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Stream bank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
■				○		○			○			●				○	●	●	○							●	●				●	●	●

Fort Ridgley Subwatershed Conclusion

There are three warmwater reaches impaired for biology in the Fort Ridgley Creek Subwatershed. County Ditch 115 (- 673) was assessed as a modified warmwater stream and is a tributary to Fort Ridgley Creek, impaired for lack of macroinvertebrate assemblage. The fish community was not assessed due to drought. County Ditch 106A (-688) was assessed as a modified warmwater stream is the headwaters reach of Fort Ridgley Creek, and is also impaired for macroinvertebrates. The lower reach of Fort Ridgley Creek (-689) was assessed as a general warmwater stream, impaired for lack of macroinvertebrate assemblage and lack of fish assemblage.

Fort Ridgley Creek's Subwatershed has the highest percentage of ditched channels when compared to the entire Minnesota River Watershed, with an average of 99% of the streams modified by way of ditching and channelizing. At all locations, altered hydrology was the primary stressor through direct or indirect impacts. Altered hydrology is occurring two ways within this subwatershed. The first is through subsurface tile drainage and the second is stream channel alteration (ditching). Alterations in this region are from agricultural practices in attempt to expedite water off the land to optimize growing conditions. Both of these practices initiate altered hydrology in the system. The streams are taking on volumes of water greater than what they are naturally designed to carry. This results in accelerated flow velocity and significantly changes the morphology of the stream at the receiving location as well as downstream areas. One of the direct biological stressors that is associated with altered hydrology is seen in loss of habitat. Within the modified upland streams, there is a complete lack of diversity that is greatly limiting the biological communities that depend on a healthy streambed as well as deep pools to thrive. Habitat improves as the gradient increases. This stream system transitions from flat upland agricultural areas and down cuts through the valley as Fort Ridgley Creek converges with the Minnesota River. Because of the steep gradient of the lower section, the surrounding land of these streams is primarily characterized as forest and prairie. These downstream areas take on a more natural course and the strong riparian vegetation helps mitigate the upstream increased velocities that pulse through the system. While there is a significant increase in habitat diversity within these downstream section, it is important to highlight that the upland areas are still greatly influencing water chemistry and base flow.

Nitrate was a common biological stressor within this area, as concentrations were consistently found at high levels throughout this subwatershed. The macroinvertebrate community also was reflective of nitrate stress. It is likely that the high stream loading of nitrates is the product of subsurface tile drainage.

There were high levels of phosphorus throughout the watersheds. The only segment that resulted in eutrophic conditions was located in the upland areas of this subwatershed that lies in an agricultural dominant area. Typically, in these areas stream canopy cover will be limited, allowing for an overabundance of sunlight. This paired with a heavy input of phosphorus and a slow stream velocity (from lack of gradient), will create optimal conditions for algal growth to occur. Other sites lacked data to confirm if eutrophication was taking place and therefore are inconclusive.

Dissolved oxygen (DO) within this system is questionable, particularly in the upland modified portions of the watershed. One site showed a clear biological response and well as chemical data the low DO levels are limiting the biology, this is primarily due to the eutrophic conditions and excess algae production. Eutrophic conditions are closely associated with low dissolved oxygen levels, due to plant/algae respiration that depletes the stream of oxygen. Two locations were listed as inconclusive for eutrophication and low DO due to a lack of data or mixed results between chemistry and the biological response.

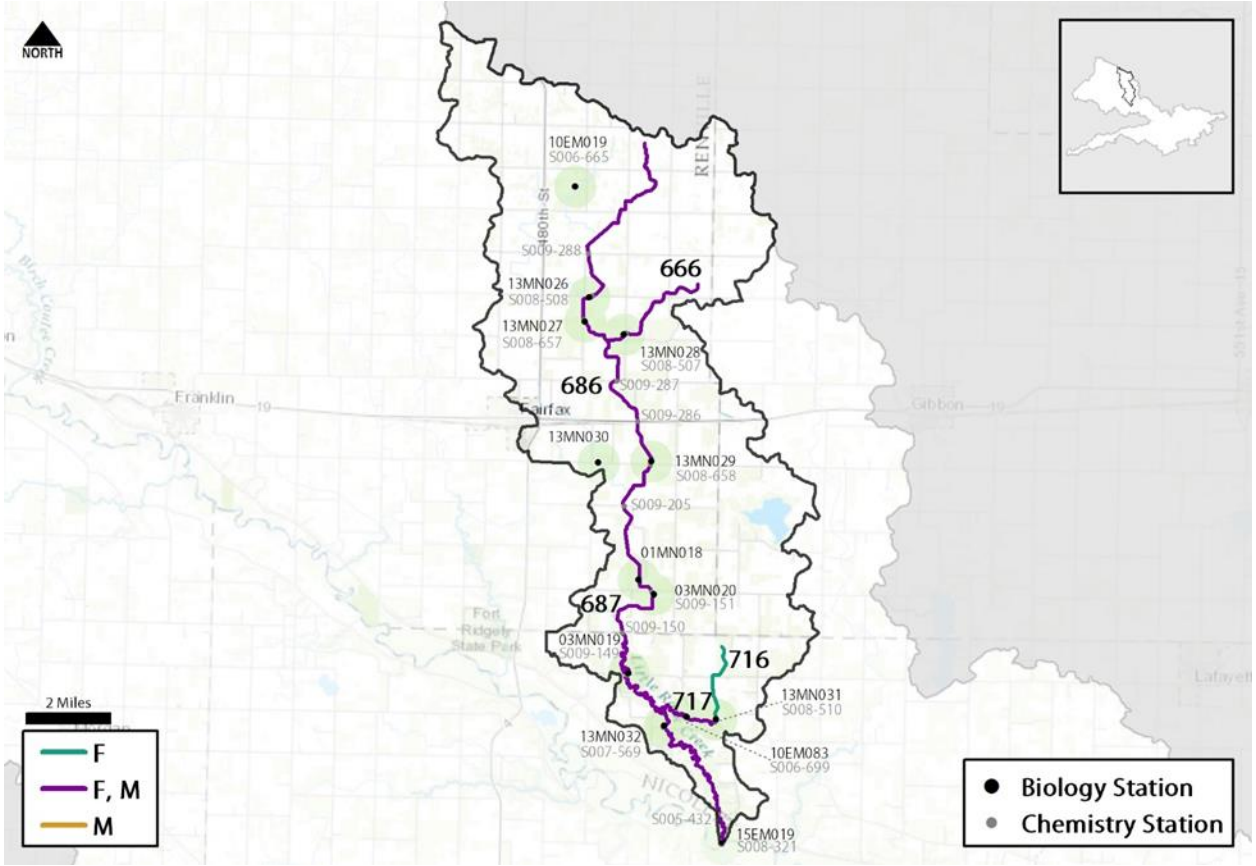
Total suspended solids (TSS) data was sparse within this subwatershed, although the biological community did show a response to being limited by TSS. What was available for analysis did indicate that suspended solids were made up largely of organic matter, with upstream eutrophic conditions as the source. Sediment is also contributing to the TSS load from accelerated erosion that ties back to altered hydrology.

There are several connectivity issues; one of the most prominent is seen in reduced base flows correlated to altered hydrology. This was a clear limitation for biological communities and migration ability for fish, particularly following a drought season. Additional information during a normal precipitation year would be helpful to fully understand the limits in longitudinal hydrological connectivity. The other potential barrier within this system is located on Fort Ridgley Creek, where there a 6ft dam. There were a few possible side tributaries that may allow fish migration around this barrier that are dependent on high flow.

Little Rock Creek – MNR Mankato North

This section encompasses biotic impaired reaches in the Little Rock Creek 10 digit HUC. There are five warmwater reaches impaired for biology in this 10 digit HUC. All five streams are impaired for fish. Macroinvertebrates are impaired on all except Judicial Ditch 13 (716).

Figure 260. Map of the Little Rock Creek Watershed with biological impairments and monitoring stations. Impairments are described as F=Fish, F, M=Fish and Macroinvertebrates, and M=Macroinvertebrates.



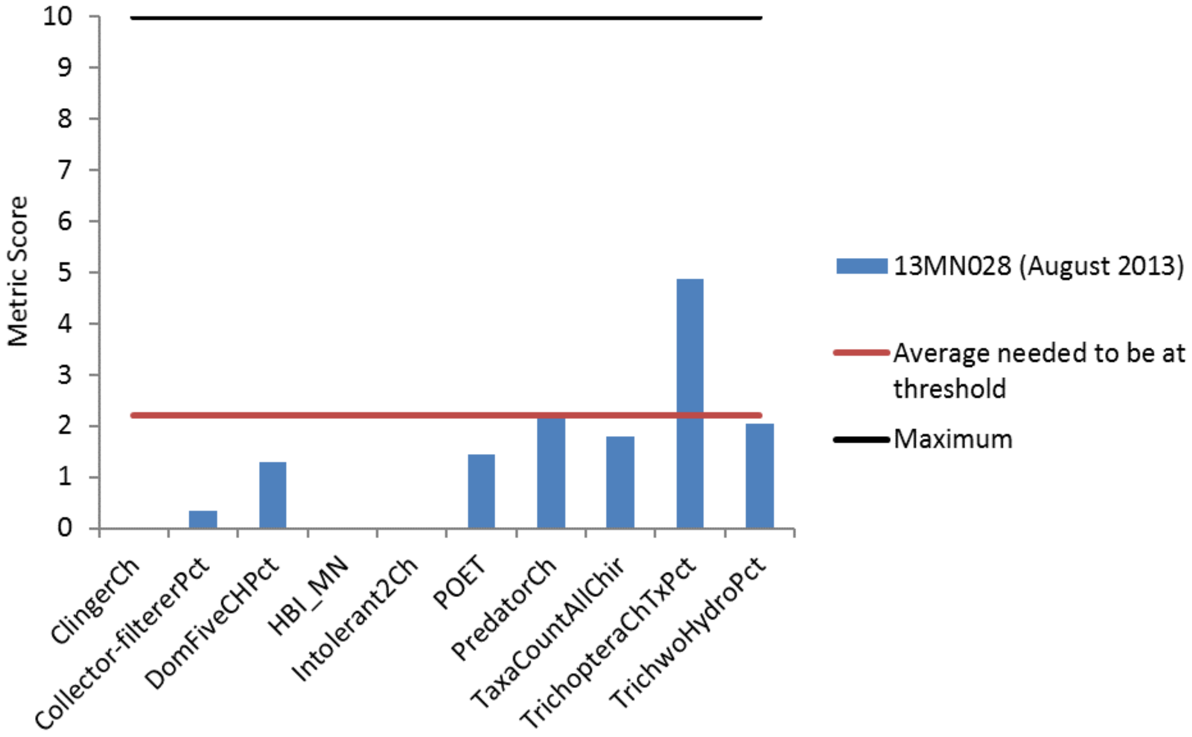
Judicial Ditch 8 (07020007-666)

Judicial Ditch 8 (07020007-666) is a tributary to Little Rock Creek, northeast of Fairfax, Minnesota. The reach is warmwater modified use Class 2B. The three-mile reach starts at an unnamed creek and goes until the confluence with JD 31. JD 8 is impaired for lack of fish assemblage and lack of macroinvertebrate assemblage. There is one biological station on this reach, station 13MN028.

4.26.15 Biological Communities

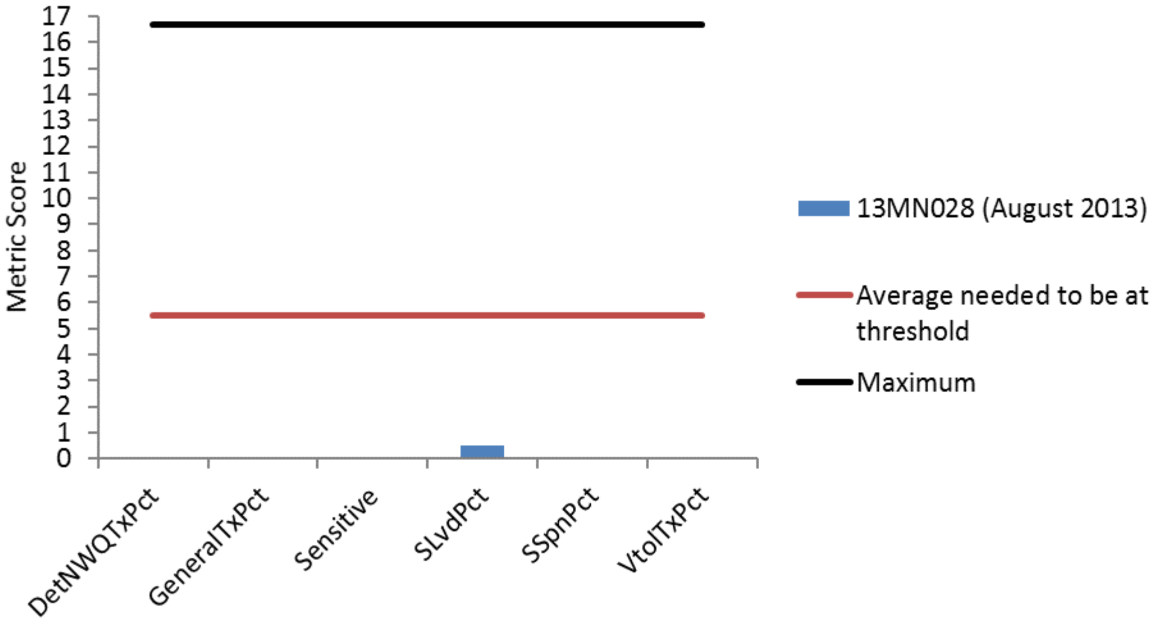
There was one macroinvertebrate visit from station 13MN028 sampled in 2013. The sample scored 13.9, which is below impairment threshold. Overall, the few taxa present represented a wetland-like community with low diversity and was dominated by tolerant taxa. Almost all of the metrics scored below the average needed to meet the impairment threshold, with the exception of Trichoptera (TrichopteraChTxPct) which only comprised a handful of the sample individuals and were still generally lacking (Figure 261). The majority of macroinvertebrates collected were snails, midges, and worms, indicating a very degraded community.

Figure 261. Macroinvertebrate metrics of the Prairie Streams class IBI for station 13MN028, Judicial Ditch 8.



There was fish samples from two visits, and one station in 2013 (13MN028). One of the visits there were no fish collected (June 2013) therefore the sample was repeated in August of 2013. The result of that sample was IBI score was one, which is well below impairment threshold. The community was almost entirely comprised of fathead minnows. This results in a very low score and metric scores across the board. (Figure 262).

Figure 262. Fish metrics of the Southern Headwaters class IBI for station 13MN028, Judicial Ditch 8.



4.26.16 Data Evaluation for each Candidate Cause

Dissolved Oxygen

During biological sample at 13MN028, the dissolved oxygen (DO) values ranged from 7.38 on June 20, 2013 to 14.91 mg/L on August 20, 2013. Five additional DO values collected at S008-507 in 2015 and 2016, and all were meeting the DO standard, with a range from 6.10-8.79 mg/L.

In 2015, an YSI sonde was deployed at station 13MN028 from July 23 to 30. The DO ranged from 1.62 to 12.62 mg/L. With violations of the DO standard (5 mg/L) each day (Figure 263). In addition, there was consistent elevated DO flux, ranging from 8.41 to 10.57 mg/L, and averaging 9.60 mg/L (Figure 264).

Figure 263. Diurnal dissolved oxygen for station 13MN028, July 23 - 30, 2015.

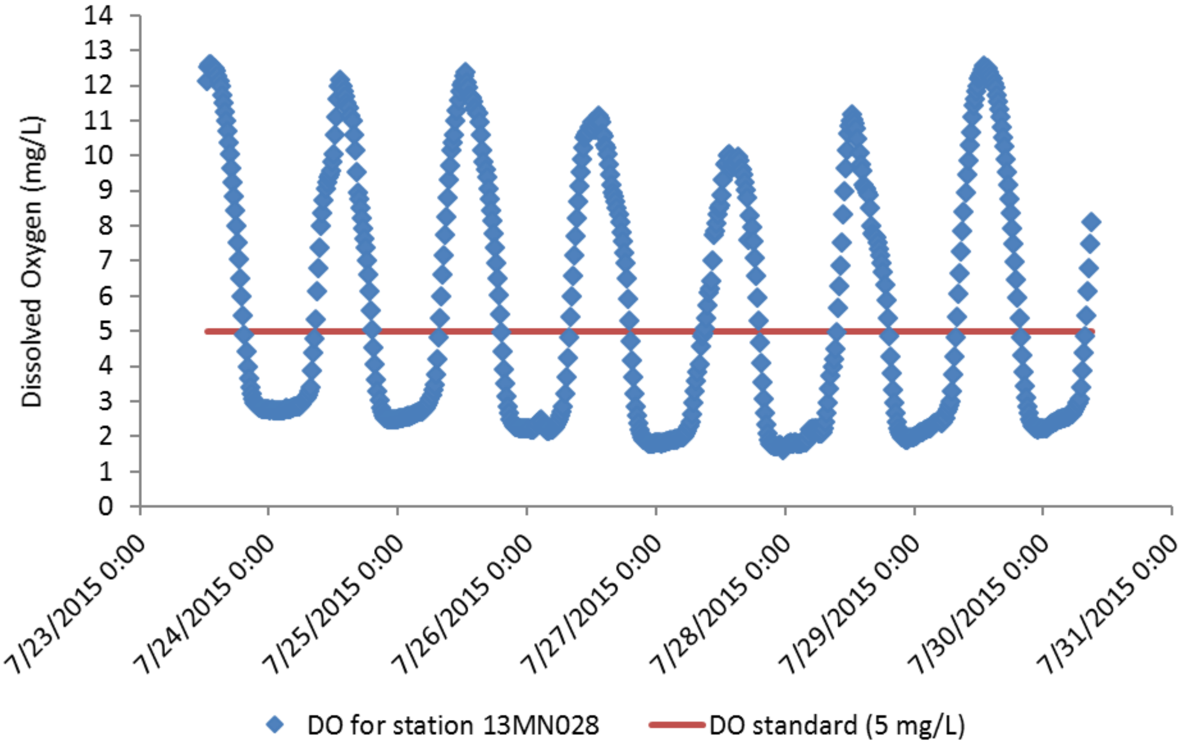
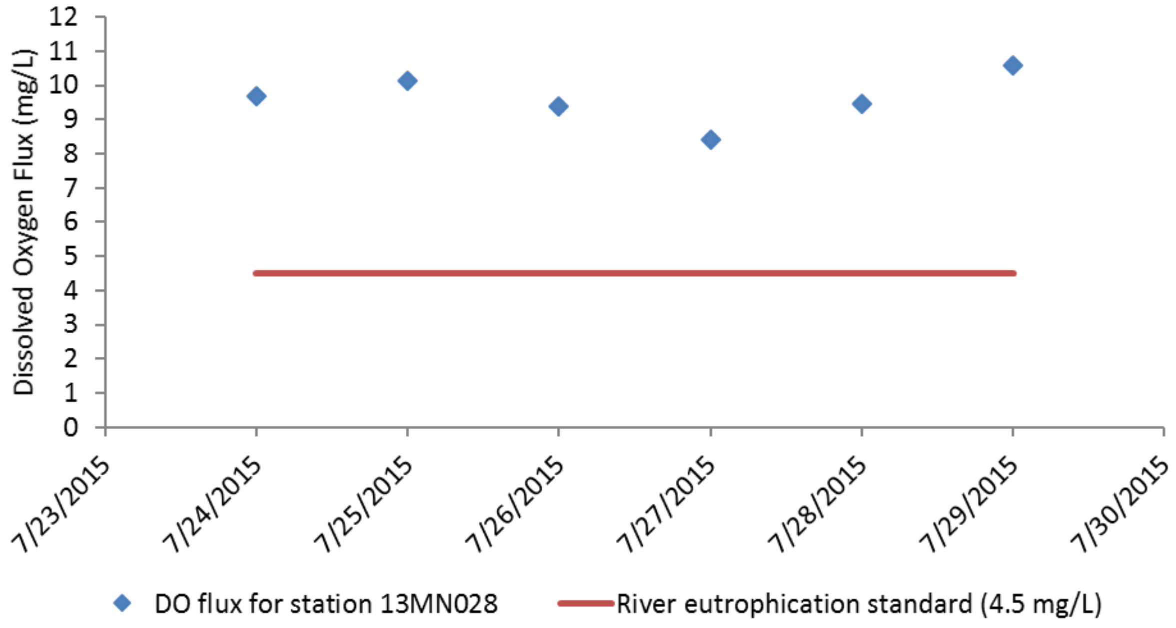


Figure 264. Dissolved oxygen flux at station 13MN028, July 24 - 29, 2015.



At station 13MN028, the macroinvertebrate metrics indicate low DO stress. There were no low DO intolerant taxa and elevated low DO tolerant taxa, but a lower percentage of low DO tolerant individuals than similar stations meeting the biocriteria.

Table 260. Macroinvertebrate metrics that respond to low DO stress in Judicial Ditch 8 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN028 (2013)	**25**	**3**	**9.27**	**6.25**	**0**	**0**	**11**	23.9
Prairie Streams GP Average	*36.8*	*7.6*	*7.92*	*6.42*	*2.4*	*4.5*	*8.4*	*25.1*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

The fish community metrics are suggestive of low DO stress as well (Table 261). The fish community at 13MN028 is comprised of a high percentage of DO tolerant fish, and no sensitive fish. There were also no individuals with a female mature age of greater than three years (MA>3Pct). These are some of the common metrics to respond to low DO stress, because sensitive fish and fish that mature later in life would not tolerate low DO conditions.

Table 261. Fish metrics that respond to low DO stress in Judicial Ditch 8 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
13MN028 (2013)	**0**	**0**	**100**	**6.35**	**0**	**0**	**1**	**89.9**
Prairie Streams MU average	*8.7*	*12.7*	*69.6*	*7.00*	*0.4*	*2.2*	*3.5*	*28.4*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is a biological stressor. Samples strongly suggest chronic low DO levels. Both the macroinvertebrate and fish community display metrics that indicate low DO is placing limitations on biology.

Eutrophication

During biological sample at 13MN028, the total phosphorus concentrations were low (average 0.06 mg/L). Additional sampling on the stream in 2015 and 2016, which showed that of five samples, the average concentration was 0.158 mg/L. Two of the values were above 0.150 mg/L, the eutrophication standard for phosphorus for the Southern Region. These two values occurred on July 20, 2015 and September 1^{t}, 2015. Additionally, there were two chlorophyll-values, 3.36 µg/L and 35.6 µg/L, with one violating the 35 µg/L standard set for the southern region. This sample was taken on September 1, 2015 when the high TP value was also recorded. No BOD data was available on this reach.

During site visits, periphyton and filamentous algae were noted as abundant and thick. A note from April 28, 2015 noted the stream was already green, early in the season.

In 2015, an YSI sonde was deployed at station 13MN028 from July 23 to 30. The DO ranged from 1.62 to 12.62 mg/L. With violations of the DO standard (5 mg/L) each day. In addition, there was consistent elevated DO flux, ranging from 8.41 to 10.57 mg/L, and averaging 9.60 mg/L (Figure 264).

The macroinvertebrate metrics indicate eutrophication related stress as well (Table 262). There were fewer collector-filterers and collector-gatherers than the average of similar stations meeting the biocriteria. There were no intolerant taxa and a very high percentage of the taxa in the sample were tolerant.

Table 262. Macroinvertebrate metrics that respond to eutrophication stress in Judicial Ditch 8 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN028 (2013)	**25**	**3**	**7**	**3**	**0**	**96.0**
Prairie Streams GP Average	*36.8*	*3.9*	*12.8*	*6.5*	*0.1*	*85.4*
Expected response to stress	↓	↓	↓	↓	↓	↑

The fish community also corresponded with eutrophication stress (Table 263). There was a lack of sensitive, darter, and intolerant individuals. There were only three species and they were all tolerant. Overall, the biological metrics correspond with the chemical data and physical observations of this stream, all pointing to eutrophication as a stressor to the biology.

Table 263. Fish metrics that respond to eutrophication stress in Judicial Ditch 8 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
13MN028 (2013)	**0**	**0**	**3.9**	**100**	**3**	**0**
Southern Headwaters Average	*4.5*	*8.5*	*27.9*	*79.9*	*10.4*	*0.8*
Expected response to stress	↓	↓	↓	↑	↓	↓

As displayed in Figure 265, at the time of biological monitoring the creek displayed abundant filamentous algae, correlating with the extreme DO fluctuations documented within this reach.

Figure 265. Station 13MN028, taken on August 14, 2013.

Eutrophication is a biological stressor within this reach. Chemistry samples show potential for phosphorus overloading, allowing for prolific growth within the stream. DO flux as a secondary measurement does verify a eutrophic response within this reach. Photo documentation clearly displays overabundant growth of filamentous algae as well. In addition, the biological metrics are suggestive of eutrophic displacement within both communities.

Nitrate

During biological sample at 13MN028, the nitrate concentrations were low in August of 2013, at 0.05 mg/L but very high in June of 2013, at 30 mg/L. Five additional samples collected at S008-507, collected in 2015 and 2016, and also showed a wide range of concentrations. The three samples collected in May and June, were greater than 20 mg/L, with the two taken in 2016 greater than 30 mg/L (35 mg/L on May 11, 2016, and 33 mg/L on June 1, 2016). The two values collected in late July and early September were less than 1 mg/L, demonstrating a clear seasonality to the nitrate fluctuations in this reach.

The macroinvertebrates in this reach show consistent indication they are stressed by the elevated nitrate concentrations (Table 264). The nitrate index score was 4.7, while the average for modified Prairie Streams meeting impairment threshold is 3.2. This suggests that overall the community present is quite tolerant to high nitrate concentrations. Increasing nitrate concentrations also correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct) and decreased intolerant and Trichoptera taxa, all of which are lacking in this reach. Additionally, the number of nitrate tolerant individuals (80%) is much higher than average. The fewer number of nitrate tolerant taxa is likely explained by an overall low taxa count for this site.

Table 264. Macroinvertebrate metrics that respond to nitrate stress in the Judicial Ditch 8 compared to the statewide average of visits meeting the modified use (MU) biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN028 (2013)	**2**	**0.6**	**4.7**	**0**	15	**80.3**
*Prairie Streams Average **(MU)***	*2.6*	*2.4*	*3.2*	*1.1*	*18.0*	*59.7*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is a stressor within Judicial Ditch 8. The chemistry data displayed extreme exceedances of nitrate multiple times. Fish metrics to evaluate nitrate have yet to be developed; macroinvertebrate metric responses are much more reliable and better understood. The macroinvertebrate community did indicate nitrate is limiting population within this reach.

Total Suspended Solids

During biological sample at 13MN028, the total suspended solids (TSS) concentrations were low, at 2.8 and 2.4 mg/L in June and August of 2013. Five additional samples collected at S008-507, collected in 2015 and 2016, also showed low concentrations. The average concentration of the five samples was 3.28 mg/L, ranging from 1.6 to 5.6 mg/L.

The macroinvertebrate and fish communities shows indication of TSS stress. The TSS index score was elevated for both fish and macroinvertebrates. There was an abundance of TSS tolerant macroinvertebrate individuals in the sample. All the fish metrics that respond to elevated TSS were zero and are skewed due to low sample numbers. Only three species were sampled during the August 14, 2013 repeat visit, which included mostly fathead minnows, and some creek chub and blacknose dace. When the fish crews tried to sample on June 20, 2013, they did not see or shock any fish, which is why they repeated the sample in August.

Table 265. Macroinvertebrate metrics that respond to high TSS stress in Judicial Ditch 8 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN028 (2013)	**1.6**	**0**	**17.17**	**0**	**0**	7	**66.7**
Prairie Streams GP Average	*11.7*	*0.1*	*16.68*	*0.8*	*1.4*	*11.8*	*41.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

Table 266. Fish metrics that respond to high TSS stress in Judicial Ditch 8 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
13MN028 (2013)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Southern Headwaters Average	*27.3*	*0.7*	*17.8*	*0.8*	*4.3*	*10.3*	*19.9*	*4.5*	*12.0*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 267. Fish metrics that respond to high TSS stress in Judicial Ditch 8 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

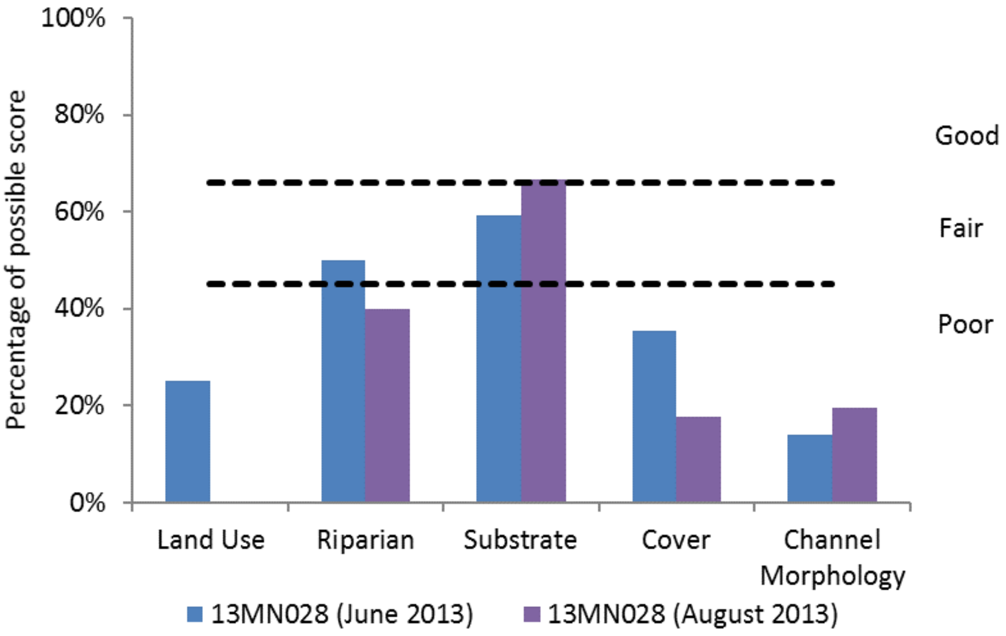
Station (Year sampled)	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN028 (2013)	**22.9**	**0**	**0**	0	0
Southern Headwaters Average	*16.2*	*0.5*	*2.9*	*0.5*	*2.5*
Expected response to stress	↑	↓	↓	↑	↑

Overall, the biological metrics do indicate TSS related stress. However, there is a lack of chemical data to confirm TSS is elevated in the reach. Additional chemical information should be collected on TSS to rule out this potential stressor, but until then, is considered inconclusive as a driver of the biological impairment in this reach.

Habitat

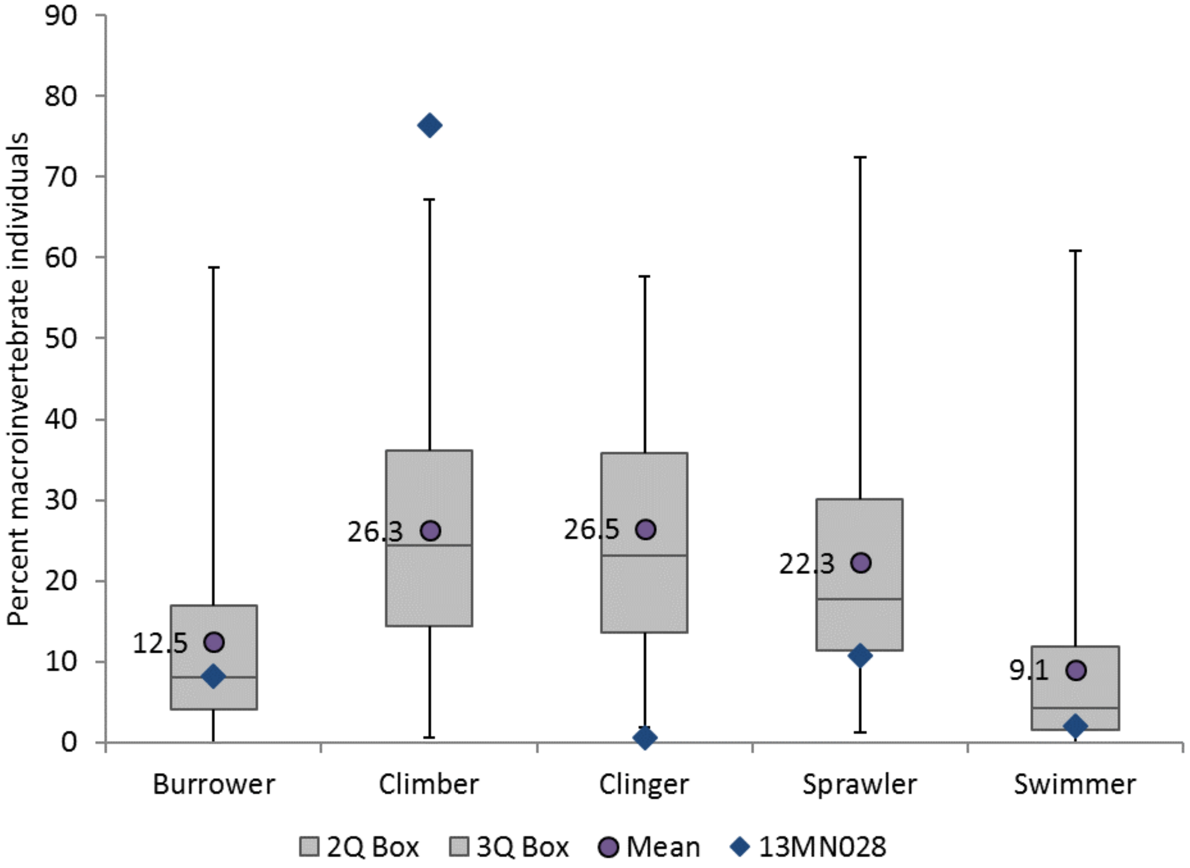
The MSHA score was poor in the August 2013 (34) visit, scoring poor to fair in all five primary categories assessed (Figure 266). The surrounding land use was primarily row crop. The riparian width was very narrow on the right and wide on the left. There was little bank erosion and light shade. The majority of the stream reach was run (95%) with little pool features (5%) and no riffle. The run and pool features were comprised primarily of gravel and sand with light embeddedness. In August, it was noted that the cover was choking vegetation only. There was moderate depth variability, poor sinuosity, poor channel development, and moderate channel stability.

Figure 266. Percentage of MSHA subcategory scores for station 13MN028, Judicial Ditch 8.



Station 13MN028 had a large proportion of climbers compared to other sites like it (Figure 267). There were less than 1% of clingers in the sample, and the low clinger taxa translated into a low MIBI metric score. These results are likely due to the fact that the macroinvertebrate community was completely dominated by snails (Physa). Snails are tolerant of very poor habitat conditions, in addition to poor water quality conditions

Figure 267. Macroinvertebrate habit metrics with box plot showing range of values from Prairie Streams stations meeting the modified use biocriteria mean of those stations, and metric values from station 13MN028.



The fish community metrics and composition do suggest habitat may be an issue with reduced numbers of benthic insectivores, riffle dwelling species, and simple lithophilic spawners (). These metrics can indicate limitations in fish habitat, among other stressors. Additionally, the reach had only three species sampled, which can skew the analysis. Given the physical measurements of the MSHA, modified use designation, in addition to the degraded biological communities, habitat is a stressor to the biology in this stream.

Habitat is considered a stressor within this reach. There is poor channel stability, paired with poor habitat diversity. Both the macroinvertebrate and well as the fish community suggest that habitat is a limiting parameter.

Longitudinal Connectivity and Altered Hydrology

At the outlet of Mud Lake, for which Little Rock Creek flows through, there is a structure with a drop of approximately five feet. The structure is a barrier to fish movement. Station 13MN028 only had three fish species present in 2013 (Table 268). Similarly, the three stations upstream of the structure had six fish species all together. Downstream the fish richness was much greater. For more information on the barrier, please see DNR's Minnesota River, Mankato Watershed Characterization Report (2015). The Mud Lake outlet structure is disrupting connectivity and is a stressor to the fish community in Judicial Ditch 8. The structure at the outlet of Mud Lake drops 5 feet and prevents fish from migrating upstream to Judicial Ditch 8.

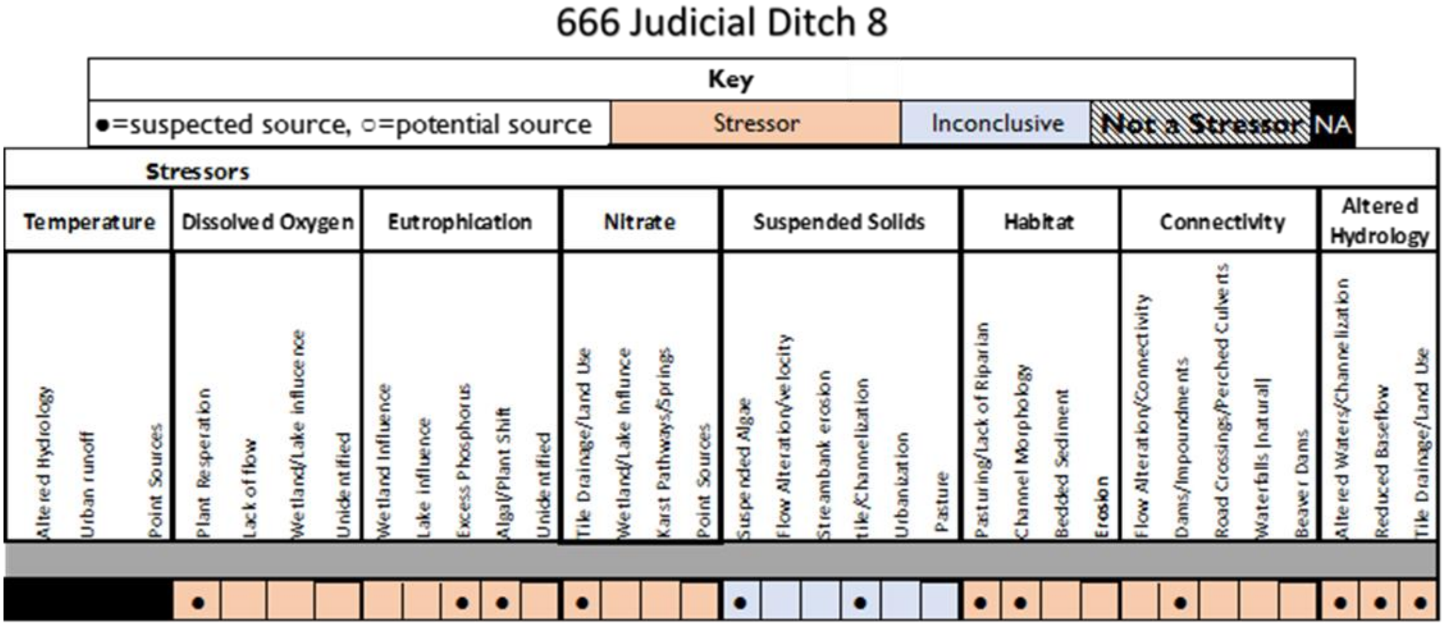
Table 268. Fish species at stations in Judicial Ditch 8 and longitudinally in Little Rock Creek. 13MN028 is the most upstream station, and 13MN032 is farthest downstream. Migratory fish highlighted in bold.

	13MN028	13MN027	13MN029		03MN020	03MN020	03MN019	03MN019	03MN019	13MN032	13MN032
	2013	2013	2013		2003	2013	2003	2013	2014	2013	2014
bigmouth buffalo				Mud Lake outlet structure			x		x		
bigmouth shiner					x		x		x	x	x
black bullhead					x	x					
blacknose dace	x				x		x	x	x	x	x
blackside darter							x		x		x
bluntnose minnow					x	x	x		x		x
brassy minnow					x		x		x		x
brook stickleback		x			x		x		x		
central stoneroller			x		x	x	x	x	x	x	x
common carp					x						
common shiner					x	x	x	x	x	x	x
creek chub	x		x		x	x	x	x	x	x	x
fantail darter										x	x
fathead minnow	x		x		x		x		x		x
hornyhead chub								x	x	x	x
hybrid minnow									x		
johnny darter			x		x	x	x	x	x	x	x
largemouth bass										x	
northern hogsucker											x
northern pike								x			
orangespotted sunfish							x				
sand shiner						x	x	x	x	x	x
shorthead redhorse					x						
spotfin shiner							x		x		x
white sucker					x		x	x	x	x	x

Additionally, the entire stream has been altered, which severely influences available habitat within the stream itself. The surrounding land use is agriculture, resulting in tile drainage and an unpredictable flow regime. This limits not only habitat in the stream, but is demonstrated in the increased nitrate concentrations from tile drainage, and lack of base flow in the summer months. This lack of base flow was the reason macroinvertebrates were not sampled at 13MN029 in 2013. For additional information on altered hydrology within this watershed, and the impacts, reference Chapter 3.1.8 of this report. Connectivity and altered hydrology are considered biological stressors within this reach.

Summary Table

Table 269. Identified stressors with suspected sources for reach 666 of Judicial Ditch 8.



666 Judicial Ditch 8

Key

●=suspected source, ○=potential source | Stressor | Inconclusive | Not a Stressor | NA

Stressors

Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
■	■	■	●						●	●		●				●			●			●	●				●				●	●	●

Little Rock Creek (Judicial Ditch 31) (07020007-686)

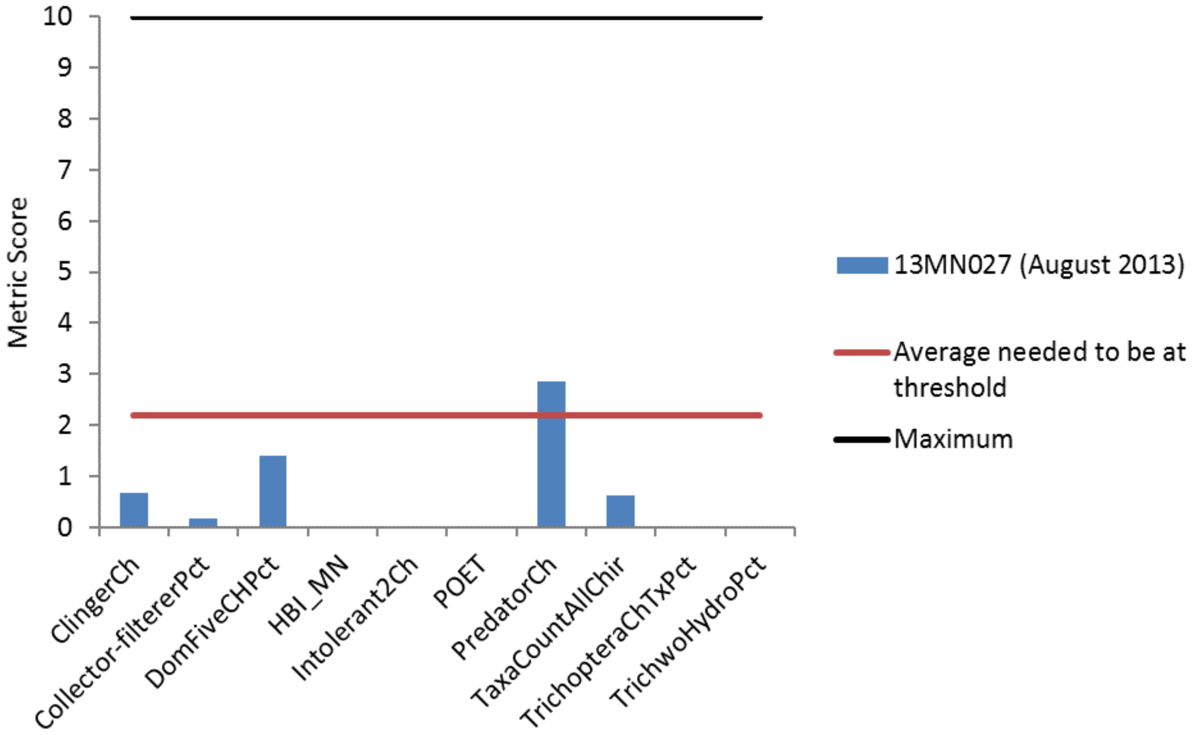
Little Rock Creek (07020007-686) is the upstream reach of the creek, east-northeast of Fairfax, Minnesota. The reach is warmwater modified use Class 2B. The reach extends from the headwaters through Mud Lake. This reach of Little Rock Creek is impaired for lack of fish assemblage and lack of macroinvertebrate assemblage. There are two biological stations on this reach, station 13MN027 and 13MN029.

4.26.17 Biological Communities

There was one macroinvertebrate visit at 13MN027 sampled in 2013, and scored 5.7, which is well below the modified use threshold. Station 13MN029 had insufficient flow and habitat to sample macroinvertebrates. Overall, station 13MN027 had very low macroinvertebrate diversity, with nearly all tolerant taxa. Almost all of the metrics scored below the average needed to meet the impairment threshold, with the exception of abundance of predator species (PredatorCh), seen in Figure 268.

Fish were sampled in 2013 at both stations as well. However, due to low sample size (<25 fish) both samples scored zero. At 13MN027 only two-brook stickleback were sampled.

Figure 268. Macroinvertebrate metrics of the Prairie Streams class IBI for station 13MN027, Little Rock Creek.



4.26.18 Data Evaluation for each Candidate Cause

Dissolved Oxygen

During biological sample at 13MN027 and 13MN029, the dissolved oxygen (DO) values were 11.39 mg/L and 12.41 mg/L on July 10, 2013. An additional four samples collected in 2015 on this reach showed a minimum concentration of 1.47 mg/L, and maximum of 9.22 mg/L. In 2016, there were 10 samples taken at multiple sites in the watershed, all with normal ranges of DO and none violating the standard (5.57-10.73 mg/L) The one violation of the 5 mg/L DO standard occurred on September 1 2015, at 11:00 am.

In 2015, YSI sondes were also deployed at station 13MN027 and station 13MN029 from July 23 to 30. The DO ranged from 3.9 to 10.5 mg/L at station 13MN027 and from 4.19 to 16.98 mg/L at station 13MN029. With violations of the DO standard (5 mg/L) each day at station 13MN027 (Figure 269 and Figure 270). Also there was consistent elevated DO flux, ranging from 4.32 to 6.13 mg/L, and averaging 4.9 mg/L for station 13MN027 (Figure 271 and Figure 272).

Figure 269. Diurnal dissolved oxygen for station 13MN027, July 23 - 30, 2015

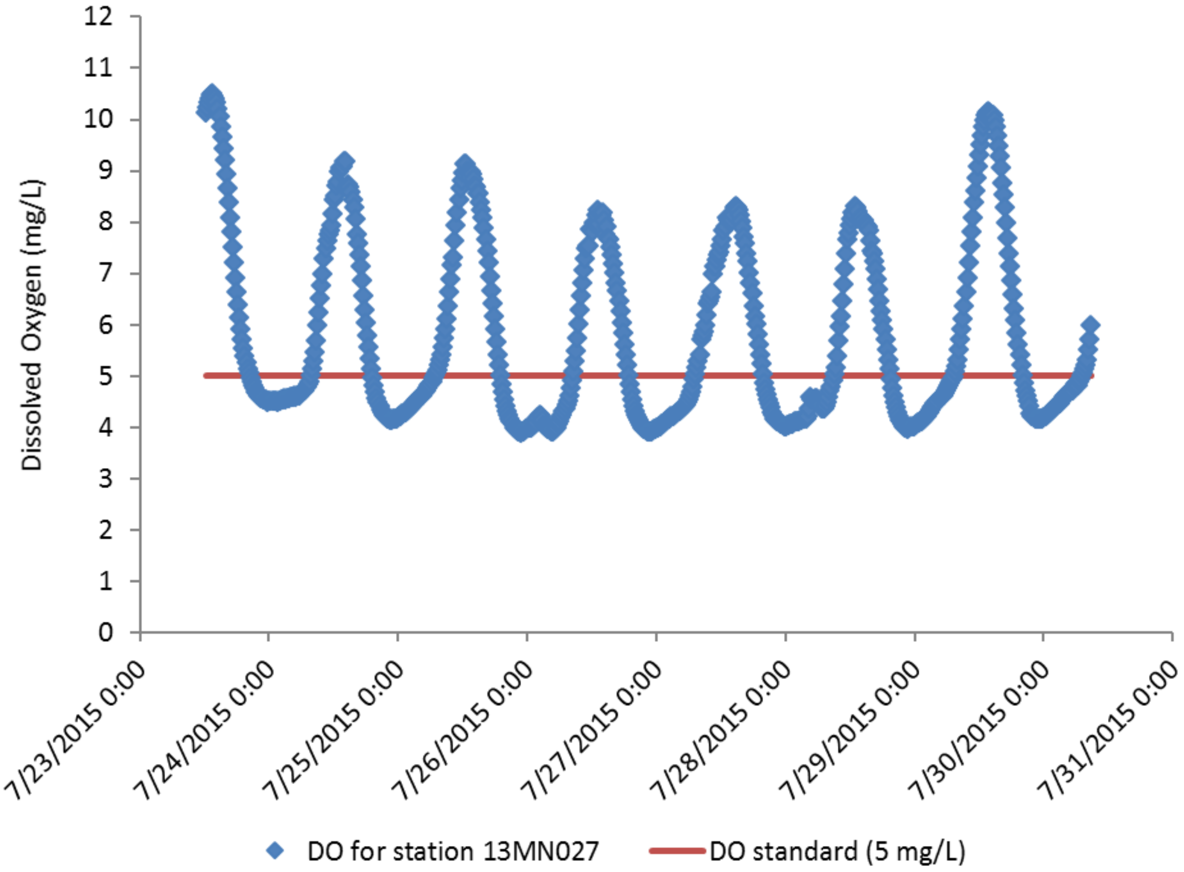


Figure 270. Dissolved oxygen flux at station 13MN027, July 24 - 29, 2015.

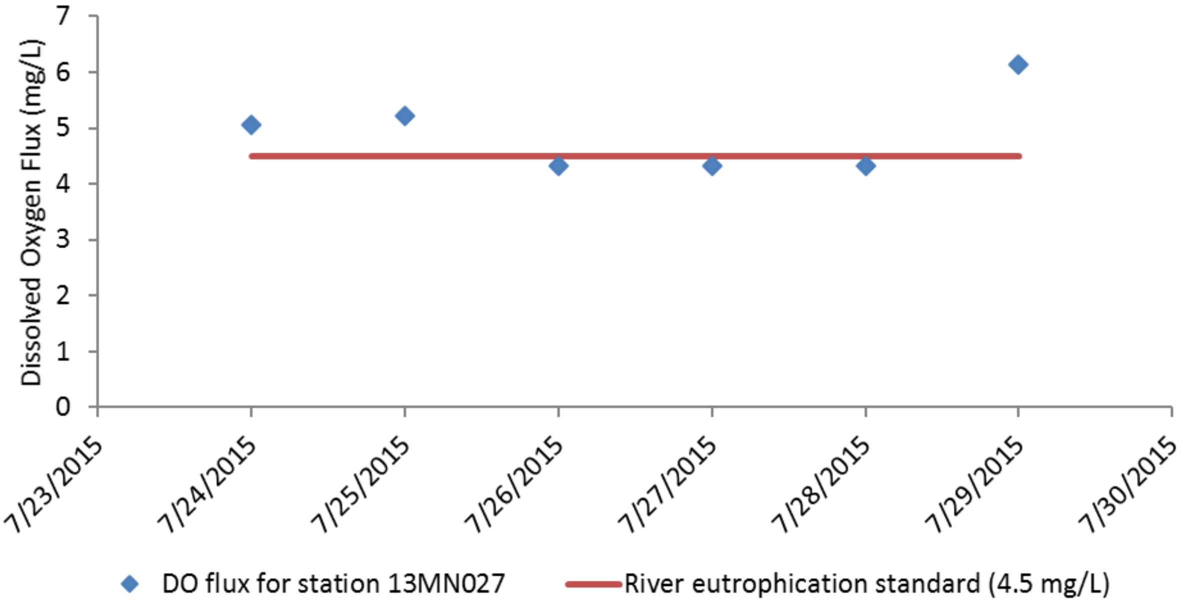


Figure 271. Diurnal dissolved oxygen at station 13MN029, July 24 - 29, 2015

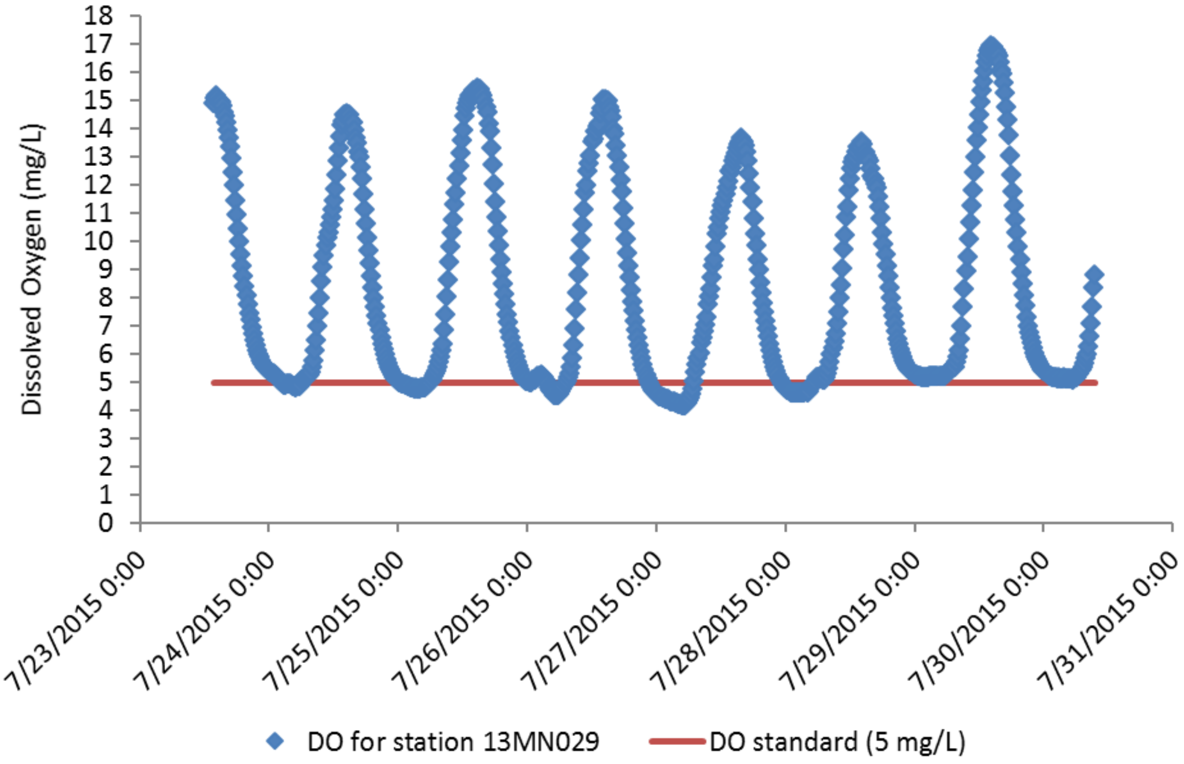
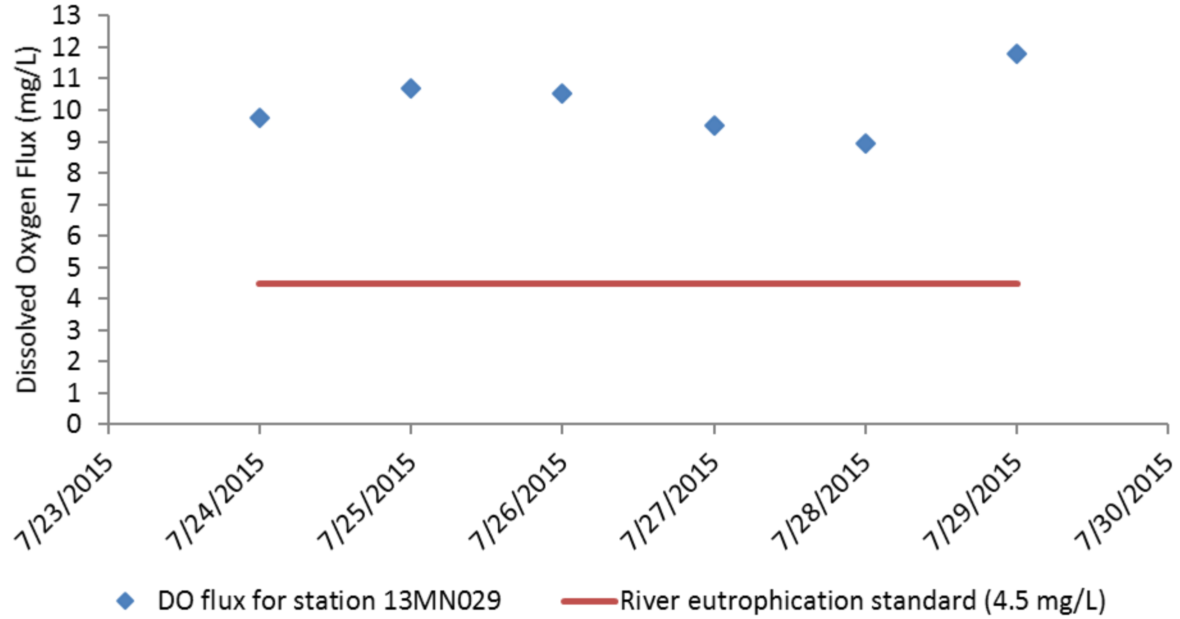


Figure 272. Dissolved oxygen flux at station 13MN029, July 24 - 29, 2015.



The macroinvertebrate metrics are suggestive of low DO stress (Table 270). Station 13MN027 had an elevated Hilsenhoff Biotic Index for Minnesota (HBI) and a lower low DO index score compared to similar stations meeting the biocriteria. There was a lack of low DO intolerant taxa, but there was not a large amount of low DO tolerant taxa or individuals. Fish metrics will not be useful for metric evaluation, as only one taxa was sampled.

Table 270. Macroinvertebrate metrics that respond to low DO stress in Little Rock Creek compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN027 (2013)	**21**	**0**	**9.31**	**6.11**	**0**	**0**	8	24.3
Prairie Streams GP Average	*36.8*	*7.6*	*7.92*	*6.42*	*2.4*	*4.5*	*8.4*	*25.1*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is considered a biological stressor. There was one low DO value detected during instantaneous readings. One sonde deployment captured almost daily low DO levels, indicating a chronic low DO impairment within this reach. In addition to the chemistry analysis, community metrics are indicative of low DO stress.

Eutrophication

Total phosphorus (TP) concentrations from three of the nine samples in this reach were above 0.15 mg/L, the river eutrophication standard for the Southern Region. These samples were collected mainly in 2015 and 2016, with some also in 2013 during biological sample. The maximum concentration recorded was 0.659 mg/L. Chlorophyll-a data, while limited to three samples, shows low concentrations ranging from 2.88-7.61 ug/L in 2015. BOD data are also considered when evaluating eutrophication stress, but were not available for analysis.

In 2015, YSI sondes were deployed at station 13MN027 and station 13MN029 from July 23 to the 30. The DO ranged from 3.9 mg/L to 10.5 mg/L at station 13MN027 and from 4.19 mg/L to 16.98 mg/L at station 13MN029. There was consistent elevated DO flux, ranging from 4.32 to 6.13 mg/L, and averaging 4.9 mg/L for station 13MN027 (Figure 272), suggesting eutrophication may be a contributing problem in this reach.

The macroinvertebrate metrics in this reach were suggestive of possible eutrophication stress as well (Table 271). There were very few collector-filterer and collector-gather taxa, and no EPT or intolerant taxa. Fish metrics are not going to be helpful in evaluation of eutrophication stress, due to the presence of only one fish taxon (brook stickleback).

Table 271. Macroinvertebrate metrics that respond to eutrophication stress in Little Rock Creek compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN027 (2013)	**21**	**1**	**2**	**0**	**0**	**95.2**
Prairie Streams GP Average	*36.8*	*3.9*	*12.8*	*6.5*	*0.1*	*85.4*
Expected response to stress	↓	↓	↓	↓	↓	↑

The phosphorus samples were limited, but had a few that exceeded the standard. However, there were a few chlorophyll a samples, all which were low. DO flux was just exceeding the standard for this reach. It is not clear if the biology is responding to eutrophication or the results are driven by other limiting factors in this reach (i.e. lack of flow). Eutrophication is inconclusive as a stressor until more connecting information can be collected.

Nitrate

During the biological sample, the nitrate concentrations at 13MN027 and 13MN029 was high at 18 and 20 mg/L (July 10, 2013). There were seven additional samples taken on this reach in 2015-2016 from May through September. The nitrate concentration ranged from 0.23 mg/L in September, up to 35 mg/L in June. About half of the nitrate values were greater than 10 mg/L, with two of those greater than 30 mg/L, all in May or June. The lowest concentrations were typically seen in late summer, when flows were likely lower.

The macroinvertebrates in this reach show consistent indication they are stressed by the elevated nitrate concentrations (Table 272). The nitrate index score was 4.5, while the average for modified Prairie Streams meeting impairment threshold is 3.2. This suggests that overall the community present is quite tolerant to high nitrate concentrations. Increasing nitrate concentrations also correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct) and decreased intolerant and Trichoptera taxa, all of which are absent in this reach. Additionally, the number of nitrate tolerant individuals (92.6%) is much higher than average. The fewer number of nitrate tolerant taxa is likely explained by an overall low taxa count for this site.

Table 272. Macroinvertebrate metrics that respond to nitrate stress in the Judicial ditch 31 compared to the statewide average of visits meeting the modified use (MU) biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN027 (2013)	**0**	**0**	**4.5**	**0**	13	**92.6**
Prairie Streams Average ***(MU)***	*2.6*	*2.4*	*3.2*	*1.1*	*18.0*	*59.7*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is a stressor within this reach. There was a strong biology response to show that nitrate is limiting the macroinvertebrate community. There is also evidence of high nitrate noted in the chemistry samples.

Total Suspended Solids

During the biological sample, the total suspended (TSS) concentrations were low, at 5.2 and 2.8 mg/L (July 10, 2013). There were seven additional samples taken on this reach in 2015-2016 from May through September, concentrations ranged from 2.4 mg/L to 16 mg/L, all meeting the regional standard for TSS of 65 mg/L.

The macroinvertebrate community at station 13MN027 was suggestive of TSS stress (Table 273. The TSS index score was slightly elevated and the percentage of TSS tolerant individuals was high. The fish community will not be evaluated since only one specie gives biased results. Brook stickleback are neither intolerant of TSS nor tolerant. It also does not belong too many of the other metrics used to evaluate whether there was plausible stress from TSS, therefore not included in this section for analysis.

Table 273. Macroinvertebrate metrics that respond to high TSS stress in Little Rock Creek compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

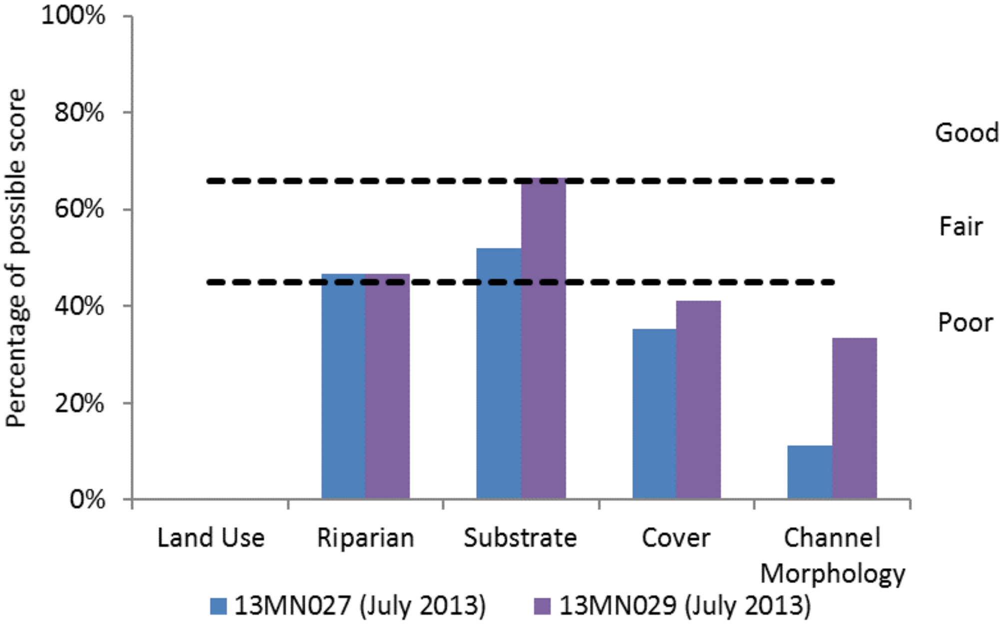
Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN027 (2013)	**1.0**	**0**	**17.19**	**0**	**0**	7	**61.8**
Prairie Streams GP Average	*11.7*	*0.1*	*16.68*	*0.8*	*1.4*	*11.8*	*41.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

Overall, there is a very little chemical data to support TSS as a stressor, while the macroinvertebrates do signal some response. This conflicting information makes TSS as a stressor inconclusive until more data is collected to understand TSS concentrations. There is a good chance other stressors may be responsible for the response seen, therefore TSS is inconclusive as a stressor.

Habitat

The MSHA score was poor (31) at station 13MN027 in July 2013 (Figure 273). The surrounding land use was predominantly row crop. The riparian width was narrow, with little bank erosion and light shade. The stream was comprised of 100% run with gravel and sand substrate. The embeddedness was severe (75-100%), with a lack of diverse substrates available. There was sparse cover (5-25%), with macrophytes, overhanging vegetation, and boulders. There was a lack of depth variability, with poor sinuosity, and poor channel development. The reach had moderate channel stability, but no riffle.

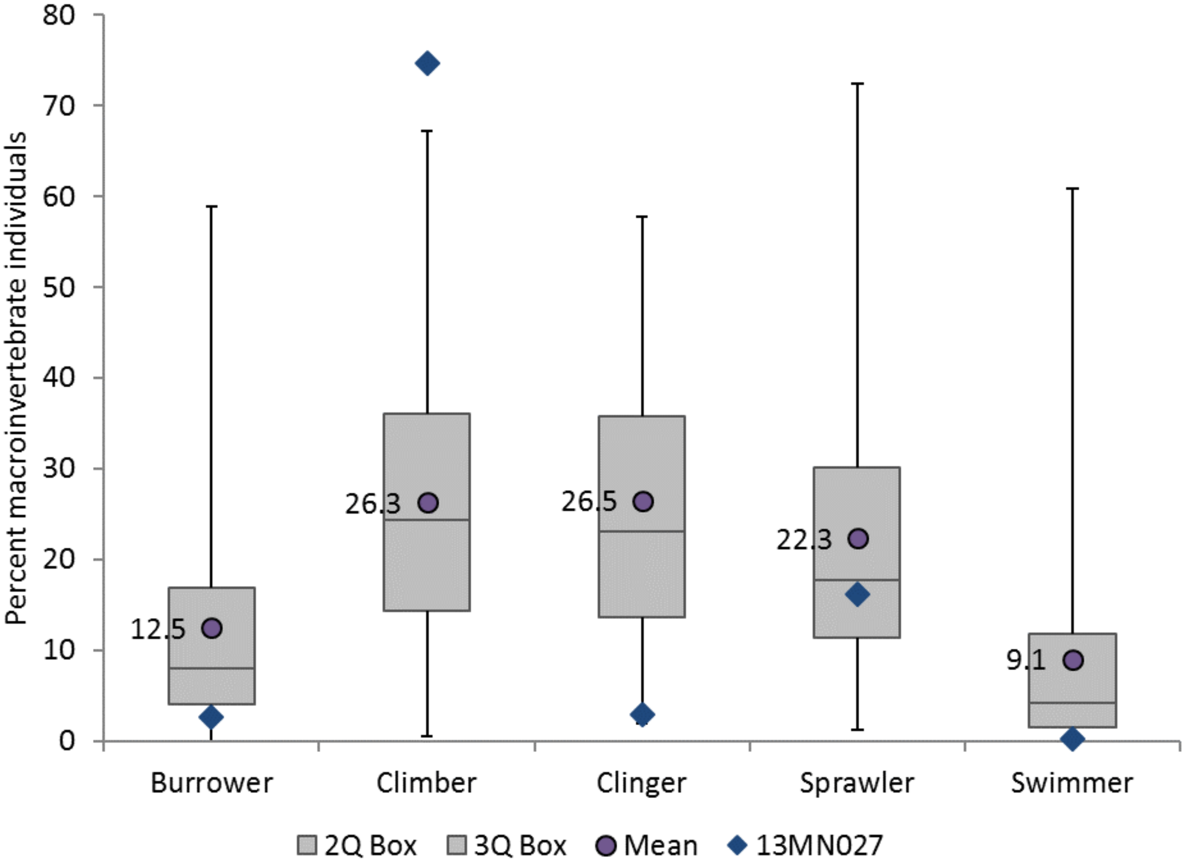
Figure 273. Percentage of MSHA subcategory scores for stations 13MN027 and 13MN029, Little Rock Creek.



The fish community metrics do suggest habitat may be an issue with low numbers of benthic insectivores, riffle dwelling species, and simple lithophilic spawners. These metrics can indicate limitations in fish habitat, among other stressors. In this case, it is hard make connections with metrics when only one specie was sampled.

The macroinvertebrate community at station 13MN027 was comprised of a large proportion of climbers (Figure 274). There was a low number of clinger taxa as well as proportion of individuals. These results are likely due to the fact that the macroinvertebrate community was completely dominated by snails (Physa). Snails are tolerant of very poor habitat conditions, in addition to poor water quality conditions.

Figure 274. Macroinvertebrate habit metrics with box plot showing range of values from Prairie Streams stations meeting the modified use biocriteria mean of those stations, and metric values from station 13MN027.



Given all of the poor habitat conditions in this reach, its modified use designation, and biological response, it seems clear that lack of quality habitat is a stressor and shaping the biological communities within this reach of Little Rock Creek.

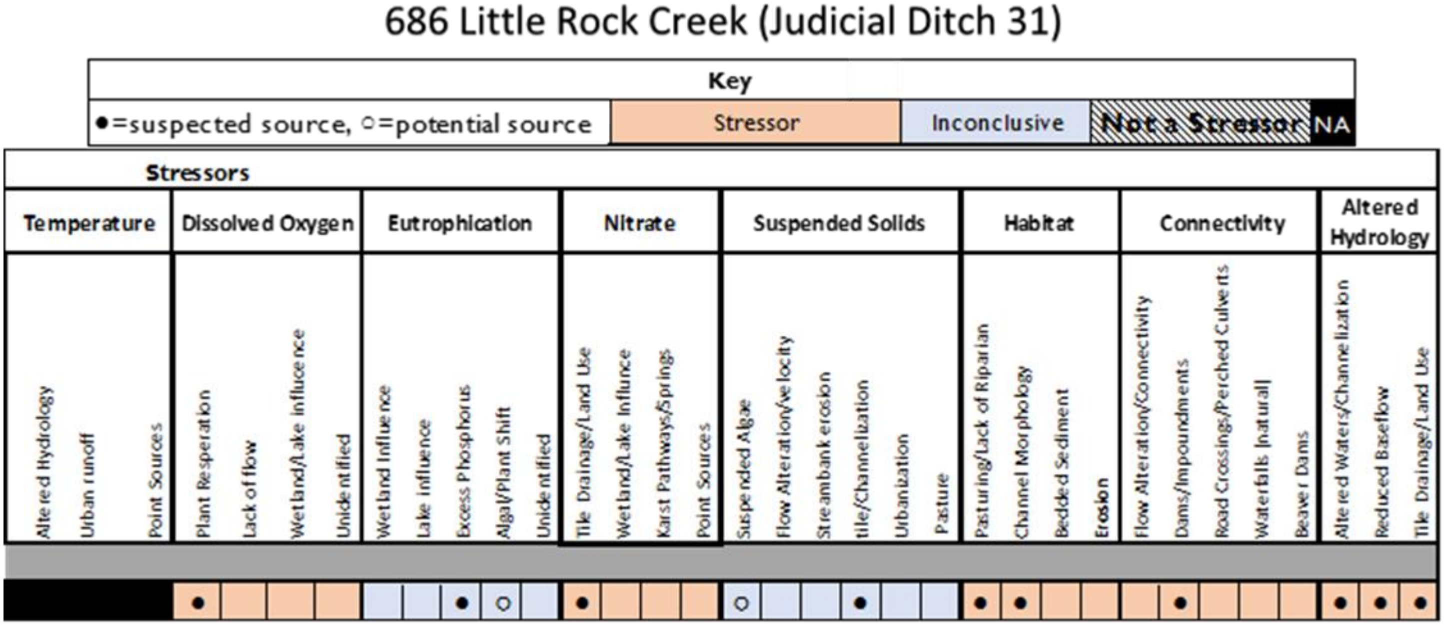
Longitudinal Connectivity and Altered Hydrology

At the outlet of Mud Lake, for which Little Rock Creek flows through, there is a structure with a drop of approximately 5 feet. The structure is a barrier to fish movement. Station 13MN027 only had one fish species present in 2013 and station 13MN029 had four. Similarly, the three stations upstream of the structure had six fish species all together. Downstream the fish richness was much greater. The Mud Lake outlet structure is a stressor to the fish community in the upper reach of Little Rock Creek. For more information on the barrier, please see DNR's Minnesota River, Mankato Watershed Characterization Report (2015).

The structure at the outlet of Mud Lake drops 5 feet and prevents fish from migrating upstream to Judicial Ditch 8. Additionally, the entire stream has been altered, which severely influences available habitat within the stream itself. The surrounding land use is agriculture, resulting in tile drainage and an unpredictable flow regime. This limits not only habitat in the stream, but is demonstrated in the increased nitrate concentrations from tile drainage, and lack of base flow in the summer months. This lack of base flow was the reason macroinvertebrates were not sampled at 13MN029 in 2013. For additional information on altered hydrology within this watershed, and the impacts, reference Chapter 3.1.8 of this report.

Summary Table

Table 274. Identified stressors with suspected sources for reach 686 of Little Rock Creek.



686 Little Rock Creek (Judicial Ditch 31)

Key				
●=suspected source, ○=potential source	Stressor	Inconclusive	Not a Stressor	NA

Stressors																																				
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
			●						●	○		●				○			●			●	●				●				●	●	●

Little Rock Creek (Judicial Ditch 31) (07020007-687)

Little Rock Creek (07020007-687) is the downstream reach of the creek, southeast of Fairfax, Minnesota. The reach is warmwater general use Class 2B. The reach extends from Mud Lake to the Minnesota River. This reach of Little Rock Creek is impaired for lack of fish assemblage and lack of macroinvertebrate assemblage. There are three biological stations on this reach, stations 03MN020, 03MN019, and 13MN032.

4.26.19 Biological Communities

There were five biological macroinvertebrate visits on three stations (03MN019, 03MN020, 13MN032) sampled in 2013 and 2014. Samples from sites 03MN020 and 13MN032 all scored below the general use impairment threshold. The sample collected from 03MN019 in 2013 scored above the threshold, but the sample collected in 2014 scored below the threshold, Reflected in Figure 275 and Figure 276.

Figure 275. Macroinvertebrate metrics of the Southern Streams RR class IBI for stations 03MN020 and 13MN032, Little Rock Creek.

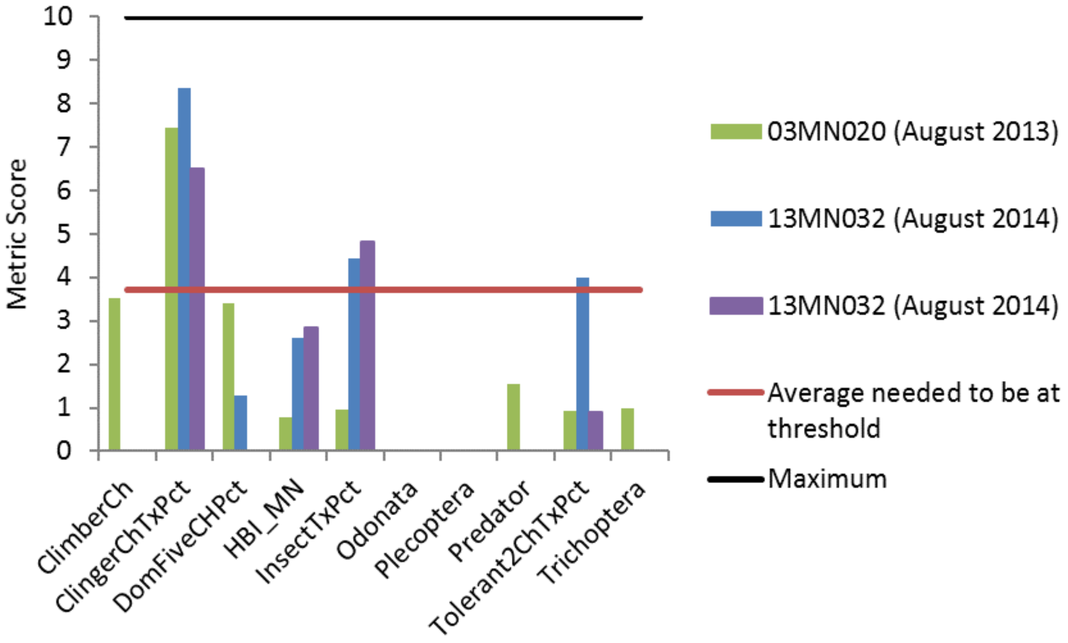
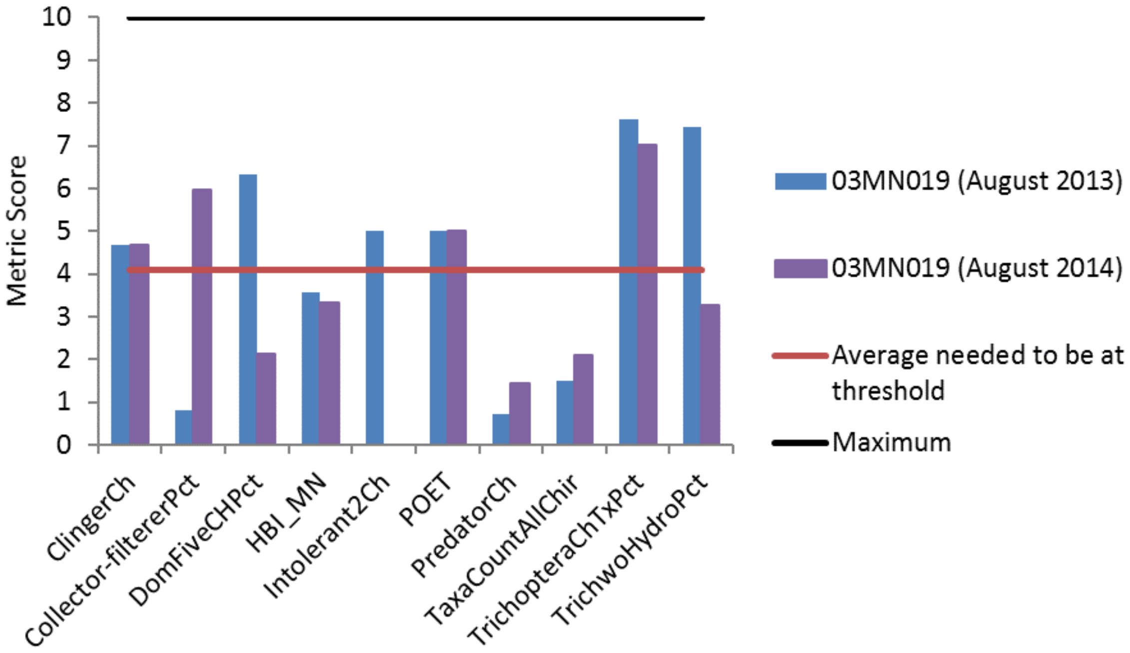
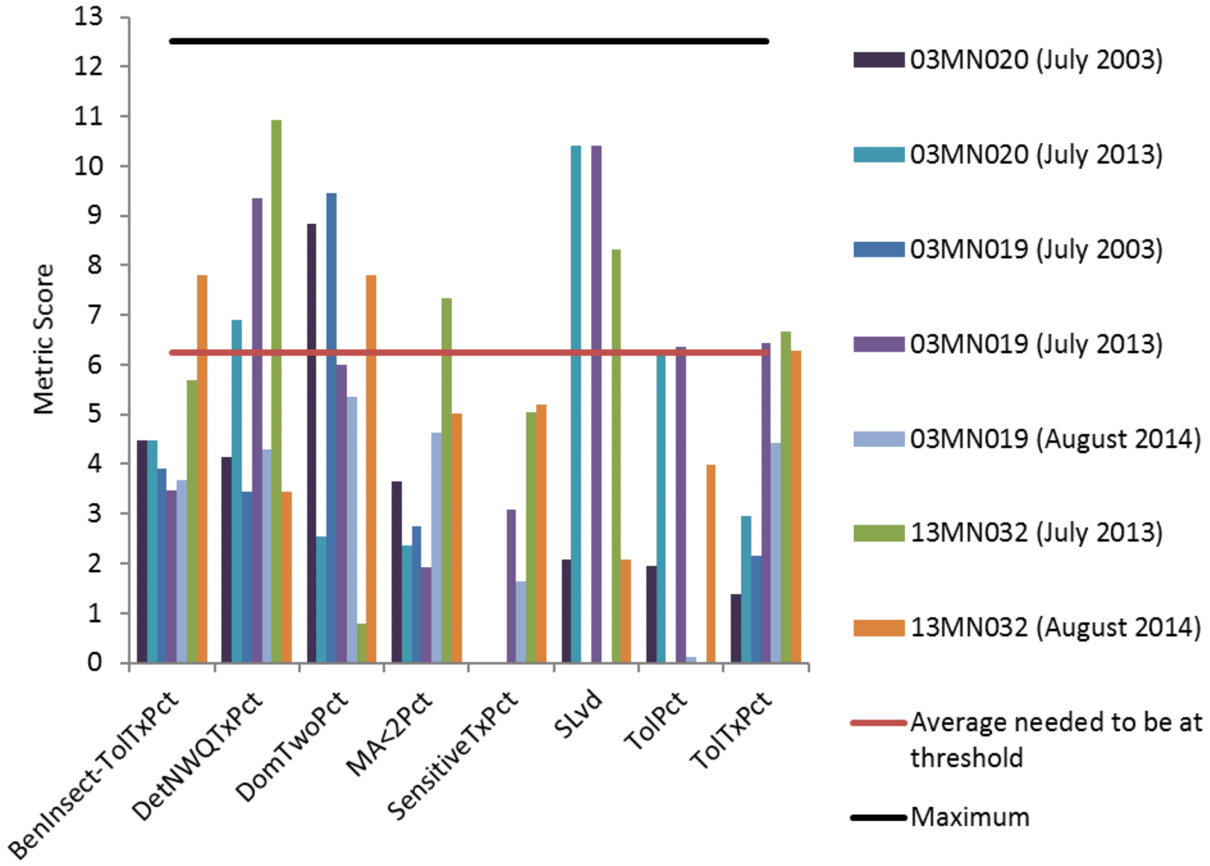


Figure 276. Macroinvertebrate metrics of the Prairie Streams RR class IBI for station 03MN019, Little Rock Creek.



There was fish samples from six visits at the three stations sampled in 2003, 2013, and 2014. Upstream most station (03MN020) scored below the general use threshold in 2013. Next downstream station (03MN019) scored just below the threshold both years it was sampled. The downstream most station (13MN032) was sampled once in 2013, and once in 2014, scored below threshold, but within CI both occasions. Fish metrics groups that made up the overall score are reflected in Figure 277.

Figure 277. Fish metrics of the Southern Streams class IBI for stations 03MN019 and 13MN032, Little Rock Creek.



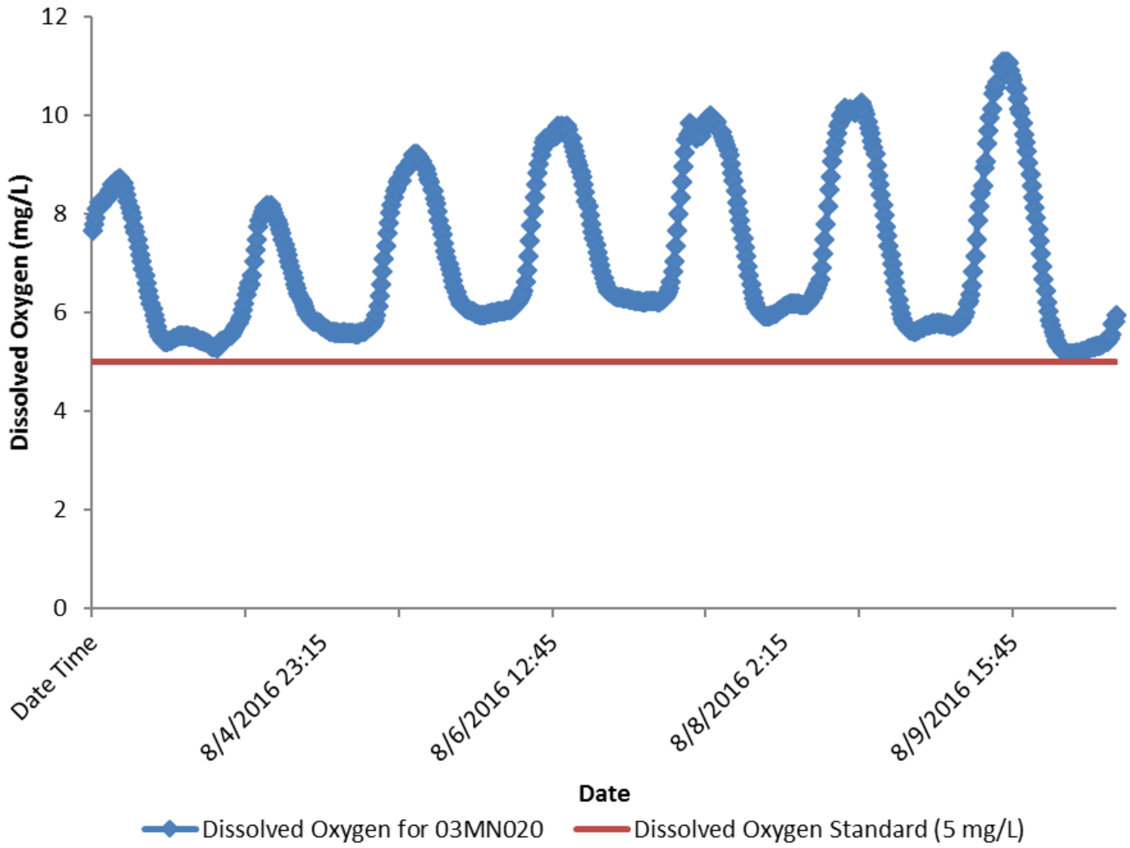
4.26.20 Data Evaluation for each Candidate Cause

Dissolved Oxygen

During biological sample at the three stations, the DO concentrations ranged from 6.87 to 9.35 mg/L. Sixteen additional DO values collected at S007-569 in 2013 and 2014, and all met the DO standard, with a range from 6.2-13.22 mg/L. Additionally, in 2016 there were eight samples taken at multiple sites in the watershed, all with normal ranges of DO and none violating the standard (5.64-9.70 mg/L)

In 2016, an YSI sonde was also deployed from August 3 through August 10. During that time frame, the average DO FLUX was about 4 mg/L each day, with some days up to 5 mg/L. There were no violations of the DO standard (5 mg/L), but it was close, with the minimum concentration of 5.1 mg/L and maximum of 11.1 mg/L (Figure 278).

Figure 278. Dissolved Oxygen data from 03MN020 in 2016.



The macroinvertebrate metrics relating to low DO show a mixed response in Little Rock Creek (Table 275). Within this reach of Little Rock Creek, station 03MN020 shows the most potential for low DO stress. Although not greatly lower, the low DO index station was below the average of similar stations meeting the biocriteria. Similarly, the percentage of low DO tolerant individuals was slightly elevated. There was not a great deal of low DO intolerant taxa, but at station 13MN032 the percentage of those low DO intolerant taxa was above the average of similar stations meeting the biocriteria.

Table 275. Macroinvertebrate metrics that respond to low DO stress in Little Rock Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Tolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
03MN020 (2013)	**28**	**7**	**8.08**	**6.94**	**4**	**6.6**	**7**	**12.3**
13MN032 (2014)	**24**	**7**	**7.46**	7.50	**3**	27.3	2	4.4
13MN032 (2014)	**19**	**6**	**7.38**	7.64	**4**	27.9	2	0.9
Southern Streams Average	*45.8*	*14.2*	*7.08*	*7.04*	*9.0*	*24.0*	*4.8*	*9.9*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

The fish community also shows a mixed response to the potential for low DO stress (Table 276). Overall, the DO related metrics do not provide a strong indication the DO is affecting the community. There are few sensitive taxa and individuals, but not an overabundance of tolerant individuals. As such, the DO index score is better than average (lower) at most stations.

Table 276. Fish metrics that respond to low DO stress in Little Rock Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates a metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
03MN020 (2003)	**0**	**0**	**51.5**	7.3	**0**	**0**	**5**	6.7
03MN020 (2013)	**0**	**3.5**	**67.6**	**7.1**	**0**	**0**	1	6.1
13MN032 (2013)	**2.6**	**2.2**	**80.0**	7.3	**1**	**0.4**	1	0.4
13MN032 (2014)	**11.4**	**0.5**	**60.0**	7.4	**1**	**5.3**	2	2.3
Southern Streams Average	*16.9*	*24.6*	*44.9*	*7.20*	*1.71*	*5.94*	*4.69*	*18.54*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

At this time the data does not clearly link DO as a stressor, therefore low DO is inconclusive at this time. The DO samples indicate DO levels could be found just at the threshold of 5 mg/L, yet there is no record of DO falling below the threshold. The biologic metrics are somewhat suggestive, yet there were some low DO intolerant species noted (often times below the expected average).

Eutrophication

Total phosphorus (TP) concentrations from 7 of 31 samples in this reach were above 0.15 mg/L, the river eutrophication standard for the Southern Region. These samples were collected from 2009-2014. The maximum concentration recorded was 0.592 mg/L. Chlorophyll-a data and BOD data are also typically considered when evaluating eutrophication stress, but no samples were available for analysis.

In 2016, an YSI sonde was deployed from August 3 through August 10. During that time frame, the average DO FLUX was about 4 mg/L each day, with some days up to 5 mg/L. There were no violations of the DO standard (5 mg/L), but it was close, with the minimum concentration of 5.1 mg/L and maximum of 11.1 mg/L (Figure 278).

Throughout both stations, the macroinvertebrates exhibited possible stress from eutrophication (Table 277). The collector-filterers and collector-gatherers were less than the average of similar stations meeting the biocriteria. There was also an abundance of taxa that were tolerant in each of the samples, which may or may not be related to eutrophication.

Table 277. Macroinvertebrate metrics that respond to eutrophication stress in Little Rock Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
03MN020 (2013)	**28**	**4**	**5**	**7**	**0**	**89.3**
13MN032 (2014)	**24**	**5**	**8**	**6**	**0**	**75**
13MN032 (2014)	**19**	**3**	**9**	**5**	**0**	**89.5**
Southern Streams Average	*45.8*	*7.3*	*15.9*	*12.2*	*0.8*	*72.6*
Expected response to stress	↓	↓	↓	↓	↓	↑

The fish community throughout this reach indicates a plausible but somewhat mixed response to possible eutrophication stress (Table 278). There was a lack of sensitive and intolerant individuals throughout the reach. There were also a high percentage of tolerant individuals. However, the percentage of darters and simple lithophilic spawners was variable throughout the samples with no strong pattern.

Table 278. Fish metrics that respond to eutrophication stress in Little Rock Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
03MN020 (2003)	**0**	15.9	47.6	**67.6**	**14**	**0**
03MN020 (2013)	**0**	**3.0**	45.5	**51.5**	**7**	**0**
03MN019 (2003)	**0**	13.4	**22.5**	**76.6**	**16**	**0**
03MN019 (2013)	**2.1**	**10.6**	44.7	**51.1**	**9**	**0**
03MN019 (2014)	**2.5**	**6.7**	**22.6**	**74.6**	**17**	**0**
13MN032 (2013)	**2.7**	13.8	**8.9**	**80.0**	**11**	**0**
13MN032 (2014)	**11.4**	13.5	**30.4**	**60.0**	**16**	**0**
Southern Streams Average	*16.9*	*11.9*	*37.0*	*44.9*	*19.3*	*4.2*
Expected response to stress	↓	↓	↓	↑	↓	↓

The borderline DO response within the stream, paired with the mixed metrics results make eutrophication inconclusive as a stressor. Phosphorus concentrations can reach concerning levels. However, often times it fell below the standard.

Nitrate

During biological sample for the three stations, seven different samples were taken from 2003, 2013 and 2014. The nitrate concentrations ranged from 3.5 mg/L to 19 mg/L, with five of the seven greater than 10 mg/L. There were 32 additional samples taken on this reach in 2009-2014 from April through

September. The nitrate concentration ranged from 2.44 mg/L in September, up to 26.2 mg/L in June. About half (15) of the nitrate values were greater than 10 mg/L, with two greater than 20 mg/L. The lowest concentrations were typically seen in August or September, when flows were likely low.

The macroinvertebrates in this reach show a mixed response to elevated nitrate concentrations (Table 279). The nitrate index score ranged from 3.5 to 3.6, while the average for Southern Streams meeting impairment threshold is 2.9. The index score, in addition to the percentage of nitrate tolerant individuals indicates a community dominated by nitrate tolerant taxa. Increasing nitrate concentrations also correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct) and decreased intolerant taxa, both which are lacking in this reach, with the exception of 03MN020 that had 31.6% non-hydropsychid Trichoptera. Overall, there were few nitrate tolerant taxa, but that may be explained by an overall low taxa count. The percentage of nitrate tolerant individuals present, was high at all stations, ranging from 74%-79%. The evidence overall points to nitrate as a stressor in this reach.

Table 279. Macroinvertebrate metrics that respond to nitrate stress in JD31 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
03MN020 (2013)	**3**	31.6	**3.5**	**0**	16	**79.4**
13MN032 (2014)	**2**	**0.63**	**3.6**	**0**	14	**75.5**
13MN032 (2014)	**2**	**2.1**	**3.6**	**0**	10	**74.5**
Southern Streams Average	*6.3*	*5.5*	*2.9*	*2.4*	*18.8*	*47.2*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate a likely stressor. High nitrate concentrations were found to be a chronic issue within this reach, as half of the sample set were found to exceed the standard. In addition, there are indications of limitations to the biology noted within the macroinvertebrate composition as nitrate sensitive taxa were lacking, and the nitrate tolerant species dominated by an overwhelming percentage for all three samples.

Total Suspended Solids

During biological sample for the three stations, seven different total suspended solids (TSS) samples were taken from 2003, 2013 and 2014. The TSS concentrations were low and ranged from 1 mg/L to 29 mg/L. There were 32 additional samples taken on this reach in 2009-2014 from April through September. The average TSS concentration among those samples was 25 mg/L, with a range of 2 to 308 mg/L. Only 3 of the 32 values exceeded the regional standard of 65 mg/L, all which were tied to high precipitation/flow events.

The macroinvertebrate communities throughout the three visits indicated possible TSS stress (Table 280). Only station 03MN020 had low percentage of collector-filterers. All three visits had slightly higher TSS index scores, lacked TSS intolerant taxa and individuals, and had elevated TSS tolerant percentages.

Table 280. Macroinvertebrate metrics that respond to high TSS stress in Little Rock Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
03MN020 (2013)	**15.8**	**0**	**16.60**	**0**	**0**	11	**47**
13MN032 (2014)	47.6	**0**	**16.85**	**0**	**0**	6	**47.6**
13MN032 (2014)	46.7	**0**	**16.59**	**0**	**0**	5	**42.4**
Southern Streams Average	*25.4*	*0.7*	*15.63*	*2.9*	*4.7*	*12.2*	*34.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

The fish community in this reach of Little Rock Creek shows a mixed response to possible TSS stress (Table 281 and Table 282). The metrics that correspond to the TSS standard indicate possible stress with some exceptions at station 13MN032. The TSS index score indicates better scores for this reach than of similar stations meeting the biocriteria. Although there were no TSS intolerant taxa present throughout the reach, the TSS tolerant individuals did not comprise of a large portion of the community.

Table 281. Fish metrics that respond to high TSS stress in Little Rock Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
03MN020 (2003)	37.5	**0**	**21.3**	**0**	**0.6**	**15.9**	**21.6**	**0**	**3.5**
03MN020 (2013)	**12.1**	**0**	**9.1**	**0**	**0**	**3.0**	**9.1**	**0**	**0**
03MN019 (2003)	**30.1**	**0**	**17.3**	**0**	**0.1**	**13.4**	**17.3**	**0**	**8.9**
03MN019 (2013)	**23.4**	**0**	**14.9**	**0**	**4.3**	**10.6**	**14.9**	**2.1**	**4.3**
03MN019 (2014)	**31.3**	**0**	27.2	**0**	**2.8**	**6.7**	**27.2**	**2.5**	**4.7**
13MN032 (2013)	55.6	**0.4**	44.0	**0**	**0.4**	**14.2**	44.4	**2.7**	**2.2**
13MN032 (2014)	42.9	**0**	35.6	**0**	**0.2**	**13.5**	40.9	**11.4**	**0.5**
Southern Streams Average	*36.0*	*5.4*	*25.7*	*4.2*	*13.6*	*20.1*	*30.2*	*16.9*	*19.1*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 282. Fish metrics that respond to high TSS stress in Little Rock Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
03MN020 (2003)	13.9	**0**	**0**	1	0.3
03MN020 (2013)	17.4	**0**	**0**	1	6.1
03MN019 (2003)	16.8	**0**	**0**	**4**	0.7
03MN019 (2013)	14.9	**0**	**0**	1	6.4
03MN019 (2014)	16.4	**0**	**0**	**3**	5.3
13MN032 (2013)	15.5	**0**	**0**	1	0.9
13MN032 (2014)	15.3	**0**	**0**	2	5.0
Southern Streams Average	*19.2*	*1.7*	*5.3*	*2.4*	*12.5*
Expected response to stress	↑	↓	↓	↑	↑

TSS is not considered a stressor. The chemistry data is extensive, with only a few exceedances around the threshold that followed storm events. In addition, both the fish and macroinvertebrate communities did not show signs of TSS stress.

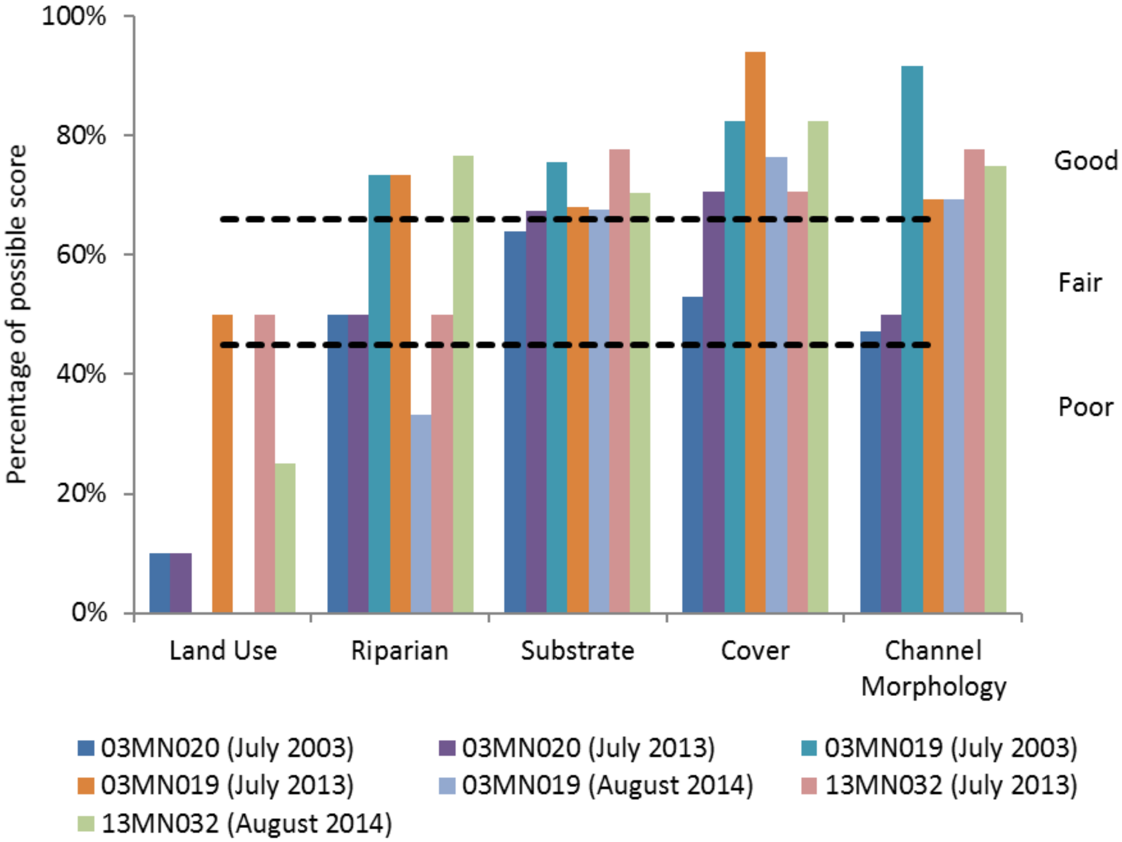
Habitat

The MSHA scores varied between monitoring station and tine of assessment (Figure 314). Station 03MN020 had a fair MSHA score in 2003 (51.25) and in 2013 (56.2). The surrounding land use was predominantly row crop in 2003 and 2013, with some residential/park on the right bank. In 2003, the riparian width was narrow with moderate bank erosion, and mixed shade, from light to substantial. In 2013, the riparian width was narrow on the left bank, but wide on the right bank with little to moderate bank erosion and light shade. In 2003, there were 50% run features in the reach with 25% pool and 25% riffle features. There was presence of boulder, gravel, and sand, but there was also severe embeddedness. Although there were numerous types of cover, the extent of cover in 2003 was sparse (5-25%). In 2013, there was a greater proportion of riffle features noted (40%), with 40% run features and 20% pool features. Cobble, gravel, sand, and clay were present with moderate embeddedness. Cover amount was greater in 2013 with moderate cover noted (25-50%) and five different cover types available.

Station 03MN019 a good MSHA score in 2003 (78.4), in 2013 (72.9), and fair in 2014 (61.25). All visits noted row crop as the surrounding land use, but in 2013, forest, wetland, prairie, shrub also was noted. The riparian width varied with the year visited, moderate in 2003, extensive in 2013, and narrow in 2014. Bank erosion was moderate in 2003 and heavy in 2013 and 2014. Heavy shade was noted in 2003 and 2013, but in 2014 dropped to moderate. In 2003, there was 50% run features, 20% riffle features, and 30% pool features in the reach, with light embeddedness. In 2013, there was 50% run features, 35% riffle features, and 15% pool features, with moderate embeddedness. In 2014, there was 45% run features, 15% riffle features, and 40% pool features, with light embeddedness. The riffles were predominantly cobble and gravel and the pools and runs were gravel and sand. Cover throughout the three visits was moderate to extensive with many types of cover available. The reach maintained good depth variability through all three visits, with good to excellent sinuosity and channel development. The channel stability varied from high in 2003, moderate in 2013 and 2014.

Station 13MN032 had MSHA scores that were good in 2013 and 2014 (71 and 72.75) and another visit that was fair in 2014 (61.5). The surrounding land use was row crop and forest, wetland, prairie, shrub. In 2013, the riparian width was noted as none, where as in 2014 extensive. Bank erosion was little to moderate, with substantial shade both years. In 2013, the reach had 50% run features, 35% riffle features, and 15% pool features. The substrates available were boulders, cobble, gravel, and sand, with light embeddedness. In 2014, the proportions of features were very similar, with similar substrates, and light embeddedness. In 2013, there was moderate cover amount noted and in 2014, extensive cover. There were many types of cover available both years. There was good depth variability, good/excellent sinuosity, good/excellent channel development, and moderately high channel stability.

Figure 279. Percentage of MSHA subcategory scores for stations 03MN020, 03MN019, and 13MN032, Little Rock Creek.

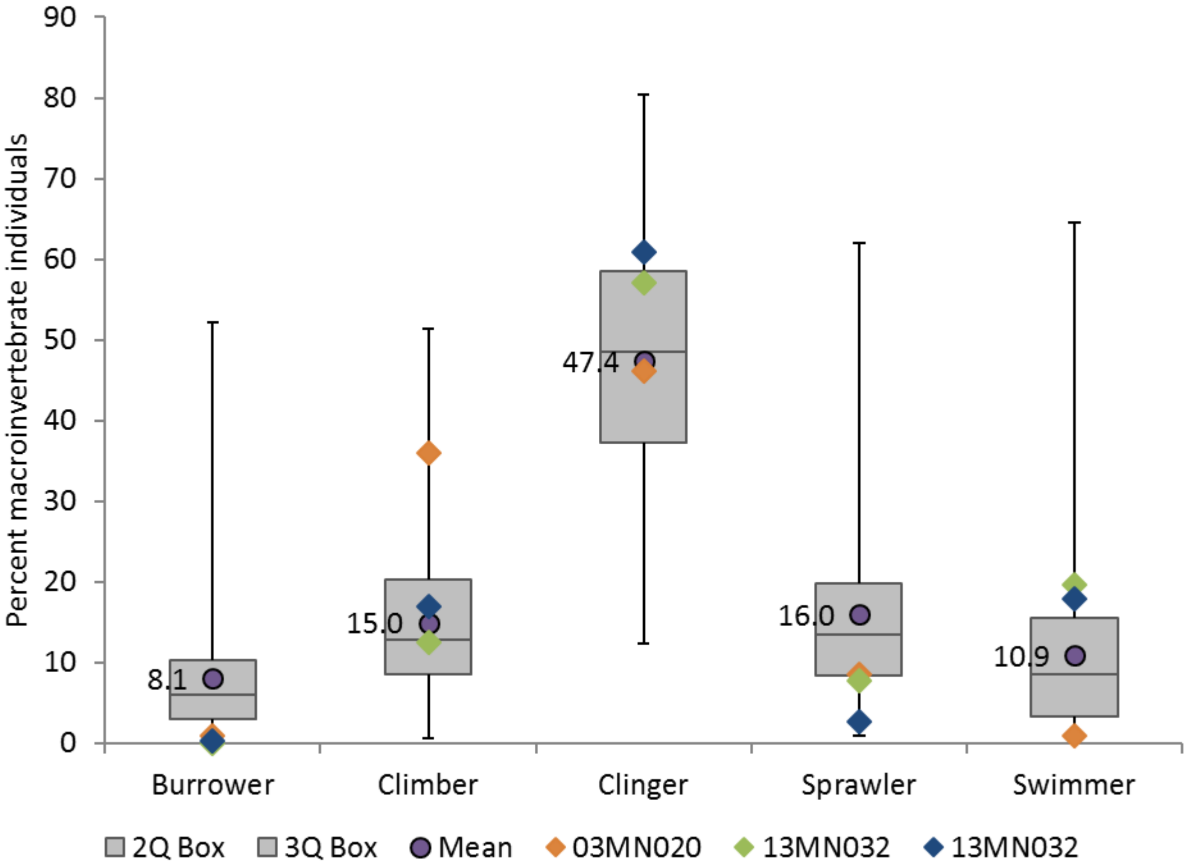


The fish community metrics give a mixed response related to habitat stress (Table 281). Benthic insectivores (BenFdFrimPct) were mixed among stations, with 13MN032 having the highest percentages overall. Similarly, riffle dwelling species (RifflePct) were higher than average at 13MN032, but lower than average at the other stations. Simple lithophilic spawners (SLithFrimPct) were reduced at all stations. Overall, these observations support what seems like better habitat conditions at 13MN032 compared to the other stations.

As displayed in Figure 280 below, the macroinvertebrate community at stations 03MN020 and 13MN032 did not have an abundance of burrowers. There were slightly higher proportions of climbers at station 03MN020. There was a lack of climber taxa as seen in the MIBI metrics, particularly for station

13MN032 visits. This visit also showed higher than average swimmer individuals, which may be tied to flow conditions as swimmers favor slow velocities.

Figure 280. Macroinvertebrate habit metrics with box plot showing range of values from Southern Streams stations meeting the general use biocriteria mean of those stations, and metric values from stations 03MN020 and 13MN032



Bank erosion is common, and moderate to severe embeddedness was also noted in the MSHA visits. Excess sediment and instability is noted in all the monitoring photos. The overall stability of the channel has also been declining over the course of site visits by the MPCA. While the MSHA scores are fair to good, they do appear variable, which may be due to variable flow conditions. Fish seem to show consistent response among all sites, with the exception of site 13MN032. When flow conditions are low, less habitat is available for biology and can limit fish mobility. There are several photos of the streambed drying up completely, or showing severely reduced flow. Overall, the habitat conditions could use improvement in this reach and are likely dependent on flow conditions in any given year (Figure 281). Habitat is a stressor in Little Rock Creek.

Figure 281. Station 03MN019 at the downstream end of the reach, demonstrating variable flow and habitat variability in three monitoring years (From Left to Right: May 2003, July 2013 and August 2014).

Longitudinal Connectivity and Altered Hydrology

Longitudinal connectivity is considered to be a stressor, due to low flows within the Little Rock Creek stream system. Utilizing Google Earth, there was no water present approximately 0.6 mi. upstream of Hwy 21 on April 22, 2015 and approximately 0.5 mi. downstream. On September 8, 2015, Jon Lore, DNR, photographed the stream with no water and appearance of ATV tracks through the streambed (Figure 282).

It is uncertain if this is a natural occurrence due to the underlying geology and slope change of the stream as it enters the Minnesota River valley. Other streams that are direct tributaries to the Minnesota River exhibit similar losing reaches.

During lower flow conditions when the streambed is dry, fish connectivity is an issue. All of the stations are upstream of this portion of the creek. The furthest downstream station had 16 species of fish present in 2014.

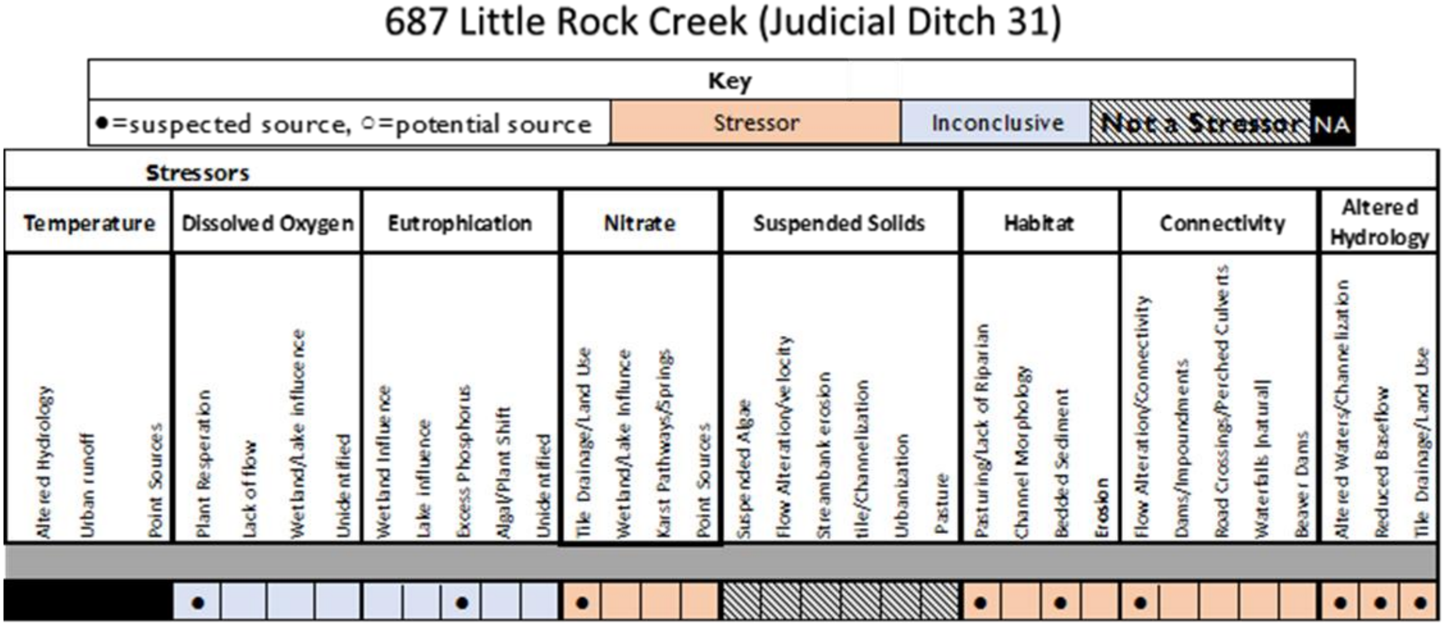
Figure 282. Little Rock Creek, September 8, 2015, photograph curtesy of Jon Lore, DNR.

It is plausible that the stream has lost its longitudinal connectivity, during times of low flow due to upstream altered hydrology that inhibits the streams water recharge potential via reservoirs, groundwater, and subsurface water exchange interactions.

Altered hydrology is considered the primary stressor within this reach, as the upland drainage area of this stream system had been modified via diching as well as the introduction of subsurface tile drainage. These practices alter the natural flow regime (that directly contribute stream instability and erosion rate, as well as increase nutrient inputs (such as nitrate) into the stream. For additional information on how this form of altered hydrology impacts reaches within the watershed, reference Chapter 3.1.8 of this report.

Summary Table

Table 283. Identified stressors with suspected sources for reach 687 of Little Rock Creek.



687 Little Rock Creek (Judicial Ditch 31)

Key

●=suspected source, ○=potential source | Stressor | Inconclusive | Not a Stressor | NA

Stressors																																	
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls (natural)	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
■	■	■	●						●			●				▨	▨	▨	▨	▨	▨	●		●		●					●	●	●

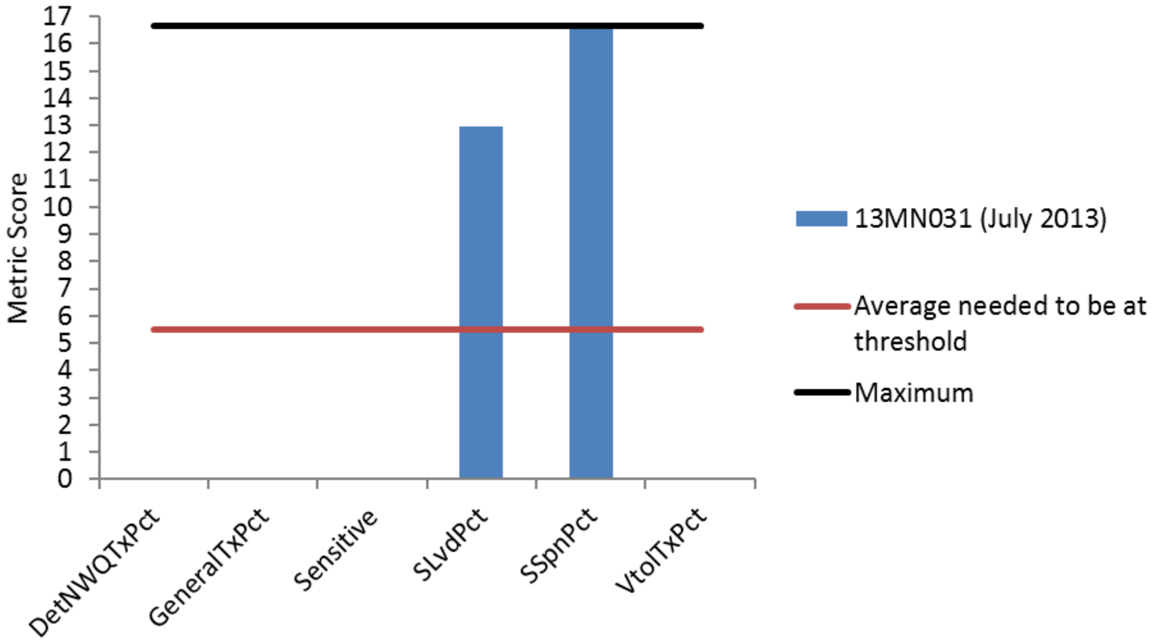
4.27 Judicial Ditch 13 (07020007-716)

Judicial Ditch 13 (07020007-716) is southeast of Fairfax, Minnesota. The reach is warmwater modified use Class 2B. The reach extends from unnamed ditch to County Road 5. This reach of Judicial Ditch 13 is impaired for lack of fish assemblage. There is one biological station located upstream of CR5, station 13MN031.

4.27.1 Biological Communities

There was fish data collected from 13MN031 in 2013, with a fish IBI score of 30, below the modified use impairment threshold (Figure 283). The fish community consisted of two tolerant species, creek chub and blacknose dace. The macroinvertebrate community scored 17 points above the modified use threshold, and therefore is considered fully supporting.

Figure 283. Fish metrics of the Southern Headwaters class IBI for station 13MN031, Judicial Ditch 13.



4.27.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

There were two oxygen measurements on this reach, collected during biological sample in 2013. Both values were in normal range (7.97 mg/L and 12.03 mg/L). Five additional values were collected in 2015 and 2016 at S008-510; all were in the normal range (8.73 mg/L to 13.03 mg/L). Two of the 2016 values were taken before 9 am, when DO conditions are usually lowest.

There were only two fish species sampled in this reach, creek chub and blacknose dace. Based on the fish community present the probability of the reach meeting the DO standard is 64.6%. These two fish are not sensitive, and are considered tolerant, however, they are not the most DO tolerant fish either (Table 284). Overall, it is hard to assess impacts of low DO to the fish community metrics when only two species are present.

Table 284. Fish metrics that respond to low DO in Judicial Ditch 13 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
13MN031 (2013)	**0**	**0**	**100**	7.40	**0**	**0**	0	0
Southern Headwaters (Modified) Average	*4.5*	*11.7*	*79.9*	*7.00*	*0.4*	*2.2*	*3.5*	*28.4*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

While the biological metrics provide some indication low DO could be a stressor, there is very little chemical data to support those conditions exist in this stream. Additional information should be collected to help confirm or rule out DO as a stressor, therefore DO is inconclusive at this time.

Eutrophication

Total phosphorus (TP) concentrations from two of six samples in this reach were above 0.15 mg/L, the river eutrophication standard for the Southern Region. These samples were collected in 2015 and 2016, with one from the biological sample in 2013. There was one chlorophyll-a sample collected in 2015, which was very low at 3 ug/L, but no other data was available to assess impacts due to eutrophication. Site visits did document some potential for excess algal growth () displays filamentous algae growing in the streambed.

The only fish species in this reach were creek chub and blacknose dace. Neither of them are darters; sensitive, or intolerant (Table 285). Blacknose dace are simple lithophilic spawners and both are considered tolerant. The metrics may have indicated possible eutrophication stress, but with only two species present, it is difficult to make a connection.

Table 285. Fish metrics that respond to eutrophication stress in Judicial Ditch 13 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
13MN031 (2013)	**0**	**0**	**22.1**	**100**	**2**	**0**
Southern Headwaters Average	*4.5*	*8.5*	*27.9*	*79.9*	*10.4*	*0.8*
Expected response to stress	↓	↓	↓	↑	↓	↓

Until further information can be collected, eutrophication is considered inconclusive. Chemistry data is lacking to clearly understand the dynamics occurring within this reach. Furthermore, while the fish metrics indicate a negative response that correlates to eutrophic conditions, the metrics could be easily skewed due to the small sample size of two taxa types.

Nitrate

During the biological sample, the nitrate concentration at 13MN031 was high, at 22 mg/L (July 10, 2013). There were five additional samples taken on this reach in 2015 and 2016. The nitrate concentration ranged from 1.8 mg/L to 32 mg/L. Four of the five samples were greater than 20 mg/L, with two greater than 30 mg/L.

Fish often do not show strong response to increased nitrate concentrations. Macroinvertebrate communities are often more affected by nitrate. The macroinvertebrates in this reach are not impaired, but show consistent indication they are stressed by the elevated nitrate concentrations (Table 286). The nitrate index score was 3.7, while the average for Prairie Streams meeting impairment threshold is 3.2. This suggests that overall the community present is tolerant to high nitrate concentrations. Increasing nitrate concentrations also correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct) and nitrate intolerant taxa, both of which are lacking abundance in this reach. There are a high number of nitrate tolerant taxa and individuals as well.

Table 286. Macroinvertebrate metrics that respond to nitrate stress in the Judicial Ditch 13 compared to the statewide average of visits meeting the modified use (MU) biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN031 (2013)	**2**	**1.3**	**3.7**	**0**	**24**	**81.3**
*Prairie Streams Average **(MU)***	*2.6*	*2.4*	*3.2*	*1.1*	*18.0*	*59.7*
Expected response to stress	↓	↓	↑	↓	↑	↑

While nitrate concentrations are high, and macroinvertebrates are showing consistent biological response, elevated nitrate is not likely the reason fish are impaired in this reach but they could be playing a role in shaping the macroinvertebrate community. Regardless, actions to mitigate nitrate transport in this watershed are important. At this time, nitrate is inconclusive as a stressor to the impaired fish community.

Total Suspended Solids

During the biological sample, the total suspended solids (TSS) concentration at 13MN031 was low, at 5.6 mg/L (July 10, 2013). There were five additional samples taken on this reach in 2015 and 2016, all showing low TSS concentrations. The average was 13 mg/L, with a maximum of 20 mg/L, all well within the standard set for the Southern Region (65 mg/L).

Due to only two species of fish sampled (creek chub and blacknose dace); the metrics are skewed and not considered useful for metric data analysis. The fish sampled here are neither overly intolerant nor tolerant to TSS generally (Table 287 and Table 288).

Table 287. Fish metrics that respond to high TSS stress in Judicial Ditch 13 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
13MN031 (2013)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Southern Headwaters Average	*27.3*	*0.7*	*17.8*	*0.8*	*4.3*	*10.3*	*19.9*	*4.5*	*12.0*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 288. Fish metrics that respond to high TSS stress in Judicial Ditch 13 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN031 (2013)	15.1	**0**	**0**	0	0
Southern Headwaters Average	*16.2*	*0.5*	*2.9*	*0.5*	*2.5*
Expected response to stress	↑	↓	↓	↑	↑

TSS is not a stressor to the fish community in this reach. Fish metrics are misleading in this case, as the fish community metrics are greatly skewed due to the low diversity of the sample. TSS concentrations were consistently found to be minimal.

Habitat

The MSHA at station 13MN031 was poor (36.5) in 2013. The surrounding land use was row crop, contributing to the low MSHA score (Figure 284). There was a narrow riparian width, with moderate bank erosion, and moderate to light shade noted during the visit. The reach was 100% run features with predominantly sand and gravel substrates, contributing to homogenous substrate availability and moderate embeddedness. Cover amount was moderate (25-50%), with undercut banks, overhanging vegetation, and macrophytes. The reach had poor depth variability, fair sinuosity, poor channel development, and low channel stability. As shown in Figure 285, below this stream is highly unstable, resulting in slumping of banks. In addition, there is a clear display of homogenous streambed.

Figure 284. Percentage of MSHA subcategory scores for station 13MN031, Judicial Ditch 13.

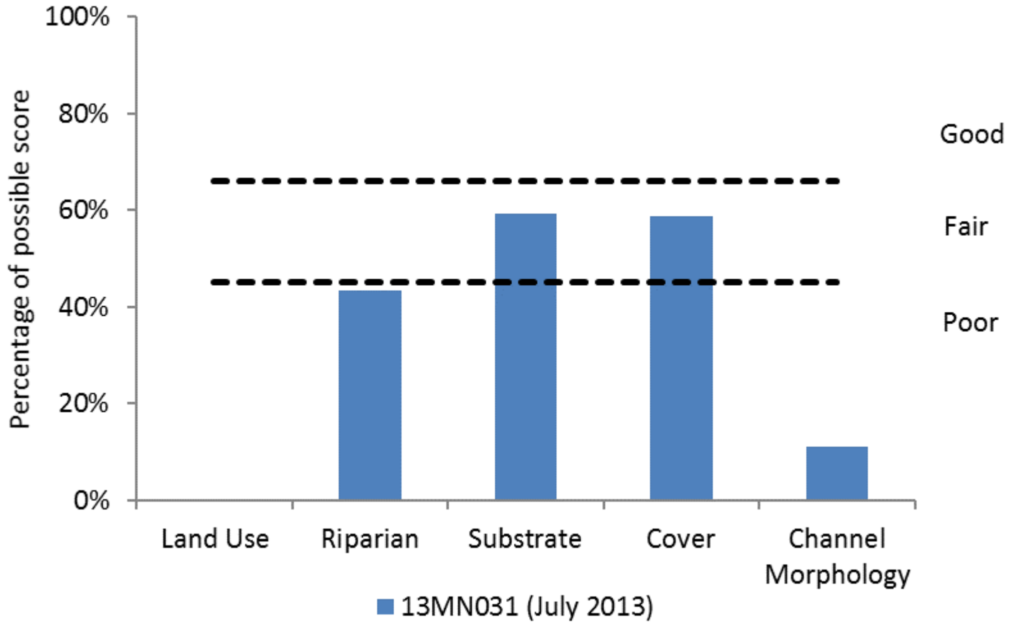


Figure 285. Slumping of banks at site 13MN031 on July 10, 2013.

The fish community metrics do suggest habitat may be an issue with reduced numbers of benthic insectivores, riffle dwelling species, and simple lithophilic spawners (Table 287). These metrics can indicate limitations in fish habitat, among other stressors. It is also important to consider that only two species were sampled in this reach, which creates bias in metric responses.

Habitat is a stressor within this reach of Judicial Ditch 13. This reach is considered modified, and habitat has already been determined to be limited due to this designation. That coupled with a poor MSHA score, and few fish species present support that lack of habitat is stressing the impaired fish community.

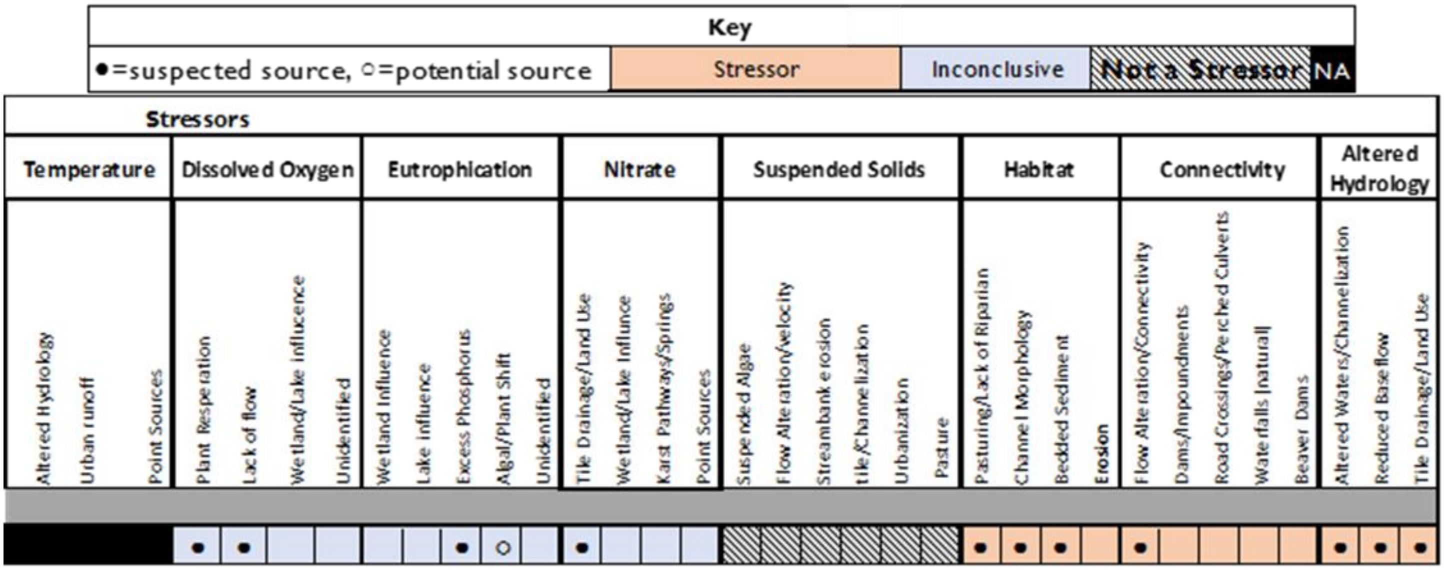
Longitudinal Connectivity and Altered Hydrology

Longitudinal connectivity is considered a stressor. Farther downstream of the confluence with JD 13, Little Rock Creek has been documented as a losing reach, which prevents fish from migrating upstream from the Minnesota River during certain times of the year. During these times, fish are cut off from not only downstream, but also upstream sources as well (see Mud Lake outlet barrier discussion in previous sections). These limitations are highly variable depending on time of year and hydrologic conditions. Everything upstream on this site is altered by way of channelization and subsurface tile drainage that have impacts to the flow regime of the stream. Within this stream, those changes are seen in the loss of habitat related to stream instability, as well as the homogenous features from ditching. Loss of water recharge is also impacted, although it is not known to what extent, as the water cycle has been greatly altered. What is known is the loss of wetlands, and change in flow patterns are likely playing a role in the loss of water recharge to the stream. For additional information on altered hydrology occurring within this watershed, reference Chapter 3.1.8 of this report.

Conclusion

Table 289. Identified stressors with suspected sources for reach 716 of Judicial Ditch 13.

716 Judicial Ditch 13



Key				
●=suspected source, ○=potential source	Stressor	Inconclusive	Not a Stressor	NA

Stressors

Temperature			Dissolved Oxygen				Eutrophication				
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake Influcence	Unidentified	Wetland Influence	Lake Influence	Excess Phosphorus	Algal/Plant Shift	Unidentified
			●	●					●	○	

Nitrate				Suspended Solids					
Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture
●									

Habitat				Connectivity					Altered Hydrology		
Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
●	●	●		●					●	●	●

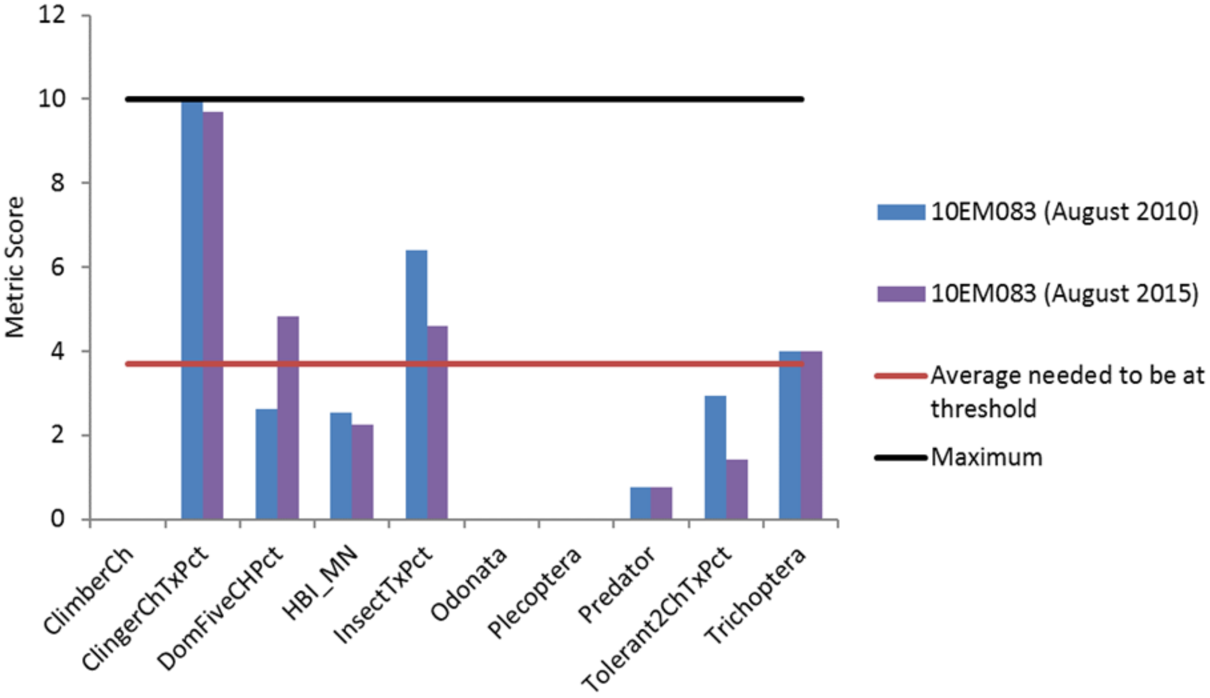
4.28 Judicial Ditch 13 (07020007-717)

Judicial Ditch 13 (07020007-717) is southeast of Fairfax, Minnesota. The reach is warmwater general use Class 2B. The reach extends from County Road 5 to Little Rock Creek. This reach of Judicial Ditch 13 is impaired for lack of fish assemblage and lack of macroinvertebrate assemblage. There is one biological station (10EM083).

4.28.1 Biological Communities

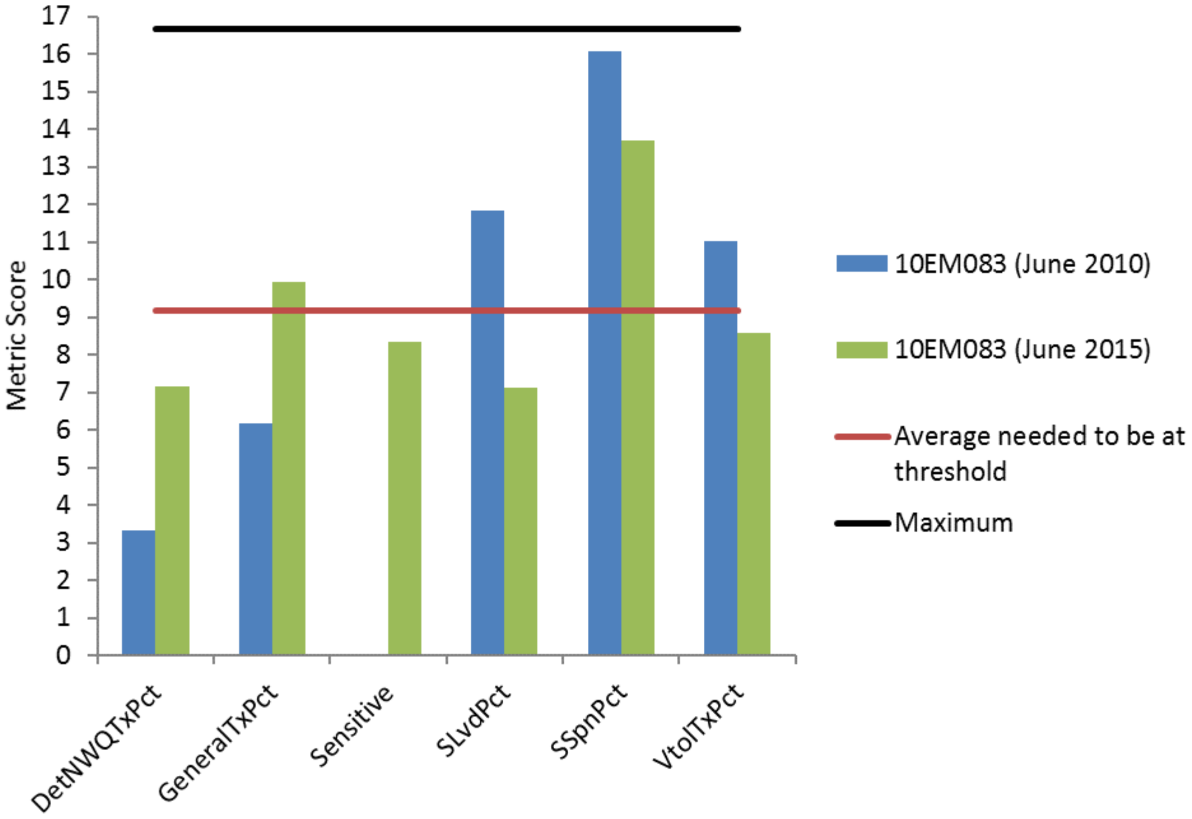
There was one station (10EM083) sampled for macroinvertebrates in 2010 and 2015. The sample scored well below impairment threshold (21 in 2010 and 25 in 2015). There was a high percent of the dominant five taxa (DomFiveCHPct), an elevated measure of pollution based on tolerance values assigned to each individual taxon developed by Chirhart (HBI_MN), a complete absence of sensitive stonefly and dragonfly taxa (Plecoptera and Odonata) were noted in both sample years. There was also a consistent absents of climbers (ClimberCh), replaced by an elevated percentage of tolerant taxa (Tolerant2ChTxPct) (Figure 286).

Figure 286. Macroinvertebrate metrics of the Southern Streams class IBI for station 10EM083, Judicial Ditch 13.



There were two fish sampling visits at 10EM083 (Figure 287). In 2010, the fish scored 48, which is below impairment threshold (55). In 2015, the site scored right at impairment threshold. Detritivorous (DetNWQTxPct) and tolerant “generalist” fish species (GeneralTxPct) were noted in both samples. These two metric groups will increase in the presents of a stressed community. 2010, differed from the 2015, fish sample, as there were not any sensitive species sampled in 2010 and was dominated by very tolerant species (VtolTxPct), whereas 2015, nearly met the average in both sensitive species and very tolerant. Short lived (SLvdPct) as well as serial spawner species (SSpnPct) made up a large portion of the community, these fish types are also typically tolerant and lack the need of specific habitats.

Figure 287. Fish metrics of the Southern Headwaters class IBI for station 10EM083, Judicial Ditch 13.



4.28.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

During biological sample at 10EM083, the dissolved oxygen (DO) values were normal, at 9.08 mg/L and 9.93 mg/L. No other oxygen related chemical data exists on this reach. Additional data on dissolved oxygen would be helpful in determining stressor status.

The macroinvertebrate community at station 10EM083 had a mixed response to possible low DO stress. There were fewer low DO intolerant taxa and proportion of individuals than similar stations meeting the biocriteria, yet there were a low percentage of low DO tolerant individuals. The other metrics were worse from the average of similar stations meeting the biocriteria, but not greatly different. In 2015, the metrics responded a bit more favorably (Table 290). Overall, there is not strong indication, based on the biology, that low DO is stressing the macroinvertebrates.

Table 290. Macroinvertebrate metrics that respond to low DO stress in Judicial Ditch 13 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
10EM083 (2010)	**40**	**13**	**7.48**	7.29	**5**	**13.5**	**5**	3.7
10EM083 (2015)	**31**	**8**	**7.58**	7.20	**6**	24.7	4	8.0
Southern Streams Average	*45.8*	*14.2*	*7.08*	*7.04*	*9.0*	*24.0*	*4.8*	*9.9*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Fish also show a mixed response to low DO stress (Table 291). Overall, the community does not appear to be dominated by DO tolerant species, yet does not have many sensitive taxa either. Overall, looking at the macroinvertebrate and fish metrics, there is not a strong indication that low DO is impacting the biology at this time.

Table 291. Fish metrics that respond to low DO stress in Judicial Ditch 13 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
10EM083 (2010)	**0**	**6.9**	**86.1**	7.29	**0**	**0**	3	4.6
10EM083 (2015)	**1.2**	**3.5**	**84.5**	7.35	1	**0.9**	**4**	11.5
Southern Headwaters Average	*7.9*	*13.9*	*72.8*	*7.12*	*0.75*	*4.24*	*3.38*	*20.23*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is inconclusive as a stressor. There is very little chemistry data collected at this location to be able to determine typical DO of the stream. In addition to little data to evaluate, the biological metrics in both communities are extremely mixed in indicating low DO and a limiting factor for the population.

Eutrophication

During biological sampling, total phosphorus (TP) concentrations were low, at 0.051 and 0.080 mg/L, both which are well below the 0.150 standard set for the southern eutrophication region. Chlorophyll-a, BOD, and DO flux are also considered when evaluating eutrophication stress, but no data on those interacting variables exist for this reach.

The macroinvertebrate community was suggestive of eutrophication stress (Table 292). However, the metric results were worse than the average of similar stations meeting the biocriteria, but they were not vastly different. The fish community exhibited mixed results to possible eutrophication stress. There was a lack of sensitive individuals in the survey and a high proportion of tolerant individuals, but there were a high percentage of darters and simple lithophilic spawners as well (Table 293).

Table 292. Macroinvertebrate metrics that respond to eutrophication stress in Judicial Ditch 13 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
10EM083 (2010)	**40**	9	**14**	**11**	**0**	**80**
10EM083 (2015)	**31**	6	**9**	**8**	**0**	**87**
Southern Streams Average	*45.8*	*7.3*	*15.9*	*12.2*	*0.8*	*72.6*
Expected response to stress	↓	↓	↓	↓	↓	↑

Table 293. Fish metrics that respond to eutrophication stress in Judicial Ditch 13 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
10EM083 (2010)	**0**	11.6	32.9	**86.1**	**10**	**0**
10EM083 (2015)	**1.2**	8.0	54.4	**84.5**	14	**0**
Southern Headwaters Average	7.9	11.5	31.5	72.8	11.5	1.6
Expected response to stress	↓	↓	↓	↑	↓	↓

Eutrophication is inconclusive as a stressor. There are a few biological metrics that do point to the potential for eutrophication as a stressor. However, with a lack of chemical data connecting the two, eutrophication as a stressor is inconclusive. More information needs to be collected on this stressor to confirm or refute it as a stressor.

Nitrate

During biological sample, there were two nitrate values recorded from June 15, 2010 and June 17, 2015. Both values were high, at 21 mg/L and 26 mg/L. No additional nitrate data was available on this reach.

The macroinvertebrates in this reach show consistent indication they are stressed by the elevated nitrate concentrations (Table 294). The nitrate index score was 3.5, while the average for Southern Streams meeting impairment threshold is 2.9. This suggests that overall the community present is quite tolerant to high nitrate concentrations. Increasing nitrate concentrations also correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct) and decreased intolerant and Trichoptera taxa, all of which are lacking in this reach. Additionally, the number of nitrate tolerant individuals and taxa are higher than average.

Table 294. Macroinvertebrate metrics that respond to nitrate stress in JD 13 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
10EM083 (2010)	**6**	**2.8**	**3.5**	**1**	**20**	**68.7**
10EM083 (2015)	**4**	**2.8**	**3.5**	**0**	17	**71.5**
Southern Streams Average	*6.3*	*5.5*	*2.9*	*2.4*	*18.8*	*47.2*
Expected response to stress	↓	↓	↑	↓	↑	↑

Elevated nitrate is a stressor in this reach, primarily concluded by the clear response in the biological metrics. While there was limited nitrate data collected, what was sampled at the time of the biological sample was over twice the threshold.

Total Suspended Solids

During biological sample, there were two total suspended solids (TSS) values recorded from June 15, 2010 and June 17, 2015. Both values were low, at 4 mg/L and 6 mg/L. No additional TSS data was available on this reach.

The macroinvertebrate community has some suggestion of possible TSS stress (Table 295). The TSS index score is slightly elevated compared to the average of similar stations meeting the biocriteria. Fifty percent of the community was tolerant to TSS.

Table 295. Macroinvertebrate metrics that respond to high TSS stress in Judicial Ditch 13 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
10EM083 (2010)	45.2	**0**	**16.82**	**0**	**0**	7	**50.0**
10EM083 (2015)	54.4	**0**	**16.74**	**1**	**0.9**	10	**49.2**
Southern Streams Average	*25.4*	*0.7*	*15.63*	*2.9*	*4.7*	*12.2*	*34.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

The fish community had a mixed response to possible TSS stress (Table 296 and Table 297). Many of the metrics were lower than the average of similar stations meeting the biocriteria, but the TSS index score was less than the average, indicating that overall the community was not overly tolerant. There were neither TSS intolerant nor TSS tolerant taxa dominating the community.

Table 296. Fish metrics that respond to high TSS stress in Judicial Ditch 13 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
10EM083 (2010)	**28.9**	**0**	**17.3**	**0**	**0**	**11.6**	**17.3**	**0**	**6.9**
10EM083 (2015)	**15.1**	**0**	**7.1**	**0**	**0**	**8.0**	**8.0**	**1.2**	**3.5**
Southern Headwaters Average	*35.0*	*1.0*	*22.4*	*1.6*	*4.5*	*13.6*	*26.2*	*7.9*	*31.5*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 297. Fish metrics that respond to high TSS stress in Judicial Ditch 13 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

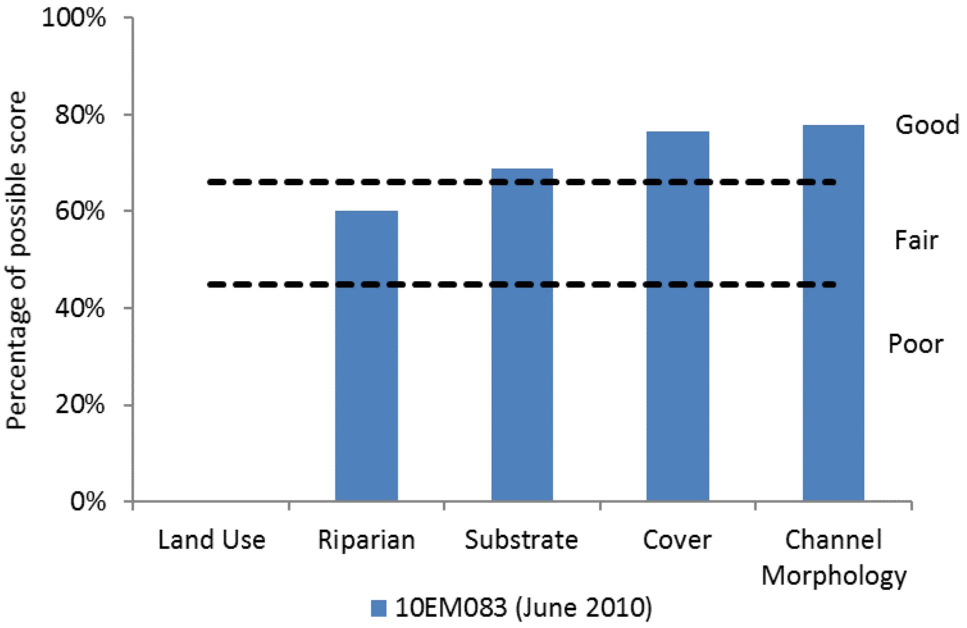
Station (Year sampled)	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
10EM083 (2010)	14.7	**0**	**0**	0	0
10EM083 (2015)	14.0	**0**	**0**	0	0
Southern Headwaters Average	*15.4*	*0.9*	*4.1*	*0.4*	*2.0*
Expected response to stress	↑	↓	↓	↑	↑

The biological data is not clearly indicating TSS as a primary limitation to the community. In addition to this, chemical data is lacking, and therefore TSS as a stressor is inconclusive until it can be fully ruled out.

Habitat

Station 10EM083 scored 68.6, which is considered a “good” MSHA score (Figure 288). The surrounding land use was row crop; the riparian width was very narrow, with little bank erosion and substantial shade. The reach was comprised of 50% run features, 30% riffle features, and 20% pool features. The riffle features had predominantly cobble and gravel, and the pool and run features had predominantly gravel and sand. The reach had moderate embeddedness. The cover amount was also noted as moderate, with undercut banks, deep pools, logs or woody debris, boulders, rootwads, and macrophytes. The reach exhibited good depth variability, with fair sinuosity, excellent channel development, and moderately high channel stability.

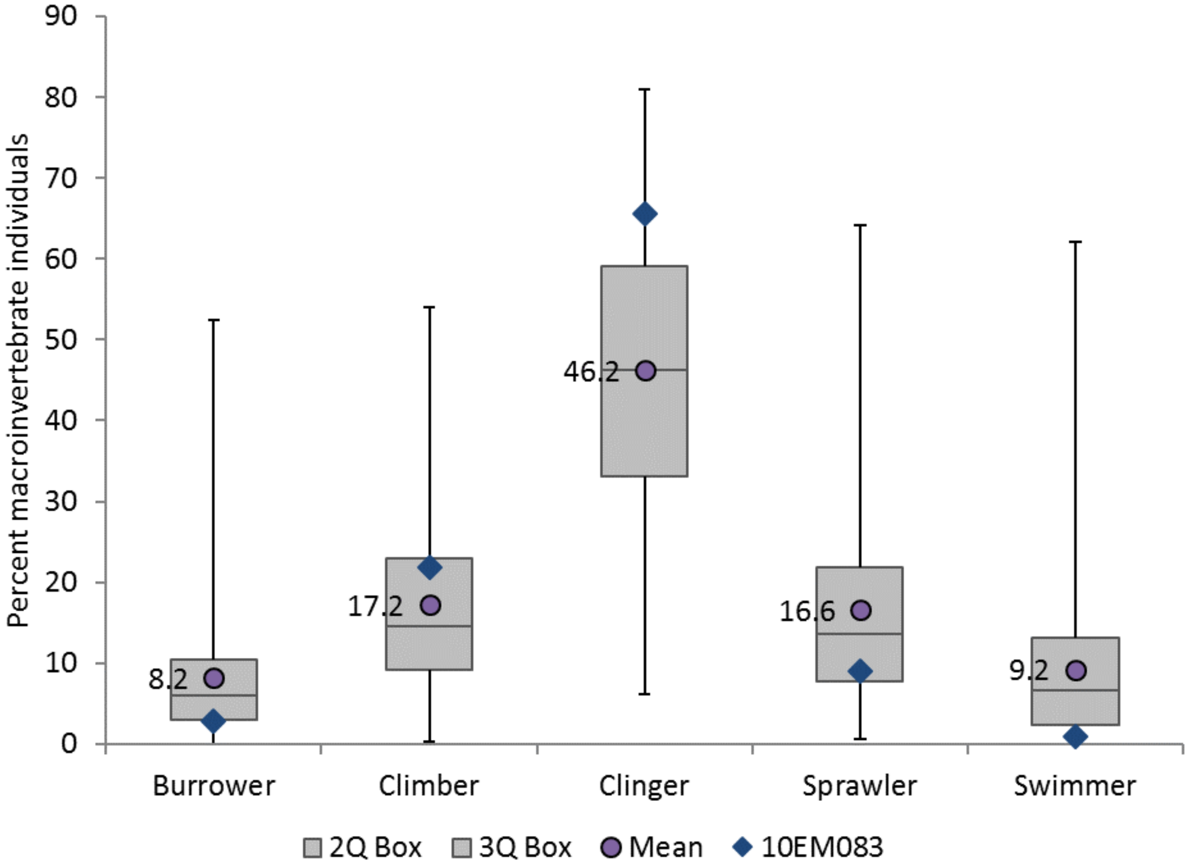
Figure 288. Percentage of MSHA subcategory scores for station 10EM083, Judicial Ditch 13.



The fish community metrics do suggest habitat may be an issue with reduced numbers of benthic insectivores, riffle dwelling species, and simple lithophilic spawners (Table 296). These metrics can indicate limitations in fish habitat, among other stressors.

The macroinvertebrate community seemed to have a good proportion of individuals amongst the different habitat preferences (Figure 289). Although there were few climbing taxa as seen in the MIBI metrics. Overall, these metrics appear to be in normal ranges and do not show strong indication of habitat related stress. The macroinvertebrates in this reach seem to have their habitat needs met, as shown in the variation of communities that rely on specific habitat characteristics.

Figure 289. Macroinvertebrate habit metrics with box plot showing range of values from Southern Streams stations meeting the general use biocriteria mean of those stations, and metric values from station 10EM083.



Fish may be impacted by the instability of the stream as well as diminishing habitat variation. Throughout the monitoring period, site 10EM083 has been declining in channel stability, as the bank erosion rates have elevated to severe. There is variation in channel types; however, there is moderate embeddedness that limits the fish community that depends on clean and sandy substrate. This could be the reason why lithophilic spawners, and benthic feeders were found below the threshold (seen in the above Table 296).

Figure 290. Biological monitoring location 10EM083 taken September 16, 2009.

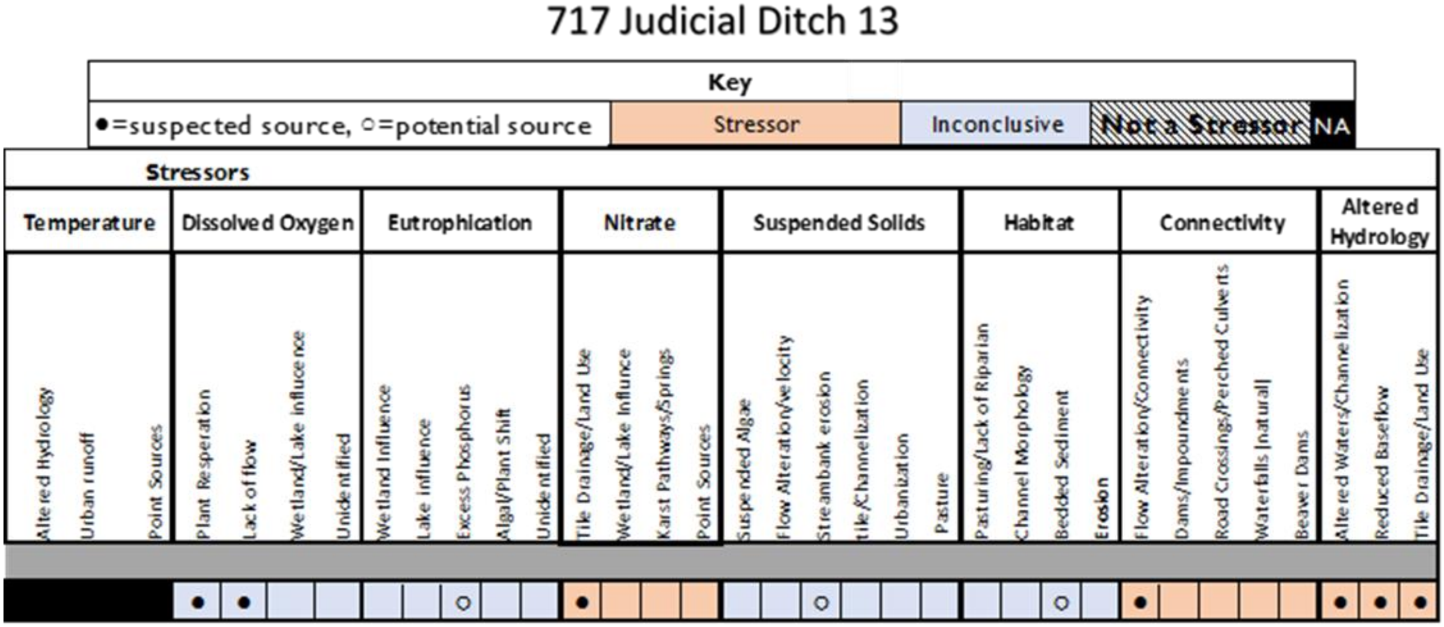
At this time habitat is inconclusive. If the stability of this channel is to decline, so will the habitat. At the time of monitoring, the macroinvertebrate community did not seem to be impacted from habitat degradation. The fish community was lacking many key groups that are telling of habitat degradation, but it is not clear if habitat is what is limiting these populations, or another biological stressor such as a connectivity issue. It should be highlighted that although this is a ditch, it has not been dredged out for some time, allowing natural stream features to reappear (as shown in Figure 290 above). In the future, it will be interesting to reassess the location to see if habitat and community metrics improve if the ditch is left undisturbed.

Longitudinal Connectivity and Altered Hydrology

Longitudinal connectivity is a stressor. Farther downstream of the confluence with JD 13, Little Rock Creek has been documented as a losing reach, which prevents fish from migrating upstream from the Minnesota River during certain times of the year. During these times, fish are cut off from not only downstream, but also upstream sources as well (see Mud Lake outlet barrier discussion in previous sections). These limitations are highly variable depending on time of year and hydrologic conditions. Altered hydrology also impacts longitudinal and lateral stream connectivity, as well as water quality and stream geomorphology. Headwaters that feed into this site are largely modified for agricultural drainage, seen by ditching and channelizing the channel, as well as the introduction of subsurface tile drainage. These practice greatly alter the natural flow regime of the system, often contributing to instable channels, as well as increased nutrient inputs. For additional information on these forms of altered hydrology, reference Chapter 3.1.8 of this report.

Summary Table

Table 298. Identified stressors with suspected sources for reach 717 of Judicial Ditch 13.



717 Judicial Ditch 13

Key

●=suspected source, ○=potential source | Stressor | Inconclusive | Not a Stressor | NA

Stressors

Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls (natural)	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
			●	●					○			●						○						○		●					●	●	●

Little Rock Creek Subwatershed Conclusion

There are five warm water reaches impaired for biology in this 10 digit HUC. All five streams are impaired for fish. Macroinvertebrates are impaired on all but one, Judicial Ditch 13 (716). The biological stressors vary with the stream types that were assessed. Judicial Ditch 8 (-666), JD 8 (-686), and JD 13 (-716) are located in the upland areas of the watershed as were assessed as warm water modified streams. Little Rock Creek (-687) and JD (-717) are on the lower section of the watershed as assessed as warm water general streams. The primary stressors within this subwatershed are altered hydrology, as it is the driver for other impairments found, in addition to connectivity that is disrupting fish migration.

Altered hydrology is occurring two ways within this subwatershed. The first is through subsurface tile drainage and the second is stream channel alteration by ditching and channelizing. Alterations in this region are from agricultural practices in attempt to expedite water off the land to optimize growing conditions. Both of these practices initiate altered hydrology in the system. The streams are taking on volumes of water greater than what they are naturally designed to carry. This results in accelerated flow velocity and significantly changes the morphology of the stream at the receiving location as well as downstream areas. Due to the geomorphology of these locations, the severity if impairments lightens as the headwaters of Little Rock Creek begins in the flat agricultural dominant uplands, as the stream down cuts through the Minnesota River Valley, the gradient drastically changes. In areas where gradient is increased, there is a strong correlation of better stream stability, habitat availability, and in some regards water quality. This is largely due to the natural vegetation that is mitigating upstream influences.

Low dissolved oxygen (DO) and eutrophication are closely associated with stream type and surrounding land use. The only stream reach (JD 8) that had clear eutrophic conditions was located in the upland areas of this subwatershed that is land use is agricultural dominant. Within these areas, the stream's natural canopy cover will be limited or completely absent, allowing for an overabundance of sunlight. Paired with heavy input of phosphorus (a limiting nutrient that dictates autotrophic growth) and a slow stream velocity (from lack of gradient); these streams provide optimal conditions for overproduction of algae growth. Other sites lacked chemistry data (secondary lines of evidence of CBOD, chlorophyll-a, DO flux) to confirm eutrophication was taking place in the upland areas and therefore are marked inconclusive. There were readings of high phosphorus in all but one site. Low dissolved oxygen was found to be limiting the biology at the upstream monitoring sites, driven from the eutrophic conditions of high amount of algae.

Nitrate samples were found at toxic levels throughout the entire system and were limiting the macroinvertebrate communities at all locations. Nitrates at JD 13 (-716) is listed as inconclusive, as macroinvertebrates as a whole were not listed as impaired, although they did indicate some degree of nitrate stress. The primary impute of nutrients such as phosphorus and nitrates is from agricultural subsurface tile drainage.

Total Suspended Solids was not clearly identified as a limiting factor to the biological communities within this subwatershed. Additional sampling is needed to determine TSS conditions of this stream.

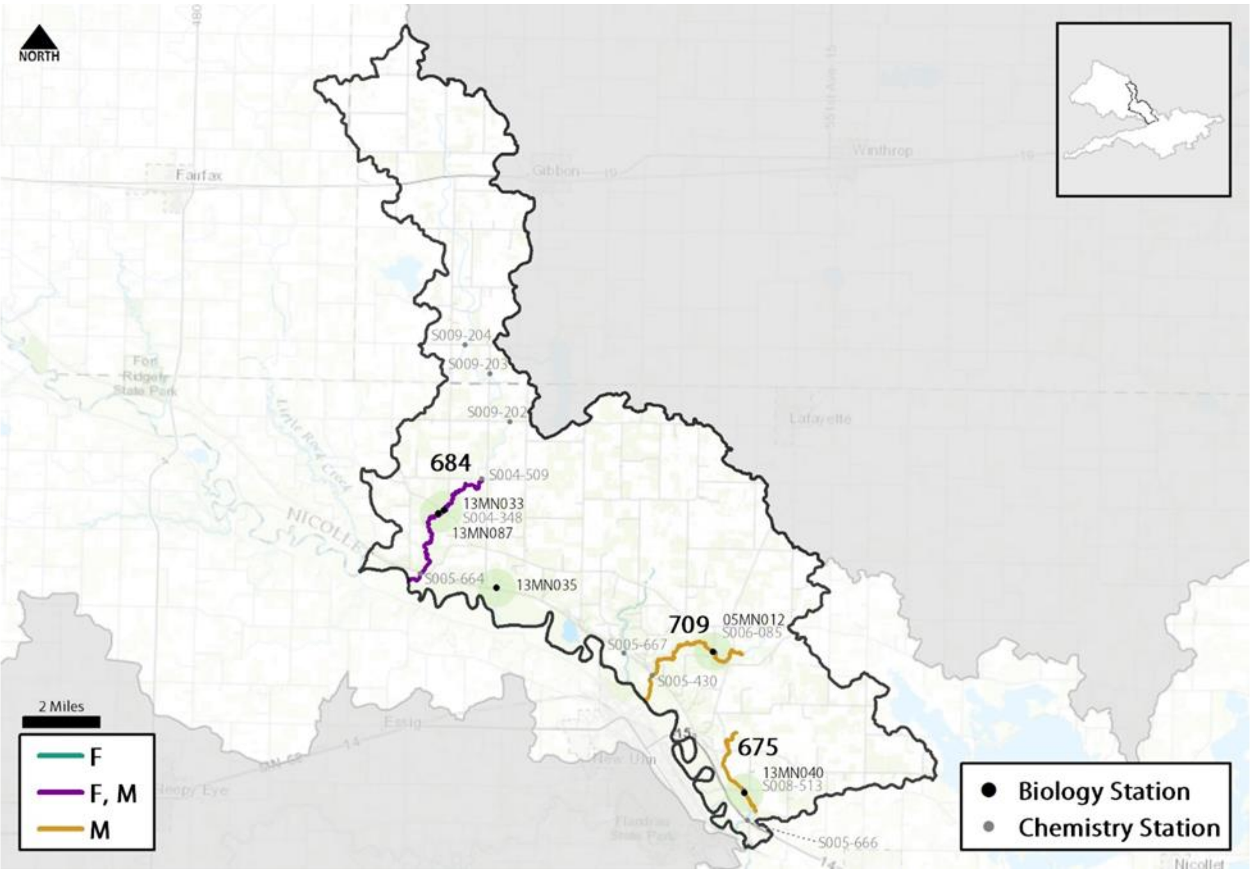
Connectivity is another stressor that is likely a result of altered hydrology within the subwatershed. At some site visits within Little Rock Creek, the streambed was completely dry. It is uncertain how much, if any of this is a natural occurrence due to the underlying geology and slope, change of the stream as it enters the Minnesota River Valley. Future flow analyses to determine if this is a natural, losing reach is recommended.

Mud Lake is a shallow small lake that Little Rock Creek flows through; the outlet of this lake has a 5-foot drop, creating a fish barrier.

City of New Ulm – MNR Mankato North

This section encompasses biotic impaired reaches in the New Ulm 10 digit HUC. There are three warmwater reaches impaired for biology in this 10 digit HUC. Eightmile Creek (07020007-684) is impaired for both fish and macroinvertebrate assemblage. Fritsche Creek (07020007-709) and Heyman’s Creek (07020007-675) are both warmwater reaches with impairments for macroinvertebrate assemblage.

Figure 291. Map of the City of New Ulm watershed with biological impairments and monitoring stations. Impairments are described as F=Fish, F, M=Fish and Macroinvertebrates, and M=Macroinvertebrates.



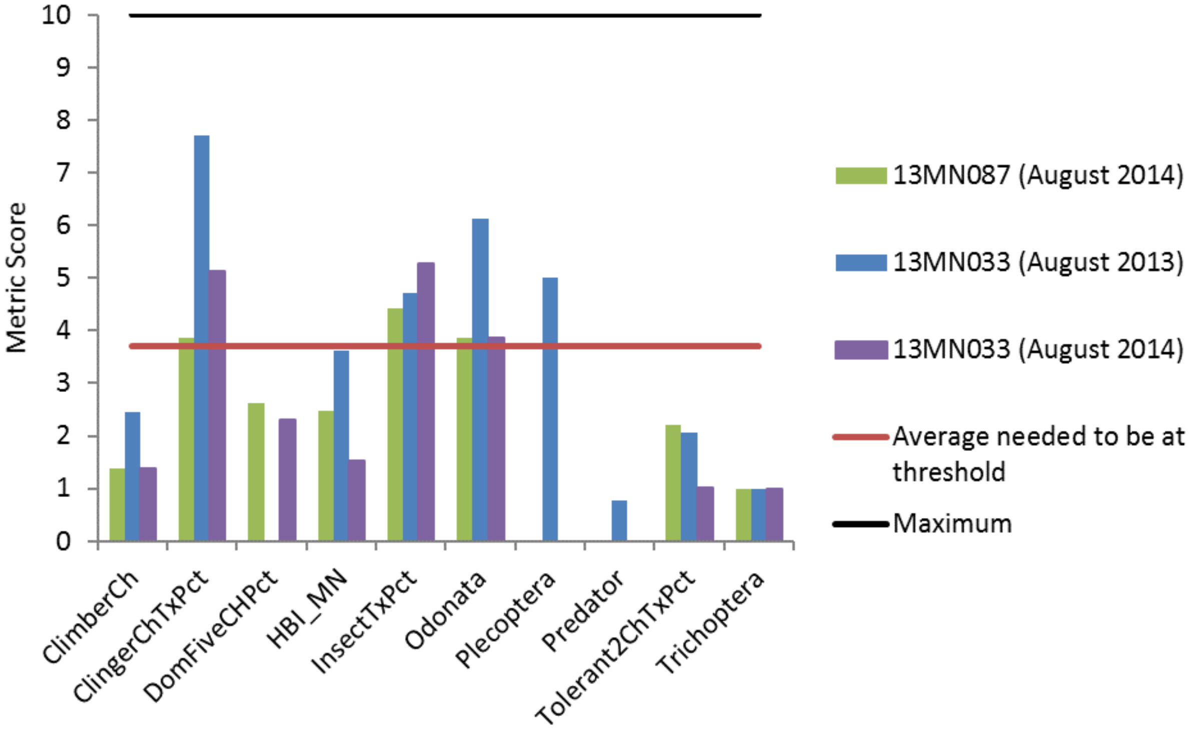
4.29 Eightmile Creek (07020007-684)

Eightmile Creek (07020007-684) is northwest of New Ulm, Minnesota. The reach is warmwater general use Class 2B. The reach extends from 366th St. to the Minnesota River. Eightmile Creek is impaired for lack of fish assemblage and lack of macroinvertebrate assemblage. There are two biological stations on this reach, station 13MN087 (upstream) and 13MN033 (downstream).

4.29.1 Biological Communities

There were three macroinvertebrates visits on two stations (13MN033, 13MN087) sampled in 2013, and 2014. The 13MN033 sample collected in 2013 scored 4 points below impairment threshold. The samples collected in 2014 scored below the threshold as well. There was a lack of stonefly taxa (Plecoptera), except at 13MN033 in 2013, a lack of climbers at all visits (ClimberCh), predators, an elevated percentage of tolerant taxa (Tolerant2ChTxPct), and general lack of caddisflies (Trichoptera) (Figure 292).

Figure 292. Macroinvertebrate metrics of the Southern Streams class IBI for stations 13MN087 and 13MN033, Eightmile Creek



There were four fish samples taken at the two biological stations in 2013 and 2014, all scoring well below impairment threshold. The majority of fish metrics scored below the average needed to meet impairment threshold, with only one (SSpnPct) with good metrics scores. This metric shows that there was not an overabundance of fish that are considered serial spawners at 13MN087 (Figure 293). Serial spawning fish are fish that continuously spawn and therefore can survive in many adverse conditions. At station 13MN033, which is in a different fish class, almost all the IBI metrics scored below the average needed to meet the threshold (Figure 294).

Figure 293. Fish metrics of the Southern Headwaters class IBI for station 13MN087, Eightmile Creek.

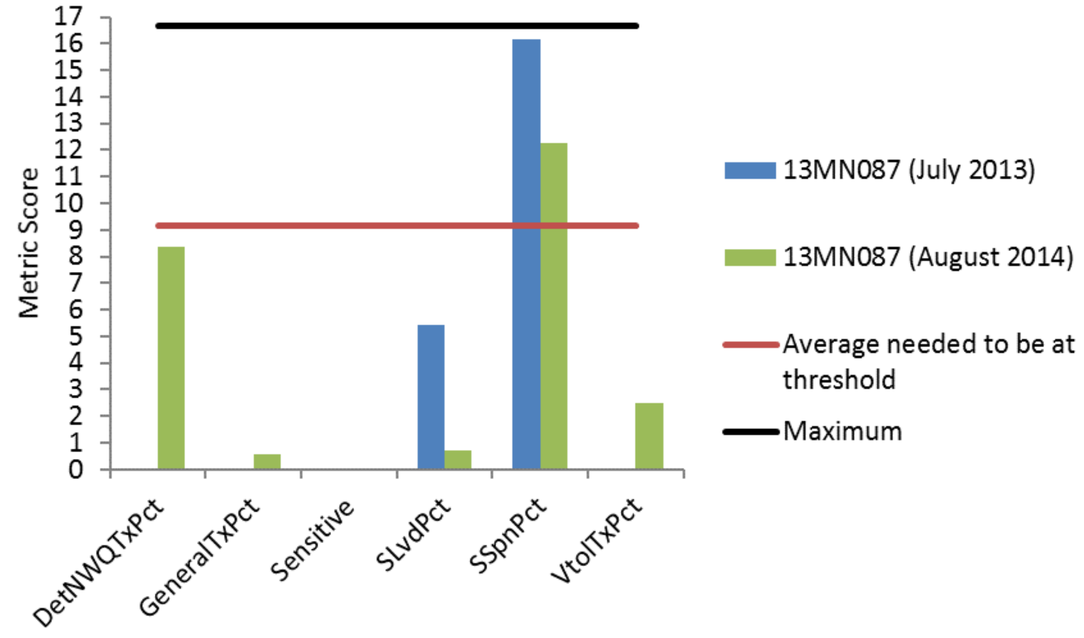
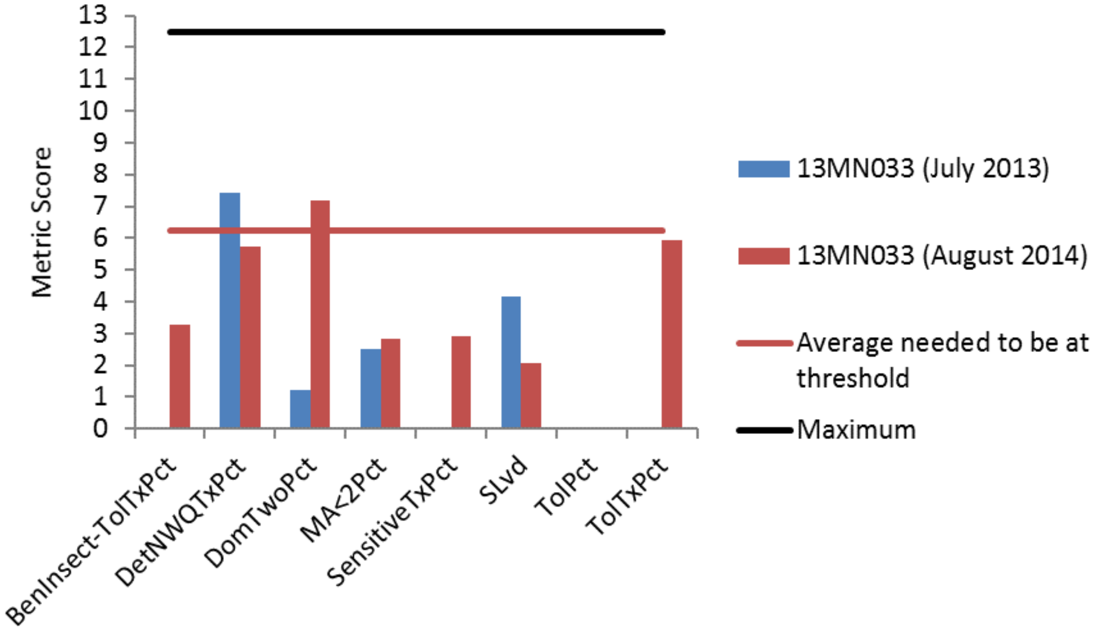


Figure 294. Fish metrics of the Southern Streams class IBI for station 13MN033, Eightmile Creek.



4.29.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

Water chemistry data was available at two chemistry and two biological monitoring stations collected between 2009 and 2016 from this reach of Eightmile Creek. Of the 21 values collected, dissolved oxygen (DO) concentrations were normal (none violating the DO standard of 5 mg/L). The range of concentrations was 5.38 to 11.87 mg/L, with an average of 7.99 mg/L. Early morning data is limited to three measurements before 9 am, all near 8 mg/L. Additional early morning DO data or diurnal DO would be helpful in understanding the DO dynamics on this stream.

The three macroinvertebrate visits had mixed results to possible low DO stress (Table 299). The Hilsenhoff Biotic Index for Minnesota was slightly elevated as well as a lower number of EPT taxa. However, the low DO index score was better than the average of similar stations meeting the biocriteria. There were less low DO intolerant individuals but there were also less low DO tolerant individuals in the sample. Overall, there is not strong or consistent indication that macroinvertebrates are stressed due to low DO.

Table 299. Macroinvertebrate metrics that respond to low DO stress in Eightmile Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN087 (2014)	**30**	**6**	**7.50**	7.29	**4**	**9.5**	**6**	9.8
13MN033 (2013)	**25**	**8**	**7.12**	7.58	**4**	**13.2**	2	2.2
13MN033 (2014)	**27**	**6**	**7.83**	7.33	**3**	**15.4**	**5**	8.7
Southern Streams Average	*45.8*	*14.2*	*7.08*	*7.04*	*9.0*	*24.0*	*4.8*	*9.9*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Similarly, fish are not showing strong response to low DO (Table 300). The DO index score for fish is better than average for stations meeting the biocriteria. The percentages of low DO tolerant taxa are fewer than average, yet there were a high percentage of generally tolerant individuals (TolPct). This tells us that the majority of fish individuals are generally tolerant at these stations, but are not necessarily tolerant of low DO, which means other stressors could be the reason. Overall, the chemical and biological data are not pointing to DO as a stressor to the biological communities.

Table 300. Fish metrics that respond to low DO stress compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
13MN087 (2013)	**0**	**0**	**100**	7.63	**0**	**0**	1	14.09
13MN087 (2014)	**0**	**0**	**100**	7.66	**0**	**0**	1	2.56
Southern Headwaters Average	*7.9*	*13.9*	*72.8*	*7.12*	*0.75*	*4.24*	*3.38*	*20.23*
13MN033 (2013)	**0.79**	**18.1**	**83.5**	7.55	**0**	**0**	**5**	10.14
13MN033 (2014)	**0**	36.2	**98.5**	7.38	**1**	**0.6**	**7**	12.10
Southern Streams Average	*16.9*	*24.6*	*44.9*	*7.20*	*1.71*	*5.94*	*4.69*	*18.54*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is not considered a biological stressor. Low do concentrations were not found in the water quality samples. In addition, both the macroinvertebrate community as well as the fish community did not indicate low DO stress within the sample.

Eutrophication

Total phosphorus (TP) concentrations on this reach ranged from 0.09 mg/L to 0.499 of 31 total values collected from 2010-2014. Only four of the values exceeded 0.15 mg/L, the river eutrophication standard for the Southern Region. Chlorophyll-a, BOD, and DO flux are also considered when evaluating eutrophication stress, but no data on those interacting variables exist for this reach.

The macroinvertebrate community in Eightmile Creek is suggestive of possible eutrophication stress (Table 301). There were fewer collector-filterer and collector-gatherer taxa than the average of similar stations meeting the biocriteria. Taxa count, EPT, and intolerant taxa are also reduced, which may be related to eutrophication or tied to other stressors.

Table 301. Macroinvertebrate metrics that respond to eutrophication stress in Eightmile Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN087 (2014)	**30**	**3**	**8**	**6**	**0**	**83.3**
13MN033 (2013)	**25**	**3**	**7**	**8**	**0**	**84**
13MN033 (2014)	**27**	**5**	**7**	**6**	**0**	**88.9**
Southern Streams Average	*45.8*	*7.3*	*15.9*	*12.2*	*0.8*	*72.6*
Expected response to stress	↓	↓	↓	↓	↓	↑

The fish metrics at station 13MN087 may be skewed due to the low number of species and the fish barrier present (discussed in the longitudinal connectivity section). Station 13MN033 had some indications of stress due to eutrophication. There were little to no sensitive or darter individuals and a high proportion of tolerant individuals (Table 302). However, there was abundance of simple lithophilic spawners and in 2014, there was near the average of similar stations meeting the biocriteria of taxa.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
13MN087 (2013)	**0**	**0**	64.1	**100**	**3**	**0**
13MN087 (2014)	**0**	**0**	74.1	**100**	**4**	**0**
Southern Headwaters Average	*7.9*	*11.5*	*31.5*	*72.8*	*11.5*	*1.6*
13MN033 (2013)	**0**	**0**	44.9	**98.6**	**11**	**0**
13MN033 (2014)	**0.8**	**4.4**	44.8	**83.5**	**19**	**0**
Southern Streams Average	*16.9*	*11.9*	*37.0*	*44.9*	*19.3*	*4.2*
Expected response to stress	↓	↓	↓	↑	↓	↓

Eutrophication as a stressor is considered inconclusive. While high TP was not consistently found to be above the threshold, there was some samples to indicate it can reach extreme levels. There is a lack of secondary chemistry data to indicate a eutrophic response within the stream. The macroinvertebrate community did show indication if eutrophic stress, however the biological metrics were mixed to indicate eutrophic stress for the fish community.

Nitrate

During biological sampling from four visits at two stations in 2013 and 2014, the nitrate concentrations ranged from 10-25 mg/L. There were 30 additional samples taken on this reach from 2009-2013, with an average value of 15 mg/L. The maximum concentration recorded was 30 mg/L, with 22 of the total values greater than 10 mg/L, and 8 greater than 20 mg/L. The samples that were greater than 20 mg/L, were all collected in either May or June. Lower concentrations were observed later in the summer when flows are reduced.

The macroinvertebrates in this reach show a fairly consistent response to elevated nitrate concentrations (Table 302). The nitrate index score ranged from 3.3 to 3.9, while the average for Southern Streams meeting impairment threshold is 2.9. The index score, in addition to the percentage of nitrate tolerant individuals indicates a community dominated by nitrate tolerant taxa. Increasing nitrate concentrations also correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct) and decreased intolerant taxa, both which are lacking in this reach.

Table 302. Macroinvertebrate metrics that respond to nitrate stress in Eightmile Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN087 (2014)	**3**	**0.6**	**3.5**	**0**	**21**	**62.8**
13MN033 (2013)	**3**	**4.0**	**3.3**	**0**	**19**	41.3
13MN033 (2014)	**3**	**0.6**	**3.9**	**0**	**18**	**81.6**
Southern Streams Average	*6.3*	*5.5*	*2.9*	*2.4*	*18.8*	*47.2*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is a stressor. Nitrate values were found to be chronically high within this reach. In addition, the macroinvertebrate metrics do indicate that nitrate is limiting the community.

Total Suspended Solids

During biological sample from four visits at two stations in 2013 and 2014, the total suspended solids (TSS) concentrations ranged from 5.2 mg/L to 20 mg/L. There were 28 additional samples taken on this reach from 2009-2013, with an average value of 31 mg/L. The maximum concentration recorded was 359 mg/L, with the majority of the samples meeting the standard. Further review of the raw dataset shows that two gross exceedances of the 65 mg/L standard occurred during times which hydrograph and precipitation data indicates a high flow event was occurring which is typical with high sediment loads. Even with these two samples, the exceedance rate does not reach 10%. Surrogate secchi tube dataset is more limited with no exceedances of the standard over a two-year period.

The macroinvertebrate community had a relatively high abundance of collector-filterers, which can be reduced with increases in TSS. The TSS index score was near the average of similar stations meeting the biocriteria at station 13MN087, but was elevated indicating possible stress at station 13MN033 (Table 303). None of the visits had any TSS intolerant taxa and the 2014 visits resulted in high percentages of TSS tolerant individuals.

Table 303. Macroinvertebrate metrics that respond to high TSS stress in Eightmile Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN087 (2014)	36.0	**0**	15.60	**0**	**0**	9	**37.7**
13MN033 (2013)	56.0	**0.3**	**16.23**	**0**	**0**	7	23.2
13MN033 (2014)	26.9	**0**	**17.67**	**0**	**0**	9	**56.6**
Southern Streams Average	*25.4*	*0.7*	*15.63*	*2.9*	*4.7*	*12.2*	*34.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

Due to the barrier, it is difficult to utilize the fish metric data at station 13MN087 as the data is potentially skewed. Station 13MN033 indicated plausible stress from TSS with some of the metrics (Table 304 and Table 305). Station 13MN033 had no TSS intolerant taxa; however, few tolerant taxa and in 2014, a low percentage of those TSS tolerant individuals. The fish TSS index scores were relatively low as well.

Table 304. Fish metrics that respond to high TSS stress in Eightmile Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
13MN087 (2013)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
13MN087 (2014)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Southern Headwaters Average	*35.0*	*1.0*	*22.4*	*1.6*	*4.5*	*13.6*	*26.2*	*7.9*	*31.5*
13MN033 (2013)	**14.5**	**0**	**14.5**	**0**	**1.4**	**0**	**14.5**	**0**	**0**
13MN033 (2014)	**21.2**	**0.8**	**17.7**	**0**	**1.4**	**5.2**	**17.7**	**0.8**	**0.4**
Southern Streams Average	*36.0*	*5.4*	*25.7*	*4.2*	*13.6*	*20.1*	*30.2*	*16.9*	*19.1*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 305. Fish metrics that respond to high TSS stress in Eightmile Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN087 (2013)	12.9	**0**	**0**	0	0
13MN087 (2014)	13.3	**0**	**0**	0	0
Southern Headwaters Average	*15.4*	*0.9*	*4.1*	*0.4*	*2.0*
13MN033 (2013)	19.2	**0**	**0**	2	**27.5**
13MN033 (2014)	15.3	**0**	**0**	**3**	2.6
Southern Streams Average	*19.2*	*1.7*	*5.3*	*2.4*	*12.5*
Expected response to stress	↑	↓	↓	↑	↑

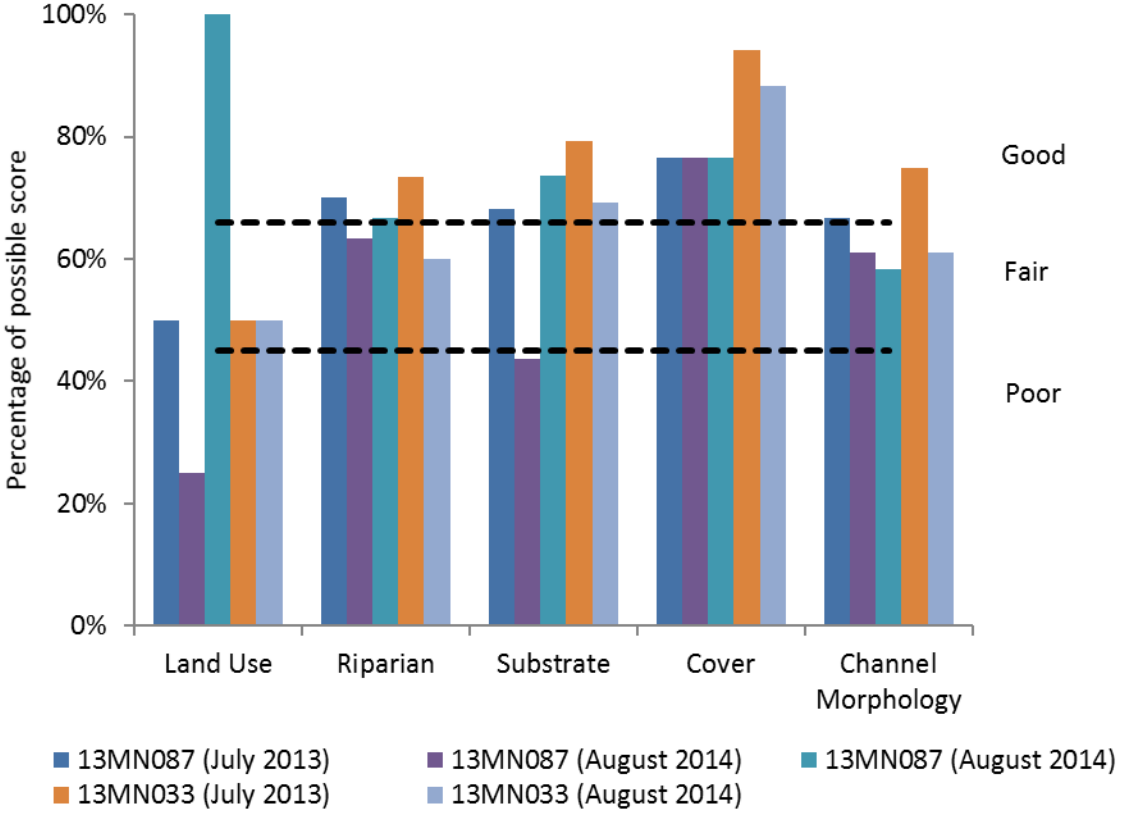
TSS is inconclusive as a stressor at this time. There was a fairly large dataset that rarely fell above the threshold for TSS. However, what did exceed the standard was of concern and was tied to rain events. This could be indicating some instability of the stream, particular upstream. The biological metrics were mixed and did not clearly indicate that TSS is a limitation to the biologic communities.

Habitat

Station 13MN087 MSHA scores ranged from fair to good (Figure 295). The visits noted the surrounding land use as a combination of row crop and forest, wetland, prairie, and shrub. In 2013, the riparian width was noted as extensive with heavy shade. The bank erosion was noted as heavy to severe. In 2013, the reach was comprised of 50% run features, 30% riffle features, and 20% pool features. At all three visits, the riffles had predominantly cobble and gravel, and the reach had moderate embeddedness, except the first visit in August 2014 had no embeddedness noted. Each of the visits noted moderate amounts of cover with numerous types available.

Station 13MN033 scored good at all three visits. The surrounding land use was a mix of row crop and forest, wetland, prairie, or shrub. The riparian width was extensive, with heavy to severe bank erosion but heavy shade. In the visits, the stream features had decent proportions of riffles, runs, and pools providing diverse habitat types. The substrate was also diverse, with gravel and cobble in the riffle features, and only light embeddedness. There was moderate to extensive cover available, good depth variability with excellent sinuosity and channel development.

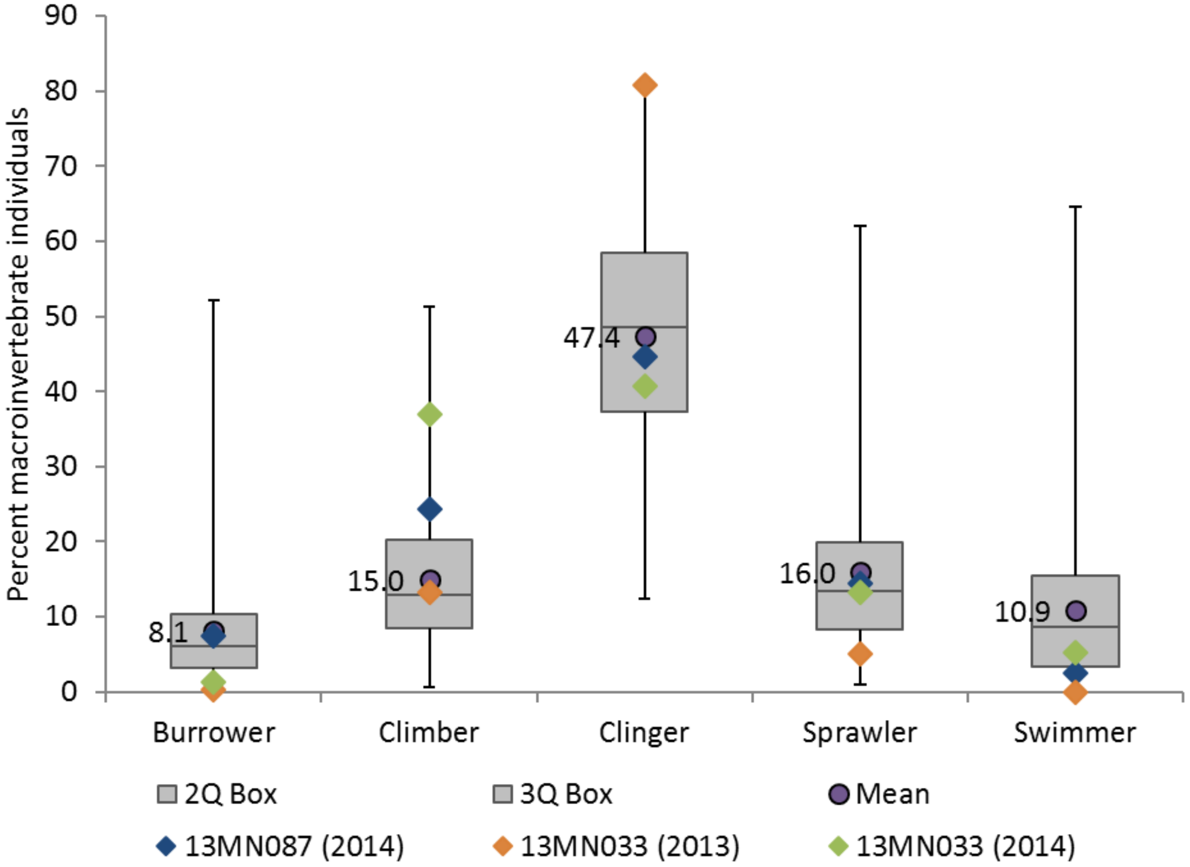
Figure 295. Percentage of MSHA subcategory scores for stations 13MN087 and 13MN033, Eightmile Creek



The fish community here had no benthic insectivores, riffle dwelling species, or simple lithophilic spawners, which can be metrics suggesting a response to poor habitat conditions. However, due to the barrier, it is difficult to utilize the fish metric data at these stations, as that could be responsible for the response seen.

The macroinvertebrate related metrics, were fairly in line with the similar stations meeting the biocriteria (Figure 296). Climber taxa and clinger taxa seemed to be within normal ranges. There was not an overabundance of burrower or sprawlers taxa that can indicate fine sedimentation.

Figure 296. Macroinvertebrate habit metrics with box plot showing range of values from Southern Streams stations meeting the general use biocriteria mean of those stations, and metric values from stations 13MN087 and 13MN033



Habitat is inconclusive. For the most part, habitat diversity and quality seems to be abundant. However, there are some indication of stream instability that can compromise the quality. The sporadic embeddedness of the substrate paired with erosive streambanks will often lead to a reduction in available habitat. The fish metrics were limited, therefore not a good indicator for habitat metric measurements.

Longitudinal Connectivity and Altered Hydrology

Longitudinal Connectivity is a stressor. At CR 5 and Eightmile Creek, there is a perched culvert. There is one biological station upstream of the culvert (13MN087) and one downstream of the road culvert (13MN033). The two stations were sampled for fish on the same dates in 2013 and 2014. The upstream station is impacted by the culvert with fewer species present both years (Table 306). There are additional stressors present affecting the communities since both stations have low FIBI scores. However, the perched culvert is clearly stressing the fish community upstream and limiting the fish diversity upstream of this barrier. For more information on the perched culvert, please refer to the DNR's Minnesota River, Mankato Watershed Characterization Report (2015).

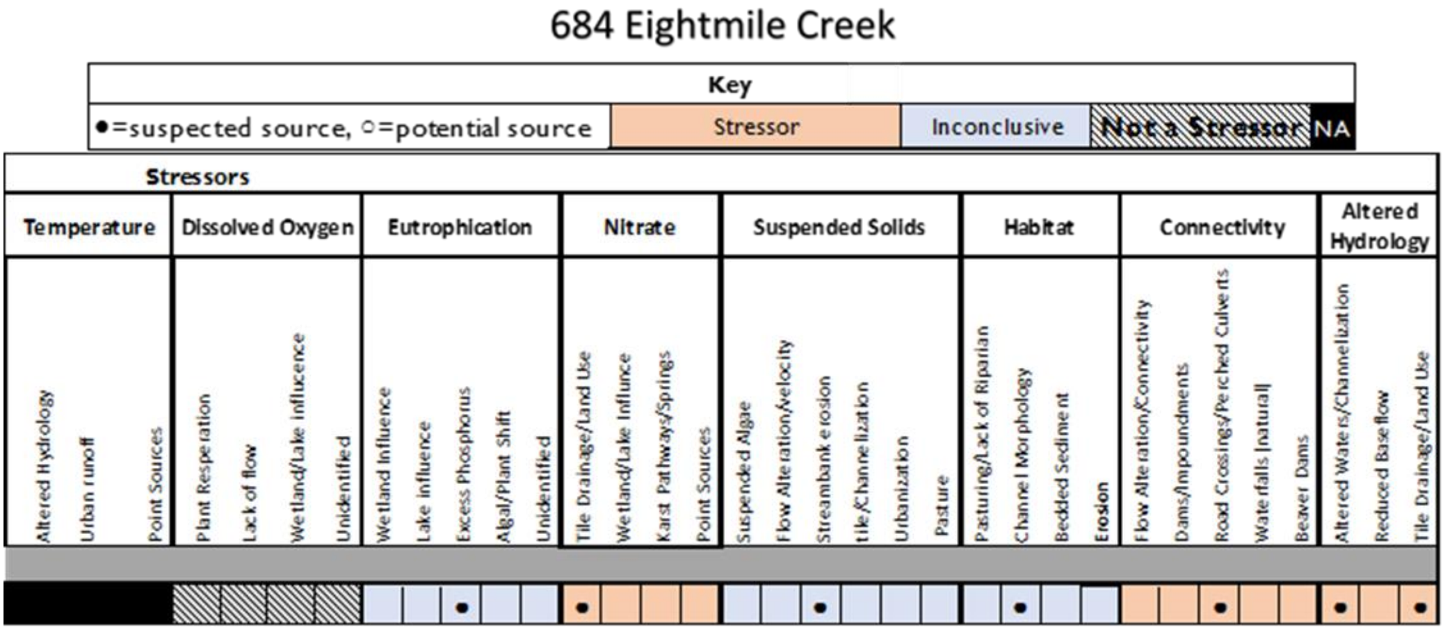
Table 306. Fish species present at monitoring stations on Eightmile Creek. Stations are listed from downstream (13MN088) to upstream (13MN087). Migratory species highlighted in bold.

Eightmile Creek	13MN088	13MN088	Culvert	13MN087	13MN087
	2013	2014		2013	2014
bigmouth shiner	X	X			X
black bullhead	X				
blacknose dace	X	X		X	X
bluntnose minnow	X	X			
brassy minnow		X			
central stoneroller	X	X			
common shiner		X			
creek chub	X	X		X	X
fantail darter		X			
fathead minnow	X	X		X	X
green sunfish	X	X			
golden shiner		X			
hornyhead chub		X			
johnny darter		X			
largemouth bass		X			
northern pike	X	X			
orangespotted sunfish	X	X			
sand shiner	X	X			
spotfin shiner		X			
white sucker		X			

Altered hydrology is also impacting the communities at these locations. A majority of Eightmile contains stream channels that have been physically altered by way of ditching and canalizing. The monitoring stations are located downstream of the upland altered portions of stream. Additionally, this streams hydrology is further being altered by the introduction of subsurface tile drainage, as this will change the base flow dynamics, as well stream velocity, and pollutant capacity. For additional information on the impacts of this form of altered hydrology, refer to Section 3.1.8 of this report.

Summary Table of Stressors

Table 307. Identified stressors with suspected sources for reach 684 of Eightmile Creek.



684 Eightmile Creek

Key				
●=suspected source, ○=potential source	Stressor	Inconclusive	Not a Stressor	NA

Stressors											
Temperature			Dissolved Oxygen				Eutrophication				
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified
NA	NA	NA	Not a Stressor	Not a Stressor	Not a Stressor	Not a Stressor	Inconclusive	Inconclusive	Inconclusive ●	Inconclusive	Inconclusive

Nitrate				Suspended Solids					
Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture
Stressor ●	Stressor	Stressor	Stressor	Inconclusive	Inconclusive	Inconclusive ●	Inconclusive	Inconclusive	Inconclusive

Habitat				Connectivity					Altered Hydrology		
Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
Inconclusive	Inconclusive ●	Inconclusive	Inconclusive	Stressor	Stressor	Stressor ●	Stressor	Stressor	Stressor ●	Stressor	Stressor ●

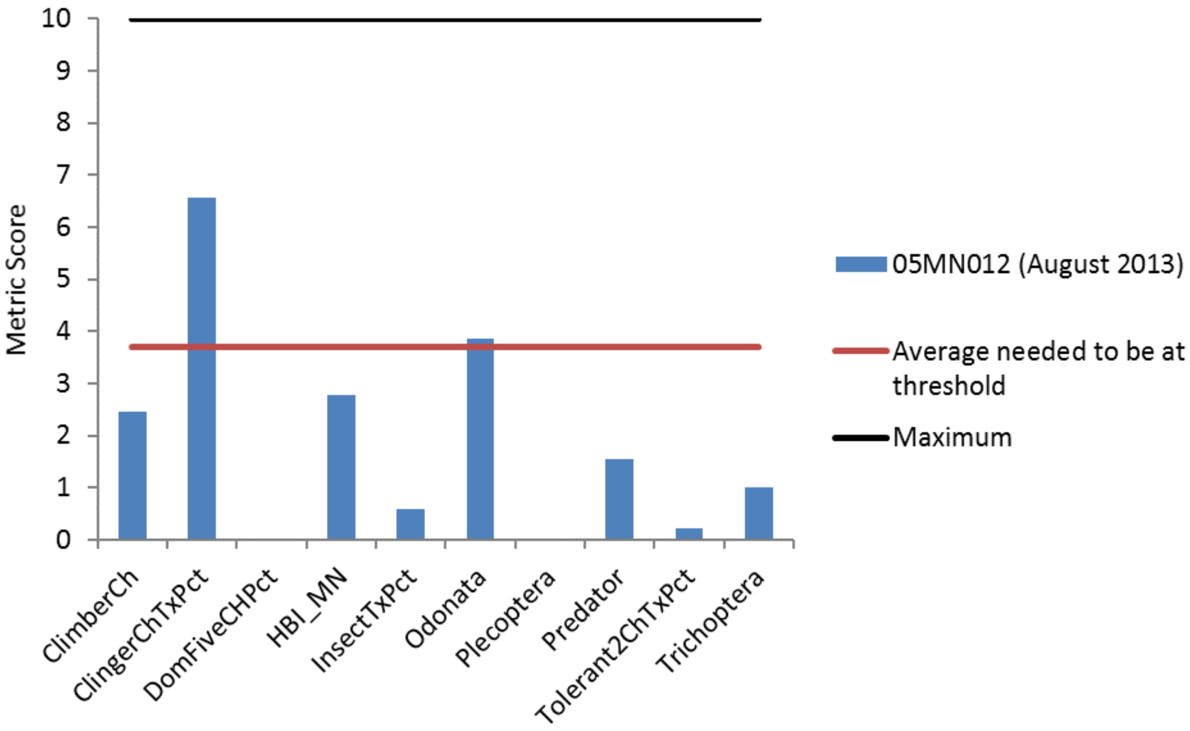
4.30 Fritsche Creek (County Ditch 77) (07020007-709)

Fritsche Creek (07020007-709) is north of New Ulm, Minnesota. The reach is warmwater general use Class 2B. The reach extends from upstream of MN-15 to the Minnesota River. Fritsche Creek is impaired for lack of macroinvertebrate assemblage. There is one biological station on this reach, station 05MN012. The reach is also impaired for *E. coli*, which will not be addressed in this report.

4.30.1 Biological Communities

There is one macroinvertebrate sample at 05MN012 in 2013. The sample scored 18 points below the threshold, and below the lower confidence interval. At this site, there is low diversity, and a dominance by tolerant taxa. The macroinvertebrate IBI metrics scored less than average for almost all metrics (Figure 297). Fish at this site scored above general use threshold, and below the upper confidence interval.

Figure 297. Macroinvertebrate metrics of the Southern Streams class IBI for station 05MN012, Fritsche Cree



4.30.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

The only dissolved oxygen (DO) measurement on this reach occurred during biological sample on August 14, 2013, at 8.5 mg/L. Two additional DO values were collected in 2016, and were considered normal, at 9.09 mg/L and 9.69 mg/L.

The macroinvertebrate community in Fritsche Creek had mixed results to possible low DO stress (Table 380). The low DO index score was relatively high, indicating unlikely stress. There was only one low DO intolerant taxa and they were fairly abundant despite being less than the average of similar stations meeting the biocriteria.

Table 308. Macroinvertebrate metrics that respond to low DO stress in Fritsche Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Tolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
05MN012 (2013)	**27**	**6**	**7.40**	7.43	**1**	**22.9**	3	4.3
Southern Streams Average	*45.8*	*14.2*	*7.08*	*7.04*	*9.0*	*24.0*	*4.8*	*9.9*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is inconclusive as a biological stressor. There is a lack of DO data that limits the ability to make a DO determination for this reach. In addition, there are also mixed metrics related to DO stress; there are a few indications of low DO stress, yet there Is not any indication the low DO intolerant macroinvertebrates have been replaced by low DO tolerant.

Eutrophication

During biological sampling at 05MN012 on July 16, 2013, the total phosphorus (TP) concentration was elevated at 0.151 mg/L. Additional total phosphorus data was collected in 2009, 2010, 2012 and 2013 at S005-430 near the downstream end of the reach. The average TP concentration of 20 samples was 0.12 mg/L, with a maxim um of 0.56 mg/L. Six of the 20 samples exceed 0.15 mg/L, the river eutrophication standard for the southern region. Chlorophyll-a, BOD, and DO flux are also considered when evaluating eutrophication stress, but no data on those interacting variables exist for this reach.

The macroinvertebrate community indicates possible stress due to eutrophication (Table 309). There were a lack of collector-filterer and collector-gatherer taxa compared to the average of similar stations meeting the biocriteria. Many of the taxa present were also generally tolerant.

Table 309. Macroinvertebrate metrics that respond to eutrophication stress in Fritsche Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
05MN012 (2013)	**27**	**5**	**7**	**6**	**0**	**92.6**
Southern Streams Average	*45.8*	*7.3*	*15.9*	*12.2*	*0.8*	*72.6*
Expected response to stress	↓	↓	↓	↓	↓	↑

Eutrophication is inconclusive at this time. While the metric table does indicate eutrophication as a stressor and phosphorus is high, and certainly should be reduced, there is little secondary response chemistry data to fully understand the system dynamics and if it is responding by way of eutrophication.

Nitrate

During the biological sample the nitrate concentration was high at 26 mg/L on July 16 2013 at 05MN012. Twenty additional measurements taken on this reach (S005-430) also showed fairly high concentrations from 2009-2010. Of the 20 samples, the average concentration was 17 mg/L, with a maximum of 24 mg/L. All but two values were greater than 10 mg/L, with six greater than 20 mg/L.

The macroinvertebrates in this reach show consistent indication they are stressed by the elevated nitrate concentrations (Table 310). The nitrate index score was 3.5, while the average for Southern Streams meeting impairment threshold is 2.9. This suggests that overall the community present is quite tolerant to high nitrate concentrations. Increasing nitrate concentrations also correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct) and decreased intolerant and Trichoptera taxa, all of which are lacking in this reach. Additionally, the number of nitrate tolerant individuals (59.4%) is higher than average. The fewer number of nitrate tolerant taxa is explained by an overall low taxa count for this site.

Table 310. Macroinvertebrate metrics that respond to nitrate stress in Fritsche Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
05MN012 (2013)	**3**	**1.8**	**3.5**	**0**	16	**59.4**
Southern Streams Average	*6.3*	*5.5*	*2.9*	*2.4*	*18.8*	*47.2*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is a biological stressor within this reach of Fritsche Creek. Nitrate levels were chronically high. In addition, the biological metrics do indicate nitrate toxicity is placing limitations on the macroinvertebrate community.

Total Suspended Solids

During biological sample, the total suspended solids (TSS) concentration was low, at only 8 mg/L on July 16, 2013 at 05MN012. Twenty additional measurements taken on this reach (S005-430) also showed mainly low concentrations from 2009-2010. Of the 20 samples, the average concentration was 29 mg/L, with a maximum of 229 mg/L. All but three values were meeting the standard set for the southern region of 65 mg/L.

The macroinvertebrate community does not indicate plausible stress from elevated TSS (Table 311). The TSS index score was the same as the average of similar stations meeting the biocriteria. There is little indication among the other metrics that TSS is a stressor but they a bit mixed and close to averages.

Table 311. Macroinvertebrate metrics that respond to high TSS stress in Fritsche Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

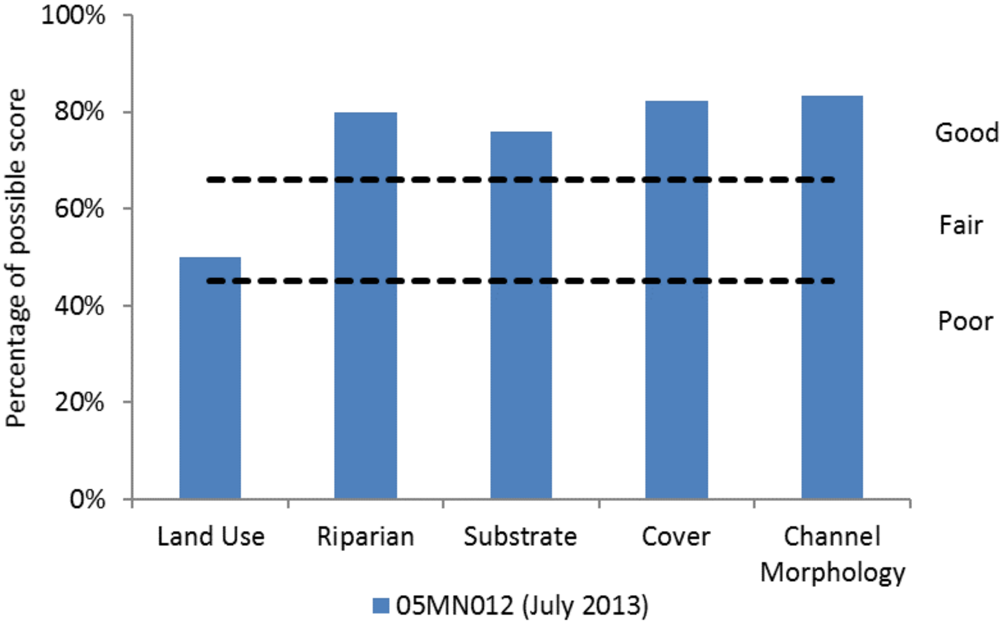
Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Tolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
05MN012 (2013)	36.7	**0**	15.63	**0**	**0**	10	31.7
Southern Streams Average	*25.4*	*0.7*	*15.63*	*2.9*	*4.7*	*12.2*	*34.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

TSS is inconclusive as a biological stressor. Samples did indicate a chronic TSS issue within the stream. However, there were a few samples that found high TSS concentrations. The macroinvertebrate metrics were mixed.

Habitat

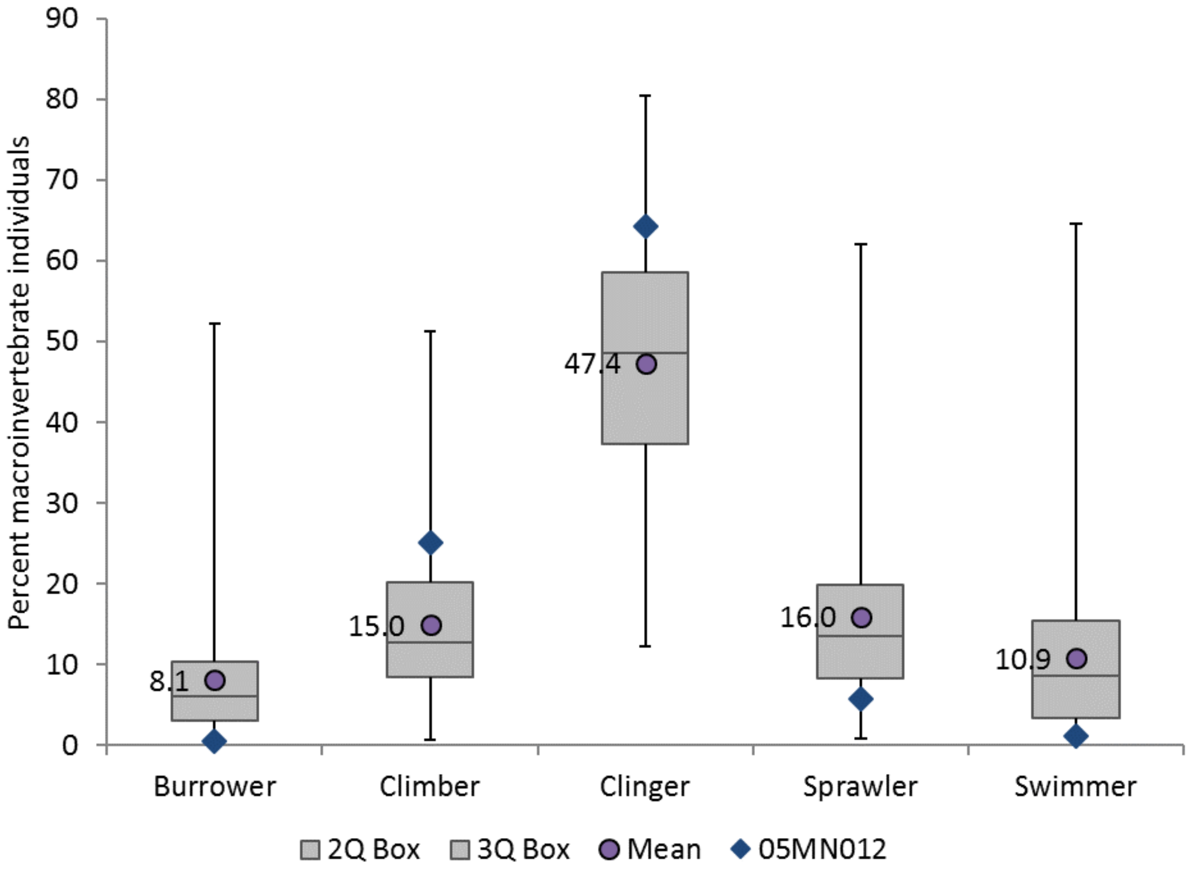
The MSHA score for station 05MN012 was good (79) (Figure 298). The surrounding land use was a mix of forest, wetland, prairie, or shrub with row crop. The riparian width was extensive with moderate bank erosion, and substantial shade. The stream features were 45% run, 35% riffle, and 20% pool. The riffle features were dominated by gravel and cobble, and there were diverse substrates available throughout the reach. Embeddedness was light throughout the reach. There was moderate cover amount in the reach with many cover types. There was also good depth variability, excellent sinuosity, excellent channel development, and moderate channel stability.

Figure 298. Percentage of MSHA subcategory scores for station 05MN012, Fritsche Creek



The habitat related macroinvertebrate metrics showed a relatively high percentage of clingers and climbers, and low percentages of burrowers, sprawlers, and swimmers (Figure 299). Although there were a decent percentage of climber individuals, there was a low abundance of climber taxa resulting in a low MIBI metric score.

Figure 299. Macroinvertebrate habit metrics with box plot showing range of values from Southern Streams stations meeting the general use biocriteria mean of those stations, and metric values from station 05MN012



Habitat is not considered a stressor. The MSHA scores for this site revealed that there is strong habitat diversity at this location. This is also reflected in the community types found in the sampled macroinvertebrates, as the low presents of “burrowers” indicate there was clean riverbed substrate. The dominance of “clingers” also speaks to a healthy habitat, as this indicates a healthy community of riffle dwelling species.

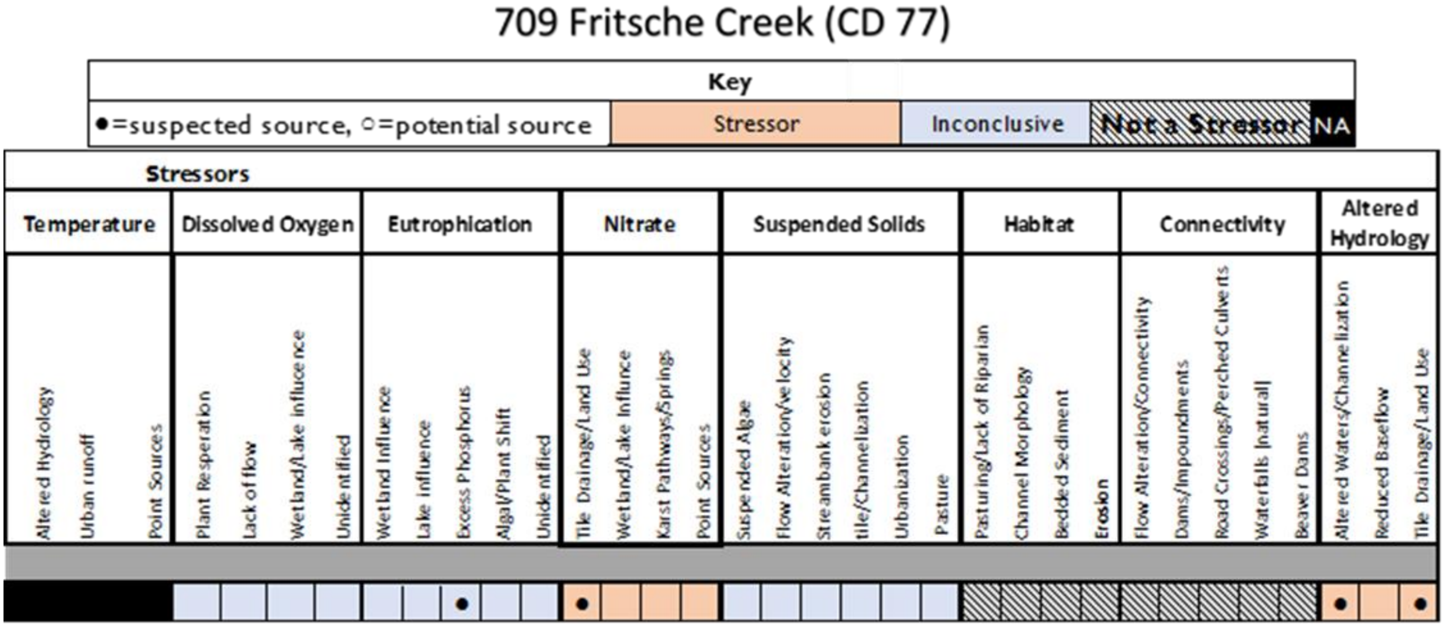
Longitudinal Connectivity and Altered Hydrology

Nearly the entire upstream reach of this monitoring station has been modified by way of channelization. Additionally, there is a high amount of subsurface tile drainage inputs used for agricultural practices. This typically will lead to a host of downstream problems and this alters the system flow regime. Refer to Section 3.1.8 for additional information on how these alterations to the streams system will change nutrient inputs (such as nitrate), as well as stream instability. Figure 300 below shows image of a culvert that has a lateral disconnection to the stream, though not currently a barrier to fish migration, this is a clear indicator of instability and potential future lateral disconnection of the stream.

Figure 300. Upstream of biomonitoring station 05MN012. Taken at the time of biological monitoring on July 16, 2013.

Summary Table of Stressors

Table 312. Identified stressors with suspected sources for reach 709 of Fritsche Creek.



709 Fritsche Creek (CD 77)

Key

●=suspected source, ○=potential source | 🟧 Stressor | 🟦 Inconclusive | ▨ Not a Stressor | ■ NA

Stressors																																	
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls (natural)	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
■	■	■	🟦	🟦	🟦	🟦	🟦	🟦	🟦 ●	🟦	🟦	🟧 ●	🟧	🟧	🟧	🟦	🟦	🟦	🟦	🟦	🟦	▨	▨	▨	▨	▨	▨	▨	▨	▨	🟧 ●	🟧	🟧 ●

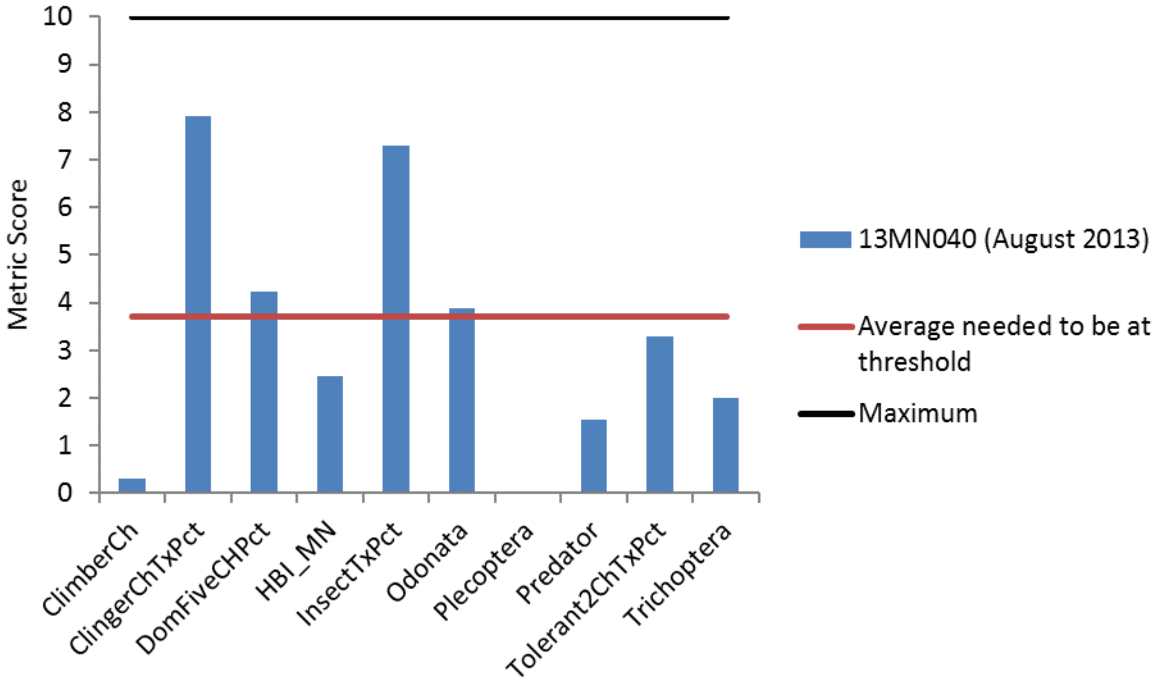
4.31 Heyman's Creek (07020007-675)

Heyman's Creek (07020007-675) is east of New Ulm, Minnesota. The reach is warmwater general use Class 2B. The reach extends from upstream of County Road 21 to the confluence with unnamed creek, just upstream of US-14. Heyman's Creek is impaired for lack of macroinvertebrate assemblage. There is one biological station on this reach, station 13MN040.

4.31.1 Biological Communities

There is one macroinvertebrate sample at 13MN040 sampled in August 2013. The sample scored 32, which is 4 points below impairment threshold. At this site, there is low diversity, and a complete lack of intolerant taxa. The macroinvertebrate IBI metrics scored less than average for many metrics (Figure 301), with an abundance of taxa tolerant to nitrate. Fish at this site scored above general use threshold, and below the upper confidence interval.

Figure 301. Macroinvertebrate metrics of the Southern Streams class IBI for station 13MN040, Heyman's Creek.



4.31.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

During biological sampling, the DO values were normal at 13MN040 (8.02 mg/L and 7.26 mg/L). Two additional data points on DO from 2015 also show normal values at 8.11 mg/L and 8.89 mg/L. Four additional dissolved oxygen values were collected in 2016 at S008-513, ranging from 9.43 to 13.85 mg/L. Two of those values were taken before 9 am, when DO is the lowest.

The macroinvertebrate community in Heyman's Creek indicates mixed results for stress from possible low DO (Table 313). There were a lower number of low DO intolerant taxa, but they were present. The low DO taxa and individuals comprised of a greater amount of the sample than the low DO tolerant taxa and individuals.

Table 313. Macroinvertebrate metrics that respond to low DO stress in Heyman's Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN040 (2013)	**37**	**8**	**7.51**	7.29	**6**	**21.8**	4	4.9
Southern Streams Average	*45.8*	*14.2*	*7.08*	*7.04*	*9.0*	*24.0*	*4.8*	*9.9*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is not a biological stressor. The chemistry data does not suggest low DO issues. In addition, the biologic metrics do not indicate that low DO is influencing the macroinvertebrate community.

Eutrophication

During biological sampling, the TP concentration at 13MN040 was low, at 0.081 mg/L. Four additional samples taken on this reach in 2015 and 2016, three of which had violations of the TP standard for the southern region (0.150 mg/L). The average concentration of those four samples was 0.130 mg/L with a maximum of 0.192 mg/L. One sample of chlorophyll-a was collected on September 1, 2015, with a low value of 4.41 ug/L. BOD and DO Flux data was not available for further analysis of eutrophication indicators.

The macroinvertebrate community displays some potential stress from eutrophication (Table 314). There were a reduced number of collector-filterer taxa compared to the average number from similar stations meeting the biocriteria. There was also a lack of intolerant taxa and a high percentage of tolerant taxa in the sample.

Table 314. Macroinvertebrate metrics that respond to eutrophication stress in Heyman's Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN040 (2013)	**37**	**4**	16	**8**	**0**	**78.4**
Southern Streams Average	*45.8*	*7.3*	*15.9*	*12.2*	*0.8*	*72.6*
Expected response to stress	↓	↓	↓	↓	↓	↑

The biological metrics may suggest eutrophication as a potential stressor. Without connecting chemical data and more information on flux and chlorophyll, it is difficult to make the connection; therefore, eutrophication is inconclusive as a stressor.

Nitrate

During biological sample at 13MN040 on June 11 2013, the nitrate concentration was 7.6 mg/L. Additional data collected on this reach at S008-513 in 2015 and 2016 show some consistently high concentrations. The average sample concentration of five samples was 27 mg/L. In May of 2016, the nitrate concentration was 36 mg/L, and in June, 42 mg/L. There is a large feedlot shortly upstream on this monitoring site that at times could be contributing to nitrate overloading within this reach. Additional monitoring is recommended to ensure there is not a correlation of high nitrate with this point source.

The macroinvertebrates in this reach show consistent indication they are stressed by the elevated nitrate concentrations (Table 315). The nitrate index score was 3.6, while the average for Southern Streams meeting impairment threshold is 2.9. This suggests that overall the community present is quite tolerant to high nitrate concentrations. Increasing nitrate concentrations also correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct) and decreased intolerant and Trichoptera taxa, all of which are lacking in this reach. Additionally, the number of nitrate tolerant individuals (75%) and nitrate tolerant taxa (23) is much higher than average.

Table 315. Macroinvertebrate metrics that respond to nitrate stress in Heyman's Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN040 (2013)	**4**	**0.7**	**3.6**	**0**	**23**	**75.3**
Southern Streams Average	*6.3*	*5.5*	*2.9*	*2.4*	*18.8*	*47.2*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is a stressor. This reach of Heyman's Creek had some of the highest concentrations of nitrate found within the entire watershed during this monitoring period. The biological metrics consistently point to nitrate limiting the community.

Total Suspended Solids

During the biological sample at 13MN040 on June 11, 2013, the total suspended solids (TSS) concentration was low, at 2 mg/L. Five additional samples were collected on this reach at S008-513 in 2015 and 2016, with varying concentrations. Of the five samples collected the average concentration was 39 mg/L, with a maximum of 85 mg/L. Two of the values are higher than 65 mg/L, the TSS standard set for the southern region.

The macroinvertebrate community indicates possible stress from elevated TSS (Table 316). The TSS index score was higher than the average of similar stations, there were few TSS intolerant, and over half of the sample was TSS tolerant. Overall, the biological evidence suggests some potential for TSS stress, but the chemical data is limited, and does not confirm that condition.

Table 316. Macroinvertebrate metrics that respond to high TSS stress in Heyman's Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

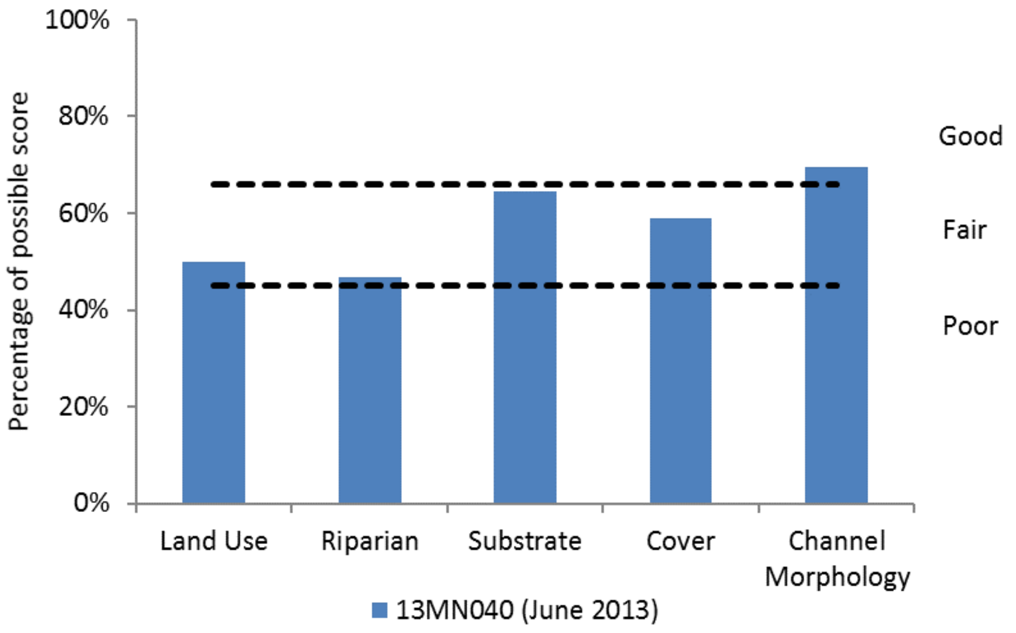
Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN040 (2013)	**17.9**	**0**	**16.39**	**1**	**0.3**	9	**52.3**
Southern Streams Average	*25.4*	*0.7*	*15.63*	*2.9*	*4.7*	*12.2*	*34.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

TSS is inconclusive as a stressor. While the biological metrics do indicate possible TSS stress, the chemistry data is lacking to be able to correlate TSS with the impaired community.

Habitat

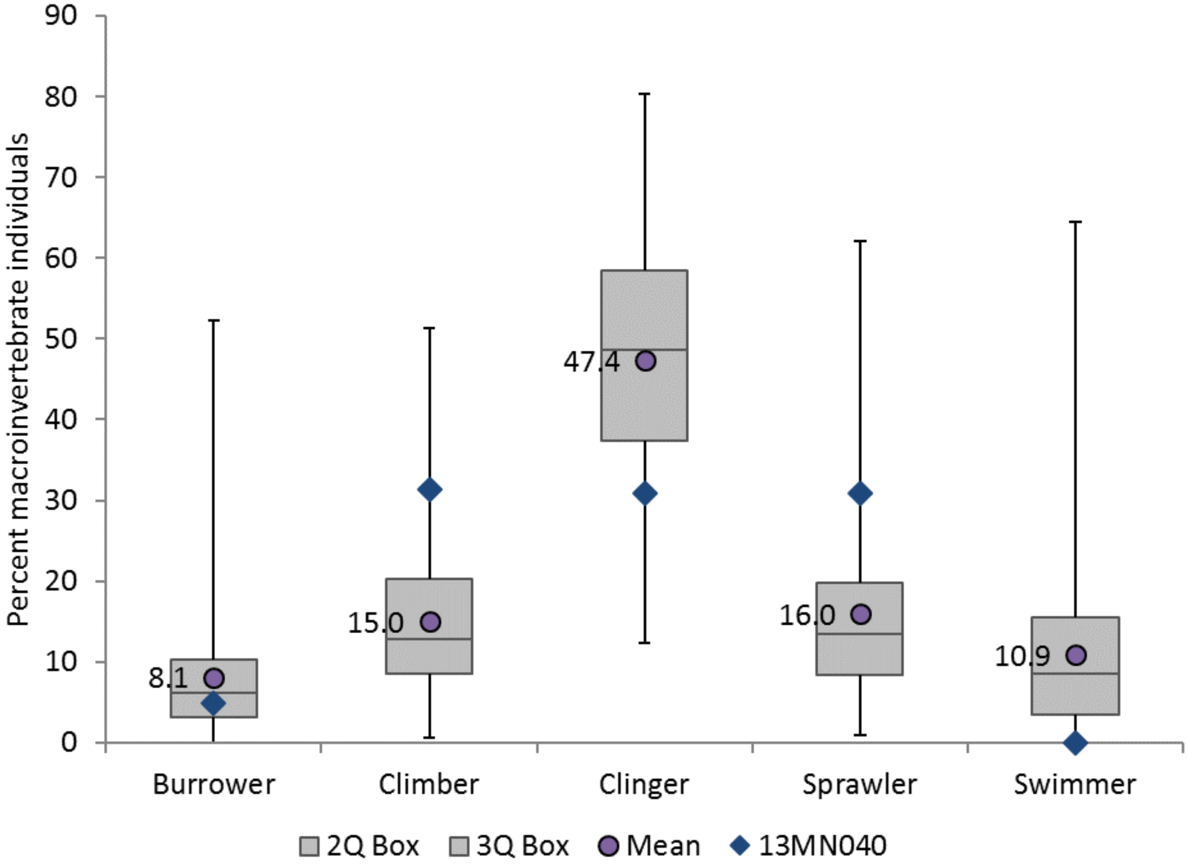
Station 13MN040 scored 61.9 (fair) on the MSHA. There was a mix of land use of forest, wetland, prairie, or shrub, and row crop. There was noted no riparian width, with heavy bank erosion and substantial shade, as reflected in Figure 302 below. The reach was comprised of 60% run features, 30% riffle features, and 10% pool features. The riffle had dominant substrates of gravel and cobble. There were a diverse number of substrates within the reach with moderate embeddedness. There was sparse (5-25%) cover available, although many types were present. The reach had good depth variability, good sinuosity, good channel development, and moderate channel stability.

Figure 302. Percentage of MSHA subcategory scores for station 13MN040, Heyman's Creek



The macroinvertebrate community had a relatively high abundance of climbers and sprawlers, and relatively low abundance of clingers, with swimmers being absent and moderate relative amount of burrowers. In the MIBI metrics, the number of climber taxa was relatively low and the percentage of clinger taxa was high. Reflecting on the composition of these groups (Figure 303), there are the same amounts of climbers, clingers, and sprawlers within the total sample, where Swimmers fell below the average, and burrowers made up the expected proportion of the total count.

Figure 303. Macroinvertebrate habit metrics with box plot showing range of values from Southern Streams stations meeting the general use biocriteria mean of those stations, and metric values from station 13MN040.



Habitat is considered inconclusive at this time. At the time of monitoring, both the biological community as well as physical habitat availability were at the lower end of acceptable measures. This reach seems to be unstable, as seen in Figure 304 below in the evidence of mass waiting of the banks. This leads to moderate embeddedness and typically will dramatically change the stream dynamics, including habitat availability. Additional monitoring is recommended in the future.

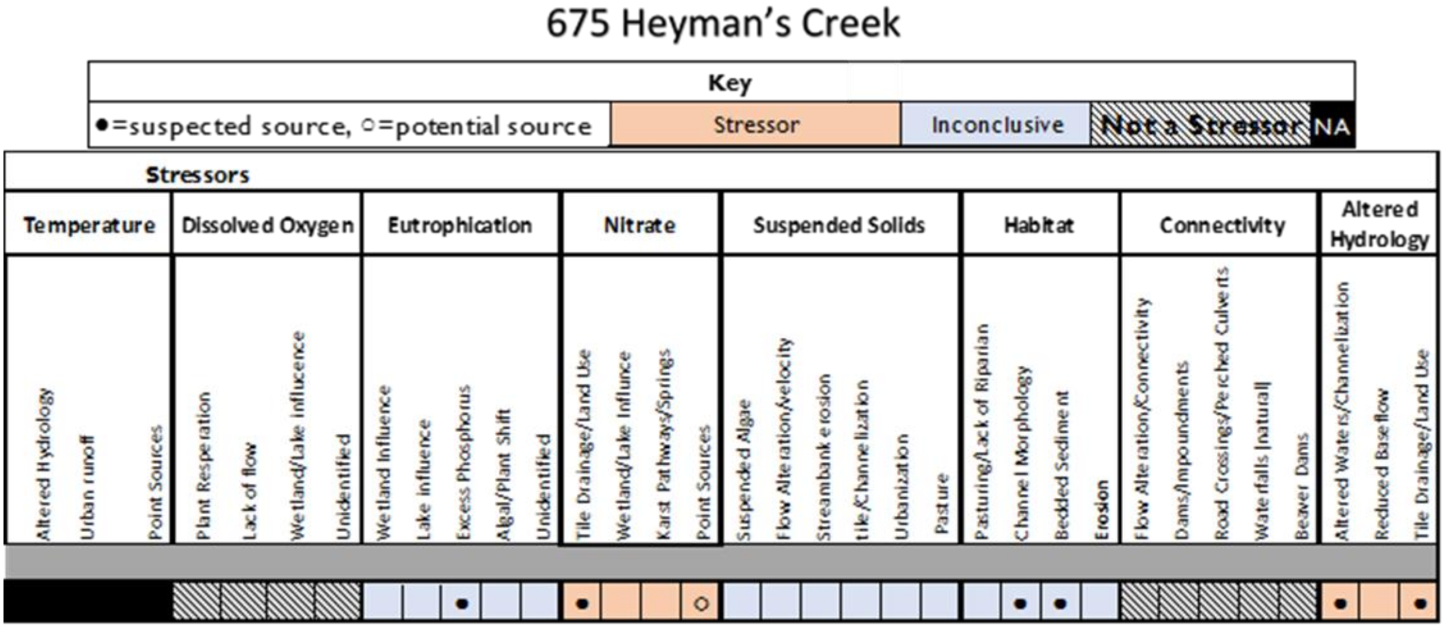
Figure 304. Station 13MN040 on June 11, 2013, displaying erosive banks.

Longitudinal Connectivity and Altered Hydrology

Connectivity is not considered a stressor to the macroinvertebrate community. Altered hydrology is considered the primary stressor to this reach, as the upstream portion of Heyman's Creek is altered by way of ditching and canalizing. Additionally, this streams hydrology is further being altered by the introduction of subsurface tile drainage, as this will change the base flow dynamics, as well stream velocity, and pollutant capacity. For additional information on the impacts of this form of altered hydrology, refer to Section 3.1.8 of this report.

Summary Table of Stressors

Table 317. Identified stressors with suspected sources for reach 675 of Heyman's Creek.



675 Heyman's Creek

Key

●=suspected source, ○=potential source | Stressor | Inconclusive | Not a Stressor | NA

Stressors

Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
NA	NA	NA							●			●			○								●	●							●		●

New Ulm Subwatershed Conclusion

Three streams were assessed for biological impairments within the New Ulm Subwatershed, all of which are classified as general use warmwater. Eightmile Creek (-684) is impaired for lack of fish assemblage and lack of macroinvertebrate assemblage. Heyman's Creek (-675) and Fritsche Creek (-709) were only found to have impairments for macroinvertebrate assemblage.

Altered hydrology is heavily occurring in the upland area of the New Ulm Subwatershed. There are two ways this is taking place; the first is through subsurface tile drainage. As channels take on extra water, they change their dimension, pattern, and profile. The second form of altered hydrology is by ditching and channelizing, this directly changes the morphology of the stream. Both of these alterations are for agricultural practices in effort to expedite water off the land to create optimal growing conditions for crop production. Due to the geomorphology of these locations, the evidence of these alterations lighten as the streams within this subwatershed travel from the agricultural dominant flat uplands and down-cuts through the Minnesota River Valley, where gradient drastically increases and meets with the Minnesota River. In areas where gradient is increased, there is a strong correlation of better stream riparian, habitat availability, and in some parameters water quality. The New Ulm Subwatershed is unique in the fact that none of the streams that are being assessed are modified. However, it is important to note that they all are being influenced from upstream-modified systems that have been greatly altered.

As the assessed reaches within the New Ulm subwatershed are stationed along the valley's steep edge rather than within the modified upland areas, physical stream alterations are minimal. There were some indications of stream instability at Heyman's Creek and Eightmile Creek that was noted in erosive banks. However, it was not clearly impacting the biological community. There was not enough data to determine if the erosive conditions were overloading these streams with suspended solids (particularly in the form of sediment), leaving Total Suspended Solids (TSS) as inconclusive at all stations.

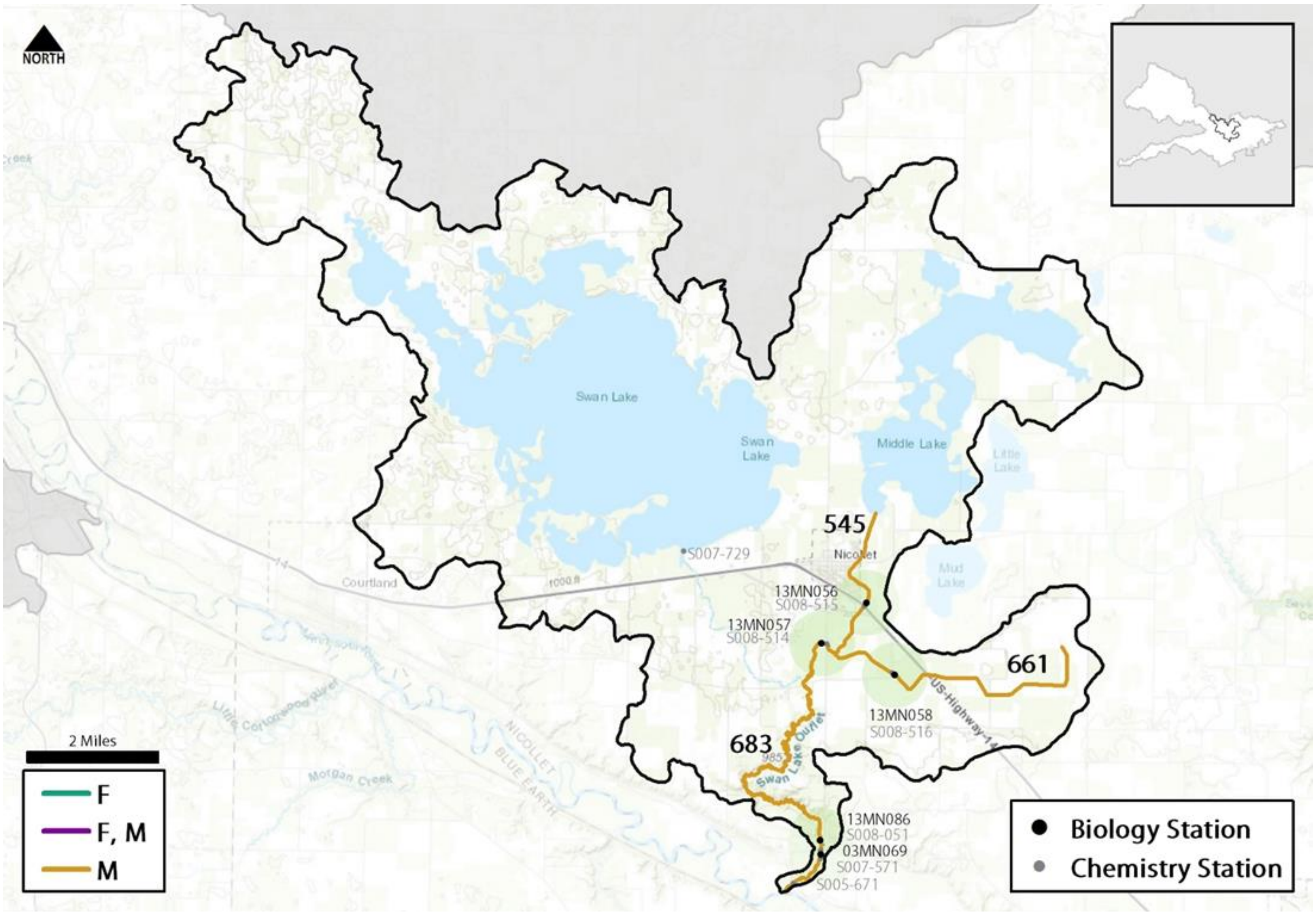
Nutrients were in abundance at all stations, likely from agricultural subsurface tile drainage from upstream. Nitrate as a stand-alone parameter can be toxic to aquatic life. At all three sites nitrate levels were found to be chronically high and limiting the macroinvertebrate community. The other nutrient found in excess at all locations was phosphorus. However, fish and macroinvertebrates are not sensitive to phosphorus itself but rather the eutrophic conditions that can occur in the presence of phosphorus. Abundance of algae will lower the dissolved oxygen in the stream during plant respiration, and high amounts of suspended algae will negatively influence habitat in the same ways that suspended sediment limit aquatic life. In this region, eutrophication will occur when there is an abundance of phosphorus, lack of stream canopy to shield the stream of sunlight, and slow velocity of the stream that prolongs water retention time. As all three of these reaches are found on a steep gradient with decent canopy cover, it is not likely eutrophic conditions are taking place within this location. It is possible that the community is still being impacted from upstream eutrophic conditions typically associated with agricultural ditches, as there was an abundance of collector and filterer species that can thrive when there is a presence of suspended organics. Low DO was able to be ruled out as a stressor at two locations based on biological composition and chemistry data. Due to a lack of chemistry data, low DO could not be ruled out in Fritsche Creek (-709) and therefore is inconclusive as a stressor.

Longitudinal stream connectivity is of concern within this subwatershed. At County Road 5 at Eightmile Creek, there is a perched culvert that was found to be limiting fish migration. There was also a perched culvert identified at 581st Ave that potentially could limit fish migration, especially during low flow conditions.

Swan Lake – MNR Mankato North

This section encompasses biotic impaired reaches in the Swan Lake 10 digit HUC. There are three warmwater reaches impaired for macroinvertebrate assemblage, those include County Ditch 4/39 (07020007-545), County Ditch 11 (07020007-661) and Nicollet Creek (07020007-683). The fish assessment could not be conducted within this watershed.

Figure 305. Map of the Swan Lake watershed with biological impairments and monitoring stations. Impairments are described as F=Fish, F, M=Fish and Macroinvertebrates, and M=Macroinvertebrates.



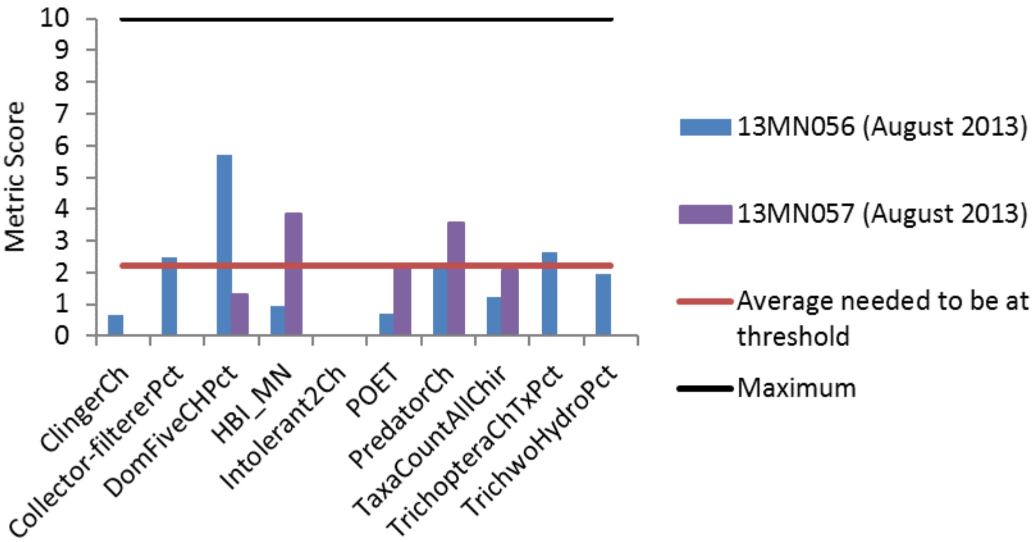
4.32 County Ditch 4/County Ditch 39 (07020007-545)

County Ditch 4/County Ditch 39 (07020007-545) extends through Nicollet, Minnesota. The reach is warmwater modified use Class 2B. The reach begins at the outlet of Middle Lake and goes until the confluence with Swan Lake Outlet. CD 4/CD 39 is impaired for lack of macroinvertebrate assemblage. There are two biological stations on this reach, station 13MN057 and station 13MN056.

4.32.1 Biological Communities

This stream segment is being recommended for a change in its designated aquatic life use to a Class 2Bm warmwater stream. Aquatic life use data was assessed against water quality criteria associated with the recommended use rather than its existing designated use. Two biological invert visit were conducted on two stations (13MN056, 13MN057), sampled in 2013. Both samples scored below the MU threshold, within the lower confidence interval (Figure 306). One site scored 3 points below (13MN056) and the other scored 9 points below (13MN057) the modified use criteria (41). Very low taxonomic diversity, lack of intolerant taxa, preponderance of low-DO and phosphorus tolerant taxa.

Figure 306. Macroinvertebrate metrics of the Prairie Streams class IBI for stations 13MN056 and 13MN057, CD4/CD39.



4.32.2 Data Evaluation for each Candidate Cause

Water chemistry data associated with this AUID was limited to three biological monitoring visits at two unique stations in 2013 near the downstream end of this sampling reach.

Dissolved Oxygen

At the time of biological monitoring dissolved oxygen (DO) at 13MN056 was at 3.7 mg/L while station 13MN057 DO was at 14.6 mg/L. Sampling at both locations took place in the afternoon on August 7, 2013. In 2015 and 2016, seven DO samples were collected with data ranging from 3.75 mg/L to 15.7 mg/L and an average of 8.81 mg/L. Two samples fell below 4.5 mg/L both in August of 2015 at S008-515 and S008-514. An additional seven grab samples were collected in the years of 2015 and 2016 with DO ranging from 3.75 – 10.77 mg/L.

In 2015, two YSI sondes were deployed at station 13MN056 and 13MN057 from July 30 to August 10. At station 13MN056 (Figure 307), the DO ranged from 1.63 to 13.82 mg/L, with each day deployed the DO concentrations fell below the DO standard of 5 mg/L. DO flux was also elevated, ranging from 2.14 to 12.01 mg/L daily, with an average of 7.18 mg/L variation(Figure 308). At station 13MN057, the DO ranged from 0.32 to 14.04 mg/L. Some days the DO was well below the standard of 5 mg/L (Figure 309). At times, the DO flux was also elevated, ranging from 2.29 to 13.72 mg/L daily, with an average of 7.27 mg/L (Figure 310).

Figure 307. Diurnal dissolved oxygen for station 13MN056, July 30 - August 10, 2015.

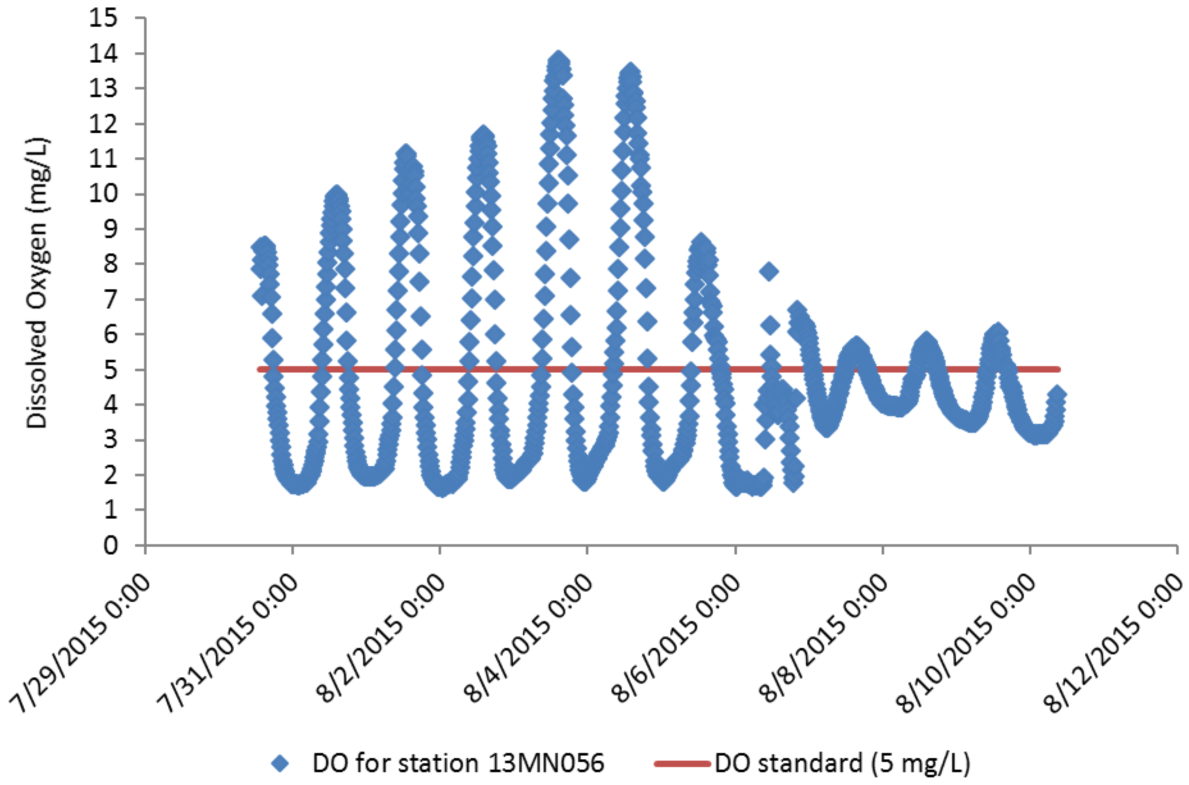


Figure 308. Dissolved oxygen flux at station 13MN056, July 31 – August 9, 2015.

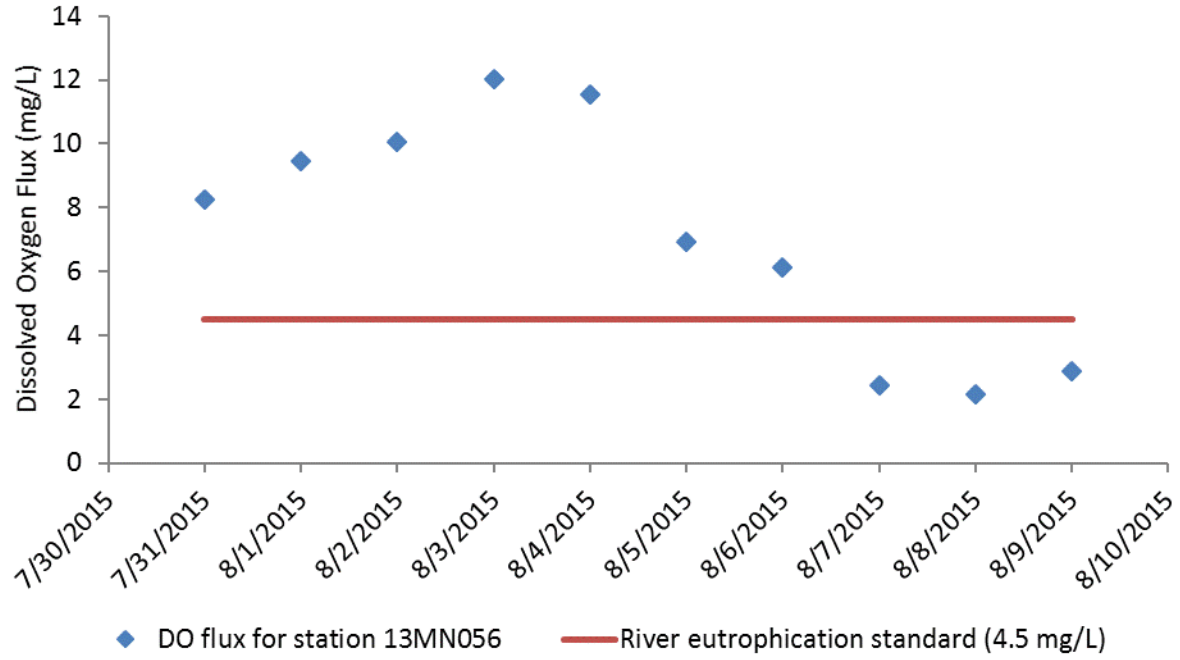


Figure 309 displays DO saturation at monitoring station 13MN057 during 2015. As shown, the DO flux is extreme (Figure 310) with DO levels peaking around 14 mg/L during the day, and falling to 0 mg/L at night during algae and respiration. It is presumed that these swings were also occurring during low flow conditions, as the probe appeared to be out of the water for a few days until a rain event took place (noted in the data gap). This same event likely helped flush the system of suspended algae and also replenished DO during the event, this is noted with the more stable DO swing following the event.

Figure 309. Diurnal dissolved oxygen for station 13MN057, July 30 - August 10, 2015

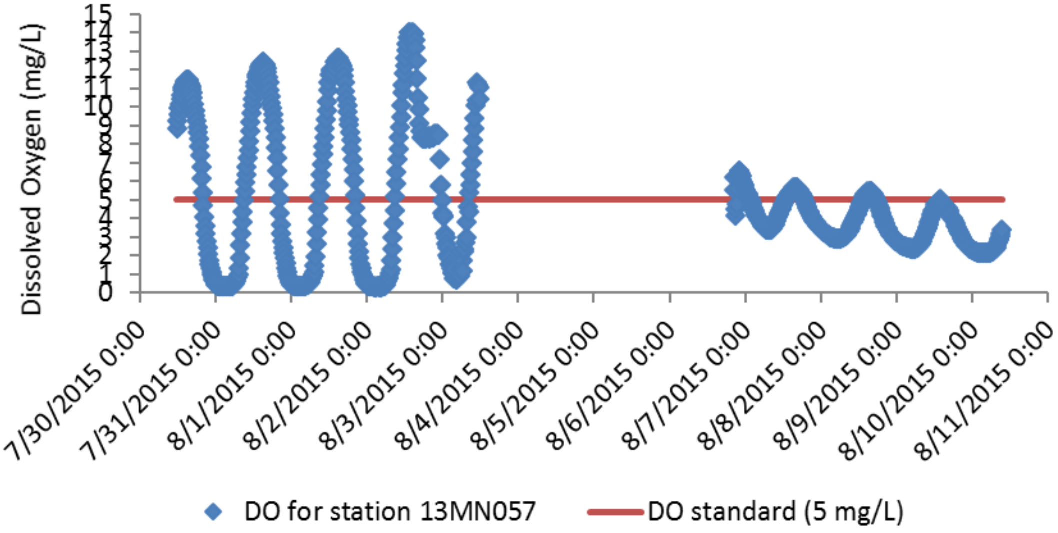
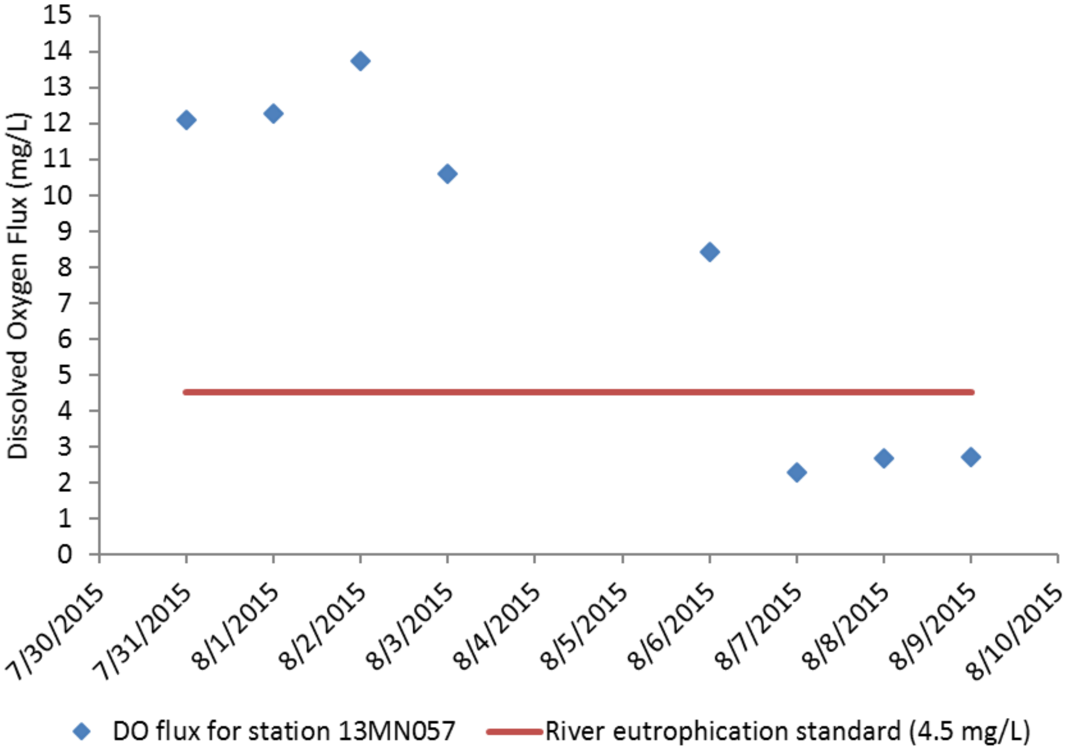


Figure 310. Dissolved oxygen flux at station 13MN057, July 31 – August 9, 2015.



The macroinvertebrate community indicates plausible stress from low DO (Table 318). The low DO index score was lower than the average of similar stations meeting the biocriteria. Additionally, low DO intolerant taxa where lacking completely and replaced a high number of low DO tolerant taxa and individuals. The low DO index scores at these two stations were at 5.66 and 5.17, falling below the state average for modified prairie streams of 6.42.

Table 318. Macroinvertebrate metrics that respond to low DO stress in County Ditch 4/County Ditch 39 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN056 (2013)	**23**	**2**	**8.59**	**5.66**	**0**	**0**	**13**	**67.7**
13MN057 (2013)	**26**	**3**	7.70	**5.17**	**0**	**0**	**16**	**78.8**
Prairie Streams Average	*36.8*	*7.6*	*7.92*	*6.42*	*2.4*	*4.5*	*8.4*	*25.1*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is considered a stressor to the macroinvertebrate community in this reach. The chemical data points to a low DO issue in this stream, especially looking at the low DO recorded at the time of sampling in 13MN056 (afternoon). Sonde data also displayed low DO readings at both sites, as there were daily observations of DO falling far below the aquatic life standard of the 5 mg/L. The macroinvertebrate community metrics are also indicative of low DO stress.

Eutrophication

During biological monitoring two total phosphorus (TP), samples were taken on July 10, 2013, with concentrations of .046 mg/L (13MN057) and 0.034 mg/L (13MN056). Six additional water chemistry samples were collected in 2015 and 2016 ranging from .016 mg/L - .107 mg/L with an average concentration of 0.046 mg/L. There were three samples of chl-a in the reach in 2015. concentrations ranged from 2.91 ug/L- 4.51 ug/L, with no exceedances of the standard of 35 ug/L. DO did display a significant decrease in concentration from spring to late summer months. Sonde data also displayed high flux, indicating high photosynthesis and respiration activity within the stream. While chemistry data is limited, photo documentation did indicate the potential for eutrophic conditions.

Both biological monitoring stations displayed metrics that were suggestive of eutrophic stress (Table 319). Overall taxa richness sampled was low at both sampling locations, and there was lack of sensitive species, as the community was composed of almost entirely tolerant species. Invertebrates that depend of filtering and gathering were also were observed to be less abundant than the state average for modified use prairie streams.

Table 319. Macroinvertebrate metrics that respond to eutrophication stress in County Ditch 4/County Ditch 39 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN056 (2013)	**23**	**1**	**6**	**2**	**0**	82.6
13MN057 (2013)	**26**	**1**	**10**	**3**	**0**	**100**
Prairie Streams Average	*36.8*	*3.9*	*12.8*	*6.5*	*0.1*	*85.4*
Expected response to stress	↓	↓	↓	↓	↓	↑

Figure 311. Station 13MN056, taken on July 30, 2015.

The biological community suggest eutrophic stress; there is also some documentation that indicated an overgrowth of suspended algae, as seen inFigure 311. However, the chemistry data is lacking for fully support the findings of eutrophic conditions being a direct stressor within county ditch 4 and county ditch 39. Eutrophication is considered inconclusive until additional data can be collected.

Nitrate

During biological monitoring in 2013 two nitrate samples were collected, concentrations for 13MN057 and 13MN056 were 6.9 mg/L and 1.7 mg/L respectively. In 2015 and 2016 seven additional water chemistry samples were collected and analyzed for nitrate with results ranging from .93 mg/L – 10 mg/L with an average of 7.10 mg/L.

The macroinvertebrate community in this reach does not show a strong indication they are stressed by elevated nitrate concentrations (Table 320). The nitrate specific metrics show fewer than average tolerant individuals. The nitrate index score fell right at the modified prairie streams average meeting impairment threshold of 3.2 at the upstream site of 13MN056 and one point under that threshold at station 13MN057. This suggests that overall the community present is not overly tolerant to high nitrate concentrations. Increasing nitrate concentrations also could correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct). While intolerant taxa and non-hydropsychid individuals are not in abundance here, their absence can also be due to another stressor present.

Table 320. Macroinvertebrate metrics that respond to nitrate stress in County Ditch 4/County Ditch 39 compared to the statewide average of visits meeting the warmwater modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN056 (2013)	**1**	**.6**	**3.2**	**0**	11	48.3
13MN057 (2013)	**0**	**0**	2.2	**0**	12	23.9
*Prairie Streams Average **(MU)***	*2.6*	*2.4*	*3.2*	*1.1*	*18.0*	*59.7*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate concentrations were found to be slightly elevated in some of the samples collected, and should be reduced, but at this time, they are not likely the main stressor of this reach and is listed as inconclusive based on the lack of water chemistry samples, as well as mixed biological metrics.

Total Suspended Solids

During biological monitoring in 2013, two total suspended solids (TSS) samples were collected on June 10. TSS concentrations for 13MN057 and 13MN056 were 2.8 mg/L and 2 mg/L respectively. Additional water chemistry sampling in 2015 and 2016 resulted in low TSS findings, with concentrations from eight samples ranging from 1.6 mg/L – 6.8 mg/L and an average of 4.75 mg/L.

The macroinvertebrate metrics do not strongly indicate TSS as a stressor as there are mixed results seen in the scores. The TSS Index score for the two sampling sites of 15.94 and 13.69 were below the threshold of 16.68, the state average for modified prairie streams. There was a lack of TSS intolerant taxa. However, there was also a lack of TSS tolerant taxa. It is likely there is something else displacing the community.

Table 321. Macroinvertebrate metrics that respond to high TSS stress in County Ditch 4/County Ditch 39 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN056 (2013)	**9.7**	**0**	15.94	**0**	**0**	6	25.4
13MN057 (2013)	**0.3**	**0**	13.69	**0**	**0**	9	12.0
Prairie Streams Average	*11.7*	*0.1*	*16.68*	*0.8*	*1.4*	*11.8*	*41.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

TSS is not a stressor. The water quality samples for TSS do not indicate a chronic issue of TSS overloading within this reach. The macroinvertebrate metrics, while displaying a limited community, did not indicate the community was displaced by TSS.

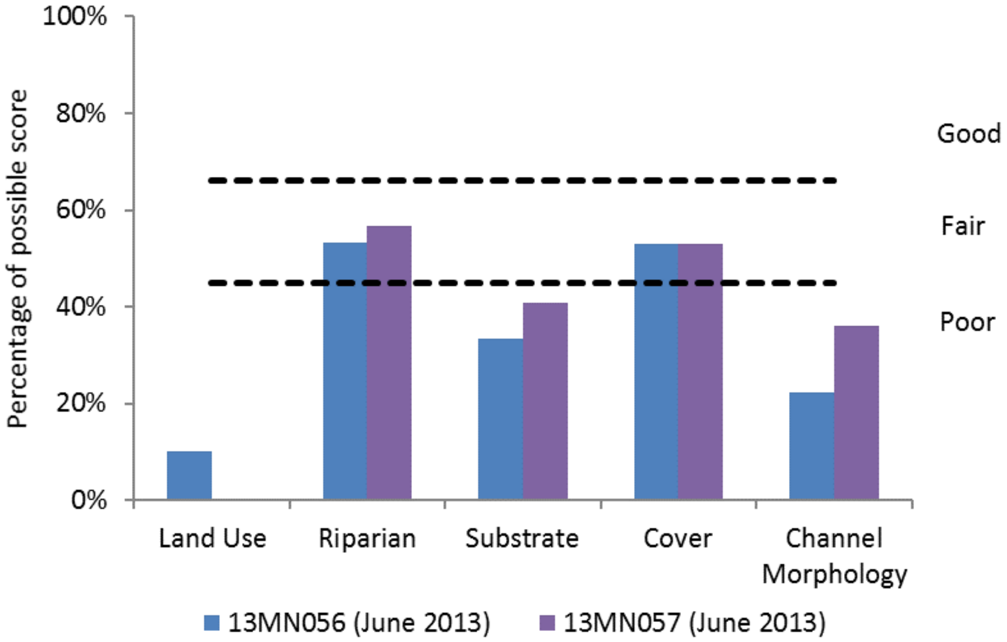
Habitat

Both monitoring locations scored similarly within the primary habitat categories (Figure 312).

Station 13MN056 had a poor (34.5) MSHA with surrounding land use of row crop with some residential/park. The riparian width was narrow at the time of fish sampling with no bank erosion and light shade. The reach was comprised of 100% run features with gravel and silt dominant substrates. The substrates were severely embedded and there were not diverse substrates available. There was moderate cover available, but only two types noted (overhanging vegetation and macrophytes). There was little depth variability in the reach, with poor sinuosity, poor channel development, but moderate/high channel stability.

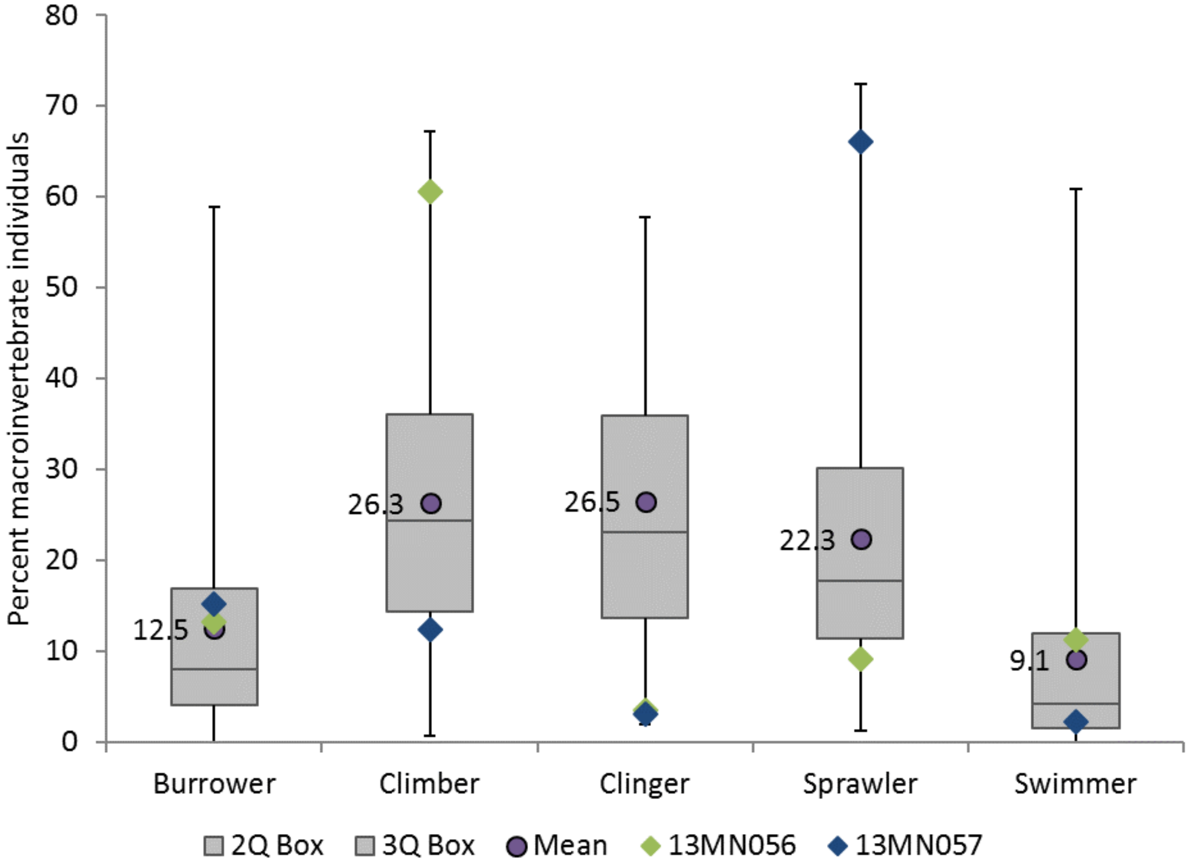
Station 13MN057 had a slightly better MSHA score, but still considered poor (41.5). The surrounding land use was row crop. The reach had a moderate riparian width with little to no bank erosion and light shading. Similar to station 13MN056, the reach was 100% run with gravel and silt. The reach was moderately embedded with a lack of diverse substrates. The cover amount was moderate with few cover types available (overhanging vegetation and macrophytes). The reach had moderate depth variability with fair sinuosity, but poor channel development. Similar to reach 13MN056, the channel had moderate/high channel stability.

Figure 312. Percentage of MSHA subcategory scores for stations 13MN056 and 13MN057, County Ditch 4/County Ditch 39.



As shown in Figure 313, burrowers and swimmer groups fell within the expected composition range, when evaluation the total sample. However, the climbers, clingers, and sprawler composition at both monitoring locations fell outside of the expected range. Particularly clingers were greatly decreased. The decrease in clinger types, paired with the robust burrower composition correlate to poor stream substrate.

Figure 313. Macroinvertebrate habit metrics with box plot showing range of values from Prairie Streams stations meeting the modified use biocriteria mean of those stations, and metric values from stations 13MN056 and 13MN057.



Habitat is considered a stressor as there is a lack of habitat types and a displacement response seen in the sampled community. Surrounding land use impacts are likely driving water quality issues and well as channel instability and lack of diversity with various habitat types.

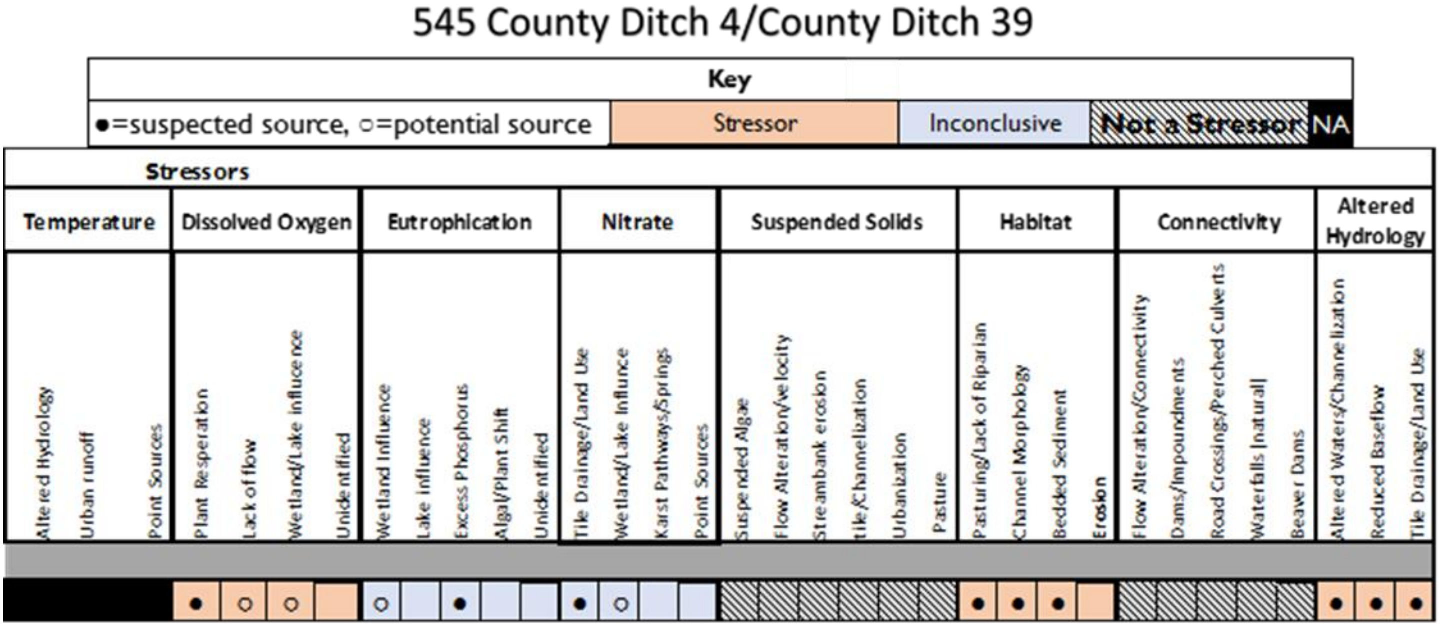
Longitudinal Connectivity and Altered Hydrology

Nicollet Creek has a natural waterfall approximately 0.3 miles upstream of the confluence with the Minnesota River. Due to this, the upstream monitoring sites of 13MN056 and 13MN057 are directly impacted for fish migration abilities. For this reason in addition to lack of refuge areas for replenishment upstream, fish were not assessed. There is also a severely perched culvert at 506th St. For more information on the waterfall please see DNR's Minnesota River, Mankato Watershed Characterization Report (2015) for more information. The waterfall and perched culvert are not direct stressors to the macroinvertebrate community in County Ditch 4/County Ditch 39. However, the perched culvert is likely a sign of stream instability.

A majority of this stream has also been altered by way of diching and channelizing as well as the introduction of subsurface tile drainage. Refer to Chapter 3.1.8 at the beginning of this report for additional information on altered hydrology and the correlated hydrological impacts. These practices directly contribute to the other impairments found within this watershed.

Summary Table of Stressors

Table 322. Identified stressors with suspected sources for reach 545 of County Ditch 4.



545 County Ditch 4/County Ditch 39

Key				
●=suspected source, ○=potential source	Stressor	Inconclusive	▨ Not a Stressor	NA

Stressors																																		
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
			●	○	○		○		●			●	○			▨	▨	▨	▨	▨	▨	●	●	●		▨	▨	▨	▨	▨	●	●	●

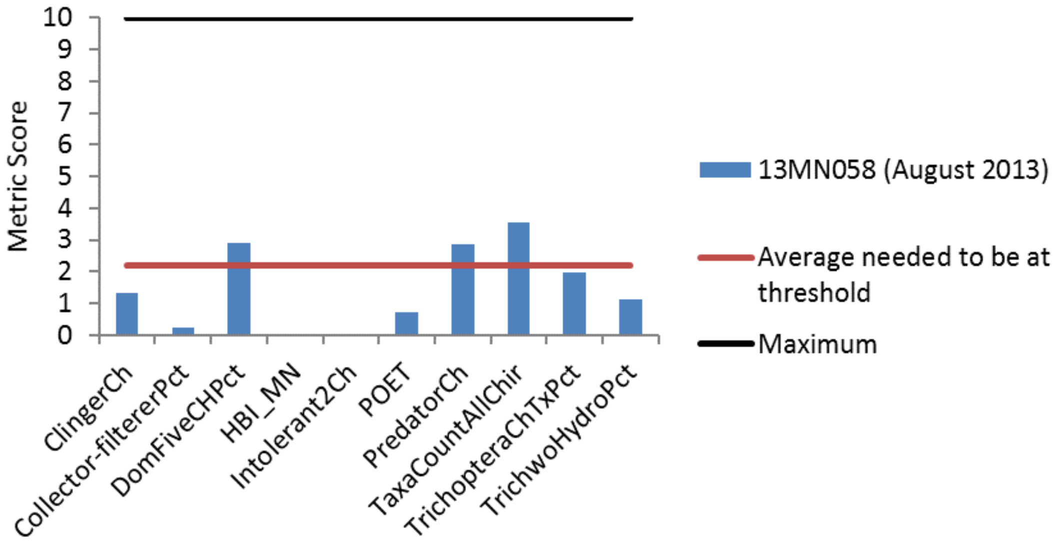
4.33 County Ditch 11 (07020007-661)

County Ditch 11 (07020007-661) is southeast of Nicollet, Minnesota. The reach is warmwater modified use class 2B. The reach begins at the outlet of Middle Lake and goes until the confluence with Swan Lake Outlet. CD 11 is impaired for lack of macroinvertebrate assemblage. There is one biological station on this reach, station 13MN058.

4.33.1 Biological Communities

Although fish were sampled in 2013, they were not assessed due to lack of flow. During fish sampling it was noted as a grass waterway. The macroinvertebrate community was sampled a week earlier than the fish visit (Figure 314). The macroinvertebrate community scored 14.7, below the Prairie Streams GP class IBI modified use threshold of 22. Snails (Physa) dominated the sample. The macroinvertebrate community scored an IBI of 14.7, well below the impairment threshold IBI of 41. There was a high percent of the dominant five taxa (DomFiveCHPct) that speaks to the elevated percentage of tolerant taxa (Tolerant2ChTxPct). Macroinvertebrate types are sparse as there are a lack of climbers (ClimberCh), clingers (ClingerCh), and filter speciese (Collector-filtererPct).

Figure 314. Macroinvertebrate metrics of the Prairie Streams GP class IBI for station 13MN058, County Ditch 11.



4.33.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

At the time of biological monitoring dissolved oxygen (DO) concentrations were recorded at 2.34 mg/L. Additional samples taken in 2015 and 2016 had a range of 1.65 mg/L – 9.19 mg/L, with an average of 6.06 mg/L. Two out of the three water quality samples collected in 2015 at S008-506 fell below the DO standard of 5mg/L with results of 1.65 mg/L (August 8) and 3.74 mg/L (September 1).

In 2015, a sonde was deployed at station 13MN058 from July 30 to August 10 (Figure 315) to track continuous DO levels. The DO ranged from 0.87 to 8.22 mg/L, with each day deployed, the DO was below the DO standard. The majority of the DO was less than 5 mg/L throughout the time of deployment. DO flux was only elevated a couple of days, ranging from 1.61 to 7.09 mg/L daily, with an average daily fluctuation in concentration of 2.82 mg/L (Figure 316). There was a noted spike in DO on August 7 that correlates to a rain event.

Figure 315. Diurnal dissolved oxygen for station 13MN058, July 30 - August 10, 2015.

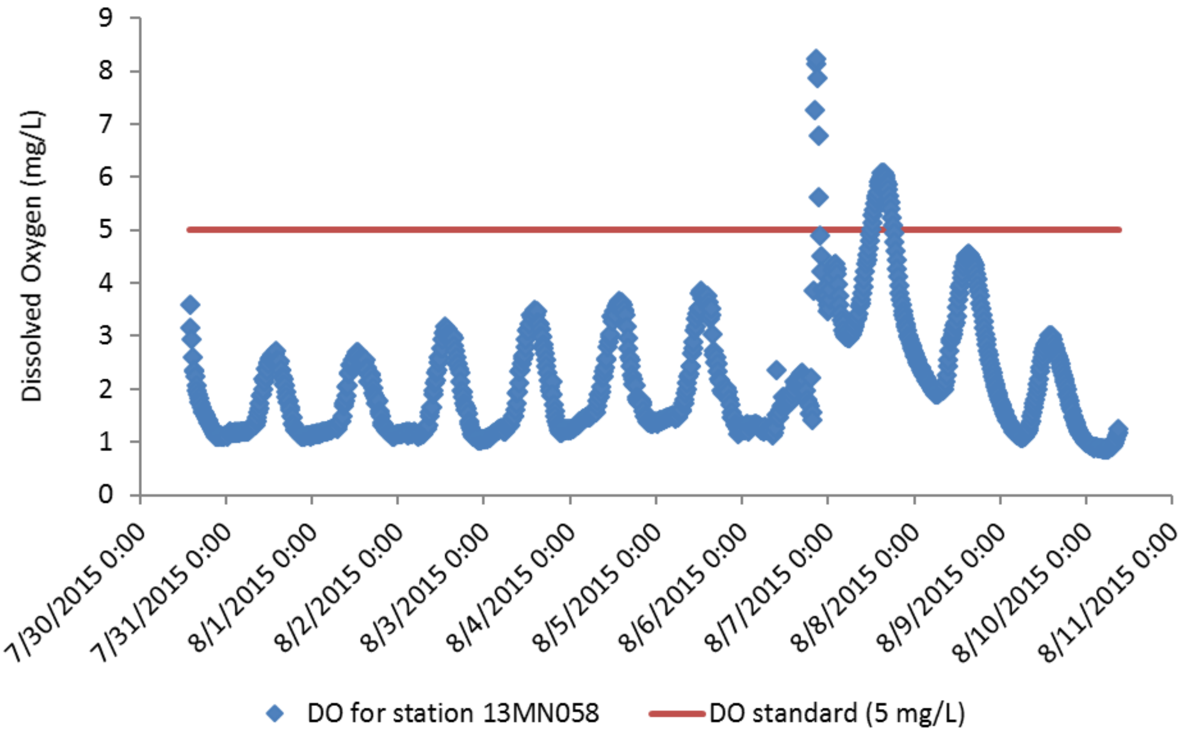
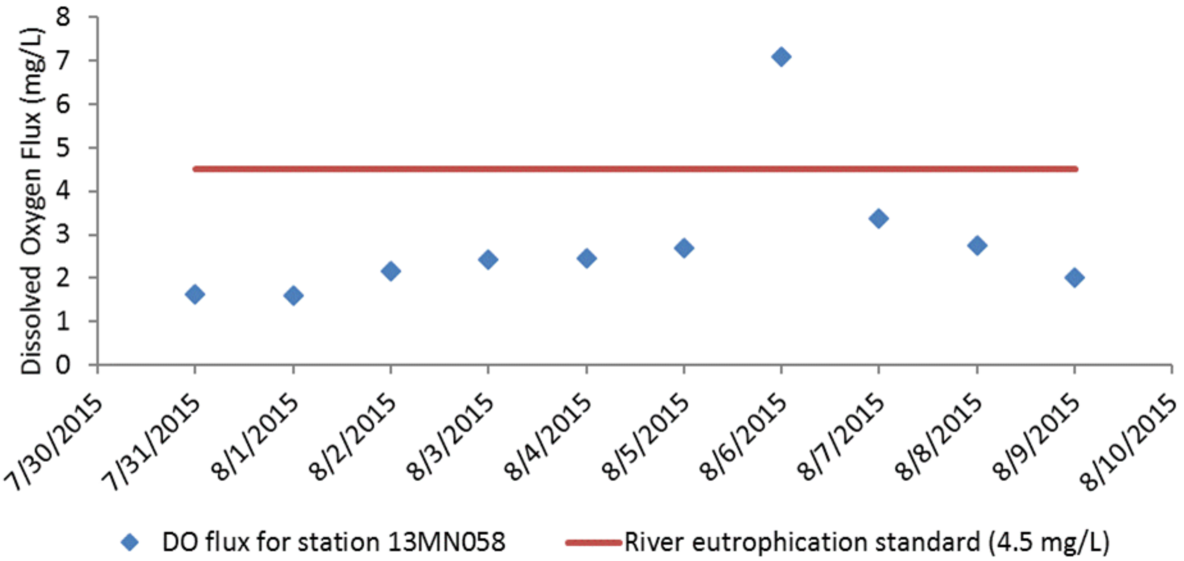


Figure 316. Dissolved oxygen flux at station 13MN058, July 31 - August 9, 2015.



The macroinvertebrate community indicates stress from low DO (Table 323). Low DO intolerant taxa where lacking completely and replaced with a high number of low DO tolerant taxa and individuals. The low DO index score was at 6.23, falling below the state average for modified prairie streams of 6.42.

Table 323. Macroinvertebrate metrics that respond to low DO stress in County Ditch 11 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN058 (2013)	**31**	**2**	**9.13**	**6.23**	**0**	**0**	**11**	**35.5**
Prairie Streams Average	*36.8*	*7.6*	*7.92*	*6.42*	*2.4*	*4.5*	*8.4*	*25.1*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is a stressor within this reach. There were clear low DO levels found during water quality assessment. The macroinvertebrate metrics consistently displayed low DO is placing restrictions on the community.

Eutrophication

During biological monitoring in 2013 two water chemistry samples were collected, both with high total phosphorus (TP) concentrations at 0.103 mg/L (June 10) and 1.19 mg/L (August 15). Six additional water chemistry samples were collected in 2015 and 2016 with TP ranging from .028 mg/L - .18 mg/L, and an average of .08 mg/L. Higher concentrations occurred in August and September of 2015. Two samples of chl-a were analyzed in September and August of 2015, with concentrations of 3.34 ug/L and .62 ug/L, with no exceedances of the standard (.15 mg/L). Furthermore, DO flux did not reflect the high DO values that are reflected in abundant photosynthesis activity, paired with low DO values at night from autotrophic respiration.

During times of sampling and reconnaissance, eutrophic conditions were documented. There was an overabundance of algae production, as displayed in Figure 317.

Figure 317. Station 13MN058 on June 10, 2013.

While there was already, an observed abundance of algal growth in June of 2013, and by August of 2013 the water was completely choked out (Figure 318).

Figure 318. Station 13MN058 on August 15, 2013.

The macroinvertebrate community metric scores within county ditch 11 was suggestive of eutrophic stress (Table 324), as taxa richness was low, there was a lack of sensitive species, and the community was composed of almost entirely tolerant taxa. Invertebrates that depend on habitats for filtering and gathering were observed to be less abundant than the state average for modified use prairie streams.

Table 324. Macroinvertebrate metrics that respond to eutrophication stress in County Ditch 11 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN058 (2013)	**31**	**3**	**11**	**2**	**0**	**93.5**
Prairie Streams Average	*36.8*	*3.9*	*12.8*	*6.5*	*0.1*	*85.4*
Expected response to stress	↓	↓	↓	↓	↓	↑

Eutrophication is considered inconclusive as a stressor for macroinvertebrates. While samples were not in abundance, what was collected for total phosphorus did display high potential for promoting eutrophic conditions. The three chl-a samples were not high, it is not telling of the actual growth conditions that were observed and documented within this stream. The same can be said for DO flux. Low DO was observed and indicated as a biological stressor. However, what was lacking as a line of evidence (in the case of eutrophication) was high concentrations of DO as a byproduct of photosynthetic activity. It is possible that the stream temperature decreased DO solubility, or that sonde deployment took place at a time when decomposing of algae was greater than growth. Additional to the 2013 samples community, the photos taken in 2013 also support the case for stream eutrophication. However, with the majority of the chemistry data being collected in different years conflict with these findings. It is difficult to determine how often the 2013 conditions are occurring.

Nitrate

During biological monitoring in 2013, two nitrate samples were collected at 13MN058. The sample collected on Juy 10 was 18 mg/L and dropped to .08 mg/L during the August 15 sample. In 2015 and 2016 six additional water chemistry samples were collected and analyzed for nitrate with results ranging from .17 mg/L – 23 mg/L and an average of 20.3 mg/L, exceeding 20 mg/L 4 out of the 6 samples. Months samples were collected were May through September, with June having the highest concentration of nitrates in both years.

The macroinvertebrate community that was sampled in 2013 does show consistent indication in all assessed parameters they are stressed by the elevated nitrate concentrations (Table 325). The nitrate score was 4.5, while the average for modified Prairie Streams meeting impairment threshold is 3.2. This suggests that overall the community present is quite tolerant to high nitrate concentrations. Increasing nitrate concentrations also correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct) and decreased intolerant and Trichoptera taxa, all of which are lacking in this reach. Additionally, the number of nitrate tolerant individuals (85%) is much higher than average. The fewer number of nitrate tolerant taxa is likely explained by an overall low taxa count for this site. The chemical and biological data support nitrate as a stressor in this reach.

Table 325. Macroinvertebrate metrics that respond to nitrate stress in County Ditch 11 compared to the statewide average of visits meeting the warmwater modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN058 (2013)	**1**	**0.3**	**4.5**	**0**	**21**	**85**
*Prairie Streams Average **(MU)***	*2.6*	*2.4*	*3.2*	*1.1*	*18.0*	*59.7*
Expected response to stress	↓	↓	↑	↓	↑	↑

Total Suspended Solids

During biological monitoringing the total suspended solids (TSS sample) of 1.2 mg/L was collected on June 10 and another sample of 810 mg/L on August 15 in 2013 this being the highest concentration compared to the other seven additional water chemistry samples taken in 2015 and 2016, with those concentrations of TSS ranging from 1.2 g/L – 4.4 mg/L and an average of 2.74 mg/L.

Limited water chemistry data was available from three biological monitoring samples in 2013. Total suspended solids and sechi tube data had one exceedance from the same day on August 15, 2013.

Macroinvertebrate metrics are not suggestive of TSS as a stressor to the community (Table 326). The TSS index score was at 15.94, below the state average of 16.68 for modified prairie streams. TSS intolerant inverts were missing from the sample, as were taxa that depend on a habitat that allows for filtering. There was not an abundance of tolerant taxa, also concluding the overall community is being impacted and decreased by a different stressor.

Table 326. Macroinvertebrate metrics that respond to high TSS stress in County Ditch 11 compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

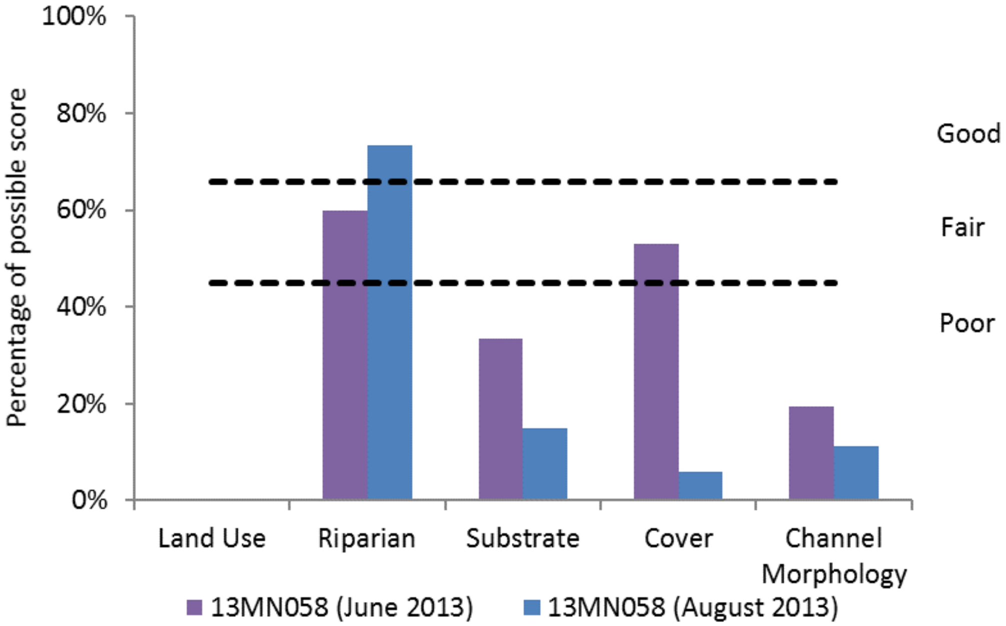
Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN058 (2013)	**1.3**	**0**	15.94	**0**	**0**	5	**46.6**
Prairie Streams Average	*11.7*	*0.1*	*16.68*	*0.8*	*1.4*	*11.8*	*41.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

TSS is inconclusive as a biological stressor. TSS does not seem to be a primary stressor, if it is one at all to the community. TSS cannot be ruled out, as there is conflicting results within the biological community response as well as the chemistry data. Additional to the limited TSS samples, there was the one sample that did indicate that when TSS does exceed the standard in this system, it is at high rates.

Habitat

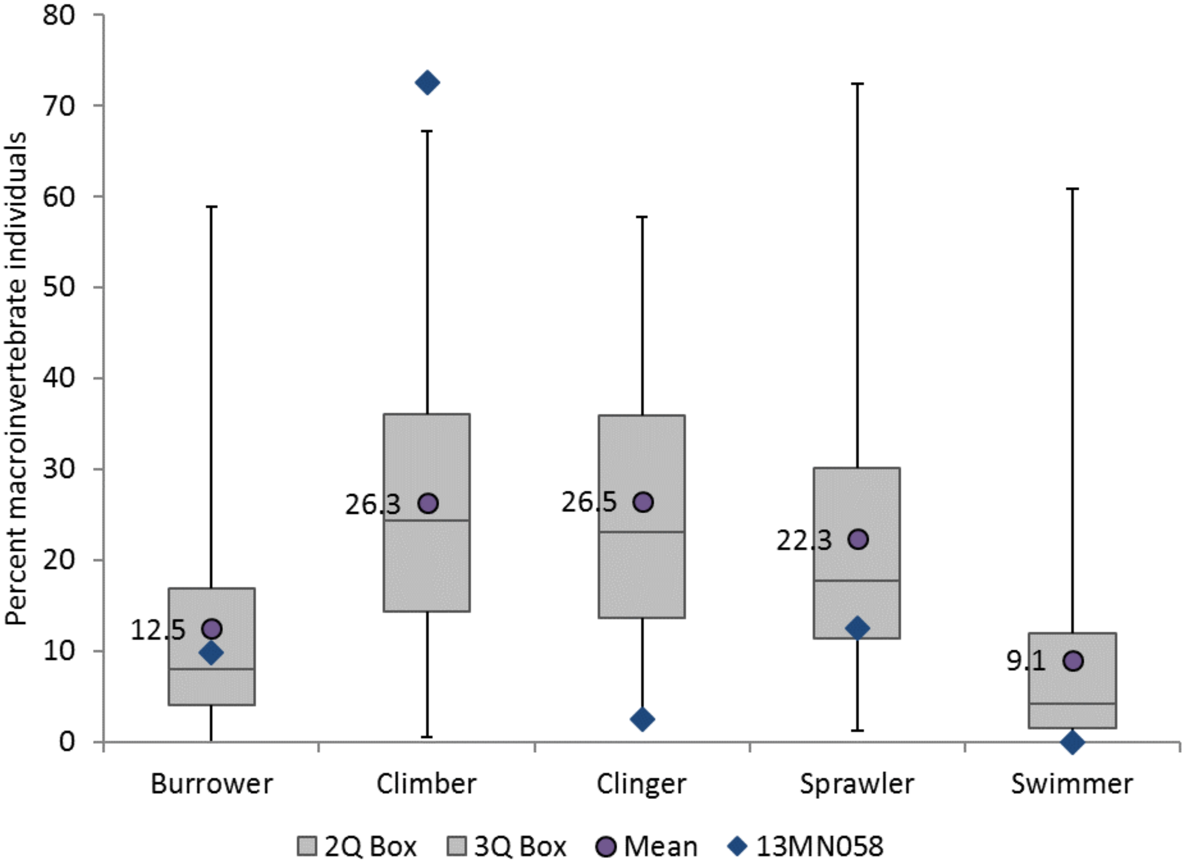
In June 2013, station 13MN058 received a poor MSHA score of 34 (Figure 319). In August, the MSHA was repeated with a poorer score of 20. The surrounding land use of the station is row crop. The riparian width was noted as narrow in June and very narrow in August. Bank erosion was not noted during either visit. In June, there was moderate shading and in August, there was heavy shading. Both visits noted that there was no coarse substrate with the entire reach being fully embedded by silt. This reach also lacked morphology as the only stream characterization was a run feature. In June, the cover amount was moderate with overhanging vegetation and macrophytes, but by August, the cover had changed to choking vegetation only. During both visits, there was poor depth variability, poor sinuosity, and poor channel development. Channel stability was noted moderate/high in June and dropped to moderate in August.

Figure 319. Percentage of MSHA subcategory scores for station 13MN058, County Ditch 11.



The taxa community types within County Ditch 11 showed a disproportionate amount of climber and a low amount of clingers. Clingers lack of abundance is likely due to embeddedness and lack of clean and diverse substrate, and often are associated as riffle dwelling species. The high amounts of climbers are due from the dominance of Physa, Stagnicola, and Gyraulus (all types of tolerant snail species) that were sampled.

Figure 320. Macroinvertebrate habit metrics with box plot showing range of values from Prairie Streams stations meeting the modified use biocriteria mean of those stations, and metric values from station 13MN058.



Habitat is considered a stressor. Lack of habitat diversity as well as the lack of quality in what is available. Metrics and MSHA score both indicate specialized habitat type groups are limited by the poor habitat conditions.

Longitudinal Connectivity and Altered Hydrology

Nicollet Creek has a natural waterfall approximately 0.3 miles upstream of the confluence with the Minnesota River. There is also a severely perched culvert at 506th St. For more information on the waterfall, please see DNR's Minnesota River, Mankato Watershed Characterization Report (2015). The fish community was not assessed within the reaches of the Swan Lake 10 digit HUC due to the natural waterfall feature limiting fish replenishment. The waterfall and perched culvert are not direct stressors to the macroinvertebrate community in County Ditch 11, but the perched culvert is likely a sign of stream instability.

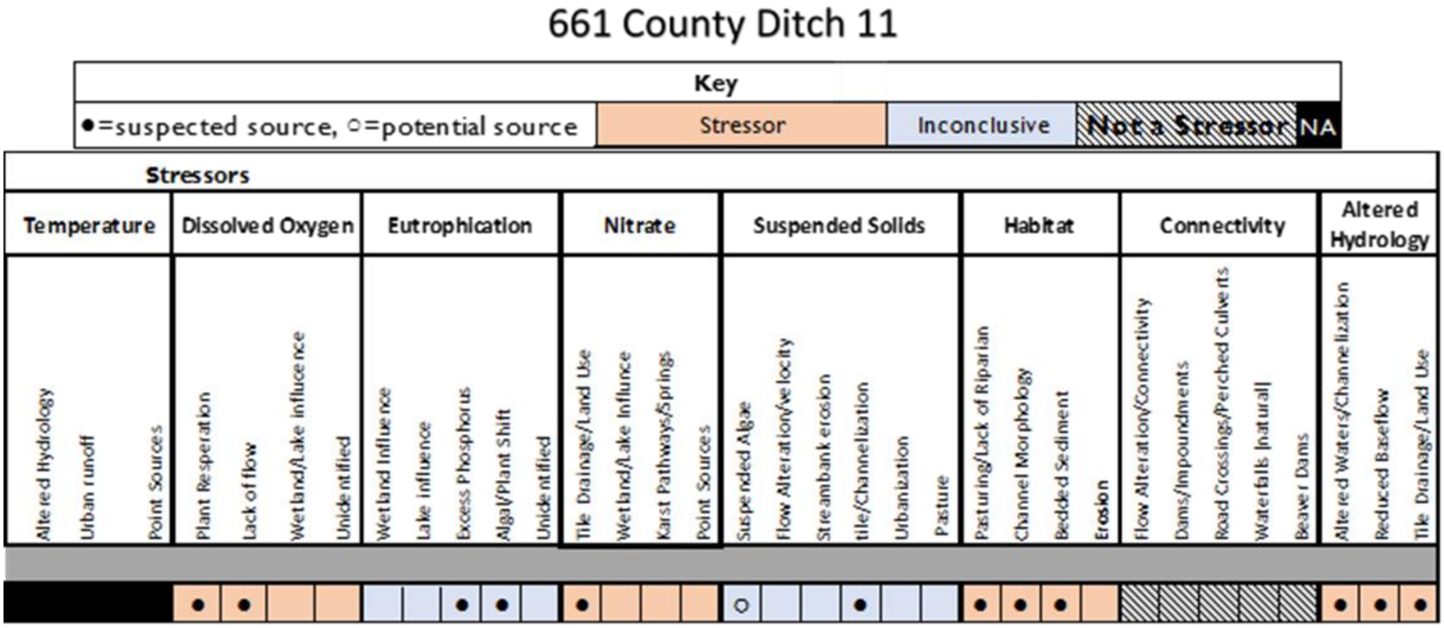
This reach is completely ditched. Due to this, there are impacts seen in water quality, channel morphology, and hydrology. Additional to the stream channel being physically modified, there is the introduction of subsurface tile drainage being introduced to this stream. These tile lines alter hydrology within this location by creating an imbalance to the flow regime as well as excess of nutrients delivered to the stream. Figure 321 and Figure 322 below shows county ditch 11, both photos display a homogenous stream that lacks diversity. There is also a visible difference in flow, with high base flows noted in August 2015 in contrast to September 2012. Tile lines disconnect the flow regime and recharge rates from the historic water retention sites, paired with the lateral soil to stream recharge rates.

Figure 321. 13MN058 August 10, 2015 in sigh flow conditions following a rain event.

Figure 322. 13MN058 September 14, 2012 showing the stream completely dry.

Summary Table of Stressors

Table 327. Identified stressors with suspected sources for reach 661 of County Ditch 11.



661 County Ditch 11

Key				
●=suspected source, ○=potential source	🟧 Stressor	🟦 Inconclusive	▨ Not a Stressor	■ NA

Stressors

Temperature			Dissolved Oxygen				Eutrophication					Nitrate			
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources
■	■	■	🟧 ●	🟧 ●	🟧	🟧	🟦	🟦	🟦 ●	🟦 ●	🟦	🟧 ●	🟧	🟧	🟧

Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
🟦 ○	🟦	🟦	🟦 ●	🟦	🟦	🟧 ●	🟧 ●	🟧 ●	🟧	▨	▨	▨	▨	▨	🟧 ●	🟧 ●	🟧 ●

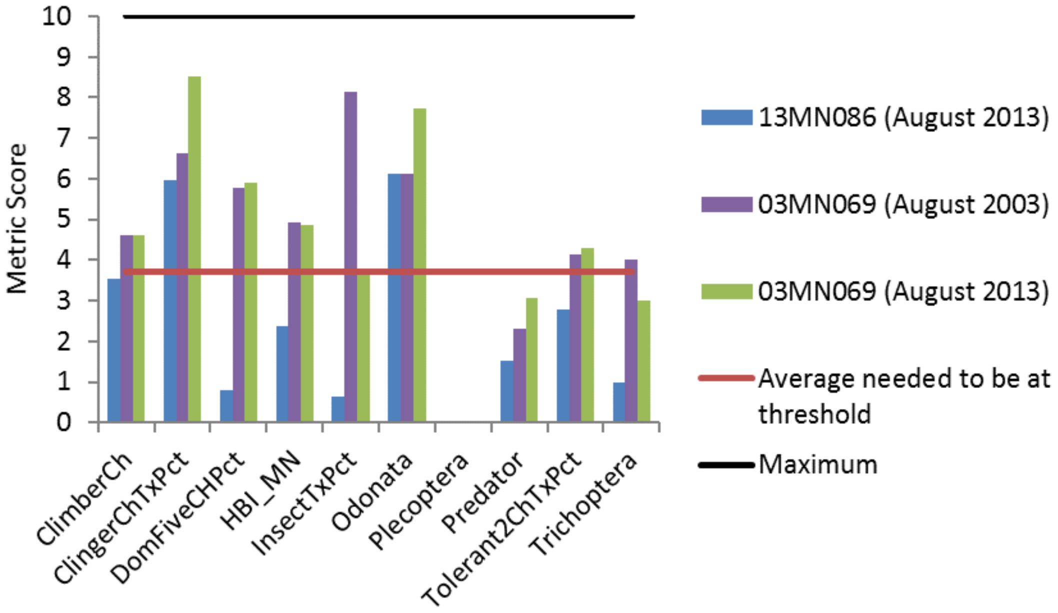
4.34 Swan Lake Outlet (Nicollet Creek) (07020007-683)

Nicollet Creek (07020007-683) is south of Nicollet, Minnesota. The reach is warmwater general use class 2B. The reach extends from CD 39 to the Minnesota River. Nicollet Creek is impaired for lack of macroinvertebrate assemblage. There are two biological stations on this reach, station 13MN086 (upstream) and station 03MN069 (downstream). The reach is also impaired for E. coli, but it will not be addressed in this report.

4.34.1 Biological Communities

There are two biological monitoring locations on this reach of Nicolett Creek. Station 13MN086's macroinvertebrate community scored 26.9, below the Southern Streams RR class IBI threshold of 37 (Figure 323). Snails (Physa) dominated the sample. The macroinvertebrate community scored an IBI of 14.7, well below the impairment threshold IBI of 41. There was a high percent of the dominant five taxa (DomFiveCHPct) that speaks to the elevated percentage of tolerant taxa (Tolerant2ChTxPct). Macroinvertebrate types are sparse as there are a lack of climbers (ClimberCh), clingers (ClingerCh), and filter species (Collector-filtererPct).

Figure 323. Macroinvertebrate metrics of the Southern Streams class IBI for stations 13MN086 and 03MN069, Swan Lake Outlet.



4.34.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

At the time of biological monitoring at station 03MN069, dissolved oxygen (DO) was recorded at 7.95 mg/L on July 16, 2003 and at 10.1 mg/L on August 8, 2013. At station, 13MN086 DO was recorded at 8.86 mg/L on June 11, 2013 and at 10.61 mg/L on August 8, 2013. Seventeen additional DO samples were collected over two years at four different stations. Overall, DO did not fall below the threshold for aquatic life of 5 mg/L (standard for 2B waters). It is worth noting that there were only two early morning data points available. More early morning data or a sonde deployment is needed to get a complete picture of DO situations across this reach. One sampling point from April 2013 was unusually high (16.7 mg/L), although this is a single measurement, large swings in DO can potentially indicate flux issues that can stress aquatic life.

The macroinvertebrate community metrics for low DO stress displayed mixed results (Table 328). Both the low DO intolerant and tolerant taxa are not in abundance within this reach. The low DO index score also did not fall below 7.04, the average for southern streams. What was consistently displaying stress at all the stations sampled were mayflies; this displacement could be due to another biological stressor.

Table 328. Macroinvertebrate metrics that respond to low DO stress in Swan Lake Outlet compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Tolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN086 (2013)	**31**	**6**	**7.54**	7.23	**6**	**2.3**	4	2.3
03MN069 (2003)	**43**	**11**	6.67	7.68	10	46.6	2	0.6
03MN069 (2013)	**38**	**7**	6.69	7.52	**8**	43.0	3	1.2
Southern Streams Average	*45.8*	*14.2*	*7.08*	*7.04*	*9.0*	*24.0*	*4.8*	*9.9*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is inconclusive at this time. Without understanding how low DO is getting within this stream, it cannot be ruled out. In the future, early morning DO readings or sonde deployments are being recommended in effort to better understand the DO dynamics occurring within this reach. The metrics are also not strongly suggestive of DO stress; however better chemistry data is needed to determine if some taxa are being impacted or if this displacement is from another stressor.

Eutrophication

During biological monitoring at 03MN069 and 13MN086 five water samples were taken and phosphorus was analyzed. TP had a range of 0.018 mg/L - 0.096 mg/L, and an average of .056 mg/L. Twenty-nine additional water chemistry samples were collected and analyzed in 2009, 2010, 2013, and 2014. Data ranged from 0.022 mg/L – 3.12 mg/L with an average of 0.098mg/L. Fourteen percent of the samples fell above 0.15 mg/L. April through June consistently had high TP concentrations. There was not any data for chl-a, DO flux, or BOD to evaluate response variables to eutrophication.

The macroinvertebrate community metric scores within this reach were suggestive of eutrophic stress (Table 329). Overall taxa richness sampled was low; there was a lack of sensitive species, as the community was composed of almost entirely tolerant taxa. Invertebrates that depend on habitat conditions for filtering and gathering were observed to be less abundant than the state average for southern streams.

Table 329. Macroinvertebrate metrics that respond to eutrophication stress in Swan Lake Outlet compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN086 (2013)	**31**	**4**	**10**	**6**	**0**	**80.6**
03MN069 (2003)	**43**	**7**	**12**	**11**	**0**	**74.4**
03MN069 (2013)	**38**	**7**	**13**	**7**	**0**	**73.7**
Southern Steams Average	*45.8*	*7.3*	*15.9*	*12.2*	*0.8*	*72.6*
Expected response to stress	↓	↓	↓	↓	↓	↑

Eutrophication as a stressor is considered inconclusive. While phosphorous was shown to be in high concentrations within this reach, there was an absence of secondary chemistry data to confirm Eutrophication is occurring here. The biological metrics are suggestive to eutrophic stress on the macroinvertebrate community.

Nitrate

During biological monitoring a total of five samples were taken at stations 03MN069 and 13MN086 in 2003 and 2013, nitrate concentrations ranged from 1.5 mg/L – 8.1 mg/L and an average of 5.26 mg/L. Additional water chemistry sampling was done in 2009, 2010, 2013, and 2014 resulting in a range of 0.28 mg/l – 14.3 mg/L and an average of 3.9 mg/L from 30 samples. This shows moderate nitrate concentrations within this reach.

The macroinvertebrates in this reach show a mixed response to elevated nitrate concentrations (Table 330). The nitrate index score ranged from 2.9 to 3.9, while the average for Southern Streams meeting impairment threshold is 2.9. The index score, in addition to the percentage of nitrate tolerant individuals indicates a community dominated by nitrate tolerant taxa. 2013 does display the number of nitrate tolerant taxa meeting the Southern Streams average, yet the percentage of nitrate tolerant species dominated in all three-sample sets. Increasing nitrate concentrations also correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct) and decreased intolerant taxa.

Table 330. Macroinvertebrate metrics that respond to nitrate stress in Nicollet Creek compared to the statewide average of visits meeting the warmwater general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
03MN069 (2003)	**6**	**1.6**	**2.9**	**1**	**20**	**49.7**
03MN069 (2013)	**5**	**3.1**	**3**	**1**	18	**50.3**
13MN086 (2013)	**3**	**3.2**	**3.9**	**0**	14	**81.2**
Southern Streams Average	*6.3*	*5.5*	*2.9*	*2.4*	*18.8*	*47.2*
Expected response to stress	↓	↓	↑	↓	↑	↑

Considering the high number of samples, and an overall moderate concentration, nitrate cannot be confirmed or ruled, out and therefore is inconclusive as a stressor. The biological community seems to be responding to high nitrate concentrations, even though the metrics are possibly displaying a response to some other biological stressor. The response seems different between the two stations, despite the concentrations being similar.

Total Suspended Solids

During biological monitoring a total of five total suspended solids (TSS) samples were taken at stations 03MN069 and 13MN086 in 2003 and 2013 to analyze for TSS; concentrations ranged from 2 mg/L – 21 mg/L and had an average of 8.5 mg/L. Additional water chemistry sampling was done in 2009, 2010, 2013, and 2014 resulting in a TSS concentration range of 2 mg/l – 62 mg/L and an average of 11.7 mg/L from 30 samples.

The TSS dataset showed no exceedances, the highest value of 62 mg/L was just below the standard but overall the dataset looked good. Secchi tube datasets met their respective standards with two years of data available.

The macroinvertebrate metrics for TSS were mixed (Table 331). The TSS index score fell just above the average of 15.63 for southern streams, when station 13MN086 scored 15.80. The other site scored below the threshold in both sampling years. TSS intolerant taxa were lacking in all three assessments. However, tolerant species were not overly abundant. While taxa that depend on a habitat suitable for filtering were lacking, they were present in all three samples.

Table 331. Macroinvertebrate metrics that respond to high TSS stress in Swan Lake Outlet compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN086 (2013)	**6.2**	**0**	**15.80**	**0**	**0**	10	**36.9**
03MN069 (2003)	**19.0**	**0**	15.11	**1**	**0.3**	11	25.0
03MN069 (2013)	42.9	**0**	14.47	**0**	**0**	10	24.7
Southern Steams Average	*25.4*	*0.7*	*15.63*	*2.9*	*4.7*	*12.2*	*34.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

TSS is not considered a biological stressor within this reach. While the metrics are mixed, they are not strongly suggestive of TSS stress. There was a decent chemistry sample size within this reach that did not display much indication TSS is a likely stressor.

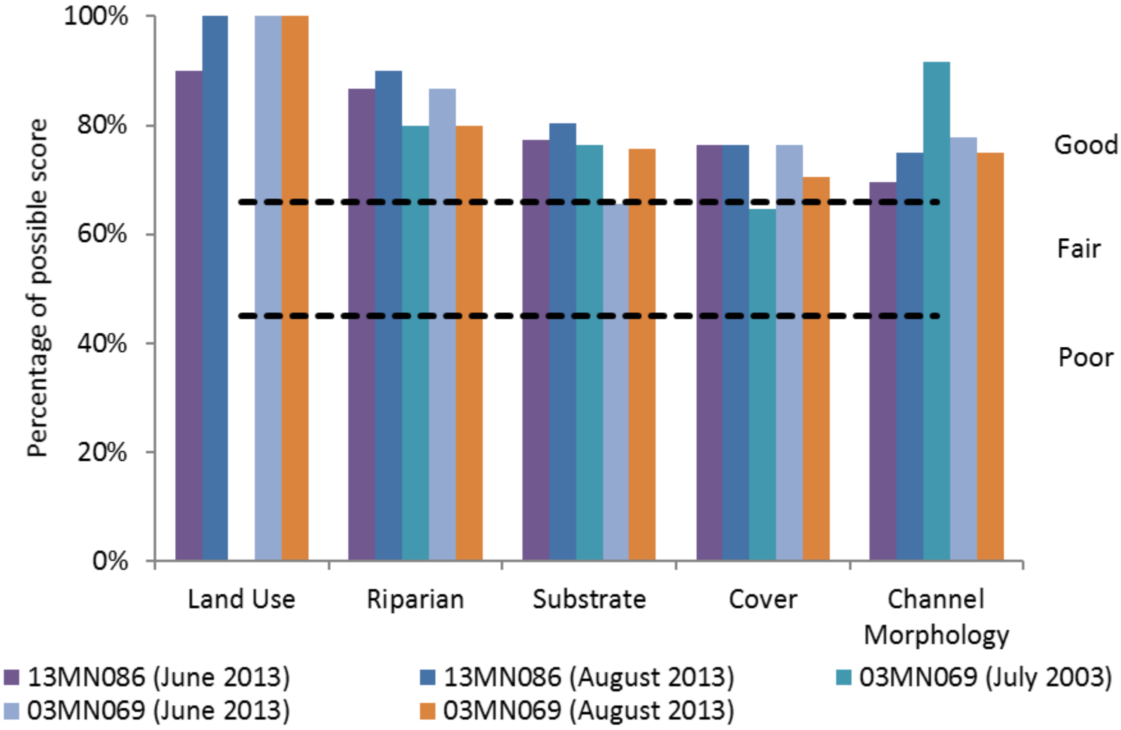
Habitat

All visits in this reach had good MSHA scores (Figure 324). In 2013, station 13MN086 MSHA scores were 76.35 (June) and 80.2 (August). Station 03MN069 had very similar MSHA scores in 2003 and 2013, ranging from 76.4 to 76.7 over the three visits. 13MN086 has a strong diversity of substrate types, with a mixture of sand, gravel cobble, and boulders with little to no observed embeddedness. Channel morphology is also noted as being diverse with scores noting pools at 15-50%, riffles at 15-35%, and runs making up 50-70% of the stream. There is also a healthy abundance of cover types for additional habitat diversity. The gradient of 13MN086 is measured as 6.07.

Station 03MN069 had slightly less instream diversity with the substrate types being sand, gravel, and cobble but an absence of boulders. Embeddedness is also noted as light within this section of the reach. Channel morphology score noted pools at 10-15%, riffles 20-30%, and runs at 55-70%. Cover types were also found to be diverse and in abundance. The gradient of 13MN086 was measured at 5.34.

Both sites had strong rating for channel stability, with little to no erosion being noted. Both locations also had moderate to extensive riparian width to continue to support channel stability.

Figure 324. Percentage of MSHA subcategory scores for stations 13MN086 and 03MN069, Swan Lake Outlet.



At the time of macroinvertebrate monitoring at station 13MN086 the general flow of the stream was noted as slow. The dominant habitat available was wood; with the dominant substrate within the streambed was sand. As shown in Figure 325, the number of "burrower and swimmer" taxa fell within the expected range of abundance. There were more than average taxa in the category of "Climber" and "Sprawlers". Physa (snails) and Gammarus (Scuds) dominated the overall sample size, also driving up the climber and sprawler communities. Clingers were below expected ranges, which prefer wood and rock habitats.

At the time of the macroinvertebrate visit in 2003 at 03MN069, the general flow of the stream was moderate, with the dominant substrate being a cobble gravel mixture. 2013 site visit conditions were not noted.

At the time of the macroinvertebrate visit in 2013 at 13MN086, the general flow of the stream was slow, with the dominant substrate being wood.

Figure 325. Macroinvertebrate habit metrics with box plot showing range of values from Southern Streams stations meeting the general use biocriteria mean of those stations, and metric values from stations 13MN086 and 03MN069

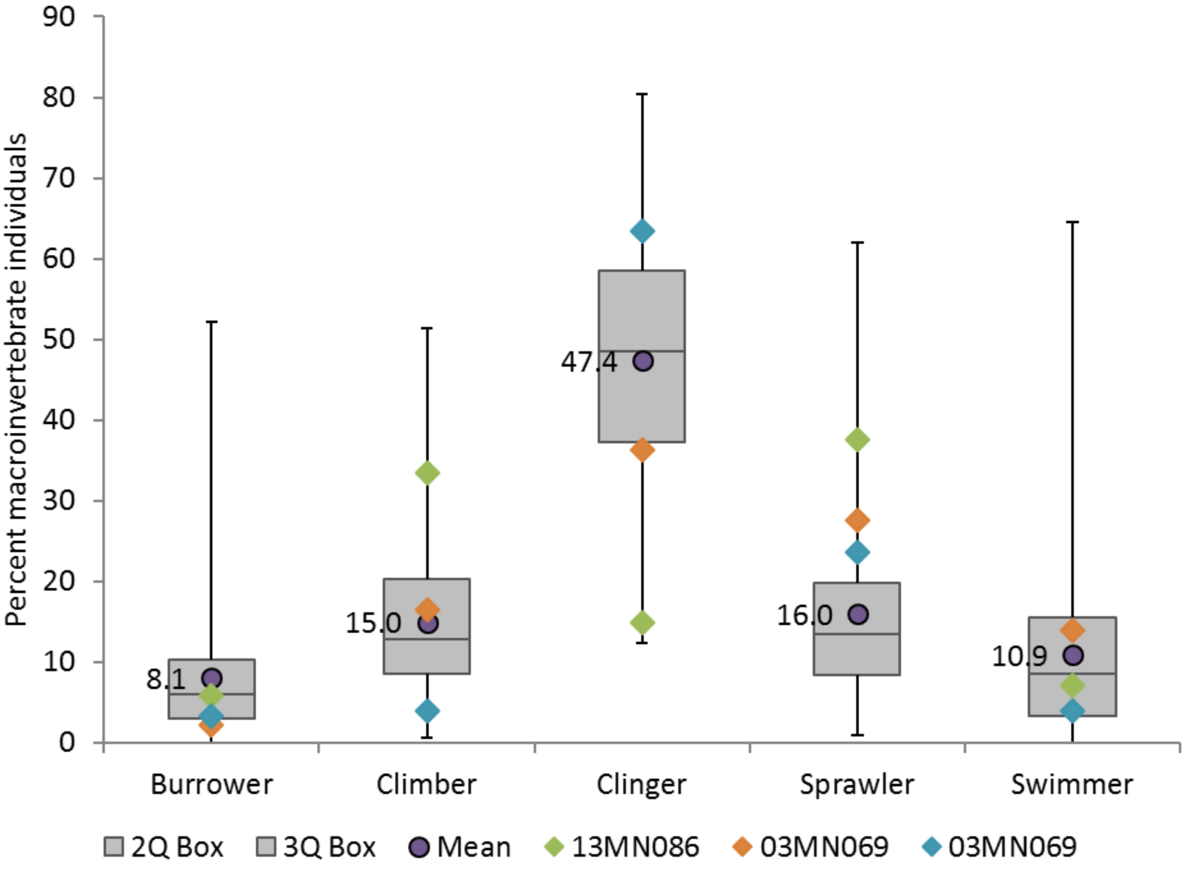


Figure 326. Station 13MN086 displaying habitat conditions on June 11 2013.

Figure 327. Station 03MN069 displaying habitat conditions on June 11 2013.

The community type metrics displayed in Figure 325 are suggestive of a habitat displacement. In this case, it is not likely that this is due from a lack of available clean streambed habitat, were clingers are usually associated. As displayed in Figure 326 and Figure 327 above, there appears to be diverse and stable habitat diversity. Habitat is not a stressor to Nicollet Creek.

Longitudinal Connectivity and Altered Hydrology

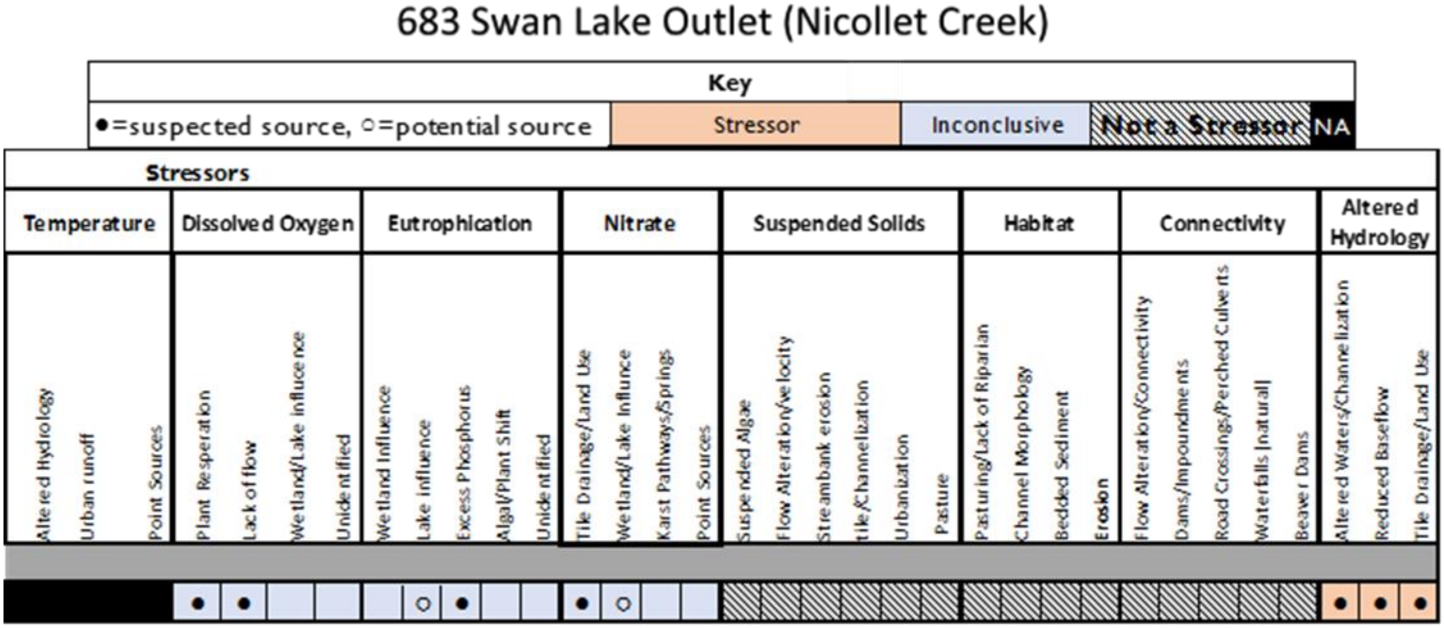
Nicollet Creek has a natural waterfall approximately 0.3 miles upstream of the confluence with the Minnesota River. There is also a severely perched culvert at 506th St. For more information on the waterfall, please see DNR's Minnesota River, Mankato Watershed Characterization Report (2015). The fish community was not assessed within the reaches of the Swan Lake 10 digit HUC due to the natural waterfall feature limiting fish replenishment. The waterfall and perched culvert are not direct stressors to the macroinvertebrate community in County Ditch 11, but the perched culvert is likely a sign of stream instability.

Altered hydrology is also prevalent at the upstream reaches of -545 and -661. Both of those reaches are extensively altered by ways of ditching as well as the introduction of subsurface tile drainage. This contributes to a host of water quality and fluvial geomorphology imbalances. See Chapter 3.1.8 for additional information on altered hydrology impacts within this region.

Figure 328. Perched culvert at 03MN069, photo taken July 12, 2012.

Summary Table

Table 332. Identified stressors with suspected sources for reach 683 of Nicollet Creek.



683 Swan Lake Outlet (Nicollet Creek)

Key				
●=suspected source, ○=potential source	Stressor	Inconclusive	Not a Stressor	NA

Stressors																																					
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls (natural)	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
■	■	■	●	●				○	●			●	○			▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	●	●	●

Overall conclusion:
There is not a clear biological stressor that is limiting the macroinvertebrate community. There is a mix of coldwater and warm water species present. There are significant differences and dynamics occurring up stream of this reach and at this reach.

The sampled community in this location was made of a mix of warmwater and cold-water species. At the time of monitoring this reach was colder than what would be expected for a warmwater stream the temperature at the time of biological monitoring was at 19.4 C° on July 16, 2003, 14.6 C° on June 11, 2013, and at 13.4 C° on August 8, 2013 at station 03MN069. At the time of biological monitoring for station 13MN086 temperatures were at 18.5 C° on August 7, 2013, and at 13.1 C° on August 8, 2013.

The dominants of Gammarus is possibly due to cool temperatures, likely from springs within the reach. The sampled macroinvertebrates were a mix of a warmwater and cold-water species. The warm water contributions are likely influenced from upstream sources. There was a presence of Physa, Hirudina, Lymnaeidae. These snails are found in wetlands, or in streams with eutrophic conditions. These species will typically be found in low gradient areas. The presence of these snail species this far downstream of the system is likely a result of being flushed through from a rain event, bringing down the MIBI score.

Swan Lake Subwatershed Conclusion

Three stream reaches were found to be impaired for biology in the Swan Lake Subwatershed; this includes Swan Lake Outlet (Nicollet Creek -683), County Ditch 11 (-661), and County Ditch 4/CD 39 (-545). Nicollet Creek was the only stream assessed as general use; the other two locations were assessed as modified. It is important to note that due to the natural stream barrier of Nicollet Creek's waterfall paired with the lack of upstream refuge habitat, fish were not assessed at any of the sites.

The primary stressor as well as driver for the other parameters limiting macroinvertebrates is altered hydrology. Altered hydrology is occurring two ways within the Swan Lake Subwatershed; the first is through subsurface tile drainage, and the second is stream channel alteration by ditching and channelizing. Both of these alterations are for agricultural practices in effort to expedite water off the land for optimal growing conditions for row crops, influencing the downstream stations water volumes as well as water quality. As these channels take on extra water from ground tile, they change their dimension, pattern, and profile to adjust that often diminishes habitat. Water quality impairments within this watershed are primarily a result from agricultural tile inputs and changes to the streams velocity.

Nitrate can be toxic to biology depending on the concentrations as well as the exposure time. There was only one site (CD 11) that yielded both high chemistry concentrations for nitrate, as well as clear stress observed in the biological community. Chemistry samples in CD 4/CD 39 were limited and therefore did not have enough to confirm nitrate is limiting biology, and therefore findings are inconclusive in determining if there was a negative impact within the community. The limited data that was available for assessment in this area was typically at toxic concentrations. Nicollet Creek had a larger set of data for assessment for nitrate, and found concentrations were relatively low. However, the biological samples were signaling mixed results and was somewhat suggestive of a nitrate stressed community. Therefore, Nicollet Creek was listed as inconclusive.

Phosphorus and secondary chemistry parameters (chlorophyll-a, DO fluctuation, BOD) were limited in sample sizes, resulting in inconclusive findings at two locations. Nicollet Creek is the only exception to lack of data. Here it was observed that there were frequently high concentrations of phosphorus. However, it is not likely that eutrophication is occurring within this section of stream. Phosphorus itself is not toxic to aquatic life, but plays a role in making the eutrophic conditions that limit biology. Eutrophication typically occurs in the upstream portion of this watershed. Here stream canopy cover will be limited, allowing for an overabundance of sunlight; this paired with heavy input of phosphorus and a slow stream velocity (from lack of gradient) will create optimal conditions for algal growth to occur.

Low dissolved oxygen was apparent in the upland ditched streams. This could be occurring for a variety of reasons. Low base flow within this subwatershed has been noted as a cause. An overabundance (both instream and upstream locations) of algae production and the associated respiration is also a likely culprit of DO within this system. Low DO is listed as inconclusive within Nicolette creek as there was not enough chemistry data to rule it out.

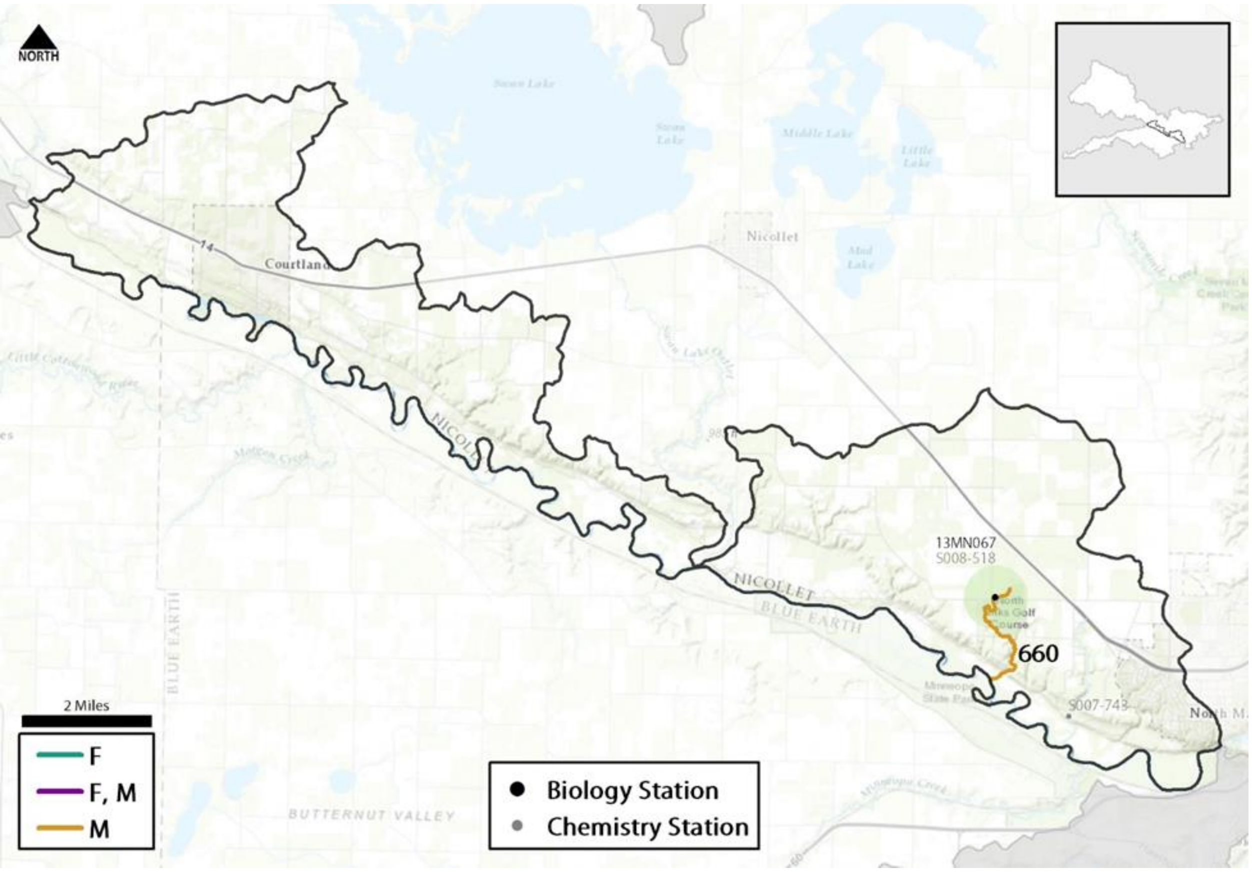
Total suspended solids (TSS) was only of potential concern within County Ditch 11. This was due to one extremely high reading of TSS and a mixed biological response to TSS. There was little to no biological response that indicate TSS is a limiting factor.

Habitat stressors are evident in the upland sites of CD 11 and CD 4/39, as both habitat quality and habitat diversity was found to be poor due to both of these streams being ditched and the stream bottom being embedded; Greatly limiting species that depend on a diverse streambed and pools to thrive. Flows within this area become critically low, and reflect an imbalance to land to stream water relationship. Downstream, Nicollet Creek displays a diverse and healthy stream habitat. While water volume and chemistry will be influenced by the upstream contributors, this channel’s healthy habitat is a result of a strong riparian area that has supported the streams banks and is able to better mitigate the upstream velocity imbalances. Nicollet Creek’s macroinvertebrate sample yielded a number of sensitive cold-water taxa. Upon further inspection of the temperature data, it is likely there are a number of springs feeding this section of stream.

Morgan Creek – MNR Mankato North

This section encompasses one biotic impaired reach in Morgan Creek 10 digit HUC. The warmwater reach is County Ditch 3 (070200007-660) impaired for macroinvertebrate assemblage.

Figure 329. Map of the Morgan Creek watershed with biological impairments and monitoring stations. Impairments are described as F=Fish, F, M=Fish and Macroinvertebrates, and M=Macroinvertebrates.



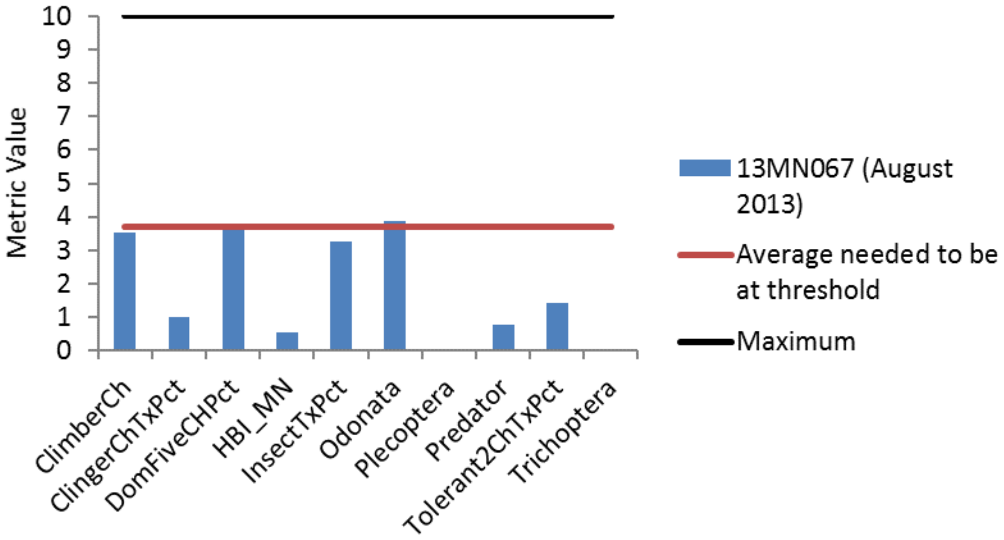
4.35 County Ditch 3 (07020007-660)

County Ditch 3 (07020007-660) is west of Mankato, Minnesota. The reach is warmwater general use Class 2B. The reach extends from upstream of 520th St. to the Minnesota River. CD 3 is impaired for lack of macroinvertebrate assemblage. There is one biological station on this reach, station 13MN067.

4.35.1 Biological Communities

Station 13MN067 was sampled for fish and macroinvertebrates in 2013. The fish community was not assessable due to the station location is above a barrier falls, naturally limiting the fish community. The macroinvertebrate community scored (18) below the Southern Streams RR class IBI threshold (37). Snails (Physa) were the most abundant macroinvertebrates in the sample, they are considered tolerant of poor habitat conditions and indicators of poor water quality. All metrics that make up the overall macroinvertebrate score fell below the expected threshold, with the exception of abundance of insects within the sample (InsectTxPct), as displayed inFigure 330.

Figure 330. Macroinvertebrate metrics of the Southern Streams RR class IBI for station 13MN067, County Ditch 3.



4.35.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

There was one dissolved oxygen (DO) measurement of 7.02 mg/L, collected during biological sample on July 7, 2013. Additional oxygen readings in 2015 were also in the normal range (8.28 mg/L to 9.63 mg/L). No additional data on DO was available on this reach.

The macroinvertebrate metrics show the potential for low DO stress in Morgan Creek (Table 333). The DO index score was less than average for visits meeting the biocriteria. Additionally, there are a lack of low DO intolerant taxa, abundant DO tolerant taxa and individuals, and little to no EPT taxa.

Table 333. Macroinvertebrate metrics that respond to low DO stress in County Ditch 3 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN067 (2013)	**31**	**2**	**8.16**	**6.43**	**3**	**11.5**	**6**	**11.5**
Southern Streams Average	*45.8*	*14.2*	*7.08*	*7.04*	*9.0*	*24.0*	*4.8*	*9.9*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is a stressor. The macroinvertebrate metrics are suggestive of low DO stress on the community. Due to limited connecting chemical information, low DO as a chronic issue within this reach cannot be concluded.

Eutrophication

During biological sample at 13MN067, the phosphorus (TP) concentration was low at 0.05 mg/L. There were a total of six additional samples for TP on this stream taken in 2015 and 2016 (S008-518/13MN067). Two samples from July 6, and September 2 of 2015 had a TP value above 0.150 mg/L, the standard for the southern eutrophication standard. These two high values correspond to high TSS values as well and likely tied to storm events. On July 6, the TP concentration was 0.258 mg/L with a TSS of 96 mg/L. On September 2, the TP concentration was 0.318, with a TSS of 350 mg/L. The remaining four TP samples, which appear to be taken during baseflow, were meeting the standard. There was one chlorophyll-a sample (23.8 ug/L) also taken on September 2, 2015, which is below the southern standard of 35 ug/L.

The macroinvertebrate community indicates some potential stress from eutrophication (Table 334). There were a reduced number of collector-filterer and collector-gatherer taxa compared to the average number from similar stations meeting the biocriteria. There was also a lack of intolerant taxa and a high percentage of tolerant taxa in the sample. Due to limited connecting chemical information, eutrophication as a stressor cannot be confirmed.

Table 334. Macroinvertebrate metrics that respond to eutrophication stress in County Ditch 3 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN067 (2013)	**31**	**4**	**8**	**2**	**0**	**87.1**
Southern Streams Average	*45.8*	*7.3*	*15.9*	*12.2*	*0.8*	*72.6*
Expected response to stress	↓	↓	↓	↓	↓	↑

Eutrophication is inconclusive within this reach. The macroinvertebrate metrics are suggestive that eutrophication is placing limitations on the community. However, additional data needed to determine if there are exceedances of phosphorus connected to DO flux, chlorophyll-a and/or BOD.

Nitrate

During biological sample, the nitrate concentration at 13MN067 was high, at 21 mg/L on June 10, 2013. There were six additional samples taken on this reach in 2015 and 2016. The nitrate concentrations ranged from 10 mg/L up to 23 mg/L in June of 2016. The average concentration was 18.3 mg/L, with four of the six samples showing concentrations greater than 20 mg/L. Those samples were all taken in April, May, or June.

The macroinvertebrates in this reach show consistent indication they are stressed by the elevated nitrate concentrations (Table 335). The nitrate index score was 3.9, while the average for Southern Streams meeting impairment threshold is 2.9. This suggests that overall the community present is tolerant to high nitrate concentrations. Increasing nitrate concentrations also correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct) and decreased intolerant taxa, both which are lacking in this reach. Additionally, the number of nitrate tolerant taxa and individuals are higher than average.

Table 335. Macroinvertebrate metrics that respond to nitrate stress in Morgan Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN067 (2013)	**1**	**0**	**3.9**	**0**	**22**	**84.7**
Southern Streams Average	*6.3*	*5.5*	*2.9*	*2.4*	*18.8*	*47.2*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is a stressor within this reach of Morgan Creek. There is a clear metric response that shows nitrate is placing limits on the macroinvertebrate community. This is consistent with the high concentrations of nitrate documented within this reach.

Total Suspended Solids

During biological sampling at 13MN067, the total suspended solids (TSS) concentration as low, at 2.8 mg/L. Additional data collected in 2015 and 2016 at this site show two violations of the TSS standard, 96 mg/L and 350 mg/L, collected in July and September of 2015. The remaining five samples average 8.68 mg/L, which are all very low and meet the TSS standard for the South Region (65 mg/L).

The macroinvertebrate community indicates possible stress from elevated TSS (Table 336). The TSS index score was better than the average of similar stations, indicating the overall the community is not overly tolerant to TSS. There were no TSS intolerant taxa/individuals overall, and the tolerant percentage of TSS tolerant individuals was just slightly greater than the average. While the majority of samples met the TSS standards, very little is known about the overall sediment dynamics in this stream given the lack of chemical information. In this location near the Minnesota River, gradient changes rapidly and may account for additional sediment erosion and transport.

Table 336. Macroinvertebrate metrics that respond to high TSS stress in County Ditch 3 compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

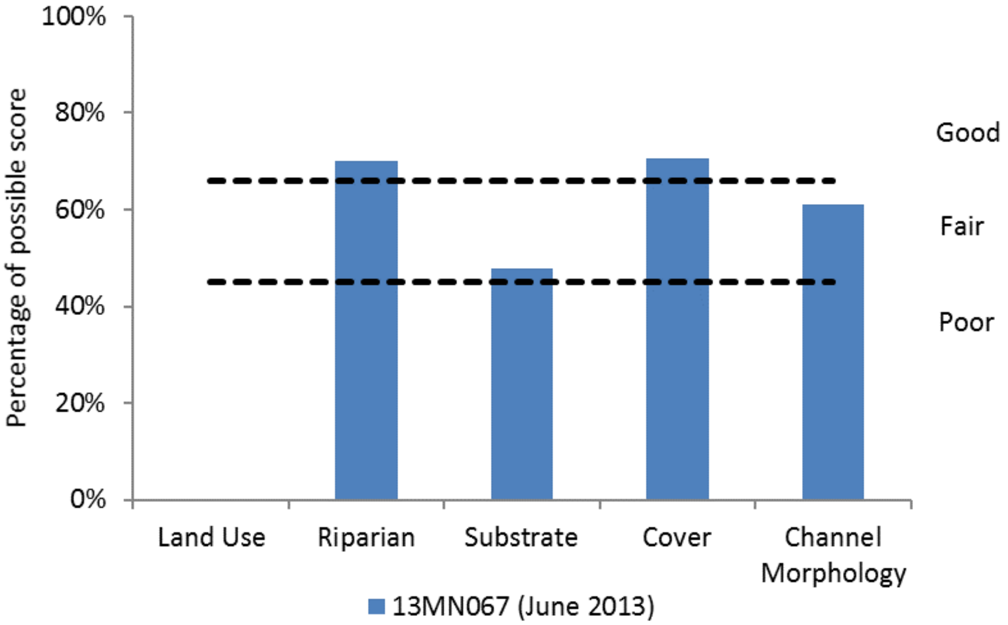
Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN067 (2013)	**7.5**	**0**	14.21	**0**	**0**	8	**41.1**
Southern Streams Average	*25.4*	*0.7*	*15.63*	*2.9*	*4.7*	*12.2*	*34.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

Additional chemical data needs to be collected to determine the duration of TSS in this stream, therefore TSS as a stressor is inconclusive.

Habitat

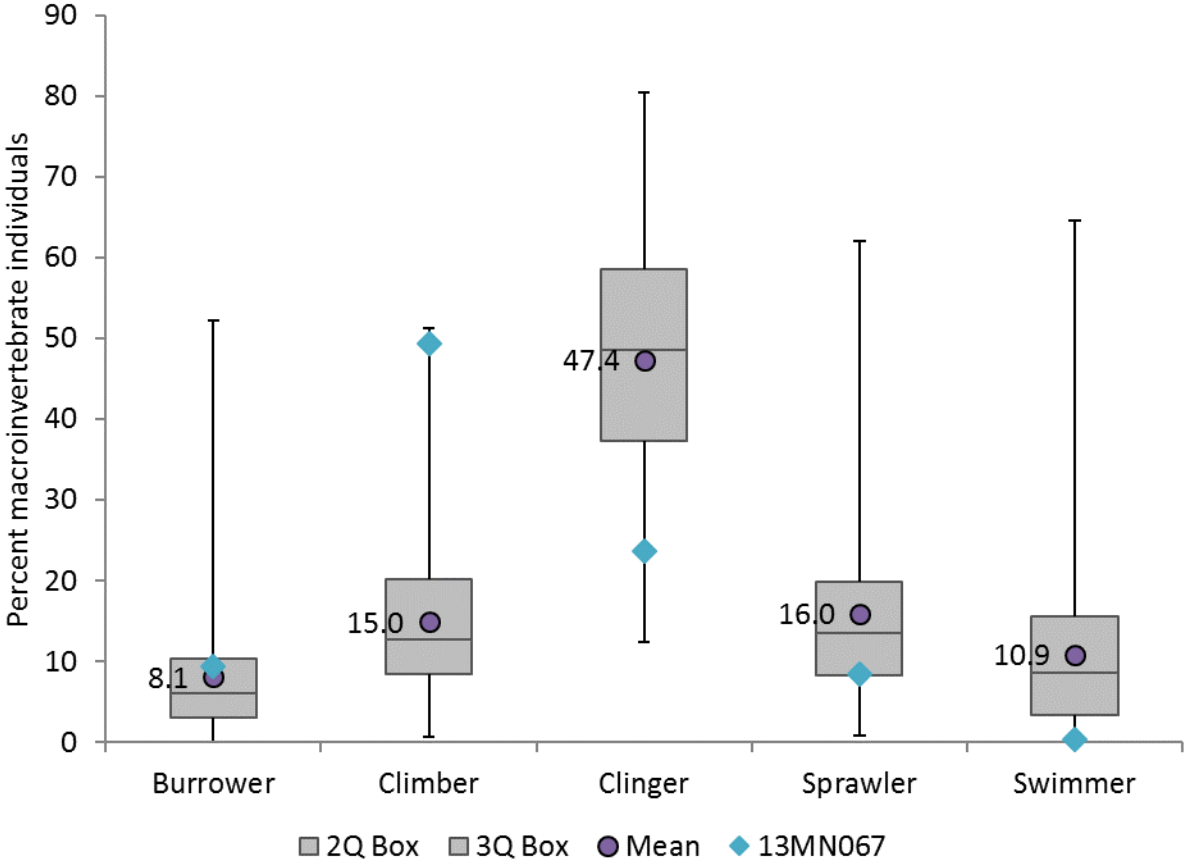
The MSHA score at station 13MN067 was 57.4 (fair) in 2013. As displayed in Figure 331, the land use was relatively poor, and substrate and channel morphology categories were fair. There was a lack of diverse substrates, mostly sand and silt, although gravel was present in the riffle features and overall embeddedness was light. For channel morphology, there was fair depth variability. This channel is noted as having heavy channel erosion giving this reach a score of overall moderate channel stability.

Figure 331. Percentage of MSHA subcategory scores for station 13MN067, County Ditch 3.



The macroinvertebrate community was collected on snags, woody debris, and/or root wads. Clinger species are typically found in streams with ample amounts of woody debris and/or course substrates. As displayed in **Error! Reference source not found.**, Station 13MN067 showed fewer clinger individuals than expected. About half the sample consisted of climber individuals. Burrowers were slightly elevated, indicating the potential for embeddedness in riffle habitats. The percentage of legless macroinvertebrates were very high, at 95%, likely because the majority macroinvertebrate individuals were either snails or midges. They can tolerate poor habitat conditions in addition to poor water quality.

Figure 332. Macroinvertebrate habit metrics with box plot showing range of values from Southern Streams stations meeting the general use biocriteria mean of those stations, and metric values from station 13MN067.



Habitat is considered a stressor, primarily from active streambank erosion that correlates to stream instability. Station 13MN067 has poor diversity of habitat types available for macroinvertebrates, which shows in the metrics results, and lack of habitat is stressing the macroinvertebrate community.

Longitudinal Connectivity and Altered Hydrology

There is a natural waterfall on Unnamed Creek, named Minnewaukon Falls. It is 0.7 miles upstream from the confluence with the Minnesota River. Minnwaukon falls has a drop of approximately 17 feet and occurs below the monitoring station (13MN067) on County Ditch 3. For more information on the waterfall, please see DNR's Minnesota River, Mankato Watershed Characterization Report (2015). The fish community was not assessable due to the station location being above a barrier, naturally limiting the fish community. The waterfall is not a direct stressor to the macroinvertebrate community.

Altered hydrology is prevalent within this system. The biomonitoring station is located less than half of a mile where the stream begins to be defined as natural. Prior to this point, the channel is 100% ditched. There is also the introduction of subsurface tile drainage that greatly influences stream base flow rates. Figure 333 and Figure 334 show the variable flow conditions within this reach.

Figure 333. Station 13MN067 dry streambed, taken on September 14, 2012.

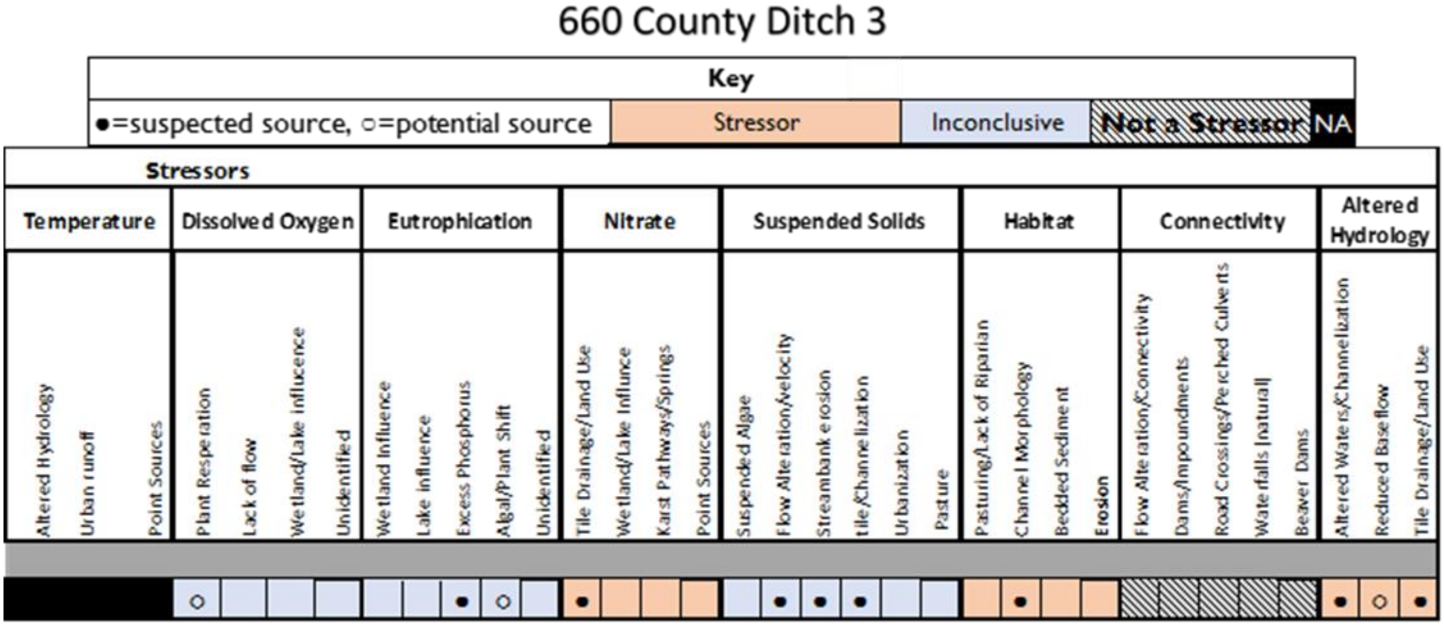
The photo above shows the streams vulnerability to conditions outside of the rain season. In a natural system, streams rely on surface water, subsurface water storage, as well as groundwater to replenish the flow.

Figure 334. Station 13MN067 taken June 10, 2013.

In contrast to the dry streambed taken in the fall of 2012, is the photo above that was taken in late spring of 2013. This documents not just the flowing stream, but also indicates the streams potential for mass channel erosion as the stream takes on higher volumes of water. In southern Minnesota, there have been many studies that have accumulated evidence-supporting changes in hydrology a result of changes in land use and drainage. Reductions in wetland storage, increases in tile drainage, channel alteration and water withdrawals all have multiple impacts on hydrology. All of these components alter stream flow in multiple ways, which negatively affect the biology and have direct or indirect effects on stressors. Altered hydrology is a foundational issue, and a primary contributor to all the impaired biological communities within Morgan. For additional information on these forms of altered hydrology within the Minnesota River – Mankato Watershed, reference Chapter 3.1.8 of this report.

Summary Table

Table 337. Identified stressors with suspected sources for reach 683 of Morgan Creek.



660 County Ditch 3

Key				
●=suspected source, ○=potential source	🟧 Stressor	🟦 Inconclusive	▨ Not a Stressor	■ NA

Stressors																																		
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
■	■	■	🟦 ○	🟦	🟦	🟦	🟦	🟦	🟦 ●	🟦 ○	🟦	🟧 ●	🟧	🟧	🟧	🟦	🟦 ●	🟦 ●	🟦 ●	🟦	🟦	🟧	🟧 ●	🟧	🟧	▨	▨	▨	▨	▨	🟧 ●	🟧 ○	🟧 ●

Morgan Creek Subwatershed Conclusion

There was only one impaired reach listed in the Morgan Creek Subwatershed. County Ditch 3 (-660) is west of Mankato, Minnesota. The reach was assessed as a warmwater general use. The reach extends from upstream of 520th St. to the Minnesota River. County Ditch 3 is impaired for lack of macroinvertebrate assemblage. The fish community was not assessable due to the station location is above a barrier falls, naturally limiting the fish community.

The stressors to the macroinvertebrate community in County Ditch 3 are nitrate, habitat and altered hydrology, with altered hydrology being the primary driving stressor. Upstream of the biological station is completely altered. Altered hydrology is occurring in two ways; the first is through subsurface tile drainage, and the second is channel alteration by way of ditching and channelizing the system. Both of these alterations are for agricultural practices in effort to expedite water off the land and create optimal growing conditions for crops. As channels take on extra water, they change their dimension, pattern, and profile to adjust.

Within the biological station and downstream is characterized as a natural channel surrounded by forest. In the assessed area, the gradient picks up significantly, as this section of the tributary transitions from the flat uplands and begins to naturally down cut through the valley towards the Minnesota River. The ability for these incised valleys to transport sediment is significant, influencing habitat availability further accelerating the upstream flow imbalances during and following rain events. The inverse side to this dynamic is as the natural land and groundwater recharge rate has shifted to occur in periodic and intense intervals (via subsurface tiles), there is dramatic reduction to base flow of the stream outside of rain events. In 2012, the road crossing at the biological station was noted to be a dry streambed. While 2012 was a drought year, additional monitoring is recommended to better understand the flow limitations that upstream hydrology is having here. The adjacent golf course could possibly be affecting available groundwater recharge to the stream as well. Without additional information though, it is difficult to understand the impacts.

Nitrate can be toxic to aquatic life depending on exposure time and concentration. All nitrate samples were found at toxic levels for macroinvertebrates. The macroinvertebrate community was also displaying that nitrate concentrations are limiting the overall population.

Phosphorus was found to be high within in this stream. However, fish and macroinvertebrates are not sensitive to phosphorus itself but rather the eutrophic conditions that can occur in the presence of phosphorus. In this region, eutrophication will occur when there is an abundance of phosphorus, lack of stream canopy to shield the stream of sunlight, and slow velocity streams. As Morgan Creek is on a steep gradient with decent canopy cover, it is not likely that eutrophic conditions are taking place at this location. It is possible that the community is still being limited from upstream eutrophic conditions that are typically associated with agricultural ditches that meet the above criteria for promoting overgrowth. Dissolved oxygen is closely associated with eutrophication within this region as excess plant and algae will lower the dissolved oxygen during times of respiration. For the case of eutrophication and low dissolved oxygen, it is not likely that these parameters are stressing the community, but could not be ruled out and are considered inconclusive.

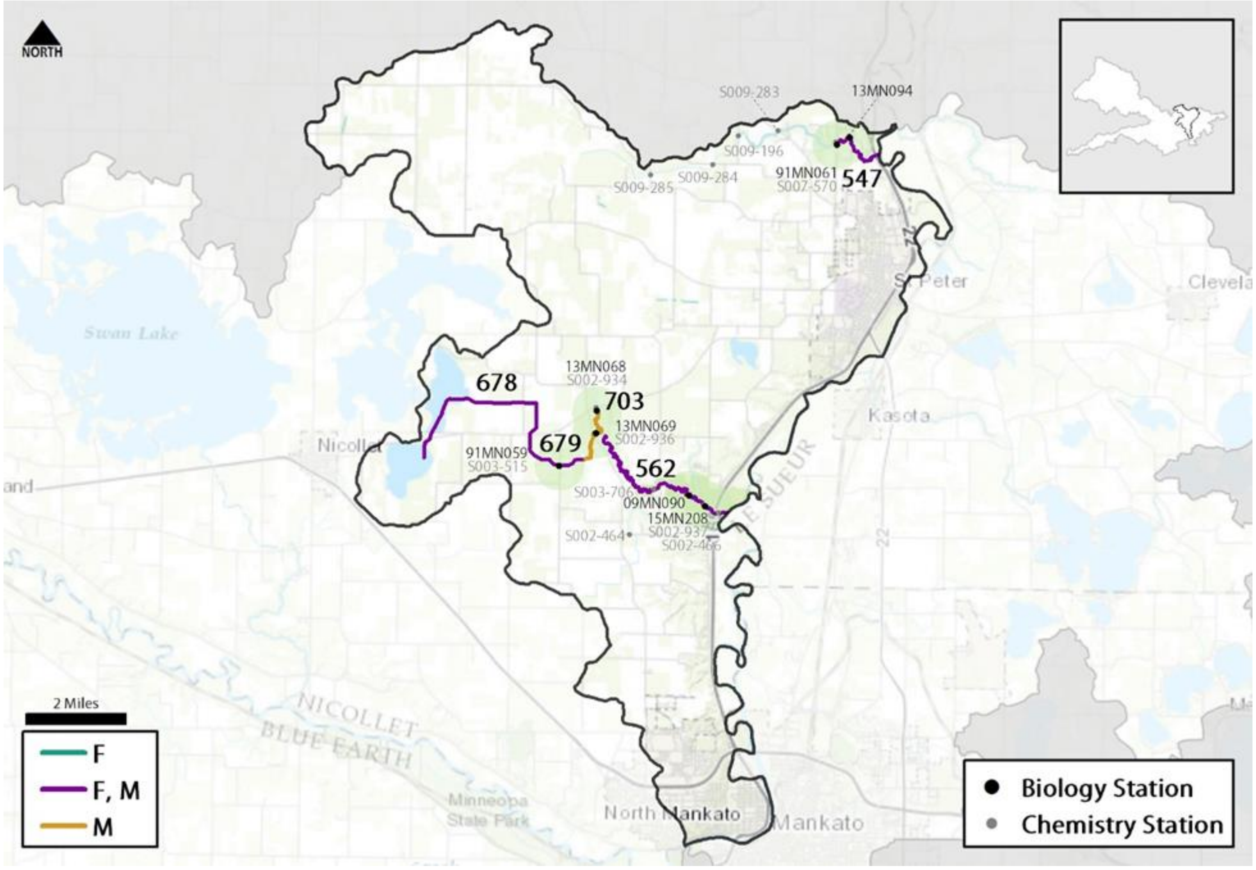
Total suspended solids (TSS) is inconclusive, also from lacking chemistry data. What little data that is available for TSS does show that this stream has a strong potential for sediment transport. Additional information should be collected to rule out or confirm TSS is overloading the system and stressing the macroinvertebrate community.

Finally, connectivity is not considered a stressor to the macroinvertebrate community, even though it has profound impacts to the fish community. In this instance, Minnewaukon Falls is limiting fish migration however this is to be expected as it is a natural barrier.

City of Mankato – MNR Mankato North

This section encompasses biotic impaired reaches in the City of Mankato – Minnesota River 10 digit HUC (0702000711). There are five reaches impaired for biology in this 10 digit HUC that are located on the north side of the Minnesota River. There is one coldwater reach within this subwatershed. A downstream reach of Seven Mile Creek (07020007-562), impaired for both fish and macroinvertebrate assemblage. There are three warmwater reaches, impaired for both fish and macroinvertebrate assemblage; County Ditch 46A (07020007-678 and -679) and Rogers Creek (07020007-547). There is one warmwater reach impaired only for macroinvertebrate assemblage, the upstream portion of Seven Mile Creek (07020007-703).

Figure 335. Map of the City of Mankato watershed with biological impairments and monitoring stations. Impairments are described as F=Fish, F, M=Fish and Macroinvertebrates, and M=Macroinvertebrates.



4.36 County Ditch 46A (07020007-678)

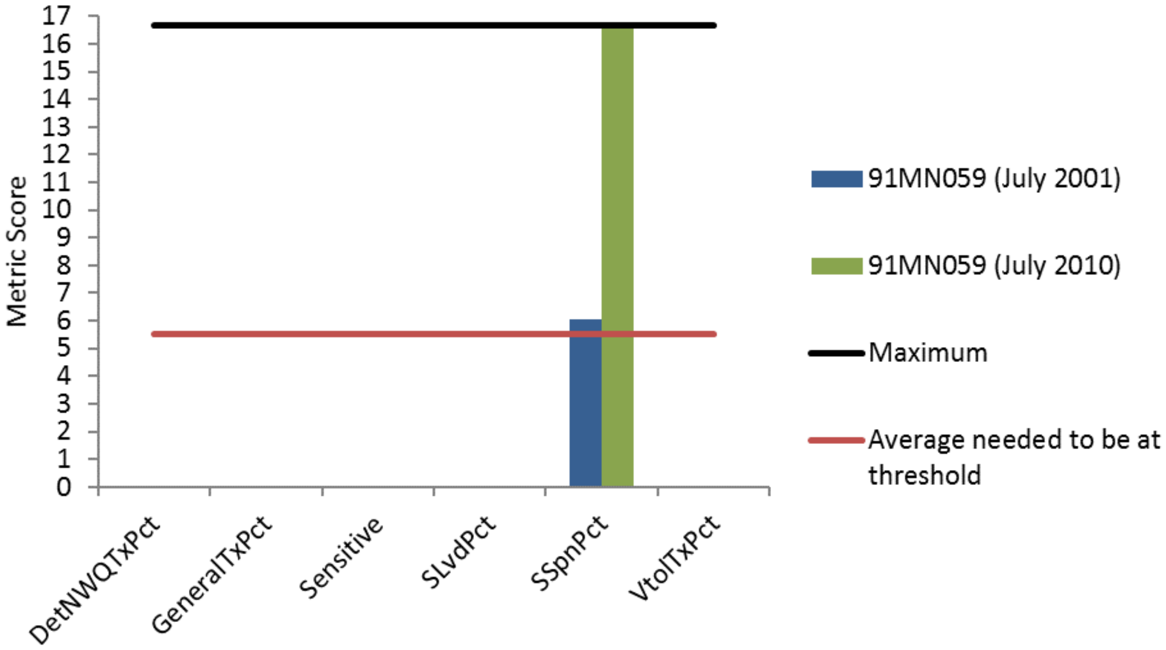
County Ditch 46A (07020007-678) is north of Mankato, Minnesota. The reach is warmwater modified use Class 2B. The reach extends from the headwaters to downstream of 411th Ave. CD 46A is impaired for lack of macroinvertebrate assemblage and lack of fish assemblage. There is one biological station on this reach, 91MN059.

4.36.1 Biological Communities

The fish community and macroinvertebrate communities were surveyed in 2001 and 2010. Both fish visits scored lower IBIs (6 & 16.7) than the modified use Southern Headwaters class IBI threshold (33).

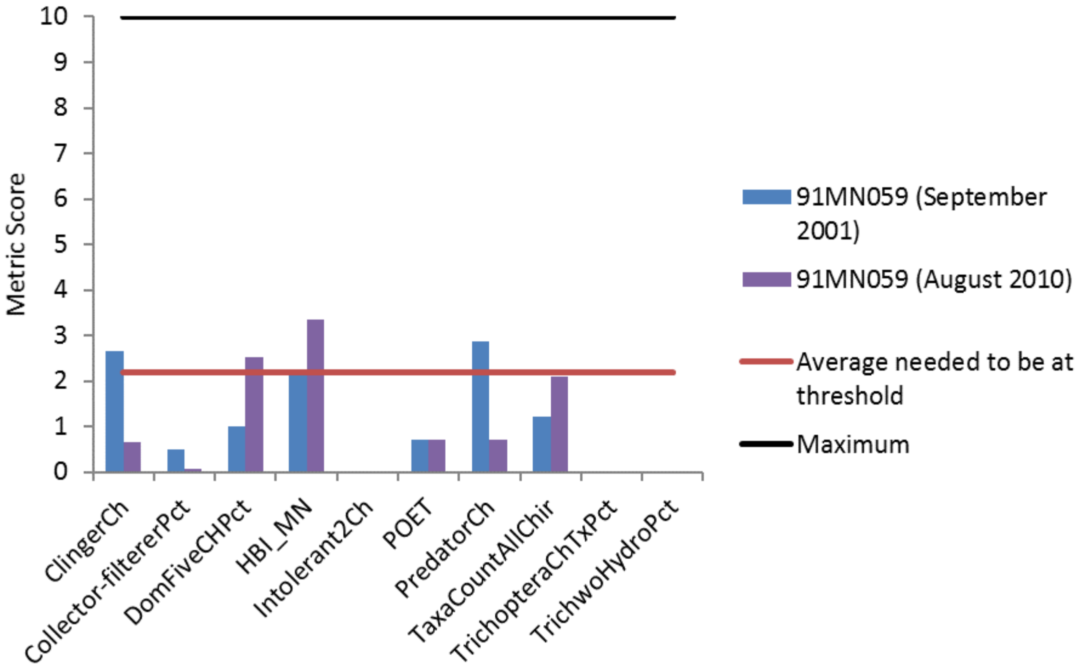
Five of the six FIBI metric scores were zero during both years (Figure 336). In 2001, the only fish species were brook stickleback and fathead minnows. In 2010, only brook stickleback were surveyed.

Figure 336. Fish metrics of the Southern Headwaters class IBI for station 91MN059, County Ditch 46A.



The macroinvertebrate community also scored lower (11.1 & 9.6) than the Prairie Streams GP modified use threshold (22) both years. Many of the MIBI metrics were below the average metric score needed to obtain a score at the threshold (Figure 337), showing a very degraded community. Mayflies (Caenis) and scuds (Hyalella) were the most abundant in 2001. In 2010, worms (Oligochaeta) and non-biting midges (Paratendipes) were most abundant.

Figure 337. Macroinvertebrate metrics of the Prairie Streams GP class IBI for station 91MN059, County Ditch 46A.

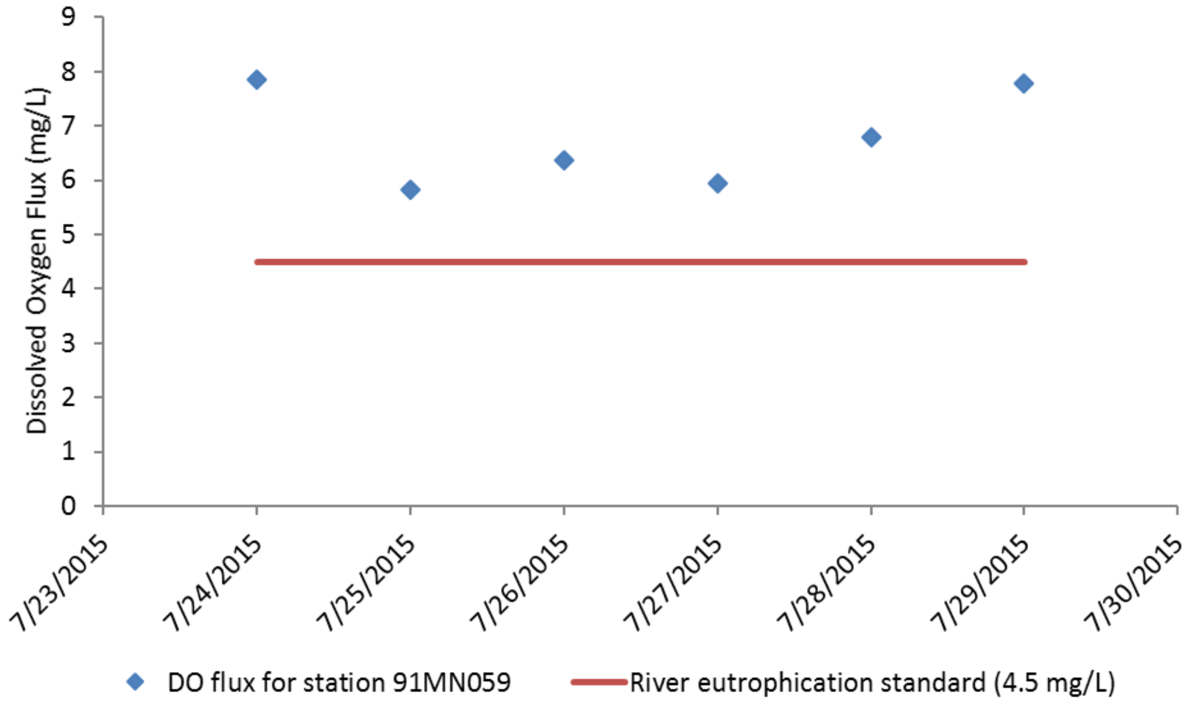


4.36.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

At the time of biological monitoring dissolved oxygen (DO) was recorded very low at 0.73 mg/L during the afternoon of July 27, 2010. In 2015, an YSI sonde was deployed at station 91MN059. The DO ranged from 0.78 to 9.38 mg/L, with daily violations of the DO standard of 5 mg/L. The DO flux was elevated ranging from 5.82 to 7.85 mg/L, with an average of 6.76 mg/L (Figure 338). One additional grab sample was taken late in the day on July 30, 2015 with a DO of 9.09 mg/L.

Figure 338. Diurnal dissolved oxygen for station 91MN059, July 23 – 30, 2015.



The macroinvertebrate community at station 91MN059 shows consistency with low DO stress (Table 338). Overall, the majority of macroinvertebrates sampled in 2001 and 2010 are considered low DO and eutrophic tolerant. The samples resulted in low taxa counts, low EPT taxa, a lack of low DO intolerant taxa, and lower than expected index scores. These results indicate low DO is likely having an impact in this reach. In 2001, there were not an abundant amount of low DO tolerant taxa; however, the overall taxa count was only 23 and the relative abundance of those low DO tolerant individuals was still elevated. In 2010, the percentage of low DO tolerant individuals was considerably lower. The Minnesota modified Hilsenhoff Biotic Index (HBI_MN) was also lower (better) than in 2001 and better than the average for similar stations meeting the biocriteria. Overall, the macroinvertebrate community is indicating that low DO is stressing the biological community.

Table 338. Macroinvertebrate metrics that respond to low DO stress in County Ditch 46A compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Tolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct	
91MN059 (2001)	**23**	**2**	**8.21**	**5.93**	**0**	**0**	7	**74.1**	
91MN059 (2010)	**26**	**1**	7.85	**4.05**	**0**	**0**	**10**	22.7	
Prairie Streams Average	*36.8*	*7.6*	*7.92*	*6.42*	*2.4*	*4.5*	*8.4*	*25.1*	
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑	

The fish are suggestive of low DO stress at both locations as well (Table 339). Species that are sensitive to low DO as well as mature females (over the age of three) were completely lacking, which can indicate low DO is interfering with their life cycle. With only a total of two species sampled between the two stations (Brook Stickleback and fathead minnow) the metrics overall reflect a tolerant community. Fish abundance can also decrease with low oxygen levels, as seen here. The DO index score also fell below 7.13, the state average for southern headwaters streams.

Table 339. Fish metrics that respond to low DO stress in County Ditch 46A compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
91MN059 (2001)	**0**	**0**	**100**	**5.91**	**0**	**0**	2	100
91MN059 (2010)	**0**	**0**	**100**	**5.62**	**0**	**0**	1	100
Southern Headwaters Average	*7.9*	*13.9*	*72.8*	*7.13*	*0.7*	*4.1*	*3.4*	*21.2*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO is considered to be a biological stressor within this section of County Ditch 46A. The metrics for fish and macroinvertebrates indicate low DO is limiting the diversity in both communities. In addition, the chemical data suggest low DO is a recurring issue within this reach.

Eutrophication

During biological monitoring total phosphorus (TP) was analyzed with a concentration of 0.079 mg/L (July 26, 2001) and 0.051 mg/L (July 27, 2010). One additional water chemistry sample was taken for TP resulting a 0.074 mg/L (July 30, 2015). One sample of chlorophyll-a had a result of 2.68 ug/L (July 30, 2015), which is considered low compared to 35 ug/L, the standard for the southern region.

The macroinvertebrate community is suggestive of eutrophic stress (Table 340). The macroinvertebrate community at station 91MN059 had few collector-filterer and EPT taxa in both 2001 and 2010. The community had no intolerant taxa and was comprised of over 92% tolerant taxa. There were a greater number of collector-gatherer taxa in 2010 than the average of similar stations meeting the biocriteria.

Table 340. Macroinvertebrate metrics that respond to high eutrophication in County Ditch 46A compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
91MN059 (2001)	**23**	**2**	**7**	**2**	**0**	**95.7**
91MN059 (2010)	**26**	**2**	13	**1**	**0**	**92.3**
Prairie Streams Average	*36.8*	*3.9*	*12.8*	*6.5*	*0.1*	*85.4*
Expected response to stress	↓	↓	↓	↓	↓	↑

The fish community is also suggestive of eutrophication stress (Table 341). In 2001, the only fish species were brook stickleback and fathead minnows. In 2010, just brook stickleback were surveyed. These two fish species are not considered sensitive, darters, simple lithophilic spawners, or intolerant. The visits had reduced taxa counts and both species are tolerant.

Table 341. Fish metrics that respond to high eutrophication in County Ditch 46A compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
91MN059 (2001)	**0**	**0**	**0**	**100**	**2**	**0**
91MN059 (2010)	**0**	**0**	**0**	**100**	**1**	**0**
Southern Headwaters Average	*4.5*	*8.5*	*27.9*	*79.9*	*10.4*	*0.8*
Expected response to stress	↓	↓	↓	↑	↓	↓

While the fish and macroinvertebrate communities suggest stress, eutrophication is inconclusive due to lack of connecting chemistry data. However, it is likely this is a problem within the reach as the DO flux is suggestive of a stream with an overabundant macrophyte and algae community. Figure 339 shown below, shows an area of the reach were water appears to be pooling with little flow. Areas like this provide optimal conditions for overgrowth to occur.

Figure 339. Monitoring station 91MN059 on July 23, 2015.

Nitrate

Nitrate samples were taken during two separate biological monitoring periods. The first sample for nitrate concentration was 16 mg/L on July 26, 2001 and 0.87 mg/L on July 27, 2010. Only one additional water sample was taken and found to have a nitrate concentration of 4.7 mg/L on July 30, 2015.

The macroinvertebrates in this reach show a mixed response to elevated nitrate (Table 342). While sampling years at this monitoring station were 9 years apart, the metrics in both 2001 and 2010 were consistent. For both periods, the nitrate index score was 2.8, scoring better than the average for modified Prairie Streams meeting impairment threshold (3.2). Percentage of nitrate tolerant individuals as well as the overall nitrate tolerant percent dominant within the community also fell below the average that is typically seen in this stream type. While increasing nitrate concentrations can correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct) and decreased intolerant taxa.

Table 342. Macroinvertebrate metrics that respond to nitrate stress in County Ditch 46A compared to the statewide average of visits meeting the warmwater modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
91MN059 (2001)	**0**	**0**	2.8	**0**	11	54.8
91MN059 (2010)	**0**	**0**	2.8	**0**	16	53.1
*Prairie Streams Average **(MU)***	*2.6*	*2.4*	*3.2*	*1.1*	*18.0*	*59.7*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is inconclusive as a biological stressor within this reach. While there is a high probability of elevated nitrate to be occurring in this reach, the lack of water chemistry data to confirm, paired with an inconsistent biological response makes nitrate difficult to call out.

Total Suspended Solids

Total suspended solids (TSS) samples were taken during two separate biological monitoring periods. TSS concentrations were recorded at 2.8 mg/L on July 26, 2001 and at 1.2 mg/L on July 27, 2010. One additional water sample was taken and found to have a TSS concentration of 4.8 mg/L, taken on July 30, 2015.

The macroinvertebrate community is not strongly suggestive of TSS stress (Table 343). There was a lack of collector-filterers and stoneflies (Plecoptera), along with no TSS intolerant taxa present. The TSS index score was less than the average of similar stations meeting the biocriteria and there were not excessive TSS tolerant taxa or individuals, all of which can indicate TSS is not a likely stressor.

Table 343. Macroinvertebrate metrics that respond to high TSS stress in County Ditch 46A compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
91MN059 (2001)	**2.2**	**0**	15.66	**0**	**0**	8	7.5
91MN059 (2010)	**0.6**	**0**	9.73	**0**	**0**	4	5.5
Prairie Streams Average	*11.7*	*0.1*	*16.68*	*0.8*	*1.4*	*11.8*	*41.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

Other than the stickleback and fathead minnow, no other species were found. Fish community evaluation is limited to two general tolerant fish species that were found in the sample, fish metrics for TSS will not be conclusive (Table 344).

Table 344. Fish metrics that respond to high TSS stress in County Ditch 46A compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
91MN059 (2001)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
91MN059 (2010)	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Southern Headwaters Average	*27.3*	*0.7*	*17.8*	*0.8*	*4.3*	*10.3*	*19.9*	*4.5*	*12.0*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 345. Fish metrics that respond to high TSS stress in County Ditch 46A compared to the statewide average of visits meeting the modified use biocriteria. Bold indicates metric value indicative of stress.

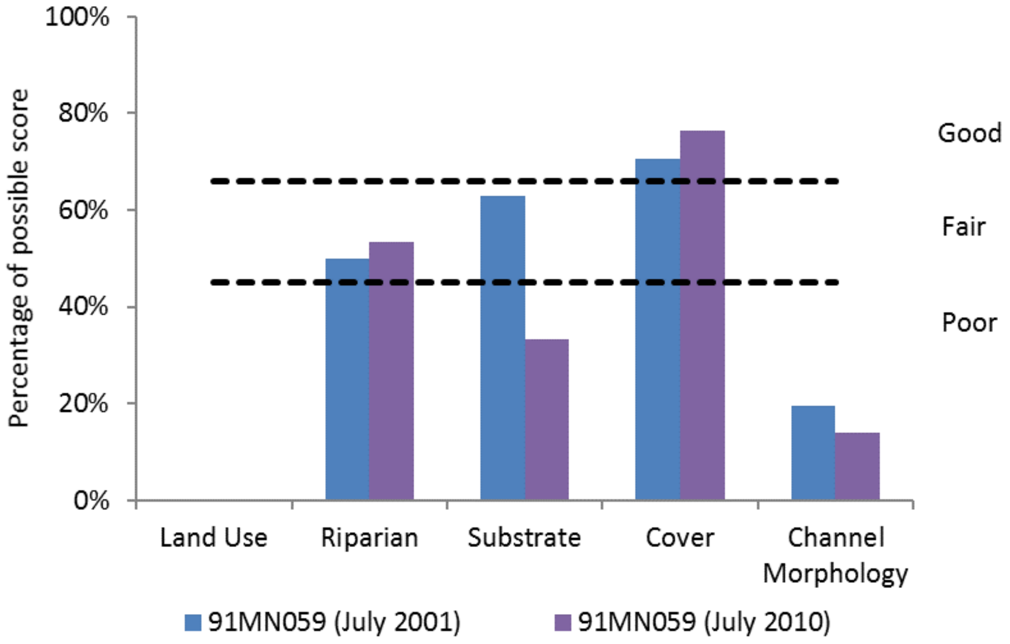
Station (Year sampled)	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
91MN059 (2001)	**19.0**	**0**	**0**	0	0
91MN059 (2010)	14.3	**0**	**0**	0	0
Southern Headwaters Average	*16.2*	*0.5*	*2.9*	*0.5*	*2.5*
Expected response to stress	↑	↓	↓	↑	↑

TSS is inconclusive, primarily due to the lack of data. Macroinvertebrate metrics are mixed and do not clearly point to TSS as a stressor, and the limited taxa collected from the fish sample do not allow for proper analysis for TSS response. More data is needed in order to make the connection to TSS as a stressor in this reach.

Habitat

In 2001, station 91MN059 had a MSHA score of 43.5 (poor). In 2010, the MSHA score was worse (35). As displayed in Figure 340, land use and channel morphology only received enough points to place in the poor category. The depth variability, sinuosity, and channel development were all poor at both visits. The reach lacked riffle features in 2001 and 2010. The reach had no coarse substrate in 2010, with a lack of diverse substrates, which was present in 2001. The substrate category shifted from fair to poor between the two visits. The riparian subcategory was fair and cover was good.

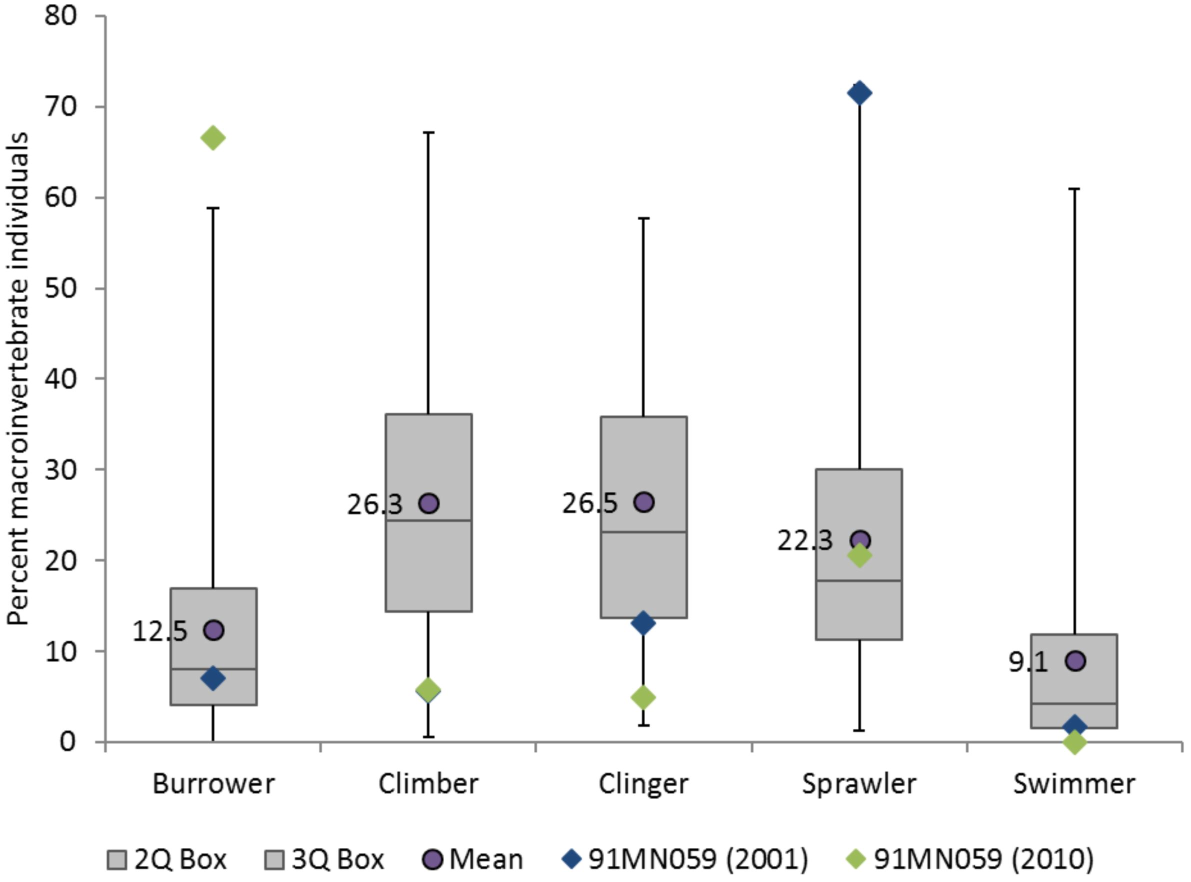
Figure 340. Percentage of MSHA subcategory scores for station 91MN059, County Ditch 46A.



Physical habitat variation was limited within this reach. In 2001 to 2010 there was a significant difference noted in the embeddedness of the stream as well as a lack of diversity of substrate types. This could account for the increase in burrowers found in 2010. This reach has been modified to an agricultural ditch; there is a lack in variation between riffles, pools, and runs.

Figure 341 below displays a box plot that categorized macroinvertebrates and their associated habitat types compared to community type averages that are found to be in support. In 2001, the community type of sprawlers was found to be in access, from the dominance of Caenis (mayflies) and Hyalella (freshwater amphipod) collected. In the same year, there was also an absence of climbers. All other community types fell within the expected percentile of the overall population. 2010 was more suggestive of direct habitat stressors. There was an overwhelming dominance in burrower types, while clingers and climbers were significantly low. This is typical in a system were embeddedness is prominent; this aligns with the MSHA findings for that year as well.

Figure 341. Macroinvertebrate habit metrics with box plot showing range of values from Prairie Streams stations meeting the modified use biocriteria mean of those stations, and metric values from station 91MN059.



Fish habitat stress is closely associated to TSS stress. As stated in the above TSS section for this reach, the fish community evaluation is limited to two general tolerant fish species that were found in the sample; therefore, community metrics will not be conclusive.

Habitat is a stressor to the biology in this reach. Stream observations noted this in the MSHA evaluation and scoring. While there is not a measurable response in the fish community, there was clear habitat stress noted within the macroinvertebrate community. In both the MSHA and looking at the macroinvertebrate composition, the largest contributor of habitat stress is the homogenous stream, and poor riverbed substrate.

Longitudinal Connectivity and Altered Hydrology

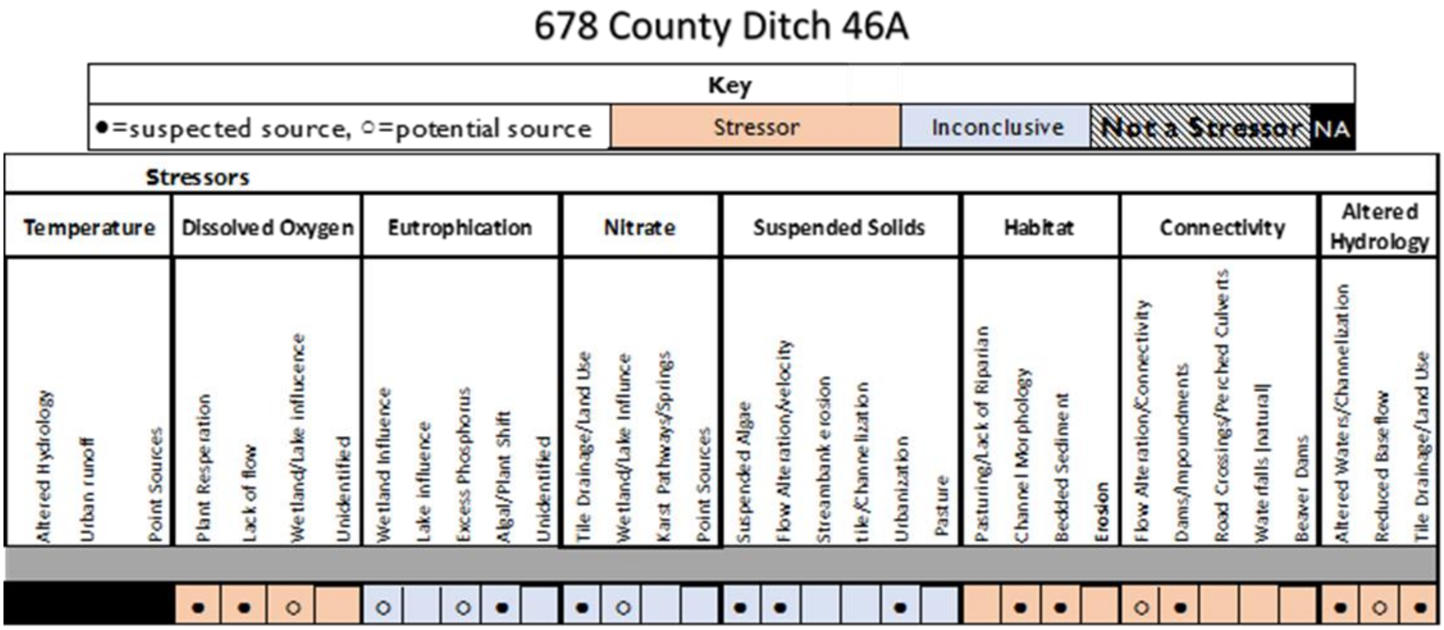
Longitudinal connectivity is thought to be placing limitations on the fish community. Downstream of this monitoring station is a man-made fish barrier on Seven Mile Cr (07020007-563). The dam was built to block migration of common carp. For more information on the dam, please see DNR's Minnesota River, Mankato Watershed Characterization Report (2015).

There are three stations upstream of the dam, one which is on this AUID (91MN059). Although there were visits to 13MN068 and 13MN069, the fish data was not assessable due to limited recolonization due to drought. Station 91MN059 had only two fish species present in 2001 (fathead minnow and brook stickleback) and in 2010, just brook stickleback were present. Downstream on Seven Mile Creek, station 09MN090 had as many as 20 species in 2010. With the limited species at station 91MN059, the dam (i.e. connectivity) is affecting the replenishment of taxa richness to this reach and a stressor to the biology. It is worth noting that the barrier does seem to be effective in blocking the migration of carp into Middle Lake.

Altered hydrology was found to be the primary stressor within this reach. Altered hydrology is occurring in the form of ditching as this reach is completely modified under this use. This greatly limits habitat diversity as well as degenerates what little habitat that is present. Alteration to water volume and quality are also prevalent in this stream from the introduction of subsurface tile drainage creating base flow instability as well as nutrient overloading. This stream has also been observed to lack adequate base flow to support a diverse community of macroinvertebrate and fish. For more information on these forms of altered hydrology impacts, reference Section 3.1.8 of this report.

Summary Table

Table 346. Identified stressors with suspected sources for reach 678 of County Ditch 46A.



678 County Ditch 46A

Key

●=suspected source, ○=potential source | Stressor | Inconclusive | Not a Stressor | NA

Stressors																																
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls (natural)	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
			●	●	○		○		○	●		●	○			●	●			●			●	●		○	●				●	○	●

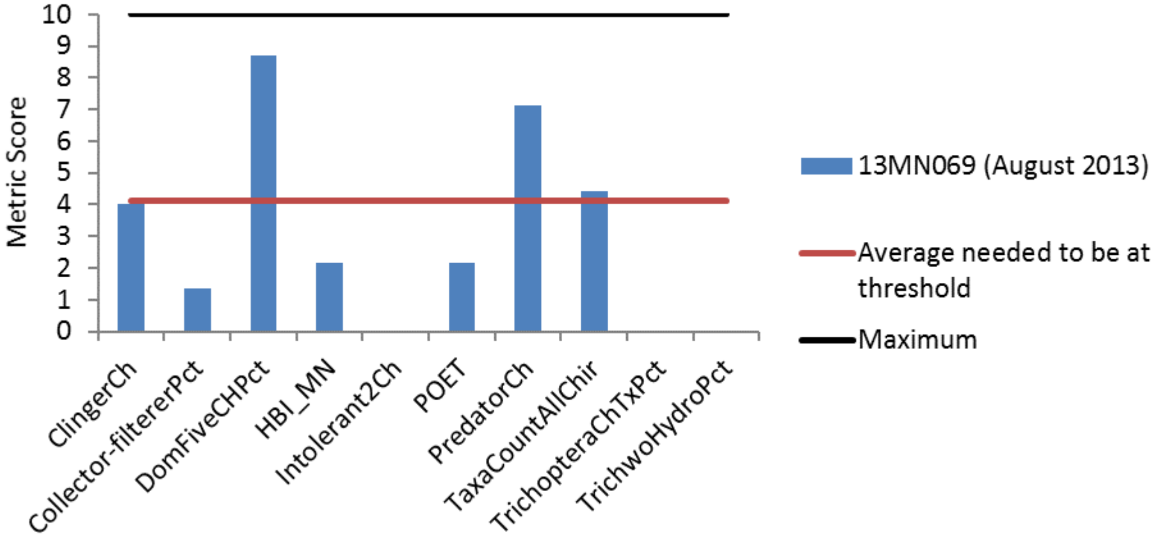
4.37 County Ditch 46A (07020007-679)

County Ditch 46A (07020007-679) is north of Mankato, Minnesota. The reach is warmwater general use Class 2B. The reach is downstream of CD 46A (07020007-678) and extends from downstream of 411th Ave to Seven Mile Creek. CD 46A is impaired for lack of macroinvertebrate assemblage. There is one biological station on this reach, 13MN069. The reach is also impaired for fecal coliform and turbidity. Fecal coliform will not be addressed in this report. Turbidity will be discusses as it relates to the biological communities.

4.37.1 Biological Communities

In 2013, station 13MN069 was sampled for fish and macroinvertebrates. The fish data was not assessable due to low flow on August 15, 2013 and biological recolonization limited by drought on June 13, 2013. The macroinvertebrate community scored (30) below the Prairie Streams GP class IBI general use threshold (41). The dominant species was snails (Physa). There was adequate predator (PredatorCh) species found within the sample, as well as diverse taxa set collected in the sample (TaxaCountAllChir). All other categories fell short of the expected threshold for this stream type.

Figure 342. Macroinvertebrate metrics of the Prairie Streams GP class IBI for station 13MN069, County Ditch 46A.



4.37.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

At the time of biological monitoring, dissolved oxygen (DO) was recorded early in the morning at 7.69 mg/L on August 15, 2013 and an additional 79 samples of DO data was analyzed. This data set was collected in 2006, 2007, 2008, 2009, 2011, and 2012 with a total range of 5 mg/l – 16.2 mg/L and an average of 9.22 mg/L.

DO data collected over the course of seven years did not have a single violation of the 5 mg/L standard for 2B waters. Only two early morning data points are available, and more early morning samples would be helpful in understanding the full range of concentrations this reach is exposed to.

The macroinvertebrate community is suggestive of low DO stress (Table 347). The macroinvertebrate DO index score was below average; as this score decreases, so does the sensitivity of the community. There were five DO intolerant taxa comprising 5% of the community, and 8 DO tolerant taxa comprising 20% of the community. Taxa richness of Ephemeroptera, Plecoptera and Trichoptera (EPTCh) and a measure of pollution based on tolerance values assigned to each individual taxon developed by Chirhart (HBI_MN) were worse than average. Total taxa richness (TaxaCountAllChir) was also worse than average found on this stream type. Overall, a majority of the macroinvertebrate metrics are suggestive of stress, with a fair number of low DO intolerant taxa present.

Table 347. Macroinvertebrate metrics that respond to low DO stress in County Ditch 46A compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN069 (2013)	**34**	**2**	**8.21**	**6.28**	5	**5.4**	**8**	**20.4**
Prairie Streams Average	*41.6*	*11.5*	*7.59*	*6.79*	*4.1*	*8.5*	*7.0*	*16.6*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO as a biological stressor is inconclusive. While this is a large grab sample, the data set does not display low values of DO. Depite the large data set there is a lack of early morning DO data (When DO it the lowest in stream systems) and diurnal DO. These are needed to understand the full range of concentrations this reach experiences. In the future sonde measurements or early morning DO readings would help to better understand the full DO dynamics in this stream. The invert metrics are signaling low DO stress in the community.

Eutrophication

During biological sampling two water quality samples were collected for total phosphorus (TP) with concentrations of 0.115 mg/L (June 13, 2013) and 0.082 mg/L (August 15, 2013). From the year of 2000 to 2012 an additional 199 water samples had a range of 0.031 mg/L – 3.99 mg/L with an average of 0.244 mg/L. The year 2003 had unusually high exceedances as three samples exceeded 1.0 mg/L. Overall, 59% of the 199 samples taken exceeded the standard of 0.15mg/L, with the highest concentrations were found April through October months in all years. There was no chlorophyll-a available for analysis to help understand if the production of suspended algae was a corresponding issue.

The macroinvertebrate community is suggestive of eutrophication stress (Table 348). In 2013, the macroinvertebrate sample at station 13MN069 scored slightly less than average for the total taxa richness (TaxaCountAllChir). Collector-filterer feeder types (Collector-filtererCh) were slightly less prevalent than what the average for this stream type is. Taxa richness of Ephemeroptera, Plecoptera & Trichoptera (EPT) was greatly declined. These orders typically do not thrive in eutrophic conditions. Eutrophic intolerant taxa were absent within the community, while in total the population was found to be 82% of tolerant taxa.

Table 348. Macroinvertebrate metrics that respond to eutrophication stress in County Ditch 46A compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN069 (2013)	**34**	**4**	**7**	**2**	**0**	**82.4**
Prairie Steams Average	*41.6*	*5.5*	*14.4*	*9.7*	*0.3*	*80.7*
Expected response to stress	↓	↓	↓	↓	↓	↑

Given the macroinvertebrate metrics show consistent response, eutrophication could potentially be playing a role in the macroinvertebrate impairment. However, there is a lack of connecting information that connects high phosphorus to eutrophication in this reach. Similar to low DO, additional diurnal DO flux, chlorophyll-a, and/or BOD analysis would be helpful in determining if eutrophication and dissolved oxygen are stressors to the community in this reach. Therefore, until secondary data can be collected eutrophication is considered inconclusive as a stressor.

Nitrate

During biological monitoring nitrogen samples were taken with concentrations of 18 mg/L on June 13, 2013 and 2.7 mg/L on August 15, 2013. This site has 128 additional nitrate samples from 2005 – 2012 with data ranging from 0.2 mg/L – 26.8 mg/L and an average of 13.6 mg/L. with 23% of the samples exceeding 20 mg/L. The highest concentrations of nitrate exceedances were found from the months of April through June.

The macroinvertebrates in this reach show consistent indication they are stressed by the elevated nitrate concentrations (Table 349). The nitrate index score was 4.0, while the average for Prairie Streams meeting impairment threshold is 3.1. This suggests that overall the community present is quite tolerant to high nitrate concentrations. Increasing nitrate concentrations also correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct) and decreased intolerant and Trichoptera taxa, all of which are lacking in this reach. Additionally, the number of nitrate tolerant individuals (72.3%) is much higher than average of 55.1% for this stream type.

Table 349. Macroinvertebrate metrics that respond to nitrate stress in County Ditch 46A compared to the statewide average of visits meeting the warmwater general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN069 (2013)	**0**	**0**	**4.0**	**0**	**20**	**72.3**
Prairie Streams Average	*4.4*	*4.8*	*3.1*	*2.0*	*18.8*	*55.1*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is considered a stressor within this reach. The chemistry data set display frequent exceedances of nitrate, often times being over twice as high as the standard used. The biological metrics also display limitations on the community due to nitrate toxicity.

Total Suspended Solids

During biological monitoring total suspended solids (TSS), samples were taken at 13MN069 with concentrations of 8.8 mg/L on June 13, 2013 and another reading of 6.8 mg/L on August 15, 2013. This site had 130 additional TSS samples that were collected in the years 2005 – 2012 with concentrations ranging from 2 mg/L – 310 mg/L and an average of 30.38 mg/L. Twelve of the samples exceeded the standard of 65 mg/L. The highest concentrations of TSS exceedances were found from the months of March through June. This reach is currently impaired for turbidity.

Macroinvertebrate metric response to TSS were mixed (Table 350).The relative abundance of collector-filterer individuals (Collector-filtererPct) were worse than the statewide average. The relative abundance of Plecoptera individuals (PlecopteraPct) was slightly higher than the statewide average. The macroinvertebrate TSS index score was slightly below average; as this score increases, so does the tolerance of the community. There were zero TSS intolerant taxa, and 10 TSS tolerant taxa. The percentage of TSS tolerant individuals made up 47% of the macroinvertebrate community. Overall, a majority of the macroinvertebrate metrics are similar to what would be found in a supporting stream of the same type.

Table 350. Macroinvertebrate metrics that respond to high TSS stress in County Ditch 46A compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN069 (2013)	**5.4**	1.3	16.08	**0**	**0**	10	**46.8**
Prairie Steams Average	*17.7*	*0.2*	*16.96*	*1.5*	*3.1*	*13.2*	*43.1*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

While the stream is impaired for turbidity, the metric response is weak in supporting TSS as a stressor. It is possible that due to the drought year (recall fish were not assessed in this stream due to this), the macroinvertebrates may not be representative of a typical community found here, and might not have been subjected to the same levels of TSS stress as in other years. Due to this inconsistency, TSS cannot be confirmed as a stressor and is considered inconclusive. Follow-up biological monitoring may provide different results.

Habitat

In June of 2013, habitat assessment was conducted that resulted in a MSHA score of 70.05 (good). In August of 2013, the score was considerably lower at 58.9 (fair). The August visit had more bank erosion noted. The difference seen in the channel morphology scores (Figure 343) were due to slight differences in channel development (good to fair) and the loss of a velocity type (fast) from the June visit. The substrate subcategory showed the largest difference between the two visits. In June, there was 15% riffle noted with gravel and cobble, and the reach had light embeddedness. In August, the percentage of riffle features dropped to 5% and the pool and run features had the presences of silt. The reach had increased in embeddedness to moderate. This is consistent with what was observed at the site regarding lack of flow and drought, which would decrease riffle features and velocity and favor poor substrate and siltation.

Figure 343. Percentage of MSHA subcategory scores for station 13MN069, County Ditch 46A.

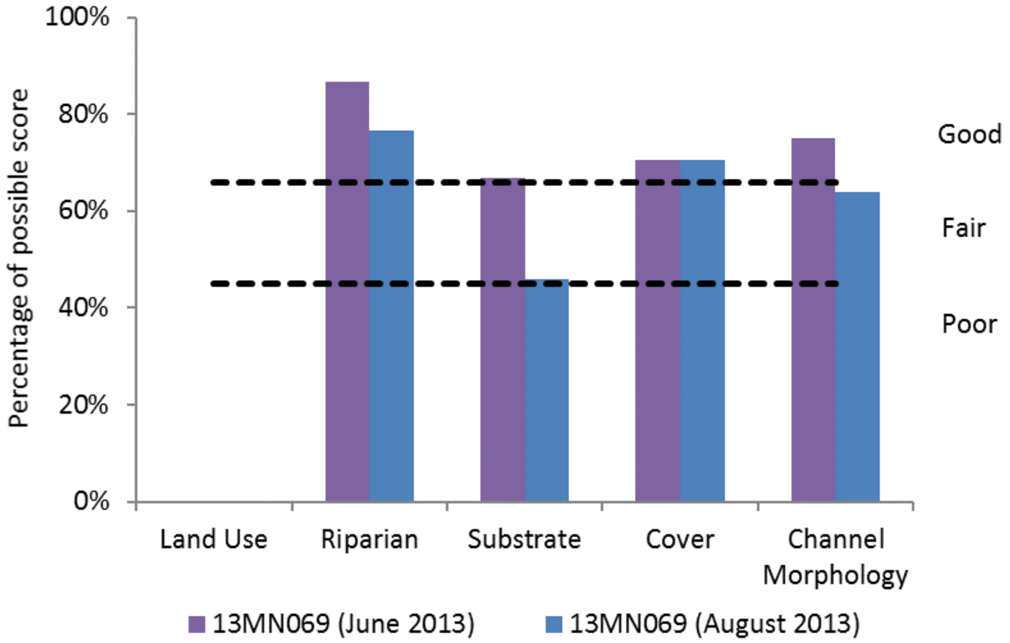
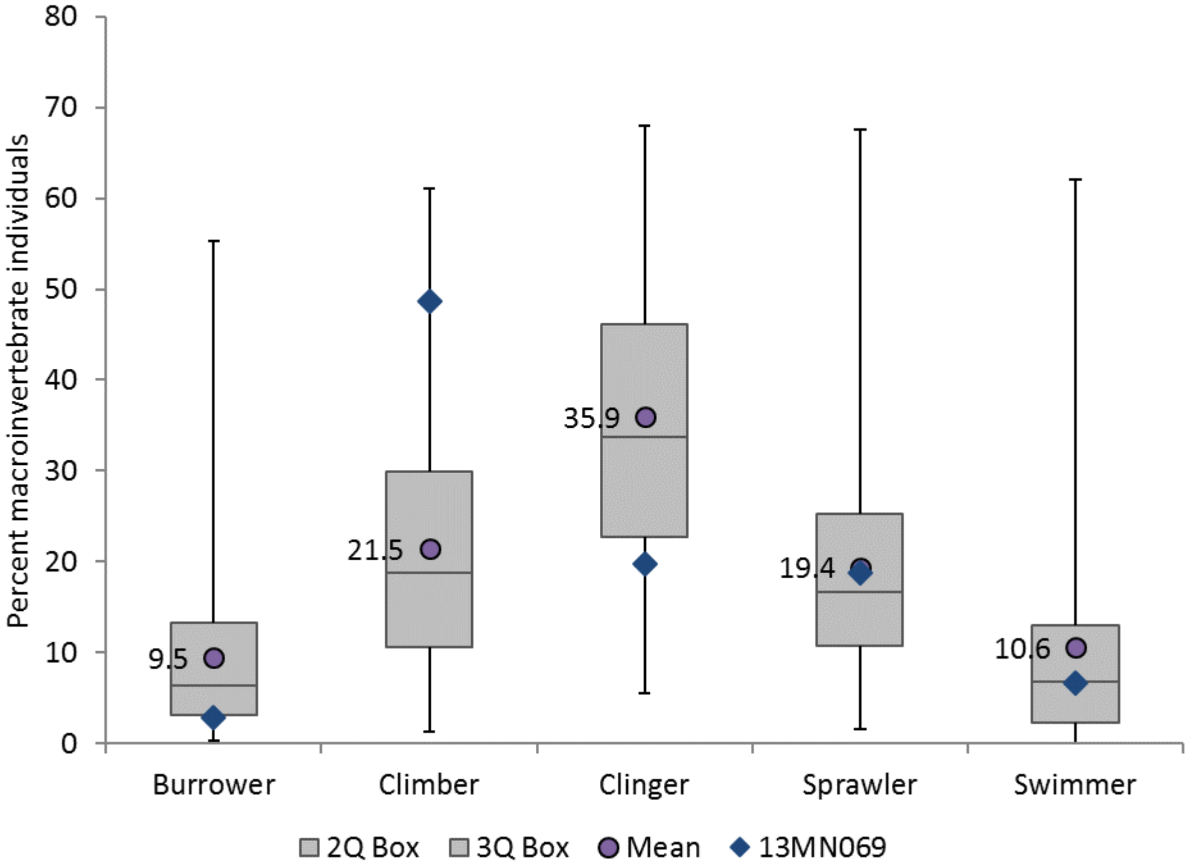


Figure 344 shown below, displays the streams habitat features at the monitoring location. The photo shows adequate cover, riffle features, as well as pools.

Figure 344. Monitoring location 13MN069 displaying habitat conditions taken on June 13, 2013.

Climbers were abundant, as clingers were less abundant than expected for this stream type. The dominant habitat type was wood. All other community habitat types were within the expected ranges. It is possible that the lack of clingers is a symptom of flow conditions or lack of riffle habitat/substrate, which would provide more habitat diversity to this reach. They also could be responding to other stressors like nitrate. Due to these uncertainties, habitat is inconclusive as a stressor.

Figure 345. Macroinvertebrate habit metrics with box plot showing range of values from Prairie Stream GP stations meeting the general use biocriteria mean of those stations, and metric values from station 13MN069.



Habitat is inconclusive as a biological stressor. While it is not a clear limitation to the community habitat types, there is a question around the dramatic change in velocity that flows through this site and the impacts it has with displacement of communities. As this site was shown to have variable habitat scores, it would be beneficial to collect additional community information to fully rule out habitat as a stressor to the macroinvertebrate community.

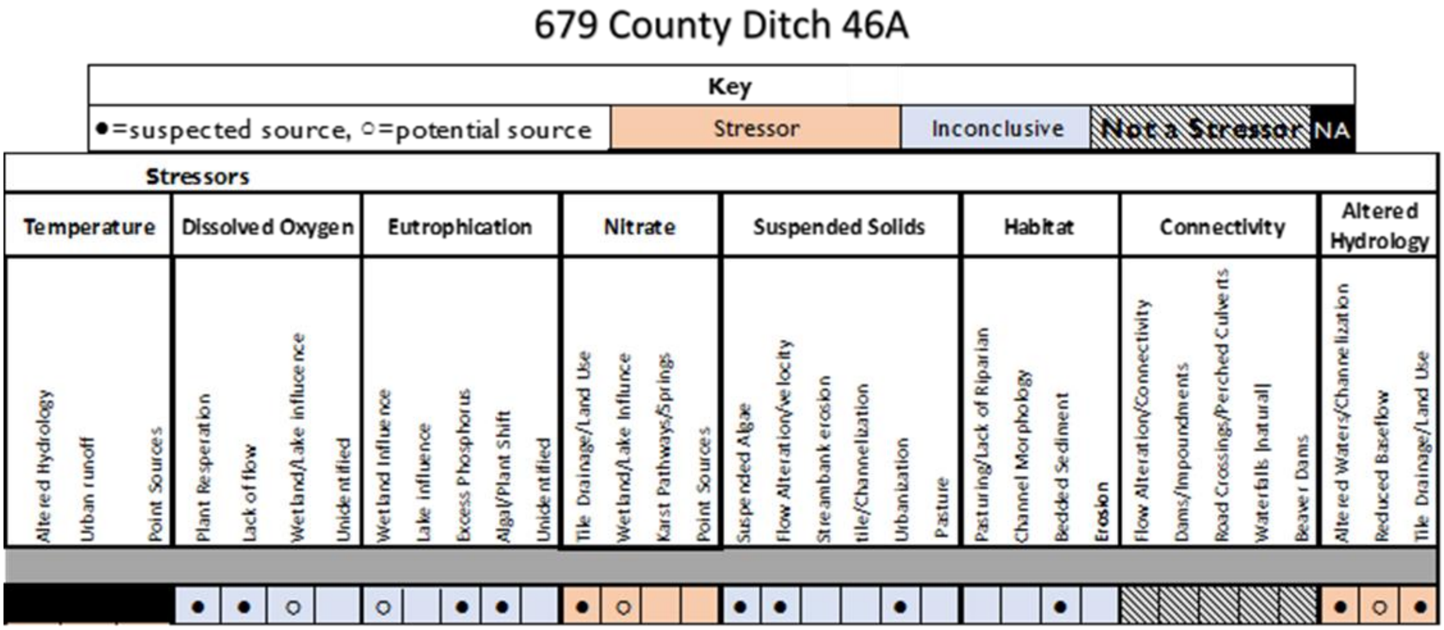
Longitudinal Connectivity and Altered Hydrology

The fish community on this AUID may be impacted by a downstream, man-made fish barrier on Seven Mile Creek (07020007-563). The dam was built to block migration of common carp. For more information on the dam, please see DNR's Minnesota River, Mankato Watershed Characterization Report (2015).There are three stations upstream of the dam. Although there were visits to 13MN068 and 13MN069, the fish data was not assessable. If assessable data were collected, the dam would be a stressor to the fish community. The dam is not a stressor to the macroinvertebrate community in this reach.

The majority of this subwatershed is altered by way of ditching and channelizing, as well as introduction of subsurface tile drainage. These modifications create dynamic changes to the streams hydrology, creating changes to the geomorphology, as well as increases in pollutant loading. Altered hydrology is a foundational issue, and a contributor to all the impaired biological communities in the Minnesota River Mankato Watershed. For additional information on how these changes are occurring, refer to Chapter 3.1.8 of this report.

Conclusion

Table 351. Identified stressors with suspected sources for reach 679 of County Ditch 46A.



679 County Ditch 46A

Key

●=suspected source, ○=potential source | Stressor | Inconclusive | Not a Stressor | NA

Stressors																																	
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
■	■	■	●	●	○		○		●	●		●	○			●	●			●				●		▨	▨	▨	▨	▨	●	○	●

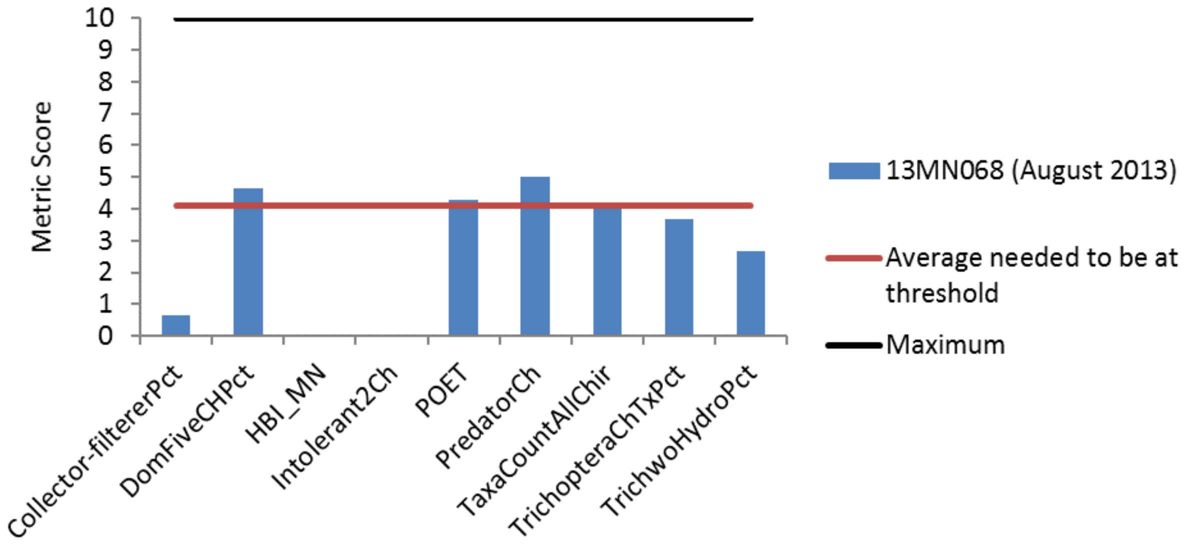
4.38 Seven Mile Creek (07020007-703)

Seven Mile Creek (07020007-703) is north of Mankato, Minnesota. The reach is warmwater general use Class 2B. The reach extends from MN-99 to CD 46A. Seven Mile Creek is impaired for lack of macroinvertebrate assemblage. There is one biological station on this reach, 13MN068. The reach is also impaired for fecal coliform and turbidity. Fecal coliform will not be addressed in this report. Turbidity will be discussed as it relates to the biological communities.

4.38.1 Biological Communities

In 2013, station 13MN068 was sampled for fish and macroinvertebrates. The fish data was not assessable due to low flow and biological recolonization limited by drought. The macroinvertebrate community scored 29.8, below the Prairie Streams GP class IBI general use threshold (41). The dominant species sampled was snails (Physa). As shown in Figure 346, the dominate 5 taxa types (DomFiveCHPct), richness of Plecoptera, Odonata, Ephemeroptera, & Trichoptera (POET), abundance of predator species (PredatorCh), and the overall abundance of taxa diversity just fell at the threshold. There were not any intolerant species found within the sample.

Figure 346. Macroinvertebrate metrics of the Prairie Streams GP class IBI for station 13MN068, Seven Mile Creek.



4.38.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

At the time of biological monitoring dissolved oxygen (DO) was recorded at 10.06 mg/L on June 13, 2013 and at 7.45 mg/L on August 13, 2013. Additional water chemistry data available at one EQUIS station S002-934, which had 78 samples for DO from 2006-2015. The maximum concentration was 19.2 mg/L, with a minimum of 4.2 mg/L. Three samples fell below the 5 mg/L DO standard, which were taken in August of 2007 and 2008. However, there were no samples taken before 9 am, when concentrations are typically the lowest.

The macroinvertebrate metrics used to analyze for dissolved oxygen stress do show a consistent response (Table 352). The responses across the table are not dramatically different than the Prairie Streams average. There are also some low DO sensitive species, while they are limited there are a few within the sample. Indicating

Table 352. Macroinvertebrate metrics that respond to low DO stress in Seven Mile Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
13MN068 (2013)	**33**	**6**	**9.03**	**6.49**	**3**	**2.3**	**8**	**29.4**
Prairie Streams Average	*41.6*	*11.5*	*7.59*	*6.79*	*4.1*	*8.5*	*7.0*	*16.6*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

At this point, without additional pre-9 am DO data or diurnal (continuous) oxygen information, it's difficult to point to dissolved oxygen as a reason for macroinvertebrate impairment, when they could be responding to other stressors. Additional data needs to be collected in order to confirm if oxygen is stressing the biology, therefore dissolved oxygen is inconclusive in this reach.

Eutrophication

Two total phosphorus (TP) samples were collected at the time of biological monitoring, resulting in concentrations of 0.024 mg/L on June 13, 2013 and 0.124 mg/L on August 13, 2013. Outside of biomonitoring water samples, no additional water monitoring was conducted at this location.

One sample for chlorophyll-a was collected on September 2 2015, with a concentration of 4.45 ug/L; well below the standard of 35 ug/L for the Southern Region.

TP data exceeds the river eutrophication level; however, insufficient data exists to determine if a secondary response is being noted in the stream. Data assessed for this site was from the load monitoring program. This program targets sampling based around rain events, therefore TP will be high simply because of the nature of sampling. Phosphorus loading is unknown in this stream during normal or low flow conditions. There was also a lack of secondary chemistry data to determine a eutrophic response (such as DO flux).

The macroinvertebrate metrics do indicate eutrophic stress (Table 353). The abundance of different taxa (TaxaCountAllChir), Colletor species (Collector-gathererCh), and the taxa richness of Ephemeroptera, Plecoptera & Trichoptera (EPT) were lower than the average for Prairie Streams. There were not any tolerant species found, while specifically tolerant species made of nearly 91% of the total sample.

Table 353. Macroinvertebrate metrics that respond to eutrophication stress in Seven Mile Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
13MN068 (2013)	**33**	**3**	**8**	**6**	**0**	**90.9**
Prairie Streams Average	*41.6*	*5.5*	*14.4*	*9.7*	*0.3*	*80.7*
Expected response to stress	↓	↓	↓	↓	↓	↑

Eutrophication is inconclusive as a biological stressor. This is largely due to the lack of secondary response data within the chemistry data. The macroinvertebrate metrics are suggestive of eutrophic conditions limiting the community.

Nitrate

Two nitrate samples were collected at the time of biological monitoring, resulting in concentrations of 19 mg/L on June 13, 2013 and .07 mg/L on August 13, 2013. There is a large sample dataset at S002-934 (which is co-located with 13MN068) that shows high nitrate concentrations. From 2005-2016, there have been 228 nitrate samples at this station, with a minimum concentration of 0.2 mg/L and a maximum of 49.5 mg/L. The average concentration of those samples was 17.8 mg/L. Thirty-nine of the samples exceeded 30 mg/L, the majority of which were taken in April, May, or June (a handful from October). These nitrate concentrations are some of the highest observed in the entire state database.

Biologically, macroinvertebrates show a consistent response to these high nitrate concentrations (Table 354). The percentage and number of nitrate tolerant taxa are much higher than the statewide average for Prairie Streams, which is also reflected in a high nitrate index score. Additionally, intolerant taxa are lacking, and specifically those which tend to be sensitive to high nitrate concentrations

(TrichopteraCh/TrichwoHydPct). The biological and chemical evidence overwhelmingly point to nitrate as a stressor to the macroinvertebrate community in this reach.

Table 354. Macroinvertebrate metrics that respond to nitrate stress in Seven Mile Creek compared to the statewide average of visits meeting the warmwater general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
13MN068 (2013)	**0**	**0.9**	**4.5**	**0**	**24**	**91.1**
Prairie Streams Average	*4.4*	*4.8*	*3.1*	*2.0*	*18.8*	*55.1*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is considered a biological stressor. There is strong evidence noted in the chemistry data as a majority of the large sample set displayed high nitrate concentrations. In addition, there was a response to the macroinvertebrate community to suggest limitations to the community from nitrate toxicity.

Total Suspended Solids

Two total suspended solids (TSS) samples were collected at the time of biological monitoring, resulting in concentrations of 25 mg/L on June 13, 2013 and 77 mg/L on August 13, 2013.

This reach is listed for a turbidity impairment, associated with data collected at S002-934. Recent data and evaluation of TSS and secchi tube readings show violations of the standard are still occurring and the impairment is still valid. However, the data that has been collected is biased towards event-based sampling, which would target those exceedances of the TSS standard for pollutant loading calculations.

Macroinvertebrate metric response to TSS were suggestive of TSS stress to the community (Table 355). The relative abundance of collector-filterer individuals (Collector-filtererPct) was lower than the statewide average. The relative abundance of Plecoptera individuals (PlecopteraPct) was slightly higher than the statewide average. The macroinvertebrate TSS index score was higher than the average; as this score increases, so does the tolerance of TSS noted in the community. There were zero TSS intolerant taxa, and 10 TSS tolerant taxa. The percentage of TSS tolerant individuals made up nearly 58% of the macroinvertebrate community.

Table 355. Macroinvertebrate metrics that respond to high TSS stress in Seven Mile Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

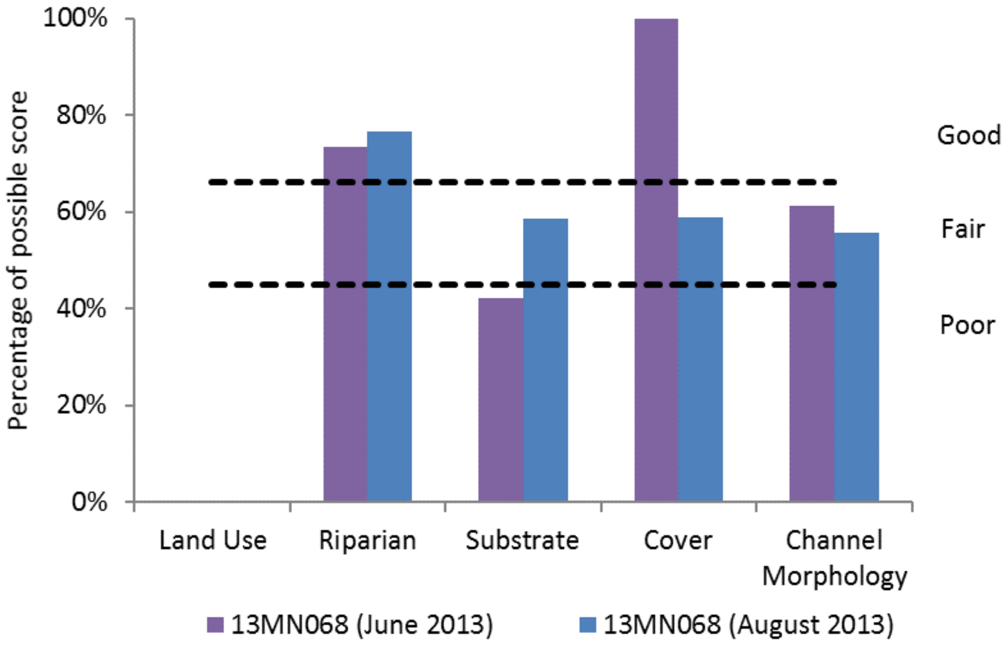
Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN068 (2013)	**2.8**	0.5	**19.10**	**0**	**0**	9	**57.9**
Prairie Streams Average	*17.7*	*0.2*	*16.96*	*1.5*	*3.1*	*13.2*	*43.1*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

TSS is considered a stressor to the macroinvertebrate community within this reach. As the fish were not assessable, it is difficult to know if there would have been a response seen, although it is feasible as TSS impairments within a stream often are associated to poor substrate; a component of the stream that is critical for most fish species to thrive.

Habitat

In 2013, station 13MN068 had MSHA scores of 61.4 and 57.3 (both fair) for the June and August visits (Figure 347). The land use subcategory was relatively poor. Similarly, the substrate category in June was also poor. The substrate had a larger proportion of the reach with silt as a second substrate type in June than in August. In June, there was also noted severe embeddedness, where as in August it was moderate embeddedness. Both visits did note the presence of more than four substrate types available though. Channel morphology was fair both visits, along with substrate and cover in August. In June, cover was extensive with many types available, in contrast to August, when moderate cover was available by deep pools, logs or woody debris, and rootwads.

Figure 347. Percentage of MSHA subcategory scores for station 13MN068, Seven Mile Creek.



The start of this biological monitoring station Is located at the start of a reach that in categorized as natural. Leading up to the start of this reach is an extensive drainage network that has been extremely altered by way of ditching. The macroinvertebrate community is likely influenced by this draiage network as the monitoring site on this reach is located at the end of it. The population sampled at 13MN068 was dominated by Physa (snails). This Tolerant inverts presents is likely due to the upstream ditch. The next most sampled taxa were Caenis diminuta and Gerridae, both are typical of wetland or eutrophic slow stream conditions. With the monitoring station being this far upstream, it plausible the sample was impacted by the impaired upstream by the modified reaches.

As shown in Figure 348, the macroinvertebrate community at this site is primarily made up of climbers (due to the high numbers of Physa collected). This high percentage of climbers throws off the remainder group percentage distribution.

However, even with this skewed population the overall presents of clinger type insects were almost complete absent from the sample, suggesting it is possible that there could be habitat limitations as well that is driving the IBI down.

Figure 348. Macroinvertebrate habit metrics with box plot showing range of values from Prairie Streams stations meeting the general use biocriteria mean of those stations, and metric values from station 13MN068.

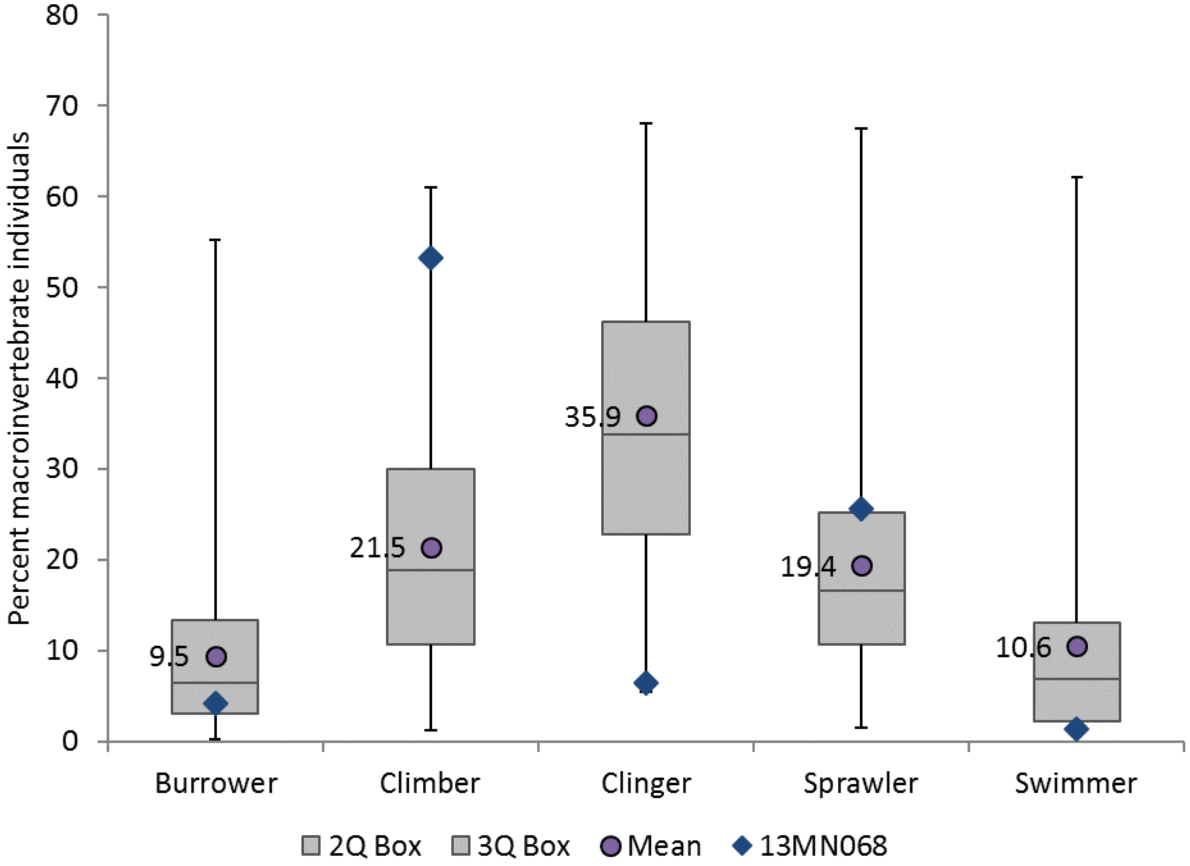


Figure 349. 13MN068 August 2013; shows erosion, possible embedded substrate, low flows.

Habitat is considered a stressor within this reach. Limitations to the habitat are largely due to the poor substrate. This is likely a secondary stressor to TSS, both of which can be seen in Figure 349.

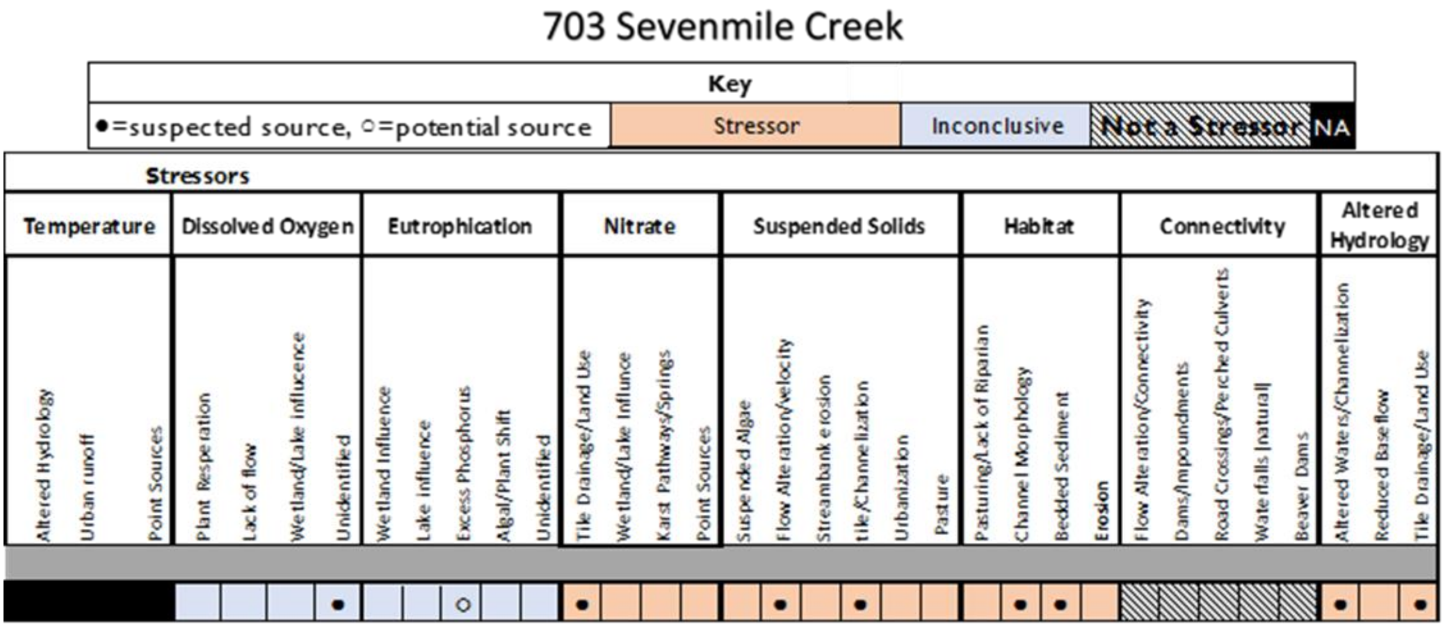
Longitudinal Connectivity and Altered Hydrology

Longitudinal connectivity is considered a stressor. The fish community on this AUID may be impacted by a downstream, man-made fish barrier on Seven Mile Creek (07020007-563). The dam was built to block migration of common carp. For more information on the dam, please see MNDNR's Minnesota River, Mankato Watershed Characterization Report (2015). There are three stations upstream of the dam. Although there were visits to 13MN068 and 13MN069, the fish data was not assessable. As connectivity rarely affects macroinvertebrate communities, the dam is not considered a stressor.

Altered hydrology is considered the primary stressor within Seven Mile Creek, due to the modified headwaters via channelization as well and introduction of subsurface tile drainage. For additional information on how these forms of land/stream modifications change hydrology, reference Chapter 3.1.8 of this report.

Summary Table

Table 356. Identified stressors with suspected sources for reach 703 of Seven Mile Creek.



703 Sevenmile Creek

Key				
●=suspected source, ○=potential source	Stressor	Inconclusive	Not a Stressor	NA

Stressors																																	
Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
■	■	■				●			○			●					●		●				●	●		▨	▨	▨	▨	▨	●		●

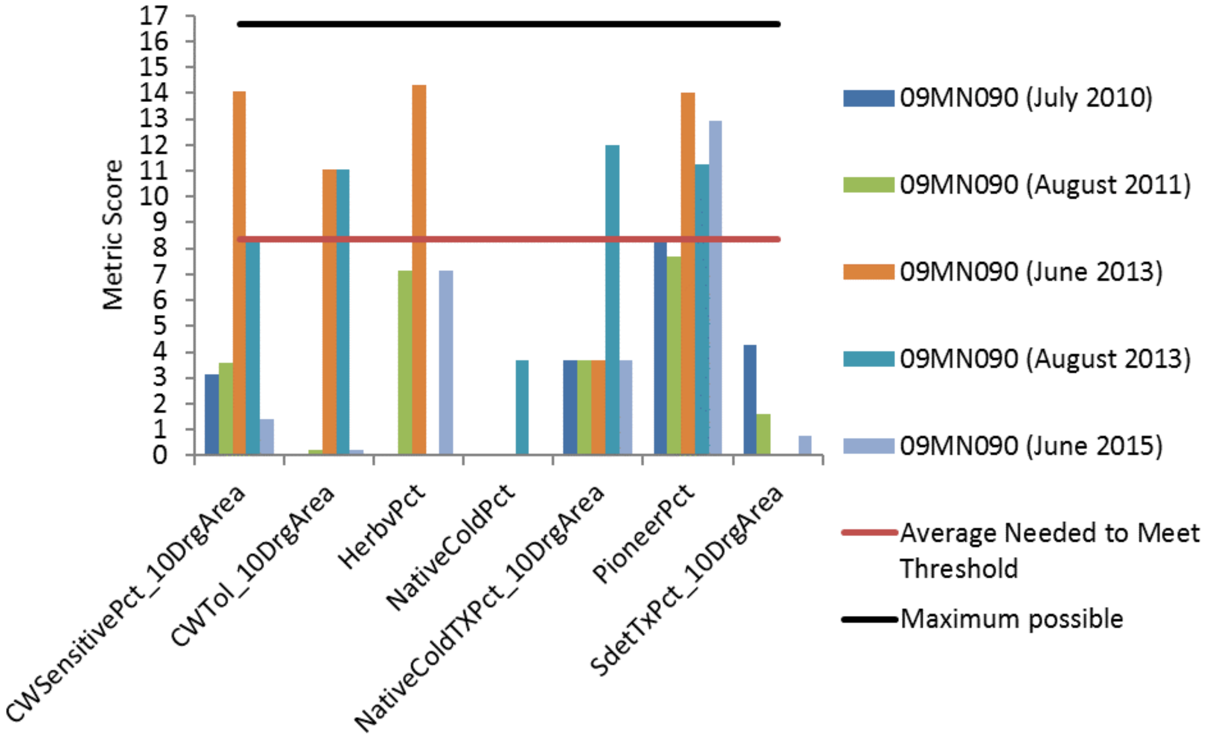
4.39 Seven Mile Creek (07020007-562)

Seven Mile Creek (07020007-562) is north of Mankato, Minnesota. The reach is coldwater Class 2A. The reach extends from downstream of the confluence with CD 46A to the Minnesota River. Seven Mile Creek is impaired for lack of macroinvertebrate assemblage and lack of fish assemblage. There are two biological stations on this reach, 09MN090 and 15MN208. The reach is also impaired for chloropyrifos, fecal coliform, nitrates, and turbidity. Fecal coliform will not be addressed in this report. Turbidity, nitrates, and chloropyrifos will be discussed as it relates to the biological communities.

4.39.1 Biological Communities

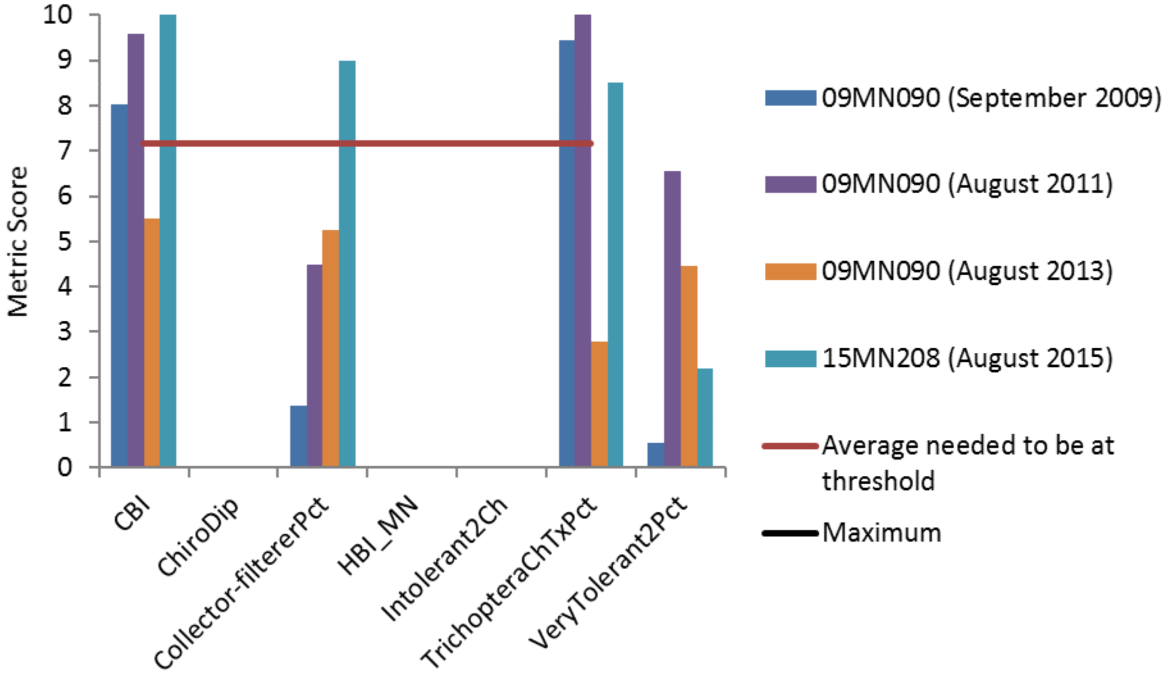
Fish data was collected from four visits at one station (09MN90) sampled from 2010 to 2013. F-IBI scores for the visits in 2010 and 2011 fell below the general use threshold of 50, and below the lower confidence interval (CI) of 13. F-IBI scores for one of the two visits in 2013 fell above the threshold, but below the upper CI. While the second 2013 visit fell below the general use threshold, but above the lower CI. One sample in 2015 the F-IBI score fell far below the general use score, and outside of the threshold at 09MN090. Further downstream of this reach, a new station was sampled (15MN208) and was found to be just slightly under the threshold, and within the CI. As reflected inFigure 350, the largest contributor to poor IBI scores were lack of native coldwater species as well as coldwater sensitive species. Given the drainage area, detriticolous fish species were also lacking.

Figure 350. Fish metrics of the Southern Coldwater class IBI for station 09MN090, Seven Mile Creek.



As reflected in Figure 351, the Macroinvertebrate community generally scored well for abundance of Collector-filterer species, Trichoptera, and coldwater species. The abundance of "very tolerant" species varied in sample years were Intolerant inverts were completely lacking across all samples. Chironomid abundance to total dipteran abundance was also of consistent concern within all samples.

Figure 351. Macroinvertebrate metrics of the Southern Coldwater IBI class for stations 09MN090 and 15MN208.



4.39.1 Data Evaluation for each Candidate Cause

Temperature

According to DNR, Seven Mile Creek is currently managed as a put-grow-take Brown Trout fishery and designated trout stream. It is currently stocked annually with 7,500 fingerling Brown Trout. Population assessments have confirmed large adult brown trout and carry-over year classes, but was noted that large deep pool habitat that holds larger fish can sometimes be limited in certain areas of Seven Mile Creek. There are large variations among years in the percentage of coldwater/coldwater sensitive fish in this reach (i.e. brown trout). All of the samples , exception of June 2013 show fewer than average coldwater and coldwater sensitive fish (Table 357). Native coldwater fish, like brook trout, were absent in the fish surveys, resulting in a zero score on all visits for the NativeColdPct metric.

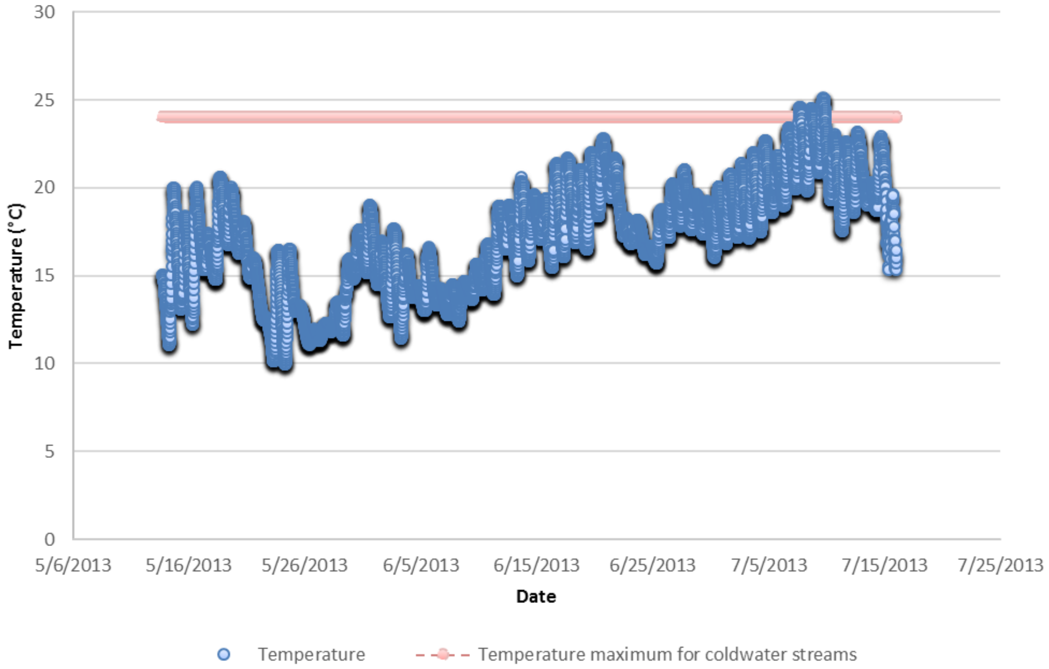
The macroinvertebrate coldwater taxa sampled included Gammarus (2010, 2013, 2015), Baetis tricaudatus/brunnicolor (2011, 2015), and Eukiefferiella (2011, 2013). Overall, coldwater macroinvertebrates appear fairly abundant as shown in the CBI (Coldwater Biotic Index) score in **Error! Reference source not found.**. All but one visit, which occurred in August 2013, had higher than average CBI scores for macroinvertebrates, despite larger disparity among MIBI scores over the time periods. This suggests that perhaps another stressor besides temperature is reducing the quality and abundance of macroinvertebrates in this reach.

Table 357. Biological metrics that respond to temperature compared to the statewide average of visits meeting the Southern Coldwater biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	ColdPct (Fish)	CWSensitivePct (Fish)	NativeColdPct (Fish)	Coldwater Biotic Index (Macroinvertebrates)	MIBI Score
09MN090 (September 2009)	na	na	na	8.03	23.1
09MN090 (July 2010)	**16.9**	**16.8**	**0**	na	na
09MN090 (August 2011)	**19.7**	**19.7**	**0**	9.60	49.9
09MN090 (June 2013)	88.4	88.4	**0**	na	na
09MN090 (August 2013)	**50.3**	**50.3**	**0**	**5.50**	**32.0**
09MN090 (2015)	**5.3**	**5.3**	**0**	10.1	64.7
15MN208 (2015)	**4.1**	**4.1**	**0**	9.2	49.1
Southern Coldwater Average	*66.4*	*70.6*	*30.3*	*7.70*	*50*
Expected response to stress	↓	↓	↓	↓	↓

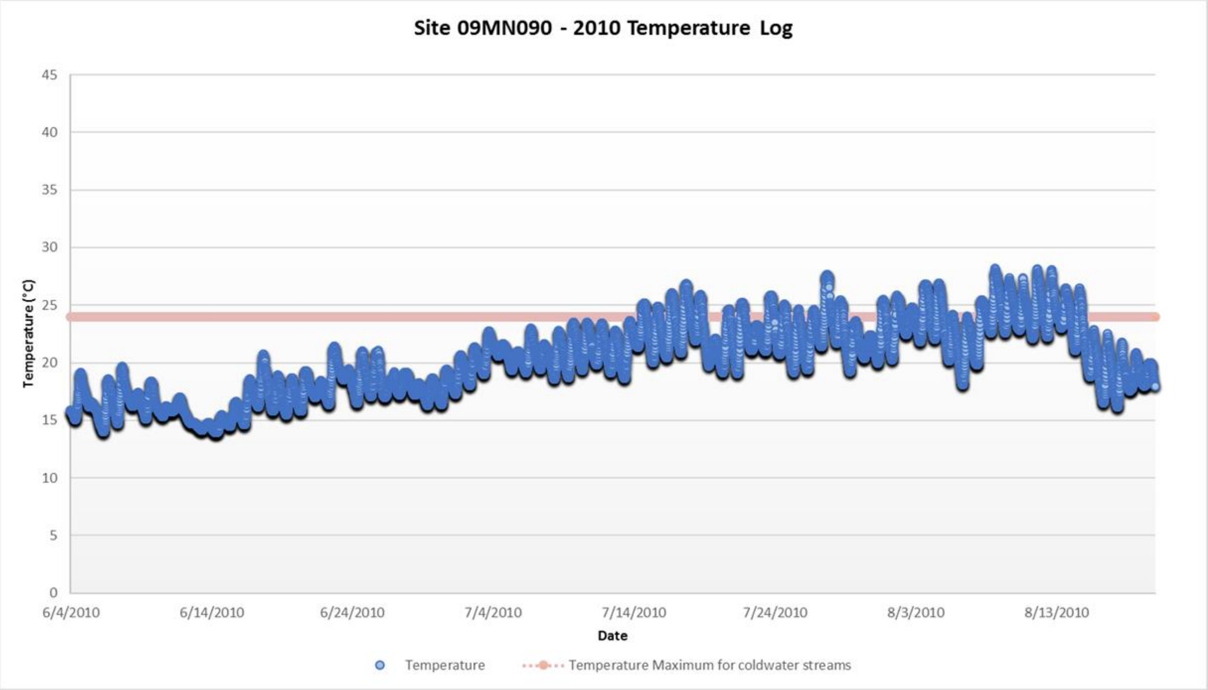
Continuous temperature data was collected during three different years on Seven Mile Creek (Figure 352). In 2013, temperatures rose above 24 degrees Celsius during the days of July 7 to July 9. With the peak temperature reaching 25.11°C on the 9th and staying above 24°C for approximately 7.5 hours the same day. This represents a fairly short period of time where temperature exceeds the critical temperature threshold for brown trout (24°C), but also shows a fair amount of time above 18°C, the threat temperature for brown trout during more critical time periods like July.

Figure 352. Temperature measurements from 09MN090 in 2013 from May-July.



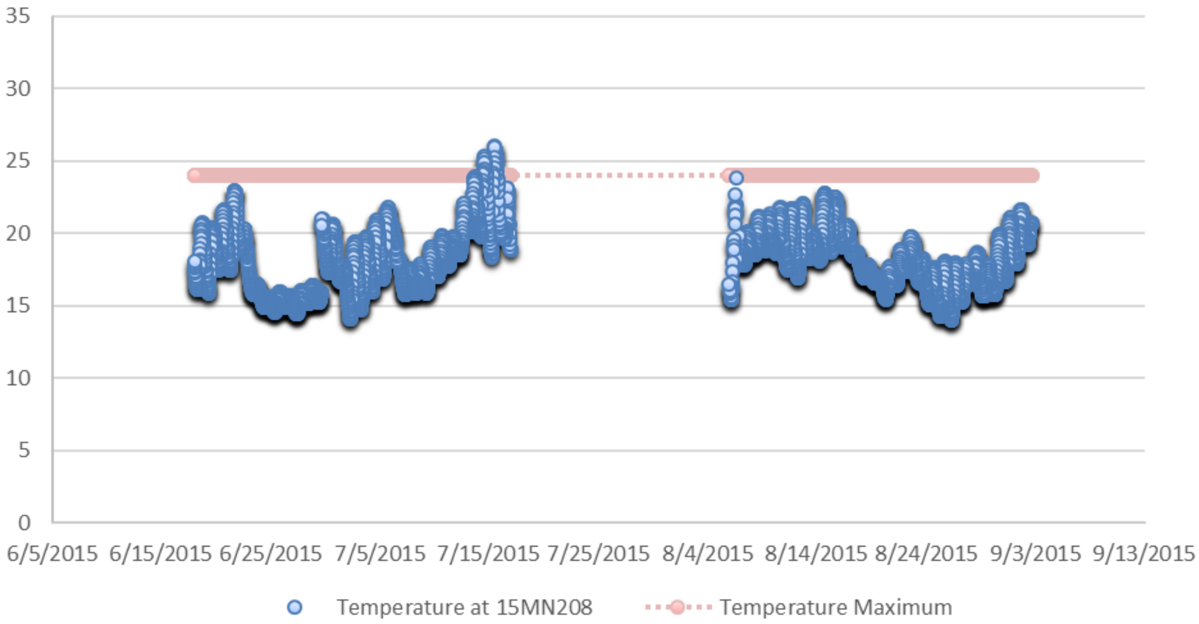
Similarly, the 2010 Temperature data, shown below in Figure 353 displays a number of days that rose above the 24-degree Celsius coldwater threshold. The peak temperature in 2010 occurred on August 8 at 28.17 °C. During late July through Mid-August, temperatures were observed to exceed 24 °C for long periods of time, the longest period recorded for 16 hours on August 9. Temperatures collected in 2010 overall appear to be warmer during the hot summer months, when thermal stress typically occurs because flows are also lower.

Figure 353. Temperature measurements from 09MN090 in 2010 from June-August.



The 2015 temperature data, shown below in Figure 354 had a number of days that rose above the 24-degree Celsius. Note that data in July had to be removed due to temperature logger being out of the water and recording air temperatures. There were numerous periods of temperatures recorded above the cold-water threshold with 38 out of the 113 days exceeding. Water temperatures were observed to remain above 24°C for up to 12-hour durations. The peak temperature was recorded at 26.0 °C.

Figure 354. Temperature measurements from 15MN208 in 2015 from June-September.



Temperature is considered a stressor to the coldwater biology within this reach of Seven Mile. The strongest line of evidence for temperature stress in noted from the data extracted from the long-term data collected via temperature loggers. Over multiple periods, temperature was found to exceed the coldwater threshold. The fish community does show stress, although lack of proper habitat (discussed in more detail below) may be a larger limitation. The coldwater macroinvertebrate community showed consistent stress.

Dissolved Oxygen

Dissolved oxygen (DO) data collected between 2006-2015 had a range from 6.2 mg/L – 15.5 mg/L with an average of 10.57 mg/L out of 169 samples. Seven of the samples were taken before 9 am; none of which exceeded the cold-water standard of 7 mg/L.

The macroinvertebrate community did not indicate a strong negative response to low DO (Table 358). Throughout all the years sampled, the total taxa richness sampled (TaxaCountAllChir) was above, or fell shortly under the state average for southern cold-water streams. There was a slight decrease in Ephemeroptera, Plecoptera, as well as Trichoptera (EPTCh). However, these orders of macroinvertebrates could be driven down from another biological stressor. The HBI_MN is a measure of pollution based on tolerance values assigned to each individual taxon, and was found to be slightly higher than the state average of 6.36 during each sample. The low DO index score measures stress response. The lower the index score for low DO, the higher the likelihood is for DO stress. 2009 was only one year were the low DO index score fell below the southern coldwater average. Low DO intolerant species were not abundant, and typically fell under the average, yet they were always present. Abundance of tolerant species slightly varied throughout the years, but was not found to dominate the community. Overall, the metrics that would indicate low DO stress to the macroinvertebrate community were not suggestive of this, as the metric scores hovered around the state averages recorded for the same stream type.

Table 358. Macroinvertebrate metrics that respond to low DO stress in Seven Mile Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
09MN090 (2009)	41	**8**	**7.26**	**7.28**	**7**	**47.9**	**5**	**12.1**
09MN090 (2011)	**20**	**5**	**6.97**	7.95	**5**	62.7	0	0
09MN090 (2013)	31	**6**	**7.16**	7.64	**8**	**32.6**	**2**	**1.9**
09MN090 (2015)	**20**	**5**	**6.72**	7.84	**9**	**38.0**	**2**	0
15MN208 (2015)	**30**	**7**	**6.96**	7.58	**9**	**30.25**	1	.64
Southern Coldwater Average	*30.8*	*8.1*	*6.36*	*7.49*	*10.4*	*56.6*	*1.8*	*1.3*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

The fish community did indicate stress (Table 359), reflected in the lack of sensitive taxa sampled (SensitivePct) compared to the overabundance of tolerant taxa sampled (TolPct). The only exception to this was seen in the first 2013 sample at station 09MN090. The community metrics within this location also revealed a lack of mature female taxa, indicating a disruption to the life cycle ability to most species. Reflecting on the metrics that focus of the population that is specifically sensitive or tolerant to DO levels, it is not as clear if the community metrics directly point to DO levels as a limiting factor.

Table 359. Fish metrics that respond to low DO stress in Seven Mile Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
09MN090 (2010)	**17.4**	**22.2**	**77.3**	**7.70**	**1**	**16.9**	**7**	4.8
09MN090 (2011)	**19.7**	**24.2**	**69.3**	**7.76**	**1**	**19.7**	**3**	4.5
09MN090 (2013)	88.4	88.4	10.5	9.24	**1**	88.4	1	1.1
09MN090 (2013)	**50.3**	**53.5**	**45.9**	8.46	**1**	**50.3**	1	6.4
09MN090 (2015)	**5.3**	**9.5**	**83.4**	**6.29**	**1**	**5.3**	**4**	**68.6**
15MN208 (2015)	**4.8**	**6.2**	**85.6**	**7.29**	**1**	**4.1**	**5**	**26.7**
Southern Coldwater Average	71.7	74.6	24.0	8.9	2.5	72.4	1.1	6.8
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

Low DO as a biological stressor to macroinvertebrates and fish is considered inconclusive. There was not enough supporting data in the chemistry analysis to indicate it is a limiting factor. The metrics in both communities was of concern, but also mixed enough to question if the scores that fell below specific DO thresholds are from a different stressor that is influencing the sensitive taxa metrics.

Eutrophication

Five total phosphorus (TP) samples were taken at the time of biological monitoring with data ranging from .024 mg/L - .274 mg/L, with concentration exceeding the standard twice at 0.274 mg/L on July 21, 2010 and 0.132 mg/L on June 13, 2013. Additional water chemistry monitoring yielded a large data set for TP, with 287 samples taken from 2006 – 2015 resulting in a data range of 005 mg/L – 3.24 mg/L and an average TP concentration of 0.22 mg/L. While phosphorus is high and should be reduced, there was a lack of secondary data (Chl-a, BOD, DO flux) to confirm or rule out eutrophic conditions within the chemistry analysis.

The macroinvertebrate community displayed a mix response to eutrophic stress (Table 360). The total richness of taxa collected (TaxaCountAllChir) hovered around the state average found for non-impaired southern coldwater streams. The taxa sample for macroinvertabrates that depend on conditions for filtering and gathering (Collector-filtererCh and Collector-gathererCh) typically were found to be just under the average. Ephemeroptera, Plecoptera & Trichoptera, (EPT) were just under the average in years the taxa counts fell under the average for this stream type. These taxa types will typically display the strongest metric signal for eutrophication; this does not appear to be the case for the macroinvertebrate community. In general, there was an absence of intolerant species in the sample; the community was abnormally dominated by tolerant taxa.

Table 360. Macroinvertebrate metrics that respond to eutrophication stress in Seven Mile Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
09MN090 (2009)	45	7	19	8	**0**	**78.0**
09MN090 (2011)	**24**	**5**	**10**	**5**	**0**	**85.0**
09MN090 (2013)	31	**5**	13	**6**	**0**	**77.4**
09MN090 (2015)	**21**	**5**	11	**5**	**0**	**71.4**
15MN208 (2015)	**30**	6	14	**7**	**0**	**90**
Southern Coldwater Average	*30.8*	*6.0*	*12.1*	*7.5*	*1.1*	*66.8*
Expected response to stress	↓	↓	↓	↓	↓	↑

The fish community showed a mix response to eutrophic stress (Table 361). The lack of general intolerant species and lack of general sensitive species is telling of a struggling community, what is unclear is if this is a direct impact of eutrophic conditions. Darter species are typically one of the most impacted fish species due to lack of water clarity. Only one year, darters were found to be completely absent. However, in all but one year the darter population was struggling. Eutrophic conditions will also have a direct impact to fish species that depend on clean riverbed substrate to spawn (SLithopPct). The population metrics for this group did not indicate a chronic limitation to the community from eutrophication.

Table 361. Fish metrics that respond to eutrophication stress in Seven Mile Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
09MN090 (2010)	**17.4**	**0.8**	**26.2**	**77.3**	**20**	**0**
09MN090 (2011)	**19.7**	6.1	**28**	**69.3**	**14**	**0**
09MN090 (2013)	88.4	**0**	**10.5**	10.5	4	**0**
09MN090 (2013)	**50.3**	**3.2**	24.2	**45.9**	**7**	**0**
09MN090 (2015)	**5.3**	**1.2**	**19.5**	**83.4**	**11**	**0**
15MN208 (2015)	4.8	**0.7**	40.4	85.6	**15**	**0**
Southern Coldwater Average	*71.7*	*3.6*	*20.2*	*24.0*	*5.8*	*26.3*
Expected response to stress	↓	↓	↓	↑	↑	↓

Eutrophication is listed as inconclusive for both the macroinvertebrate and fish community. The chemistry data did display frequent phosphorus overloading of the system. However, there was a lack of secondary parameters to determine if phosphorus is creating overgrowth within this reach. The biological metrics in both communities was not strongly suggestive of eutrophic displacement. The metrics were clear on a lack of general sensitive species, paired with an abundance of general tolerant. There were only slight indications of a eutrophic response, however there is a possibility there is another parameter driving down the metrics.

Nitrate

At the time of biological monitoring five samples were taken to analyze nitrate. Monitoring was conducted in the months of June – August in 2010, 2011, 2013, and 2015 with a range of 6.2mg/L – 21 mg/L and an average of 11.4 mg/L. The highest concentration of samples taken during biological monitoring was 21 mg/L taken on June 29, 2015. Two hundred and eighty-nine additional samples were taken and analyzed for Nitrate. Concentrations raged from .2 mg/L – 42.8 mg/L, with a total average concentration of 16.38 mg/L. 197 (68%) of all samples for nitrate exceeded 10 mg/L, with the highest exceedances typically occurring in spring months.

Fish often do not show a strong response to increased nitrate concentrations. Macroinvertebrate communities are often more affected by nitrate. The macroinvertebrates in this reach show consistent indication they are stressed by the elevated nitrate concentrations (Talbe 362). The nitrate index score displayed high ranges for all the sampling years, with ranges from 3.25 to 3.69, while the average for Southern Coldwater Streams meeting impairment threshold is 3.04. This suggests that overall the community present is quite tolerant to high nitrate concentrations. Increasing nitrate concentrations also correlate with a decrease in non-hydropsychid Trichoptera individual percentages in cold-water streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct) and decreased intolerant and Trichoptera taxa, all of which are lacking in this reach. Additionally, the number of nitrate tolerant individuals is always dominant ranging from 70.5% - 77.6% is higher than average of 60.8% for this stream type. The chemical and biological data support nitrate as a stressor in this reach.

Table 362. Macroinvertebrate metrics that respond to nitrate stress in Seven Mile Creek compared to the statewide average of visits meeting the southern coldwater use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TrichopteraCh	TrichopteraChTxPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
09MN090 (2009)	**5**	**12.19**	**3.69**	2	**23**	**77.58**
09MN090 (2011)	**4**	20	**3.49**	**0**	12	**77.57**
09MN090 (2013)	**3**	**9.67**	**3.46**	**0**	**18**	**70.53**
09MN090 (2015)	**4**	20	**3.25**	**0**	13	53.04
Southern Coldwater Average	*5.3*	*17.3*	*3.04*	*1.35*	*14.29*	*60.79*
Expected response to stress	↓	↓	↑	↓	↑	↑

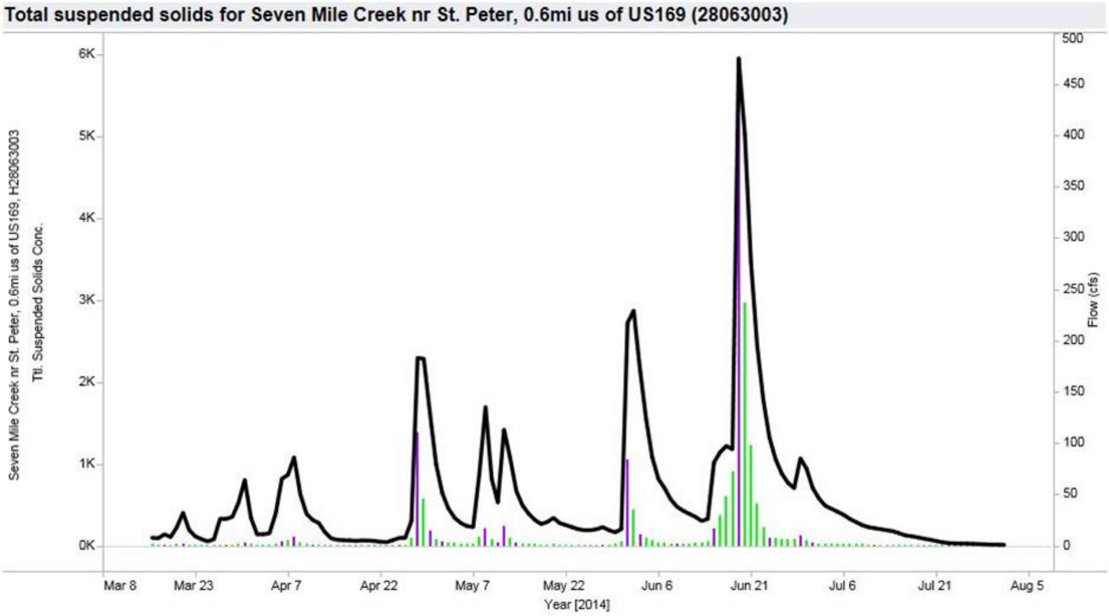
Total Suspended Solids

At the time of biological monitoring five samples were taken to analyze total suspended solids (TSS). Monitoring was conducted in the months of June – August in 2010, 2011, 2013, and 2015 with a data range of 2 mg/L – 29 mg/L and an average of 11.2 mg/L.

This reach of Seven Mile Creek was listed as impaired for turbidity in 2006 from data collected prior to the 2005 assessment cycle. A robust water chemistry dataset associated with this reach of Seven Mile Creek is available from one EQUIS station S002-937. Both the TSS and secchi tube dataset are large, and both have numerous violations over the course of the dataset resulting in abnormally high exceedance rates. Out of 292 samples, concentrations were found to be as high as 5970 mg/L and have an average of 140 mg/L. 60% of the samples collected fell above the coldwater standard for TSS of 10 mg/L. By analyzing the organic suspended material in the Total Suspended solids samples, it was found that on average organic material makes up less than 10% of the sample on average. Concluding that the majority of the solids coming through the system are sediment.

The MPCA's Pollutant Load Monitoring Network developed a hydrograph that incorporates TSS concentrations. As shown inTable 363, TSS loading in this system is closely tied to rain events. The event in June was responsible for approximately 50% of the annual TSS load to come through the system in 2014. Additional hydrograph information for this site, as well as others can be found online on the MPCA's WPLMN data viewer (https://public.tableau.com/profile/mpca.data.services#!/vizhome/WatershedPollutantLoadMonitoringNetworkWPLMNDataViewer/WPLMNBrowser).

Table 363. Hydrograph shown in black, comparing TSS samples in purple, along with modeled TSS concentrations are seen in green for Seven Mile Creek in the year 2014.



Macroinvertebrate metric response to TSS was suggestive of stress to the community (Talbe 364). The relative abundance of collector-filterer individuals (Collector-filtererPct) was typically lower than the statewide average. The population of this feeding type is important when looking at TSS concerns, as they rely on a water column with minimal sediment loading to better filter out organics.

TSS sensitive Plecoptera (PlecopteraPct) were absent in all samples. The macroinvertebrate TSS index score was consistently higher than the average TSS Index for this stream type; as this score increases, it reflects the tolerance of TSS noted in the community. There was a complete absence of TSS intolerant community composition in all years sampled. In contrast, the community composition of specific TSS tolerant species was typically above the average of what would be seen in healthy southern coldwater streams.

Table 364. Macroinvertebrate metrics that respond to high TSS stress in Seven Mile Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
09MN090 (2009)	**11.9**	**0**	**14.36**	**0**	**0**	**6**	**20.6**
09MN090 (2011)	**21.8**	**0**	**14.95**	**0**	**0**	4	**11.2**
09MN090 (2013)	**24.3**	**0**	**14.54**	**0**	**0**	**6**	9.7
09MN090 (2015)	47.9	**0**	**14.37**	**0**	**0**	4	**12.8**
15MN208 (2015)	36.4	**0**	**15.08**	**0**	**0**	**6**	**15**
Southern Coldwater Average	*32.7*	*0.4*	*13.34*	*2.3*	*3.5*	*5.2*	*10.8*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

The fish community did indicate stress from TSS (Table 365), primarily noted in the lack of species that are dependent on clean riverbed substrate in coldwater systems such as benthic feeders (BenFdFrimPct), Riffle dwelling species (RifflePct), and herbivore species (HrbNWQPct). Another concern noted within the sampled community is noted with the lack of long-lived species present. The only year that had an adequate long-lived community was in 2013. This indicates that typically there is a disruption in the life cycle of the community.

Like a majority of the metrics for this site, Fish TSS response metrics were at its best in 2013. This correlates with the pattern of annual rain events, and by extension TSS loading within the stream. 2013 was comparably a dry year with only one rain event noted.

As mentioned before, there was an overall lack of general sensitive fish species and an overabundance of general tolerant. As found inTable 366, the abundance of tolerant species generally correlate the average concentrations of TSS within that year.

Table 365. Fish metrics that respond to high TSS stress in Seven Mile Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
09MN090 (2010)	**11.3**	**0.3**	**10.6**	**0**	**21.7**	**3.5**	**11.3**	**17.4**	**3.8**
09MN090 (2011)	**11.0**	**0**	**7.6**	**0**	**23.9**	9.1	**7.6**	**19.7**	**1.5**
09MN090 (2013)	22.3	**0.6**	19.1	**0**	**51.0**	**3.8**	**19.1**	**50.3**	**3.2**
09MN090 (2013)	**0**	**0**	**0**	**0**	88.4	**0**	**0**	88.4	**0**
09MN090 (2015)	**9.5**	**0**	**4.1**	**0**	**9.5**	**1.2**	**8.3**	**5.3**	**4.1**
15MN208 (2015)	**3.4**	**0**	**2.7**	**0**	**4.8**	**0.7**	**2.7**	**4.8**	**2.1**
Southern Coldwater Average	*28.3*	*1.0*	*15.1*	*26.3*	*53.9*	*4.7*	*34.2*	*71.7*	*15.3*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 366. Fish metrics that respond to high TSS stress in Seven Mile Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

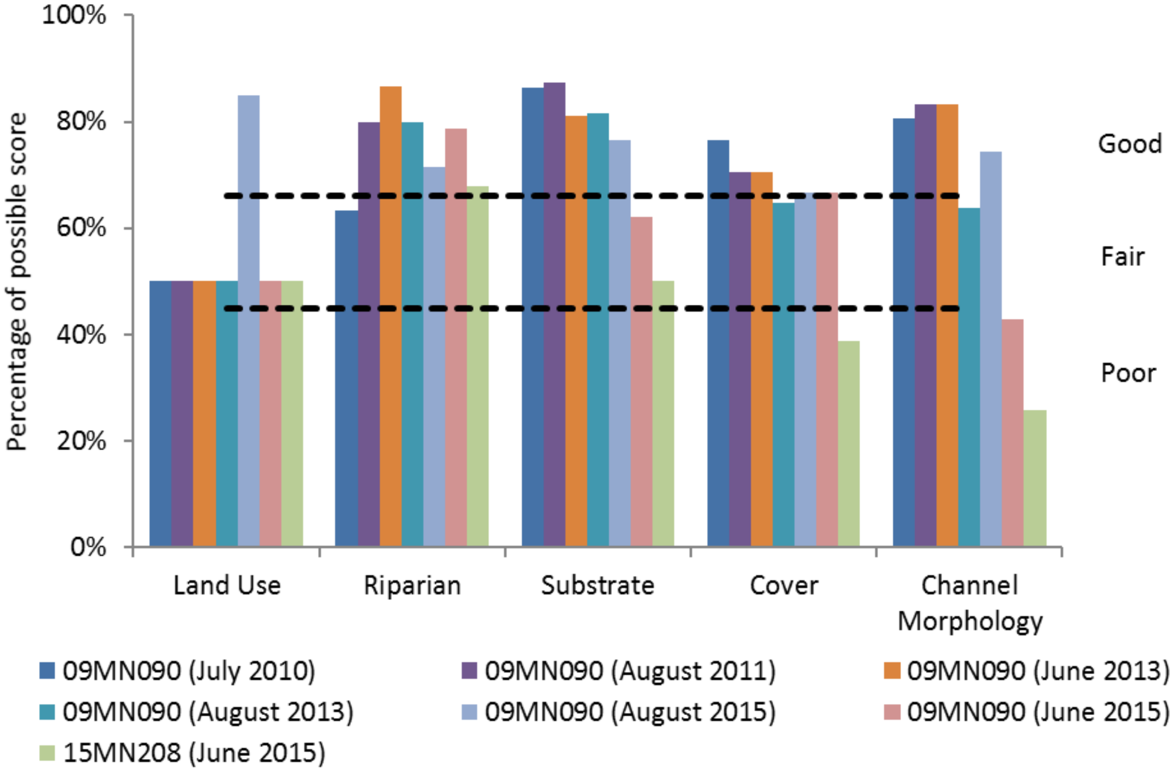
Station (Year sampled)	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct	Number of TSS Samples in Year	Average concentration of TSS in year (mg/L)
09MN090 (2010)	**17.9**	**0**	**0**	**2**	**21.7**	*12*	*82*
09MN090 (2011)	**14.8**	**0**	**0**	**1**	**6.1**	*13*	*67*
09MN090 (2013)	**11.8**	**0**	**0**	0	0	*32*	*22*
09MN090 (2013)	10.2	**0**	**0**	0	0	*32*	*22*
09MN090 (2015)	**14.8**	**0**	**0**	**1**	**1.2**	*26*	*312*
15MN208 (2015)	**19.2**	**0**	**0**	**1**	**17.8**	*26*	*312*
Southern Coldwater Average	*10.5*	*1.4*	*33.6*	*0.1*	*0.3*		
Expected response to stress	↑	↓	↓	↑	↑		

TSS is considered a biological stressor to both the macroinvertebrate and fish community. Historically, this reach was listed as impaired for turbidity. The chemical data set from this monitoring period did show TSS is still a chronic problem that correlates to the poor TSS metric response within the biological communities.

Habitat

As reflected in Figure 355, MSHA Scores in all the years assessed were found to be fair to good; with total scores being 77.3 for the 2010 assessment, 80.1 for August 2011, 79.4 in June of 2013, 70.5 in August of 2013, 57.9 June of 2015, and 73.65 in August of 2015 for 09MN090. The MSHA at site 15MN208 on June 29, 2015 scored the lowest at 42. The below graph shows a breakdown of the primary categories assessed.

Figure 355. Percentage of MSHA subcategory scores for station 09MN090, Seven Mile Creek



At station, 09MN090 channel stability is consistently rated as stable. The sinuosity and channel development also rates well. While the majority of the river ben substrate consists of a variety of sand, gravel, cobble, and boulders. There is some evidence of embeddedness and sedimentation. Pools were not abundant within this reach, and what was present lacked in width. The section of this reach has a steep gradient at 12.1

Station 15MN208 (Figure 356) is further downstream where the gradient drops significantly to 5.7. As this gradient is, less than half the slope of the upstream station there is a significant difference in the available habitat. The channel's stability is more vulnerable with poor sinuosity and poor channel development. Run is the dominant channel type at 95% and pools making up the other 5%. The Substrate types within this section are limited to silt, sand, gravel and there is moderate embeddedness and sedimentation. Cover amount within this reach is limited as well.

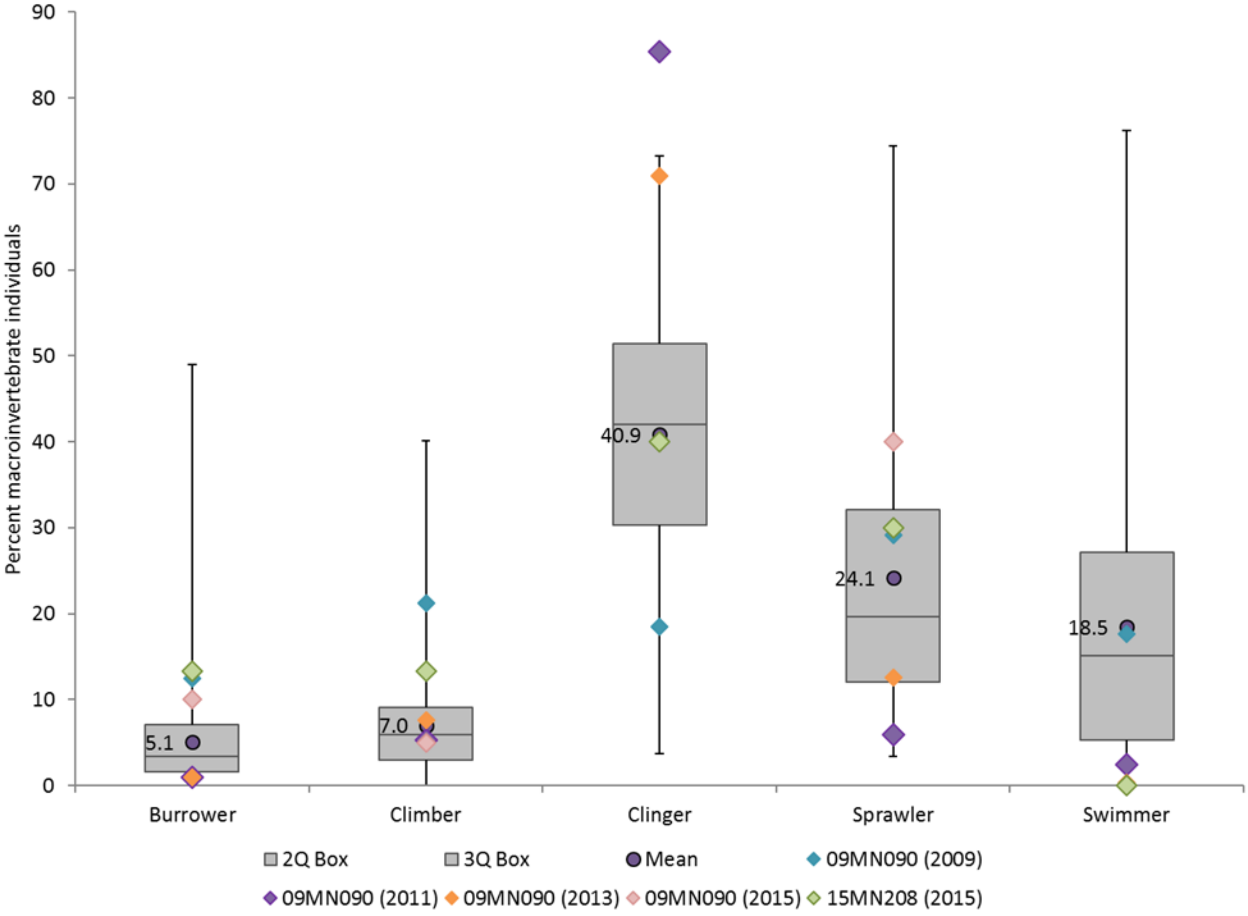
Figure 356. Station 15MN508 taken on June 29, 2015.

There is some variation between the two monitoring locations seen in the macroinvertebrate community habitat types (Figure 357), 09MN090 is located in a portion of the stream where the gradient is steeper and experiences flashier changes.

In 2011, the clinger population was driven up from the dominance of Baetis (mayflies) in the sample. The number of Baetis was nearly three times higher in 2011, compared to any other samples. The other year at this location that displayed community imbalance in habitat type was seen in 2009. In 2009, the population had a high percentage of tolerant macroinvertebrates such as Dicrotendipes (non-biting midges) that drove up the burrower group; and Physa (snails) that drove up the climber group. These larger than usual distributions skewed the other percentages in the two years.

The downstream location of 15MN208 is located downstream were the stream gradient decreases. The dominant invert habitat was overhanging bank vegetation, sampled on a riffle section of the stream. Here, particulate washout from upland portions of the stream has a chance to settle. It is this location were sedimentation will occur, at times creating embeddedness. The sample taken in 2015 at this location is reflective of these conditions, with the high number of “burrowers” that need fine riverbed sediment to thrive.

Figure 357. Macroinvertebrate habit metrics with box plot showing range of values from Southern Coldwater stations meeting the general use biocriteria mean of those stations, and metric values from station 09MN090.



TSS metrics are often reflective of habitat stress, as TSS metrics are indicative sedimentation degradation that occurs from high amounts of suspended solids through a system. Referencing the TSS metrics (Table 365) above, The fish community did indicate stress from TSS/habitat loss, primarily noted in the lack of species that are dependent on clean riverbed substrate in coldwater systems such as benthic feeders (BenFdFrimPct), Riffle dwelling species (RifflePct), and herbivore species (HrbNWQPct), and simple lithophilic spawning species (SLithFrimPct). The downstream site of 15MN208 displayed the poorest scores for TSS/habitat, once again correlating habitat degradation to sedimentation, as this is where it is found to be occurring the most.

The DNR undergone a comprehensive geomorphologic study for this reach, developing the 2016 Minnesota River, Mankato Watched Characterization report. Within this study, the sedimentation dynamics were found to correlate to what is being seen within the biological communities. The image below (Figure 358) displays sediment deposition at the lower location of Seven Mile Stream (15MN208).

Figure 358. Lower reach of Seven Mile Creek, displaying pre deposition conditions after construction of trout habitat, and stream aggregation following 2014 to the left. Phot taken by Lore, of the DNR (2016).

Habitat is considered a biological stressor to both the macroinvertebrate and fish communities, largely tied to sedimentation issues. Habitat improvement projects are ongoing. Within the Hutchinson fisheries area, Seven Mile Creek is currently, the most actively managed stream in terms of assessment and project work.

Longitudinal Connectivity and Altered Hydrology

Dam Upstream, Perched Culvert at HWY 99 crossing. As mentioned above, the DNR conducted a comprehensive geomorphology study in several locations along this section of Seven Mile Creek. There were identified gaining and losing areas from the groundwater relationship within the stream. Figure 359 and Figure 360 below display loss of flow. In total there was found to be a 3,800' section of losing reach (DNR 2016). Sections of stream where flow is vulnerable to dry conditions will have direct impacts on fish migration ability. Paired with variable flow conditions, the other factor that can have impacts to connectivity, seen at the lower end of the reach in extensive sedimentation.

Figure 359. August 29, 2011 station 09MN090 showing low flow within reach.

Figure 360. 09MN090 taken August 13, 2013 displays low flow.

The majority of the headwaters to this stream are altered by way of ditching and channelizing, as well as introduction of subsurface tile drainage. These modifications create alterations to the streams hydrology, creating changes to the geomorphology, as well as increases in pollutant loading. Altered hydrology is a foundational issue, and a contributor to all the impaired biological communities in the Minnesota River Mankato Watershed. For additional information on how these changes are occurring, refer to Chapter 3.1.8 of this report.

Impacts of altered hydrology were also found in the DNR's report. Upland altered hydrology primarily is influencing this section of stream by accelerating erosion rates. The largest geomorphic change is noted in entrenchment within sections of this stream, were the lateral floodplain connection is lost.

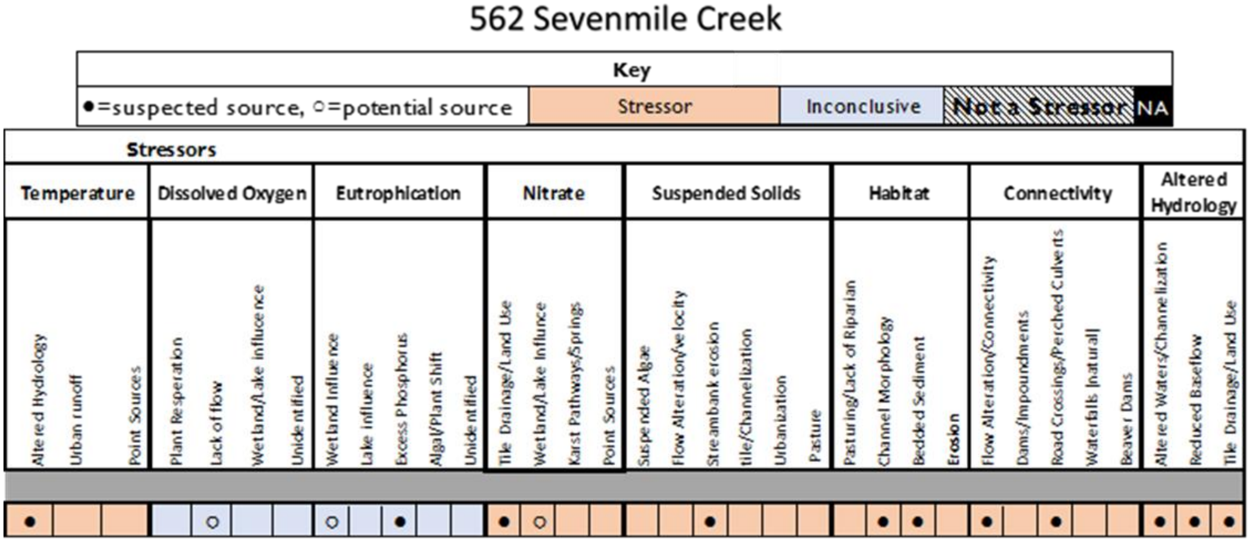
In all sections assessed, the 2014 flood event yielded the most dramatic changes to the streams profile and dimension. Downstream of the cross sectional areas assessed, the stream gradient decreases as the stream joins the Minnesota River. This portion of the stream is vulnerable to aggregation. The images seen in **Error! Reference source not found.**displays nearly three feet of sediment deposition. This was found to deplete trout habitat throughout this segment of Seven Mile Creek (Lore 2016). The photos below to the right displays constructed Trout habitat along this reach. To the left is the same portion of stream aggregated after 2014.

Figure 361. Lower reach of Seven Mile Creek, displaying pre deposition conditions after construction of trout habitat, and stream aggregation following 2014 to the left. Photo taken by Lore, of the DNR (2016).

As already noted Seven Mile Creek has a turbidity impairment due to high amounts of TSS that is directly and indirectly (such as TSS contributing to the loss in habitat) displacing the biology. TSS overloading is largely being driven by altered hydrology.

Summary Table

Table 367. Identified stressors with suspected sources for reach 562 of Seven Mile Creek.



562 Sevenmile Creek

Key

●=suspected source, ○=potential source | Stressor | Inconclusive | Not a Stressor | NA

Stressors

Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls (natural)	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
●				○			○		●			●	○					●					●	●		●		●			●	●	●

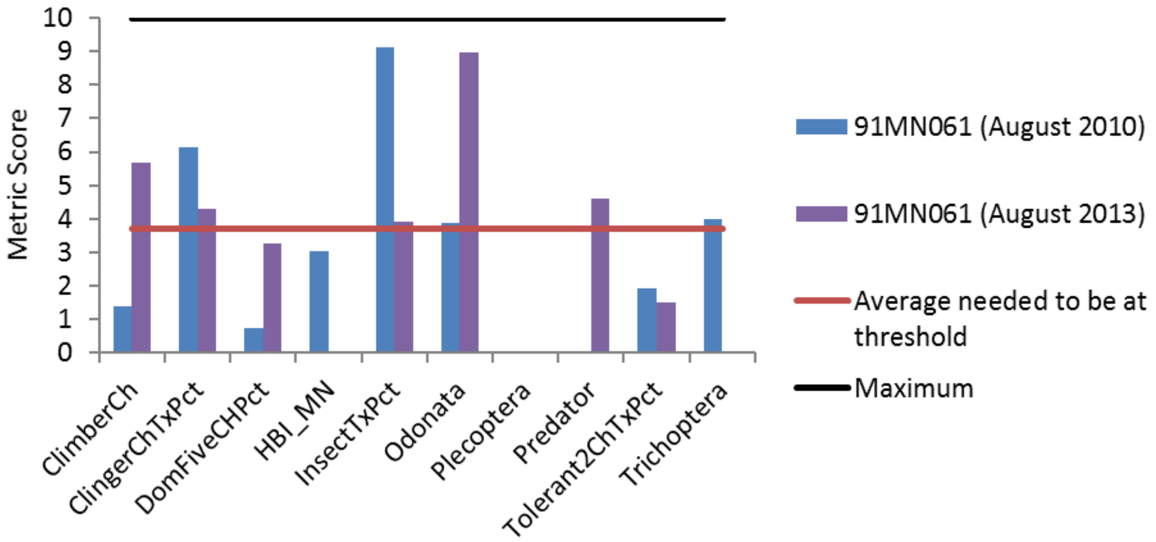
4.40 Rogers Creek (07020007-547)

Rogers Creek (07020007-547) is north of St. Peter, Minnesota. The reach is warmwater general use Class 2B. The reach extends from an unnamed creek to the Minnesota River. Rogers Creek is impaired for lack of macroinvertebrate assemblage and lack of fish assemblage. There are two biological stations on this reach. One is upstream of a natural barrier, station 91MN061, and the other is downstream, station 13MN094. The upstream station was later deemed not assessable for fish due to the station location upstream of a barrier falls and naturally limiting the fish community.

4.40.1 Biological Communities

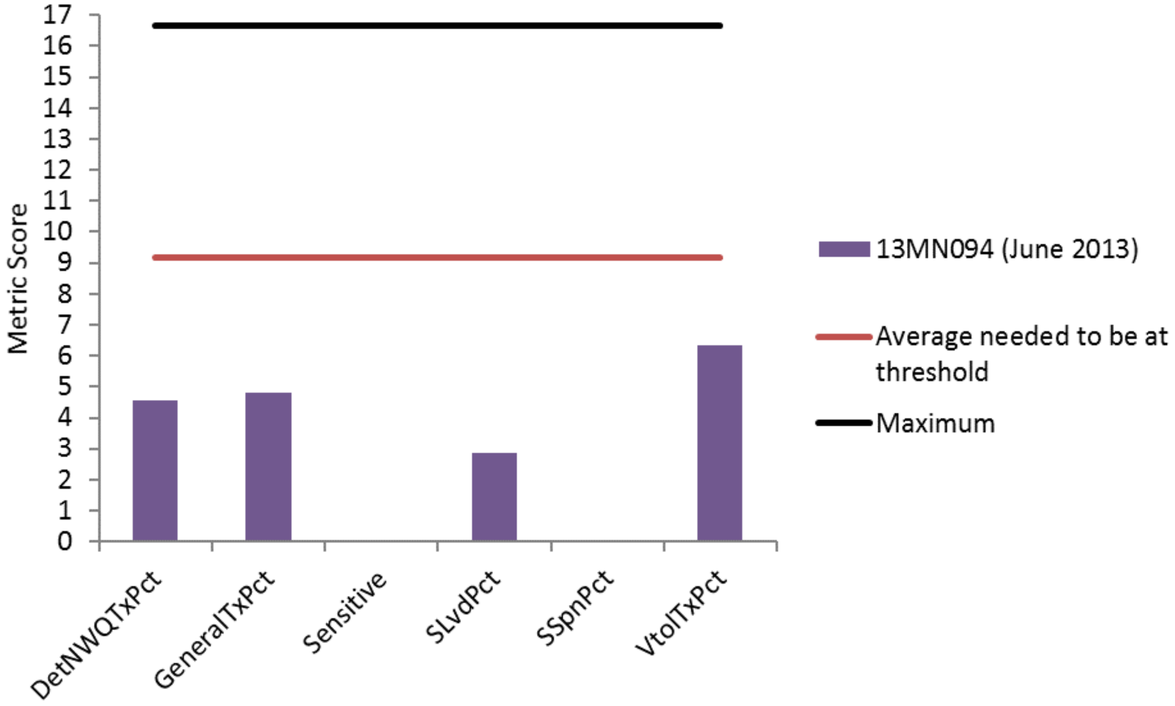
In 2010, station 91MN061 scored 28.5, which is below the Southern Streams RR macroinvertebrate class threshold (37). In 2013, the station scored slightly better (32.2), but still below the threshold. In 2010, the sample was dominated by mayflies (Baetis) and black flies (Simulium). In 2013, the sample was overwhelmingly dominated by snails (Physa). Both visits had some similar low IBI metric scores (Figure 362). In particular, there was a high percent of the dominant five taxa (DomFiveCHPct), an elevated measure of pollution based on tolerance values assigned to each individual taxon developed by Chirhart (HBI_MN), a lack of stonefly taxa (Plecoptera), and an elevated percentage of tolerant taxa (Tolerant2ChTxPct). There was not a macroinvertebrate visit to station 13MN094.

Figure 362. Macroinvertebrate metrics of the Southern Streams RR class IBI for station 91MN061, Rogers Creek.



In 2013, fish were sampled at station 13MN094 and 91MN061. Station 13MN094 FIBI score (8.6) was below the Southern Headwaters class threshold (55). Station 13MN094 had a 12-point DELT deduction from the FIBI. DELTs were all identified as lesions. This reach yielded one of the highest DELT deduction scores in the entire Minnesota River – Mankato Watershed and the highest for lesions. All of the FIBI metrics were below the average metric score needed to obtain a FIBI score at the threshold (Figure 363). At station 13MN094, the community was dominated by fathead minnows. Station 91MN061 was not assessable due to the barrier falls, and had a naturally limited fish community.

Figure 363. Fish metrics of the Southern Headwaters class IBI for station 13MN094, Rogers Creek.



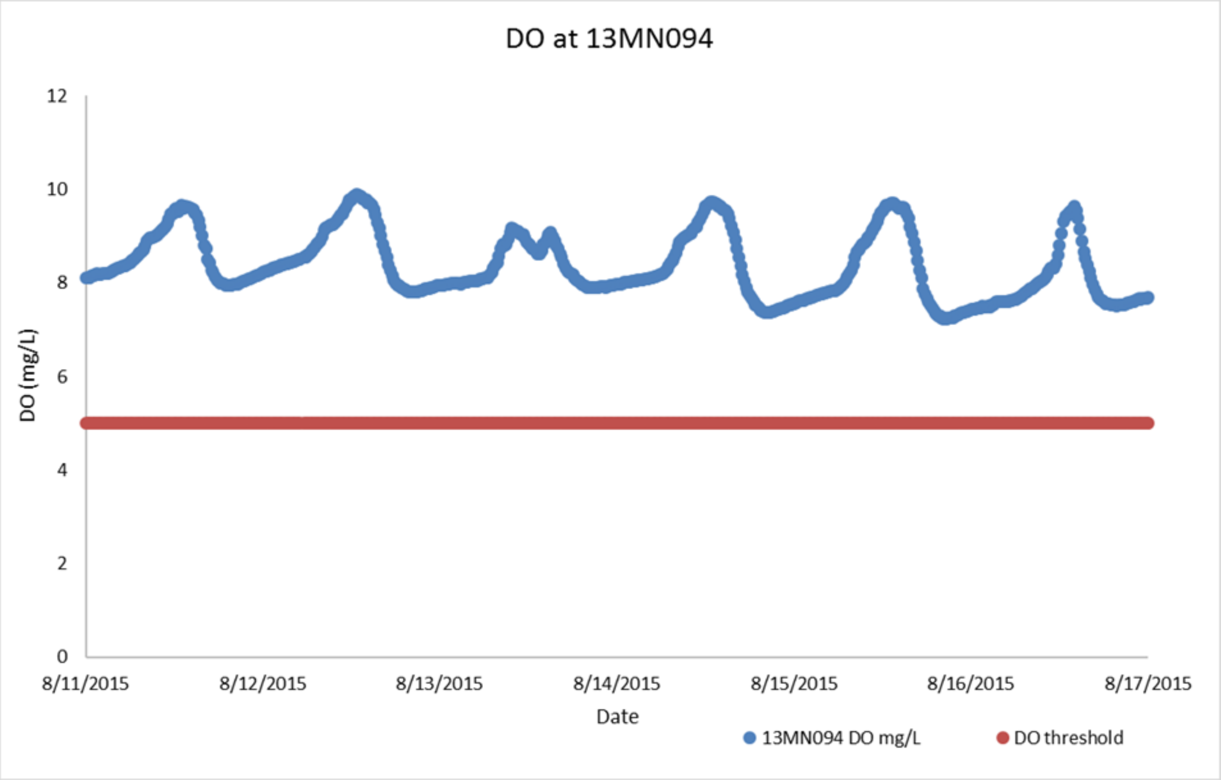
4.40.2 Data Evaluation for each Candidate Cause

Dissolved Oxygen

At the time of biological monitoring at 91MN061 dissolved oxygen (DO) was recorded at 9.45 mg/L on July 26, 2001; 8.29 mg/L (early morning reading) on July 21, 2010; and at 10.02 mg/L on June 11, 2013. During biological monitoring at 13MN094 DO was recorded at 9.27 mg/L on June 11, 2013. Twenty additional DO samples were taken in 2013 through 2015. The range was 6.48 mg/L – 9.73 mg/L, with an average concentration of 8.39 mg/L.

In 2015, an YSI sonde was deployed at station 13MN094 from August 10 – 17 (Figure 364). The DO ranged from 7.73 to 9.89 mg/L, with no violations of the DO standard of 5 mg/L. The DO fluxuation was low, with concentrations within a 24-hour period only varying at a range of 1.28 to 2.49 mg/L.

Figure 364. YSI continuous DO data at 13MN094.



The macroinvertebrate community exhibited variable response to possible low DO stress (Table 368). In 2010, the low DO index score was good with few low DO tolerant taxa, but also had few low DO intolerant taxa. In 2013, there were more low DO tolerant individuals in the sample. There was also a greater number of low DO intolerant taxa.

Table 368. Macroinvertebrate metrics that respond to low DO stress in Rogers Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	EPTCh	HBI_MN	Low DO Index Score	Low DO Intolerant Taxa	Low DO Tolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct
91MN061 (2010)	**39**	**12**	**7.31**	7.57	**4**	**22.4**	4	1.9
91MN061 (2013)	**45**	**7**	**8.77**	**6.08**	**6**	**3.3**	**8**	**12.2**
Southern Streams Average	*45.8*	*14.2*	*7.08*	*7.04*	*9.0*	*24.0*	*4.8*	*9.9*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

The fish metrics were suggestive of DO stress (Table 369). The fish community was largely made up of tolerant (to low DO) species, making up nearly 82% of the population sampled. Species that are tolerant to low DO are generally tolerant of multiple parameters. In systems were there are multiple stresses identified, it is not clear how prominent low DO is acting as the driving stressor. There was not any general sensitive species found at the time of biological monitoring, nor was there any species that were found to be over the age of three, showing a disconnect with the communities lifecycle needs. The DO index score of 6.4 fell just under the threshold of 7.2, the average for southern streams that support the fish community.

Table 369. Fish metrics that respond to low DO stress in Rogers Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	MA>3Pct	TolPct	DO Index Score	DO Sensitive Taxa	DO Sensitive Pct	DO Tolerant Taxa	DO Tolerant Pct
13MN094 (2013)	**0**	**0**	**98.0**	**6.4**	**0**	**0**	**4**	**81.8**
Southern Streams Average	*16.9*	*24.6*	*44.9*	*7.20*	*1.71*	*5.94*	*4.69*	*18.54*
Expected response to stress	↓	↓	↑	↓	↓	↓	↑	↑

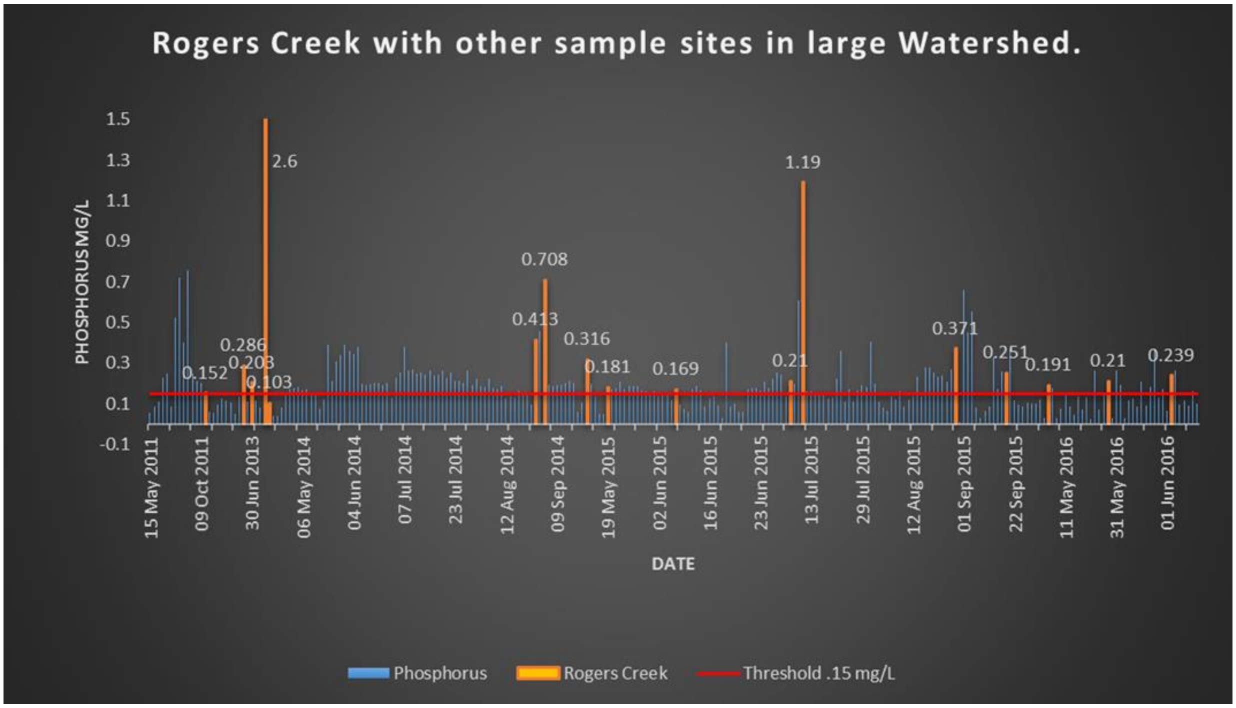
Chemistry analysis is not suggestive of this reach being degraded from low DO. However, they metrics for the macroinvertebrate and fish are suggestive, but it is likely due to another stressor. Without additional information, low DO is inconclusive as it cannot fully be ruled out.

Eutrophication

Samples for total phosphorus (TP) was collected during three of the biological sampling events, with concentrations for TP ranging from 0.063 mg/L to 0.194 mg/L. Seventeen additional samples were taken throughout 2013 through 2016, with a range of 0.103 mg/L – 2.6 mg/L. The average concentration was high at 0.460 mg/L. 16 out of 17 (94%) of the samples taken fell above the standard of 0.15 mg/L, indicating a chronic exceedance of phosphorus. The TP values are high consistently, during both turbid and non-turbid events. All seasons throughout the monitoring period displayed exceedances of the standard (.15 mg/L). We often see high TSS during events, with correlated high phosphorus but this stream retains high TP concentrations throughout all seasons. Usually in these ditch systems, there will be drops in phosphorus around July and August. Instead, in Rodgers Creek, phosphorus stays elevated.

A comparison was done to evaluate TP concentrations within Rogers's Creek, with all monitoring locations within the Minnesota River- Mankato Watershed, that have been collected from 2011 to 2016 (Figure 365). Highlighted in orange are the samples that were collected for Rogers Creek. Often, Rogers Creek's TP concentrations were significantly higher compared to other sites throughout the watershed. The consistently high concentrations of TP is an indicator of strong eutrophic potential and anthropogenic pollution.

Figure 365. Total phosphorus within Rogers Creek compaired to the rest of the Minnesota River – Mankato Watershed.



Secondary chemistry responses for eutrophication were not found within Rogers Creek. However, these samples were limited. Chlorophyll a was collected twice during this monitoring period, both times being lower than the standard of 35 µg/L. One September 2, 2015 chl-a was at 4.76 µg/L and on August 17, 2015 was 13.9 µg/L. As stated in the dissolved oxygen section, the DO flux at this site was low, with concentrations within a 24-hour period only varying at a range of 1.28 to 2.49 mg/L.

The macroinvertebrate community responded in a way that may suggest eutrophication stress (Table 370). The metrics indicated worse values than that of the average of similar stations meeting the biocriteria, but at the same time, they are not wildly different. Due to the close proximity, it is not clear if eutrophication is a driving stressor, as there may be another stressor causing the response.

Table 370. Macroinvertebrate metrics that respond to eutrophication stress in Rogers Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	TaxaCountAllChir	Collector-filtererCh	Collector-gathererCh	EPT	Intolerant2Ch	Tolerant2ChTxPct
91MN061 (2010)	**39**	10	**13**	**12**	**0**	**84.6**
91MN061 (2013)	**45**	**5**	**12**	**6**	**0**	**86.7**
Southern Streams Average	*45.8*	*7.3*	*15.9*	*12.2*	*0.8*	*72.6*
Expected response to stress	↓	↓	↓	↓	↓	↑

The fish community at station 13MN094 had metric values that differed from the average of similar stations meeting the biocriteria (Table 371). There was a lack of sensitive, darter, and intolerant fish. There was a very high percentage of tolerant fish. However, with very few fish sampled, the metrics are skewed.

Table 371. Fish metrics that respond to eutrophication stress in Rogers Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	SensitivePct	DarterPct	SLithopPct	TolPct	TaxaCount	IntolerantPct
13MN094 (2013)	**0**	**0.5**	**0**	**98.0**	**11**	**0**
Southern Headwaters Average	*7.9*	*11.5*	*31.5*	*72.8*	*11.5*	*1.6*
Expected response to stress	↓	↓	↓	↑	↓	↓

As displayed in Figure 366 and 367 below, there is abundant algae growth noted in the stream. Benthic filamentous algae was noted at both site visits. Due to the gradient and increased stream velocity of this portion of the stream system, natural aeration that is occurring via the surface turbulence is likely mitigating any low DO response the over – production of algae would create during times of respiration.

Figure 366. Station 91MN061, July 21, 2010 with filamentous algae.

Figure 367. Station 91MN061, July 12, 2012 filamentous algae.

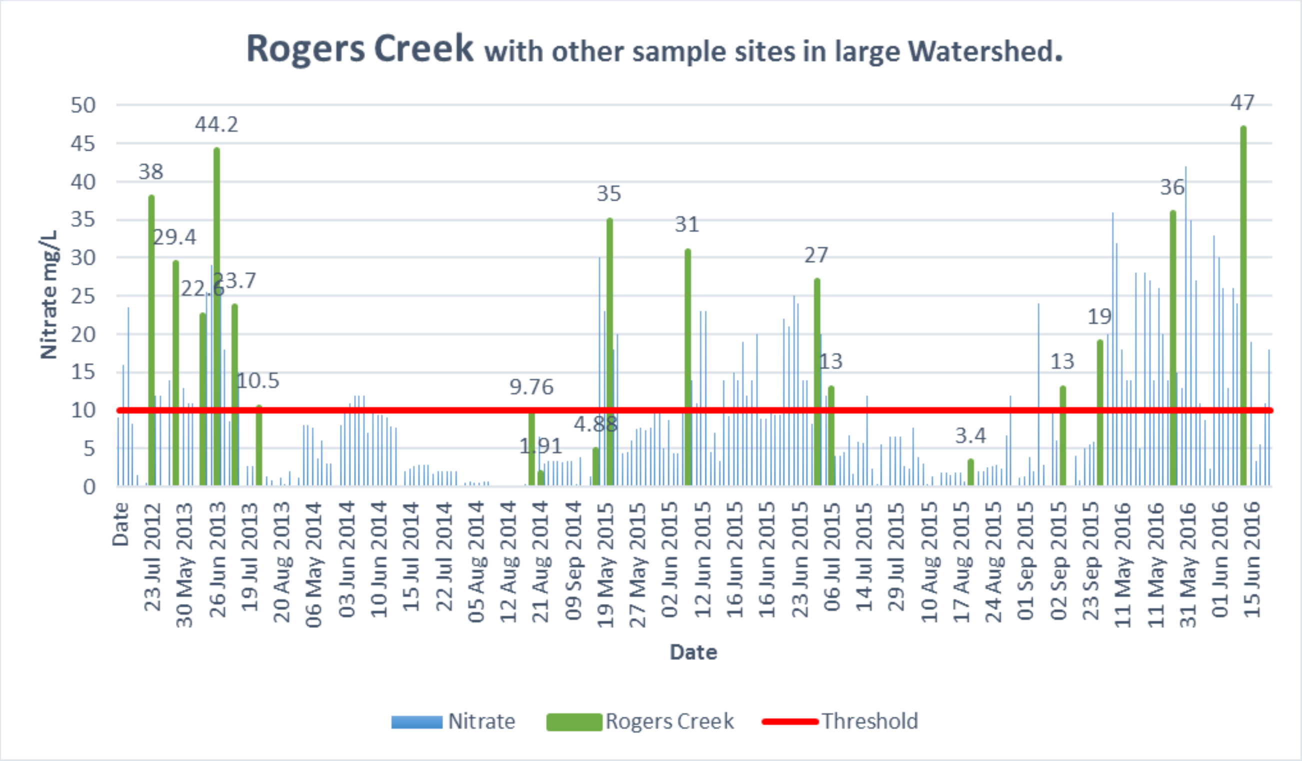
Phosphorus is high, yet the continuous DO samples did not show significant 24-hour fluctuation in concentrations that would reflect autotrophic photosynthesis and respiration. Filamentous algae growth was observed in the stream, and suspended algae was not captured in the two chl-a samples (indicating there is not an issue with suspended algae). This reach is inconclusive for eutrophication due to mixed responses within the chemistry data, metrics, as well as observations. What is clear is Rogers Creek has high potential for overgrowth, due to the high concentrations of available phosphorus, as well as observed overgrowth (noted with the presents of benthic algae).

Nitrate

Samples for nitrogen were collected during two of the biological sampling events, with concentrations ranging from 11 mg/L (July 21, 2010) and 24 mg/L (June 11, 2013). There were an additional 19 samples of N collected throughout 2013 – 2015, with concentrations ranging from 1.91 mg/L to 47 mg/L. The average was 22.7, with 14 out of the 18 samples (78%) exceeding 10 mg/L.

Nitrate in Rogers Creek is much higher than what has been seen in other systems within the Minnesota River – Mankato Watershed (Figure 368). However, the higher values found do correlate to the pattern of what we see in an agricultural tile drained systems as the higher concentrations are found in spring months and level off in July and August. It is likely that tile drainage is playing a part to the high concentrations. What is not clear is why concentrations are significantly higher in this subwatershed compared to others that have large upland agricultural drainage systems. The highest value recorded for this stream during the monitoring period is 47 mg/L. Out of the 20 samples taken at the 10X station, there are multiple (5) samples with concentrations over 30 mg/L, which is highly unusual. For perspective, there are over 50,000 sample values for nitrate concentrations statewide in the MPSA data system, less than 1% of those values are greater than 30 mg/L. There were only two samples in the entire database with values higher than 47 mg/L, both of those were recorded at the same location within the Des Moines Watershed.

Figure 368. Nitrates within Rogers Creek compaired to the rest of the Minnesota River – Mankato Watershed.



Fish communities often do not show strong response to increased nitrate concentrations, therefore, there is not a metric table to measure the fish community's response to nitrate in this report. However, there is a possibility that the fish community sampled at 13MN094 did display some signals of stress. As mentioned before, there were 12 fish noted to have lesions. Lesions in DELT definitions encompass multiple fish defects, ranging from external flesh injuries to internal hemorrhaging signs. It is unclear what prompted the DELT scores. There is the potential that in this case, the fish noted as having lesions were of the hemorrhagic variety. Internal hemorrhagic lesions occur primarily from two things; illness and pollutant concentrations (particularly nitrate and ammonia); this scenario would correlate with the high nitrate concentrations detected in this stream.

Macroinvertebrate communities are often more affected by nitrate. The macroinvertebrates in this reach show a strong indication they are stressed by the elevated nitrate concentrations (Table 372). The nitrate index score was 3.6 in 2010 and 4.1, while the average for Southern Streams meeting impairment threshold is 2.9. The higher the nitrate index score the more suggestive the nitrate impairment is for the macroinvertebrate community. The nitrate specific metrics show a lower than average Trichoptrera taxa individuals. The increased nitrate concentrations also correlate with a decrease in non-hydropsychid Trichoptera individual percentages in warmwater streams (sensitive caddisflies that do not spin nets; TrichwoHydroPct). Intolerant taxa and non-hydropsychid individuals are depleted, and in place the dominate community is largely made up of nitrate tolerant species.

Table 372. Macroinvertebrate metrics that respond to nitrate stress in Rogers Creek compared to the statewide average of visits meeting the warmwater general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TrichopteraCh	TrichwoHydroPct	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Nitrate Tolerant Pct
91MN061 (2010)	**6**	**1.3**	**3.6**	**1**	**26**	**61.4**
91MN061 (2013)	**2**	**0.3**	**4.1**	**0**	**27**	**78.3**
Southern Streams Average	*6.3*	*5.5*	*2.9*	*2.4*	*18.8*	*47.2*
Expected response to stress	↓	↓	↑	↓	↑	↑

Nitrate is considered a biological stressor. Nitrate overloading is clearly occuring based on the chemistry data set. There is also a strong negative response noted in the macroinvertebrate metrics. It is not clear if there is a direct correlation in the fish community, but it is possible. Rogers Creek had the highest score for lesions on the sampled fish recorded out of the entire Minnesota River – Mankato Watershed.

Total Suspended Solids

Three samples for total suspended solids (TSS) were collected at the time of biological monitoring, with concentrations for TSS ranging from 2.4 mg/L to 8 mg/L. Additional TSS data was available from S007-570, which is at the same road crossing as the biological station. Twenty samples were collected from 2013-2016. The average concentration was 128 mg/L, with a maximum of 1500 mg/L and minimum of 3 mg/L. 30% (6) of the samples violated the 65 mg/L TSS standard for warmwater streams. Those exceedances occurred in 2013, 2015 and 2016 each corresponding to storm events.

The macroinvertebrate metrics did display a community response to TSS (Table 373). The TSS index score was 16.57 in 2010 and at 15.84 in 2013, this is slightly above the threshold of 15.63, the average for southern streams that are found to be supporting for the macroinvertebrate community. Macroinvertebrates that depend on habitat conditions for filter feeding often will decline in streams with excess turbidity. In 2010, the filer feeders were in abundance and dominated the community making up 52%, in 2013 the filter feeders significantly dropped to 9.5% of the community make up. Southern streams that support a healthy macroinvertebrate community had an average of about 25% of the community being made up of filters. *Plecoptera* (stoneflys) are especially sensitive to suspended solids affecting their habitat needs. In both sampling years there were not any found. Overall, TSS tolerant species were in higher abundance than what would be seen in a supporting stream, while TSS intolerant species were missing.

Table 373. Macroinvertebrate metrics that respond to high TSS stress in Rogers Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	Collector-filtererPct	PlecopteraPct	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
91MN061 (2010)	52.2	**0**	**16.57**	**0**	**0**	**14**	**40.5**
91MN061 (2013)	**9.5**	**0**	**15.84**	**1**	**0.3**	10	**51.0**
Southern Streams Average	*25.4*	*0.7*	*15.63*	*2.9*	*4.7*	*12.2*	*34.5*
Expected response to stress	↓	↓	↑	↓	↓	↑	↑

The fish community was suggestive of TSS stress (Table 374). Species that depend on clean riverbed substrate for spawning, such as central stonerollers, were completely absent. The nonexistence of long-lived species also indicates a disconnect in the lifecycle ability. Benthic feeders, herbivorous fish, and riffle dwelling species fell far below the expected average. Table 375 below show that TSS sensitive fish species are completely lacking in this system. TSS tolerant fish species did make up the community, but not much more than what is found in a supporting stream.

Table 374. Fish metrics that respond to high TSS stress in Rogers Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

Station (Year sampled)	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LlvdPct	Percfm-TolPct	RifflePct	Sensitive Pct	SLithFrimPct
13MN094 (2013)	**2.0**	**0**	**1.5**	**0**	**0**	**0.5**	**1.5**	**0**	**0**
Southern Headwaters Average	*35.0*	*1.0*	*22.4*	*1.6*	*4.5*	*13.6*	*26.2*	*7.9*	*31.5*
Expected response to stress	↓	↓	↓	↓	↓	↓	↓	↓	↓

Table 375. Fish metrics that respond to high TSS stress in Rogers Creek compared to the statewide average of visits meeting the general use biocriteria. Bold indicates metric value indicative of stress.

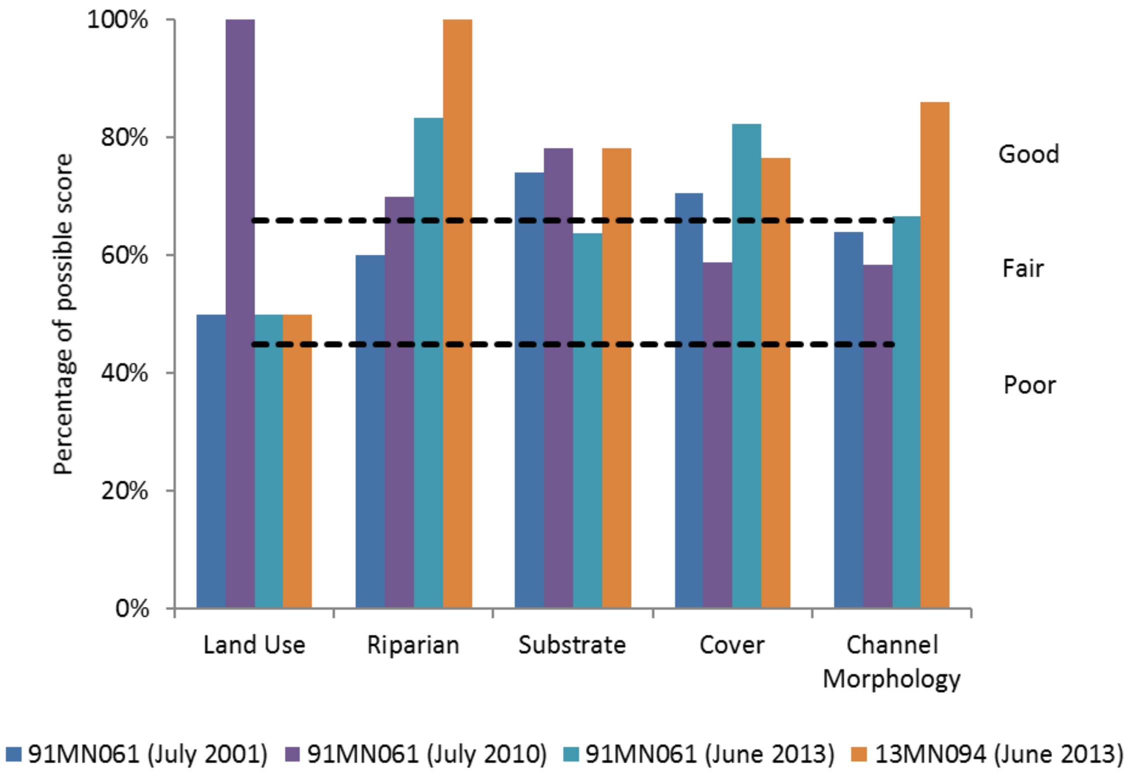
Station (Year sampled)	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct
13MN094 (2013)	**23.4**	**0**	**0**	**2**	**2.5**
Southern Headwaters Average	*15.4*	*0.9*	*4.1*	*0.4*	*2.0*
Expected response to stress	↑	↓	↓	↑	↑

TSS a stressor. While TSS is not found to be one of the primary stressors within this reach, there is some indication of community displacement from the TSS intolerant by the TSS tolerant fish species. Chemistry samples showed that this stream system contributed to high amounts of TSS, especially after rain events.

Habitat

The habitat at station 91MN061 has ranged from fair to good (52 - 70.2) on the MSHA (Figure 369). Station 13MN094 scored a good (82.6) on the MSHA in 2013. In 2010, station 91MN061 had heavy to severe bank erosion despite a wide to extensive riparian width and substantial shade. However, in 2010, bank erosion was noted as little (5-25%) with light to moderate shade. In 2013, one bank was noted as having heavy bank erosion (50-75%) with heavy shade. Moderate embeddedness was also noted in 2013.

Figure 369. Percentage of MSHA subcategory scores for stations 91MN061 and 13MN094, Rogers Creek.



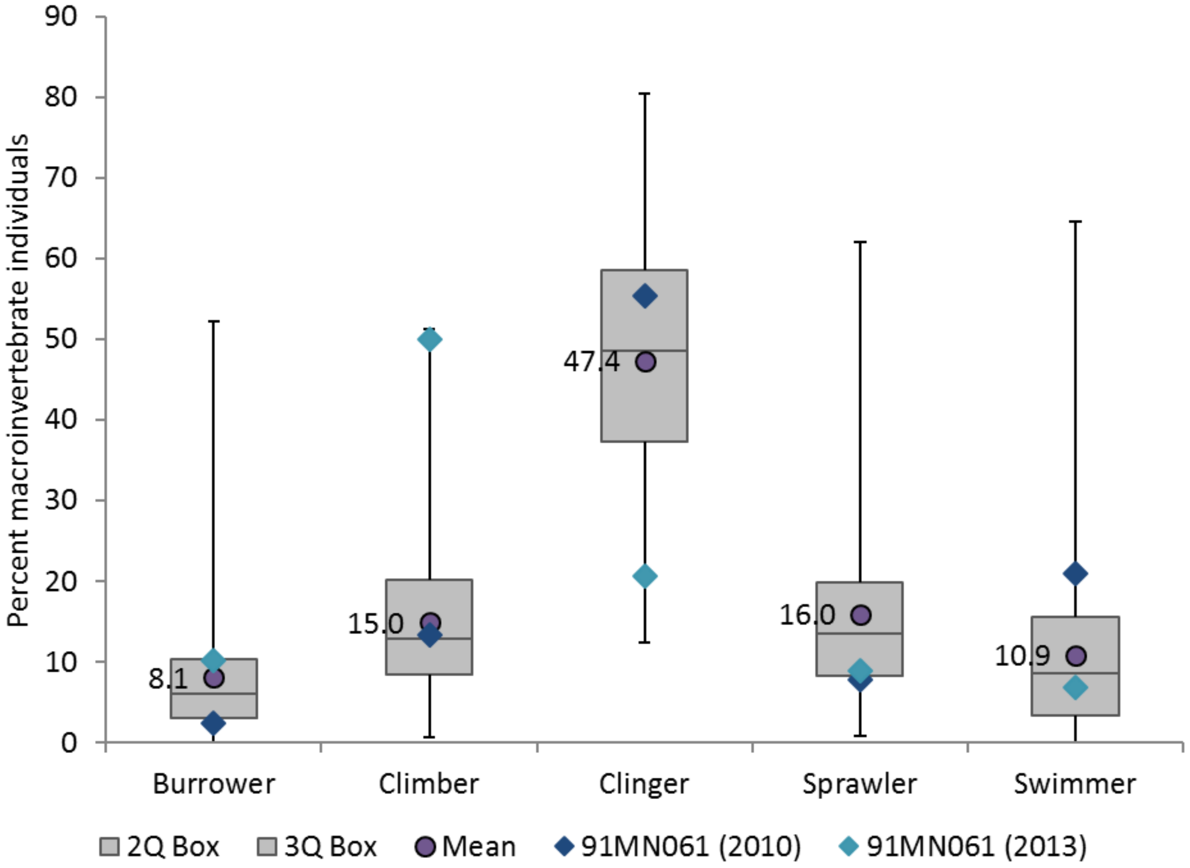
The differences noted on the MSHA between the two monitoring locations can be seen inFigure 370, which displays the upstream monitoring location (91MN061), were bank erosion is prevalent. Figure 371, captures the habitat diversity found in the downstream station 13MN094, with slightly better habitat features than the upstream location.

Figure 370. Upstream monitoring station 91MN061, taken on May 26, 2016.

Figure 371. Monitoring station 13MN094, taken in June 11, 2013.

The macroinvertebrate sample displayed two different habitat group compositions between the two sampling years at station 91MN061 (Figure 372). In 2010, the habitat group had significantly more swimmers, lacking in sprawlers, climbers, and burrowers compared to average composition of this stream type. In 2013, there was a slight elevation of burrowers that raises concerns of substrate health.

Figure 372. Macroinvertebrate habit metrics with box plot showing range of values from Southern Streams stations meeting the general use biocriteria mean of those stations, and metric values from station 91MN061.



Habitat is inconclusive. TSS stress often related to habitat degradation, particularly from sedimentation as particulates settle out and settle in pools and riffles, and smother the riverbed. As stated within the above TSS section, fish and macroinvertebrate species that depend on clean riverbed substrate were completely absent. The nonexistence of long-lived species also indicates a disconnect in the lifecycle ability. While other habitat features are strong within this reach, it is noted that at times, there are erosion and slight embeddedness noted. In a steep gradient stream it is unknown at this time how much of the streambed habitat is degraded or how often. There is a slight imbalance of macroinvertebrates, showing more burrowers and less clingers than would be expected.

Longitudinal Connectivity and Altered Hydrology

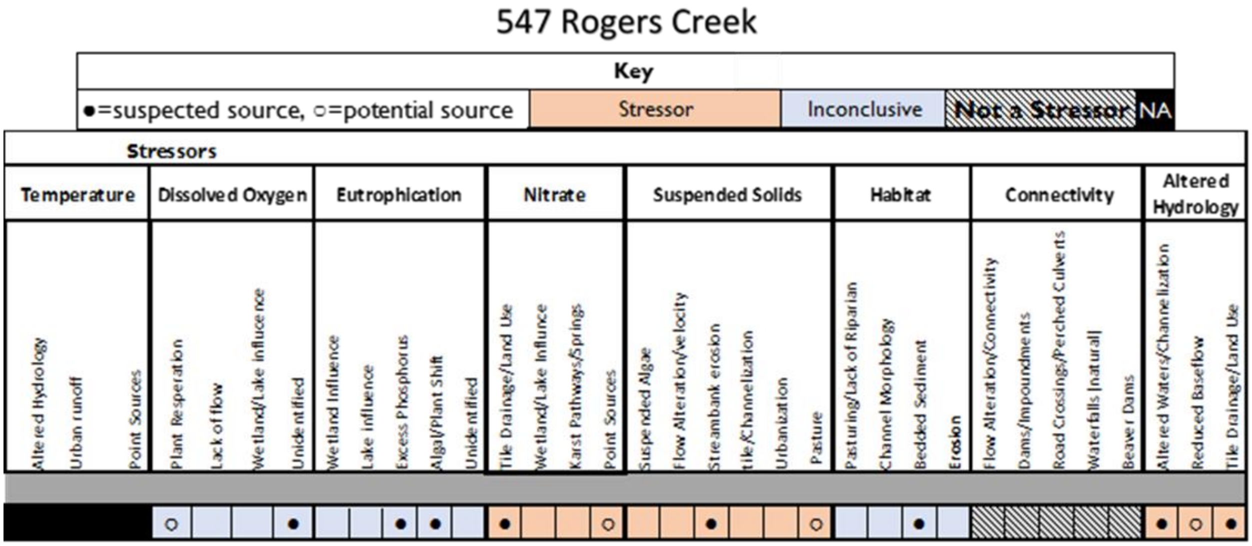
Rogers Creek has a natural waterfall approximately 1.1 miles upstream of the confluence with the Minnesota River (DNR, 2015). The waterfall is approximately 6 feet and a barrier at all flows to fish passage. For more information on the barrier, please see DNR's Minnesota River, Mankato Watershed Characterization Report (2015).

The waterfall poses a natural fish barrier to the upstream station 91MN061, but not to station 13MN094. The upstream station is not assessable due to the barrier. The downstream station confirmed that there were other stressors present affecting the fish community. There are no known fish barriers affecting the fish community at station 13MN094, therefore it is not a stressor.

Altered Hydrology is playing a large role in contributing to the other impairments described within this report. Upland of the biological monitoring locations within Rogers Creek is altering the hydrologic regime by way of tile and channelization. Refer to Section 3.1.8 of this report on how this form of altered hydrology is influencing the overall stream.

Summary Table

Table 376. Identified stressors with suspected sources for reach 574 of Rogers Creek.



547 Rogers Creek

Key

●=suspected source, ○=potential source | Stressor | Inconclusive | Not a Stressor | NA

Stressors

Temperature			Dissolved Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Altered Hydrology		
Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influnce	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls [natural]	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
			○			●			●	●		●			○			●			○			●							●	○	●

City of Mankato (North) Subwatershed Conclusion

Five stream reaches were found to have biological impairments within the Mankato (north section) Subwatershed. The streams within this area vary on stream type and class. County Ditch 46A (-678) is the only warmwater modified use class stream. This reach extends from the headwater upland areas and feeds into Seven Mile Creek. CD 46A is impaired for lack of macroinvertebrate assemblage and lack of fish assemblage. Three other reaches were assessed as warm water general use; another section of County Ditch 46 (-679) extends from downstream of 411th Ave to Seven Mile Creek. Seven Mile Creek (-703) is the start of Seven Mile Creek and extends to CD 46A. This portion is only impaired for macroinvertebrates as fish could not be assessed due to low flows. Rogers Creek (-547) is the third warm water general use stream, located north of St. Peter and does not contribute to Seven Mile Creek's drainage system. Rogers Creek was found to be impaired for both macroinvertebrates and fish. There was one cold-water stream within this subwatershed, Seven Mile Creek (-562). The reach extends from downstream of the confluence with CD 46A to the Minnesota River. The reach is also impaired for chloropyrifos, fecal coliform, nitrates, and turbidity.

The primary biological stressor throughout the Mankato North Subwatershed is altered hydrology. This is occurring in two ways. The first is through subsurface tile drainage, and the second is by stream channel alteration via ditching and channelizing. Both of these alterations are for agricultural practices in effort to expedite water off the land making in more farmable. As these channels take on extra water from these practices, they change their dimension, pattern, and profile. Additional pollutants (nitrates, phosphorus, and pesticides) within this area are largely introduced from agricultural subsurface tile drainage. Many of the streams assessed in this area are on steep gradients as they are down cutting through the valley and converge with Minnesota River. Because of the steep gradient of the valley, these sections of stream are not channelized, as farming practices are restricted in the upland flat areas. However, all of these reaches are being influenced from the large upland drainage area that is heavily altered.

Eutrophication is listed as inconclusive at all sites, despite there being some of the largest phosphorus loads within the entire Minnesota River, Mankato Watershed found here. There were not additional signals of eutrophic conditions occurring within these reaches. This is largely attributed to the fast velocity of the streams as well as the strong canopy cover that blocks overproduction from sunlight that limits overgrowth. However, as phosphorus is a limiting nutrient it should be decreased so it is not picked up at downstream suitable sites that would promote overgrowth.

Low dissolved oxygen in southern Minnesota streams will typically be closely linked to Eutrophic conditions, due to plant respiration. As just discussed, overgrowth is not likely to occur within these conditions, therefore low DO is not likely, but could not be fully ruled out as eutrophication could not be fully ruled out. There was just one exception to these findings, this was at the upstream reach of CD 46A. As this area is heavily modified by way of ditching and lacks canopy cover, eutrophic conditions are likely to occur here, but could not be confirmed due to lack of chemistry data collected.

Nitrate is toxic to aquatic life in high-prolonged concentrations within the stream. A strong collection of data, paired with the sampled macroinvertebrate community did show that the streams have nitrate overloading that is limiting the macroinvertebrate community.

Total Suspended Solids (TSS) is a major stressor to the biological community within the downstream reaches. Seven Mile stream was listed as impaired for turbidity in 2006, this study found that this impairment is still valid today. Here concentrations of sediment are higher than those found in the Minnesota River. Additional monitoring confirmed that high sedimentation is the main source of TSS, likely from accelerated erosion rates from upstream altered hydrology. TSS will often have direct impacts on habitat availability as well. The primary influence to poor habitat quality is sedimentation. This eliminates streambed diversity as well as will fill in pools, a critical habitat for stream life diversity and longevity.

Connectivity was found to be impacting fish migration within a few streams. There are two man-made fish barriers on Seven Mile Creek, a dam that was built to block migration of common carp, and a perched culvert at the Highway 99 crossing. Both of these barriers are affecting fish migration upstream into CD 46A. CD 46A also is also vulnerable to low to no flows, further limiting migration ability. It is important to note that low flow conditions are likely limiting throughout this sub watershed for fish and macroinvertebrates, tying back to altered hydrology and land to stream recharge. There were a couple reaches that could not be sampled due to lack of flow. Rogers Creek has a six-foot waterfall that is located one mile upstream from the Minnesota River, as this was found upstream of the monitoring location it is not flagged as a barrier for that assessment site.

Temperature is considered a stressor within the cold-water reach of Seven Mile Creek. This stream is particularly vulnerable to increased temperatures during low flow conditions. There are a number of cold-water springs with in this area to help maintain cool temperatures; however, they cannot consistently mitigate the warm water influence that is being introduced from upstream ditches. Many of the contributing upland streams are slow flowing outside of rain events; paired with poor canopy coverage allows water to heat up to restrictive temperatures from the long exposure of direct sunlight. The other contributing factor to increased stream temperatures is likely from the high amounts of suspended sediment, as sediment absorbs and distributes heat.

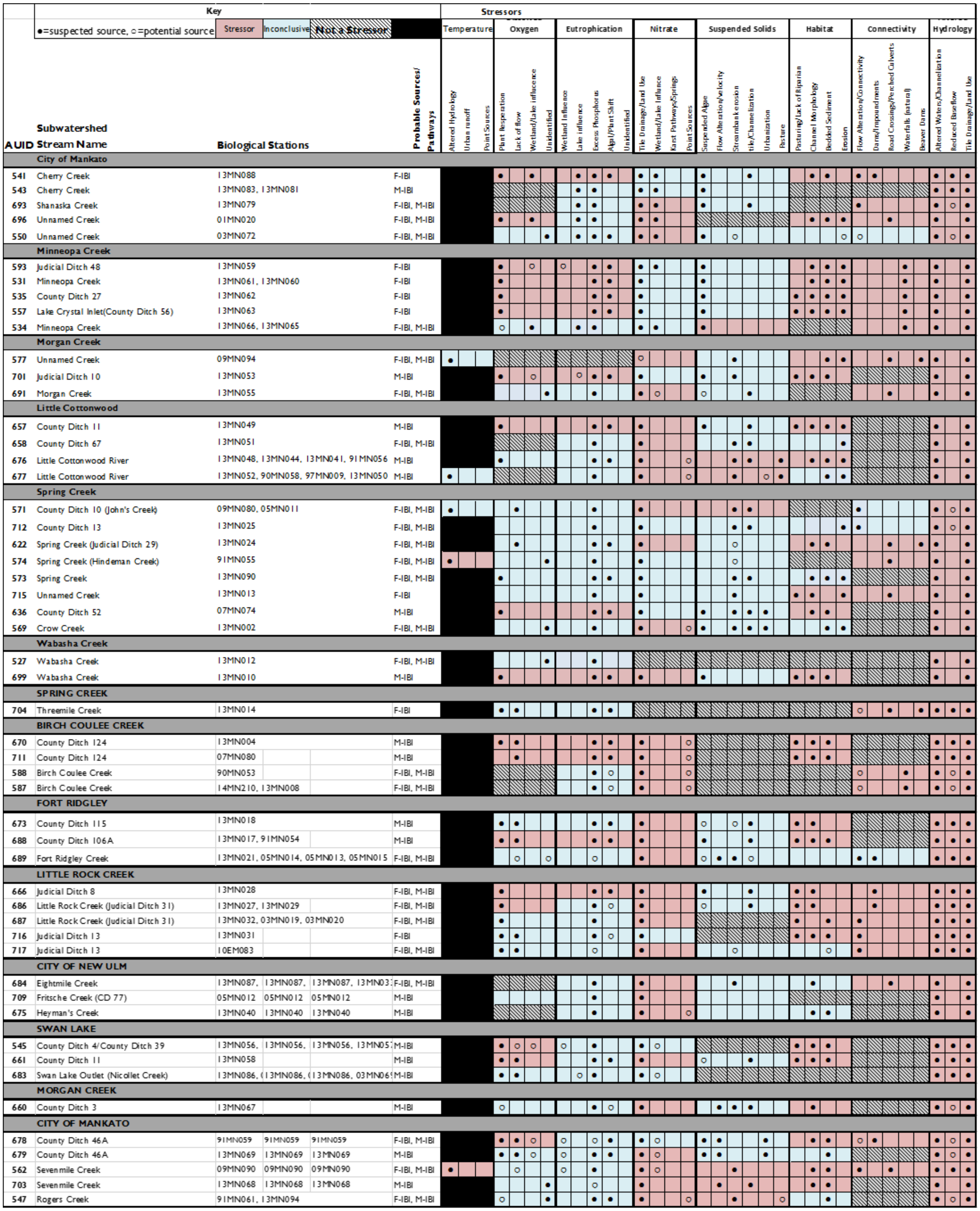
The subwatershed is unique as this is where the only pesticide impairment is listed for the entire subwatershed. A 2010 detection of Chloryrifos and Tebupirimfo tripped the listing and triggered intense monitoring efforts by the Department of Agriculture. It is likely this site will soon be delisted, as there has not been high detection levels since the initial 2010 finding. Currently, the additive effect of pesticides on aquatic organisms at levels below state or federal standards is unknown. Research is currently being done to better characterize the potential impacts. Given the current gaps in understanding of the additive effects, it is difficult to rule out pesticide toxicity as a possible stressor or conclude that it may be a stressor at this time.

Rogers Creek stood out in this study due to the extremely high pollutant loading detected at this reach throughout the monitoring period. This location should have follow up monitoring to determine causes and sources of these pollutants.

5. Conclusions and Recommendations

5.1 Summary Table of Probable Stressors

Figure 373. Summary table of identified stressors with suspected sources all assessed reaches within the Minnesota River –Mankato Watershed.



Key				
●=suspected source, ○=potential source	🟥 Stressor	🟦 Inconclusive	▨ Not a Stressor	■

AUID	Subwatershed Stream Name	Biological Stations	Probable Sources/ Pathways	Stressors																																	
				Temperature			Oxygen				Eutrophication					Nitrate				Suspended Solids						Habitat				Connectivity					Hydrology		
				Altered Hydrology	Urban runoff	Point Sources	Plant Resperation	Lack of flow	Wetland/Lake influcence	Unidentified	Wetland Influence	Lake influence	Excess Phosphorus	Algal/Plant Shift	Unidentified	Tile Drainage/Land Use	Wetland/Lake Influence	Karst Pathways/Springs	Point Sources	Suspended Algae	Flow Alteration/velocity	Streambank erosion	tile/Channelization	Urbanization	Pasture	Pasturing/Lack of Riparian	Channel Morphology	Bedded Sediment	Erosion	Flow Alteration/Connectivity	Dams/Impoundments	Road Crossings/Perched Culverts	Waterfalls (natural)	Beaver Dams	Altered Waters/Channelization	Reduced Baseflow	Tile Drainage/Land Use
	City of Mankato																																				
541	Cherry Creek	13MN088	F-IBI	■	■	■	🟥 ●	🟥	🟥 ●	🟥	🟥	🟥 ●	🟥 ●	🟥 ●	🟥	🟦 ●	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	🟥	🟥 ●	🟥 ●	🟥	🟥 ●	🟥 ●	🟥	🟥	🟥	🟥 ●	🟥 ●	🟥 ●
543	Cherry Creek	13MN083, 13MN081	M-IBI	■	■	■	▨	▨	▨	▨	🟦	🟦 ●	🟦 ●	🟦	🟦	🟦 ●	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	🟦	🟦	🟦	▨	▨	▨	▨	▨	▨	▨	▨	▨	🟥 ●	🟥 ●	🟥 ●
693	Shanaska Creek	13MN079	F-IBI, M-IBI	■	■	■	▨	▨	▨	▨	🟦	🟦 ●	🟦 ●	🟦	🟦	🟥 ●	🟥 ●	🟥	🟥	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	▨	▨	▨	▨	🟥 ●	🟥	🟥	🟥	🟥	🟥 ●	🟥 ○	🟥 ●
696	Unnamed Creek	01MN020	F-IBI, M-IBI	■	■	■	🟥 ●	🟥	🟥 ●	🟥	🟦	🟦 ●	🟦 ●	🟦	🟦	🟥 ●	🟥 ●	🟥	🟥	▨	▨	▨	▨	▨	▨	🟥	🟥 ●	🟥 ●	🟥 ●	🟥	🟥	🟥 ●	🟥	🟥	🟥 ●	🟥	🟥 ●
550	Unnamed Creek	03MN072	F-IBI, M-IBI	■	■	■	🟦	🟦	🟦	🟦 ●	🟦	🟦 ●	🟦 ●	🟦 ●	🟦	🟥 ●	🟥 ●	🟥	🟥	🟦 ●	🟦	🟦 ○	🟦	🟦	🟦	🟦	🟦	🟦	🟦 ○	🟦 ○	🟦	🟦	🟦	🟦	🟥 ●	🟥 ○	🟥 ●
	Minneopa Creek																																				
593	Judicial Ditch 48	13MN059	F-IBI	■	■	■	🟥 ●	🟥	🟥 ○	🟥	🟥 ○	🟥	🟥 ●	🟥 ●	🟥	🟦 ●	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	🟦	🟦	🟦	🟥	🟥 ●	🟥 ●	🟥 ●	🟥	🟥	🟥	🟥 ●	🟥	🟥 ●	🟥	🟥 ●
531	Minneopa Creek	13MN061, 13MN060	F-IBI	■	■	■	🟥 ●	🟥	🟥	🟥	🟥	🟥	🟥 ●	🟥 ●	🟥	🟦 ●	🟦	🟦	🟦	🟦 ●	🟦	🟦	🟦	🟦	🟦	🟥	🟥 ●	🟥 ●	🟥 ●	🟥	🟥	🟥	🟥 ●	🟥	🟥 ●	🟥	🟥 ●
535	County Ditch 27	13MN062	F-IBI	■	■	■	🟥 ●	🟥	🟥	🟥	🟥	🟥	🟥 ●	🟥 ●	🟥	🟦 ●	🟦	🟦	🟦	🟦 ●	🟦	🟦	🟦	🟦	🟦	🟥 ●	🟥 ●	🟥 ●	🟥 ●	🟥	🟥	🟥	🟥 ●	🟥	🟥 ●	🟥	🟥 ●
557	Lake Crystal Inlet(County Ditch 56)	13MN063	F-IBI	■	■	■	🟥 ●	🟥	🟥	🟥	🟥	🟥	🟥 ●	🟥 ●	🟥	🟦 ●	🟦	🟦	🟦	🟦 ●	🟦	🟦	🟦	🟦	🟦	🟥 ●	🟥 ●	🟥 ●	🟥 ●	🟥	🟥	🟥	🟥 ●	🟥	🟥 ●	🟥	🟥 ●
534	Minneopa Creek	13MN066, 13MN065	F-IBI, M-IBI	■	■	■	🟦 ○	🟦	🟦 ●	🟦	🟦	🟦 ●	🟦 ●	🟦	🟦	🟦 ●	🟦 ●	🟦	🟦	🟥 ●	🟥	🟥	🟥	🟥	🟥	▨	▨	▨	▨	🟥	🟥	🟥	🟥 ●	🟥	🟥 ●	🟥	🟥 ●
	Morgan Creek																																				
577	Unnamed Creek	09MN094	F-IBI, M-IBI	🟦 ●	🟦	🟦	▨	▨	▨	▨	▨	▨	▨	▨	▨	🟥 ○	🟥	🟥	🟥	🟦	🟦	🟦 ●	🟦	🟦	🟦	🟥	🟥	🟥 ●	🟥 ●	🟥	🟥	🟥 ●	🟥	🟥 ●	🟥 ●	🟥	🟥 ●
701	Judicial Ditch 10	13MN053	M-IBI	■	■	■	🟥 ●	🟥	🟥 ○	🟥	🟥	🟥 ○	🟥 ●	🟥 ●	🟥	🟦 ●	🟦	🟦	🟦	🟦 ●	🟦	🟦 ●	🟦	🟦	🟦	🟥 ●	🟥 ●	🟥 ●	🟥	▨	▨	▨	▨	▨	🟥 ●	🟥	🟥 ●
691	Morgan Creek	13MN055	F-IBI, M-IBI	■	■	■	🟦	🟦	🟦	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	🟥 ●	🟥 ○	🟥	🟥	🟦 ○	🟦	🟦	🟦 ●	🟦	🟦	▨	▨	▨	▨	🟥	🟥	🟥 ●	🟥	🟥	🟥 ●	🟥	🟥 ●
	Little Cottonwood																																				
657	County Ditch 11	13MN049	M-IBI	■	■	■	🟥 ●	🟥	🟥	🟥	🟥	🟥	🟥 ●	🟥 ●	🟥	🟥 ●	🟥	🟥	🟥	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	🟥 ●	🟥 ●	🟥 ●	🟥 ●	▨	▨	▨	▨	▨	🟥 ●	🟥	🟥 ●
658	County Ditch 67	13MN051	F-IBI, M-IBI	■	■	■	▨	▨	▨	▨	🟦	🟦	🟦 ●	🟦	🟦	🟥 ●	🟥	🟥	🟥	🟦	🟦	🟦 ●	🟦 ●	🟦	🟦	🟦	🟦	🟦	🟦 ●	▨	▨	▨	▨	▨	🟥 ●	🟥	🟥 ●
676	Little Cottonwood River	13MN048, 13MN044, 13MN041, 91MN056	M-IBI	■	■	■	🟦 ●	🟦	🟦	🟦	🟦	🟦	🟦 ●	🟦 ●	🟦	🟥 ●	🟥	🟥	🟥 ○	🟥	🟥	🟥 ●	🟥 ●	🟥	🟥 ●	🟥	🟥 ●	🟥 ●	🟥 ●	▨	▨	▨	▨	▨	🟥 ●	🟥	🟥 ●
677	Little Cottonwood River	13MN052, 90MN058, 97MN009, 13MN050	M-IBI	🟦 ●	🟦	🟦	▨	▨	▨	▨	🟦	🟦	🟦 ●	🟦	🟦	🟥 ●	🟥	🟥	🟥 ○	🟥	🟥	🟥 ●	🟥	🟥 ○	🟥 ●	🟦	🟦	🟦 ●	🟦 ●	▨	▨	▨	▨	▨	🟥 ●	🟥	🟥 ●
	Spring Creek																																				
571	County Ditch 10 (John's Creek)	09MN080, 05MN011	F-IBI, M-IBI	🟦 ●	🟦	🟦	🟦	🟦 ●	🟦	🟦	🟦	🟦	🟦 ●	🟦	🟦	🟥 ●	🟥	🟥	🟥	🟥	🟥	🟥 ●	🟥 ●	🟥	🟥	▨	▨	▨	▨	🟦 ●	🟦	🟦	🟦	🟦	🟥 ●	🟥 ○	🟥 ●
712	County Ditch 13	13MN025	F-IBI, M-IBI	■	■	■	🟦	🟦	🟦	🟦	🟦	🟦	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	🟦	🟦	🟦	🟦 ●	🟦 ●	🟦	🟦	🟦	🟦	🟦	🟦 ●	🟦 ●	🟦	🟦	🟦	🟦	🟥 ●	🟥 ○	🟥 ●
622	Spring Creek (Judicial Ditch 29)	13MN024	F-IBI, M-IBI	■	■	■	🟦	🟦 ●	🟦	🟦	🟦	🟦	🟦 ●	🟦 ●	🟦	🟥 ●	🟥	🟥	🟥	🟦	🟦	🟦 ○	🟦	🟦	🟦	🟥	🟥 ●	🟥 ●	🟥	🟥	🟥	🟥 ●	🟥	🟥 ●	🟥 ●	🟥	🟥 ●
574	Spring Creek (Hindeman Creek)	91MN055	F-IBI, M-IBI	🟥 ●	🟥	🟥	🟦	🟦	🟦	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	🟦	🟦	🟦	🟦 ○	🟦	🟦	🟦	▨	▨	▨	▨	🟥	🟥	🟥 ●	🟥	🟥	🟥 ●	🟥	🟥 ●
573	Spring Creek	13MN090	F-IBI, M-IBI	■	■	■	🟦 ●	🟦	🟦	🟦	🟦	🟦	🟦 ●	🟦 ●	🟦	🟦 ●	🟦	🟦	🟦	🟦	🟦	🟦 ●	🟦 ●	🟦	🟦	🟦	🟦 ●	🟦 ●	🟦 ●	▨	▨	▨	▨	▨	🟥 ●	🟥	🟥 ●
715	Unnamed Creek	13MN013	F-IBI	■	■	■	🟦	🟦	🟦	🟦	🟦	🟦	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	🟦	🟦	🟦	🟦 ●	🟦	🟦	🟦	🟥 ●	🟥 ●	🟥	🟥 ●	🟥	🟥	🟥 ●	🟥	🟥	🟥 ●	🟥	🟥 ●
636	County Ditch 52	07MN074	M-IBI	■	■	■	🟥 ●	🟥	🟥	🟥	🟥	🟥	🟥 ●	🟥 ●	🟥	🟦 ●	🟦	🟦	🟦	🟦 ●	🟦	🟦 ●	🟦 ●	🟦 ●	🟦	🟥	🟥 ●	🟥 ●	🟥	▨	▨	▨	▨	▨	🟥 ●	🟥	🟥 ●
569	Crow Creek	13MN002	F-IBI, M-IBI	■	■	■	🟦	🟦	🟦	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	🟥 ●	🟥	🟥	🟥 ○	🟦 ●	🟦	🟦 ●	🟦 ●	🟦 ●	🟦	🟦	🟦	🟦 ●	🟦 ●	▨	▨	▨	▨	▨	🟥 ●	🟥	🟥 ●
	Wabasha Creek																																				
527	Wabasha Creek	13MN012	F-IBI, M-IBI	■	■	■	🟦	🟦	🟦	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	🟥 ●	🟥	🟥 ●
699	Wabasha Creek	13MN010	M-IBI	■	■	■	🟥 ●	🟥	🟥	🟥	🟥	🟥	🟥 ●	🟥 ●	🟥	🟥 ●	🟥	🟥	🟥	🟦 ●	🟦	🟦	🟦	🟦	🟦	🟥 ●	🟥 ●	🟥 ●	🟥	▨	▨	▨	▨	▨	🟥 ●	🟥	🟥 ●
	SPRING CREEK																																				
704	Threemile Creek	13MN014	F-IBI	■	■	■	🟦 ●	🟦 ●	🟦	🟦	🟦	🟦	🟦 ●	🟦 ●	🟦	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	🟥 ○	🟥	🟥 ●	🟥	🟥 ●	🟥 ●	🟥 ●	🟥 ●
	BIRCH COULEE CREEK																																				
670	County Ditch 124	13MN004	M-IBI	■	■	■	🟥 ●	🟥 ●	🟥	🟥	🟥	🟥	🟥 ●	🟥 ●	🟥	🟥 ●	🟥	🟥	🟥 ○	▨	▨	▨	▨	▨	▨	🟥 ●	🟥 ●	🟥 ●	🟥	▨	▨	▨	▨	▨	🟥 ●	🟥 ●	🟥 ●
711	County Ditch 124	07MN080	M-IBI	■	■	■	🟥	🟥 ●	🟥	🟥	🟥	🟥	🟥 ●	🟥 ●	🟥	🟥 ●	🟥	🟥	🟥 ○	▨	▨	▨	▨	▨	▨	🟥 ●	🟥 ●	🟥 ●	🟥	▨	▨	▨	▨	▨	🟥 ●	🟥 ●	🟥 ●
588	Birch Coulee Creek	90MN053	F-IBI, M-IBI	■	■	■	▨	▨	▨	▨	🟦	🟦	🟦 ●	🟦 ○	🟦	🟥 ●	🟥	🟥	🟥 ○	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	🟥 ○	🟥	🟥	🟥 ●	🟥	🟥 ●	🟥 ○	🟥 ●
587	Birch Coulee Creek	14MN210, 13MN008	F-IBI, M-IBI	■	■	■	▨	▨	▨	▨	🟦	🟦	🟦 ●	🟦 ○	🟦	🟥 ●	🟥	🟥	🟥 ○	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	🟥 ○	🟥	🟥	🟥 ●	🟥	🟥 ●	🟥 ○	🟥 ●
	FORT RIDGLEY																																				
673	County Ditch 115	13MN018	M-IBI	■	■	■	🟦 ●	🟦 ●	🟦	🟦	🟦	🟦	🟦 ●	🟦 ●	🟦	🟥 ●	🟥	🟥	🟥	🟦 ○	🟦	🟦 ○	🟦 ●	🟦	🟦	🟥 ●	🟥 ●	🟥	🟥	▨	▨	▨	▨	▨	🟥 ●	🟥 ●	🟥 ●
688	County Ditch 106A	13MN017, 91MN054	M-IBI	■	■	■	🟥 ●	🟥 ●	🟥	🟥	🟥	🟥	🟥 ●	🟥 ●	🟥	🟥 ●	🟥	🟥	🟥	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	🟥 ●	🟥 ●	🟥 ●	🟥	▨	▨	▨	▨	▨	🟥 ●	🟥 ●	🟥 ●
689	Fort Ridgley Creek	13MN021, 05MN014, 05MN013, 05MN015	F-IBI, M-IBI	■	■	■	🟦	🟦 ○	🟦	🟦 ○	🟦	🟦	🟦 ○	🟦	🟦	🟥 ●	🟥	🟥	🟥	🟦 ○	🟦 ●	🟦 ●	🟦 ○	🟦	🟦	🟦	🟦	🟦	🟦	🟦 ●	🟦 ●	🟦	🟦	🟦	🟥 ●	🟥 ●	🟥 ●
	LITTLE ROCK CREEK																																				
666	Judicial Ditch 8	13MN028	F-IBI, M-IBI	■	■	■	🟥 ●	🟥	🟥	🟥	🟥	🟥	🟥 ●	🟥 ●	🟥	🟥 ●	🟥	🟥	🟥	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	🟥 ●	🟥 ●	🟥	🟥	🟥	🟥 ●	🟥	🟥	🟥	🟥 ●	🟥 ●	🟥 ●
686	Little Rock Creek (Judicial Ditch 31)	13MN027, 13MN029	F-IBI, M-IBI	■	■	■	🟥 ●	🟥	🟥	🟥	🟦	🟦	🟦 ●	🟦 ○	🟦	🟥 ●	🟥	🟥	🟥	🟦 ○	🟦	🟦	🟦 ●	🟦	🟦	🟥 ●	🟥 ●	🟥	🟥	🟥	🟥 ●	🟥	🟥	🟥	🟥 ●	🟥 ●	🟥 ●
687	Little Rock Creek (Judicial Ditch 31)	13MN032, 03MN019, 03MN020	F-IBI, M-IBI	■	■	■	🟦 ●	🟦	🟦	🟦	🟦	🟦	🟦 ●	🟦	🟦	🟥 ●	🟥	🟥	🟥	▨	▨	▨	▨	▨	▨	🟥 ●	🟥	🟥 ●	🟥	🟥 ●	🟥	🟥	🟥	🟥	🟥 ●	🟥 ●	🟥 ●
716	Judicial Ditch 13	13MN031	F-IBI	■	■	■	🟦 ●	🟦 ●	🟦	🟦	🟦	🟦	🟦 ●	🟦 ○	🟦	🟦 ●	🟦	🟦	🟦	▨	▨	▨	▨	▨	▨	🟥 ●	🟥 ●	🟥 ●	🟥	🟥 ●	🟥	🟥	🟥	🟥	🟥 ●	🟥 ●	🟥 ●
717	Judicial Ditch 13	10EM083	F-IBI, M-IBI	■	■	■	🟦 ●	🟦 ●	🟦	🟦	🟦	🟦	🟦 ○	🟦	🟦	🟥 ●	🟥	🟥	🟥	🟦	🟦	🟦 ○	🟦	🟦	🟦	🟦	🟦	🟦 ○	🟦	🟥 ●	🟥	🟥	🟥	🟥	🟥 ●	🟥 ●	🟥 ●
	CITY OF NEW ULM																																				
684	Eightmile Creek	13MN087, 13MN087, 13MN087, 13MN03	F-IBI, M-IBI	■	■	■	▨	▨	▨	▨	🟦	🟦	🟦 ●	🟦	🟦	🟥 ●	🟥	🟥	🟥	🟦	🟦	🟦 ●	🟦	🟦	🟦	🟦	🟦 ●	🟦	🟦	🟥	🟥	🟥 ●	🟥	🟥	🟥 ●	🟥	🟥 ●
709	Fritsche Creek (CD 77)	05MN012 05MN012 05MN012	M-IBI	■	■	■	🟦	🟦	🟦	🟦	🟦	🟦	🟦 ●	🟦	🟦	🟥 ●	🟥	🟥	🟥	🟦	🟦	🟦	🟦	🟦	🟦	▨	▨	▨	▨	▨	▨	▨	▨	▨	🟥 ●	🟥	🟥 ●
675	Heyman's Creek	13MN040 13MN040 13MN040	M-IBI	■	■	■	▨	▨	▨	▨	🟦	🟦	🟦 ●	🟦	🟦	🟥 ●	🟥	🟥	🟥 ○	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦 ●	🟦 ●	🟦	▨	▨	▨	▨	▨	🟥 ●	🟥	🟥 ●
	SWAN LAKE																																				
545	County Ditch 4/County Ditch 39	13MN056, 13MN056, 13MN056, 13MN05	M-IBI	■	■	■	🟥 ●	🟥 ○	🟥 ○	🟥	🟦 ○	🟦	🟦 ●	🟦	🟦	🟦 ●	🟦 ○	🟦	🟦	▨	▨	▨	▨	▨	▨	🟥 ●	🟥 ●	🟥 ●	🟥	▨	▨	▨	▨	▨	🟥 ●	🟥 ●	🟥 ●
661	County Ditch 11	13MN058	M-IBI	■	■	■	🟥 ●	🟥 ●	🟥	🟥	🟦	🟦	🟦 ●	🟦 ●	🟦	🟥 ●	🟥	🟥	🟥	🟦 ○	🟦	🟦	🟦 ●	🟦	🟦	🟥 ●	🟥 ●	🟥 ●	🟥	▨	▨	▨	▨	▨	🟥 ●	🟥 ●	🟥 ●
683	Swan Lake Outlet (Nicollet Creek)	13MN086, (13MN086, (13MN086, 03MN06	M-IBI	■	■	■	🟦 ●	🟦 ●	🟦	🟦	🟦	🟦 ○	🟦 ●	🟦	🟦	🟦 ●	🟦 ○	🟦	🟦	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	🟥 ●	🟥 ●	🟥 ●
	MORGAN CREEK																																				
660	County Ditch 3	13MN067	M-IBI	■	■	■	🟦 ○	🟦	🟦	🟦	🟦	🟦	🟦 ●	🟦 ○	🟦	🟥 ●	🟥	🟥	🟥	🟦	🟦 ●	🟦 ●	🟦 ●	🟦	🟦	🟥	🟥 ●	🟥	🟥	▨	▨	▨	▨	▨	🟥 ●	🟥 ○	🟥 ●
	CITY OF MANKATO																																				
678	County Ditch 46A	91MN059 91MN059 91MN059	F-IBI, M-IBI	■	■	■	🟥 ●	🟥 ●	🟥 ○	🟥	🟦 ○	🟦	🟦 ○	🟦 ●	🟦	🟦 ●	🟦 ○	🟦	🟦	🟦 ●	🟦 ●	🟦	🟦	🟦 ●	🟦	🟥	🟥 ●	🟥 ●	🟥	🟥 ○	🟥 ●	🟥	🟥	🟥	🟥 ●	🟥 ○	🟥 ●
679	County Ditch 46A	13MN069 13MN069 13MN069	M-IBI	■	■	■	🟦 ●	🟦 ●	🟦 ○	🟦	🟦 ○	🟦	🟦 ●	🟦 ●	🟦	🟥 ●	🟥 ○	🟥	🟥	🟦 ●	🟦 ●	🟦	🟦	🟦 ●	🟦	🟦	🟦	🟦 ●	🟦	▨	▨	▨	▨	▨	🟥 ●	🟥 ○	🟥 ●
562	Sevenmile Creek	09MN090 09MN090 09MN090	F-IBI, M-IBI	🟥 ●	🟥	🟥	🟦	🟦 ○	🟦	🟦	🟦 ○	🟦	🟦 ●	🟦	🟦	🟥 ●	🟥 ○	🟥	🟥	🟥	🟥	🟥 ●	🟥	🟥	🟥	🟥	🟥 ●	🟥 ●	🟥	🟥 ●	🟥	🟥 ●	🟥	🟥	🟥 ●	🟥 ●	🟥 ●
703	Sevenmile Creek	13MN068 13MN068 13MN068	M-IBI	■	■	■	🟦	🟦	🟦	🟦 ●	🟦	🟦	🟦 ○	🟦	🟦	🟥 ●	🟥	🟥	🟥	🟥	🟥 ●	🟥	🟥 ●	🟥	🟥	🟥	🟥 ●	🟥 ●	🟥	▨	▨	▨	▨	▨	🟥 ●	🟥	🟥 ●
547	Rogers Creek	91MN061, 13MN094	F-IBI, M-IBI	■	■	■	🟦 ○	🟦	🟦	🟦 ●	🟦	🟦	🟦 ●	🟦 ●	🟦	🟥 ●	🟥	🟥	🟥 ○	🟥	🟥	🟥 ●	🟥	🟥	🟥 ○	🟦	🟦	🟦 ●	🟦	▨	▨	▨	▨	▨	🟥 ●	🟥 ○	🟥 ●

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 Minnesota River –Mankato (AKA Middle Minnesota River) WRAPS report for additional information, as well as specific targeting.

6. References

Adams, R., Barry, J., & Green, J. (2016). *Minnesota Regions Prone to Karst* (1st ed., Vol. GW) Department Of Natural Resources, Minnesota). St Paul, MN: DNR. Retrieved from http://files.dnr.state.mn.us/waters/groundwater_section/mapping/gw/gw01_report.pdf

Behnke, R. J. (1992). *Native trout of western North America*. Bethesda, MD: American Fisheries Society.

Boesel, M. W. "A review of the genus cricotopus in Ohio, with a key to." *Ohio Journal of Science*, vol. 83, no. 3, 1983, pp. 74–90.

Brooker, M. (1981). The impact of impoundments on the downstream fisheries and general ecology of rivers. *Advances in Applied Biology, 6*, 91 - 152.

Bruton, M.N. (1985). The effects of suspensoids on fish. Hydrobiologica 125(1), 221-242.

Carlisle, D.M., Meador, M.R., Moulton, S.R., Ruhl, P.M., 2007. Estimation and application of indicator values for common macroinvertebrate genera and families of the United States. Ecol. Indic. 7 (1), 22–33.

Chapman, D. (1988). Critical review of variables used to define effects of fines in reds of large salmonids. Transactions of the American Fisheries Society 117, 1-21.

Cormier S., S. Norton, G. Suter and D. Reed-Judkins. 2000. Stressor Identification Guidance Document. U.S. Environmental Protection Agency, Washington D.C., EPA/822/B-00/025. http://water.epa.gov/scitech/swguidance/standards/criteria/aqlife/biocriteria/upload/stressorid.pdf

Cummins, K. (1979). *The natural stream ecosystem.* New York: Plenum.

Erman, D. C. & Ligon, F.K. (1988). Effects of discharge fluctuation and the addition of fine sediment on stream fish and macroinvertebrates below a water-filtration facility. Environmental Management 12, 85-97.

Gray, L.J. & Ward, J.V. (1982). Effects of sediment releases from a reservoir on stream macroinvertebrates. Hydrobiologia 96 (2), 177-184.

Heiskary, S., W. Bouchard, Jr. and H. Markus. Minnesota River Nutrient Criteria Development for Rivers. 2010. MPCA

Leopold, L.B., Wolman, M.G., Miller, J.P., 1964. Fluvial Processes in Geomorphology. W.H. Freeman and Co., San Francisco, CA.

Lore, Jon. 2015. Minnesota River, Mankato Watershed Characterization Report. Division of Ecological and Water Resources, Minnesota Department of Natural Resources, St Paul, Minnesota.

Menétrey Perrottet, N., Sager, L., Oertli, B. and Lachavanne, J. (2008). *Looking for metrics to assess the trophic state of pounds*.

MPCA 2015. Sediment Reduction Strategy for the Minnesota River Basin and South Metro Mississippi River https://www.pca.state.mn.us/sites/default/files/wq-iw4-02.pdf

Minnesota Pollution Control Agency (MPCA). 2008. Draft Biota TMDL Protocols and Submittal Requirements. Minnesota Pollution Control Agency, St. Paul, MN. http://www.pca.state.mn.us/index.php/view-document.html?gid=8524

Mitchell, S.C. and Cunjak, R.A. 2007. Stream flow, salmon and beaver dams: roles in the construction of stream fish communities within an anadromous salmon dominated stream. Journal of Animal Ecology 76: 1062-1074.

Newcombe, C. P., and D. D. MacDonald. "Effects of suspended sediments on aquatic ecosystems." *North American Journal of Fisheries Management 11:72-82*, 1991: 11:72-82.

Omernik, J.M. and A.L. Gallant. 1988. Ecoregions of the Upper Midwest States. EPA/600/3-88/037. Corvallis, OR: United States Environmental Protection Agency. 56 p.

Pekarsky, B.L. (1984) Predator-prey interactions among aquatic insects. In V.H. Resch and D.M. Rosenberg (Eds.), the Ecology of Aquatic Insects (pp. 196-254). NY: Praeger Scientific.

Raleigh, R.F., Zuckerman, L. D. & Nelson, P.C. (1986). Habitat suitability index models and instream flow suitability curves: brown trout. Biological Report 82 (10.124). U.S. Fish and Wildlife Service.

Rhoads, B. L., and K. D. Massey. “Flow Structure and Channel Change in a Sinuous Grass-Lined Stream within an Agricultural Drainage Ditch: Implications for Ditch Stability and Aquatic Habitat.” *River Research and Applications*, vol. 28, no. 1, Apr. 2010, pp. 39–52

Rosenberg, D. & Wiens, A. (1978). Effect of sediment addition on macrobenthic invertebrates in a Northern Canadian river. Water Research 12, 753 - 763.

Rounds, K. (n.d.). Fisheries Lake Surveys - Minnesota DNR - MN Department of Natural Resources. Retrieved from https://www.dnr.state.mn.us/lakefind/showreport.html?downum=40010900

Thorp, J.H. and A.P. Covich. 2010. Ecology and Classification of North American Freshwater Invertebrates, pp. 587-657. Elsevier Inc. Boston.

Tiemann, J., Gillette, D., Wildhaber, M., & Edds, D. (2004). Effects of lowhead dams on riff dwelling fishes and macroinvertebrates in a midwestern river. *Transactions of the American Fisheries Society, 133*, 705-717.

Waters, T.F. 1977. The Rivers and Streams of Minnesota. University of Minnesota Press, Minneapolis, Minnesota.

Waters, T. 1995. *Sediment in Streams: Sources, Biological Effects, and Control.* Bethesda, Maryland: American Fisheries Society.

Wiken, Ed, Francisco Jiménez Nava, and Glenn Griffith. 2011. North American Terrestrial Ecoregions—Level III. Commission for Environmental Cooperation, Montreal, Canada.

U.S. EPA. 2010. Causal Analysis/Diagnosis Decision Information System (CADDIS). Environmental Protection Agency. Office of Research and Development, Washington, DC. Available online at http://www.epa.gov/caddis.

7. Appendix

7.1 Appendix A

Table 377. Fish and macroinvertebrate metrics used in stressor analysis in the Minnesota River-Mankato Watershed. Some of the metrics below are more "general" stress indicators, while others are more "stressor specific" indicators.

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

Metric Name	Type	Metric Description	Use in Report
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
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

Metric Name	Type	Metric Description	Use in Report
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
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

Metric Name	Type	Metric Description	Use in Report
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
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

Metric Name	Type	Metric Description	Use in Report
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
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

Metric Name	Type	Metric Description	Use in Report
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

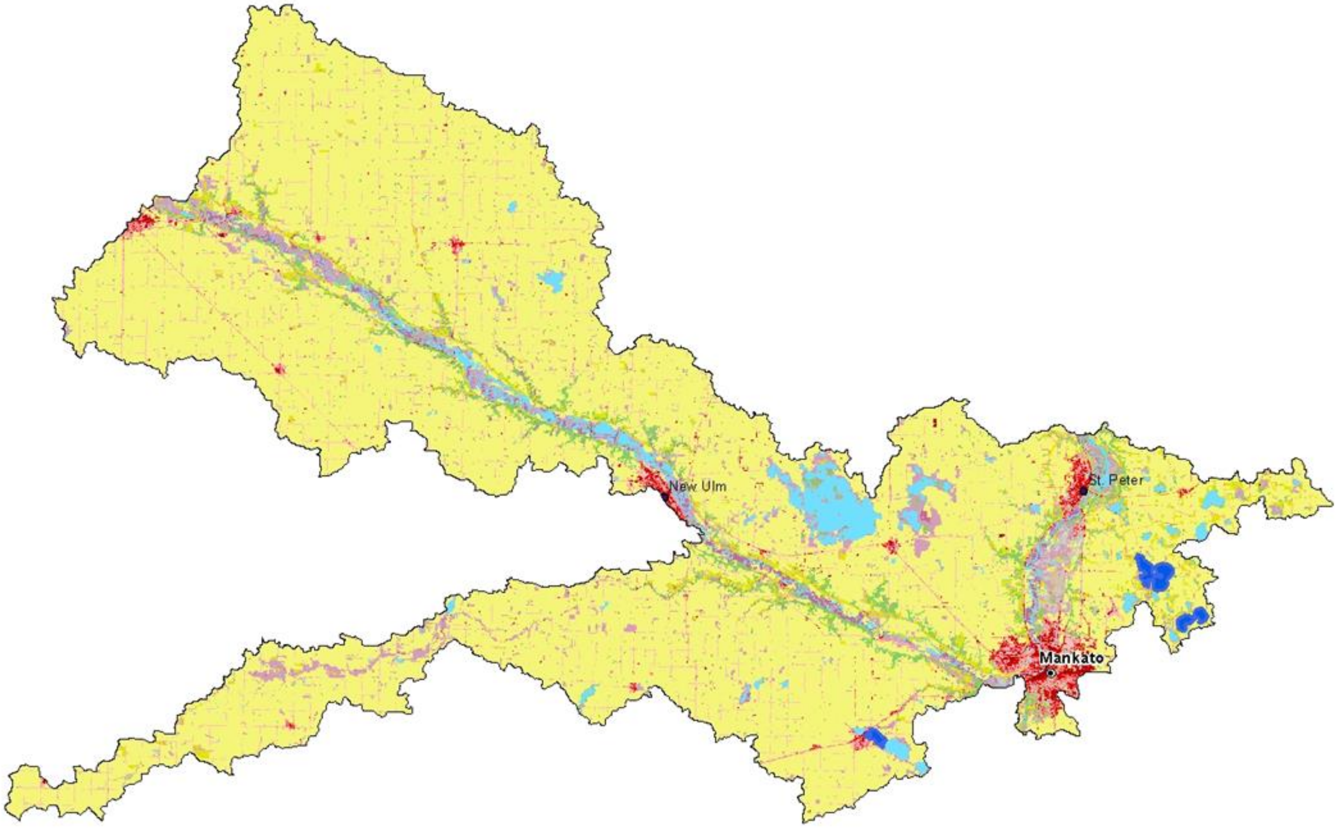
7.2 Appendix AS

DNR Lake Stressor ID - Minnesota River Mankato Watershed *Draft provided to the MPCA*

Four lakes assessed with the Fish IBI in the Minnesota River-Mankato Watershed. Ballantyne Lake had a repeated nearshore survey.

Lake Crystal and Lake Washington had Fish IBI scores below the impairment threshold. Ballantyne Lake and Duck Lake had Fish IBI scores at or just above the impairment threshold.

This report will examine potential stressors for the two lakes with Fish IBI scores below the impairment threshold.



DOW	Lake Name	County	Nearshore Survey Year	Notes	DNR GIS Acres	Lake Type-IBI Tool	% Littoral	Fish IBI Score	Below Impairment Threshold	Meeting Standard, but within 90% CI of Impairment Threshold
07005300	Duck	Blue Earth	2013	Gillnet & Trapnet survey in 2011	290	7	80	36		x (threshold = 36)
07005400	Ballantyne	Blue Earth	2014	Repeated Nearshore Survey in 2014	371	7	81	40, 38		x (threshold = 36)
07009800	Crystal	Blue Earth	2013	Gillnet & Trapnet survey in 2011	379	7	100	10	x	
40011700	Washington	LeSueur	2013		1519	2	52	29	x	

Lake Crystal, 07-0098-00, Blue Earth County

Impairment: Lake Crystal was assessed as impaired for not meeting fish community expectations based on data from a 2013 nearshore survey and trapnet and gillnet data from a survey completed in 2011. The Fish IBI score (10) was well below the impairment threshold (36), and below the lower bound of the 90% confidence limit (27).

Biological Community:

Fish Community: Basin characteristics place Lake Crystal in lake Class 43, which is scored with the Fish IBI for Group 7 lakes, which are characterized as being very shallow (over 80% littoral).

Five tolerant species were sampled (Black Bullhead, Common Carp, Fathead Minnow, Bigmouth Buffalo, and Green Sunfish) and dominated the fish community. Nearshore fish sampled were predominantly Fathead Minnows, Black Bullheads, and Yellow Bullheads. Trapnets were dominated by Black Bullheads (69% by biomass). Gillnets were also dominated by tolerant species including Black Bullheads (32% by biomass) and Common Carp (22%); however, stocked walleye also composed a significant portion of the gillnet catch (17% by biomass). Common Carp are not a native species, and catches of carp increased markedly between the 2006 and 2011 surveys. The Fish IBI score was low because all metrics scored poorly.

The current fish community has largely been shaped by stocking. However, Lake Crystal and upstream waters likely had low fish species richness prior to settlement due to their isolation and shallow depth, which limits the expectation of sampling cyprinid and darter species. Fisheries management activities have consisted of stocking fish since 1908 or earlier, removing carp and bullheads, dissolved oxygen monitoring and aeration since 1979 to prevent winterkill. Carp were stocked prior to 1946. Winterkill was likely frequent prior to aeration, and periodic partial winterkills still occur. However, in recent years, netting following partial winterkills has indicated minimal impact to sport fish populations (DNR Fisheries Lake Management Plan, 2012). Golden Shiners and Fathead Minnows, both common bait species, and Johnny Darters were sampled during the 2013 nearshore survey.

Plant Community: A tool to evaluate aquatic life use standards in lakes based on aquatic plant community data is currently being developed based on work by Radomski and Perleberg (2012). A transect plant survey on Lake Crystal was completed by DNR Fisheries in 2006. No submerged plants were sampled and only one total aquatic plant species was noted (cattail) and the floristic quality index was four. This scored well below the thresholds developed by Radomski and Perleberg (2012), suggesting that the plant community was degraded. Note that the Radomski and Perleberg plant community indices were designed to respond to nutrient impairment and resulting loss in water clarity and work continues to develop tools to describe impairments to the nearshore fringe plant community (emergent and/or floating-leaf).

Potential Stressors:

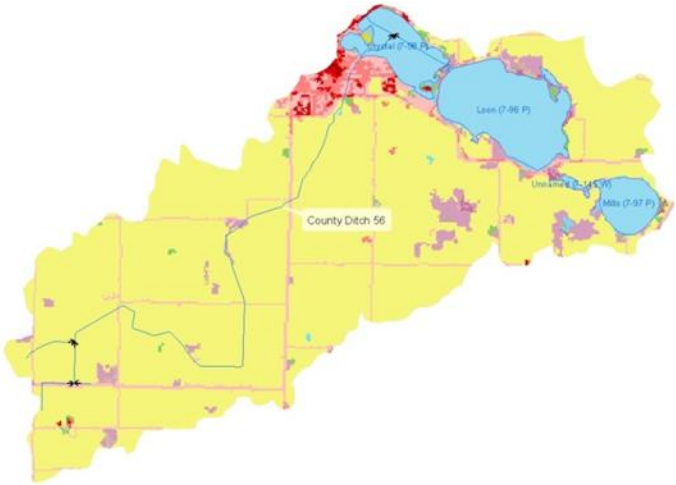
Watershed Disturbance: Lake Crystal is located in the Minneopa Creek Watershed, which drains into the Minnesota River west of the city of Mankato. All of the lakes within the Minneopa Creek Watershed are isolated from the Minnesota River by Minneopa Falls, an impassable barrier for fish. A fixed crest sheet-piling weir is located at the outlet of the lake. The crest of the weir is approximately four feet above the streambed and the weir elevation determines the elevation of both Lake Crystal and Loon Lake, immediately upstream.

The contributing watershed for Lake Crystal is very large (ratio of watershed to lake size is about 50:1), and includes upstream lakes and the City of Lake Crystal. About 84% of the watershed land cover is disturbed: 76% cultivated, 8% developed (NLCD 2011). The percent of developed and cultivated land cover remained unchanged from 2001 – 2011 (NLCD). Corn was the most common crop type in most years from 2006-2014, and was present on 40-50% of the land within the contributing watershed. Soybeans and/or legumes were also common, present on about 28-41% of the land within the contributing watershed. Few wetlands remain in the contributing watershed (about 4% of land), but the acreage of wetlands has been stable from 2001-2011.

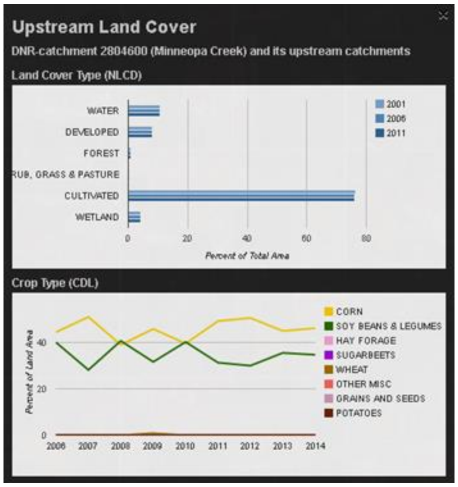
There are about four permitted feedlots in the contributing watershed (MNPCA Feedlots ArcGIS layer 4/2015). One permitted location (49 horses) is located adjacent to Lake Crystal, on the east side of the lake.

Lake Crystal receives surface water from two primary sources, Blue Earth County Ditch 56 and the outlet of Loon Lake. County Ditch 56 drains approximately 9,472 acres of agricultural land to the southwest of Lake Crystal and then passes through the City of Lake Crystal before draining to the lake. County Ditch 56 has been monitored though several projects, including the Clean Water Partnership (Phase I Diagnostic and II Implementation) and the TMDL; the 1996 Clean Water Assessment estimated that the equivalent of 50 dump truck loads of soil were deposited into Lake Crystal from
CD 56 each year.

Contributing watershed 2011 NLCD Land Cover Classification



Contributing watershed land use and crop type



Contributing watershed Aerial Photo, FSA 2013

Shoreline Aerial Photo, FSA 2013

Land Use	Sample Size	Mean Lakeshore Habitat Score (0-100)	Rating
			Fair
			Poor
			Excellent

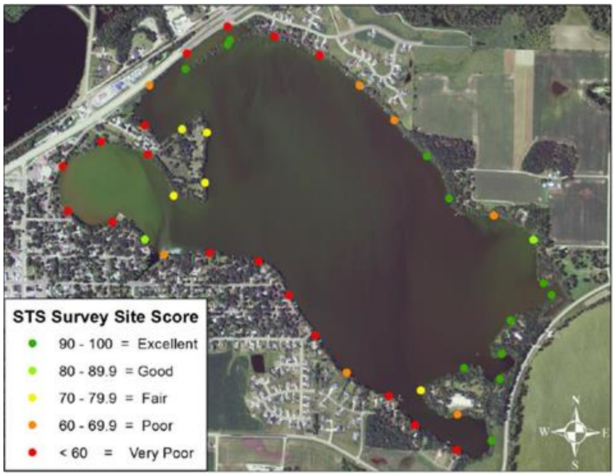
Riparian Disturbance: Lake Crystal is a round and shallow basin with a maximum depth of about 10.5 feet.

Publicly owned lakeshore includes a city owned public water access site and park along the west shore and county land in the northwest portion of the lake. The remaining lakeshore has a range of residential development density that has resulted in about 55 docks, 6 per km of shoreline, based on 2013 Google Earth imagery color aerial photography (photo date 9/30/2013). An assessment of riparian development was conducted in May 2015 following Score the Shore survey protocols and resulted in a mean score of 71.1 (range is 0 to 100). The Score the Shore survey score is comprised of scores for three zones: shoreland, shoreline, and aquatic – see tables below.

Zone	Sample Size	Mean Zone Habitat Score (0-33.3)	Rating
Shoreland	43	13.8	Poor
Shoreline	43	27.0	Good
Aquatic	43	30.3	Excellent

In a 2006 DNR Fisheries plant transect survey, cattail was the only emergent plant and was extremely rare. No floating leaf vegetation was sampled at the transect locations. Coarse woody habitat was noted in 40% of the vegetation transects. During the 2015 Score the Shore Survey, emergent of floating leaf vegetation was only noted at 1 of 43 sites, coarse woody habitat was noted at 75% of Score the Shore sites.

June 2015 Score the Shore Survey Map – Crystal Lake



In-lake Habitat Disturbance: Algae dominate the plant community. Aquatic plants have been rare in historic surveys, likely as a result of stable high water levels, perturbation by carp, sediment suspension, and poor water clarity. The non-native plant, curly-leaf pondweed, was documented first in 1987, but has been at low levels since 1994 according to the Waterville Area Fisheries Office. No submerged plant species were sampled during the 2006 DNR transect survey; cattails were noted as extremely rare. There were efforts to reestablish submerged plants into Crystal Lake in 2008 through a direct planting. One Aquatic Plant Management permit was issued for a small algae treatment in 2014.

According to the 2006 DNR Fisheries survey, available spawning habitat was best suited for benthic omnivores such as common carp and black bullheads. Some habitat also exists for black crappie and probably channel catfish. Lack of submerged vegetation limits spawning opportunities for northern pike and high periphyton limits walleye and other lithophilic fishes.

Dredging was conducted in 1967 and 1968 to remove the buildup of sediment and deepen the lake near the inlet of County Ditch 56.

Water Quality: Lake Crystal is considered hypereutrophic based on the Carlson Trophic Status Index (TSI). Lake Crystal was listed on the 303d impaired waters list for excess nutrients in 2006 based on previous monitoring data and a toxic algae bloom in 2004 (MPCA Draft TMDL Report 2012). The lake has been sampled for water quality by MPCA and local partners regularly since 1988. Throughout the TMDL study in 2008-2009 Lake Crystal had an average total phosphorus concentration of 226 ppb, approximately two and half times the WCBP standard of 90 ppb, with 83% of the samples in exceedance. Lake Crystal chlorophyll values indicate severe nuisance algae levels occurring throughout the summer. Transparency has been stable from 1988-2011 (MPCA website).

Conclusion: Lake Crystal is a good candidate to be listed as impaired for the fish community. Some variables that measure human disturbance identified in this report appear to be contributing to the current status of the fish community. Potential stressors include poor water quality, high nutrient levels, and lack of aquatic habitat likely caused by land use within the watershed. The cumulative effects of multiple stressors can differ greatly from the sum of their independent effects. Simultaneous impacts by multiple stressors make it difficult to describe clear relationships between individual metrics and individual stressors, but several relationships are discussed below.

Modeling by Cross and Jacobson in Minnesota lakes suggests that total phosphorus concentrations increase significantly over natural concentrations when land use disturbances occur in greater than around 40% of the watershed area and this relationship tends to be stronger in shallow lakes (Cross and Jacobson, 2013). About 84% of the contributing watershed for Lake Crystal is disturbed, mostly in row agriculture.

Elevated nutrient concentrations stress fish and plant communities resulting in lower diversity of species and the dominance of pollutant tolerant fish species.

This listing supports MPCA's listing of Lake Crystal as impaired for nutrients (recreational use) and the associated TMDL recommendations. Lake Crystal and the surrounding watershed have completed Clean Water Partnership (CWP) Phase 1 (Diagnostic Study) and Phase Two (Implementation) projects through the MPCA and with several local cooperators. Additional monitoring was completed through the TMDL to assess the current water quality conditions and several models were used to identify sources of nutrient enrichment. The diagnostic study indicated that the major water quality concern is excess phosphorus from the rural portions of the watershed and a recommendation was made to focus on rural BMPs that would reduce nutrient and sediment transport to the lake, as rural sources contributed approximately 95% of the total phosphorus load.

Additionally, the TMDL report indicates substantial recycling of nutrients within the lake. A fish community dominated by carp and bullheads, along with the excess nutrient loads, contributes to the overall poor water quality through the re-suspension of sediments and phosphorus. Carp and bullheads can reduce water clarity by stirring up the lake bottom; a behavior that inhibits the growth of rooted aquatic vegetation and changes water chemistry. These increased levels of turbidity impact aquatic plant communities.

Shoreline development reduces the availability and quality of shoreline habitat, but shoreline disturbance on Crystal Lake is likely a relatively small contributor to the fish impairment. Dock density has been used as a measure of shoreline disturbance since dock placement is typically accompanied by riparian and nearshore habitat alteration. Dock density in Crystal Lake is about six docks per shoreline kilometer and DNR-Fisheries research indicates that somewhere between 10 to 20 docks per kilometer has been a breakpoint in several analyses where noticeable impacts to the lake are observed (Bacigalupi J., 2015 personal communication). Score the Shore survey protocols were developed by DNR-EWR in 2013 and adopted for use by DNR-Fisheries for the 2015 field season to assess riparian habitat. The scores from surveys completed statewide (185 surveys) have ranged from 37 to 99 with an average of 74. The lakewide average score on Crystal Lake was 71, with 12 of 43 stations scoring 100. The average lakewide shoreland development scores were much lower than scores related to disturbance on the immediate shoreline or in the nearshore aquatic zone indicating that efforts to reduce riparian impacts should likely focus on the shoreland – the upland area immediately adjacent to the lake.

Activities that protect, enhance, or restore watershed function and riparian habitat are the most beneficial to preserving the biological integrity of the fish community. Projects that buffer the lake from additional phosphorous loading should also be considered.

Lake Washington, 40-0117-00, LeSueur County

Impairment: Lake Washington was assessed as impaired for not meeting fish community expectations based on data from a 2013 nearshore survey and trapnet and gillnet data from a survey completed in 2011. The Fish IBI score (29) was well below the impairment threshold (45), and below the lower bound of the 90% confidence limit (36).

Biological Community:

Fish Community: Basin characteristics place Lake Washington in lake Class 24, which is scored with the Fish IBI for Group 2 lakes. Group 2 lakes are characterized as having areas of deep water, irregular shorelines, and hard water.

Two tolerant species were sampled but do not seem to dominate the fish community: Common Carp and Black Bullheads, while present, were sampled in low abundance (combined, 8% of gillnet and less than 1% of trapnet catch by biomass). Only one intolerant species was sampled – 33 Iowa Darters were sampled in the nearshore. The nearshore catches were dominated by Bluegill, Bluntnose Minnnow, and Black Crappie. In a lake of this size, the lack of intolerant cyprinids and only one intolerant species likely indicate subpar nearshore habitat and/or poor water quality. The dominant species, by biomass, sampled in both gillnets and trapnets was Freshwater Drum. Walleye and Yellow Bullheads were also common in the trapnets; Northern Pike and Walleye were also common in the gillnet catches.

Without historical information, it is impossible to say whether intolerant fish species have been lost from Lake Washington due to anthropogenic stressors. There are records of Blackchin Shiners, Mimic Shiners, and Logperch being sampled within the Minnesota River – Mankato watershed, and several additional intolerant species within the Greater Minnesota River Watershed that may have historically been present.

Fisheries management activities on Lake Washington have largely consisted of stocking fish and fish removal. Stocking records kept since 1908 indicate Crappies, Sunfish, Largemouth Bass, Northern Pike, Walleye, Smallmouth Bass, and White Sucker have been stocked at some point. In recent years, stocking has been limited to Walleye. Fish removal efforts included Bigmouth Buffalo, Bowfin, Bullheads, Common Carp, Freshwater Drum, Gar, and Quillback.

Plant Community: A tool to evaluate aquatic life use standards in lakes based on aquatic plant community data is currently being developed based on work by Radomski and Perleberg (2012). A point-intercept plant survey on Lake Washington was completed by DNR Fisheries in 2008. Nineteen aquatic plant species were sampled including 13 submerged species and the floristic quality index was 24. This scored above the thresholds for plant assessment (Radomski and Perleberg, 2012). Note that the Radomski and Perleberg plant community indices were designed to respond to nutrient impairment and resulting loss in water clarity and work continues to develop tools to describe impairments to the nearshore fringe plant community (emergent and/or floating-leaf).

Potential Stressors:

Watershed Disturbance: Lake Washington is located in the Shanaska Creek Watershed, which drains into the Minnesota River south of St. Peter. There are several lakes upstream of Lake Washington including Emily, George, Ballantyne, Duck, and Gilfillin. The water level of Lake Washington is controlled by a concrete structure. The outlet creek is intermittent. Shanasta Creek dam is located downstream of the lake and is likely a barrier to fish migration from the Minnesota River.

The contributing watershed for Lake Washington is about 5859 acres (the ratio of watershed to lake size is about 10:1). About 70% of the watershed land cover is disturbed: 65% cultivated, 5% developed (NLCD 2011). The percent of developed and cultivated land cover remained unchanged from

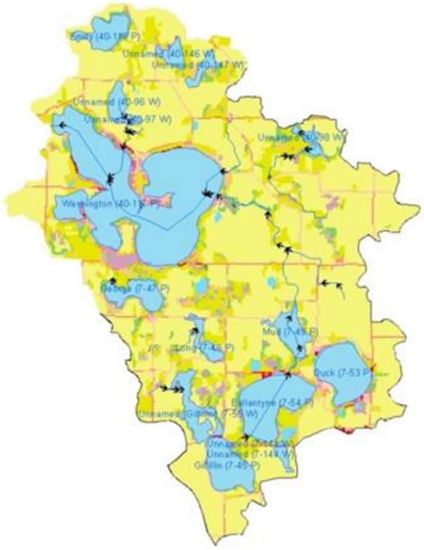
2001 – 2011 (NLCD). Corn was the most common crop type in most years from 2006-2014, and was present on 23-43% of the land within the contributing watershed. Few wetlands remain in the contributing watershed (about 4% of land), the percent of land cover reported as wetlands reduced slightly (from 4.27% in 2001 to 3.55% in 2011). About 20% of the contributing watershed is classified as water and 5% forest.

There are about 11 permitted feedlots in the contributing watershed (MNPCA Feedlots ArcGIS layer 4/2015). Homes around Lake Washington are connected to the Mankato wastewater treatment plant for sanitary sewer treatment.

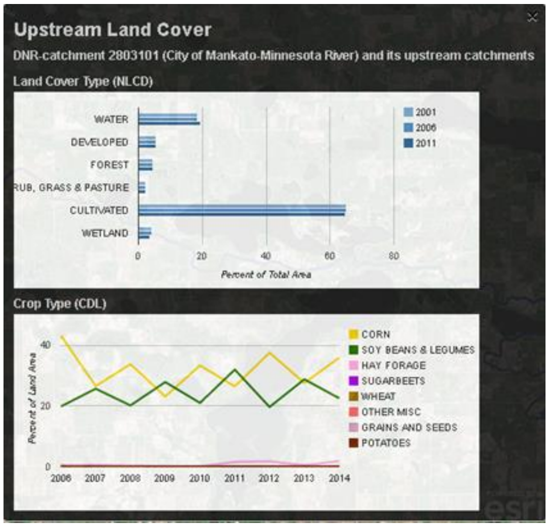
Photo Lake Washington Outlet

Photo Shanasta Creek dam

2011 NLCD Land Cover Classification



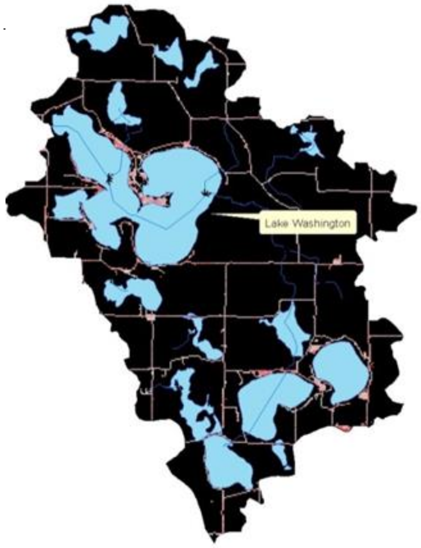
Contributing watershed land use and crop type



Impervious Cover, 2011 NLCD *Aerial Photo, FSA 2013*

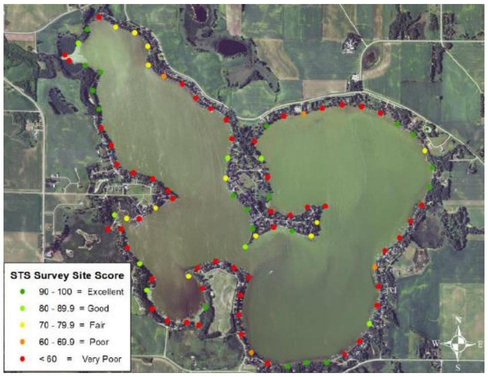
Riparian Disturbance: Lake Washington is an irregularly shaped lake with several points and bays. Publicly owned lakeshore includes a county owned park along northwest shore and two DNR public boat access sites. The remaining lakeshore has a range of residential development density that has resulted in about 274 docks, 14 per km of shoreline, based on analysis using aerial imagery (described in Beck et al. 2013). DNR-Fisheries research indicates that somewhere between 10 to 20 docks per kilometer has been a consistent breakpoint in several analyses where noticeable impacts to some sensitive nearshore fish species are observed (Bacigalupi J., 2015 personal communication). An assessment of riparian development was conducted in June 2015 following Score the Shore survey protocols and resulted in a mean lakeshore habitat score of 59.0 (scores range 0 – 100). Only 8% of sampled sites had coarse woody habitat noted. The Score the Shore survey score is comprised of scores for three zones: shoreland, shoreline, and aquatic. See tables below.

Land Use	Sample Size	Mean Lakeshore Habitat Score (0-100)	Rating
All Sites	96	59.0	Poor
Developed Sites	79	80.4	Good
[illegible]	[illegible]	[illegible]	

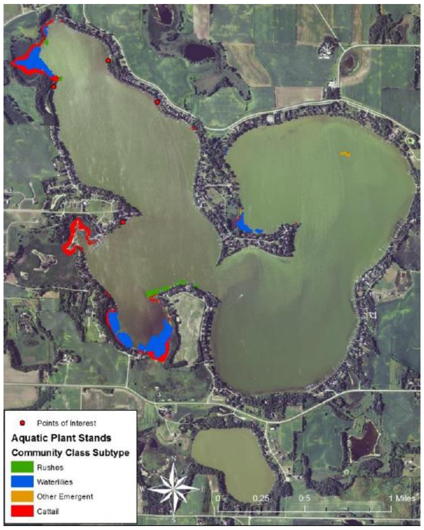


Zone	Sample Size	Mean Zone Habitat Score (0-33.3)	Rating
Shoreland	96	20.1	Fair
Shoreline	96	15.6	Poor
Aquatic	96	23.2	Fair

June 2015 Score the Shore Survey Map – Lake Washington



September 2015 Emergent and Floating Leaf Vegetation Map – Lake Washington

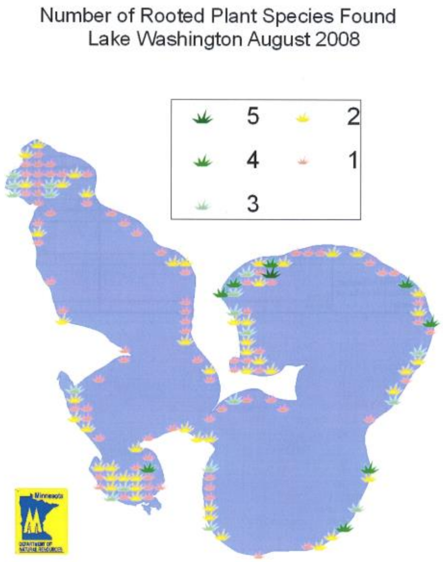


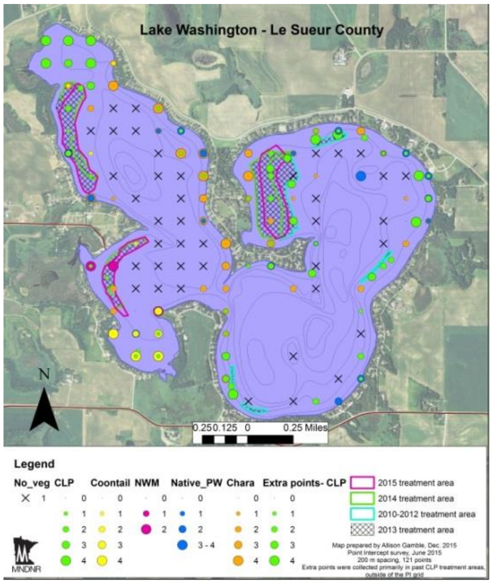
In-lake Habitat Disturbance:

Emergent and floating-leaf plant stands were surveyed in September 2015 by DNR-Fisheries. Cattail, waterlilies, bulrush, and other emergent are present along a relatively small portion of the shoreline. A review of aerial photos from the 1930s, 1950s, and 2000s show some change in the distribution of emergent fringe with losses noted particularly in the eastern arm of the lake.

A point-intercept survey of aquatic plants in August 2008 sampled plants out to 7 feet of depth. Thirteen submerged species or species groups were sampled, including some plant species that are noteworthy in southern Minnesota lakes: Chara (found at 34% of sites within 7 feet of depth), Clasping-leaf pondweed (13% of sites), White-stem pondweed (11% of sites), Wild celery (7% of sites), Water stargrass (6% of sites), and Floatingleaf pondweed (0.5% of sites). Filamentous algae were found at 33% of sites within 7 feet of depth.

2008 Point Intercept Survey Map *2015 Point Intercept Survey Map showing dominant plants and curly-leaf pondweed herbicide treatment area*





Curly-leaf pondweed has been a concern for lake residents in Lake Washington residents in that it tends to form mats across some areas of the lake. The non-native plant, curly-leaf pondweed had senesced by the August 2008 survey date therefore the survey is not a good representation of the distribution of the curly-leaf pondweed. Permits have been issued to the Lake Association for large herbicide treatments targeting areas of the lake with curly-leaf since 2001. Permit conditions require treatment only early in the spring to minimize damage to native plant species. The permitted areas have varied according to mapping conducted during the spring by DNR staff. Over the past 10 years, the permitted areas have varied from 43 acres in 2008 and 2009 to 105 acres in 2013.

In addition to the large herbicide treatments targeted toward offshore curly-leaf pondweed, permits are issued to a large number of riparian property owners for herbicide removal of all submerged vegetation across about half of their riparian frontage. From 2004-2014 about 10 acres/year were permitted annually adjacent to residential properties. The average overall percentage of the littoral zone (15’ or less) permitted for vegetation removal from 2004 – 2014 was 11%. However note that the vegetated zone during the 2008 survey was 7 feet and shallower, approximately 26% of areas shallower than 7 feet in depth was permitted annually for removal of submerged vegetation from 2004-2014.

Chemistry: Lake Washington was listed on the 303d impaired waters list for excess nutrients in 2007 based on water quality monitoring data. According to the MPCA website, data collected from 2004-2013 indicated the average secchi transparency was 1 meter, average chlorophyll A was 52 ppb, and average total phosphorus was 65 ppb – classifying the lake as eutrophic. Transparency has been stable or slightly increasing from 1976-2011 (MPCA website).

Conclusion: Lake Washington is a good candidate to be listed as impaired for fish IBI. This listing would support MPCA’s listing of Lake Washington as impaired for nutrients (recreational use). Potential stressors include poor water quality, high nutrient levels, substantial riparian habitat disturbance, and fragmented nearshore aquatic habitat. The cumulative effects of multiple stressors can differ greatly from the sum of their independent effects. Simultaneous impacts by multiple stressors make it difficult to describe clear relationships between individual metrics and individual stressors, but several relationships are discussed below.

Modeling by Cross and Jacobson in Minnesota lakes suggests that total phosphorus concentrations increase significantly over natural concentrations when land use disturbances occur in greater than around 40% of the watershed area and this relationship tends to be stronger in shallow lakes (Cross and Jacobson, 2013). About 70% of the contributing watershed for Lake Washington is disturbed, and has been since at least the 1930s per aerial photo review. Wetlands are rare in the contributing watershed (4%), although recently wetland restoration projects have been completed. Poor water quality caused by sediment delivery and resulting high nutrient levels is likely the primary stressor affecting the fish IBI score in Lake Washington.

The shoreline of Lake Washington is also heavily developed. The lakeshore habitat score of undeveloped sites is 80.4 vs. 54.3 on developed sites. The zone scores indicate that development practices are eliminating habitat in all three zones assessed on a lakewide basis. The immediate shoreline zone scored lowest and shoreline vegetation buffer restorations are advised. Note that eighteen percent of developed sites scored above 80, and another eighteen percent of sites were noted as undeveloped in Score the Shore survey. Efforts should be directed toward retaining the natural condition of the remaining undeveloped sections of shoreline and encouraging protection and restorations along the developed areas, particularly in areas with quality emergent and floating leaf aquatic vegetation.

The emergent and floating leaf vegetation is fragmented, and appears to be reduced in distribution per historical aerial photo review. Preserving remaining stands of emergent and floating leaf vegetation should be a high priority and restoration in appropriate areas could be considered. The submersed habitat is fragmented by herbicide removal of aquatic plants, but still supports a diverse species list, with several species uncommon in nearby lakes. Aquatic vegetation loss is frequently correlated with losses in fish species diversity (reviewed by Smokorowski &Pratt, 2007). Valley et al. (2010) found suggest that both controlling lake eutrophication and protecting refuge areas of dense aquatic plants and Chara may be needed to conserve intolerant shiner and banded killifish species.

Activities that protect, enhance, or restore watershed function and riparian habitat are the most beneficial to preserving the biological integrity of the fish community. Projects that reduce additional phosphorous loading should also be considered.

7.3 Appendix A3

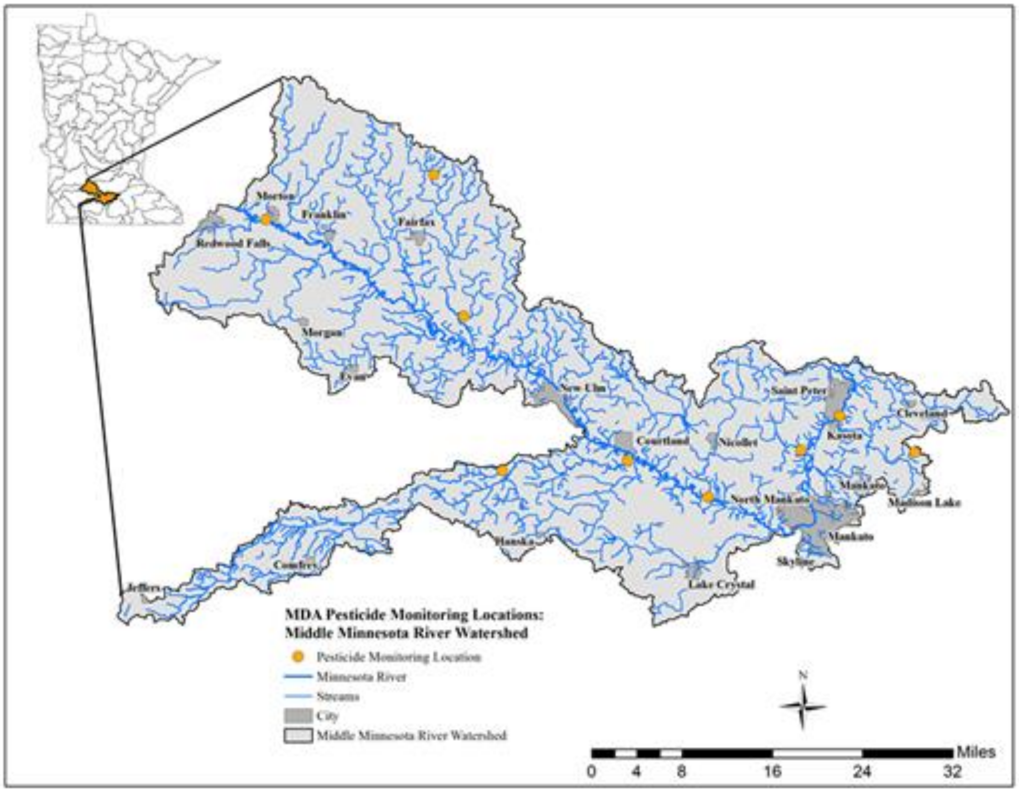
Pesticide Monitoring in the Middle Minnesota River Watershed

Prepared by David Tollefson and Matt Ribikawskis, MDA

The Minnesota Department of Agriculture (MDA) has been conducting pesticide monitoring in surface waters since 1991. Annually, the MDA completes approximately 1,000 sample collection events from rivers, streams, lakes, and wetlands across the state. In general, MDA analyzes water samples for pesticides that are widely used and/or pose the greatest risk to water resources. The purpose of MDA's pesticide monitoring program is to determine the presence and concentration of pesticides in Minnesota waters. Samples are collected statewide during the late spring and throughout the summer when the potential for pesticide movement is the greatest.

The MDA has conducted a large amount of pesticide monitoring in the Middle Minnesota River Watershed. Since 1999, the MDA has completed 491 pesticide sample collection events at nine locations within the Middle Minnesota River Watershed. Two locations have extensive pesticide water quality data: Minnesota River at Judson (S001-759; 220 sample collection events) and Seven Mile Creek (S002-937; 238 sample collection events). As of 2017, the Minnesota River at Judson is a Tier 2 monitoring location, and Seven Mile Creek is a Tier 3 monitoring location. Both of these locations will be monitored for several additional years. The Little Cottonwood River near Cambria (S001-377; 26 sample collection events) was monitored from 2002-2010. In addition, seven additional sample collection events occurred from six other locations in the Middle Minnesota River. Pesticide water quality monitoring locations in the Middle Minnesota River Watershed are presented in Figure 1. For more information regarding MDA's monitoring, please refer to http://www.mda.state.mn.us/monitoring.

Figure 1. Pesticide water quality monitoring locations in the Middle Minnesota Watershed.



Pesticides (including herbicides, fungicides, and insecticides) are considered potential stressors in the Middle Minnesota River Watershed due to the surrounding land use. Pesticide water quality results are presented in Table 1 below. Since 1999, a total of 42 different pesticide compounds have been detected in the watershed including 24 herbicides, 13 herbicide degradates, three fungicides, and two insecticides. When comparing water quality pesticide results to standards and reference values, duration of pesticide occurrence in a waterbody must be assessed in conjunction with the numeric result. For example, MPCA Class 2Bd Chronic Standards are developed with a duration exposure of four days (aquatic toxicity) or 30 (human health). Therefore, concentration data cannot solely be used for assessment. All of the data collected by MDA is reviewed annually by MPCA for the assessment of water quality standards. As of May 2017, Seven Mile Creek is impaired due to a single 2010 detection of chlorpyrifos, an organophosphate insecticide, above the Minnesota maximum standard. Chlorpyrifos has not been detected since 2010, delisting is being considered for the 2018 Impaired Waters List.

Of the 42 different pesticide compounds detected, chlorpyrifos (once in 2010) was the only pesticide detected above a Minnesota water quality standard. In addition, tebupirimfos (once in 2010) was detected above the EPA Chronic Value Aquatic Life Benchmark. Metolachlor ESA and metolachlor OXA were detected in 198% of samples, respectfully. Many pesticides have low detection frequencies, and many detections occur near the laboratory MRL and concentrations are extremely low when compared to applicable water quality reference values and standards (Table 1). Table 1 presents all compounds that were detected at a monitoring location within the Middle Minnesota River Watershed.

MDA will continue to conduct statewide pesticide monitoring in the future and will provide additional information related to the occurrence of pesticides in Minnesota surface waters.

Table 1. Middle Minnesota River Watershed Pesticide Water Quality Data (1999-2015).

Pesticide Name	Pesticide Type	Total Samples	Number of Detections	Detection Frequency (%)	Detection Concentration Distribution (ng/L)*					Water Quality Standards and/or Reference Values (ng/L)[1]			
					Median	75th Percentile	90th Percentile	95th Percentile	Maximum	MPCA Class 2Bd[5] Chronic Standard[3]	MPCA Maximum Standard[4]	EPA Acute Value Aquatic Life Benchmark (ng/L)[2]	EPA Chronic Value Aquatic Life Benchmark (ng/L)[2]
2,4-D	Herbicide	122	54	44%	nd	70	269	637	30,500	70,000 H	--	na	na
Acetochlor	Herbicide	487	278	57%	P (<50)	130	430	740	2,800	3,600 T	86,000 T	na	na
Acetochlor ESA	Degradate	98	92	94%	296	472	773	911	1,870	--	--	> 62,500,000 (i)	9,900,000 (n)
Acetochlor OXA	Degradate	98	62	63%	82	215	390	613	1,550	--	--	--	--
Alachlor	Herbicide	487	28	6%	nd	nd	nd	P (<50)	180	4,200 H; 59,000 T	800,000T	na	na
Alachlor ESA	Degradate	98	95	97%	147	229	357	392	560	--	--	>52,000,000(f)	–
Alachlor OXA	Degradate	98	3	3%	nd	nd	nd	nd	70	--	--	>47,500,000 (i)	–
AMPA	Degradate	30	3	10%	nd	nd	nd	P (<500)	P (<500)	--	--	249,5000,000 (f)	–
Atrazine	Herbicide	487	375	77%	50	146	590	977	10,000	3,400 H; 10,000 T	323,000T	na	na
Azoxystrobin	Fungicide	68	3	4%	nd	nd	nd	nd	32	--	--	130,000 (i)	44,000 (i)
Bentazon	Herbicide	99	15	15%	nd	nd	2	8	35	--	--	>50,000,000(f)(i)	4,500,000(n)
Chlorpyrifos	Insecticide	465	1	<1 %	nd	nd	nd	nd	240	41 H	83 T	na	na
Clopyralid	Herbicide	175	3	2%	nd	nd	nd	nd	60	--	--	56,500,000 (i)	–
Cyanazine	Herbicide	427	7	2%	nd	nd	nd	nd	670	--	--	--	--
Deisopropylatrazine	Degradate	486	45	9%	nd	nd	nd	P (<100)	290	--	--	8,500,000 (f)	2,500,000(n)

Pesticide Name	Pesticide Type	Total Samples	Number of Detections	Detection Frequency (%)	Detection Concentration Distribution (ng/L)*					Water Quality Standards and/or Reference Values (ng/L)[1]			
					Median	75th Percentile	90th Percentile	95th Percentile	Maximum	MPCA Class 2Bd[5] Chronic Standard[3]	MPCA Maximum Standard[4]	EPA Acute Value Aquatic Life Benchmark (ng/L)[2]	EPA Chronic Value Aquatic Life Benchmark (ng/L)[2]
Desethylatrazine	Degradate	487	304	62%	P (<50)	60	110	147	390	--	--	–	1,000,000(n)
Dicamba	Herbicide	119	18	15%	nd	nd	P (<120)	373	700	--	--	14,000,000 (f)	61,000 (n)
Dimethenamid	Herbicide	486	193	40%	nd	P (<50)	130	210	2,000	--	--	3,150,000 (f)	5,100 (v)[6]
Dimethenamid ESA	Degradate	98	64	65%	17	40	70	80	120	--	--	–	–
Dimethenamid OXA	Degradate	98	18	18%	nd	nd	18	29	65	--	--	–	–
EPTC	Herbicide	486	1	<1 %	nd	nd	nd	nd	P (<230)	--	--	3,250,000 (i)	800,000 (i)
Ethofumesate	Herbicide	115	2	2%	nd	nd	nd	nd	68	--	--	8,750,000 (i)	300,000 (i)
Flumetsulam	Herbicide	44	12	27%	nd	51	73	83	136	--	--	127,000,000(i)	3,100 (v)
Glyphosate	Herbicide	30	6	20%	nd	nd	nd	1,000	1,000	--	--	21,500,000 (f)	1,800,000 (f)
Hydroxyatrazine	Degradate	69	55	80%	16	23	46	55	636	--	--	> 1,500,000 (f)	>10,000,000(n)
Imazethapyr	Herbicide	69	21	30%	nd	7	14	27	109	--	--	120,000,000(f)	59,200,000 (n)
MCPA	Herbicide	122	1	1%	nd	nd	nd	nd	10	--	--	90,000 (i)	20,000 (v)
MCPP	Herbicide	119	1	1%	nd	nd	nd	nd	57	--	--	>45,500,000(i)	14,000 (n)
Mesotrione	Herbicide	66	2	3%	nd	nd	nd	nd	78	--	--	> 60,000,000 (f)	9,800 (v)
Metalaxyl	Fungicide	69	2	3%	nd	nd	nd	nd	11	--	--	14,000,000 (i)	100,000 (i)
Metolachlor	Herbicide	487	390	80%	70	220	652	1,311	6,650	23,000 T	271,000T	na	na
Metolachlor ESA	Degradate	98	98	100 %	1,280	1,710	2,141	2,532	4,370	--	--	24,000,000 (f)	>95,100,000(v)

Pesticide Name	Pesticide Type	Total Samples	Number of Detections	Detection Frequency (%)	Detection Concentration Distribution (ng/L)*					Water Quality Standards and/or Reference Values (ng/L)[1]			
					Median	75th Percentile	90th Percentile	95th Percentile	Maximum	MPCA Class 2Bd[5] Chronic Standard[3]	MPCA Maximum Standard[4]	EPA Acute Value Aquatic Life Benchmark (ng/L)[2]	EPA Chronic Value Aquatic Life Benchmark (ng/L)[2]
Metolachlor OXA	Degradate	98	88	90%	143	240	528	726	1,520	--	--	7,700,000 (i)	57,100,000 (n)
Metribuzin	Herbicide	393	12	3%	nd	nd	nd	nd	550	--	--	2,100,000 (i)	8,700 (n)
Metribuzin DA	Degradate	336	1	<1 %	nd	nd	nd	nd	1,010	--	--	--	--
Pendimethalin	Herbicide	465	2	<1 %	nd	nd	nd	nd	140	--	--	69,000 (f)	5,200 (n)
Prometon	Herbicide	331	3	1%	nd	nd	nd	nd	P (<100)	--	--	6,000,000 (f)	98,000 (n)
Propazine	Herbicide	331	4	1%	nd	nd	nd	nd	P (<500)	--	--	>2,660,000 (i)	24,800 (n)
Saflufenacil	Herbicide	68	15	22%	nd	nd	32	50	155	--	--	> 49,000 ,000(f)	42,000 (n)
Simazine	Herbicide	444	1	<1 %	nd	nd	nd	nd	P (<500)	4,000 H	4,000 H	500,000 (i)	2,240 (n)
Tebupirimfos	Fungicide	370	1	<1 %	nd	nd	nd	nd	100	--	--	39 (i)	11 (i)
Thiamethoxam	Insecticide	68	4	6%	nd	nd	nd	20	53	--	--	17,500 (i)	20,000,000 (f)

*nd=non-detect or not detected above the method reporting limit.

P (< *MRL*) = concentration listed as being present but below the method reporting limit

Key to value types and symbols in surface water reference values

– – For some analytes, reference values have not been identified or evaluated

na – not applicable

(f) – USEPA/OPP benchmark value for fish.

(i) – USEPA/OPP benchmark value for invertebrates.

(n) – USEPA/OPP benchmark value for nonvascular plants

(v) – USEPA/OPP benchmark value for vascular plants.

H – “H” Chronic Standard values are human health-based and protective for an exposure duration of 30 days.

T – “T” Chronic Standard values are toxicity-based for aquatic organisms and protective for an exposure duration of 4 days.

[1] **Reference Values** are given for all detected target and non-target analytes. They are also given for non-detected target analytes when a reference value is available. Other non-detected analytes do not have an available reference value from the sources listed below.

[2] **Aquatic Life Benchmarks** based on toxicity values derived from data available to the USEPA OPP supporting registration of the pesticide are provided only when an MPCA value is not available. Current values posted by the USEPA's OPP may differ from those of previous MDA reports. See USEPA's web site for more detailed information and definitions.

[3] **Chronic Standard** as defined in Minn. Rule Chap. 7050. "H" value is human health-based and is protective for an exposure duration of 30 days. Human health-based values are shown only when they are less than toxicity-based values. "T" value is toxicity-based for aquatic organisms and is protective for an exposure duration of 4 days.

[4] **Maximum Standard Value for Aquatic Life & Recreation** as defined on MPCA's web site and Minn. R. ch. 7050. Values are the same for all classes of surface waters.

[5] **State Water Classification for aquatic life** (2B – sport and commercial; 2C – non-commercial; 2D – wetlands) & recreation (2B – all types; 2C,D – limited types). Not protected as drinking water sources.

[6] **For the Dimethenamid Chronic Value,** the MPCA has calculated a non-promulgated criterion for aquatic plants using two point estimates of toxicity to the vascular plant duckweed.

Minnesota water quality standards

Since 1985, MDA and Minnesota Department of Health have been monitoring the concentrations of common pesticides in groundwater near areas of intensive agricultural land-use. In 1991, these monitoring efforts were expanded to include surface water monitoring sites on select lakes and streams. To learn more about the MDA pesticide monitoring plan and results, refer to the following website: http://www.mda.state.mn.us/protecting/cleanwaterfund/pesticidemonitoring.aspx.

Surface water reference values (text from MDA, 2010)

The MPCA has developed toxicity-based (for aquatic life) or human health-based enforceable chronic standards for pollutants detected in surface water. The toxicity-based standard is designed to be protective of aquatic life exposure, and is typically based on exposure duration of four days. The human health-based standard (protective for drinking water plus fish consumption) is based on exposure duration of 30 days. For the most current MPCA water quality rules see Chapter 7050: Standards for Protection of Waters of the State (www.revisor.leg.state.mn.us/rules/?id=7050). A summary of MPCA's chronic and maximum standard values for common pesticides used in Minnesota are shown in Table 2.

Table 2. Summary of MPCA Toxicity Based Surface Water Standards Associated with Target Pesticide Analytes – Chronic[1] and Maximum[2] Standards

Pesticide Analyte	Class 2A[1] (ng/L)	Class 2B[1] (ng/L)	Maximum Standard[2] (ng/L)
Acetochlor	3,600	3,600	86,000
Alachlor	59,000	59,000	800,000
Atrazine	10,000	10,000	323,000
Chlorpyrifos	41	41	83
Metolachlor	23,000	23,000	271,000

Pesticides as a Biological Stressor in Minnesota Watersheds

The presence and concentrations of pesticides detected in a Minnesota watershed have been presented in the above tables. The presence and detection frequency of pesticides in surface waters is reason for concern. Although individual pesticide toxicity has been determined for many pesticides, there is concern that the biological effects of various combinations of pesticides under varying environmental conditions are less understood.

With the exception of a single chlorpyrifos detection in 2010, results above indicate that at this time there are no pesticide concentrations exceeding an applicable standard for aquatic toxicity and therefore no direct evidence that concentrations are high enough to cause known impacts to sensitive aquatic life. This does not mean that pesticides are not acting as stressors, only that the existing monitoring data does not implicate a pesticide as a likely stressor. Extensive chlorpyrifos monitoring since 2010 has not resulted in additional chlorpyrifos detection(s).

The MDA monitoring program targets watersheds with landuses dominated by agriculture and collects samples during storm flow periods when pesticide concentrations are likely to be highest. The MDA operates one of the largest state level pesticide monitoring efforts in the nation. With this said, in order to document the potential contribution of pesticides to stream biology impacts, one would have to design a site-specific study that, among other factors, simultaneously looked at pesticide application timetables while measuring pesticide concentration in adjacent water bodies, complete water chemistry (including the presence of other toxins), water temperature, and fluctuations in hydrology and biological diversity. The study would need to ascertain how the chemical is entering the water, the exposure time, and look for impacts to sensitive organisms. This work has not been performed and is not currently anticipated.