Rock River Watershed Biotic Stressor Identification Report

Minnesota Pollution Control Agency

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Cover photo: Top: Rock River at site 11MS001, Lower Right: North Branch Chanarambie Creek at site 11MS123, Lower Left: Unnamed Creek at site 11MS096

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Executive summary

The purpose of stressor identification is to explain the results of the biological monitoring and assessment process. The information obtained answers the questions of why one stream has a low index of biological integrity (IBI) score, while another has a high score. It looks at causal factors – negative ones harming fish and insects, and positive ones leading to healthy biology. Stressors may be physical, chemical, or biological.

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 (EPA, 2000). In simpler terms, it is the process of identifying the major factors causing harm to fish and other river and stream 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 Rock River Watershed. Located in southwest Minnesota, the Rock River Watershed encompasses approximately 582,106 acres within the state of Minnesota. This watershed includes many large and small tributaries to the Rock River.

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 rivers and streams. The basic approach is to look at fish and aquatic macroinvertebrates (mostly insects), and related habitat conditions, at sites throughout a major watershed. The resulting information is used to produce an IBI. Index of biological integrity scores can then be compared to a range of regionally developed thresholds. The regional thresholds were developed to maintain a healthy community of aquatic life and meet water quality standards. Stream and river reaches are assigned an Assessment Unit Identification (AUID) number and will be referred to as the AUID in this report. AUIDs with low IBI scores are determined to have a biological impairment.

This report analyzed the biological impairments in thirteen subwatersheds within the Rock River Watershed. After examining many candidate causes for the biological impairments, the following stressors were identified in their respective subwatershed (Table 1).

Table 1: Stressors to the biologically impaired reaches within the Rock River Watershed

Stream Name	AUID #	Stressors				
		Low Dissolved Oxygen	High Phosphorus	High Nitrates	High Turbidity/TSS	Lack of Habitat
Ash Creek Watershed						
Ash Creek	10170204-539	•	•	•		•
Champepadan Creek Watershed						
Champepadan Creek	10170204-520	-	•	•	•	-
Unnamed Creek	10170204-583		•	•		-
Chanarambie Creek Watershed						
Chanarambie Creek	10170204-522	-	•	•	•	-
North Branch Chanarambie Creek	10170204-560	-	•	•	-	-
Unnamed Creek	10170204-559			•		•
East Branch Rock River Watershed						
East Branch Rock River	10170204-530		•	-		•
Elk Creek Watershed						
Elk Creek	10170204-519	-	•	•	-	-
Kanaranzi Creek Watershed						
Kanaranzi Creek	10170204-517	-	•	•	•	•
Kanaranzi Creek	10170204-516	-	•	•	-	•
Kanaranzi Creek	10170204-515		•	•	•	•
East Branch Kanaranzi Creek	10170204-514	-	•	•	•	•
Little Rock River Watershed						
Little Rock River	10170204-513	-	•	•	•	•
Little Rock River	10170204-512	-	•	•	•	•
Little Rock Creek	10170204-511	-	•	•	•	•
Unnamed Creek	10170204-579	-	•	•	-	-
Lower Rock River Watershed						
Rock River	10170204-501	-	-	•	•	-
Rock River	10170204-509	-	•	•	•	-
Rock River	10170204-508	-	•	•	•	-

Lower Rock River Watershed						
Rock River	10170204-501	-	-	•	•	-
Rock River	10170204-509	-	•	•	•	-
Rock River	10170204-508	-	•	•	•	-
Mud Creek Watershed						
Mud Creek	10170204-525	•	-	•	•	•
Poplar Creek Watershed						
Poplar Creek	10170204-523	-	•	•	•	-
Unnamed Creek	10170204-588	•	•	•	•	•
Unnamed Creek	10170204-589		•	•	•	-
Town of Leota-Rock River Watershed						
Unnamed Creek	10170204-571	-	•	•	-	•
Unnamed Creek	10170204-572		•	•	-	-
Upper Rock River Watershed						
Rock River	10170204-506	-	•	•	•	•
Rock River	10170204-504	-	•	•	•	•
City of Edgerton-Rock River Watershed						
Unnamed Creek	10170204-593	-		•	•	•

(• = stressor, - = not a stressor, and blank = inconclusive/not enough evidence)

Introduction

Monitoring and assessment

As part of the MPCA's intensive Watershed monitoring (IWM) approach, monitoring activities increased in rigor and intensity during the years of 2011-2012, 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 dated back until 2001, were used to identify stream reaches that were not supporting healthy fish and macroinvertebrate assemblages (Figure 1).

Once a biological impairment is discovered, the next step is to identify the source(s) of stress on the biological community. A 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). The product of the SID process is the identification of the stressor(s) for which the TMDL may be developed. In other words, the SID process may help investigators nail down excess fine sediment as the cause of biological impairment, but a separate effort is then required to determine the TMDL and implementation goals needed to restore the impaired condition.

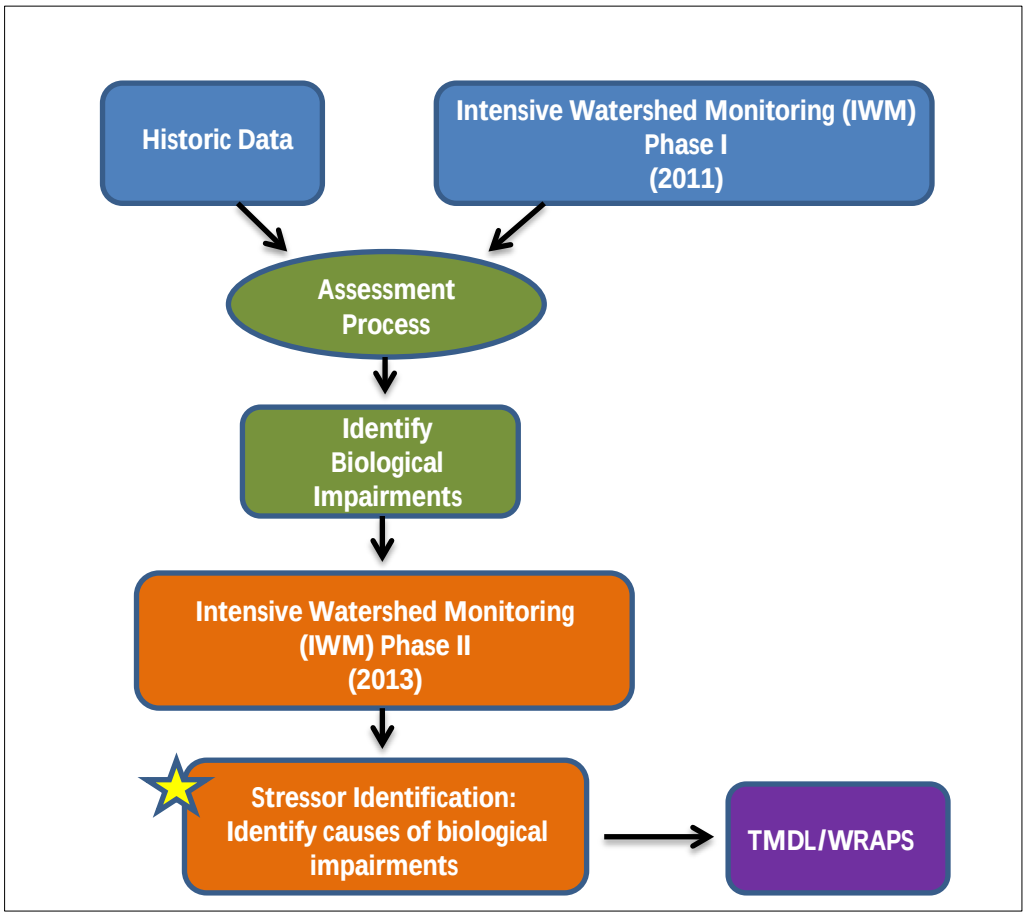

Figure 1: Process map of IWM, assessment, SID, and TMDL processes

Stressor identification process

The SID process is used in this report to weigh evidence for or against various candidate causes of biological impairment (see Cormier et al., 2000). The SID process is prompted by biological assessment data indicating that a biological impairment has occurred. Through a review of available data, stressor scenarios are developed that may accurately characterize the impairment, the cause, and the sources/pathways of the various stressors (Figure 2). Confidence in the results often depends on the quality of data available to the SID process. In some cases, additional data collection may be necessary to accurately identify the stressor(s).

Stressor identification draws upon a broad variety of disciplines, such as aquatic ecology, geology, geomorphology, chemistry, land-use analysis, and toxicology. Strength of evidence (SOE) analysis is used to develop cases in support of, or against various candidate causes. Typically, the majority of the information used in the SOE analysis is from the study watershed, although evidence from other case studies or scientific literature can also be drawn upon in the SID process.

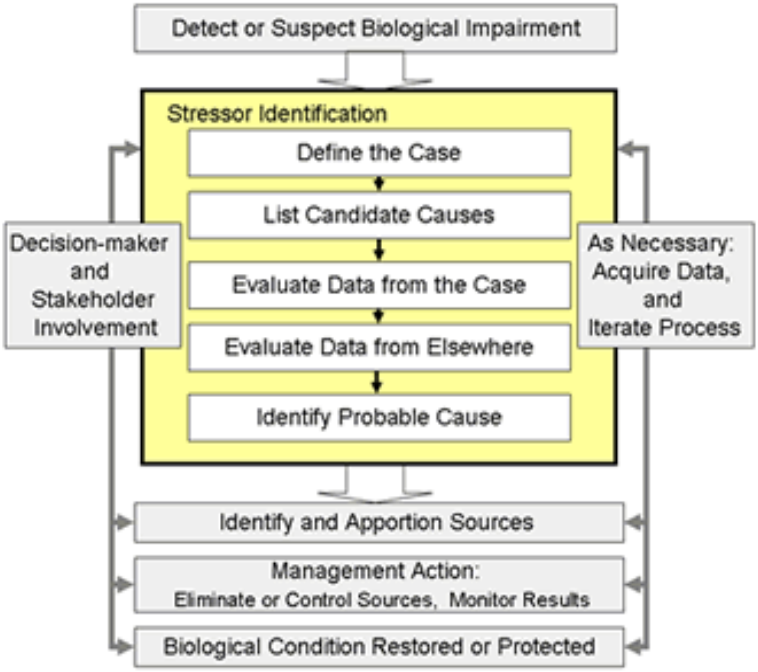

Figure 2: Conceptual model of stressor identification (SID) process

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 2 lists the common stream stressors to biology relative to each of the major stream health categories.

Table 2: 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. Stream temperatures also become elevated due to lack of shade.
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 Channel Assessment	**Loss of Habitat due to excess sediment** **Elevated levels of TSS** · 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.
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.

Report format

This report follows a format to first summarize candidate causes of stress to the biological communities at the 8-digit HUC scale. Within the summary, there is information about how the stressor relates broadly to the Rock River Watershed, water quality standards and general effects on biology. After that section, the report is organized into six different subwatersheds. Each biological impairment within the subwatersheds is evaluated and discussed in further detail.

Overview of Rock River Watershed

Background

The Rock River Watershed consists of27- 12-digit Hydrologic Unit Code (HUC) subwatersheds (Figure 3). The Rock River Watershed encompasses approximately 582,106 acres within the state of Minnesota. This area includes the cities or villages of Luverne, Edgerton, Adrian, Hills, Kanaranzi among others. Land use in the watershed consists mainly of cropland (80.53%), followed by rangeland (10.99%), and developed land (6.25%).

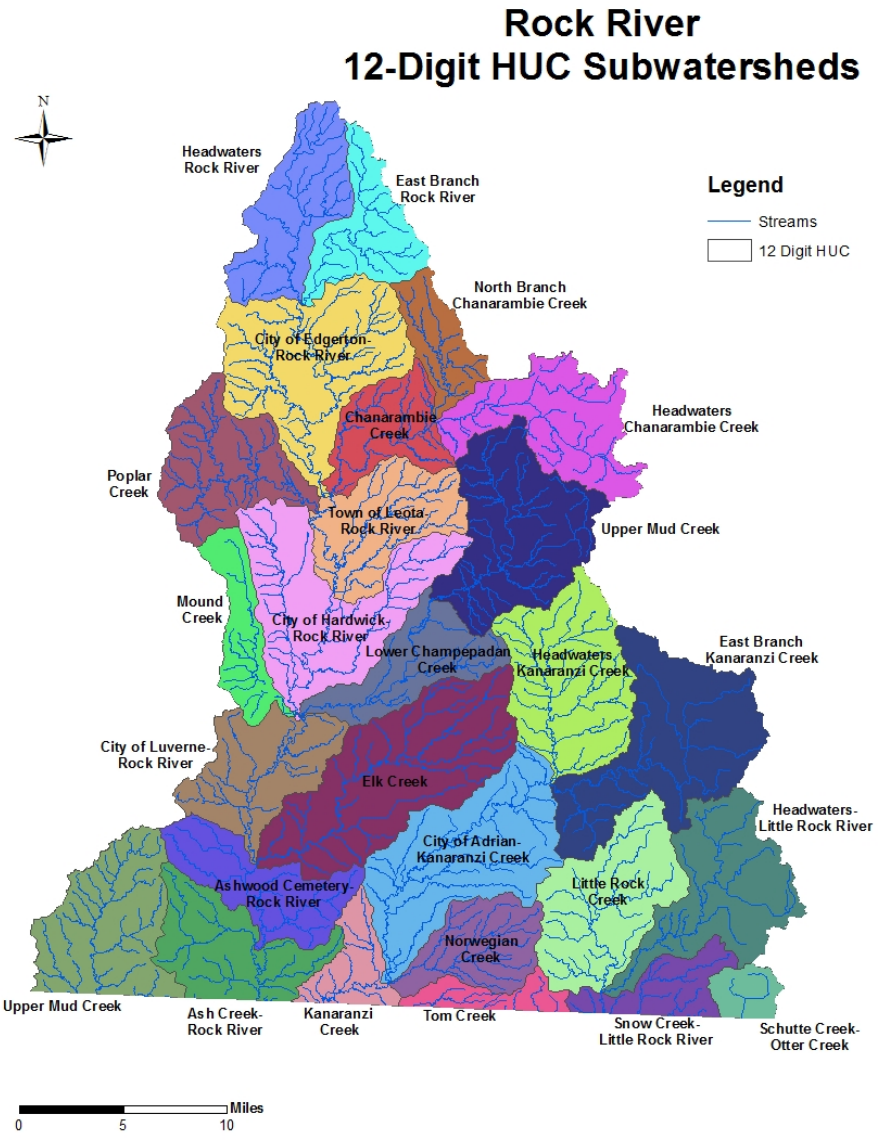

Figure 3: The 12-HUC subwatersheds in the Rock River Watershed

Monitoring overview

In 2011-2012, IWM was performed in the Rock River Watershed. This sampling effort included 89 biological monitoring sites. Biological monitoring and water chemistry data from these sites as well as data from other water monitoring stations taken within 10 years of the biological monitoring were used to assess the conditions of the Rock River Watershed. The watershed assessment for this area occurred in 2013. Figure 4 displays all of the biological monitoring stations and the biological impairments that exist in the watershed.

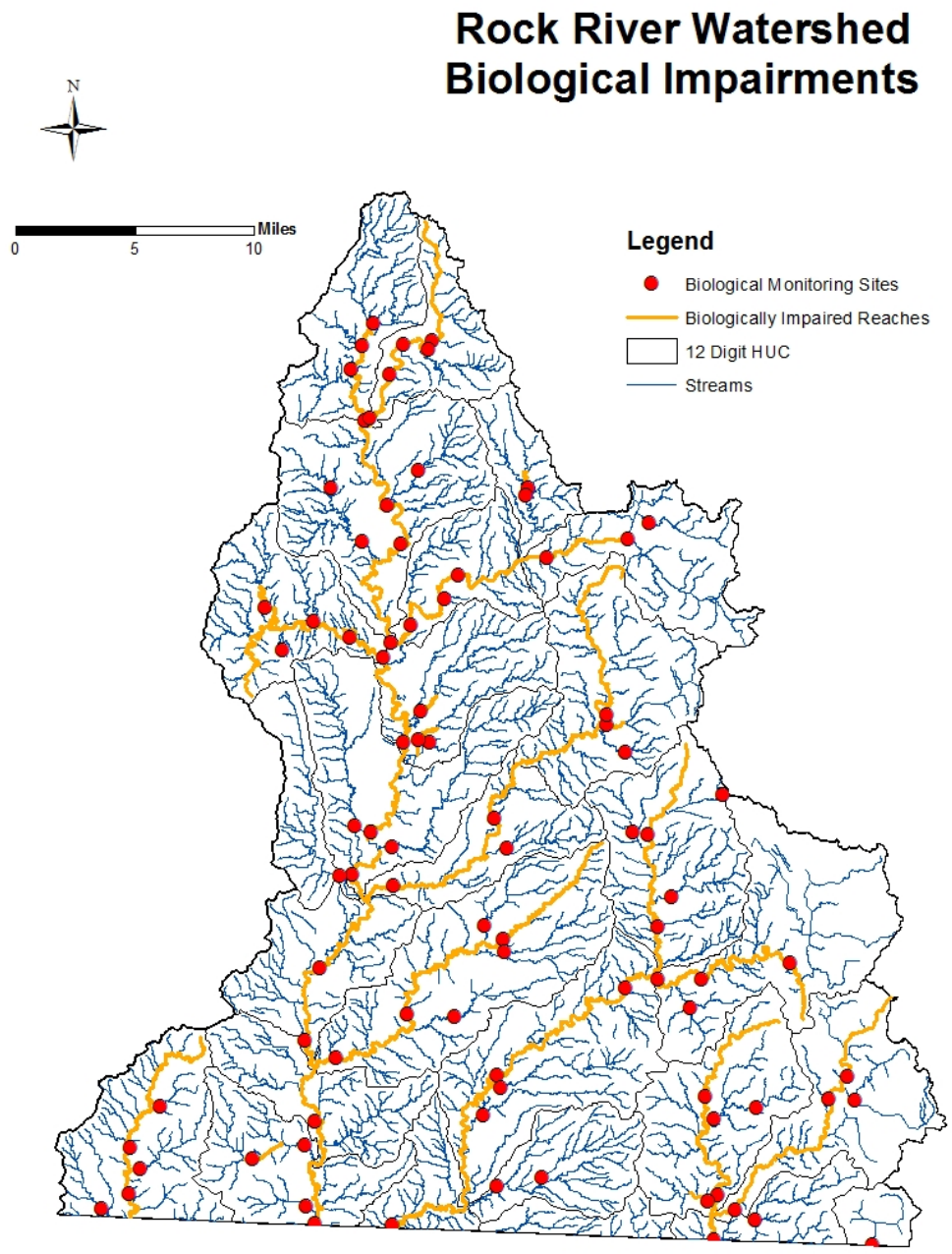

Figure 4: Biological monitoring stations and biological impairments in the Rock River Watershed

Summary of biological impairments

The approach used to identify biological impairments includes monitoring of fish and aquatic macroinvertebrates communities and related habitat conditions at sites throughout a watershed. The resulting information is used to develop an IBI. The IBI scores can then be compared to a range of regionally developed thresholds. For further descriptions of the fish and macroinvertebrate IBI class criteria, please see Appendices 1.1-2.

The fish and macroinvertebrates within each 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. Intensive watershed monitoring scores provide a measurement tool to assess the health of the aquatic communities. Intensive watershed monitoring 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 Rock River Watershed, 27 AUIDs are currently impaired for a lack of biological assemblage (Table 3).

Table 3: Biologically impaired AUIDs in the Rock River Watershed

Rock River Watershed				Impairments	
Stream Name	**AUID #**	**HUC-12**	**Reach Description**	**Biological**	**Water Quality**
Rock River	10170204-501	101702040305 to 101702040306	Elk Cr to MN/IA border	Macroinvertebrate IBI, Fish IBI	Turbidity
Rock River	10170204-504	101702040102 to 101702040106	T107 R44W S30, east line to Chanarambie Cr	Macroinvertebrate IBI, Fish IBI	Turbidity
Rock River	10170204-506	101702040108 to 101702040110	Poplar Cr to Unnamed cr	Macroinvertebrate IBI, Fish IBI	Turbidity
Rock River	10170204-508	101702040110	Unnamed cr to Champepadan Cr	Macroinvertebrate IBI, Fish IBI	Turbidity
Rock River	10170204-509	101702040304	Champepadan Cr to Elk Cr	Macroinvertebrate IBI, Fish IBI	Turbidity
Little Rock Creek	10170204-511	101702040601	Headwaters to Little Rock R	Macroinvertebrate IBI	Turbidity
Little Rock River	10170204-512	101702040602	Headwaters to Little Rock Cr	Macroinvertebrate IBI, Fish IBI	Turbidity
Little Rock River	10170204-513	101702040603	Little Rock Cr to MN/IA border	Macroinvertebrate IBI, Fish IBI	Turbidity
Kanaranzi Creek, East Branch	10170204-514	101702040201	Headwaters to Kanaranzi Cr	Macroinvertebrate IBI, Fish IBI	Turbidity
Kanaranzi Creek	10170204-515	101702040202	Headwaters to E Br Kanaranzi Cr	Macroinvertebrate IBI, Fish IBI	

Kanaranzi Creek	10170204-516	101702040204	E Br Kanaranzi Cr to Norwegian Cr	Macroinvertebrate IBI, Fish IBI	
Kanaranzi Creek	10170204-517	101702040205	Norwegian Cr to MN/IA border	Macroinvertebrate IBI, Fish IBI	Turbidity
Elk Creek	10170204-519	101702040303	Headwaters to Rock R	Macroinvertebrate IBI, Fish IBI	Turbidity
Champepadan Creek	10170204-520	101702040301 to 101702040302	Headwaters to Rock R	Macroinvertebrate IBI, Fish IBI	Turbidity
Chanarambie Creek	10170204-522	101702040104 to 101702040105	Headwaters to Rock R	Macroinvertebrate IBI, Fish IBI	Turbidity
Poplar Creek	10170204-523	101702040107	Headwaters to Rock R	Macroinvertebrate IBI, Fish IBI	Turbidity
Mud Creek	10170204-525	101702040401	Headwaters to MN/IA border	Macroinvertebrate IBI, Fish IBI	
Rock River, East Branch	10170204-530	101702040101	Headwaters to Rock R	Macroinvertebrate IBI	
Ash Creek	10170204-539	101702040306	Unnamed cr to Unnamed cr	Macroinvertebrate IBI, Fish IBI	
Unnamed creek	10170204-559	101702040103	Unnamed cr to N Br Chanarambie Cr	Macroinvertebrate IBI	
North Branch Chanarambie Creek	10170204-560	101702040103	Unnamed cr to Unnamed cr	Macroinvertebrate IBI	
Unnamed creek	10170204-571	101702040108	Unnamed cr to Unnamed cr	Macroinvertebrate IBI	
Unnamed creek	10170204-572	101702040108	Unnamed cr to Unnamed cr	Macroinvertebrate IBI	
Unnamed creek	10170204-579	101702040601	Unnamed cr to Little Rock Cr	Macroinvertebrate IBI	
Unnamed creek	10170204-583	101702040301	Unnamed cr to Champepadan Cr	Macroinvertebrate IBI	
Unnamed creek	10170204-588	101702040107	Unnamed cr to Poplar Cr	Macroinvertebrate IBI, Fish IBI	
Unnamed creek	10170204-589	101702040107	Unnamed cr to Poplar Cr	Macroinvertebrate IBI	
Unnamed creek	10170204-593	101702040106	Unnamed cr to T106 R45W S25, south line	Macroinvertebrate IBI, Fish IBI	

For further information regarding the fish and macroinvertebrate classes, their respective thresholds, and the IBI scores of all sites within the Rock River Watershed, please see the Missouri River Basin Monitoring and Assessment Report.

Hydrological Simulation Program - FORTRAN (HSPF) Model

The Hydrological Simulation Program - FORTRAN (HSPF) is a comprehensive package for simulation of watershed hydrology and water quality for both conventional and toxic organic pollutants. HSPF incorporates watershed-scale Agricultural Runoff Model (ARM) and Non-Point Source (NPS) models into a basin-scale analysis framework that includes fate and transport in one dimensional stream channels. It is the only comprehensive model of watershed hydrology and water quality that allows the integrated simulation of land and soil contaminant runoff processes with in-stream hydraulic and sediment-chemical interactions. The result of this simulation is a time history of the runoff flow rate, sediment load, and nutrient and pesticide concentrations, along with a time history of water quantity and quality at the outlet of any subwatershed. HSPF simulates three sediment types (sand, silt, and clay) in addition to a single organic chemical and transformation products of that chemical.

The HSPF watershed model contains components to address runoff and constituent loading from pervious land surfaces (PERLNDs), runoff and constituent loading from impervious land surfaces (IMPLNDs), and flow of water and transport/transformation of chemical constituents in stream reaches (RCHRESs). Primary external forcing is provided by the specification of meteorological time series. The model operates on a lumped basis within subwatersheds. Upland responses within a subwatershed are simulated on a per-acre basis and converted to net loads on linkage to stream reaches. Within each subwatershed, the upland areas are separated into multiple land use categories.

The HSPF watershed model was run for the Rock River Watershed to help simulate outputs used for analysis. In this report, the minor watersheds with biological impairments used the model results to supplement information that was not collected.

Candidate causes

Candidate cause: Low dissolved oxygen

Dissolved oxygen (DO) refers to the concentration of oxygen gas within the water column. Low or highly fluctuating concentrations of DO can have detrimental effects on many fish and macroinvertebrate species (Davis, 1975; Nebeker et al., 1991). Dissolved oxygen concentrations change seasonally and daily in response to shifts in ambient air and water temperature, along with various chemical, physical, and biological processes within the water column. If DO concentrations become limited or fluctuate dramatically, aerobic aquatic life can experience reduced growth or fatality (Allan, 1995). Some macroinvertebrates that are intolerant to low levels of DO include mayflies, stoneflies, and caddisflies (Marcy, 2007). Many species of fish avoid areas where DO concentrations are below 5 mg/L (Raleigh et al., 1986). Additionally, fish growth rates can be significantly affected by low DO levels (Doudoroff and Warren, 1965).

In most streams and rivers, the critical conditions for stream DO usually occur during the late summer season when water temperatures are high and stream flows are reduced to baseflow. As temperatures increase, the saturation levels of DO decrease. Increased water temperature also raises the DO needs for many species of fish (Raleigh et al., 1986). Low DO can be an issue in streams with slow currents, excessive temperatures, high biological oxygen demand, and/or high groundwater seepage (Hansen, 1975).

Water quality standards

In Class 2B streams, the Minnesota standard for DO is 5.0 mg/L as a daily minimum. Additional stipulations have been recently added to this standard. The following is from the *Guidance Manual for Assessing the Quality of Minnesota Surface Waters (MPCA, 2009)*:

> *Under revised assessment criteria beginning with the 2010 assessment cycle, the DO standard must be met at least 90 percent of the time during both the 5-month period of May through September and the 7-month period of October through April. Accordingly, no more than 10 percent of DO measurements can violate the standard in either of the two periods.*
>
> *Further, measurements taken after 9:00 in the morning during the 5-month period of May through September are no longer considered to represent daily minimums, and thus measurements of > 5 DO later in the day are no longer considered to be indications that a stream is meeting the standard.*
>
> *A stream is considered impaired if 1) more than 10 percent of the "suitable" (taken before 9:00) May through September measurements, or more than 10 percent of the total May through September measurements, or more than 10 percent of the October through April measurements violate the standard, and 2) there are at least three total violations.*

Types of dissolved oxygen data

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 YSI sonde. Because DO concentrations can vary significantly as a result of changing flow conditions and time of sampling, instantaneous measurements need to be used with caution and are not completely representative of the DO regime at a given site.

Diurnal (continuous)

A YSI sonde was deployed for 14 day intervals at one location in the Rock River Watershed in late summer to capture diurnal fluctuations over the course of a number of diurnal patterns. This information was then used to look at the diurnal flux of DO along with the patterns of DO fluctuation. Hieskary et al. (2010) observed several strong negative relationships between fish and macroinvertebrate metrics and DO flux. Their study found that a diurnal (24 hour) DO flux over 4.5 mg/L reduced macroinvertebrate taxa richness and the relative abundance of sensitive fish species in a population.

Overview of dissolved oxygen in the Rock River Watershed

Dissolved oxygen was measured throughout the watershed. Continuous DO monitoring was performed in just Kanaranzi Creek. This reach did not have a daily flux greater than 4.5 mg/L.

Unfortunately, due to vast numbers of biological impairments in this watershed and in the entire Missouri basin, continuous DO monitoring could not feasibly be done at all impaired reaches. Frequent DO monitoring was performed along these reaches instead. This monitoring found some DO values as high as 20 mg/L in Unnamed Creek (10170204-572) and as low as 2.86 mg/L in Ash Creek. This data, along with the modeling data and biological responses will be used to determine the degree of stress DO is having on the impaired reach.

Sources and causal pathways for low dissolved oxygen

Dissolved oxygen concentrations in lotic environments are often driven by a combination of natural and anthropogenic factors. Natural background characteristics of a watershed, such as topography, hydrology, climate, and biological productivity can influence the DO regime of a waterbody. Agricultural and urban land-uses, impoundments (dams), and point-source discharges are just some of the anthropogenic factors that can cause unnaturally high, low, or volatile DO concentrations. The conceptual model for low DO as a candidate stressor in the Rock River Watershed is modeled at EPA's CADDIS Dissolved Oxygen webpage.

Candidate cause: High phosphorus

Phosphorus is an essential nutrient for all aquatic life, but elevated phosphorus concentrations can result in an imbalance which can impact stream organisms. Excess phosphorus does not result in direct harm to fish and macroinvertebrates. Rather, its detrimental effect occurs as it alters other factors in the water environment. Dissolved oxygen, pH, water clarity, and changes in food resources and habitat are all stressors that can result when there is excess phosphorus.

Water quality standards

There is no current water quality standard for total phosphorus; however there is a draft nutrient standard for rivers of Minnesota as well as ecoregion data to show if the data is within the expected norms. The current draft standard is a maximum concentration of 0.15 mg/l. For more information, please reference the Missouri River Basin Monitoring and Assessment Report.

Total phosphorus concentrations in the Rock River Watershed

From 2000-2014, there has been 850 phosphorus samples collected in streams in the Rock River Watershed. Of those samples, 353 (41.53%) were at or above the 0.15 mg/L proposed draft standard for phosphorus. The high rate and degree of exceedance of the standard, shows that phosphorus is a watershed-wide issue and will need to be addressed.

Sources and causal pathways for high phosphorus

Phosphorus is delivered to streams by wastewater treatment facilities, urban stormwater, agriculture, and direct discharges of sewage. The causes and potential sources for excess phosphorus in the Rock River Watershed are modeled at U. S. Environmental Protection Agency (EPA's) Nutrient CADDIS webpage.

Candidate cause: High nitrate - nitrite

Nitrate is both a naturally occurring nutrient and important in the life-cycle of plants. Nitrate can influence biological communities in streams when present at concentrations exceeding those of reference areas where there is little human impact to the landscape (Monson, 2010). Certain species of caddisflies, amphipods, and salmonid fishes seem to be the most sensitive to nitrate toxicity according to Camargo and Alonso (2006).

Water quality standards

Streams classified as Class 1 waters of the state, designated for domestic consumption, in Minnesota have a nitrate-N (nitrate plus nitrite) water quality standard of 10 mg/L. At this time, none of the AUIDs in the Rock River Watershed that are impaired for biota are classified as Class 1 streams. Minnesota currently does not have a nitrate standard for other waters of the state besides for Class 1.

Ecoregion data

McCollor & Heiskary (1993) developed a guidance of stream parameters by ecoregion for Minnesota streams. The Rock River Watershed encompasses portions of two ecoregions: the majority being WCBP and NGP which is located in the northern headwaters and comprises just 5.31% of the watershed. The annual 75th percentile nitrate-N values were used for comparison (Table 4).

Table 4: Ecoregions in the Rock River Watershed with the associated annual 75 percentile nitrate-nitrite level

Ecoregion	75 Percentile value (mg/L)
Northern Glaciated Plains	0.52
Western Corn Belt Plains	6.9

Collection methods for nitrate and nitrite

Water samples analyzed for nitrate-N were collected throughout the watershed for purposes of assessment and stressor identification. Nitrate-N is comprised of both nitrate (NO3-) and nitrite (NO2-). Typically, water samples contain a small proportion of nitrite relative to nitrate due to the instability of nitrite, which quickly oxidizing to nitrate. The water samples collected were analyzed for nitrate-N at a Minnesota Department of Health certified lab.

Nitrate and nitrite in the Rock River Watershed

From 2000-2014, there were 991 nitrate samples collected throughout the Rock River Watershed. Values ranged from less than 0.05 mg/l up to 42.9 mg/l. In general, the months with the highest nitrate values were March through June. There are many high values throughout the watershed and a nitrate reduction plan is needed to control and reduce the impact it is having on water quality.

Sources and causal pathways for nitrate and nitrite

The elevated nitrate levels during the spring months coincide with fertilizer applications and periods of snowmelt/runoff. The abundance of row crop agriculture and intensive grazing in the watershed makes this a large scale issue. For a complete model of causes and potential causes of nitrates in the Rock River Watershed, please see the EPA's CADDIS Nitrogen webpage.

Candidate cause: Altered hydrology/connectivity/geomorphology

Increased flows may directly impair the biological community or may contribute to additional stressors. Increased channel shear stresses, associated with increased flows, often causes increased scouring and bank destabilization. With these stresses added to the stream, the fish and macroinvertebrate community may be influenced by the negative changes in habitat and sediment.

High flows can also cause the displacement of fish and macroinvertebrates downstream if they cannot move into tributaries or refuges along the margins of the river; or if refuges are not available. Such aspects as high velocities, the mobilization of sediment, woody debris and plant material can also be detrimental especially to the fish and macroinvertebrates which can cause significant dislodgement. When high flows become more frequent, species that do not manage well under those conditions will be reduced, leading to altered population. Macroinvertebrates may shift from those of long life cycles to short life cycles needing to complete their life history within the bounds of the recurrence interval of flow conditions (CADDIS, 2011).

Across the conterminous United States, Carlisle et al. found that there is a strong correlation between diminished streamflow and impaired biological communities (2010). Habitat availability can be scarce when flows are interrupted, low for a prolonged duration, or extremely low, leading to a decreased wetted width, cross sectional area, and water volume. Aquatic organisms require adequate living space and when flows are reduced beyond normal baseflow, competition for resources increases. Pollutant concentrations often increase when flows are lower than normal, making it more difficult for populations to maintain a healthy diversity. Often tolerant individuals that can outcompete in limiting situations will thrive. Low flows of prolonged duration tend to lead to macroinvertebrate and fish communities that have preference for standing water or are comprised of generalist species (CADDIS, 2011).

Altered hydrology/connectivity/geomorphology in the Rock River Watershed

The Minnesota Department of Natural Resources (MDNR) has done a comprehensive study on altered hydrology, connectivity, and geomorphology in the entire Missouri River basin. This study, "Missouri River Watershed Hydrology, Connectivity, and Geomorphology Assessment Report" analyzes historical gage data along the Rock River, stream crossing data, and applied fluvial geomorphology assessment to find relationships that would help understand water quality and biological impairments throughout the watershed.

Candidate cause: Turbidity/total suspended solids

Increases in suspended sediment and turbidity within aquatic systems are now considered one of the greatest causes of water quality and biological impairment in the United States (U.S. EPA, 2003). Although sediment delivery and transport are important natural processes for all stream systems, sediment imbalance (either excess sediment or lack of sediment) can result in the loss of habitat in addition to the direct harm to aquatic organisms. As described in a review by Waters (1995), excess suspended sediments cause harm to aquatic life through two major pathways: (1) direct, physical effects

on biota (i.e. abrasion of gills, suppression of photosynthesis, avoidance behaviors); and (2) indirect effects (i.e. loss of visibility, increase in sediment oxygen demand). Elevated turbidity levels and Total Suspended Solids (TSS) concentrations can reduce the penetration of sunlight and thus impede photosynthetic activity and limit primary production (Munavar et al., 1991; Murphy et al., 1981).

Elevated volatile suspended solids (VSS) concentrations can impact aquatic life in a similar manner as TSS – with the suspended particles reducing water clarity – but unusually high concentrations of VSS can also be indicative of nutrient imbalance and an unstable DO regime.

Water quality standards

The water quality standard for turbidity is 25 Nephelometric Turbidity Units (NTUs) for Class 2b waters. Total suspended solids and transparency tube measurements can be used as surrogate standard. A regression of the TSS to turbidity indicates impairment at 60 mg/L for waters within the NGP ecoregion.

Turbidity is a measure of reduced transparency that can increase due to suspended particles such as sediment, algae and organic matter. Minnesota currently has a turbidity standard of 25 NTU for protection of aquatic life.

A strong correlation exists between the measurements of TSS concentration and turbidity. In 2010, MPCA released draft TSS standards for public comment (Markus). The new 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 draft TSS standard for Rock River has been set at 65 mg/L. For assessment, this concentration is not to be exceeded in more than 10 percent of samples within a 10-year data window.

As well as TSS, sestonic algae can lead to increases in turbidity and can be evaluated by tests which measure the percentage of the solids from a sample that are burned off VSS and by total phosphorus. There are no current standards for either.

For the purposes of stressor identification, transparency tube measurements, TSS, VSS, and HSPF modeling results will be relied upon to quantify the suspended material present from which inferences can be made regarding the effects of suspended solids on fish and macroinvertebrate populations.

Turbidity in the Rock River Watershed

The most recent assessments for the Rock River Watershed determined there were 14 turbidity impairments. These impairments included five along the Rock River (10170204-501, -504, -506, -508, -509, two along the Little Rock River (10170204-512, -513), Little Rock Creek (10170204-511), Kanaranzi Creek (10170204-517), East Branch Kanaranzi Creek (10170204-514), Elk Creek (10170204-519), Champepadan Creek (10170204-520), Chanarambie Creek (10170204-522), and Poplar Creek (10170204-523).

For a spatial reference of turbidity issues in the Rock River Watershed, please see Figure 5 below.

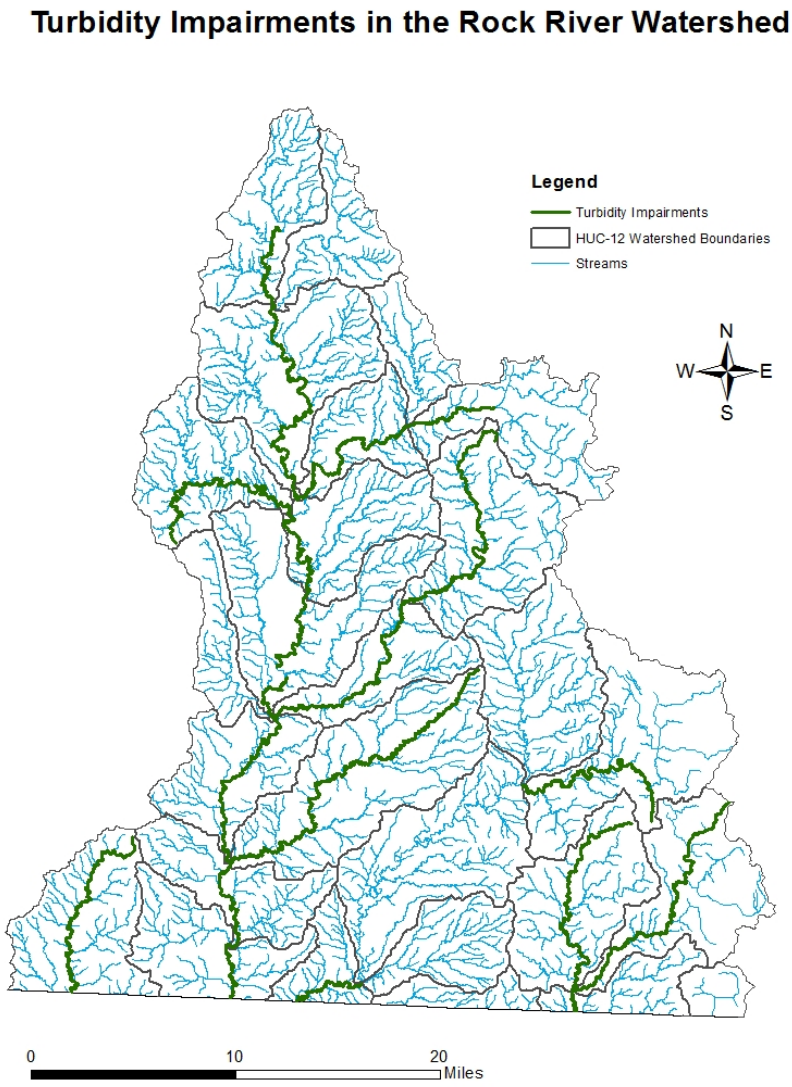

Figure 5: Rock River Watershed turbidity issues

Sources and causal pathways for turbidity

The causes and potential sources for increases in turbidity in the Rock River Watershed are modeled at EPA's CADDIS Sediments webpage. High turbidity occurs when heavy rains fall on unprotected soils, dislodging the soil particles which are transported by surface runoff into the rivers and streams (MPCA and MSUM, 2009). The soil may be unprotected for a variety of reasons, such as construction, mining, agriculture, or insufficiently vegetated pastures. Decreases in bank stability may also lead to sediment loss from the stream banks, often caused by perturbations in the landscape such as channelization of waterways, riparian land cover alteration, and increases in impervious surfaces.

Candidate cause: Lack of habitat

Habitat is a broad term encompassing all aspects of the physical, chemical, and biological conditions needed to support a biological community. This section will focus on the physical habitat structure including geomorphic characteristics and vegetative features (Griffith et al., 2010). Physical habitat is

often interrelated to other stressors (e.g., sediment, flow, DO) and will be addressed separately. Fish passage will also be addressed in a separate section.

Physical habitat diversity enables fish and macroinvertebrate habitat specialists to prosper, allowing them to complete their life cycles. Some examples of the requirements needed by habitat specialists are: sufficient pool depth, cover or refuge from predators, and riffles that have clean gravel or cobble which is and are unimpeded by fine sediment (Griffith et al., 2010).

Specific habitats that are required by a healthy biotic community can be minimized or altered by practices on our landscape by way of resource extraction, agriculture, forestry, silviculture, urbanization, and industry. These landscape alterations can lead to reduced habitat availability, such as decreased riffle habitat; or reduced habitat quality, such as embedded gravel substrates. Biotic population changes can result from decreases in availability or quality of habitat by way of altered behavior, increased mortality, or decreased reproductive success Griffith et al., 2010).

Water quality standards

At this time there are no applicable standards for lack of habitat for biotic communities.

Habitat characteristics in the Rock River Watershed

Habitat quality differs throughout the Rock River Watershed and is an essential tool when understanding and describing the biological communities. Habitat was measured using the Minnesota Stream Habitat Assessment (MSHA) during the fish sampling event. The MSHA is useful in describing the aspects of habitat needed to obtain an optimal biological community. It includes five subcategories: land use, riparian zone, substrate, cover, and channel morphology.

In the Rock River Watershed, habitat scores were predominantly fair or poor throughout (see Figure 6). Many of these areas are farmed intensively or have been channelized in some cases.

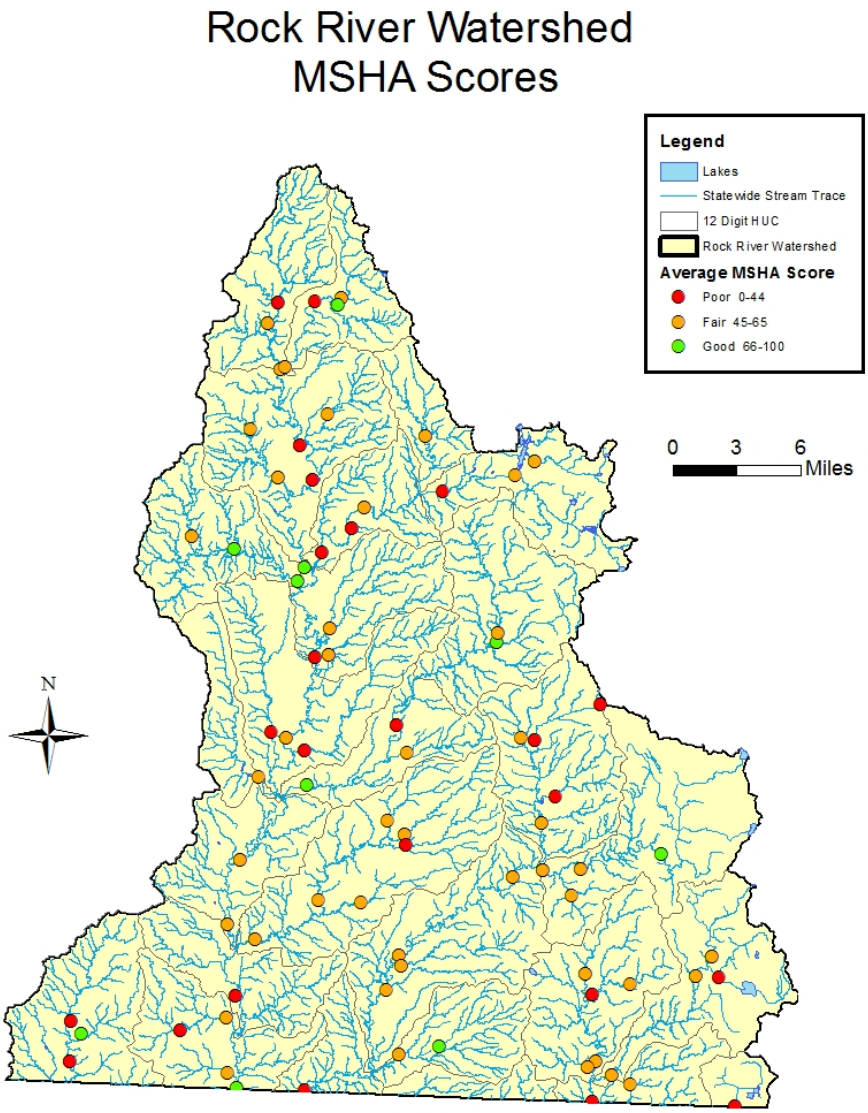

Figure 6: Average MSHA scores at biological sampling stations in the Rock River Watershed

Sources and causal pathways model for habitat

The causes and potential sources for lack of habitat in Rock River Watershed are modeled at EPA's CADDIS Physical Habitat webpage. Many riparian areas in this watershed are dominated by row crops and intensive grazing, which decreases the riparian and bank vegetation which leads to unstable and erodible banks.

Subwatersheds with biological impairments

Ash Creek

Overview

Ash Creek is located in the southwestern portion of the Rock River Watershed (Figure 7). The AUID, 10170204-539, is 2.4 miles long and extends from Unnamed Creek to the confluence with Unnamed Creek just upstream of the Highway 75 crossing. This reach was sampled for fish and macroinvertebrates in 2004 and found to be impaired for both of these assemblages during the watershed assessment in 2013. Land use in the Ash Creek is mainly cropland, followed by rangeland and developed.

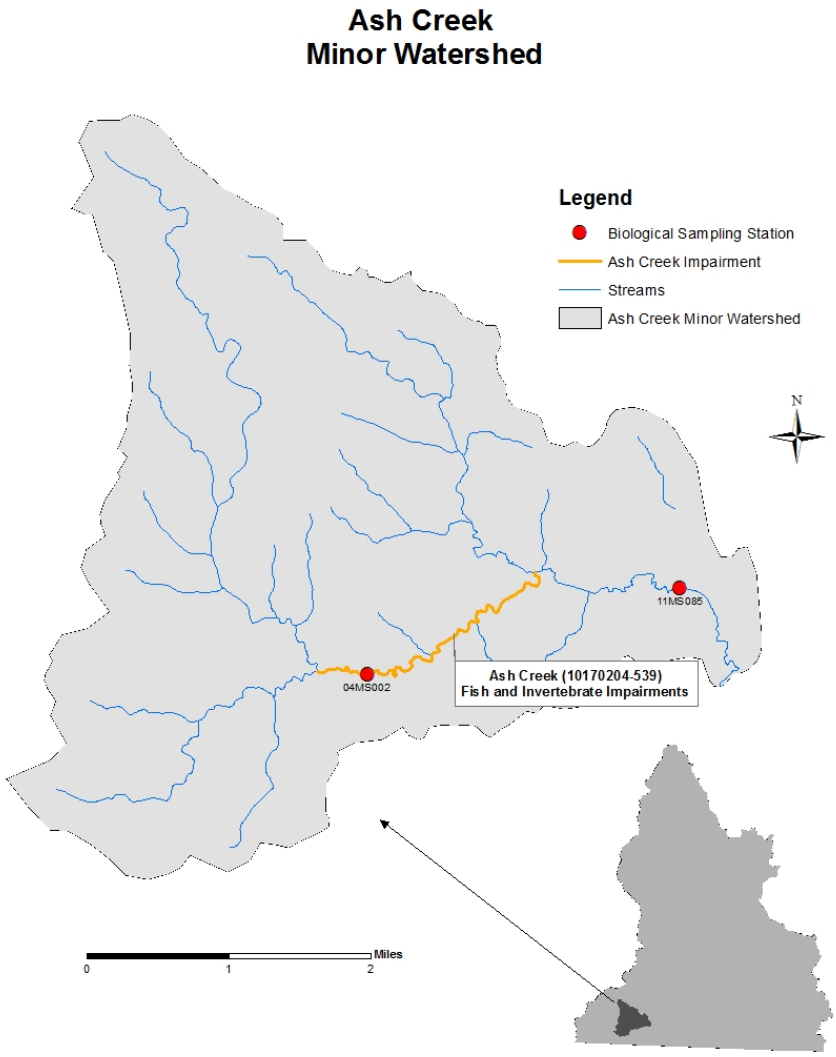

Figure 7: Ash Creek Watershed with biologically impaired reaches highlighted

Biology in Ash Creek

Fish

This impaired section of Ash Creek has one biological sampling station, 04MS002, located along it. This site is upstream of US 75, 2 miles northeast of Steen. The site was sampled for fish on July 14, 2004.

Ash Creek (10170204-539) has a low gradient fish classification (Class 7) at site 04MS002. The fish IBI at this site scored 13, which is well below the impairment threshold of 40. To reach this score, each metric would need an average score of 4.44. The only metric to achieve this is OmnivoreTxPct, which signifies that this stream had a low amount of omnivorous fish species present. All other metrics scored poorly at this site (Figure 8).

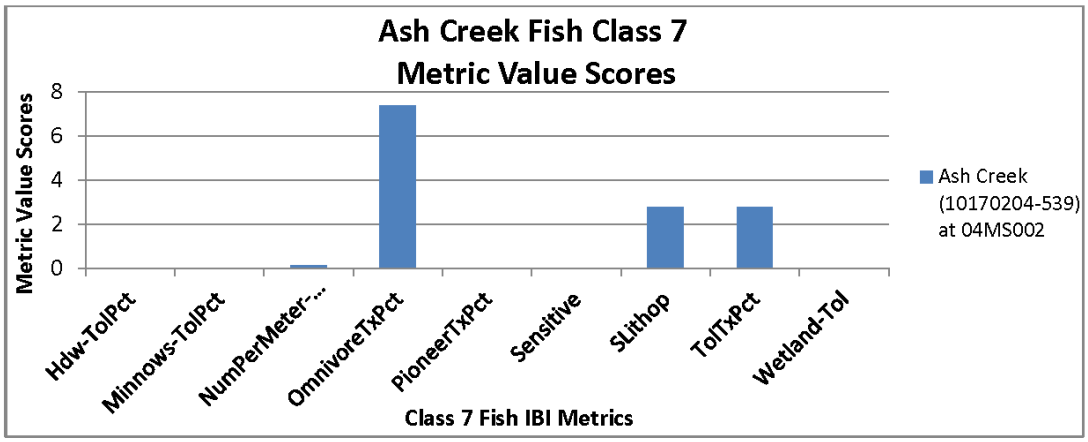

Figure 8: Fish Class 7 IBI metric value scores for Ash Creek (10170204-539) at site 04MS002

Macroinvertebrates

One macroinvertebrate sampling visit occurred at 04MS002 along this impaired section of Ash Creek on August 31, 2004.

Ash Creek (10170204-539) had a macroinvertebrate IBI (MIBI)score of 32.14 at 04MS002. This score fell short of the Class 7 (Prairie Streams GP) MIBI threshold of 43. To reach this threshold, each metric would need an average score of 3.83. Reasons for scoring this low were the low numbers of Clinger taxa (ClingerCh), lack of taxa richness of macroinvertebrates with tolerance values less than or equal to two (Intolerant2Ch), few Plecoptera, Odonata, Ephemeroptera, and Trichoptera taxa (POET), low numbers of just Trichoptera taxa (TrichopteraCHTxPct), and few non-hydropsychid Trichoptera species (TrichwoHydroPct). (Figure 9)

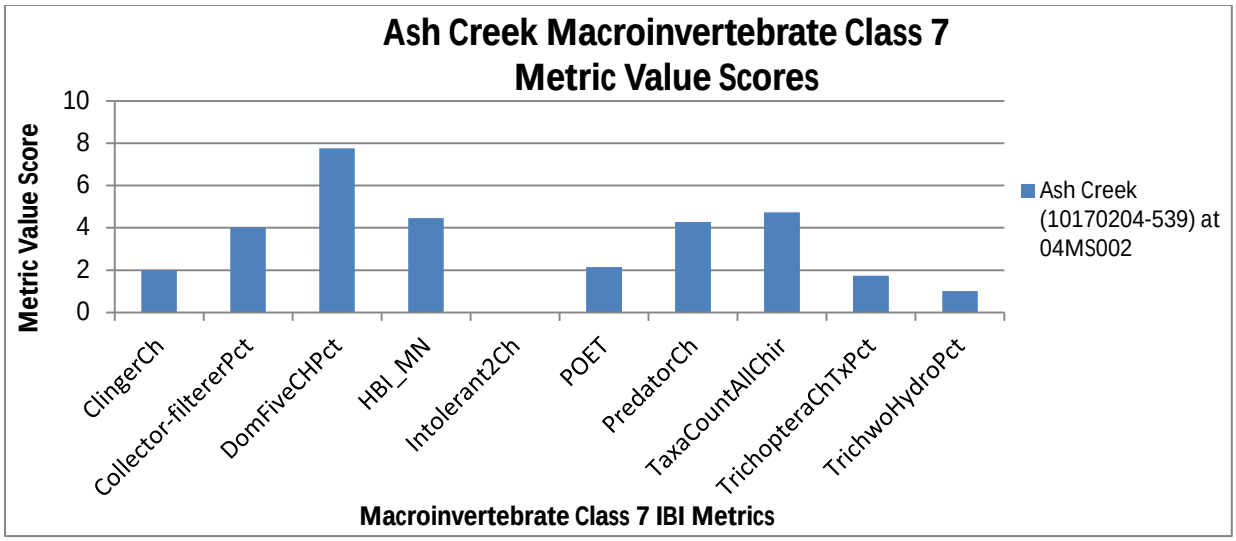

Figure 9: Macroinvertebrate Class 7 IBI metric value scores for Ash Creek (10170204-539) at site 04MS002

Candidate cause: Low dissolved oxygen

The daily minimum standard for DO in Minnesota Class 2B streams is 5 mg/L. All streams in the Ash Creek Watershed have this 2B classification. No streams in this grouping are currently listed as impaired for DO.

There were a total of seven DO readings taken from Ash Creek in 2013 (Table 5). One of these readings was below the daily minimum standard. The high value of 15.16 mg/L could potentially indicate a problem with daily flux and make Ash Creek a prime candidate for continuous DO monitoring with a sonde. However, low flow conditions were present throughout the summer and prevented sonde placement.

Table 5: Dissolved oxygen measurements taken in 2013 at site 04MS002 along Ash Creek (10170204-539)

Sample Location	Sample Date and Time	Result (mg/l)	Daily Minimum Standard (mg/l)
04MS002	5/6/2013 11:10 AM	15.16	5
04MS002	6/10/2013 9:45 AM	8.72	5
04MS002	7/1/2013 2:05 PM	9.04	5
04MS002	7/15/2013 10:15 AM	8.97	5
04MS002	8/14/2013 7:50 AM	6.01	5
04MS002	8/19/2013 9:00 AM	6.48	5
04MS002	9/10/2013 10:30 AM	2.86	5

The HSPF model calculated hourly DO concentrations for Ash Creek from 1996-2009. These values ranged from 1.51-14.05 mg/L with an average value of 8.01 mg/L. Of these calculations, 5.65% were below the daily minimum standard of 5 mg/L for DO.

Biologically, Ash Creek macroinvertebrate populations had a fair amount of total taxa (23), a slightly above average amount of tolerant taxa (62.86%), and a well below average amount of EPT taxa (17.14%) when compared to other streams in Minnesota. Fish populations completely lacked any sensitive and late maturing fish, while also having a very high amount of tolerant fish taxa (83.33%) when compared to all streams statewide. Site 04MS002 did contain very few serial spawning individuals (4.17%). Serial spawning are fish that have the ability to spawn multiple times throughout the summer. This ability can provide an advantage over single season spawning fish in that if there is a disturbance event such as scouring floods or a period of low-DO the eggs of single season spawning fish may not survive that year, or multiple years if this is an annual stress. The DO tolerance indicator value (TIV) for 04MS002 was below average when compared to all other sites in Minnesota.

Based on the wide ranging measured values with one below the standard, many exceedances calculated by the HSPF model, the majority of DO related biological metrics, as well as the high phosphorus values that help alter the DO conditions, the low DO in Ash Creek is indeed stressing the impaired fish and macroinvertebrate assemblages.

Candidate cause: High phosphorus

The proposed draft standard for phosphorus for streams in the Missouri River basin is currently 0.15 mg/L. Although phosphorus is an essential nutrient for all aquatic life, elevated levels can lead to an imbalance which impacts stream ecology. In the Ash Creek Watershed phosphorus levels have exceeded this proposed standard multiple times.

From 2011-2013 there were eight phosphorus samples taken from Ash Creek (Table 6). Of these samples, two were above and one was right at the proposed draft standard of 0.15 mg/L.

Table 6: Phosphorus sample results from 2004-2013 at site 04MS002 along Ash Creek (10170204-539)

Sample Location	Sample Date and Time	Result (mg/l)	Proposed Draft Standard (mg/l)
04MS002	7/14/2004	0.082	0.15
04MS002	5/6/2013	0.059	0.15
04MS002	6/10/2013	0.192	0.15
04MS002	7/1/2013	0.066	0.15
04MS002	7/15/2013	0.085	0.15
04MS002	8/14/2013	0.15	0.15
04MS002	8/19/2013	0.121	0.15
04MS002	9/10/2013	0.487	0.15

From 1996-2009, the HSPF model calculated daily phosphorus values for Ash Creek. These values ranged from 0.08-0.73 mg/L with an average value of 0.205 mg/L. Of these predictions, 77.94% were above the 0.15 mg/L proposed draft standard for phosphorus.

Biologically, macroinvertebrate populations had low amounts of EPT taxa (17.14%), Tanytarsini taxa (5.71%), intolerant species (5.71%), and collector-filterer taxa (15.38%) while also having a higher amount of tolerant taxa (62.86%). These results are common in streams with elevated phosphorus

levels. Ash Creek did have lower numbers of crustacean/mollusca taxa (8.57%) and scraper species (11.43%). These types of macroinvertebrates are typically found in greater numbers in a stream with high phosphorus.

Fish populations along Ash Creek had high amounts of tolerant fish taxa (83.33%) while also having few simple lithophilic spawning and no sensitive species. These results are typical in streams with elevated phosphorus levels.

The proposed phosphorus standard was exceeded at a high rate in both the collected and calculated values. These results are backed up by the biological metric data available. This concludes that high phosphorus is a stressor to the impaired fish and macroinvertebrate assemblages in Ash Creek.

Candidate cause: High nitrates

Currently, the state of Minnesota does not have a nitrate standard in place for streams not used as a drinking water source. However, the overabundance of nitrates can stress a biological community. Nitrates in the Ash Creek Watershed did at times reach levels that could potentially be stressing the biological assemblages.

From 2004-2013 there were eight nitrate samples taken from the impaired section of Ash Creek. These nitrate values ranged from 0.31-29 mg/L (Table 7). Additionally, quantile regression analyses of Class 7 macroinvertebrate sites like 04MS002 have a 90% probability of being impaired if the nitrate values exceed 11.5 mg/L. This site along Ash Creek exceeded this value five times. Extremely high levels were observed throughout the spring and summer months.

Table 7: Nitrate sampling results from 2004-2013 at site 04MS002 along Ash Creek (10170204-539)

Sample Location	Sample Date and Time	Result (mg/l)	Nitrate Standard (mg/l)
04MS002	7/14/2004	16	n/a
04MS002	5/6/2013	13	n/a
04MS002	6/10/2013	28	n/a
04MS002	7/1/2013	29	n/a
04MS002	7/15/2013	23	n/a
04MS002	8/14/2013	9.8	n/a
04MS002	8/19/2013	8.4	n/a
04MS002	9/10/2013	0.31	n/a

Biologically, this impaired section of Ash Creek had an average amount of macroinvertebrate taxa (23) and very few Trichoptera taxa (2.86%). Trichoptera are typically reduced at sites with high nitrates. Fish taxa were present lower than expected numbers (6) and no sensitive fish species were found. These results can also indicate elevated nitrate levels.

With the very high measured nitrate values, the quantile regression analyses, along with the agreement of the majority of nitrate related biological metrics makes the presence of excess nitrates a stressor to the impaired fish and macroinvertebrate communities in Ash Creek.

Candidate cause: High turbidity/TSS

From 2004-2013 there were 8 TSS samples taken from this section of Ash Creek, with the majority of the work being done in 2013. Of these samples, one was above the TSS daily maximum standard of 65 mg/l

(Table 8). During this time period, there were also eight Secchi tube measurements taken. Two of these measurements were below the minimum standard of 20 cm.

Table 8: TSS and Secchi tube sampling results at site 04MS002 along Ash Creek (10170204-539) from 2004-2013

Sample Location	Sample Date	TSS Result (mg/l)	TSS Standard (mg/l)	Secchi Tube Value (cm)	Secchi Tube Standard (cm)
04MS002	7/14/2004	15	65	60	20
04MS002	5/6/2013	4.8	65	>100	20
04MS002	6/10/2013	74	65	15	20
04MS002	7/1/2013	10	65	52	20
04MS002	7/15/2013	6.8	65	66	20
04MS002	8/14/2013	18	65	44.5	20
04MS002	8/19/2013	10	65	39	20
04MS002	9/10/2013	35	65	17	20

The HSPF model calculated TSS values for Ash Creek from 1996-2009. These values ranged from 0.05-3322.6 mg/L with an average value of 17.78 mg/L. Of these calculations, 4.97% were above the 65 mg/L proposed standard for TSS.

Ash Creek had low amounts of Trichoptera taxa (2.86%), collector-filterer species (5.72%), scraper species (11.43%), and a higher than state average amount of tolerant taxa (62.86%). These results often occur in streams with elevated TSS levels. Ash Creek did have an above average amount of Ephemeroptera taxa (14.29%), a fair amount of diversity (23 taxa), with lower amounts of chironomidae species (31.43%). These results are not typically found in streams stressed by TSS.

Figure 10: Surrounding land use at 04MS002

The fish assemblage was highly tolerant (83.33%), but did have an above average amount of herbivorous fish species (16.67%) which typically aren't found in streams with elevated TSS levels. The TSS tolerance indicator value (TIV) for site 04MS002 was higher than average when compared to all other fish Class 7 sites.

Based on the collected and model predicted data, in addition to the biological metric results, and TIV score, high turbidity/TSS should not be considered a stressor to the impaired fish and macroinvertebrate assemblages in Ash Creek at this time.

Candidate cause: Lack of habitat

A qualitative habitat assessment was performed along Ash Creek during the fish sampling event in 2004. The MSHA score for this site was 41, which is considered to be a "fair" score. Habitat conditions were mainly limited by surrounding land use practices (Figure 10), poor channel development, little depth variability, the high presence of silt and clay substrates, and just a moderately stable channel.

See Figure 11 for a breakdown of the MSHA score by category at site 04MS002.

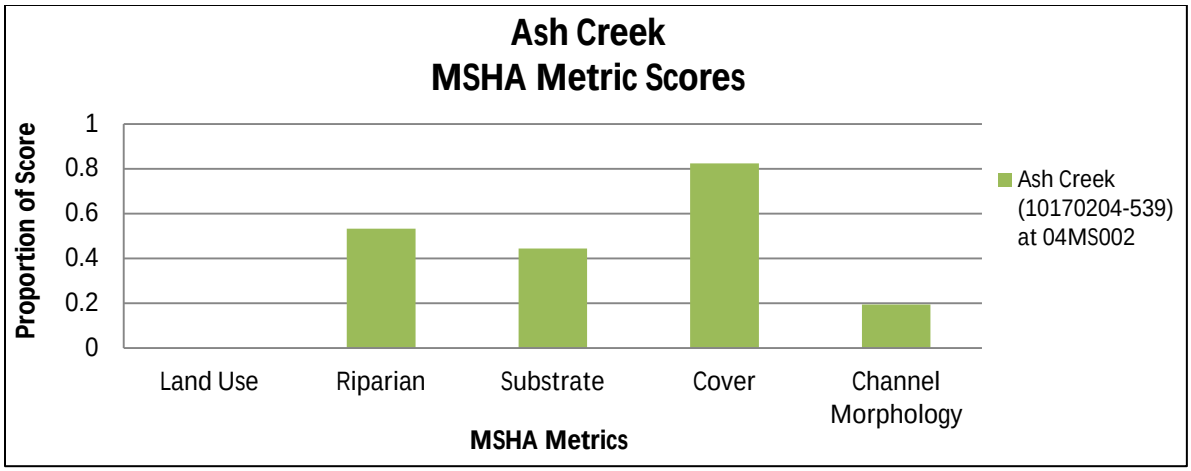

Figure 11: MSHA metrics scores at site 04MS002 along Ash Creek (10170204-539)

The macroinvertebrate community had its sample taken from the overhanging vegetation habitat that was available at site 04MS002. This site had a macroinvertebrate assemblage that containing many tolerant taxa (88.6%), burrower individuals (45.61%), and Oligochaeta (16.51%) species. These worms are often found in degraded habitat conditions as they prefer a substrate consisting of fine sediments like the one found at 04MS002. This site did also have few climber individuals (18.8%), which can also indicate potential habitat problems as these species are more abundant in streams with abundant overhanging vegetation and woody debris habitat.

The fish community had above average amounts of riffle dwelling fish taxa (16.67%) and species classified as darters/sculpins/round-bodied suckers. These metrics typically score well in streams with good habitat conditions. However, there were very high amounts of tolerant fish (83.33%), a below average amount of simple lithophilic spawning taxa (16.67%) and benthic insectivore species (16.67%) when compared to all other Minnesota streams. The scores in these metrics indicate potential habitat problems related to too much fine sediment.

With the "fair" MSHA score and with many habitat related biological metrics indicating habitat problems, the lack of habitat in Ash Creek is a stressor to the impaired fish and macroinvertebrate communities in this stream reach.

Weight of evidence

Weight of evidence tables for the biologically impaired streams in the Ash Creek Watershed, as well as all of the biologically impaired AUIDs are available upon request.

Conclusion

Ash Creek (10170204-539) is a system that has multiple stressors negatively impacting the impaired fish and macroinvertebrate communities (Table 9).

Dissolved oxygen levels in Ash Creek had a wide range of values and even fell under 3 mg/L during a routine measurement in 2013. Levels that low can significantly impact the biological communities in a negative way. The HSPF model predicted similar results while many tolerant fish and macroinvertebrate species dominated this reach. The wide range of DO values may be partly attributed to the high nutrient values found in this watershed.

Phosphorus and nitrate values in the Ash Creek Watershed reached very high levels. These results were found through observations and through the HSPF modeled data. These levels may lead to potential eutrophication, which can have altering effects on other candidate causes such as DO and habitat. The

high amount of intensive grazing and row crop agriculture in the Ash Creek Watershed is a likely cause for the excess of nutrients in Ash Creek. These types of land use practices allow these nutrients to more easily enter the waterways.

Habitat conditions in Ash Creek were found to be fair according to the MSHA. The high presence of tolerant taxa and Oligochaeta both signal that there is an abundant supply of fine sediment covering the course substrates that more desirable fish and macroinvertebrate species prefer. Habitat conditions in Ash Creek were also limited by poor channel development and little depth variability. Habitat improvement projects and natural stream channel design practices are recommended along this reach to help improve these conditions.

Overall, the Ash Creek Watershed has a significant number of stressors negatively impacting the fish and macroinvertebrate assemblages. Until these stressors are addressed, the biological communities will likely remain impaired.

Table 9: Stressors to the biologically impaired reaches within the Ash Creek Watershed

		Stressors				
Stream Name	**AUID #**	**Low Dissolved Oxygen**	**High Phosphorus**	**High Nitrates**	**High Turbidity/ TSS**	**Lack of Habitat**
Ash Creek Watershed						
Ash Creek	10170204-539	•	•	•		•

(• = stressor, - = not a stressor, and blank = inconclusive/not enough evidence)

Champepadan Creek

Overview

The Champepadan Creek Watershed consists of two 12-digit HUC subwatersheds (Figure 12) and is located in the central to northeast portion of the Rock River Watershed. The watershed contains two stream AUIDs designated as impaired for aquatic life (Figure 1X): Champepadan Creek (10170204-520) and Unnamed Creek (10170204-583). The land use in this watershed is dominated by cropland (83.05%) followed by rangeland (9.68%) and developed (5.31%).

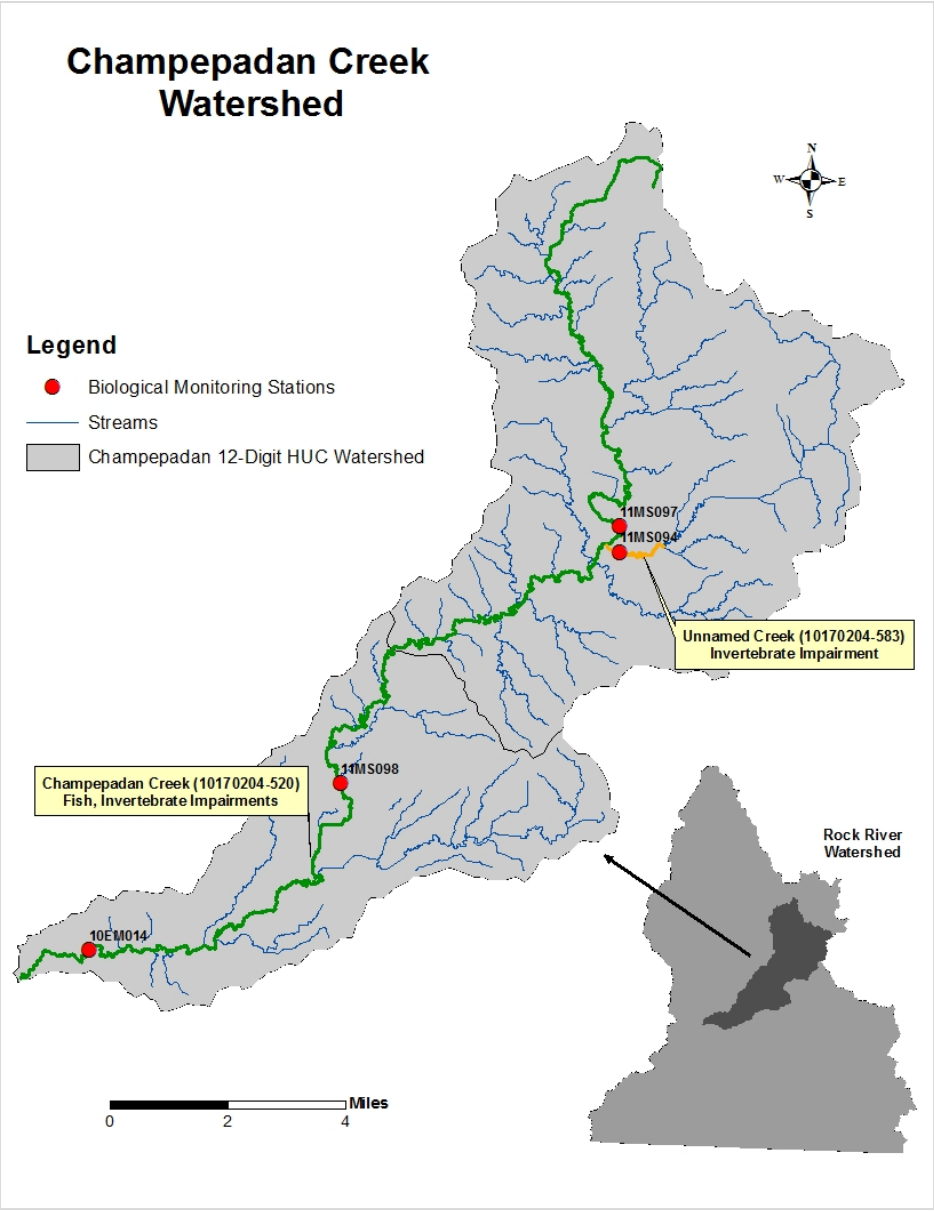

Figure 12: Champepadan Creek Watershed with biologically impaired reaches highlighted

Champepadan Creek (10170204-520) is a 38.47 mile long stream reach extending from the headwaters of Champepadan Creek down to the confluence with the Rock River. This stream reach was sampled for fish and macroinvertebrates at various times from 2010-2012 at its three biological monitoring stations, 10EM014, 11MS097, and 11MS098. The AUID was determined to be impaired for aquatic life due to its fish and macroinvertebrate assemblages as well as turbidity during the watershed assessment in 2013.

Unnamed Creek (10170204-583) is a very short stream reach compared to Champepadan Creek and is only 1.83 miles long. This reach extends from the confluence with Unnamed Creek to the confluence with Champepadan Creek. This stream reach was sampled for fish and macroinvertebrates in 2011 at its lone biological monitoring station, 11MS094. The AUID was determined to be impaired for aquatic life due to its macroinvertebrate assemblage during the watershed assessment in 2013.

Biology in Champepadan Creek

Fish

Champepadan Creek (10170204-520) has three biological monitoring stations located on it. The most downstream site, 10EM014, is located upstream of CSAH 9, 5 miles northeast of Luverne and was sampled for fish on August 17, 2011 and June 21, 2012. Moving upstream, site 11MS098 is downstream of County Route Creek, 1.5 miles east of Kenneth and had a fish sampled taken on August 10, 2011. The headwaters site, 11MS097, is located downstream of 120th Street, 4.5 miles north of Lismore and was sampled for fish on August 11, 2011.

Unnamed Creek has one biological monitoring station, 11MS094. This site is located Downstream of Cory Avenue, 4 miles north of Lismore and was sampled for fish on August 11, 2011. Two sites, 10EM014 and 11MS098, along Champepadan Creek (10170204-520) have a fish Class 2 (Southern Streams) designation (Figure 13). The IBI threshold for this class is 45 and to reach this level, each metric would need an average score of 5.625. Site 10EM014 had a fish IBI score of 38 for both fish sampling visits. This site had high numbers of benthic insectivore taxa (BenInsect-TolTxPct), while also having few detritivorous species (DetNWQTxPct) resulting in a high metric value score. The site scored poorly in the remaining six metrics. Further upstream, site 11MS098 had a fish IBI score of 35. This site also had high numbers of benthic insectivores, few detritivorous taxa, and lower numbers of early maturing fish (MA<2Pct) and Tolerant taxa (TolTxPct) resulting in a higher metric value score.

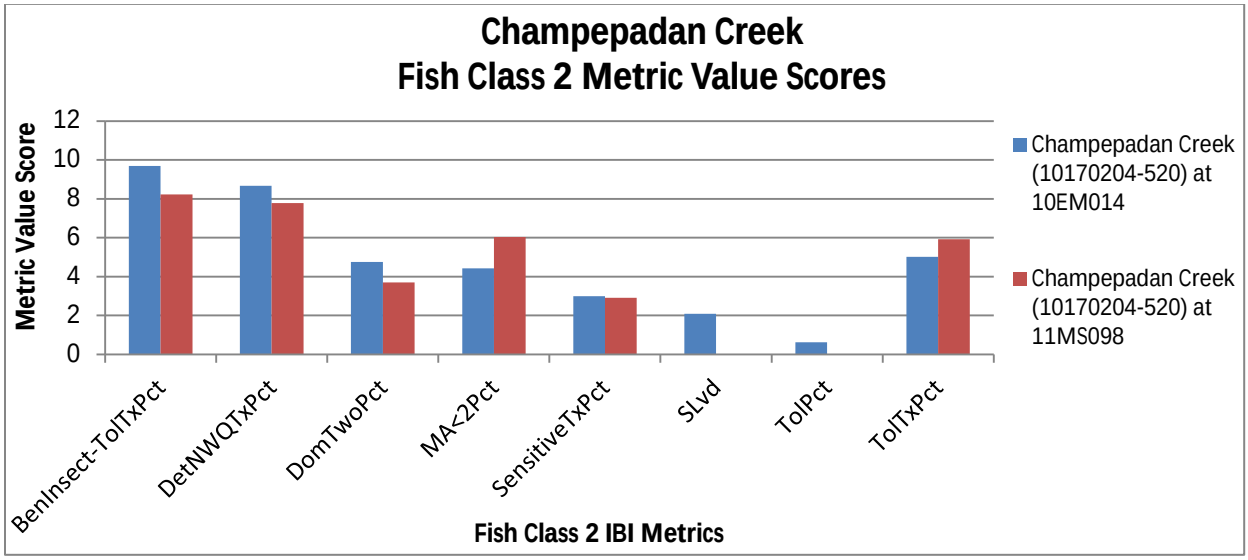

Figure 13: Fish Class 2 IBI metric value scores at two sites along Champepadan Creek (10170204-520)

Both sites located in the headwaters of this watershed have a Fish Class 3 (Southern Headwaters) designation. The IBI threshold for this class is 51 and each metric would need an average score of 8.5 to reach this level (Figure 14). Site 11MS097 located on Champepadan Creek (10170204-520) had an IBI score of 55. This site had very few short-lived (SLvdPct) and serial spawning (SSpnPct) taxa resulting in very high metric value scores. This site scored below average in the remaining four metrics. Site 11MS094 on Unnamed Creek (10170204-583) had an IBI score of 63. This site had many generalist feeding taxa (GeneralTxPct) while having no sensitive taxa resulting in low metric value scores. The remaining metrics scored quite well. This AUID is not currently impaired for aquatic life due to its fish assemblage.

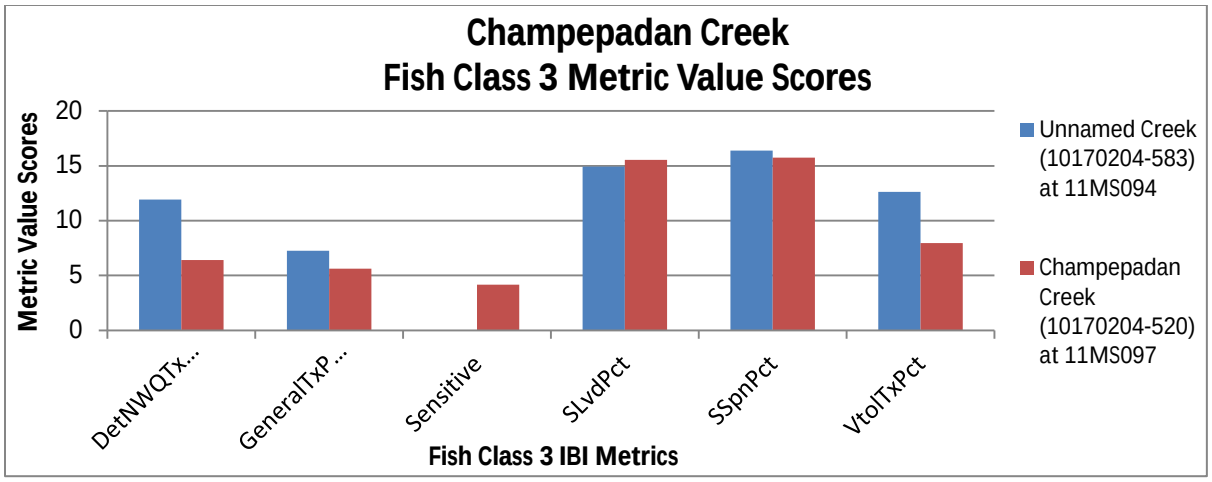

Figure 14: Fish Class 3 IBI metric value scores in the Champepadan Creek Watershed

Macroinvertebrates

In Champepadan Creek (10170204-520), site 10EM014 was sampled for macroinvertebrates on August 18, 2010 and August 9, 2011. While sites 11MS097 and 11MS098 were sampled on August 16, 2011 and August 4, 2011. Unnamed Creek had one macroinvertebrate sampled taken on August 16, 2011.

Both impaired reaches in the Champepadan Watershed were designated as Class 5 (Southern Streams RR) sites. The MIBI threshold for this class is 35.9. To reach the MPCA's MIBI threshold for this class, each metric would need an average score of 3.59. Champepadan Creek (10170204-520) had four macroinvertebrate sampling events at the three different sampling stations (10EM014, 11MS097, 11MS098). The average values are represented in Figure 15. Champepadan Creek scored below the metric score needed to reach the impairment threshold in 8 of the 10 MIBI metrics. This stream only showed good levels of Clinger (ClingerChTxPct) taxa and Insect (InsectTxPct) taxa. Unnamed Creek (10170204-583) had a MIBI score of 17.9 at site 11MS094. This site had too had high levels of clinger taxa, but scored poorly in all other MIBI metrics resulting in the impairement designation.

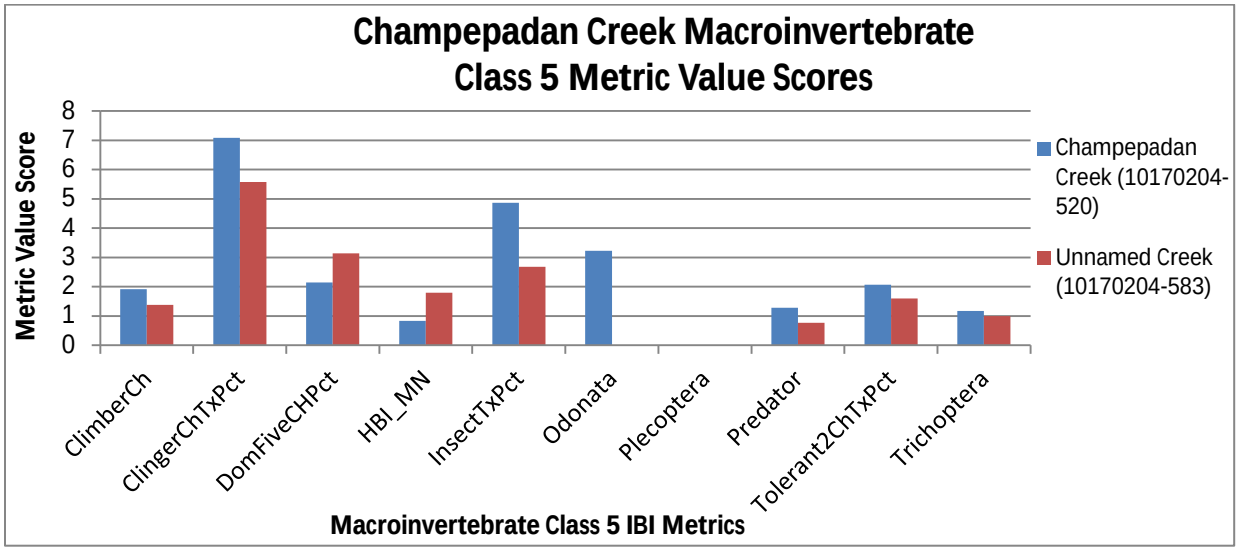

Figure 15: Macroinvertebrate Class 5 IBI metric values scores for two AUIDs in the Champepadan Creek Watershed

Candidate cause: Low dissolved oxygen

The daily minimum standard for DO in Minnesota Class 2B streams is 5 mg/L. All streams in the Champepadan Creek Watershed have this 2B classification. No streams in this grouping are currently listed as impaired for DO.

Champepadan Creek (10170204-520)
Champepadan Creek had a total of 115 DO readings taken from 2009-2013. These readings ranged from 5.84-14.44 mg/L with no values falling below the daily minimum standard. Of these samples, only four were taken before 9 AM.

The HSPF model calculated hourly DO values along Champepadan Creek (10170204-520) from 1996-2009. These values ranged from 0.24-17.71 mg/L with an average value of 9.06 mg/L. These values were below the daily minimum standard 5.5% of the time.

Biologically, the macroinvertebrate community had few DO tolerant individuals present (0.78%) and also had a high level of EPT taxa (40.01%). EPT taxa tend do decrease when negatively impacted by the DO conditions. However, the sites along this AUID did average fewer overall taxa (20.56) when compared to all other sites in Minnesota. The fish assemblage in this reach had few sensitive fish taxa (9.68%) and late maturing fish species (17.36%). This stream also had many tolerant taxa (65.61%) and serial spawning taxa (35.2%). The DO TIV scores for these sites were above average when compared to all other Minnesota streams.

While the HSPF model data had many occurrences under 5 mg/L, the observed data never fell below the standard and the biological results were fairly mixed. It is likely that other stressors are impacting the biological communities in Champepadan Creek and low DO is not a stressor at this time.

Unnamed Creek (10170204-583)
From 2011-2013, a total of 7 DO readings were taken from Unnamed Creek (Table 10). Sample values ranged from 7.79-14.57 mg/L. No values were below the daily minimum standard; however the very high value of 14.57 mg/L may indicate problems with daily flux.

Table 10: Dissolved oxygen values from 2011-2013 at site 11MS094 along Unnamed Creek (10170204-583)

Sample Location	Sample Date and Time	Result (mg/l)	Daily Minimum Standard (mg/l)
11MS094	8/11/2011 8:00 AM	9.22	5
11MS094	8/16/2011 12:10 PM	9.45	5
11MS094	5/6/2013 3:45 PM	14.57	5
11MS094	6/10/2013 11:40 AM	8.53	5
11MS094	7/1/2013 5:30 PM	7.79	5
11MS094	7/15/2013 12:15 PM	9.12	5
11MS094	8/19/2013 10:45 AM	8.22	5

The HSPF model calculated hourly DO values along Unnamed Creek (10170204-583) from 1996-2009. These values ranged from 1.06-14.12 mg/L with an average value of 6.98 mg/L. This reach was predicted to be below the DO standard 16.26% of the time.

Biologically, the macroinvertebrate community had higher levels of DO sensitive EPT taxa (27.59%), but also had a very tolerant assemblage (65.52% taxa), and had fewer species present (17). The fish assemblage completely lacked any sensitive fish taxa, had lower amounts of late maturing species (14.29%), and many tolerant species (71.43%). Unnamed Creek did have a lower amount of serial spawning taxa (14.29%). These species tend to be in high numbers in streams affected by low DO. Site 11MS094 did have an above average DO TIV score when compared to all other Class 3 sites in Minnesota.

While the HSPF model and many of the biological metrics suggest a potential stressor, all of the observed measurements were well above the minimum standard for DO. Further monitoring, including continuous measurements with a sonde is recommended before calling DO a stressor to the impaired biological communities in Unnamed Creek (10170204-583).

Candidate cause: High phosphorus

The proposed draft standard for phosphorus for streams in the Missouri River basin is currently 0.15 mg/L. Although phosphorus is an essential nutrient for all aquatic life, elevated levels can lead to an imbalance which impacts stream ecology. In the Champepadan Creek Watershed phosphorus levels have exceeded this proposed standard multiple times.

Champepadan Creek (10170204-520)
From 2010-2012 there were a total of 20 phosphorus samples taken from Champepadan Creek. Sample values ranged from 0.019-0.185 mg/L, with 3 (15%) samples at or above the 0.15 mg/L proposed draft standard for phosphorus (Figure 16).

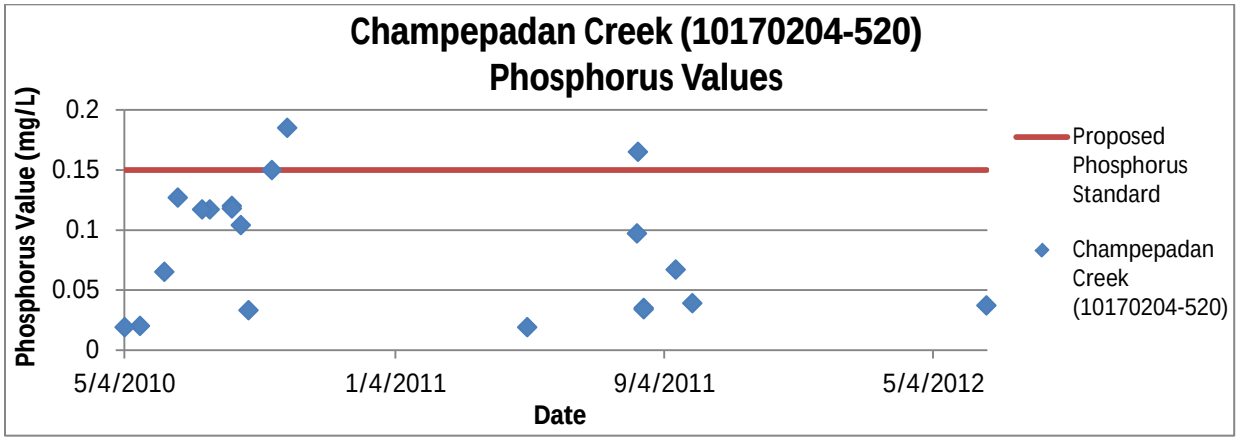

Figure 16: Phosphorus sample values from 2010-2012 along Champepadan Creek (10170204-520)

From 1996-2009, the HSPF model calculated daily phosphorus values. These values ranged from 0.03-0.66 mg/L. These values were above the 0.15 mg/L proposed draft standard for phosphorus 47.5% of the time.

Biologically, the macroinvertebrate population in Champepadan Creek had high levels of EPT taxa (40.01%) and intolerant taxa (19.75%). These types of macroinvertebrates tend to be much less abundant in streams with elevated phosphorus levels. This stream did however have low numbers of Tanytarsini taxa (4.19%), while also have higher levels of crustacean/mollusca species (9.93%), scraper taxa (17.5%), and tolerant taxa (53.38%). The fish community in this stream had many tolerant taxa

(65.61%) and had few sensitive species (9.68%) and darter individuals (1.6%).These results are common in streams with high phosphorus levels. Additionally, the sites along this AUID had an average phosphorus TIV score that was well below the statewide average.

Based on the observed and modeled data, as well as the majority of the related biological metrics, high phosphorus is a stressor to the impaired fish community in Champepadan Creek.

Unnamed Creek (10170204-583)
Unnamed Creek had six phosphorus samples taken from 2011-2013 with sample values ranging from 0.064-0.195 mg/L (Table 11). One of these samples was over the 0.15 mg/L proposed draft standard for phosphorus.

Table 11: Phosphorus sample values from 2011-2013 at site 11MS094 along Unnamed Creek (10170204-583)

Sample Location	Sample Date	Result (mg/l)	Proposed Draft Standard (mg/l)
11MS094	8/11/2011	0.085	0.15
11MS094	5/6/2013	0.084	0.15
11MS094	6/10/2013	0.195	0.15
11MS094	7/1/2013	0.113	0.15
11MS094	7/15/2013	0.093	0.15
11MS094	8/19/2013	0.064	0.15

The HSPF model calculated daily phosphorus values for Unnamed Creek from 1996-2009. These values ranged from 0.07-0.56 mg/L with an average value of 0.19 mg/L. Over 66.37% of the predicted values were above the proposed draft standard for phosphorus.

Biologically, the macroinvertebrate population consisted of many tolerant taxa (65.52%) and scraper taxa (13.79%). These species are much more common in streams with elevated phosphorus levels. This stream also had few Tanytarsini species (6.9%) and intolerant taxa (6.89%), which is expected in streams with high phosphorus values. The fish assemblage in Unnamed Creek was very tolerant (71.43% species) and completely lacked any sensitive fish taxa, while having very few darter individuals (0.93%). These results are often found in streams with high phosphorus conditions. Site 11MS094 also had a below average phosphorus TIV score when compared to all other Minnesota streams.

Based on a sample that was well over the proposed draft standard, the significant amount of exceedances predicted by the HSPF model, as well as the majority of the related biological metrics; phosphorus is a stressor to the impaired macroinvertebrate assemblage in Unnamed Creek.

Candidate cause: High nitrates

Currently, the State of Minnesota does not have a nitrate standard in place for streams not used as a drinking water source. However, the overabundance of nitrates can stress a biological community. Nitrates in the Champepadan Creek Watershed did at times reach levels that could potentially be stressing the biological assemblages.

Champepadan Creek (10170204-520)
From 2010-2012, 20 nitrate samples were taken from Champepadan Creek. Sample values ranged from 3.08-10.9 mg/L (Figure 17).

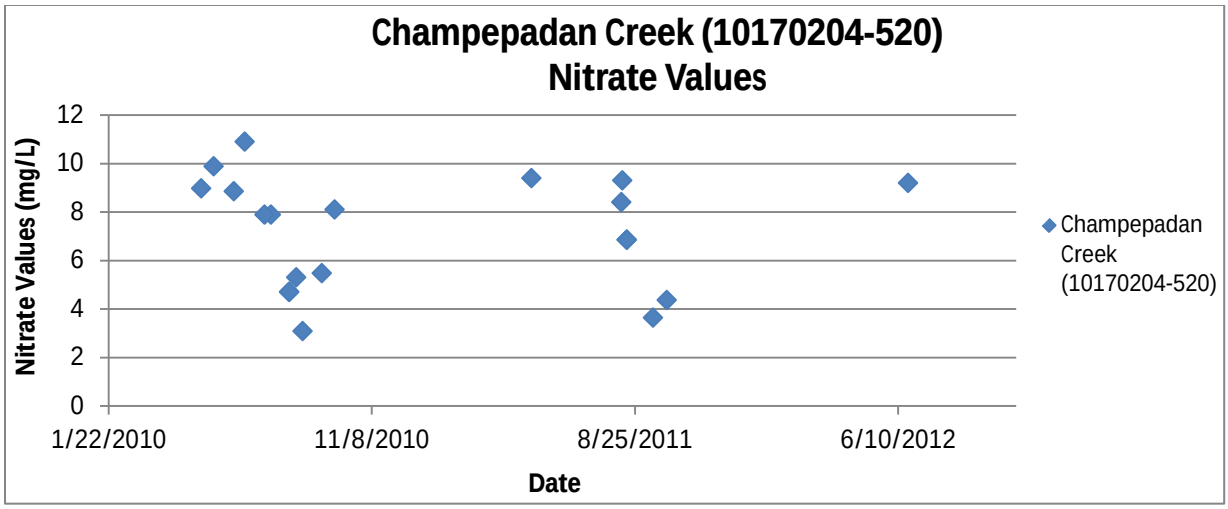

Figure 17: Nitrate values from 2010-2012 along Champepadan Creek (10170204-520)

Daily nitrate values were calculated for Champepadan Creek (10170204-520) by the HSPF model from 1996-2009. These values ranged from 1.36-18.25 mg/L with an average value of 5.83 mg/L.

Biologically, the macroinvertebrate community in Champepadan Creek showed fewer than normal amounts of species (20.56 average), while having a slightly above average amount of Trichoptera taxa (11.67%). The community did have a very high amount of nitrate tolerant individuals (89.76%). A quantile regression analysis showed that sites with extremely high levels of nitrate tolerant individuals like in Champepadan Creek have a greater than 90% probability to be impaired. The fish assemblage averaged 15.5 species between the three biological monitoring stations, but did have a small amount of sensitive taxa (9.68%). These results are common in streams with elevated nitrate levels.

Based on the elevated measured and calculated results as well as the majority of the related biological metrics, high nitrates are indeed stressing the impaired biological communities in Champepadan Creek.

Unnamed Creek (10170204-583)

Unnamed Creek had six nitrate samples taken from 2011-2013 with sample values ranging from 2.3-20 mg/L (Table 12). A quantile regression analysis comparing macroinvertebrate IBI scores with nitrate levels showed that Class 5 sites like 11MS094 with nitrate levels above 18.1 mg/L have a greater than 90% of being impaired.

Table 12: Nitrate sample values from 2011-2013 at site 11MS094 along Unnamed Creek (10170204-583)

Sample Location	Sample Date	Result (mg/l)	Nitrate Standard (mg/l)
11MS094	8/11/2011	8.3	n/a
11MS094	5/6/2013	7.1	n/a
11MS094	6/10/2013	20	n/a
11MS094	7/1/2013	19	n/a
11MS094	7/15/2013	11	n/a
11MS094	8/19/2013	2.3	n/a

Daily nitrate values for Unnamed Creek (10170204-583) were calculated by the HSPF model from 1996-2009. These values ranged from 2.38-16.41 mg/L with an average value of 5.8 mg/L.

Biologically, the macroinvertebrate assemblage in Unnamed Creek had few taxa (17) while having an average amount of Trichoptera taxa (10.34%) when compared to other streams throughout Minnesota. Additionally, Class 5 sites with macroinvertebrate populations having greater than 83.78% of nitrate

tolerant individuals have a 90% probability of being impaired. Site 11MS094 along Unnamed Creek had a macroinvertebrate community consisting of 86.33% of nitrate tolerant individuals. The fish community in this stream also had low numbers of species (7) and completely lacked any sensitive taxa.

Based on the high measured and predicted values, the biological metrics, and the quantile regression analysis all suggest that high levels of nitrates are indeed stressing the impaired fish and macroinvertebrate communities in Unnamed Creek.

Candidate cause: High turbidity/TSS

The water quality standard for Turbidity is 25 NTU, 65 mg/L for TSS, and 20 cm for Transparency Tube for these Class 2B warmwater streams in the Champepadan Creek Watershed. Excess sediment is a commonly recognized stressor in many biologically impaired streams because it can reduce habitat, cause direct physical harm, as well as reduce visibility and increase oxygen demand.

Champepadan Creek (10170204-520) was determined to be impaired for aquatic life due to turbidity in addition to their biological assemblages. A less extensive data set along Unnamed Creek was available and indicates potential impairment.

Champepadan Creek (10170204-520)
From 2009-2012, a total of 75 TSS samples were taken from Champepadan Creek. Sample values ranged from 4-290 mg/L with 5 samples over the 65 mg/L standard for TSS (Figure 18). In addition, 12 of 55 (21.8%) turbidity measurements were above the 25 NTU standard. This reach has been designated as impaired for Turbidity as a result of the watershed assessment in 2013.

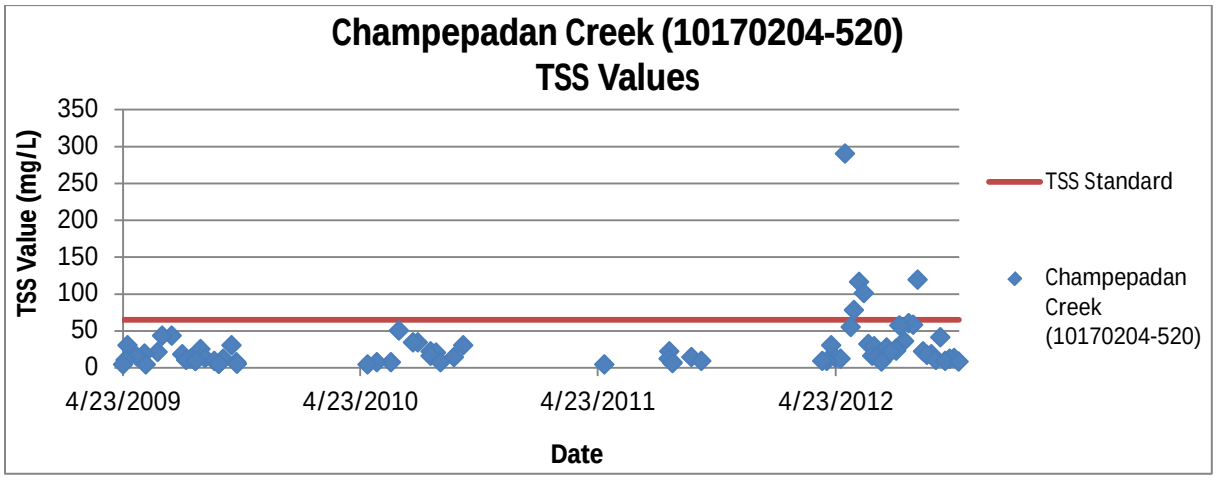

Figure 18: TSS values from 2009-2012 from Champepadan Creek (10170204-520)

Biologically, the macroinvertebrate community in Champepadan Creek showed good numbers of Ephemeroptera taxa (28.35%), while also having higher numbers of scraper species (17.5%) and lower numbers of chironomidae taxa (22.62%). These results are commonly found in streams not experiencing problems with turbidity/TSS. However, this stream section did have lower numbers of overall macroinvertebrate taxa (20.56 average) and a high percentage (53.38%) of tolerant species. The fish assemblage had few herbivorous species (6.64%) and also consisted of many tolerant taxa (65.61%).

With many of the biological metrics in agreement with the significant chemistry data that resulted in an impairment listing, the high levels of turbidity/TSS is a stressor to the impaired biological communities of Champepadan Creek.

Unnamed Creek (10170204-583)

Unnamed Creek had six TSS and seven Secchi/transparency readings taken from 2011-2013 (Table 13). TSS sample values ranged from 3.6-98 mg/L with one of the samples being over the 65 mg/L standard. Of the transparency measurements, four were at or below the 20 cm minimum standard.

Table 13: TSS and Secchi tube values from 2011-2013 at site 11MS094 along Unnamed Creek (10170204-583)

Sample Location	Sample Date	TSS Result (mg/l)	TSS Standard (mg/l)	Secchi Tube Value (cm)	Secchi Tube Standard (cm)
11MS094	8/11/2011	36	65	20	20
11MS094	8/16/2011	n/a	65	73	20
11MS094	5/6/2013	3.6	65	>100	20
11MS094	6/10/2013	98	65	15	20
11MS094	7/1/2013	53	65	19.5	20
11MS094	7/15/2013	29	65	20	20
11MS094	8/19/2013	26	65	17	20

The HSPF model calculated daily TSS values for Unnamed Creek from 1996-2009. These values ranged from 0.02-4321.1 mg/L with an average value of 12.67 mg/L. Of these calculations, 2.68% were above the 65 mg/L draft standard for TSS.

Biologically, the macroinvertebrate assemblage in Unnamed Creek had good levels of turbidity/TSS sensitive Ephemeroptera (17.24%) and collector-filterer taxa (17.24%), but also had few macroinvertebrate taxa (17), many tolerant species (65.52%), and chironomidae (37.93%). The fish community had many tolerant species (71.43%), but did have a relatively high amount of herbivorous fish taxa (14.29%) when compared to other streams throughout Minnesota. Also, site 11MS094 did have a below average TSS TIV score when compared to all Class 3 streams.

Based on the low number of observed and predicted exceedances, as well as the majority of the related biological metrics, high TSS is not a stressor to the impaired biological communities in Unnamed Creek at this time.

Candidate cause: Lack of habitat

Habitat quality in the Champepadan Creek Watershed varied from poor to good in the biologically impaired reaches. The MSHA was the main tool used for evaluating this potential stressor and the results of these habitat scores can be seen in Figure 19.

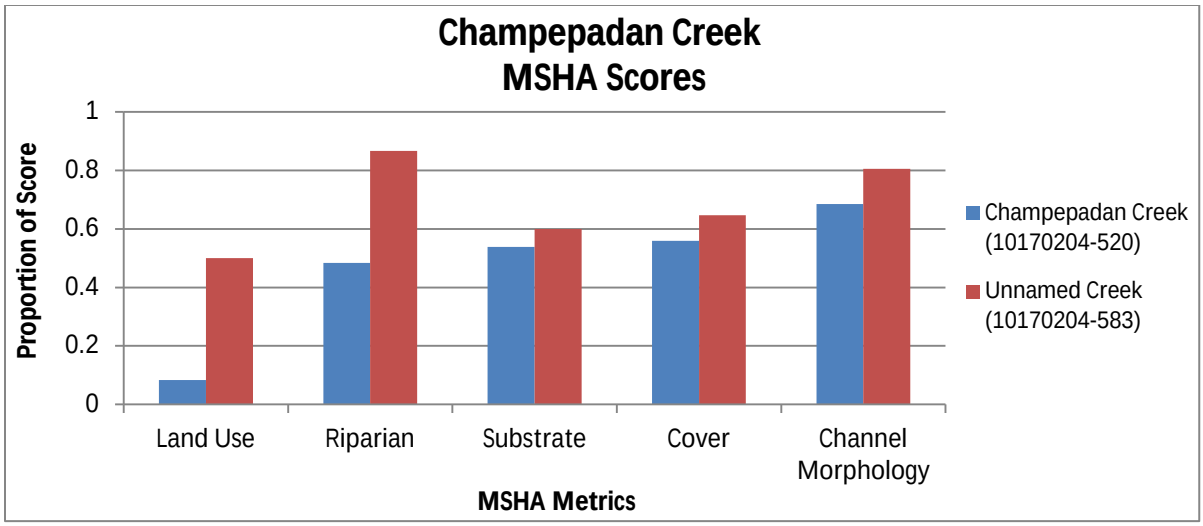

Figure 19: MSHA metric scores in the Champepadan Creek Watershed

Champepadan Creek (10170204-520)

Champepadan Creek had qualitative habitat assessments performed during the fish sampling events at its three biological monitoring stations, 10EM014, 11MS097, and 11MS098. Site 10EM014 had MSHA scores of 51.5 and 78.6. These are considered fair and good. Moving upstream, site 11MS098 had an MSHA score of 39.3 which is considered to be poor. In the headwaters, 11MS097 had a fair MSHA score of 64.75. Limiting the habitat scores at these sites were poor surrounding land use, moderate bank erosion (Figure 20), a sometimes narrow riparian buffer, sand and silty substrates, low to moderate channel stability, and limited channel development.

Figure 20: Eroded banks at 11MS098 along Champepadan Creek (10170204-520)

The macroinvertebrate samples along Champepadan Creek came from equal parts of overhanging vegetation and riffles. The community found was fairly tolerant (53.38%), but did have a higher amount of clinger taxa (38.06%). Clingers have a tendency to be less abundant in streams with degraded habitat conditions. The sites did also have a lower amount of burrower individuals (2.57%), which are present in greater numbers when large amounts of fine substrates are present.

The fish population in this stream was also very tolerant (65.61%) and had lower numbers of simple lithophilic spawning taxa (23.29%) and darter/sculpin/round-bodied sucker taxa (13.04%). However, there were high numbers of riffle dwelling taxa (22.25%) and benthic insectivores (28.31%).

The MSHA scores along Champepadan Creek scored fairly well for the most part as did the habitat related biological metrics. The fish and macroinvertebrate communities appear to be affected by other stressors. Therefore, the lack of habitat is not a stressor to the biological assemblages at this time.

Unnamed Creek (10170204-583)

In Unnamed Creek, a qualitative habitat assessment was performed during the fish sampling visit at the biological monitoring station, 11MS094. The MSHA score at this site was 71.7, which is considered to be good. Limiting the habitat at this site was the sandy and silty substrate, the lack of variety of substrates, and a moderate amount of fish cover.

The macroinvertebrate sample was taken from overhanging vegetation and riffle habitats. This sample showed that Unnamed Creek had a high amount of tolerant macroinvertebrate taxa (65.52%), but did have a high amount of habitat sensitive clinger species (34.58%). Site 11MS094 did have a higher amount of burrower individuals (17.96%) when compared to all other Minnesota streams.

The fish community had high numbers of riffle dwelling species (28.57%), benthic insectivores (28.57%), and simple lithophilic spawners (42.86%). An average amount of darters/sculpins/round-bodied sucker taxa (14.29%) were present along with a high amount of tolerant fish taxa (71.43%).

The very high MSHA score along with the majority of biological metric scores in agreement, the lack of habitat should not be considered a stressor to the impaired macroinvertebrate community at this time.

Conclusion

The two biologically impaired reaches in the Champepadan Creek Watershed are being impacted by multiple stressors (Table 14).

High phosphorus levels were found to be stressing the biological assemblages in both impaired reaches in this watershed. The high phosphorus levels may lead to excessive algae growth and stream productivity. Prolonged periods of elevated phosphorus, may eventually disrupt the DO conditions in the watershed by creating a high range of daily flux. This excess phosphorus is a likely result from the highly pastured riparian areas and cropland throughout the watershed where concentrations of phosphorus tend to be high. Runoff following rain events is a likely pathway for these phosphorus contributions to easily enter the stream system.

High nitrate values were also found to be a stressor to the fish and macroinvertebrate communities in the watershed. Nitrate levels reaching up to 20 mg/L were observed in Unnamed Creek. These elevated levels do not appear to be just seasonal, as high levels were both observed and calculated from January through August. High percentages of nitrate tolerant individual macroinvertebrates were present, which often signals impairment. The high levels of nitrates are likely a result from fertilizer applications and have entered the stream as runoff as well as the presence of tile drains present in many headwater streams within this watershed.

Currently, Champepadan Creek (10170204-520) is impaired for turbidity. This parameter was also found to be a stressor to the fish and macroinvertebrate communities. This reach is missing many of the fish and macroinvertebrate species that are sensitive to increased levels of sediment. These species are critical to the overall health of a properly functioning aquatic ecosystem. Again, the highly pastured land use with minimal buffer area has led to unstable and erosive banks. Fortunately, the conditions in Unnamed Creek (10170204-583) are not yet to the point where turbidity/TSS is stressing the impaired macroinvertebrate assemblage, however, this will likely change if conditions do not improve.

The Champepadan Creek Watershed has a significant amount of stressors along Champepadan Creek, while Unnamed Creek currently just has nutrient issues. Addressing these stressors will be imperative to restoring the biological communities to a healthy condition. Until this is done, expect the fish and macroinvertebrate communities to be impaired.

Table 14: Stressors to the biologically impaired reaches within the Champepadan Creek Watershed

		Stressors				
Stream Name	**AUID #**	**Low Dissolved Oxygen**	**High Phosphorus**	**High Nitrates**	**High Turbidity/ TSS**	**Lack of Habitat**
Champepadan Creek Watershed						
Champepadan Creek	10170204-520	-	•	•	•	-
Unnamed Creek	10170204-583		•	•		-

(• = stressor, - = not a stressor, and blank = inconclusive/not enough evidence)

Chanarambie Creek Watershed

Overview

Located in the northeast portion of the Rock Creek Watershed, the Watershed of Chanarambie Creek is comprised of the three 12-digit HUC subwatersheds (Figure 21) spanning 74.81 square miles. The watershed contains three stream AUIDs impaired for aquatic life: Chanarambie Creek (10170204-522), North Branch Chanarambie Creek (10170204-560), and Unnamed Creek (10170204-559). Land use in the Chanarambie Creek Watershed is predominantly cropland (68.98%), but also has large amounts of rangeland (23.27%) and some development (5.22%).

Chanarambie Creek (10170204-522) is a 20.51 mile long stream reach that is extends from the Chanarambie Creek headwaters down to the confluence with the Rock River. Biological monitoring sites along this reach: 11MS016, 11MS121, 04MS026, and 11MS091 were either sampled in 2004 or in most cases 2011. During the watershed assessment in 2013, this reach was found to be impaired for both fish and macroinvertebrate communities, as well as for turbidity.

North Branch Chanarambie Creek (10170204-560) is a 0.95 mile long reach located between Unnamed Creek and unnamed Creek. The biological monitoring station, 11MS123, was sampled in 2011 and determined to be impaired for aquatic life due to its macroinvertebrate assemblage.

Unnamed Creek (10170204-559) is a 1.32 mile long stream AUID located between Unnamed Creek to the confluence with North Branch Chanarambie Creek. The biological monitoring station along Unnamed Creek, 10EM142, was sampled for fish and macroinvertebrates in 2010 and determined to be impaired for aquatic life due to its macroinvertebrate assemblage.

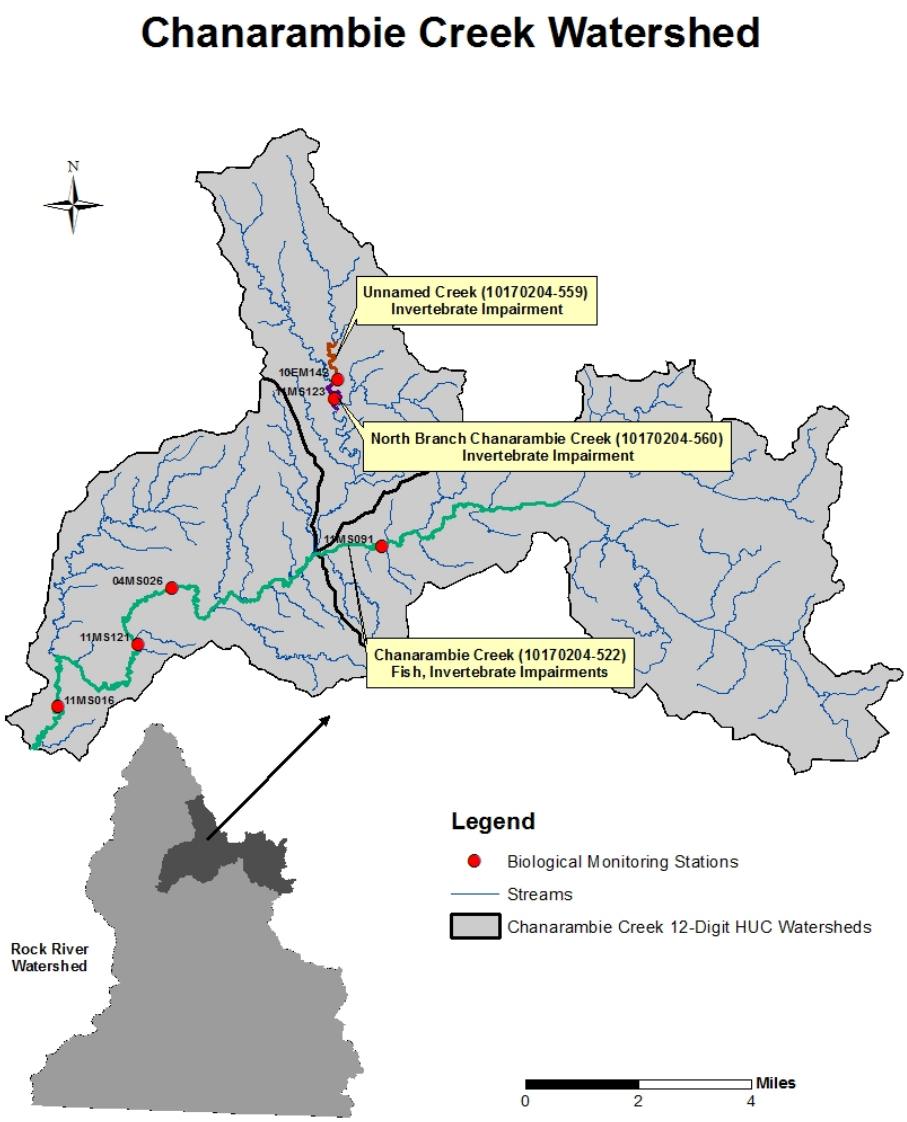

Figure 21: Chanarambie Creek Watershed with biologically impaired reaches highlighted

Biology in Chanarambie Creek Watershed

Fish

The three biologically impaired reaches in the Chanarambie Creek Watershed had a total of six biological monitoring stations. On Chanarambie Creek (10170204-522), site 11MS016 is located downstream of CR 1 (Mill St), southeast of Edgerton and was sampled for fish on August 10, 2011. Moving upstream site 11MS121 which is located upstream of 26th Street, 1.5 miles northeast of Edgerton and was sampled for fish on August 18, 2011. Site 04MS026 is adjacent to 41st Street, 2.5 miles northeast of Edgerton and was sampled on August 12, 2004 and the furthest site upstream on this AUID is 11MS091. This site is located downstream of 300th Avenue, 3 miles southwest of Chandler and was sampled on August 17, 2011. North Branch Chanarambie Creek (10170204-560) has one biological monitoring station, 11MS123, that is located upstream of CSAH 5, 3 miles southwest of Lake Wilson and was sampled on August 16, 2011. Finally, Unnamed Creek (10170204-559) has one biological monitoring station, 10EM142 that was sampled on August 17, 2010 and is located 0.5 mile upstream of CSAH 5, 4 miles northwest of Chandler.

All four biological monitoring stations on Chanarambie Creek (10170204-522) were designated as fish Class 2 (Southern Streams) streams. To reach the fish Class 2 IBI threshold, each site would need an IBI score of at least 45. To achieve this, each metric would need an average metric value score of 5.625. The most downstream site on this AUID, 11MS016, had a fish IBI score of 38. This site failed to reach the average needed to reach the IBI threshold in half of the metrics. This site had few sensitive fish taxa (SensitiveTxPct) while having high numbers of early maturing fish (MA<2 Pct), short lived species (SLvd) and tolerant individuals of fish (TolPct) resulting in the poor metric value scores (Figure 22). Moving upstream site 11MS121 had an IBI score of 48. This site had few sensitive fish taxa, while also having higher numbers of early maturing and tolerant fish. Site 04MS026 had a fish IBI score of 27 and had good numbers of benthic insectivore taxa (excluding tolerant species) and the two most dominant fish species were not overwhelmingly present more than other species (DomTwoPct). Site 11MS091, the most upstream site, had an IBI score of 59. This site scored poorly in three of the metrics and lacked sensitive fish taxa, while having too many early maturing and tolerant fish.

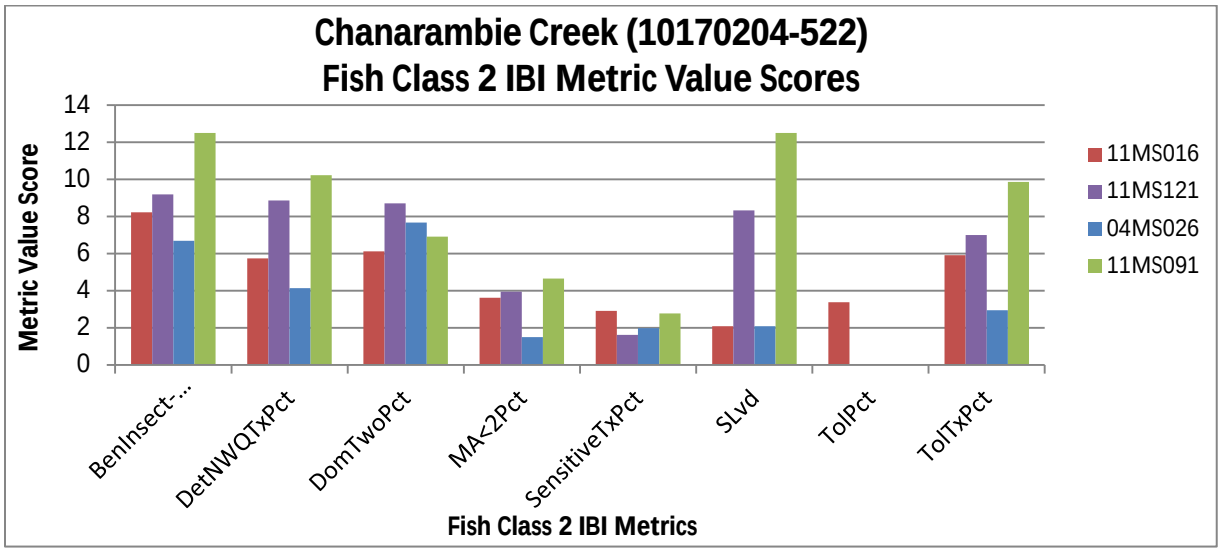

Figure 22: Fish Class 2 IBI metric value scores at 4 sites along Chanarambie Creek (10170204-522)

Two AUIDS in this watershed have a Fish Class 3 (Southern Headwaters) designation. The IBI threshold for this class is 51 and each metric would need an average score of 8.5 to reach this level (Figure 23). Site 11MS123 on North Branch Chanarambie Creek (10170204-560) had a fish IBI score of 60. This AUID is not impaired for fish at this time. Unnamed Creek (10170204-559) had one biological monitoring station, 10EM142, which had an IBI score of 69. This reach is not impaired for its fish assemblage at this time.

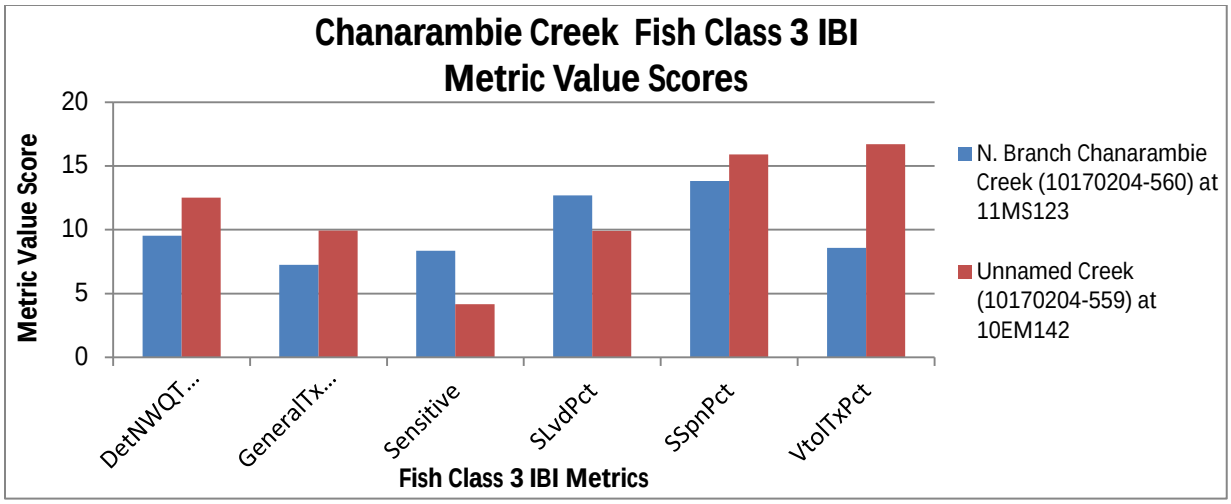

Figure 23: Fish Class 3 IBI metric value scores along two reaches in the Chanarambie Creek Watershed

Macroinvertebrates

In the Chanarambie Creek Watershed, Chanarambie Creek (10170204-522) had four macroinvertebrate samples taken at its four biological monitoring stations. Sites 11MS016 and 11MS121 were sampled on August 9, 2011, while 04MS026 was sampled on September 2, 2004 and 11MS091 was sampled on August 2, 2011. North Branch Chanarambie Creek (10170204-560) had one macroinvertebrate sample taken on August 2, 2011 at site 11MS123 and Unnamed Creek (10170204-559) had one sample taken on August 18, 2010, at site 10EM142.

To reach the MPCA's macroinvertebrate IBI threshold for a Class 5 (Southern Streams RR) stream, each metric would need an average score of 3.59. In the watershed, site 04MS026 on Chanarambie Creek (10170204-522) was the only site in this macroinvertebrate class and had a MIBI score of 20.3. This site scored poorly in 8 of the 10 MIBI metrics (Figure 24). This site had a good population of clinger taxa (ClingerChTxPct) an had a fairly diverse macroinvertebrate community which is represented by a high score in the DomFiveChPct metric.

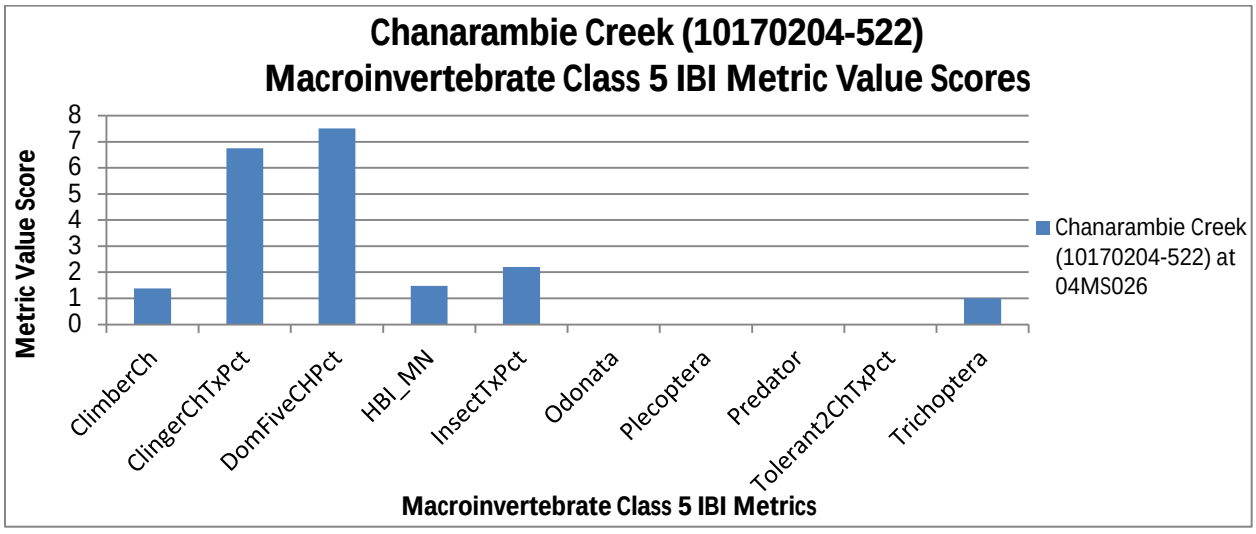

Figure 24: Macroinvertebrate Class 5 IBI metric value scores at site 04MS026 along Chanarambie Creek (10170204-522)

The macroinvertebrate IBI threshold for a Class 7 (Prairie Streams GP) site is 38.3 and an average metric score of 3.83 is needed to reach this level. Chanarambie Creek (10170204-522) had three sites designated as Class 7 and they had an average IBI score of 27. These sites showed good numbers of clinger taxa, Trichoptera taxa (TrichopteraChTxPct) and high levels of Plecoptera, Odonata, Ephemeroptera, and Trichoptera taxa (POET) (Figure 25). Site 11MS123 on North Branch Chanarambie Creek (10170204-560) had a MIBI score of 27.8. This site scored well in DomFiveCHPct meaning that the relative abundance of dominant five taxa in the sample was low, taxa richness was high (TaxaCountAllChir), and had a good HBI_MN score meaning the site had a lower level of pollution based on tolerance values assigned to each individual taxon. Unnamed Creek (10170204-559) had a MIBI score of 8.7 at its biological monitoring station 10EM142. This site scored poorly in all IBI metrics.

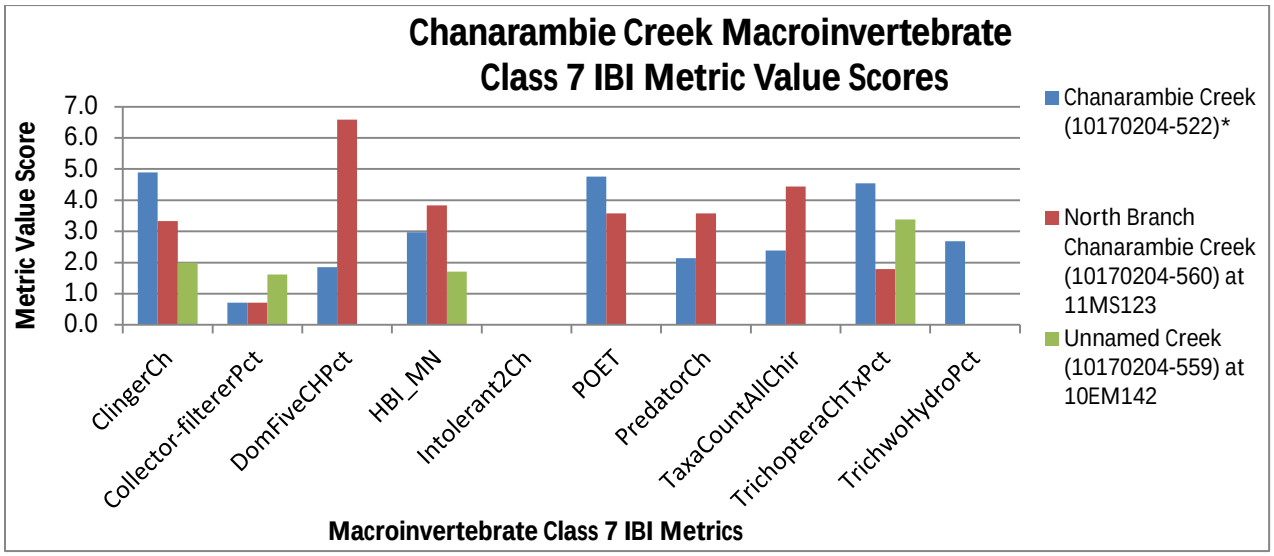

Figure 25: Macroinvertebrate Class 7 IBI metric value scores along three reaches in the Chanarambie Creek Watershed

*Average Metric Value score from 11MS016, 11MS121, and 11MS091

Candidate cause: Low dissolved oxygen

The daily minimum standard for DO in Minnesota Class 2B streams is 5 mg/L. All streams in the Chanarambie Creek Watershed have this 2B classification. No streams in this grouping are currently listed as impaired for DO.

Chanarambie Creek (10170204-522)

From 2011-2012, there were 57 DO readings taken from this portion of Chanarambie Creek. These values ranged from 4.45-17.04 mg/L, with only one reading below the daily minimum standard of 5 mg/L for DO (Figure 26). Only two data points were taken before 9 AM. With elevated values like 17.04 mg/L, this may indicate a problem with daily flux.

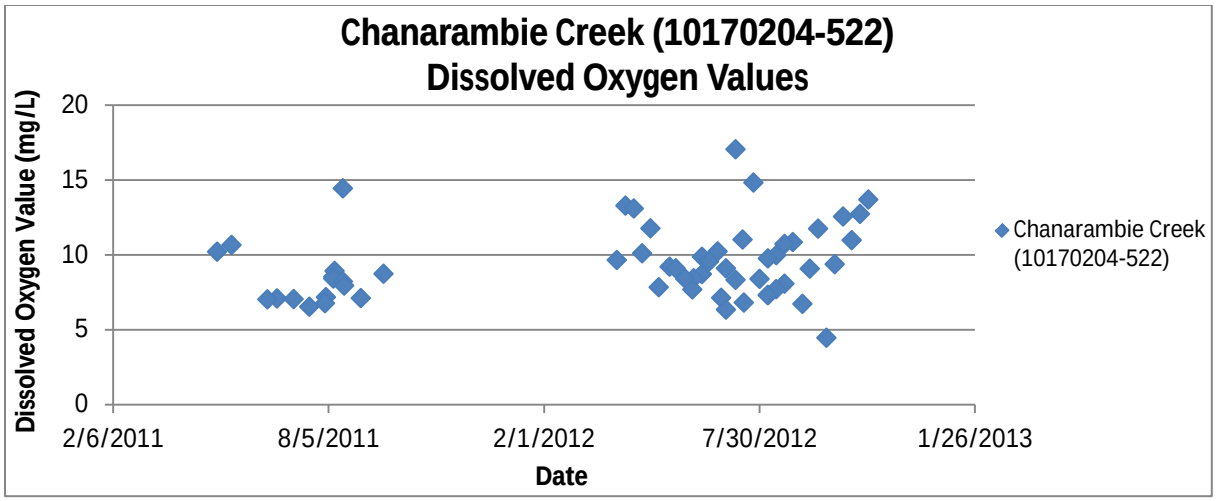

Figure 26: Dissolved oxygen values from 2011-2012 along Chanarambie Creek (10170204-522)

Biologically, the macroinvertebrate populations in Chanarambie Creek showed an above average amount of EPT taxa (36.07%). These types of taxa typically are present in lower numbers in streams experience DO problems. There were few DO tolerant individuals (2.74%) and there were an average of four DO intolerant taxa at each site.

Fish populations also had high amounts of tolerant taxa (55.57%), while also having low numbers of sensitive fish species (8.39%), late maturing fish taxa (14.43%), and high amounts of serial spawning fish species (32.72%). These results are more common in streams experiencing DO problems. The sites along this reach did have above average DO TIV scores when compared to all other streams statewide.

Based on the observed values, and the DO related macroinvertebrate metrics, DO is not a stressor to the impaired biological communities in Chanarambie Creek. It is likely that other stressors are negatively impacting this reach causing a false positive in many of the fish metrics. Continuous DO monitoring with a sonde is recommended to better understand the DO conditions in this reach of Chanarambie Creek.

North Branch Chanarambie Creek (10170204-560)

A total of eight DO readings were taken from North Branch Chanarambie Creek from 2011-2013. Dissolved oxygen readings ranged from 7.06-14.16 mg/L with no results below the 5 mg/L daily minimum standard (Table 15).

Table 15: Dissolved oxygen values from 2011-2013 at site 11MS123 along North Branch Chanarambie Creek (10170204-560)

Sample Location	Sample Date and Time	Result (mg/l)	Daily Minimum Standard (mg/l)
11MS123	8/2/2011 3:48 PM	7.06	5
11MS123	8/16/2011 4:00 PM	7.76	5
11MS123	5/7/2013 9:55 AM	14.16	5
11MS123	5/20/2013 1:30 PM	12.05	5
11MS123	6/11/2013 11:30 AM	8.95	5
11MS123	7/2/2013 10:45 AM	9.02	5
11MS123	7/16/2013 11:45 AM	8.72	5
11MS123	8/20/2013 11:10 AM	11.43	5

Biologically, macroinvertebrate populations had an average amount of DO sensitive EPT taxa (23.53%) when compared across the state. Site 11MS123 did have few DO tolerant individuals (7.67%), while also have three DO intolerant taxa. These results are common in streams not impacted by low DO values.

Fish populations had below average amounts of sensitive taxa (14.29%) and late maturing fish (14.29%), while having above average levels of serial spawning taxa (28.57%) and tolerant fish species (57.14%). Site 11MS123 had an above average DO TIV score when compared to all other Minnesota streams.

Based on the observed values as well as the DO related macroinvertebrate metrics and fish TIV score, low DO is not a stressor to the impaired biological communities in North Branch Chanarambie Creek. It is likely that other stressors are negatively impacting this reach causing a false positive in many of the fish metrics.

Unnamed Creek (10170204-559)

Unnamed Creek had seven DO readings taken from 2010-2013. Values ranged from 4.55-13.99 mg/L with one sample below the daily minimum standard of 5 mg/L (Table 16).

Table 16: Dissolved oxygen values from 2010-2013 along Unnamed Creek (10170204-559)

Sample Location	Sample Date and Time	Result (mg/l)	Daily Minimum Standard (mg/l)
10EM142	8/17/2010 4:00 PM	7.32	5
S007-378	5/7/2013 9:45 AM	13.99	5
S007-378	5/20/2013 2:45 PM	13.48	5
S007-378	6/11/2013 11:20 AM	9.57	5
S007-378	7/2/2013 10:55 AM	8.46	5
S007-378	7/16/2013 11:30 AM	7.83	5
S007-378	9/12/2013 10:50 AM	4.55	5

Modeling data for Unnamed Creek (10170204-559) was done as part of a larger reach of North Branch Chanarambie Creek. The HSPF model calculated hourly DO values from 1996-2009. Of these calculations, only three were below the 5 mg/L daily minimum standard.

Biologically, the impaired macroinvertebrate population had low levels of EPT taxa (5.56%), but did have few DO tolerant individuals (1.97%) and two DO intolerant taxa. The DO TIV score for the macroinvertebrate community was also above average when compared to all other Minnesota streams.

The fish community in Unnamed Creek had low amounts of sensitive fish taxa (12.5%) and late maturing fish species (12.5%), while also having a high amount of tolerant fish taxa (62.5%) and a low DO TIV score. There was also a below average amount of serial spawning fish taxa (12.5%), which are typically more abundant in streams with DO problems.

The measured and predicted results conflict with many of the biological metrics. Further DO monitoring with a sonde is recommended before DO can be ruled out as a stressor to the impaired macroinvertebrate assemblage in Unnamed Creek (10170204-559).

Candidate cause: High phosphorus

The proposed draft standard for phosphorus for streams in the Missouri River basin is currently 0.15 mg/L. Although phosphorus is an essential nutrient for all aquatic life, elevated levels can lead to an imbalance which impacts stream ecology. In the Chanarambie Creek Watershed phosphorus levels have exceeded this proposed standard multiple times.

Chanarambie Creek (10170204-522)
From 2004-2011 a total of 15 phosphorus samples were taken along this portion of Chanarambie Creek. Sample values ranged from 0.036-0.502 mg/L with seven samples above the proposed draft standard of 0.15 mg/L. Figure 27 displays the 14 samples taken in 2011.

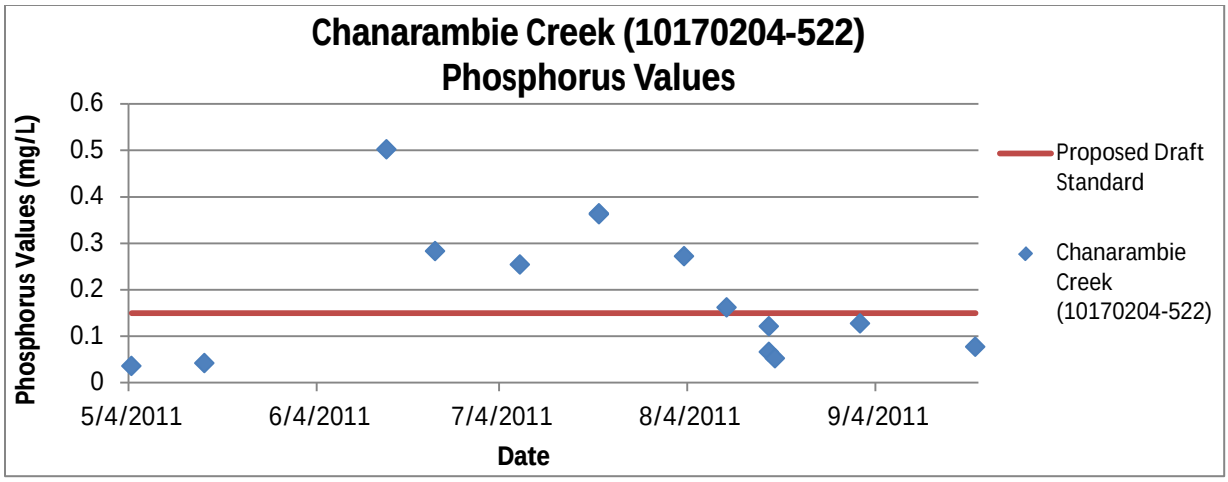

Figure 27: Phosphorus values from 2011 along Chanarambie Creek (10170204-522)

The HSPF model calculated daily phosphorus values for Chanarambie Creek from 1996-2009. These values ranged from 0.04-0.77 mg/L with 34.87% of the predictions over the 0.15 mg/L proposed draft standard for phosphorus.

Biologically, macroinvertebrate populations in Chanarambie Creek had high amounts of EPT taxa (36.07%), while having low amounts of phosphorus tolerant metrics like crustacea/mollusca species (9.06%) and Scraper taxa (11.51%). However, this stream also had a high amount of tolerant species (56.77%) and low levels of Tanytarsini taxa (5.92%), which tend to disappear in streams with elevated phosphorus levels. The fish assemblage had high amounts of tolerant fish taxa (55.57%), very few sensitive species (8.39%), and darter individuals (3.73%). These results are common in streams negatively impacted by high phosphorus levels.

Based on the high levels of measured and predicted phosphorus levels and the agreement by the majority of the related biological metrics, makes high phosphorus a stressor to the impaired fish and macroinvertebrate communities in Chanarambie Creek.

North Branch Chanarambie Creek (10170204-560)

From 2011-2013, there were seven phosphorus samples taken from this impaired section of North Branch Chanarambie Creek (Table 17). Sample values ranged from 0.014-0.127 mg/L with no samples exceeding the proposed draft standard.

Table 17: Phosphorus sample values from 2011-2013 at site 11MS123 along North Branch Chanarambie Creek (10170204-560)

Sample Location	Sample Date	Result (mg/l)	Proposed Draft Standard (mg/l)
11MS123	8/6/2011	0.127	0.15
11MS123	5/31/2013	0.014	0.15
11MS123	6/17/2013	0.016	0.15
11MS123	7/8/2013	0.066	0.15
11MS123	7/30/2013	0.043	0.15
11MS123	8/12/2013	0.1085*	0.15
11MS123	9/12/2013	0.054	0.15

* Average value of two samples

The HSPF model calculated daily phosphorus values for North Branch Chanarambie Creek from 1996-2009. These values ranged from 0.07-0.59 mg/L with an average value of 0.18 mg/L. The calculations predicted that the proposed draft stand for phosphorus would be exceeded 61.58% of the time.

Biologically, the macroinvertebrate community in North Branch Chanarambie Creek had an average amount of EPT taxa (23.53%), but had few Tanytarsini species (2.94%), intolerant taxa (2.94%), while having higher amounts of crustacean/mollusca species (14.71%), scrapers (17.65%), and tolerant taxa (67.65%). These results are often found in streams with elevated phosphorus levels. The fish population in this stream reach also had high amounts of tolerant fish species (57.14%), a below average amount of sensitive fish taxa (14.29%), and few darter individuals (6.12%) when compared to all other Minnesota streams.

Figure 28: Excessive algae growth at 11MS123 along North Branch Chanarambie Creek (10170204-560)

While the collected data did not have any phosphorus values that exceeded the standard, the modeled data, photographic evidence (Figure 28), as well as the related biological metrics all strongly signal that high phosphorus is stressing the impaired macroinvertebrate community in Chanarambie Creek.

Unnamed Creek (10170204-559)

Unnamed Creek had seven phosphorus samples taken from 2010-2013 (Table 18). Sample values ranged from 0.012-0.159 mg/L with only one sample exceeding the proposed draft standard for phosphorus.

Table 18: Phosphorus sample values from 2010-2013 along Unnamed Creek (10170204-559)

Sample Location	Sample Date	Result (mg/l)	Proposed Draft Standard (mg/l)
10EM142	8/17/2010	0.159	0.15
S007-378	5/7/2013	0.018	0.15
S007-378	5/20/2013	0.012	0.15
S007-378	6/11/2013	0.032	0.15
S007-378	7/2/2013	0.018	0.15
S007-378	7/16/2013	0.09	0.15
S007-378	9/12/2013	0.146	0.15

Biologically, the macroinvertebrate community in Unnamed Creek had an elevated amount of Tanytarsini taxa (16.67%), which tend to disappear in streams with high phosphorus concentrations. This reach also had low levels of EPT taxa (5.56%) and intolerant taxa (5.56%), while having high levels of phosphorus tolerant crustacean/mollusca species (22.22%), scrapers (22.22%), and tolerant macroinvertebrate taxa (66.67%). The fish assemblage had high levels of tolerant species (62.5%) and a below average amount of sensitive fish taxa (12.5%), while also having few darter individuals (4.88%).

While the majority of the biological metrics strongly suggest that phosphorus is indeed a stressor, only one observed value exceeded the proposed standard. Additional chemistry monitoring is needed to confirm that high phosphorus is a stressor to the biological communities in Unnamed Creek.

Candidate cause: High nitrates

Currently, the state of Minnesota does not have a nitrate standard in place for streams not used as a drinking water source. However, the overabundance of nitrates can stress a biological community. Nitrates in the Chanarambie Creek Watershed did at times reach levels that could potentially be stressing the biological assemblages.

Chanarambie Creek (10170204-522)
From 2004-2011, 15 nitrate samples were taken from this section of Chanarambie Creek. Sample values ranged from 1.9-6.04 mg/L. Figure 29 shows the 14 samples taken in 2011.

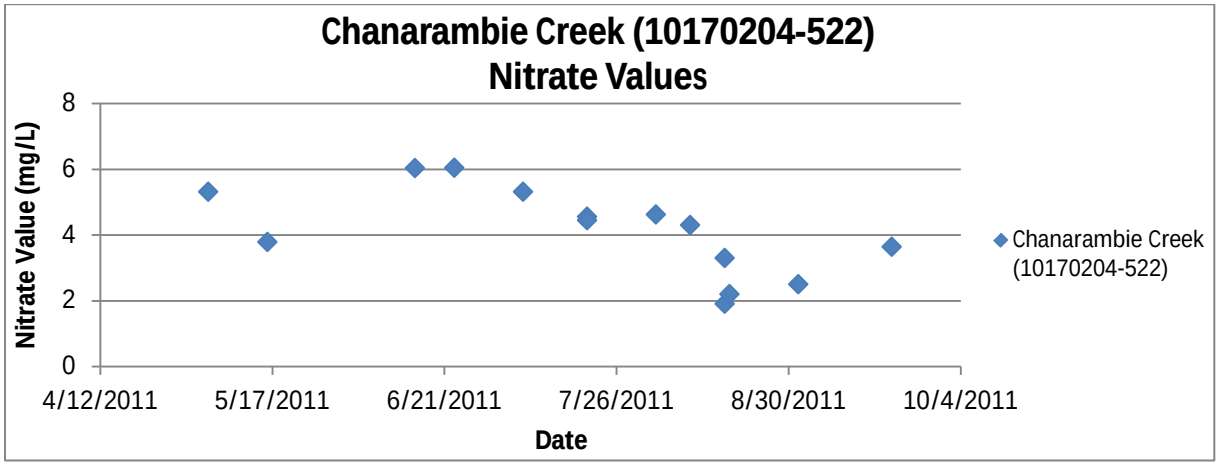

Figure 29: Nitrate sample values from 2011 along Chanarambie Creek (10170204-522)

The HSPF model calculated daily nitrate values for Chanarambie Creek from 1996-2009. These values ranged from 1.62-17.12 mg/L with an average value of 4.97 mg/L.

Biologically, the macroinvertebrate community in this section of Chanarambie Creek had an average of 19.25 taxa across the four biological monitoring stations. This result is below the state average of 23 species. Trichoptera taxa (7.94%) were also low along this stream reach. Trichoptera taxa tend to deplete in areas affected by nitrates. The macroinvertebrate communities had an average of 87.62% of its sample consisting of nitrate tolerant individuals. This amount is very high when compared to all other values statewide. With this many nitrate tolerant individuals; a quantile regression analysis shows that this reach has a greater than 90% probability of being impaired.

The fish population in Chanarambie Creek had 15 taxa, which is above the state average. There was however a lower amount of sensitive fish taxa (8.39%) which often occurs in streams with elevated nitrate levels.

Based on the observed and predicted values, as well as the strong biological evidence, high nitrates in Chanarambie Creek (10170204-522) are stressing the impaired biological communities in this reach.

North Branch Chanarambie Creek (10170204-560)
North Branch Chanarambie Creek had 7 nitrate samples taken from 2011-2013. Sample values ranged from 1.5-17 mg/L. (Table 19)

Table 19: Nitrate sample values from 2011-2013 at site 11MS123 along North Branch Chanarambie Creek (10170204-560)

Sample Location	Sample Date	Result (mg/l)	Nitrate Standard (mg/l)
11MS123	8/16/2011	7.5	n/a
11MS123	5/7/2013	7.2	n/a
11MS123	5/20/2013	4.1	n/a
11MS123	6/11/2013	13	n/a
11MS123	7/2/2013	17	n/a
11MS123	7/16/2013	8.6*	n/a
11MS123	8/20/2013	1.5	n/a

* Average value of two samples

Biologically, the macroinvertebrate community in North Branch Chanarambie Creek at site 11MS123 had low levels of nitrate sensitive Trichoptera taxa (2.94%), while having an average amount of macroinvertebrate taxa (24). Site 11MS123 also had a high amount of nitrate tolerant individuals (73.63%). The fish assemblage in this stream reach had an above average amount of taxa (14), but also had lower numbers of sensitive fish species (14.29%) which is typical of streams with elevated nitrate levels.

Based on the elevated observed nitrate levels, as well as the majority of the nitrate related biological metrics, high nitrates are a stressor to the impaired biological communities in North Branch Chanarambie Creek.

Unnamed Creek (10170204-559)

From 2010-2013, seven nitrate samples were taken from Unnamed Creek. Sample values ranged from 2-16 mg/L (Table 20). A quantile regression analysis comparing nitrate values to macroinvertebrate IBI scores showed that Class 7 sites with nitrate values greater than 11.5 mg/L have a greater than 90% chance of being impaired. This reach had two measurements greater than this value.

Table 20: Nitrate sample values from 2010-2013 along Unnamed Creek (10170204-559)

Sample Location	Sample Date	Result (mg/l)	Nitrate Standard (mg/l)
10EM142	8/17/2010	6.6	n/a
S007-378	5/7/2013	6.2	n/a
S007-378	5/20/2013	5.7	n/a
S007-378	6/11/2013	13	n/a
S007-378	7/2/2013	16	n/a
S007-378	7/16/2013	10	n/a
S007-378	9/12/2013	2	n/a

Biologically, the macroinvertebrate populations in Unnamed Creek had low levels of Trichoptera taxa (5.56%), while also only have 11 different macroinvertebrate taxa present. Additionally, site 10EM142 had its macroinvertebrate community consist of 93.79% nitrate tolerant individuals. A quantile

regression study showed that any Class 7 macroinvertebrate site with more than 87.71% of nitrate tolerant individuals had a greater than 90% probability of being impaired. The fish population also had few species (8) and a below average amount of sensitive fish taxa (12.5%).

The observed elevated nitrate levels, both of the quantile regression studies, along with the agreement of the nitrate related biological metrics makes excess nitrates a stressor to the impaired macroinvertebrate assemblage in Unnamed Creek.

Candidate cause: High turbidity/TSS

The water quality standard for turbidity is 25 NTU, 65 mg/L for TSS, and 20 cm for transparency tube for these Class 2B warmwater streams in the Chanarambie Creek Watershed. Excess sediment is a commonly recognized stressor in many biologically impaired streams because it can reduce habitat, cause direct physical harm, as well as reduce visibility and increase oxygen demand.

One of the reaches, Chanarambie Creek (10170204-522), was determined to be impaired for aquatic life for turbidity. Less extensive data sets on the smaller streams in this category reduces the ability to define the magnitude that elevated Turbidity/TSS values are having on these impaired stream reaches.

Chanarambie Creek (10170204-522)
From 2011-2012 there were 47 TSS samples taken from this section of Chanarambie Creek. Sample values ranged from 6-218 mg/L with 16 (34%) at or above the 65 mg/L standard for TSS (Figure 30).

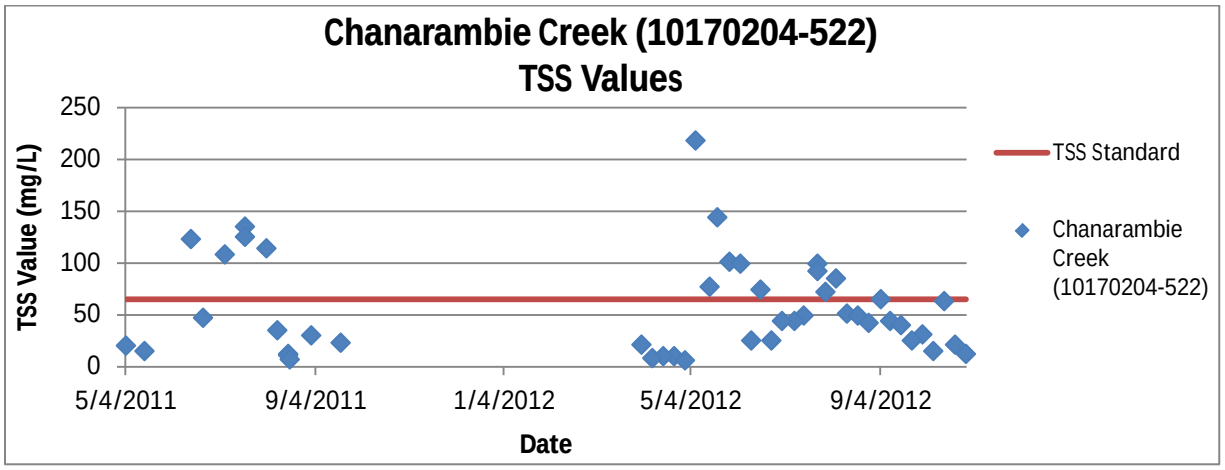

Figure 30: TSS sampled values from 2011-2012 along Chanarambie Creek (10170204-522)

Biologically, the macroinvertebrate assemblage in Chanarambie Creek had good numbers of Ephemeroptera taxa (28.14%) and collector-filterer species (14.09%), but had few turbidity/TSS sensitive Trichoptera taxa (7.94%), scraper species (11.51%), and overall taxa (19). Both tolerant macroinvertebrate (56.77%) and fish species (55.57%) were present in high numbers. This stream reach also had few herbivorous fish taxa (6.36%), which can also indicate stress from turbidity/TSS.

Considering the majority of biological metrics for both fish and macroinvertebrate communities along with the current impairment designation on Chanarambie Creek; turbidity/TSS should be considered as a stressor to the biological communities.

North Branch Chanarambie Creek (10170204-560)
North Branch Chanarambie Creek had seven TSS samples taken from 2010-2013 at biological monitoring station 11MS123 (S007-377). TSS sample values ranged from 3.2-40 mg/L (Table 21) with no samples over the 65 mg/L TSS maximum standard. Eight Secchi/transparency tube readings were also taken from 2010-2013, with 3 values under the 20 cm minimum standard.

Table 21: TSS and Secchi tube values from 2011-2013 at site 11MS123 along North Branch Chanarambie Creek (10170204-560)

Sample Location	Sample Date	TSS Result (mg/l)	TSS Standard (mg/l)	Secchi Tube Value (cm)	Secchi Tube Standard (cm)
11MS123	8/2/2011	n/a	65	12	20
11MS123	8/16/2011	25	65	18.5	20
11MS123	5/7/2013	3.6	65	>100	20
11MS123	5/20/2013	5.2	65	86	20
11MS123	6/11/2013	10	65	62	20
11MS123	7/2/2013	15	65	30	20
11MS123	7/16/2013	40*	65	15	20
11MS123	8/20/2013	3.2	65	>100	20

* Average value of two samples

Biologically, the macroinvertebrate population in North Branch Chanarambie Creek had an above average amount of Ephemeroptera taxa (20.59%) and scraper species (17.65%) when compared to all other Minnesota streams. These types of macroinvertebrates tend to disappear in streams with elevated turbidity/TSS levels. This stream did also have a highly tolerant population (67.65%), while containing few Trichoptera taxa (2.94%), and collector-filterer species (8.82%). The fish community, which is not impaired, had an above average amount of herbivorous taxa (14.29%), while also having 14 fish species.

Based on the measured data and the majority of the TSS related biological metrics, high turbidity/TSS is not a stressor to the impaired macroinvertebrate community at this time.

Unnamed Creek (10170204-559)

Unnamed Creek had seven TSS samples taken from 2010-2013. TSS sample values ranged from 2.8-64 mg/L (Table 22) with no samples over the 65 mg/L TSS standard. Eight Secchi tube readings were also taken from 2010-2013, with two values under the 20 cm minimum standard.

Table 22: TSS and Secchi tube values from 2010-2013 along Unnamed Creek (10170204-559)

Sample Location	Sample Date	TSS Result (mg/l)	TSS Standard (mg/l)	Secchi Tube Value (cm)	Secchi Tube Standard (cm)
10EM142	8/17/2010	64	65	15	20
10EM142	8/18/2010	n/a	65	58	20
S007-378	5/7/2013	9.2	65	55	20
S007-378	5/20/2013	8	65	>100	20
S007-378	6/11/2013	4.4	65	95	20
S007-378	7/2/2013	2.8	65	>100	20
S007-378	7/16/2013	16	65	35	20
S007-378	9/12/2013	22	65	14	20

Biologically, the impaired macroinvertebrate community had no Ephemeroptera taxa, and few Trichoptera species (5.56%), collector-filterers (11.11%), and macroinvertebrate taxa (11). In addition, high amounts of tolerant species (66.67%) were sampled along with a high amount of chironomid taxa (44.44%). Chironomidae are often present in greater numbers in streams stressed by turbidity/TSS. Site

10EM142 also had a very high amount of TSS tolerant individuals (82.35%) when compared to all other Minnesota streams. The fish population contained only eight species and had a low TSS TIV score when compared to all other Minnesota streams.

The TSS related biological metrics strongly suggest TSS is a stressor, however no samples collected were above the TSS proposed standard and only two are below the Secchi tube standard. It is inconclusive if high TSS/turbidity is a stressor to this stream reach at this time.

Candidate cause: Lack of habitat

Qualitative habitat assessments were performed on all three biologically impaired reaches in the Chanarambie Creek Watershed during the fish sampling visits at each site. Results of these assessments can be seen in Figure 31 for the sites along Chanarambie Creek (10170204-522) and Figure 32 for the sites located along North Branch Chanarambie Creek (10170204-560) and Unnamed Creek (10170204-559).

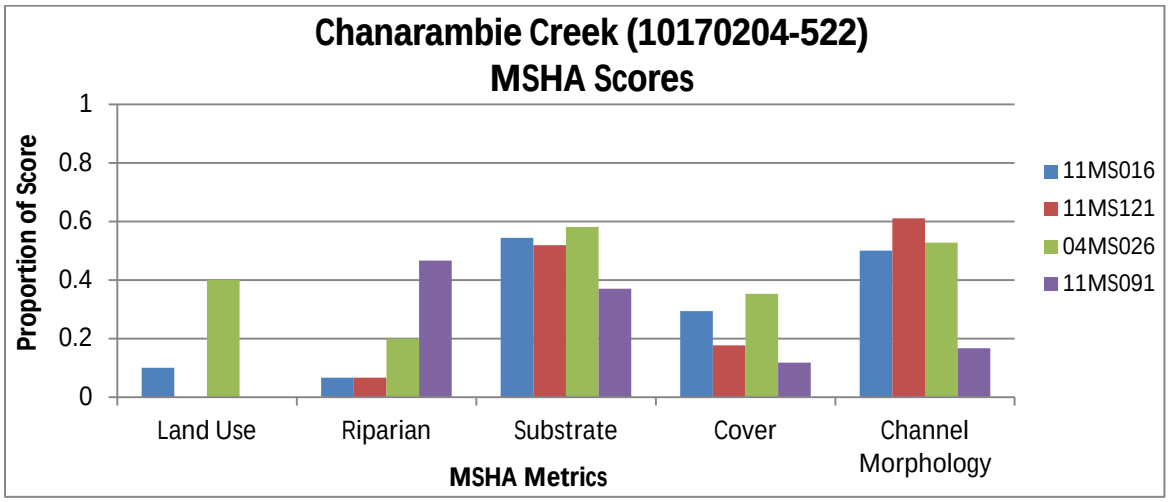

Figure 31: MSHA metric scores at 4 sites along Chanarambie Creek (10170204-522)

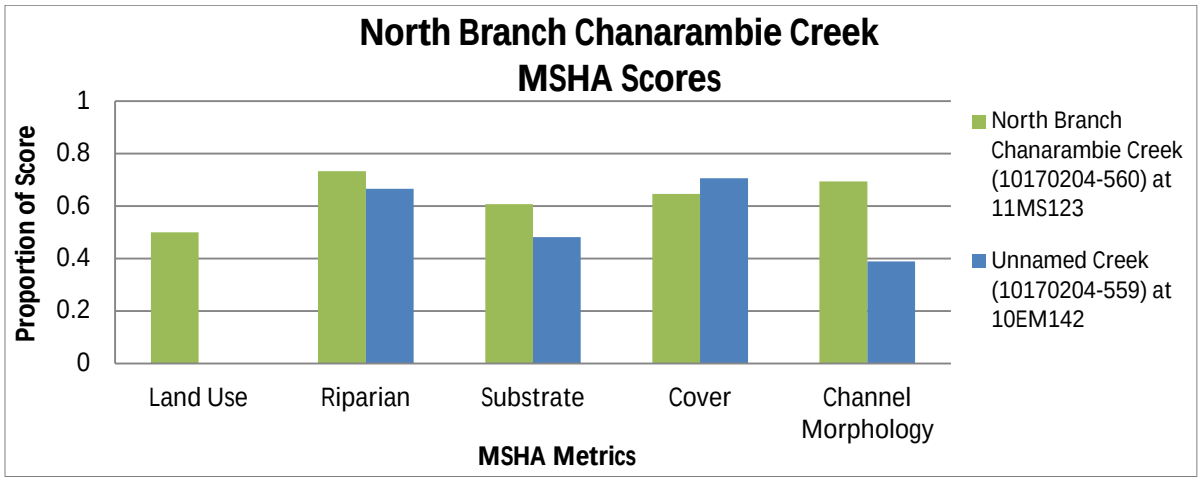

Figure 32: MSHA metric scores along North Branch Chanarambie Creek (10170204-560) and Unnamed Creek (10170204-559)

Chanarambie Creek (10170204-522)

The MSHA scores at the four biological sampling sites on Chanarambie Creek were 39.2, 40, 45.7, and 25 at sites 11MS016, 11MS121, 04MS026, and 11MS091. These scores were considered to be fair with the

exception being the poor score at 11MS091. Limiting the habitat conditions in this AUID was the poor surrounding land use, a limited riparian buffer, bank erosion (Figure 33), predominant sand/silt substrates, sparse fish cover, and moderate channel stability and development.

Figure 33: Severe bank erosion at sites 11MS016 (Left) and 11MS121 (Right) along Chanarambie Creek (10170204-522)

The macroinvertebrate sample was taken from just overhanging vegetation at sites 11MS016, 11MS091, and 11MS121. Site 04MS026 had its sample taken from equal parts overhanging vegetation and riffle habitat. This community had good numbers of clinger taxa (35.2%), while also having few burrower individuals (5.33%) which are more common in streams with degraded habitat conditions. However, for the amount of overhanging vegetation sampled, this reach averaged very few climber individuals (8.85%). The fish assemblage in Chanarambie Creek did have higher amounts of riffle dwelling species (22.69%), benthic insectivore taxa (31.08%), and darters/sculpin/round-bodied sucker species (18.96%). These metrics are usually much lower in streams lacking habitat.

While the MSHA scores along this reach range from fair to poor, the habitat related biological metrics do not indicate a stressor. The lack of habitat is not yet a stressor to the biological communities in Chanarambie Creek at this time. It will be important to protect these conditions in the future.

North Branch Chanarambie Creek (10170204-560)

The MSHA at biological monitoring station 11MS123 on North Branch Chanarambie Creek scored 65.9 (Table 34), which is considered to be fair habitat. Limiting the stream habitat in this stream was the presence of row crops upstream on the left bank, the presence of silt and excess sedimentation in pools, and moderate channel stability.

Biologically, the macroinvertebrate sample was taken from overhanging vegetation. The community sampled had lower levels of clinger taxa (20.59%). These taxa tend to decline in degraded habitat conditions. Site 11MS123 did however have a low amount of burrower individuals (7.31%).

Figure 34: Eroding bank at site 11MS123 along North Branch Chanarambie Creek (10170204-560)

Burrowers tend to be more abundant in streams with high amounts of fine sediment. This reach did have a high amount of climber individuals (40.2%). Climbers prefer woody debris and overhanging vegetation. The fish community in this reach was fairly tolerant (57.14%), but it did have a good amount of riffle dwelling fish species (21.43%), benthic insectivore taxa (21.43%), simple lithophilic spawning

species (28.57%), and a slightly above average amount of darters/sculpin/round-bodied suckers (14.29%) when compared statewide. These types of fish are less commonly found in streams lacking habitat.

With a fair MSHA score and mixed biological results, the lack of habitat does not appear to be a stressor to the impaired biological assemblages at this time. These communities are likely being stressed by other factors.

Unnamed Creek (10170204-559)
Unnamed Creek had an MSHA score of 49 at biological monitoring station 10EM142 (Figure X). This score is considered to be fair. Limiting the MSHA in Unnamed Creek was the poor surrounding land use, the nonexistent riparian buffer, the silty substrate, the lack of any riffles, bank erosion (Figure X) poor channel development, limited depth variability and moderate channel stability.

The macroinvertebrate sample from 10EM142 was taken from overhanging vegetation. This sample showed that the site had a high amount of climber individuals (82.37%). This sample also had a low amount of clinger taxa (27.78%), while also having a very high amount of tolerant taxa (66.67%). Site 10EM142 did have few burrower individuals (7.37%). Burrowers tend to be more abundant in streams with fine substrates. The fish community had high amounts of riffle dwelling taxa (25%) and simple Lithophilic spawning taxa (37.5%). These results are common in streams with good habitat conditions. This site did have a high amount of tolerant species (62.5%), and low numbers of benthic insectivore taxa (12.5%) and darters/sculpin/round-bodied sucker species (12.5%). These results reflect streams degraded by habitat.

The fair MSHA score along with many poor scoring habitat related biological metrics alludes to the lack of habitat being a stressor to the impaired macroinvertebrate community in Unnamed Creek.

Conclusion

The three biologically impaired reaches in the Chanarambie Creek Watershed are being impacted by multiple stressors (Table 23).

High phosphorus was determined to be a stressor to the biological assemblages in both Chanarambie Creek and North Branch Chanarambie Creek, while evidence was inconclusive for Unnamed Creek. The high phosphorus levels may lead to excessive algae growth as evidenced in North Branch Chanarambie Creek. While DO is currently not a stressor, prolonged periods of high phosphorus may eventually disrupt the DO conditions in the watershed by creating a high range of daily flux. This excess phosphorus is a likely result from the highly pastured riparian areas and cropland throughout the watershed where concentrations of phosphorus tend to be high. Runoff following rain events is a likely pathway for these phosphorus contributions to easily enter the stream system.

High nitrate values were also found to be a stressor to the fish and macroinvertebrate communities at all three impaired reaches in the Chanarambie Creek Watershed. Nitrate levels in excess of 16 mg/L were observed in North Branch Chanarambie Creek as well as Unnamed Creek. High percentages of nitrate tolerant individual macroinvertebrates were present, which often signals impairment. The high levels of nitrates are likely a result from fertilizer applications and have entered the stream as runoff.

Currently, Chanarambie Creek (10170204-522) is impaired for turbidity and was also found to be a stressor to the fish and macroinvertebrate communities within the reach. This reach was missing many Trichoptera and scraper macroinvertebrates as well as herbivorous fish species that are sensitive to higher turbidity/TSS concentrations. High intensity grazing with minimal riparian buffers in the watershed has led to unstable and erosive banks. Biological conditions further upstream in the headwaters do not seem to be affected by high levels of turbidity/TSS at this time. However, these sensitive areas are still in need of protection before they progress into a stressor.

The lack of habitat was found to be a stressor to the biological assemblages in Unnamed Creek. This reach had many tolerant fish and macroinvertebrates, while having few clinger taxa, and low numbers of benthic insectivore and darters/sculpin/round-bodied sucker species. Likely causes to the stressor habitat was the poor surrounding land use, limited riparian buffer, silty substrate, bank erosion, lack of riffles, limited depth variability and moderate channel stability. Furthermore, MDNR assessments have also found that Chanarambie Creek is unstable leading to limited access to the floodplain, high erosion rates and sediment supply and poor recovery potential. Improvements to near stream land use, using natural design practices, restoring natural vegetation, as well as no till practices are recommended within this watershed are needed to help improve the habitat conditions.

The Chanarambie Creek Watershed has many biological stressors throughout the basin. Addressing these stressors is needed to restore the biological communities to a healthy condition. Until this is done, the fish and macroinvertebrate communities will remain impaired.

Table 23: Stressors to the biologically impaired reaches within the Chanarambie Creek Watershed

		Stressors				
Stream Name	**AUID #**	**Low Dissolved Oxygen**	**High Phosphorus**	**High Nitrates**	**High Turbidity/TSS**	**Lack of Habitat**
Chanarambie Creek Watershed						
Chanarambie Creek	10170204-522	-	•	•	•	-
North Branch Chanarambie Creek	10170204-560	-	•	•	-	-
Unnamed Creek	10170204-559			•		•

(• = stressor, - = not a stressor, and blank = inconclusive/not enough evidence)

East Branch Rock River Watershed

Overview

East Branch Rock River is located in the far northern portion of the Rock River Watershed. The AUID, 10170204-530, is 17.22 miles long and extends from the far headwaters of the watershed down to the confluence with the Rock River (Figure 35). This reach was sampled for fish and macroinvertebrates in 2004 and 2011 and found to be impaired for aquatic life due to its macroinvertebrate assemblage during the watershed assessment in 2013. Land use in the East Branch Rock River 12-Digit HUC watershed consists mainly of cropland (62.17%), rangeland (30.74%), and developed (5.4%).

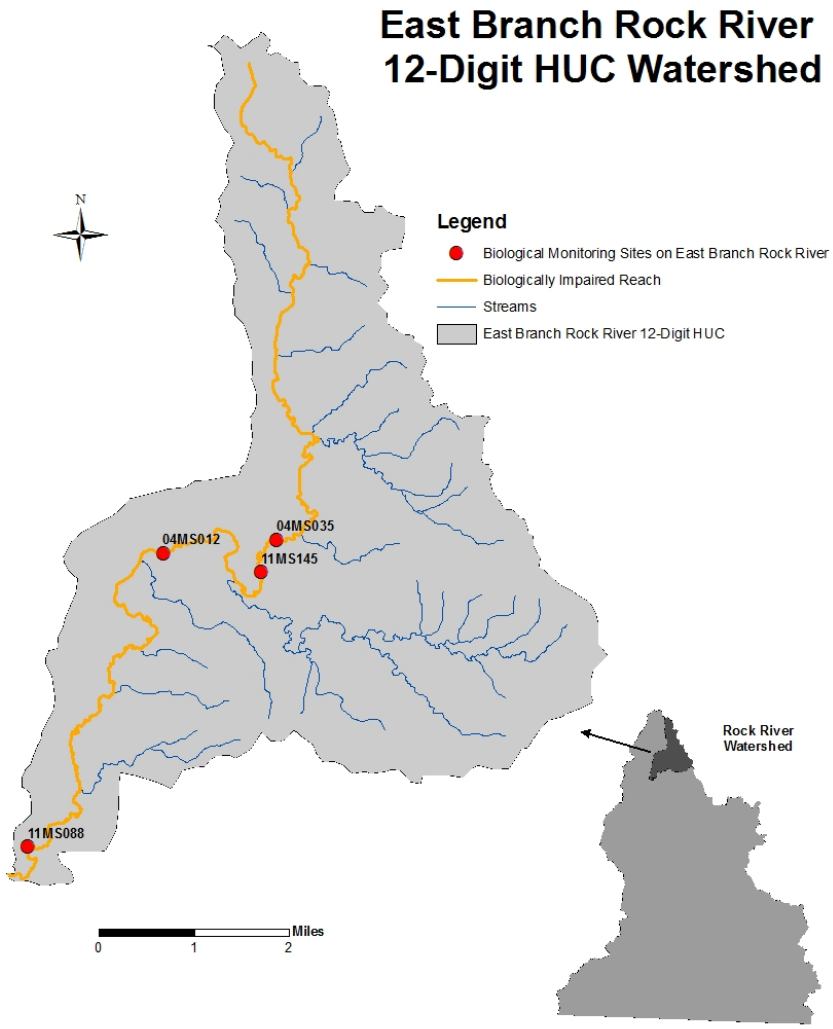

Figure 35: East Branch Rock River Watershed with biologically impaired reach highlighted

Biology in East Branch Rock River

Fish

Four biological monitoring stations are located along East Branch Rock River (10170204-530). The most downstream site, 11MS088, is located upstream of State Route 30, 3 miles north of Hatfield and was sampled for fish on August 3, 2011. Moving upstream, the next site is 04MS012 which is located on a channelized stream section. This site is upstream of CR 6, 4 miles southeast of Holland and had a fish sampling event occur on July 13, 2004. Next is site 11MS145 which is located Upstream of CR 6, 1.5 miles north of Woodstock and was sampled for fish on September 7, 2011. Lastly, the most upstream site on this AUID is 04MS035 which is located upstream of CR 6, 2.5 miles north of Woodstock. This site was sampled for fish on July 26, 2004.

The four sites along East Branch Rock River had an average fish IBI score of 67.25 which is well above the Class 3 (Southern Headwaters) threshold of 51 of which all of these sites belong to. Therefore, this AUID is not impaired for its fish community at this time.

Macroinvertebrates

Four macroinvertebrate samples were taken at biological monitoring stations along this impaired AUID. Site 11MS088 and 11MS145 had macroinvertebrate samples taken on August 2, 2011, while sites 04MS012 and 04MS035 were both sampled on September 1, 2004.

Three of the sites along this AUID are designated as Class 5 (Southern Streams RR) sites. The average MIBI score for the three sites in this classification is 23.4. Their average metric values scores are displayed in Figure 36. To reach the MPCA's macroinvertebrate IBI threshold of 35.9 for this class, each metric would need an average score of 3.59. As Figure 36 shows, only three metrics reached this level. This reach had a good presence of climber species (ClimberCh) and Odonata taxa, while not overly dominated by the five most abundant taxa (DomFiveCHPct). The remaining metrics all scored poorly.

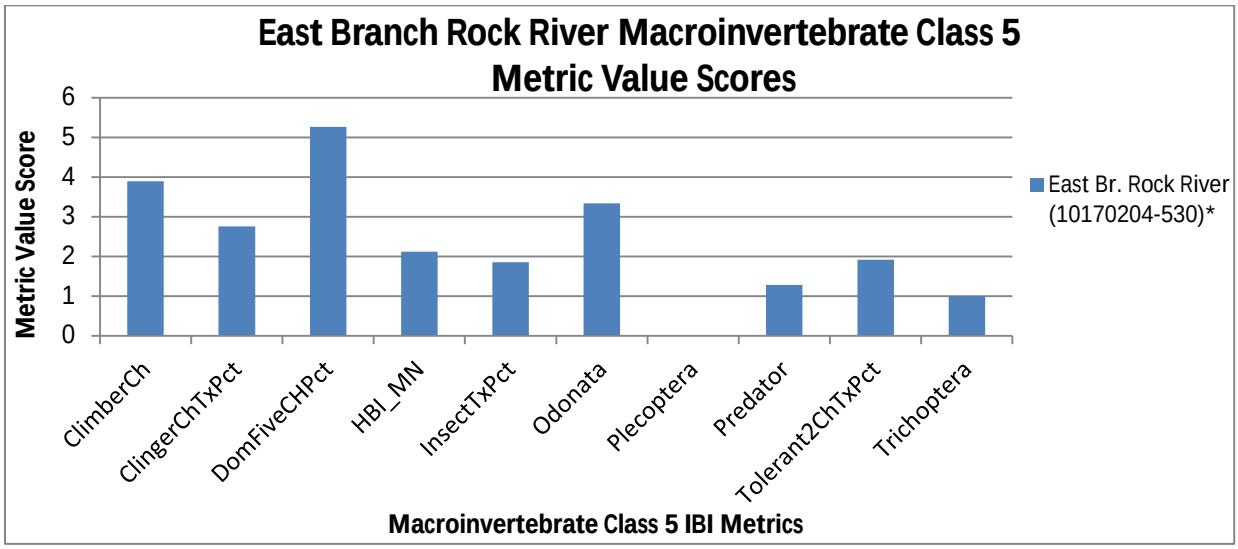

Figure 36: Macroinvertebrate Class 5 IBI metric value scores along East Branch Rock River (10170204-530)
*Average Value of Sites (11MS088, 04MS012, 04MS035**)**

The MIBI threshold for a Class 7 (Prairie Streams GP) sites is 38.83 and an average metric score of 3.83 is needed to reach this level. East Branch Rock River (10170204-530) had a MIBI score of 39.1 at site 11MS145. This site was just above the impairment threshold. However, due to the poor scores at the Class 5 sites on the stream section, this reach is impaired for macroinvertebrates. This site scored well on six of the metrics. The few numbers of collector-filterer species (Collector-filtererPct), Trichoptera taxa (TrichopteraChTxPct), and non-hydropsychid Trichoptera species (TrichwoHydroPct) as well as having a poor taxa richness of macroinvertebrates with tolerance values less than or equal to two lowered the MIBI score at this site (Figure 37).

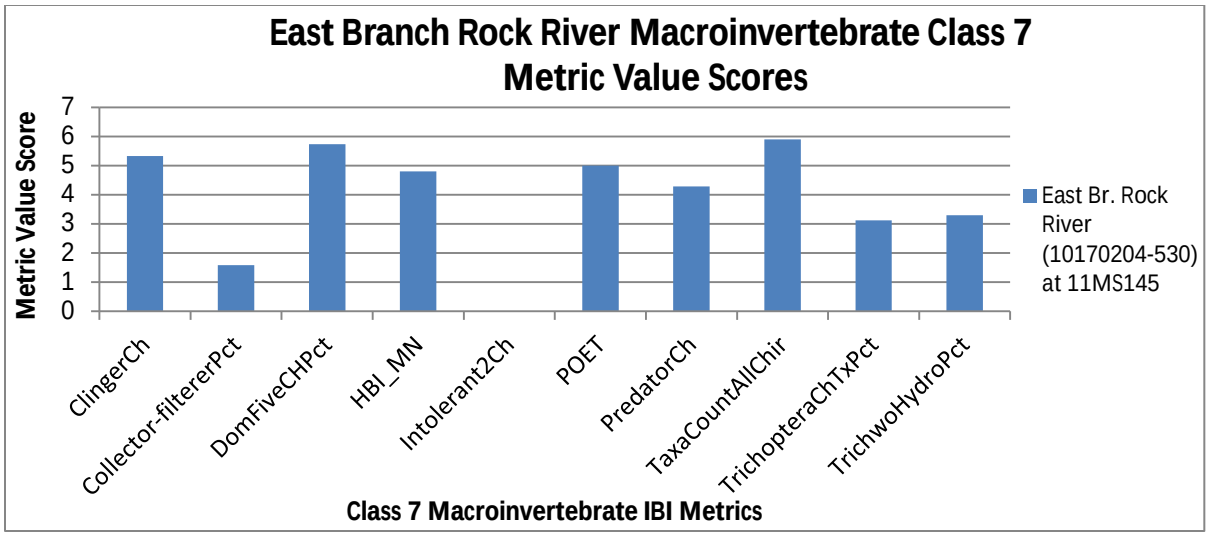

Figure 37: Macroinvertebrate Class 7 IBI metric value scores at site 11MS145 along East Branch Rock River (10170204-530)

Candidate cause: Low dissolved oxygen

The daily minimum standard for DO in Minnesota Class 2B streams is 5 mg/L. All streams in the East Branch Rock River Watershed have this 2B classification. No streams in this grouping are currently listed as impaired for DO.

There were a total of 13 DO readings taken from East Branch Rock River from 2004-2013. These measurements ranged from 6.5-12.7 mg/L with no values falling below the 5 mg/L daily minimum standard. None of the DO measurements taken along this reach were before 9 AM.

The HSPF model calculated hourly DO values for the East Branch Rock River from 1996-2009. These values ranged from 0-14.46 mg/L. The model calculated an exceedance rate of nearly 61% for the DO standard.

Biologically, the macroinvertebrate community in East Branch Rock River had an average amount of EPT taxa (22.37%) when compared to all other Minnesota streams. These sites had a high amount of DO tolerant taxa (27.19%), while also having a below average macroinvertebrate TIV score for DO.

The fish assemblage in this stream had many serial spawning taxa (29.83%) and tolerant taxa (56.5%), while also have few sensitive (11.35%) and late maturing (12.23%) taxa. The sites along this reach did have a DO TIV score for fish that was above the statewide average.

The model and predicted results both strongly suggest that DO is a stressor. However, none of the measurements taken fell below 5 mg/L. Further DO monitoring with a sonde is needed to better understand the negative impact, if any, DO is having on the biological communities in East Branch Rock River.

Candidate cause: High phosphorus

The proposed draft standard for phosphorus for streams in the Missouri River basin is currently 0.15 mg/L. Although phosphorus is an essential nutrient for all aquatic life, elevated levels can lead to an imbalance which impacts stream ecology.

From 2004-2013 there were 11 phosphorus samples taken from East Branch Rock River (Table 24). These samples ranged from less than 0.010-0.158 mg/L with one value above the proposed draft standard of 0.15 mg/L.

Table 24: Phosphorus values from 2004-2013 along East Branch Rock River (10170204-530)

Sample Location	Sample Date	Result (mg/l)	Proposed Draft Standard (mg/l)
04MS012	7/13/2004	0.11	n/a
04MS035	7/26/2004	0.158	n/a
11MS088	8/3/2011	0.093	n/a
11MS145	9/7/2011	0.077	n/a
11MS088	5/7/2013	<.010	n/a
11MS088	6/11/2013	0.084	n/a
11MS088	7/2/2013	0.05	n/a
11MS088	7/16/2013	0.033	n/a
11MS088	7/31/2013	0.026	n/a
11MS088	8/20/2013	0.035	n/a
11MS088	9/12/2013	0.049	n/a

From 1996-2009, the HSPF model calculated daily phosphorus values for East Branch Rock River. These values ranged from 0.05-0.82 mg/L with 68.09% of the predictions above the 0.15 mg/L proposed phosphorus standard.

Figure 38: Hyalella

Biologically, the macroinvertebrate assemblage had average numbers of both EPT taxa (22.37%) and Tanytarsini species (7%) when compared to all other Minnesota streams. This reach did also have a few intolerant taxa (3.85%), while also having many crustacean/mollusca (14.65%), scraper (14.68%), and tolerant (68.09%) taxa. These metrics tend to be higher in streams experiencing higher levels of phosphorus. Also, many Hyalella (Figure 38) were sampled. This genus of crustaceans is often found in abundance in degraded and possibly eutrophic conditions. The fish community had many tolerant taxa (56.5%) and few sensitive species (11.35%).

Based on the majority of the related biological metrics and the high rate of exceedance predicted by the model, high phosphorus is indeed stressing the biological communities in this impaired AUID. Further phosphorus monitoring will likely show higher phosphorus values.

Candidate cause: High nitrates

Currently, the State of Minnesota does not have a nitrate standard in place for streams not used as a drinking water source. However, the overabundance of nitrates can stress a biological community. Nitrates in the East Branch Rock River Watershed did at times reach levels that could potentially be stressing the biological assemblages.

From 2004-2013 there were 11 nitrate samples taken from East Branch Rock River (Table 25). These values ranged from 2.5-9.8 mg/L.

Table 25: Nitrate sample values from 2004-2013 along East Branch Rock River (10170204-530)

Sample Location	Sample Date	Result (mg/l)	Proposed Draft Standard (mg/l)
04MS012	7/13/2004	3.6	n/a
04MS035	7/26/2004	3.2	n/a
11MS088	8/3/2011	5	n/a
11MS145	9/7/2011	2.7	n/a
11MS088	5/7/2013	3.7	n/a
11MS088	6/11/2013	7.7	n/a
11MS088	7/2/2013	9.8	n/a
11MS088	7/16/2013	4.5	n/a
11MS088	7/31/2013	3.9	n/a
11MS088	8/20/2013	2.5	n/a
11MS088	9/12/2013	3.3	n/a

The HSPF model calculated daily nitrate values for East Branch Rock River from 1996-2009. These values ranged from1.22-14.62 mg/L with an average value of 5.47 mg/L.

Biologically, the macroinvertebrate community in East Branch Rock River had an average overall taxa count (24.5), but did have few of the nitrate sensitive Trichoptera taxa (7.02%). Site 11MS145 had a high percentage (85.81) of nitrate tolerant taxa. Quantile regression analyses showed that Class 7 sites like 11MS145 have a greater than 75% chance of being impaired when there is more than 79.53% nitrate tolerant taxa. The remaining sites are Class 5 sites. These sites averaged 59.71% nitrate tolerant taxa. Class 5 sites have 25% probability of being impaired when levels are 54.66% and lower and a 50% chance of being impaired when levels reach 68.66%. The fish assemblage had a higher average taxa count (17.13), but did have few sensitive species (11.35%).

Based on the relatively low observed and predicted nitrate results along with the mixed nitrate related biological results, it is likely that the biological communities are being stressed by other parameters. Therefore, high nitrates are not a stressor to the fish and macroinvertebrate assemblages in East Branch Rock River at this time.

Candidate cause: High turbidity/TSS

The water quality standard for turbidity is 25 NTU, 65 mg/L for TSS, and 20 cm for transparency tube for these Class 2B warmwater streams in the East Branch Rock River Watershed. Excess sediment is a commonly recognized stressor in many biologically impaired streams because it can reduce habitat, cause direct physical harm, as well as reduce visibility and increase oxygen demand.

From 2004-2013, 11 TSS samples were taken from various sites along East Branch Rock River (10170203-530) (Figure 26). These TSS values ranged from 6.4-32 mg/L with no readings above the 65 mg/L standard. Additionally, 13 Secchi tube readings were taken during this time period. These values ranged from 13 cm to greater than 100cm, with only one reading falling below the 20 cm minimum standard for transparency.

Table 26: TSS and Secchi tube values from 2001-2013 along East Branch Rock River (10170204-530)

Sample Location	Sample Date	TSS Result (mg/l)	TSS Standard (mg/l)	Secchi Tube Value (cm)	Secchi Tube Standard (cm)
04MS012	7/13/2004	23	65	36	20
04MS035	7/26/2004	26	65	24	20
11MS088	8/2/2011	n/a	65	36	20
11MS145	8/2/2011	n/a	65	13	20
11MS088	8/3/2011	16	65	55	20
11MS145	9/7/2011	9.2	65	55	20
11MS088	5/7/2013	6.4	65	>100	20
11MS088	6/11/2013	32	65	59	20
11MS088	7/2/2013	26	65	33	20
11MS088	7/16/2013	9.2	65	78	20
11MS088	7/31/2013	10	65	80.5	20
11MS088	8/20/2013	8.4	65	48	20
11MS088	9/12/2013	16	65	30	20

The HSPF model calculated daily TSS values for East Branch Rock River from 1996-2009. These values ranged from 0-3459.9 mg/L with an average value of 24.15 mg/L. The model calculated an exceedance rate of 9.72%.

Biologically, the macroinvertebrate assemblage in this stream reach had an average overall taxa count (24.5) and chironomid taxa (34.92%) when compared to all other Minnesota streams. This AUID also had few Trichoptera taxa (7.02%), collector-filterer species (9.57%), while also having many tolerant taxa (68.09%). This reach did have a higher amount of Ephemeroptera taxa (15.35%), which tend to decrease in streams with elevated TSS values. The fish population had many tolerant taxa (56.5%), but did have a slightly above average amount of herbivorous taxa (8.53%) when compared to all other Minnesota streams.

The collected data has very few instances of exceeding the standard and the TSS/turbidity related biological metric results have mixed results. At this time, more expansive TSS sampling is needed to better understand TSS concentrations under different flow conditions.

Candidate cause: Lack of habitat

Qualitative habitat assessments were performed at each of the four biological monitoring sites along East Branch Rock River (10170204-530) during their fish sampling events. MSHA scores ranged from 42 (poor)-66.1 (good), with an average score of 54.1 (fair). Site 04MS021, which is located on a channelized stream section, not surprisingly had the lowest MSHA score. Channelized streams are typically limited by their habitat conditions. Figure 39 displays the average MSHA metric scores for East Branch Rock River.

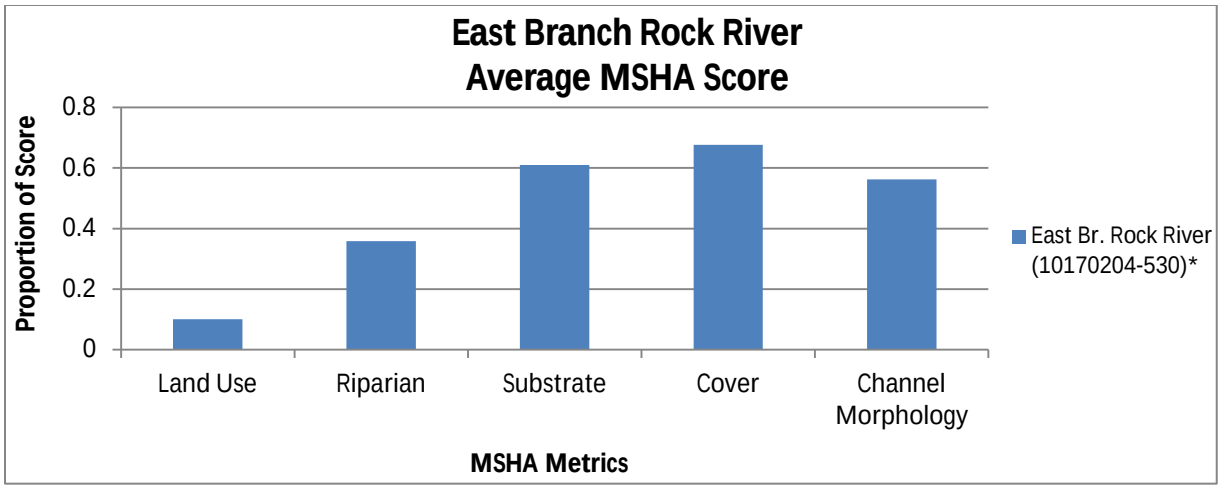

Figure 39: Average MSHA metric scores from sites along East Branch Rock River (10170204-530)
*Average MSHA Values from sites (11MS088, 04MS012, 11MS145, 04MS035)

The MSHA at the biological monitoring sites was limited by the poor surrounding land use (Figure 40), limited riparian buffer, some sand and silty substrates, moderate channel stability, and fair channel development.

The macroinvertebrate samples along this reach were taken from wide variety of habitat types including overhanging vegetation, riffle, and aquatic macrophytes. The macroinvertebrate assemblage had many tolerant taxa (68.09%) and a lower amount of clinger species (26.78%). This reach also had a lower amount of climber individuals (19.63%). Climber species prefer overhanging vegetation and woody debris habitat conditions. The fish assemblage had a high amount of tolerant taxa (56.5%). This AUID also had a high amount of riffle-dwelling (16.95%), benthic insectivore (27.51%), simple lithophilic spawning (25.95%), and darter/sculpin/round-bodied sucker (15.58%) species. These metrics all signal good habitat conditions.

Figure 40: Heavily pastured land use at site 11MS088 along East Branch Rock River (10170204-530)

The majority of the habitat related fish metrics point to good habitat conditions despite the fair average MSHA score. The lack of habitat should only be considered a minor or secondary stressor to the impaired macroinvertebrate community in East Branch Rock River at this time.

Conclusion

The East Branch Rock River was found to have two stressors to the biological community, high phosphorus and the lack of habitat (Table 27). High nitrates were ruled out as a stressor, while low DO and high turbidity/TSS need more information to determine whether or not they are stressors to the fish and macroinvertebrate communities.

High phosphorus has been observed throughout the Rock River Watershed, but also the entire Missouri River basin within Minnesota. Both the biological and modeled data strongly suggest high phosphorus problems. The high phosphorus levels may lead to excessive algae growth. While DO is currently not a

stressor, prolonged periods of high phosphorus may eventually disrupt the DO conditions in the watershed by creating a high range of daily flux. This excess phosphorus is a likely result from the highly pastured riparian areas and cropland throughout the watershed where concentrations of phosphorus tend to be high. Runoff following rain events is a likely pathway for these phosphorus contributions to easily enter the stream system.

The lack of habitat was found to be a secondary stressor in the East Branch Rock River conditions were mainly "fair" throughout the AUID. The stream reach was found to be limited by the poor surrounding land use, limited riparian buffer, presence of sand and silty substrates, having a moderate channel stability, and fair channel development. Upgrading the habitat conditions in this reach is recommended to improve the impaired aquatic life conditions.

Table 27: Stressors to the biologically impaired reaches within the East Branch Rock River Watershed

		Stressors				
Stream Name	**AUID #**	**Low Dissolved Oxygen**	**High Phosphorus**	**High Nitrates**	**High Turbidity/ TSS**	**Lack of Habitat**
East Branch Rock River Watershed						
East Branch Rock River	10170204-530		•	-		•

(• = stressor, - = not a stressor, and blank = inconclusive/not enough evidence)

Elk Creek Watershed

Overview

Elk Creek is located in the south central portion of the Rock River Watershed and is a significant tributary to the Rock River. The biologically impaired AUID, 10170204-519, is 31.43 miles long and extends from the Elk Creek headwaters to the confluence with the Rock River (Figure 41). This reach was sampled for fish and macroinvertebrates in 2011-2012 at its biological sites (11MS020, 11MS100, 11MS118) and found to be impaired for both fish and macroinvertebrate assemblages during the watershed assessment in 2013. Land use in the Elk Creek Watershed predominantly cropland (86.59%), with developed (6.23%) and rangeland (4.85%) making up the next highest uses.

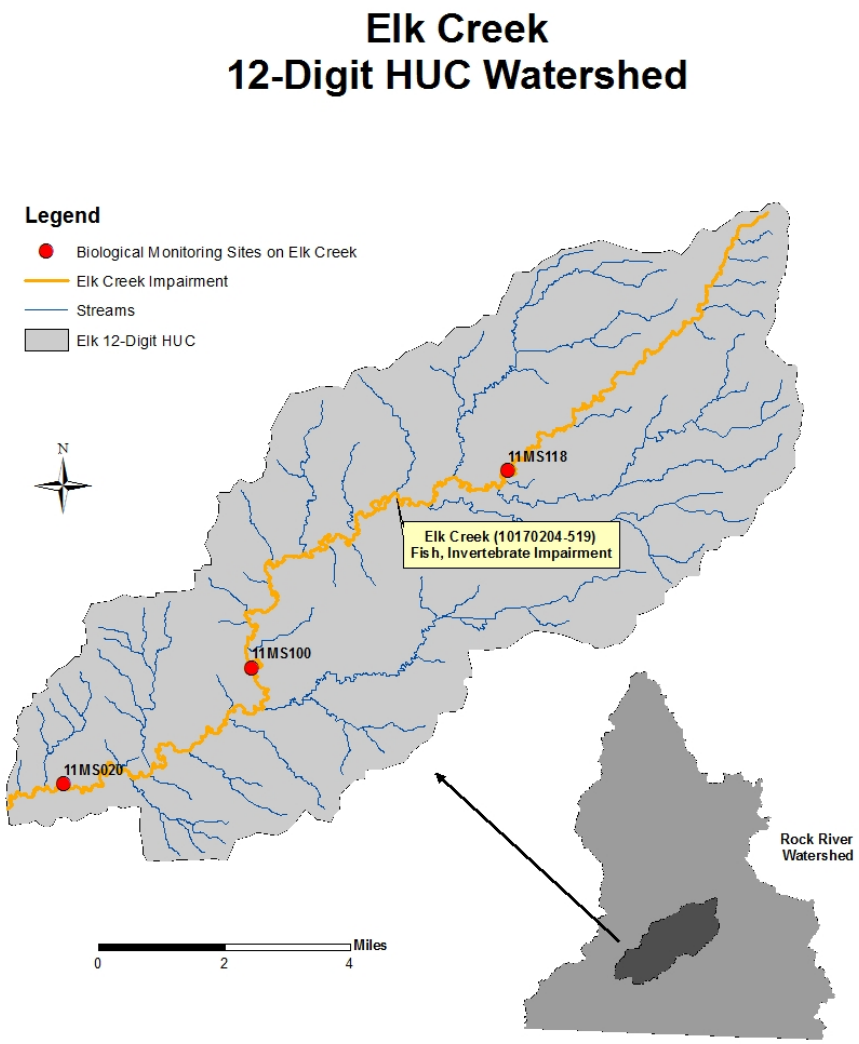

Figure 41: Elk Creek Watershed with biologically impaired reach highlighted

Biology in Elk Creek

Fish

There were three fish sampling events at three different biological monitoring stations along Elk Creek. Site 11MS020 is located upstream of CR 9, 3 miles south of Luverne and was sampled on June 12, 2012. Moving upstream, site 11MS100 is located on a channelized portion of Elk Creek upstream of 101st Street, 2 miles southwest of Magnolia and was sampled on August 9, 2011. In the headwaters, site 11MS118, is located downstream of Ahlers Avenue, 2.5 miles northeast of Magnolia and was sampled on August 2, 2011.

Two sites, 11MS020 and 11MS100, along Elk Creek (10170204-519) have a Fish Class 2 (Southern Streams) designation (Figure 42). The IBI threshold for this class is 45 and to reach this level, each metric would need an average metric value score of 5.625. Site 11MS020 had a fish IBI score of 19. This site was not overly dominated by its two most abundant taxa (DomTwoPct) resulting in a higher metric value score. The remaining metrics at this site scored poorly. Site 11MS100 had a fish IBI score of 36. This site also scored well in the DomTwoPct metic, but also had good numbers of benthic insectivores (BenInsect-TolTxPct) and late maturing fish taxa (MA<2ct). The remaining metrics scored poorly.

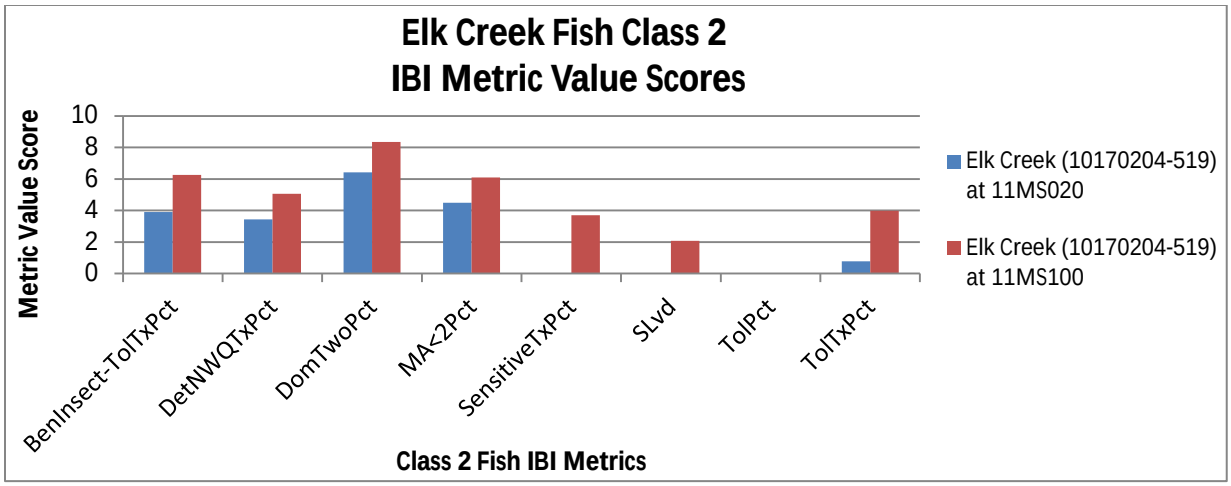

Figure 42: Fish Class 2 IBI metric value scores at two sites along Elk Creek (10170204-519)

Site 11MS118 along Elk Creek (10170204-519) is designated as a fish Class 3 (Southern Headwaters) stream. The fish IBI threshold for this class is 51, which means that each metric would need an average score of 8.5 to reach this level (Figure 43). Site 11MS118 along this reach had a fish IBI score of 56. While this site scored above the threshold and had many good scoring metrics, the very poor scoring Class 2 sites along this reach led to the fish impairment designation.

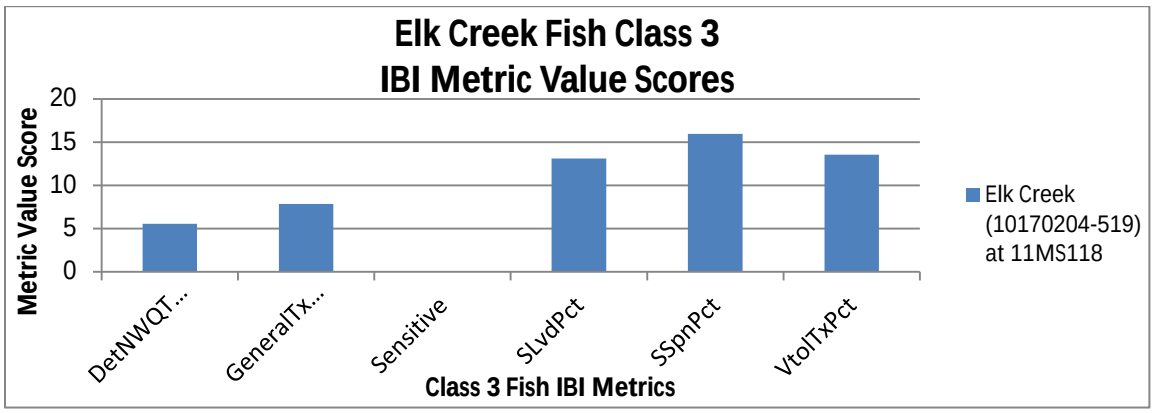

Figure 43: Fish Class 3 IBI metric value scores at site 11MS118 along Elk Creek (10170204-519)

Macroinvertebrates

There were three macroinvertebrate sampling events at the three biological monitoring stations, 11MS020, 11MS100, and 11MS118. All three of these sites were sampled for macroinvertebrates on August 4, 2011.

All sites along Elk Creek have an macroinvertebrate IBI Class 5 (Southern Streams RR) designation. The impairment threshold in this class is 35.9, so each metric would need an average score of 3.59 to reach this level (Figure 44). The most downstream site, 11MS020, had an macroinvertebrate IBI score of 27.9. This site had good numbers of Clingers (ClingerChTxPct), insects (InsectTxPct) and Odonata species while scoring low in all of the other metrics. Moving upstream, site 11MS100 had very similar results. This site was located on a channelized portion of Elk Creek and therefore, was not used during the assessment of Elk Creek. Site 11MS118, the furthest upstream site on Elk Creek, had good numbers of Climbers, (ClimberCh), Clingers, Odonata, and a relative low abundance of dominant five taxa which results in a higher IBI score. All other metrics did not score very well at this site.

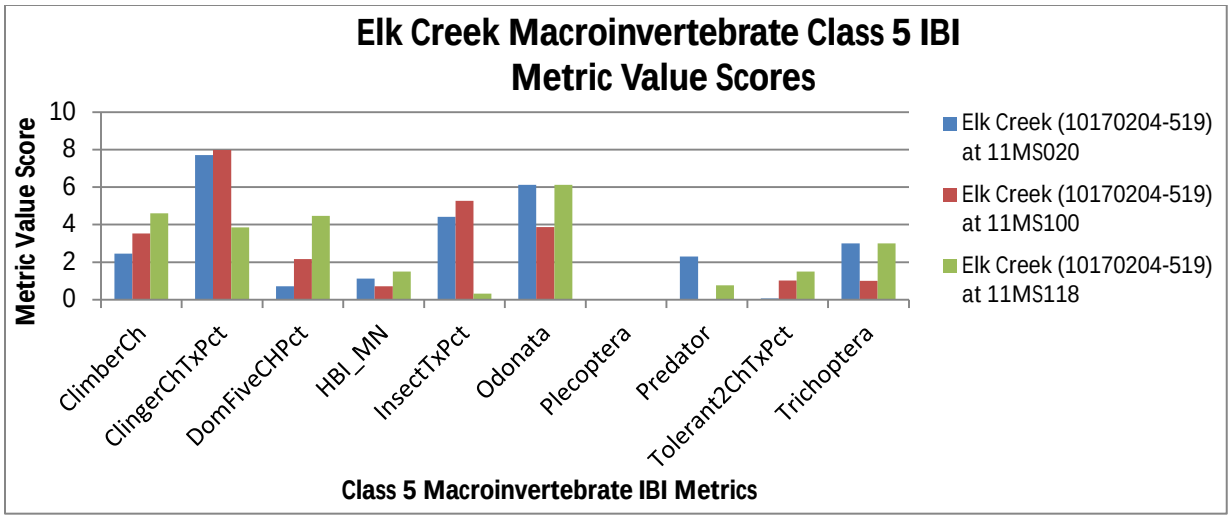

Figure 44: Macroinvertebrate Class 5 IBI metric value scores from three sites along Elk Creek (10170204-519)

Candidate cause: Low dissolved oxygen

The daily minimum standard for DO in Minnesota Class 2B streams is 5 mg/L. All streams in the Elk Creek Watershed have this 2B classification. No streams in this grouping are currently listed as impaired for DO.

From 2011-2012, there were 76 DO readings taken from this reach of Elk Creek (Figure 45). These values ranged from 3.86-13.51 mg/L with only 2 values below the minimum daily standard of 5 mg/L.

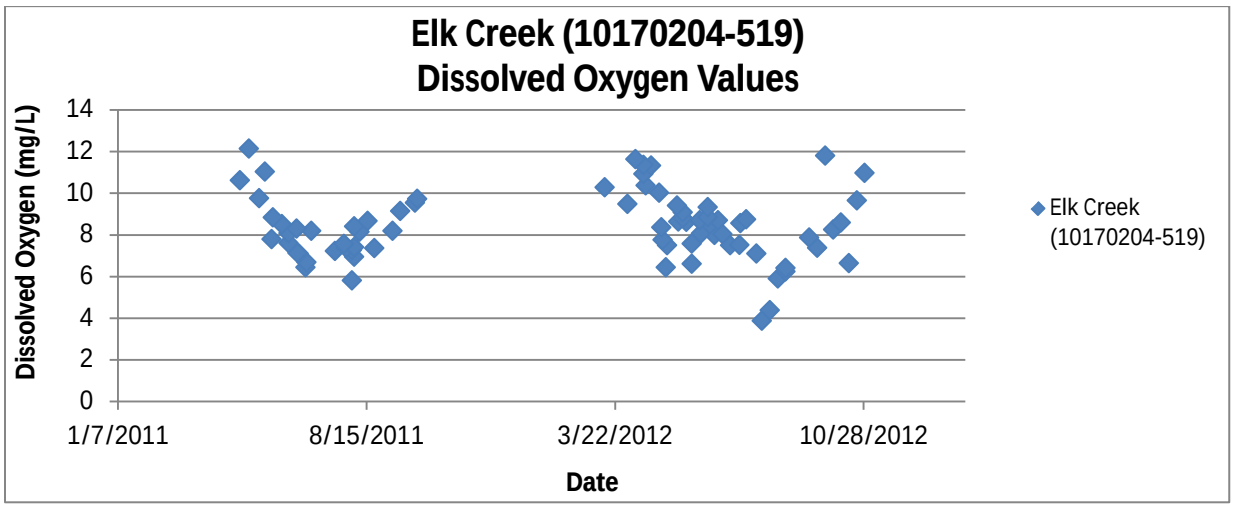

Figure 45: Dissolved oxygen values from 2011-2012 along Elk Creek (10170204-519)

Biologically, the macroinvertebrate population in Elk Creek had below average amounts of tolerant taxa (57.65%), while also having an average of 22 species sampled at each site which is below the state average. Streams affected by low DO tend to have high percentages of tolerant taxa and fewer species. This reach had a high amount of EPT individuals (77.79%), which is expected in streams not stressed by low DO conditions. Furthermore, the sites along this reach averaged 6.67 DO intolerant species per site, which is indicative of a stream with healthy DO levels.

In streams with low DO, there tends to be low numbers of sensitive taxa, high numbers of serial spawning and tolerant fish taxa, and low number numbers of late maturing fish. The fish assemblage had a below average amount of sensitive taxa (4.44%), high amounts of serial spawning species (31.02%) and tolerant fish species (75.23%), while also having a below average amount of late maturing fish taxa

(12.31%). However, sites along Elk Creek did have an above average DO TIV score when compared to all other Minnesota sites.

Based on the observed values, the DO related macroinvertebrate metrics, and the high scoring TIV value for Elk Creek, low DO is not a stressor to the biological communities at this time. It is likely that other stressors are providing a false positive in many of the fish metrics.

Candidate cause: High phosphorus

The proposed draft standard for phosphorus for streams in the Missouri River basin is currently 0.15 mg/L. Although phosphorus is an essential nutrient for all aquatic life, elevated levels can lead to an imbalance which impacts stream ecology. In the Elk Creek Watershed phosphorus levels have exceeded this proposed standard multiple times.

From 2011-2012, there were a total of 46 phosphorus samples taken from Elk Creek. Sample values ranged from 0.021-1.85 mg/L, with 22 (47.8%) above the proposed draft standard of 0.15 mg/L (Figure 46).

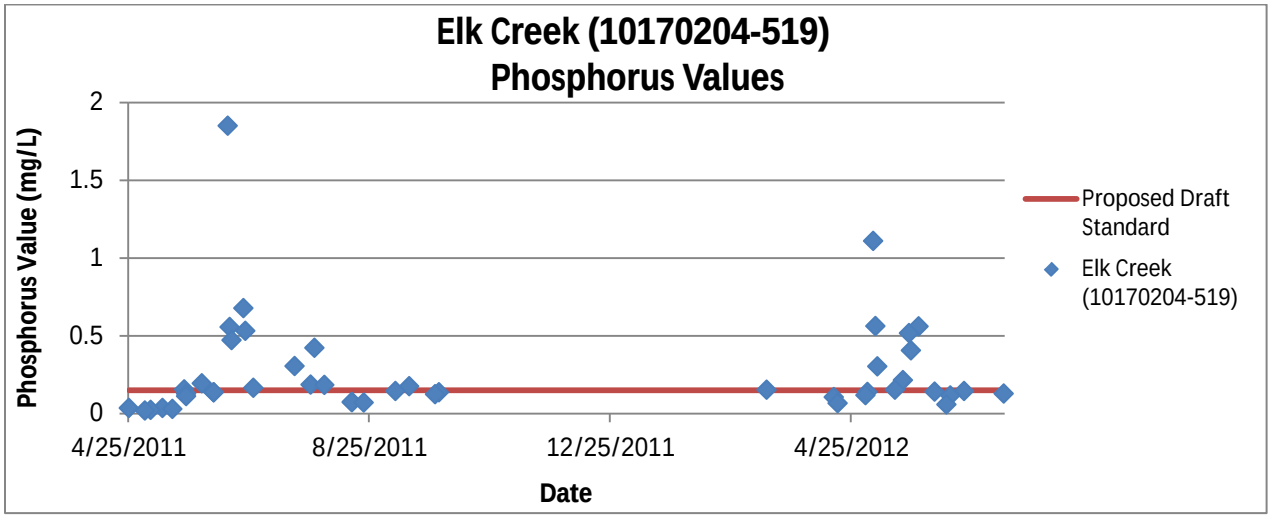

Figure 46: Phosphorus values from 2011-2012 along Elk Creek (10170204-519)

The HSPF model calculated daily phosphorus values for Elk Creek from 1996-2009. These values ranged from 0.06-1.05 mg/L with 63.24% of the calculations exceeding 0.15 mg/L proposed phosphorus standard.

Biologically, the macroinvertebrate population in Elk Creek consisted of a relatively high amount of EPT taxa (41.36%) and also had an average amount of intolerant taxa (9.14%). This reach did have a below average amount of tolerant (57.65%) when compared to all other Minnesota streams. Results like these are typically found in streams with low phosphorus levels. However, Elk Creek did have low amounts of phosphorus sensitive Tanysarsini taxa (2.47%), and higher than average amounts of phosphorus tolerant crustacean/mollusca taxa (12.59%) and scraper species (16.05%). Fish populations had high amounts of tolerant fish taxa (75.23%) and few sensitive taxa (4.44%). These results are common in streams with high phosphorus levels.

The high numbers of exceedances of the data, the modeling information, as well as the majority of biological metrics all signal that high phosphorus is a stressor to the impaired biological communities in Elk Creek.

Candidate cause: High nitrates

Currently, the state of Minnesota does not have a nitrate standard in place for streams not used as a drinking water source. However, the overabundance of nitrates can stress a biological community. Nitrates in the Elk Creek Watershed did at times reach levels that could potentially be stressing the biological assemblages.

From 2011-2012 there were 46 nitrate samples taken from Elk Creek (Figure 47). Sample values ranged from 5.03-16.1 mg/L.

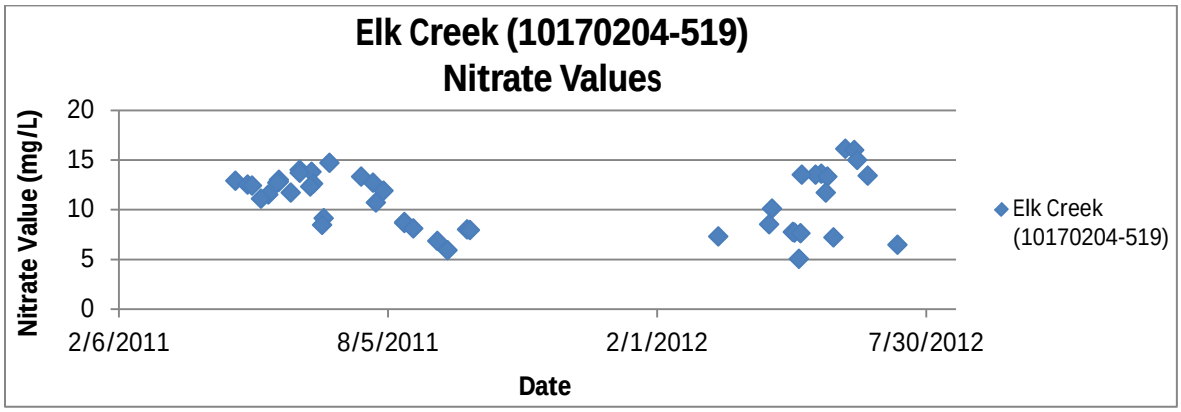

Figure 47: Elk Creek (10170204-519) nitrate values from 2011-2012

The macroinvertebrate assemblage in Elk Creek had a higher than average amount of Trichoptera taxa (14.82%) when compared to all other Minnesota stream. Trichoptera tend to be more sensitive to elevated levels of nitrates. There was also a high amount of tolerant macroinvertebrate species (57.65%). Additionally, a quantile regression analysis comparing nitrate tolerant individuals and Class 5 IBI scores showed that streams having more than 83.78% of its population consisting of nitrate tolerant individuals, the site would have a 90% chance of being impaired. The sites along Elk Creek had an average of 90.93% of its macroinvertebrate population consisting of nitrate tolerant individuals. The fish populations of Elk Creek had a high amount of tolerant fish species (75.23%) and lacked many sensitive fish taxa (4.44%) which can signal that nitrates are affecting the biological conditions.

The very high observed measurements, along with the strong evidence of the quantile regression analyses and many poorly scoring biological metrics makes the presence of elevated nitrates a stressor to the impaired biological communities along Elk Creek.

Candidate cause: High turbidity/TSS

Elk Creek had 66 turbidity samples taken from 2011-2012. Sample values ranged from 3.5-490 NTU with 52 of 66 (78.79%) of the samples at or over the maximum turbidity standard of 25 NTU. Furthermore, 32 of 80 TSS samples were over the 65 mg/L maximum standard for TSS with samples ranging from 4-553 mg/L (Figure 48). Elk Creek was previously listed as impaired for turbidity in 2006 and the most recent assessment confirmed this impairment.

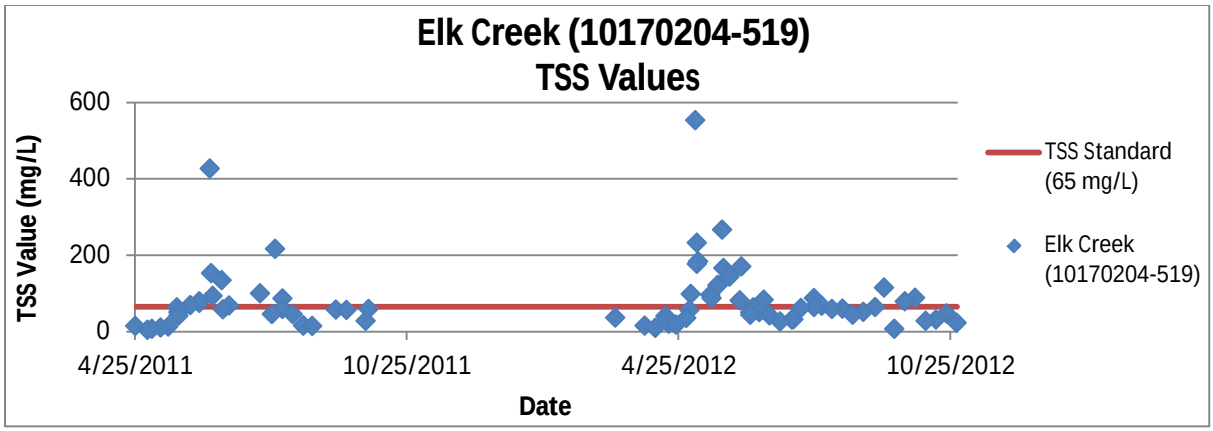

Figure 48: TSS sample values from 2011-2012 along Elk Creek (10170204-519)

Biologically, the macroinvertebrate community in Elk Creek had good numbers of Ephemeroptera taxa (26.54%), but this was likely due to the high presence of Trichorythodes, which can be found in high populations in degraded conditions. This reach did have a higher number of Trichoptera taxa (14.82%), but did have a lower overall taxa count (22) and many tolerant taxa (57.65%). The fish assemblage in this reach had a very high number of herbivorous taxa (16.37%), which is not expected in a reach impaired for turbidity.

While this reach of Elk Creek is currently impaired for turbidity, based on the related biological metric information, high turbidity/TSS is not a stressor to the biological communities at this time.

Candidate cause: Lack of habitat

Qualitative habitat assessments were performed at all three biological monitoring sites (11MS020, 11MS100, 11MS118) along Elk Creek. The MSHA score of these sites from moving upstream were 49.1, 53.8, and 46.85. See Figure 49 for a more detailed breakdown of MSHA scores by category. All of these scores are considered to be fair. Habitat conditions at these sites were mainly limited by the poor surrounding land use, little riparian buffer, some bank erosion, sparse fish cover, some embeddedness, and moderate to low channel stability.

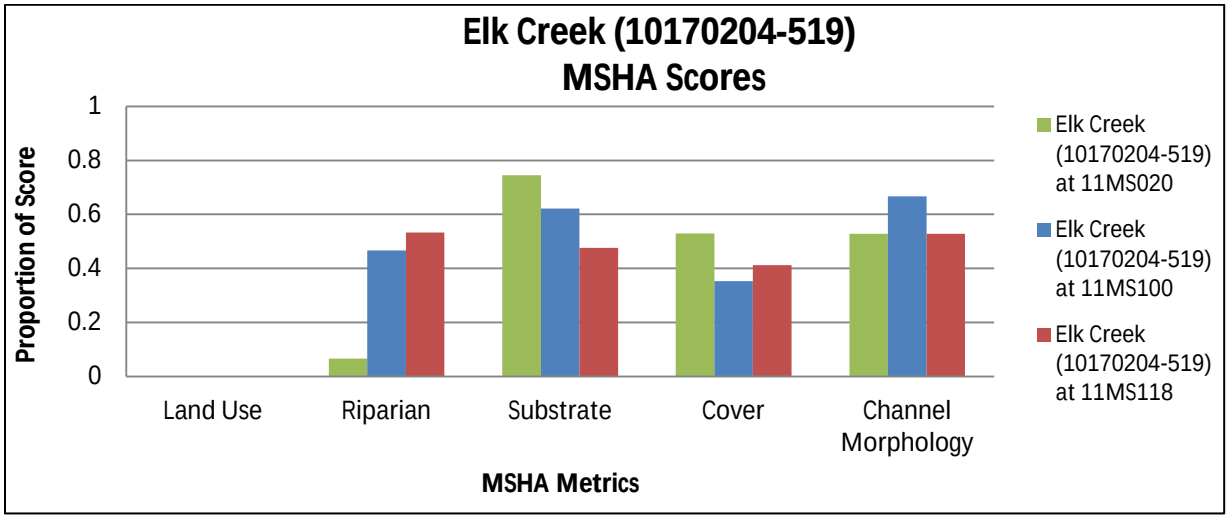

Figure 49: MSHA metric scores for three sites along Elk Creek (10170204-519)

The macroinvertebrate samples along this reach were taken from equal parts riffle and overhanging vegetation. The sampled community in Elk Creek had good numbers of Clinger taxa (36.91%), as well as sprawler individuals (26.27%). Sprawler taxa prefer course gravel and cobble habitats without fine sediment. The low amount of burrower individuals (1.76%) present also signals that fine sediment is not an issue.

The fish assemblage had above average numbers of riffle dwelling fish taxa (20.32%) and simple Lithophilic spawning taxa (28.33%), while having below average numbers of benthic insectivore taxa (16.62%) and darters/sculpins/round-bodied sucker species (12.31%). All of these metrics tend to score higher in streams not limited by habitat conditions. Elk Creek did also have a high average amount of tolerant fish species (75.23%).

With mixed results between the MSHA scores and the habitat related biological metrics, the lack of habitat is not a primary stressor to the impaired fish and macroinvertebrate communities, but could still be having a smaller impact.

Conclusion

Excess levels of phosphorus and nitrates were found to be the two main stressors to the impaired biological assemblages in Elk Creek (Table 28).

Phosphorus levels in Elk Creek frequently exceeded the proposed phosphorus standard, with one sample collected having a value over 12 times the standard. The high phosphorus levels may lead to excessive algae growth. While DO is currently not a stressor, prolonged periods of high phosphorus may eventually disrupt the DO conditions in the watershed by creating a high range of daily flux. This excess phosphorus is a likely result from the highly pastured riparian areas and cropland throughout the watershed where concentrations of phosphorus tend to be high. Runoff following rain events is a likely pathway for these phosphorus contributions to easily enter the stream system.

High nitrate values were also found to be a stressor to the fish and macroinvertebrate communities in Elk Creek. Nitrate levels in excess of 16 mg/L were observed. High percentages of nitrate tolerant individual macroinvertebrates were present, which often signals impairment. Many tolerant fish were present with very few sensitive species sampled. These high levels of nitrates are likely a result from fertilizer applications and have entered the stream as runoff.

Nutrient management in the Elk Creek Watershed will be extremely important to the impaired fish and macroinvertebrate communities moving forward. Until significant changes are made in regards to nutrient management, expect the biological assemblages to remain impaired in Elk Creek.

Table 28: Stressors to the biologically impaired reaches within the Elk Creek Watershed

		Stressors				
Stream Name	**AUID #**	**Low Dissolved Oxygen**	**High Phosphorus**	**High Nitrates**	**High Turbidity/TSS**	**Lack of Habitat**
Elk Creek Watershed						
Elk Creek	10170204-519	-	•	•	-	-

(• = stressor, - = not a stressor, and blank = inconclusive/not enough evidence)

Kanaranzi Creek Watershed

Overview

The Kanaranzi Creek Watershed in Minnesota consists of four 12-digit HUCs located in east central of the Rock Creek Watershed. The Kanaranzi Creek Watershed contains four stream AUIDs designated as impaired for aquatic life (Figure 50): Kanaranzi Creek (10170204-517), Kanaranzi Creek (10170204-516), Kanaranzi Creek (10170204-515), and East Branch Kanaranzi Creek (10170204-514). The land use in the watershed consists primarily of cropland (83.19%) followed by rangeland (7.53%) and developed (6.52%).

Kanaranzi Creek (10170204-517) is the most downstream stretch of Kanaranzi Creek, this AUID is 6.77 miles long and begins at the confluence of Norwegian Creek and ends at the Iowa/Minnesota border. This stream reach was sampled for fish and macroinvertebrates in 2011 at its lone biological monitoring station 11MS006. The AUID was determined to be impaired for aquatic life due to its fish and macroinvertebrate assemblages as well as turbidity during the watershed assessment in 2013.

Kanaranzi Creek (10170204-516) is a 25.98 mile reach extending from the East Branch Kanaranzi Creek to the confluence with Norwegian Creek. This reach was sampled for fish and macroinvertebrates in 2004 and 2011 at biological sampling stations 04MS020 and 11MS101. This section of Kanaranzi Creek is impaired for aquatic life due to its fish and macroinvertebrate assemblages.

Kanaranzi Creek (10170204-515) is a 16.42 mile long AUID extending from the Headwaters of Kanaranzi Creek down to the confluence with East Branch Kanaranzi Creek. This reach was sampled for fish and macroinvertebrates from 2011-2012 at its two biological monitoring stations 11MS004 and 11MS126. This reach was deemed impaired for aquatic life due to its fish and macroinvertebrate assemblages during the watershed assessment in 2013.

East Branch Kanaranzi Creek (10170204-514) is a 17.15 mile long stream reach that is located in the headwaters of East Branch Kanaranzi Creek down to the confluence with Kanaranzi Creek. This reach contains three biological monitoring stations, 11MS018, 04MS050, and 11MS109 and was sampled for fish and macroinvertebrates in 2004 and 2011. This reach is impaired for aquatic life due to its fish and macroinvertebrate assemblages as well as turbidity.

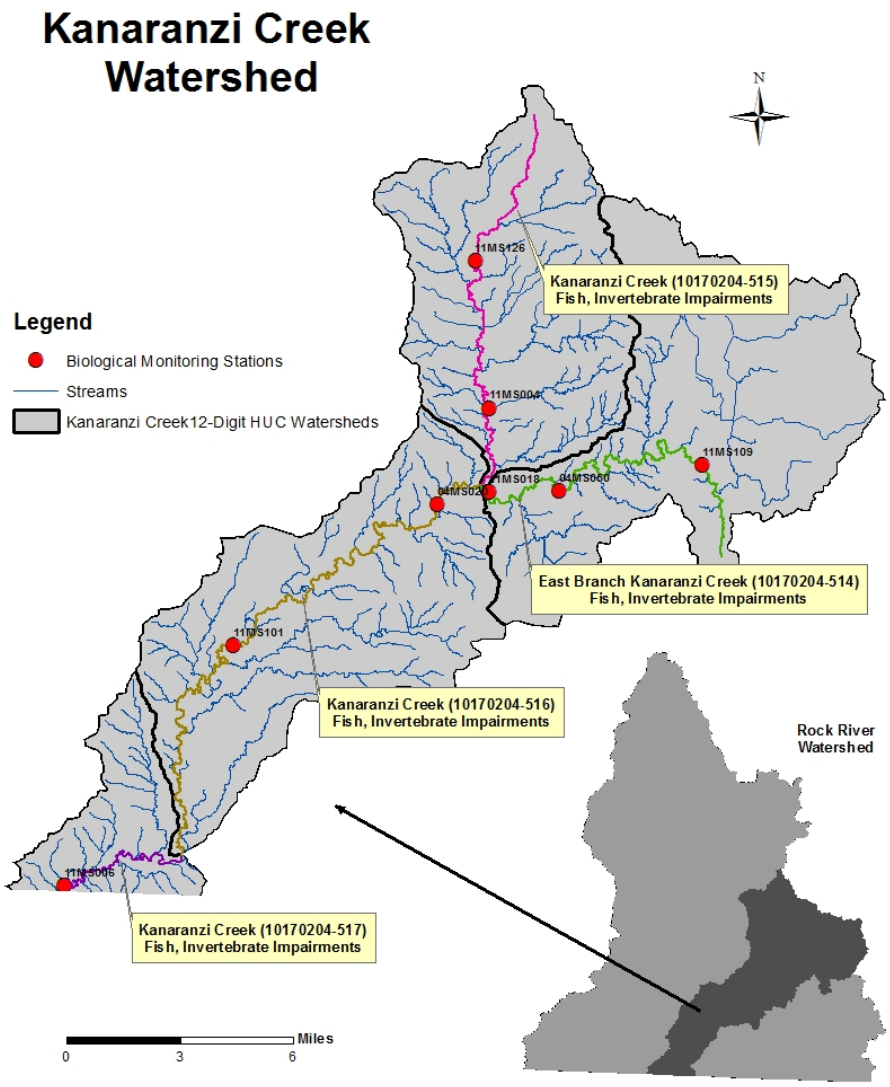

Figure 50: Kanaranzi Creek Watershed with biologically impaired streams highlighted

Biology in Kanaranzi Creek

Fish

The four biologically impaired reaches in the Kanaranzi Creek Watershed had a total of eight biological monitoring stations. On Kanaranzi Creek (10170204-517), the lone station, 11MS006, is located upstream of 11th St, 4 miles W of Ellsworth and was sampled for fish on August 31, 2011. Moving upstream, Kanaranzi Creek (10170204-516) has two biological monitoring stations. Site 04MS020 is located upstream of State Route 91, 1 mile north of Adrian and was sampled on July 27, 2004 and site 11MS101 is located upstream of State Route 91, 1 mile north of Adrian and was sampled on August 11, 2011. The next upstream AUID, Kanaranzi Creek (10170204-515), has two biological monitoring stations. Site 11MS004 is located upstream of 210th Street, 4 miles north of Adrian and was sampled on June 13, 2012, while 11MS126 is downstream of 170th Street, 1.5 mile east of Lismore and was sampled for fish on July 26, 2011.The last impaired stream segment in this watershed, East Branch Kanaranzi Creek (10170204-514) has three biological monitoring sites. Site 11MS018 is located upstream of Dolan

Avenue, 2 miles northeast of Adrian and was sampled on August 11, 2011, 04MS050 is approximately 3 miles northeast of Adrian, east of CR 15 and was sampled on July 21, 2004, and finally 11MS019 is upstream of CR 13, 6 miles west of Pipestone and had a fish sampled collected on June 12, 2012.

Seven of the eight sites were classified as fish Class 2 (Southern Streams). To reach the fish Class 2 IBI threshold, the site would need an IBI score of 45 and each metric would need to average 5.625 points. The metric value score for Kanaranzi Creek (10170204-515) was from site 11MS004. This site only scored above the average needed to make the threshold in one metric, DetNWQTxPct, which means the site had a lower percentage of detritivorous taxa (Figure 51). The metric value score for Kanaranzi Creek (10170204-517) comes from its biological site 11MS006. This site scored well in three of the eight metrics. Abundant benthic insectivore taxa (excluding tolerant species) were present (BenInsect-TolTxPct), the two most dominant fish species were not overwhelmingly present more than other species (DomTwoPct), and fewer tolerant taxa were present (TolTxPct) which helped boost the IBI score. The metric value score for Kanaranzi Creek (10170204-516) was averaged from its two biological monitoring stations, 04MS020 and 11MS101. This AUID scored well in only two of the metrics, DetNWQTxPct and DomTwoPct. Lastly, the metric value score for East Branch Kanaranzi Creek (10170204-517) was averaged from its biological monitoring stations, 11MS018, 04MS050, and 11MS109. This stream only scored well in one metric, DomTwoPct.

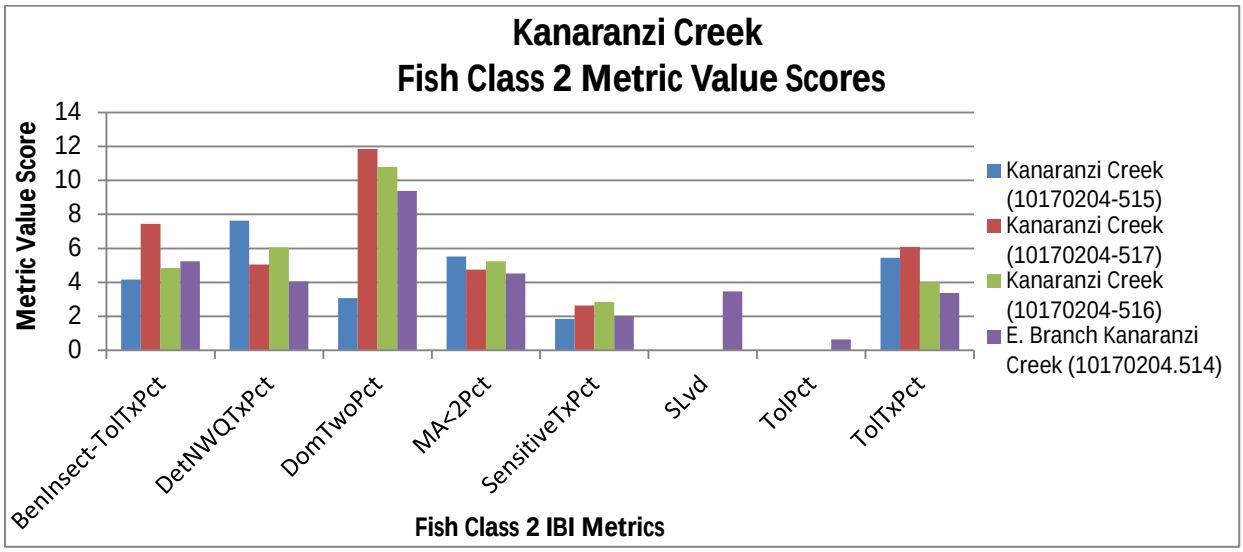

Figure 51: Fish Class 2 IBI metric value scores in the Kanaranzi Creek Watershed

Also important to note, Kanaranzi Creek (10170204-515) had one site, 11MS126, with a fish Class 3 (Southern Headwaters) classification. This site had an IBI score of 53 which was above the fish IBI threshold for this class.

Macroinvertebrates

Along Kanaranzi Creek (10170204-517), site 11MS006 as sampled on August 3, 2011. Kanaranzi Creek (10170204-516) had macroinvertebrate samples taken at site 04MS020 on August 24th and again on September 8th in 2004. Site 11MS101 was sampled for macroinvertebrates on August 4, 2011. Both sites along Kanaranzi Creek (10170204-515), 11MS004 and 11MS126, were sampled for macroinvertebrates on August 11, 2011. Along East Branch Kanaranzi Creek (10170204-514), sites 11MS018 and 11MS109 were sampled on August 11, 2011, while site 04MS050 was sampled on August 24, 2004.

Six of the eight biological monitoring stations on the impaired reaches in Kanaranzi Creek belong to the macroinvertebrate Class 5 (Southern Streams RR). The threshold for this class is 35.9 meaning each metric would need to average 3.59 points to meet this level. The metric value score for Kanaranzi Creek

(10170204-516) averaged scores from its two biological monitoring sites, 04MS020 and 11MS101. This stream had good numbers of Clinger taxa (ClingerChTxPct), a low abundance of the top 5 most abundant taxa (DomFiveCHPct), a fair amount of insect taxa (InsectTxPct) and ample odonata species (Odonata)(Figure 52). The metric value score for Kanaranzi Creek (10170204-515) is generated from site 11MS004. This site scored poorly in all metrics comprising the macroinvertebrate Class 5 IBI. Lastly, the metric value score for East Branch Kanaranzi Creek is averaged from its three biological monitoring stations, 11MS018, 04MS050, and 11MS109. This AUID only scored well in two metrics (ClingerCHTxPct and InsectTxPct).

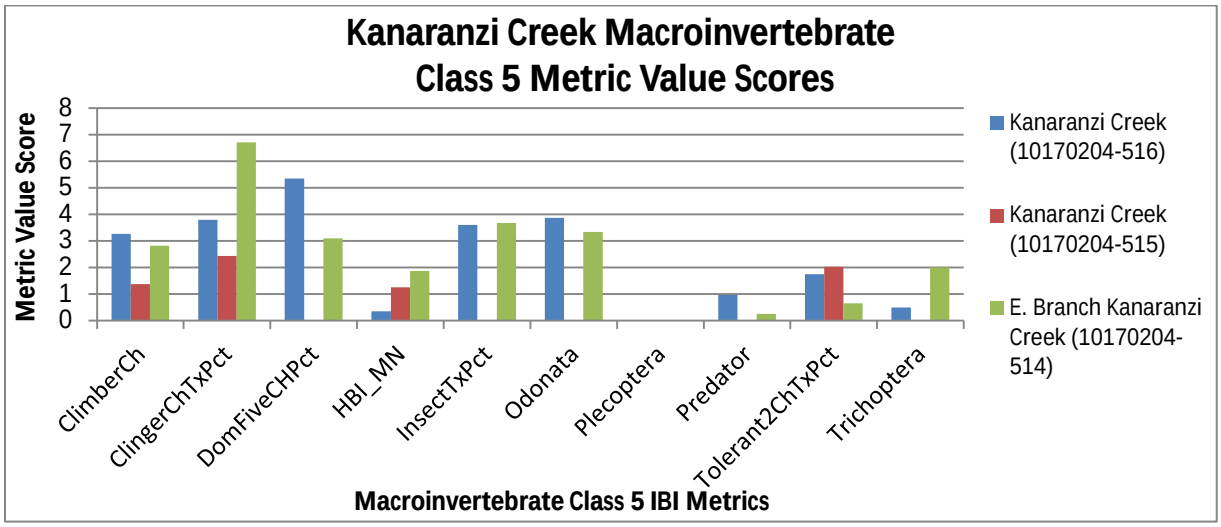

Figure 52: Macroinvertebrate Class 5 metric value scores along three reaches in the Kanaranzi Creek Watershed

The MIBI threshold for a Class 7 (Prairie Streams GP) site is 38.3 and an average metric score of 3.83 is needed to reach this level. Kanaranzi Creek (10170204-517) had metric value scores at its biological monitoring station, 11MS006, above the average needed to meet the threshold at two of the metrics. This stream had good populations of Plecoptera, Odonata, Ephemeroptera, and Trichoptera (POET) and also scored well in the Trichoptera (TrichopteraCHTxPct) metric (Figure 53). The metric value score for Kanaranzi Creek (10170204-515) at site 11MS126 scored well in half of the metrics. High numbers of Clinger taxa (ClingerCh), a low abundance of the top five most abundant taxa (DomFiveCHPct), POET taxa, total taxa richness of all macroinvertebrates (TaxaCountAllChir) and Trichoptera taxa.

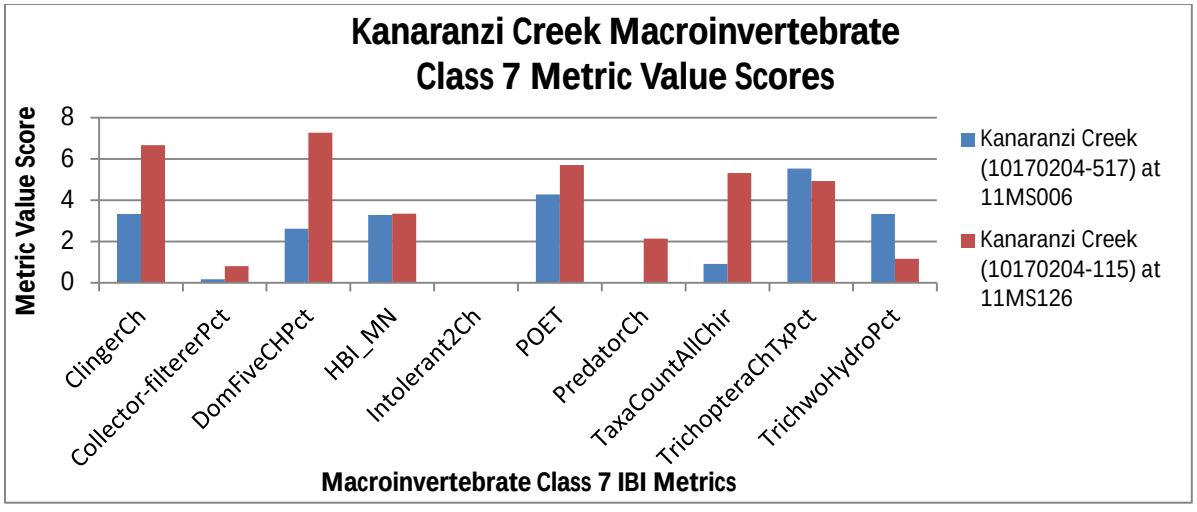

Figure 53: Macroinvertebrate Class 7 IBI metric value scores along two reaches in the Kanaranzi Creek Watershed

Candidate cause: Low dissolved oxygen

The daily minimum standard for DO in Minnesota Class 2B streams is 5 mg/L. All streams in the Kanaranzi Creek Watershed have this 2B classification. No streams in this grouping are currently listed as impaired for DO.

Kanaranzi Creek (10170204-517)

A total of 75 DO readings were taken from this section of Kanaranzi Creek from 2008-2013. Sample values ranged from 6.62-12.38 mg/L (Figure 54). This data includes 12 samples taken before 9 AM.

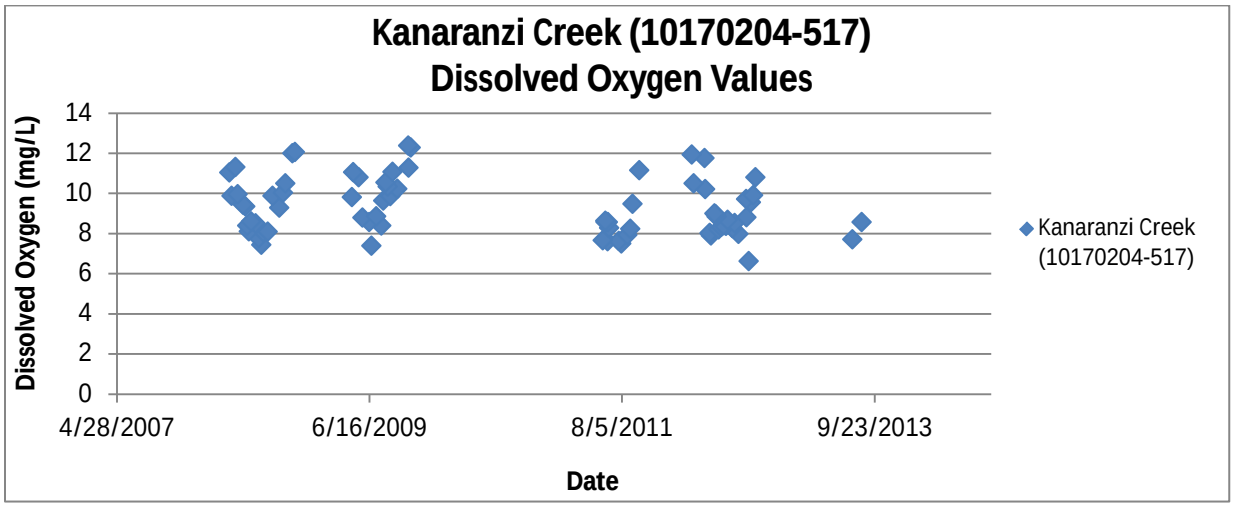

Figure 54: Dissolved oxygen values from 2008-2013 along Kanaranzi Creek (10170204-517)

The HSPF model calculated hourly DO values for Kanaranzi Creek from 1996-2009. These values ranged from 1.47-14.29 mg/L with an average value of 9.95 mg/L. Of these calculations, only 0.5% were below the 5 mg/L standard for DO.

Biologically, the macroinvertebrate community in the most downstream section of Kanaranzi Creek had good numbers of EPT taxa (40.91%), but also had a below average amount of macroinvertebrate species (16) when compared to all Minnesota streams. This stream also had a fairly tolerant macroinvertebrate community (59.09%). The fish assemblage consisted of many tolerant taxa (57.14%) and serial spawning species (28.57%). Few sensitive fish taxa (9.52%) were present. This section did have a slightly above average amount of late maturing fish taxa (23.81%) and an above average DO TIV score when compared to all other Minnesota streams.

Based on the observed and predicted DO values, as well as many of the DO related biological metrics, the lack of DO is not a stressor to the impaired biological communities in Kanaranzi Creek (10170204-517) at this time.

Kanaranzi Creek (10170204-516)

In 2013, from July 30th to August 13th, a sonde was deployed at water quality monitoring station S007-380 in this section of Kanaranzi Creek for continuous DO monitoring. During this time frame, DO readings ranged from 5.75-9.81 mg/L (Figure 55). Not once did the daily value dip below the daily minimum standard of 5 mg/L nor did the daily flux exceed 4.5 mg/L.

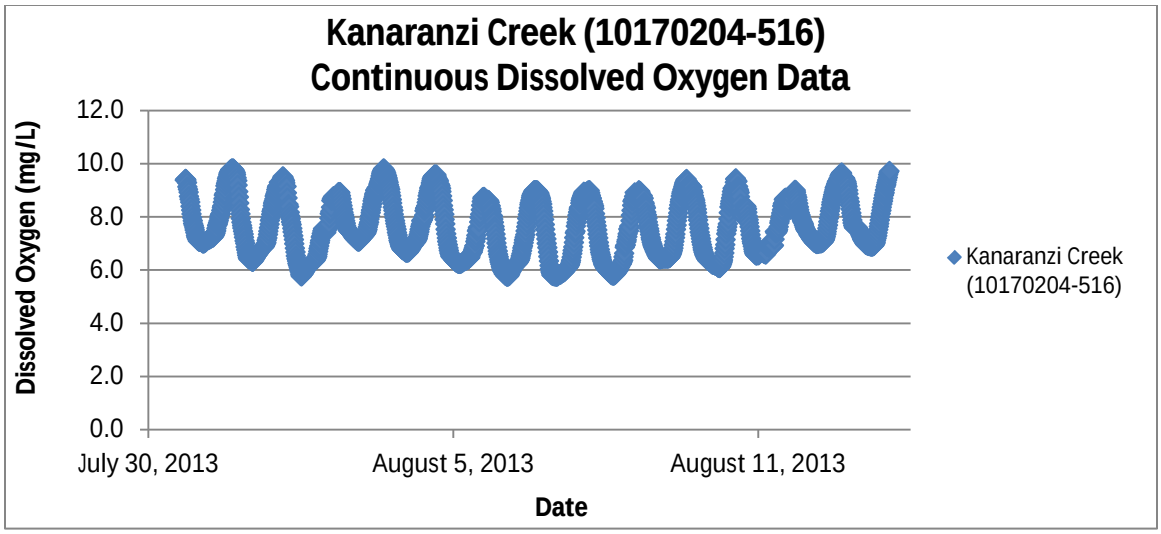

Figure 55: Continuous dissolved oxygen monitoring in 2013 along Kanaranzi Creek (10170204-516)

Biologically, the macroinvertebrate community in this section had high amounts of EPT taxa (39.90%) especially at site 11MS101, which is located in the lower portion of the reach. The macroinvertebrate assemblage was fairly diverse averaging 25 species at the two sites, but also was fairly tolerant (57.58% taxa). The fish community in Kanaranzi Creek (10170204-516) had high amounts of tolerant taxa sampled (66.58%), but also had few sensitive fish species (10.27%) and late maturing taxa (15.53%). High amounts of serial spawning fish species were also present (33.16%). These metrics mostly indicate problems with DO. Site 04MS020 and 11MS101 did have an above average DO TIV score when compared to all other Minnesota streams. It

The continuous DO monitoring did not have a daily flux exceeding the 4.5 mg/L standard. It is likely that other stressors are having a greater impact on the biology and bringing some metrics scores down. Based on the information, low DO is not a stressor to this reach of Kanaranzi Creek at this time.

Kanaranzi Creek (10170204-515)
This biologically impaired AUID along Kanaranzi Creek had 13 DO readings taken from 2011-2013. During this time frame, DO values ranged from 5.31-14.25 mg/L.

The HSPF model calculated hourly DO values for Kanaranzi Creek from 1996-2009. These values ranged from 0-14.07 mg/L with an average value of 7.81 mg/L. Of these calculations, 6.56% were below the 5 mg/L daily minimum standard.

Biologically, the macroinvertebrate community in this AUID had lower levels of EPT taxa (18.78%), high numbers of tolerant taxa (63.66%) and only averaged 17.5 species per sampling visit. The fish assemblage had many tolerant taxa (65%) and serial spawning taxa (35%), while also having few sensitive species (3.34%) and late maturing fish (15%). All of the metrics indicate likely problems with DO levels. Site 11MS004 had a below average DO TIV score when compared to all other fish Class 2 sites, while site 11MS126 had a TIV score that was slightly above the Class 3 average.

The majority of the biological metrics signal that DO is a stressor to the fish and macroinvertebrate communities, however, there have been no observed values below 5 mg/L and the HSPF model does not predict a high exceedance rate either. Further monitoring with a sonde is needed to better the DO conditions in this reach of Kanaranzi Creek.

East Branch Kanaranzi Creek (10170204-514)
East Branch Kanaranzi Creek had 45 DO readings taken from 2008-2012 with values ranging from 4.93-16.32 mg/L (Figure 56). Only one of the samples was below the 5 mg/L daily minimum standard. Two values were over 15 mg/L which may indicate problems with daily flux.

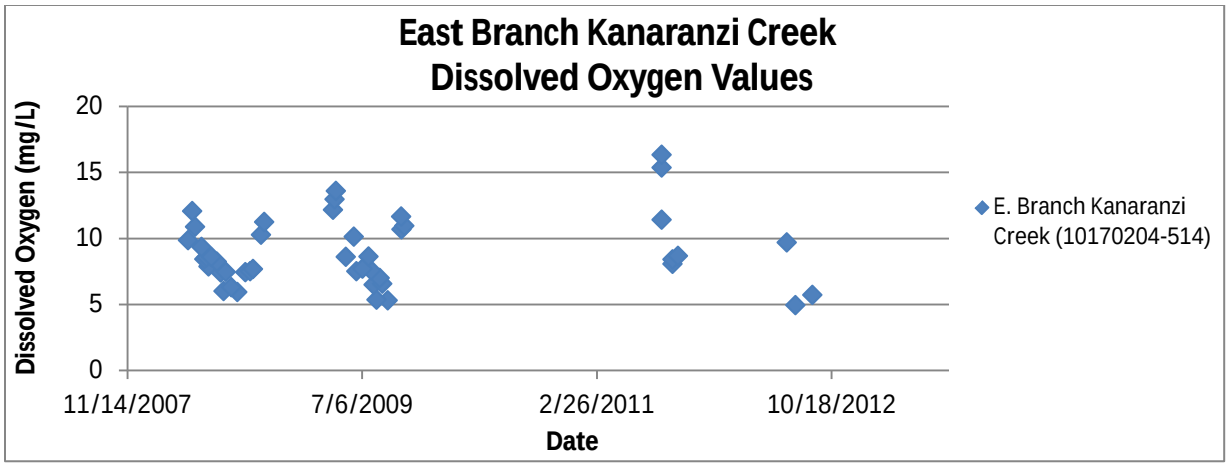

Figure 56: Dissolved oxygen values from East Branch Kanaranzi Creek (10170204-514) from 2008-2012

The HSPF model calculated hourly DO values for East Branch Kanaranzi Creek from 1996-2009. These values ranged from 1.12-13.53 mg/L with an average value of 7.81 mg/L. Of these calculations, 4.14% were below the 5 mg/L daily minimum standard.

Biologically, the macroinvertebrate assemblage in East Branch Kanaranzi Creek had a high average amount of EPT taxa (33.83). EPT taxa are generally more prevalent in streams with adequate DO levels. This stream also had a lower amount of overall taxa (20.33 average). The macroinvertebrate sample at the biological sites found at least 5 DO intolerant taxa at each site and had a low amount of DO tolerant individuals. The fish assemblage was very tolerant (70.02%), had few sensitive taxa (7.3%), and a below average amount of late maturing fish species (20.11%). This section also had a high amount of serial spawning fish species (35.69%). These types of fish tend to be fairly abundant in streams experiencing low daily DO levels or a high daily flux. Sites 04MS050, 11MS018, and 11MS109 had a slightly above average DO TIV score when compared to all other fish Class 2 sites.

Based on the observed and calculated DO values, only one sample was found below the standard and the model predicted a low percentage of exceedances. The macroinvertebrate community strongly suggests that DO is not a stressor. The fish assemblage does score low in some metrics, but this is likely due to other stressors as the DO TIV score does not reflect a stream affected by low DO conditions. At this time, low DO is not a stressor to the impaired biological communities in East Branch Kanaranzi Creek.

Candidate cause: High phosphorus

The proposed draft standard for phosphorus for streams in the Missouri River basin is currently 0.15 mg/L. Although phosphorus is an essential nutrient for all aquatic life, elevated levels can lead to an imbalance which impacts stream ecology. In the Kanaranzi Creek Watershed phosphorus levels have exceeded this proposed standard multiple times.

Kanaranzi Creek (10170204-517)
Kanaranzi Creek had 82 phosphorus samples taken from 2008-2012 with samples ranging from 0.03 to 1.21 mg/L (Figure 57). Of these samples, 42 were at or above the proposed draft standard for phosphorus of 0.15 mg/L.

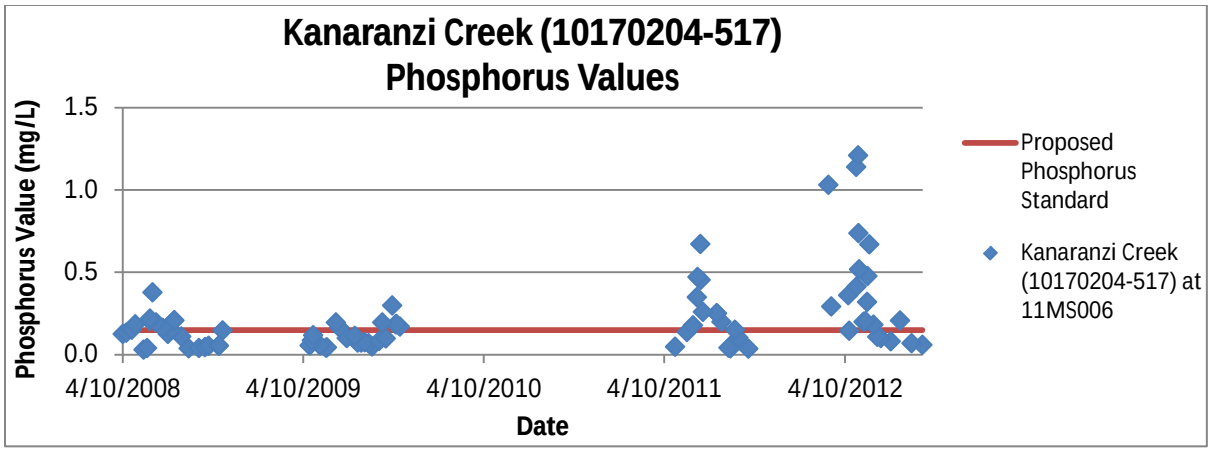

Figure 57: Phosphorus values from 2008-2012 along Kanaranzi Creek (10170204-517)

Biologically, the macroinvertebrate populations in Kanaranzi Creek had high amounts of EPT taxa (40.91%) and lower levels of crustacae/mollusca taxa (9.09%). These results are typical in streams not affected by high levels of phosphorus. However, this stream also had few Tanytarsini taxa (4.55%), intolerant species (9.09%), while having high amounts of scraper taxa (18.18%) and tolerant macroinvertebrate species (59.09%) when compared statewide. The fish assemblage had quite a few tolerant taxa (57.14%) while having few sensitive fish taxa (9.52%).

Kanaranzi Creek had numerous violations of the proposed phosphorus standard, while also scoring very poorly in phosphorus related biological metrics. Phosphorus is indeed a stressor to the impaired fish and macroinvertebrate communities in this section of Kanaranzi Creek.

Kanaranzi Creek (10170204-516)

From 2004-2013, there were nine phosphorus samples taken from this portion of Kanaranzi Creek. Sample values ranged from 0.027-0.34 mg/L with two of these samples above the proposed draft standard for phosphorus of 0.15 mg/L (Table 29).

Table 29: Phosphorus sample values from 2004-2013 along Kanaranzi Creek (10170204-516)

Sample Location	Sample Date and Time	Result (mg/l)	Proposed Phosphorus Standard (mg/l)
04MS020	7/27/2004	0.08	0.15
11MS101	8/11/2011	0.059	0.15
11MS101	5/6/2013	0.027	0.15
11MS101	6/10/2013	0.34	0.15
11MS101	7/1/2013	0.175	0.15
11MS101	7/15/2013	0.05	0.15
11MS101	8/13/2013	0.042	0.15
11MS101	8/19/2013	0.032	0.15
11MS101	9/9/2013	0.041	0.15

The HSPF model calculated daily phosphorus values for Kanaranzi Creek (10170204-516) from 1996-2009. These values ranged from 0.05-1.07 mg/L with an average value of 0.19 mg/L. Of these calculations, 61.5% were at or above the 0.15 mg/L proposed draft standard for phosphorus.

Biologically, this impaired AUID on Kanaranzi Creek had high numbers of EPT taxa (39.9%), while also having an above average amount of Tanytarsini taxa (7.58%) and intolerant taxa (15.47%) when compared to all other Minnesota streams. This stream section did have higher amounts of scraper species (18.47%) and tolerant taxa (57.58%). The fish community was very tolerant with 66.58% of all species sampled being considered tolerant and low amounts of sensitive fish taxa (10.27%) and darter individuals (3.47%) were present.

Based on the observed and calculated values as well as the majority of the related biological metrics, high phosphorus is a stressor to the impaired biological communities in this portion of Kanaranzi Creek.

Kanaranzi Creek (10170204-515)
From 2011-2012, 12 phosphorus samples were taken from this portion of Kanaranzi Creek. Sample values ranged from 0.013-0.448 mg/L with three samples above the proposed draft standard for phosphorus of 0.15 mg/L (Figure 58).

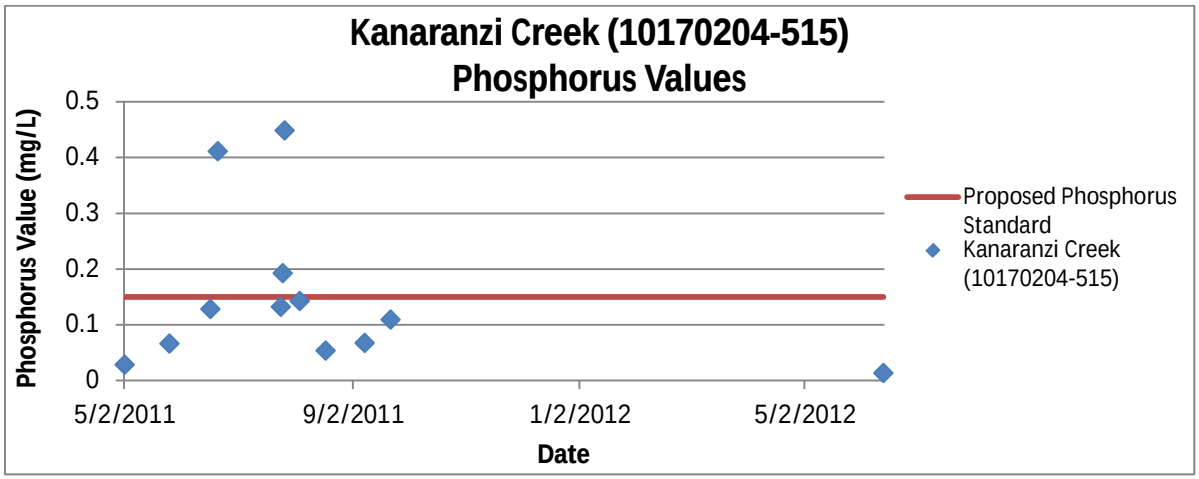

Figure 58: Phosphorus sample values from 2011-2012 along Kanaranzi Creek (10170204-515)

Biologically, the macroinvertebrate community in Kanaranzi Creek (10170204-515) had low amounts of EPT taxa (18.78%), Tanytarsini species (4.06%), and intolerant taxa (4.06%). This assemblage also had high numbers of crustacean/mollusca taxa (15.93%), scraper species (14.65%), and tolerant taxa (63.66%). These metrics tend to be much lower in streams without elevated phosphorus levels. The fish population was again mostly tolerant (65%) and had very few sensitive fish species (3.34%).

The fairly high exceedance rate along with extremely high values that were nearly three times the proposed draft standard along with poor scores of phosphorus related biological metrics makes phosphorus a stressor to the impaired fish and macroinvertebrate communities in this headwaters section of Kanaranzi Creek.

East Branch Kanaranzi Creek (10170204-514)
From 2008-2011, there were 57 phosphorus samples taken from this section of East Branch Kanaranzi Creek. Sample values ranged from 0.011-0.748 mg/L with 12 (21.05%) of the samples of above the proposed draft standard of 0.15 mg/L (Figure 59).

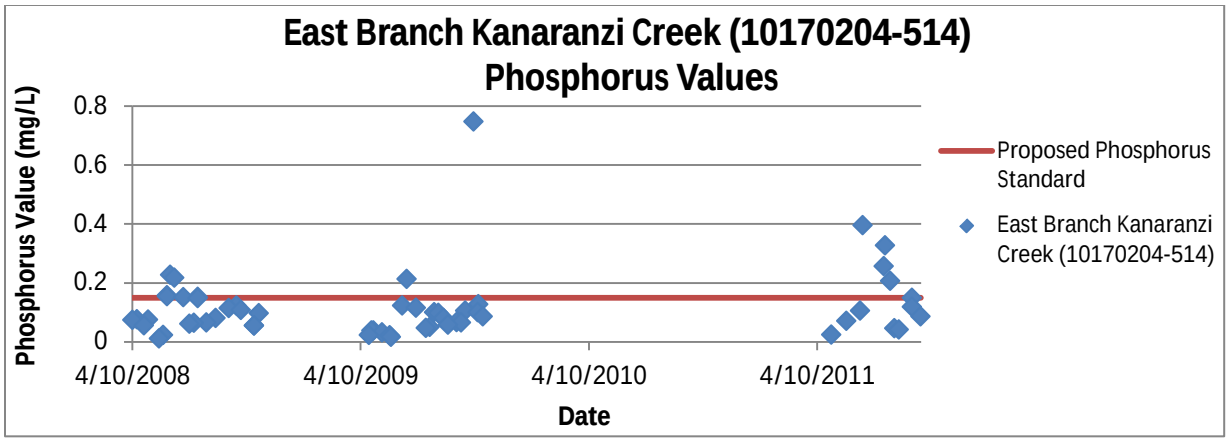

Figure 59: Phosphorus sample values from 2008-2011 along East Branch Kanaranzi Creek (10170204-514)

The HSPF model calculated daily phosphorus values for East Branch Kanaranzi Creek from 1996-2009. These values ranged from 0.046-0.84 mg/L with an average value of 0.18 mg/L. Of these calculations, 52.05% were above the 0.15 mg/L proposed draft standard.

Biologically, the macroinvertebrate assemblage in East Branch Kanaranzi Creek had an above average amount of EPT taxa (33.83%) and intolerant taxa (11.97%). Tanytarsini taxa (4.77%) were present in small numbers. Tolerant macroinvertebrates were abundant (60.33%), while scraper taxa (12.32%) and crustacean/mollusca (10.11%) were present in average numbers. The fish community was mostly tolerant (70.02%) and had few sensitive fish taxa (7.3%). These sites did have an average number of darter individuals (6.56%) when compared statewide.

With the high rate of observed and calculated exceedances and the agreement of the majority of the related biological metrics, high phosphorus is indeed a stressor to the impaired biological communities in East Branch Kanaranzi Creek.

Candidate cause: High nitrates

Currently, the State of Minnesota does not have a nitrate standard in place for streams not used as a drinking water source. However, the overabundance of nitrates can stress a biological community. Nitrates in the Kanaranzi Creek Watershed did at times reach levels that could potentially be stressing the biological assemblages.

Kanaranzi Creek (10170204-517)

A total of 82 nitrate samples were taken from this section of Kanaranzi Creek from 2008-2012 (Table 60). Sample values ranged from 0.44-13.9 mg/L. A quantile regression comparing macroinvertebrate IBI scores to nitrate values showed that if a nitrate value in a macroinvertebrate Class 7 stream of which site 11MS006 on Kanaranzi Creek belongs to, there's a 90% chance of impairment if the value exceeds 11.5 mg/L. This site exceeded this level 14 different times during this time frame.

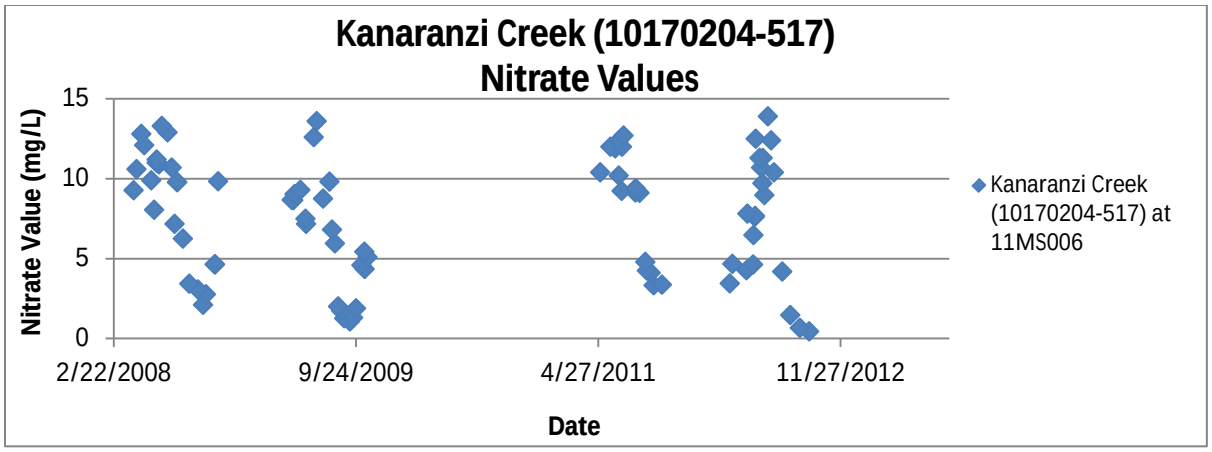

Figure 60: Nitrate sample values from site 11MS006 along Kanaranzi Creek (10170204-517)

Biologically, the macroinvertebrate assemblage in this portion of Kanaranzi Creek had a low macroinvertebrate diversity with only 16 different species present and few nitrate sensitive Trichoptera species (9.09%). Additionally, site 11MS006 had a macroinvertebrate population consisting of 91.67% of nitrate tolerant individuals. A quantile regression analyses showed that Class 7 sites like 11MS006 have a greater than 90% chance of being impaired when more than 87.71% of the macroinvertebrate community is comprised of nitrate tolerant individuals. The fish community did have quite a few species (21), but they also had a small percentage (9.52) of sensitive fish taxa which is common in streams with elevated nitrate levels.

The very high nitrate sample values along with both of the quantile regression studies and the nitrate related biological metrics all point to the conclusion that excess nitrates are indeed stressing the impaired fish and macroinvertebrate assemblages along this reach of Kanaranzi Creek.

Kanaranzi Creek (10170204-516)

Nine nitrate samples were taken from this section of Kanararanzi Creek from 2004-2013 with sample values ranging from 0.21-20 mg/L (Table 30).

Table 30: Nitrate sample values from 2011-2013 along Kanaranzi Creek (10170204-516)

Sample Location	Sample Date	Result (mg/l)	Nitrate Standard (mg/l)
04MS020	7/27/2004	15	n/a
11MS101	8/11/2011	7.7	n/a
11MS101	5/6/2013	6.6	n/a
11MS101	6/10/2013	20	n/a
11MS101	7/1/2013	19	n/a
11MS101	7/15/2013	12	n/a
11MS101	8/13/2013	1.8	n/a
11MS101	8/19/2013	1.5	n/a
11MS101	9/9/2013	0.21	n/a

The HSPF model calculated daily nitrate values for this portion of Kanaranzi Creek from 1996-2009. These values ranged from 1.93-18.36 mg/L with an average value of 5.64 mg/L.

Biologically, the macroinvertebrate community in Kanaranzi Creek (10170204-516) had a slightly above average amount of taxa (25) when compared to all Minnesota streams, but this reach did show few numbers of nitrate sensitive Trichoptera species (6.36%). Furthermore, the sites along this reach averaged 82.32% of nitrate tolerant individuals. Quantile regression analyses showed that sites having more than 78.22% of nitrate tolerant individuals have a greater than 75% chance of being impaired. The fish assemblage averaged 19.5 species, which is above normal, but this portion of Kanaranzi Creek had a lower amount of sensitive fish taxa (10.27%).

Based on the very high observed values, as well as strong evidence from the related biological metrics and analysis, high nitrates are a stressor to the impaired biological communities in this stream.

Kanaranzi Creek (10170204-515)
Twelve nitrate samples were collected from Kanaranzi Creek from 2011-2012 with sample values ranging from 5.16-18 mg/L (Figure 61). These samples had an average value of 12.17 mg/L with seven values over 11.5 mg/L meaning there's a 90% chance that this reach would be impaired according to some quantile regression analysis.

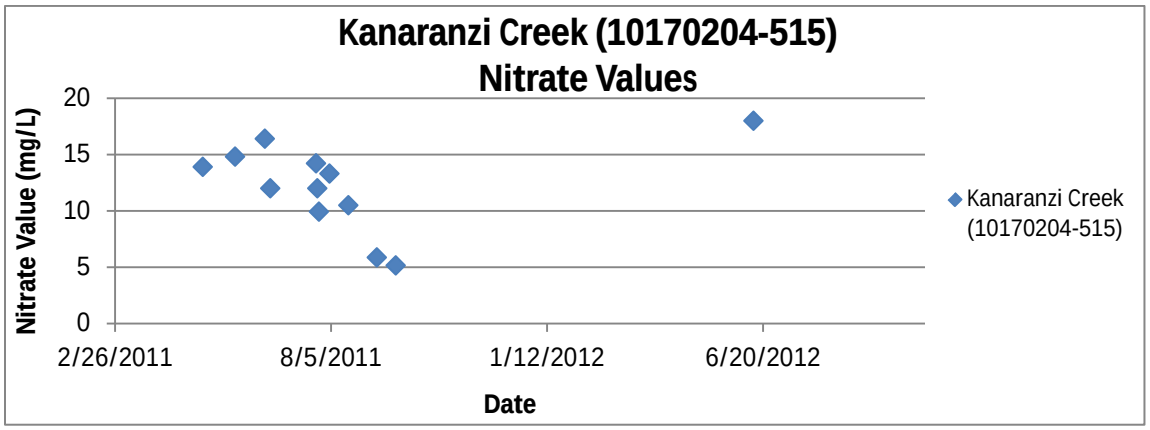

Figure 61: Nitrate sample values from 2011-2012 along Kanaranzi Creek (10170204-515)

Biologically the macroinvertebrate community in this section of Kanaranzi Creek had an average of 17.5 of species, which is lower than expected while also having few nitrate sensitive Trichoptera taxa (9.32%). The sites along this reach have high amounts of nitrate tolerant macroinvertebrate individuals (79.56% average) and both would have a greater than 75% chance of being impaired according to quantile regression analysis. The fish community had an average amount of species (12.5), while having an average of 9.32% of sensitive fish taxa which is fairly low.

The high observed nitrate values, the quantile regression analyses, along with the agreement of the nitrate related biological metrics makes the excessive amounts of nitrates in Kanaranzi Creek (10170204-515) a stressor to the impaired fish and macroinvertebrate assemblages in this reach.

East Branch Kanaranzi Creek (10170204-514)
From 2008-2011, 57 phosphorus samples were taken from East Branch Kanaranzi Creek. Phosphorus values ranged from 1.62-16.2 mg/L (Figure 62). The average value for all of these samples was 8.9 mg/L.

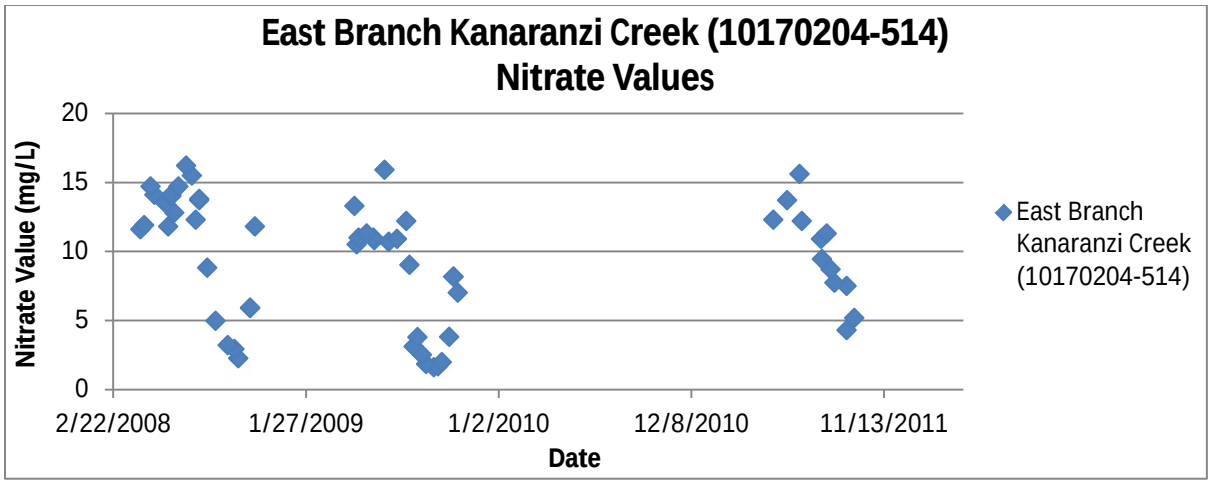

Figure 62: Nitrate sampling values from 2008-2011 along East Branch Kanaranzi Creek (10170204-514)

The HSPF model calculated daily nitrate values for East Branch Kanaranzi Creek from 1996-2009. These values ranged from 1.97-17.78 mg/L with an average value of 5.68 mg/L.

Biologically, the macroinvertebrate assemblage had a below average amount of taxa (20.33 average), while having a fair amount of Trichoptera taxa (13.96%). The most downstream site, 11MS018, had a very high amount of nitrate tolerant individuals (92.62%) and would have a greater than 90% probability of being impaired. Further upstream, sites 04MS050 and 11MS109 averaged 62.44% of nitrate tolerant and have less than a 50% probability of being impaired. The fish community had an average of 14 different species, but did lack many sensitive fish taxa (7.3%).

Based on the high observed and model results, along with the majority of the related biological metrics including the quantile regression analysis, high nitrates are a stressor to the impaired fish and macroinvertebrate assemblages in this reach.

Candidate cause: High turbidity/TSS

The water quality standard for Turbidity is 25 NTU, 65 mg/L for TSS, and 20 cm for Transparency Tube for these Class 2B warmwater streams in the Kanaranzi Creek Watershed. Excess sediment is a commonly recognized stressor in many biologically impaired streams because it can reduce habitat, cause direct physical harm, as well as reduce visibility and increase oxygen demand.

Two of the reaches, Kanaranzi Creek (10170204-517) and East Branch Kanaranzi Creek (10170204-514) were determined to be impaired for aquatic life due to turbidity in addition to their biological assemblages. Less extensive data sets on the other two reaches along Kanaranzi Creek are available, but indicate potential impairment.

Kanaranzi Creek (10170204-517)

Kanaranzi Creek had 82 TSS samples taken from 2008-2012. Sample values ranged from 4-927 mg/L with 44 samples over the TSS maximum standard of 65 mg/L (Figure 63). This stream was determined to be impaired for aquatic life due to turbidity during its assessment in 2013.

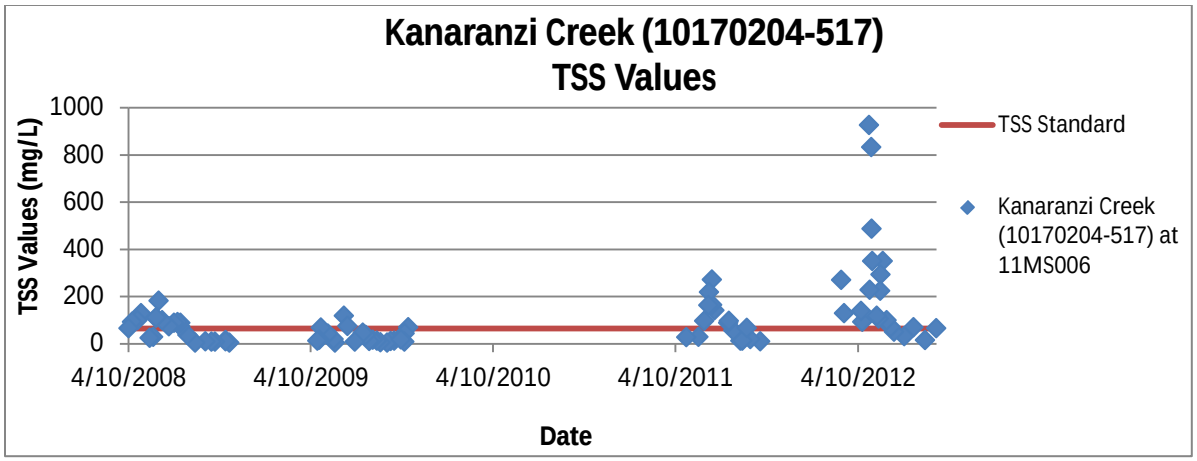

Figure 63: TSS values along Kanaranzi Creek (10170204-517) from 2008-2012

The macroinvertebrate assemblage in the most downstream section of Kanaranzi Creek had low levels of Trichoptera taxa (9.09%), overall taxa (16), and collector-filterer species (9.09%) while also having a community consisting of many tolerant taxa (59.09%). The biological monitoring site, 11MS006, also showed many scraper species (28.18%) and fewer chironomidae taxa (22.73%). The fish assemblage consisted of many tolerant taxa (57.14%), but the stream did have an above average amount of herbivorous fish species (9.52%) when compared to other Minnesota streams.

The current turbidity listing, the high measured values, along with the agreement of the majority of turbidity related biological metrics makes the turbidity/TSS a stressor to the impaired biological assemblages in this reach.

Kanaranzi Creek (10170204-516)

From 2004-2013, nine TSS samples were taken from Kanaranzi Creek with sample values ranging from 11-390 mg/L. Two of the samples were over the 65 mg/L maximum standard for TSS. Also, 11 Secchi/transparency tube readings were taken. Three of these samples were below the 20 cm minimum standard (Table 31).

Table 31: TSS and Secchi tube values from 2004-2013 along Kanaranzi Creek (10170204-516)

Sample Location	Sample Date	TSS Result (mg/l)	TSS Standard (mg/l)	Secchi Tube Value (cm)	Secchi Tube Standard (cm)
04MS020	7/27/2004	11	65	43	20
11MS101	8/4/2011	n/a	65	15	20
11MS101	8/11/2011	15	65	52	20
11MS101	5/6/2013	10	65	80	20
11MS101	6/10/2013	390	65	5	20
11MS101	7/1/2013	80	65	14	20
11MS101	7/15/2013	18	65	37	20
11MS101	7/30/2013	n/a	65	84	20
11MS101	8/13/2013	17	65	49	20
11MS101	8/19/2013	18	65	36	20
11MS101	9/9/2013	20	65	25	20

The HSPF model calculated daily TSS values for Kanaranzi Creek (10170204-516) from 1996-2009. These values ranged from 0-3681.1 mg/L with an average value of 30.81 mg/L. Over 8% of the calculations were above the proposed TSS standard of 65 mg/L.

Biologically, the macroinvertebrate assemblage in this portion of Kanaranzi Creek had few TSS-sensitive Trichoptera taxa (6.36%) and collector-filterer species (10.93%), while also having a high amount of tolerant taxa (57.58%). High numbers of Ephemeroptera taxa (33.54%), scraper taxa (18.7%) and total species (25) were present. The fish community was mostly tolerant (66.58% taxa), but did have a higher than expected amount of herbivorous species (12.77%). Sites 04MS020 and 11MS101 did have a lower TSS TIV score when compared to all other fish Class 2 sites statewide.

Kanaranzi Creek had relatively few observed exceedances of the TSS and Secchi tube standards, while the model calculated a low exceedance rate as well. The biological results were fairly mixed and it is likely that the fish and macroinvertebrate communities are being negatively impacted by other stressors. Therefore, high turbidity/TSS is not a stressor at this time.

Kanaranzi Creek (10170204-515)

In 2011, 11 TSS samples were collected for this portion of Kanaranzi Creek (Table 32). Sample values ranged from 2-128 mg/L with two samples over the TSS standard of 65 mg/L. In addition, 14 transparency/Secchi tube readings were taken from 2011-2012 with three of these samples falling below the 20 cm minimum standard.

Table 32: TSS and Secchi tube values from 2011-2012 along Kanaranzi Creek (10170204-515)

Sample Location	Sample Date	TSS Result (mg/l)	TSS Standard (mg/l)	Secchi Tube Value (cm)	Secchi Tube Standard (cm)
S006-904	5/2/2011	6	65	> 100	20
S006-904	5/26/2011	21	65	38	20
S006-904	6/17/2011	31	65	22	20
S006-904	6/21/2011	84	65	22	20
S006-904	7/25/2011	2	65	30	20
11MS126	7/26/2011	22	65	33	20
S006-904	7/27/2011	128	65	10	20
S006-904	8/4/2011	23	65	22	20
S006-904	8/18/2011	6	65	54	20
S006-904	9/8/2011	3	65	43	20
S006-904	9/22/2011	5	65	15	20
S006-904	7/18/2012	n/a	65	47	20
S006-904	8/30/2012	n/a	65	17	20
S006-904	9/6/2012	n/a	65	30	20

The HSPF model calculated daily TSS values for Kanaranzi Creek (10170204-515) from 1996-2009. These values ranged from 0-2882.8mg/L with an average value of 20.07 mg/L. Of these calculations, 5.36% were above the proposed TSS standard of 65 mg/L.

Biologically, the macroinvertebrate assemblage in this headwaters section of Kanaranzi Creek had low amounts of Trichoptera taxa (9.32%), collector-filterer species (11.95%), and Ephemeroptera taxa (9.46%). These metrics scores are typical in streams experience problems with turbidity/TSS. In addition, high levels of tolerant macroinvertebrate taxa (63.66%) and Chironomidae species (38.63%) also are indicative of stress due to turbidity/TSS. Sites 11MS004 and 11MS126 had a high amount of TSS tolerant individuals (54.4%) and TSS tolerant species (7.5) per site. The fish community in this stream did have a

higher amount of herbivorous species (16.67%), but did have a high amount of tolerant taxa (65%) as well. The TSS TIV score was below average when compared to all other sites in Class 2 (11MS004) and Class 3 (11MS126).

TSS and transparency measurements have instances in which they exceed their proposed standards and the biology overwhelmingly indicates stress due to high turbidity/TSS. Therefore, high levels of turbidity/TSS are a stressor to the impaired fish and macroinvertebrate assemblages in Kanaranzi Creek (10170204-515).

East Branch Kanaranzi Creek (10170204-514)
There were 57 TSS samples taken from East Branch Kanaranzi Creek from 2008-2011 with values ranging from 2-179 mg/L. Of these samples, nine were above the TSS standard of 65 mg/L (Figure 64). In addition, 18 of 57 (31.58%) transparency/Secchi tube measurements from 2008-2012 were below the 20 cm standard. This AUID was listed as impaired for turbidity during the watershed assessment in 2013.

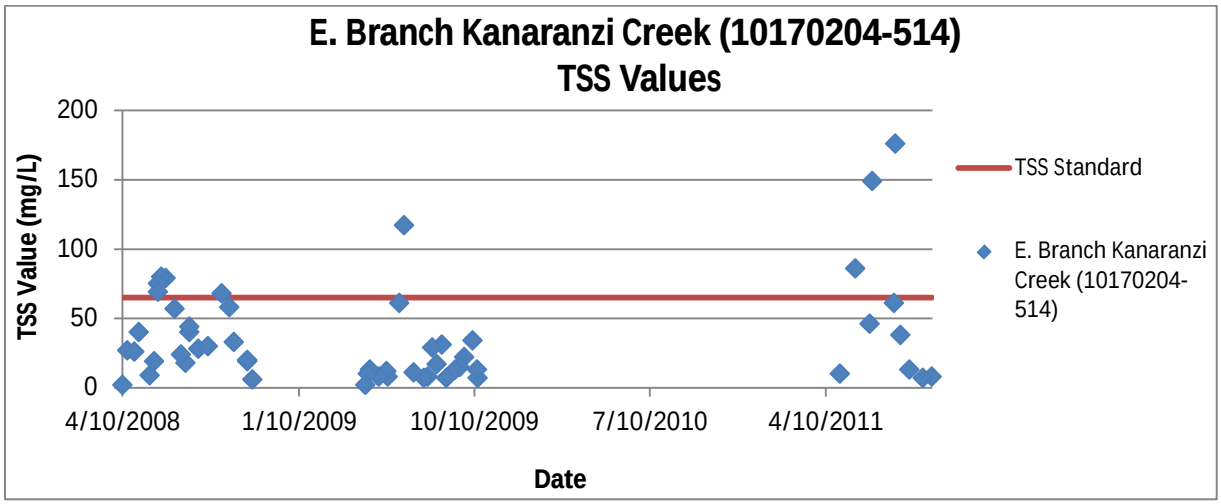

Figure 64: TSS values from 2008-2011 along East Branch Kanaranzi Creek (10170204-514)

Biologically, the macroinvertebrate population in East Branch Kanaranzi Creek had an above average amount of Trichoptera taxa (13.96%), Ephemeroptera taxa (19.87%), and collector-filterer species (16.17%). A high amount of tolerant taxa (60.33%) and fewer total taxa (20.33) were found at the three sites along this AUID. The fish community had many tolerant taxa (70.02%), but did have an above average amount of herbivorous fish taxa (9.26%) when compared to all other streams in Minnesota. The fish assemblage at the three biological sites had a below average TSS TIV score when compared to all other fish Class 2 sites.

The high amount of exceedances of both transparency and TSS values along with the poor showing in some biological metrics as well as a low TIV score, turbidity/TSS is a stressor to the impaired fish and macroinvertebrate communities in East Branch Kanaranzi Creek.

Candidate cause: Lack of habitat

Qualitative habitat assessments were performed on all four biologically impaired reaches in the Kanaranzi Creek Watershed during the fish sampling visits at each site. Results of these assessments can be seen in Figure 65.

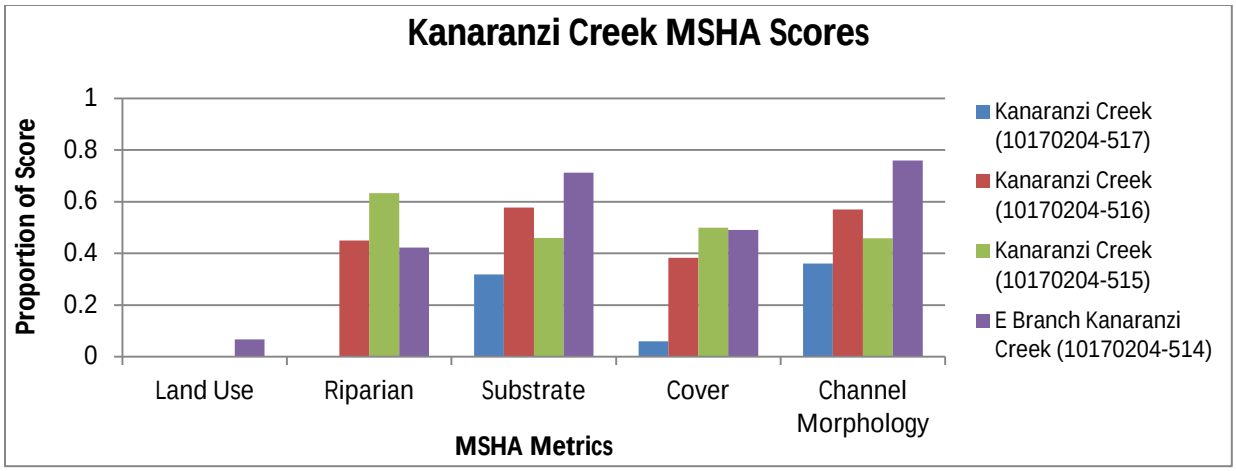

Figure 65: MSHA metric scores at the four biologically impaired reaches in the Kanaranzi Creek Watershed

Kanaranzi Creek (10170204-517)

A qualitative habitat assessment was performed on this section of Kanaranzi Creek during the fish sampling event at 11MS006. The MSHA score at this site was 22.6, which is considered to be poor. Limiting the habitat in this stream was the heavily pastured surrounding land use with no stream buffer (Figure 66), severe bank erosion, the predominance of a sand/silt substrate, nearly absent fish cover, low channel stability and limited channel development.

Figure 66: Surrounding land use at 11MS006 along Kanaranzi Creek (10170204-517)

Biologically, the macroinvertebrate community was mostly tolerant (59.09% taxa), but also had a fair amount of clinger taxa (31.82%). Clingers tend to be less present in streams with poor habitat. The fish assemblage was also very tolerant (57.14%), and had low numbers of simple lithophilic spawning species (19.05%). These types of fish prefer clean gravels to complete their life cycle. Above average of benthic insectivores taxa (28.57%), riffle dwelling species (19.05%), and darters/sculpin/round-bodied sucker taxa (14.29%) were present.

The poor MSHA score, with numerous poor habitat metric scores along with many low habitat related biological metric scores make the lack of habitat a stressor to the impaired macroinvertebrate community in this lower end of Kanaranzi Creek.

Kanaranzi Creek (10170204-516)

Habitat assessments were performed at both biological monitoring sites along this portion of Kanaranzi Creek. MSHA scores were 48.6 and 50.1 at sites 04MS020 and 11MS101 respectively. These scores are considered to be fair. Limiting the habitat in these sites were the row crops in the surrounding land use, some eroded banks, sparse fish cover, low channel stability, and the high presence of silt/sand substrates (Figure 67).

The macroinvertebrate assemblage was mostly tolerant (57.58%), and had an average amount of clinger taxa (29.84%). The fish community had a high number of tolerant taxa (66.58%), along with low numbers of benthic insectivores (18.03%), simple lithophilic spawning species (20.53%), and darters/sculpins/round-bodied suckers (10.4%). These metrics indicate potential problems with the in-stream habitat conditions.

With the fair MSHA scores and the majority of the biological related habitat metrics indicating limiting conditions, the lack of habitat is a stressor to the impaired fish and macroinvertebrate assemblages in this section of Kanaranzi Creek.

Figure 67: Eroded bank and minimal buffer at 11MS101 along Kanaranzi Creek (10170204-516)

Kanaranzi Creek (10170204-515)

The headwaters section of Kanaranzi Creek had habitat assessment performed on both of its biological monitoring stations, 11MS004 and 11MS126. MSHA scores of these sites were 54.85 (fair) and 39 (poor) (Figure 65). Limiting the habitat scores in this stream section was the poor surrounding land use, the sometimes narrow riparian corridor, substrates dominated by sand, silt, and clay with few course substrates, moderate channel stability, and limited channel development.

Biologically, the macroinvertebrate population had high amounts of tolerant taxa (63.66%) while also having an average amount of clinger species (29.38%). The fish assemblage was mostly tolerant (65%), while also having few benthic insectivore taxa (15%) and darters/sculpins/round-bodied sucker species (8.84%). These sites did however have an above average amount of riffle dwelling taxa (20%) and simple lithophilic spawning species (33.34%). These two metric scores are typically lower in streams with degraded habitat conditions.

With the MSHA scores in the fair to poor range and many of the habitat related biological metrics in agreement, the lack of habitat is a stressor to the impaired fish and macroinvertebrate communities in this portion of Kanaranzi Creek.

East Branch Kanaranzi Creek (10170204-514)

East Branch Kanaranzi Creek had qualitative habitat assessments performed during the fish sampling visits at the three biological monitoring stations along this reach, (11MS018, 04MS050, and 11MS109). The MSHA scores during these visits were 52.25 (fair), 59.1 (fair), 79.33 (good). Limiting these habitat scores were the poor surrounding land use, a limited riparian buffer at times, areas of heavy bank erosion, sparse fish cover, and moderate channel stability.

Biologically, the macroinvertebrate assemblage in East Branch Kanaranzi Creek consisted of many tolerant taxa (60.33%), but also had a high amount of clinger taxa (37.46%). Clinger taxa tend to be much more abundant in streams with good habitat conditions. Site 11MS109 had a very high amount of clingers (46.15%), while also having the highest MSHA score in this AUID. These sites did have few burrower individuals (6.92%). Burrowers are often abundant in streams with soft and fine sediments which can be a sign of a degraded habitat condition.

The fish community had high amounts of tolerant taxa (70.02%), while also having fewer darters/sculpin/round-bodied sucker species (10.08%). This reach also had abundant riffle dwelling taxa (22.12%), benthic insectivore species (21.3%) and simple lithophilic spawning taxa (24.69%), which are more prevalent in streams with good habitat conditions.

With the fair to good MSHA scores and mixed biological results for habitat related metrics, makes the lack of habitat a minor stressor to the impaired biological communities in East Branch Kanaranzi Creek. Habitat improvements in this stream would aid the fish and macroinvertebrate assemblages in this stream; however, eliminating other stressors in this reach would likely have a greater impact to these impaired communities.

Conclusion

The four biologically impaired reaches in the Kanaranzi Creek Watershed are being negatively impacted by multiple stressors (Table 33).

High phosphorus was determined to be a stressor to the fish and macroinvertebrate communities in all of the impaired reaches within this watershed. While DO is currently not a stressor, prolonged periods of high phosphorus may eventually disrupt the DO conditions in the watershed by creating a high range of daily flux. This excess phosphorus is a likely result from the highly pastured riparian areas and cropland throughout the watershed where concentrations of phosphorus tend to be high. Runoff following rain events is a likely pathway for these phosphorus contributions to easily enter the stream system.

High nitrate values were also found to be a stressor to the biological assemblages at all four impaired reaches. Nitrate levels reached as high as 20 mg/L in Kanaranzi Creek (10170204-516), with many high values sampled in the other reaches as well. High percentages of nitrate tolerant individual macroinvertebrates as well as few Trichoptera taxa were present. These results can often signal impairment. The high levels of nitrates are likely a result from fertilizer applications and have entered the stream as runoff.

Currently, Kanaranzi Creek (10170204-517) is impaired for aquatic life due to turbidity in addition to its biological assemblages. This reach as well as Kanaranzi Creek (10170204-515) and East Branch Kanaranzi Creek (10170204-514) were found to be stressed by the high turbidity/TSS that exists in these stream reaches. High intensity grazing with minimal riparian buffers in the watershed has led to unstable and erosive banks. Biological conditions in Kanaranzi Creek (10170204-516) do not seem to be affected by high levels of turbidity/TSS at this time. However, unless improvements such as rotational grazing, fencing off cattle access to streams, and increasing the riparian buffer are made, the biological communities in this reach will likely become stressed from turbidity/TSS.

The lack of habitat was mainly found to be a stressor in the Kanaranzi Creek reaches. These reaches were limited by severe bank erosion, limited fish cover, low channel stability, the presence of sand and silt substrates, and sparse fish cover. These reaches contained many tolerant fish and macroinvertebrate species, while having few simple lithophilic spawning and riffle-dwelling fish species. Habitat improvement projects are recommended along this reach to help improve these conditions. East Branch Kanaranzi Creek (10170204-514) was not as impacted by the poor habitat conditions as the other reaches within this watershed. However, the lack of habitat is still a minor stressor in this reach and will need to be addressed.

Table 33: Stressors to the biologically impaired reaches within the Kanaranzi Creek Watershed

		Stressors				
Stream Name	**AUID #**	**Low Dissolved Oxygen**	**High Phosphorus**	**High Nitrates**	**High Turbidity/TSS**	**Lack of Habitat**
Kanaranzi Creek Watershed						
Kanaranzi Creek	10170204-517	-	•	•	•	•
Kanaranzi Creek	10170204-516	-	•	•	-	•
Kanaranzi Creek	10170204-515		•	•	•	•
East Branch Kanaranzi Creek	10170204-514	-	•	•	•	•

(• = stressor, - = not a stressor, and blank = inconclusive/not enough evidence)

Little Rock River Watershed

Overview

The Little Rock River Watershed in Minnesota fully encompasses two 12-digit HUC watersheds and also shares an additional 12-digit HUC with Iowa. The watershed is 99.5 mi^2 and contains four AUIDs listed as impaired for aquatic life (Figure 68): Little Rock River (10170204-513), Little Rock River (10170204-512), Little Rock Creek (10170204-511) and Unnamed Creek (10170204-579). The land use in this watershed consists of mainly cropland (86.16%), rangeland (6.16%), and developed land (6%).

Little Rock River (10170204-513) is the most downstream portion of Little Rock River. This AUID is 2.22 miles long extending from Little Rock Creek to the Minnesota River/Iowa border. This stream reach was sampled for fish in 2012 and macroinvertebrates in 2011 at its lone biological monitoring station 11MS002. This AUID was determined to be impaired for aquatic life due to its fish and macroinvertebrate assemblages as well as turbidity during the watershed assessment in 2013.

Little Rock River (10170204-512) is a 23.67 mile long AUID extending from the headwaters to the Little Rock Creek confluence. This stream was sampled for fish and macroinvertebrates at sites in 2004, 2011, and 2012 at the three biological monitoring stations along this reach, 04MS053, 11MS047, and 11MS110. This AUID was assessed in 2013 and found to be impaired for aquatic life due to its fish and macroinvertebrate assemblages as well as turbidity.

Little Rock Creek (10170204-511) is a 17.37 mile long AUID located from the headwaters of the watershed down to the confluence with the Little Rock River. The two biological monitoring sites along this reach, 11MS009 and 11MS132, were sampled for fish in 2011-2012 and were sampled for macroinvertebrates in 2011. This stream reach was designated as impaired for aquatic life due to its macroinvertebrate community, but also for turbidity during the watershed assessment in 2013.

Unnamed Creek (10170204-579) is a 1.67 mile long stream reach that extends from Unnamed Creek to the confluence with Little Rock Creek. The one biological monitoring station, 11MS105, was sampled for fish and macroinvertebrates in 2011. This stream was determined to be impaired for its macroinvertebrate community during the 2013 watershed assessment.

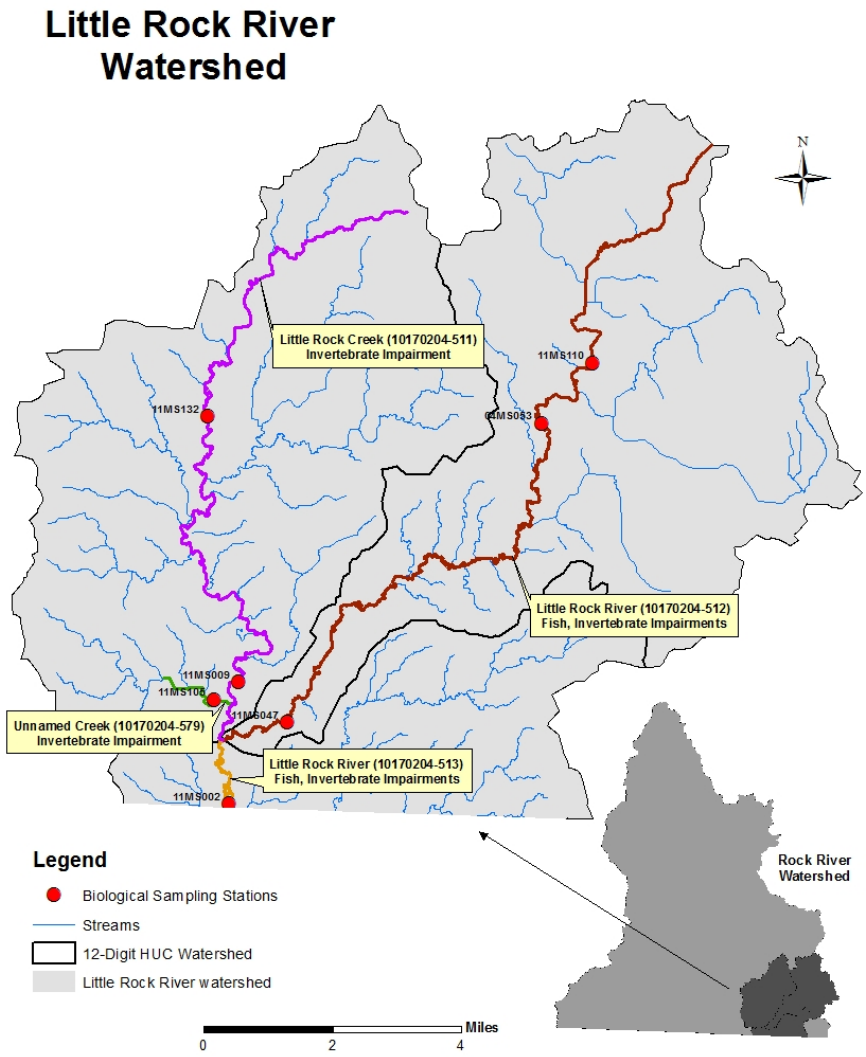

Figure 68: Little Rock River Watershed with biologically impaired reaches highlighted

Biology in the Little Rock River Watershed

Fish

The four biologically impaired reaches in the Little Rock River Watershed had a total of seven biological monitoring stations. On Little Rock River (10170204-513), the lone station, 11MS002, is located upstream of CR 58, 7 miles west of Bigelow and was sampled for fish on June 19, 2012. Moving upstream, Little Rock River (10170204-512) has three biological monitoring stations. Site 11MS047 is upstream of Fellows Avenue, 6.5 miles west of Bigelow and was sampled on June 19, 2012. Site 04MS043 is approximately seven miles southwest of Worthington at the intersection of CR 61 and 280th Street and was sampled August 11, 2004. Also on this AUID, 11MS110, is upstream of 270th Street, 2.5 miles southeast of Rushmore and was sampled on August 4, 2011. Little Rock Creek (10170204-511) has two biological monitoring stations. Site 11MS009 is located downstream of 320th Street, 8 miles northwest of Bigelow and was sampled on June 20, 2012 while site 11MS132 is upstream of 280th Avenue, 2.5 miles southwest of Rushmore and was sampled on July 27, 2011. Finally, site 11MS105 on Unnamed Creek (10170204-579) is located upstream of Erickson Avenue, 8 miles northwest of Bigelow and had a fish sample taken on July 27, 2011.

Four of the seven biological monitoring stations from the biologically impaired reaches in this watershed were classified as Fish Class 2 (Southern Streams). To reach the Fish Class 2 IBI threshold, the site would need an IBI score of at least 45. To achieve this, each metric would need an average metric value score of 5.625. The Little Rock River (10170204-512) reached this level in three of the eight IBI metrics (Figure 69). This AUID had abundant benthic insectivore taxa (excluding tolerant species) present (BenInsect-TolTxPct), a lower amount of detritivorous taxa (DetNWQTxPct) resulting in a higher score, and the two most dominant fish species were not overwhelmingly present more than other species (DomTwoPct). Little Rock River (10170204-513) fared slightly better scoring above the average value needed to reach the IBI threshold in four of the eight IBI categories. This reach scored well in the DetNWQTxPct and DomTwoPct metrics, while also having a lower populations of early maturing fish (MA<2Pct) and tolerant fish taxa (TolTxPct) resulting in higher metric value scores. Lastly, Little Rock Creek (10170204-511) scored well in five of the eight metrics. This AUID is not impaired for its fish assemblage at this time.

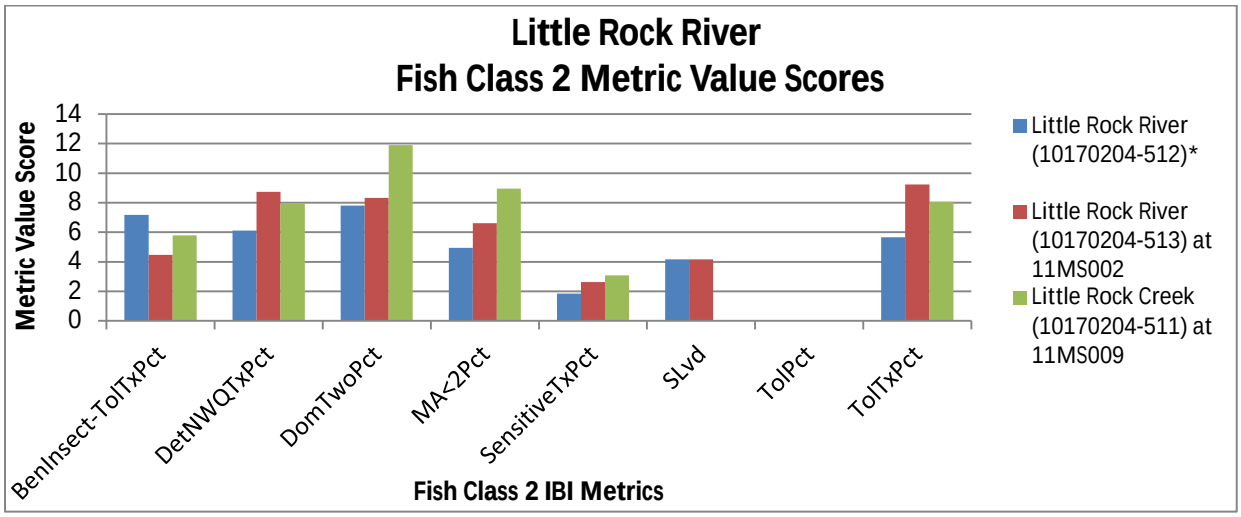

Figure 69: Fish Class 2 IBI metric value scores in the Little Rock River Watershed
*Average IBI Metric Value scores from biological monitoring stations 04MS053, 11MS047

Three sites located in the headwaters of this watershed have a Fish Class 3 (Southern Headwaters) designation. The IBI threshold for this class is 51 and each metric would need an average score of 8.5 to reach this level (Figure 70). Site 11MS110 on the Little Rock River (10170204-512) had a fish IBI score of 52. While this specific site is above the IBI threshold, the AUID it is located on has two sites further downstream with a Class 2 designation that are both below the IBI threshold resulting in the impaired AUID. Site 11MS132 on Little Rock Creek (10170204-511) had a fish IBI score of 66. This AUID is not impaired due to its fish assemblage at this time. Site 11MS105 located on Unnamed Creek (10170204-579) had an IBI score of 57 and the AUID is not impaired for fish at this time.

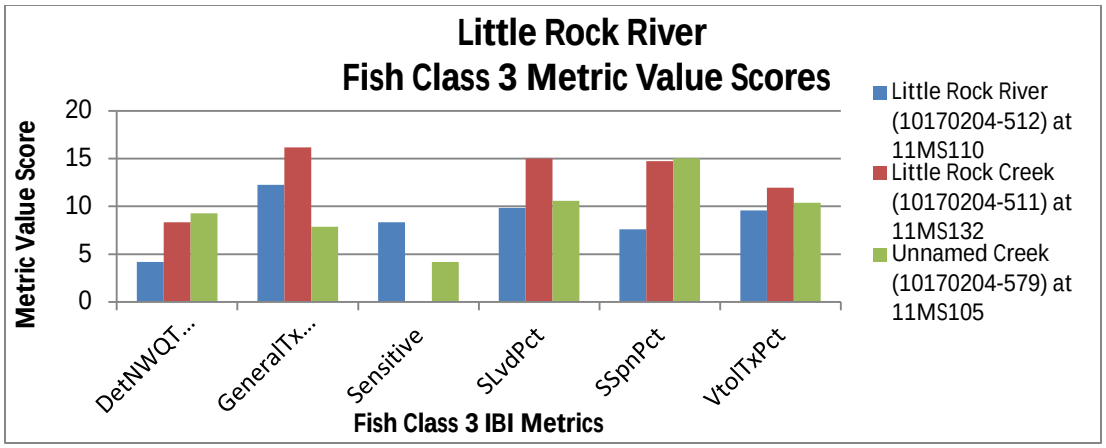

Figure 70: Fish Class 3 IBI metric value scores in the Little Rock River Watershed

Macroinvertebrates

In the watershed, Little Rock Creek (10170204-513) had one macroinvertebrate sample taken on August 2, 2011, at its biological monitoring station 11MS002. The Little Rock River (10170204-512) had four macroinvertebrate sampling visits at its three biological monitoring stations. Site 04MS053 was sampled on August 24, 2004, and 11MS047 on August 2, 2011. Site 11MS110 had duplicate samples collected on August 12, 2011. Little Rock Creek (10170204-511) was sampled on August 2, 2011 at 11MS009 and 11MS132 was sampled on August 11, 2011. Unnamed Creek (10170204-579) had one macroinvertebrate sample taken on August 11, 2011, at station 11MS105.

Three of the impaired streams were designated as Class 5 (Southern Streams RR) streams. The MIBI threshold for this class is 35.9. To reach the MPCA's macroinvertebrate IBI threshold for this class, each metric would need an average score of 3.59. Little Rock River (10170204-512) had metric value scores averaged from its three sites and scored above the average needed to reach the IBI threshold in three of the ten metrics (Figure 71). This AUID had abundant numbers of climber taxa (ClimberCh), Odonata species, and had a fairly diverse macroinvertebrate community represented by a good score in the DomFixChPct metric. Little Rock River (10170204-511) had a good populaton of clinger taxa (ClingerChTxPct) and scored well in the DomFixChPct metric as well, while scoring poorly in the remaining eight IBI metrics. Unnamed Creek (10170204-579) also had good numbers of climber and odonata taxa, while scoring well in the DomFiveChPct metric as well.

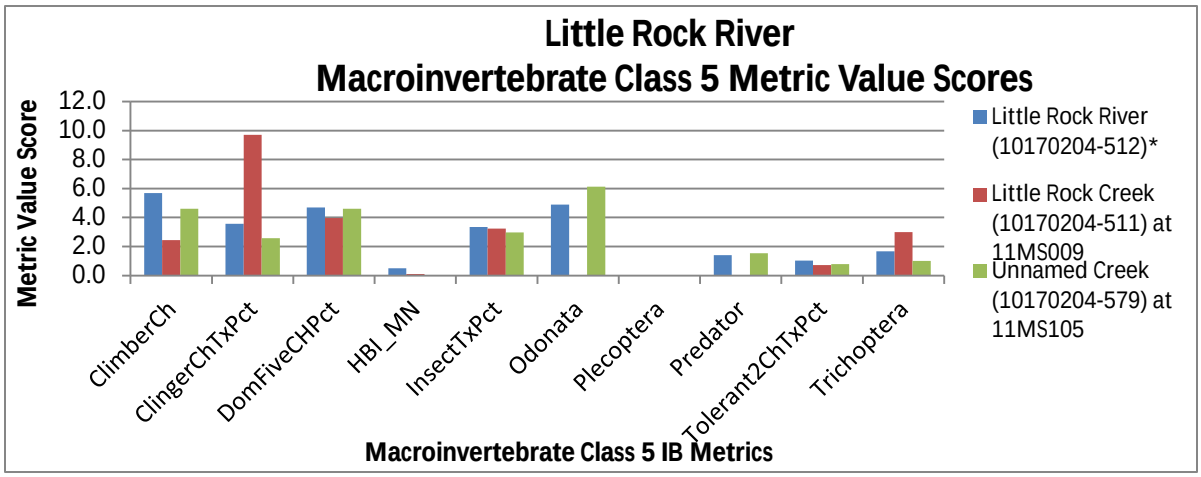

Figure 71: Macroinvertebrate Class 5 IBI metric value scores in the Little Rock River Watershed

*Average Values of sites 04MS053, 11MS047, 11MS110

The MIBI threshold for a Class 7 (Prairie Streams GP) sites is 38.83 and an average metric score of 3.83 is needed to reach this level. Little Rock River (10170204-513) had metric value scores at its biological monitoring station, 11MS002, above the average needed to meet the threshold for just two of the metrics. This stream had good numbers of Trichoptera taxa (TrichopteraChTxPct) and non-hydropsychid Trichoptera (TrichwoHydroPct) that raised the IBI scores, however, the metric value scores were low in the remaining metrics. Little Rock Creek (10170204-511) reached the average needed to attain the IBI threshold in half of the metrics. This reach lacked many collector-filterer macroinvertebrates (Collector-filtererPct), had poor taxa richness of macroinvertebrates with tolerance values less than or equal to 2 (Intolerant2Ch), had low numbers of Plecoptera, Odonata, Ephemeroptera, and Trichoptera (POET) taxa, had few non-hydropsychid Trichoptera species, and had a high HBI score (HBI_MN). The HBI_MN is a measure of pollution based on tolerance values assigned to each individual taxon. A low value in Figure 72 represents a high (poor) HBI score.

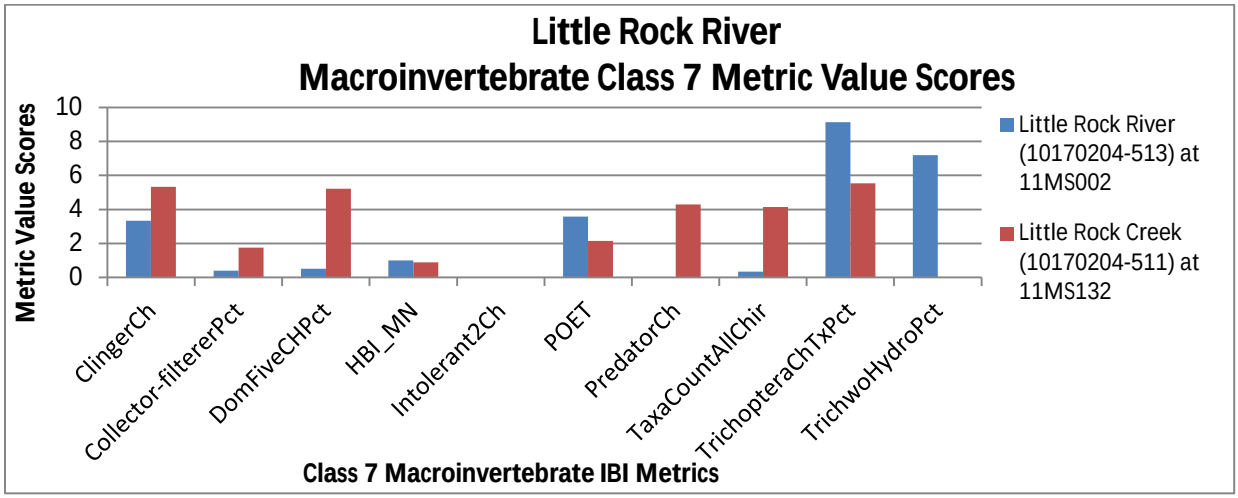

Figure 72: Macroinvertebrate Class 7 IBI metric value scores in the Little Rock River Watershed

Candidate cause: Low dissolved oxygen

The daily minimum standard for DO in Minnesota Class 2B streams is 5 mg/L. All streams in the Little Rock River Watershed have this 2B classification. No streams in this grouping are currently listed as impaired for DO.

Little Rock River (10170204-513)

From 2008-2013, there were 57 DO readings taken from this portion of the Little Rock River with values ranging from 6.5-15.07 mg/L. None of these samples are below the daily minimum standard and four of the samples were taken at or before 9 AM. However, the very high value of 15.07 mg/L may indicate problems with daily flux.

The HSPF model calculated hourly DO values for Little Rock River (10170204-513) from 1996-2009. These values ranged from 2.13-14.43 mg/L with an average value of 10.9 mg/L. Of these calculations, 0.05% was below the 5 mg/L daily minimum standard.

Biologically, the macroinvertebrate assemblage in the most downstream section of the Little Rock River had many tolerant taxa (55%) and few overall taxa (17), but also had a high percentage of DO sensitive EPT taxa (35%). The fish community had high numbers of serial spawning fish taxa (33.33%), while having few sensitive fish species (9.52%). The fish assemblage did have a high amount (42.86%) of late maturing fish, which is not common in streams experiencing low DO levels. Additionally, site 11MS002 along this reach had a high DO TIV score when compared to all other Minnesota streams.

Based on the observed and calculated scores, along with the majority of the DO related biological metrics, low DO is not a stressor at this time on the Little Rock River. Further continuous monitoring is recommended to check daily flux values.

Little Rock River (10170204-512)
From 2004-2013, 28 DO readings were taken from this section of Little Rock River. Dissolved oxygen values ranged from 7.21-14.02 mg/L with no readings below the 5 mg/L minimum standard. No samples were taken before 9 AM, which may better indicate potential problems with daily flux.

The HSPF model calculated hourly HSPF values for Little Rock River (10170204-512) from 1996-2009. These values ranged from 0-14.53 mg/L with an average value of 9.95 mg/L. Of these calculations, 3.45% were below 5 mg/L.

The macroinvertebrate community in this lengthy AUID of the Little Rock River consisted of many tolerant species (59.77%); however this site did average a high amount of overall taxa (25.17) and had a large presence of EPT taxa (32.33%). The fish population in this stream had high levels of tolerant fish species (58.1%) and serial spawning fish (33.43%). This stream also lacked many sensitive fish taxa (8.61%), but did however have a slightly above average amount of late maturing fish species (22.58%). The DO TIV score for the sites along this reach was above average when compared to all other Minnesota streams.

Based on the low observed values, the very few calculated exceedances, along with the majority of related biological metrics shows that low DO is not a stressor to the impaired biological assemblages in Little Rock River (10170204-512) at this time.

Little Rock Creek (10170204-511)
From 2010-2013, 22 DO samples were taken from Little Rock Creek with values ranging from 4.45-15.67 mg/L. Only one sample was below the 5 mg/L minimum standard. The wide ranges of DO values may indicate potential problems with daily flux.

The HSPF model calculated hourly DO values for Little Rock Creek (10170204-511) from 1996-2009. These values ranged from 0-14.52 mg/L with an average value of 10.03 mg/L. Of these calculations, 1.57% was below the 5 mg/L daily minimum standard.

Biologically, the macroinvertebrate community in Little Rock Creek consisted of many tolerant species (68.72%) and only averaged 20.5 taxa between the two biological monitoring sites, 11MS009 and 11MS132. This AUID did have an above average amount of EPT taxa (30.26%). The fish assemblage in this stream section had few sensitive species (5.56%), and also had high amounts of serial spawning fish (33.33%) and tolerant taxa (53.24%). Sites 11MS009 and 11MS132 did have above average DO TIV scores in their respective fish classes.

Based on the low exceedance rate with the measured and calculated values, as well as the high amounts of EPT taxa and high DO TIV score, low DO is not a stressor to the biological communities in Little Rock Creek at this time. The low metrics scores are likely due to other stressors.

Unnamed Creek (10170204-579)
From 2011-2013, eight DO readings were taken from Unnamed Creek. These values ranged from 5.96-15.08 mg/L with no level detected below the daily minimum standard (Table 34).

Table 34: Dissolved oxygen values from 2011-2013 at site 11MS105 along Unnamed Creek (10170204-579)

Sample Location	Sample Date and Time	Result (mg/l)	Daily Minimum Standard (mg/l)
11MS105	7/27/2011 *4:15 PM*	5.96	5
11MS105	8/9/2011 3:54 PM	10.98	5
11MS105	5/6/2013 10:40 AM	15.08	5
11MS105	5/21/2013 1:05 PM	11.17	5
11MS105	6/10/2013 8:50 AM	9.01	5
11MS105	7/1/2013 12:10 PM	9.21	5
11MS105	7/15/2013 9:15 AM	8.61	5
11MS105	8/14/2013 8:50 AM	6.51	5

The HSPF model calculated hourly DO values for Unnamed Creek (10170204-579) from 1996-2009. These values ranged from 0-14.53 mg/L with an average value of 8.11 mg/L. Of these calculations, 5.07% were below the 5 mg/L daily minimum standard.

Biologically, the macroinvertebrate assemblage in Unnamed Creek had lower levels of EPT taxa (16.67%) and overall species (21). Site 11MS105 did have five very intolerant DO species, while also having very few DO tolerant individuals (0.37%). The fish community had few sensitive (11.11%) and late maturing taxa (11.11%). Site 11MS105 also had a below average DO TIV score when compared to all other fish Class 3 sites.

Unnamed Creek had low observed DO values while also having a low exceedance rate calculated by the model. Additionally, the presence of many very intolerant macroinvertebrate taxa signals that low DO is not a stressor to the impaired macroinvertebrate community in this reach. The low scoring fish metrics are likely due to other stressors.

Candidate cause: High phosphorus

The proposed draft standard for phosphorus for streams in the Missouri River basin is currently 0.15 mg/L. Although phosphorus is an essential nutrient for all aquatic life, elevated levels can lead to an imbalance which impacts stream ecology. In the Little Rock River Watershed phosphorus levels have exceeded this proposed standard multiple times.

Little Rock River (10170204-513)

From 2011-2012 a total of 43 phosphorus samples were taken from this section of the Little Rock River. Sample values ranged from 0.03-1.28 mg/L (Figure X) with 25 (58.14%) of the samples above the 0.15 mg/L proposed draft standard for phosphorus. As Figure 73 shows, phosphorus levels in 2012 were much higher than in 2011.

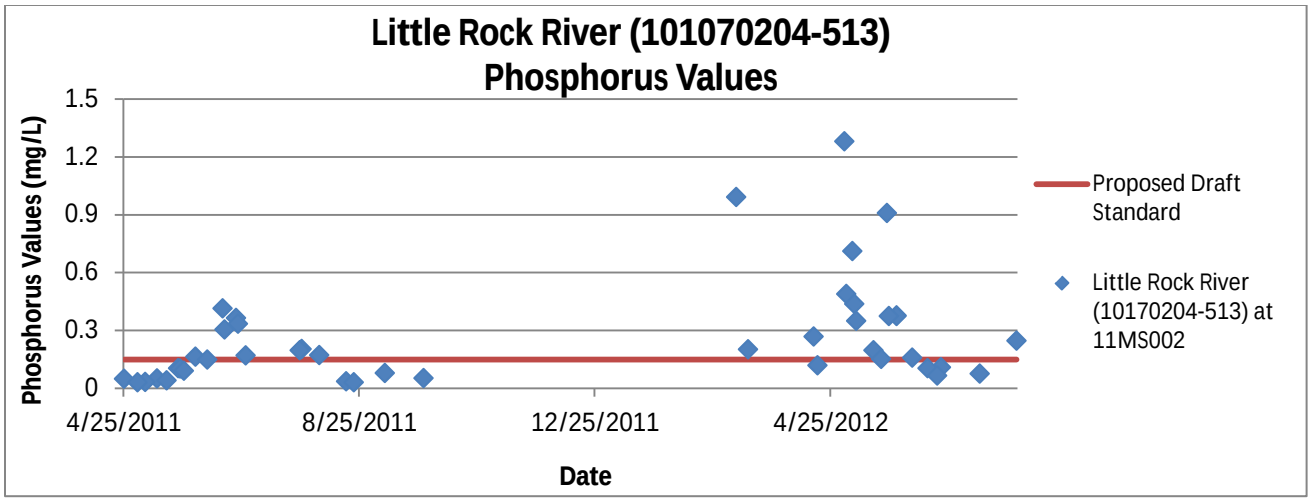

Figure 73: Phosphorus values from 2011-2012 along Little Rock River (10170204-513)

The HSPF model calculated daily phosphorus values for Little Rock River (10170204-513) from 1996-2009. These values ranged from 0.06-0.77 mg/L with an average value of 0.19 mg/L. Of these calculations, 62.1% were above the 0.15 mg/L proposed phosphorus standard.

Biologically, the macroinvertebrate community had high numbers of EPT taxa (35%), but did however have many tolerant species (55%), scraper taxa (25%) and crustacean/mollusca species (20%). These types of macroinvertebrates are much more prevalent in waters with elevated phosphorus levels. Additionally, this site lacked phosphorus sensitive Tanytarsini taxa and had few intolerant species (10%). The fish assemblage in Little Rock River did have increased numbers of tolerant taxa (42.86%), while having few sensitive species (9.52%) and very few darter individuals (1.87%). These results are common in streams affected by high phosphorus levels.

Based on the very high observed and calculated results as well as the majority of the related biological metrics, high phosphorus is a stressor to the impaired biological assemblages in the Little Rock River.

Little Rock River (10170204-512)
From 2011-2013 a total of 18 phosphorus were taken at various point along this portion of the Little Rock River. Sample values ranged from 0.024-0.455 mg/L with six samples being above the proposed draft standard (Figure 74).

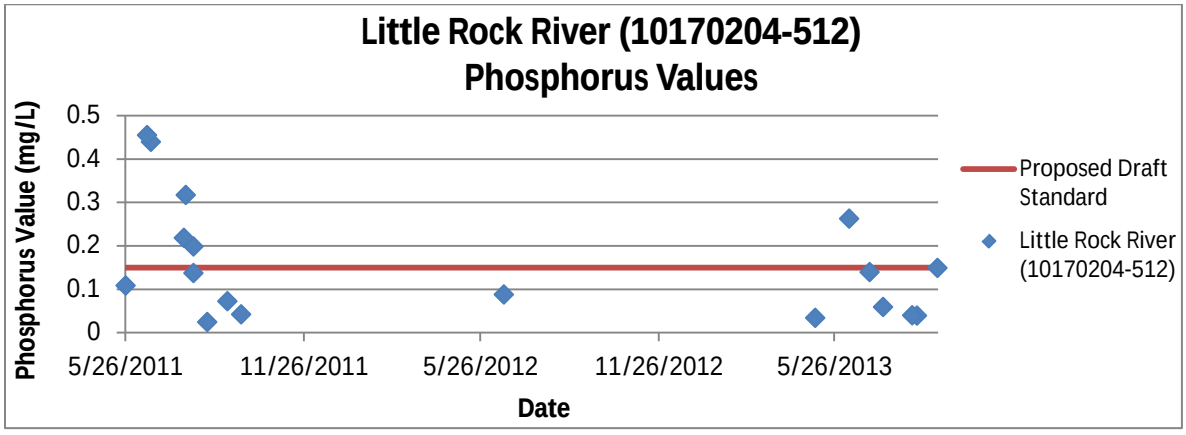

Figure 74: Phosphorus values from 2011-2013 along Little Rock River (10170204-512)

The HSPF model calculated daily phosphorus values for this portion of the Little Rock River from 1996-2009. These values ranged from 0.06-1.12 mg/L with an average value of 0.19 mg/L. Of these calculations, 58.88% were above the 0.15 mg/L proposed phosphorus standard.

The macroinvertebrate assemblage in this section of the Little Rock River again showed good numbers of EPT taxa (32.33%) and a slightly above average amount of intolerant species (11.85%). This stream did have low numbers of Tanytarsini species (5.47%), while having higher numbers of tolerant taxa (59.77%), Scraper species (13.17%) and crustacean/mollusca taxa (12.24%). The fish community in this reach had many tolerant taxa (58.1%), few sensitive species (8.61%) and darter individuals (3.91%). These results are common in streams with elevated phosphorus values.

Based on the very high observed and calculated results as well as the majority of the related biological metrics, high phosphorus is a stressor to the impaired biological assemblages in the Little Rock River.

Little Rock Creek (10170204-511)

Little Rock Creek had 12 phosphorus samples taken from 2011-2012 with sample values ranging from 0.018-0.385 mg/L (Table 35). Three of the samples were greater than the 0.15 mg/L proposed draft standard for phosphorus.

Table 35: Phosphorus sample values from 2011-2012 along Little Rock Creek (10170204-511)

Sample Location	Sample Date	Result (mg/l)	Proposed Draft Standard (mg/l)
S006-271	5/2/2011	0.018	0.15
S006-271	5/26/2011	0.054	0.15
S006-271	6/17/2011	0.088	0.15
S006-271	6/21/2011	0.294	0.15
S006-271	7/25/2011	0.119	0.15
S006-271	7/27/2011	0.186	0.15
11MS132	7/27/2011	0.385	0.15
S006-271	8/4/2011	0.132	0.15
S006-271	8/18/2011	0.129	0.15
S006-271	9/8/2011	0.134	0.15
S006-271	9/22/2011	0.138	0.15
11MS009	6/20/2012	0.078	0.15

The HSPF model calculated daily phosphorus values for Little Rock Creek (10170204-511) from 1996-2009. These values ranged 0.07-1.49 mg/L with an average value of 0.22 mg/L. Of these calculations, 79.16% were above the proposed phosphorus standard.

Biologically, the macroinvertebrate assemblage in this AUID was very similar to those in the Little Rock River in that it had a high amount of EPT taxa (30.26%) while having few Tanytarsini species (6.26%) and intolerant taxa (7.87%). Elevated numbers of tolerant taxa (68.72%), crustacean/mollusca taxa (12.51%), and scraper taxa (17.25%) were also present. The fish population consisted of many tolerant taxa (53.24%) with very few sensitive fish species (5.56%) and darter individuals (5.63%) at the two biological monitoring stations along this stream reach.

Based on the very high observed and calculated results as well as the majority of the related biological metrics, high phosphorus is a stressor to the impaired macroinvertebrate assemblage in Little Rock Creek at this time.

Unnamed Creek (10170204-579)
Unnamed Creek had six phosphorus samples taken from 2011-2013. Sample values ranged from 0.019-0.194 mg/L with one sample over the proposed draft standard (Table 36).

Table 36: Phosphorus sampling values from 2011-2013 at site 11MS105 along Unnamed Creek (10170204-579)

Sample Location	Sample Date	Result (mg/l)	Proposed Draft Standard (mg/l)
11MS105	7/27/2011	0.194	0.15
11MS105	5/6/2013	0.019	0.15
11MS105	6/10/2013	0.102	0.15
11MS105	7/1/2013	0.044	0.15
11MS105	7/15/2013	0.046	0.15
11MS105	8/14/2013	0.086	0.15

The HSPF model calculated daily phosphorus values for Unnamed Creek (10170204-579) from 1996-2009. These values ranged from 0.1-0.92 mg/L with an average value of 0.24 mg/L. Of all of the calculations, 91.34% were above the 0.15 mg/L proposed phosphorus standard.

Biologically, Unnamed Creek had an macroinvertebrate community consisting of low numbers of EPT (16.67%), intolerant (0%), and Tanytarsini taxa (3.33%), while having high levels of tolerant (60%), scraper (13.33%), and crustacean/mollusca species (13.33%) All of these metrics indicate stress caused by elevated phosphorus levels. The fish assemblage also had a highly tolerant population (66.67% taxa) with decreased numbers of sensitive species (11.11%). Site 11MS105 did have a higher amount of darter individuals (10.21%) when compared to all other Minnesota streams.

Based on the high observed and calculated phosphorus values along with the agreement with the majority of the related biological metrics, high phosphorus is a stressor to the impaired macroinvertebrate community in Unnamed Creek.

Candidate cause: High nitrates

Currently, the state of Minnesota does not have a nitrate standard in place for streams not used as a drinking water source. However, the overabundance of nitrates can stress a biological community. Nitrates in the Little Rock River Watershed did at times reach levels that could potentially be stressing the biological assemblages.

Little Rock River (10170204-513)
From 2011-2012, 43 nitrate samples were taken from the Little Rock River. Nitrate sample values ranged from 0.2-14.9 mg/L (Figure 75). A quantile regression for Class 7 macroinvertebrate sites like 11MS002 shows impairment at levels above 11.5 mg/L. This site had samples above this level 13 different times.

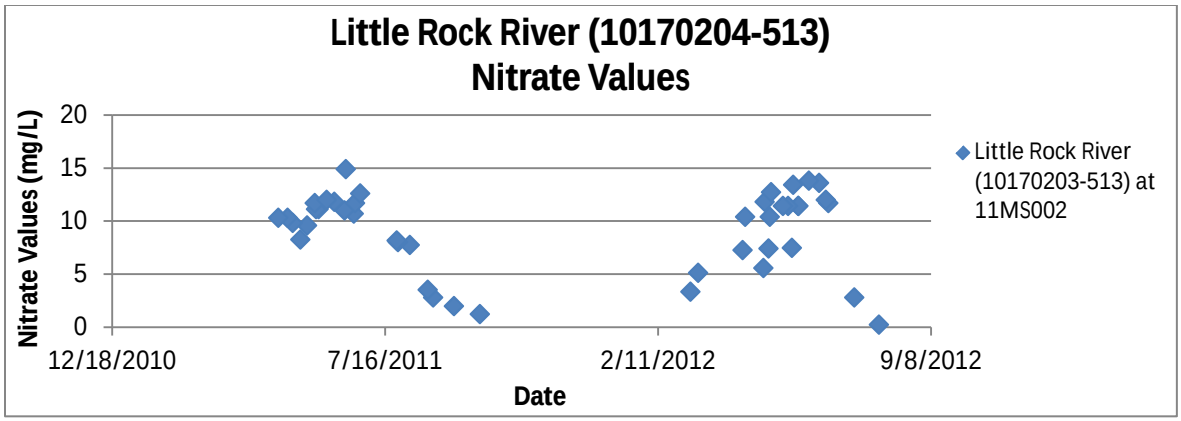

Figure 75: Nitrate sample values from 2011-2012 along Little Rock River (10170204-513)

The HSPF model calculated daily nitrate values for Little Rock River (10170204-513) from 1996-2009. These values ranged from 2.02-19.19 mg/L with an average value of 5.9 mg/L.

Biologically, the macroinvertebrate assemblage in the downstream portion of the Little Rock River did have a slightly above average amount of nitrate sensitive Trichoptera taxa (15%) when compared to all other streams in Minnesota, but did have fewer overall taxa (17) than expected. Site 11MS002 had an extremely high amount of nitrate tolerant individuals (94.48%), which according to a quantile regression study, this site would have a greater than 90% probability of being impaired. Additionally, the fish community had quite a few species (21), but had few sensitive fish species (9.52%).

Based on the very high nitrate observations and calculations, as well as the majority of the related biological metrics and quantile regression study, high nitrate values are a stressor to the impaired biological assemblages in Little Rock River (10170204-513).

Little Rock River (10170204-512)

This portion of Little Rock River had 18 nitrate samples taken from 2011-2013. Sample values ranged from 0.06-18 mg/L (Figure 76). These nitrate values were all much higher in May-June, which coincides with the majority of fertilizer applications in the areas farm fields.

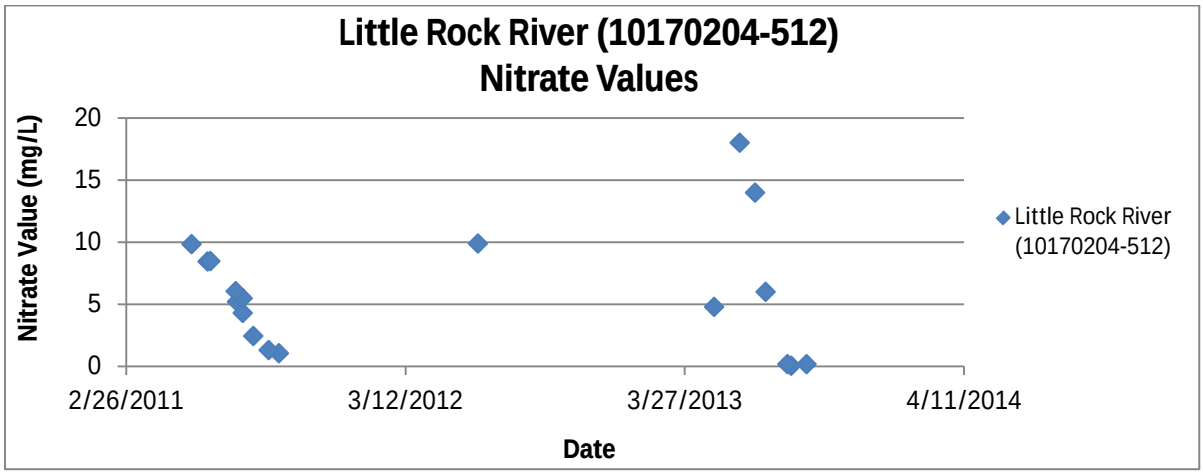

Figure 76: Nitrate sample values from 2011-2013 along Little Rock River (10170204-512)

The HSPF model calculated daily nitrate values for Little Rock River (10170204-512) from 1996-2009. These values ranged from 1.8-19.86 mg/L with an average value of 5.93 mg/L.

The macroinvertebrate population in this section of the Little Rock River had average amounts of overall taxa (25.17) and Trichoptera species (10.67%) at its three biological monitoring stations. These sites did have an extremely high amount of nitrate tolerant individuals (90.36%). Levels this high have a greater

than 90% probability of being impaired. The fish community lacked many sensitive species (8.61%), but did average 16 species per sampling site. This result is a bit higher than the average found in streams throughout Minnesota.

Based on the very high nitrate observations and calculations, as well as the majority of the related biological metrics and quantile regression study, high nitrate values are a stressor to the impaired biological assemblages in Little Rock River (10170204-512).

Little Rock Creek (10170204-511)

From 2011-2012, a total of 12 nitrate samples were taken from Little Rock Creek. Sample values ranged from 2-15.7 mg/L (Table 37). These samples averaged over 10.5 mg/L, with the highest values coming in May, June, and July.

Table 37: Nitrate sample values from 2011-2012 along Little Rock Creek (10170204-511)

Sample Location	Sample Date	Result (mg/l)	Nitrate Standard (mg/l)
S006-271	5/2/2011	13	n/a
S006-271	5/26/2011	13.4	n/a
S006-271	6/17/2011	15.7	n/a
S006-271	6/21/2011	12.8	n/a
S006-271	7/25/2011	13.4	n/a
S006-271	7/27/2011	10.7	n/a
11MS132	7/27/2011	12	n/a
S006-271	8/4/2011	11.6	n/a
S006-271	8/18/2011	6.2	n/a
S006-271	9/8/2011	2.32	n/a
S006-271	9/22/2011	2	n/a
11MS009	6/20/2012	15	n/a

The HSPF model calculated daily nitrate values for Little Rock Creek (10170204-511) from 1996-2009. These values ranged from 2.23-19.78 mg/L with an average value of 6.17 mg/L.

Biologically the macroinvertebrate assemblage in Little Rock Creek averaged 20.5 species at the two biological monitoring sites while having a slightly above average amount of Trichoptera taxa (12.61%). Both of these values decreased as you moved further upstream. Additionally, both of these sites have a greater than 90% chance of being impaired according to a quantile regression analysis of the extremely high amounts of nitrate sensitive taxa present at both 11MS132 and 11MS009.The fish community had a very high average amount of taxa (19.5) for the given size of this stream, but few sensitive taxa (5.56%) were present, especially in the headwaters site.

The elevated measured nitrate values, the quantile regression analysis, and the agreement of many of the biological metrics makes the high levels of nitrates a stressor to the impaired macroinvertebrate community in Little Rock Creek.

Unnamed Creek (10170204-579)

Unnamed Creek had six nitrate samples taken from 2011-2013. Sample values ranged from 7.2-25 mg/L (Table 38). A quantile regression of Class 5 macroinvertebrate sites like 11MS105 shows with 90% confidence that if a stream's nitrate value exceeds 18.1 mg/L, that it will likely be impaired. Unnamed Creek exceeded this level in half of the samples taken.

Table 38: Nitrate sample values from 2011-2013 at site 11MS105 along Unnamed Creek (10170204-579)

Sample Location	Sample Date	Result (mg/l)	Nitrate Standard (mg/l)
11MS105	7/27/2011	10	n/a
11MS105	5/6/2013	13	n/a
11MS105	6/10/2013	23	n/a
11MS105	7/1/2013	25	n/a
11MS105	7/15/2013	20	n/a
11MS105	8/14/2013	7.2	n/a

The HSPF model calculated daily nitrate values for Unnamed Creek from 1996-2009. These values ranged from 2.81-20.66 mg/L with an average value of 6.74 mg/L.

Biologically the macroinvertebrate community in Unnamed Creek had fewer than normal species (21) and had an average amount of Trichoptera taxa (10%) when compared statewide. Site 11MS105 had a macroinvertebrate community comprised of 86.35% nitrate tolerant individuals which is above the 90th percentile. The fish assemblage also had fewer than normal species (9) and had fewer sensitive taxa (11.11%) than average.

The extremely high observed and calculated values, the quantile regression analyses, and the agreement with the biological metrics all conclude that the excess nitrates present in Unnamed Creek are indeed stressing the impaired macroinvertebrate assemblage.

Candidate cause: High turbidity/TSS

The water quality standard for turbidity is 25 NTU, 65 mg/L for TSS, and 20 cm for transparency tube for these Class 2B warmwater streams in the Little Rock River Watershed. Excess sediment is a commonly recognized stressor in many biologically impaired streams because it can reduce habitat, cause direct physical harm, as well as reduce visibility and increase oxygen demand.

Three of the reaches, Little Rock River (10170204-513), Little Rock River (10170204-512) and Little Rock Creek (10170204-511) were determined to be impaired for aquatic life due to turbidity in addition to their biological assemblages. A less extensive data set on Unnamed Creek is available.

Little Rock River (10170204-513)

A total of 43 TSS measurements were taken along this portion of the Little Rock River from 2011-2012. Sample values ranged from 8-867 mg/L. Twenty six of these samples were at or over the TSS standard of 65 mg/L (Figure 77). In addition, 60 transparency/Secchi tube readings were taken from 2008-2013 with 33 of these measurements falling below the 20 cm minimum standard. This reach was designated as impaired for turbidity in 2013 during the watershed assessment.

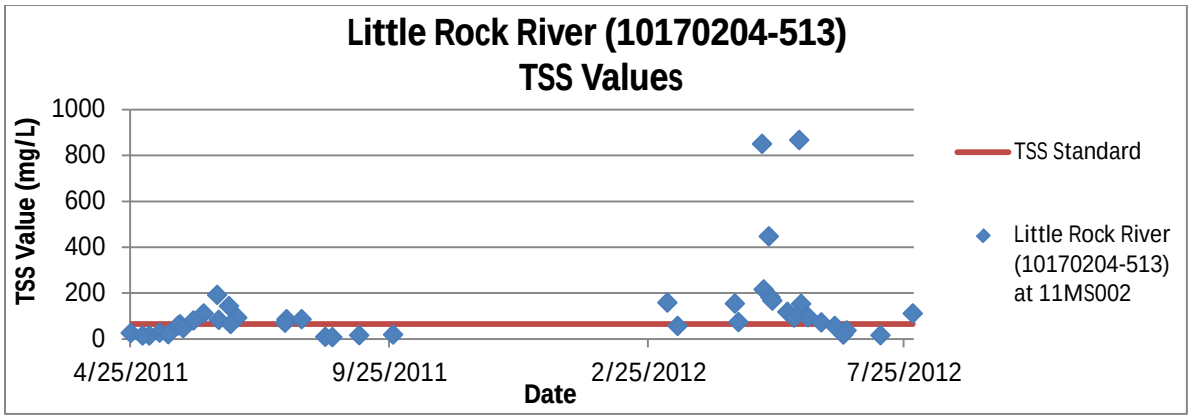

Figure 77: TSS values from 2011-2012 along Little Rock River (10170204-513)

Biologically, the macroinvertebrate community in this section of the Little Rock River showed decent numbers of TSS sensitive Ephemeroptera (20%), Trichoptera (15%), and scraper (25%) taxa. However, there was a low overall taxa count (17), low amount of collector-filterer species (10%), while also having a higher amount of tolerant taxa (55%). The fish assemblage completely lacked herbivorous fish species, which tend to disappear in streams with elevated TSS level.

The large data set and number of violations of the turbidity/TSS/transparency standards have led this AUID to be listed as impaired for turbidity. The majority of the biological connections are in agreement with this. Therefore, turbidity/TSS is a stressor to the impaired fish and macroinvertebrate communities in this portion of the Little Rock River.

Little Rock River (10170204-512)

From 2011-2013, 18 TSS samples were taken from this AUID of Little Rock River. Sample values ranged from 4-240 mg/L with seven values above the TSS standard of 65 mg/L (Figure 78). In addition, 32 transparency/Secchi tube readings were taken from 2004-2013. Of these readings, 18 were at or below the 20 cm minimum standard for transparency. This reach was designated as impaired for aquatic life due to its turbidity during the watershed assessment in 2013.

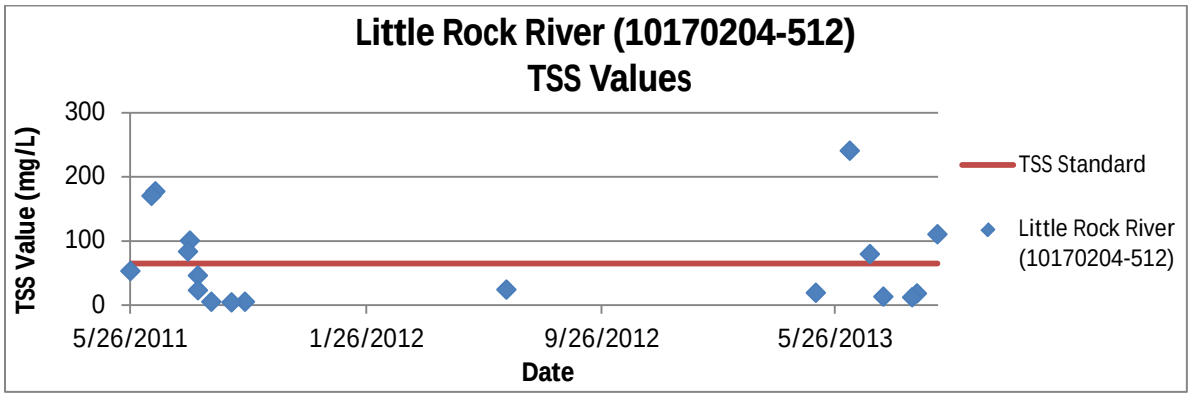

Figure 78: TSS sample values from 2011-2013 along Little Rock River (10170204-512)

Biologically, the macroinvertebrate assemblage had good numbers of Ephemeroptera (21.65%) species and overall taxa (21). Average numbers of Trichoptera (10.67%), collector-filterer taxa (13.1%) and scraper species (13.17%) while having increased tolerant taxa (59.77%). The fish population consisted of many tolerant species (58.1%), but the stream did have some herbivorous fish taxa (10.31%), which were absent in the AUID further downstream.

This section of the Little Rock River was listed as impaired for turbidity in 2013, which is backed up by both the numerous TSS samples and transparency readings, but also many biological metrics are in agreement. This biologically impaired reach is being stressed by turbidity/TSS.

Little Rock Creek (10170204-511)

A total of 12 TSS samples were taken from Little Rock Creek in 2011 with sample values ranging from 7-83 mg/L. Two of these samples were above the 65 mg/L standard for TSS. Additionally, 30 transparency/Secchi tube measurements were taken from 2010-2013 with 20 readings either at or below the 20 cm minimum standard for transparency (Figure 79). This reach was listed as impaired due to turbidity during the 2013 watershed assessment.

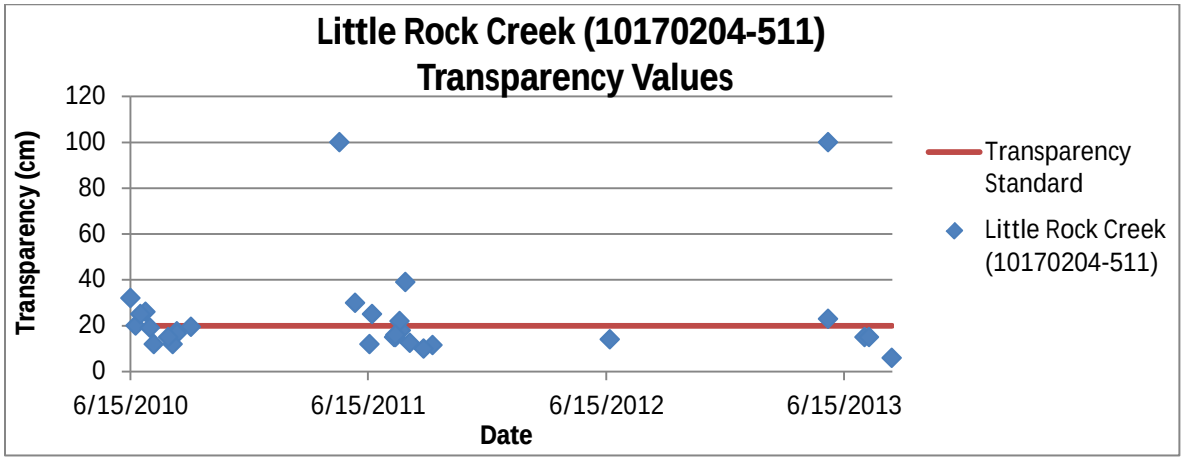

Figure 79: Transparency values from 2010-2013 along Little Rock Creek (10170204-511)

The macroinvertebrate community in Little Rock Creek had lower levels of Ephemeroptera taxa (11.76%) than the downstream AUIDs on the Little Rock River. There were also few overall taxa (20.5) and collector-filterer taxa (8.34%), while being dominated by many tolerant taxa (68.72%). This stream section did have a higher amount of scraper taxa (17.25%). The fish assemblage had a lot of tolerant taxa (53.24%) and few herbivorous species (7.87%).

Little Rock Creek was listed as impaired for turbidity in 2013, which is backed up by both the numerous TSS samples and transparency readings, but also many biological metrics are in agreement. This biologically impaired reach is being stressed by turbidity/TSS.

Unnamed Creek (10170204-579)

Unnamed Creek had six TSS samples taken from 2011-2013 with sample values ranging from 2.8-25 mg/L. None of these samples were near exceeding the TSS standard. Additionally, seven transparency/Secchi tube readings were taken with no measurements below the 20 cm minimum standard (Table 39).

Table 39: TSS and Secchi tube values from 2011-2013 at site 11MS105 along Unnamed Creek (10170204-579)

Sample Location	Sample Date	TSS Result (mg/l)	TSS Standard (mg/l)	Secchi Tube Value (cm)	Secchi Tube Standard (cm)
11MS105	7/27/2011	25	65	31	20
11MS105	5/6/2013	2.8	65	>100	20
11MS105	5/21/2013	n/a	65	34	20
11MS105	6/10/2013	20	65	38	20
11MS105	7/1/2013	19	65	45	20
11MS105	7/15/2013	8.4	65	43	20
11MS105	8/14/2013	11	65	43	20

The HSPF model calculated daily TSS values for Unnamed Creek from 1996-2009. These values ranged from 0-957.58 mg/L with an average value of 9.37 mg/L. Of these calculations, 2.78% exceeded the 65 mg/L proposed TSS standard.

Biologically, the macroinvertebrate assemblage in Unnamed Creek had a low amount of Ephemeroptera taxa (6.67%) and overall taxa (24). There was an average amount of Trichoptera taxa (10%), while the stream had a slightly above average amount of scraper (13.33%), and collector-filterer taxa (13.33%). There was also a high amount of tolerant taxa (60%). The fish community had many tolerant taxa (66.67%), but did show the highest amount of herbivorous fish taxa of all the biologically impaired reaches in the Little Rock River Watershed. Site 11MS105 did have a higher TSS TIV score when compared to all other Minnesota streams.

Based on the low observed values, the few calculated exceedances, and the majority of the related biological metrics, high turbidity/TSS is not a stressor to the impaired biological communities in Unnamed Creek at this time.

Candidate cause: Lack of habitat

Qualitative habitat assessments were performed on all four biologically impaired reaches in the Little Rock River Watershed during the fish sampling visits at each site. Results of these assessments can be seen in Figure 80.

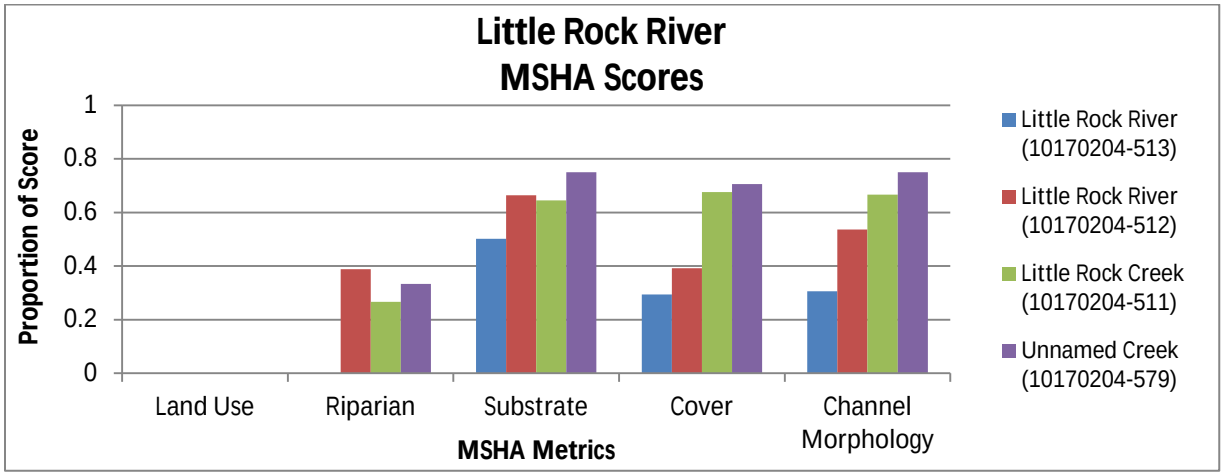

Figure 80: MSHA metric scores in the Little Rock River Watershed

Little Rock River (10170204-513)

A qualitative habitat assessment was performed on this section of the Little Rock River during the fish sampling event at 11MS002. The MSHA score at this site was 29.55, which is considered to be poor. Limiting the habitat in this stream was the poor surrounding land use, the absence of a riparian area, severe bank erosion (Figure 81), a sand dominated substrate, sparse fish cover, poor channel stability and poor channel development.

Figure 81: Heavy bank erosion at 11MS002 along Little Rock River (10170204-513)

Biologically, the macroinvertebrate community in Little Rock River (10170204-513) had a high amount of clinger species (35%). These types of macroinvertebrates tend to be less abundant in

degraded habitat conditions. However, there was an increased amount of tolerant taxa (55%), which is a very common signal in streams lacking good habitat. The fish assemblage in this reach had decreased riffle dwelling (9.52%) and simple lithophilic spawning taxa (14.29%). These species were limited by the lack of riffles and clean substrates needed to complete their respective life cycles.

The numerous habitat related issues resulted in a very poor MSHA score at site 11MS002 on the Little Rock River. For the most part, the biological communities reflect these conditions; therefore, the lack of habitat is a stressor to the impaired fish and macroinvertebrate assemblages at this time.

Little Rock River (10170204-512)

Qualitative habitat assessments were performed on the three biological monitoring stations, 11MS047, 11MS110, and 04MS053, along this section of the Little Rock River. MSHA scores of these sites were 45.2, 50.85, and 53.2. All of these scores are considered to be fair. Limiting the habitat in this stream reach was the poor surrounding land use, heavy bank erosion (Figure 82), a sometimes minimal riparian buffer, a predominantly sand substrate, sparse fish cover, low to moderate channel stability and limited channel development.

Biologically, the macroinvertebrate community in this stream had an increased amount of tolerant taxa (59.77%), while also having an average amount of clinger species (29.25%). These sites did have a lower amount of burrower individuals (5.88%), which are present in greater numbers in streams dominated by soft substrates. The fish assemblage had good numbers of riffle dwelling taxa (20.88%), benthic insectivore species (27.67%), and species classified as darters/sculpin/round-bodied suckers (19.18%). This stream did also have increased tolerant taxa (58.1%) and a lower amount of simple lithophilic spawning species (20.88%).

Figure 82: Eroded bank at 11MS047 along Little Rock River (10170204-512)

With consistently "fair" MSHA scores throughout this reach, the biological results were mixed. The lack of habitat should be considered a secondary stressor to the fish and macroinvertebrate communities at this time.

Little Rock Creek (10170204-511)

A qualitative habitat assessment was performed at sites, 11MS009 and 11MS132, on Little Rock Creek during the fish sampling events. The MSHA scores for these sites were 59.5 and 54.35. These scores are considered to be fair. Limiting the MSHA scores at these sites was the poor surrounding land use, bank erosion, a minimal riparian buffer, and moderate channel stability.

The macroinvertebrate assemblage in Little Rock Creek had high amounts of clinger species (37.73%), which can be sensitive of poor habitat conditions. Many tolerant taxa (68.72%) were also present, while these sites had few burrower individuals (3.49%). The fish population consisted of few riffle dwelling species (15.74%) and simple lithophilic spawning taxa (19.91%), while also having a high amount of tolerant fish taxa (53.24%). These sites did have a good amount of benthic insectivore species (27.78%) and an average amount of darter/sculpin/round-bodied sucker taxa (13.89%).

Given the fair MSHA scores and mixed biological results, the lack of habitat should be considered a secondary stressor to the biological assemblages in Little Rock Creek at this time.

Unnamed Creek (10170204-579)

A qualitative habitat assessment was performed on Unnamed Creek during the fish sampling event at 11MS105. The MSHA score at this site was 64.25, which is considered to be fair. Limiting the habitat in this stream was the poor surrounding land use, and the absence of a riparian area.

The macroinvertebrate community in Unnamed Creek had a large population of tolerant taxa (60%) and a lower amount of clinger species (26.67%) than the other studied sites in this watershed. The fish assemblage had many tolerant species (66.67%), but did have a good amount of riffle dwelling (22.22%), benthic insectivores (22.22%), simple lithophilic spawners (22.22%) and species classified as darters/sculpin/round-bodied suckers (22.22%).

The MSHA score was nearly scored as "good," and there were many high scoring habitat related biological metrics at site 11MS105 on Unnamed Creek. While improvements to habitat can be made, the lack of habitat is not a stressor to the impaired macroinvertebrate community in Unnamed Creek at this time.

Conclusion

The four biologically impaired reaches in the Little Rock River Watershed are being stressed by multiple parameters (Table 40).

High phosphorus was determined to be a stressor to the fish and macroinvertebrate communities in all of the impaired reaches within this watershed. While DO is currently not a stressor, prolonged periods of high phosphorus may eventually disrupt the DO conditions in the watershed by creating a high range of daily flux. This excess phosphorus is a likely result from the highly pastured riparian areas and cropland throughout the watershed where concentrations of phosphorus tend to be high. Runoff following rain events is a likely pathway for these phosphorus contributions to easily enter the stream system.

High nitrate values were also found to be a stressor to the biological assemblages at all four impaired reaches. Nitrate levels in excess of 25 mg/L were observed in Unnamed Creek, with many high values sampled in the other reaches as well. High percentages of nitrate tolerant individual macroinvertebrates were present, which often signals impairment. The high levels of nitrates are likely a result from fertilizer applications and have entered the stream as runoff.

Currently, three of the reaches, Little Rock River (10170204-513), Little Rock River (10170204-512) and Little Rock Creek (10170204-511) were determined to be impaired for aquatic life due to turbidity in addition to their biological assemblages. These three reaches were also found to be stressed by the high turbidity/TSS that persists in these streams. High intensity grazing with minimal riparian buffers in the watershed has led to unstable and erosive banks. Biological conditions further upstream in Unnamed Creek (10170204-579) do not seem to be affected by high levels of turbidity/TSS at this time. However, these sensitive areas are still in need of protection before they progress into a stressor.

The lack of habitat was mainly found to be a stressor in the most downstream reach, Little Rock River (10170204-513). This site was limited by the poor surrounding land use, the absence of a riparian area, severe bank erosion, a sand dominated substrate, sparse fish cover, poor channel stability and poor channel development. This reach also had many clinger taxa, which are often present in streams lacking ample habitat, as well as simple lithophilic spawning and riffle dwelling fish species, which prefer course substrates to complete their respective life cycles. To lesser extents, reaches Little Rock River (10170204-512) and Little Rock Creek (10170204-511) were negatively impacted by their current habitat conditions. Habitat improvement projects and natural stream channel designs are recommended along this reach to help improve stream stability and habitat conditions.

The Little Rock River Watershed has many biological stressors throughout. Addressing these stressors is needed to restore the biological communities to a healthy condition. Until this is done, the fish and macroinvertebrate communities will remain impaired.

Table 40: Stressors to the biologically impaired reaches within the Little Rock River Watershed

		Stressors				
Stream Name	**AUID #**	**Low Dissolved Oxygen**	**High Phosphorus**	**High Nitrates**	**High Turbidity/ TSS**	**Lack of Habitat**
Little Rock River Watershed						
Little Rock River	10170204-513	-	•	•	•	•
Little Rock River	10170204-512	-	•	•	•	•
Little Rock Creek	10170204-511	-	•	•	•	•
Unnamed Creek	10170204-579	-	•	•	-	-

• = stressor, - = not a stressor, and blank = inconclusive/not enough evidence

Lower Rock River

Overview

The Lower Rock River flows through four different 12-digit HUC watersheds in the southern portion of the Rock River Watershed within the Missouri River basin. This section includes three impaired AUIDs of the Rock River (Figure 83): (10170204-501, 10170204-509, 10170204-508). The land use in these subwatersheds dominated by cropland (81.35%), followed by rangeland (7.78%), and developed land (7.46%).

Rock River (10170204-501) is the most downstream AUID of the Rock River. This reach is 11.55 miles long and extends from the confluence with Elk Creek down to the Minnesota/Iowa border. This AUID was sampled for fish and macroinvertebrates in 2004 and 2011 at its biological monitoring stations 04MS016 and 11MS001. This reach was determined to be impaired for aquatic life due to its fish and macroinvertebrate assemblages during the watershed assessment in 2013. This reach is also impaired for turbidity.

Rock River (10170204-509) is the AUID immediately upstream of 10170204-501. This reach is 12.75 miles long and is located between the confluences of Champepadan Creek and Elk Creek with the Rock River. This AUID was sampled for fish and macroinvertebrates in 2004 and 2011 at its biological monitoring stations 04MS019 and 11MS145. This reach was determined to be impaired for aquatic life due to its fish and macroinvertebrate assemblages during the watershed assessment in 2013. This reach is also impaired for turbidity.

Rock River (10170204-508) is the next AUID upstream. This reach is 4.35 miles long and is located between the confluences of Unnamed Creek and Champepadan Creek with the Rock River. This AUID was sampled for fish in 2012 and macroinvertebrates in 2011 at its biological monitoring station 11MS003. This reach was determined to be impaired for aquatic life due to its fish and macroinvertebrate assemblages during the watershed assessment in 2013. This reach is also impaired for turbidity.

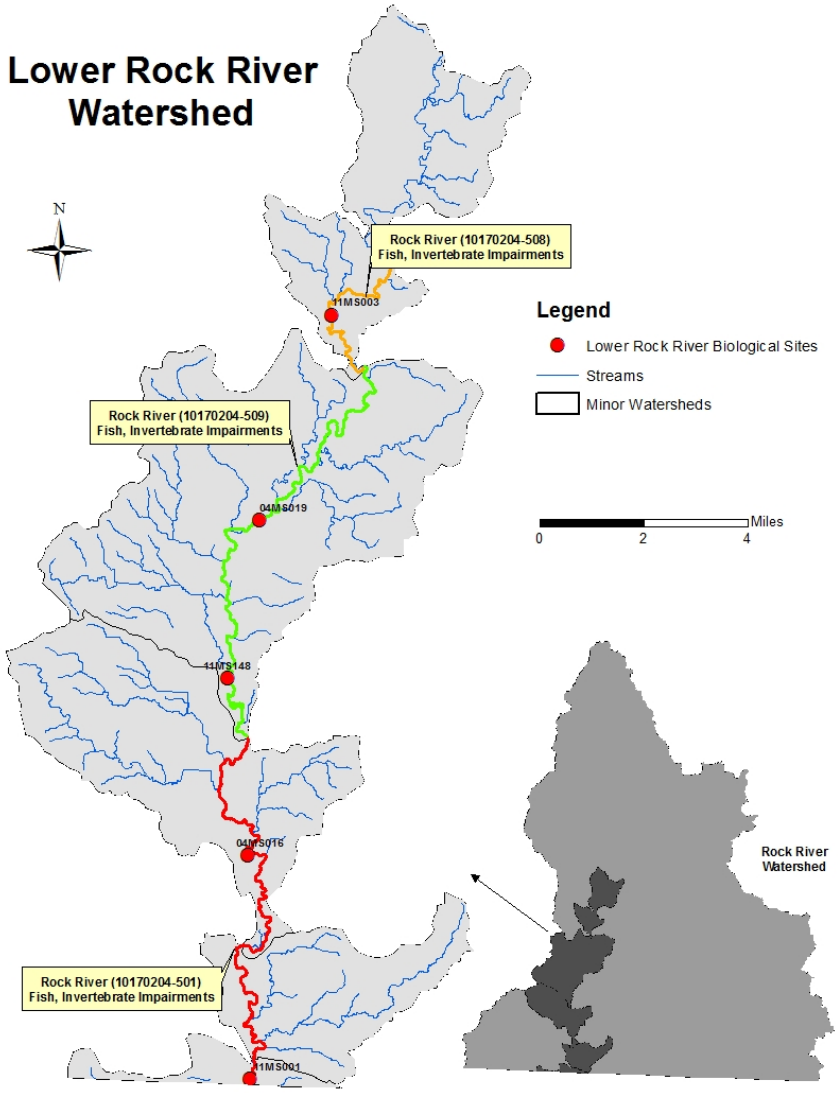

Figure 83: Lower Rock River Watershed with biologically impaired reaches highlighted

Biology in the Lower Rock River

Fish

The three biologically impaired reaches along the lower Rock River area had a total of five biological monitoring stations. On the most downstream reach, Rock River (10170204-501), there were two stations. Site 11MS001 is located upstream of Stateline Road, 10 miles south of Luverne and was sampled for fish on August 31, 2011. Further upstream, site 04MS016 is approximately 3 miles upstream of CR 1, in Clinton Township and was sampled on July 27, 2004. Rock River (10170204-509) had two biological monitoring sites. Site 04MS019 is located upstream of CR 4, 1 mile east of Luverne and was sampled for fish July 21, 2005, August 16, 2004, and June 20, 2012. Also on this reach, 11MS148 is downstream of CR 16, 2 miles south of Luverne and was sampled on June 14, 2012. Rock River (10170204-508) has one biological monitoring station, 11MS003, that is located downstream of CR 8, 3.5 miles northeast of Luverne and had a fish sampling event on June 19, 2012.

All of the biological monitoring sites in this lower section had a fish Class 1 (Southern Rivers) designation. The IBI threshold for this class is 46, which means that each metric comprising this IBI would need an average score of 4.6 to reach the threshold. The most downstream AUID, Rock River

(10170204-501) only reached this level at one of the metrics. This reach was not dominated by the two most abundant taxa (DomTwoPct) resulting in a higher metric value score (Figure 84). The two remaining reaches also only scored well in this metric.

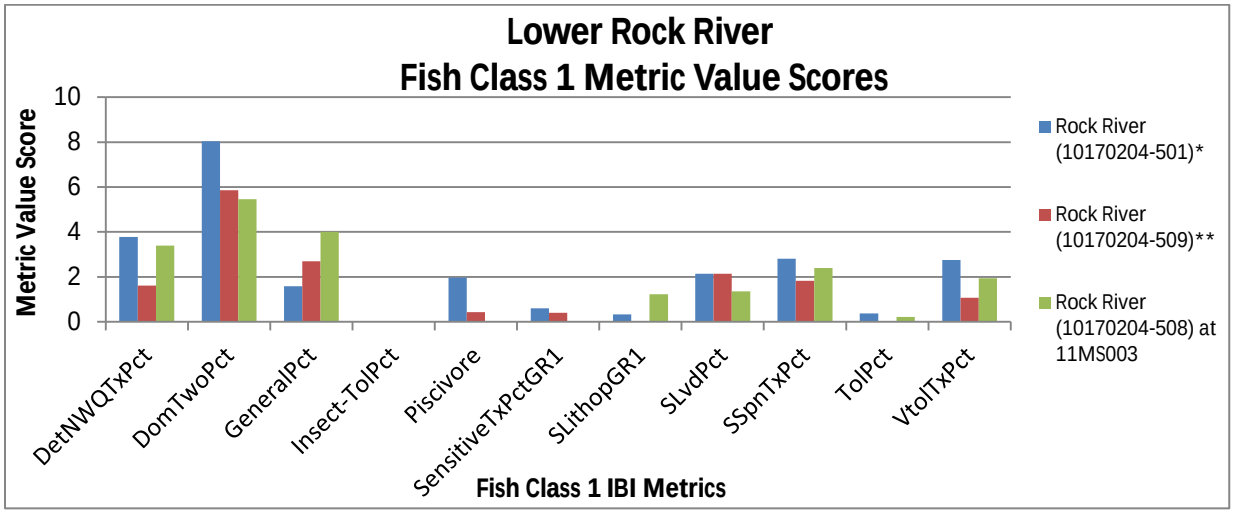

Figure 84: Fish Class 1 IBI metric value scores in the Lower Rock River Watershed
* Average Metric Values from sites 11MS001 and 04MS016
** Average Metric Value scores from sites 04MS019 and 11MS148

Macroinvertebrates

Rock River (10170204-501) had one macroinvertebrate sample taken from its biological monitoring station 11MS001 on August 31, 2011 and also at site 04MS016 on August 31, 2004. Moving upstream, Rock River (10170204-509) had samples taken at 04MS019 on August 31, 2004 and again on September 8, 2004. Also on this AUID, site 11MS148 had a sample taken on August 9, 2011. Lastly, biological monitoring site 11MS003 on Rock River (10170204-508) was also sampled on August 9, 2011.

The MIBI threshold for a Class 2 (Prairie Forest Rivers) stream site is 30.7 and an average metric value score of 3.84 is needed to reach this level. Rock River (10170204-501) had two sites fall in this category and their metric value scores were averaged and represented in Figure 85. This AUID only scored well in one of the metrics by having a fairly diverse macroinvertebrate population resulting in a higher score in the DomFiveCHPct metric.

Two of the impaired streams had sites designates as Class 5 (Southern Streams RR) streams. The macroinvertebrate IBI threshold for this class is 35.9. To reach the MPCA's macroinvertebrate IBI threshold or this class, each metric would need an average metric score of 3.59. Rock River (10170204-509) at site 04MS019 met this at four of the metrics (Figure X). This site had good numbers of clinger taxa (ClingerChTxPct), a diverse population (DomFiveCHPct), and high amounts of insect taxa (InsectTxPct) and Odonata. Site 11MS003 on Rock River (10170204-508) had a high number of insect and odonata taxa. These are the only metrics that this site scored above the average score needed to reach the IBI threshold for a Class 5 stream site.

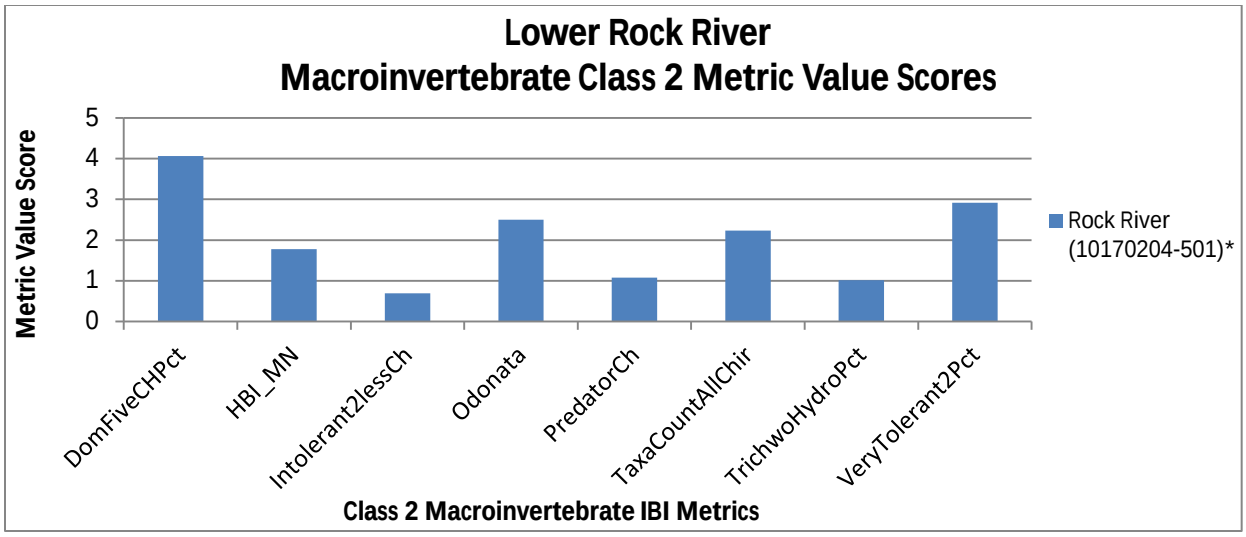

Figure 85: Macroinvertebrate Class 2 IBI metric value scores in the Lower Rock River Watershed
*Average Metric value scores from sites 04MS016 and 11MS001

The MIBI threshold for a Class 7 (Prairie Streams GP) sites is 38.83 and an average metric score of 3.83 is needed to reach this level. Site 11MS148 on the Rock River (10170204-148) is the only site on this lower portion of the Rock River belonging to this class. This site scored above the average needed to reach the threshold in five of the metrics. This site had a high presence of clinger taxa, Plecoptera ,Odonata, Ephemeroptera, and Trichoptera species (POET), predator species (PredatorCh), and Trichoptera taxa (TrichopteraChTxPct) while having poor taxa richness of macroinvertebrates with tolerance values less than or equal to 2 (Intolerant2Ch).

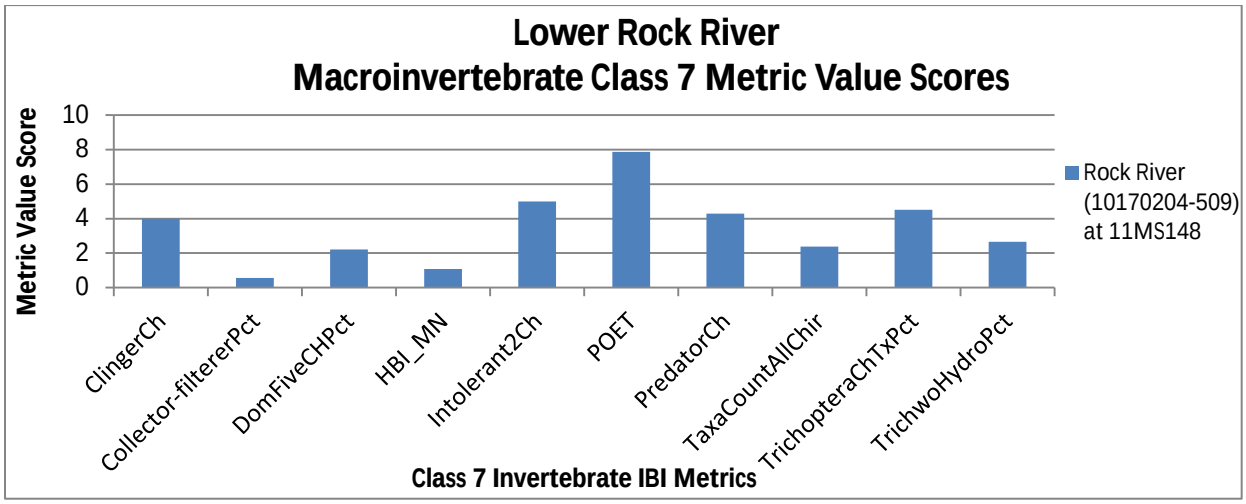

Figure 86: Macroinvertebrate Class 7 metric value scores at site 11MS148 along Rock River (10170204-509)

Candidate cause: Low dissolved oxygen

The daily minimum standard for DO in Minnesota Class 2B streams is 5 mg/L. All streams along the Lower Rock River have this 2B classification. No streams in this grouping are currently listed as impaired for DO.

Rock River (10170204-501)
From 2000-2013 a total of 141 DO readings were taken from this most downstream section of the Rock River before it crosses the Minnesota/Iowa border. These measurements ranged from 2.9-14.24 mg/L

with only one of the measurements falling below the 5 mg/L minimum standard. Of these measurements, 44 were taken before 9 AM, which is a good representation of when values would be expected to be lowest.

Biologically, the macroinvertebrate assemblage in this most downstream section of the Rock River had many tolerant taxa (50.39%) and a relatively low overall average taxa count (16) between the two sites, 11MS001 and 04MS016, along this reach. The AUID did have an abundant population of EPT taxa (41.22%), which tend to disappear in streams affected by poor DO conditions. The fish community in this reach had few sensitive fish taxa (10.1%) while also have many serial spawning taxa (30.73%) and tolerant species (51.35%). Additionally, the DO TIVs for this reach scored among the best within the Missouri River basin.

Despite a couple poorly scoring DO related biological metrics, the chemical data along with many biological metrics and the TIVs indicate that low DO is not a stressor to the impaired fish and macroinvertebrate communities in this portion of the Rock River at this time.

Rock River (10170204-509)
From 2004-2013 a total of 124 DO readings were taken from this AUID of the Rock River. These values ranged from 5.24-15.84 mg/L with no values below the 5 mg/L daily minimum. The wide range of values may indicate potential problems with DO flux.

The HSPF model calculated hourly DO values for this reach of the Rock River from 1996-2009. These values ranged from 1.21-14.73 mg/L with an average value of 10.19 mg/L. Of these calculations, only 1.53% was below the 5 mg/L minimum standard for DO.

The macroinvertebrate community in this portion of the Rock River had many tolerant taxa (55.14%), but did have high amount of EPT taxa (37.95%) and an improved overall average taxa count (23.75) at its biological monitoring sites 04MS019 and 11MS148. The fish assemblage had low numbers of sensitive species (5.55%) and late maturing taxa (18.96%), while also having a highly tolerant population (61.88% taxa) and many serial spawning species (33.3%). The biological sites also did have a very high DO TIV scores that ranked among the best in Missouri River basin within Minnesota.

Based on the observed and calculated DO values along with the majority of the related biological metrics, low DO is not a stressor to the impaired fish and macroinvertebrate communities at this time.

Rock River (10170204-508)
From 2007-2013 a total of 63 DO measurements were taken from this section of the Rock River. These values ranged from 5.84-13.34 mg/L with no values below the 5 mg/L daily minimum.

The HSPF model calculated hourly DO values for this reach of the Rock River from 1996-2009. These values ranged from 2.46-15.05 mg/L with an average value of 10.53 mg/L. Of these calculations, only 0.3% was below the 5 mg/L minimum standard for DO.

Biologically, the macroinvertebrate community in this AUID of the Rock River also had a high population of EPT taxa (44%) and had relatively few tolerant taxa (36%), while also having seven DO intolerant taxa. However, the overall taxa count for this reach was a bit low (18). The fish assemblage in this reach had few sensitive taxa (4.55%) and late maturing fish (18.18%) that are commonly more abundant in streams without DO problems. A high presence of tolerant taxa (59.09%) and serial spawning species (31.82%) were also found in this stream section. Like the other streams in the Lower Rock River, this AUID did have a high DO TIV score at site 11MS003.

Based on the observed and calculated DO values along with the majority of the related biological metrics, low DO is not a stressor to the impaired fish and macroinvertebrate communities at this time.

Candidate cause: High phosphorus

The proposed draft standard for phosphorus for streams in the Missouri River basin is currently 0.15 mg/L. Although phosphorus is an essential nutrient for all aquatic life, elevated levels can lead to an imbalance which impacts stream ecology. In the Lower Rock River, phosphorus levels have exceeded this proposed standard multiple times.

Rock River (10170204-501)
From 2000-2013 at total of 154 phosphorus samples were taken from this section of the Rock River. These values ranged from 0.013-2.37 mg/L with 69 (44.81%) samples at or above the 0.15 mg/L proposed draft standard for phosphorus (Figure 87).

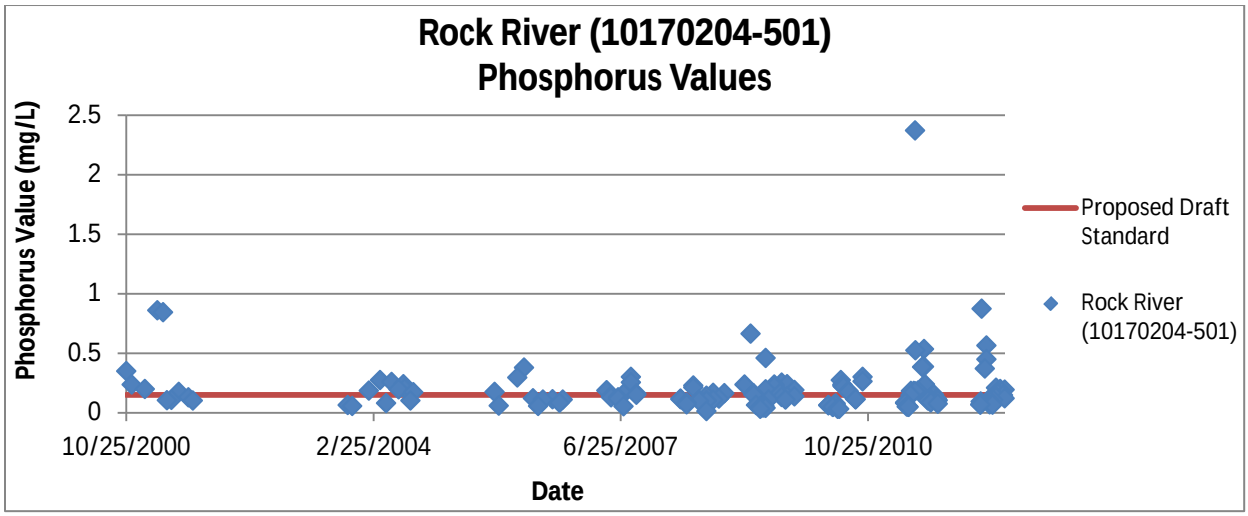

Figure 87: Phosphorus sample values from 2000-2013 along Rock River (10170204-501)

The HSPF model calculated daily phosphorus values for this reach of the Rock River from 1996-2009. These values ranged from 0.06-0.58 mg/L with an average value of 0.18 mg/L. Of these calculations, 56.65% were above the proposed standard for phosphorus.

Biologically, the macroinvertebrate community in this portion of the Rock River showed higher numbers of EPT taxa (41.22%), Tanytarsini species (10.12%), and intolerant taxa (16.57%) while also having low amounts of crustacean/mollusca species (1.62%) and scraper taxa (11.4%). This stream reach did however have an increased amount of tolerant taxa (50.39%). The fish assemblage had many tolerant species (51.35%), while also having few sensitive fish taxa (10.1%) and darter individuals (1.7%).

Despite the high observed and modeled results, the macroinvertebrate community does not signal a stressor from high phosphorus values. The fish assemblage has some low scoring metrics, but it could be from other stressors as well. At this time, phosphorus is not a stressor to the biological communities in this portion of the Rock River at this time.

Rock River (10170204-509)
From 2004-2013, a total of 164 phosphorus samples were taken from this section of the Rock River. Phosphorus values ranged from 0.01-1.12 mg/L with 85 (51.8%) of the samples at or above the proposed draft standard (Figure 88).

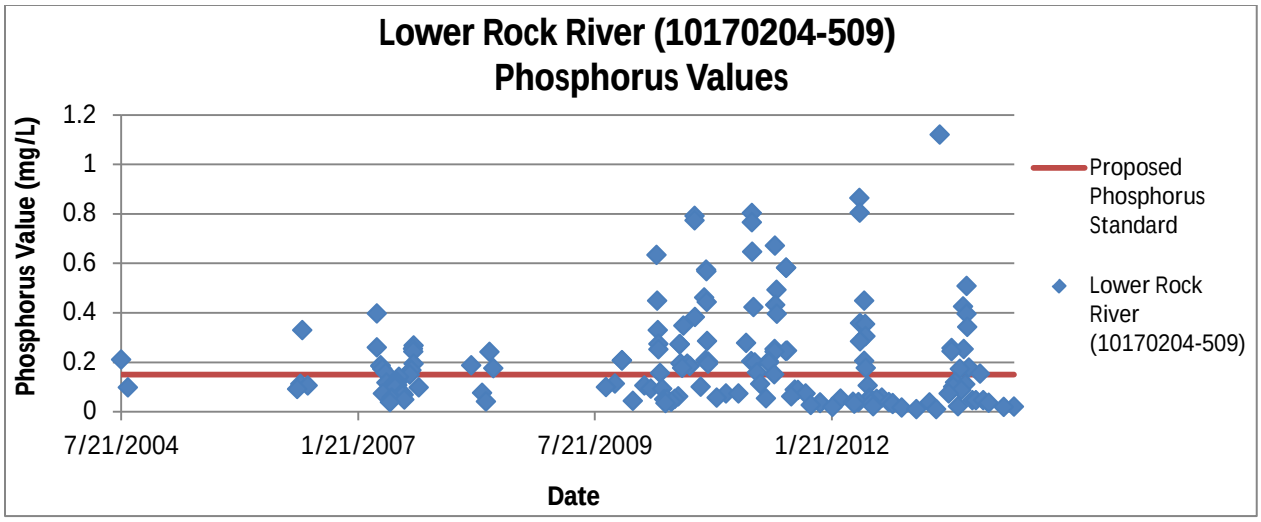

Figure 88: Phosphorus sample values from 2004-2013 along Rock River (10170204-509)

Biologically, the macroinvertebrate community in this AUID had good amounts of EPT taxa (37.95%), intolerant species (12.59%), while also having low amounts of crustacean/Mollusca taxa (10.86%). However, this stream did have low amounts of Tanytarsini species (6.29%), and high amounts of tolerant (55.14%) and scraper species (14.53%). The fish assemblage in this reach was very tolerant (61.88% species) and contained few sensitive taxa (5.55%).

The phosphorus values in this stream were above the proposed draft standard numerous times from 2004-2013. Many of the phosphorus related biological metrics agree with these chemical results. This information paired with the wide ranging DO values this stream reach experiences may attribute to the problems with that parameter as well. The fish and macroinvertebrate communities in this reach of the Rock River are being stressed by the elevated levels of phosphorus.

Rock River (10170204-508)

From 2007-2013 a total of 54 phosphorus samples were taken from this AUID along the Rock River. These values ranged from 0.026-0.512 mg/L with 18 of the samples having values at or greater than the 0.15 proposed phosphorus standard (Figure 89).

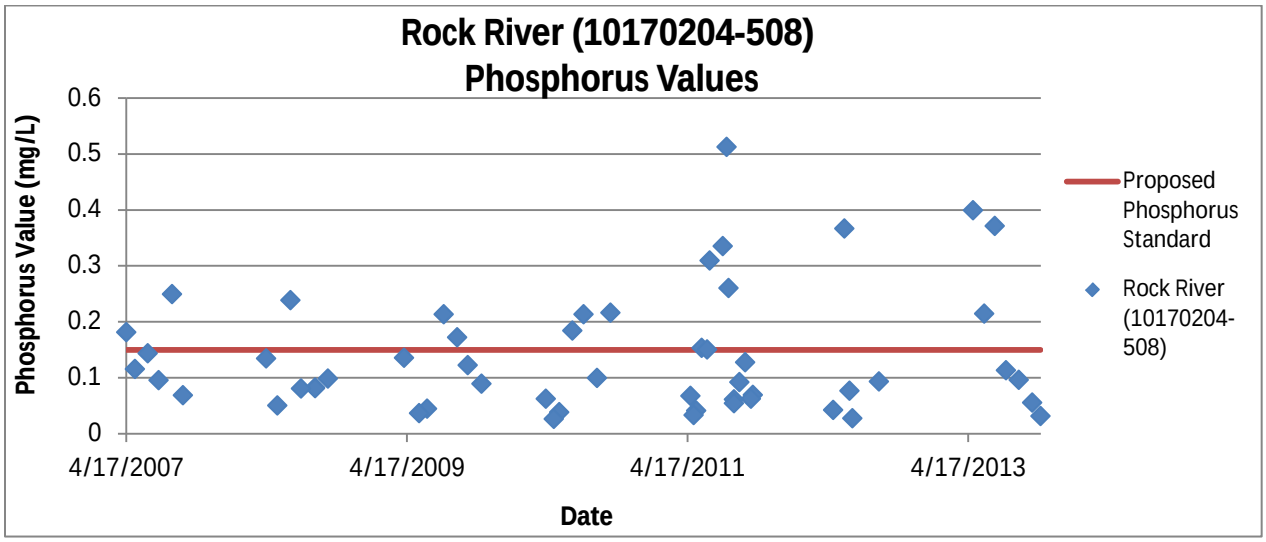

Figure 89: Phosphorus sampled values from 2007-2013 along Rock River (10170204-508)

The HSPF model calculated daily phosphorus values for this reach of the Rock River from 1996-2009. These values ranged from 0.05-0.54 mg/L with an average value of 0.15 mg/L. Of these calculations, 37.02% were above the proposed standard for phosphorus.

Biologically, the macroinvertebrate community at biological site 11MS003 on this portion of the Rock River had higher numbers of EPT (44%), Tanytarsini (8%), and intolerant (20%) taxa, while also having a lower amount of crustacean/mollusca (4%) and tolerant (36%) species. The fish population in this reach had many tolerant fish species (59.09%), few sensitive fish taxa (4.55%), and few darter individuals (1.26%).

Based on the high observed and calculated exceedance rates, along with the majority of the related biological metrics, high phosphorus is indeed stressing the impaired biological communities in this portion of the Rock River.

Candidate cause: High nitrates

Currently, the state of Minnesota does not have a nitrate standard in place for streams not used as a drinking water source. However, the overabundance of nitrates can stress a biological community. Nitrates in the Lower Rock River Watershed did at times reach levels that could potentially be stressing the biological assemblages.

Rock River (10170204-501)
From 2000-2012 a total of 158 nitrate samples were taken from this portion of the Rock River. Nitrate values ranged from 0.34-10 mg/L (Figure 90).

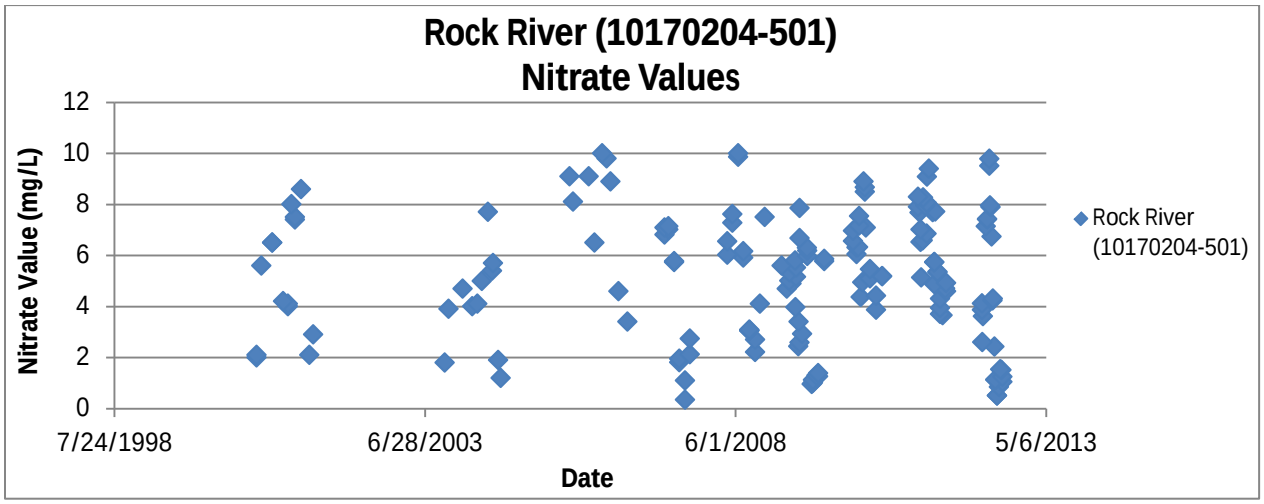

Figure 90: Nitrate sample values from 2000-2012 along Rock River (10170204-501)

Biologically, the macroinvertebrate assemblage in this most downstream section of the Rock River in Minnesota had a low average of overall taxa (16), and averaged few Trichoptera taxa (9.79%), especially at 11MS001 (3.45%). Additionally, a quantile regression analysis of Class 2 sites like stations 11MS001 and 04MS016 and the percentage of nitrate tolerant individuals present shows that streams with greater than 78.71% of the population consisting of these macroinvertebrate will be below the impairment threshold 90% of the time. The two sites averaged 81.83% of nitrate tolerant individuals. The fish population in this stream reach had a high amount of taxa (24.5), but also had decreased sensitive fish species (10.1%).

The lack of Trichoptera taxa and sensitive fish taxa, the high percentage of nitrate tolerant individual macroinvertebrates along with many elevated levels of nitrates makes this parameter a stressor to the impaired biological communities in this section of the Rock River.

Rock River (10170204-509)
From 2004-2013 a total of 164 nitrate samples were taken from this portion of the Rock River. Nitrate values ranged from 0.05-12 mg/L with an average value of 5.13 mg/L (Figure 91).

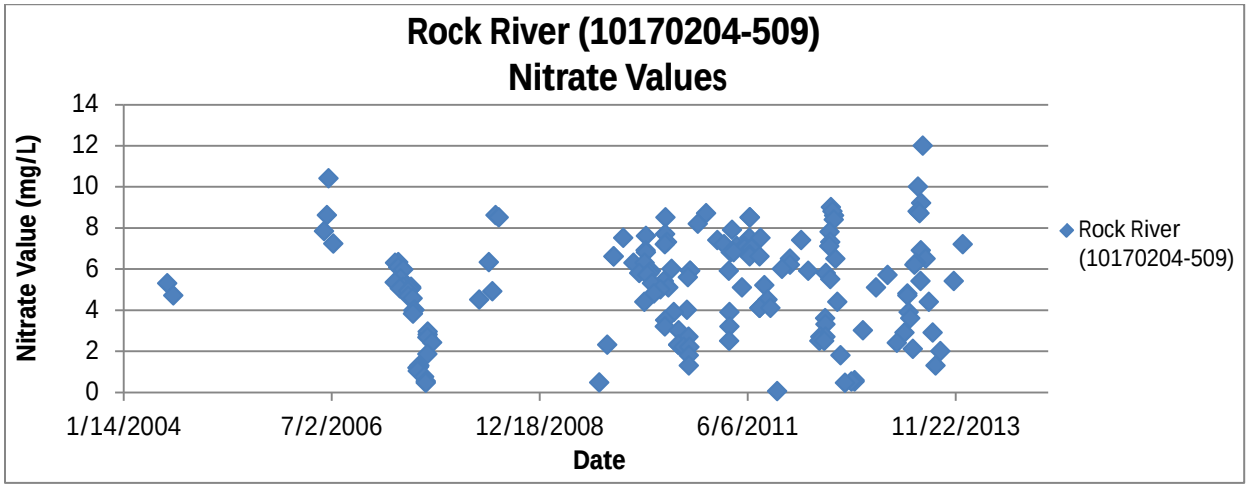

Figure 91: Nitrate sample values from 2004-2013 along Rock River (10170204-509)

Biologically, the macroinvertebrate community had an average amount of overall taxa (23.75) when compared to all other Minnesota streams, while also having a low amount of nitrate sensitive Trichoptera species (9.79%). Additionally, site 04MS019 averaged 78.13% of nitrate tolerant individuals and a quantile regression analysis showed that this site has a 75% chance of being below the Class 5 IBI threshold. Site 11MS148 had a greater than 90% chance of being impaired for a Class 7 macroinvertebrate stream as it had many nitrate tolerant individual macroinvertebrates (87.96%).The fish community had a higher amount of overall taxa (19), but did have few sensitive fish species (5.55%), which can indicate potential problems due to elevated nitrate levels.

This AUID of the Rock River had few Trichoptera species and was overwhelmed by many nitrate tolerant macroinvertebrates that indicate likely impairment. The fish community did lack many sensitive taxa and the frequent nitrate samples indicated many elevated nitrate levels. Therefore, nitrate is a stressor to the impaired fish and macroinvertebrate communities along this section of the Rock River.

Rock River (10170204-508)
From 2007-2013, a total of 55 nitrates samples were taken along this portion of the Rock River. Sample values ranged from 0.85-8.22 mg/L.

The HSPF model calculated daily nitrate values for this reach of the Rock River from 1996-2009. These values ranged from 1.68-14.47 mg/L with an average value of 5.3 mg/L.

Biologically, the macroinvertebrate community consisted of few overall taxa (18) and Trichoptera species (12%) when compared to other streams throughout the state. The macroinvertebrate population at site 11MS003 had 88.64% nitrate tolerant individuals and according to quantile regression analysis, this site would have a greater than 90% probability of being below the Class 5 IBI threshold. The fish assemblage at site 11MS003 had very few sensitive species (4.55%) while having 22 fish species.

Based on the elevated observed and calculated nitrate values, along with the strong macroinvertebrate evidence, the elevated presence of nitrates are indeed stressing the impaired biological communities in this reach of the Rock River at this time.

Candidate cause: High turbidity/TSS

The water quality standard for turbidity is 25 NTU, 65 mg/L for TSS, and 20 cm for transparency tube for these portions of the lower Rock River. Excess sediment is a commonly recognized stressor in many biologically impaired streams because it can reduce habitat, cause direct physical harm, as well as reduce visibility and increase oxygen demand.

All three of the reaches along this lower section of the Rock River were determined to be impaired for aquatic life due to turbidity in addition to their biological assemblages.

Rock River (10170204-501)
From 2000-2012 a total of 126 TSS samples were taken from this AUID with values ranging from 4.8-840 mg/L. Of these samples, 32 were above the proposed TSS standard of 65 mg/L. Additionally, on this reach there was an exceedance rate of 61% for turbidity measurements and 49% for Secchi/transparency tube readings.

Biologically, the macroinvertebrate community had many chironomid species (40.38%) which is common in streams experiencing turbidity/TSS issues. This reach also had a low overall taxa count (16) and had few scraper taxa (11.4%). There were also an above average Oligochaeta individuals (5.11%) present. These types of worms tend to live in the deposited fine sediment that this section of the Rock River possesses. The fish community had many tolerant species (51.35%) and a low amount of herbivorous fish taxa (8.25%).

The current turbidity impairment on this reach is backed up by many of the turbidity/TSS related biological metrics. The elevated levels of turbidity/TSS and overall poor transparency this stream is experiencing, makes turbidity/TSS a stressor to the impaired fish and macroinvertebrate communities in this AUID of the Rock River.

Rock River (10170204-509)
From 2004-2013 a total of 151 TSS samples were taken from this portion of the Rock River. TSS values ranged from 2-1200 mg/L with 67 (44.37%) of the values at or above the 65 mg/L proposed standard for TSS. Additionally, from 2007-2013 a total of 204 turbidity samples were taken from this reach with values ranging from 0-940 NTU. Of these samples, 113 (55.39%) were over the 25 NTU turbidity standard.

Biologically, the macroinvertebrate assemblage had lower numbers of turbidity/TSS tolerant chironomid taxa (26.54%), but did have low numbers of Trichoptera taxa (8.83%), collector-filterer species (11.99%), while also having many tolerant species (55.14%). The fish community in this reach also had increased tolerant taxa (61.88%) and decreased herbivorous species (9.78%).

This AUID is currently impaired for turbidity. Many of the turbidity/TSS related biological metrics are in agreement with this listing; therefore, this parameter is a stressor to the impaired fish and macroinvertebrate communities in this AUID of the Rock River.

Rock River (10170204-508)
From 2007-2013 a total of 54 TSS samples were taken along this section of the Rock River. These values ranged from 0.5-280 mg/L with 13 samples above the 65 mg/L proposed draft standard for TSS. Additionally, from 2007-2013 a total of 63 transparency/Secchi tube readings were taken from the reach. These measurements ranged from 5-53 cm with 28 values below the 20 cm standard.

The macroinvertebrate community in this portion of the Rock River also had decreased amounts of chironomids (28%) and tolerant taxa (36%), but did have a lower overall taxa count (18), few collector-filterer (12%) and scraper (12%) species. The fish assemblage in this reach also had increased tolerant taxa (59.09%) and decreased herbivorous species (9.09%).

This reach is impaired for turbidity like the reaches immediately downstream of this AUID. Similar poor scores in many of the turbidity/TSS related biological metrics were also observed in this stream reach. Turbidity/TSS is indeed a stressor to the impaired fish and macroinvertebrate communities in this section of the Rock River.

Candidate cause: Lack of habitat

Qualitative habitat assessments were performed on the three biologically impaired reaches along the Lower Rock River during the fish sampling visits at each site. Results of these assessments can be seen in Figure 92.

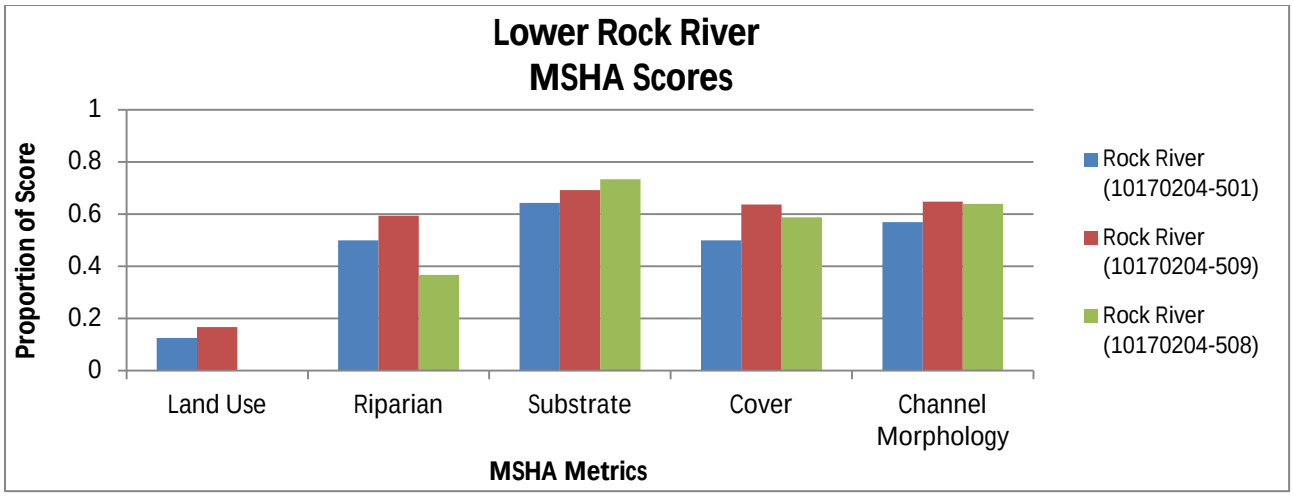

Figure 92: Lower Rock River Watershed MSHA metric scores

Rock River (10170204-501)

Qualitative habitat assessments were performed at sites 11MS001 and 04MS016 during their fish sampling visits in 2011 and 2004. The average MSHA score of these two sites is 54.5, which is considered to be fair. The most downstream site, 11MS001, had much better habitat conditions than at 04MS016. Limiting the habitat at these sites was the poor surrounding land use, bank erosion (Figure 93), low to moderate channel stability, and fair channel development.

Figure 93: Eroded bank at 11MS001 along Rock River (10170204-501)

Biologically, the macroinvertebrate community in this downstream section of the Rock River did have a high number of tolerant taxa (50.39%), but also had many clinger species (39.94%). Clinger species tend to decrease in degraded habitat conditions. The fish assemblage had many tolerant taxa (51.35%) and few simple lithophilic spawning species (16.5%). These scores are common for streams with a lack of habitat; however, this reach did have good numbers of benthic insectivore species (27.02%), riffle-dwelling taxa (16.5%), and darter/sculpin/round- bodied sucker species (14.65%). These types of fish decrease in streams limited by their habitat conditions.

While improvement can be made, the fair MSHA scores and the many habitat related biological metrics scoring well, the lack of habitat is not more than a secondary or minor stressor to the impaired fish and macroinvertebrate communities in the Rock River at this time.

Rock River (10170204-509)
This portion of the Rock River had four qualitative habitat assessments take place. Three of these were done at biological monitoring station 04MS019. This site had an average MSHA score of 63.63, which is considered to be fair. The remaining site, 11MS148, had an MSHA score of 61.6 which is also fair. Limiting the MSHA scores at these sites was the poor surrounding land use, heavy bank erosion, sparse fish cover, sandy substrates, and moderate channel stability.

Biologically, the macroinvertebrate community in this portion of the Rock River had many tolerant taxa (55.14%), while also having an average amount of clinger taxa (28.39%) when compared to all other Minnesota streams. The fish assemblage in this reach had many tolerant species (61.88%) and also had fewer simple lithophilic spawning taxa (17.41%) and darter/sculpin/round-bodied sucker species (10.73%). This reach did show higher numbers of riffle-dwelling taxa (18.21%) and benthic insectivore species (22.1%).

The average MSHA score fell just below the good range in this AUID of the lower Rock River. The results of the habitat related biological metrics are mixed indicating that habitat could be improved, but is not a major stressor to the impaired fish and macroinvertebrate communities in this reach at this time.

Rock River (10170204-508)
Site 11MS003 had a qualitative habitat assessment performed during the fish sampling event in 2012. This site had an MSHA score of 58.3 which is considered to be fair. The habitat was limited by the poor surrounding land use, heavy to severe bank erosion (Figure 94), a sandy substrate, sparse fish cover, and low channel stability.

Figure 94: Eroded bank at 11MS003 along Rock River (10170204-508)

Biologically, the macroinvertebrate community in this section of the Rock River had a decreased amount of clinger taxa (24%), which tend to be more prevalent in good habitat conditions. Site 11MS003 also had decreased tolerant taxa (36%), which tend to be much more abundant in degraded habitat conditions. The fish assemblage in this reach had increased levels of riffle dwelling (18.18%) and benthic insectivore (27.27%) taxa, while having fewer simple lithophilic spawning (22.73%) species. This reach also had an average amount of darter/sculpin/round-bodied sucker species (13.64%) when compared to all other Minnesota streams and had an increased amount of tolerant fish taxa (59.09%).

The average MSHA score fell just below the good range in this AUID of the lower Rock River. The results of the habitat related biological metrics are mixed indicating that habitat could be improved, but is not a major stressor to the impaired fish and macroinvertebrate communities in this reach at this time.

Conclusion

The three biologically impaired reaches in the Lower Rock River Watershed are being negatively impacted by multiple stressors (Table 41).

High phosphorus was determined to be a stressor to the fish and macroinvertebrate communities in two of the three impaired reaches. While Rock River (10170204-501) had a high number of phosphorus exceedances, however, the biological response was not as strong as the two impaired reaches immediately upstream. Currently, DO was not found to be a stressor. Prolonged periods of high phosphorus may eventually disrupt the DO conditions along these reaches. The excess phosphorus in these reaches is a likely result from the highly pastured riparian areas and cropland throughout the watershed where concentrations of phosphorus tend to be high. Runoff following rain events is a likely pathway for these phosphorus contributions to easily enter the stream system.

Figure 95: Poor silt fence installation at 11MS003 along the Rock River

High nitrates were also found to be a stressor to the biological assemblages in all three of the impaired reaches. Nitrate levels in excess of 12 mg/L were observed in Rock River (10170204-509), with many elevated levels also measured in the other reaches. Few nitrate sensitive Trichoptera taxa were present, but high percentages of nitrate tolerant individual macroinvertebrates were, which often signals impairment. The high levels of nitrates are likely a result from fertilizer applications and have entered the stream as runoff.

All three reaches of the Rock River within this watershed are impaired for turbidity. High turbidity/TSS was also determined to be a stressor to the biological assemblages. High intensity grazing with minimal riparian buffers in the watershed has led to unstable and erosive banks. Numerous watershed and basin-wide activities/improvements (Figure 95) are needed to reduce the issue of elevated turbidity/TSS levels and poor transparency in the Rock River to eliminate this parameter as a stressor to the biological communities.

The lack of habitat was found to be a minor or secondary stressor in each of the reaches. While other stressors are having a greater impact on the fish and macroinvertebrate assemblages, the lack of habitat in these reaches is still limiting the potential of these biotic communities.

These reaches along the lower portion of the Rock River have stressors to the biological communities. Addressing these stressors is needed to restore the biological communities to a healthy condition. Until this is done, the fish and macroinvertebrate communities will remain impaired

Table 41: Stressors to the biologically impaired reaches along the Lower Rock River

		Stressors				
Stream Name	**AUID #**	**Low Dissolved Oxygen**	**High Phosphorus**	**High Nitrates**	**High Turbidity /TSS**	**Lack of Habitat**
Lower Rock River Watershed						
Rock River	10170204-501	-	-	•	•	-
Rock River	10170204-509	-	•	•	•	-
Rock River	10170204-508	-	•	•	•	-

(• = stressor, - = not a stressor, and blank = inconclusive/not enough evidence)

Mud Creek

Overview

Mud Creek is located in the southwest corner of the Rock River Watershed. The Mud Creek (Figure 96), (AUID: 10170204-525), is 16.33 miles long extending from the headwaters of Mud Creek down to the Minnesota/Iowa border. This reach was sampled for fish and macroinvertebrates at its biological monitoring sites 11MS021 and 11MS106 in 2011 and found to be impaired for both fish and macroinvertebrate assemblages during the watershed assessment in 2013. Land use in the Mud Creek 12-digit HUC watershed is dominated by cropland (85.83%), followed by rangeland (6.6%) and developed land (6.31%).

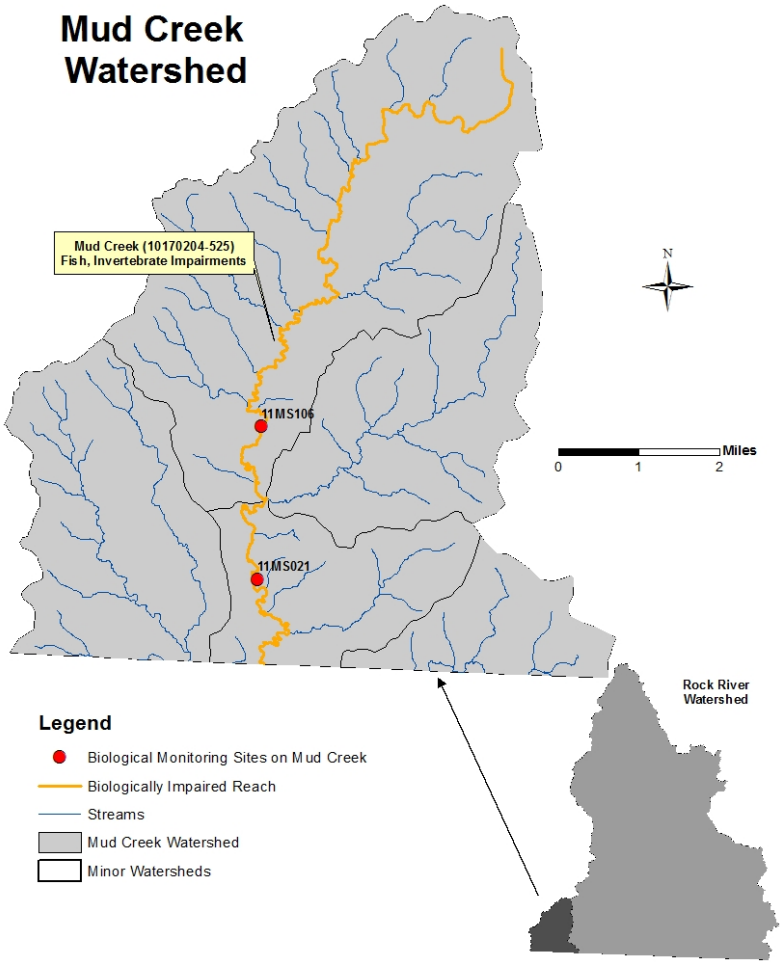

Figure 96: Mud Creek Watershed with biologically impaired reach highlighted

Biology in Mud Creek

Fish

There were two fish sampling events at two different biological monitoring stations along this impaired reach of Mud Creek. Site 11MS021 is located upstream of 21st Street, 1 mile southeast of Hills and was sampled on August 4, 2011. Moving upstream, site 11MS106 is located downstream of 41st Street, 1 mile northeast of Hills. This site was sampled for fish on August 9, 2011.

Both fish sampling sites along Mud Creek are classified as Southern Headwaters (Class 3) streams. To reach the fish IBI threshold in this classification, the site would need a score of 51. Fish IBI scores at sites 11MS021 and 11MS106 were 48 and 34 respectively. To reach the IBI threshold for this class, each metric would need an average score of 8.5. As Figure 97 shows, the fish assemblages at these sights are quite similar, with only slight improvements in most metrics at 11MS021. Both sites had low numbers of short lived (SLvdPct) and serial spawning (SSpnPct) fish taxa resulting in higher metric scores.

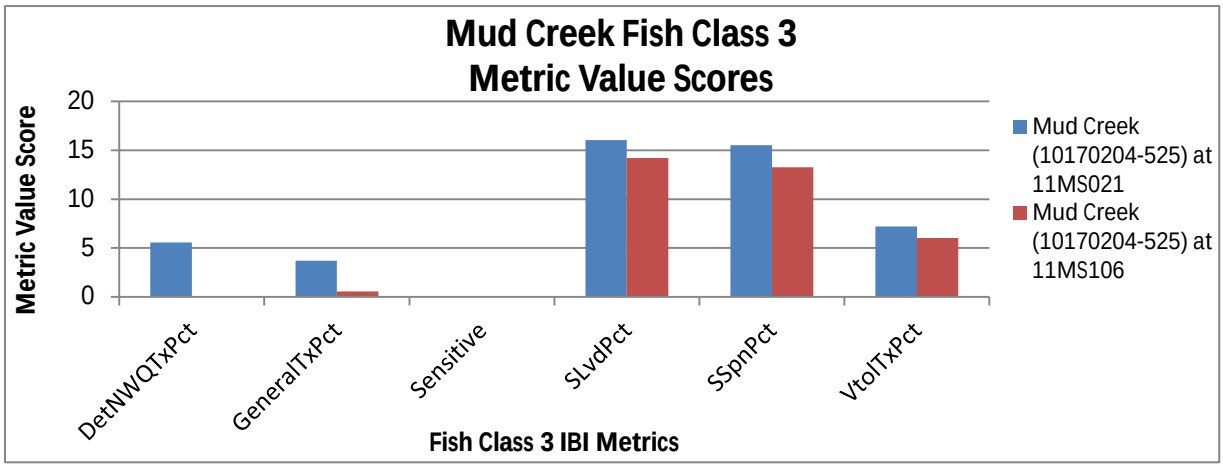

Figure 97: Fish Class 3 IBI metric value scores at both sites along Mud Creek (10170204-525)

Macroinvertebrates

There were two macroinvertebrate sampling events at the two biological stations, 11MS021 and 11MS106, as well. Both sites were sampled on August 3, 2011.

Both macroinvertebrate sampling sites along Mud Creek are classified as Prairie Streams GP (Class 7) streams. To reach the macroinvertebrate IBI threshold in this classification, the site would need a score of 38.3. Macroinvertebrate IBI scores at sites 11MS021 and 11MS106 were 32.6 and 36.2 respectively. To reach the threshold, each metric would need an average score of 3.83. As Figure 98 shows, the sites met the average average metric score needed to reach the threshold for many metrics. These sites were mainly brought down in score by having poor taxa richness of macroinvertebrates with tolerance values less than or equal to two (Intolerant2Ch), small amounts of collector-filterer species, and by having higher HBI scores, which is a measure of pollution based on tolerance values assigned to each individual taxon.

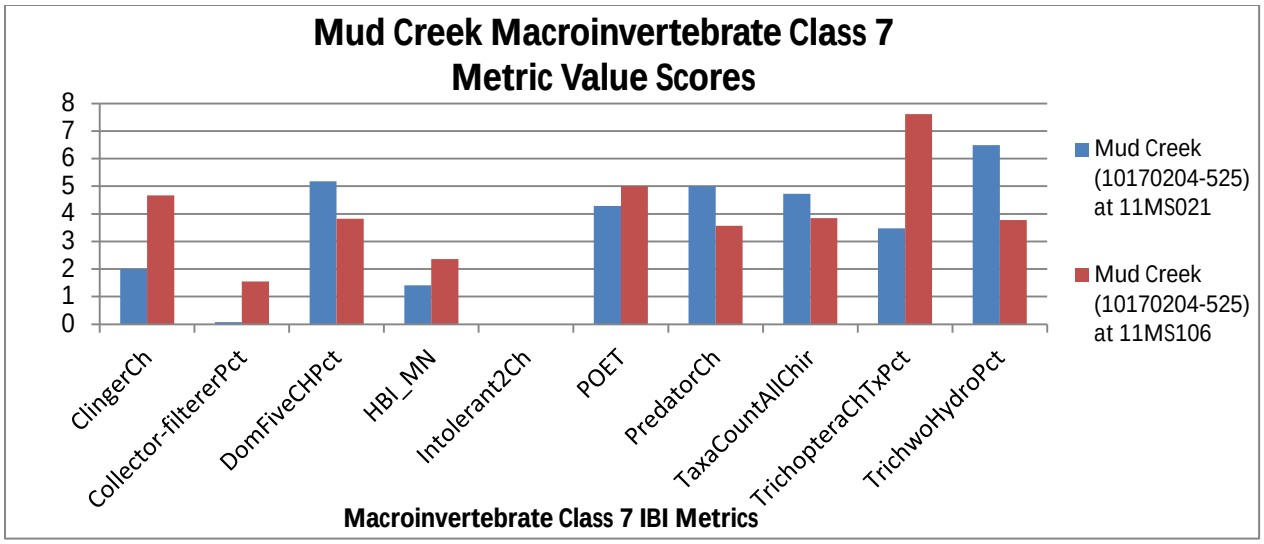

Figure 98: Macroinvertebrate Class 7 IBI metric value scores at both sites along Mud Creek (10170204-525)

Candidate cause: Low dissolved oxygen

The daily minimum standard for DO in Minnesota Class 2B streams is 5 mg/L. All streams in the Mud Creek Watershed have this 2B classification. No streams in this grouping are currently listed as impaired for DO.

There were a total of 75 DO readings taken from Mud Creek from 2007-2013 (Figure 99). Dissolved oxygen values ranged from 1.59-15.38 mg/L with seven (9.33%) of the readings falling below the daily minimum standard of 5 mg/L for DO. The very low values and the high value of 15.38 mg/L could potentially indicate a problem with daily flux. Continuous monitoring with a sonde is needed to confirm this condition.

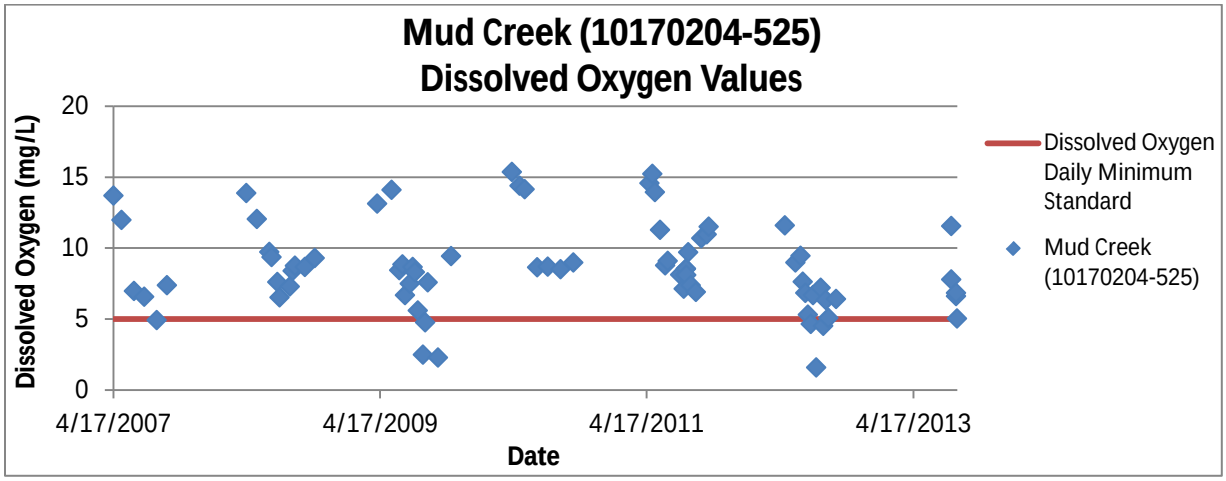

Figure 99: Dissolved oxygen values from 2007-2013 along Mud Creek (10170204-525)

The HSPF model calculated hourly DO values for Mud Creek from 1996-2009. These values ranged from 0-13.81 mg/L with an average value of 6.36 mg/L. Of these calculations, 28.74% fell below the DO standard.

Biologically, the macroinvertebrate populations in Mud Creek were less diverse than the average stream in Minnesota with an average of 21.5 species sampled at sites 11MS106 and 11MS021. Above average amounts of EPT taxa (28.62%) were present which can indicate healthy levels of DO. There were also an average amount of tolerant macroinvertebrate taxa sampled (59.69%).

Fish populations in Mud Creek completely lacked sensitive species, had low diversity (8.5 species average), high amounts of serial spawning taxa (29.86%), high amounts of tolerant fish taxa (77.09%), and a slightly below average amount of late maturing fish species (11.81%) when compared to all other Minnesota streams. All of this metrics can signify a problem with low DO.

Based on the frequent observed and calculated standard exceedances, as well as the majority of the related biological metrics, low DO is stressing the impaired fish and macroinvertebrate communities in Mud Creek.

Candidate cause: High phosphorus

The proposed draft standard for phosphorus for streams in the Missouri River basin is currently 0.15 mg/L. Although phosphorus is an essential nutrient for all aquatic life, elevated levels can lead to an imbalance which impacts stream ecology. In the Mud Creek Watershed phosphorus levels have exceeded this proposed standard multiple times.

From 2007-2011 there were 48 phosphorus samples taken from Mud Creek (Figure 100). Of these samples, 27 (56.3%) were at or above the proposed draft standard of 0.15 mg/L.

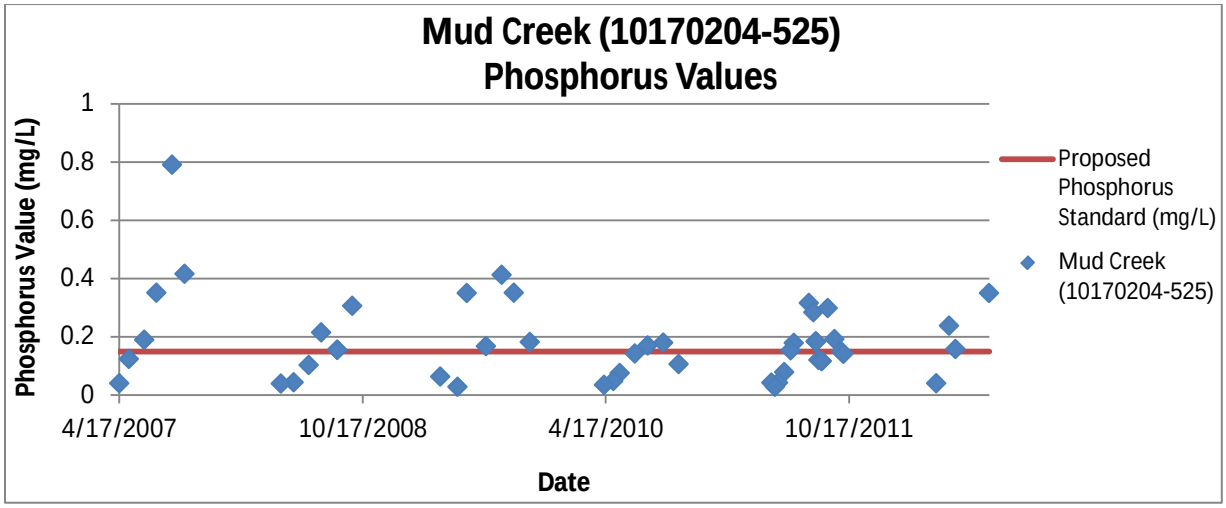

Figure 100: Phosphorus sample values from 2007-2011 along Mud Creek (10170204-525)

The HSPF model calculated daily phosphorus values for Mud Creek from 1996-2009. These values ranged from 0.06-0.93 mg/L with an average value of 0.2 mg/L. Of these calculations, the proposed phosphorus standard was exceeded 62.23% of the time.

Biologically, Mud Creek had above average amounts of EPT taxa (28.62%), Tanytarsini species (7.55%), and below average amounts of crustacean/mollusca taxa (10.41%) and scraper taxa (8.98%) when compared to all other Minnesota streams. Results like these are typically found in streams with low phosphorus levels. The fish assemblage in Mud Creek had a high amount of tolerant fish species (77.1%), zero sensitive fish taxa, and few darter individuals (0.67%). These results are common in streams negatively impacted by phosphorus levels.

While the observed and predicted phosphorus results for Mud Creek are very high, the macroinvertebrate community suggests that high phosphorus is not yet a stressor. If continued, the elevated phosphorus levels will likely have a negative impact on both the fish and macroinvertebrate assemblages. Currently, phosphorus is not a stressor to the impaired biological communities in Mud Creek.

Candidate cause: High nitrates

Currently, the State of Minnesota does not have a nitrate standard in place for streams not used as a drinking water source. However, the overabundance of nitrates can stress a biological community. Nitrates in the Mud Creek Watershed did at times reach levels that could potentially be stressing the biological assemblages.

From 2007-2011 there were 49 nitrate samples taken from three different sampling station along Mud Creek. Nitrate values ranged from 0.2-18.2 mg/L (Figure 101). Biological monitoring stations on Mud Creek, 11MS106 and 11MS021, are both classified as macroinvertebrate Class 7 (Prairie Streams GP) sites. A quantile regression of these sites shows that if a stream has a nitrate value at or greater than 11.5 mg/L, it has a 90% chance of being impaired. The Mud Creek nitrate data has 34 instances above this value.

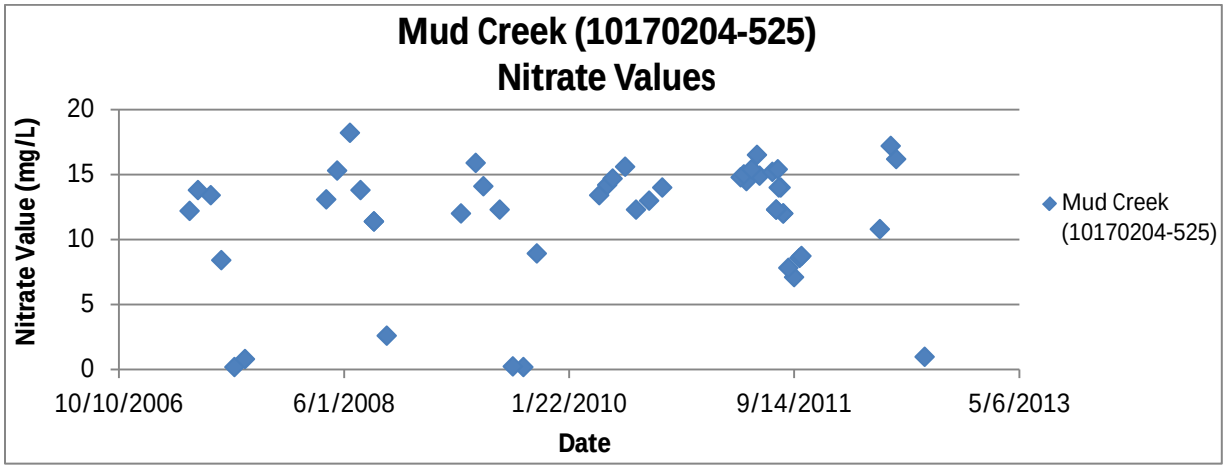

Figure 101: Nitrate sample values from 2007-2011 along Mud Creek (10170204-525)

The macroinvertebrate populations in Mud Creek had an average of 9.1% of Trichoptera taxa at the two biological monitoring stations along this reach. This is slightly below the average of Minnesota streams. These taxa tend to be more sensitive to higher nitrate levels. Species diversity was also below average, with an average of 21.5 species found at each site. Diversity typically drops at sites with elevated nitrate levels. Additionally, the sites along Mud Creek consisted of 91.27% of nitrate tolerant individuals, which according to a quantile regression analysis, this reach has a greater than 90% chance of being impaired. The fish assemblage along this reach completely lacked any sensitive fish taxa and had really low diversity with an average of 8.5 species caught per site.

The very high observed nitrate values, the strong evidence from the quantile regression analyses, and the majority of the biological metrics are in agreement that excess nitrate is stressing the biological assemblages in Mud Creek.

Candidate cause: High turbidity/TSS

The water quality standard for turbidity is 25 NTU, 65 mg/L for TSS, and 20 cm for transparency tube for these Class 2B warmwater streams in the Mud Creek Watershed. Excess sediment is a commonly recognized stressor in many biologically impaired streams because it can reduce habitat, cause direct physical harm, as well as reduce visibility and increase oxygen demand. Mud Creek (10170204-525) was determined to be impaired for aquatic life due to turbidity in addition to the biological assemblages.

From 2007-2012, there were a total of 48 TSS samples taken along Mud Creek (Figure X). Sample values ranged from 6.8-194 mg/L and 18 of the 48 samples (37.5%) were above the TSS maximum standard of 65 mg/L. Additionally, from 2007-2013, there were a total of 76 transparency/Secchi tube readings taken along Mud Creek (Figure 102). Sixty (78.95%) of these samples were above the 20 minimum standard.

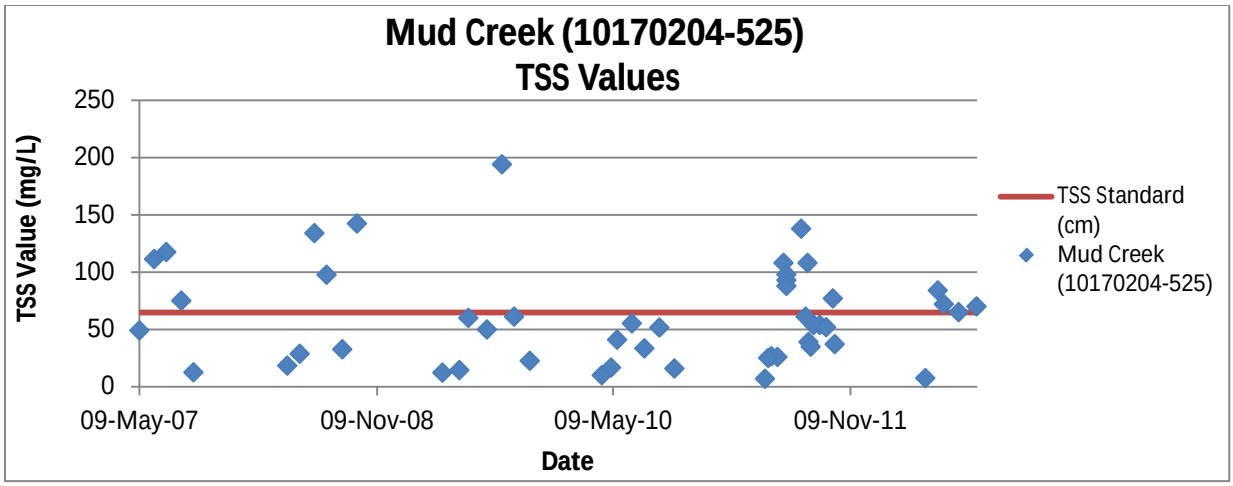

Figure 102: TSS values from 2007-2012 along Mud Creek (10170204-525)

Biologically, macroinvertebrate populations in Mud Creek showed good numbers of Ephemeroptera taxa (19.51%), which is unusual since these species tend to struggle in streams with elevated TSS values. Mud Creek also showed lower levels of Trichoptera taxa (9.11%), collector-filterer species (7.68%), scraper taxa (8.98%) and had a low diversity (average of 21.5 species). The fish community in Mud Creek did have an above average TSS TIV score when compared to all other Class 3 streams.

With the overwhelming data indicating that Mud Creek is still impaired for turbidity and the majority of biological metrics in agreement, turbidity/TSS is a stressor to the impaired fish and macroinvertebrate communities in Mud Creek.

Candidate cause: Lack of habitat

A qualitative habitat assessment was performed on Mud Creek during the fish sampling events at 11MS021 and 11MS106 (Figure 103). The MSHA score for 11MS021 was 21 and the score for 11MS106 was 39.7. Both of these scores are considered to be poor. Limiting habitat conditions at these sites was mainly due to poor surrounding land use, no riparian buffer, heavy erosion, a heavy silt substrate with limited course substrates, sparse fish cover amounts, low to moderate channel stability and poor to fair channel development.

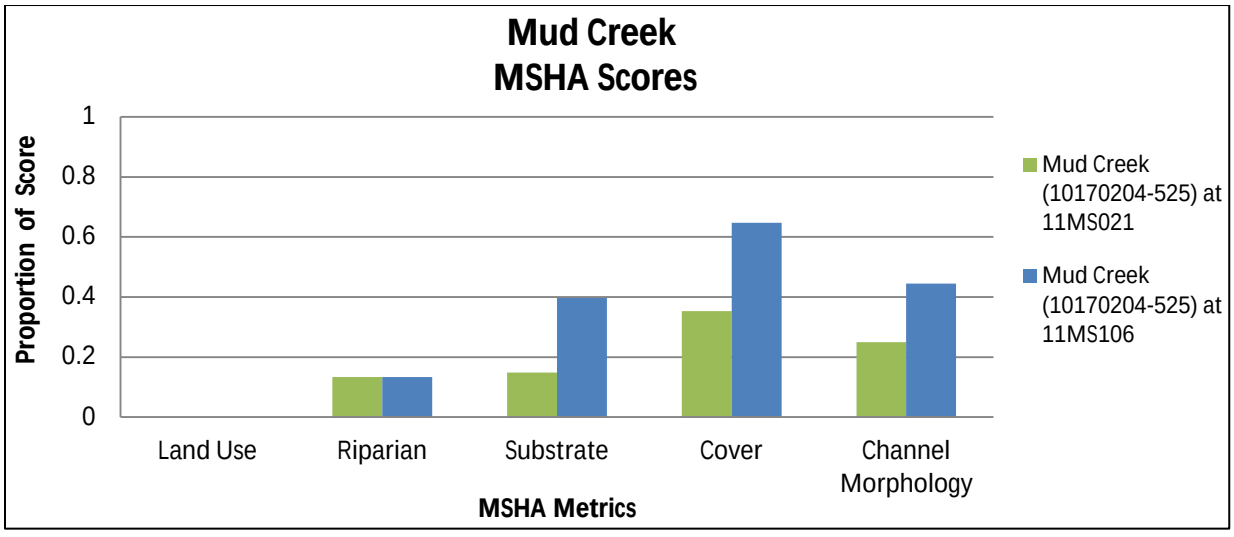

Figure 103: MSHA metric scores along Mud Creek (10170204-525)

Biologically, Mud Creek had macroinvertebrate populations with average amounts of tolerant taxa (59.69%), but also had low amounts of habitat sensitive clinger taxa (21.21%) when averaging both biological sampling sites along Mud Creek.

The fish assemblage in Mud Creek had an above average amount of riffle dwelling taxa (23.61%). These taxa are found more often in streams scoring well in the MSHA. However, the stream reach also had high amounts of tolerant taxa (77.1%), few benthic insectivore taxa (5.56%), simple lithophilic spawning taxa (17.36%), and species classified as darters/sculpins/round-bodied suckers (5.56%). Those metrics all indicate that habitat is likely stressing the fish community.

The low MSHA scores at both sites along Mud Creek, along with the majority of fish and macroinvertebrate habitat related metrics indicate that the lack of habitat is indeed stressing the impaired fish and macroinvertebrate assemblages in Mud Creek.

Conclusion

Mud Creek was determined to be impaired to be impaired for aquatic life due to its inadequate fish and macroinvertebrate communities. Stressors negatively impacting this reach were low DO, high nitrates, high turbidity/TSS and a lack of habitat (Table 42).

Low DO conditions persist in Mud Creek. These levels frequently drop below the DO standard. The HSPF model also calculated a high exceedance rate. The fish community in this reach also strongly suggested that low DO was a stressor. Continuous DO monitoring with a sonde is recommended to better understand the daily flux conditions present in this stream.

High nitrates were also found to be a stressor to the fish and macroinvertebrates in Mud Creek. Nitrate levels often exceeded 15 mg/L and had a high reading of 18.2 mg/L. Levels this high often lead to a biological impairment. Mud Creek also had a very high amount of nitrate tolerant individuals. The high levels of nitrates are likely a result from fertilizer applications and have entered the stream as runoff.

A nutrient management plan is needed within this watershed to better control the levels of nitrates entering Mud Creek.

Mud Creek is currently impaired for turbidity/TSS and this parameter was also found to be a stressor to the biotic communities. The macroinvertebrate assemblage lacked Trichoptera, collector-filterer, and scraper species that prefer streams with low turbidity/TSS levels. High intensity grazing with minimal riparian buffers in the watershed has led to unstable and erosive banks. Numerous watershed and basin-wide activities are needed to reduce the issue of elevated turbidity/TSS levels in Mud Creek.

The lack of habitat was also found to be negatively impacting the fish and macroinvertebrate assemblages in Mud Creek. Along this reach, the MSHA scores were poor and limited by the high amounts of erosion, silty substrates, a lack of buffer, poor channel stability, and limited amounts of fish cover. This reach had few benthic insectivore and simple lithophilic spawning species while having many tolerant fish and macroinvertebrate taxa. Significant habitat improvement projects and natural stream channel design practices are recommended along this reach to help improve the habitat conditions.

Overall, the Mud Creek Watershed is in relatively poor conditions. The biological assemblages will likely remain impaired until significant improvements and watershed wide changes are made.

Table 42: Stressors to the biologically impaired reaches within the Mud Creek Watershed

		Stressors				
Stream Name	**AUID #**	**Low Dissolved Oxygen**	**High Phosphorus**	**High Nitrates**	**High Turbidity/ TSS**	**Lack of Habitat**
Mud Creek Watershed						
Mud Creek	10170204-525	•	-	•	•	•

(• = stressor, - = not a stressor, and blank = inconclusive/not enough evidence)

Poplar Creek

Overview

The Poplar Creek 12-Digit HUC watershed (101702040107) has three biologically impaired streams within its boundaries (Figure 104): Poplar Creek (10170204-523), Unnamed Creek (10170204-588), and Unnamed Creek (10170204-589). The land use in this watershed consists of mostly cropland (77.35%), range land (14.46%), and developed land (6.53%).

Poplar Creek (10170204-523) is a 19.18 mile long stream reach that extends from the headwaters of Poplar Creek down to the confluence with the Rock River. This reach was sampled for fish and macroinvertebrates at its biological monitoring station, 11MS014, in 2011 and found to be impaired for aquatic life due to its fish and macroinvertebrate assemblages, but also turbidity during the watershed assessment in 2013.

Unnamed Creek (10170204-588) is a 5.04 mile AUID located from Unnamed Creek to the confluence with Poplar Creek. This reach was sampled for fish and macroinvertebrates at its biological monitoring station, 11MS093, in 2011 and found to be impaired for aquatic life due to its fish and macroinvertebrate assemblages during the watershed assessment in 2013.

Unnamed Creek (10170204-589) is a 0.58 mile long reach that extends from Unnamed Creek to the confluence with Poplar Creek. This reach was sampled for fish and macroinvertebrates at its biological monitoring station, 11MS096, in 2011 and found to be impaired for aquatic life due to its macroinvertebrate community during the watershed assessment in 2013.

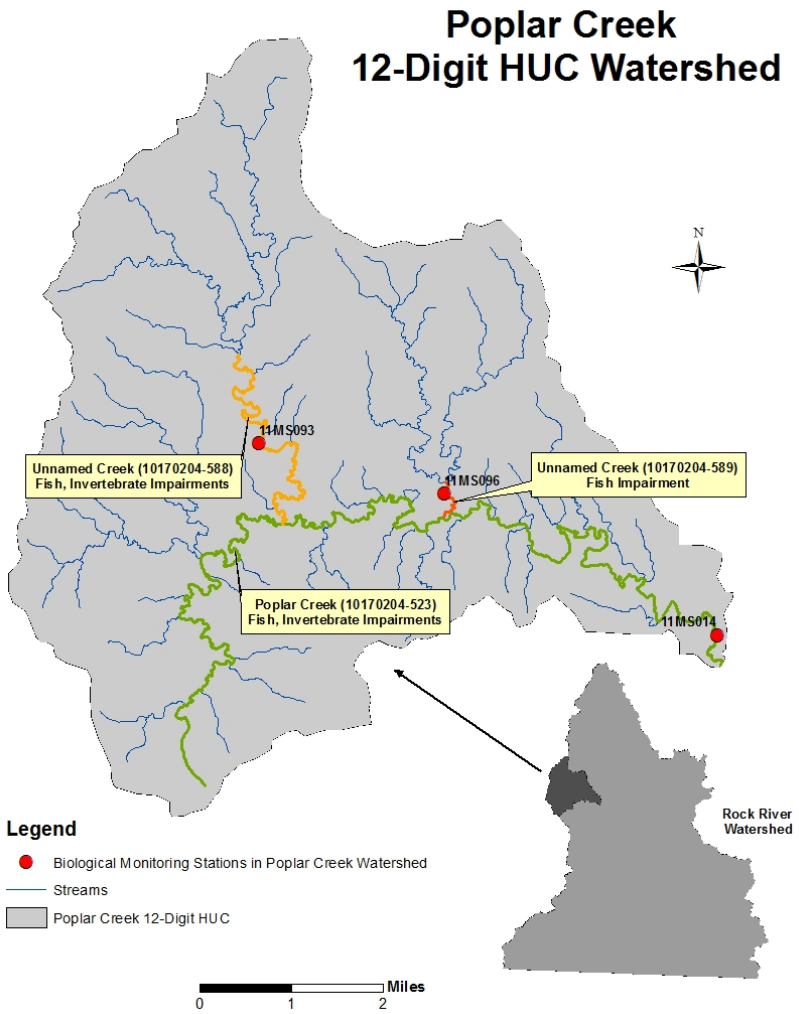

Figure 104: Poplar Creek Watershed with biologically impaired reaches highlighted

Biology in Poplar Creek

Fish

Each of the biologically impaired reaches in this watershed had one biological monitoring station. The biological monitoring site along Poplar Creek (10170204-523), 1MS014, is located downstream of CSAH 1, 2 miles south of Edgerton and was sampled for fish on August 16, 2011. Site 11MS093 along Unnamed Creek (10170204-588) is located downstream of CR 9, 1 mile southeast of Trosky and was sampled for fish on August 31, 2011. Site 11MS096 along Unnamed Creek (10170204-589) is located just off of 130th Avenue, 3 miles west of Edgerton. This site was sampled for fish on August 2, 2011.

Site 11MS014 along Poplar Creek has a fish Class 2 (Southern Streams) classification. In this class each metric would need an average score of 5.625 to reach the IBI threshold of 45 (Figure 105). The site had a fish IBI score of 44. Limiting the IBI score on Poplar Creek was the high presence of short lived individuals (SLvd), the elevated number of tolerant taxa (TolPct), and the relatively few numbers of sensitive taxa (SensitiveTxPct).

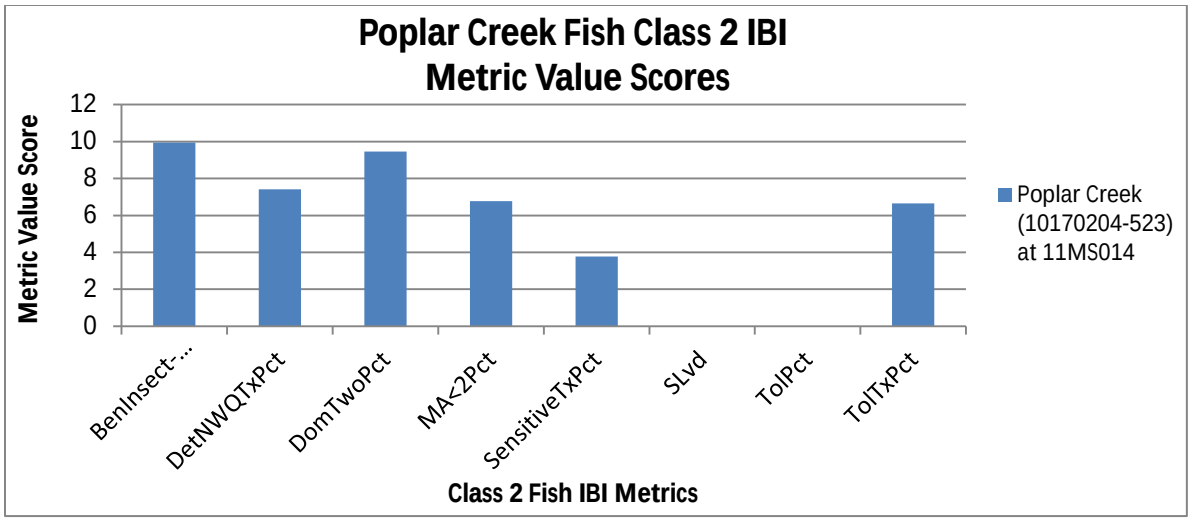

Figure 105: Fish Class 2 IBI metric value scores at site 11MS014 along Poplar Creek (10170204-523)

Sites 11MS093 and 11MS096 both belong to the Southern Headwaters (Fish Class 3) class. In this class each metric would need an average score of 8.5 to reach the IBI threshold of 51 (Figure 106). Site 11MS093 had a fish IBI score of 39, scoring well below average in all the metrics except for GeneralTxPct. This metric means that the site had a lower population of Generalist feeder taxa resulting in a high metric score. Site 11MS096 had a fish IBI score of 55. This AUID (10170204-589) is not impaired for aquatic life due to its fish assemblage at this time.

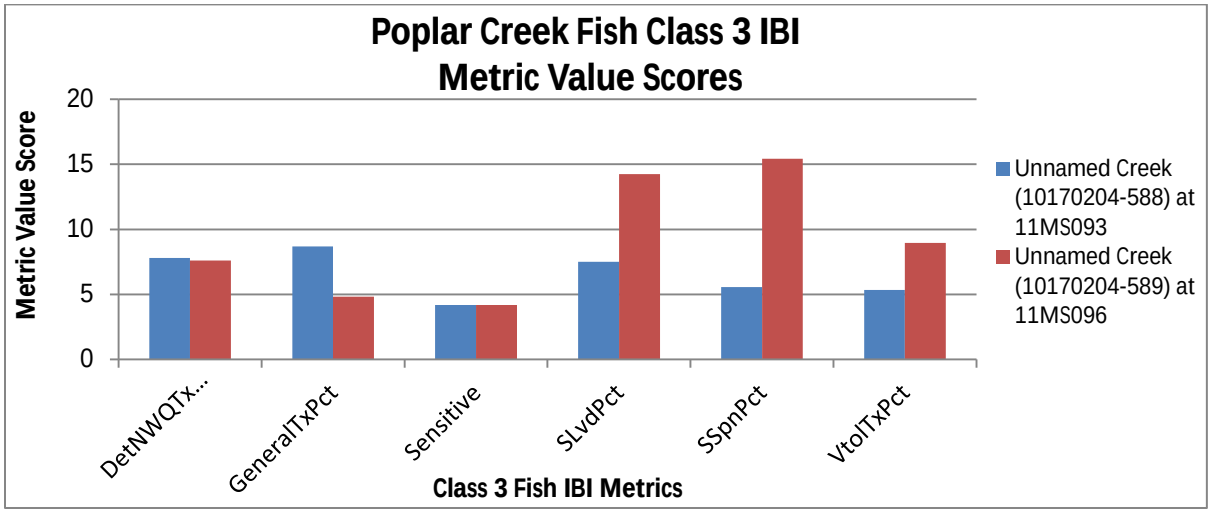

Figure 106: Fish Class 3 IBI metric value scores in the Poplar Creek Watershed

Macroinvertebrates

All three sites within the Poplar Creek 12-Digit HUC, 11MS014, 11MS093, and 11MS096, were sampled for macroinvertebrates on August 9, 2011.

Two sites, 11MS014 and 11MS096, in the Poplar Creek 12-Digit HUC had a macroinvertebrate IBI Class 5 (Southern Streams) designation. Each metric would need an average score of 3.59 to reach the threshold of 35.9 for this classification. Site 11MS014 along Poplar Creek had an IBI score of 23. This site had higher amounts of Clinger taxa (ClingerChTxPct) and a high percentage of insect taxa (InsectTxPct), but scored poorly in all other metrics comprising this IBI. Site 11MS096 on Unnamed Creek had a macroinvertebrate IBI score of 21.1. This site scored well in 2 of the metrics by having a high percentage of Odonata and Clinger species present. All other metrics scored below the needed average to reach the IBI threshold (Figure 107).

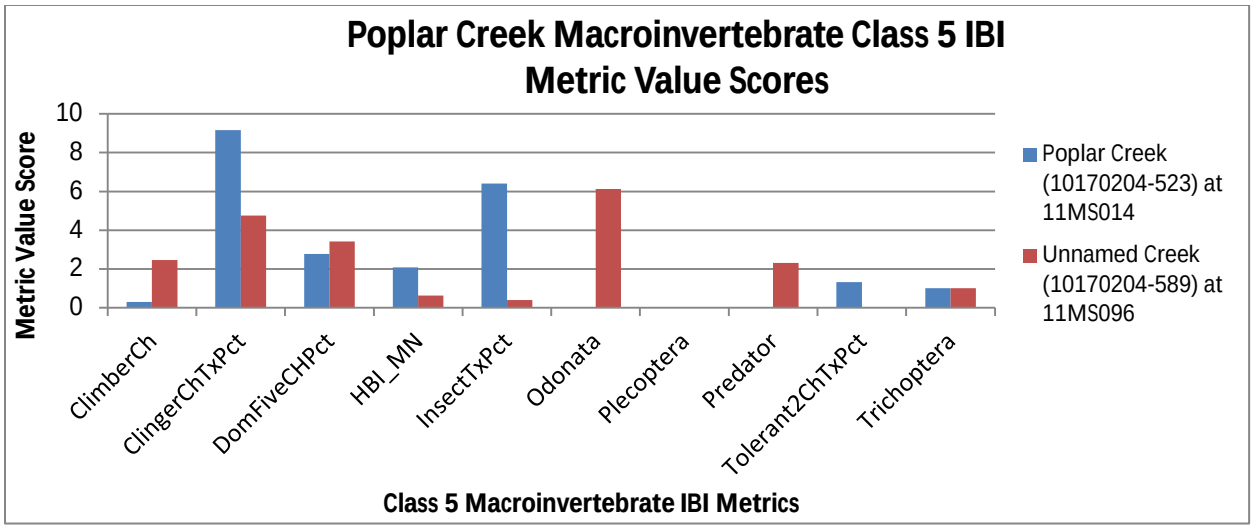

Figure 107: Macroinvertebrate Class 5 IBI metric value scores in the Poplar Creek Watershed

To reach the MPCA's macroinvertebrate IBI threshold for a Class 7 (Prairie Streams GP) stream, each metric would need an average score of 3.83 (Figure 108). Site 11MS093 along Unnamed Creek had a macroinvertebrate IBI score of 28.2. The IBI at this site was mainly limited by the limited numbers of collector-filterer species (Collector-filtererPct), lack of macroinvertebrates with tolerance values less than or equal to two (Intolerant2Ch), low numbers of non-hydropsychid Trichoptera individuals (TrichowoHydroPct), as well as the high numbers of taxa with high HBI scores (HIB_MN).

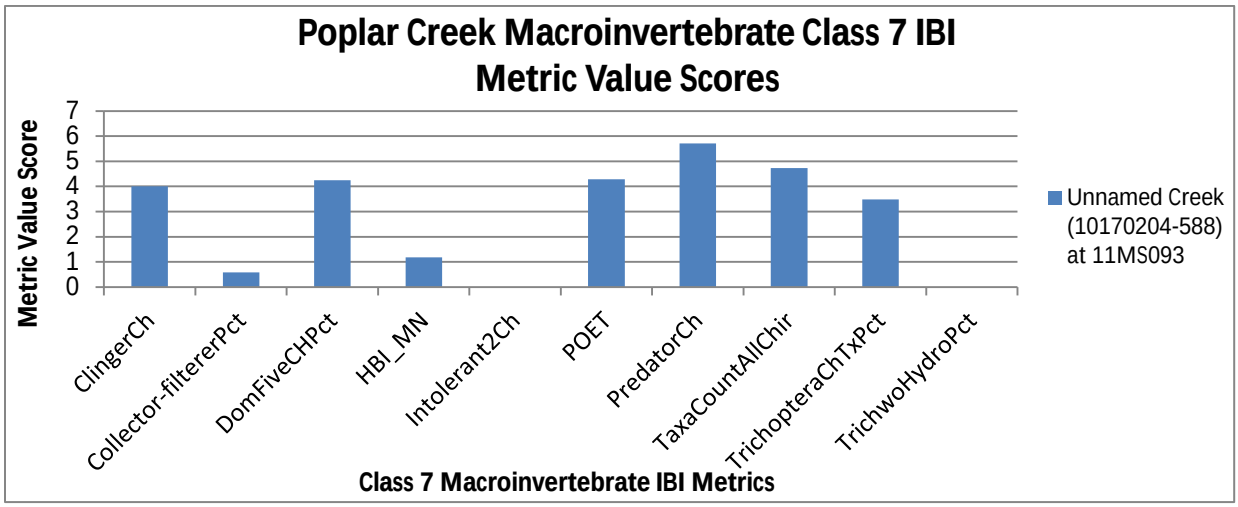

Figure 108: Macroinvertebrate Class 7 IBI metric value scores at site 11MS093 along Unnamed Creek (10170204-588)

Candidate cause: Low dissolved oxygen

The daily minimum standard for DO in Minnesota Class 2B streams is 5 mg/L. All streams in the Poplar Creek Watershed have this 2B classification. No streams in this grouping are currently listed as impaired for DO.

Poplar Creek (10170204-523)

Poplar Creek had 53 DO readings taken from 2011-2012 (Figure 109). These readings ranged from 4.32-13.66 mg/L with three samples falling below the 5 mg/L daily minimum standard.

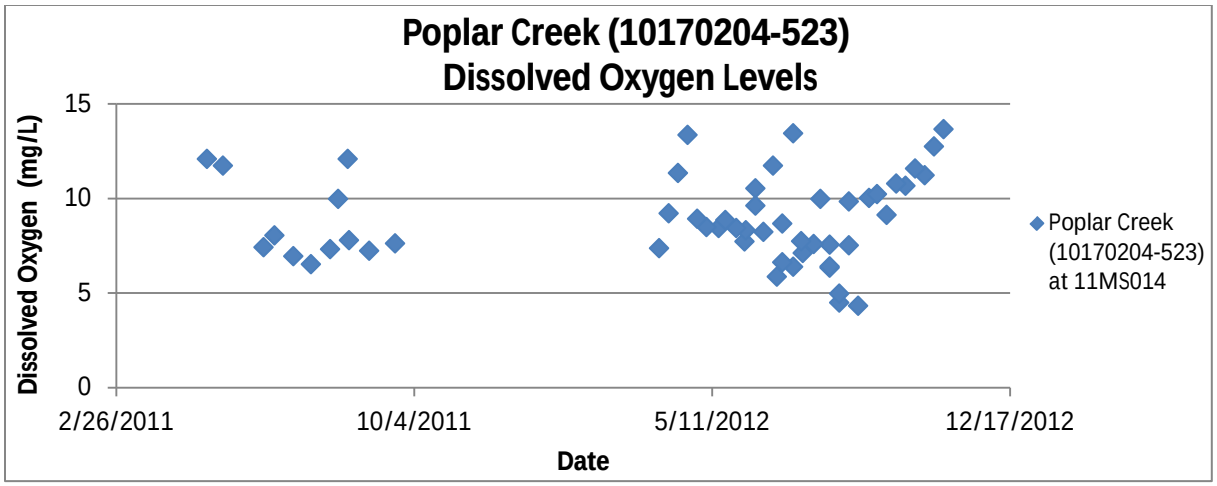

Figure 109: Dissolved oxygen values from 2011-2012 along Poplar Creek (10170204-523)

The HSPF model calculate hourly DO values for Poplar Creek (10170204-523) from 1996-2009. These values ranged from 0.75-14.37 mg/L with an average value of 9.96 mg/L. Of these calculations, 0.2% was below the 5 mg/L daily minimum standard.

Biologically, the macroinvertebrate assemblage in Poplar Creek had increased amounts of DO sensitive EPT taxa (46.88%), while also having nine DO intolerant taxa, and a very low amount of DO tolerant individuals (1.28%). Fish populations in Poplar Creek had decreased amounts of sensitive fish taxa (13.64%) and late maturing fish taxa (13.64%). These types of fish are affected by poor DO conditions. There was also an increased amount of tolerant fish taxa (56.25%) and serial spawning fish species (27.27%). These types of fish are found in large numbers in streams with DO problems. Site 11MS014 did have an above average DO TIV score when compared to all other fish Class 2 sites.

Based on the low exceedance rates observed and predicted by the model, as well as the high presence of EPT taxa, intolerant macroinvertebrate species, and fish TIV score, low DO is not a stressor to the biotic communities at this time.

Unnamed Creek (10170204-588)

From 2011-2013, seven DO readings were taken from Unnamed Creek. These readings ranged from 4.05-18.33 mg/L with one sample falling below the 5 mg/L daily minimum standard for DO (Table 43).

Table 43: Dissolved oxygen values from 2011-2013 at site 11MS093 along Unnamed Creek (10170204-588)

Sample Location	Sample Date and Time	Result (mg/l)	Daily Minimum Standard (mg/l)
11MS093	8/9/2011 5:01 PM	9.19	5
11MS093	8/31/2011 3:17 PM	12.28	5
11MS093	5/6/2013 2:30 PM	18.33	5
11MS093	6/11/2013 10:00 AM	6.65	5
11MS093	7/1/2013 4:35 PM	7.52	5
11MS093	7/16/2013 10:15 AM	7.34	5
11MS093	8/20/2013 10:00 AM	4.05	5

The HSPF model calculate hourly DO values for Unnamed Creek (10170204-588) from 1996-2009. These values ranged from 0-15.33 mg/L with an average value of 7.43 mg/L. Of these calculations, 29.65% were below the 5 mg/L daily minimum standard.

Biologically, macroinvertebrate populations in Unnamed Creek had increased amounts of tolerant species (77.14%) and decreased numbers of sensitive taxa (11.43%). This reach had zero DO intolerant taxa, while having six DO tolerant species. This reach also had a high amount of DO tolerant individuals when compared to all other Minnesota streams. The fish community in this stream reach was also very tolerant (73.33%), while also having few sensitive fish taxa (6.67%), few late maturing fish species (6.67%), and a large amount of serial spawning fish taxa (26.67%). All of these metrics indicate potential DO problems. Site 11MS093 did have a slightly above average DO TIV score when compared to all other fish Class 3 sites.

Dissolved oxygen levels in Unnamed Creek do drop below 5 mg/L based on an observance, the model calculated a high exceedance rate, and the majority of the biological metrics were in agreement that low DO is indeed a stressor to the biological communities in Unnamed Creek.

Unnamed Creek (10170204-589)
From 2011-2013, eight DO readings were taken from Unnamed Creek. These readings ranged from 6.6-20.05 mg/L with no values falling below the 5 mg/L daily minimum standard for DO (Table 44).

Table 44: Dissolved oxygen values from 2011-2013 at site 11MS096 along Unnamed Creek (10170204-589).

Sample Location	Sample Date and Time	Result (mg/l)	Daily Minimum Standard (mg/l)
11MS096	8/2/2011 4:00 PM	7.11	5
11MS096	8/9/2011 4:32 PM	8.03	5
11MS096	5/6/2013 2:45 PM	20.05	5
11MS096	5/21/2013 7:15 AM	6.97	5
11MS096	6/11/2013 10:10 AM	7.24	5
11MS096	7/1/2013 4:45 PM	8.14	5
11MS096	7/16/2013 10:30 AM	6.6	5
11MS096	8/20/2013 10:15 AM	7.11	5

The HSPF model calculate hourly DO values for Unnamed Creek (10170204-589) from 1996-2009. These values ranged from 0-14.5 mg/L with an average value of 4.86 mg/L. Of these calculations, 53.44% were below the 5 mg/L daily minimum standard.

Biologically, the macroinvertebrate populations in this stream reach was very tolerant (82.35%) and had a below average amount of EPT taxa (17.65%). Site 11MS096 had three DO intolerant species present, while also having a low amount of DO tolerant individuals (5.44%). The fish community in Unnamed Creek was also tolerant (63.64%), with decreased amounts of sensitive taxa (9.09%) and late maturing

fish species (18.18%). Unnamed Creek did have a below average amount of serial spawning fish species (18.18%). These types of fish are usually present in high numbers in streams experiencing DO problems. The DO TIV score was slightly above average when compared to all other fish Class 3 sites.

The DO values in Unnamed Creek get to extremely high levels, which can often indicate problems with daily flux. The model also predicted a high rate of exceedance. The DO related biological metrics were a bit mixed. Continuous DO monitoring with a sonde is recommended along this reach to better understand the DO conditions present before this parameter is determined to be a stressor or not.

Candidate cause:High phosphorus

The proposed draft standard for Phosphorus for streams in the Missouri River basin is currently 0.15 mg/L. Although phosphorus is an essential nutrient for all aquatic life, elevated levels can lead to an imbalance which impacts stream ecology. In the Poplar Creek Watershed phosphorus levels have exceeded this proposed standard multiple times.

Poplar Creek (10170204-523)
Poplar Creek had a total of 12 phosphorus samples taken in 2011. Sample values ranged from 0.035-0.754 mg/L with 8 (75%) of the samples above the proposed draft standard of 0.15 mg/L (Figure 110).

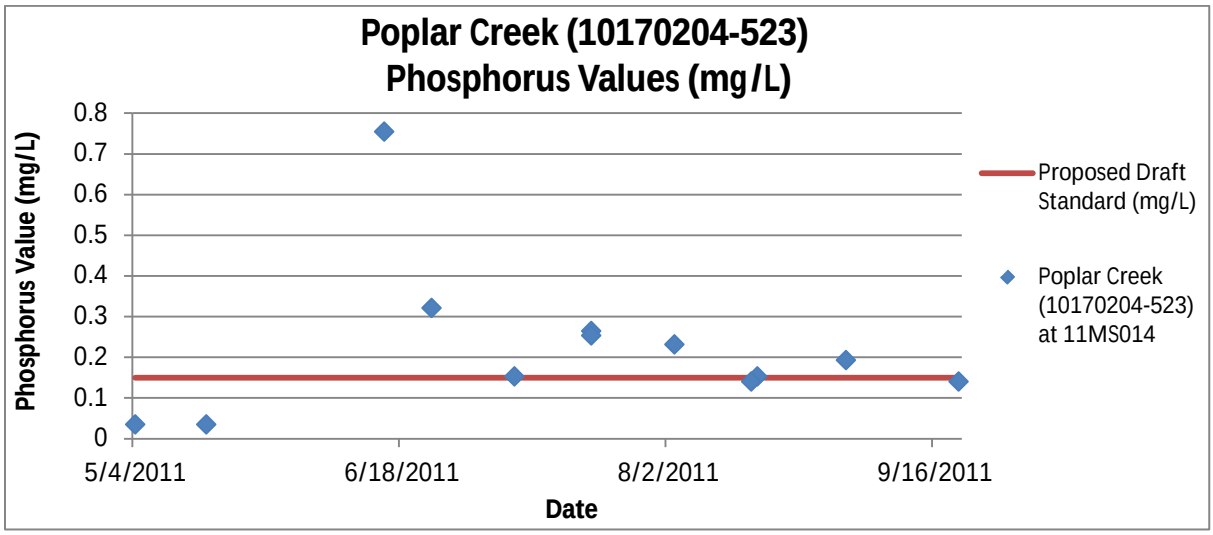

Figure 110: Phosphorus sample values from 2011 at site 11MS014 along Poplar Creek (10170204-523)

The HSPF model calculated daily phosphorus values for Poplar Creek (10170204-523) from 1996-2009. These values ranged from 0.07-0.58 mg/L with an average value of 0.18 mg/L. Of these calculations, 59.57% were above the 0.15 mg/L proposed phosphorus standard.

Biologically, the macroinvertebrate community in Poplar Creek had an increased amount of EPT taxa (46.88%), intolerant taxa (12.5%), and scraper species (18.75%). However, this site also had few Tanytarsini species (6.25%) and increased tolerant taxa (56.25%). Site 11MS014 did have a very high amount of Polypedilum (78 individuals), which is a genus of the non-biting midge family of chironomidae. These types of macroinvertebrates tend to be very abundant in eutrophic conditions. The fish assemblage in this reach had increased tolerant taxa (54.55%), while also having decreased sensitive species (13.64%). Site 11MS014 did have a higher amount of darter individuals (8.29%), when compared to all other Minnesota streams.

Phosphorus concentrations in Poplar Creek frequently reach elevated levels. These levels were both observed and also predicted by the HSPF model. The biotic communities are beginning to signal stress from phosphorus by the increased presence of Polypedilum species, as well as the low numbers of

Tanytarsini species and high presence of both tolerant fish and macroinvertebrates. Therefore, high phosphorus is a stressor to the impaired biological assemblages in Poplar Creek.

Unnamed Creek (10170204-588)

From 2011-2013 a total of six phosphorus samples were taken along Unnamed Creek. These values ranged from 0.032-0.263 mg/L (Table 45) with three samples at or above the proposed draft standard of 0.15 mg/L for phosphorus.

Table 45: Phosphorus sample values from 2011-2013 at site 11MS093 along Unnamed Creek (10170204-588)

Sample Location	Sample Date	Result (mg/l)	Proposed Draft Standard
11MS093	8/31/2011	0.263	0.15
11MS093	5/6/2013	0.032	0.15
11MS093	6/11/2013	0.131	0.15
11MS093	7/1/2013	0.077	0.15
11MS093	7/16/2013	0.176	0.15
11MS093	8/20/2013	0.15	0.15

The HSPF model calculated daily phosphorus values for Unnamed Creek (10170204-588) from 1996-2009. These values ranged from 0.05-0.67 mg/L with an average value of 0.18 mg/L. Of these calculations, 59.58% were above the 0.15 mg/L proposed phosphorus standard.

Biologically, the macroinvertebrate assemblage in Unnamed Creek had very few EPT (11.43%), intolerant (0%), and scraper (8.57%) taxa, while having an extremely high amount of tolerant species (77.14%). The fish community also had many tolerant taxa (73.33%), few sensitive species (6.67%) and darter individuals (3.18%).

Based on the very high observed and predicted values, along with the agreement of the majority of the related biological metrics, high phosphorus is a stressor to the impaired biological assemblages in Unnamed Creek.

Unnamed Creek (10170204-589)

Unnamed Creek had five phosphorus samples taken from 2011-2013 at site 11MS096 (Table 46). These values ranged from 0.025-0.177 mg/L with two of the values being above the 0.15 mg/L proposed draft standard for phosphorus.

Table 46: Phosphorus sample values from 2011-2013 at site 11MS096 along Unnamed Creek (10170204-589)

Sample Location	Sample Date	Result (mg/l)	Proposed Draft Standard
11MS096	8/2/2011	0.177	0.15
11MS096	5/6/2013	0.025	0.15
11MS096	6/11/2013	0.1625*	0.15
11MS096	7/1/2013	0.102	0.15
11MS096	7/16/2013	0.111	0.15

* Average value of two samples

The HSPF model calculated daily phosphorus values for Unnamed Creek (10170204-589) from 1996-2009. These values ranged from 0.07-0.66 mg/L with an average value of 0.21 mg/L. Of these calculations, 80.78% were above the 0.15 mg/L proposed phosphorus standard.

Biologically, the macroinvertebrate community at site 11MS096 along Unnamed Creek had lower amounts of EPT (17.65%), Tanytarsini (5.88%), intolerant (0%), and scraper (8.82%) species, while also having many tolerant (82.35%) and crustacean/mollusca (14.71%) taxa. All of these results are common in streams with elevated phosphorus levels. The fish assemblage in this reach also had many tolerant species (63.64%) along with few sensitive taxa (9.09%) and darter individuals (3.1%).

Based on the very high observed and predicted values, algae present (Figure 111), along with the agreement of the majority of the related biological metrics, high phosphorus is a stressor to the impaired macroinvertebrate assemblage in Unnamed Creek (10170204-589).

Figure 111: Algae at 11MS096 along Unnamed Creek (10170204-53)

Candidate cause: High nitrates

Currently, the State of Minnesota does not have a nitrate standard in place for streams not used as a drinking water source. However, the overabundance of nitrates can stress a biological community. Nitrates in the Poplar Creek Watershed did at times reach levels that could potentially be stressing the biological assemblages.

Poplar Creek (10170204-523): Poplar Creek had 12 nitrate samples taken in 2011. Sample values ranged from 2.53-15 mg/L (Figure 112

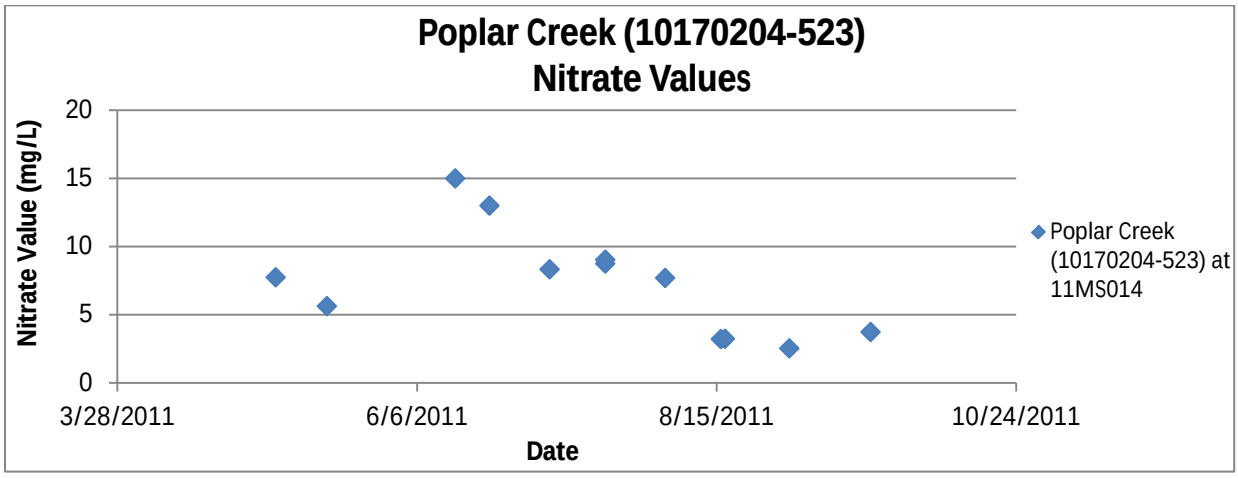

Figure 112: Nitrate sample values from 2011 along Poplar Creek (10170204-523)

The HSPF model calculated daily nitrate values for Poplar Creek (10170204-523) from 1996-2009. These values ranged from 1.55-16.25 mg/L with an average value of 5.58 mg/L.

Biologically, the macroinvertebrate community had a few Trichoptera taxa (9.38%) and a below average amount of overall taxa (19) when compared to all other Minnesota streams. Additionally, site 11MS014 had 89.78% of its population consisting of nitrate tolerant individuals. Quantile regression analysis for Class 5 macroinvertebrate sites says that this site would have a 90% probability of being impaired with these high numbers of nitrate tolerant individuals. The fish assemblage in the reach had a high overall taxa count (11), but did have few sensitive species (13.64%).

Based on the elevated observed and calculated nitrate values, along with the quantile regression analysis and the majority of the related biological metrics, high nitrates are a stressor to the impaired biological communities in Poplar Creek.

Unnamed Creek (10170204-588)

From 2011-2013 a total of six nitrate samples were taken along Unnamed Creek. These values ranged from 2.3-28 mg/L (Table 47). This site had two values over 18.1 which means it would have a greater than 90% probability of being impaired according to a quantile regression analysis comparing nitrate values and macroinvertebrate IBI scores of Class 7 streams.

Table 47: Nitrate sample values from 2011-2013 at site 11MS093 along Unnamed Creek (10170204-588)

Sample Location	Sample Date	Result (mg/l)	Nitrate Standard (mg/L)
11MS093	8/31/2011	2.3	n/a
11MS093	5/6/2013	5.5	n/a
11MS093	6/11/2013	22	n/a
11MS093	7/1/2013	28	n/a
11MS093	7/16/2013	3.1	n/a
11MS093	8/20/2013	8.8	n/a

The HSPF model calculated daily nitrate values for Unnamed Creek (10170204-588) from 1996-2009. These values ranged from 1.55-16.25 mg/L with an average value of 5.58 mg/L.

Biologically, the macroinvertebrate community at Unnamed Creek had very few nitrate sensitive Trichoptera taxa (5.71%) and also had a lower amount of overall taxa (20). All of the macroinvertebrate taxa sampled are tolerant of nitrates. This site did also have a high amount of nitrate tolerant individuals (54.95%).The fish assemblage in this reach had 15 overall taxa, but did have few sensitive fish species (6.67%).

Based on the high observed and predicted values, along with the majority of the nitrate related biological metrics, high nitrates are a stressor to the impaired biological communities in Unnamed Creek at this time.

Unnamed Creek (10170204-589)

From 2011-2013 a total of five nitrate samples were taken from Unnamed Creek at site 11MS096 (Table 48). These values ranged from 1.1-27 mg/L. Two of the values were above 18.1 mg/L which according to a quantile regression study, this macroinvertebrate Class 5 stream has a greater than 75% chance of being impaired because of those values.

Table 48: Nitrate sample values from 2011-2013 at site 11MS096 along Unnamed Creek (10170204-589)

Sample Location	Sample Date	Result (mg/l)	Nitrate Standard (mg/l)
11MS096	8/2/2011	7.6	n/a
11MS096	5/6/2013	1.1	n/a
11MS096	6/11/2013	22*	n/a
11MS096	7/1/2013	27	n/a
11MS096	7/16/2013	2	n/a

* Average value of two samples

The HSPF model calculated daily nitrate values for Unnamed Creek (10170204-589) from 1996-2009. These values ranged from 2.04-16.01 mg/L with an average value of 6.01 mg/L.

Biologically, the macroinvertebrate assemblage in Unnamed Creek had a lower overall taxa count (23) and had few Trichoptera taxa (8.82%). These averages are both below average when compared to all other streams in Minnesota. Additionally, this stream had 90.14% of its population comprised of nitrate tolerant individuals and according to a quantile regression analysis study, this Class 5 macroinvertebrate stream would have a greater than 90% chance of being impaired because of that high population. The fish community in this reach had an average overall taxa count (11), but did have decreased sensitive species (9.09%) present.

Based on the very high observed and predicted nitrate values, along with the agreement of the majority of the related biological metrics, high nitrates are a stressor to the impaired macroinvertebrate assemblage in Unnamed Creek.

Candidate cause: High turbidity/TSS

The water quality standard for turbidity is 25 NTU, 65 mg/L for TSS, and 20 cm for transparency tube for these Class 2B warmwater streams in the Poplar Creek Watershed. Excess sediment is a commonly recognized stressor in many biologically impaired streams because it can reduce habitat, cause direct physical harm, as well as reduce visibility and increase oxygen demand. Poplar Creek (10170204-523) was determined to be impaired for aquatic life due to turbidity in addition to the biological assemblages.

Poplar Creek (10170204-523)

Poplar Creek had a total of 44 TSS values taken from 2011-2012. TSS sample values ranged from 4-254 mg/L, with 4 samples registering over the 65 mg/L maximum standard (Figure 113). In addition, 31 of 53 (58.5%) of transparency samples taken from 2011-2012 were below the 20 cm minimum standard. Also, half of the 26 turbidity samples taken in 2012 were over the 25 NTU maximum standard.

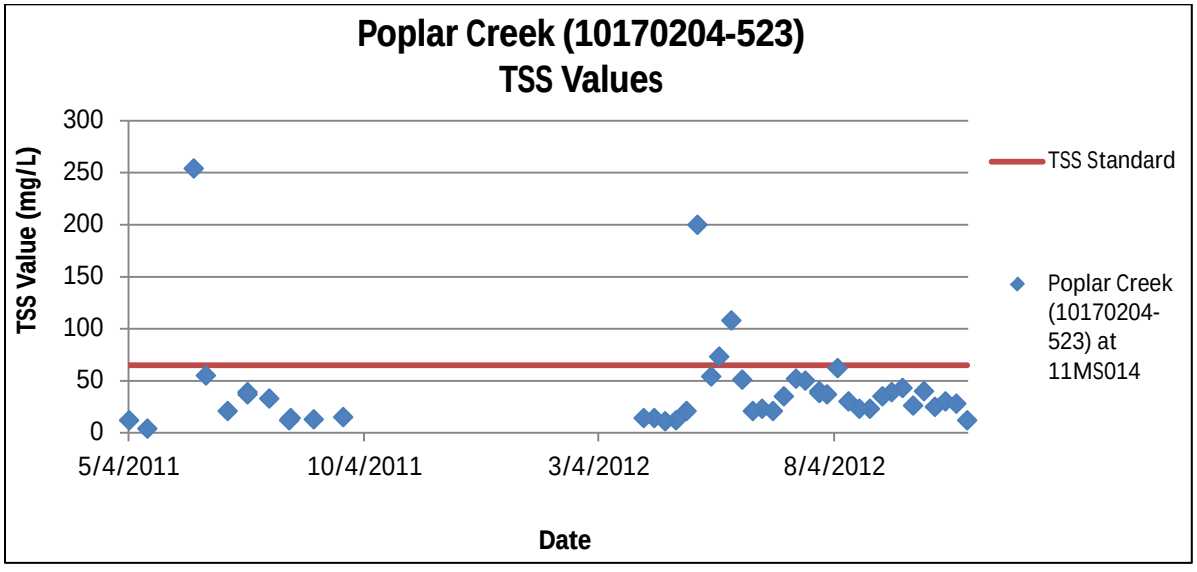

Figure 113: TSS sample values from 2011-2012 along Poplar Creek (10170204-523)

Biologically, the macroinvertebrate community at site 11MS014 along Poplar Creek had few Trichoptera (9.38%) and collector-filterer (12.5%) taxa and a lower overall taxa count (19), while also having many TSS tolerant species (13). These results reflect a stream that is affected by excess TSS and turbidity conditions. This site did also have higher numbers of scraper (18.75%) and Ephemeroptera (37.5%) taxa. The fish assemblage in this reach did have a higher amount of turbidity sensitive herbivorous taxa (9.09%), however this stream had increased tolerant fish species (54.55%).

The current turbidity impairment along this portion of Poplar Creek is backed up by the many recent TSS and Secchi tube samples, as well as the majority of the biological metrics related to this parameter. Therefore, excess turbidity/TSS is a stressor to the impaired fish and macroinvertebrate assemblages in this reach.

Unnamed Creek (10170204-588)

From 2011-2013 a total of six TSS samples were taken along Unnamed Creek at site 11MS093 (Table 49). These samples ranged from 19-79 mg/L with value over the 65 mg/L proposed draft standard for TSS. Additionally, seven Secchi tube measurements were made over this same time frame. These values ranged from 14-52 cm with three readings below the 20 cm minimum standard.

Table 49: TSS and Secchi tube values from 2011-2013 at site 11MS093 along Unnamed Creek (10170204-588)

Sample Location	Sample Date	TSS Result (mg/l)	TSS Standard (mg/l)	Secchi Tube Value (cm)	Secchi Tube Standard (cm)
11MS093	8/9/2011	n/a	65	24	20
11MS093	8/31/2011	44	65	15	20
11MS093	5/6/2013	19	65	36	20
11MS093	6/11/2013	45	65	52	20
11MS093	7/1/2013	25	65	24	20
11MS093	7/16/2013	79	65	14	20
11MS093	8/20/2013	30	65	14	20

The HSPF model calculated daily TSS for Unnamed Creek (10170204-588) from 1996-2009. These values ranged from 0-1647.3 mg/L with an average value of 24.59 mg/L. Of these calculations, 5.26% were above the 65 mg/L proposed standard for TSS.

Biologically, the macroinvertebrate community in Unnamed Creek had few Trichoptera (5.71%), scraper (8.57%), and Ephemeroptera (5.71%) taxa while also having few overall taxa (20). This site also had many TSS tolerant individuals (50.16%), chironomid species (45.71%), and TSS tolerant taxa species (11). Both of these metrics tend to increase in streams affected by turbidity/TSS. The fish community in this stream did have an increased amount of herbivorous taxa (13.33%), but also did have many tolerant species (73.33%). Site 11MS093 had a high TSS TIV score when compared to all other fish Class 3 sites.

Unnamed Creek has instances where the TSS and transparency levels exceed their respective standards. All of the related macroinvertebrate metrics suggest that turbidity/TSS is impacting this community. The fish community does not show strong signals of stress yet, but will likely if high TSS conditions continue. Based on this information, turbidity/TSS is a stressor to the macroinvertebrate assemblage.

Unnamed Creek (10170204-589)

From 2011-2013 a total of five TSS samples were taken from site 11MS096 along Unnamed Creek (Table 50). These values ranged from 6-90 mg/L with one sample above the 65 mg/L proposed draft standard for TSS. Additionally, seven Secchi tube measurements were made during this same time period. These values ranged from 11 to over 100 cm with only one sample falling below the 20 cm minimum standard.

Table 50: TSS and Secchi tube values from 2011-2013 at site 11MS096 along Unnamed Creek (10170204-589)

Sample Location	Sample Date	TSS Result (mg/l)	TSS Standard (mg/l)	Secchi Tube Value (cm)	Secchi Tube Standard (cm)
11MS096	8/2/2011	21	65	22	20
11MS096	8/9/2011	n/a	65	22	20
11MS096	5/6/2013	6	65	>100	20
11MS096	5/21/2013	n/a	65	57	20
11MS096	6/11/2013	25.5*	65	22	20
11MS096	7/1/2013	90	65	27	20
11MS096	7/16/2013	46	65	11	20

* Average value of two samples

The HSPF model calculated daily TSS for Unnamed Creek (10170204-589) from 1996-2009. These values ranged from 0-699.81 mg/L with an average value of 13.76 mg/L. Of these calculations, 2.97% were above the 65 mg/L proposed standard for TSS.

Figure 214: Turbid water at site 11MS096 along Unnamed Creek (10170204-589)

Biologically, the macroinvertebrate assemblage at 11MS096 also had few Trichoptera (8.82%), scraper (8.82%) and Ephemeroptera (8.82%) species, while also having few overall taxa (23) and many tolerant species (82.35%). This site also had an increased amount of TSS tolerant macroinvertebrate species (10) and high amount of TSS tolerant individuals (52.72%). The fish community in this reach did have a fair amount of herbivorous taxa (9.09%), but also had a population consisting of many tolerant species (63.64%). Site 11MS096 did also have a low TSS TIV score when compared to all other fish Class 3 sites.

Unnamed Creek has instances where the TSS and transparency levels exceed their respective standards (Figure 114). The related biological metrics strongly suggest that turbidity/TSS is a stressor to the impaired macroinvertebrate assemblage in Unnamed Creek.

Candidate cause: Lack of habitat

Qualitative habitat assessments were performed on all three biologically impaired reaches in the Poplar Creek Watershed during the fish sampling visits at each site. Results of these assessments can be seen in Figure 115.

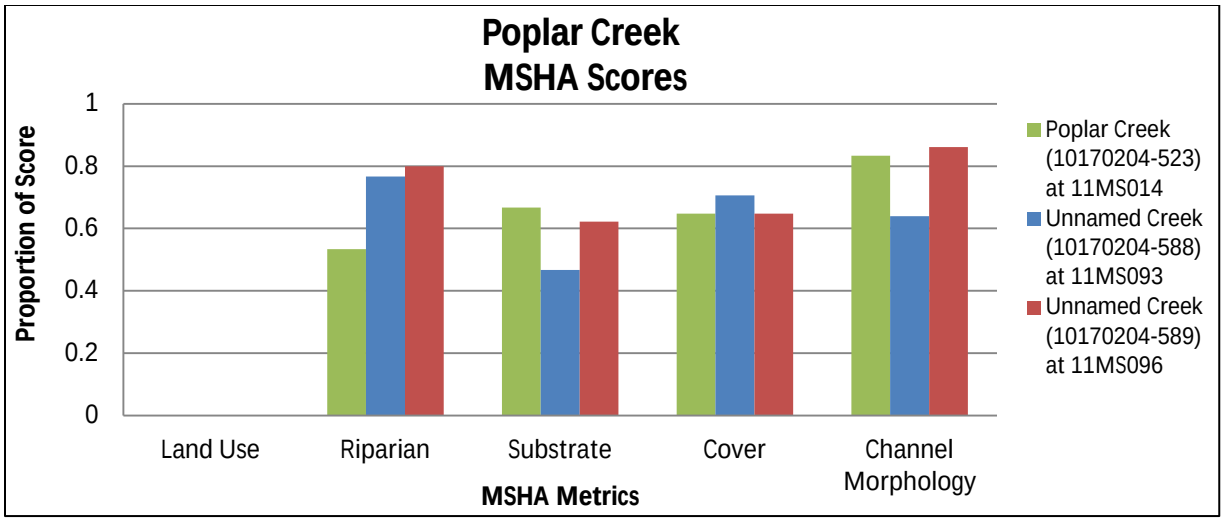

Figure 115: MSHA metrics scores in the Poplar Creek Watershed

Poplar Creek (10170204-523)

A qualitative habitat assessment was performed at site 11MS014 along Poplar Creek during the fish sampling event. The MSHA score for this site was 67, which is considered to be a "good" score. Factors lowering the MSHA score at this site include: the poor surrounding land use, a moderate riparian area, some clay and silty substrates, and moderate channel stability.

Biologically, the macroinvertebrate community had a good presence of clinger taxa (43.75%) with few burrower individuals present (0.95%). The fish assemblage in this reach had good numbers of riffle-dwelling (18.18%), benthic insectivore (36.36%), and darter/sculpin/round-bodied sucker (18.18%) taxa. The fish community did also have increased tolerant taxa (54.55%) and a slightly below average amount of simple lithophilic spawning taxa (22.73%) when compared to all other Minnesota streams.

The majority of the habitat related biological metrics agree with the good MSHA score. The lack of habitat should not be considered a stressor to the impaired biological assemblages in Poplar Creek at this time.

Unnamed Creek (10170204-588)

A qualitative habitat was assessment was performed during the fish sampling visit at site 11MS093. The MSHA score at this site was 59.1 which is considered to be a fair score. Limiting the MSHA score at this site was the poor surrounding land use (Figure 116), silt and sandy substrates, and fair channel development.

Figure 116: Surrounding land use at 11MS093 along Unnamed Creek (10170204-588

Biologically, the macroinvertebrate community in this reach had fewer clinger taxa (22.86%), while having many tolerant species (77.14%). This reach also had a below average amount of burrower individuals (6.65%) when compared statewide. The fish assemblage had fewer riffle dwelling (13.33%) and darter/sculpin/round-bodied sucker (13.33%) species, while also having many tolerant taxa (73.33%). This site did have good numbers of benthic insectivore (20%) and simple lithophilic spawning (26.67%) taxa.

The mixed biological metrics along with the fair MSHA score makes the lack of habitat a secondary stressor to the impaired biological communities along this reach.

Unnamed Creek (10170204-589)

A qualitative habitat was assessment was performed during the fish sampling visit at site 11MS096. The MSHA score at this site was 70.8. Limiting the MSHA score was poor surrounding land use, sand and silty substrates, eroded banks (Figure 117) and moderate fish cover.

Figure 117: Eroded bank at site 11MS096 along Unnamed Creek (10170204-589)

Biologically, the macroinvertebrate assemblage in Unnamed Creek had a good amount of clinger taxa (32.36%), while also having a below average amount of burrower individuals (10.54%) when compared statewide. This reach did have many tolerant species (82.35%). The fish community showed higher numbers of riffle-dwelling (18.18%) and simple lithophilic spawning (27.27%) species. This stream reach did have lower numbers of darter/sculpin/round-bodied sucker (9.09%) and benthic insectivore (9.09%) taxa, while having many tolerant species (63.64%).

The habitat related biological metrics were fairly mixed in response to the good MSHA score. This means that there are likely other parameters that are affecting the impaired macroinvertebrate community in Unnamed Creek at this time and the lack of habitat should not be considered a stressor.

The three biologically impaired reaches in the Poplar Creek Watershed are being stressed by multiple parameters (Table 51).

Low DO is a stressor to the biological communities at Unnamed Creek (10170204-588) due to observed and predicted values falling below the 5 mg/L daily minimum standard. The biological station, 11MS093, also had a higher number of DO tolerant macroinvertebrate taxa (6), while zero intolerant species were present. This site also had many serial spawning fish species and few late maturing taxa, which can also signal problems due to DO. These DO conditions may be partly attributed to the high nutrient values found throughout this watershed.

High phosphorus was determined to be a stressor to the fish and macroinvertebrate communities in all of the impaired reaches within this watershed. Phosphorus levels frequently exceeded the proposed standard of 0.15 mg/L. This excess phosphorus is a likely result from the highly pastured riparian areas and cropland throughout the watershed where concentrations of phosphorus tend to be high. Runoff following rain events is a likely pathway for these phosphorus contributions to easily enter the stream system.

High nitrate values were also found to be a stressor to the biological assemblages at all three impaired reaches. Nitrate levels in excess of 27 mg/L were observed in Unnamed Creek (10170204-588) and Unnamed Creek (10170204-589), with many high values sampled in Poplar Creek as well. High percentages of nitrate tolerant individual macroinvertebrates were present, which often signals impairment. The high levels of nitrates are likely a result from fertilizer applications and have entered the stream as runoff.

Currently, Poplar Creek (10170204-523) is impaired for aquatic life due to turbidity in addition to the biological assemblages. This reach along with the other two biologically impaired reaches in the watershed were also found to be stressed by high levels of turbidity/TSS. High intensity grazing with

minimal riparian buffers in the watershed has led to unstable and erosive banks. Increasing stream buffer widths, rotational or flash grazing, as well as limiting cattle access to streams is recommended to help reduce the TSS/turbidity issues currently present in this watershed.

Habitat conditions in the Poplar Creek Watershed were in relatively good shape. Unnamed Creek (10170204-588) had the lack of habitat identified as a secondary stressor at this time. This reach was limited by the poor surrounding land use, the presence of silt and sand substrates, as well as fair channel development. Improving these conditions will help eliminate the stress experienced by the fish and macroinvertebrate communities.

The Poplar Creek Watershed has many biological stressors throughout. Addressing these stressors is needed to restore the biological communities to a healthy condition. Until this is done, the fish and macroinvertebrate communities will remain impaired.

Table 51: Stressors to the biologically impaired reaches within the Rock River Watershed

		Stressors				
Stream Name	**AUID #**	**Low Dissolved Oxygen**	**High Phosphorus**	**High Nitrates**	**High Turbidity/ TSS**	**Lack of Habitat**
Poplar Creek Watershed						
Poplar Creek	10170204-523	-	•	•	•	-
Unnamed Creek	10170204-588	•	•	•	•	•
Unnamed Creek	10170204-589		•	•	•	-

(• = stressor, - = not a stressor, and blank = inconclusive/not enough evidence)

Town of Leota-Rock River Watershed

Overview

Located in the central part of the Rock River Watershed, the town of Leota-Rock River 12-Digit HUC watershed drains an area of 31.7 mi^2. The watershed contains two biologically impaired stream reaches within its boundaries (Figure 118), Unnamed Creek (10170204-571) and Unnamed Creek (10170204-572). The land use in this watershed consists of cropland (82.5%), rangeland (9.71%) and developed (5.25%).

Unnamed Creek (10170204-571) is a 1.93 mile long AUID extending from Unnamed Cr just south of Cr-10 to the confluence with Unnamed Creek just west of Cr 2. This stream was sampled for fish and macroinvertebrates in 2011 at its lone biological monitoring station 11MS113. This AUID was determined to be impaired for aquatic lie due to its macroinvertebrate assemblage during the watershed assessment in 2013.

Unnamed Creek (10170204-572) is a 2.59 mile long AUID extending from Unnamed Cr to Unnamed Cr, which runs north from 211th St to just north of 221st Street. This stream was sampled for fish and macroinvertebrates in 2011 at its lone biological monitoring station 11MS083. This AUID was determined to be impaired for aquatic lie due to its macroinvertebrate assemblage during the watershed assessment in 2013.

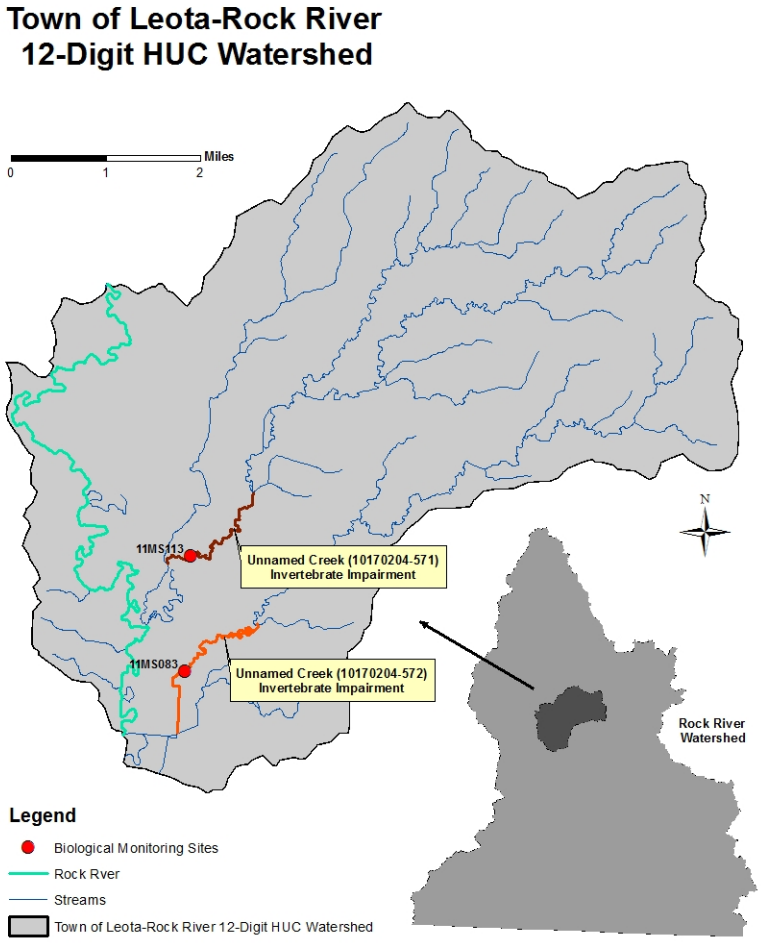

Figure 118: Town of Leota-Rock River Watershed with biologically impaired reaches highlighted

Biology in town of Leota-Rock River Watershed

Fish

The two biologically impaired reaches in the town of Leota-Rock River Watershed had just the two biological monitoring stations. On Unnamed Creek (10170204-571), the lone station, 11MS113, is located upstream of CR 2, 4 miles south of Edgerton and was sampled for fish on August 16, 2011. The biological monitoring station, 11MS083, along Unnamed Creek (10170204-572) is located upstream of CR 2, 4 miles northwest of Hardwick. This site was sampled for fish on August 10, 2011.

Both of these sites have a Fish Class 3 (Southern Headwaters) designation. Site 11MS113 and 11MS083 had fish IBI scores of 66 and 69 respectively. Both of these scores are above the IBI threshold for a Class 3 site. These sites are not impaired for their fish assemblages.

Macroinvertebrates

In the watershed, Unnamed Creek (10170204-571) had one macroinvertebrate sample take on August 10, 2011 at site 11MS113, while Unnamed Creek (10170204-572) was sampled for macroinvertebrates at site 11MS083 on the same day.

Both biological monitoring sites on the impaired AUIDs in this watershed were classified as Class 5 (Southern Streams RR) streams. To reach the MPCA's macroinvertebrate IBI threshold for this class, each metric would need an average score of 3.59. Site 11MS113 on Unnamed Creek (10170204-571) had an

IBI score of 20.6. This site had large amounts of Clinger taxa (ClingerChTxPct) and Odonata. These were the only two metrics that scored above the average needed to reach the IBI threshold. Site 11MS083 on Unnamed Creek (10170204-572) scored well in the same two metrics and had below average scores in all other metrics (Figure 119).

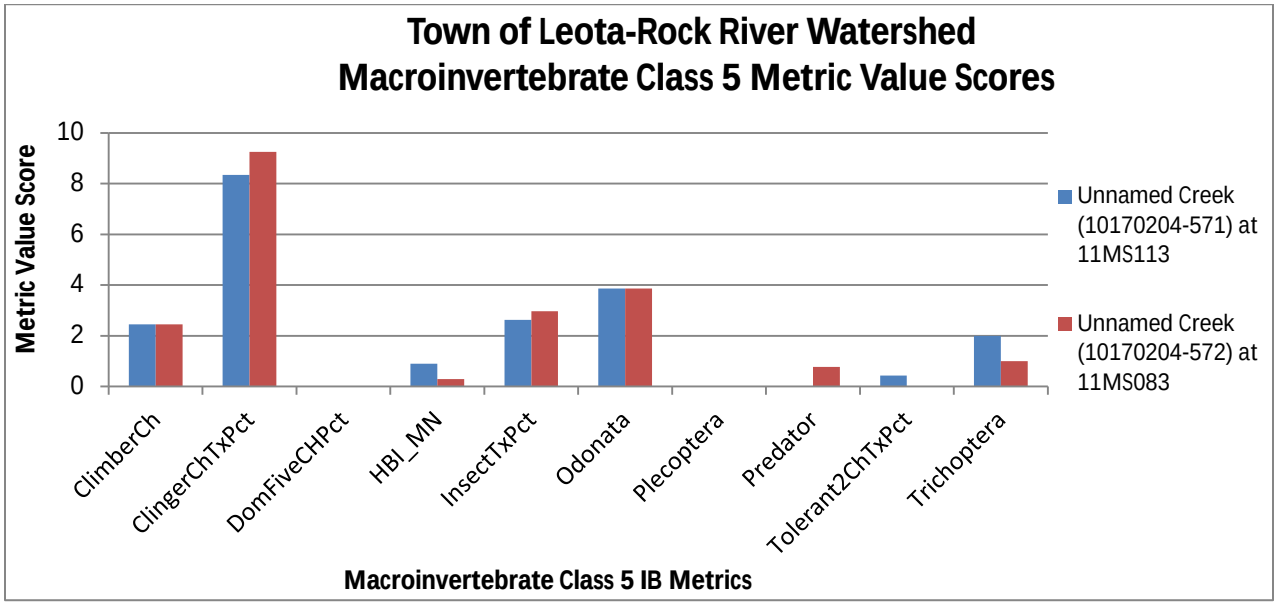

Figure 119: Macroinvertebrate Class 5 IBI metric value scores in the town of Leota-Rock River Watershed

Candidate cause: Low dissolved oxygen

The daily minimum standard for DO in Minnesota Class 2B streams is 5 mg/L. All streams in the town of Leota- Rock River Watershed have this 2B classification. No streams in this grouping are currently listed as impaired for DO. No sondes were deployed in these streams for continuous DO monitoring due to low flow conditions.

Unnamed Creek (10170204-571)

From 2011-2013 a total of eight DO measurements were taken from Unnamed Creek at site 11MS113. These values ranged from 7.89-18.64 mg/L with no values under the 5 mg/L minimum standard (Table 52). The high value of 18.64 mg/L is of concern and may indicate problems associated with DO daily flux.

Table 52: Dissolved oxygen values from 2011-2013 at site 11MS113 along Unnamed Creek (10170204-571)

Sample Location	Sample Date and Time	Result (mg/l)	Daily Minimum Standard (mg/l)
11MS113	8/10/2011 3:01 PM	10.63	5
11MS113	8/16/2011 9:46 AM	7.89	5
11MS113	5/6/2013 3:10 PM	18.64	5
11MS113	5/21/2013 9:00 AM	10.5	5
11MS113	6/10/2013 12:15 PM	9.38	5
11MS113	7/1/2013 5:05 PM	8.91	5
11MS113	7/15/2013 12:45 PM	10.85	5
11MS113	8/19/2013 11:15 AM	8.19	5

The HSPF model calculated daily DO values for Unnamed Creek (10170204-571) from 1996-2009. These values ranged from 0-14.9 mg/L with an average value of 8.86 mg/L. Of these calculations, 15.46% were below the DO standard.

Biologically, the macroinvertebrate assemblage in Unnamed Creek had a higher amount of DO sensitive EPT taxa (25%), and few DO tolerant individuals (0.74%). The fish community had low amounts of sensitive fish taxa (10.53%) and late maturing fish species (5.26%), while also having a high amount of serial spawning species (36.84%) and tolerant fish taxa (68.42%). Site 11MS113 had an above average DO TIV score when compared to all other fish Class 3 sites.

Based on the observed values, the high amounts of EPT taxa, and the high DO TIV score at site 11MS113, low DO is not a stressor in Unnamed Creek at this time. Further DO monitoring with a sonde is recommended to better capture the daily flux conditions.

Unnamed Creek (10170204-572)

Unnamed Creek had eight DO measurements taken from 2011-2013. These values ranged from 7.48-20.03 mg/L with no values falling under the 5 mg/L standard. The extremely high value (20.03 mg/L) may potentially indicate a problem with DO flux (Table 53).

Table 53: Dissolved oxygen values from 2011-2013 at site 11MS083 along Unnamed Creek (10170204-572)

Sample Location	Sample Date and Time	Result (mg/l)	Daily Minimum Standard (mg/l)
11MS083	8/10/2011 7:50 AM	9.37	5
11MS083	8/10/2011 2:31 PM	8.7	5
11MS083	5/6/2013 3:20 PM	20.03	5
11MS083	5/21/2013 9:20 AM	10.63	5
11MS083	6/10/2013 12:00 PM	7.48	5
11MS083	7/1/2013 5:10 PM	7.79	5
11MS083	7/15/2013 12:30 PM	10.14	5
11MS083	8/19/2013 10:15 AM	8.77	5

The HSPF model calculated daily DO values for Unnamed Creek (10170204-572) from 1996-2009. These values ranged from 0-14.67 mg/L with an average value of 8.86 mg/L. Of these calculations, 25.35% were below the DO standard.

Biologically, the macroinvertebrate community in Unnamed Creek had a high amount of EPT taxa (28%), and a high number of DO intolerant species (4). The fish assemblage had a lower amount of serial spawning taxa (15.38%). These species are much more abundant in streams affected by low DO conditions. Unnamed Creek also had decreased sensitive fish taxa (7.69%), late maturing fish species (15.38%), and had an increased amount of tolerant taxa (53.85%). Site 11MS083 did have an above average DO TIV score when compared to all other fish Class 3 sites.

The biological results in Unnamed Creek (10170204-572) are fairly mixed. The high value measured on May 6, 2013, and the numerous model calculations below 5 mg/L may indicate problems with daily flux. Continuous DO monitoring with a sonde during base flow conditions is recommended to better understand the impacts, if any, that DO is having on the impaired macroinvertebrate community in Unnamed Creek.

Candidate cause: High phosphorus

The proposed draft standard for phosphorus for streams in the Missouri River basin is currently 0.15 mg/L. Although phosphorus is an essential nutrient for all aquatic life, elevated levels can lead to an imbalance which impacts stream ecology. In the town of Leota-Rock River Watershed phosphorus levels have exceeded this proposed standard multiple times.

Unnamed Creek (10170204-571)

From 2011-2013 a total of six phosphorus samples were taken from sampling location 11MS113 along Unnamed Creek. These values ranged from 0.014-0.176 mg/L with two of the samples above the 0.15 mg/L proposed draft standard for phosphorus (Table 54).

Table 54: Phosphorus sample values from 2011-2013 at site 11MS113 along Unnamed Creek (10170204-571)

Sample Location	Sample Date	Result (mg/l)	Proposed Draft Standard (mg/l)
11MS113	8/16/2011	0.086	0.15
11MS113	5/6/2013	0.014*	0.15
11MS113	6/10/2013	0.176	0.15
11MS113	7/1/2013	0.065	0.15
11MS113	7/15/2013	0.175	0.15
11MS113	8/19/2013	0.031	0.15

The HSPF model calculated daily phosphorus values for Unnamed Creek (10170204-571) from 1996-2009. These values ranged from 0.06-0.64 mg/L with an average value of 0.19 mg/L. Of these calculations, 60.64% were above the 0.15 mg/L proposed phosphorus standard.

Biologically, the macroinvertebrate community in Unnamed Creek completely lacked any intolerant taxa, while also having few Tanytarsini species (4.17%), high amounts of tolerant taxa (75%) and above average amounts of crustacean/mollusca (12.5%) and scraper species (12.5%). These results often reflect a community affected by elevated levels of phosphorus. This stream did also have a higher amount of phosphorus sensitive EPT taxa (25%). The fish assemblage in this stream had many tolerant taxa (68.42%), while also having decreased sensitive species (10.53%) and darter individuals (2.02%). These results are common in streams with high phosphorus values.

Figure 120: Algae build-up at 11MS113 along Unnamed Creek (10170204-571)

Based on the high number of observed and calculated exceedances, presence of algae (Figure 120), as well as the agreement with the majority of the related biological metrics, high phosphorus is a stressor to the impaired macroinvertebrate assemblage in Unnamed Creek.

Unnamed Creek (10170204-572)

From 2011-2013 a total of six phosphorus samples were taken from sampling location 11MS083 along Unnamed Creek. These values ranged from 0.125-0.374 mg/L with five of the samples above the 0.15 mg/L proposed draft standard for phosphorus (Table 55).

Table 55: Phosphorus sample values from 2011-2013 at site 11MS083 along Unnamed Creek (10170204-572)

Sample Location	Sample Date	Result (mg/l)	Proposed Draft Standard (mg/l)
11MS083	8/10/2011	0.332	0.15
11MS083	5/6/2013	0.125	0.15
11MS083	6/10/2013	0.374	0.15
11MS083	7/1/2013	0.172	0.15
11MS083	7/15/2013	0.163	0.15
11MS083	8/19/2013	0.161	0.15

* Average value of two samples

The HSPF model calculated daily phosphorus values for Unnamed Creek (10170204-571) from 1996-2009. These values ranged from 0.05-2.37 mg/L with an average value of 0.21 mg/L. Of these calculations, 64.59% were above the 0.15 mg/L proposed phosphorus standard.

Biologically, the macroinvertebrate population in Unnamed Creek had a high number of EPT taxa (28%), while also having a lower amount of crustacean/mollusca species (8%). These results are typical in streams unaffected by high phosphorus levels. However, this stream had few Tanytarsini species (4%), no intolerant taxa, while also having high amounts of scraper (20%) and tolerant taxa (68%). These results more accurately reflect the conditions in this stream. The fish assemblage at 11MS083 also had increased tolerant species (53.85%), while having few sensitive taxa (7.69%) and few darter individuals (1.98%).

Based on the high number of observed and calculated exceedances, as well as the agreement with the majority of the related biological metrics, high phosphorus is a stressor to the impaired macroinvertebrate assemblage in Unnamed Creek.

Candidate cause: High nitrates

Currently, the state of Minnesota does not have a nitrate standard in place for streams not used as a drinking water source. However, the overabundance of nitrates can stress a biological community. Nitrates in the town of Leota-Rock River Watershed did at times reach levels that could potentially be stressing the biological assemblages.

Unnamed Creek (10170204-571)
From 2011-2013 there were 6 nitrate samples taken from Unnamed Creek (Table 56). These nitrate value ranged from 12-29 mg/L (Table X). A quantile regression comparing nitrate values and macroinvertebrate IBIs showed that when a Class 5 site like 11MS113 has a nitrate value over 18.1 mg/L, there's a 90% chance it will be below the IBI threshold. Site 11MS113 had an average nitrate value of 18.67 mg/L.

Table 56: Nitrate sample values from 2011-2013 at site 11MS113 along Unnamed Creek (10170204-571)

Sample Location	Sample Date	Result (mg/l)	Nitrate Standard (mg/l)
11MS113	8/16/2011	15	n/a
11MS113	5/6/2013	12*	n/a
11MS113	6/10/2013	24	n/a
11MS113	7/1/2013	29	n/a
11MS113	7/15/2013	19	n/a
11MS113	8/19/2013	13	n/a

Biologically, the macroinvertebrate community in Unnamed Creek had a higher number of Trichoptera taxa (16.67%), but did also have a lower overall taxa count (17). The fish assemblage had a good taxa count (19), but also lacked many sensitive fish species (10.53%), which can be indicative of a stream potentially stressed by high amounts of nitrates.

With the very high nitrate data collected, along with the quantile regression analysis and agreement with many of the biological metrics, the elevated levels of nitrates are stressing the impaired macroinvertebrate community in Unnamed Creek.

Unnamed Creek (10170204-572)

Unnamed Creek had six nitrate samples taken from 2011-2013 at site 11MS113 (Table 57). These samples ranged from 1.2-28 mg/L while averaging 13.05 mg/L. As with site 11MS113, this site is a Class 5 macroinvertebrate site and according to a quantile regression of this category, with nitrate values above 18.1 mg/L there is a 90% chance that the IBI will fall below the impairment threshold.

Table 57: Nitrate sample values from 2011-2013 at site 11MS083 along Unnamed Creek (10170204-572)

Sample Location	Sample Date	Result (mg/l)	Nitrate Standard (mg/l)
11MS083	8/10/2011	1.2	n/a
11MS083	5/6/2013	7.8	n/a
11MS083	6/10/2013	19	n/a
11MS083	7/1/2013	28	n/a
11MS083	7/15/2013	13	n/a
11MS083	8/19/2013	9.3	n/a

Biologically, the macroinvertebrate community had a lower amount of Trichoptera taxa (12%) than Unnamed Creek (10170204-571) and still had a low overall amount of taxa (17). The fish assemblage also had a lower taxa count (13) than at site 11MS113, but it was still above the state average amount. This site did have even fewer amounts of sensitive fish species (7.69%)

With the very high nitrate data collected, along with the quantile regression analysis and agreement with many of the biological metrics, the elevated levels of nitrates are stressing the impaired macroinvertebrate community in Unnamed Creek.

Candidate cause: High turbidity/TSS

The water quality standard for turbidity is 25 NTU, 65 mg/L for TSS, and 20 cm for transparency tube for these Class 2B warmwater streams in this watershed. Excess sediment is a commonly recognized stressor in many biologically impaired streams because it can reduce habitat, cause direct physical harm, as well as reduce visibility and increase oxygen demand.

Unnamed Creek (10170204-571)

Unnamed Creek had six TSS samples taken from 2011-2013 at its biological monitoring station 11MS113, with sample values ranging from 5.6-170 mg/L (Table 58). Only one of these samples was above the 65 mg/L standard for TSS. Additionally, eight transparency/Secchi tube readings were taken during the same time period with one sample falling below the 20 cm minimum standard.

Table 58: TSS and Secchi tube values from 2011-2013 at site 11MS113 along Unnamed Creek (10170204-571).

Sample Location	Sample Date	TSS Result (mg/l)	TSS Standard (mg/l)	Secchi Tube Value (cm)	Secchi Tube Standard (cm)
11MS113	8/10/2011	n/a	65	41	20
11MS113	8/16/2011	10	65	51	20
11MS113	5/6/2013	7.4	65	>100	20
11MS113	5/21/2013	n/a	65	>100	20
11MS113	6/10/2013	8.4	65	61	20
11MS113	7/1/2013	18	65	46	20
11MS113	7/15/2013	170	65	7	20
11MS113	8/19/2013	5.6	65	66	20

The HSPF model calculated daily TSS for Unnamed Creek (10170204-571) from 1996-2009. These values ranged from 0-1235.8 mg/L with an average value of 19.74 mg/L. Of these calculations, 5.26% were above the 65 mg/L proposed standard for TSS.

Biologically, the macroinvertebrate community in Unnamed Creek had an increased amount of TSS tolerant individuals (75.09%), while also have a low taxa count (17), and few Ephemeroptera species (8.33%). This stream did have a higher amount of Trichoptera taxa (16.67%), and an above average amount of collector-filterer species (16.67%). Site 11MS113 did have an above average macroinvertebrate TSS TIV score when compared to all other macroinvertebrate Class 5 sites. These results are common in streams not affected by high turbidity/TSS levels. The fish assemblage at 11MS113 on Unnamed Creek had a high amount of herbivorous fish (15.79%), which tend to be less abundant in streams with excess TSS. A large amount of tolerant fish taxa (68.42%) was also present. The TSS TIV score for site 11MS113 was slightly above average when compared to all other Minnesota streams.

Based on the relatively low amount of observed and calculated exceedances along with the agreement of the majority of the related biological metrics, high turbidity/TSS is not a stressor to the impaired macroinvertebrate assemblage at this time.

Unnamed Creek (10170204-572)

Unnamed Creek had six TSS samples taken from 2011-2013 at site 11MS083. Sample values ranged from 6.4-180 mg/L with one of the samples above the 65 mg/L standard. Additionally, seven transparency/Secchi tube readings were taken during this time period. One of these transparency readings was below the 20 cm minimum standard (Table 59).

Table 59: TSS and Secchi tube values from 2011-2013 at site 11MS083 along Unnamed Creek (10170204-572)

Sample Location	Sample Date	TSS Result (mg/l)	TSS Standard (mg/l)	Secchi Tube Value (cm)	Secchi Tube Standard (cm)
11MS083	8/10/2011	180	65	7.5*	20
11MS083	5/6/2013	9.6	65	>100	20
11MS083	5/21/2013	n/a	65	>100	20
11MS083	6/10/2013	18	65	30	20
11MS083	7/1/2013	46	65	20.5	20
11MS083	7/15/2013	18	65	31	20
11MS083	8/19/2013	6.4	65	67	20

* Average value of two samples

The HSPF model calculated daily TSS for Unnamed Creek (10170204-572) from 1996-2009. These values ranged from 0-1196.6 mg/L with an average value of 27.92 mg/L. Of these calculations, 7.98% were above the 65 mg/L proposed standard for TSS.

Biologically, the macroinvertebrate assemblage in Unnamed Creek had many tolerant taxa (68%) and a below average amount of overall taxa (17). Site 11MS083 had an increased amount of TSS tolerant individuals (80.14%) and TSS tolerant taxa (7).This stream did have a higher amount of Ephemeroptera (16%), Trichoptera (12%), collector-filterer (16%) and scraper (20%) taxa. The fish community also had many tolerant species (53.85%) and had a slightly above average amount of herbivorous taxa (7.69%). Site 11MS083 had a below average TSS TIV score when compared to all other fish Class 3 sites.

TSS and transparency levels in Unnamed Creek can reach levels that exceed their respective standards. The higher amounts of Trichoptera, Ephemeroptera, collector-filterer, and scraper macroinvertebrates, as well as a higher amount of herbivorous fish species, signals that other stressors are likely causing the biological impairment in this reach.

Candidate cause: Lack of habitat

Qualitative habitat assessments were performed on the two biologically impaired reaches in the town of Leota-Rock River Watershed during the fish sampling visits at each site. Results of these assessments can be seen in Figure 121.

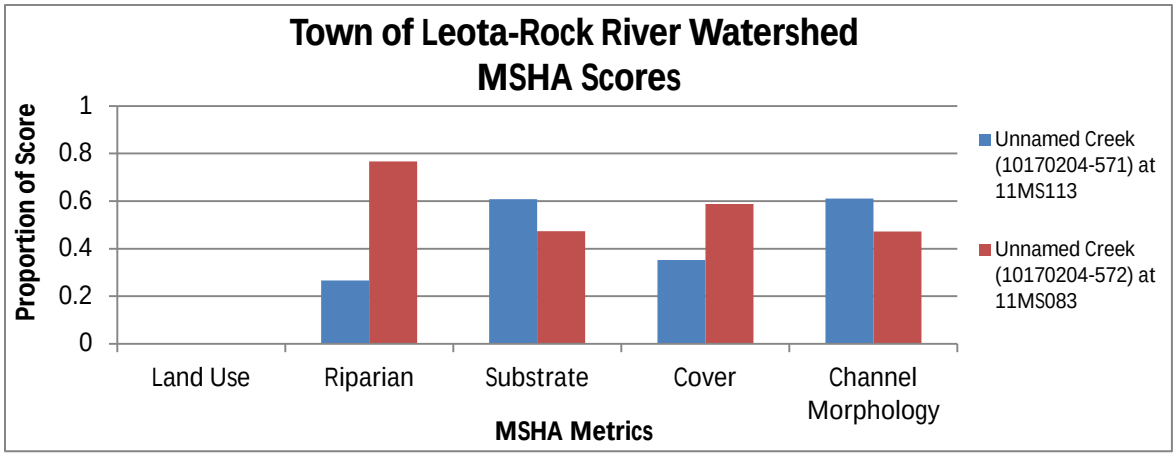

Figure 121: MSHA metric scores at two sites along reaches named Unnamed Creek

Unnamed Creek (10170204-571)

A qualitative habitat assessment was performed on Unnamed Creek during the fish sampling event at 11MS113. The MSHA score at this site was 48.4, which is considered to be fair. Limiting the MSHA score in this stream was the poor surrounding land use, the absence of a riparian buffer, moderate bank erosion (Figure 122), sparse fish cover, moderate channel stability, and fair sinuosity.

Biologically, the macroinvertebrate assemblage in Unnamed Creek had a high amount of clinger taxa (41.67%), while having few burrower individuals (3.25%). Clinger species tend to be less abundant in streams with degraded habitat conditions, while burrowers are more common when sand and silt substrates are present. There was also a very large amount of tolerant taxa (75%). The fish assemblage was also very tolerant (68.42% taxa), while having lower numbers of riffle dwelling (10.53%), benthic insectivore (15.79%), simple Lithophilic spawning (21.05%) and darter/sculpin/round-bodied sucker (10.53%) species. All of these metrics tend to score much lower in streams affected by poor habitat.

Figure 122: Bank erosion at 11MS113 along Unnamed Creek (10170204-571)

With the fair MSHA score and the overwhelmingly majority of habitat related biological metrics in agreement; the lack of habitat is a stressor to the impaired macroinvertebrate community in Unnamed Creek.

Unnamed Creek (10170204-572)

A qualitative habitat assessment was performed on Unnamed Creek during the fish sampling event at 11MS083. The MSHA score at this site was 51.3, which is considered to be fair. Limiting the MSHA score in this stream was the poor surrounding land use (Figure 123), a moderately narrow riparian buffer, many sand, silt, and clay substrates, moderate channel stability, and fair channel development.

Biologically, the macroinvertebrate community had a high amount of tolerant taxa (68%), but did also have a large number of Clinger species (44%) and few burrower individuals (5.83%). The fish assemblage had high amounts of benthic insectivore taxa (38.46%), darter/sculpin/round-bodied sucker species (30.77%), riffle dwelling species (23.08%) and simple Lithophilic spawning taxa (38.46%).

Despite the fair MSHA score, the majority of the habitat related biological metrics scored well. While the habitat in Unnamed Creek can certainly be improved, the lack of habitat does not appear to be stressing the impaired macroinvertebrate community at this time.

Figure 123: Surrounding land use at 11MS083 along Unnamed Creek (10170204-572)

Conclusion

In the town of Leota-Rock River Watershed, numerous stressors exist in the two biologically impaired reaches (Table 60).

High phosphorus was found to be a stressor at both reaches as levels frequently exceeded the proposed standard. Excessive algae growth was documented, which could lead to the eutrophication of the stream. This excess phosphorus is a likely result from the highly pastured riparian areas and cropland throughout the watershed where concentrations of phosphorus tend to be high. Runoff following rain events is a likely pathway for these phosphorus contributions to easily enter the stream system.

High nitrate values were also found to be a stressor to the biological assemblages at both impaired reaches. Nitrate levels in excess of 28 mg/L were observed in both reaches, with many high values also sampled and predicted by the HSPF model. High percentages of nitrate tolerant individual macroinvertebrates were present, which can often signal impairment. These reaches also lacked diversity. The high levels of nitrates are likely a result from fertilizer applications and have entered the stream as runoff.

High turbidity/TSS was determined to be a stressor to the impaired macroinvertebrate assemblage in Unnamed Creek (10170204-572). This reach had measurements exceeding the standard, as well as an overwhelming biological response to stress from this parameter. High intensity grazing with minimal riparian buffers and other poor land use practices in the watershed have led to unstable and erosive banks causing excess sediment to reach the stream. Limiting these activities will be imperative to improving the suspended sediment conditions present in this reach.

The lack of habitat was also found to be a stress at site 11MS113 in Unnamed Creek (10170204-571) as it had poor surrounding land use, the absence of a riparian buffer, moderate bank erosion, sparse fish cover, moderate channel stability, and fair sinuosity. Improving these conditions will help eliminate the stress experienced by the fish and macroinvertebrate communities.

Overall, significant changes need to be made in this watershed. High priorities must be given to controlling the amount of nutrients and sediment reaching the waterways. Until some of these issues are addressed, the macroinvertebrate assemblage will remain impaired.

Table 60: Stressors to the biologically impaired reaches within the Rock River Watershed

		Stressors				
Stream Name	**AUID #**	**Low Dissolved Oxygen**	**High Phosphorus**	**High Nitrates**	**High Turbidity/ TSS**	**Lack of Habitat**
Town of Leota-Rock River Watershed						
Unnamed Creek	Unnamed Creek	Unnamed Creek	Unnamed Creek	Unnamed Creek	Unnamed Creek	Unnamed Creek
Unnamed Creek	Unnamed Creek	Unnamed Creek	Unnamed Creek	Unnamed Creek	Unnamed Creek	Unnamed Creek

(• = stressor, - = not a stressor, and blank = inconclusive/not enough evidence)

Upper Rock River

Overview

The upper Rock River flows through four different 12-digit HUC watersheds in the central and northern parts of the Rock River Watershed with the Missouri River basin. This section includes the two biologically impaired AUIDs (10170204-506 and 10170204-504) along this upper section of the Rock River (Figure 124). The land use in these subwatersheds is predominantly cropland (76.98%), followed by rangeland (15.86%) and developed land (5.31%).

Rock River (10170204-506) is a 15.7 mile long AUID that is located between the confluences with Unnamed Creek and Poplar Creek. This reach was sampled for fish and macroinvertebrates in 2004, 2011, and 2012 at its biological monitoring stations 04MS032 and 11MS114. This reach was determined to be impaired for aquatic life due to its fish and macroinvertebrate assemblages during the watershed assessment in 2013. This reach is also impaired for turbidity.

Rock River (10170204-504) is a 31.77 mile long stream reach that runs from the confluence with Chanarambie Creek upstream to T107 R44W S30 east line. This stream reach has six biological monitoring stations (11MS116, 11MS147, 11MS011, 04MS009, 04MS010, and 04MS051) that were sampled at various times in 2004, 2011, or 2012. This reach was determined to be impaired for aquatic life due to its fish and macroinvertebrate assemblages during the watershed assessment in 2013. This reach is also impaired for turbidity.

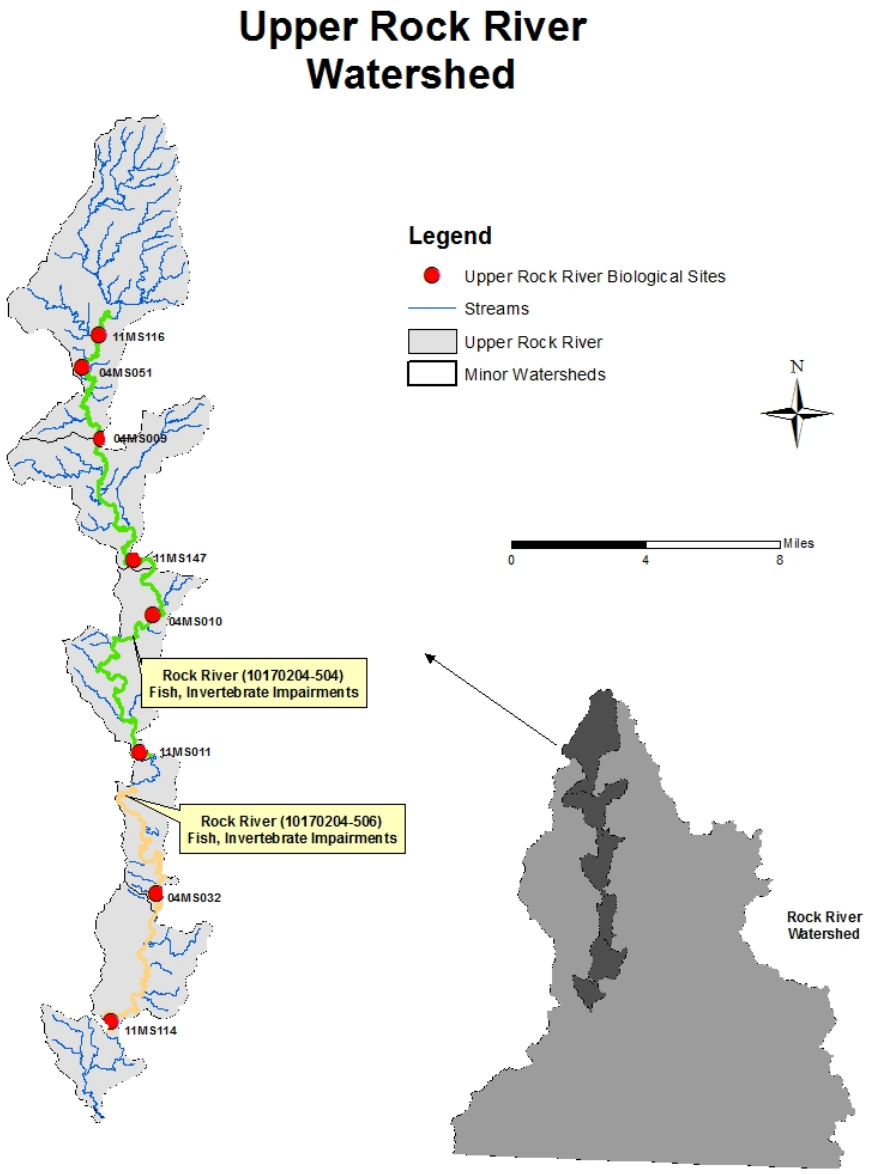

Figure 124: Upper Rock River Watershed with biologically impaired reaches highlighted

Biology in the Upper Rock River

Fish

The two biologically impaired reaches along the upper Rock River area had a total of eight biological monitoring stations. On the most downstream reach, Rock River (10170204-506), there were two stations. Site 11MS114 is located upstream of 175th Street, 2.5 miles southeast of Hardwick and was sampled for fish on June 18, 2012. Further upstream, site 04MS032 is downstream of CR 21, 4 miles northeast of Kenneth and was sampled on July 22, 2004. Along Rock River (10170204-504), site 11MS011 is located upstream of 105th Avenue, 1 mile south of Edgerton and was sampled for fish on June 13, 2012. Moving upstream along this reach is 04MS010 which is downstream of CR 2, 2.1 miles north of Edgerton and had a fish sampling event occur on July 13, 2004. Site 11MS147 is located upstream of 160th Ave, 3 miles southeast of Hatfield and was sampled on August 10, 2011. Site 04MS009 is downstream of SR 30, 7 miles east of Pipestone and was sampled on July 7, 2004, August 17, 2004, and again on August 9, 2011. Moving

upstream is site 04MS051 which is located 6 miles east northeast of Pipestone in a wildlife management area (WMA) and was sampled on July 7, 2004. Lastly, site 11MS116 is located upstream of CSAH 6, 3 miles northwest of Woodstock and was sampled on August 30, 2011.

Five sites in the upper Rock River area have a fish Class 2 (Southern Streams) designation (Figure 125). The IBI threshold for this class is 45 and to reach this level, each metric would need an average score of 5.625. Rock River (10170204-506) had an average fish IBI score of 33 at sites 04MS032 and 11MS114. This reach had good numbers of benthic insectivore species excluding tolerant taxa (BenInsect-TolxPct), detritivorous taxa (DetNWQTxPct) and was not dominated by the two most abundant species (DomTwoPct). Rock River (10170204-504) had an average fish IBI score of 36.75 between its Class 2 sites (04MS010, 11MS011, 11MS147). This reach scored well in the same metrics as the reach downstream, but did have fewer tolerant taxa (TolTxPct) resulting in a higher metric score. This reach scored poorly in the remaining four metrics.

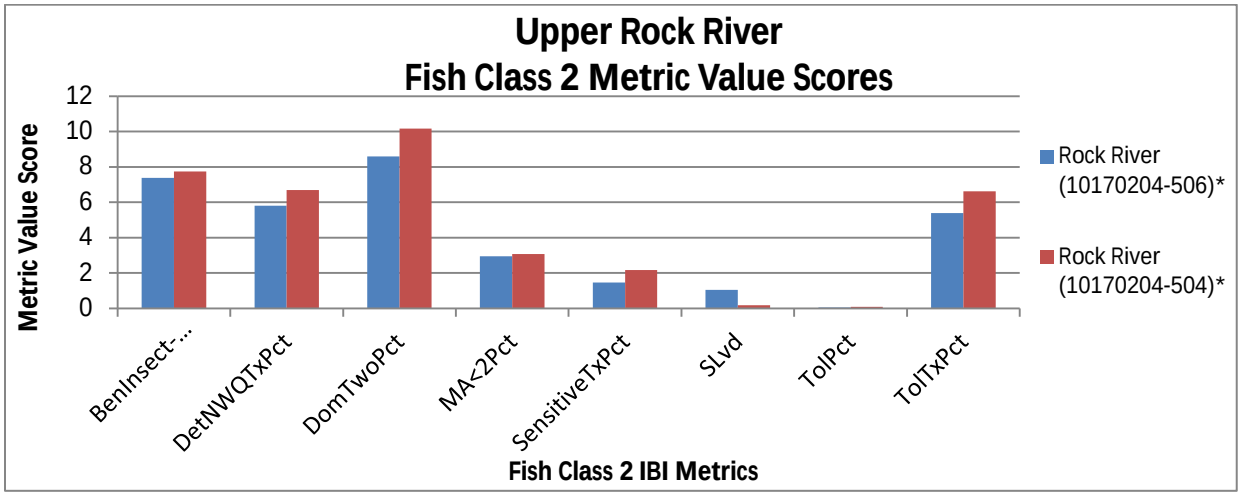

Figure 125: Fish Class 2 IBI metric value scores in the Upper Rock River Watershed

Two sites (04MS051, 11MS116) along Rock River (10170204-504) have a fish Class 3 (Southern Headwaters) designation. The IBI threshold for this class is 51 and each metric would need an average score of 8.5 to reach this level. The average IBI score of the two sites was 47.09. This reach had few sensitive taxa (Sensitive), many very tolerant taxa (VtolTxPct), and a high amount of detritivorous species. Additionally, site 04MS051 had a fish community that contained DELTs (Deformities, Eroded Fins, Lesions, Tumors) and was deducted five points from its IBI score. The other remaining fish IBI metrics had metric value scores above the average needed to attain the threshold (Figure 126).

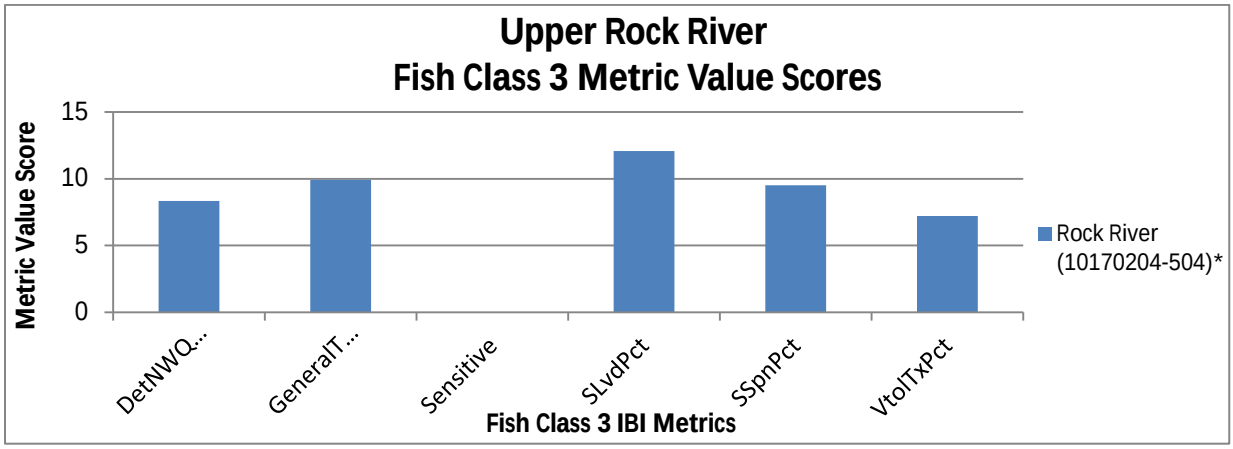

Figure 126: Fish Class 3 IBI metric value scores in the Upper Rock River Watershed
*Average Metric Value Score of Sites (04MS051, 11MS116)

Macroinvertebrates

Site 11MS114 along Rock River (10170204-506) had a macroinvertebrate sample taken on August 8, 2011 while the other site along this reach, 04MS032) was sampled on August 31, 2004. Site 11MS011 along Rock River (10170204-504) was sampled for macroinvertebrates on August 9, 2011. Site 04MS010 was sampled for macroinvertebrates on September 2, 2004 and site 11MS147 was sampled on August 3, 2011. Site 04MS009 was sampled on September 1, 2004 and again on August 9, 2011 while the most upstream site, 11MS116, had a macroinvertebrate sample taken on August 2, 2011.

Five sites in the upper Rock River have a macroinvertebrate Class 5 (Southern Streams RR) designation. To reach the impairment threshold of 35.9, each metric would need a metric value score of 3.59. Rock River (10170204-506) had an average IBI score of 22.74 at sites 04MS032 and 11MS114. This site had good numbers of clinger taxa (CliongerChTxPct), which are taxa that have adapted to cling to substrate in swift flowing water. This reach also had high numbers of insect taxa (InsectTxPct) and odonata taxa (Odonata), while scoring poorly in the remaining IBI metrics in this class. Rock River (10170204-504) had an average IBI score of 26.08. This AUID was fairly diverse and not dominated by the five most abundant taxa (DomFiveCHPct), and had good numbers of clinger and odonata taxa (Figure 127).

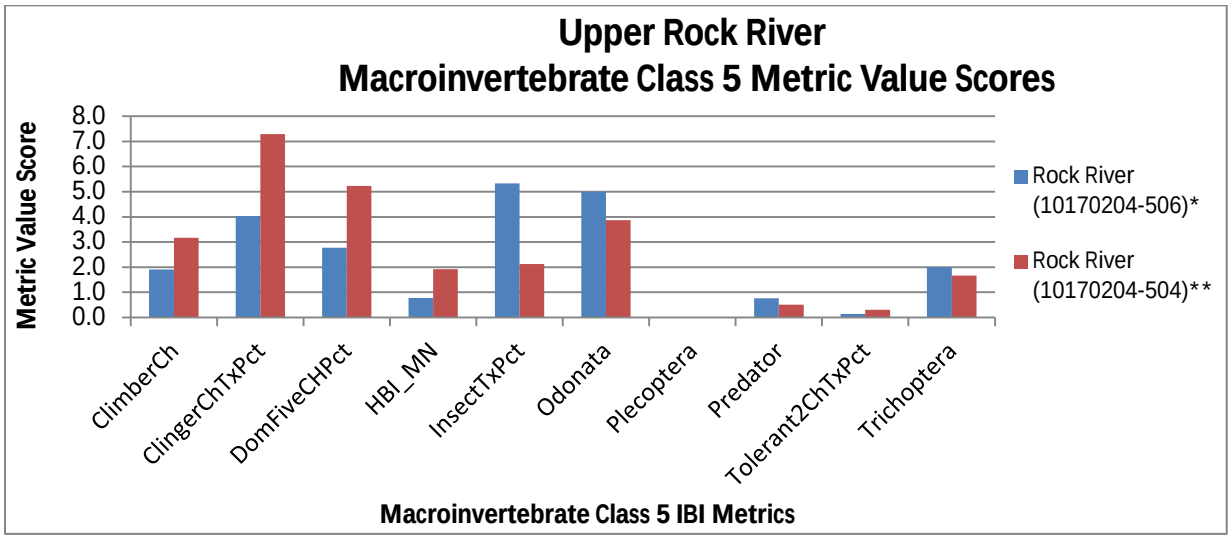

Figure 127: Macroinvertebrate Class 5 IBI metric value scores from the Upper Rock River Watershed.
*Average Metric Value scores from sites (04MS032, 11MS114)
** Average Metric Value scores from sites (04MS009, 04MS010, 11MS011)

The MIBI threshold for a Class 7 (Prairie Streams GP) site is 38.3 and an average metric score of 3.83 is needed to reach this level. Rock (10170204-504) had an average IBI score of 29.09 at its three Class 7 biological monitoring sites, 04MS051, 11MS116, and 11MS147. This AUID had good numbers of Clinger taxa (ClingerCh) and Plecoptera, Odonata, Ephemeroptera, and Trichoptera (POET) taxa. This reach scored poorly in the remaining metrics (Figure 128).

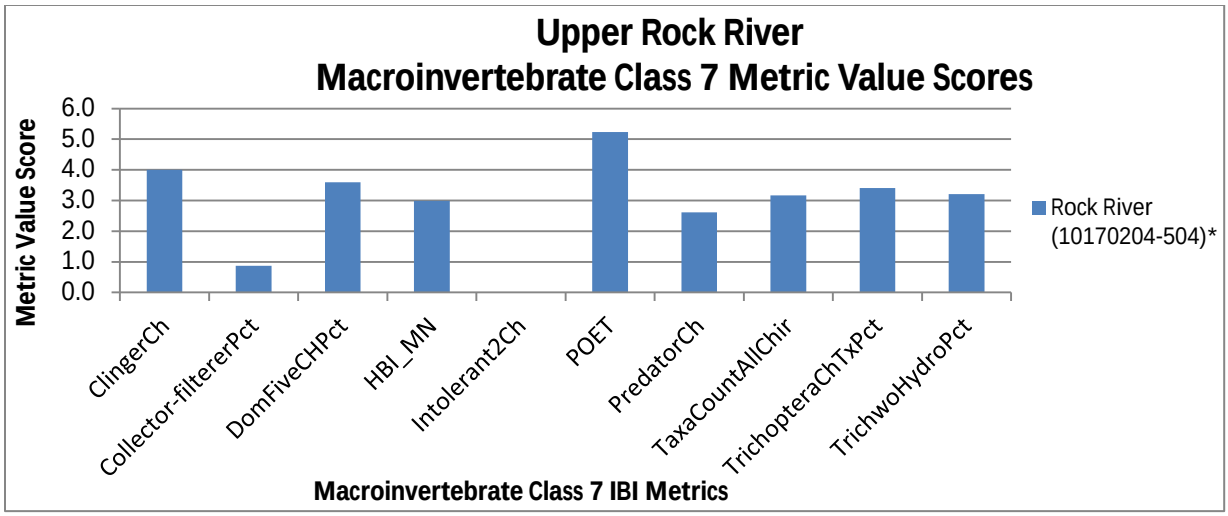

Figure 128: Macroinvertebrate Class 7 IBI metric value scores in the Upper Rock River Watershed
*Average Metric Value Scores of sites (04MS051, 11MS116, 11MS147)

Candidate cause: Low dissolved oxygen

The daily minimum standard for DO in Minnesota Class 2B streams is 5 mg/L. All streams along the Lower Rock River have this 2B classification. No streams in this grouping are currently listed as impaired for DO.

Rock River (10170204-506)
From 2004-2013, 49 DO measurements were taken from this portion of the Rock River. These values ranged from 6.15-16.25 with no values falling below the 5 mg/L daily minimum standard. The wide range of values may potentially indicate problems with DO flux.

The HSPF model calculated daily DO values for this section of the Rock River from 1996-2009. These values ranged from 4.04-14.21 mg/L with an average value of 1 mg/L. Of these calculations, 0.04% was below the DO standard.

Biologically, the macroinvertebrate community had a high amount of EPT taxa (41.35%), DO intolerant species (5.5 average per site) as well as a low percentage of DO tolerant individuals (3.68%). The fish assemblage in this section of the Rock River had many serial spawning species (39.72%) which can signal problems with DO. This stream also had an average amount of late maturing species (21.11%), few sensitive taxa (5.28%), and an increased amount of tolerant species (60.28%). The biological stations along this portion of the Rock River had above average DO TIV scores when compared to their respective classes.

With no observed measurements below 5 mg/L, very few calculated exceedances, along with the agreement of the majority of the related biological metrics, low DO is not a stressor to the impaired biological communities in this reach of the Rock River at this time.

Rock River (10170204-504)
From 2004-2013, 110 DO readings were taken along Rock River (10170204-504). These measurements ranged from 5.53-14.21 mg/L.

Biologically, the macroinvertebrate assemblage along this lengthy section of the Rock River also had a high amount of EPT taxa (36.28%) and a slightly below average amount of overall taxa (22.67) when compared to all other streams in Minnesota. The sites along this reach averaged 5 DO intolerant species and also had a low amount of DO tolerant individuals (10.05%). The fish community had low amounts of

sensitive taxa (5.24%) and late maturing fish species (15.7%), while also having many serial spawning (34.35%) and tolerant (57.28%) taxa. The biological sites along this reach had an above average DO TIV score when compared to all other Minnesota streams.

This section of the Rock River did not have any observed values below the 5 mg/L standard. The majority of the biological metrics are in agreement that low DO is not a stressor to the impaired fish and macroinvertebrate assemblages.

Candidate cause: High phosphorus

The proposed draft standard for phosphorus for streams in the Missouri River basin is currently 0.15 mg/L. Although phosphorus is an essential nutrient for all aquatic life, elevated levels can lead to an imbalance which impacts stream ecology. In the upper Rock River, phosphorus levels have exceeded this proposed standard multiple times.

Rock River (10170204-506)
From 2004-2013 there were 47 phosphorus samples collected along this AUID of the Rock River. These values ranged from 0.016-0.791 mg/L with 14 samples above the 0.15 mg/L proposed draft standard for phosphorus (Figure 129).

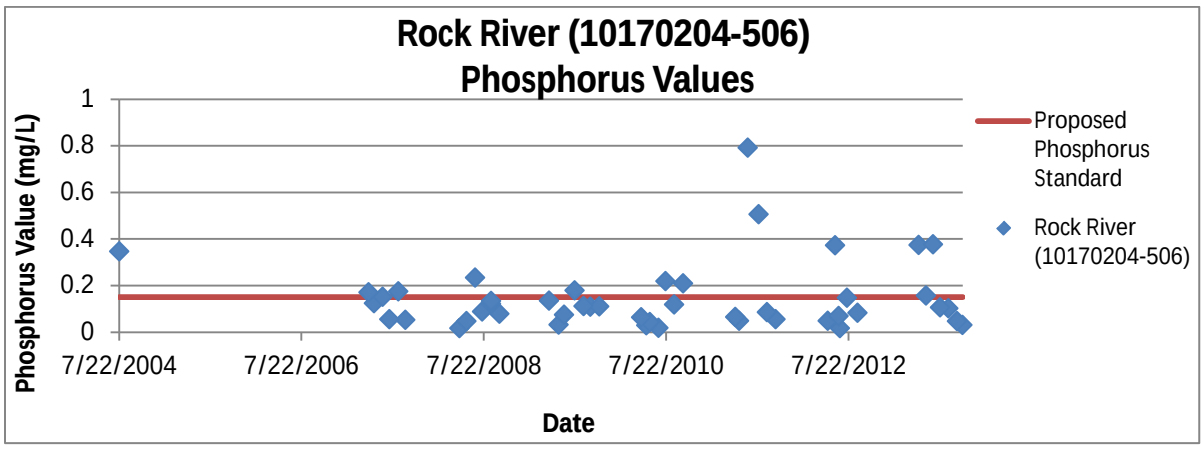

Figure 129: Phosphorus sample values from 2004-2013 along Rock River (10170204-506)

Biologically, the macroinvertebrate community had an increased amount of EPT taxa (41.35%), intolerant species (16.03%), while also having few crustacean/mollusca (8.81%) and scraper (14.74%) taxa. These results are common in streams not affected by excess phosphorus. This stream did also have few Tanytarsini species (6.73%), which tend to be low in streams with high phosphorus levels. Increased tolerant macroinvertebrate taxa (50.16%) were also sampled. The fish assemblage had few sensitive species (5.28%), darter individuals (0.87%), and many tolerant taxa (60.28%), which is typical in streams with high phosphorus levels.

Based on the high exceedance rate of the observed values along with the majority of the related biological metrics, high phosphorus is a stressor to the impaired fish assemblage in this section of the Rock River.

Rock River (10170204-504)
From 2004-2013 a total of 64 phosphorus samples were taken from this AUID of the Rock River. These values ranged from 0.01-1.95 mg/L with 29 of the values above the 0.15 mg/L proposed draft standard for phosphorus. Figure 130 displays the phosphorus values from 2011-2013.

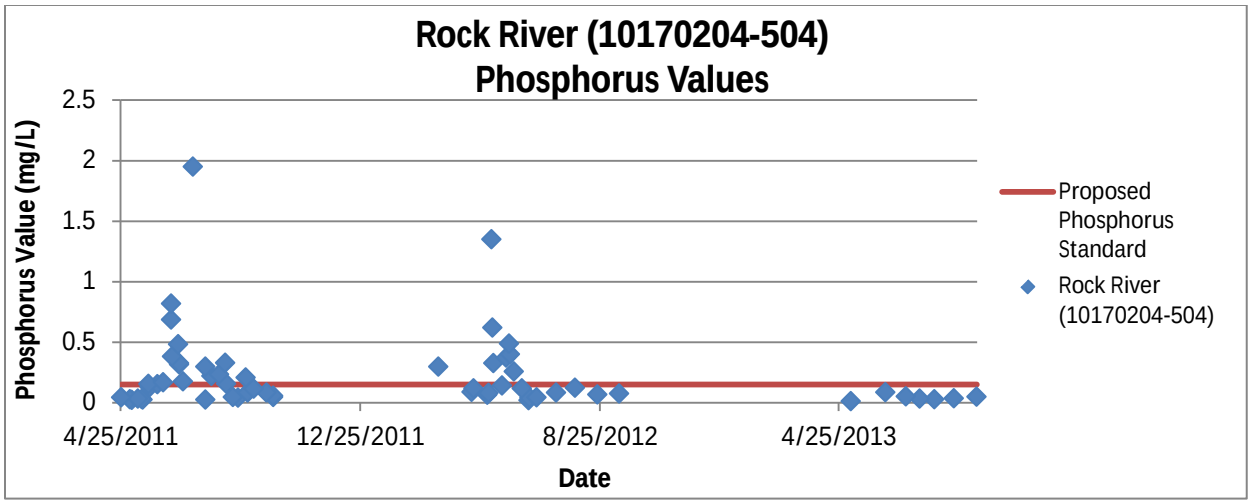

Figure 130: Phosphorus sample values from 2011-2013 along Rock River (10170204-504)

Biologically, the macroinvertebrate community in this reach of the Rock River showed good numbers of EPT taxa (36.28%) and intolerant species (13.28%). This reach also had few Tanytarsini species (4.25%) and high numbers of crustacean/mollusca (14.48%), and scraper (17.87%) taxa, which is typical of streams affected by elevated phosphorus levels. The fish assemblage also had few sensitive taxa (5.24%), darter individuals (4.12%) and many tolerant species (57.28%).

The high exceedance rate (45.31%) of the proposed phosphorus standard, many poor scoring biological metrics related to phosphorus, along with the wide ranging DO readings suggest that high phosphorus is having a negative impact on the biotic communities in this section of the Rock River and therefore is a stressor to the impaired fish and macroinvertebrate assemblages.

Candidate cause: High nitrates

Currently, the state of Minnesota does not have a nitrate standard in place for streams not used as a drinking water source. However, the overabundance of nitrates can stress a biological community. Nitrates in the upper Rock River Watershed did at times reach levels that could potentially be stressing the biological assemblages.

Rock River (10170204-506)
From 2004-2013 a total of 47 nitrate samples were taken from this portion of the Rock River. These nitrate values ranged from 0.2-8.06 mg/L (Figure 131).

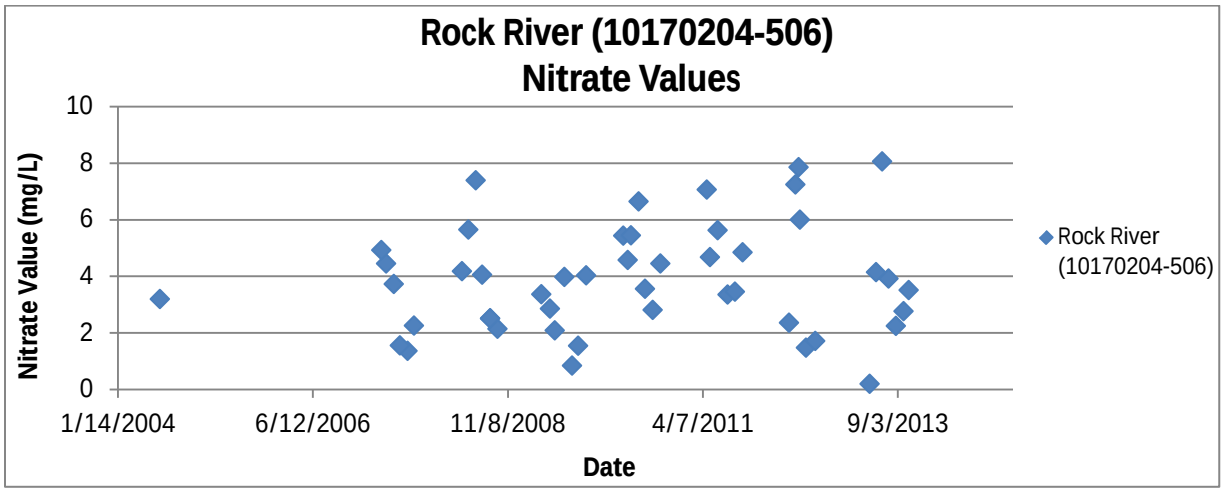

Figure 131: Nitrate sample values from 2004-2013 along Rock River (10170204-506)

Biologically, the macroinvertebrate community in this portion of the Rock River had a lower overall taxa count (21) yet did have good numbers of Trichoptera taxa (12.66%) present. Sites 04MS032 and 11MS114 had an average of 81.3% of nitrate tolerant individual taxa present. Quantile regression analysis showed that streams with greater than 78.22% nitrate tolerant individual taxa have a greater than 75% probability of being impaired for macroinvertebrates. The fish assemblage in this reach had many taxa species (19), but contained very few sensitive taxa (5.28%).

The high presence of nitrate tolerant individuals, elevated nitrate values, along with some of the poor scoring biological metrics makes elevated nitrates a stressor to the impaired biological communities in this portion of the Rock River.

Rock River (10170204-504)
From 2004-2013 a total of 64 nitrate samples were taken from this reach of the Rock River. These values ranged from 0.73-9.8 mg/L (Figure 132).

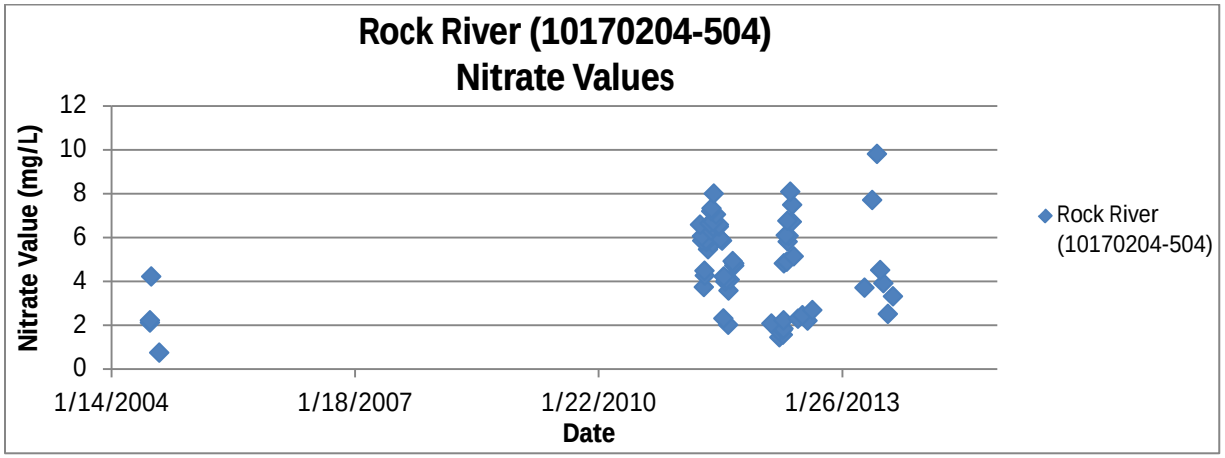

Figure 132: Nitrate sample values from 2004-2013 along Rock River (10170204-504)

Biologically, the macroinvertebrate assemblage in this reach of the Rock River had a lower overall taxa count (22.67) and few Trichoptera taxa (8.48%). These numbers are typically much higher in streams not experiencing high nitrate levels. Sites 11MS011 and 11MS147 averaged 91.58% of nitrate tolerant individual taxa and quantile regression analysis showed that these sites have a greater than 90% probability of being impaired. The remaining sites averaged 65.17% of nitrate tolerant taxa and have greater than 50% probability of being impaired.

The high presence of nitrate tolerant individuals, elevated nitrate values, along with some of the poor scoring biological metrics makes elevated nitrates a stressor to the impaired biological communities in this portion of the Rock River.

Candidate cause: High turbidity/TSS

The water quality standard for turbidity is 25 NTU, 65 mg/L for TSS, and 20 cm for transparency tube for these portions of the upper Rock River. Excess sediment is a commonly recognized stressor in many biologically impaired streams because it can reduce habitat, cause direct physical harm, as well as reduce visibility and increase oxygen demand.

Both of the reaches along this upper section of the Rock River were determined to be impaired for aquatic life due to turbidity in addition to their biological assemblages.

Rock River (10170204-506)
From 2004-2013 a total of 44 TSS samples were taken from this reach of the Rock River. These values ranged from 1.6-266 mg/L with eight values over the 65 mg/L TSS standard. Additionally, 48 Secchi/transparency tube measurements were taken along this AUID from 2007-2013. These values ranged from 6-57 cm with 19 readings below the 20 cm minimum standard.

The macroinvertebrate community in this portion of the upper Rock River had good numbers of Trichoptera (12.66%), collector-filterer (16.03%), and Ephemeroptera (28.69%) taxa, but also had a lower overall taxa count (21) and had increased tolerant taxa (50.16%). The fish assemblage in this reach had decreased herbivorous fish species (7.78%) and increased tolerant taxa (60.28%).

The current turbidity impairment along with many poor scoring TSS/transparency biological metrics makes this parameter a stressor to the impaired fish community in this part of the Rock River.

Rock River (10170204-504)
From 2004-2013 a total of 103 TSS samples were taken from this AUID of the Rock River. These values ranged from 2-1450 mg/L with 21 (20.4%) of the samples above the 65 mg/L proposed draft standard for TSS. Additionally, 179 transparency/Secchi tube readings were taken from 2004-2013. These values ranged from 3-100 cm with 60 readings below the 20 cm minimum standard. These results led to this reach being impaired for turbidity during the watershed assessment in 2013.

Biologically, the macroinvertebrate community in Rock River (10170204-504) had good numbers of Ephemeroptera taxa (27.79%), but did have few collector-filterer (10.11%) and Trichoptera (8.48%) species. The biological sites along this reach averaged 12.5 TSS tolerant species and had relatively few overall taxa (22.67) present. The fish assemblage in this reach had very few herbivorous species (5.13%) and increased tolerant species (57.28%).

The current turbidity impairment along with many poor scoring TSS/Transparency biological metrics makes this parameter a stressor to the impaired biological communities in this part of the Rock River.

Candidate cause: Lack of habitat

Qualitative habitat assessments were performed on the two biologically impaired reaches along the Upper Rock River during the fish sampling visits at each site. Results of these assessments can be seen in Figure 133.

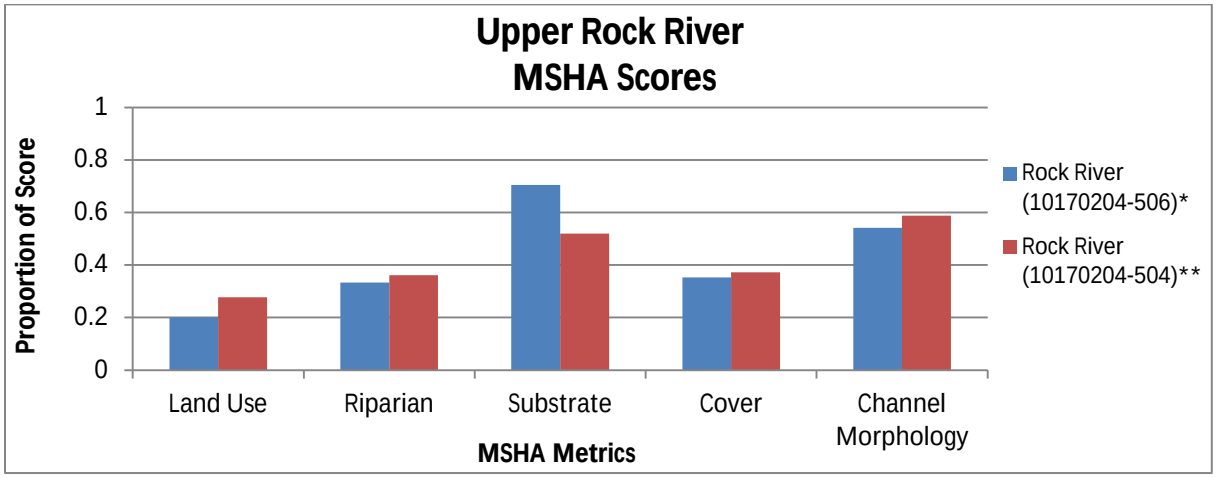

Figure 133: MSHA Metric scores from the two biologically impaired reaches in the Upper Rock River Watershed
*Average MSHA metric scores at sites 04MS032 and 11MS114
**Average MSHA metric scores at sites (11MS116, 11MS147 and 11MS011, 04MS009, 04MS010. 04MS051)

Rock River (10170204-506)
This portion of the Rock River had two qualitative habitat assessments performed during the fish sampling events at sites 04MS032 and 11MS114 (Figure X). These sites had an average MSHA score of 50.53 which is considered to be fair. Limiting the MSHA score at these sites were poor surrounding land use, minimal riparian buffer, some eroded banks, sparse fish cover, moderate channel stability, moderate channel development, and limited depth variability.

Biologically, the macroinvertebrate community in this reach of the Rock River had an average amount of clinger taxa (30.45%) when compared to all other streams in Minnesota. This AUID also had many tolerant species (50.16%). Site 04MS032 had an increased amount of burrower individuals (12.62%), which can often indicate higher levels of fine sediment. The fish assemblage showed good numbers of benthic insectivore (28.89%) and riffle dwelling (21.11%) species. This reach also had low numbers of simple lithophilic spawning (18.33%) and darter/sculpin/round-bodied sucker (13.06%) species while having increased tolerant taxa (60.28%).

The fair MSHA scores between the two sites along this AUID along with many poorly scoring habitat related metrics makes the lack of habitat a stressor to the impaired biological assemblages in this reach of the Rock River.

Rock River (10170204-504)
This portion of the Rock River had a total of eight habitat assessments performed during the fish sampling events at sites 11MS116, 11MS147 and 11MS011, 04MS009, 04MS010, and 04MS051. The average MSHA score of these sites was 48.35 which is considered to be fair. Limiting the habitat scores at these sites were the poor surrounding land use, narrow riparian corridor, bank erosion, sparse fish cover, low to moderate channel stability, fair channel development, and limited depth variability.

Biologically, the macroinvertebrate population in this stream had slightly improved numbers of clinger taxa (31.97%) than the reach immediately downstream. This AUID did also have an increased amount of tolerant taxa (62.19%). The macroinvertebrate community at the biological sites along this reach did have a lower amount of burrower individuals (7.65%) when compared to all other Minnesota streams. Site 04MS051 had a much higher amount of burrower individuals (27.14%) than the other sites.The fish assemblage in this reach had good numbers of benthic insectivore species (26.64%), but also had few riffle-dwelling (14.99%), and simple lithophilic spawning (17.38%) species. This reach also had many tolerant fish taxa (57.28%).

The fair MSHA scores between the two sites along this AUID along with many poorly scoring habitat related metrics makes the lack of habitat a stressor to the impaired biological assemblages in this reach of the Rock River.

Conclusion

The two biologically impaired reaches in the Upper Rock River Watershed are being negatively impacted by multiple stressors (Table 61).

High phosphorus was determined to be a stressor to the fish and macroinvertebrate communities in both impaired reaches along the Upper Rock River. The excess phosphorus in these reaches is a likely result from the highly pastured riparian areas and cropland throughout the watershed where concentrations of phosphorus tend to be high. Runoff following rain events is a likely pathway for these phosphorus contributions to easily enter the stream system. Increased prolonged periods of high phosphorus may lead to DO problems along these reaches as well.

High nitrates were also found to be a stressor to the biological assemblages in both of the impaired reaches. Nitrate levels in excess of 9.8 mg/L were observed in Rock River (10170204-504), with many elevated levels also measured in these reaches. Few nitrate sensitive Trichoptera taxa were present, but

high percentages of nitrate tolerant individual macroinvertebrates were, which often signals impairment. The high levels of nitrates are likely a result from fertilizer applications and have entered the stream as runoff.

Both reaches of the Rock River within this watershed are impaired for turbidity. High turbidity/TSS was also determined to be a stressor to the biological assemblages. High intensity grazing with minimal riparian buffers in the watershed has led to unstable and erosive banks. Numerous watershed and basin-wide activities (Figure 12) are needed to reduce the issue of elevated turbidity/TSS levels and poor transparency in the Rock River to eliminate this parameter as a stressor to the biological communities.

The lack of habitat was found to be a stressor in both reaches as well. These stream sections had poor surrounding land use, eroded banks, sparse fish cover, low channel stability, and limited depth variability. Improving these conditions will help eliminate the stress experienced by the fish and macroinvertebrate communities.

These reaches along the upper portion of the Rock River have stressors to the biological communities. Addressing these stressors is needed to restore the biological communities to a healthy condition. Until this is done, the fish and macroinvertebrate communities will remain impaired.

Table 61: Stressors to the biologically impaired reaches within the Rock River Watershed

		Stressors				
Stream Name	**AUID #**	**Low Dissolved Oxygen**	**High Phosphorus**	**High Nitrates**	**High Turbidity/ TSS**	**Lack of Habitat**
Upper Rock River Watershed						
Rock River	10170204-506	-	•	•	•	•
Rock River	10170204-504	-	•	•	•	•

(• = stressor, - = not a stressor, and blank = inconclusive/not enough evidence)

City of Edgerton-Rock River Watershed

Overview

Located in the northern part of the Rock River Watershed, the city of Edgerton-Rock River 12-Digit HUC watershed drains an area of 56.41 mi2. The watershed contains one biologically impaired stream reach within its boundaries (Figure 134), Unnamed Creek (10170204-593). The land use in this watershed consists of cropland (76.94%), rangeland (15.89%) and developed (5.82%).

Unnamed Creek (10170204-593) is a 0.13 mile long AUID extending from Unnamed Creek to T106 R45W S25, south line. This stream was sampled for fish in 2012 and macroinvertebrates in 2011 at its lone biological monitoring station 11MS138. This AUID was determined to be impaired for aquatic lie due to its fish and macroinvertebrate assemblage during the watershed assessment in 2013.

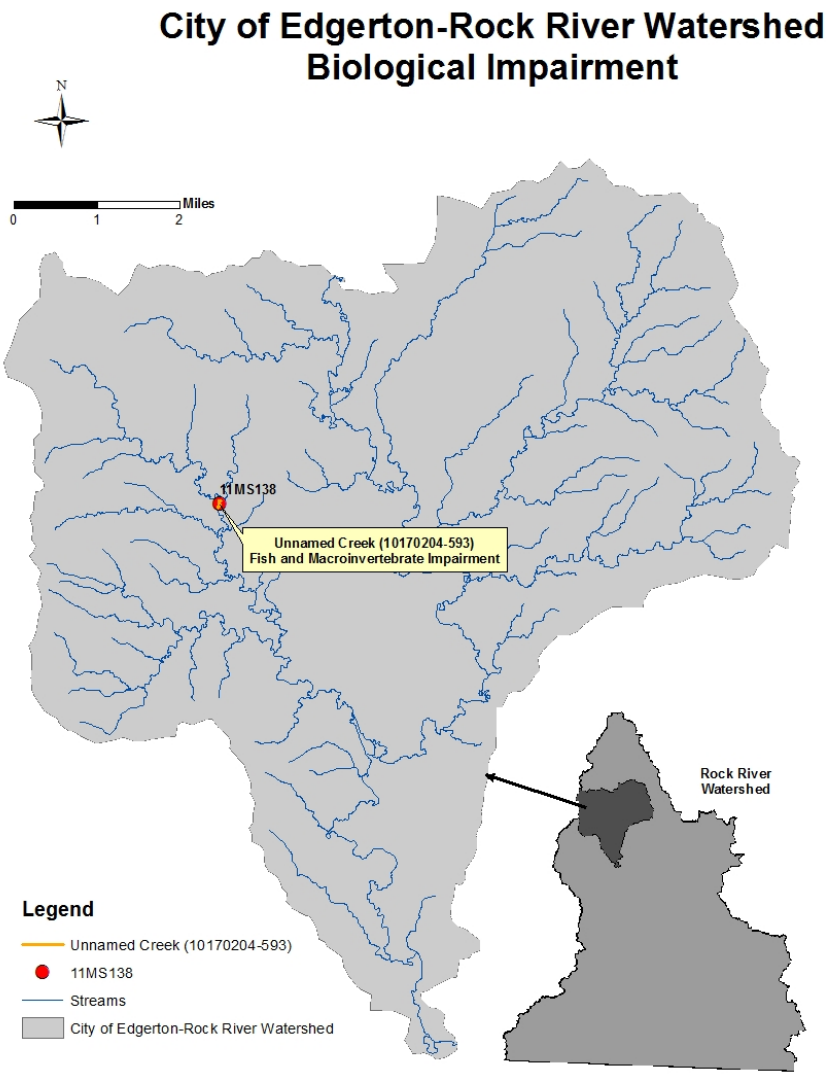

Figure 134: Town of Leota-Rock River Watershed with biologically impaired reaches highlighted

Biology in city of Edgerton-Rock River Watershed

Fish

The biologically impaired reach in the city of Edgerton-Rock River Watershed had just one biological monitoring station. On Unnamed Creek (10170204-593), the lone station, 11MS138, is located upstream of 71st Street, a half mile south of Hatfield and was sampled for fish on June 12, 2012.

This site has a fish Class 3 (Southern Headwaters) designation. The fish IBI score at 11MS138 was 15.7. This score is well below the IBI threshold (51) for a Class 3 site. To reach this threshold, each metric would need an average score of 8.5 (Figure 135). All fish metrics scored well below the score needed to reach the threshold.

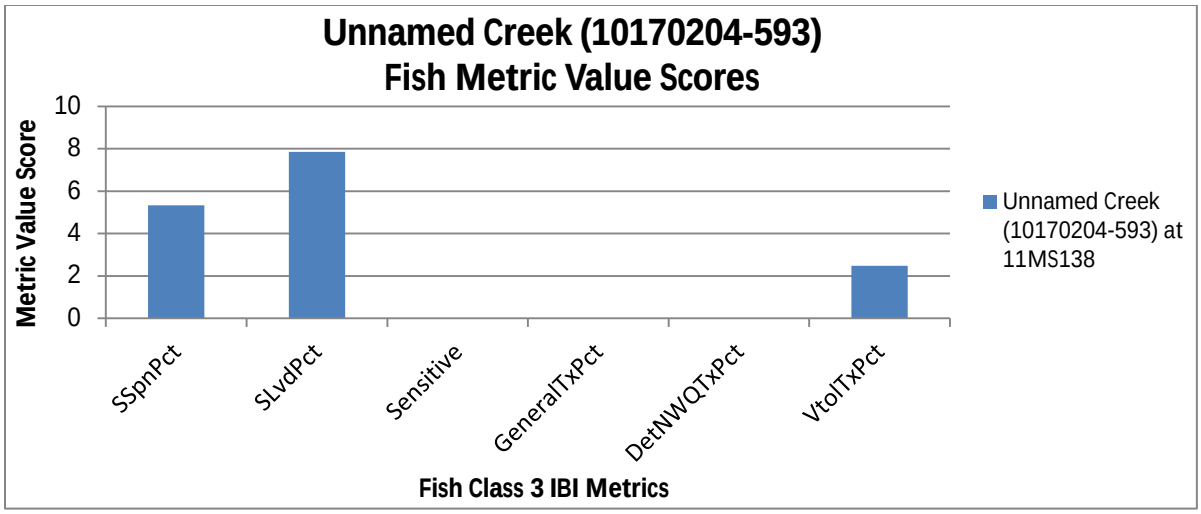

Figure 135: Fish Class 3 IBI metric values scores at site 11MS138 along Unnamed Creek (10170204-593)

Macroinvertebrates

In the watershed, Unnamed Creek (10170204-593) had one macroinvertebrate sample take on August 3, 2011 at site 11MS138.

To reach the MPCA's macroinvertebrate IBI threshold for a Class 7 (Prairie Streams GP) stream, each metric would need an average score of 3.83 (Figure 136). Site 11MS138 along Unnamed Creek had a macroinvertebrate IBI score of 29.7. The MIBI at this site was mainly limited by the limited numbers of lack of macroinvertebrates with tolerance values less than or equal to 2 (Intolerant2Ch) and the low numbers of non-hydropsychid Trichoptera individuals (TrichowoHydroPct). Six additional MIBI metrics also scored below the average needed to reach the threshold.

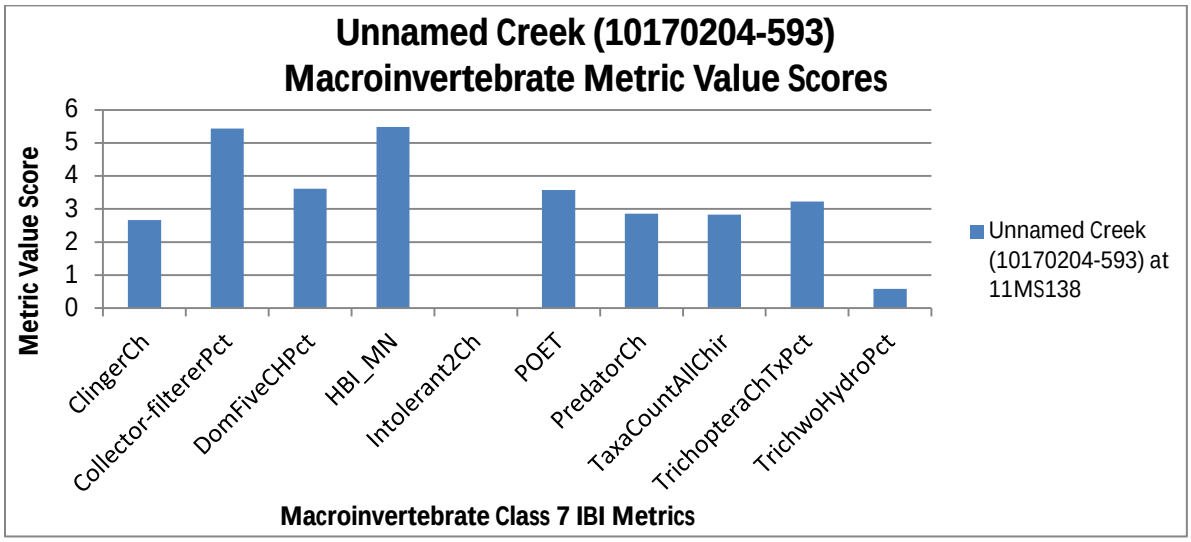

Figure 136: Macroinvertebrate Class 7 IBI metric value scores at site 11MS138 along Unnamed Creek (10170204-593)

Candidate cause: Low dissolved oxygen

The daily minimum standard for DO in Minnesota Class 2B streams is 5 mg/L. All streams in the city of Edgerton- Rock River Watershed have this 2B classification. No streams in this grouping are currently listed as impaired for DO. No sondes were deployed in these streams for continuous DO monitoring due to low flow conditions.

Unnamed Creek (10170204-593)
From 2011-2013 a total of seven DO measurements were taken from Unnamed Creek at site 11MS138 (S007-368). These values ranged from 6.4-11.82 mg/L with no values under the 5 mg/L minimum standard (Table 62).

Table 62: Dissolved oxygen values from 2011-2013 at site 11MS138 along Unnamed Creek (10170204-593)

Sample Location	Sample Date and Time	Result (mg/l)	Daily Minimum Standard (mg/l)
11MS138	8/3/2011 10:15 AM	6.89	5
11MS138	8/16/2011 2:50 PM	9.09	5
S007-368	5/67/2013 10:20 AM	11.82	5
S007-368	6/11/2013 10:45 AM	6.4	5
S007-368	7/2/2013 11:25 AM	10.22	5
S007-368	7/16/2013 11:15 AM	7.66	5
S007-368	7/31/2013 7:00 AM	7.19	5

Biologically, the macroinvertebrate assemblage in Unnamed Creek had a lower amount of EPT taxa (21.43%) when compared statewide, but did have a decreased amount of DO tolerant individuals (3.28%). Site 11MS138 did also have an above average DO TIV score when compared to all other sites in Minnesota. The fish community had an increased amount of serial spawning taxa (25%), tolerant species (75%), while also having zero sensitive species. The fish TIV score did score above average when compared to all other Minnesota streams.

Based on the observed values, the above average TIV scores for both assemblages, and the very few DO tolerant macroinvertebrate individuals present; low DO is not a stressor to the impaired biological communities at this time. Continuous DO monitoring with a sonde is recommended to better capture the daily flux conditions.

Candidate cause: High phosphorus

The proposed draft standard for phosphorus for streams in the Missouri River basin is currently 0.15 mg/L. Although phosphorus is an essential nutrient for all aquatic life, elevated levels can lead to an imbalance which impacts stream ecology. In the city of Edgerton-Rock River Watershed phosphorus levels have exceeded this proposed standard once.

Unnamed Creek (10170204-593)
From 2011-2013 a total of six phosphorus samples were taken from sampling location 11MS138 (S007-368) along Unnamed Creek. These values ranged from 0.04-0.302 mg/L with one of the samples above the 0.15 mg/L proposed draft standard for phosphorus (Table 63).

Table 63: Phosphorus sample values from 2011-2013 at site 11MS138 along Unnamed Creek (10170204-593)

Sample Location	Sample Date	Result (mg/l)	Proposed Draft Standard (mg/l)
11MS138	6/12/2012	0.058	0.15
S007-368	5/7/2013	0.073	0.15
S007-368	6/11/2013	0.107	0.15
S007-368	7/2/2013	0.04	0.15
S007-368	7/16/2013	0.302	0.15
S007-368	7/31/2013	0.056	0.15

Biologically, the macroinvertebrate community in Unnamed Creek had above average amounts of Tanytarsini taxa (10.53%). Tanytarsini species are less likely to be found in streams with high phosphorus values. This reach did also have increased amounts of tolerant (66.75%) and crustacean/mollusca (12.25%) taxa. The fish assemblage along this reach had many tolerant taxa (75%), and completely lacked any darter and sensitive species. These results can signal issues caused by excess phosphorus.

One phosphorus measurement was extremely high (0.302 mg/L), while the majority of the measurements were at acceptable levels and were much lower than most of the Rock River Watershed in general. Many of the related biological metrics scored poorly at this site, however this may be from the lack of consistent baseflow this reach receives. Further monitoring of phosphorus is recommended to better determine the impact, if any, this parameter is having on the fish and invertebrate communities.

Candidate cause: High nitrates

Currently, the state of Minnesota does not have a nitrate standard in place for streams not used as a drinking water source. However, the overabundance of nitrates can stress a biological community. Nitrates in the city of Edgerton-Rock River Watershed did at times reach levels that could potentially be stressing the biological assemblages.

Unnamed Creek (10170204-593)
From 2011-2013 there were six nitrate samples taken from Unnamed Creek (Table 64). These nitrate value ranged from 2.4-20 mg/L. A quantile regression comparing nitrate values and macroinvertebrate IBIs showed that when a Class 7 site like 11MS138has a nitrate value over 11.5 mg/L, there's a 90% probability it will be below the IBI threshold. Site 11MS138 had two of its' six values well above this level.

Table 64: Nitrate sample values from 2012-2013 at site 11MS138 along Unnamed Creek (10170204-593)

Sample Location	Sample Date	Result (mg/l)	Nitrate Standard (mg/l)
11MS138	6/12/2012	11	n/a
S007-368	5/7/2013	4.8	n/a
S007-368	6/11/2013	20	n/a
S007-368	7/2/2013	19	n/a
S007-368	7/16/2013	7.9	n/a
S007-368	7/31/2013	2.4	n/a

Biologically, the macroinvertebrate community in Unnamed Creek had a very high amount of nitrate tolerant individuals (89.56%). A level that high is a strong signal of stress. Site 11MS138 also had very limited numbers of Trichoptera taxa (5.3%) and decreased taxa count (17). The fish assemblage at 11MS138 had only four species and no sensitive taxa. These results can signal stress.

With the very high nitrate data collected, along with the quantile regression analysis and agreement with the majority of the related biological metrics, the elevated levels of nitrates are stressing the impaired biological communities in Unnamed Creek.

Candidate cause: High turbidity/TSS

The water quality standard for turbidity is 25 NTU, 65 mg/L for TSS, and 20 cm for transparency tube for these Class 2B warmwater streams in this watershed. Excess sediment is a commonly recognized stressor in many biologically impaired streams because it can reduce habitat, cause direct physical harm, as well as reduce visibility and increase oxygen demand.

Unnamed Creek (10170204-593)

Unnamed Creek had six TSS samples taken from 2012-2013 at its biological monitoring station 11MS138, with sample values ranging from 2-260 mg/L (Table 65). Only one of these samples was above the 65 mg/L standard for TSS. Additionally, seven transparency/Secchi tube readings were taken during the same time period with four readings falling below the 20 cm minimum standard.

Table 65: TSS and Secchi tube values from 2011-2013 at site 11MS138/S007-368 along Unnamed Creek (10170204-593)

Sample Location	Sample Date	TSS Result (mg/l)	TSS Standard (mg/l)	Secchi Tube Value (cm)	Secchi Tube Standard (cm)
11MS138	8/3/2011	n/a	65	7	20
11MS138	6/12/2012	49	65	17	20
S007-368	5/7/2013	2	65	>100	20
S007-368	6/11/2013	9.2	65	>100	20
S007-368	7/2/2013	2.4	65	>100	20
S007-368	7/16/2013	260	65	7	20
S007-368	7/31/2013	35	65	20	20

Biologically, the macroinvertebrate community in Unnamed Creek had average numbers of Ephemeroptera species (12.31%), a below average amount of collector-filter taxa (10.53%), and a low amount of Trichoptera species (5.3%). The fish community at site 11MS138 had mostly tolerant taxa (75%), of which, none of these species were herbivorous. Herbivorous fish are much more prevalent in streams with low turbidity and high transparency. The fish community TIV score was very high, which is expected in a stream with low transparency values.

Based on the many low transparency values and the majority of the related biological metrics, high turbidity/TSS is indeed a stressor to the impaired biological communities in Unnamed Creek. Further monitoring of this parameter is recommended to get a greater indication of the severity this stressor is on the impaired fish and macroinvertebrate assemblages.

Candidate cause: Lack of habitat

A qualitative habitat assessment was performed at 11MS138 along Unnamed Creek during the fish sampling event in 2012. The MSHA score at this site was 47.35, which is considered to be fair. Limiting the MSHA score in this stream was the poor surrounding land use, the narrow riparian buffer, sand/silt substrate, moderate embeddedness, moderate channel stability, and fair channel development. (Figure 137)

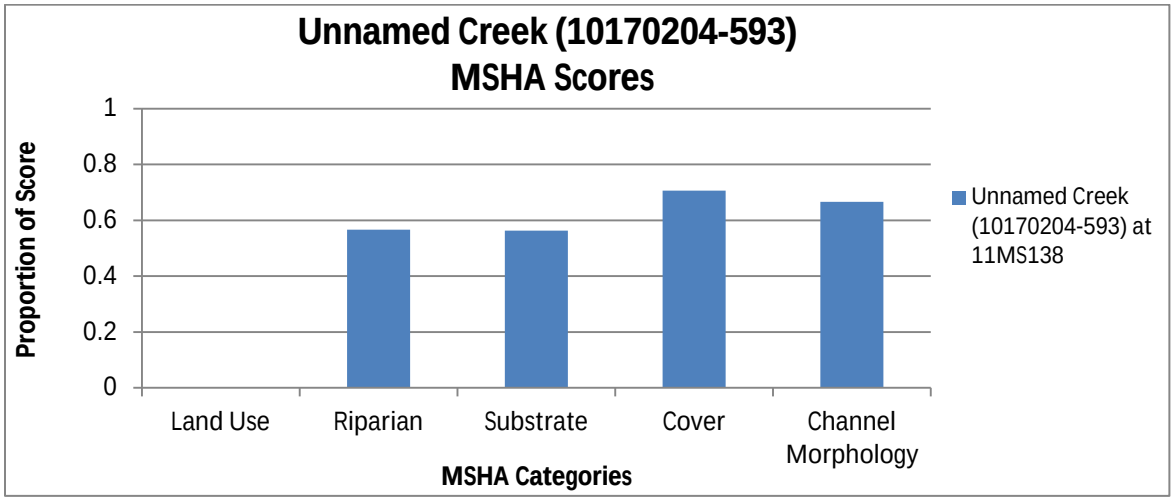

Figure 137: MSHA metric scores at two sites along reaches named Unnamed Creek

The macroinvertebrate sample at site 11MS138 was taken from the overhanging vegetation available. This sample showed that the macroinvertebrate assemblage contained an above average amount of climber 26.29%) species, which is expected given how these species prefer overhanging vegetation. This site did also have an above average amount of sprawler taxa (27.96%). Sprawlers prefer course gravel, cobble, and boulder habitats and can often signal good habitat conditions. However, this site also had an increased amount of legless taxa (59.54%) and a decreased amount of EPT species (17.61%). The scores of these metrics can signal poor habitat conditions.

The fish community along this reach had very few species (4) of which, three are considered tolerant. Of the 63 individual fish captured, 33 were fathead minnows. Fathead minnows are known to be extremely tolerant to poor habitat conditions. The remaining species caught, white sucker (22), common shiner (5), black bullhead (3) can also be found in poor habitat conditions.

Based on the fair MSHA score, many poorly scoring habitat related macroinvertebrate metrics, as well as the limited, but yet very tolerant fish community present; the lack of habitat is a stressor to the impaired biological assemblages in Unnamed Creek.

Conclusion

In the city of Edgerton-Rock River Watershed, many stressors to the impaired fish and macroinvertebrate in Unnamed Creek (10170204-593) exist (Table 66).

High nitrate values were found to be a stressor along this reach. These levels exceeded 19 mg/L on two occasions. High percentages of nitrate tolerant individual macroinvertebrates were present, which can often signal impairment. This stream also lacked macroinvertebrate diversity and had few Trichoptera species. The high levels of nitrates are likely a result from fertilizer applications and have entered the stream as runoff.

High turbidity/TSS was determined to be a stressor to the impaired biological communities as well. The reach had many transparency readings that fell below the standard set forth. Site 11MS138 had lower numbers of collector-filterer and Trichoptera species, while the fish assemblage completely lacked any herbivorous taxa. These results often signal streams stressed by high levels of turbidity/TSS. High intensity grazing with minimal riparian buffers and other poor land use practices in the watershed have led to unstable and erosive banks causing excess sediment to reach the stream. Limiting these activities will be imperative to improving the suspended sediment conditions present in this reach.

The lack of habitat was also found to be a stressor at site 11MS138 as it had poor surrounding land use, a narrow riparian buffer, sand/silt substrate, moderate embeddedness and channel stability, and fair channel development. Limiting the MSHA score in this stream was the poor surrounding land use, the narrow riparian buffer, sand/silt substrate, moderate embeddedness, moderate channel stability, and fair channel development. Improving these conditions will help eliminate the stress experienced by the fish and macroinvertebrate communities.

Overall, significant changes need to be made in this watershed. High priorities must be given to controlling the amount of nutrients and sediment reaching the waterways. Until some of these issues are addressed, the macroinvertebrate assemblage will remain impaired.

Table 66: Stressors to the biologically impaired reaches within the Rock River Watershed

		Stressors				
Stream Name	**AUID #**	**Low Dissolved Oxygen**	**High Phosphorus**	**High Nitrates**	**High Turbidity/ TSS**	**Lack of Habitat**
City of Edgerton-Rock River Watershed						
Unnamed Creek	10170204-593	-		•	•	•

(• = stressor, - = not a stressor, and blank = inconclusive/not enough evidence)

Summary and recommendations

The Rock River Watershed is impaired for aquatic life due to its biological assemblages at 27 different AUIDs. These fish and macroinvertebrate impairments are being impacted by numerous stressors (Table 1).

Low DO was found to be a stressor in three of the impaired AUIDs. Many sites lacked pre 9:00 AM DO data that can provide more insight of the DO conditions during these times. Continuous DO monitoring with a sonde is also recommended in the sites with relatively few data points, as this method of data collection will provided a clear understanding of the DO conditions that the stream experiences.

High fluxes in DO can often be correlated with the high phosphorus levels that are present in much of the watershed. Phosphorus was found to be a stressor in 24 of the AUIDs. In the Rock River Watershed, a large scale plan to reduce phosphorus levels is greatly needed. This plan should include efforts to improve the timing and rate of fertilizer application, as well as increasing riparian buffers and minimalizing cattle access to streams. Without some of these changes, phosphorus will continue to easily runoff into the stream system and negatively impact the biological assemblages within this watershed, but also the Missouri River basin.

Elevated nitrate values are also of concern in the Rock River Watershed. This study found that 27 AUIDs were having their impaired biological assemblage stressed by high nitrate levels. This was frequently evidenced by high numbers of nitrate tolerant macroinvertebrate individuals, low numbers of Trichoptera taxa, as well as many tolerant fish and macroinvertebrate taxa among other nitrate related biological metrics. Similar to phosphorus, a large scale plan to reduce nitrate levels is needed in this watershed. Often times nitrate levels spiked during times of fertilizer applications. Reducing the application time and rate, and improving the pathways nitrates have to the surface water will greatly improve the nitrate conditions in this watershed. Until improvements are made, expect the biological conditions to degrade.

To read more about nitrate conditions, trends, sources, and ways to reduce nitrates throughout Minnesota, please refer to *Nitrogen in Minnesota Surface Waters* (MPCA 2013).

Excess amounts of turbidity and TSS are issues that will also need to be addressed in the Rock River Watershed. This study found that 18 biologically impaired reaches are being stressed due to high turbidity and TSS levels. Effects from this parameter were especially profound in the Kanaranzi, Chanarambie, and Poplar Creek Watersheds as well as the Little Rock River Watershed and Rock River itself. These watersheds had the majority of impaired reaches were also stressed by high turbidity/TSS levels. Currently, 14 reaches in this watershed are impaired for aquatic life due to the turbidity conditions present, so this problem has existed for an extended period of time. Ways to reduce this watershed wide issue would be to limit cattle access to streams, practicing rotational and flash grazing, maintaining an ample riparian corridor, apply natural stream channel design practices, and to install deep rooted vegetation along the stream banks. These improvements would help stabilize the stream channel and banks, which often lead to eroded banks and the release of sediment throughout the water column. These upgrades would also help lessen the impact on stream banks during high flow events.

The habitat conditions in the Rock River Watershed often limited the success and health of the biological assemblages. This study identified 16 stream reaches that were found to be stressed due to their lack of suitable habitat conditions. Habitat conditions in the watershed were mostly fair to poor. Commonly found problems were the poor surrounding land use, lack of ample riparian buffer, eroding banks, low channel stability, the high presence of silt or sand substrates, and sparse fish cover. Like the other stressors found, habitat conditions will improve by increasing the immediate riparian area, limiting cattle access to the stream, restoring floodplain connectivity and incorporating other best management practices. Stabilizing the stream banks will also help limit the amount of sediment entering the stream covering the course substrates that are preferred by many types of sensitive types of fish species. This

may be achieved by incorporating natural channel design practices to restore stream channels by moving them to their stable form. Other habitat improvement projects that provide more cover for fish are greatly needed in this watershed.

Overall, significant problems and stressors to the biological communities exist in Rock River Watershed. Substantial changes are needed watershed wide to help mitigate the damages caused by the prolonged poor land use and lack of riparian buffer. Until these improvements and long term changes are made, expect the fish and macroinvertebrate assemblages in the Rock River Watershed to remain stressed and impaired.

Table 1: Stressors to the biologically impaired reaches within the Rock River Watershed

		Stressors				
Stream Name	**AUID #**	**Low Dissolved Oxygen**	**High Phosphorus**	**High Nitrates**	**High Turbidity/TSS**	**Lack of Habitat**
Ash Creek watershed						
Ash Creek	10170204-539	•	•	•		•
Champepadan Creek watershed						
Champepadan Creek	10170204-520	-	•	•	•	-
Unnamed Creek	10170204-583		•	•		-
Chanarambie Creek watershed						
Chanarambie Creek	10170204-522	-	•	•	•	-
North Branch Chanarambie Creek	10170204-560	-	•	•	-	-
Unnamed Creek	10170204-559			•		•
East Branch Rock River watershed						
East Branch Rock River	10170204-530		•	-		•
Elk Creek watershed						
Elk Creek	10170204-519	-	•	•	-	-
Kanaranzi Creek watershed						
Kanaranzi Creek	10170204-517	-	•	•	•	•
Kanaranzi Creek	10170204-516	-	•	•	-	•
Kanaranzi Creek	10170204-515		•	•	•	•
East Branch Kanaranzi Creek	10170204-514	-	•	•	•	•

Little Rock River watershed						
Little Rock River	10170204-513	-	•	•	•	•
Little Rock River	10170204-512	-	•	•	•	•
Little Rock Creek	10170204-511	-	•	•	•	•
Unnamed Creek	10170204-579	-	•	•	-	-
Lower Rock River watershed						
Rock River	10170204-501	-	-	•	•	-
Rock River	10170204-509	-	•	•	•	-
Rock River	10170204-508	-	•	•	•	-
Mud Creek watershed						
Mud Creek	10170204-525	•	-	•	•	•
Poplar Creek watershed						
Poplar Creek	10170204-523	-	•	•	•	-
Unnamed Creek	10170204-588	•	•	•	•	•
Unnamed Creek	10170204-589		•	•	•	-
Town of Leota-Rock River watershed						
Unnamed Creek	10170204-571	-	•	•	-	•
Unnamed Creek	10170204-572		•	•	-	-
Upper Rock River watershed						
Rock River	10170204-506	-	•	•	•	•
Rock River	10170204-504	-	•	•	•	•
City of Edgerton-Rock River watershed						
Unnamed Creek	10170204-593	-		•	•	•

(• = stressor, - = not a stressor, and blank = inconclusive/not enough evidence)

Appendix 1.1 - MPCA fish IBI class criteria for Rock River Watershed streams

Fish IBI Class	Class Name	Drainage Area	Gradient
1	Southern Rivers	> 300 mi^2	not specified
2	Southern Streams	> 30 mi^2, < 300 mi^2	not specified
3	Southern Headwaters	< 30 mi^2	> 0.50 m/km
7	Low Gradient	< 30 mi^2	< 0.50 m/km

Appendix 1.2- MPCA macroinvertebrate IBI class criteria for Rock River Watershed streams

M-IBI IBI Class	Class Name	Drainage Area	Description
2	Prairie Forest Rivers	>500 mi^2	Sites in Minnesota that are representative of the Eastern Broadleaf forest, Prairie Parklands, and Tall Aspen Parklands ecological provinces
5	Southern Streams (Riffle/Run Habitats)	<500 mi^2	Sites within this class are representative of the Eastern Broadleaf forest, Prairie Parklands, and Tall Aspen Parklands ecological provinces, as well as streams in HUC 07030005.
7	Prairie Streams (Glide/Pool Habitats)	<500 mi^2	Sites in Minnesota that are representative of the Prairie Parklands and Tall Aspen Parklands ecological provinces

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