South Fork Crow River Watershed Stressor Identification Report

A study of local Stressors limiting the biotic communities in the South Fork Crow River Watershed.

Minnesota Pollution Control Agency

February 2017

wq-ws5-07010205a

Legislative charge

Minn. Stat. § 116.011 Annual Pollution Report

A goal of the Pollution Control Agency is to reduce the amount of pollution that is emitted in the state. By *April 1 of each year, the MPCA shall report the best estimate of the agency of the total volume of water and air pollution that was emitted in the state the previous calendar year for which data are available. The agency shall report its findings for both water and air pollution, etc., etc.*

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Key term and abbreviations

AUID	Assessment Unit Identification
BOD	Biological Oxygen Demand
CADDIS	Causal Analysis/Diagnosis Decision Information System
cfs	cubic foot per second
DNR	Minnesota Department of Natural Resources
DO	Dissolved oxygen
EPA	U.S. Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, and Trichoptera
FIBI	Fish Index of Biological Integrity
GP	Glide/Pool
HSPF	Hydological Simulation Program-FORTRAN
HUC	Hydrologic unit code
IBI	Index of Biological Integrity
IWM	Intensive Watershed Monitoring
MIBI	Macroinvertebrate Index of Biological integrity
mg/L	milligrams per Liter
MPCA	Minnesota Pollution Control Agency
MSHA	Minnesota Stream Habitat Assessment
SID	Stressor Identification
SOE	Strength of Evidence
TIV	Tolerance Indicator Values
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSS	Total Suspended Solids
TSVS	Total Suspended Volatile Solids
WRAPS	Watershed Restoration and Protection Strategy

Executive summary

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

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

This report summarizes stressor identification work in the South Fork Crow River Watershed. There were 42 reaches identified with biological impairment in the South Fork Crow River Watershed. The impairments in this report are organized by 10-digit hydrologic unit code (HUC). There are seven HUCs discussed in this report.

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

- Lack of habitat
- Phosphorus/Eutrophication
- Nitrate
- Altered hydrology
- Dissolved oxygen (DO)
- Ionic strength

In the South Fork Crow River Watershed, there were 42 stream reaches with fish and macroinvertebrate impairments. A summary of the stressors identified in each stream reach is found at the end of this document in Table 50.

1. Introduction

1.1 Monitoring and assessment

Water quality and biological monitoring in the South Fork Crow River Watershed have been ongoing. As part of the MPCA's Intensive Watershed Monitoring (IWM) approach, monitoring activities increased in rigor and intensity during the years of 2012-2013 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 2002, were used to identify stream impairments (Figure 1).

Once a biological impairment is discovered, the next step is to identify the source(s) of stress on the biological community. A Stressor Identification (SID) analysis is a step-by-step approach for identifying probable causes of impairment in a particular system. Completion of the SID process does not result in a finished Total Maximum Daily Load (TMDL) study. The product of the SID process is the identification of the stressor(s) for which a TMDL or restoration plan may be developed, depending on if the stressor is a pollutant (DO) or a non-pollutant (habitat). 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.

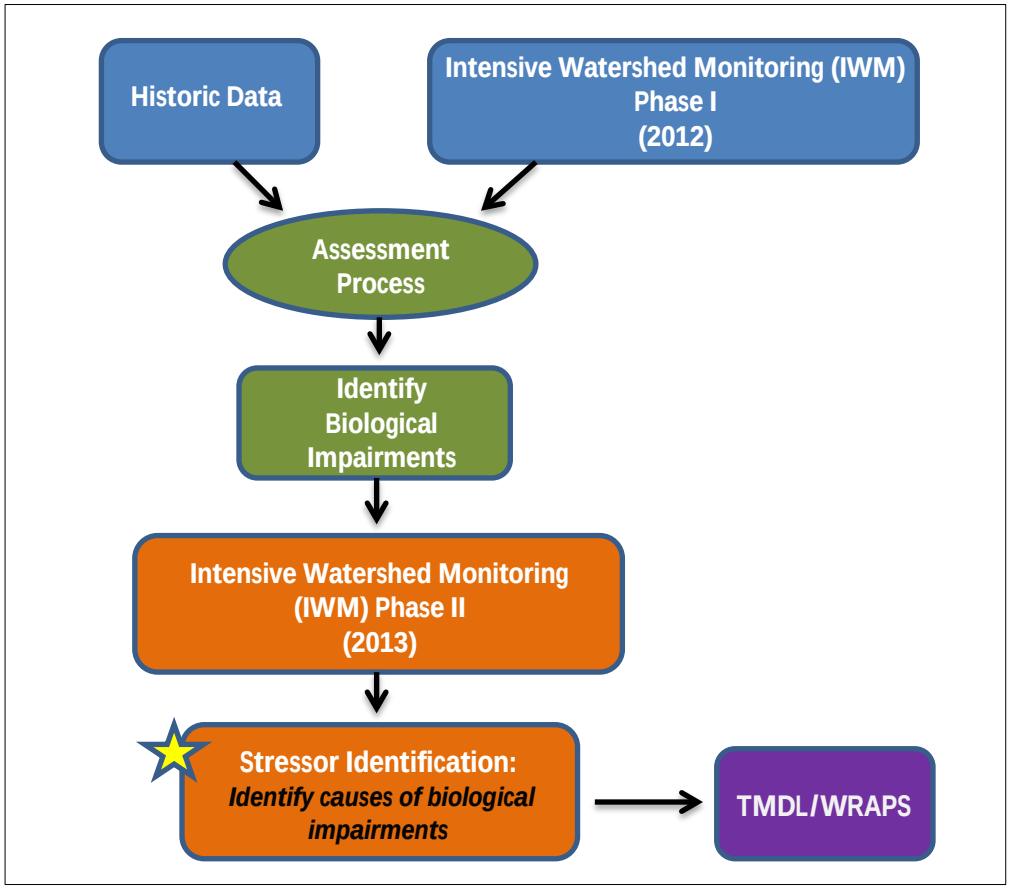

Figure 1. Process map of Intensive Watershed Monitoring, Assessment, SID and TMDL processes.

1.2 Stressor Identification Process

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

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

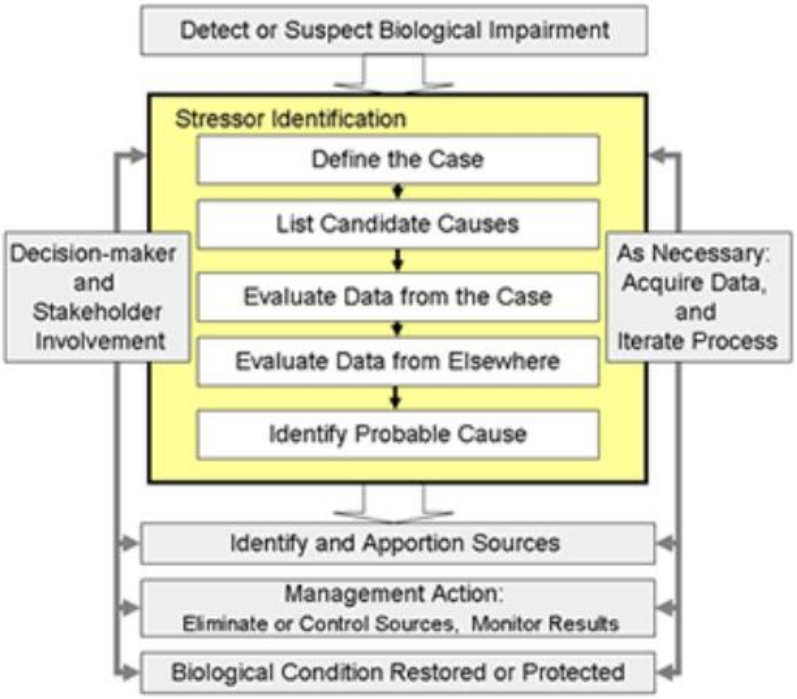

Figure 2. Conceptual model of SID process (Cormier et al. 2000)

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

Developed by the EPA, a standard scoring system is used to tabulate the results of the SOE analysis for the available evidence. A narrative description of how the scores were obtained from the evidence should be discussed as well. The SOE table allows for organization of all of the evidence, provides a checklist to ensure each type has been carefully evaluated and offers transparency to the determination process.

The existence of multiple lines of evidence that support or weaken the case for a candidate cause generally increases confidence in the decision for a candidate cause. Evaluating each type of evidence in support of or against a stressor is completed. Additionally, confidence in the results depends on the quantity and quality of data available to the SID process. In some cases, additional data collection may be necessary to accurately identify the stressor(s) causing impairment. Additional detail on the various types of evidence and interpretation of findings can be found here: http://www.epa.gov/caddis/si_step_scores.html.

1.3. Common stream stressors

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

Table 1. Common stream 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 Condition/Morphology	**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 Health	Stressor(s)	Link to Biology
Stream Biology	Fish and macroinvertebrate communities are affected by all of the above listed stressors as well as invasive species	If one or more of the above stressors are affecting the fish and macroinvertebrate community, the IBI scores will not meet expectations and the stream will be listed as impaired.

1.4. Format

This report first summarizes the 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 South Fork Crow River Watershed, water quality standards and general effects on biology.

Due to the large number of impairments, AUIDs were grouped by 10- digit HUC in this report. All 42 biological impairments within the subwatersheds is evaluated and discussed in further detail.

2. Overview of South Fork Crow River Watershed

2.1. Background

The South Fork Crow River Watershed is located in the Upper Mississippi River Basin and the watershed encompasses approximately 818,428 acres within the state of Minnesota. The watershed includes part of Kandiyohi, Meeker, Renville, McLeod, Carver, Wright, and Hennepin counties. The largest cities located in the watershed are Hutchinson, Glencoe, and Delano. The majority of the streams in the watershed are warm-water (class 2B) streams; while there are a handful of limited use waters (class 7).

Prior to settlement, the western part of the watershed was dominated by grassland and the eastern section was deciduous forest. These land uses correspond with the ecoregions; Western Corn Belt to the west and the North Central Hardwood Forest to the east. Buffalo Creek is entirely within the Western Corn Belt Plains ecoregion except for the last four miles. The majority of the South Fork Crow River and tributaries throughout the watershed are also in the Western Corn Belt Plain ecoregion. Current land use consists mainly of cropland, rangeland, and developed land. Cropland is dominated by corn; sugar beets, peas, and hay; each make up a smaller percentage of crops grown in the watershed. Considering similar land use, there are consistent chemical and physical stressors found throughout the watershed.

DNR conducted geomorphic surveys of the South Fork Crow River Watershed. It was found that bank measurements were eroding at least two times the modeled estimates. Of the areas they studied, the Buffalo Creek site and the South Fork Crow River near the town of Mayer had the highest erosion in the watershed. Both these sites as well as the site at Otter Creek had high width to depth ratios, resulting in excessive siltation (DNR 2015).

A comprehensive assessment of the aquatic life and recreational designated uses in the watershed took place in 2014. This SID report investigates the stream aquatic life impairments found during assessments, and should be seen as a companion to the Monitoring and Assessment Report. Background information on the watershed can be found in that report to avoid duplication here. Impairments are grouped and discussed by the HUC-10 watershed in which they occur (Figure 3).

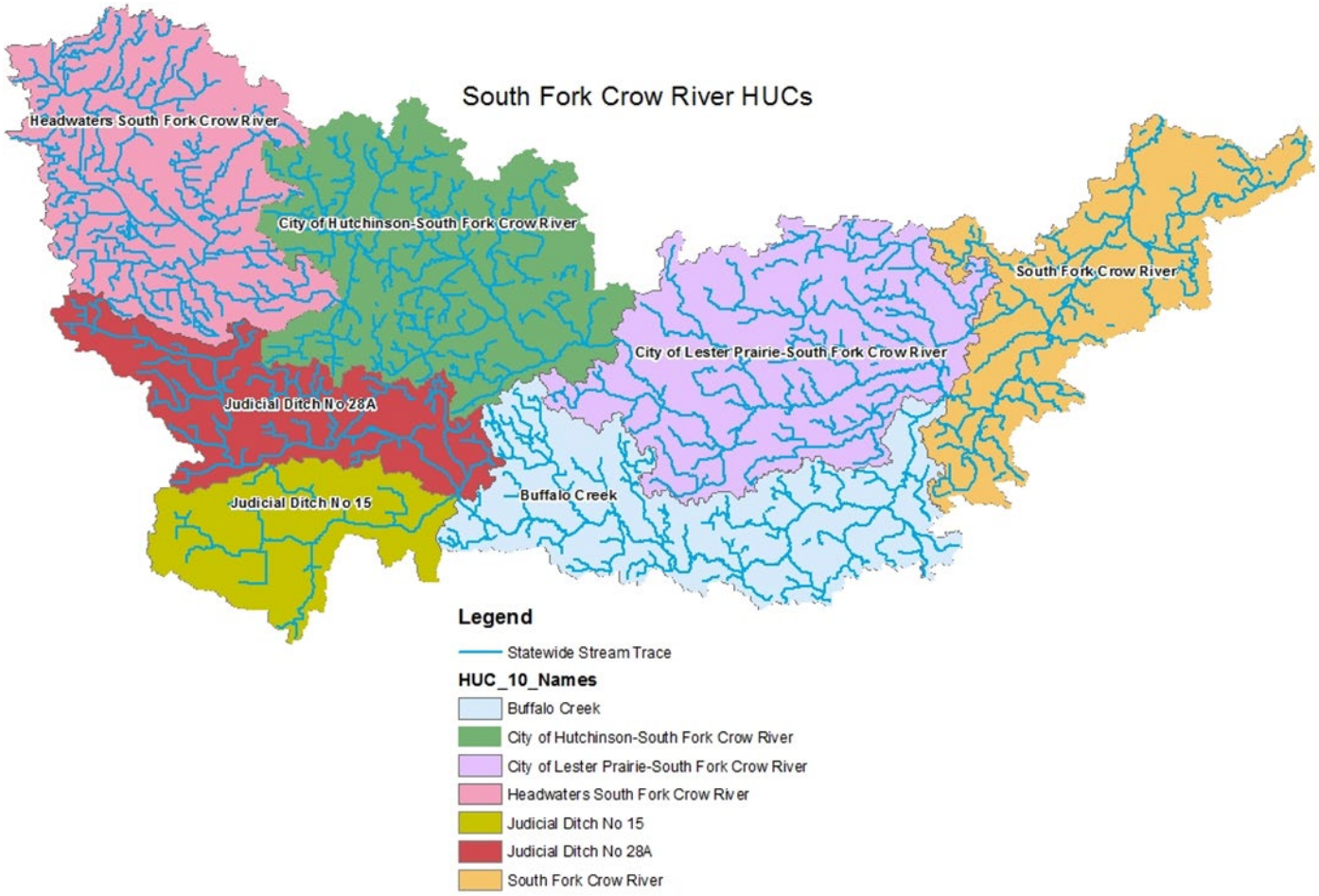

Figure 3. Map showing 10-digit HUCs in the South Fork Crow River Watershed

2.2. Monitoring overview

In 2012-2013, IWM was performed in the South Fork Crow River Watershed. Biological monitoring and water chemistry data from systematically selected sites throughout the watershed as well as data from other water monitoring stations taken within ten years of the biological monitoring were used to assess the conditions of the watershed (Figure 4).

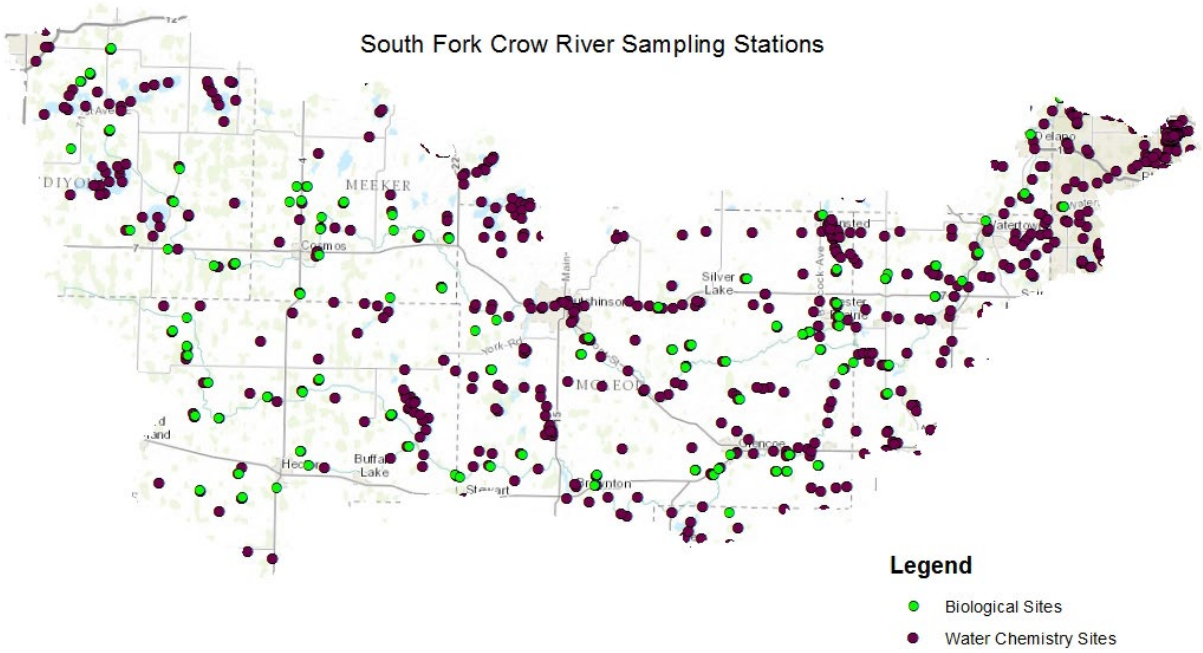

Figure 4. Map of monitoring stations in the South Fork Crow River Watershed

2.3. Summary of biological impairments

The approach used to identify biological impairments includes monitoring fish and aquatic macroinvertebrate communities and related habitat conditions at sites throughout a watershed. The resulting information is used to develop an IBI for each community. The IBI scores can then be compared to thresholds or biocriteria that vary according to stream IBI class (i.e., river vs. stream, low gradient vs. high gradient) and designated use (modified or general aquatic life). Designated uses have been determined under Tiered Aquatic Life Uses (TALU) framework which has been implemented to classify streams based on attainable biological condition. For further descriptions of the fish and macroinvertebrate IBI class criteria, please see Appendices 1.1-2.

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

In the South Fork Crow River Watershed, 42 AUIDs are currently impaired for aquatic life based on assessments of fish and/or aquatic macroinvertebrate communities (Table 2). The purpose of stressor identification is to interpret the data collected during the biological monitoring and assessment process. Spatial and temporal trends in the IBI scores can help to identify causal factors for biological impairments. IBI scores and class thresholds can be found in the Monitoring and Assessment Report.

Table 2. Biologically impaired AUIDs in the South Fork River Watershed

			Impairments	
Stream Name	**AUID #**	**Reach Description**	**Biological**	**Water Quality**
South Fork Crow River	07010205-658	Headwaters to 145th St	Macroinvertebrate IBI, Fish IBI	
South Fork Crow River	07010205-659	145th St to Hutchinson Dam	Macroinvertebrate IBI, Fish IBI	
South Fork Crow River	07010205-510	Hutchinson Dam to Bear Cr	Macroinvertebrate IBI, Fish IBI	DO, Turbidity
South Fork Crow River	07010205-511	Bear Cr to Otter Cr	Macroinvertebrate IBI, Fish IBI	Turbidity
South Fork Crow River	07010205-508	Buffalo Cr to N Fk Crow R	Macroinvertebrate IBI, Fish IBI	Turbidity, Chloride
Buffalo Creek	07010205-502	Headwaters to Judicial Ditch 15	Macroinvertebrate IBI, Fish IBI	
Buffalo Creek	07010205-638	Judicial Ditch 15 to S Fk Crow R	Macroinvertebrate IBI, Fish IBI	DO
Judicial Ditch 67	07010205-504	Headwaters to Buffalo Cr	Macroinvertebrate IBI, Fish IBI	
Judicial Ditch 15	07010205-509	Headwaters to T115 R32 W S31, east line	Macroinvertebrate IBI, Fish IBI	
Bear Creek	07010205-515	Headwaters to S Fk Crow	Macroinvertebrate IBI, Fish IBI	
County Ditch 4	07010205-528	Unnamed ditch to Buffalo Cr	Macroinvertebrate IBI, Fish IBI	
Unnamed Creek	07010205-533	Unnamed Cr to Unnamed Cr	Macroinvertebrate IBI, Fish IBI	
Belle Creek	07010205-549	Headwaters to Judicial Ditch 18	Macroinvertebrate IBI, Fish IBI	
Judicial Ditch 18	07010205-550	Belle Cr to S Fk Crow	Fish IBI	
Judicial Ditch 1	07010205-572	Unnamed ditch to Unnamed Cr	Macroinvertebrate IBI, Fish IBI	
Unnamed Creek	07010205-585	County Ditch 11 to Winsted Lk	Fish IBI	
Judicial Ditch 8	07010205-591	Unnamed Cr to Buffalo Cr	Macroinvertebrate IBI, Fish IBI	
State Ditch Branch 2	07010205-608	Unnamed ditch to Unnamed ditch	Macroinvertebrate IBI, Fish IBI	
County Ditch 18	07010205-609	Headwaters to S Fk Crow R	Macroinvertebrate IBI, Fish IBI	
County Ditch 24A	07010205-610	Unnamed ditch to Unnamed ditch	Fish IBI	
County Ditch 26/27	07010205-611	165th ST to S Fk Crow R	Macroinvertebrate IBI, Fish IBI	
King Creek	07010205-613	T118 R32W S36, north line to S Fk Crow R	Fish IBI	
Unnamed Creek	07010205-614	Lk Mary to RR crossing	Fish IBI	
Unnamed Creek	07010205-615	Unnamed Cr to Buffalo Cr	Fish IBI	
Unnamed Creek	07010205-617	Headwaters to Otter Cr	Fish IBI	

			Impairments	
Stream Name	**AUID #**	**Reach Description**	**Biological**	**Water Quality**
Unnamed Creek	07010205-618	Unnamed Cr to Eagle Lk Outlet	Macroinvertebrate IBI, Fish IBI	
Unnamed Creek	07010205-621	Unnamed Cr to S Fk Crow R	Macroinvertebrate IBI	
Unnamed Creek	07010205-622	T116 R27W S5, west line to S Fk Crow R	Fish IBI	
Unnamed Creek	07010205-623	Unnamed Cr to Judicial Ditch 18	Macroinvertebrate IBI, Fish IBI	
Unnamed Creek	07010205-624	Unnamed Cr to Lippert Lk	Macroinvertebrate IBI, Fish IBI	
Judicial Ditch 9	07010205-625	Headwaters to Buffalo Cr	Macroinvertebrate IBI, Fish IBI	
Judicial Ditch 15	07010205-626	Headwaters to Judicial Ditch 15	Fish IBI	
Judicial Ditch 15	07010205-627	Headwaters to Judicial Ditch 15	Fish IBI	
Judicial Ditch 15	07010205-628	Headwaters to Judicial Ditch 15	Macroinvertebrate IBI, Fish IBI	
Unnamed Ditch	07010205-630	Headwaters to Buffalo Cr	Macroinvertebrate IBI, Fish IBI	
County Ditch 7A	07010205-631	Unnamed Cr to Buffalo Cr	Macroinvertebrate IBI, Fish IBI	
Silver Creek (County Ditch 13)	07010205-641	Unnamed Cr to S Fk Crow R	Macroinvertebrate IBI, Fish IBI	
Otter Creek	07010205-642	Headwaters to Cable Ave	Fish IBI	
Otter Creek	07010205-643	Cable Ave to S Fk Crow R	Fish IBI	
County Ditch 33	07010205-645	100th St to Buffalo Cr	Macroinvertebrate IBI, Fish IBI	
County Ditch 9	07010205-648	Headwaters to -93.9053 44.9055	Macroinvertebrate IBI, Fish IBI	
Pioneer Creek	07010205-654	T118 R24W S31, north line to T118 R24W S31, south line	Macroinvertebrate IBI, Fish IBI	
Unnamed Creek	07010205-656	140th St to Unnamed Cr	Macroinvertebrate IBI, Fish IBI	

3. Possible stressors to biological communities

A comprehensive list of potential stressors to aquatic biological communities compiled by the EPA can be found here (http://www.epa.gov/caddis/si_step2_stressorlist_popup.html). This comprehensive list serves two purposes. First, it can serve as a checklist for investigators to consider all possible options for impairment in the watershed of interest. Second, it can be used to identify potential stressors that can be eliminated from further evaluation. In some cases, the data may be inconclusive and limit the ability to confidently determine if a stressor is causing impairment to aquatic life. It is imperative to document if a candidate cause was suspected, but there was not enough information to make a scientific determination. In this case, management decisions can include modification of sampling plans and future evaluation of the inconclusive case. Alternatively, there may be enough information to conclude that a candidate cause is not causing biological impairment and therefore can be eliminated. The inconclusive or eliminated causes will be discussed in more detail in the following section.

3.1. Inconclusive causes

- Ammonia
- Pesticides
- Temperature
- Physical trampling

3.1.1. Ammonia

The concentration of ammonia in water is measured as total ammonia and is reported in mg/L. The fraction of unionized ammonia (NH_3) is not directly measured, but instead is calculated using measures of total ammonia, pH, temperature, and specific conductivity. Ammonia nitrogen contains both the ionized form (ammonium, NH_4^+) and the unionized form (ammonia, NH_3). An increase in pH favors formation of the more toxic unionized ammonia (NH_3). Ammonia also exerts a biochemical oxygen demand and can promote algae growth (U.S. EPA 2012). The chronic standard for unionized ammonia is 0.04 mg/L. Increases in unionized ammonia are linked to decreased growth rates, reproduction, and susceptibility to other stressors.

There was an unionized ammonia value in the South Fork Crow River at Cosmos just above the chronic standard of 0.042 mg/L. Other values throughout the watershed were much lower. During assessment, Buffalo Creek and the South Fork Crow River have both found to be meeting aquatic life standards for unionized ammonia. It is difficult to separate possible biological effects from effects of other stressors. Further sampling would help determine if nitrogen, temperature, or pH are driving values.

3.1.2. Pesticides

A pesticide is defined by the EPA as “any substance intended for preventing, destroying, repelling or mitigating any pest.” For the purpose of this document, pesticides refer to fungicides, insecticides, and herbicides used to control various pests.

A few presence/absence tests for Atrazine were taken on Judicial Ditch 15 and Buffalo Creek, but the results were negative both in May and June of 2014. The Minnesota Department of Agriculture (MDA) has sampled the South Fork Crow River in Cosmos and Mayer since 2011 from May to August.

The herbicide Acetochlor was detected in 2014 with a value of 3,150 ng/L. The 4-day chronic standard for Acetochlor is 3,600 ng/L. The insecticide Chlorpyrifos was detected in both an unnamed ditch and on three occasions on the South Fork Crow River with values from 46-50 ng/L. The chronic standard is 41 ng/L.

The herbicide Dimethenamid was sampled in 2014 with a result of 5,260 ng/L. This EPA chronic value is 5,100 ng/L. With limited data available, the effects of pesticides on the biological community within this reach are unknown. The possible additive effects of pesticides on aquatic organisms at levels below state or federal standards are also unknown. Additional monitoring is recommended to further understand the presence of pesticides and their potential impacts to the biological community.

3.1.3. Temperature

Stream temperature naturally varies due to air temperature, geology, shading, and the inputs from tributaries and springs. Different organisms are adapted to and prefer different temperature regimes. Water temperature regulates the ability of organisms to survive and reproduce (U.S.EPA, 1986). Thermal pollution can increase stream temperatures through loss of riparian shading, urban and agricultural runoff, and direct discharges to the stream. Warmer water holds less DO, and higher water temperatures also affects the toxicity of numerous chemicals in the aquatic environment. Algal blooms often occur with temperature increases (U.S.EPA, 1986).

Effects on aquatic communities in warm-water systems are not as clear as is in cold-water systems. CADDIS (U.S.EPA 2012) describes changes in growth and thermal stress, and impaired fish and macroinvertebrate assemblages. Warmer water impacts organisms indirectly due to the relationship with DO and directly through changes in growth and reproduction, egg mortality, disease rates, and direct mortality. A publication by EPA (1986) shows a maximum weekly temperature of 28 oC for optimum white sucker growth and 29 oC for optimum smallmouth bass growth. The short-term maximum temperature for survival of northern pike is 30 oC. The monthly average recorded in July of 2012 was 28 oC at stations 00UM053 and 12UM071 on the South Fork Crow River and station 12UM043 a tributary. July monthly average temperatures on Buffalo Creek were 27 oC at stations 12UM006 and 12UM072. In a study in the Minnesota River basin, Feist and Niemela (2005) found significant relationships between increased temperatures and temperature fluctuations and fish populations. Increased temperatures in warm-water streams were related to decreases in top carnivores and sucker species, and an increase in the number of minnow species.

There is a sizable temperature database throughout the watershed. The state standard is that warm-water streams are not to exceed the daily average temperature of 86 ° Fahrenheit (30 °C). Of the 3,178 data points in the watershed, four were above 30°C. The highest value was 32.22 °C at station S001-845 on the South Fork Crow River in Hutchinson just downstream of the Hutchinson dam. Where continuous data was collected, the highest average weekly temperature was 24 °C at station 12UM041 on the South Fork Crow River in Delano with a maximum individual value of 28.30 °C. Other high values included 27.38 °C at station 07UM098 on Otter Creek, 27.95 °C at station 00UM050 on County Ditch 4, 28.03 °C at station 12UM024 on a tributary to Buffalo Creek, 28.99 °C at station 12UM020 on King Creek, 30 °C at station S001-514 on South Fork Crow River, and 30.45 °C at station 12UM006 on Buffalo Creek.

It is difficult to determine if temperature is having an effect on the biological communities, but is likely contributing to low DO conditions. The majority of stations with an elevated temperature also experienced low DO, but there was not a consistent biological response of minnows, suckers, and carnivores making temperature inconclusive.

3.1.4. Physical Trampling

Rangeland and pasture land use makes up 27.7% of the watershed. Pastured animals in the stream or river would be the most likely cause of crushing or trampling. While there are impaired reaches where cattle have direct access to the river, these are limited in scope and their influence on biological impairments is inconclusive.

3.2. Summary of Candidate causes in the South Fork Crow River Watershed

Seven candidate causes were selected as possible drivers of biological impairments in the South Fork Crow River Watershed. The list of candidate causes was then narrowed down after initial data evaluation resulting in six candidate causes for final analysis in this report. The remaining candidate causes are:

- Phosphorus/Eutrophication
- Dissolved oxygen (DO)
- Nitrate
- Suspended sediments
- Altered hydrology
- Habitat
- Ionic strength

3.2.1. Candidate cause: Dissolved oxygen

DO concentrations and fluctuations are affected by shifts in ambient air and water temperature, precipitation, stream flow, atmospheric pressure, plant/algal growth and decomposition, salinity, and ammonia concentrations. If DO concentrations become limited or fluctuate dramatically, aerobic aquatic life can experience reduced growth or fatality (Allan, 1995). Fish and aquatic macroinvertebrates require oxygen for respiration. Many species of fish avoid areas where DO concentrations are below 5.0 mg/L (Raleigh et al., 1986). Some macroinvertebrates that are intolerant to low levels of DO include mayflies, stoneflies and caddisflies (Marcy, 2007).

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 (BOD), and/or high groundwater seepage (Hansen, 1975).

3.2.1.1. Water quality standards

The standard for Class 2B (warm-water) streams in the state of Minnesota for DO is 5.0 mg/L as a daily minimum (Minn. Stat. § 7050.0222 subp. 4). Additional information water quality standards in Minnesota (Minn. R. ch. 7050) can be found here: https://www.revisor.leg.state.mn.us/rules/?id=7050.

3.2.1.2. Sources and causal pathways model for dissolved oxygen

Dissolved oxygen concentrations in lotic environments are driven by a combination of natural and anthropogenic factors. Natural background characteristics of a watershed, such as topography,

hydrology, climate, and biological productivity define 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 is modeled at EPA's CADDIS Dissolved Oxygen webpage.

3.2.1.3. Overview of dissolved oxygen in the South Fork Crow River Watershed

Low DO levels are present throughout the watershed, and were identified as a stressor on the South Fork Crow River, Buffalo Creek, and their tributaries. The lowest recorded value was 0.64 mg/L on the mainstem South Fork Crow River just below the Hutchinson dam. Continuous data recorded the lowest DO values on County Ditch 26, County Ditch 9, King Creek, a tributary to Buffalo Creek, and the South Fork Crow River in Delano.

3.2.2. Candidate cause: Phosphorus/Eutrophication

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 results in indirect impacts to fish and macroinvertebrates, by influencing variables such as DO flux, chlorophyll-a, and BOD(Heiskary et al., 2013). Heiskary et al. (2013) observed several strong negative relationships between fish and macroinvertebrate metrics and DO flux. Elevated phosphorus levels increase algae and aquatic plant growth which may lead to reduced water clarity, elevated daytime DO concentrations, and changes to the type and availability of food and habitat resources. Increased plant and algal growth causes increased oxygen production through photosynthesis during the day. The excess plant material eventually dies, and bacterial activity during decomposition strips oxygen from the water. This leads to low early morning DO readings in streams, and high readings in the afternoon. Streams dominated with submerged macrophytes experience the largest swings in DO and pH (Wilcox and Nagels 2001). Values of pH outside the range of 6.5-9.0 or highly fluctuating values are stressful to aquatic life.

3.2.2.1 Water quality standards

The water quality standard for total phosphorus (TP) in the southern region of the state is a maximum concentration of 0.15 mg/L with at least one response variable out of desired range (BOD, DO flux, chlorophyll-a, and/or pH). The proximate standard for DO flux is 4.5 mg/L, chlorophyll-a is 35 µg/L, and BOD is 3 mg/L.

3.2.2.2. Sources and causal pathways model for phosphorus

Phosphorus is delivered to streams by wastewater treatment facilities, urban stormwater, and agricultural runoff. Phosphorus bound to sediments in the river channel could be contributing to concentrations, however there is no data available. Orthophosphate is the form of phosphorus that is readily available for plant and algal uptake, and can influence excess algae growth. While orthophosphates occur naturally in the environment, river and stream concentrations may become elevated with additional inputs from waste water treatment plants, noncompliant septic systems, and fertilizers in urban and agricultural runoff. The causes and potential sources for excess phosphorus are modeled at EPA's CADDIS Phosphorus webpage.

3.2.2.3. Overview of phosphorus in the South Fork Crow River Watershed

Only two of the 10-digit HUCs discussed in the report did not have eutrophication as a stressor. The large daily fluctuations of DO levels that are present in the South Fork Crow River and its many tributaries are tied to the high phosphorus loads coming into the streams. The nutrient inputs from

agricultural runoff, urban runoff, and point sources are upsetting the natural dynamics by increasing algae and macrophyte production, which in turn increases photosynthesis, respiration, and decomposition. This cycle creates large fluctuations in DO levels, spanning from 0.64 to greater than 20 mg/L which is stressful to aquatic communities. This stress results in a shift from functional assemblages of aquatic communities to tolerant or generalist species (Heiskary et al. 2013).

Longitudinal data collected on June 13, 2013, along the South Fork Crow River shows a general trend of phosphorus values increasing along the South Fork Crow River from upstream to downstream (Figure 5). The tributaries with the highest phosphorus values were Buffalo Creek, Judicial Ditch 15, Crane Creek, and Judicial Ditch 1.

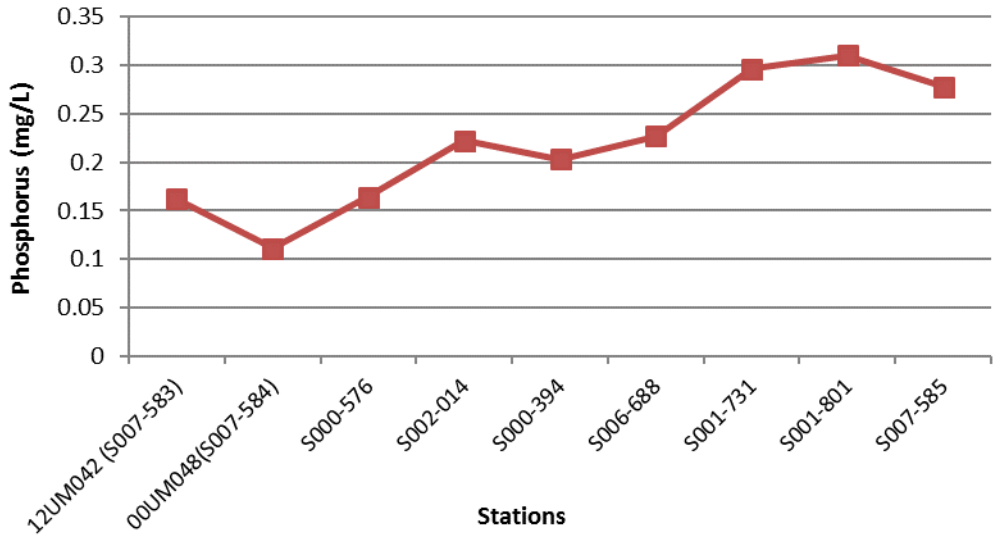

Figure 5. Phosphorus values on the South Fork Crow River (June 12, 2013)

One caveat regarding TP concentrations is that 2012 and 2013 samples may be biased low due to lab methodologies.

3.2.3. Candidate cause: Nitrate

Nitrate toxicity to freshwater aquatic life is dependent on concentration and exposure time, as well as the overall sensitivity of the organism(s) in question. Certain species of caddisflies, amphipods, and salmonid fishes seem to be the most sensitive to nitrate toxicity according to Camargo et al. (2005). Camargo et al (2005) cited a maximum level of 2.0 mg/L Nitrate-N as appropriate for protecting the most sensitive freshwater species and that NO3-N concentrations are under 10.0 mg/L to be protective of several sensitive fish and aquatic invertebrate taxa. The intake of nitrite and nitrate by aquatic organisms has been shown to convert oxygen-carrying pigments into forms that are unable to carry oxygen, thus inducing a toxic effect on fish (Grabda et al, 1974; Kroupova et al, 2005).

3.2.3.1. Water quality standards

Minnesota currently does not have a nitrate standard for aquatic life though one is in development.

3.2.3.2. Sources and causal pathways model for nitrogen

The conceptual model for nitrogen as a candidate stressor is modeled at EPA's CADDIS Nitrogen webpage. Lefebvre et al. (2007) determined that fertilizer application and land-cover were the two major determinants of nitrate signatures observed in surface water and that nitrate signatures in surface waters increased with fertilization intensity. Nitrogen is commonly applied as a crop fertilizer,

predominantly for corn. Land applications can reach waterways through surface runoff, tile drainage, and leaching to groundwater, with tile drainage being the largest pathway (MPCA, 2013). Tile line influence increases from 37% of the Nitrogen load to surface waters to 43% of the N load to surface waters during the wet years (MPCA 2013).

3.2.3.3. Overview of nitrogen in the South Fork Crow River Watershed

Nitrate values were higher than 20 mg/L throughout the watershed. The highest values were taken on Buffalo Creek, Judicial Ditch 15, and County Ditch 24A a value of 24 mg/L on each stream. A study by Wenck in June 2011 showed nitrate values were highest in Buffalo Creek just downstream of where Judicial Ditch 15 flows into the creek. A longitudinal study in June 2013 on Buffalo Creek reaffirmed these results (Figure 6). Station S002-017 is upstream of Judicial Ditch 15, station S007-616 is Judicial Ditch 15, and station S000-466 is just downstream of Judicial Ditch 15. Values were also taken throughout the watershed from tile drains, with a high value at 23 mg/L at two different locations.

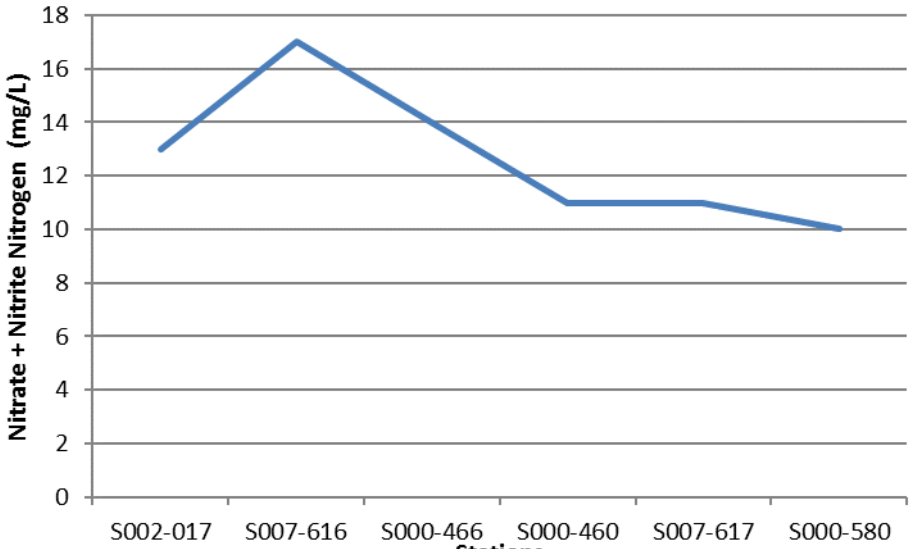

Figure 6. Nitrate values on Buffalo Creek (June 2013)

3.2.4. Candidate cause: Suspended sediment

Reduced transparency can increase due to suspended particles such as sediment, algae and organic matter. Increases in suspended solids 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 an important natural process for all stream systems, sediment imbalance (either excess sediment or lack of sediment) can result in the loss of habitat and/or direct harm to aquatic organisms. As described in a literature 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 levels of total suspended solids (TSS) concentrations can reduce the penetration of sunlight and can thwart photosynthetic activity and limit primary production (Munawar et al., 1991; Murphy et al., 1981). Sediment can also cause increases in water temperature through particles trapping heat. Excess streambed sediment was also identified in the National Rivers and Streams Assessment as stressor to aquatic communities in 15% of the river miles across the United States (U.S.EPA, 2016).

The presence of algae and other volatile solids, such as detritus in the water column can contribute to elevated TSS concentrations and high turbidity. Total suspended volatile solids (TSVS) can provide a rough estimation of the amount of organic matter present in suspension in the water column. Elevated TSVS concentrations can impact aquatic life in a similar manner as suspended sediment with the suspended particles reducing water clarity, but unusually high concentrations of TSVS can also be indicative of nutrient imbalance and an unstable DO regime.

3.2.4.1. Water quality standards

The TSS criteria are stratified by geographic region and stream class due to differences in natural background conditions resulting from the varied geology of the state and biological sensitivity. The TSS standard for the southern region of the state has been set at 65 mg/L.

3.2.4.2. Sources and causal pathways model for TSS

High levels of suspended sediment in the water column 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, extensive drain tile installations, riparian land cover alteration, and increases in impervious surfaces.

Rangeland and pasture are also common landscape features in Minnesota. Cattle pasture within the riparian corridor of rivers and streams has been shown to increase streambank erosion and reduce substrate quality (Kauffman, 1984). In some areas, the riparian corridor has been cleared for pasture and is heavily grazed, resulting in a riparian zone that lacks deep-rooted vegetation necessary to protect streambanks and provide shading. Exposures of these areas to weathering, trampling, and shear stress (water friction) from high flow events are increasing the quantity and severity of bank erosion. The causes and potential sources for increases in sediment are modeled at EPA's CADDIS Sediments webpage.

3.2.4.3. Overview of TSS in the South Fork Crow River Watershed

TSS was identified as a stressor on the South Fork Crow River from the headwaters to the Hutchinson dam. The dam is likely slowing down flow and causing sediments to settle. TSS is also a stressor in the headwaters of Buffalo Creek. Longitudinal surveys along the South Fork Crow River displayed the highest TSS values at station S001-801 (immediately upstream of Watertown dam) in June and station S002-014 (just upstream of Hutchinson dam) in October (Figure 7). Flow seems to be driving TSS concentrations at some locations (Figure 8).

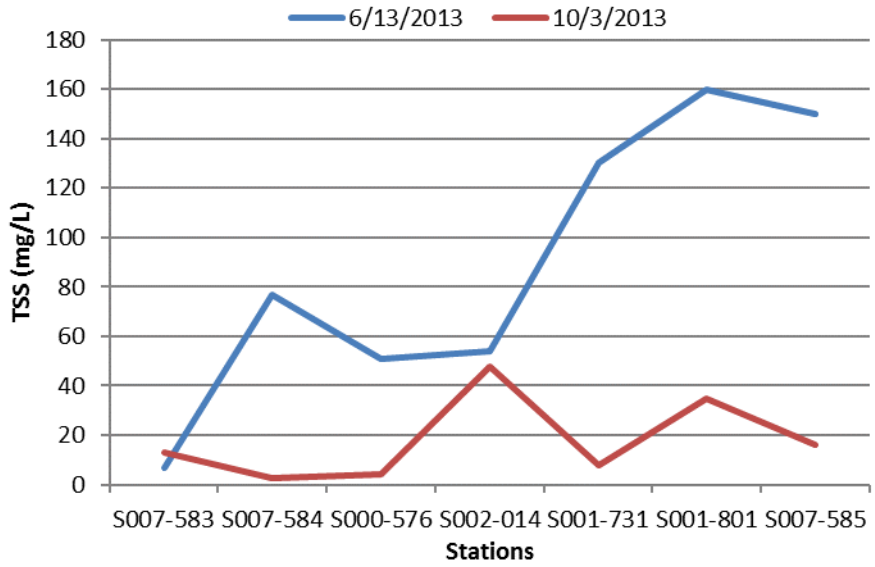

Figure 7. TSS values on the South Fork Crow River in 2013

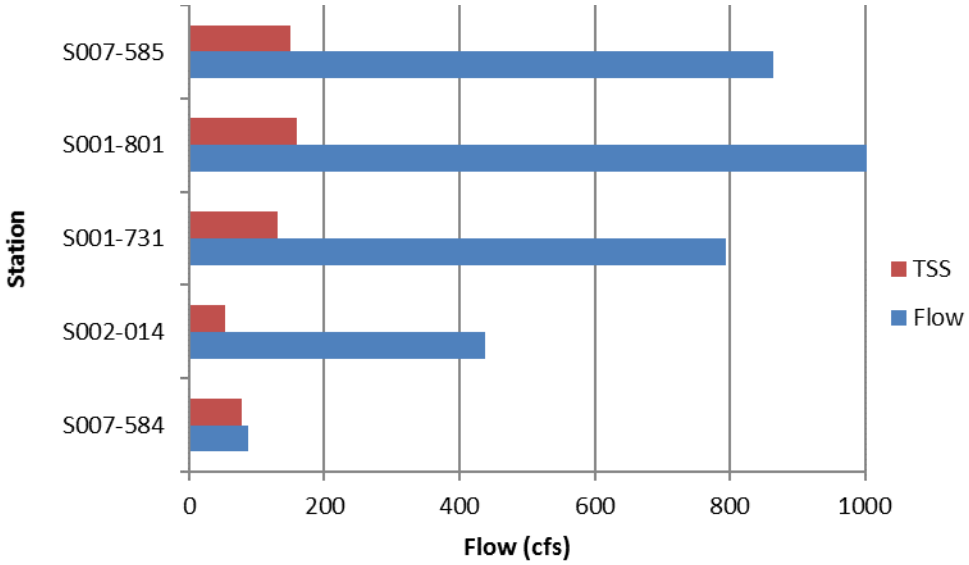

Figure 8. Flow and TSS

3.2.5. Candidate cause: Altered hydrology

Across the conterminous U.S., Carlisle et al. (2010) found that there is a strong correlation between diminished streamflow and impaired biological communities. 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 can increase when flows are lower than normal, making it more difficult for communities to maintain a healthy diversity. Often tolerant organisms that can out-compete others in such limiting situations will thrive. Low flows of prolonged duration lead to macroinvertebrate and fish communities comprised of generalist species or those that have preference for standing water (U.S.EPA 2012). Water withdrawals can also impact low flow events.

Altered hydrology also impacts flows by increasing peak events. High flows and the associated increased flow velocities can cause displacement of fish and macroinvertebrates downstream, and mobilization and possible removal to the floodplain of habitat features such as woody debris, which are important as flow refugia for fish and living surfaces for clinging invertebrates. Macroinvertebrate types may shift from those species having long life cycles to shorter ones; species that can complete their life history within the bounds of the recurrence interval of the elevated flow conditions (U.S.EPA 2012).

Flow conditions can have an effect on the type of fish species that are present. Active swimmers, such as the green sunfish, contend better under low velocity conditions (Carlisle et al., 2010). EPA's CADDIS lists the response of low flow alteration with reduced total stream productivity, elimination of large fish, changes in taxonomic composition of fish communities, fewer species of migratory fish, fewer fish per unit area, and a greater concentration of some aquatic organisms (potentially benefiting predators).

More than 90% of the South Fork Crow River Watershed watercourses have been altered. A channelized stream has limited connection to its surrounding floodplain. When a stream cannot access its floodplain, all of the energy is concentrated within the stream channel, increasing bank erosion and limiting aquatic habitat.

3.2.5.1. Water quality standards

There currently is no applicable standard for flow alteration.

The standard for minimum streamflow, according to Minn. Stat. § 7050.0210, subp. 7 is:

> *Point and nonpoint sources of water pollution shall be controlled so that the water quality standards will be maintained at all stream flows that are equal to or greater than the* $7Q_{10}$ [the lowest streamflow for 7 consecutive days that occurs on average once every 10 years] *for the critical month or months, unless another flow condition is specifically stated as applicable in this chapter*.

3.2.5.2. Sources and causal pathways model for altered hydrology

The conceptual model for flow alteration can be found on the EPA webpage. The causes and potential sources for altered flow are modeled at EPA's CADDIS Flow Alteration webpage.

3.2.5.3 Overview of altered hydrology in the South Fork Crow River Watershed

Almost all of the tributaries in the watershed have been channelized as well as the headwaters of both Buffalo Creek and the South Fork Crow River (Figure 9). Flow has slightly increased in the South Fork Crow River at Rockford from 2004 to 2013, but not to a statistically significant amount (MPCA 2016). Years where data is available show 46% or less of a calendar year had flows at or above Q10, with the highest discharge in 2011 (Figure 10).

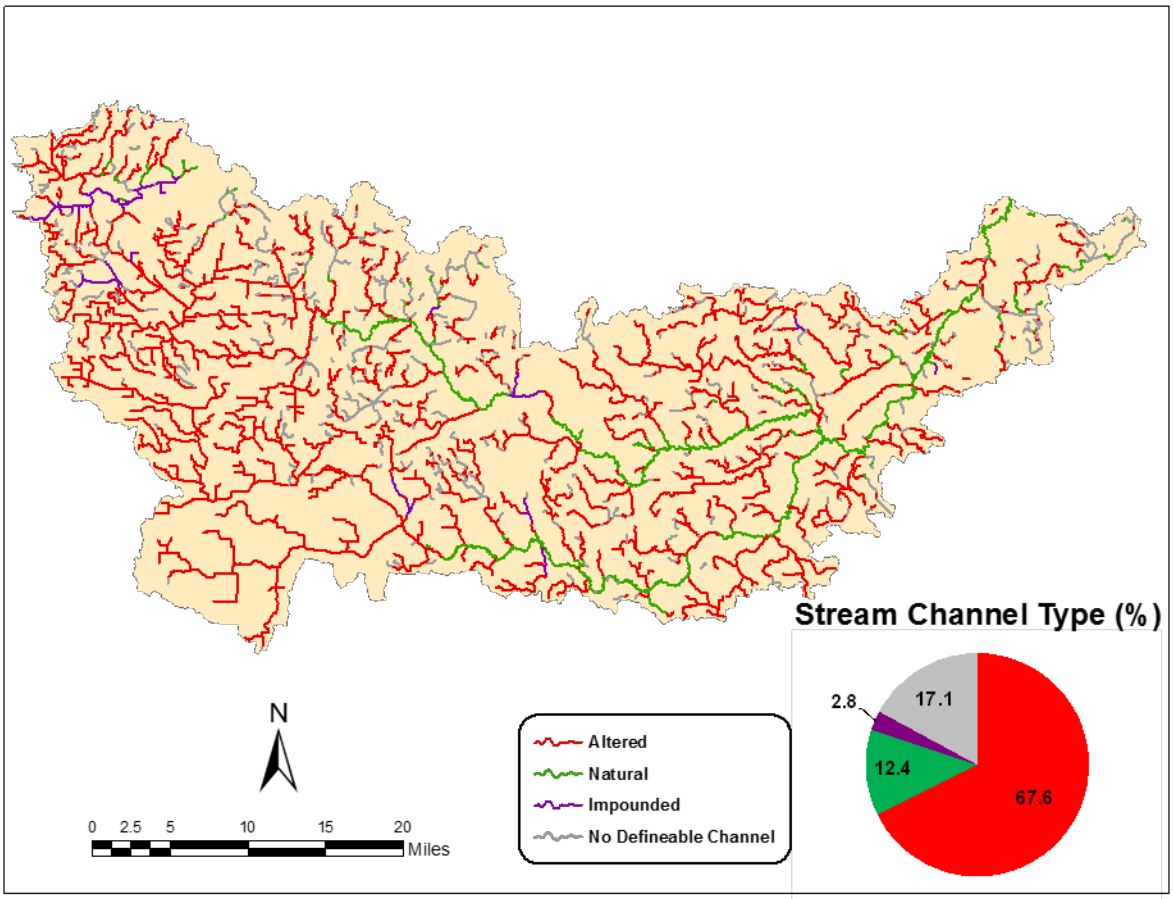

Figure 9. Channelization in the watershed

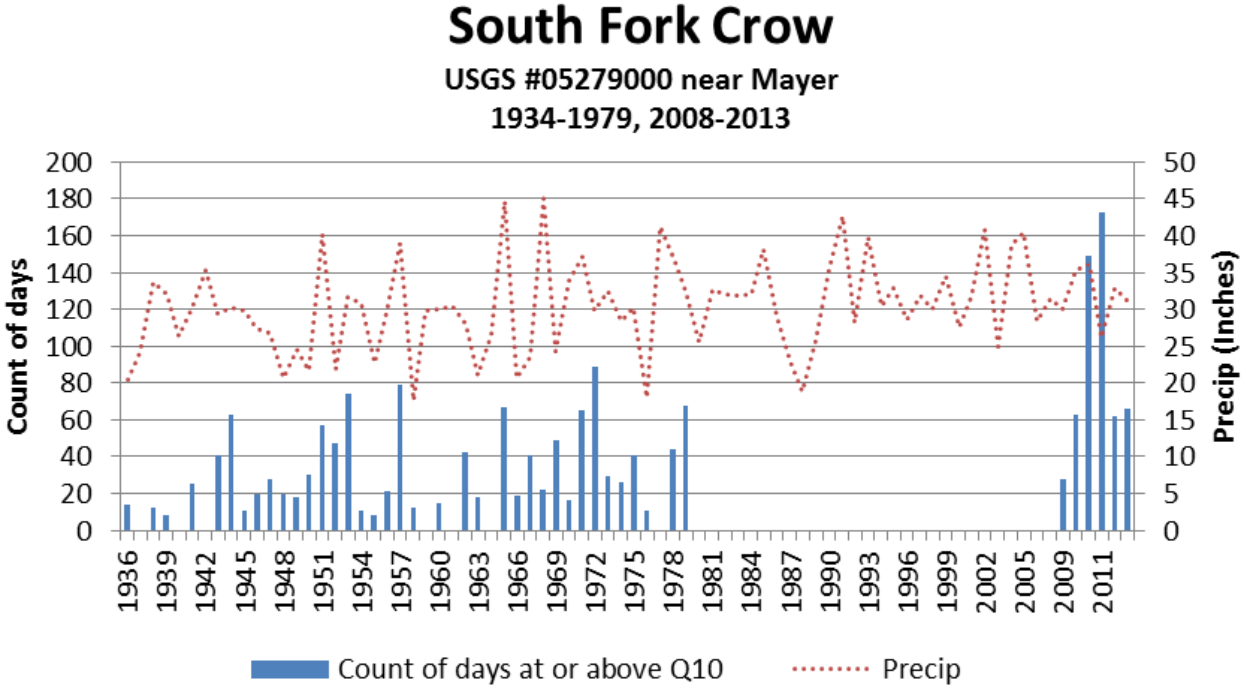

Figure 10. Days at or above Q10 flow (DNR)

Humans can also alter the degree of connectivity within stream systems. In Minnesota, there are more than 800 dams on streams and rivers for a variety of purposes, including flood control, maintenance of lake levels, wildlife habitat, and hydroelectric power generation. Dams change stream habitat by altering streamflow, water temperature, and sediment transport (Cummins M.J., 1979); (Waters, 1995). Dams also directly block seasonal fish migration for reproduction and overwintering. Disrupted migration not only holds the capacity to alter reproduction of fish, it also impacts mussel species that utilize fish movement to disperse their offspring. Structures, such as dams, have been shown to reduce species richness of systems, while also increasing abundance of tolerant or undesirable species (Winston, 1991), (Santucci V.A., 2005).

Culverts at road crossings can also be significant barriers to fish passage if they are installed or sized incorrectly (Figure 11). Culverts can be perched above the downstream water level, have too high an angle, resulting in high velocity flow which many species cannot traverse, or be undersized for the stream size, which also results in high velocity within the culvert. An excellent review of studies regarding culvert impacts to fish migration, including information specifically from Minnesota, has been conducted by the Minnesota Department of Transportation (MNDOT, 2013).

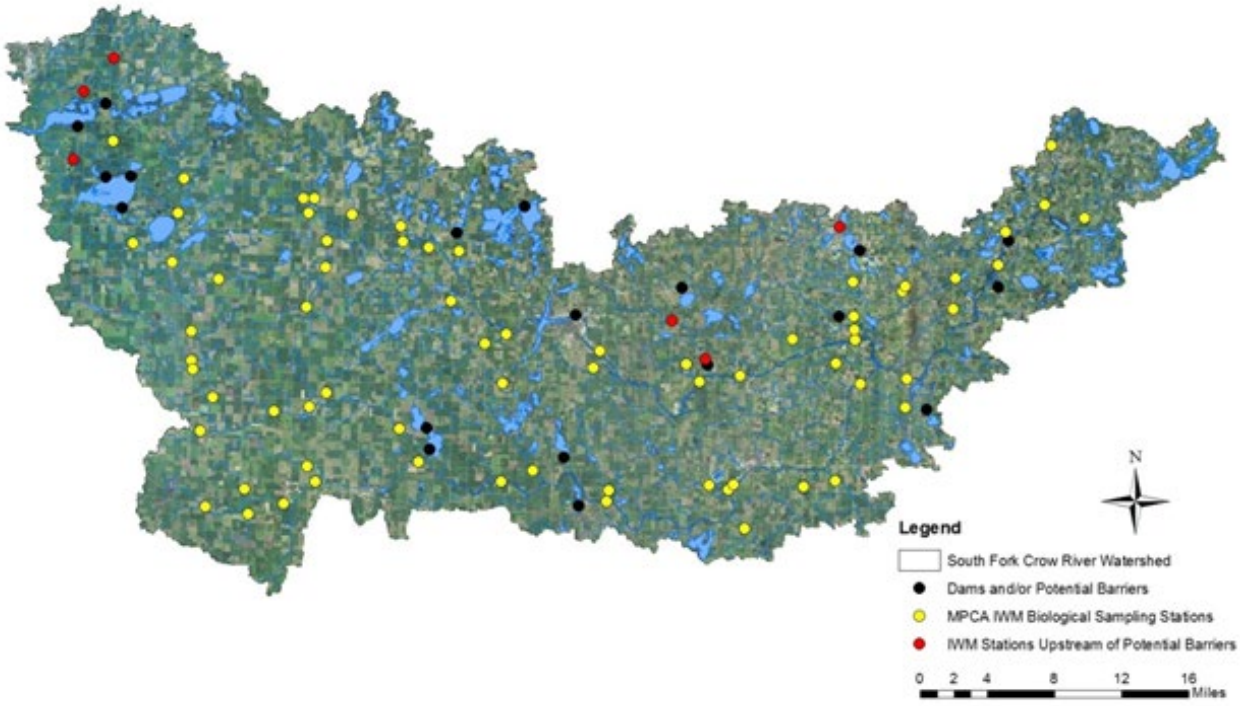

Figure 11. Potential fish barriers in the South Fork Crow River Watershed (DNR 2015)

3.2.6 Candidate cause: Lack of habitat

Excess fine sediment deposition on benthic habitat has been proven to adversely impact fish and macroinvertebrate species that depend on clean, coarse stream substrates for feeding, refugia, and/or reproduction (Newcombe et al., 1991). Aquatic macroinvertebrates are generally affected in several ways: (1) loss of certain taxa due to changes in substrate composition (Erman and Ligon, 1988); (2) increase in drift (avoidance by movement with current) due to sediment deposition or substrate instability (Rosenberg and Wiens 1978); and (3) changes in the quality and abundance of food sources

such as periphyton and other prey items (Pekarsky 1984). Fish communities are typically influenced through: (1) a reduction in spawning habitat or egg survival (Chapman, 1988) and (2) a reduction in prey items as a result of decreases in primary production and benthic productivity (Bruton, 1985; Gray and Ward, 1982). Fish species that are simple lithophilic spawners require clean, coarse substrate for reproduction. These fish do not construct nests for depositing eggs, but rather broadcast them over the substrate. Eggs often find their way into interstitial spaces among gravel and other coarse particles in the stream bed. Increased sedimentation can reduce reproductive success for simple lithophilic spawning fish, as eggs become smothered by sediment and become oxygen deprived. The sediments primarily responsible for causing an embedded condition in southern Minnesota streams are sand and silt particles, which can be transported in the water column under higher flows, or as a bedload component. When stream velocities decrease, these sediments can "settle out" into a coarser bottom substrate area, thus causing an embedded condition.

3.2.6.1. Water quality standards

There currently is no applicable standard for lack of habitat for biotic communities.

3.2.6.2. Sources and causal pathways model for lack of habitat

Many human activities and land uses can lead to myriad changes in in-stream physical habitat. Mining, agriculture, forestry and silviculture, urbanization, and industry can contribute to increased sedimentation (e.g., via increased erosion) and changes in discharge patterns (e.g., via increased stormwater runoff and point effluent discharges), as well as lead to decreases in streambank habitat and in-stream cover, including large woody debris.

Direct alteration of stream channels also can influence physical habitat, by changing discharge patterns, changing hydraulic conditions (water velocities and depths), creating barriers to movement, and decreasing riparian habitat. These changes can alter the structure of stream geomorphological units (e.g., by increasing the prevalence of run habitats, decreasing riffle habitats, and increasing or decreasing pool habitats).

Typically, physical habitat degradation results from reduced habitat availability (e.g., decreased snag habitat, decreased riffle habitat) or reduced habitat quality (e.g., increased fine sediment cover). Decreases in habitat availability or habitat quality may contribute to decreased condition, altered behavior, increased mortality, or decreased reproductive success of aquatic organisms; ultimately, these effects may result in changes in population and community structure and ecosystem function. Narrative and conceptual model can be found on the U.S. EPA CADDIS webpage here.

3.2.6.3. Overview of lack of habitat in the South Fork Crow River Watershed

Sand and silt are dominant substrates throughout the watershed. Coarse substrates are often embedded with fine sediments. Fine sediments are a natural part of stream substrate; they become a problem when they cover and fill in the gaps between coarse substrate, limiting the habitat availability for fish and macroinvertebrates.

The physical lack of habitat was a stressor on Buffalo Creek and all of the tributaries in the watershed. The South Fork Crow River mainstem is the only waterbody among the impaired streams not to have lack of habitat identified as a stressor. Scores from the Minnesota Stream Habitat Assessment (MSHA) survey were all rated either poor or fair throughout the watershed except for three sites. These sites were located on the South Fork Crow River between Hutchinson and Bear Creek (stations 12UM071 and 12UM031) and on a tributary to the South Fork Crow near Cedar Mills (12UM043). Altered hydrology and more intense flows affect channel morphology and in stream habitat.

3.2.7 Candidate cause: Ionic strength

Specific conductance refers to the collective amount of ions in the water. In general, the higher the level of dissolved minerals in a volume of water, the more electrical current (or conductance) can be transmitted through that water. Aquatic organisms maintain a careful water and ion balance, and can become stressed by an increase in ion concentrations (SETAC, 2004). Calcium, sodium, and magnesium are all necessary for aquatic health, and occur naturally, but imbalances can be toxic (SETAC, 2004).

3.2.7.1. Water quality standards

A standard of 1,000 µmhos/cm at 25 °C exists for class 4 waters of the state (Minn. Stat. § 7050.0224 subp. 2) that is protective of agricultural and irrigation uses, but is a not an aquatic life standard.

3.2.7.2. Sources and causal pathways model for ionic strength

The presence of dissolved salts and minerals in surface waters does occur naturally, and biota are adapted to a natural range of ionic strengths. However, industry runoff and discharges, road salt, urban stormwater drainage, agricultural drainage, wastewater treatment plant (WWTP) effluent, and other point sources can increase ions in downstream waters. The causes and potential sources for ionic strength are modeled at EPA's CADDIS Ionic strength webpage.

3.2.7.3. Overview of ionic strength in the South Fork Crow River Watershed

Elevated values of specific conductance were recorded on Buffalo Creek, Judicial Ditch 15, and the South Fork Crow River. A longitudinal survey on Buffalo Creek displayed the highest specific conductance values in the headwaters of Buffalo Creek, upstream of Judicial Ditch 15 (Figure 12). Values decreased at station S002-017, and then increased at station S000-466 just downstream of Judicial Ditch 15. The South Fork Crow River experienced increases after Hutchinson, Watertown, and Delano. The highest value during the longitudinal survey was located just downstream of Watertown (Figure 13).

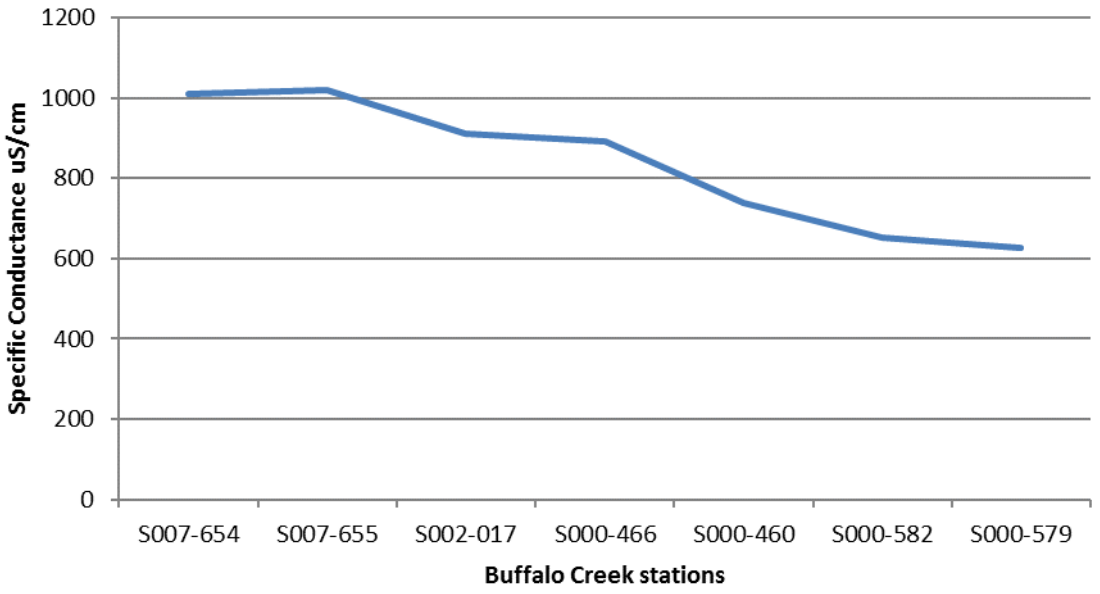

Figure 12. Specific conductance values on Buffalo Creek

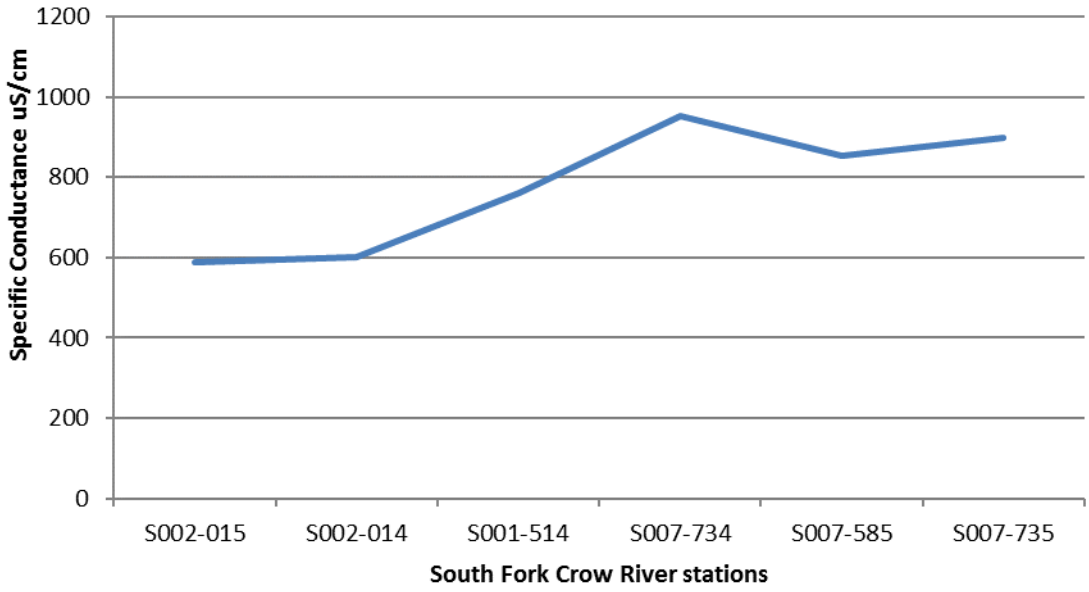

Figure 13. Specific conductance values on the South Fork Crow River

4. Evaluation of candidate causes

4.1. Headwaters South Fork Crow 10-digit HUC

The headwaters of the South Fork Crow River flow out of Wakanda, Little Kandiyohi, and Kasota Lakes near Willmar. Each lake is impaired for nutrients. This section includes the South Fork Crow mainstem and the two impaired tributaries in the area; County Ditch 24A and State Ditch 2. The mainstem South Fork Crow River and the tributaries are discussed in two separate sections.

Prior to settlement, the area was dominated by grassland, wetlands, and lakes. Land use was converted to predominantly cropland and hay fields. The South fork Crow River has been sampled throughout the reach both for biology and chemistry (Figure 14). Both tributaries had only one sampling location.

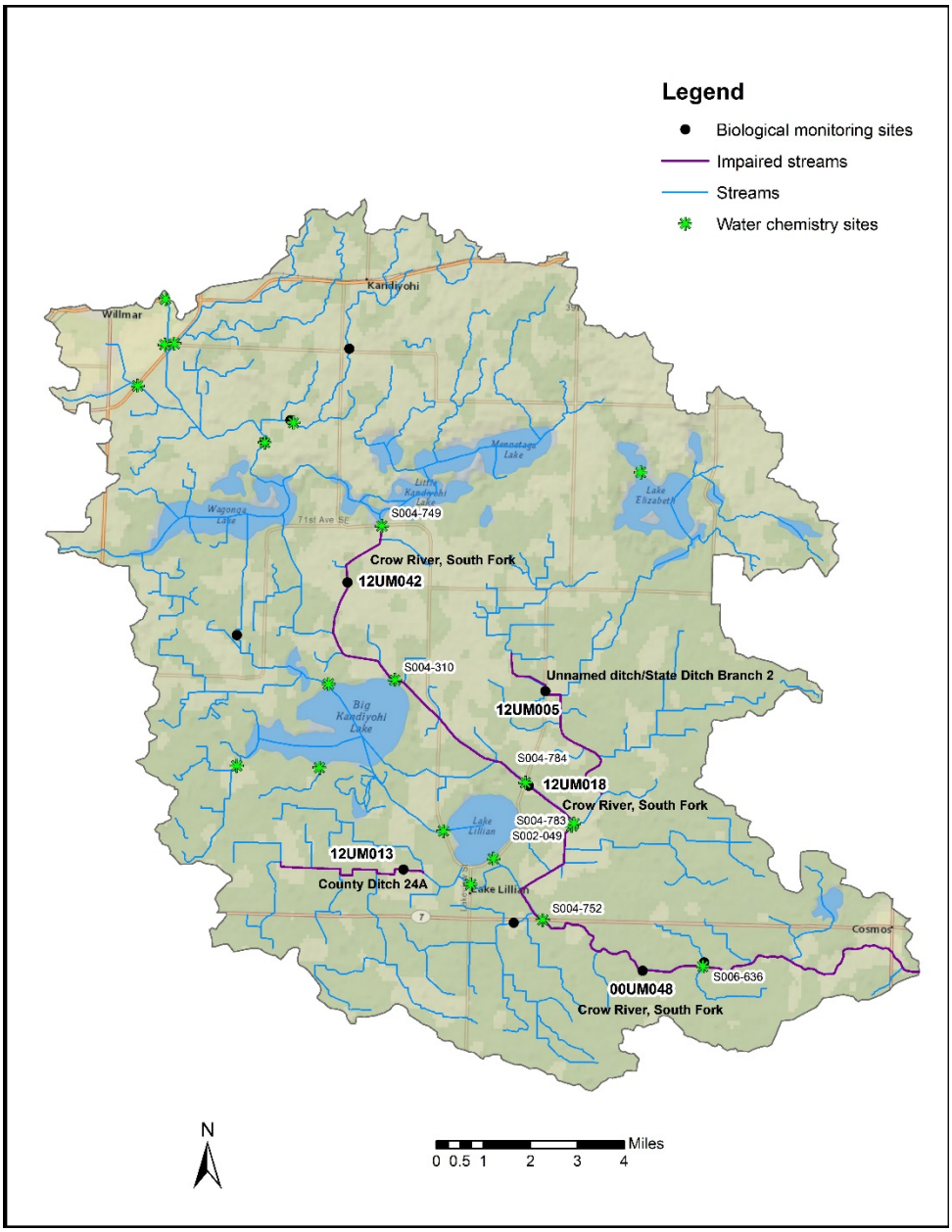

Figure 14. Sampling locations

4.1.1. Tributaries (-608& -610)

- State Ditch Branch 2 (-608)
- County Ditch 24A (-610)

State Ditch Branch 2 and County Ditch 24A are channelized tributaries to the South Fork Crow River near the city of Lake Lillian. State Ditch Branch 2 (station 12UM005) is impaired for aquatic life for both the fish and macroinvertebrate communities while County Ditch 24A (12UM013) is impaired for just the fish community (it was not sampled for macroinvertebrates). Both sites are low gradient and were assessed using the class 7 fish and macroinvertebrate IBIs. Both sites had filamentous algae throughout the reach.

Biological communities

The predominant fish species located at these sites were fathead minnows and central mudminnows. Both tributaries had fish IBI scores of less than 20 on a scale of 100. Contributing to the low scores were metric scores of zero for the number of minnows found, the number of headwater species, and the number of fish captured per meter (Figure 15). Station 12UM013 also had a score of zero for sensitive species. Sensitive species are often the first to disappear upon disturbance. The total score possible for each metric is 11, but all scores were less than 6.

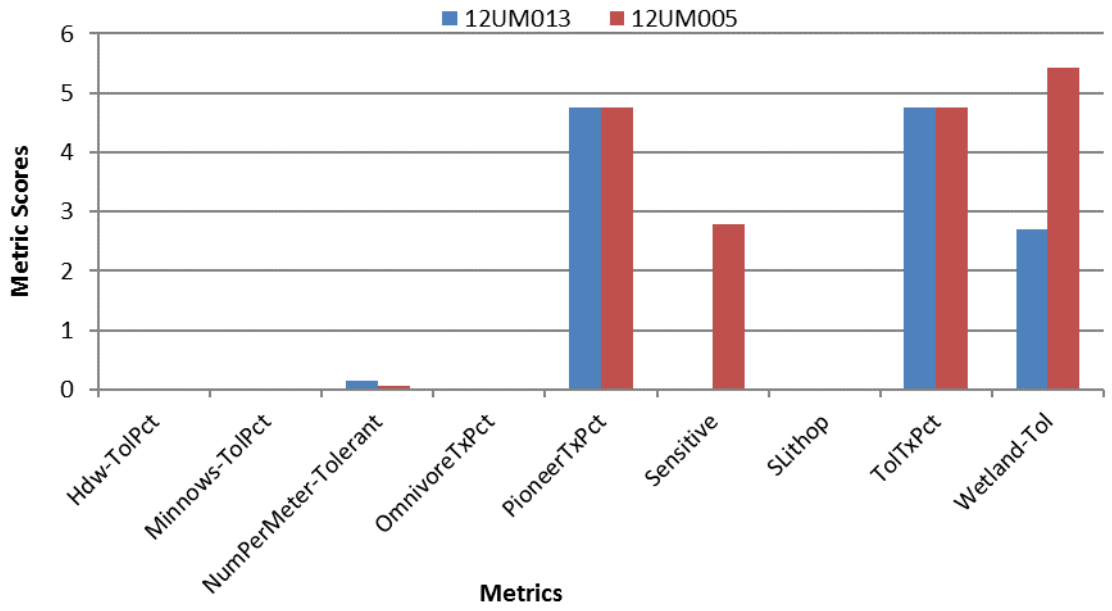

Figure 15. Fish IBI metrics

Only station 12UM005 was sampled for macroinvertebrates. Station 12UM013 was not sampled due to insufficient flow. The habitat sampled at station 12UM005 was filamentous algae due to lack of sampling habitat (rocks, overhanging vegetation, woody debris, etc.) Station 12UM005 had a macroinvertebrate score of 21.9 with a population dominated by snails and freshwater amphipods. Contributing to the low score were low metric scores for the collector-filterer individuals, clingers, and Tricoptera (Figure 16).

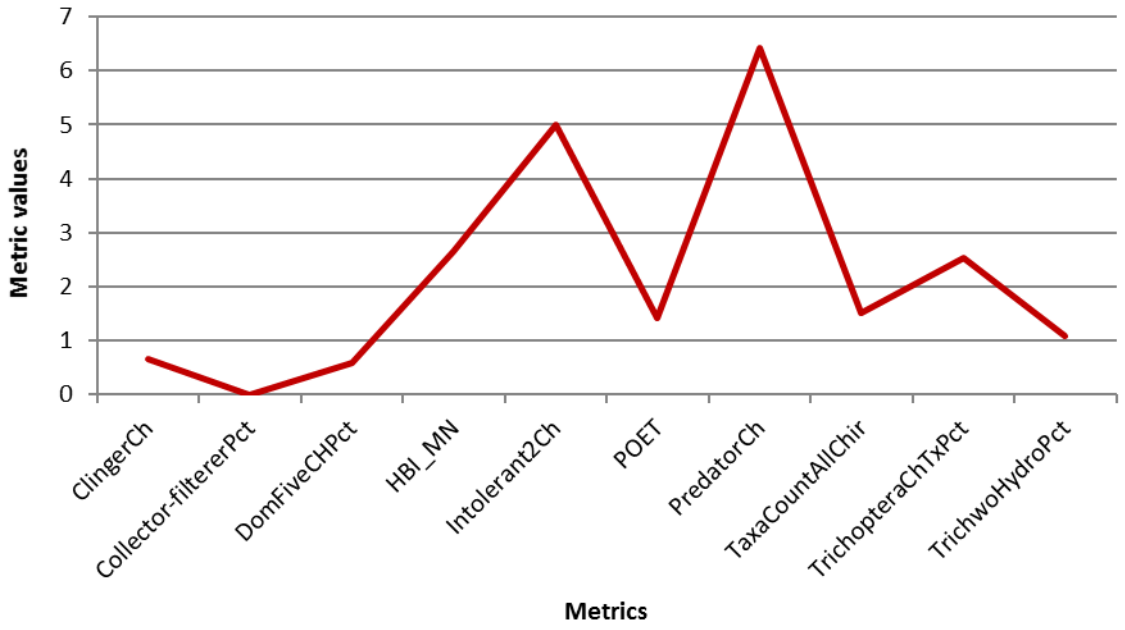

Figure 16. Macroinvertebrate metric scores for 12UM005

Phosphorus/Eutrophication

Algae were prevalent at both stations (Figure 17). Seven phosphorus samples were collected in 2012 and 2014 after both rain events and during base flow conditions. Of the seven values, three were above the southern regional standard of 0.150 mg/L. The highest value was seen during base flow on County Ditch 24A; a value of 0.747 mg/L at station 12UM013. Increased chlorophyll-a, DO fluctuations, and BOD result from eutrophication and are proximate values for phosphorus. The BOD at station 12UM013 was 3.5 mg/L and 1.7 mg/L at station 12UM005. The greater the BOD, the faster oxygen is consumed and the less that is available for fish and macroinvertebrates. The proposed standard for BOD_5 is 3 mg/L. There is no chlorophyll-a or DO flux data available on these reaches.

Table 3. Metrics related to eutrophication

Phosphorus relevant metrics	Sensitive Pct	Darter Pct	Fish Tolerant Pct	Omnivorous fish Pct	Invert Taxa	Low DO Tolerant Pct	EPT Pct	Dominant 2 Invert Taxa Pct
12UM013	0	0	98.21	97.76	_	_	_	_
12UM005	0.88	0.88	98.25	62.28	24	61	9.26	61.42
Average for fish class 7 streams	**8.16**	**5.21**	**70.59**	**22.40**				
Average for invert class 7 streams					**32**	**30.3**	**19.39**	**41.95**
Expected response with increased TP stress	↓	↓	↑	↑	↓	↑	↓	↑

Fish species that are specifically tolerant and intolerant to DO were analyzed at each station. Intolerant fish were zero at both stations and DO tolerant percentage ranged from 96% to 100%. Both tributaries have smaller than average sensitive and darter percentages for class 7 streams statewide, and greater than 98% tolerant percentages. Both the sensitive and darter percentages at station 12UM013 were zero, which is not surprising when looking at the amount of nutrient fueled algae growth (Figure 18). These stations also have higher than average omnivore percentages. Omnivorous fish have a positive relationship with nutrients, chlorophyll-a and DO flux. Station 12UM013 was not sampled for macroinvertebrates due to lack of flow, while station 12UM005 had higher than average percentage of low DO tolerant individuals. The number of macroinvertebrate taxa and EPT percentage were below average while the dominant two taxa were above average.

Figure 17. Algae at station 12UM005 (June 4, 2014)

Figure 18. Algae at station 12UM013

The early morning DO tolerance indicator values (TIV) for fish at the two tributaries show highly tolerant fish communities, with both at 96% or greater fish that are tolerant to low DO. This tolerance corresponds with DO measurements of 3.52 mg/L taken at station 12UM013 and 1.26 mg/L at station 12UM005. Sensitive fish individuals ranged from 0 to 0.88% on these two streams. Based on the elevated phosphorus levels, documented algal growth, preponderance of low DO tolerant fish, the lack of sensitive fish and macroinvertebrate taxa, and the presence of low DO and elevated BOD, eutrophication is determined to be the main stressor.

Lack of habitat

MSHA scores were poor at both stations. Station 12UM005 had poor channel development, no riffles, lack of depth variability, and was comprised primarily of silt. Station 12UM013 was also comprised primarily of fine sediments (clay and silt in this case). There was a lack of both depth variability and channel development (Figure 19).

Figure 19. Lack of channel development at station 12UM005 (July 31, 2012)

There were no simple lithophilic spawners at these two sites, which require coarse substrate for spawning. Benthic insectivore and simple lithophilic species can decrease with channelization as bedload increases. Both stations were dominated by fine sediments. Both stations are modified ditches and have no pools or riffles, and as a result no riffle species. Darter and sculpin species prefer riffle habitat with rocky substrate, which is why the percentages are low at both sites. The percentage of tolerant species is above 98% at both sites. While other stressors also affect the number of tolerant fish, the lack of variety in the habitat of the stations is affecting the fish community.

Table 4. Habitat related metrics

Habitat relevant metrics	SLithophilic Spawners Pct	DarterSculpin Pct	Tolerant Pct	Riffle Pct	Benthic Insectivore Pct
12UM013	0	0	98.21	0	0
12UM005	0	0.88	98.25	0	0.88
Average for fish class 7 streams	**26.76**	**8.9**	**57.42**	**16.84**	**13.81**
Expected response habitat stress	↓	↓	↑	↓	↓

Scores are only available at station 12UM005 (Figure 20). The percentage of clingers was very low (1.54 %). Clingers fix on firm substrates, but only silt is available at this station. Swimmers were also below average. Burrowers live inside fine sediments, while sprawlers live on top. The percentage of burrowers was right at the class average, while the sprawlers were much higher (49.39). Silt was prevalent at this site. The percentage of climbers was just above average. Climbers live on aquatic plants or debris, and filamentous algae were the only available habitat available for sampling. Based on these macroinvertebrate percentages, lack of habitat is a stressor.

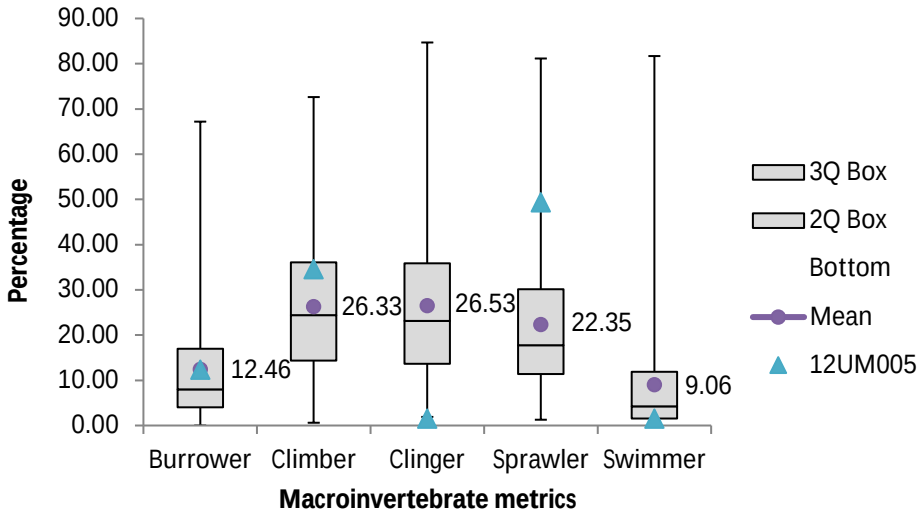

Figure 20. Macroinvertebrate scores affected by lack of habitat

Altered hydrology

The watersheds of stations 12UM005 and 12UM013 are almost completely channelized. Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency and velocity, increasing the impact of high flow events and increasing the intensity of low flow periods, both of which affect biological communities. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat. Increased flow and low events are also affected by extreme weather events. Hydological Simulation Program-FORTRAN (HSPF) models show State Ditch Branch 2 experiencing low flow with less than one cubic foot per second (cfs) 24% of the time, and County Ditch 24A experiencing low flows less than 1 cfs 36% of the time. Flow conditions seem to be affecting the biology due to extended periods of low flow.

Generalized fish species, which are adaptable to different habitats through generalized food preferences, are also correlated with channelization. The average percentage for generalized fish in class 7 waters was 36.44%. The two sites had general percentages of 66.67 and 98.21% respectively. The numbers of nest guarder species are also positively related with low flow conditions. The two stations in this area were about average for fish class 7.

Channelization is connected to and contributing to the lack of habitat. The effects of altered hydrology seem to be contributing to the increase of generalized fish percentages, which are more adaptable to changing conditions and food sources. This is very pronounced at station 12UM013. While the increase in generalist fish numbers indicates an area of disturbance, other contributing factors are likely affecting the high percentage of general fish species. Altered hydrology is a contributing stressor to County Ditch 24A (-610) and State Ditch Branch 2 (-608) through channelization and drainage changes. Altered hydrology is also likely contributing to both eutrophication and lack of habitat.

AUID summary

The main stressors of the tributaries to the South Fork Crow River from the headwaters to the city of Cosmos are eutrophication, lack of habitat and altered hydrology. These stressors are all connected.

4.1.2 South Fork Crow River (07010205-658)

- South Fork Crow River (Headwaters to city of Cosmos)

This section includes the headwaters of the South Fork Crow River in the headwaters South Fork Crow 10-digit HUC. Sites in the downstream HUC are also included through the town of Cosmos since the AUID -658 ends there. It was decided to keep all of the information about -658 in one section.

The South Fork Crow River is impaired for aquatic life for both the fish and macroinvertebrate communities. The five biological monitoring stations along this reach are in two different fish classes (classes 5 and 7) and one macroinvertebrate class (class 7).

Biological communities

Station 12UM042, the most upstream station had an IBI score of 32, and station 12UM018 had an IBI score of 22. Both stations in fish class 7 scored poorly for the headwater, minnow, and number of fish per meter metrics (Figure 21). Station 12UM018 also had a score of zero for the sensitive metric. The most common fish sampled at these two sites were common carp (a tolerant fish species that can survive in many different habitat types).

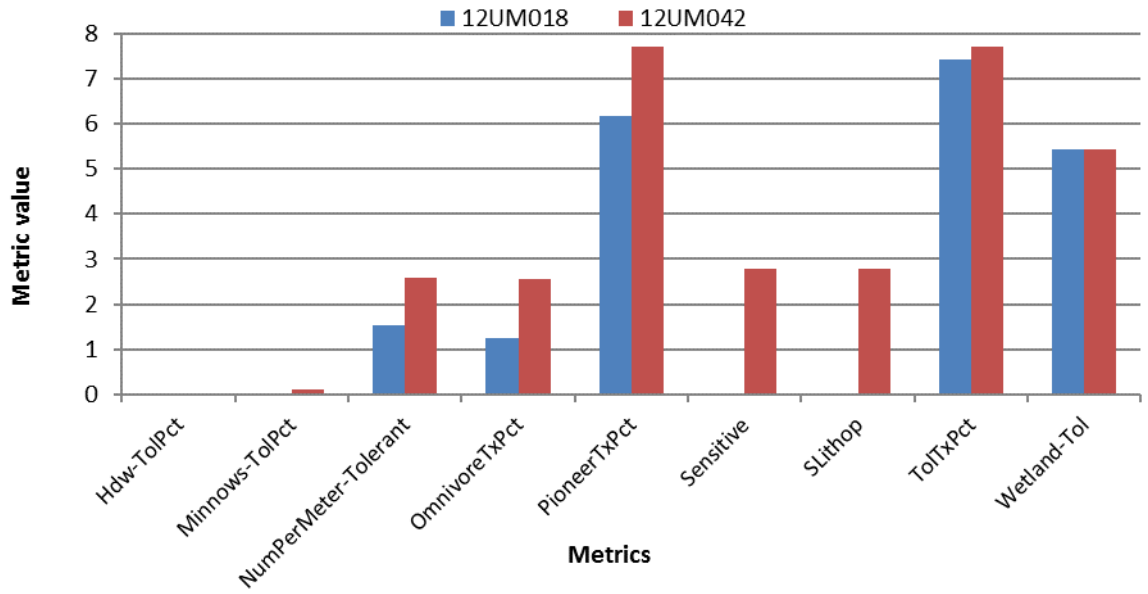

Figure 21. Metric values for fish class 7

There were three stations in fish class 5, where the highest possible metric score was nine (Figure 22). Downstream of Dog Lake and the impaired tributaries County Ditch 24A and State Ditch Branch 2, station 00UM048 had the lowest scoring FIBI. Stations 00UM048 and 00UM053 were both sampled in 2000 and 2012. Station 00UM053 scored lower over time with a higher percentage of the fish population dominated by two species (fish IBI score from 21 to 15). Station 00UM048 saw an increase in the fish IBI score from 6 to 12. Station 12UM058 had a score of 23. The lowest scoring metric among all five visits measured the number of taxa that are very tolerant to human disturbance. The most common fish species collected were johnny darter, carp, fathead minnow, and black bullheads.

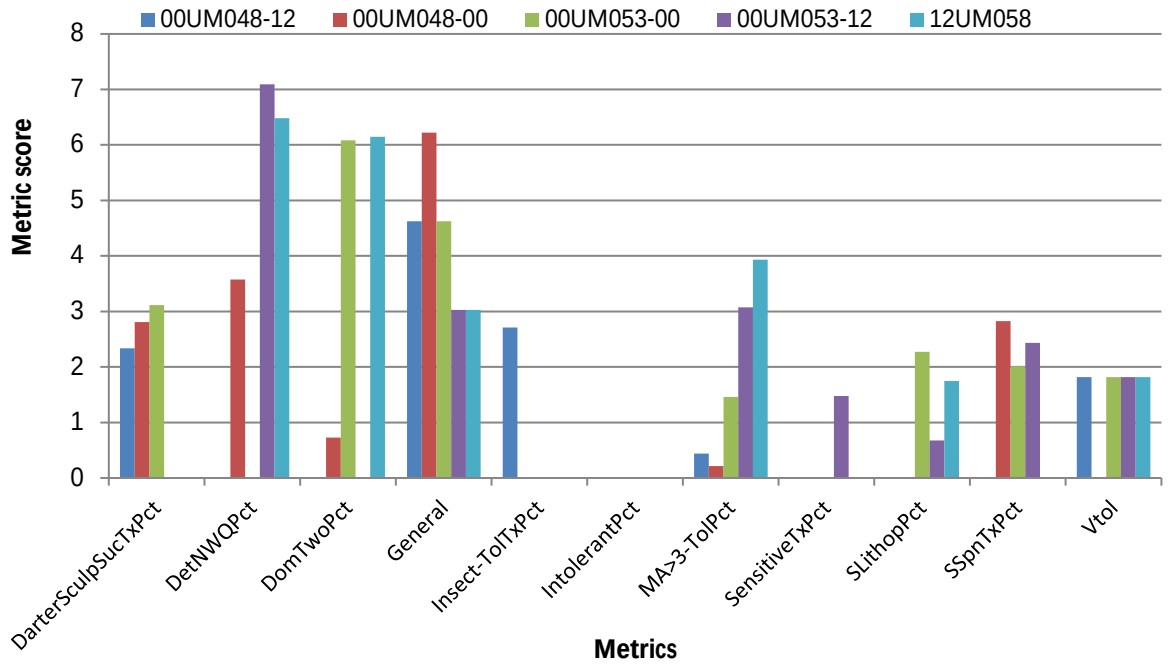

Figure 22. Metric scores for fish stations in class 5

All stations on the South Fork Crow River were in macroinvertebrate class 7 (prairie streams). The MIBI scores increased from upstream to downstream, with the most downstream station scoring at the impairment threshold (41). Station 12UM018 was not sampled for macroinvertebrates due to insufficient flow. The high possible metric score was 10. Each station had a score of zero for macroinvertebrates intolerant to disturbance (Figure 23). The two downstream stations (00UM053 and 12UM058) both scored well for caddisfly species (TricopteraChTxPct). The caddisfly species collected at station 12UM058 were moderately intolerant to disturbance (EPA 2013).

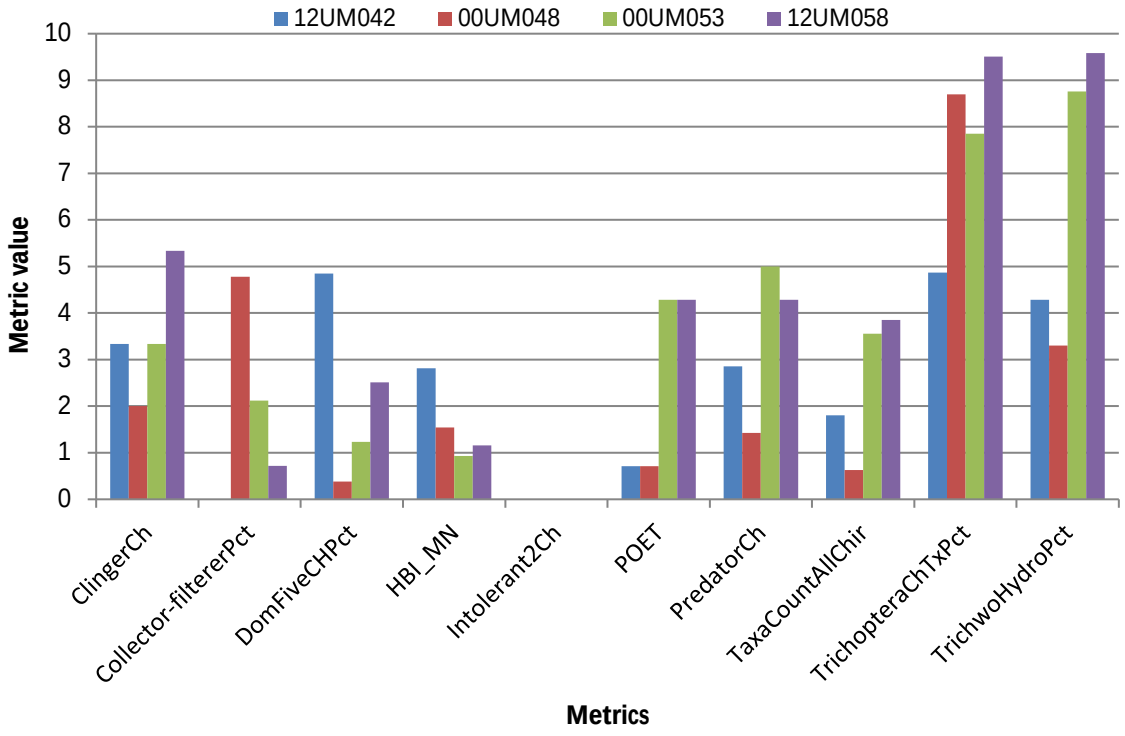

Figure 23. Macroinvertebrate metric scores

Phosphorus/Eutrophication

Phosphorus values were taken both after rain events and during base flow conditions. The highest values were taken at station S002-015 (0.562 mg/L). The standard of phosphorus in the southern region is 0.150 mg/L, with 27 samples above this value (82%). Elevated values were found downstream of Little Kandiyohi, State Ditch Branch 2, and the towns of Lake Lillian and Cosmos. Values of pH raised to 9.7 during the fall, with 8 other values above 8.5 (16%). Values greater than 8.5 are tied to eutrophication. Continuous data showed pH flux ranged from 0.35 to 0.65. Typical daily pH fluctuations are 0.2-0.3 (Heiskary et al., 2013). DO flux ranged from 3.7 to 8.6 mg/L, 11 of the 12 days experiencing flux above the southern river eutrophication standard of 4.5 mg/L (Figure 24). The highest DO value recorded was 17.4 mg/L.

Numerous paired phosphorus and orthophosphate samples were taken on this section of the South Fork Crow River. The majority of samples were taken at station S002-015, where orthophosphate values ranged from 1% up to 71% of the TP concentration, with an average of 15%. On average, the form of phosphorus available for plant uptake does not make up the majority of the phosphorus values.

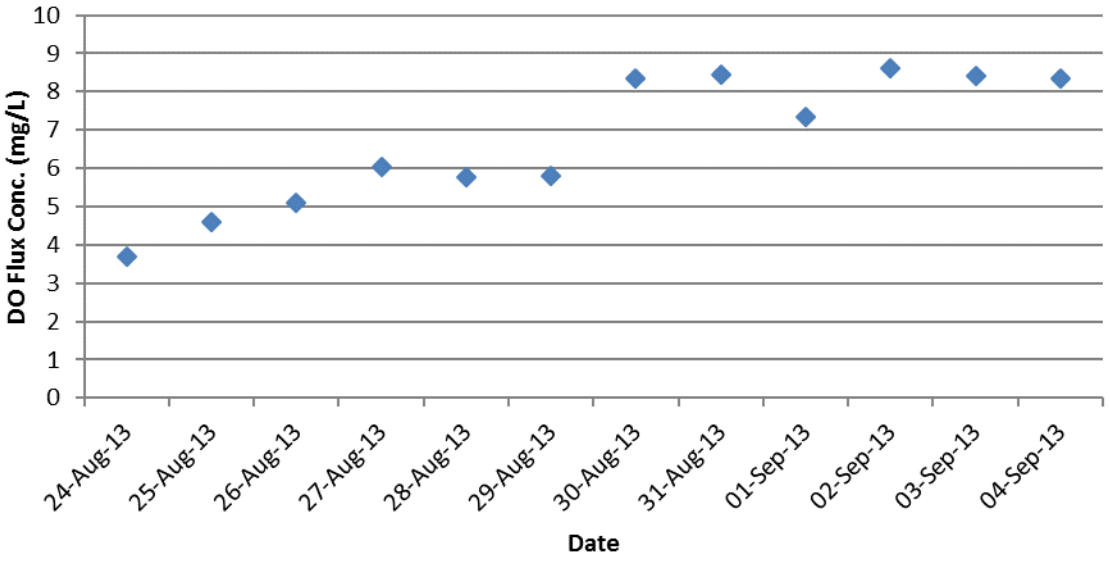

Figure 24. DO flux on the South Fork Crow River

All stations have less than 1% of sensitive and darter species, much lower than the average class values. Four of the five stations did not have any darters collected. Tolerant percentages were all greater than 72%, with the three stations in fish class 5 all two times greater than average. Omnivorous fish have a positive relationship with nutrients, chlorophyll-a and DO flux. All stations had high percentages of omnivorous fish, with the highest percentage at station 00UM048 where thick algae growth was observed (Figure 25). This was also reflected in the macroinvertebrate community through the elevated dominance of two species at every station except 12UM042. The number of macroinvertebrate taxa increased near the downstream section of the AUID. The lowest number was again at station 00UM048. The biological communities, particularly the fish community are showing the effects of the elevated phosphorus, DO flux, and pH values. Eutrophication is a stressor on the headwaters section of the South Fork Crow River (Figure 26). The three lakes (Kasota, Little Kandiyohi, and Wakanda) at the headwaters of the river are likely one of the influences.

Table 5. Eutrophication related metrics

Station	Sensitive Pct	Darter Pct	Fish Tolerant Pct	Omnivorous Fish Pct	Invert Taxa	Low DO Tolerant Pct	EPT Pct	Dominant 2 Invert Taxa Pct
12UM042	0.49	0	93.89	86.32	25	98.43	2.82	34.17
12UM018	0	0	88.81	88.11	-	-	-	-
Averages for class 7 fish stations	**8.16**	**5.21**	**70.59**	**22.40**				
00UM048	0	0.11	96.64	95.15	21		18.29	80.44
00UM053	0.43	0	84.83	83.76	31		17.54	71.08
12UM058	0	0	72.13	48.63	32		14.50	56.49
Averages for class 5 fish stations	**22.31**	**13.48**	**36.11**	**14.23**				
Averages for class 7 invert stations					**32**	**30.3**	**19.39**	**49.31**
Expected response to stress	↓	↓	↑	↑	↓	↑	↓	↑

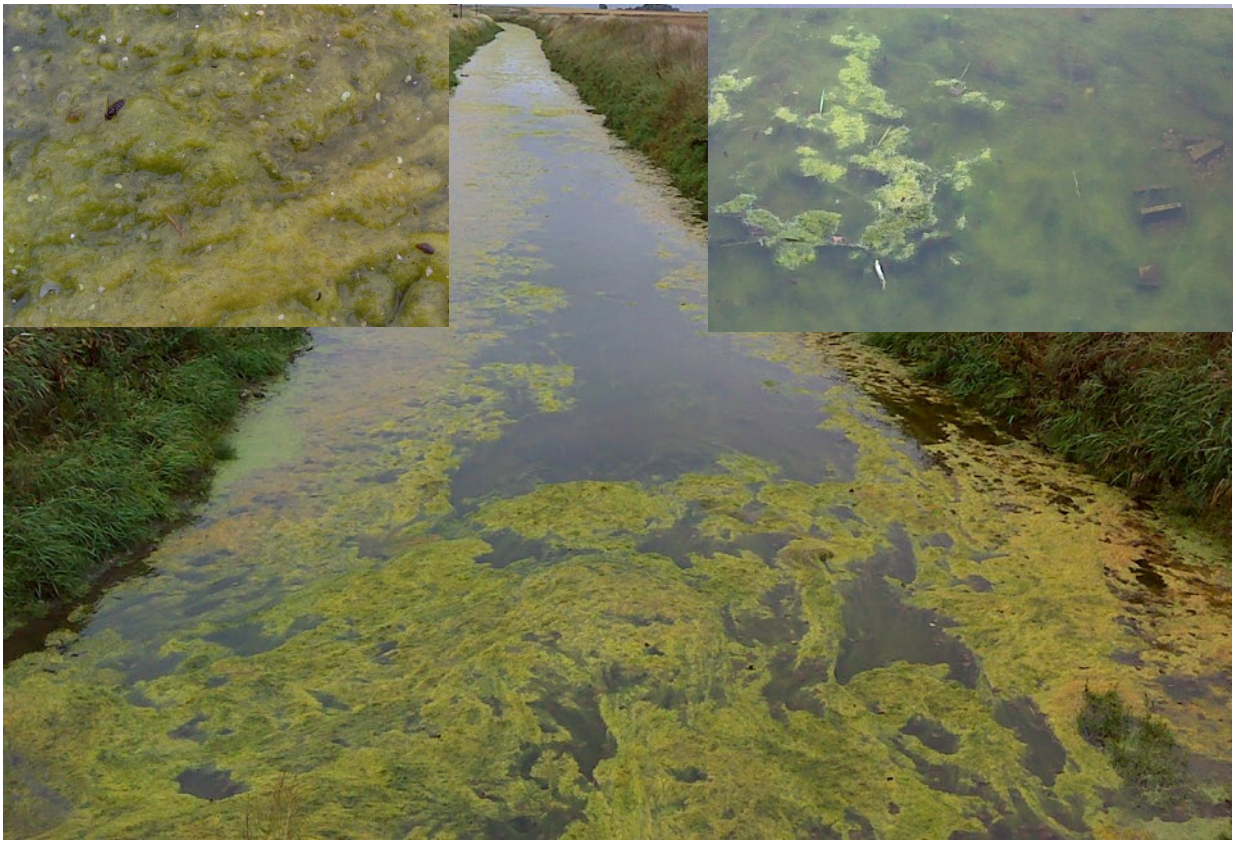

Figure 25. Algae on 00UM048 (October 3, 2013)

Figure 26. Algal growth at station 12UM058

Dissolved oxygen

There is a sizeable DO dataset on this reach in recent years. Concentrations ranged from 2.6 mg/L to 16.57 mg/L with 12 days below 5 mg/L (20%). Each year DO samples taken between 2010 and 2014 at station S007-583 had values below 5 mg/L with a low value of 2.6 mg/L. station S007-583 (12UM042) is just downstream of Little Kandiyohi, Wakanda and Kasota Lakes which is impaired for nutrients. Values below 5 mg/L were taken at stations S007-582, S002-049, S007-584 (00UM048), S002-015 (00UM053), and S000-577 (12UM058). Low DO values were found throughout the entire reach of the South Fork Crow River. Continuous data was recorded at station S002-015 in 2013, with 9 out of 14 days below 5 mg/L. The lowest value recorded during deployment was 2.74 mg/L.

The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. Stations 12UM042 and 12UM058 have small percentages fish that take three years or longer to mature, indicating that fish are quick to reproduce due to short life spans from the influence of human disturbance. The other stations had percentages of fish that mature at greater than three years ranging from 6.47 to 14.75%, close to class averages. Low DO values also correspond with increased serial spawning fish percentage. Stations ranged from 8.12 to 29.32%. Stations 12UM042 and 12UM058 had higher than class averages of serial spawners.

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed at each station. Intolerant macroinvertebrate taxa ranged from zero to three that were collected and DO tolerant percentage ranged from 4.42 to 70.94. While there are low DO values spread throughout this reach, there is not a consistent biological response throughout the reach. Station 12UM042 shows the strongest response. Low DO is inconclusive as a stressor.

Table 6. DO related metrics

Station	MA>3 years Percentage	Serial Spawning Fish Percentage	Low DO Index score	HBI_MN	Percentage DO Tolerant Macroinvertebrate	Intolerant DO Macroinvertebrate Taxa
12UM042	0.98	29.32	6.35	8.01	70.94	0
12UM018	6.47	15.56	6.35	_	_	_
Averages for class 7 fish stations	**4.62**	**19.58**				
00UM048	1.76	9.58	6.30	8.39		0
00UM053	11.54	8.12	6.28	8.59	4.42	3
12UM058	14.75	27.87	6.56	8.52	11.1	2
Averages for class 7 invert stations				**8.07**	**30.29**	**1.88**
Averages for class 5 fish stations	**13.46**	**19.03**				
Expected response to stress	↓	↑		↑	↑	↓

Suspended sediment

TSS values in recent years ranged from 2.4 to 127 mg/L. 15% of samples were above the central region standard of 65mg/L. The highest values were taken at station S002-015 in August. Numerous paired organic solids (TSVS) and inorganic solids (TSS) samples were taken on this section of the South Fork

Crow River. The majority of samples were taken at station S002-015, where TSVS values range from 12% up to 83% of the suspended solid concentrations, with an average of 30%. On average, inorganic solids make up the majority of the suspended solids.

Fish species that are specifically tolerant and intolerant to TSS were analyzed at each station. There were not any intolerant fish at any station. TSS tolerant percentage range from 12% (00UM053) to 85% (00UM048). Herbivore species of fish decrease as TSS values increase. In this headwater section of the South Fork Crow River, the biological stations had no herbivore fish taxa or TSS intolerant macroinvertebrate taxa. All stations had high numbers of fish collected that were tolerant to elevated TSS values. The most common fish include common carp, fathead minnows, black bullhead, and orangespotted sunfish.

At station 00UM048 the percentage of TSS tolerant macroinvertebrates increased from 54.26% in 2000 to 88.16% in 2012. Station 00UM048 also had a low percentage of long-lived macroinvertebrates as did station 12UM042. The long-lived macroinvertebrate percentage increases from up to downstream. Perciforms species (smallmouth bass, walleye, etc.) have been demonstrated to decrease as TSS increases. Perciform percentages were low at all stations except for the most downstream station, 12UM058 where 22 walleyes were located. Based on the low TSS intolerant taxa, herbivore, and long-lived percentages and the elevated TSS tolerant taxa, evidence supports TSS is a stressor on the headwater section of the South Fork Crow River.

Table 7. Metrics related to TSS

TSS relevant metrics	TSS Intolerant Taxa	TSS Tolerant Taxa	Percentage TSS Tolerant Macroinvertebrate Individuals	Long-lived Macroinvertebrate Percent	Herbivore Percent	Perciform-Tolerant Percent
12UM042	0	8	44.03	0.94	0	4.89
12UM018	_	_	_	_	0	3.15
Averages for class 7 fish					**4.01**	**12.86**
00UM048	0	6	88.16	1.58	0	1.87
00UM053	0	12	85.80	6.46	0	5.13
12UM058	0	14	77.60	7.25	0	23.50
Averages for class 5 fish					**2.07**	**26.78**
Expected response with increased TSS stress	↓	↑	↑	↓	↓	↓
Average for class 7 inverts	**0.54**	**9.04**	**29.06**	**5.71**		

Lack of habitat

Habitat conditions were shown to be poor by MSHA scores at all stations except for the fair score at station 00UM053. All stations were lacking in habitat by having no riffles and lack of channel development. Stations 00UM048, 12UM018, 12UM042, and 12UM058 also had a lack of depth variability, sinuosity, and severe embeddedness of coarse substrates with fine substrates. Each station also had a lack of cover for fish and macroinvertebrates.

Simple lithophilic spawners, which require coarse substrate for spawning, typically decrease in numbers with limited habitat and were low in abundance along this headwater stretch of the South Fork Crow River. Benthic insectivore and simple lithophilic species can decrease with channelization as bedload increases. Percentages of lithophilic spawners increased near the downstream section of this AUID. The downstream stations had sand and gravel substrates embedded with silt, but walleye were still collected at both sites increasing the score. While this whole section of the river was channelized earlier, the stations downstream of the town of Cosmos (00UM053 and 12UM058) have a substantial wooded buffer unlike the upstream sites. While the stations did not have any riffles present, small amounts of riffle species were collected at some stations due to white sucker presence. Riffle species also tend to decrease due to lack of habitat. Darter and sculpin species prefer riffle habitat with rocky substrate, which is why the percentages are less than 1% at each site; there are no riffles present and there is an overabundance of fine sediments. The percentage of tolerant species is above 72% at both sites, much higher than both fish class averages.

Table 8. Metrics related to habitat

Habitat relevant metrics	SLithophilic Spawners Pct	DarterSculpin Pct	Tolerant Pct	Riffle Pct	Benthic Insectivore Pct
12UM042	0.24	0	93.89	0.24	0.24
12UM018	0	0	88.81	0	0.52
Average for fish class 7 streams	**14.92**	**5.43**	**70.59**	**8.43**	**6.55**
00UM048	0.06	0.11	96.64	0	0.11
00UM053	6.41	0	84.83	4.06	0
12UM058	14.21	0	72.13	2.19	0.55
Average for fish class 5 streams	**37.10**	**14.69**	**36.11**	**19.49**	**21.68**
Expected response with lack of habitat	↓	↓	↑	↓	↓

The number of clingers decreases with the increase in percent fines. The percentages of clingers in macroinvertebrate class 7 were at or below average at all stations. Clingers use firm substrates, which are not available at these stations. Burrowers live inside fine sediments, and are abundant at station 12UM042 where severe embeddedness was recorded. This response was not seen at the other stations where severe embeddedness was found however. Sprawlers live on top of fine sediments. Station 12UM042 again had the highest number of sprawlers, while the other sites were all below average (Figure 27). The percentage of climbers were both well above average, particularly at station 12UM060. Climbers live on aquatic plants or debris, and this section of the river had high numbers except for station 12UM042. Except for station 12UM042 there is not a consistent response to habitat stressors with the macroinvertebrate communities. However, a response to the lack of channel development and overabundance of fine sediments is seen in decreased numbers of simple lithophilic spawners, riffle species, darter and sculpin species, benthic insectivores, and an increase in tolerant individuals. Lack of habitat is a stressor to fish and macroinvertebrate in this section, and reduced substrate quality is also associated with the TSS stressor identified in the previous section.

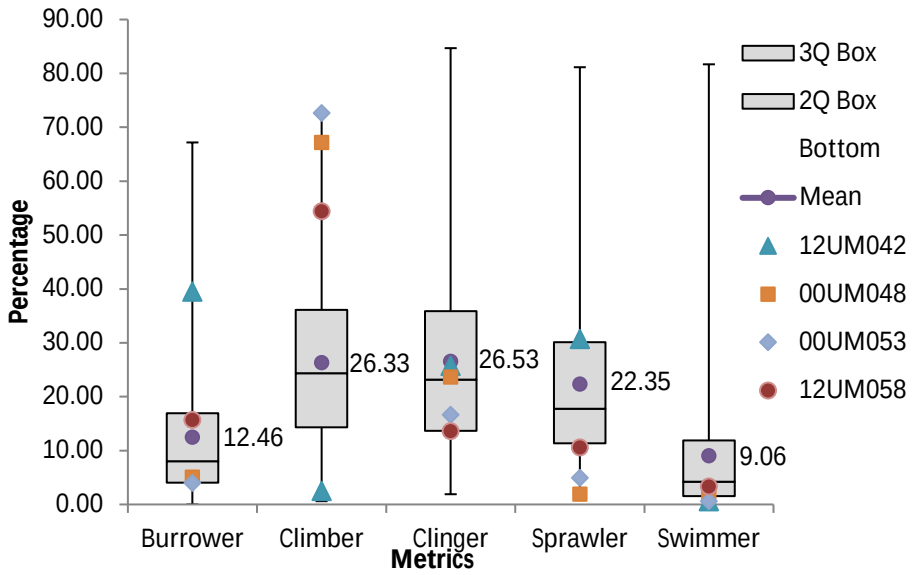

Figure 27. Macroinvertebrate metrics affected by habitat

Altered hydrology

This headwater section of the South Fork Crow River was all channelized at some point (Figure 28). The area downstream of Cosmos in particular has recovered some of its sinuosity. Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency, increasing the impact of high flow events and increasing the intensity of low flow periods, both of which affect biological communities. Station 12UM018 was not able to be sampled for macroinvertebrates due to lack of flow. Increased flow events can cause increased bank erosion and bedload transport, eventually leading to excess sedimentation once flows subside, affecting fish and macroinvertebrate species that rely on clean substrate for habitat and/or reproduction. Channelization and tile drainage increase the hydraulic efficiency of the watershed, causing flashy flows; high in the spring and during rain events and low or dry later in the summer.

Figure 28. Station 00UM048 (June 3, 2013)

The South Fork Crow River in Cosmos is classified as a C5c- stream, which have high sensitivity to disturbance and bank erosion potential (Rosgen, 1994). The stability rating was poor and the stream is incised and in danger of losing floodplain connection (DNR, 2015). This section also had a lack of pool depth. The DNR estimated 190 pounds of streambank erosion per linear foot annually. DNR suggests adding deep rooted riparian vegetation and that channel excavation should not occur.

Benthic insectivore and simple lithophilic species can decrease with channelization as bedload increases. Riffle species are shown to decrease with low flow conditions. Generalized fish species, which are adaptable to different habitats through generalized food preferences, are also correlated with channelization and flow changes. The average percentage for generalized fish in class 7 waters was 36.44% and 38.96% in class 5. Station 12UM058 had 55.74% general individuals, while the rest of the sites were all over 84% with the highest 95.15% at station 00UM048. This corresponds with the number of nest guarder taxa, which tend to increase with low flow. The numbers of nest guarding fish were above class averages and stations 00UM048 and 00UM053 both saw an increase between 2000 and 2012. While nest guarders both increase with low flows, they do not necessarily represent flashy flows due to flow alteration.

Macroinvertebrate swimmers are shown to increase at low flow; values on this reach range from 0.62 to 3.32% while the average is 9.06%. Channelization is connected to and contributing to the lack of habitat. The effects of altered hydrology seem to be contributing to the increase of generalized fish percentages, which are more adaptable to changing conditions and food sources. The number of nest guarder fish species was also elevated. Other contributing factors could also be affecting the high percentage of general fish species. Altered hydrology is a contributing stressor linked to habitat, TSS, and eutrophication.

AUID summary

The main stressors to the South Fork Crow River from the headwaters to the city of Cosmos are eutrophication, TSS, and lack of habitat. These stressors are all connected.

4.2 City of Hutchinson-South Fork Crow 10 Digit HUC

This section includes the South Fork Crow River and its tributaries ranging from Cosmos to Hutchinson. Tributaries include King Creek, Belle Creek, Judicial Ditch 18, County Ditch 18, and a number of Unnamed creeks. The mainstem South Fork Crow River and the tributaries are discussed in two separate sections.

Prior to settlement, the area was dominated by grassland. Land use was converted to predominantly cropland. The South fork Crow River has been sampled throughout the reach both for biology and chemistry (Figure 29). Each tributary had only one sampling location except for Judicial Ditch 18.

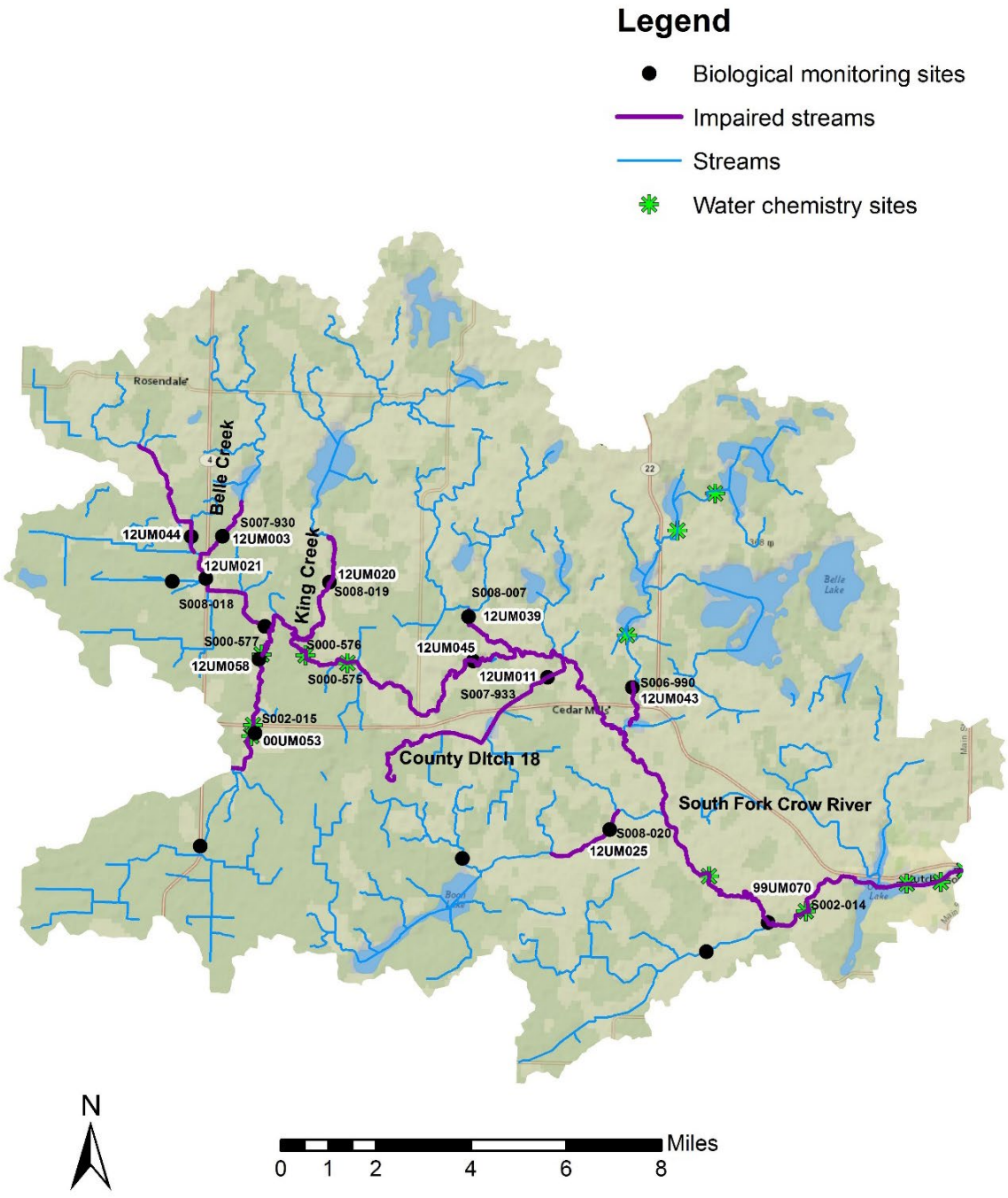

Figure 29. Monitoring locations

4.2.1. Tributaries (-533,549,550,609,613, 621, 623 & -656)

- Belle Creek (12UM003 on -549)
- King Creek (12UM020 on -613)
- Judicial Ditch 18 (12UM021 on -550) and tributary to Judicial Ditch 18 (12UM044 on -623)
- County Ditch 18 (12UM011 on -609)
- Tributaries to South Fork Crow River (12UM025 on -533, 12UM039 on -621, 12UM043 on -656)

Biological communities

Station 12UM011 on County Ditch 18 had the lowest score with metric scores of zero in all categories; only one fish individual was collected (central mudminnow) so was not graphed (Figure 30). The most common fish collected at the remaining stations were fathead minnows, black bullhead, central mudminnows, and yellow perch. Headwater species, minnows, and darter and sculpin species were universally low at all stations in this region.

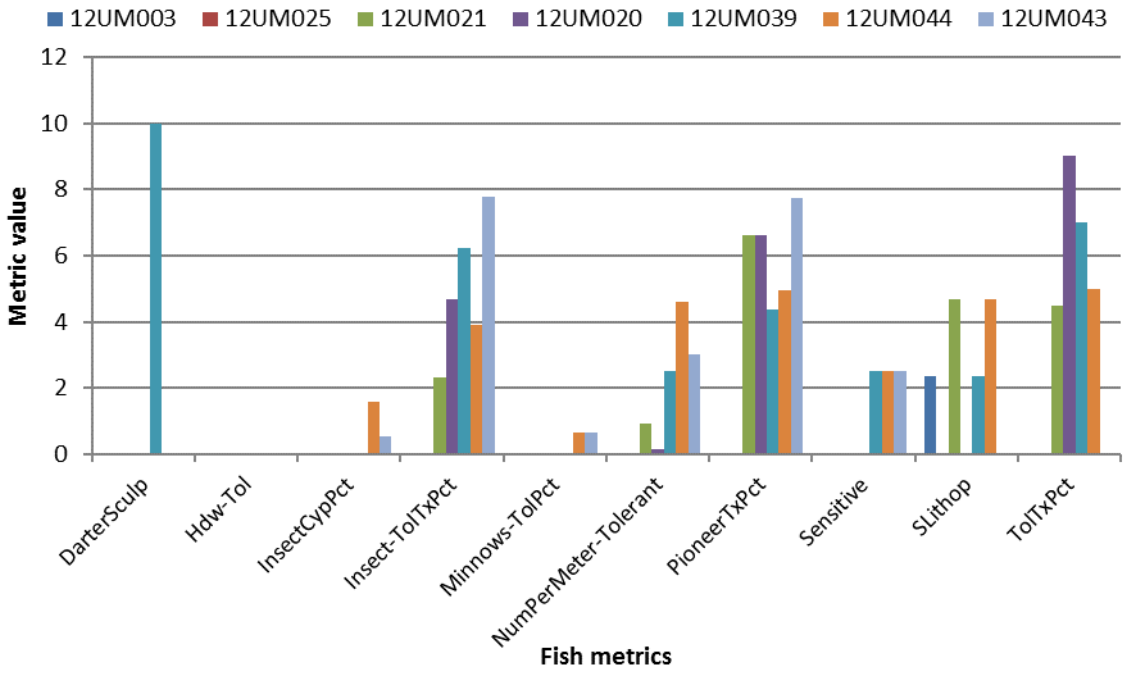

Figure 30. Fish metric values

Six of the stations on the tributaries were in macroinvertebrate class 7 (Figure 31). Each station had a score of zero for macroinvertebrates intolerant to disturbance. Eight of the ten scores at station 12UM011 were zero. The high possible metric score was 10. The highest metric score was located at station 12UM020 with a caddisfly (TrichopteraCHTxPct) score of 9.4.

The other two stations were in class 5 (Figure 32). The caddisfly species collected at station 12UM058 were moderately intolerant to disturbance (U.S.EPA 2013).

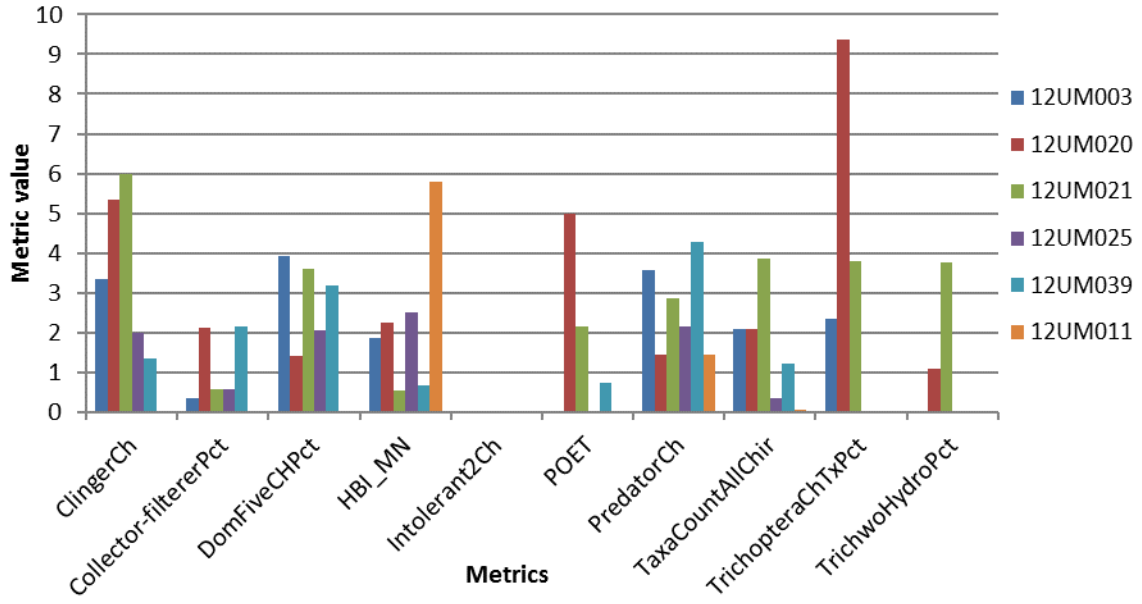

Figure 31. Macroinvertebrate metrics for class 7

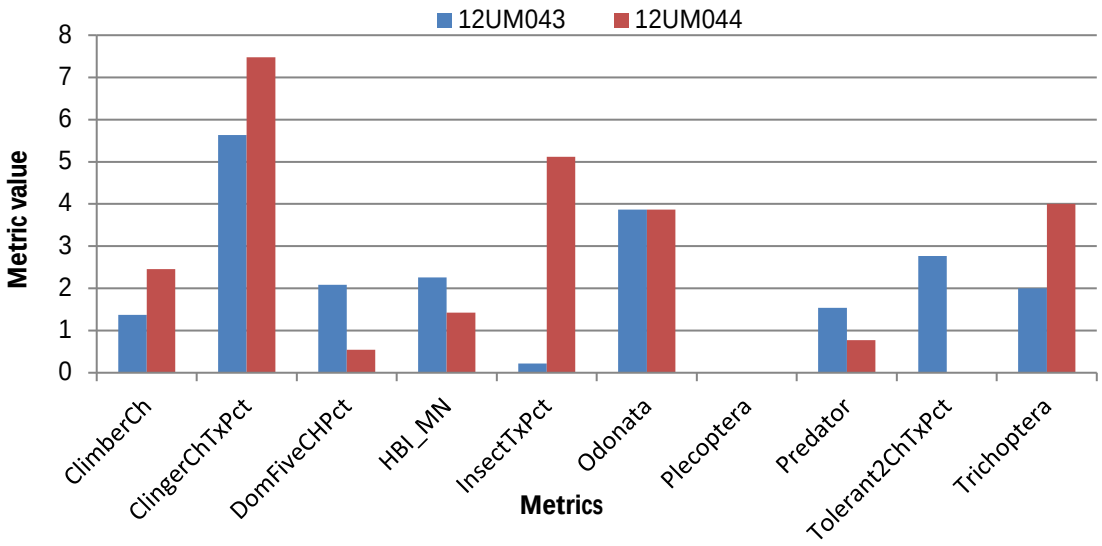

Figure 32. Macroinvertebrate metrics for class 5

Phosphorus/Eutrophication

Phosphorus values were taken both after rain events and during base flow conditions during 2012 and 2014. Twenty-five samples were available from the eight stations. The highest value was taken during base flow on Judicial Ditch 18. The value of 0.37 mg/L was taken at station 12UM011. The standard of phosphorus in the southern region is 0.150 mg/L. Six values were above 0.150 mg/L, all at stations 12UM021, 12UM011, and 12UM003. During sampling, the channel at station 12UM011 was choked with macrophytes and algae. Thick algae and/or macrophytes a present at many of these stations (Figure 33).

Figure 33. Macrophytes at station 12UM043 (right) on August 7, 2012 and 12UM025 on August 1, 2012

All tributaries have lower than average sensitive, darter, and intolerant percentages for class 6 streams statewide. The values for stations 12UM003, 12UM011, 12UM020, 12UM021, 12UM025, and 12UM043 (August 7, 2012) were all zero. Only one fish was collected at station 12UM011. The only station not to have higher average tolerant percentages for class 6 streams is station 12UM044. This is in comparison to station 12UM038 which is not impaired and had 7.32% sensitive species and 19.51% darter species including a sensitive darter; the Iowa darter.

A positive relationship exists between eutrophication and omnivorous fish. This relationship is most pronounced at stations 12UM003, 12UM020 and 12UM021. Station 12UM011 would be expected to have a higher omnivore percentage based on other values but only one fish which was not an omnivore was collected; a central mudminnow. Station 12UM003 and 12UM021 are both located downstream of Belle Lake and station 12UM020 is located downstream of King Creek. These lakes could be influencing eutrophication in these streams, but there is not monitoring data available on the lakes. Station 12UM042 is located downstream of Hoff Lake which has monitoring data and is impaired for nutrients.

Table 9. Phosphorus related metrics

Phosphorus relevant metrics	Sensitive Pct	Darter Pct	Fish Tolerant Pct	Omnivorous fish Pct	Invert Taxa	Low DO Tolerant Pct	EPT Pct	Dominant 2 Invert Taxa Pct
12UM003	0	0	100	98.54	26	49.44	1.57	41.07
12UM011	**0**	**0**	**100**	**0**	19	93.70	0	90.65
12UM020	0	0	77.8	77.8	26	2.98	7.62	73.78
12UM021	0	0	74.2	60.8	32	23.73	15.6	34.66
12UM025	0	0	100	75	20	58.92	0	50.62
12UM039	1.1	1.6	62.6	8.8	23	26.52	8.71	46.55
12UM043 (7-11-12)	1.1	0	46.0	15.2	26	6.76	43.7	47.52
12UM043 (8-7-12)	0	0	44.0	13.8				
12UM044	3.3	0	30.7	17	33	5.08	46.0	39.43
12UM038 *(not impaired)*	7.32	19.51	56.1	12.2	40	6.51	23.72	38.78
Average for fish class 6 streams	**15.1**	**6.3**	**66.5**	**3.2**				
Average for fish class 7 streams	**8.16**	**5.2**	**70.6**	**22.4**				
Average for invert class 7 streams					**32**	**30.3**	**19.3**	**49.31**
Average for invert class 5 streams					**38**	**10.3**	**38.3**	**39.30**
Expected response to increased TP stress	↓	↓	↑	↑	↓	↑	↓	↑

While low DO is also having an effect on the macroinvertebrate community, it is not as pronounced as with the fish. The effect is strongest at station 12UM011 with 93.70% low DO tolerant macroinvertebrates. There was also 0% EPT present, which is where phosphorus was highest and choking vegetation was present (Figure 34).

Continuous DO data was taken at two sites; 12UM003 and 12UM020 (Figure 35). This data showed both stations had values that dipped below the standard of 5.0 mg/L, with daily fluxes up to 5.10 mg/L. The central regional standard of daily DO flux is 3.5 mg/L. Daily DO fluctuations are a measure of stress on the aquatic community. Chlorophyll-a values at these two stations were 4.21 and 25.7 mg/L respectively. Algal respiration and photosynthesis are considered primary drivers of daily flux in DO, and high daily fluctuations of DO are connected to nutrient concentrations. Other stations in the HUC also had observed DO values on the low and high end; with 4.29 mg/L at station 12UM025 and 14.45 mg/L at station 12UM039. All BOD values were below 2.6 mg/L.

Figure 34. Algae and macrophytes at station 12UM011 (July 10, 2012)

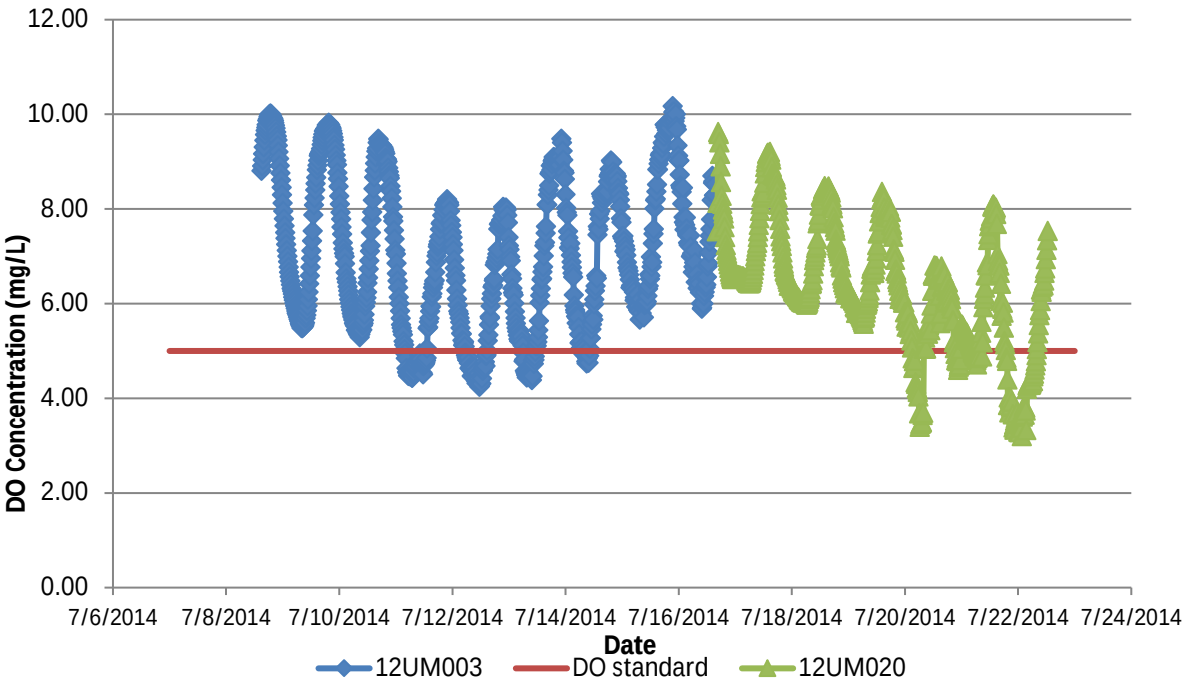

Figure 35. Continuous DO data

pH was also elevated at station 12UM003. Elevated pH above 8.5 is another indicator of eutrophication. All readings at station 12UM003 were above 8.5 and were as high as 9.66 (Figure 36). Station 12UM003 is located downstream of Belle Lake. Upstream of Belle Lake, pH was recorded at 7.91 on September 24, 2014 when station 12UM003 was 8.72. Based on the pH values upstream and downstream of the lake, Belle Lake appears to be a significant source of nutrients and eutrophication in Belle Creek. Typical daily pH fluctuations are 0.2-0.3 (Heiskary et al., 2013). On Belle Creek they ranged from 0.5 to 0.8.

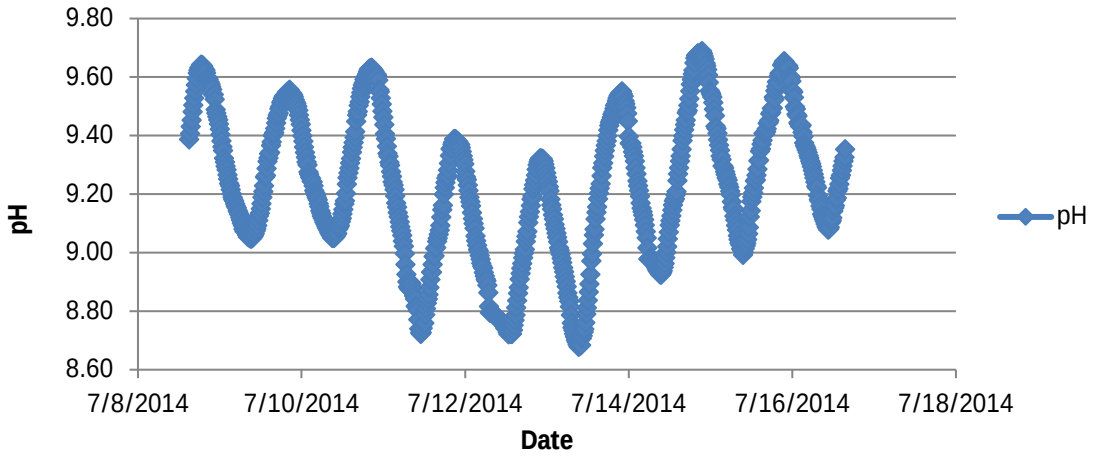

Figure 36. pH values at station 12UM003

Where continuous data was collected both stations had elevated pH, pH flux, low DO, and DO flux. Based on the elevated phosphorus concentrations, algal documentation, preponderance of low DO tolerant fish, the lack of sensitive fish, darters and EPT% and the lack of intolerant macroinvertebrates; eutrophication is a stressor. There is a stronger effect on fish from eutrophication than the macroinvertebrate community at this time.

Dissolved oxygen

Station 12UM025 (S008-020) had two DO recorded values of 4.29 and 10.08 mg/L. Belle Creek at station 12UM003 (S007-930) had four recorded DO readings ranging from 4.67 to 9.41 mg/L. Judicial Ditch 18 at station 12UM021 (S008-018) had three DO readings ranging from 5.38 to 9.67 mg/L. County Ditch 18 at station 12UM011 (S007-933) had two DO readings recorded at 5.44 and 6.34 mg/L. King Creek at station 12UM020 (S008-019) had three readings between 6.14 and 10.03 mg/L. Twenty-two DO readings are available at station 12UM043 (S006-990), ranging from 2.04 to 11.63 mg/L. Station 12UM039 (S008-007) had an elevated DO reading of 14.45 mg/L and station 12UM044 had an elevated DO value of 11.75 mg/L. Continuous data was collected at stations 12UM003 and 12UM020 where recorded minimums were 4.31 and 3.34 mg/L respectively.

Fish species that are specifically tolerant and intolerant to DO were analyzed at each station. There were not any intolerant fish at any station. DO tolerant percentage range from 86% (12UM021) to 100% (12UM025 and 12UM011). The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. Stations 12UM003, 12UM011, and 12UM025 all had zero fish that take three years or longer to mature, indicating that fish are quick to reproduce due to short life spans from the influence of human disturbance. The other stations had percentages of fish that mature at greater than three years ranging from 16.67 to 64.84%, much higher than class averages. Low DO values also correspond with increased serial spawning fish percentage. Serial spawning occurs based on environmental stress. Stations ranged from 0 to 81.75%. Stations 12UM003, 12UM043, and 12UM044 had the highest percentages of serial spawners.

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed at each station. Intolerant macroinvertebrate taxa ranged from 0 to 3 that were collected and DO tolerant percentage ranged from 2.98 to 93.70. Only one central mudminnow was collected at station 12UM011, and since central mudminnows are not serial spawners this metric is potentially minimized. However, central mudminnows are very tolerant to low DO and the macroinvertebrate taxa tolerant to low DO made up 93.70% of the community.

Table 10. Dissolved oxygen related metrics

DO relevant metrics	MA>3 years Percentage	Serial Spawning Fish Percent	Intolerant DO Macroinvertebrate Taxa	Percentage DO Tolerant Macroinvertebrate	HBI_MN
12UM003	0	81.75	1	49.44	8.30
12UM011	0	0	0	93.70	7.10
12UM020	16.67	5.56	2	2.98	8.19
12UM021	21.65	10.31	0	23.73	8.71
12UM025	0	0	0	58.92	8.11
12UM039	30.22	9.34	0	26.52	8.66
12UM043 (7-11-12)	33.71	37.08	2	6.76	7.58
12UM043 (8-7-12)	28.44	47.71			
12UM044	64.84	12.64	3	5.08	7.86
Expected response to increased DO stress	↓	↑	↓	↑	↑
Average for fish class 6 streams	**2.99**	**1.80**			
Average for fish class 7 streams	**4.62**	**1.92**			
Average for invert class 7 streams			**1.88**	**30.3**	**8.07**
Average for invert class 5 streams			**6.91**	**10.45**	**7.45**

The predominance of low DO tolerant fish corresponds with the low DO measurements. Each station had fish communities that were made up of over 87% fish tolerant to low DO (87% at station 12UM021 and 100% at stations 12UM011 and 12UM025). All of the tributaries in this HUC had communities predominantly comprised of fish in the first and second quartile.

Based on the overall evidence of fish that mature at greater than three years of age, percentage of serial spawners, intolerant DO taxa, DO tolerant percentage, and HBI_MN, low DO is a stressor to the macroinvertebrate and fish community. Tributaries that are particularly stressed include Belle Creek, County Ditch 18, and the tributary to South Fork Crow River at station 12UM025.

Lack of habitat

Habitat availability is lacking in these South Fork Crow River tributaries. The MSHA scores taken during biological sampling were poor at all sampling sites except at stations 12UM043 (fair) and 12UM044 (fair and good). The lack of channel development and depth variability were the main contributors to the low scores.

Landscape changes (Figure 37) also help contribute to vegetation growth and sedimentation. Upstream of station 12UM039 all of the large trees along this stream buffer were cut down. The lack of buffer at station 12UM003 shows the ability for fields to erode into the stream at multiple locations (Figure 38).

Figure 37. Aftermath of riparian tree removal (June 11, 2014).

Figure 38. Lack of buffer at station 12UM003 on June 4, 2014 (left) and June 11, 2014

Station 12UM039 had a substrate entirely comprised of silt. Clean cobble and gravel presence have a positive relationship with a higher fish IBI. Station 12UM020 had a gravel substrate that was 100% embedded with sand and silt. Measurements with a rod averaged 34.6 cm of fine substrate at station 12UM020 with measurements up to 56 cm. Station 12UM003, which also had embedded gravel had an average 13.3 cm of fine sediments with measurements up to 14 cm. Station 12UM025 also had a gravel substrate that was severely embedded. Biological samplers noted the lack of habitat at this station. Many stations in this HUC had no coarse substrate or had substrate that was embedded while stations 12UM043 and 12UM044 only had light embeddedness.

The lack of coarse substrates and riffles results in the lack of simple lithophilic spawners, darter and sculpins, and riffle species at the stations. Benthic insectivore and simple lithophilic species can decrease with channelization as bedload increases. Station 12UM039 also had choking vegetation. The majority of fish collected were tolerant at all stations except 12UM043 and 12UM044 where the habitat MSHA scores were higher. Gravel substrate was available at both stations.

Table 11. Metrics related to habitat

Habitat relevant metrics	SLithophilic Spawners Pct	DarterSculpin Pct	Tolerant Pct	Riffle Pct	Benthic Insectivore Pct
12UM003	1.46	0	100	1.46	0
12UM020	0	0	77.78	0	0
12UM021	9.28	0	74.23	5.15	0
12UM025	0	0	100	0	0
12UM039	0.55	1.65	62.64	0	3.85
12UM043 (7/12)	0	0	46.07	0	11.24
12UM043 (8/12)	0	0	44.04	0	1.83
12UM044	1.1	0	30.77	0.55	0
Average for fish class 6 streams	**21.68**	**7.75**	**66.56**	**11.87**	**9.72**
Expected response with habitat stress	↓	↓	↑	↓	↓

The number of clinger taxa decreases with the increase in percent fines. The percentages of clingers for each macroinvertebrate class were below average at all stations (Figure 39). Clingers use firm substrates, which were only available and not embedded at stations 12UM043 and 12UM044. Burrowers live inside fine sediments, and a connection is seen with a lack of fine sediments and below average burrowers at stations 12UM043 and 12UM044 (Figure 40). Stations 12UM003, 12UM021, 12UM025, and 12UM039 all had above average percentages of burrowers, where embeddedness ranged from no coarse substrate available to severe embeddedness. Sprawlers live on top of fine sediments, the percentages were below average at all of the stations. The percentage of climbers were both well above average, particularly at station 12UM060. Climbers live on macrophytes, and station 12UM060 had choking vegetation providing a lot of habitat. A lack of habitat is a stressor based on a prevalence of fine substrates and embeddedness.

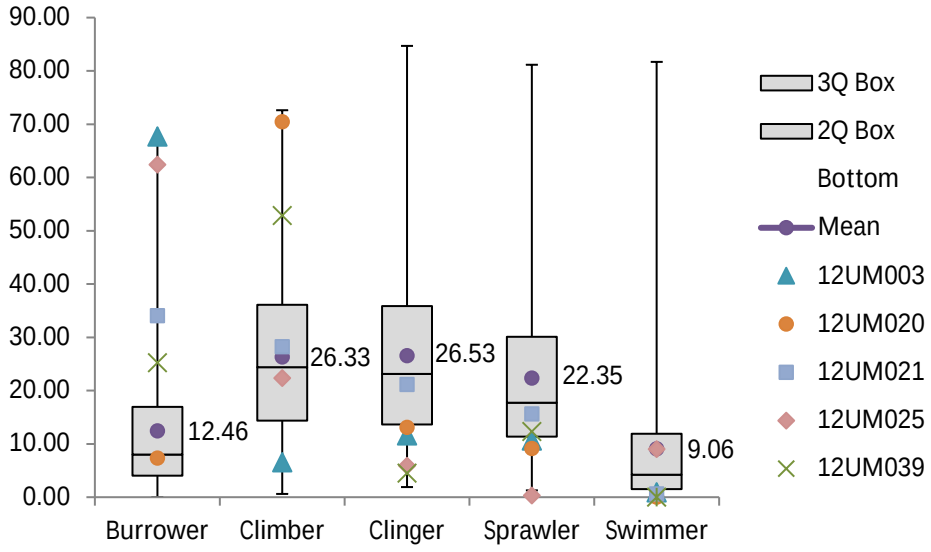

Figure 39. Macroinvertebrate metrics for class

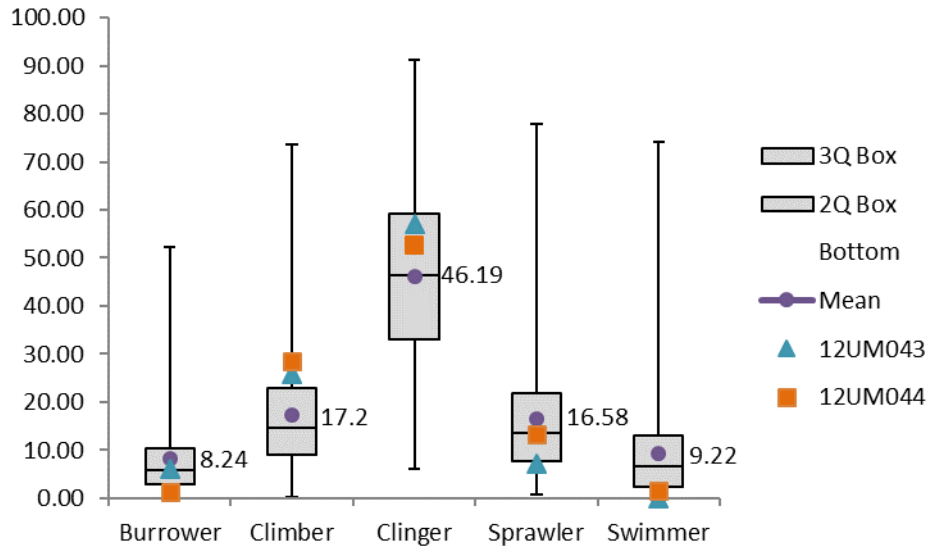

Figure 40. Macroinvertebrate metrics for class

Altered hydrology

The tributaries to the South Fork Crow River in this HUC are all channelized. Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency, increasing the impact of high flow events and increasing the intensity of low flow periods, both of which affect biological communities. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat. A culvert at station 12UM025 appears to cut off fish migration between the tributary and the South Fork Crow River particularly during extreme high and low flow events (Figure 41). HSPF models show Judicial Ditch 18 experiencing low flow at less than 1 cfs 29% of the time, and County Ditch 18 experiencing low flows at less than 1 cfs 47% of the time. Flow conditions experienced extended periods of low flow.

Figure 41. Culvert at station 12UM025 (June 11, 2014)

Table 12. Metrics related to altered hydrology

Altered hydrology relevant metrics	General Fish Percentage	Nest Guarding Taxa
12UM011 (Old Channelization)	0	0
Average for fish class 7 streams	**36.44**	**2.58**
12UM003 (Old Channelization)	100	1
12UM020 (Old Channelization)	77.78	2
12UM021 (Old Channelization)	63.92	3
12UM025 (Old Channelization)	75	0
12UM039 (Old Channelization)	19.23	7
12UM043 (7-11-12) (Old Channelization)	31.46	6
12UM043 (8-7-12)	27.52	6
12UM044 (Old Channelization)	25.82	4
Average for fish class 6 streams	**41.54**	**2.39**
Expected response to altered hydrology	↑	↑

Generalized fish species, which are adaptable to different habitats through generalized food preferences, are also correlated with channelization. The average percentage for generalized fish in class 6 waters was 41.54%. The sites were all in fish class 6 and had a general percentages range of 19.23% at station 12UM039 to 100% at station 12UM003. This corresponds with the simple lithophilic spawner percentages of 0 to 9.28% and 0 to 3.85% of benthic insectivores discussed in the habitat section. The average simple lithophilic spawner percentage for class 6 is 21.65% and benthic insectivores are 9.71%.

Channelization is connected to and contributing to the lack of habitat. The effects of altered hydrology seem to be contributing to the increase of generalized fish percentages, which are more adaptable to changing conditions and food sources. This is most pronounced at stations 12UM003, 12UM020, 12UM021, and 12UM025 which all had percentages greater than 63%. Other contributing factors are likely affecting the high percentage of general fish species. Altered hydrology is a contributing stressor to lack of habitat.

AUID summary

The main stressors of the tributaries to the South Fork Crow River from the city of Cosmos to the city of Hutchinson are eutrophication to fish, low DO, lack of habitat and altered hydrology. These stressors are all connected.

4.2.2. South Fork Crow River (07010205-659)

- South Fork Crow River (city of Cosmos to Hutchinson Dam)

This section includes the South Fork Crow River from just downstream of the city of Cosmos to the Hutchinson Dam. The South Fork Crow River is impaired for aquatic life for both the fish and macroinvertebrate communities. The two biological monitoring stations along this reach are in one fish classes (class 5) and two macroinvertebrate classes (class 5 and class 7). Station 12UM045 is near Cedar Mills and 99UM070 is located above the reservoir created by the Hutchinson dam.

Biological communities

Both stations scored below the FIBI threshold of 47 but site 99UM070 scored significantly higher than 12UM045. There were a lack of intolerant species at both stations 12UM045 and 99UM070 (Figure 42). Station 99UM070 scored better with a few good metric scores, while station 12UM045 scored poorly across the metrics. The most common species collected were fathead minnows and orangespotted sunfish.

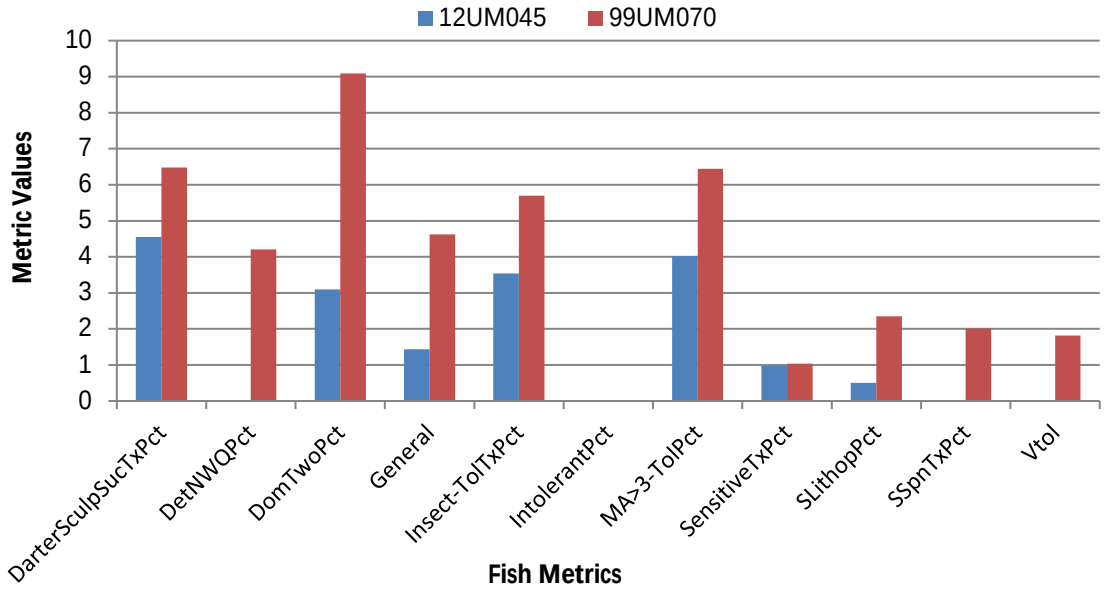

Figure 42. Fish metric scores

Station 12UM045 was in macroinvertebrate class 7 and station 99UM070 was in class 5. The MIBI scores decreased from upstream to downstream, with the most upstream station scoring at the impairment threshold (42). The high possible metric score was 10. Station 99UM070 saw slight increases in metric scores from 1999 to 2012 (Figure 43). Both visits had the highest possible score for the number of clinger taxa collected, while four metrics had a score of zero. Station 12UM045 had the highest possible metric scores both for collector-filterer and Tricoptera (caddisflies) taxa percentages (Figure 44), but did not have any intolerant species.

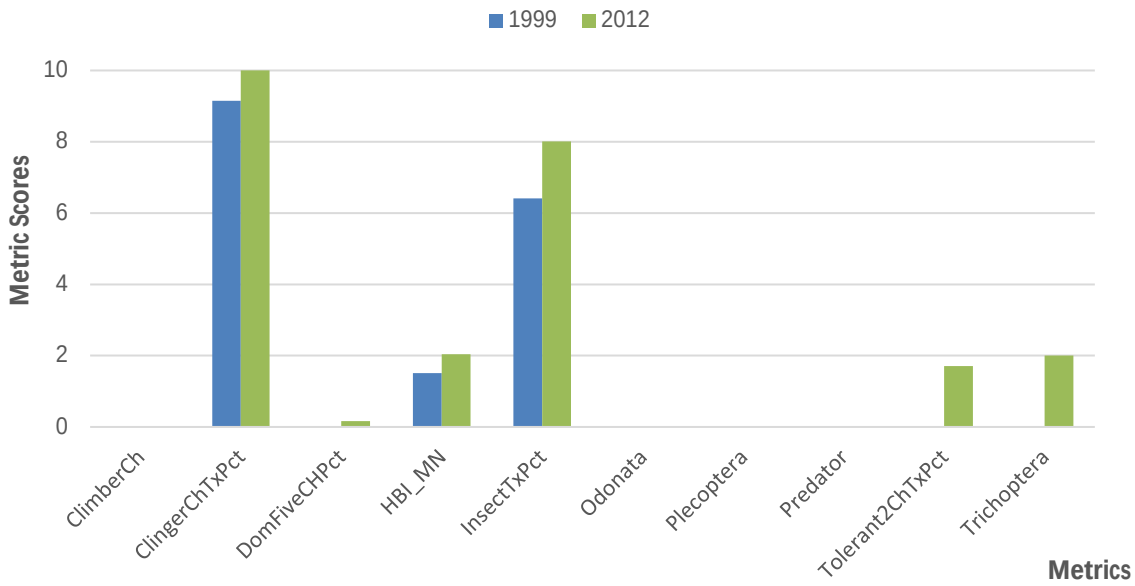

Figure 43. Metric values for station 99UM070

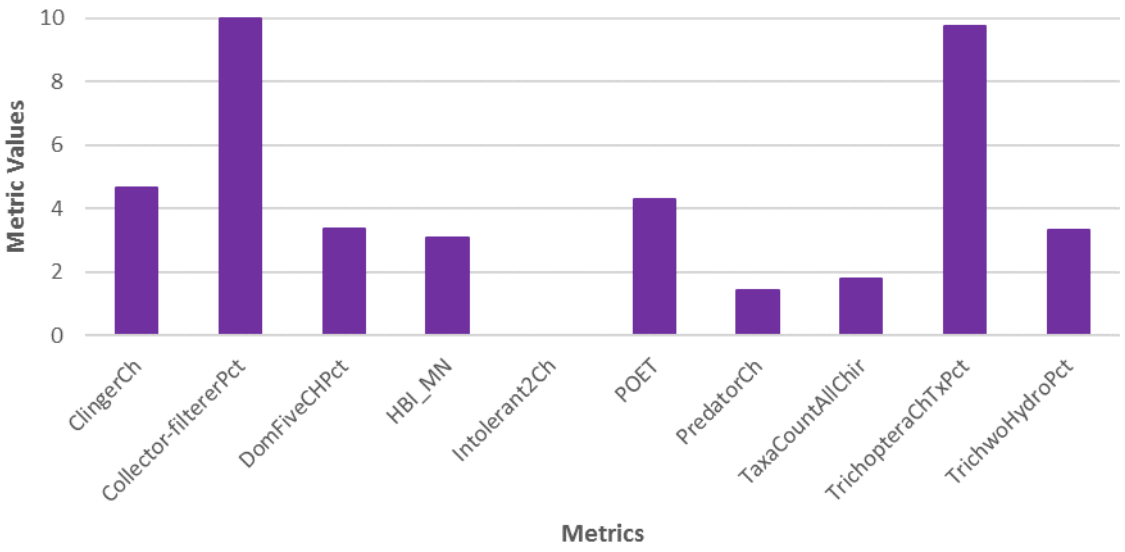

Figure 44. Metric values for station 12UM045

Phosphorus/Eutrophication

Phosphorus values were taken both after rain events and during base flow conditions. Values ranged from 0.061 to 0.597 mg/L. The highest values were taken at station S002-014, just above the Hutchinson reservoir (0.597 mg/L). Elevated values were also located in the upper section of the reach at station S000-575 (0.584 mg/L). The standard of phosphorus in the southern region is 0.150 mg/L, with 56 samples above this value (65%). Values of pH raised to 8.71 during the fall, with five other values above 8.5 (8%). Values greater than 8.5 can be tied to eutrophication. Continuous data showed pH flux ranged from 0.11 to 0.34. Typical daily pH fluctuations are 0.2-0.3 (Heiskary et al., 2013). DO flux ranged from 0.6 to 4.8 mg/L, with only 1 of the 12 days experiencing flux above the southern standard of 4.5 mg/L. Chlorophyll-a values range from 3 ug/L to 132 and BOD values range from 2 to 8.8 mg/L at station S002-014. Nineteen (51%) of the BOD sample concentrations were above the southern standard of 3 mg/L. Eight (40%) chlorophyll-a values were above 35 ug/L, which is the southern streams standard for eutrophication. Green water was noted during biological sampling (Figure 45).

Figure 45. Green water at station 12UM045 (August 8, 2012)

Both stations have less than 1% of sensitive species but both stations had three different darter species collected. Tolerant percentages were 53.02 and 73.87% respectively. Omnivorous fish have a positive relationship with nutrients, chlorophyll-a and DO flux. Both stations had high percentages of omnivorous fish, with fathead minnows and common carp the most dominant fish collected at the two stations. EPT percentages were high while, however the most common EPT species (Cheumatopsyche, Tricorythodes, and Ceratopsyche) are more tolerant to disturbance. The macroinvertebrate communities had about half of their samples dominated by two species. The biological communities are showing a response to elevated phosphorus, DO flux, and pH values. Eutrophication is a stressor on this section of the South Fork Crow River.

Table 13. Eutrophication metrics

Station	Sensitive Pct	Darter Pct	Tolerant Pct	Omnivorous fish Pct	Invert Taxa	EPT Pct	Dominant 2 Invert Taxa Pct
99UM070	0.67	13.87	53.02	86.32	21	75.08	56.07
12UM045	0.39	6.05	73.87	63.71	**25**	**61**	**50.8**
Averages for class 5 fish stations	**22.31**	**13.48**	**36.11**	**14.23**			
Averages for class 5 invert stations					**38**	**38.21**	**39.30**
Averages for class 7 invert stations					**32**	**19.4**	**49.32**
Expected response to stress	↓	↓	↑	↑	↓	↓	↑

Dissolved oxygen

There is a sizeable DO dataset on this reach in recent years. Concentrations ranged from 4 to 15.81 mg/L. Both of these values were taken at station S002-014. Continuous data was also recorded at station S002-014, but values were all above 6 mg/L.

Fish species that are specifically tolerant and intolerant to DO were analyzed at both stations. There were no intolerant fish at either station. DO tolerant percentage were 46% (99UM070) to 74% (12UM045) respectively. The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. Both stations had higher than average percentages of fish that take three years or longer to mature, indicating that conditions are amenable to longer lived fish. Low DO values also correspond with increased serial spawning fish percentage. The stations had percentages of 43.85% and 63.06% respectively. The percentages of low DO tolerant fish individuals were 46% and 74% respectively.

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed at both stations. Intolerant macroinvertebrate taxa collected were six and seven respectively and DO tolerant percentages were 0 and 0.95. These values show a macroinvertebrate community that is not being affected by low DO conditions. The fish communities also reflect this. Low DO is not a stressor for the South Fork Crow River in this section of the river.

Table 14. Low DO metrics

Station	MA>3 years Percentage	Serial Spawning Fish Percentage	HBI_MN	Percentage DO Tolerant Macroinvertebrate	Intolerant DO Macroinvertebrate Taxa
12UM045	15.06	63.06	7.93	0	7
99UM070	24.16	43.85	7.65	0.95	6
Averages for class 5 fish stations	**13.46**	**19.03**			
Averages for class 7 invert stations			**8.07**	**30.3**	**1.88**
Averages for class 5 invert stations			**7.45**	**10.45**	**6.91**
Expected response to stress	↓	↑	↑	↑	↓

Suspended sediment

TSS values in recent years ranged from 1.0 to 184 mg/L. 11% of samples were above the central region standard of 65 mg/L. The highest values were taken at station S000-575 in the upper part of the reach, but numerous elevated values were also collected near the end of the reach at station S002-014 (140 mg/L). There is a lot of erosion occurring on this section of the river, adding sediment to the system (Figure 46 and Figure 47). Numerous paired organic solids (TSVS) and inorganic solids (TSS) samples were taken on this section of the South Fork Crow River. Samples were taken at stations S002-014 and S000-575, where TSVS values range from 12% up to 55% of the suspended solid concentrations, with an average of 30%. Inorganic solids make up the majority of the suspended solid values. The largest percentage of organic to inorganic ratio was at station S002-014, upstream of the Hutchinson dam and reservoir.

Figure 46. Eroding bank along the South Fork Crow River (August 7, 2013)

Figure 47. Eroding banks along the South Fork Crow River (August 7, 2013)

In this section of the South Fork Crow River, the biological stations had no herbivore fish taxa or TSS intolerant macroinvertebrate taxa. Herbivore species of fish decrease as TSS values increase. Both stations had increased numbers of fish collected that were tolerant to elevated TSS values (25%-53%). The most common fish collected were fathead minnows, orangespotted sunfish, and channel catfish. These fish all have a high tolerance to TSS disturbance. Macroinvertebrates tolerant to TSS were also elevated. Smallmouth bass, part of the order Perciforms (perch like fish) decrease as TSS increase. Both Perciform percentages and long-lived percent were lower at station 12UM045 and about average at 99UM070. Based on the low TSS intolerant taxa, herbivore, and the elevated TSS tolerant percentages, TSS is a stressor on this section of the South Fork Crow River.

Table 15. Metrics related to TSS

TSS relevant metrics	TSS Intolerant Taxa	TSS Tolerant Taxa	Percentage TSS Tolerant Macroinvertebrate Individuals	Long-lived Macroinvertebrate Percent	Herbivore Percent	Perciform-Tolerant Percent
12UM045	0	12	73.14	1.92	0	11.07
99UM070	0	9	65.93	6.85	0	22.15
Averages for class 5 fish stations					**2.07**	**26.78**
Average for class 7 invert streams	**0.54**	**9.04**	**29.06**	**4.99**		
Averages for invert class 5 stations	**1.42**	**9.96**	**37.27**	**6.37**		
Expected response with increased TSS stress	↓	↑	↑	↓	↓	↓

Altered hydrology

The upstream section is the only area that has been channelized, however most of its tributaries have been. Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency, increasing the impact of high flow events and increasing the intensity of low flow periods, both of which affect biological communities. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat. Channelization and tile drainage often causes flashy flows; high in the spring and during rain events and low or dry later in the summer.

While precipitation slightly increased, flow increased at a higher rate (Figure 48). Flow was not recorded during the entire time period but from 1934-1979 and 2008-2013. Carlisle et. al (2010) found that biological impairment was positively related to the severity of streamflow alteration.

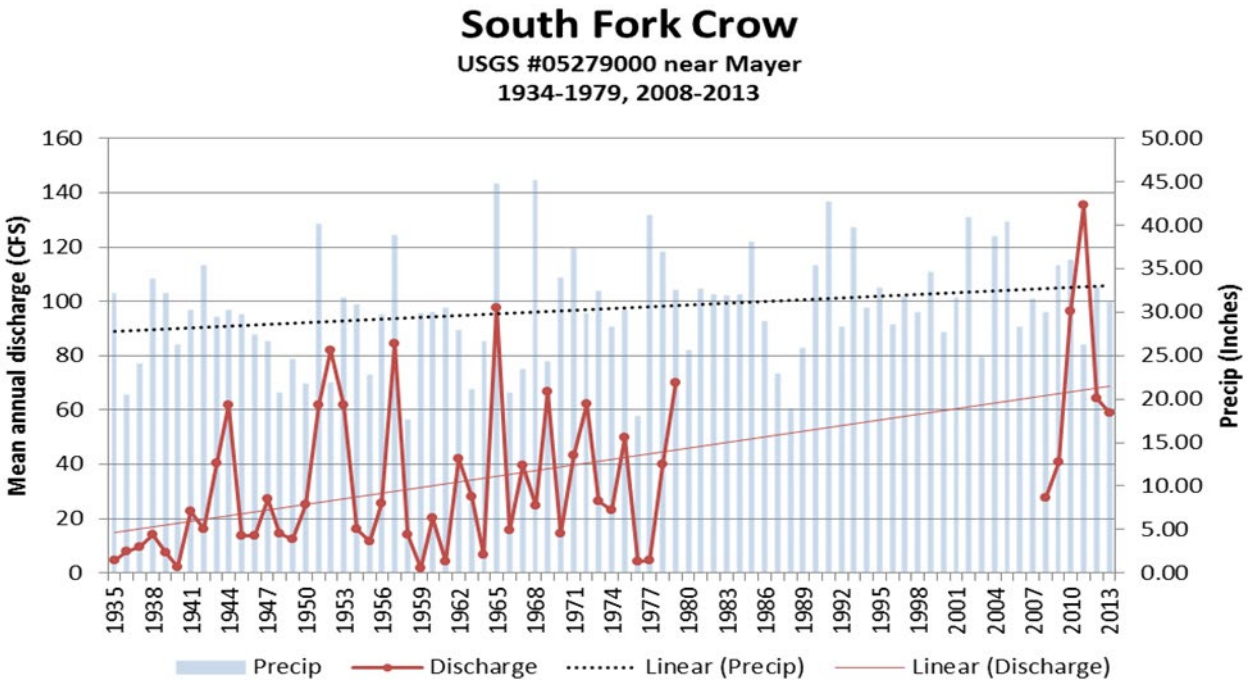

Figure 48. Precipitation and discharge

Generalized fish species, which are adaptable to different habitats through generalized food preferences, are also correlated with channelization and flow changes. The average percentage for generalized fish in class 5 waters was 38.96%. Station 99UM070 had 25.95% and 38.66% respectively. The generalized fish percentage was 65.64 at 12UM045. The percentage of long-lived macroinvertebrates at station 12UM045 was 1.92. At station 99UM070, the percentage dropped from 22.40% in 1999 to 6.85% in 2012. Long-lived macroinvertebrates decrease with flow changes as they are not able to stay in one place as conditions change.

Connectivity is another important aspect of hydrology. Fish migration is dependent on stream connectivity. A dam is located in Hutchinson. The dam does not seem to be having an impact on the presence of migratory fish. Shorthead redhorse, walleye, and Iowa darters were found both upstream and downstream of the dam. Connectivity is not a stressor but flow is increasing in this section, and is affecting the biological community as a contributing stressor at station 12UM045.

AUID Summary

The main stressors to the South Fork Crow River from the city of Cosmos to the Hutchinson Dam are TSS and altered hydrology.

4.3. City of Lester Prairie-South Fork Crow 10 digit HUC

This section includes the South Fork Crow River and its tributaries ranging from below the Hutchinson dam to the mouth of Buffalo Creek just south of Lester Prairie. Tributaries include Bear Creek, Otter Creek, Silver Creek, and tributaries to Winsted, Otter Creek, and the South Fork Crow River. The mainstem South Fork Crow River and the tributaries are discussed in two separate sections.

The majority of the section is in the Western Corn Belt Plains ecoregion, with the most downstream section of the South Fork Crow River and Otter Creek in the North Central Hardwood Forests ecoregion. Prior to settlement, the area was dominated by grassland and deciduous forest. Land use was converted to predominantly cropland with corn and soybeans the predominant crops. The South Fork Crow River has been sampled throughout the reach both for biology and chemistry (Figure 49). Bear Creek and Otter Creek both had two sampling locations, while the rest of the tributaries had one.

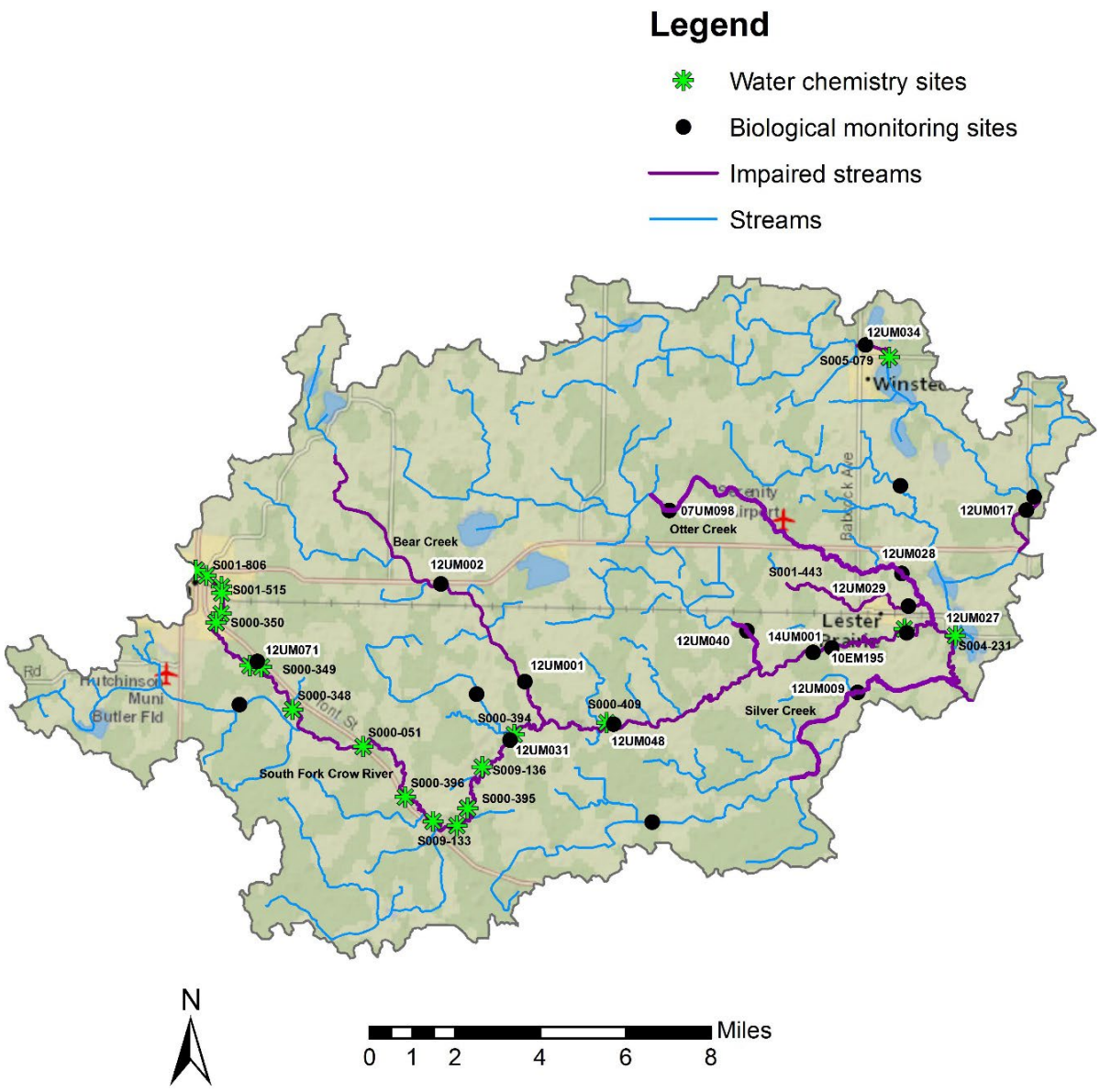

Figure 49. Biology and chemistry sampling locations

4.3.1. Tributaries (-515,572,585,611,617,622,641,642 & 643)

- Bear Creek (12UM001 and 12UM002 on -515)
- Judicial Ditch 1 (12UM017 on -572)
- Otter Creek and tributary to Otter Creek (07UM098 on -642, 12UM028 on -643, and 12UM029 on -617)
- Tributary to Winsted Lake (12UM034 on -585)
- Tributary to South Fork Crow River (12UM040 on -622)
- Silver Creek (12UM009 on -641)

Biological communities

All of the stations are in fish class 6 except for station 07UM098 which is in fish class 7. Stations 07UM098 and 12UM002 only had one metric score that was not zero; omnivore taxa percentage for 07UM098 and number of fish collected per meter for 12UM002. The stations universally scored zero for sensitive, minnow, and headwater metrics (Figure 50). Sensitive or pollution intolerant fish species are typically the first to disappear when conditions become increasingly unfavorable. The most common species collected at these tributaries were fathead minnow, green sunfish, and carp.

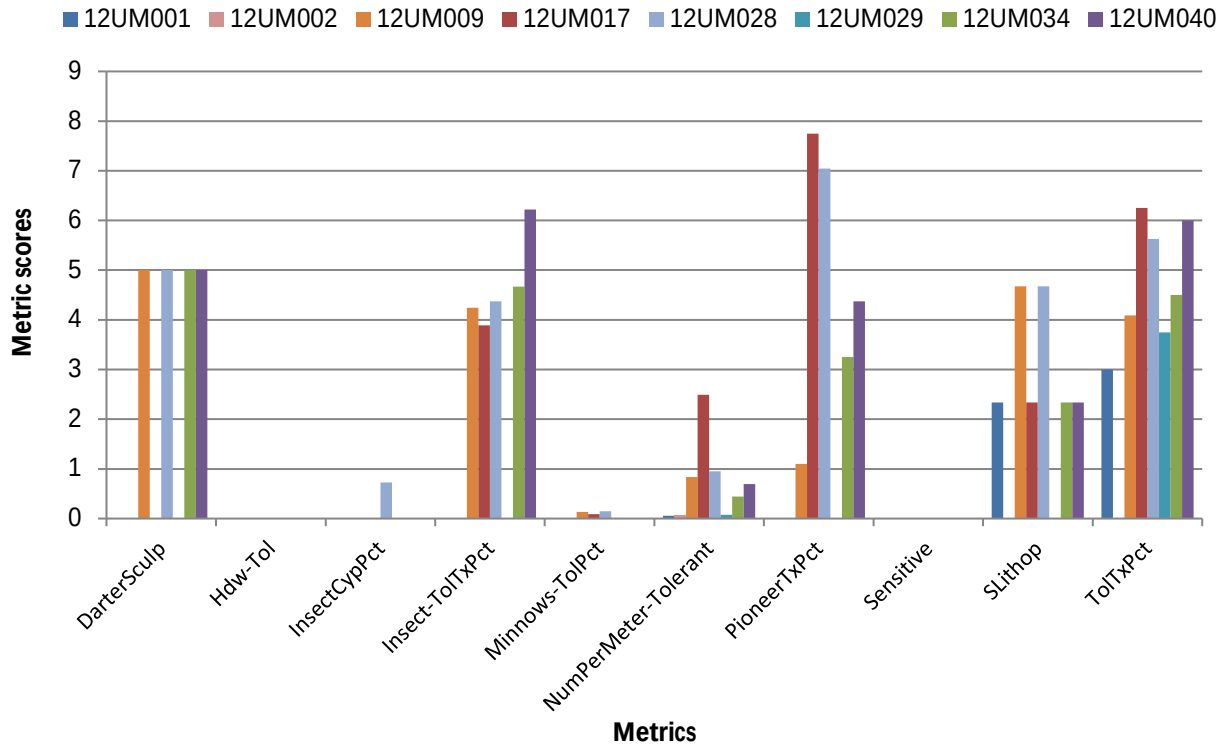

Figure 50. Metric scores for South Fork Crow River tributaries

Four of the stations on the tributaries were in macroinvertebrate class 6 and three were in macroinvertebrate class 5. Stations 07UM098 and 12UM029 were not sampled for macroinvertebrates; station 12UM029 was not sampled due to insufficient flow. Stations 12UM002 (Bear Creek) and 12UM028 (Otter Creek) scored above the class 6 threshold (43), while none of the stations in class 5 scored above the threshold (37), including the other station on Bear Creek (12UM001). Each station in class 6 had a score of zero for macroinvertebrates intolerant to disturbance (Figure 51). The high possible metric score was 10 for both classes. The stations in class 5 all had a Plectoptera (stoneflies) score of zero with a high score of eight at station 12UM001 (Figure 52).

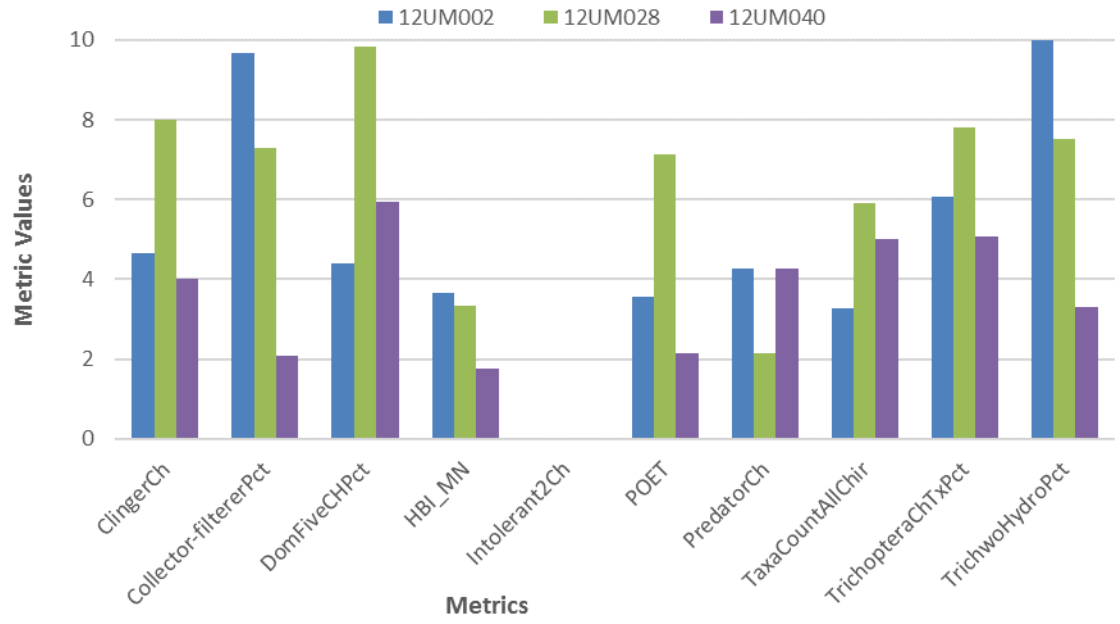

Figure 51. Metric scores for stations in class 6

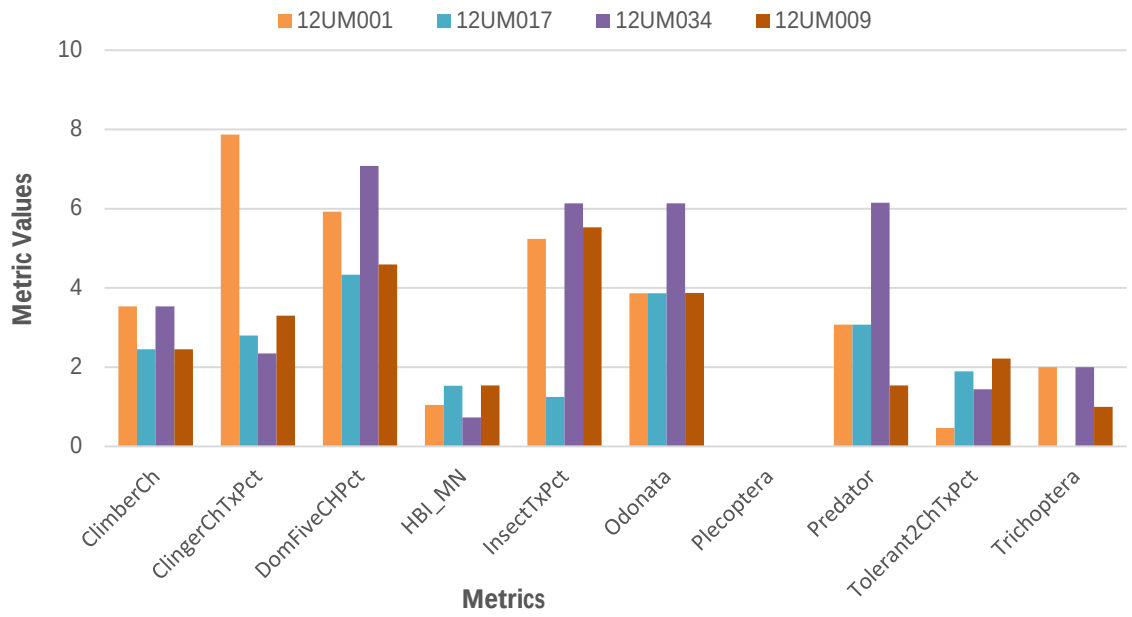

Figure 52. Metric scores for stations in class 5

Phosphorus/Eutrophication

Phosphorus and eutrophication are closely tied. Biological communities are more directly affected by DO flux, chlorophyll-a, and BOD than phosphorus. The standard of phosphorus in the southern region is 0.150. Values ranged from 0.088 to 1.05 mg/L with the highest values at station 12UM017 on Judicial Ditch 1 during base flow in August. All eleven samples taken in 2012 and 2014 at this station were above 0.150 mg/L. Each of the tributaries in this section had elevated values with samples taken March through October. Of the 58 samples taken in this HUC, 82% were above 0.150 mg/L.

Chlorophyll-a values ranged from 2.48 ug/L to 86.5 ug/L with the highest chlorophyll value also at station 12UM017. The highest value was taken during August. Chlorophyll-a values were taken at all stations except station 12UM040. Station 12UM017 was the only station with a value over 35, the southern standard. The value was 86.5 ug/L, which is more than two times the standard. Thick algae and/or macrophytes are present at many of these stations (Figure 53and Figure 54).

Figure 53. Macrophytes at station 12UM002 (August 21, 2012)

Figure 54. Algae at station 12UM009

Continuous data was collected at numerous stations. At stations 12UM002, 12UM009, 12UM014, and 12UM017, only one day was above the DO flux standard (Figure 55). Station 12UM001 had an increase in flux over its deployment with six days above the southern region 4.5 mg/L standard with the highest value at 5.76 mg/L. Station 12UM014 experienced daily fluxes from 4.82 to 9.36, all above the standard. The rest of the stations did not experience DO flux during their deployments. Station 12UM011 also had pH values (8.7) recorded over 8.5, which is indicative of eutrophication. Station 12UM014 experienced pH flux from 0.2 to 0.54, with four of nine days over 0.4. Typical daily pH fluctuations are 0.2-0.3 (Heiskary et al., 2013). Low DO was also recorded, which will be discussed in the next section.

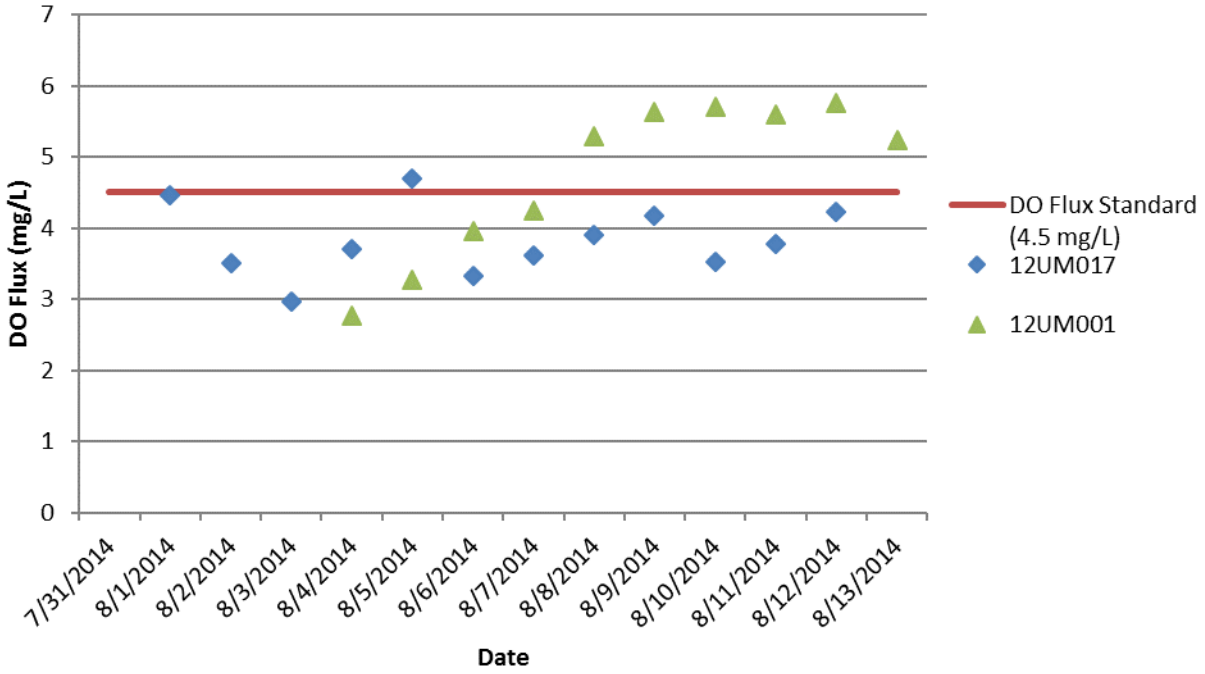

Figure 55. DO flux at stations 12UM001 and 12UM017

All tributaries have lower than average sensitive, darter, and intolerant percentages for both fish class 6 and class 7 streams statewide. The values for sensitive species were all zero, except at station 12UM014. Tolerant percentages were near or higher than average at each station, ranging from 60.63% at station 12UM017 to 100% at station 07UM098, averaging 91.27%. Fish communities with phosphorus tolerant fish ranged from 58% (12UM017) to 99% (12UM001). Of the 12 visits, seven had phosphorus tolerant communities over 90%. Omnivore percentages were also increased, which can occur when phosphorus values increase. The macroinvertebrate community is not as affected by eutrophication as the fish community. Eutrophication is a stressor in this 10 digit HUC, particularly at stations 12UM001 and 12UM017.

Table 16. Metrics related to Eutrophication

Phosphorus relevant metrics	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct	Invert Taxa	EPT Pct	Dominant 2 Invert Taxa Pct
07UM098	0	0	100	29.40			
12UM001 (7-11-12)	0	0	97.22	55.56	47	40	33.13
12UM001 (8-9-12)	0	0	99.37	70.35			
12UM002	0	0	99.37	99.37	**16**	**25.40**	**49.22**
12UM009	0	14.86	83.78	35.81	42	22.11	29.28
12UM014	2.78	2.78	91.67	13.89	25	1.57	43.71
12UM017	0	0	60.63	18.55	33	7.83	39.46
12UM028	0	3.03	80.3	11.36	**24**	**43.63**	**28.66**
12UM029	0	0	97.53	54.32	_	_	_
12UM034 (7-30-12)	0	2.68	95.99	85.28	31		25.39
12UM034 (9-8-14)	0	3.98	94.89	31.25			
12UM040	0	0.54	94.86	18.38	**15**	**6.94**	**44.79**
Average for fish class 6 streams	**15.13**	**6.34**	66.59	**3.27**			
Average for fish class 7 streams	**8.16**	**5.21**	70.59	**22.40**			
Average for invert class 5 streams					**38**	**38.30**	**39.30**
Average for invert class 6 streams					**23**	**19.01**	**44.72**
Expected response to increased TP stress	↓	↓	↑	↑	↓	↓	↑

Dissolved oxygen

Low DO concentrations were recorded at stations 07UM098 (1.57 mg/L), 12UM017 (3.30 mg/L), 12UM028 (4 mg/L), and 12UM001 (4.50 mg/L). These values were all taken in 2012. Stations 12UM040 and 12UM002 were the only stations with continuous data that fell below the DO standard of 5 mg/L in 2014. This occurred daily at station 12UM002, while this only occurred two days at station 12UM040 after 2.5 inches of rain (Figure 56). While station 12UM001 was downstream of a wetland which can influence low DO values, all of the continuous DO values recorded were above 6 mg/L.

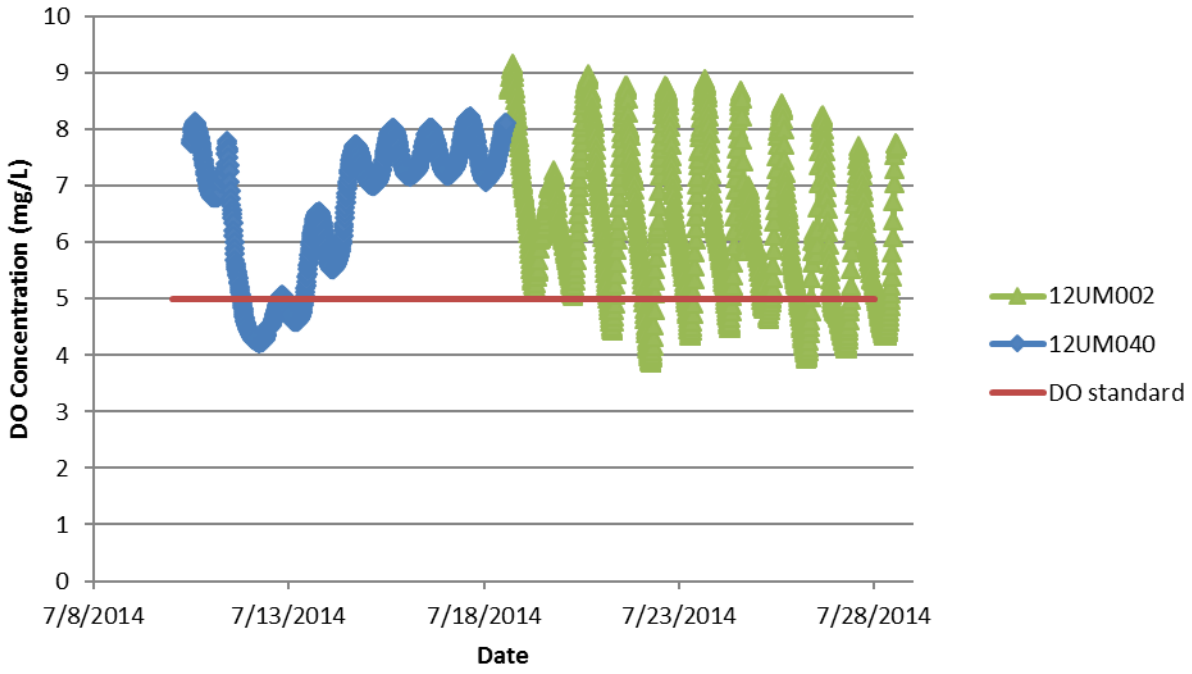

Figure 56. Continuous DO data

The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. All stations had lower than average percentages of fish that take three years or longer to mature, indicating that conditions are amenable to longer lived fish. Values ranged from 0% to 2.78%. In comparison, station 12UM026 which was not impaired had a percentage of 10.73%. Low DO values also correspond with increased serial spawning fish percentage. The stations had a range of 0.31 to 59.80% with the highest values at stations 12UM001 and 12UM029. Effects on the fish communities are seen most at 07UM098, 12UM017, 12UM029, and 12UM040. This is reinforced by fish tolerant to low DO, where tolerances ranged from 64% to 99%; all stations except for 12UM009 and 12UM017 had percentages greater than 80. There are some mixed biological responses at these tributaries

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed at all stations. Intolerant macroinvertebrate taxa collected ranged from zero at station 12UM040 to nine at station 12UM028. The percentage of DO tolerant individuals ranged from 2.3% to 32.57%. These values show macroinvertebrate communities that are not being limited by low DO conditions. DO is only a stressor to fish on these tributaries. Low DO is a stressor to the headwaters of Otter Creek (07UM098), the tributary to Otter Creek (12UM029), and the unnamed tributary to the South Fork Crow River (12UM040).

Table 17. Low DO related metrics

Station	MA>3 Tol years Percentage	Serial Spawning Fish Percentage	HBI_MN	Percentage DO Tolerant Macroinvertebrate	Intolerant DO Macroinvertebrate Taxa
07UM098	0	29.40	-	-	-
12UM001 (7-11-12)	2.78	54.17	7.99	6.45	5
12UM001 (8-9-12)	2.51	59.80			
12UM002	0.63	0.31	7.75	8.28	3
12UM009	0.68	17.57	7.82	20.93	6
12UM014	0	5.56			
12UM017	0.90	30.32	7.82	32.57	3
12UM028	0	8.33	7.85	2.3	9
12UM029	0	54.32	-	-	-
12UM034	0	6.69	8.10	20.51	2
12UM040	0.27	30.00	8.33	20.92	0
12UM026 (not impaired)	10.73	20.34	8.69	25.91	1
Averages for class 6 fish stations	**2.99**	**15.44**			
Averages for class 7 fish stations	**4.62**	**19.58**			
Averages for class 7 invert stations			**8.07**	**30.3**	**1.88**
Averages for class 5 invert stations			**7.45**	**10.45**	**6.91**
Averages for class 6 invert stations			**7.55**	**24.88**	**3.83**
Expected response to stress	↓	↑	↑	↑	↓

Lack of habitat

Habitat availability is lacking in these South Fork Crow River tributaries. The MSHA scores taken during biological sampling were a mixture of poor and fair at all sampling sites except at station 12UM001, which had one visit that was fair and one visit that was good. Sparse cover and depth variability were the main lacking factors throughout the sites. Lack of channel development was an issue at stations 12UM001, 12UM017, 12UM028, 12UM029 and 12UM034. Embeddedness was an issue at stations 12UM009, 12UM034, and 12UM040.

Station 12UM029 had a substrate entirely comprised of sand and had no riffles. Clean cobble and gravel presence have a positive relationship with a higher fish IBI. Depth measurements with a rod averaged 16.3 cm of fine substrate at station 12UM017 with measurements up to 32 cm at station 12UM001 and 49 cm at station 12UM029 (100% sand). Stations 12UM028 and 12UM009 had shallower depth of fines with an average below 5 cm. Station 12UM017 is incised and has moderately eroding banks on both sides. Land use and lack of buffers (Figure 57) contribute to erosion.

Figure 57. Sediments and erosion at stations 12UM001 (top on July 28, 2014), Bear Creek (middle on May 28, 2014), and 12UM009 (bottom on July 31, 2014)

A geomorphology study by the DNR was done one mile upstream of station 12UM028 on Otter Creek. The site is categorized as a C5, high sensitivity to disturbance and bank erosion potential. The stream is a deeply incised channel with a high width to depth ratio. Erosion predictions estimate that streambanks contribute 13 tons of sediment annually (DNR 2015).

Habitat and tolerant fish have a positive relationship. The percentages of tolerant fish collected were higher than 80% at all sites except 12UM017. At station 12UM017, bluegill and largemouth bass, which are not tolerant, made up about one third of the community. In comparison, station 12UM029 only had two individuals that were not tolerant. The lack of coarse substrates and riffles results in the lack of simple lithophilic spawners, darter and sculpins, and riffle species. The abundance of these percentages were all below average except for station 12UM009. However, there were 22 johnny darters collected at station 12UM009, which are a tolerant darter. The prevalence of fine sediments and embeddedness is affecting the fish community. Lack of habitat is a stressor to the fish habitat.

Table 18. Habitat related metrics

Stations	SLithophilic Spawners Pct	DarterSculpin Pct	Tolerant Pct	Riffle Pct	Benthic Insectivore Pct
12UM001 (7/12)	2.78	0	97.22	0	0
12UM001 (8/12)	2.51	0	97.49	0	0
12UM009	6.76	14.86	83.78	6.08	14.86
12UM017	2.26	0	60.63	2.26	0
12UM028	4.55	3.03	80.3	1.52	5.3
12UM029	0	0	97.53	0	0
12UM034 (2012)	1	2.68	95.99	1	2.68
12UM034 (2014)	2.84	3.98	94.89	2.84	3.98
12UM040	0.81	0.54	94.86	0.81	1.08
Average for fish class 6 streams	**21.68**	**7.75**	**66.56**	**11.87**	**9.72**
Expected response with habitat stress	↓	↓	↑	↓	↓

The percentages of climbers and burrowers were at or above average at all stations (Figure 58, Figure 59, and Figure 60). Burrowers live inside fine sediments, and were highest at station 12UM017 where the depth of fines was 32 cm. All swimmer percentages were low. Climbers live on aquatic plants and detritus; the highest values are at stations 12UM017 and 12UM040. Clingers were highest at station 12UM028 and 12UM009 where fine sediments were most shallow, as clingers need firm substrate. Station 12UM040 had the lowest percentage of clingers due to embeddedness and filling in of runs and pools. While gravel and cobble and woody debris is available in this HUC, the influx of fine sediment has covered a lot of the coarse substrate. Habitat is a stressor for the macroinvertebrate community, particularly at station 12UM017 and 12UM040.

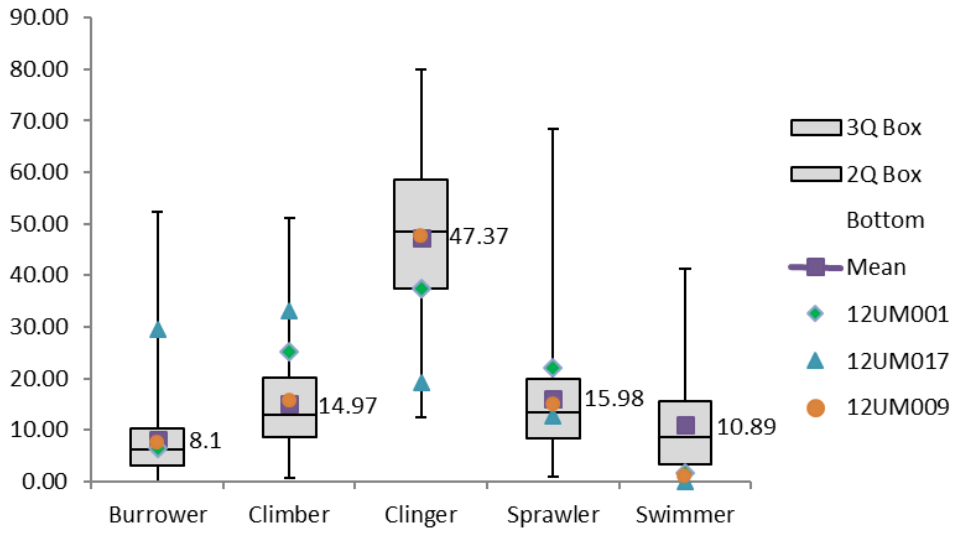

Figure 58. Habitat metrics at macroinvertebrate class 5

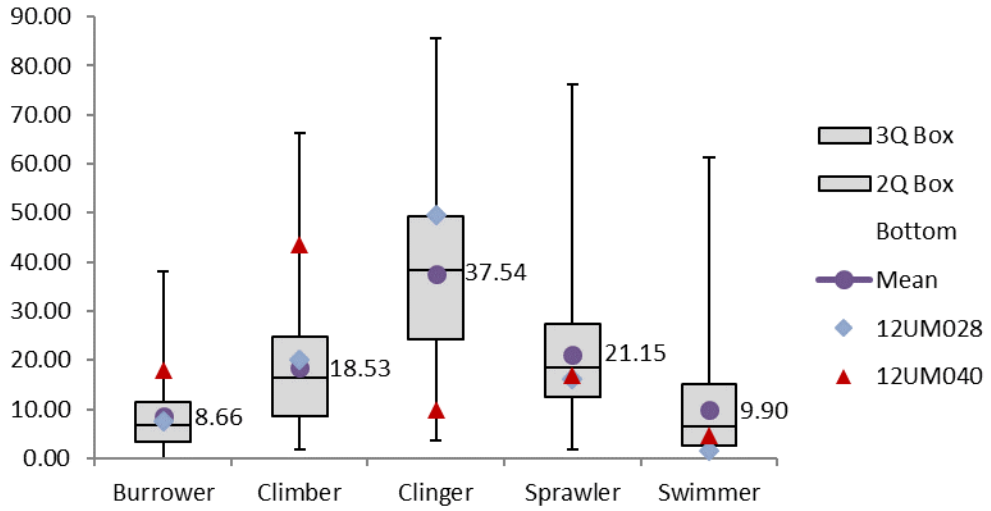

Figure 59. Habitat metrics at macroinvertebrate class 6

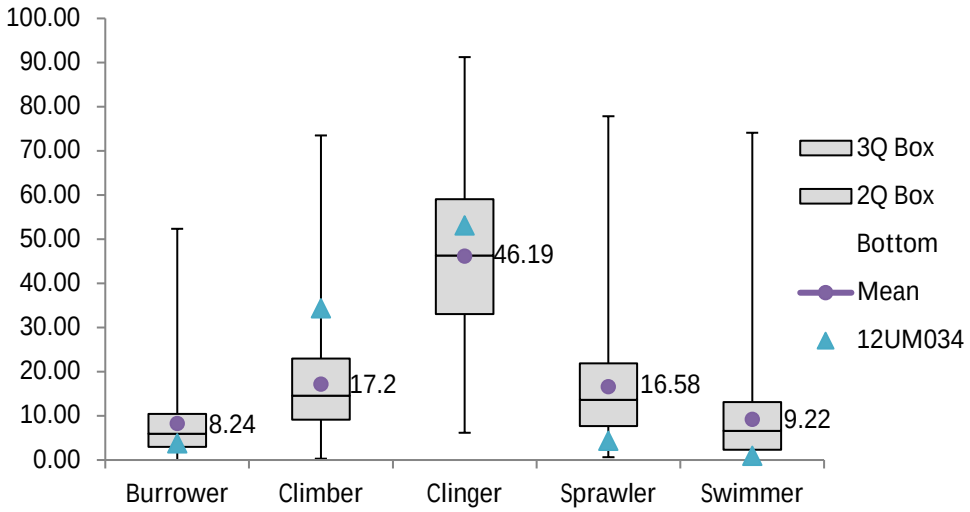

Figure 60. Habitat metrics at macroinvertebrates class 5 modified

Altered hydrology

The tributaries to the South Fork Crow River in this HUC and their upstream watersheds were predominantly channelized. The Otter Creek watershed is about 84% channelized (DNR 2015). Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency, increasing the impact of high flow events and increasing the intensity of low flow periods, both of which affect biological communities. HSPF models show Bear Creek experiencing low flow with less than 1 cfs 30% of the time, and Otter Creek experiencing less than 1 cfs 17% of the time.

Generalized fish species, which are adaptable to different habitats through generalized food preferences, are also positively correlated with channelization and flow changes. The average percentage for generalized fish in class 6 waters was 41.54%. Stations in class 6 ranged from 57.92% (12UM017) to 99.37% (12UM002). Station 07UM098 in class 7 had a general population of 32.64% with a class average of 36.44%. Long-lived macroinvertebrates decrease with flow changes as they are not able to stay in one place as conditions change. The percentage of long-lived macroinvertebrates ranged from 0% (stations 12UM002, 12UM009, 12UM017) to 10.53% (12UM034).

Connectivity is another important aspect of hydrology. Fish migration is dependent on stream connectivity. Bear Creek has a perched culvert between station 12UM001 and the South Fork Crow, which could be affecting fish migration. A geomorphology study by the DNR was done one mile upstream of station 12UM028. A lowhead dam is located 550 ft. downstream of the DNR site on Otter Creek (Figure 61). The dam is creating a fish barrier, altering flow and causing sediment deposition upstream of the dam. The DNR recommends removal of the lowhead dam to restore connectivity and restore pool habitat and restoration of basins to hold water (ex. wetlands).

Based on extended low flow periods shown in the models, sediment deposition and increased generalized and decreased long lived individuals, altered hydrology is a stressor that is also affecting habitat.

Figure 61. Dam on Otter Creek (DNR)

AUID summary

The main stressors of the tributaries to the South Fork Crow River from the Hutchinson dam to Otter Creek are eutrophication, low DO, altered hydrology, and lack of habitat.

4.3.2. South Fork Crow River (07010205-510)

The South Fork Crow River from the City of Hutchinson to Bear Creek has two biological monitoring stations located within the AUID; 12UM071 which is located upstream near Hutchinson and 12UM031 which is located downstream near the confluence with County Ditch 26.

Biological communities

Metric scores at both stations were uniformly low. Station 12UM071 is in fish class 5 (Figure 62), and station 12UM031 is in fish class 4 (Figure 63). Both stations had one high score; the dominant two species (DomTwoPct) at station 12UM071 and exotic percent at station 12UM031. The most common species collected were channel catfish, green sunfish, and fathead minnows. Green sunfish and fathead minnows are species very tolerant to human disturbance.

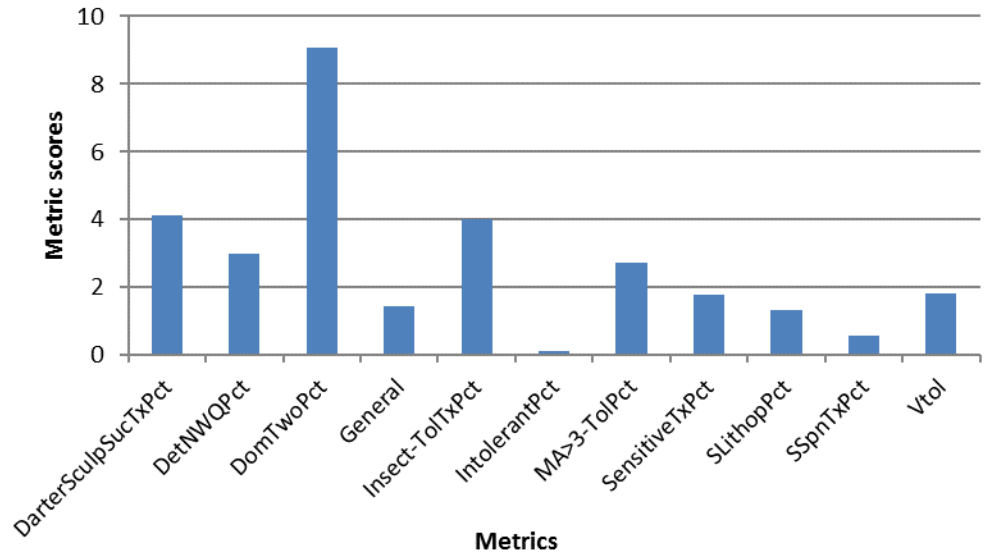

Figure 62. Metric scores at station 12UM071

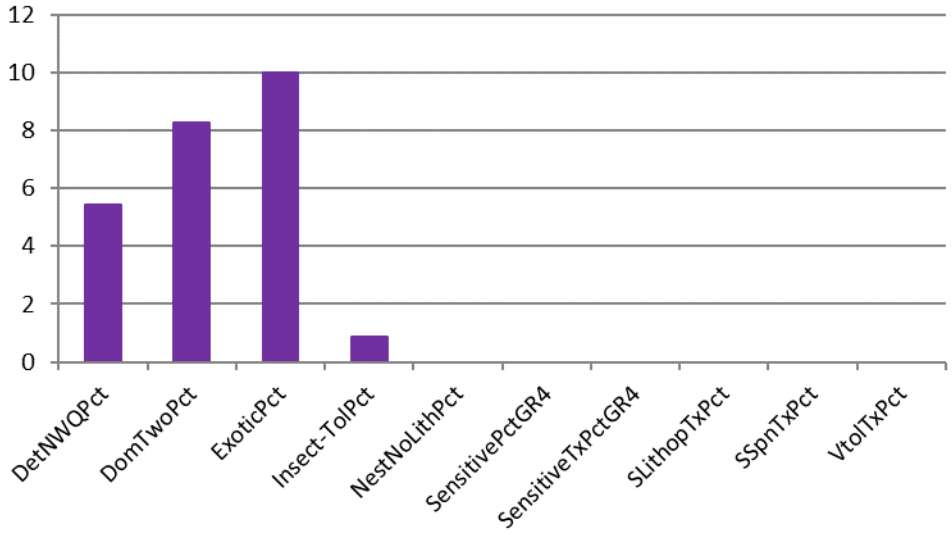

Figure 63. Metric scores for station 12UM031

Station 12UM071 was in macroinvertebrate class 7 with a high score of 10 and station 12UM031 was in macroinvertebrate class 2 with a high score of 12.5. Station 12UM071 had scores of 10 for metrics Tricoptera and Clingers (Figure 64), but other scores were low. Four of the ten metrics at station 12UM031 were zero (Figure 65).

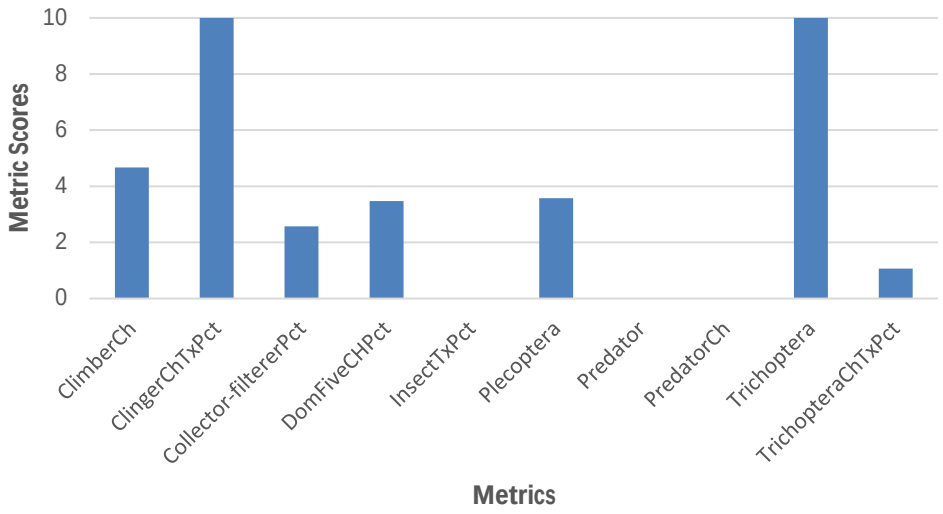

Figure 64. Metric scores for station 12UM071

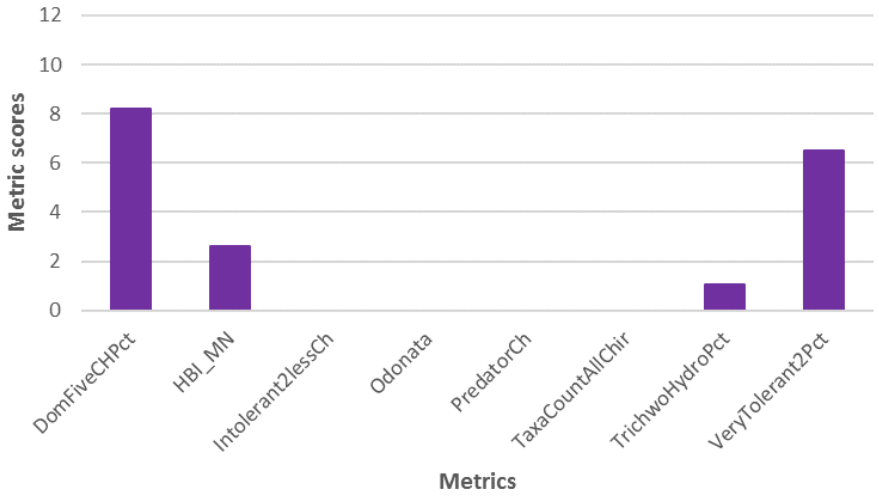

Figure 65. Metric scores for station 12UM031

Phosphorus/Eutrophication

Phosphorus values were taken both after rain events and during base flow conditions. Values ranged from 0.074 to 0.998 mg/L. The highest values were taken at stations S000-395 and S000-051 (0.711 mg/L and 0.518 mg/L). The standard of phosphorus in the southern region is 0.150 mg/L, with 45 samples above this value (87%). Elevated values were taken throughout the reach starting downstream of Airport Road.

Values of pH were as high as 8.81 during the fall, with five other values above 8.5 (9%). Values greater than 8.5 can be tied to eutrophication. Higher pH values were most often found during lower flow periods. Typical daily pH fluctuations are 0.2-0.3 (Heiskary et al., 2013). Continuous data showed pH flux on each of the 13 days at 0.5 or above, with values up to 0.71. DO flux values were also high (8.5-15.94 mg/L), with each of the 12 deployment days experiencing flux above the southern standard of 4.5 mg/L. Low DO values were also recorded, which are discussed in the next section. Chlorophyll-a values ranged from 8 to 128 ug/L with 14 values over 35 (70%). BOD values ranged from 1.9 to 10.9 mg/L with 34 values over 3 (92%).

Both stations had higher sensitive and darter percentages collected than upstream sections of the South Fork Crow River. Omnivorous fish have a positive relationship with nutrients, chlorophyll-a and DO flux. Station 12UM071 had high percentages of omnivorous fish, with the most dominant fish collected fathead minnows and green sunfish. Fish communities with phosphorus tolerant fish ranged from 64% (12UM071) to 71% (12UM031).

The macroinvertebrate community was dominated by a few species, with over half dominated by two species. EPT percentages were very high at both stations; however the most common EPT species collected are more tolerant. Station 12UM071 was dominated by a caddisfly (145 Cheumatopsyche individuals while the next most common species had 40 species) that can be found in high numbers in eutrophic situations. The biological communities are showing a response to the elevated phosphorus, DO flux, and pH values in the upper part of this AUID including station 12UM071, where eutrophication is a stressor.

Table 19. Phosphorus related metrics

Phosphorus relevant metrics	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct	Invert Taxa	EPT Pct	Dominant 2 Invert Taxa Pct
12UM031	4.17	7.51	40.33	15.44	47	77.34	29.61
Average for invert class 2 streams					**36**	**51.1**	**40.86**
12UM071	0.66	8.01	54.59	70.35	17	77.34	55.89
Average for fish class 5 streams	**22.31**	**13.48**	**36.11**	**14.23**			
Average for fish class 4 streams	**29.59**	**12.52**	**15.01**	**7.68**			
Average for invert class 7 streams					**32**	**19.37**	**49.31**
Expected response to increased TP stress	↓	↓	↑	↑	↓	↓	↑

Dissolved oxygen

Numerous DO records occur in this AUID. Concentrations ranged from 0.64 at station S001-844 just downstream of the Hutchinson dam in July to 17.58 mg/L at station S001-514 in September. Stations S001-844 and S001-845 both had values below 5 mg/L (9% of samples). Both stations were upstream of Airport Road, low DO values were not recorded throughout the rest of the reach. Continuous data was collected at station S001-514 where the minimum DO was recorded daily as right around 5 mg/L.

The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. Both stations had slightly lower than average percentages of fish that take three years or longer to mature. Low DO values also correspond with increased serial spawning fish percentage. The stations had percentages of 47.64 and 36.30% respectively. Station 12UM071 had a much higher than average percentage, with three of the four most common fish all serial spawners.

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed at both stations. Intolerant macroinvertebrate taxa collected were two and nine respectively and low DO tolerant percentages were zero and 0.31. These values show a macroinvertebrate community that is not being affected by low DO conditions. Fish do seem affected, especially in the upstream section where low DO was recorded. There was a high percentage of serial spawners at station 12UM071, and a higher than average percentage of fish that take three years or longer to mature. The preponderance of evidence show low DO is a stressor for fish in the upper section of the river near station 12UM071 (S001-514), just downstream of Hutchinson.

Table 20. Metrics related to low DO

Station	MA>3 years Percentage	Serial Spawning Fish Percentage	HBI_MN	Percentage DO Tolerant Macroinvertebrate Taxa	Intolerant Low DO Macroinvertebrate Taxa
12UM071	10.24	47.64	7.81	0	2
Averages for fish class 5 stations	**13.46**	**19.03**			
12UM031	26.01	36.30	7.75	0.31	9
Averages for fish class 4 stations	**35.53**	**21.47**			
Average for invert class 7			**8.07**	**30.3**	**1.88**
Average for invert class 2			**7.46**	**9.28**	**6.32**
Expected response to stress	↓	↑	↑	↑	↑

Ionic strength

Specific conductance values ranged from 347 to 1344 uS/cm. The ecoregion norm for the Western Corn Belt Plain (based on the 75th percentile of annual specific conductance values) is 820 (McCollor et. al, 1993). Specific conductance values in the watershed are highest at station S001-514 (just downstream of Hutchinson and the WWTP) in September. Continuous data was taken at station S001-514 where values ranged from 679 to 1041 with seven of thirteen days having concentrations above 900 uS/cm. Two longitudinal studies showed specific conductance values from the headwaters to the mouth increasing between stations S001-514 and S000-394. Values ranged from 509 to 954.

Increased ionic strength can cause an increase in ion tolerant taxa and an increase in ion tolerant life stages, causing fish and invert impairments, but it is difficult to separate this effect from other stressors. As salinity increases, macroinvertebrate taxa richness and Ephemeroptera has been found to decrease (Piscart et al., 2005). Echols et. al (2009) also found a reduction in EPT abundance as conductivity values increased. A study of Minnesota biological data and stressor linkages found that sites with conductivities higher than 1,000 µS/cm rarely meet the biological thresholds for general use streams (MBI, 2012). There were three values over 1,000 µS/cm recorded, all at station S001-514. Taxa counts were below average for their respective classes. The EPT percentage at both stations 12UM031 and 12UM071 was 77.34%. Increases in conductivity can result similarly in decreases in mayflies (Ephemeroptera). Percentages at stations 12UM071 and 12UM031 were 8.46% and 18.73% respectively.

Taxa count also is related to other stressors, so ionic strength could be contributing to this decline along with other stressors. The Ephemeroptera and EPT percentages were lower at station 12UM071 (S001-514) just downstream of Hutchinson versus station 12UM031 which is further downstream. There are instances of elevated specific conductance concentrations especially in the fall, that might be influencing the biological community at station 12UM071 (S001-514) but there is still a healthy EPT percentage. While the periodic elevated values might be contributing as a stressor, it is not a clear stressor at this time. Additional sampling throughout the reach and throughout the year would be beneficial.

AUID summary

The main stressors of the South Fork Crow River from the Hutchinson dam to Bear Creek is eutrophication and low DO.

4.3.3. South Fork Crow River (07010205-511)

The South Fork Crow River from Bear Creek to Otter Creek has four biological monitoring stations located within the AUID. Three were sampled for fish, and all four were sampled for macroinvertebrates. 12UM071 which is located upstream near Hutchinson and 12UM031 which is located downstream near the confluence with County Ditch 26.

Biological communities

There was a lack of sensitive and simple lithophilic spawning species at all three stations in this reach, which are all in fish class 4 (Figure 66). All stations also had high numbers of serial spawners (SSpnTxPct) and very tolerant species (VtolTxPct). The most common fish collected were carp and green sunfish at station 12UM048, sand shiners at 10EM195, and channel catfish at station 12UM027. FIBI scores increase from up to downstream throughout the reach.

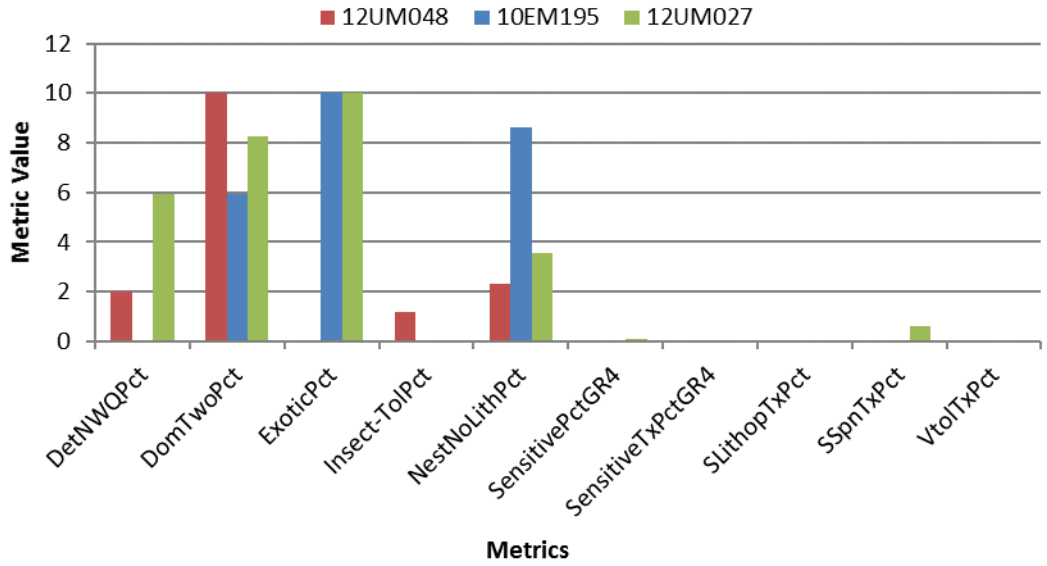

Figure 66. Metrics on the South Fork Crow River

Each station in this reach were in macroinvertebrate class 2 with a high score of 12.5. Five of the eight metrics at station 12UM027 had scores of zero and all scores at station 12UM048 were less than 4.5 (Figure 67). Station 10EM195, in the middle of the AUID was the highest scoring station with the score being right at the threshold (31).

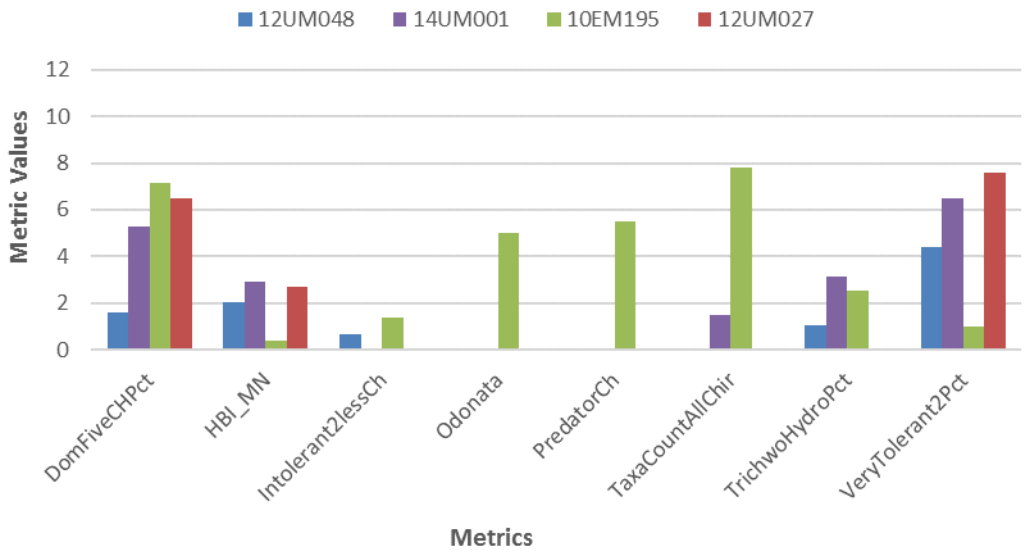

Figure 67. Metric values on the South Fork Crow River

Phosphorus/Eutrophication

Phosphorus values were taken both after rain events and during base flow conditions. Values ranged from 0.062 to 0.723 mg/L. The highest values were taken at station S001-443. Tile drainage values were taken in April at station 14UM001 with a value of 0.193 mg/L. The standard of phosphorus in the southern region is 0.150 mg/L, with 93 samples above this value (87%). Values of pH were as high as 8.64, with 10 other values above 8.5 (10%). Values greater than 8.5 can be tied to eutrophication. Chlorophyll-a values ranged from 7 to 148 ug/L with 6 values over 35 (55%). BOD values ranged from 1.81 to 10.6 mg/L with 17 values over 3 (61%). Continuous data was collected at station 12UM048. DO flux range up to 3.54 mg/L. The southern standard of DO flux is 4.5 mg/L. Low DO was also recorded, and is discussed in the next section. Typical daily pH fluctuations are 0.2-0.3 (Heiskary et al., 2013). Continuous data showed pH flux ranged up to 0.31.

The three stations with fish information had low percentages of sensitive and darter percentages and elevated percentage of fish tolerant to pollution. Station 10EM195 had a higher darter percentage based on the collection of 39 blackside darters. Omnivorous fish have a positive relationship with nutrients, chlorophyll-a and DO flux. Each station had a higher than average percentage, with station 12UM048 the highest at 30.77%. Fish communities with phosphorus tolerant fish ranged from 27% (10EM195) to 61% (12UM048).

EPT percentages were high at each station except 10EM195, which is most likely based on the higher taxa count (50 at station 10EM195 compared to 18 at station 12UM027). There were nine EPT taxa collected at station 12UM027, 11 at station 10EM195, and 15 at station 14UM001. The most common EPT species collected are more tolerant. The biological communities are showing a mixed response to the elevated phosphorus, chlorophyll-a, and pH values. Eutrophication is a stressor for fish while the macroinvertebrate stress seems to be limited to the upper section (near station 12UM027).

Table 21. Phosphorus related metrics

Station	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct	Invert Taxa	EPT Pct	Dominant 2 Invert Taxa Pct
12UM027	1.75	1.24	56.04	11.46	18	78.23	31.86
14UM001	-	-	-	-	28	68.48	35.15
10EM195	0	9.58	75.65	12.77	50	21.34	32.01
12UM048	3.08	4.62	53.23	30.77	21	79.94	48.90
Average for fish class 4 streams	**29.59**	**12.52**	**15.01**	**7.68**			
Average for invert class 2 streams					**36**	**51**	**40.86**
Expected response to increased TP stress	↓	↓	↑	↑	↓	↓	↑

Dissolved oxygen

Summer concentrations on this reach ranged from 3.71 mg/L in July to 11.07 mg/ in May. Both values were taken at station S001-443. Two values have been recorded below 5 mg/L (3.71 and 4.45 mg/L). Continuous data was collected at station 12UM048 in 2014 in late August and early September. DO was at healthy levels throughout the 14-day duration; above 6 mg/L.

The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. All stations had lower than average percentages of fish that take three years or longer to mature, with station 10EM195 the lowest with 3.99%. Low DO values also correspond with increased serial spawning fish percentage. The stations had percentages ranging from 22.70 to 74.85%. These are all above average, with station 10EM195 having the highest percentage of serial spawners (74.85%).

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed and ranged from four to eight low DO intolerant taxa and 0.63 to 16.45% DO tolerant percent. These values show a macroinvertebrate community that is not being affected by low DO conditions. The fish communities show a different impact; station 10EM195 had both the lowest percentage of fish that mature at greater than three years of age and the highest percentage of serial spawners. Station 10EM195 was dominated by sand shiners which are both serial spawners and fish that mature at less than one year of age. The dominance of sand shiners could also be due to other stressors such as habitat. Fish tolerance indicator values indicate that based on the fish captured and their relationship to low DO, the stations fall from the 15.5 (12UM027) to 43.8 (10EM195) percentile of all stations in fish class 4. The fish metrics are depressed, especially at station 10EM195, but low DO is not a stressor in this section of the river for macroinvertebrates. Even though low DO was not captured during deployment, based on the preponderance of evidence and low DO recorded at other times, low DO is a stressor for fish in this section.

Table 22. Low DO related metrics

Station	MA>3 years Percentage	Serial Spawning Fish Percentage	HBI_MN	Percentage DO Tolerant Macroinvertebrate Taxa	Intolerant Macroinvertebrate Taxa
12UM048	17.85	41.23	7.87	0.63	4
14UM001	-	-	7.67	0.96	7
10EM195	3.99	74.85	8.24	16.45	8
12UM027	24.66	22.70	7.72	2.87	6
Averages for fish class 4 stations	**35.53**	**21.47**			
Averages for invert class 2 stations			**7.46**	**9.28**	**6.32**
Expected response to stress	↓	↑	↑	↑	↓

Suspended sediment

TSS values in recent years ranged from 3.0 to 138 mg/L. 19% of samples were above the central region standard of 65mg/L. The highest values were taken at stations S001-443 and S000-409, which are on the upstream and downstream portions of the watershed indicating elevated values throughout the reach. There are eroding banks on this section of the river, adding sediment to the system (Figure 68).

Figure 68. Eroding bank at station 14UM001 (October 3, 2013)

Numerous paired organic solids (TSVS) and inorganic solids (TSS) samples were taken on this section of the South Fork Crow River. All of the paired values were taken at station S001-443, where TSVS values range from 16% up to 50% of the suspended solid concentrations, with an average of 23%. On average, inorganic solids make up the majority of the suspended solids. The ratio when the values were highest (101-138 mg/L) all had percentages of 16%.

Herbivore fish and TSS intolerant macroinvertebrates decrease as TSS values increase. In this section of the South Fork Crow River, the percentage of herbivore individuals was zero except at station 12UM027 (1.55%). The number of TSS intolerant macroinvertebrate taxa was zero except for station 12UM048 which had one. Macroinvertebrates tolerant to TSS were also elevated with percentages all over 69%. The percentage of long-lived individuals decrease as TSS values increase, the only station with a lowered value was station 12UM027 (3.47%).

All stations had high numbers of fish collected that were tolerant to elevated TSS values. The most common fish collected were common carp, green sunfish, sand shiner, and channel catfish. These fish all have a high tolerance to TSS disturbance. Perciforms (perch like fish) decrease as TSS increase. Perciform percentages were lowered at each station with the lowest at station 12UM027. Station 12UM027 does seem to be effected by elevated concentrations based on lower long-lived macroinvertebrate and perciform fish percentages. The herbivore percentage was higher than average at this location (1.55%), but brassy minnows make up this metric and they are one of the species most tolerant to high TSS values. Fish tolerance indicator values indicate that TSS tolerant fish communities ranged from 44% (12UM027) to 63% (10EM195). TSS is a limited stressor in the downstream section of the reach.

Table 23. TSS related metrics

Stations	TSS Intolerant Taxa	TSS Tolerant Taxa	Percentage TSS Tolerant Macroinvertebrate Individuals	Long-lived Macroinvertebrate Percent	Herbivore Percent	Perciform-Tolerant Percent
12UM048	1	10	84.54	10.97	0	14.77
14UM001				20.91	-	-
10EM195	0	18	78.95	17.68	0	10.78
12UM027	0	9	69.21	3.47	1.55	6.71
Averages for class 4 fish stations					**0.31**	**39.62**
Average for class 2 invert streams	**1.7**	**13.16**	**54.49**	**5.7**		
Expected response with increased TSS stress	↓	↑	↑	↓	↓	↓

AUID summary

The main stressors of the South Fork Crow River from Bear Creek to Otter Creek are eutrophication and TSS.

4.4. South Fork Crow

This section includes the South Fork Crow River and its tributaries ranging from Buffalo Creek to the North Fork Crow River. The river flows through the towns of Mayer, Watertown, and Delano. Tributaries include the impaired County Ditch 9, Pioneer Creek, and an unnamed tributary to the South Fork Crow River. The mainstem South Fork Crow River and the tributaries are discussed in two separate sections.

The entirety of the section is in the North Central Hardwood Forests ecoregion. Prior to settlement, the area was dominated by deciduous forest. Land use was converted to predominantly hayfields, pasture, and cropland. The cropland is predominantly comprised of corn, alfalfa, and soybeans (USDA 2013). The South Fork Crow River has been sampled throughout the reach both for biology and chemistry (Figure 69).

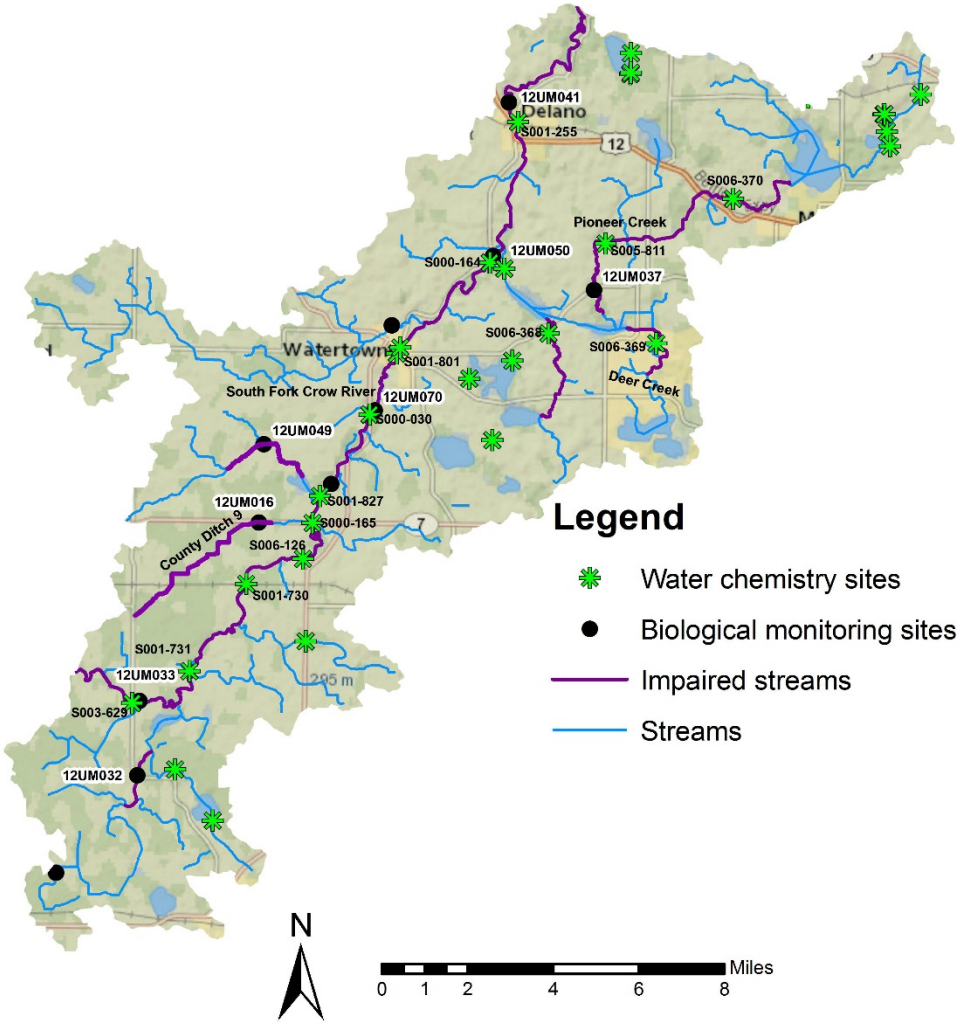

Figure 69. Biological and chemistry monitoring stations

4.4.1. Tributaries (-618,624,648 & -654)

- Pioneer Creek (12UM037 on -654)
- County Ditch 9 (12UM016 on -648)
- Tributary to Lippert Lake (12UM049 on -624)
- Tributary to South Fork Crow River (12UM032 on -618)

Biological communities

Each FIBI score was well below the threshold of 42. All stations were in fish class 6. The metric scores of sensitive, intolerant minnows, darter and sculpin, and headwater species were zero at each tributary (Figure 70). The highest scoring metric was the pioneer species metric, which was highest at station 12UM037. The most common fish collected were bluegill, central mudminnows, fathead minnows, green sunfish, and carp.

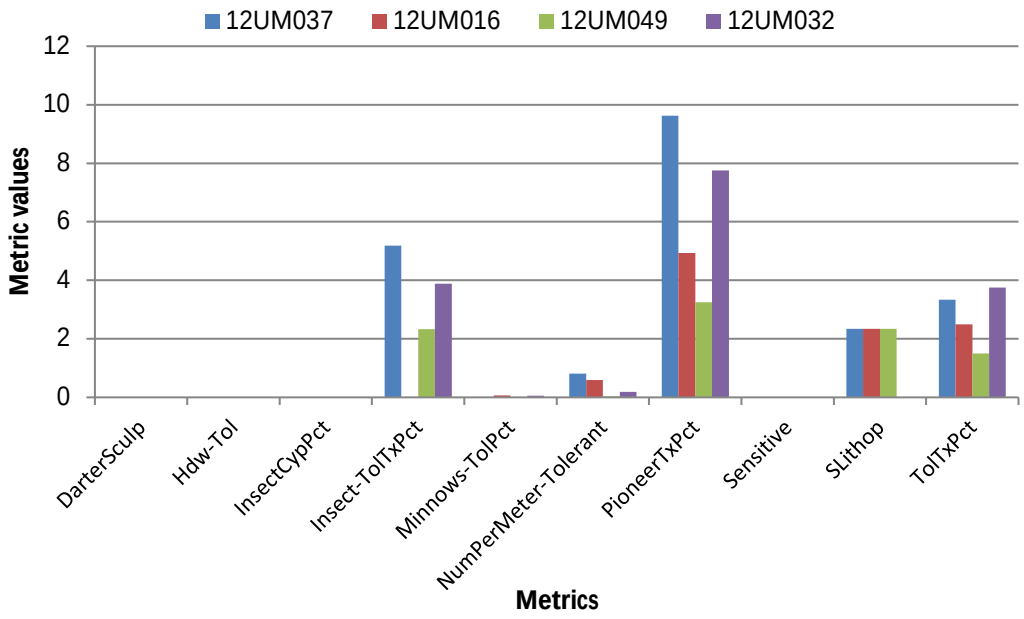

Figure 70. Fish metrics

Station 12UM049 is in macroinvertebrate class 5 (Figure 71), while the other three were all in class 6 (Figure 72). Stations 12UM049 and 12UM016 scored below their respective thresholds threshold (37 and 43). Station 12UM049 had a score of 0 for stoneflies (Plectoptera) and dragonflies (Odonata) which are not tolerant to disturbance. The highest score at station 12UM049, where 10 is the highest possible score was DomFiveCHPct (7.7), which means the community was not dominated by a few species.

Station 12UM032 had a macroinvertebrate score just below the threshold (43), while station 12UM037 had a score just above. The main differences between these stations and 12UM016, which was well below the threshold were clingers, collector-filterers, and the number of stoneflies, dragonflies, mayflies, and caddisflies (POET and Tricoptera). The highest score was 10 in this class.

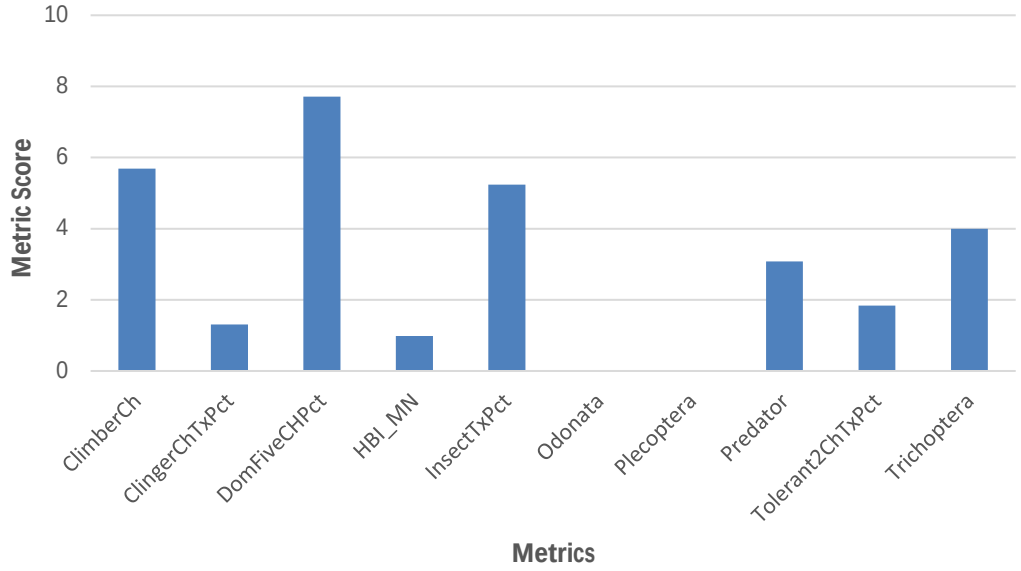

Figure 71. Metric values at station 12UM049

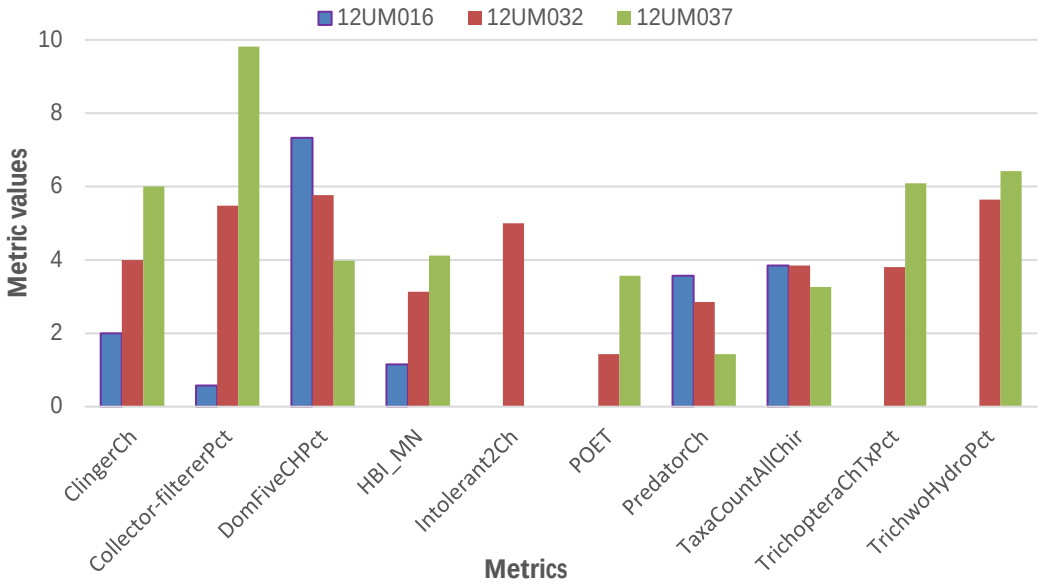

Figure 72. Metrics for stations in class 6

Phosphorus/Eutrophication

Phosphorus values were taken both after rain events and during base flow conditions. Fifteen samples were available from the four stations. The highest value was taken during base flow in August on County Ditch 9. The value of 1.1 mg/L was taken at station 12UM016. The standard of phosphorus in the southern region is 0.150. There were not any elevated values recorded at station 12UM037 on AUID -654, but an upstream sample was 0.302 mg/L during spring snowmelt on AUID -653. All values from stations 12UM016 and 12UM032 were over 0.150 mg/L with values ranging from 0.249 to 1.1 mg/L.

Table 24. Phosphorus values

Station	Min (mg/L)	Max (mg/L)	# of samples
12UM016	0.204	1.1	4
12UM032	0.249	0.275	3
12UM037	0.046	0.137	5
12UM049	0.11	0.172	3

Two values of BOD were taken at station 12UM037 in August 2013 and 2014 with values of 12.4 and 1.4 mg/L. The value in 2013 was more than four times the southern standard of 3 mg/L. A chlorophyll-a value was also available at station 12UM037 along with stations at 12UM016, 12UM049, and 12UM032. All chlorophyll-a values were below 3 mg/L. The southern standard is 35 mg/L.

Continuous data was collected at stations 12UM049, 12UM032 and 12UM016. Stations 12UM032 and 12UM049 both had low DO flux. DO flux was low early in the deployment at station 12UM016 after 2.5 inches of rain (0.76 mg/L) but increased by the end of deployment (5.21 mg/L). Eutrophication is a problem at this site (Figure 73), which can be diluted by rain. Low flow periods are more common which indicates eutrophication is occurring throughout most of the summer (flows were less than 1 cfs 42% of the time).

Figure 73. Macrophytes at station 12UM016 (July 28, 2014)

All tributaries have percentages of zero sensitive fish, darter, and intolerant macroinvertebrate percentages. Macrophytes were present at all of these stations, with algae present at different degrees (Figure 74). Three of the stations were comprised of more than 94% tolerant fish species. Specific tolerance to elevated phosphorus levels ranged from 49% of the fish community (12UM037) to 98% (12UM032). All stations had zero low DO intolerant macroinvertebrate taxa except station 12UM049, which had six taxa that are intolerant to low DO values.

Figure 74. Algae at stations 12UM049 (top) and 12UM037 (bottom) on August 6, 2012

Based on the DO flux during base flow, phosphorus values and the lack of sensitive fish, lack of darters, high levels of tolerant fish and lack of macroinvertebrate taxa and EPT species, phosphorus and eutrophication is determined to be a main stressor at station 12UM016. Station 12UM032 has the same metric results and elevated phosphorus values, but did not experience low DO or flux during deployment in 2014. However, near the end of deployment, DO values begin to increase above 11 mg/L, which is also a sign of eutrophication. Excessive algal growth was noted during biological sampling at stations 12UM032 and 12UM037. Based on the metric values and algal growth, phosphorus reduction should also be targeted in this area.

Table 25. Phosphorus related metrics

Stations	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous fish Pct	Invert Taxa	EPT Pct	Dominant 2 Invert Taxa Pct
12UM016	0	0	94.58	31.19	16	6.25	31.56
Average for fish class 7 streams	**8.16**	**5.21**	**70.59**	**22.40**			
12UM032	0	0	99.24	46.81	17	6.10	40.03
12UM037	0	0	56.86	17.65	16	22	49.84
12UM049	0	0	99.79	30.08	27	27.76	26.81
Average for fish class 6 streams	**15.13**	**6.34**	**66.59**	**16.87**			
Average for invert class 5 streams					**38**	**38.30**	**39.30**
Average for invert class 6 streams					**23**	**19.01**	**44.72**
Expected response to increased TP stress	↓	↓	↑	↑	↓	↓	↑

Dissolved oxygen

There is a small DO dataset available at these tributaries. Two one-time measurements were recorded under the standard of 5 mg/L; 2.91 mg/L and 4.14 mg/L. Both concentrations were taken on Pioneer Creek at station 12UM037. Continuous data was collected at stations 12UM049, 12UM032 and 12UM016. DO was at healthy levels throughout the duration; above 6 mg/L at station 12UM032 and above 7 mg/L at 12UM049. However, station 12UM016 had values below 5 mg/L daily, getting as low as 3.22 mg/L (**Figure 75**).

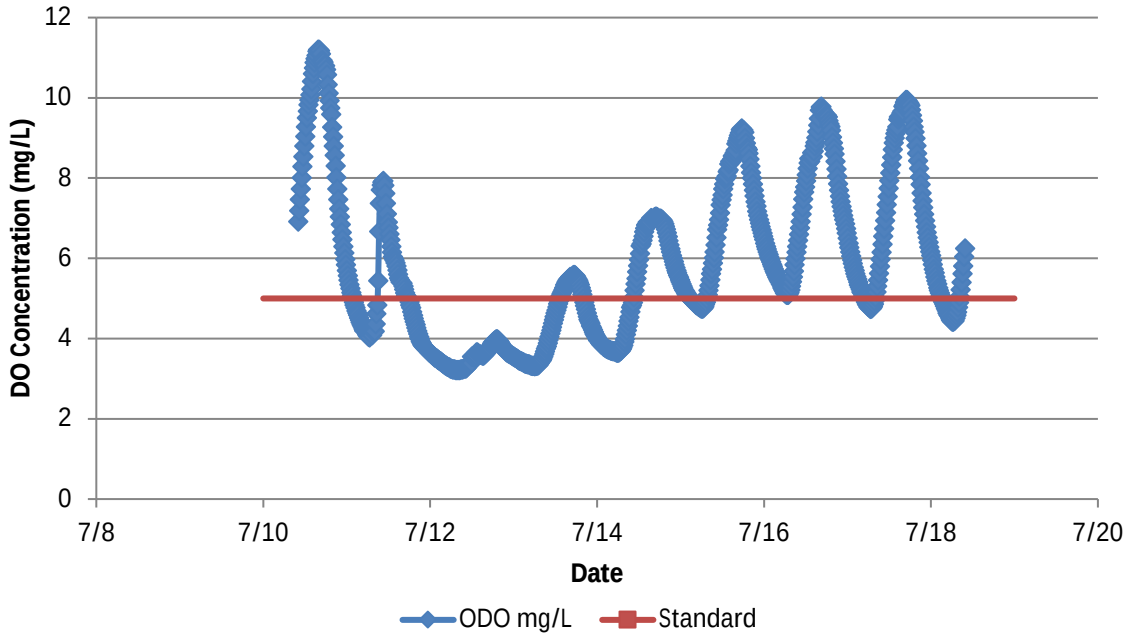

Figure 75. Continuous DO at station 12UM016 in 2014

The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. None of the stations had any fish that take three years or longer to mature, indicating that conditions are less amenable to longer lived fish. Low DO values also correspond with increased serial spawning fish percentage. The stations had percentages ranging from 4.56% at station 12UM032 to 47.06% at station 12UM037. Stations 12UM016, 12UM037, and 12UM049 were all above average for their respective classes. Based on the fish captured, the communities ranged from 49% (12UM037) to 91% (12UM032) low DO tolerant communities.

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed at both stations. Intolerant macroinvertebrate taxa collected ranged from zero to six and DO tolerant percentages ranged from 7.59% to 49.36%. Stations 12UM016 and 12UM032 had the highest percentage of DO tolerant individuals and both had zero low DO intolerant taxa. Based on the preponderance of low DO tolerant fish and lack of fish that mature at greater than three years of age low DO is a stressor at stations 12UM016 and 12UM049.

Table 26. Low DO related metrics

Station	MA>3 years Percentage	Serial Spawning Fish Percentage	HBI_MN	Percentage DO Tolerant Macroinvertebrate Taxa	Intolerant Macroinvertebrate Taxa
12UM016	0	24.75	8.52	49.36	0
Average for fish class 7 streams	**4.62**	**19.58**			
12UM032	0	4.56	7.91	41.64	0
12UM037	0	47.06	7.62	23.45	3
12UM049	0	31.36	8.01	7.59	6
Averages for fish class 6 stations	**2.99**	**15.44**			
Averages for invert class 5 stations			**7.45**	**10.45**	**6.91**
Averages for invert class 6 stations			**7.55**	**24.88**	**3.83**
Expected response to stress	↓	↑	↑	↑	↓

Lack of habitat

Habitat availability is lacking in these South Fork Crow River tributaries. The MSHA scores taken during biological sampling were poor and fair at all sampling sites. Lack of channel development and depth variability were the main lacking factors. Station 12UM016 had no coarse substrate (all silt and muck) or riffle. Where coarse substrate was available, periphyton was a noted problem at stations 12UM032, 12UM037 and 12UM049. Submerged macrophytes made up 25% of the stream channel. Station 12UM037 also had no riffles, while at station 12UM032 the pool width equaled the riffle width. Both stations had moderate embeddedness of fine sediments.

Clean cobble and gravel presence have a positive relationship with a higher fish IBI. Excess sedimentation was noted at each of the stations. Depth measurements of fine substrates averaged 18.6 cm at station 12UM049 (Figure 76) with measurements up to 30 cm (11.8 in.) at station 12UM032. Station 12UM016 had an average of 20.3 cm (8 in.) fines.

Figure 76. Sand at station 12UM049 (July 28, 2014)

The percentages of tolerant fish collected were higher than 94% at all sites except station 12UM037. At station 12UM037 bluegill were the most common fish collected making up 41% of the community, which are not tolerant fish. Bluegill are a lake species, and station 12UM037 is just over a mile upstream of Ox Lake. In comparison, station 12UM049 only had one individual that was not tolerant (tadpole madtom). The lack of coarse substrates and riffles results in the lack of darter and sculpins and benthic insectivores. Simple lithophilic spawners, darter and sculpin, riffle, and benthic insectivore percentages were all below average except for the simple lithophilic spawners and riffle percentages at station 12UM016. These percentages (22.03) are entirely made up of white suckers, which are a tolerant fish. The prevalence of fine sediments and embeddedness is affecting the fish community. Lack of habitat is a stressor to the fish community.

Table 27. Habitat related metrics

Habitat relevant metrics	SLithophilic Spawners Pct	DarterSculpin Pct	Tolerant Pct	Riffle Pct	Benthic Insectivore Pct
12UM016	22.03	0	94.58	22.03	0
Average for fish class 7 streams	**14.90**	**5.41**	**70.64**	**8.41**	**6.54**
12UM032	0	0	99.24	0	0.3
12UM037	7.84	0	56.86	7.84	0
12UM049	0.21	0	99.79	0.21	0.21
Average for fish class 6 streams	**21.68**	**7.75**	**66.56**	**11.87**	**9.72**
Expected response with habitat stress	↓	↓	↑	↓	↓

The number of clinger taxa decreases with the increase in percent fines (Figure 77). The percentages of clingers in macroinvertebrate class 5 were above average at station 12UM049 which had the highest measured average fines. Station 12UM016 had no coarse substrates and stations 12UM032 and 12UM037 were embedded. Station 12UM037 which had a score right at the threshold, and although embeddedness was recorded the percentages of burrowers and clingers are not affected to the extent of station 12UM049 (Figure 78). Burrowers live inside fine sediments, and were above average at station 12UM049 as were sprawlers where the depth of fines was high. The percentage of climbers were both well above average, particularly at station 12UM060. Climbers live on macrophytes, and station 12UM049 had prevalent algae and macrophytes providing a lot of habitat. All swimmer percentages were low. A lack of habitat is a stressor.

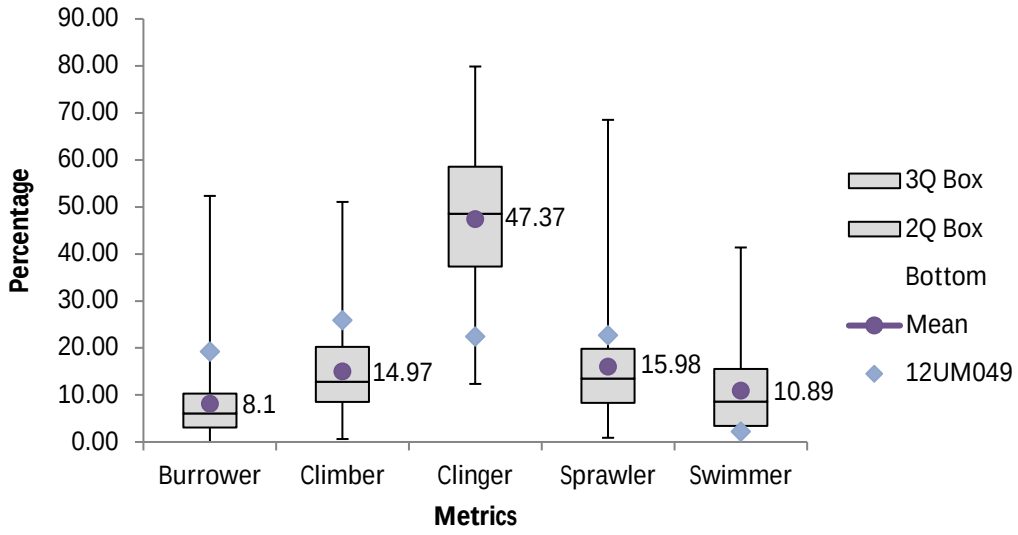

Figure 77. Metrics for class 5 macroinvertebrates

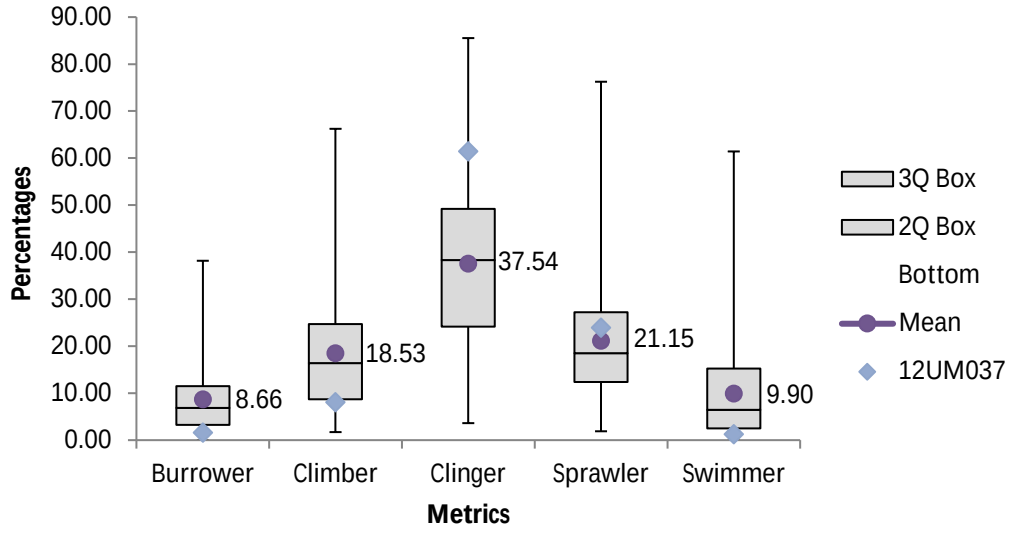

Figure 78. Metrics for class macroinvertebrates

Altered hydrology

The tributaries to the South Fork Crow River in this HUC and their upstream watersheds were predominantly channelized. Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency, increasing the impact of high flow events and increasing the intensity of low flow periods, both of which affect biological communities. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat. HSPF models show Pioneer Creek experiencing low flow with less than 1 cfs 27% of the time. Flow conditions seem to be affecting the biology due to extended periods of low flow.

Benthic insectivore and simple lithophilic species can decrease with channelization as bedload increases. Generalized fish species, which are adaptable to different habitats through generalized food preferences, are also correlated with channelization. The average percentage for generalized fish in class 6 waters was 41.54%. Stations 12UM032, 12UM037, and 12UM049 were all in fish class 6 and had a general percentage range of 33.33% at station 12UM037 to 84.5% at station 12UM032. This corresponds with the simple lithophilic spawner percentages of 0 to 0.3% and 0.21 to 3.85% of benthic insectivores discussed in the habitat section. The average simple lithophilic spawner percentage for class 6 was 21.65% and benthic insectivores were 9.71%. Station 12UM016 which was in fish class 7 had a general percentage of 53.56, a simple lithophilic spawner percentage of 22.03 and benthic insectivore percentage of 0%.

Channelization is connected to and contributing to the lack of habitat. The effects of altered hydrology do not seem to be contributing to the increase of generalized fish percentages at all of the tributaries. Station 12UM032 does have an elevated percentage of generalized species, along with no simple lithophilic spawners and two fish that are benthic insectivores, and station has extended low flow periods and increased generalized fish species. Altered hydrology is a contributing stressor to lack of habitat to a portion of this area.

AUID summary

The main stressors of the tributaries to the South Fork Crow River from Buffalo Creek to the North Fork Crow River are eutrophication, DO, lack of habitat and altered hydrology. These stressors are all connected.

4.4.2. South Fork Crow River (07010205-508)

The South Fork Crow River from Buffalo Creek to the North Fork Crow River has four biological monitoring stations located within the AUID. Each station was sampled for both fish and macroinvertebrates.

Biological communities

Each station was in fish class 4. Fish IBI scores were highest at the upstream station (12UM033) where the score was right above the threshold (38), while the rest of the scores ranged from 23 to 27.

The metric scores of sensitive and simple lithophilic spawning species were zero at all stations (Figure 79). Also lacking were the very tolerant taxa, serial spawners taxa, insectivores, and non-lithophilic nest guarder scores. The dominant two percent metric and exotic metric were the highest scores at all four stations. The most common fish collected were channel catfish, fathead minnows, and green sunfish.

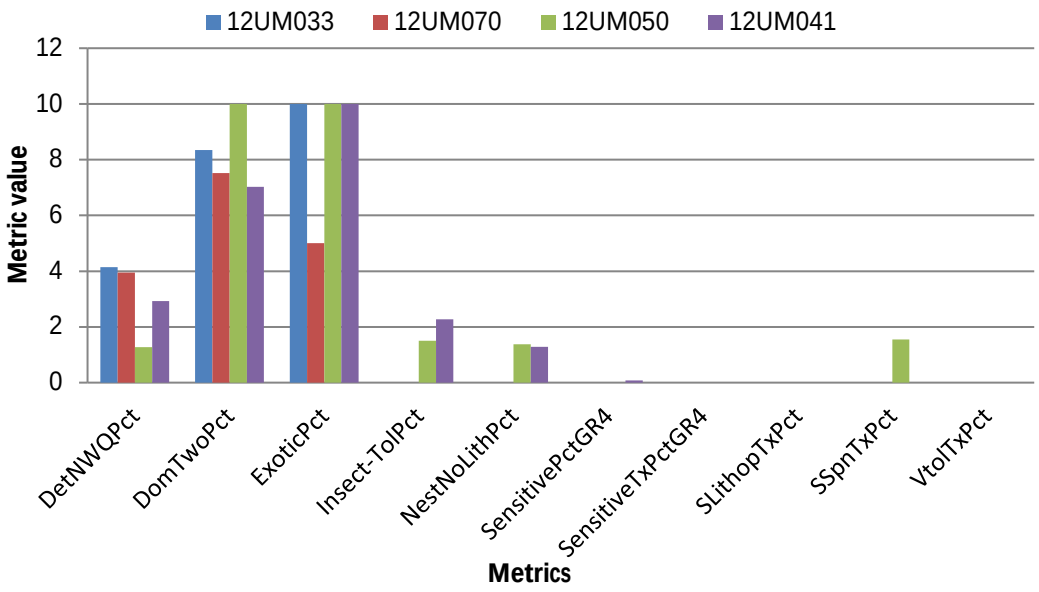

Figure 79. Biological metrics

All stations were in macroinvertebrate class 2, with the highest possible score 12.5 (Figure 80). Scores increased from station 12UM033 to station 12UM050 (at the threshold of 31), with a decrease at station 12UM041 the most downstream station. The highest score was at station 12UM050, with a caddisfly (TrichwoHydroPct) score of 9.2. The intolerant and HBI scores were uniformly low. The main differences between the highest scoring station 12UM050 and the other stations were taxa count, caddisflies, and a lack of dominant species (DomFiveCHPct).

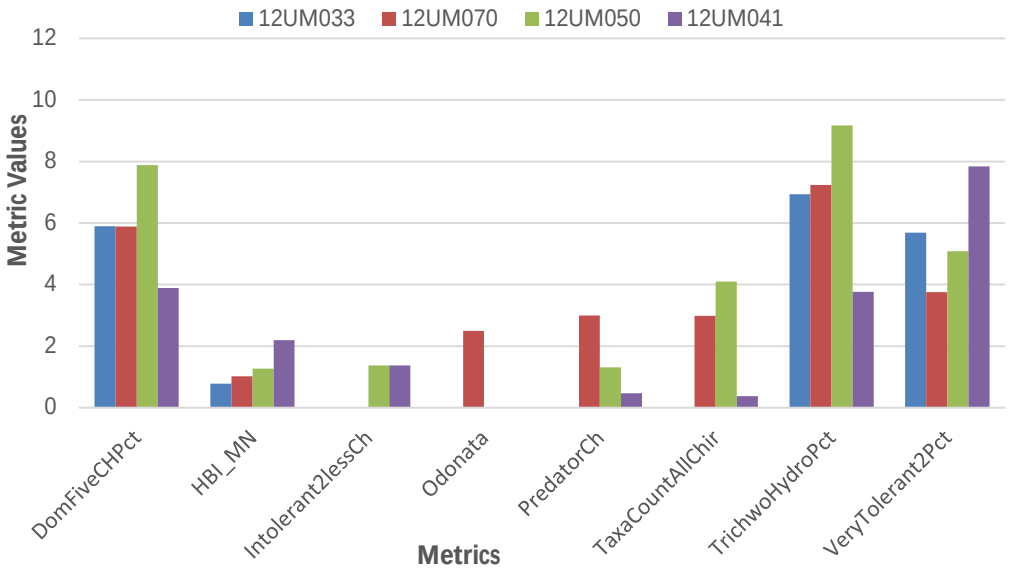

Figure 80. Metric values

Phosphorus/Eutrophication

Phosphorus values were taken both after rain events and during base flow conditions. Values ranged from 0.039 to 0.68 mg/L. The highest values were taken at stations S000-165 (downstream of Mayer) and S001-255 (in Delano), but values were elevated throughout this section of the river. The standard of phosphorus in the southern region is 0.150 mg/L, with 253 samples above this value (91%). Chlorophyll-a, BOD, and DO daily fluctuation values are a proximate measurement of eutrophication and have more direct impacts on biology than phosphorus. Increases in chlorophyll-a are directly related to elevated phosphorus and are commonly used to measure algal productivity in surface water. Chlorophyll-a values ranged from 5.77 to 210 ug/L, and were also highest at station S001-255 in Delano with 37 values over 35 (82%). BOD values ranged from 1.1 to 10.6 mg/L with 30 values over 3, the southern standard (83%).

Eutrophication drives elevated pH values and pH fluctuations. Values of pH were as high as 9.1, with 65 other values above 8.5 (19%). Typical daily pH fluctuations are 0.2-0.3 (Heiskary et al., 2013). Continuous data at station 12UM041 showed pH flux ranging from 0.35 to 0.67 (Figure 81). Nine of the 13 days of continuous DO experienced DO daily fluctuations above the southern standard of 4.5 mg/L (Figure 82). Flow data in Delano shows flows were low during the elevated DO fluctuations.

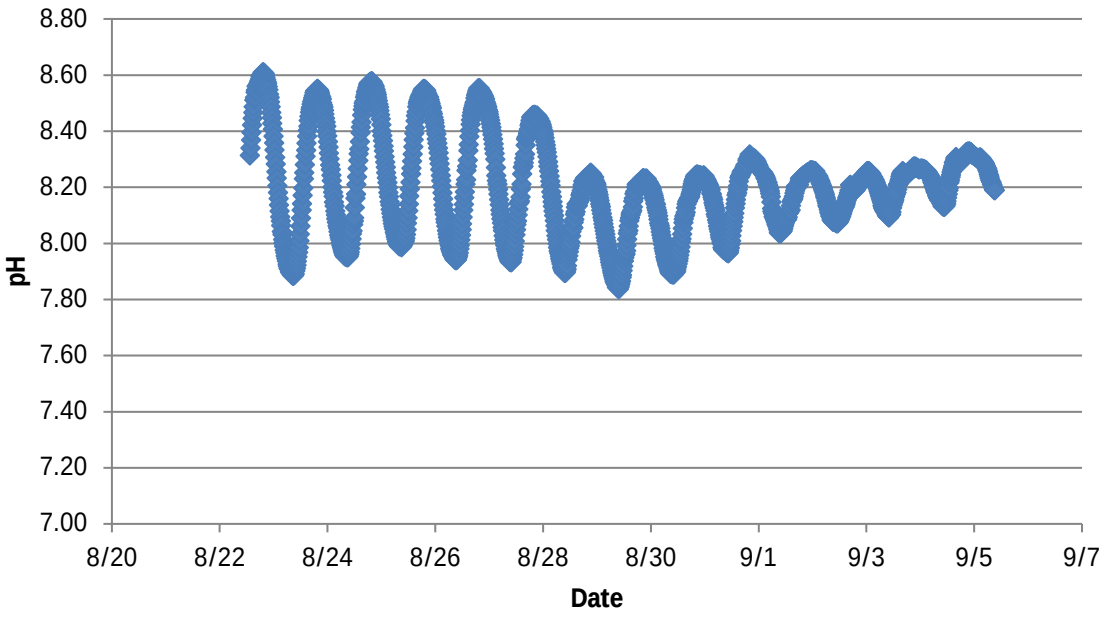

Figure 81. Continuous pH at station 12UM041

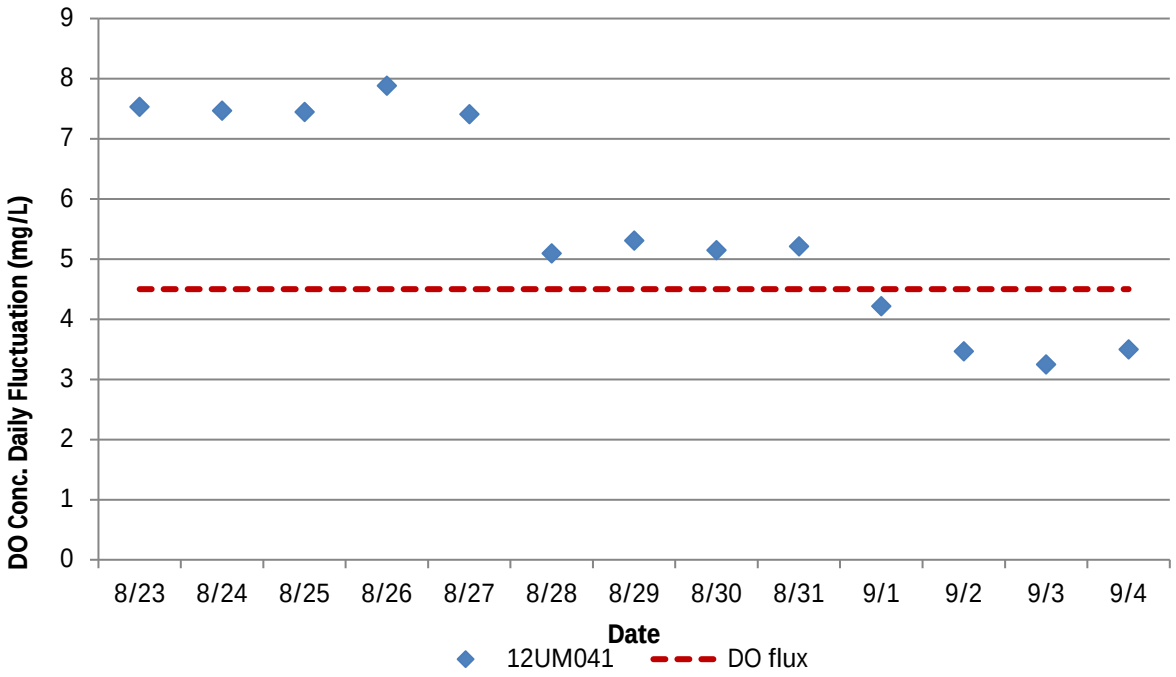

Figure 82. DO flux at station 12UM041

The five fish visits had low percentages of sensitive individuals. Darter percentages were also low except at station 12UM070 where a high number of blackside darters were collected. The upstream stations had elevated percentages of fish tolerant to pollution. Omnivorous fish have a positive relationship with nutrients, chlorophyll-a and DO flux. Each station had a higher than average percentage of omnivorous fish, with station 12UM050 the highest at 25.58%. Fish communities with phosphorus tolerant fish ranged from 48% (12UM050) to 70% (12UM070).

EPT percentages were high at each station ranging from 71.05 to 89.14%. EPT percentages were very high at both stations; however, the most common EPT species collected are more tolerant. The biological communities are showing a mixed response to the elevated phosphorus, chlorophyll-a, and pH values. Eutrophication is a stressor for fish.

Table 28. Phosphorus related metrics

Stations	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct	Invert Taxa	EPT Pct	Dominant 2 Invert Taxa Pct
12UM033	2.16	1.30	57.2	10.66	24	71.79	36.54
12UM041	1.09	4.35	28.15	11.51	25	89.14	40.26
12UM050	0.26	3.32	50.13	25.58	35	75.16	38.85
12UM070	0	8.4	42.6	24.80	32	71.05	38.16
Average for fish class 4 streams	**29.59**	**12.52**	**15.01**	**7.68**			
Average for invert class 2 streams					**36**	**51.1**	**40.86**
Expected response to increased TP stress	↓	↓	↑	↑	↓	↓	↑

Dissolved oxygen

There is a sizeable DO dataset on this reach in recent years. Concentrations ranged from 1.8 mg/L to 17.41 mg/L, both values taken at station 12UM041. All values below 5 mg/L were taken at stations 12UM041 and S001-827, which are on opposite ends of the reach. Continuous data was collected at station 12UM041 where the DO was recorded as less than 4 mg/L over eight days over the 14 day deployment (Figure 83).

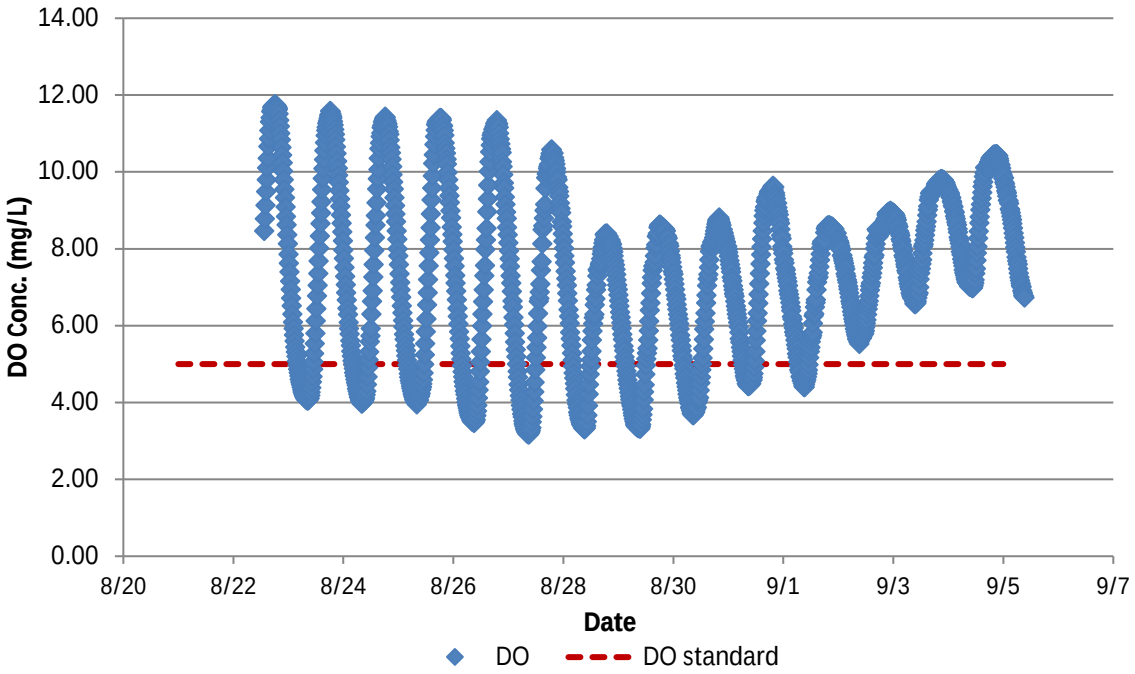

Figure 83. Continuous data at station 12UM041

The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. The two upstream stations; 12UM033 and 12UM050 had lower than average percentages of fish that take three years or longer to mature, indicating that conditions are less amenable to longer lived fish. Low DO values also correspond with increased serial spawning fish percentage. All stations had higher than average percentages with the highest at station 12UM050 (46.04%). Fish that are tolerant to low DO made up the 15% (12UM041) to 40% (12UM070) of the communities. While there are low DO values recorded and some biological response at station 12UM050, low DO is inconclusive as a stressor in this section of the river.

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed at each station. Intolerant macroinvertebrate taxa collected ranged from 5 to 10 and DO tolerant percentages were very low and ranged from 0 to 4.19%. These values show a macroinvertebrate community that is not being affected by low DO conditions. While there is low DO present at station 12UM041, the DO flux seems to be more of a stressor than low DO. Low DO is not a stressor for macroinvertebrates in this section of the river.

Table 29. Low DO related metrics

Station	MA>3 years Percentage	Serial Spawning Fish Percentage	HBI_MN	Percentage DO Tolerant Macroinvertebrate Taxa	Intolerant Macroinvertebrate Taxa
12UM033	20.61	45.82	8.16	2.24	5
12UM070	35.40	30.40	8.10	1.02	8
12UM050	13.04	46.04	8.05	4.19	9
12UM041	45.57	39.81	7.83	0	10
Averages for fish class 4 stations	**35.53**	**21.47**			
Averages for invert class 2 stations			**7.46**	**9.28**	**6.32**
Expected response to stress	↓	↑	↑	↑	↓

Suspended sediment

TSS values in recent years ranged from 1.2 to 320 mg/L. 17% of samples were above the central region standard of 65 mg/L. Elevated values were taken throughout the reach with the highest values downstream of Mayer (S000-165) and Delano (S001-255) with values of 264 and 320 mg/L respectively. The highest values were during May and June.

Numerous paired organic solids (TSVS) and inorganic solids (TSS) samples were taken on this section of the South Fork Crow River. Paired values were taken throughout the reach, where TSVS values range from 10% up to 100% of the suspended solid concentrations, with an average of 32%. On average, inorganic solids make up the majority of the suspended solids.

Herbivore fish and TSS intolerant macroinvertebrates decrease as TSS values increase. In this section of the South Fork Crow River, the herbivore percentages were near average at each station except station 12UM050 where they were increased, but brassy minnows make up this metric and they are one of the species most tolerant to high TSS values. The most common fish collected were green sunfish, fathead minnows, and channel catfish. These fish all have a high tolerance to TSS disturbance. Fish tolerance indicator values indicate that TSS tolerant fish communities ranged from 30% (12UM041) to 42% (12UM070). Station 12UM033 had one TSS intolerant species. Perciforms (perch like fish) decrease as TSS increase. Perciform percentages were lowered at each station with the lowest at station 12UM033 (4.18).

The number of TSS intolerant macroinvertebrate taxa was zero at two stations and one at the other two stations. Macroinvertebrates tolerant to TSS were also elevated with percentages all over 80%. The percentage of long-lived individuals decrease as TSS values increase, the only station with a lowered value was station 12UM041 (1.59%).

While there are indicators of TSS stress to the biological communities, there is not a consistent response. TSS is inconclusive as a stressor.

Table 30. TSS related metrics

Station	TSS Intolerant Taxa	TSS Tolerant Taxa	Percentage TSS Tolerant Macroinvertebrate Individuals	Long-lived Macroinvertebrate Percent	Herbivore Percent	Perciform-Tolerant Percent
12UM033	0	15	87.5	7.69	0.29	4.18
12UM070	0	16	80.55	13.49	0.40	16.80
12UM050	1	19	81.35	6.37	2.81	22.25
12UM041	1	15	86.45	1.59	0.31	9.64
Averages for class 4 fish stations					**0.31**	**39.62**
Average for class 2 invert streams	**1.7**	**13.16**	**54.49**	**5.7**		
Expected response with increased TSS stress	↓	↑	↑	↓	↓	↓

Lack of habitat

Habitat availability is lacking in these South Fork Crow River tributaries. The MSHA scores taken during biological sampling were fair at all sampling sites. Lack of channel development, lack of riffles, and embeddedness of coarse substrates with fines were the main lacking factors. Each of the stations had excessive sedimentation and problematic bank erosion. Stations 12UM033, 12UM041, and 12UM050 had mid channel bars and an over widened channel, indicating a higher sediment load than the river can carry. This is related to both sites being incised, causing erosion of the banks (Figure 84). The DNR measured 0.601 feet of bank erosion between 2012 and 2013 and 2.34 feet between 2013 and 2014 (DNR 2015). Clean cobble and gravel presence have a positive relationship with a higher fish IBI. Depth measurements of fine substrates averaged 8.42 cm. While coarse substrate make suitable habitat, dumping rocks and debris does not contribute to habitat (Figure 85).

Figure 84. Bank erosion on the South Fork Crow River (August 8, 2014)

Figure 85. Dumped granite at 12UM041 (August 22, 2013)

The percentages of tolerant fish collected were lower in this section of the South Fork Crow River than upstream, ranging from 28.15 to 57.35%. The presence of fines and lack of riffles result in the lack of darter, sculpin and benthic insectivore percentages. Simple lithophilic spawners, darter and sculpin, riffle, and benthic insectivore percentages were all below average. The lowest values were at station 12UM033, the most upstream station and the highest were at station 12UM041, the most downstream station. The prevalence of fine sediments and embeddedness is affecting the fish community, but to a lesser extent than upstream sections. Lack of habitat is contributing to the biological impairment but not a main stressor.

Clingers need coarse substrates and decrease with the increase in percent fines. Even with the prevalence of fine sediments, the percentages of clingers were above average at all stations. Burrowers and sprawlers both use fine sediments as habitat, and are low in this section of the river. Station 12UM070 had slightly higher numbers than the other stations. Based on the percentages of present clingers, sprawlers, and burrowers even with the amount of fine sediment present, habitat is not a stressor.

Table 31. Habitat related metrics

Stations	SLithophilic Spawners Pct	DarterSculpin Pct	Tolerant Pct	Riffle Pct	Benthic Insectivore-Tol Pct	ClingerPct	SprawlerPct	BurrowerPct
12UM033	4.76	1.3	57.20	3.6	7.35	58.33	12.18	1.92
12UM070	16.2	8.4	42.6	8.2	14.80	55.92	25.66	3.95
12UM050	16.62	3.32	50.13	12.53	8.44	68.79	7.0	6.05
12UM041	20.37	4.35	28.15	16.02	18.04	82.43	4.47	0.96
Averages for fish class 4 stations	**38.56**	**12.88**	**15.01**	**16.5**	**27.81**			
Averages for invert class 2 stations						**41.91**	**17.92**	**9.45**
Expected response with habitat stress	↓	↓	↑	↓	↓	↓	↑	↑

Altered hydrology

The South Fork Crow mainstem is natural, however the majority of the tributaries have been channelized. Forty-two of the 81 subwatersheds within the catchment have had channel alteration (DNR 2015). Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency, increasing the impact of high flow events and increasing the intensity of low flow periods, both of which affect biological communities. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat. Channelization and tile drainage often causes flashy flows; high in the spring and during rain events and low or dry later in the summer. The DNR found measured erosion rates greater than estimated; likely due to changing hydrology. More frequent large precipitation events occurred in 2012, which magnifies the effects of altered hydrology. A geomorphology study by the DNR found a high width to depth ratio of the river near Mayer, reducing the depth and available habitat and areas of refuge.

Generalized fish species, which are adaptable to different habitats through generalized food preferences, are also correlated with channelization and flow changes. The average percentage for generalized fish in class 4 waters was 20.75% and sites ranged from 15.86-42.46.

Connectivity is another important aspect of hydrology. Fish migration is dependent on stream connectivity. A low head dam is located in Watertown. The dam seems to be having an impact on the presence of migratory fish. Silver redhorse and spottail shiners were only found downstream of the dam. Connectivity is a stressor on this section of the South Fork Crow River.

Common Name	12UM033	12UM070		12UM050	12UM041
blackside darter	X	X		X	X
shorthead redhorse	X	X		X	X
silver redhorse			Lowhead dam	X	X
spottail shiner					X
walleye	X	X		X	X
white sucker	X	X		X	X

AUID summary

The main stressors to the South Fork Crow River from Buffalo Creek to the North Fork Crow River are eutrophication and lack of connectivity, with lack of habitat a contributing stressor.

4.5. Judicial Ditch 28A

This section includes Buffalo Creek and its tributaries from the headwaters to where it meets Judicial Ditch 15. Impaired tributaries include the County Ditch 4 and 7A, Judicial Ditch 9 and 67, and an unnamed tributary to Buffalo Creek. The mainstem Buffalo Creek and the tributaries are discussed in two separate sections.

The entirety of the section is in the Western Corn Belt Plains ecoregion. Prior to settlement, the area was dominated by grasslands and wetlands. Land use was predominantly converted to cropland in the form of corn and soybeans (USDA 2013). Buffalo Creek and its tributaries have been sampled for both biology and chemistry (Figure 86).

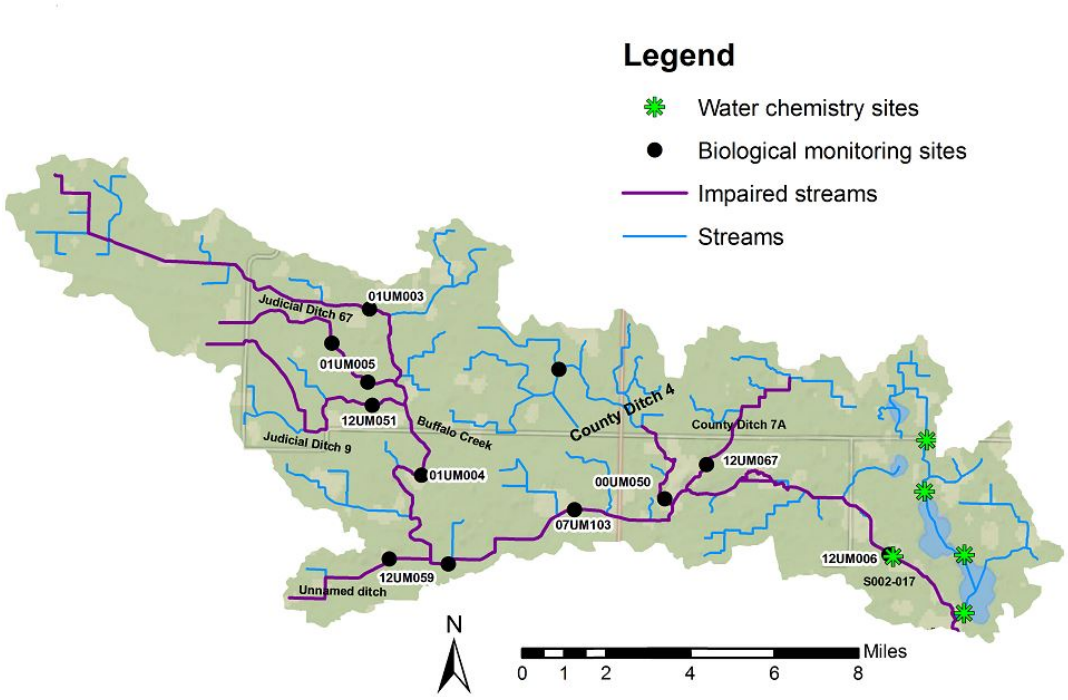

Figure 86. Sampling locations

4.5.1. Tributaries (-504,528,625,630 & -631)

- Judicial Ditch 67 -504 (01UM005)
- County Ditch 4 -528 (00UM050)
- Judicial Ditch 9 -625 (12UM051)
- Tributary to Buffalo Creek -630 (12UM059)
- County Ditch 7A -631 (12UM067)

Biological communities

Each FIBI score was well below the threshold of 42 with all stations in fish class 7 having a score lower than 14. There were a lack of sensitive, intolerant minnows, headwater species, and number of fish caught per meter species at all four stations in fish class 7 (Figure 87). The highest metric was the pioneer species metric at all stations except 01UM005. Station 01UM050 had a score of zero for all nine metrics. The most common fish collected were carp, brook stickleback, and fathead minnows, which are all tolerant species.

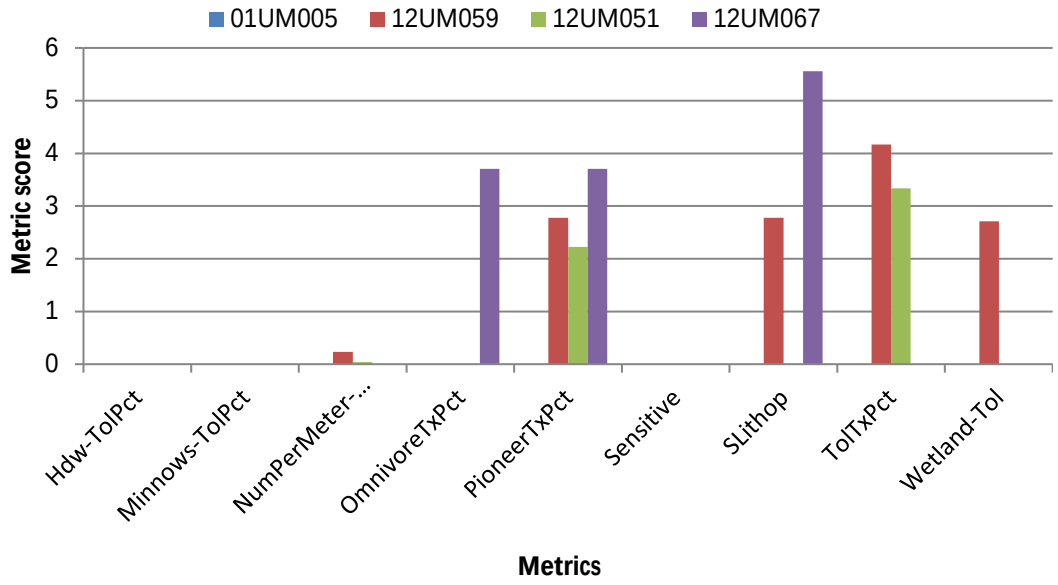

Figure 87. Metric scores in fish class

Station 00UM050 had the highest FIBI score with a visit in 2012 scoring 34 with a threshold of 42. There were a lack of sensitive, intolerant minnows, and headwater species at all three visits in fish class 6 (Figure 88). The two visits from 2012 scored higher than the 2000 visit. The most common fish collected were blacknose dace and central stonerollers, which are tolerant species.

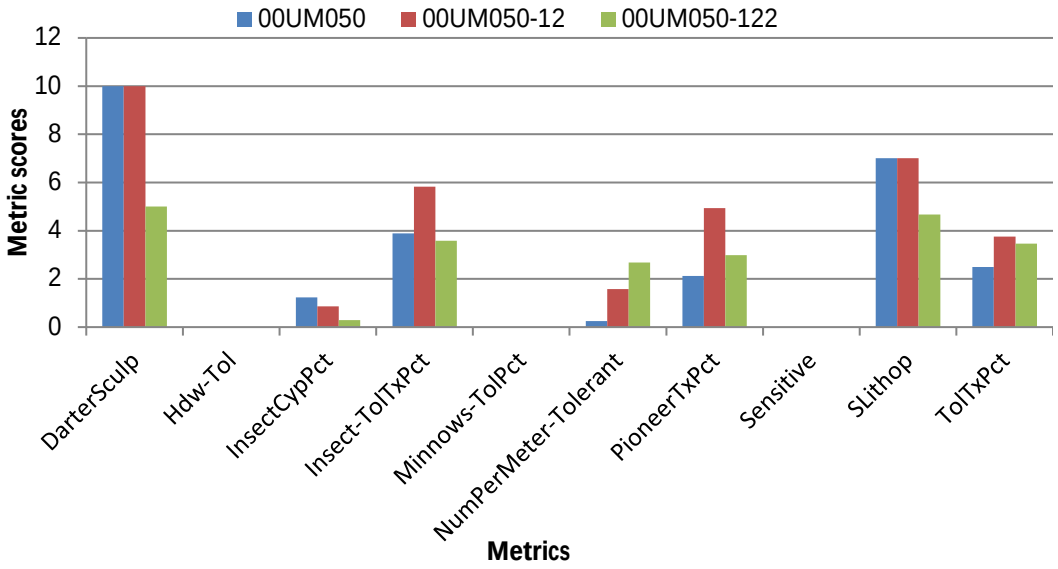

Figure 88. Metric scores in fish class

Station 00UM050 was in macroinvertebrate class 5 (Figure 89), while the other four stations were in class 7 (Figure 90). All stations scored below their respective threshold (36 for class 5 and 38 for class 7). Station 01UM005 had the lowest MIBI score (3.49). Each station in class 7 had a score of zero for intolerant individuals. The highest metric score possible was 10 for both classes. All scores were less than 4.5 at each station in class 7 and station 00UM050 had a high score of 6.6.

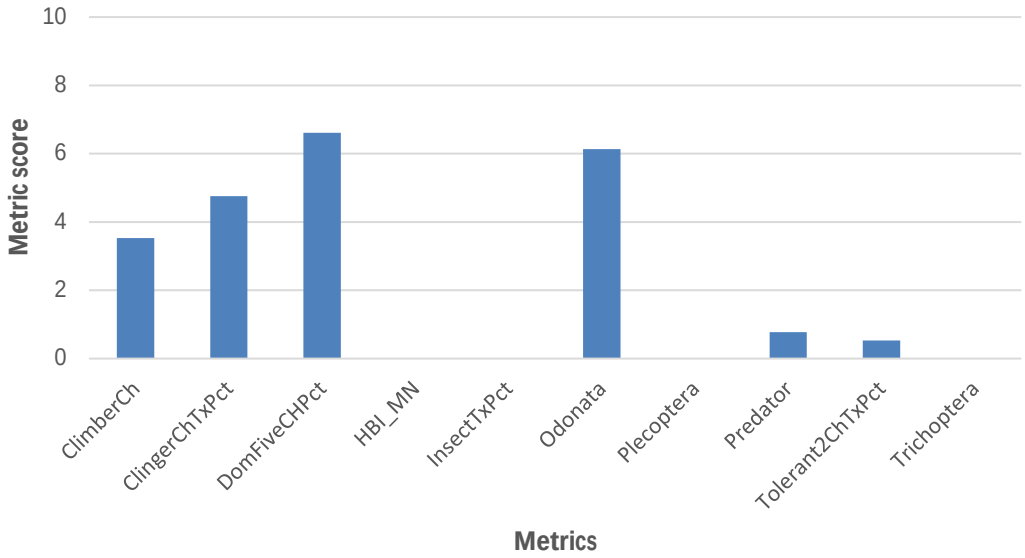

Figure 89. Metric scores at station 00UM050

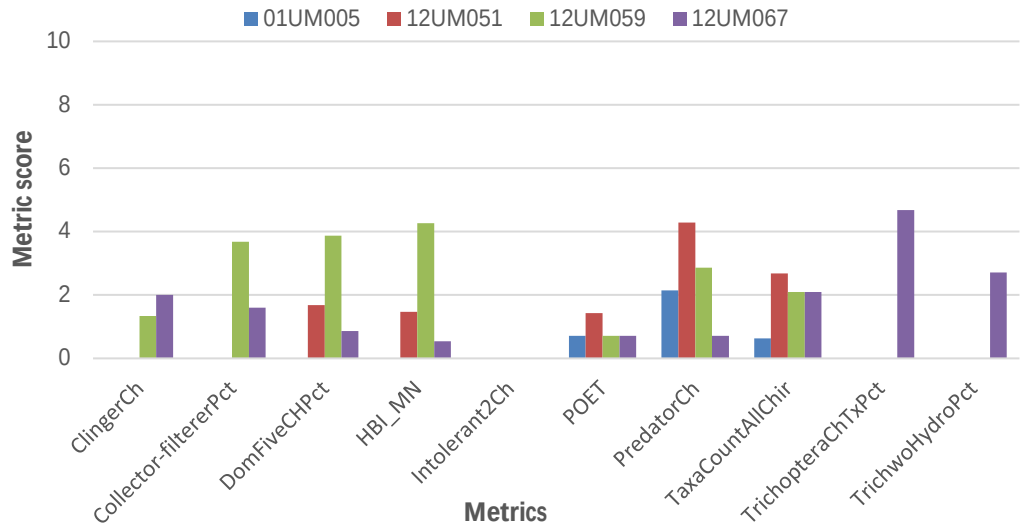

Figure 90. Metric scores for class 7

Phosphorus/Eutrophication

Phosphorus and eutrophication are closely tied. Biological communities are more directly affected by DO flux, chlorophyll-a, and BOD than phosphorus. The standard of phosphorus in the southern region is 0.150. Phosphorus values were taken during spring high flow events and during base flow conditions. Values ranged from 0.038 to 0.472 mg/L with the highest values at station S007-939 on Judicial Ditch 67 during base flow in July. Of the 18 samples taken in this HUC, 78% were above 0.150 mg/L. Elevated phosphorus can lead to excessive algae growth. Thick algae were present at all stations except 00UM050 (Figure 91, Figure 92, Figure 93).

Figure 91. Excess algae at station 12UM067 (July 16, 2014)

Figure 92. Algae at station 01UM005 (July 8, 2014)

Figure 93. Algae at station 12UM051

Continuous data was collected at stations 12UM051, 12UM059, 00UM050, and 12UM067. All sites had elevated DO flux; up to 15.32 at station 12UM051, 12.71 mg/L at station 12UM059, and 13.92 at station 00UM050 mg/L (Figure 94 and Figure 95). These values are all more than 2.5 times the southern standard of 4.5 mg/L. Low DO values were also found, which are discussed in the next section. Typical daily pH fluctuations are 0.2-0.3 (Heiskary et al., 2013). Continuous data showed pH flux up to 0.5 at stations 12UM067 and 00UM050 and 0.94 at station 12UM051.

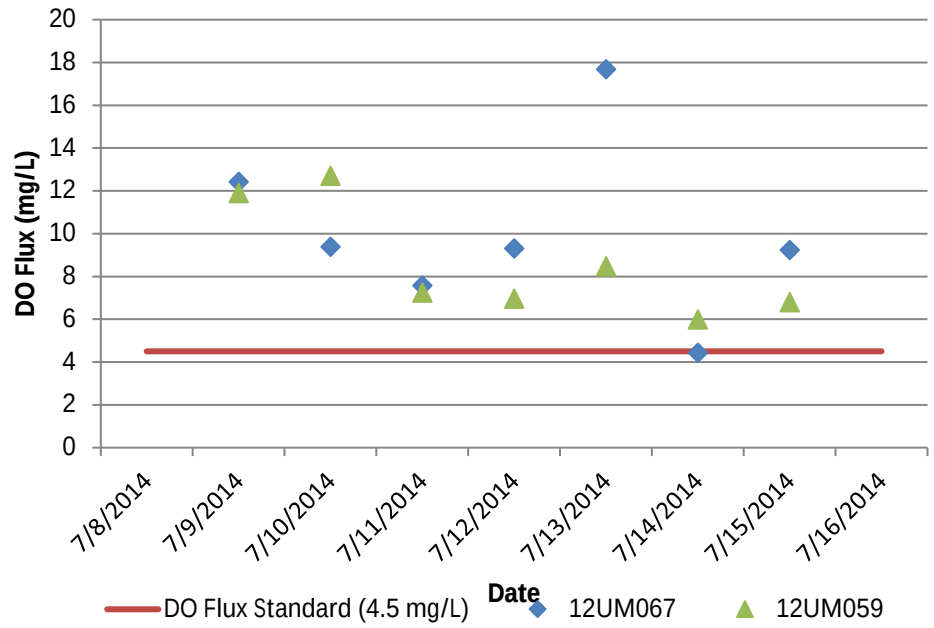

Figure 94. DO flux

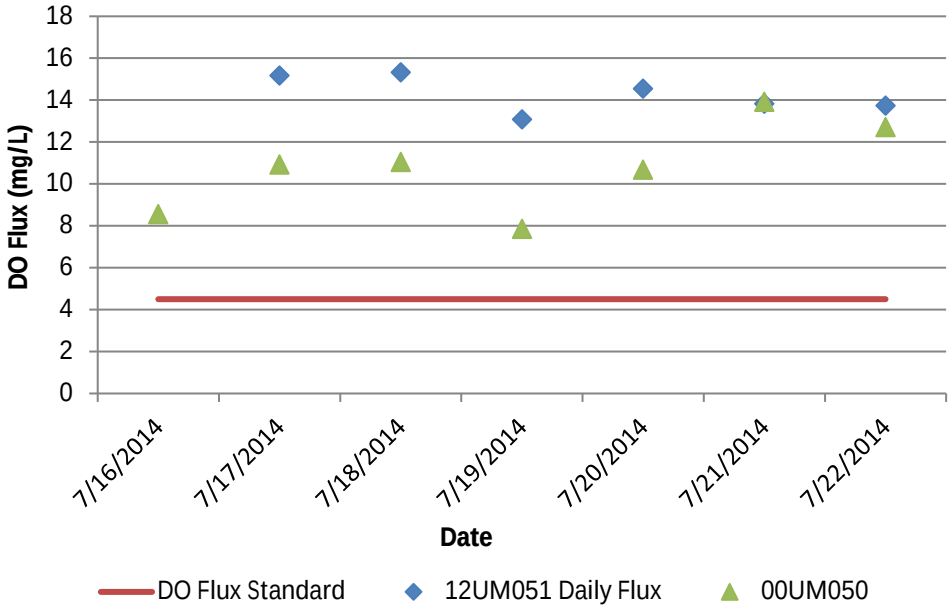

Figure 95. DO flux at station 12UM051

All tributaries had percentages of zero sensitive fish and were comprised of more than 85% tolerant fish species. Omnivorous fish have a positive relationship with nutrients, chlorophyll-a and DO flux. The stations in fish class 7 all had high percentages of omnivorous fish, with brook stickleback, carp, and fathead minnows the most common fish collected. While station 00UM050 had averages closer to the class 5 average, omnivore percentage increased from 1.55% in 2000 to a range of 13.13-19.91% in 2012. The percentage of EPT individuals is negatively related to eutrophication, while the abundance of the dominant two invert taxa is positively related to eutrophication. The EPT percentages were all low in the class 7 streams and much lower than average, while station 00UM050 was still below average but closer. The abundance of dominance of the macroinvertebrate community by two taxa ranged from 31.97% at station 00UM050 to 84.42% at station 01UM005.

Table 32. Phosphorus related metrics

Station	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct	Invert Taxa	EPT Pct	Dominant 2 Invert Taxa Pct
01UM005	0	0	100	45.45	21	0.312	84.42
12UM051	0	3.33	96.67	86.67	28	3.38	69.23
12UM059	0	1.23	92.59	38.27	26	2.57	36.66
12UM067	0	0	100	83.64	26	0.95	71.11
Average for fish class 7 streams	**8.16**	**5.21**	**70.59**	**22.40**			
00UM050 (7/10/2012)	0	5.5	93.61	19.91	34	27.59	31.97
00UM050 (8/8/2012)	0	9.7	85.25	13.13			
Average for fish class 6 streams	**15.13**	**6.34**	**66.59**	**16.87**			
Average for invert class 7 streams					**32**	**19.3**	**49.31**
Average for invert class 5 streams					**38**	**38.21**	**39.30**
Expected response to increased TP stress	↓	↓	↑	↑	↓	↓	↑

Based on the lack of sensitive fish, EPT individuals, and the presence of tolerant and omnivore fish, thick algal growth, high phosphorus concentrations and DO flux, eutrophication is determined to be a main stressor in this HUC. Station 00UM050 on County Ditch 4 had less of a response than the other streams.

Dissolved oxygen

There is a limited DO dataset on this HUC in recent years. Concentrations ranged from 1.64 at station 12UM059 in July to 16.3 mg/L at station S008-017 in June. Continuous data was collected at station S001-514 where the minimum DO was recorded daily as right around 5 mg/L. Continuous data was collected at stations 12UM051, 12UM059, 00UM050, and 12UM067 (Figure 96 and Figure 97). All stations had DO values at or below 5 mg/L, getting as low as 0.49 mg/L at station 12UM051, 2.76 mg/L at station 12UM059, and 3.32 mg/L at station 00UM050. Station 00UM050 had the lowest amount of days below 5 mg/L with two.

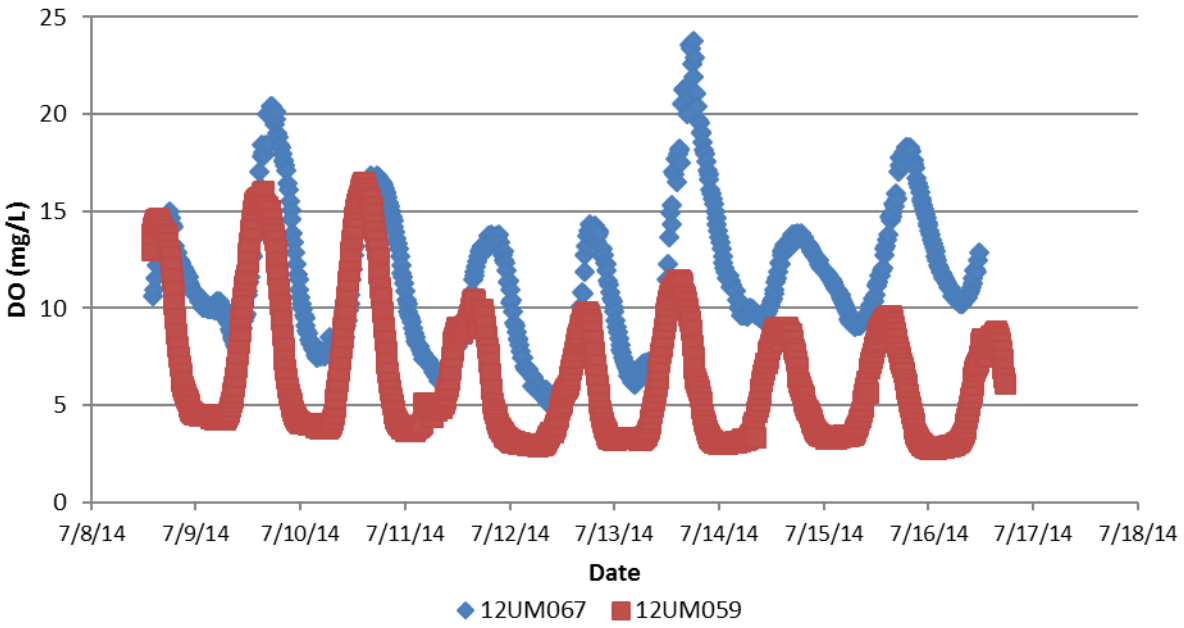

Figure 96. Continuous DO

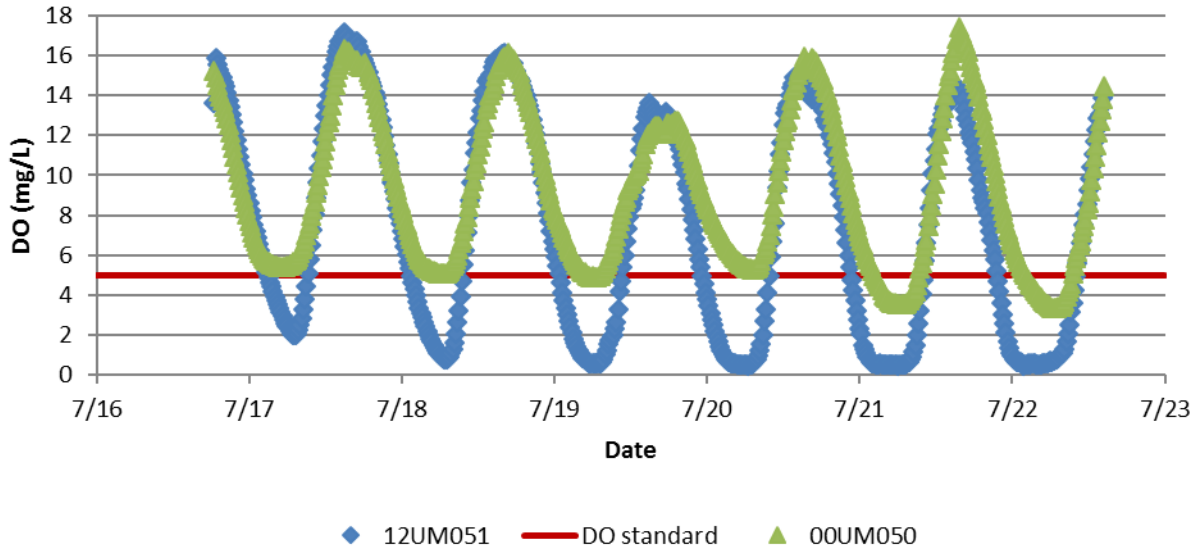

Figure 97. Continuous DO at station 12UM051

The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. Stations 01UM005, 12UM051, and 12UM067 did not have any fish that take three years or longer to mature, indicating that conditions are less amenable to longer lived fish. Low DO values also correspond with increased serial spawning fish percentage. The only station that had a high percentage was station 12UM067 with 83.27%. Fish that are tolerant to low DO made up 26% (00UM050) to 100% (01UM005) of the communities.

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed at each station. All stations had zero low DO intolerant taxa except station 00UM050, which had two taxa that are intolerant to low DO values. DO tolerant individuals range from 13.45 to 69.36% of the community.

The majority (greater than 90%) of the fish collected at the tributaries are comprised of low DO tolerant species except for station 00UM050. Station 00UM050 also experienced less of an impact on its macroinvertebrate community. The largest effects were seen at stations 01UM005 and 12UM051 which are located parallel to each other 0.5 miles apart. Low DO is a stressor to each tributary except for County Ditch (00UM050).

Table 33. Low DO related metrics

Station	MA>3 years Percentage	Serial Spawning Fish Percentage	HBI_MN	Percentage DO Tolerant Macroinvertebrate Pct	Intolerant Macroinvertebrate Taxa
01UM005	0	0	9.56	22.70	0
12UM059	6.17	7.41	7.57	67.5	0
12UM051	0	6.67	8.42	69.35	0
12UM067	0	83.27	8.71	13.45	0
Average for fish class 7 streams	**4.62**	**19.58**			
00UM050 (7-10-12)	0.59	17.83	8.34	15.31	2
00UM050 (8-7-12)	4.44	8.48			
Averages for fish class 6 stations	**2.99**	**15.44**			
Averages for invert class 7 stations			**8.07**	**30.30**	**1.88**
Average for invert class 5 streams			**7.45**	**10.45**	**6.91**
Expected response to stress	↓	↑	↑	↑	↓

Suspended sediment

TSS values in recent years ranged from 6.8 to 54 mg/L. None of the samples were above the central region standard of 65 mg/L. The highest values (50 and 54 mg/L) were at station 01UM005. The highest values were during July and September. Transparency tube values ranged from 10 cm to >100 cm. The transparency tube central region standard is 10 cm. All values on the tributaries were at or above the standard. The lowest value was located at 01UM005, also where the highest TSS value was collected.

A few paired organic solids (TSVS) and inorganic solids (TSS) samples were taken on these tributaries to Buffalo Creek. TSVS values range from 22% up to 43% of the suspended solid concentrations. On average, inorganic solids make up the majority of the suspended solids.

Herbivore fish and TSS intolerant macroinvertebrates decrease as TSS values increase. In the tributaries to Buffalo Creek, the herbivore percentages were below average at each station except at station 00UM050. Community populations had TSS tolerant percentages that ranged from 0% (12UM067) to 76% (12UM051). Perciforms (perch like fish) decrease as TSS increase. Perciform percentages were lowered except for at station 00UM050 (14.75).

The number of TSS intolerant macroinvertebrate taxa was zero at each station. However, macroinvertebrates tolerant to TSS were not elevated with percentages all under 38%. The percentage of long-lived individuals decrease as TSS values increase, each station in this area had a value lower than average. While there are indicators of TSS stress to the biological communities, there is not a consistent response or a large dataset. TSS is inconclusive as a stressor.

Table 34. TSS related metrics

Station	TSS Intolerant Taxa	TSS Tolerant Taxa	Percentage TSS Tolerant Macroinvertebrate Individuals	Long-lived Macroinvertebrate Percent	Herbivore Percent	Perciform-Tolerant Percent
01UM005	0	5	8.69	0	0	0
12UM051	0	10	12.07	0.31	0	3.33
12UM059	0	6	22.73	0.32	0	7.41
12UM067	0	4	1.25	0.63	1.12	0
Average for fish class 7 streams					**4.01**	**12.86**
00UM050 (7-10-12)					28.97	6.09
00UM050 (8-7-12)	0	6	37.18	3.76	19.6	14.75
Averages for fish class 6 stations					**5.67**	**10.08**
Averages for invert class 7 stations	**0.54**	**9.04**	**29.06**	**4.99**		
Average for invert class 5 streams	**1.42**	**9.96**	**37.27**	**6.37**		
Expected response to stress	↓	↑	↑	↓	↓	↓

Lack of habitat

Habitat availability is lacking in these South Fork Crow River tributaries. The MSHA scores taken during biological sampling were poor and fair at all sampling sites. Lack of depth variability, channel development and either lack of coarse substrates or embeddedness of coarse substrates were the main lacking factors. The stream channel of 12UM067 was comprised of choking vegetation and station 12UM051 had heavy filamentous algae.

Clean cobble and gravel presence have a positive relationship with a higher fish IBI. Measurements with a rod averaged 9.6 cm of fine substrate over embedded gravel at station 12UM051 with measurements up to 40 cm of silt on gravel at station 12UM059. In comparison, station 00UM050 had an average of 2.6 cm of fine sediments over cobble and gravel. A tributary to station 12UM067 exhibited sheet erosion (Figure 98) that is similar to other areas in the region contributing to fine sediments in the streams.

Figure 98. Field erosion on tributary to 12UM067 (July 8, 2014)

The percentages of tolerant fish collected were higher than 85% at all sites. Station 01UM005 had a substrate comprised of 100% silt and had no riffles. Simple lithophilic spawners, darter and sculpin, riffle, and benthic insectivore percentages were all zero at this station. All of these values were below average at the other stations except for station 00UM050. Station 00UM050 had the highest IBI (23 & 34) of the stations, due to the presence of blacknose dace, blackside darter, and white suckers. Blacknose dace and white suckers are both tolerant. The prevalence of fine sediments and embeddedness is affecting the fish community. Lack of habitat is a stressor to the fish community.

Table 35. Habitat related metrics

Station	SLithophilic Spawners Pct	DarterSculpin Pct	Tolerant Pct	Riffle Pct	Benthic Insectivore Pct
00UM050 (7-10-12)	22.44	5.5	93.61	29.42	5.79
00UM050 (8-8-12)	23.03	9.7	85.25	20.20	9.7
Average for fish class 6 streams	**21.68**	**7.75**	**66.56**	**11.87**	**9.72**
01UM005	0	0	100	0	0
12UM051	0	3.33	96.67	0	3.33
12UM059	3.70	1.23	92.59	3.7	1.23
12UM067	1.12	0	100	0.37	0
Average for fish class 7 streams	**14.90**	**5.41**	**70.64**	**8.41**	**6.54**
Expected response with habitat stress	↓	↓	↑	↓	↓

The number of clinger taxa decreases with the increase in percent fines. The percentages of clingers were low at every station. Station 12UM067 had no coarse substrates while stations 12UM059 and 12UM051 had coarse substrate but were severely embedded. This is reflected in the burrower percentages at stations 12UM051 and 12UM059 since burrowers live inside fine sediments (Figure 99). The only station to have enough rock habitat to sample was at station 00UM050 (Figure 100). All other samples were collected on overhanging vegetation and aquatic macrophytes. Climbers live on aquatic plants and debris, and are highest at stations 12UM051 and 12UM067 which both had excessive vegetation or algae. A lack of habitat is a stressor to these tributaries.

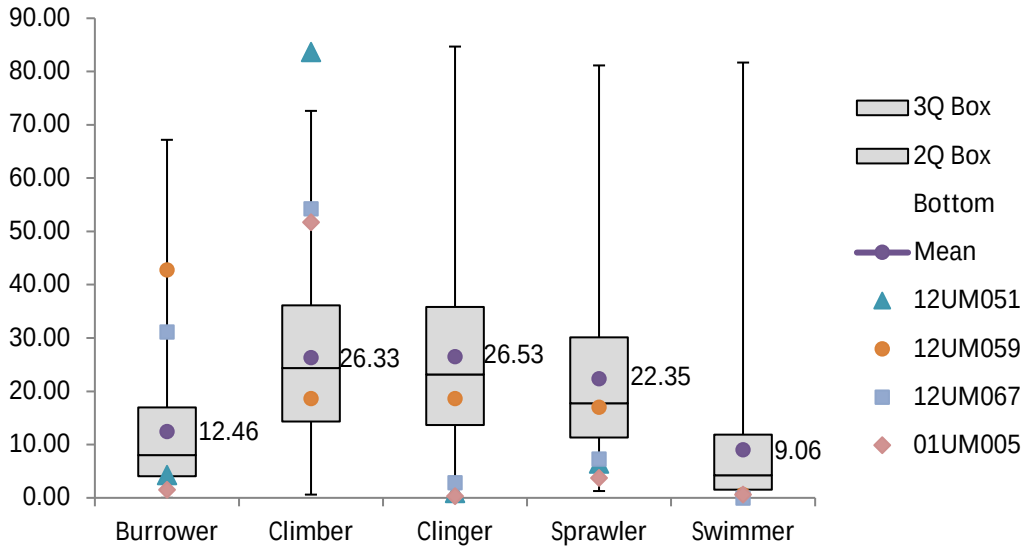

Figure 99. Habitat metrics in class 7

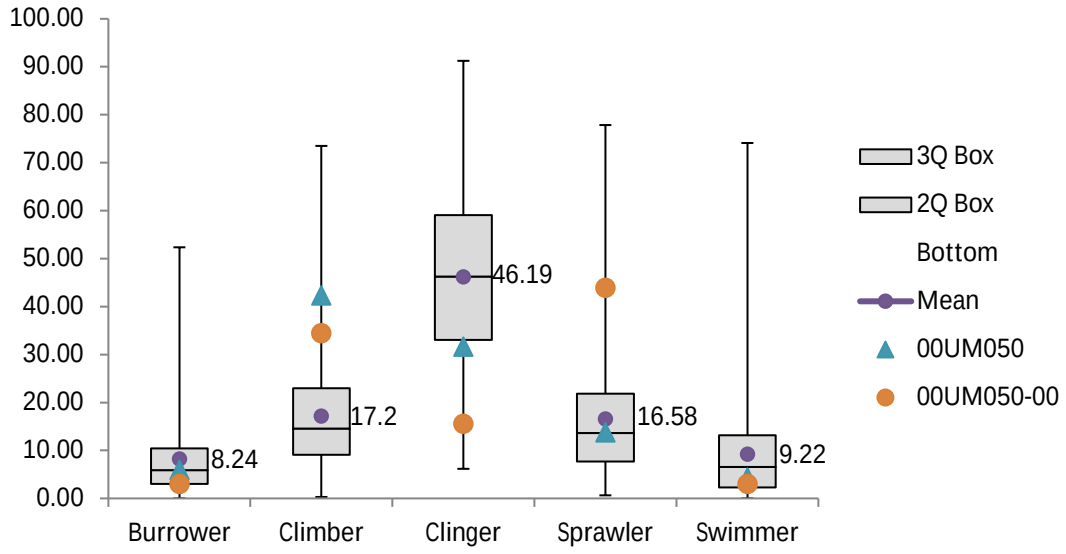

Figure 100. Habitat metrics for visits in class 5

Altered hydrology

The tributaries to Buffalo Creek in this HUC are all completely channelized. Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency, increasing the impact of high flow events and increasing the intensity of low flow periods, both of which affect biological communities. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat. Tile networks can be large (Figure 101), and affect streams in other ways such as opening up soil to wind erosion that settles in streams (Figure 102).

Figure 101. Newly dug tile lines (March 31, 2014)

Figure 102. Soil erosion covering frozen stream (March 31, 2014)

Benthic insectivore and simple lithophilic species can decrease with channelization as bedload increases. Generalized fish species, which are adaptable to different habitats through generalized food preferences, are also correlated with channelization. The average percentage for generalized fish in class 7 waters was 36.44%. All sites were in fish class 7 except 00UM050, and had a general percentage range of 43.21% at station 12UM059 to 88.48% at station 12UM067. This corresponds with the simple lithophilic spawner percentages of 0 to 3.70% and 0 to 3.33% of benthic insectivores discussed in the habitat section. The average simple lithophilic spawner percentage for class 7 was 14.92% and benthic insectivores were 6.55%. Station 00UM050 was in class 7 and during the two 2012 visits, there were 23.03 and 22.44% simple lithophilic spawners and 9.70 and 5.79% benthic insectivores. The average for class 7 streams was 9.71% for benthic insectivores and 21.65% simple lithophilic spawners. The percentage of general individuals was 62.53 and 61.81. The average for class 7 was 36.44%.

Channelization is connected to and contributing to the lack of habitat at stations 01UM005, 12UM051, 12UM059, and 12UM067. The effects of altered hydrology seem to be contributing to the increase of generalized fish percentages, which are more adaptable to changing conditions and food sources. Other contributing factors are likely affecting the high percentage of general fish species. Altered hydrology is a contributing stressor to lack of habitat.

Ionic strength

Specific conductance values ranged from 369 to 1486 with 41% of 22 measurements over 1000 us/cm. Specific conductance values in the watershed are highest on Judicial Ditch 67 which is a tributary to Buffalo Creek. The highest specific conductance concentrations were recorded in June and July in 2001 (1486 uS/cm) and 2014 (1421 uS/cm). The ecoregion norm for the Western Corn Belt Plain (based on the 75th percentile of annual specific conductance values) is 820 (McCollor et. al, 1993). Station 12UM059 which was recorded at 1050 uS/cm was downstream of the Toren gravel and dewatering pit. Only four chloride values are available in the area, ranging from 9.39 to 27.3 mg/L.

Increased ionic strength can cause an increase in ion tolerant taxa and an increase in ion tolerant life stages, causing fish and invert impairments, but it is difficult to separate this effect from other stressors. As salinity increases, macroinvertebrate taxa richness and Ephemeroptera has been found to decrease (Piscart et al., 2005). Echols et. al (2009) also found a reduction in EPT abundance as conductivity values increased. A study of Minnesota biological data and stressor linkages found that sites with conductivities higher than 1,000 µS/cm rarely meet the biological thresholds for general use streams (MBI, 2012). Stations 00UM050, 01UM005, and 12UM059 have all had recorded values of specific conductance of 1,000 µS/cm, all of which failed to meet the threshold. The station with the highest taxa count and EPT% (00UM050) also had the lowest specific conductance (597 µS/cm). Increases in conductivity can result similarly in decreases in mayflies (Ephemeroptera). Station 00UM050 also had the highest percentage of mayflies (12.9%), while the other sites were all less than 3%.

Taxa count also is related to other stressors, so ionic strength could be contributing to this decline along with other stressors. Salts are one of the main agents used in pesticides and herbicides, which could be contributing to elevated values. The macroinvertebrate taxa richness and EPT% could also be affected by the elevated nutrient levels and high DO fluxes. The high concentration of ions as measured by specific conductance, is inconclusive as a stressor to the macroinvertebrate communities.

Nitrogen

Nitrogen values range from 0.05 mg/L to 21 mg/L. The highest nitrogen value (21 mg/L) was taken at all of the following stations; 01UM006, 00UM050, 12UM051, and 12UM067. Values at station 00UM050 ranged from 7.2 mg/L during base flow up to 15 mg/L during spring runoff. Station 01UM005 ranged from 1.6 mg/L in the fall, 12 mg/L during base flow, and 20 mg/L during spring runoff.

Station 00UM050 had a population of 57.4% of nitrogen tolerant macroinvertebrate individuals during sampling in 2000 and increased to 80.9% during the 2012 sample. The intolerant taxa also disappeared between 2000 and 2012. A community of macroinvertebrates with a percentage of nitrate tolerant individuals greater than 78% has only a 25% chance of meeting the MIBI. Nitrate tolerant individuals comprised of 75% (12UM059) to 100% (01UM005) of the fish communities.

Based on the nitrate tolerant species at stations 00UM050 (69% very tolerant) and 12UM067 (75% very tolerant) and the decreasing trend at station 00UM050 of both Tricoptera percentage and nitrogen TIVs, nitrogen is a stressor to these two streams.

Table 36. Nitrogen related metrics

Stations	Nitrogen Tolerant Pct	Nitrogen Intolerant Invert Taxa	TricopterawoHydro Pct	Taxa Count
00UM050 (2000)	57.4	1	9.8	30
00UM050 (2012)	80.77	0	2.5	34
01UM005	76.5	0	0	21
12UM051	27.6	1	0	28
12UM059	29.8	0	0	26
12UM067	77.9	0	0.9	26
Expected response to increased nitrate stress	↑	↓	↓	↓
Average for invert class 7 streams	**60.72**	**1.06**	**1.5**	**32.3**
Average for invert class 5 streams	**56.9**	**2.4**	**3.7**	**38.3**

AUID summary

The main stressors of the tributaries to Buffalo Creek from the headwaters to Judicial Ditch 15 were eutrophication, lack of habitat, altered hydrology, nitrogen, and ionic strength. County Ditch 4 (station 00UM050) differed from the other streams where the stressors were limited to altered hydrology, nitrogen, and ionic strength.

4.5.2. Buffalo Creek (07010205-502)

Buffalo Creek from headwaters to Judicial Ditch 15 has four biological monitoring stations located within the AUID. Each station was sampled for both fish and macroinvertebrates. As stated in the Monitoring and Assessment Report there was an increasing trend of IBI from upstream to downstream (MPCA 2016).

Biological communities

Four stations on this reach have been sampled for fish during six visits. Stations 01UM003 and 01UM004 were in the fish stream class 7 (threshold 42) with scores ranging from 14 to 31. Both stations had sensitive, intolerant minnow, and intolerant headwater metric scores of zero (Figure 103). The simple lithophilic metric score at station 01UM003 was zero while this was the highest score during both visits to station 01UM004. The most common fish collected were carp and fathead minnows at station 01UM003, and creek chubs and johnny darters at station 01UM004.

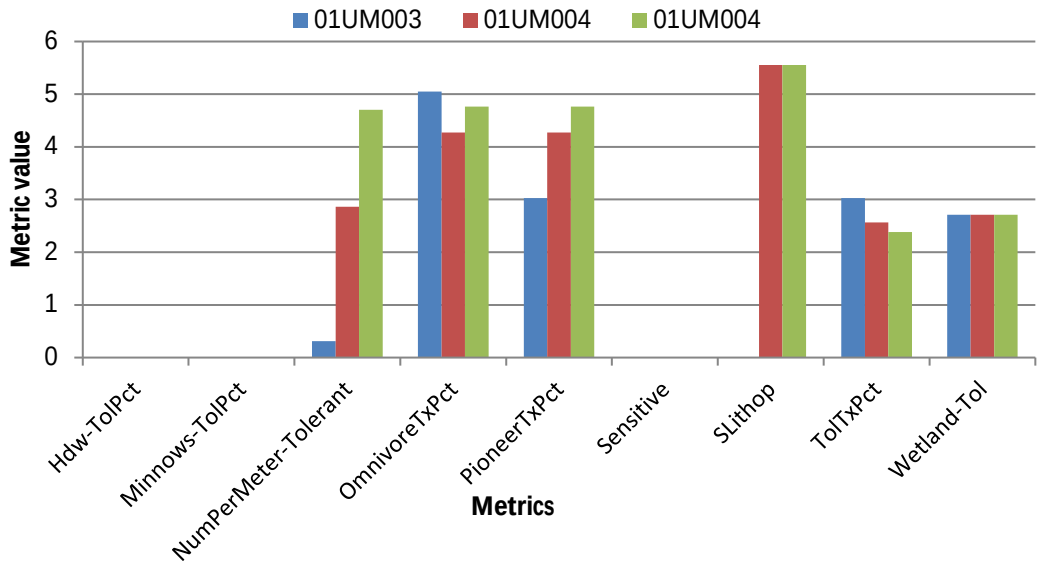

Figure 103. Metric scores for fish class 7

Stations 07UM103 and 12UM006 were in fish class 5 (threshold 47) with FIBI scores ranging from 15 to 30. Both the high and low IBI scores for this fish class were at station 07UM103, where the IBI score decreased from 30 in 2007 to 15 in 2012. Both stations had scores of zero for the insectivore, intolerant, and sensitive metrics (Figure 104). Fish that mature at greater than three years of age were also low at all three visits. The most common fish collected were creek chubs, bigmouth shiners, black bullheads, and sand shiners. The biological sampling crew noted numerous dead fish at station 07UM103; suckers, shiners, sunfish, carp, and minnows as well as crayfish.

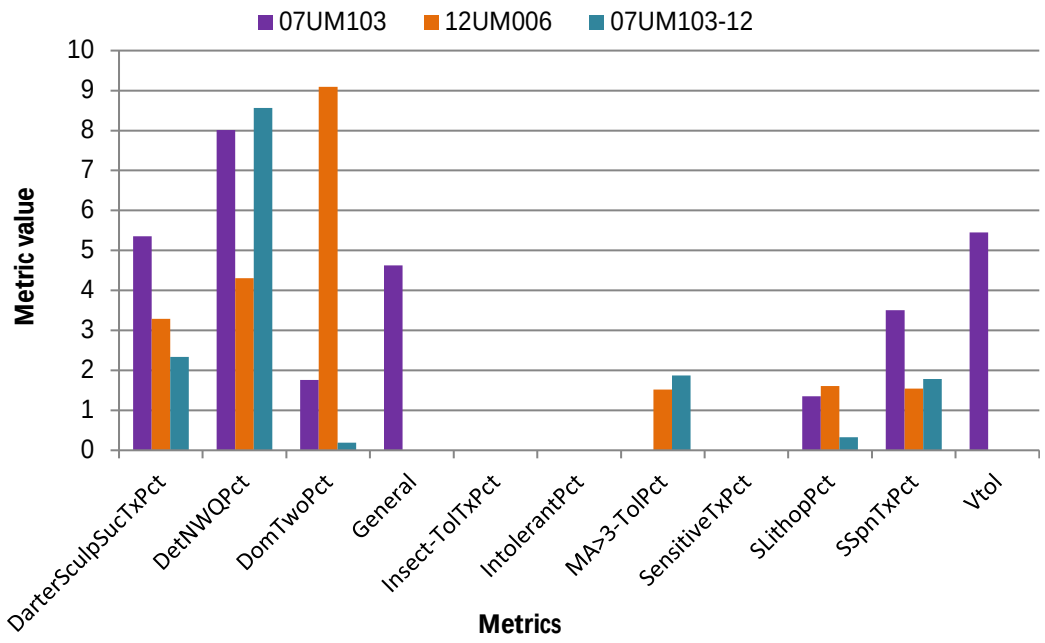

Figure 104. Metric scores in class 5

Three stations were in macroinvertebrate class 7, and one station in class 5. All stations in class 7 were well below the threshold (38), while station 12UM006 in class 5 was just below the threshold of 36 with a score of 31. The highest score at station 12UM006 was the clinger taxa percent metric at 7.7 (Figure 105). The intolerant and collector-filterer metric scores were uniformly low in macroinvertebrate class 5. The highest scoring metric in class 7 was 4.8 at station 07UM103 (Figure 106).

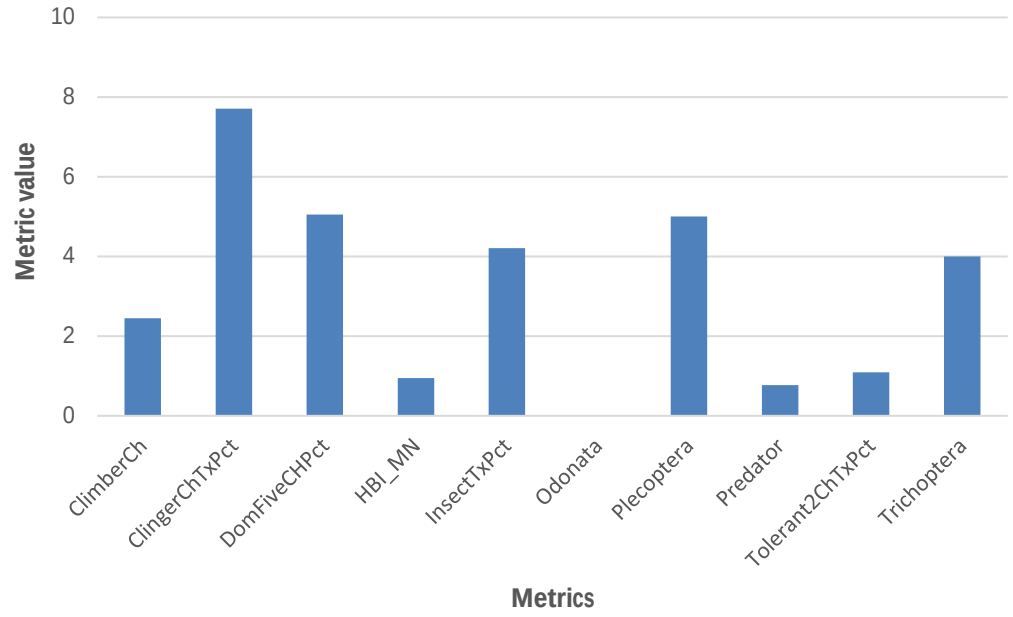

Figure 105. Metrics at station 12UM006

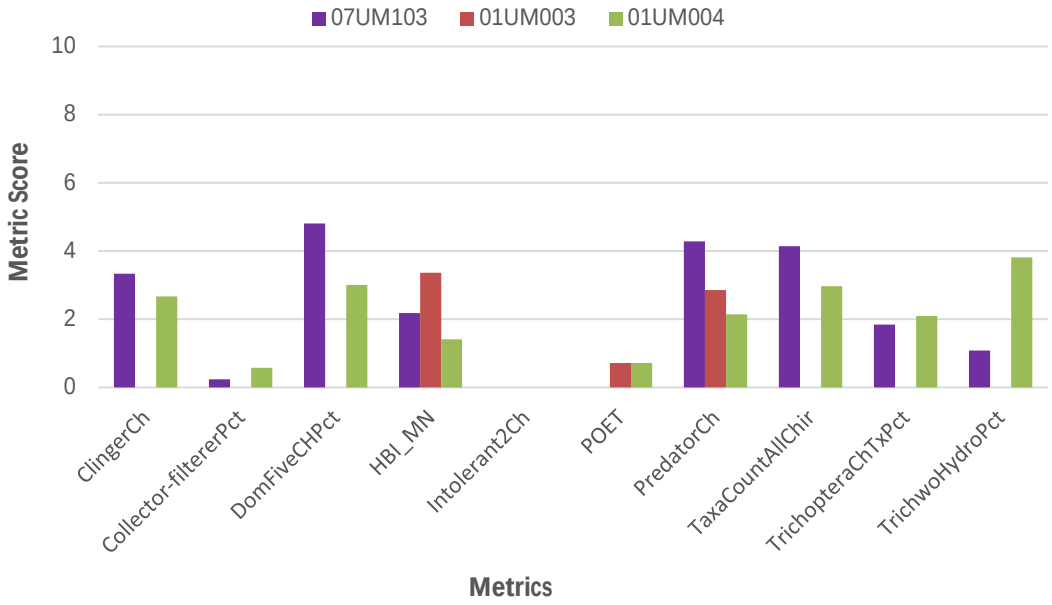

Figure 106. Metric values in class 7

Phosphorus/Eutrophication

Phosphorus and eutrophication are closely tied. Biological communities are more directly affected by DO flux, chlorophyll-a, and BOD than phosphorus. Phosphorus from recent years was analyzed by month (Figure 107). These data include all sampling locations on the impaired reach. 27% of the samples were above the southern standard of 0.150 mg/L. Elevated values were recorded both after rain events and during base flow. Values ranged from 0.03 mg/L to 0.903 mg/L with concentrations on average highest during March and June. Values were highest at station S002-017. Samples were taken from two tile drains at station 01UM004. Phosphorus values for the tile drains in March were 0.504 and 0.522 mg/L.

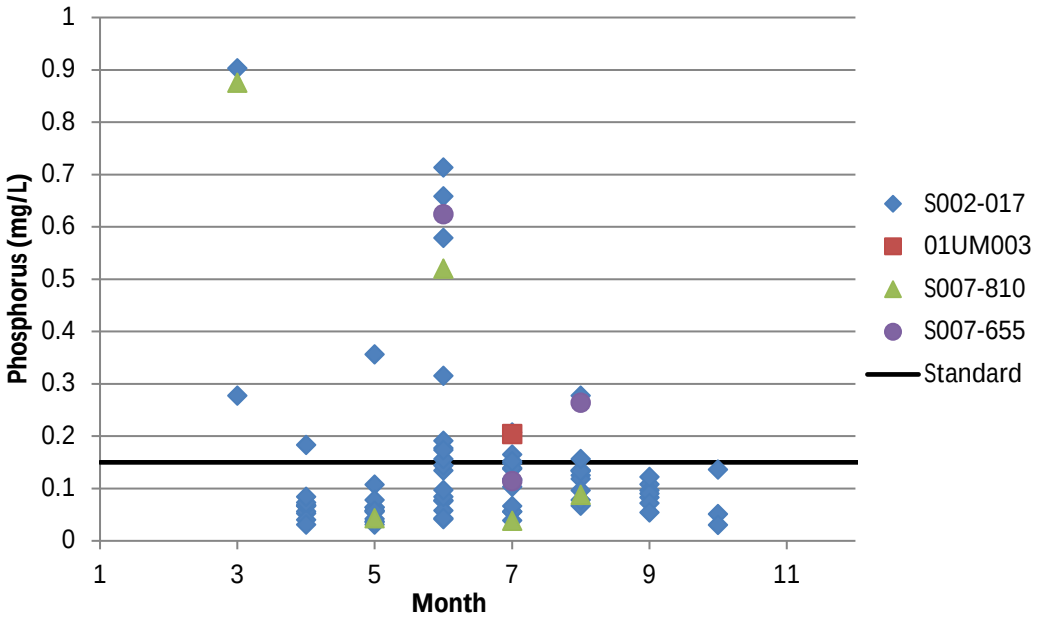

Figure 107. Phosphorus values by month

Orthophosphorus is the form of phosphorus that is readily available for plant and algal uptake, and can influence excess algae growth (Figure 108). The average percentage of orthophosphorus compared to phosphorus concentrations at station S002-017 averaged 51%, and was highest in 2010 at 89%. Eutrophication drives elevated pH values. The standard for pH in surface waters is a range of 6.5-8.5. Values over 8.5 and large daily pH fluctuations can be tied to nutrient enrichment. pH values at station 12UM006 ranged up to 8.66.

Figure 108. Algae at station 12UM006 on July 19, 2013

Continuous DO data were collected along Buffalo Creek from July 19 to August 2, 2013. Values ranged from 5.51 to 17.49 mg/L at station S002-017 where daily fluxes were consistently above the proposed south regional standard of 4.5 mg/L (Figure 109). DO flux values between 2.0 to 4.0 are typical in a 24-hour period (Heiskary et al. 2010). Daily DO fluctuations are a measure of stress on the aquatic community. Algal respiration and photosynthesis are considered the primary drivers of daily flux in DO, and high daily fluctuations of DO are connected to nutrient concentrations. The elevated phosphorus values are fueling photosynthesis and algal respiration, which in turn are effecting the daily oxygen production and oxygen demand, as seen by fluctuations as high as 11.39 mg/L in a single day. Of 62 BOD values, 11% were above the southern standard of 3 mg/L with values ranging from <0.5 to 14. Of 35 chlorophyll-a values, only one was above the southern standard of 35 ug/L with a value of 114 ug/L.

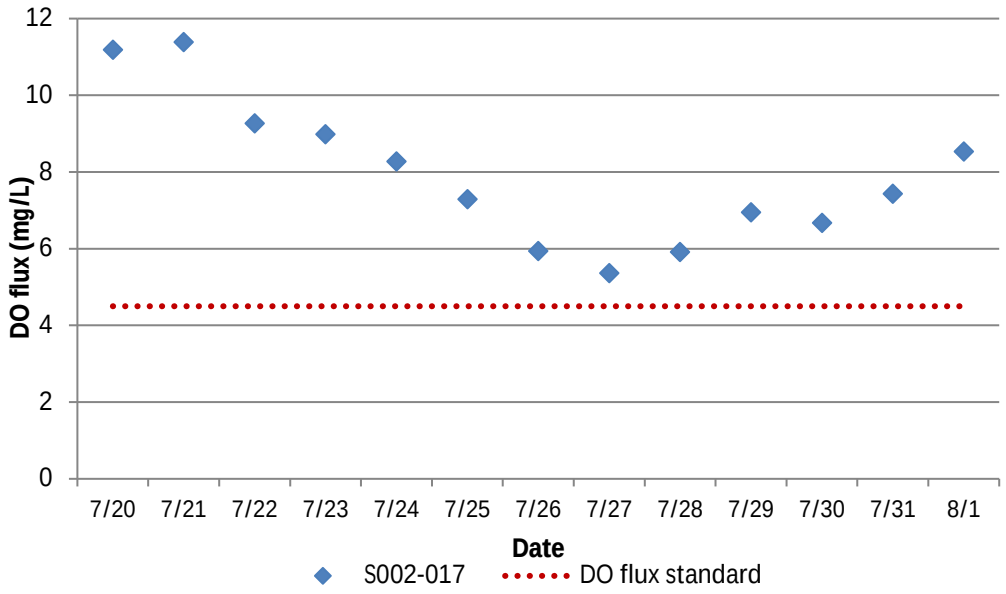

Figure 109. Continuous DO data at station S002-017

Increased phosphorus levels have an inverse relationship with sensitive individual fish percentages and an increase in tolerant percentages of fish. Sensitive individual fish percentages were zero during all visits on this section of Buffalo Creek. Tolerant fish percentage ranged from 73.51 to 95.51%, averaging 84.52%. These percentages were above average for each of the fish classes. Darter percentages are also inversely correlated with phosphorus. Darter percentages ranged from 0.56% to 25.82%, averaging 12.04%. The lowest values were at stations 01UM003 and 07UM103 in 2012. There was a decrease in darters at station 07UM103, from 132 johnny darters in 2007 to 2 johnny darters in 2012. Johnny darters were the only darter collected at station 01UM004, but they made up a larger percentage of the collection. Increases in phosphorus correspond with increases in omnivore individuals. Based on increased omnivorous and tolerant fish, and lowered sensitive percentages, eutrophication is a stressor to the fish community.

Effects of phosphorus are also seen through a decrease in macroinvertebrate taxa, and an increase in tolerant percentage. The number of macroinvertebrate taxa ranged from 18 to 35. Station 01UM003 was sampled in 2001 and 38 taxa were collected while in 2012, only 18 taxa were collected. Station 01UM004 was also sampled during both years but the number of taxa increased; 24 in 2001 and 29 in 2012. The percent tolerant macroinvertebrate individuals ranged from 69.63% to 99.38%. Station 01UM003 had the highest number of tolerant individual macroinvertebrates. Values ranged from 5.39% to 84.83%. Station 07UM103 increased from 5.39% in 2007 to 75% in 2012. EPT percentages have a negative relationship with increases in phosphorus. Values in this reach are healthy except at station 07UM103 (1.22%). The abundance of the two dominant macroinvertebrate species comprised at least 30% of each of the macroinvertebrate communities. Dominant taxa ranged from 30.67 to 91.08, all values are at or above average. Macroinvertebrate taxa were elevated in the headwaters of Buffalo Creek. The two headwater sites also had the highest dominant two species percent, which makes sense with a lower taxa count. The dominant two species at station 01UM004 were both non-biting midges; in 2001 mayflies dominated the sample. Station 01UM003 was dominated by amphipods and mayflies (leading to the high EPT percentage). Based on the mixed results, eutrophication is inconclusive to the macroinvertebrate community.

Table 37. Phosphorus related metrics

Station	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct	Invert Taxa	EPT Pct	Dominant 2 Invert Taxa Pct
01UM003	0	0.56	95.51	84.83	18	29.54	91.08
Average for fish class 7 streams	**8.16**	**5.21**	**70.59**	**22.40**			
01UM004 (7-9-12)	0	14.56	82.58	37.5	29	15.36	52.66
01UM004 (8-8-12)	0	23.84	73.51	19.21			
Average for fish class 6 streams	**15.13**	**6.34**	**66.59**	**16.87**			
07UM103 (2007)	0	10.02	87.56	5.39			
07UM103 (2012)	0	1.56	86.72	75	33	1.22	43.73
12UM006	0	7.89	84.21	14.47	35	25.46	30.67
Average for fish class 5 streams	**22.31**	**13.48**	**36.11**	**14.23**			
Average for invert class 7 streams					**32**	**19.37**	**49.31**
Average for invert class 5 streams					**38**	**38.21**	**30.67**
Expected response to increased TP stress	↓	↓	↑	↑	↓	↓	↑

Dissolved oxygen

In recent years concentrations ranged from 3.68 to 20.7 mg/L along this reach of Buffalo Creek. There is a sizeable DO dataset. Three values below 5 mg/L were taken at station 12UM006. Continuous data was collected at station 12UM006 where the DO was recorded as greater than 6 mg/L each day during deployment (Figure 110). Elevated supersaturated DO values and wide fluctuations in one day are stressful to aquatic communities. This stress results in a shift from functional assemblages of aquatic communities to tolerant or generalist species (Heiskary et al. 2013).

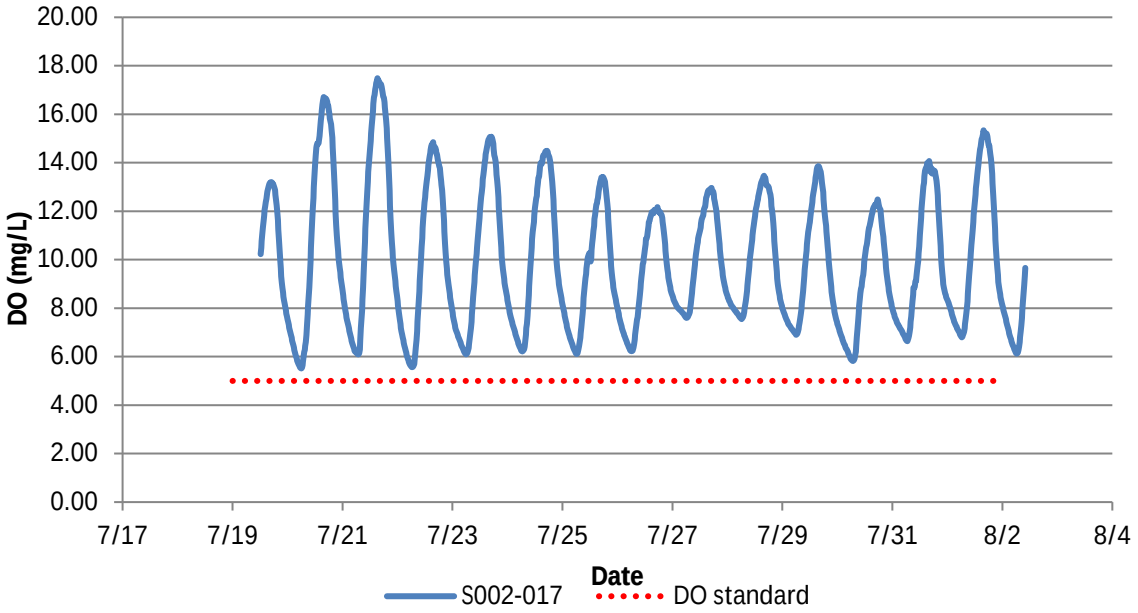

Figure 110. Continuous DO at station S002-017

The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. Each value was below average. Values ranged from 0 to 7.03%; both at station 07UM103 but in different years (2007 and 2012). Stations are close to average in the headwaters, but are lower than average at the two class 5 stations. Low DO values also correspond with increased serial spawning fish percentage. Values ranged from 13.25 to 46.93%.

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed at both stations. Stations had a range of zero to three low DO intolerant taxa. DO tolerant individuals percentages had a range of 21.59 to 66.77%. While supersaturated DO conditions are harmful to fish, there is not a consistent effect on the biological communities, making DO an inconclusive stressor.

Table 38. Low DO related metrics

Station	MA>3 years Percentage	Serial Spawning Fish Percentage	HBI_MN	Percentage DO Tolerant Macroinvertebrate Pct	Intolerant Macroinvertebrate Taxa
01UM003	3.93	30.34	7.85	66.77	1
Averages for fish class 7 stations	**4.62**	**19.58**			
01UM004 (7/9/2012)	2.86	30.07	8.44	42.86	1
01UM004 (8/8/2012)	2.65	13.25			
Averages for fish class 6 stations	**2.99**	**15.44**			
07UM103 (2007)	0	15.17			
07UM103 (2012)	7.03	11.72	8.21	47.68	0
Averages for class 7 invert stations			**8.07**	**30.30**	**1.98**
12UM006	5.70	46.93	8.02	21.59	3
Averages for class 5 fish stations	**13.46**	**19.03**			
Averages for class 5 invert stations			**7.45**	**10.45**	**6.91**
Expected response with DO stress	↓	↑	↑	↑	↓

Nitrogen

Nitrate concentrations are high along this section of Buffalo Creek. Nitrate concentrations in recent years were analyzed by month (Figure 111); these data include all sampling locations in the impaired reach. Some locations have much higher concentrations than others, leading to a range of values between <0.05 and 24 mg/L. The highest nitrate values were collected in May and June. Nitrate values were highest at station S002-017, but this is also where the majority of samples were taken. A tile drain sample was taken at station S002-017 with a value of 14 mg/L. Samples were also taken from two tile drains at station 01UM004. Nitrate values in March were 0.62 and 1.8 mg/L, and 20 mg/L in June.

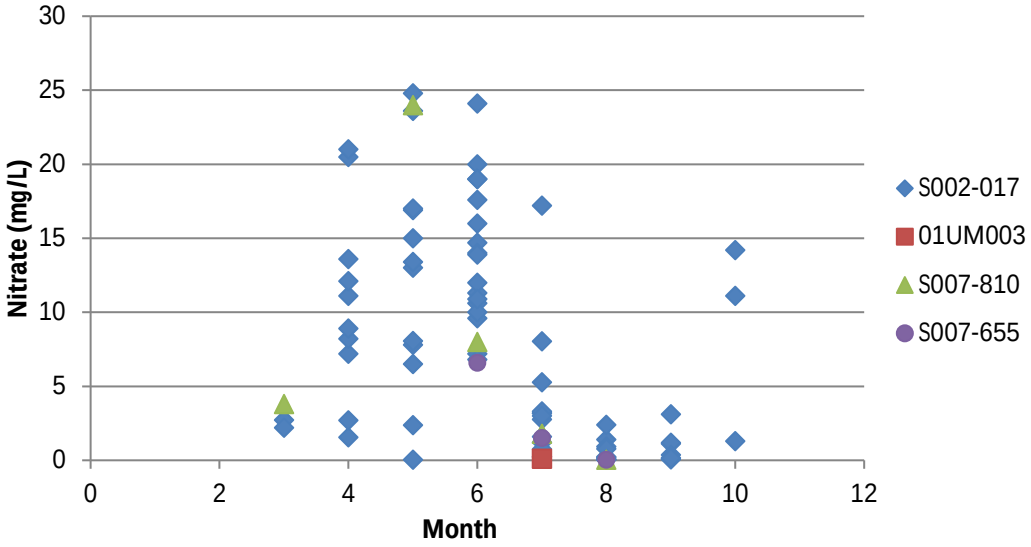

Figure 111. Phosphorus values by month

Sensitive species have a negative relationship with nitrate, but sensitive species are also affected by DO and phosphorus. Better relationships have been made with respect to macroinvertebrate impairment and nitrate concentration. Nitrate intolerant macroinvertebrate taxa range from 0 to 1 and averaged 0.25.

Nitrate tolerant individuals comprised of 68% (12UM006) to 89% (01UM003) of the fish communities. Nitrate intolerant taxa was 0 at all stations. Nitrate tolerant macroinvertebrate individuals ranged from 31.06% (01UM003) to 82.97% (01UM004) tolerant nitrate individuals.

Increasing nitrate concentrations also have a negative relationship with non-hydropsychid Trichoptera (caddisfly) individual percentages. Non-hydropsychid Trichoptera are all caddisflies that do not spin nets. Values range from 0 to 4.29%. Based on the preponderance of evidence with elevated nitrogen tolerant percentages, and decreased Tricoptera and nitrate intolerant taxa, nitrate is a stressor to Buffalo Creek.

Table 39. Nitrate related metrics

Station	Nitrate Station Index Score	Nitrate Intolerant Taxa	Nitrate Tolerant Taxa	Percentage Nitrate Tolerant Macroinvertebrate Individuals	Non-hydropsychid Trichoptera %
01UM003	1.79	0	4	31.06	0
01UM004	3.33	1	7	82.97	1.57
07UM103	2.69	0	13	65.74	0.31
Averages for class 7 stations	**3.02**	**1.06**	**14.26**	**60.72**	**1.49**
12UM006	3.39	0	19	79.50	4.29
Averages for class 5 stations	**3.10**	**1.41**	**18.60**	**63.97**	**3.77**
Expected response with increased TSS stress		↓	↑	↑	↓

Suspended sediments

TSS values in recent years were analyzed by month (Figure 112). 5% of samples were above the proposed standard of 65 mg/L with values ranging from 1 to 321 mg/L. Most elevated values occurred after rain events. Values were highest in June. Values were highest at station S002-017, but this is also where the majority of samples were taken.

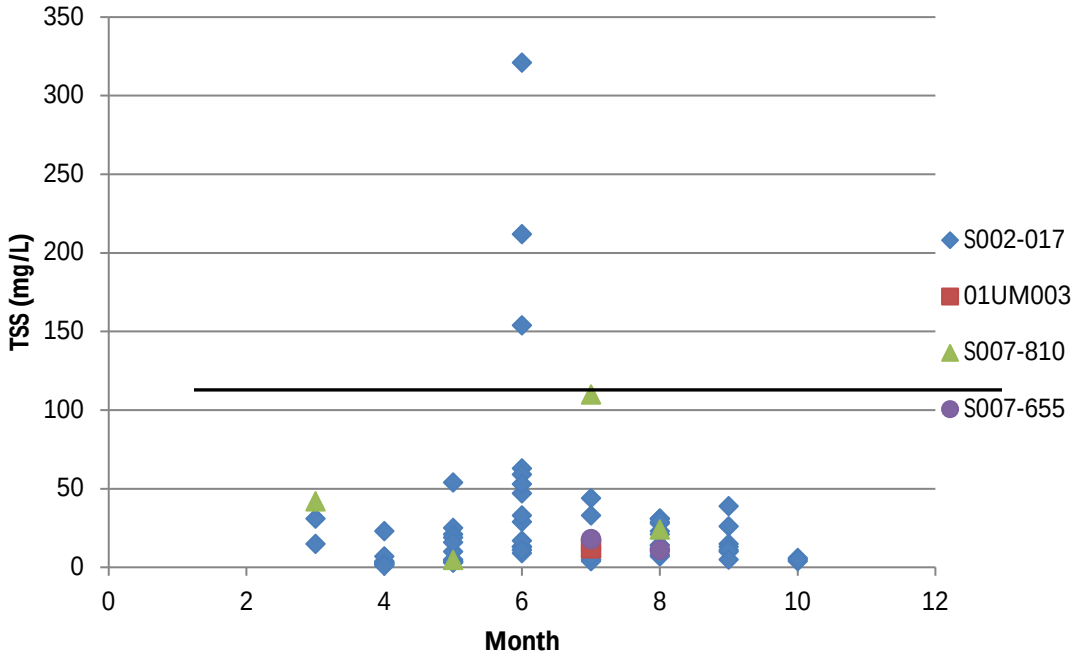

Figure 112. TSS values by month

Numerous paired TSVS and TSS samples were taken on this section of Buffalo Creek. The majority of samples were taken at station S002-017, where TSVS values range from 13% up to 100% of the suspended solid concentrations with an average of 31%. On average, inorganic solids (sediment not algae) make up the majority of the suspended solids.

Herbivore species of fish decrease as TSS values increase. Herbivores are fish species that consume plant material. These species are negatively impacted by the loss of vegetation which can be caused by sedimentation (Markus 2011). The individual herbivore percentages ranged from 0 to 10.09, averaging 4.41%. TSS can also affect both the number and growth of smallmouth bass and other Perficormes. During the five biological visits on this section of Buffalo Creek, Perficormes species were somewhat decreased at all stations except 07UM103. TSS tolerant fish populations made up percentages that ranged from 0.01% (00UM0) to 0.5% (01UM003) of the community, which is very low.

The number of macroinvertebrate taxa collected that were intolerant to TSS was zero at two of the sites sampled while one taxa was collected at the other two sites. Stations 01UM003 and 01UM004 both had very low numbers of long-lived percentages, indicating conditions are not amenable to macroinvertebrates having a long life. While the herbivore percentage has decreased from 2007 to 2012 at station 07UM103, the percentages of both fish and macroinvertebrates TSS tolerant species were not elevated. TSS is inconclusive as a stressor at this time based on an inconsistent biological response.

Table 40. TSS related metrics

Station	Herbivore Percentage	Perciforms-Tolerant %	TSS Intolerant Taxa	Percent TSS Tolerant Macroinvertebrate Individuals	Long-lived Macroinvertebrate Percent
01UM003	1.12	4.49	0	5.28	0
Averages for class 7 fish stations	**4.01**	**12.86**			
01UM004 (7-9-12)	2.39	17.42	1	36.91	0.63
01UM004 (8-8-12)	6.18	26.49			
Averages for class 6 fish stations	**5.67**	**10.08**			
07UM103 (2007)	6.68	10.02			
07UM103 (2012)	0	9.38	0	11	16.51
Averages for class 7 invert stations			**0.54**	**29.06**	**4.99**
12UM006	10.09	13.6	1	41	10.12
Averages for class invert 5 stations			**1.42**	**37.27**	**6.37**
Averages for class 5 fish stations	**2.07**	**26.78**			
Expected response with increased TSS stress	↓	↓	↓	↑	↓

Ionic strength

Specific conductance values ranged from 342 to 1366 uS/cm. The ecoregion norm for the Western Corn Belt Plain (based on the 75th percentile of annual specific conductance values) is 820 (McCollor et. al, 1993). Specific conductance values in the watershed are highest at stations S002-017 in spring and early summer. Elevated values are found throughout the reach. Continuous data was taken at station 12UM006 where values ranged from 387 to 1067 with three values above 1000 uS/cm. A longitudinal study showed specific conductance values from the headwaters to the mouth slowly decreasing (Figure 113). Stations S007-654, S007-655, and S002-017 are all in this AUID.

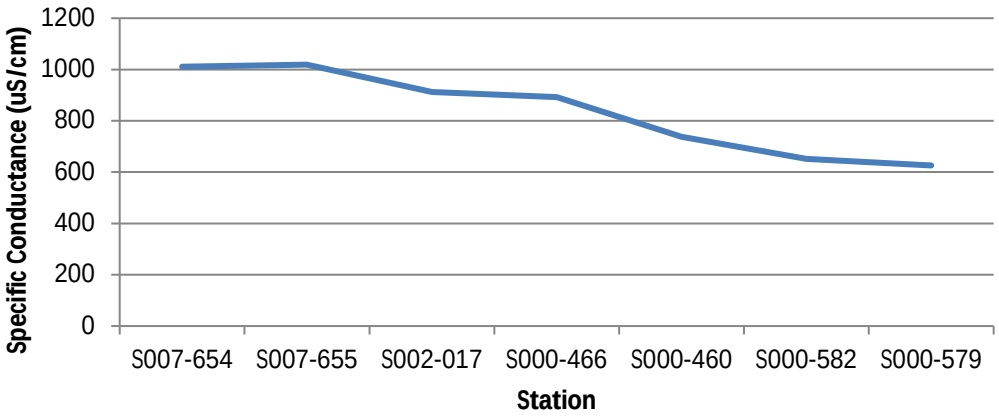

Figure 113. Longitudinal specific conductance values on Buffalo Creek

Increased ionic strength can cause an increase in ion tolerant taxa and an increase in ion tolerant life stages, causing fish and invert impairments, but it is difficult to separate this effect from other stressors. As salinity increases, macroinvertebrate taxa richness and Ephemeroptera has been found to decrease (Piscart et al., 2005). Echols et. al (2009) also found a reduction in EPT abundance as conductivity values increased. A study of Minnesota biological data and stressor linkages found that sites with conductivities higher than 1,000 µS/cm rarely meet the biological thresholds for general use streams (MBI, 2012). Stations 01UM003, 01UM004, 07UM103, 12UM006, and 12UM059 all had recorded values of specific conductance over 1,000 µS/cm, and failed to meet the threshold. The stations with the highest taxa count and EPT% (12UM006 and 01UM003 respectively) also had the highest recorded specific conductance values. Increases in conductivity can result similarly in decreases in mayflies (Ephemeroptera). While station 12UM006 had a high percentage of EPT individuals (25.5%), only 1.84% was comprised of mayflies. Station 07UM103 had very low percentages of EPT and mayflies (1.2 and 0.9% respectively) but had a healthy number of taxa (33).

There is not a consistent pattern between elevated specific conductance values and decreased taxa count, EPT%, and mayfly percent. While there are elevated specific conductance values, it is not a stressor to the biological communities. Specific conductance should continue to be monitored especially in the headwaters where the dataset is limited.

Lack of habitat

Habitat availability is lacking in this section of Buffalo Creek. The MSHA scores taken during biological sampling were poor during all site visits except the 2007 visit at station 07UM103 where it was fair. Lack of channel development, lack of riffles, and moderate to severe embeddedness of coarse substrates with fines were the main lacking factors. On average gravel was 91.7% embedded with sand at station 07UM103. Station 01UM003 did not have any coarse substrate. Severe bank erosion was noted at station 12UM006 due to no buffer (Figure 114), as well as upstream of this station (Figure 115). Clean cobble and gravel presence have a positive relationship with a higher fish IBI.

Figure 114. Erosion at station 12UM006 (October 9, 2013)

Figure 115. Erosion at 520th (June 21, 2013)

The percentages of tolerant fish were all higher than 66% in this section of Buffalo Creek, and range up to 95.51% at station 01UM003 where carp and fathead minnows dominated the catch. Simple lithophilic spawners, darter and sculpin, riffle, and benthic insectivore percentages were below average at each station except station 01UM004. Values at station 07UM103 saw large drops in simple lithophilic spawners, darters, sculpins, riffle, and benthic insectivore percentages from 2007 to 2012. The prevalence of fine sediments, embeddedness, and lack of riffles is affecting the fish community. Lack of habitat is a stressor for fish.

Table 41. Habitat related metrics

Station	SLithophilic Spawners Pct	DarterSculpin Pct	Tolerant Pct	Riffle Pct	Benthic Insectivore Pct
01UM003	0	0.56	95.51	1.12	0.56
Average for fish class 7 streams	**14.92**	**5.43**	**70.59**	**8.43**	**6.55**
01UM004 (7/12)	13.6	14.56	82.58	10.26	14.56
01UM004 (8/12)	12.36	23.84	73.51	13.47	23.84
Average for fish class 6 streams	**21.65**	**7.75**	**66.59**	**11.87**	**9.72**
07UM103 (2007)	11.31	10.02	87.56	8.35	12.44
07UM103 (2012)	3.91	1.56	86.72	0.78	1.56
12UM006	13.16	7.89	84.21	7.02	8.77
Average for fish class 5 streams	**37.10**	**14.7**	**36.10**	**19.49**	**21.68**
Expected response lack of habitat	↓	↓	↑	↓	↓

Clingers need coarse substrates, and decrease with the increase in percent fines. Along with the prevalence of fine sediments (Figure 116), the percentages of clingers were below average at all stations. Burrowers and sprawlers both use fine sediments as habitat, however the sprawlers made up 93.23% at station 01UM003 while the burrowers were very low (Figure 117). Sprawlers were all near average at the other three sites, while burrowers percentages were all higher than average (Figure 118). Climbers require aquatic plants and debris that have not been covered in fine sediments. Values were at or above average at all stations except station 01UM003. Based on the percentages of clingers, sprawlers, and burrowers habitat is a stressor to the macroinvertebrate community especially in the headwaters near station 01UM003.

Figure 116. Fine sediment substrate at station S002-017 (July 10, 2013)

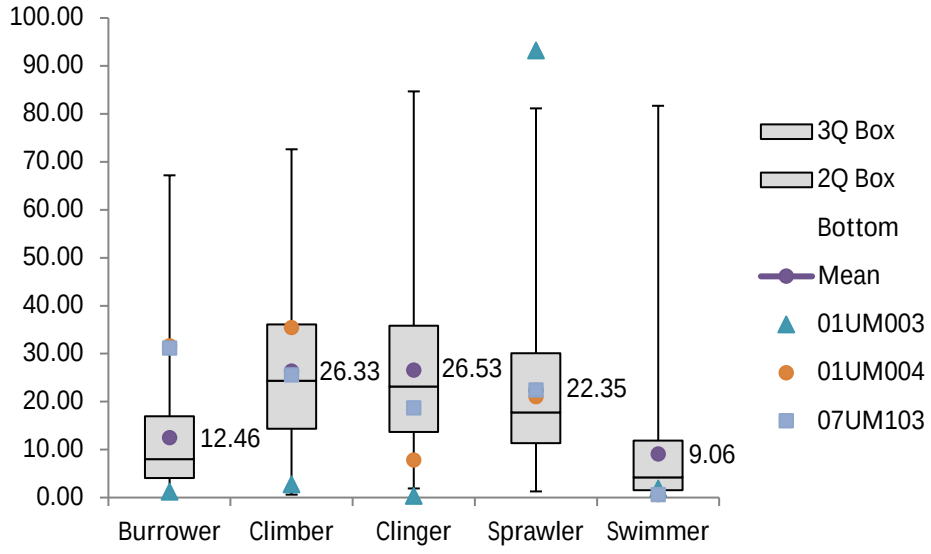

Figure 117. Habitat metrics in class 7

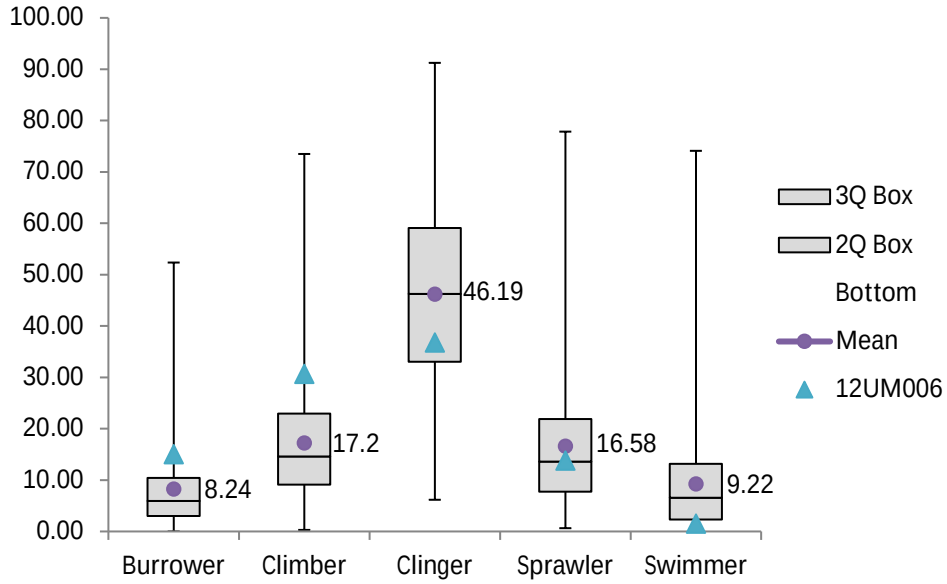

Figure 118. Habitat metrics in class 5

Altered hydrology

The entire reach of Buffalo Creek within this HUC has been or is currently channelized, along with all of its tributaries. Station 12UM006 was regaining sinuosity (Figure 119) but was channelized and rip-rapped in 2014 (Figure 120). Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency, increasing the impact of high flow events and increasing the intensity of low flow periods, both of which affect biological communities. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat. Channelization and tile drainage often causes flashy flows; high in the spring and during rain events and low or dry later in the summer.

Figure 119. Station 12UM006 (June 21, 2013)

Figure 120. Station 12UM006 (September 8, 2014)

Generalized fish species, which are adaptable to different habitats through generalized food preferences, are positively correlated with channelization. The average percentages for generalized fish in class 5 waters were 38.96%, class 6 was 41.54%, and class 7 was 36.44%. The two sites in class 6 had a general percentages range of 33.33% at station 12UM006 to 84.38% at station 07UM103. The general percentage increased from 65.33% in 2007 to 84.38% in 2012. Station 01UM004 in fish class 6 had a general percentage of 52.74%, which decreased from 75% in 2001. Station 01UM003 in fish class 7 had a general percentage of 89.89% increased from 30.77% in 2001. This corresponds with the simple lithophilic spawner percentages of 0 to 13.16% and 0.56 to 23.84% of benthic insectivores discussed in the habitat section.

Channelization is connected to and contributing to the lack of habitat. The effects of altered hydrology seem to be contributing to the increase of generalized fish percentages, which are more adaptable to changing conditions and food sources. Other contributing factors are likely affecting the high percentage of general fish species. Altered hydrology is a contributing stressor to lack of habitat.

AUID summary

The main stressors of Buffalo Creek from the headwaters to Judicial Ditch 15 were eutrophication, lack of habitat, nitrate, and TSS.

4.6. Buffalo Creek

The Buffalo Creek 10-HUC watershed is located in parts of Sibley, McLeod, and Renville County. The watershed is comprised of Buffalo Creek and its tributaries ranging from Judicial Ditch 15 to the South Fork Crow River. Buffalo Creek flows through the cities of Browntown and Glencoe. Tributaries include the impaired County Ditch 33, Judicial Ditch 8, and two unnamed tributaries to Buffalo Creek. The mainstem Buffalo Creek and the tributaries are discussed in two separate sections.

The majority of the section is in the Western Corn Belt Plains ecoregion with just the mouth of Buffalo Creek in the North Central Hardwood Forests ecoregion. Prior to settlement, the area was dominated by grasslands and shrubs. Land use was converted to predominantly hayfields, pasture, and cropland. The cropland is predominantly comprised of corn and soybeans (USDA 2013). Buffalo Creek and its tributaries were sampled both for biology and chemistry (Figure 121).

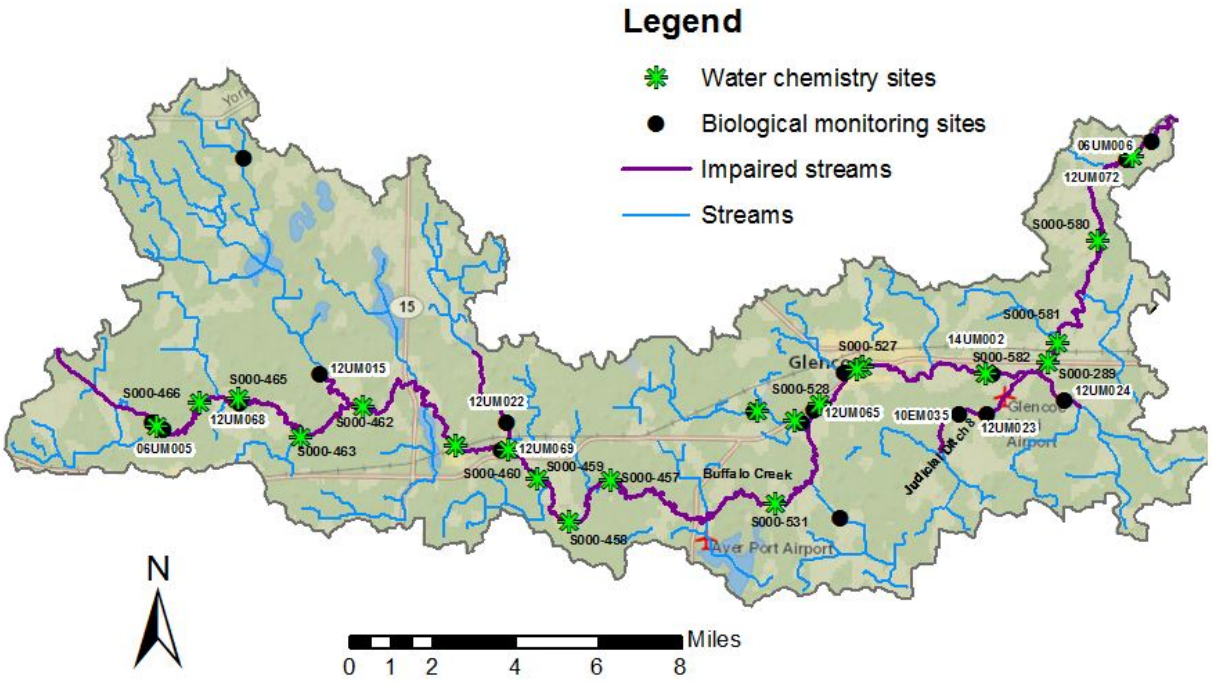

Figure 121. Sampling locations

4.6.1. Tributaries (-591,614,615 & 645)

- County Ditch 33 -645 (12UM015)
- Tributaries to Buffalo Creek -614 (12UM022), - 615 (12UM024)
- Judicial Ditch 8 -591 (12UM023, 10EM035)

Biological communities

Four stations were sampled for fish; station 12UM015 was in fish class 7, while the rest of the stations were in fish class 6. All stations had a threshold value of 42. Each station in class 7 had a score below 20 and station 12UM015 had a score just below the threshold (39). All four stations had metric scores of zero in both headwater species and the abundance of Cyprinids (minnows, shiners, carp) that are insectivores (Figure 122). The most common fish collected were black bullheads at station 12UM015, fathead minnows at station 12UM022, common carp at station 12UM023, and orangespotted sunfish at station 12UM024. Minnows and sensitive species were relatively low at all stations in this region.

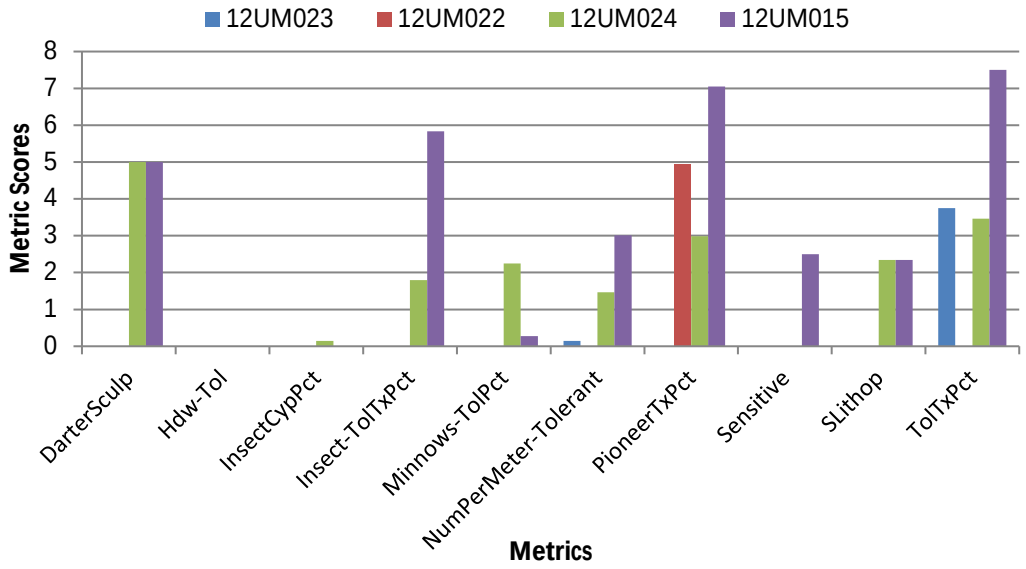

Figure 122. Metric scores for Buffalo Creek tributaries

Only stations 12UM023 and 12UM015 were sampled for macroinvertebrates, as the other two stations had insufficient flow. Station 12UM015 was in macroinvertebrate class 5 (Figure 123), while station 12UM023 was in class 6 (Figure 124). Both stations scored below their respective threshold (36 for class 5 and 47 for class 6). The highest metric score possible was 10 for both classes. Scores were uniformly low at station 12UM015 except for the climber and insectivore metrics at station 12UM015 and collector-filterer at station 12UM023.

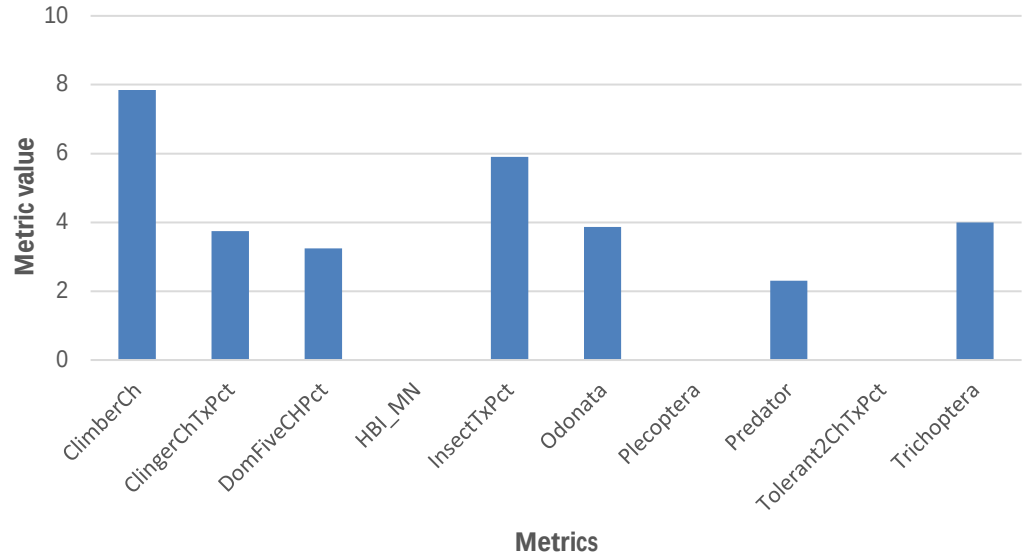

Figure 123. Metrics at station 12UM015

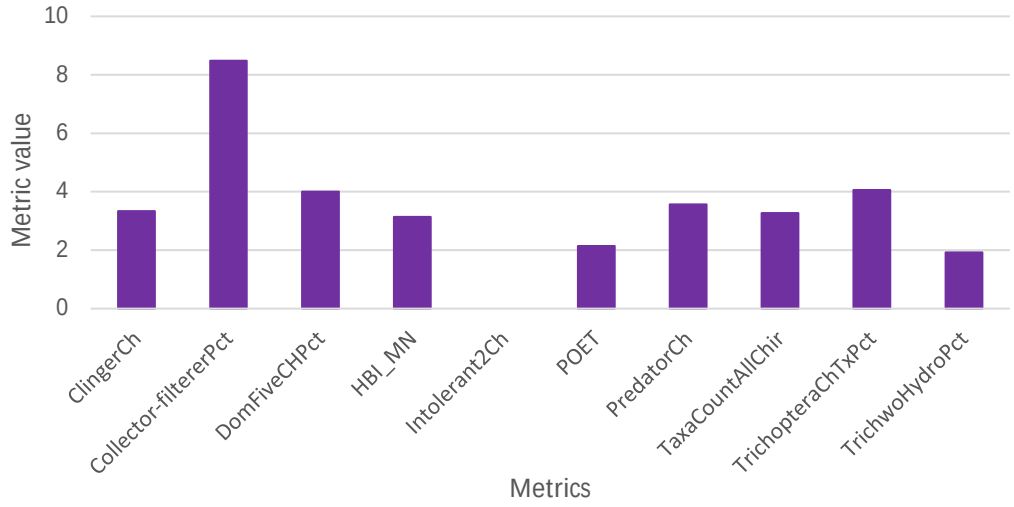

Figure 124. Metrics at station 12UM023

Phosphorus/Eutrophication

Phosphorus and eutrophication are closely tied. Biological communities are more directly affected by DO flux, chlorophyll-a, and BOD than phosphorus. Phosphorus values were taken both after rain events and during base flow conditions. Eleven values were taken in 2012 and 2014; values ranged from 0.059 to 1.35 mg/L. The highest value was taken in July on Judicial Ditch 8 at station 12UM023. The standard of phosphorus in the southern region is 0.150 mg/L. Of the small dataset, 45% values were above 0.150 mg/L. The three values of chlorophyll-a ranged from 8.6 to 47.2, and BOD data was not available.

Continuous data was collected at stations 12UM022, 12UM023, and 12UM024. Station 12UM024 was the only station with elevated DO flux; two out of six days had a DO flux above 3.5 mg/L (Figure 125). Station 12UM024 had a chlorophyll-a value of 47.2 ug/L and station 12UM022 had pH flux that ranged up to 0.71. Typical daily pH fluctuations are 0.2-0.3 (Heiskary et al., 2013). A tile line into station 12UM022 had a phosphorus concentration of 0.099 mg/L and 22 mg/L nitrate in June and 0.033 mg/L phosphorus and 14 mg/L nitrate in July.

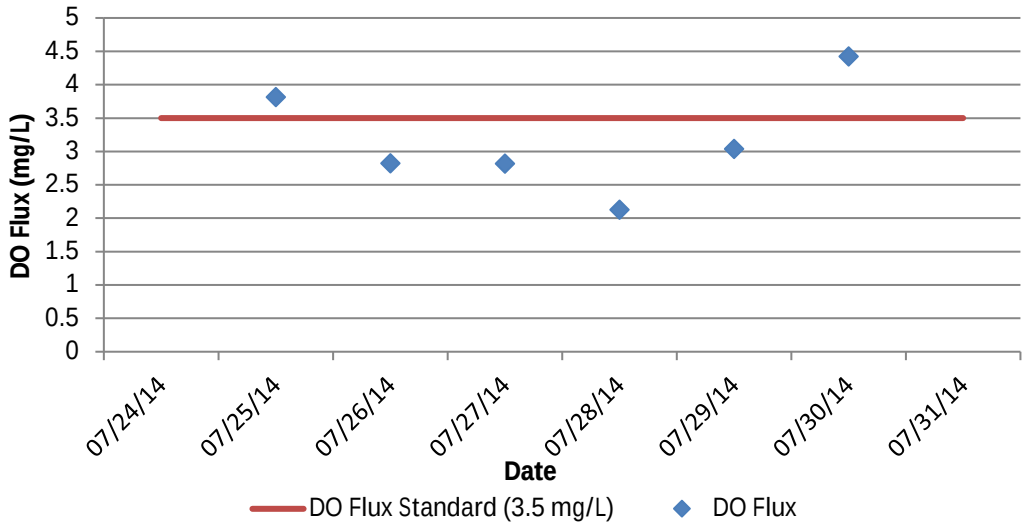

Figure 125. DO flux at station 12UM024

All tributaries had percentages of less than 1% sensitive fish, darters, and intolerant macroinvertebrate percentages, all of which decrease as TP increases. All of the stations were comprised of more than 75% tolerant fish species. Fish that are specifically phosphorus tolerant comprised more than 78% of the community at each station, ranging from 78% (12UM015) to 100% (12UM022). Omnivore fish have a positive relationship with phosphorus increases. The omnivorous fish ranged from 0% at station 12UM023 to 75.54% at station 12UM022.

Macroinvertebrate data is limited to stations 12UM015 and 12UM023. The number of macroinvertebrate taxa and the abundance of the dominant two taxa were near or above average. The percentage of EPT was 36.05% at station 12UM015 but only 6.99% at station 12UM023.

Table 42. Eutrophication related metrics

Station	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct	Invert Taxa	EPT Pct	Dominant 2 Invert Taxa Pct
12UM015	0.57	0.57	76.50	58.45	37	36.05	37.30
Average for fish class 7 streams	**8.16**	**5.21**	**70.59**	**22.40**			
12UM022	0	0	100	75.53	_	_	_
12UM023 (7-11-12)	0	0	91.30	0	30	6.99	40.12
12UM023 (8-8-12)	0	0	93.48	15.22			
12UM024	0	0.30	87.84	56.53	_	_	_
Average for fish class 6 streams	**15.13**	**6.34**	**66.59**	**16.87**			
Average for invert class 5 streams					**38**	**38.30**	**39.30**
Average for invert class 6 streams					**23**	**19.01**	**44.72**
Expected response to increased TP stress	↓	↓	↑	↑	↓	↓	↑

Based on the preponderance of lack of sensitive fish and darters, and the elevated tolerant and omnivorous fish phosphorus and eutrophication are determined to be a main stressor in this HUC for fish. Station 12UM022 in particular seems to be affected.

Dissolved oxygen

There is limited DO datasets on these tributaries. Concentrations ranged from 5.85 mg/L at station 12UM023 in July to 11.93 mg/L at station 12UM015 in August. Continuous data was collected at stations 12UM022, 12UM023, and 12UM024. Stations 12UM022 and12UM023 had DO values at or below 5 mg/L. Three days dropped below 5 mg/L over the seven day deployment at station 12UM022, getting as low as 3.59 mg/L (Figure 126). Station 12UM022 is downstream of a wetland, which could be influencing low DO values. Five days dropped below 5 mg/L at station 12UM023.

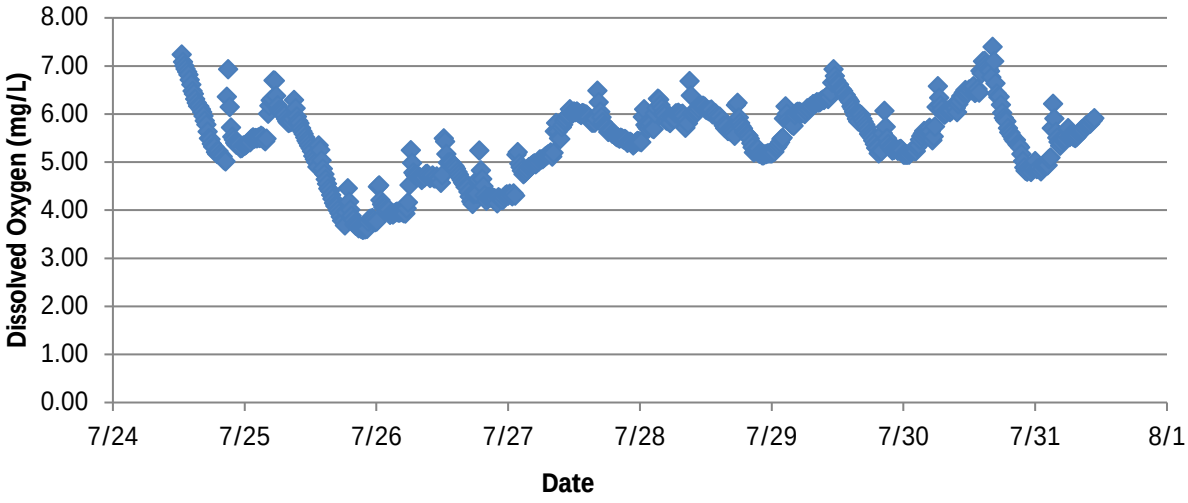

Figure 126. Continuous DO at station 12UM022

The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. Stations 12UM022, 12UM023, and 12UM024 did not have any fish that take three years or longer to mature, in comparison to station 12UM015 where 16.05% of individuals matured at greater than three years of age. Low DO values also correspond with increased serial spawning fish percentage. Stations 12UM022 and 12UM024 had elevated percentages (54.41 and 73.40% respectively). The percentage of fish tolerant to low DO made up 73% (12UM024) to 100% (12UM022) of the fish communities. Low DO is a stressor to the fish communities at stations 12UM022 and 12UM024.

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed at each station. Station 12UM023 had zero low DO intolerant taxa and station 12UM015 had three taxa that are intolerant to low DO values. DO tolerant macroinvertebrate individuals range from 5.71 to 11.78%? Based on the lack of consistent evidence, low DO is a stressor at station 12UM022. Stations 12UM015 and 12UM023 both had indications of DO stress but are inconclusive at this time.

Table 43. Low DO related metrics

Station	MA>3 years Percentage	Serial Spawning Fish Percentage	HBI_MN	Percentage DO Tolerant Macroinvertebrate Pct	Intolerant Macroinvertebrate Taxa
12UM015	16.05	11.17	8.43	11.78	3
Average for fish class 7 streams	**4.62**	**19.58**			
12UM022	0	73.40	-	-	-
12UM023 (7-11-12)	0	0	7.91	5.71	0
12UM023 (8-8-12)	**0**	**0**			
12UM024	0	54.41	-	-	-
Averages for fish class 6 stations	**2.99**	**15.44**			
Averages for class 6 invert stations			**7.55**	**24.88**	**3.83**
Averages for class 5 invert stations			**7.45**	**10.45**	**6.91**
Expected response with DO stress	↓	↑	↑	↑	↓

Lack of habitat

Habitat availability is lacking in these Buffalo Creek tributaries; the MSHA scores taken during biological sampling were poor at all sampling sites. The lack of channel developmental and depth variability were the main contributors to the low scores. All of the stations lacked shade cover. Erosion was noted at each station, and recorded as severe at station 12UM024 (Figure 127). Cobble and gravel presence also have a positive relationship with a higher fish IBI. All of the stations had embedded gravel as a substrate. The gravel at stations 12UM023 and 12UM024 was 100% embedded by fine sediments. This relationship was mirrored by the macroinvertebrate community, where the number of clinger taxa decreases with the increase in percent fines.

Clean cobble and gravel presence have a positive relationship with a higher fish IBI. Measurements with a rod averaged 10.3 cm of fine substrate over embedded gravel at station 12UM024 with measurements up to 32 cm of silt on gravel at station 12UM023. In comparison, station 12UM022 had an average of 3 cm of fine sediments over cobble and gravel.

Figure 127. Bank erosion at 12UM022 (top) and 12UM024 (bottom)

There was a lack of darters, sculpins, riffle, simple lithophilic spawners, and benthic insectivores at each of the stations. Each of these fish types has negative relationships with a lack of habitat availability. The majority of fish collected at all four stations were tolerant species, with stations comprised of 70% or more tolerant fish.

Table 44. Habitat related metrics

Station	SLithophilic Spawners Pct	DarterSculpin Pct	Tolerant Pct	Riffle Pct	Benthic Insectivore Pct
12UM015	0.29	0.57	76.50	0.29	0.57
Average for fish class 7 streams	**14.90**	**5.41**	**70.64**	**8.41**	**6.54**
12UM022	0	0	100	0	0
12UM023 (7-11-12)	0	0	91.30	0	0
12UM023 (8-8-12)	0	0	93.48	0	0
12UM024	4.26	0.3	87.84	4.26	0.3
Average for fish class 6 streams	**21.68**	**7.75**	**66.56**	**11.87**	**9.72**
Expected response with habitat stress	↓	↓	↑	↓	↓

Excessive sedimentation was recorded at all stations. The number of clinger taxa decrease with an increase in percent fines as they require coarse substrates. Burrowers live inside fine sediments and have a positive relationship with percent fines. Borrower percentage were 4.7% at station 12UM015 Figure 128) and 14.89% at station 12UM023. Clinger percentages were 27.59% at station 12UM015 and 37.08% at station 12UM023. Climbers live on aquatic plants and debris, and tend to decrease as sedimentation increases and covers vegetation. Percentages at the two sampled sites were 43.57% at station 12UM015 and 24.32% at station 12UM023. While erosion and sedimentation were recorded as problems at each site, the biological effect is limited to fish where lack of habitat is a stressor.

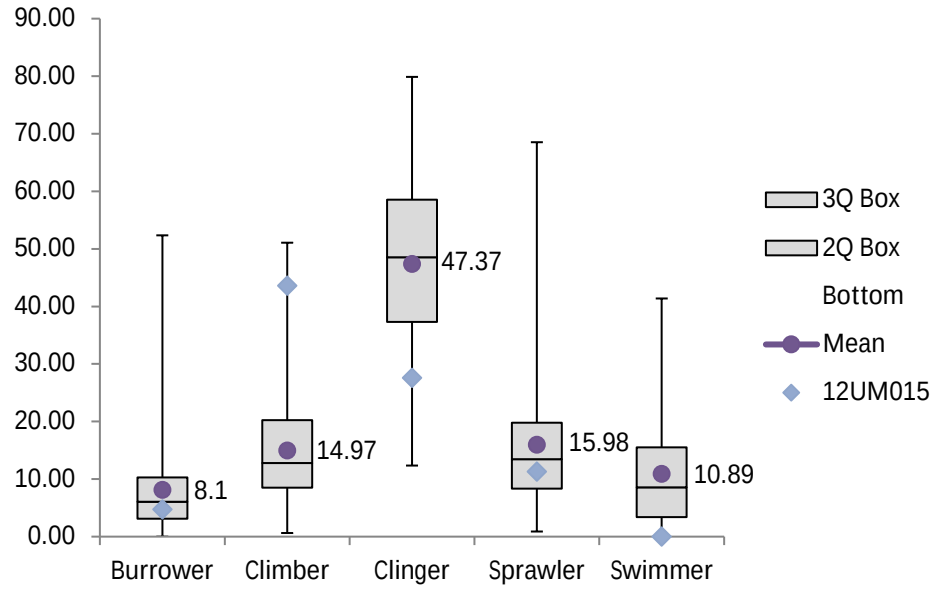

Figure 128. Habitat metrics at station 12UM015

Altered hydrology

The tributaries to Buffalo Creek in this HUC are all channelized. Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency, increasing the impact of high flow events and increasing the intensity of low flow periods, both of which affect biological communities. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat.

Benthic insectivore and simple lithophilic species can decrease with channelization as bedload increases. Generalized fish species, which are adaptable to different habitats through generalized food preferences, are also correlated with channelization. The average percentage for generalized fish in class 6 waters was 41.54%. Three of the stations were in fish class 6 and had a general percentage range of 19.57% at station 12UM023 to 75.53% at station 12UM022. This corresponds with the simple lithophilic spawner percentages of 0 to 4.26% and 0 to 0.3% of benthic insectivores discussed in the habitat section. The average simple lithophilic spawner percentage for class 6 is 21.65% and benthic insectivores are 9.71%. Station 12UM015 was in class 7. There was a general percentage of 79.08%, simple lithophilic spawners 0.29%, and 0.57% benthic insectivores.

Channelization is connected to and contributing to the lack of habitat. The effects of altered hydrology seem to be contributing to the increase of generalized fish percentages, which are more adaptable to changing conditions and food sources. Other contributing factors are likely affecting the high percentage of general fish species. Altered hydrology is a contributing stressor to lack of habitat.

AUID summary

The main stressors of the tributaries to Buffalo Creek from the headwaters to Judicial Ditch 15 were eutrophication, DO, lack of habitat, and altered hydrology.

4.6.2. Buffalo Creek (07010205-638)

Buffalo Creek from Judicial Ditch 15 to the South Fork Crow River had seven biological monitoring stations located within the AUID. One station was sampled only for macroinvertebrates and not for fish. No clear longitudinal trends were seen in either the fish or macroinvertebrate scores.

Biological communities

All stations were in the fish stream class 5 and had IBI scores below the threshold (37). All stations had intolerant and sensitive metric scores of zero except station 12UM072. Serial spawners metric scores were also low among the stations (Figure 129). The most common fish collected were sand shiners at station 06UM006, orangespotted sunfish at station 06UM005, common carp at station 12UM065, brassy minnow at station 12UM068, green sunfish at station 12UM069, and green sunfish at station 12UM072. These are all fish that are tolerant to human disturbance. Station 06UM006 had a similar IBI score both in 2006 and 2012 (13 and 15 respectively). In between the samples a bank restoration project took place.

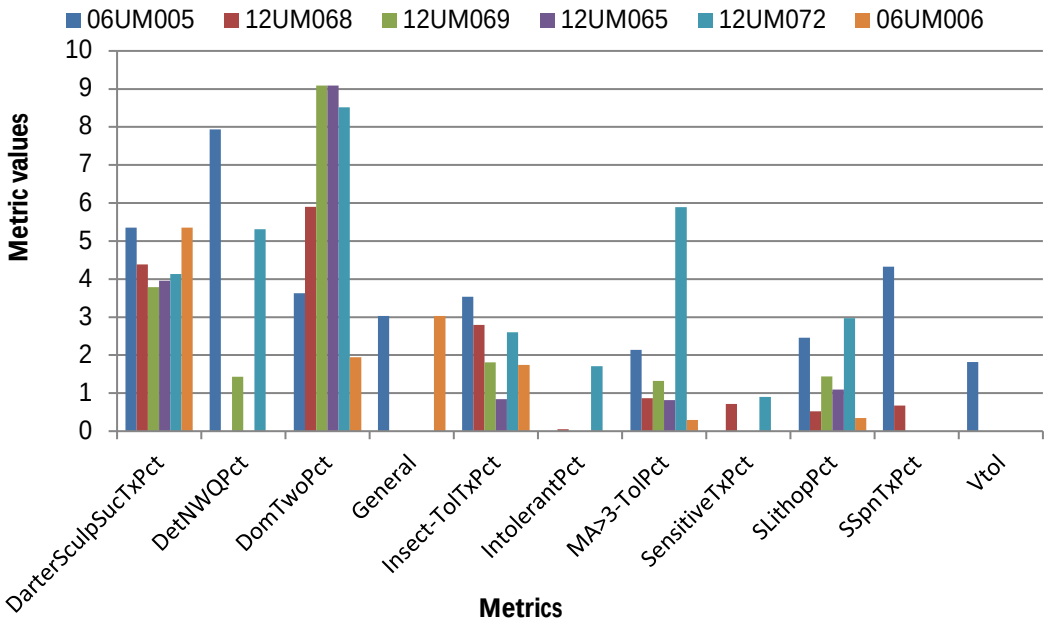

Figure 129. Metric values on Buffalo Creek

Five stations were in macroinvertebrate class 5, and one station in both classes 6 and 7. All stations in class 5 were well below the threshold (37), except for station 06UM006 with a score of 49 (Figure 130). Stations 12UM068 and 14UM002 were just above the threshold (41 and 43 respectively). The highest score at each station was 10. Clingers and collector-filterers scored well at the majority of sites. The two downstream sites; 06UM006 and 12UM072 both had high scores of stonefly (Plecoptera) taxa, but the upstream stations all had scores of zero. The number of dragonflies and damselflies (Odonata) taxa were much lower. The intolerant taxa scores were both zero at stations 14UM002 and 12UM068 (Figure 131).

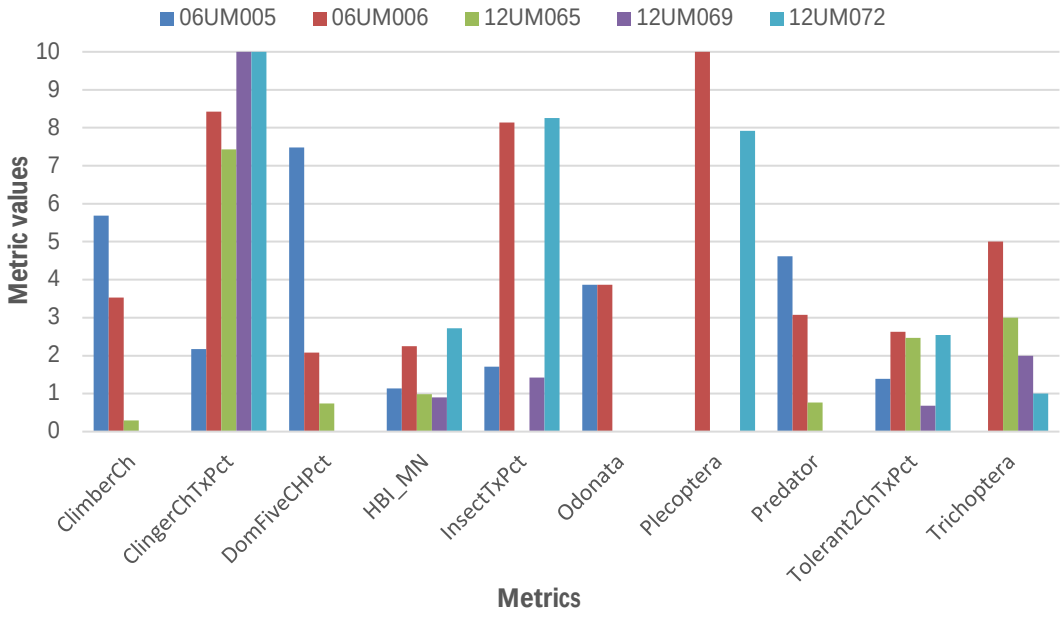

Figure 130. Metrics for class 5

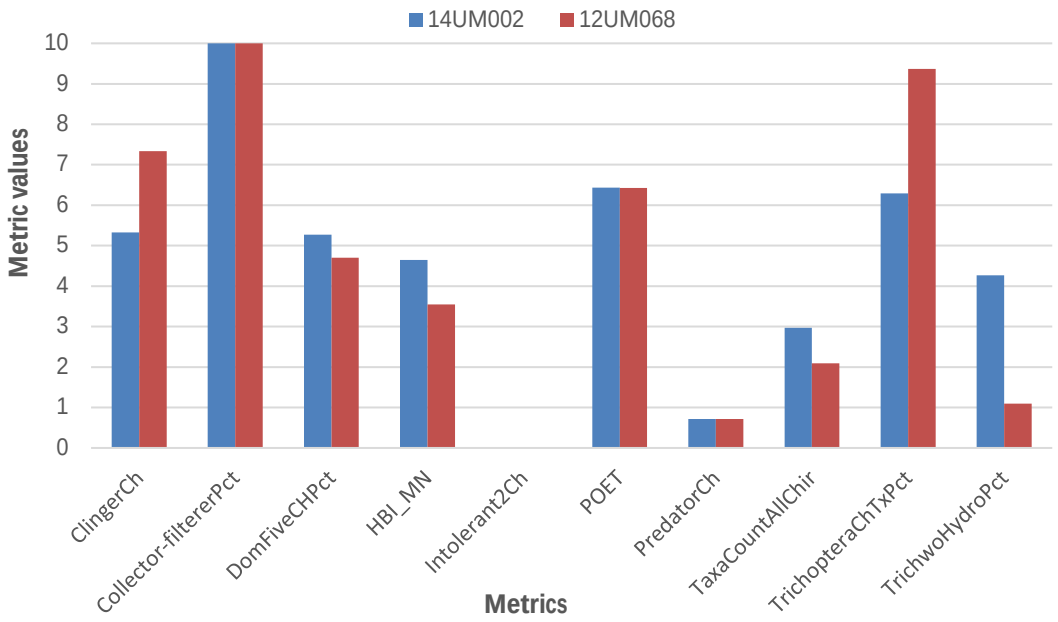

Figure 131. Metric scores for class 7 and class 6

Phosphorus/Eutrophication

Phosphorus and eutrophication are closely tied. Biological communities are more directly affected by DO flux, chlorophyll-a, and BOD than phosphorus. Of phosphorus data collected in recent years, 82% of the samples throughout the reach were above the southern standard of 0.150 mg/L. Values ranged from 0.02 mg/L to 3.72 mg/L with concentrations on average highest during August and early fall. The highest values were located downstream of Brownton (S007-457) and downstream of Glencoe (S000-582). Eutrophication drives elevated pH values. Values of pH were as high as 8.98, with 28 other values above 8.5 (6%). Chlorophyll-a values ranged from 1.77 to 136 ug/L, and were also highest downstream of Brownton (S000-460) and downstream of Glencoe (S000-582) with 22 values over 35 ug/L (24%). BOD values ranged from 0.6 to 10.2 mg/L with 71 values over 3 (53%).

Longitudinal surveys of phosphorus were taken June 21 and October 9, 2013 (Figure 132). The highest value was located at station 06UM005 in June and station 12UM065 in the fall (just upstream of Glencoe and downstream of discharge ponds). In contrast, sampling in October of 2013 showed a higher phosphorus value downstream of Glencoe and the WWTP (2.26 mg/L at station S007-709) than upstream (0.574 at station 12UM069). A longitudinal study of BOD samples showed the values highest at station S000-460 just downstream of Brownton (Figure 133).

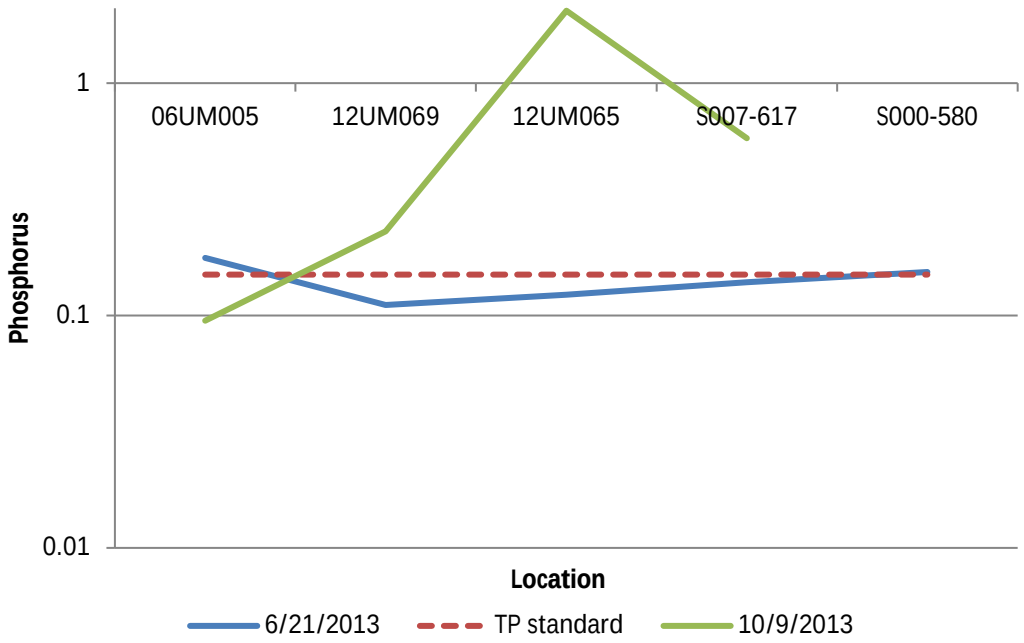

Figure 132. Longitudinal phosphorus values

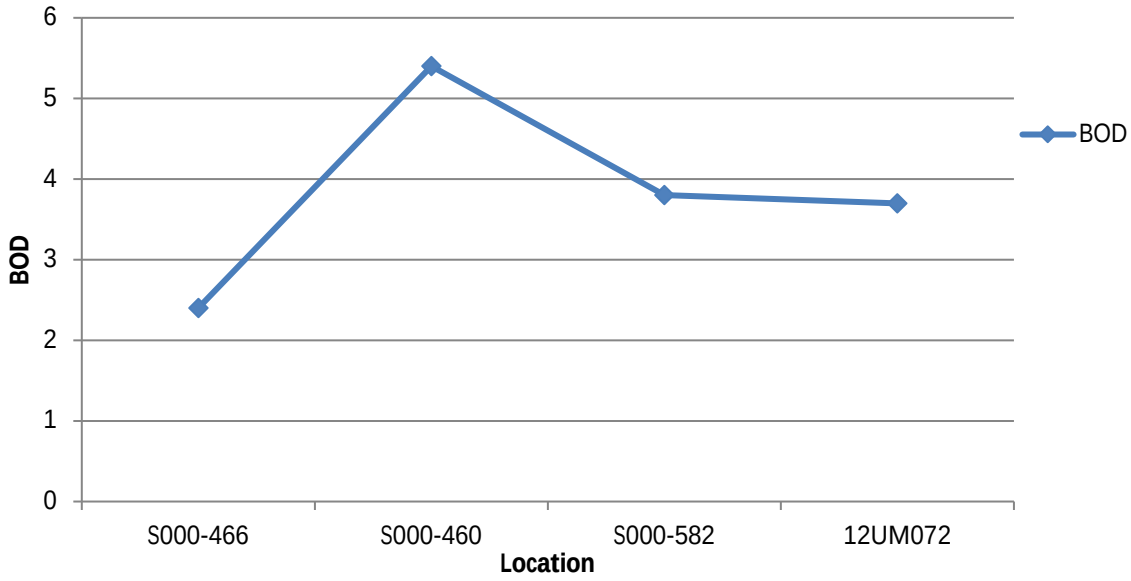

Figure 133. Longitudinal BOD values

Orthophosphorus is the form of phosphorus that is readily available for plant and algal uptake, and can influence excess algae growth (Figure 134). The average ratio of orthophosphorus compared to phosphorus concentrations throughout the reach averaged 55%, and was highest downstream of Glencoe (S000-582) with orthophosphorus comprising 98% of the phosphorus concentration.

Figure 134. Algae on Buffalo Creek

Continuous DO data were collected on Buffalo Creek both downstream of Brownton and Glencoe. Neither station had low DO during deployment. Values ranged from 5.53 to 17.46 mg/L at station 12UM069 where all but one day were above the daily flux south regional standard of 4.5 mg/L (Figure 135). Daily DO fluctuations are a measure of stress on the aquatic community. Algal respiration and photosynthesis are considered the primary drivers of daily flux in DO, and high daily fluctuations of DO are connected to nutrient concentrations. The elevated phosphorus values are fueling photosynthesis and algal respiration, which in turn are effecting the daily oxygen production and oxygen demand, as seen by fluctuations as high as 11.33 mg/L in a single day. Typical daily pH fluctuations are 0.2-0.3 (Heiskary et al., 2013), whereas values ranged to 0.77 during continuous monitoring. Twelve of the thirteen days of deployment had values of pH greater than 8.5, with seven days above 8.8 and the highest value at 9.08 (Figure 136).

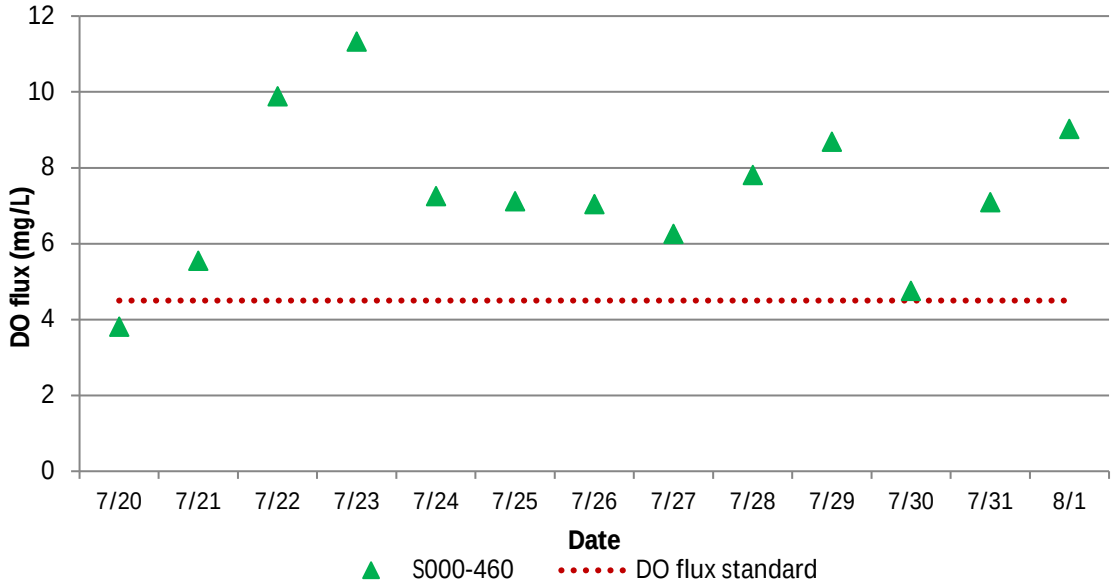

Figure 135. DO flux at 12UM069

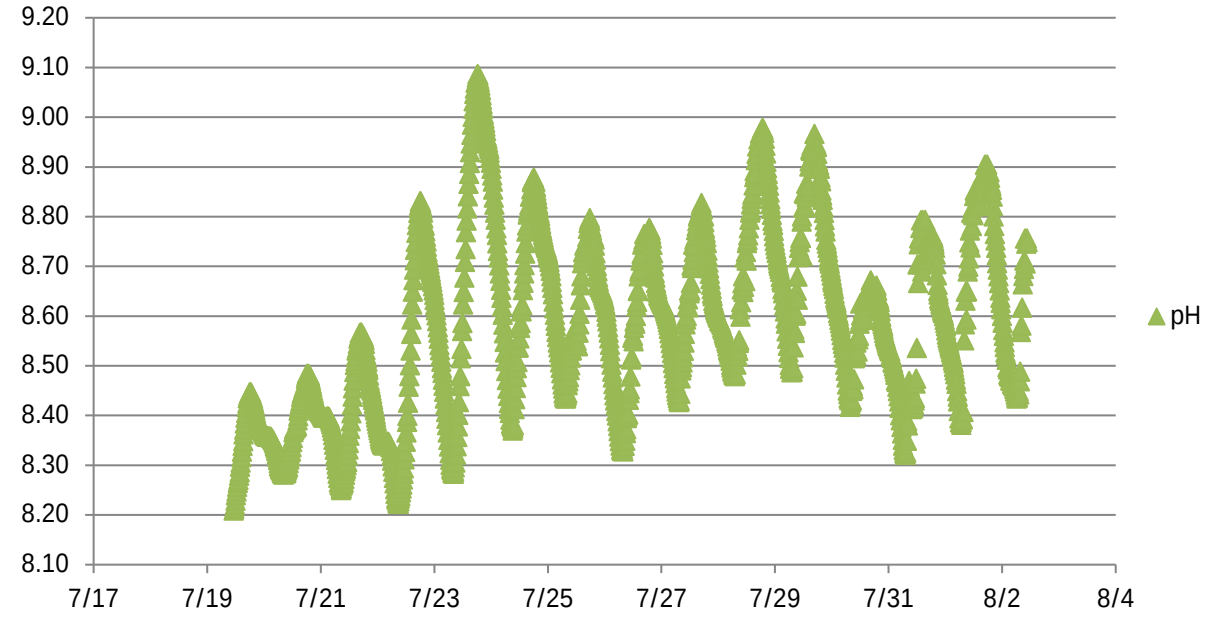

Figure 136. Continuous pH at 12UM069

All sites had percentages of less than 1% of sensitive fish except for station 12UM072 where 60 longnose dace were collected. All of the stations were comprised of more than 48% tolerant fish species, all higher than the class average. Omnivorous fish have a positive relationship with nutrients, chlorophyll-a and DO flux. Each station had a higher than average percentage except station 12UM068. Station 06UM006 had an increase of omnivorous fish between 2006 (2.06) and 2014 (17.47).

Taxa count and EPT percentages both have negative correlations with eutrophication. EPT percentages were near or above average except for station 06UM005 (29.21), which also had one of the highest taxa counts. The abundance of the dominant two taxa ranged from 26.35% at station 06UM005 in 2006 and 75.94% at station 12UM069. Based on the preponderance of evidence and the negative changes at station 06UM006, eutrophication is a stressor to this section of Buffalo Creek.

Table 45. Phosphorus related metrics

Station	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct	Invert Taxa	EPT Pct	Dominant 2 Invert Taxa Pct
06UM005 (2006)	0	16.44	74.03	32.18	44	29.21	26.35
06UM006 (9-20-06)	0	7.05	78.77	2.06	48	60.89	47.76
06UM006 (9-22-14)	0	6.69	80.24	17.47	22	75.23	52.94
12UM065 (7-26-12)	0	6.41	75.49	45.68	28	35.37	46.30
12UM065 (8-13-12)	0	8.99	64.75	39.63			
12UM068	0.23	4.15	82.48	8.46	26	72.44	48.61
12UM069	0	8.15	69.72	23.44	21	75.94	59.06
12UM072	7.89	13.55	48.68	17.24	29	48.91	57.94
Average for fish class 5 streams	**22.31**	**13.48**	**36.11**	**14.23**			
Average for invert class 7 streams					**32**	**19.37**	**49.31**
Average for invert class 5 streams					**38**	**38.21**	**30.67**
Expected response to increased TP stress	↓	↓	↑	↑	↓	↓	↑

Suspended sediments

TSS values in recent years were analyzed and 14% of samples were above the proposed standard of 65 mg/L with values ranging from 1 to 592 mg/L. Values were highest in May and June. Values were elevated throughout the reach with values highest at stations S000-460 and S000-582. Stations S000-460 and S000-582 were just downstream of Brownton and Glencoe respectively.

Numerous paired TSVS and TSS samples were taken on this section of Buffalo Creek. TSVS values range from 9% up to 79% of the suspended solid concentrations with an average of 26%. On average, inorganic solids (sediment not algae) make up the majority of the suspended solids.

Herbivore species of fish decrease as TSS values increase. Herbivores are fish species that consume plant material. These species are negatively impacted by the loss of vegetation which can be caused by sedimentation (Markus 2011). The individual herbivore percentages ranged from 0 to 34.37%, averaging 7.77%. TSS can also affect both the number and growth of smallmouth bass and other fish in the Perciforms order. During the seven biological visits on this section of Buffalo Creek, smallmouth bass were not surveyed but other perch like fish made up 7.13 to 22.38% of the population. Herbivores and Perciforms percentages both increased slightly from 2006 to 2014 at station 06UM006. The percentage of TSS tolerant individuals at each station ranged from 27% (12UM072) to 62% (06UM006). Stations and both had one TSS intolerant species.

The number of macroinvertebrate taxa collected that were intolerant to TSS ranged from 0 to 2. The percentage of TSS tolerant individuals ranged from 44.24 to 84.62%, all above class average. The percentage of long-lived individuals ranged from 3.74 to 24.36%. This indicates conditions are not preventing macroinvertebrates from having a long life. While the fish community shows some TSS effects, there is not a consistent response patterns. The TSS intolerant taxa, long-lived individuals, and TSS tolerant individual percentages indicate suspended sediments are a stressor to the macroinvertebrate community concentrated at stations 12UM068 and 12UM069 near Brownton.

Table 46. TSS related metrics

Station	Herbivore Percent	Perciforms-Tolerant %	TSS Intolerant Taxa	Percent TSS Tolerant Macroinvertebrate	Long-lived Macroinvertebrate Percent
06UM005	0.14	22.38	1	44.24	7.94
12UM069	14.99	15.28	0	84.62	5.94
12UM065 (7-26-12)	7.52	8.36	0	52.49	7.07
12UM065 (8-13-12)	0.23	14.29			
12UM072	0	16.71	-	-	3.74
06UM006 (2006)	1.54	7.13	2	78.57	24.36
06UM006 (2014)	3.39	8.18	0	55.14	12.38
Averages for class 5 invert stations			**1.42**	**37.27**	**6.37**
12UM068	34.37	8.46	0	73.86	4.64
Averages for class 5 fish stations	**2.07**	**26.78**			
Averages for class 7 invert stations			**0.54**	**29.06**	**4.99**
Expected response with increased TSS stress	↓	↓	↓	↑	↓

Lack of habitat

Habitat availability is lacking in this section of Buffalo Creek. The MSHA scores taken during biological sampling were fair during all site visits except the visit at station 06UM005 where it was poor. Bank erosion, excess sedimentation, and moderate to severe embeddedness of coarse substrates with fines were the main issues identified. Mid-channel bars were noted at four stations, which is an indication of a broken sediment cycle. Mid-channel bars are comprised of a sediment load that is too large for the stream to carry. The intensive bank erosion and embeddedness of coarse substrate with the excess sedimentation are all connected (Figure 137). Clean cobble and gravel presence have a positive relationship with a higher fish IBI.

Station 14UM002, which was only sampled for fish, is a C4 channel type. C4 channels have high sensitivity to disturbance and streambank erosion (Rosgen 1994). Excessive erosion was measured between 2012 and 2013 due to bank sloughing (DNR 2015). It was also noted that there were inadequate buffers in many areas, likely causing bank erosion rates at 6-12 times higher than estimates. The DNR recommends reducing lateral bank erosion to slow channel widening. The widening of channels is compounded by unstable hydrology and lack of riparian vegetation, affecting the instream habitat.

Figure 137. Eroded bank on Buffalo Creek (October 9, 2013)

The percentages of tolerant fish were higher than 48% in this section of Buffalo Creek. The highest percentage was at station 06UM006 in 2014, not changing from 2006. Both visits were dominated by sand shiners. Simple lithophilic spawners, darter and sculpin, riffle, and benthic insectivore percentages were below average at each station with the highest values at station 12UM072. Values at station 06UM006 all increased after restoration work due to an increase in shorthead redhorse, white suckers, and the introduction of central stonerollers in the fish c ommunity. Sand deposition was less prevalent in 2014 than in 2006 (Figure 138). The prevalence of erosion, fine sediments, and embeddedness is affecting the fish community, but is having more of an affect in some areas than others. Areas most affected were located in the center part of the reach at stations 12UM068, 12UM069, and 12UM065.

Figure 138. Station 06UM006 in 2006 (top) and 2014 (bottom)

Table 47. Habitat related metrics

Stations	SLithophilic Spawners Pct	DarterSculpin Pct	Tolerant Pct	Riffle Pct	Benthic Insectivore Pct
06UM005 (2006)	19.34	16.44	74.03	5.39	19.2
06UM006 (2006)	4.04	7.05	78.77	1.32	8.45
06UM006 (2014)	8.78	6.69	80.24	6.39	8.68
12UM065 (7/12)	9.47	6.41	75.49	4.18	10.86
12UM065 (8/12)	11.98	8.99	64.75	3	13.13
12UM068	5.29	4.15	82.48	7.02	5.82
12UM069	11.94	8.15	69.72	4.8	11.35
12UM072	23.03	13.55	48.68	13.42	26.97
Average for fish class 5 streams	**37.02**	**14.7**	**36.10**	**19.49**	**21.71**
Expected response with lack of habitat	↓	↓	↑	↓	↓

Clingers need coarse substrates and decreases with the increase in percent fines. Even with the prevalence of fine sediments (Figure 139), the percentages of clingers were above average except at stations 12UM065 and 06UM005. Burrowers and sprawlers both use fine sediments as habitat; however, the sprawlers and burrowers were low except again at station 06UM005 and sprawlers at 12UM065. (Figure 140 and Figure 141). Climbers require aquatic plants and debris that have not been covered in fine sediments. Values were at or above average at all stations except stations 06UM006, 12UM068, and 14UM002. Station 06UM005 is the most upstream station in this AUID, and had the highest percentage of embeddedness where quantitative habitat was measured, at 53.57%. Based on the percentages of clingers, sprawlers, and burrowers habitat is a localized stressor in the headwaters near station 06UM005.

Figure 139. Deposited sediment at station 14UM002 (August 2, 2013)

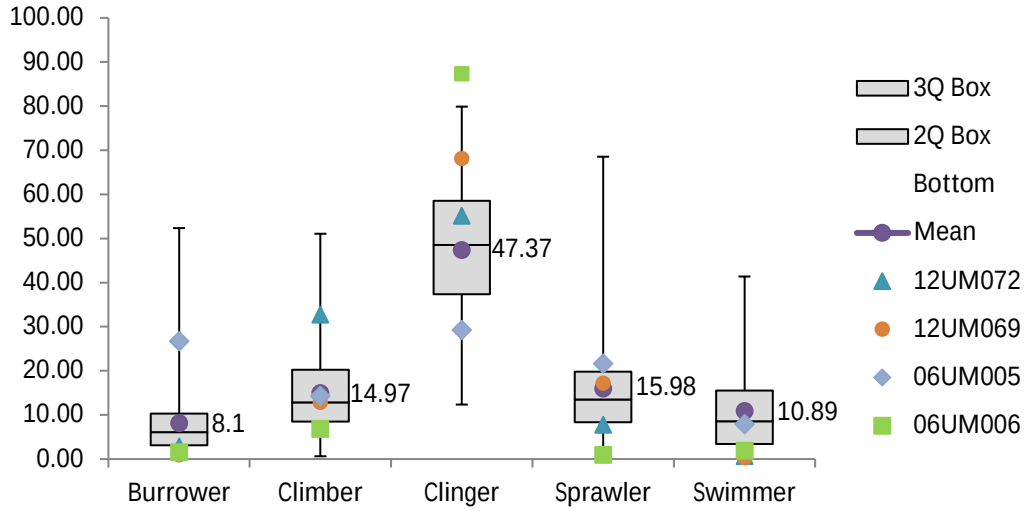

Figure 140. Habitat metrics in class 5

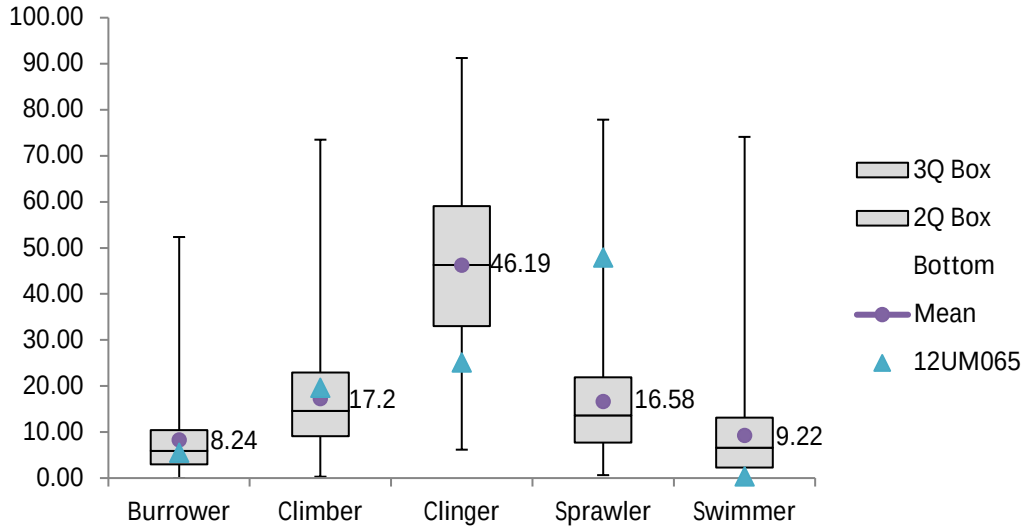

Figure 141. Habitat metrics in modified class 5

AUID summary

The main stressors of Buffalo Creek from Judicial Ditch 15 to the South Fork Crow River were eutrophication, TSS, and lack of habitat.

4.7. Judicial Ditch 15

The Judicial Ditch 10-HUC watershed is located in Renville County. The watershed is comprised of Judicial Ditch 15 and its branches. The reach discussed extends from the headwaters of Judicial Ditch 15 to the city of Hector. Downstream of Hector, Judicial Ditch 15 becomes a class 7 water which are not assessed for biology.

The entirety of the section is in the Western Corn Belt Plains ecoregion. Prior to settlement, the area was dominated by grasslands. Land use was predominantly converted to corn, soybeans, and sugar beets (USDA 2013). Judicial Ditch 15 and its tributaries were sampled both for biology and chemistry (Figure 142).

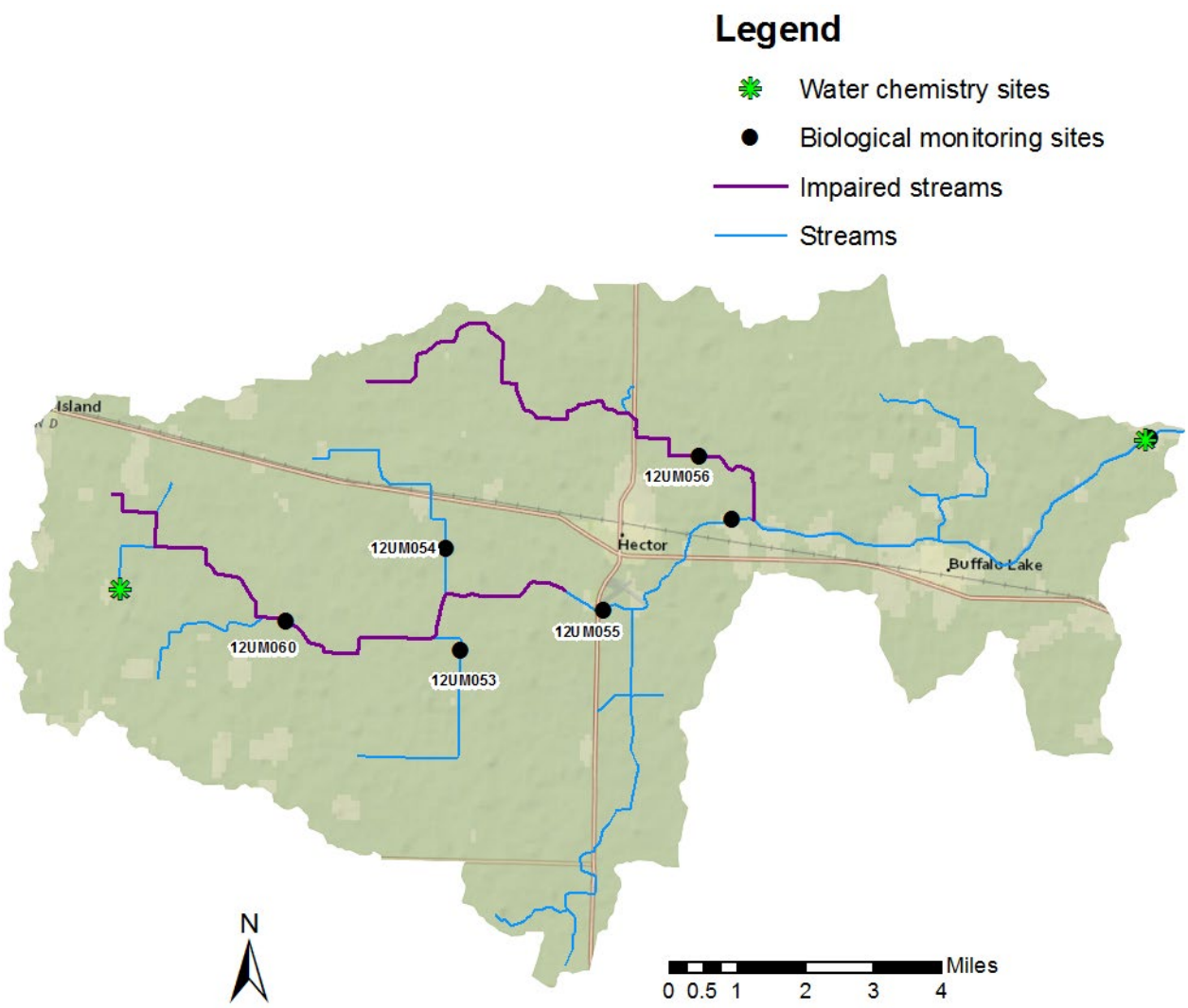

Figure 142. Sampling location in the Judicial Ditch 15 HUC

4.7.1. Judicial Ditch 15 and Tributaries (-509, -626, 627, 628)

Biological communities

Station 12UM060 on Judicial Ditch 15 is in fish class 7, while the rest of the branches are in fish class 6. Of the ten metrics that made up the IBI score for station 12UM060, only three did not have a score of zero; darter and sculpins, insectivores, and tolerant taxa (Figure 143). Only 11 fish were collected, with black bullheads the dominant species. The FIBI scores were all well below the threshold of 42 with all scores below 23. The branches of Judicial Ditch 15 all had scores of zero for the pioneer, headwater, sensitive, and minnow metrics (Figure 144). The most common fish collected at each station were brook sticklebacks at station 12UM053, creek chubs at station 12UM054, and black bullhead at station 12UM056.

Station 12UM055 located upstream of the Hector WWTP had a biological score of 15.7 and a specific conductance value of 799, while station 12UM052 downstream of the Hector WWTP in fish class 5 had an IBI score of 24.3 with a specific conductance value of 887 on July 17 2012. Both stations are on AUID -513 which has a class 7 use class. Sampled on August 7, 2012, station 12UM055 had a MIBI score of 27 while station 12UM052 had an IBI score of 13.5.

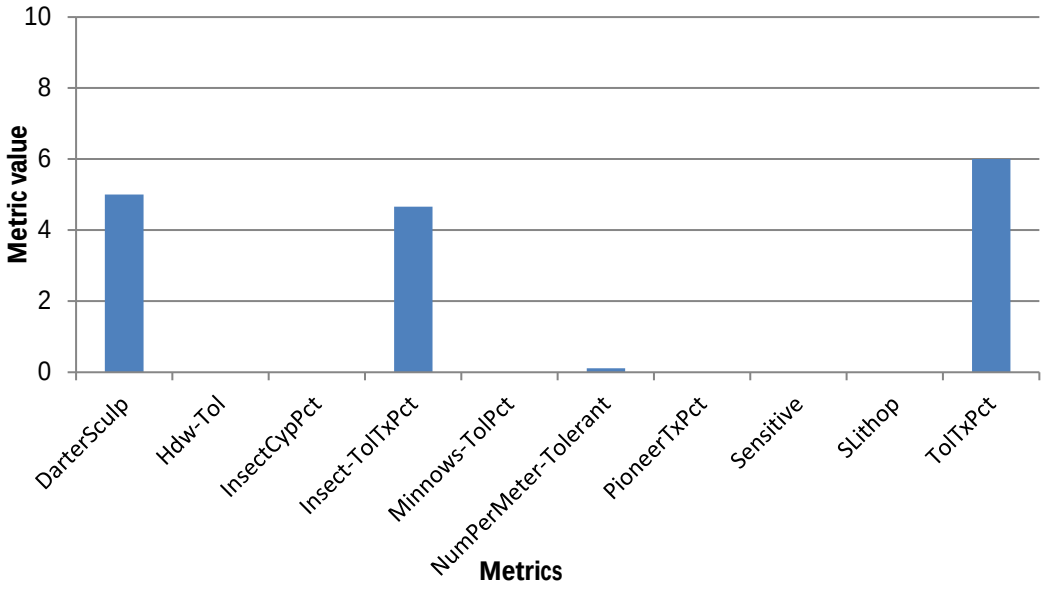

Figure 143. Fish metrics for Judicial Ditch 15 at station 12UM060

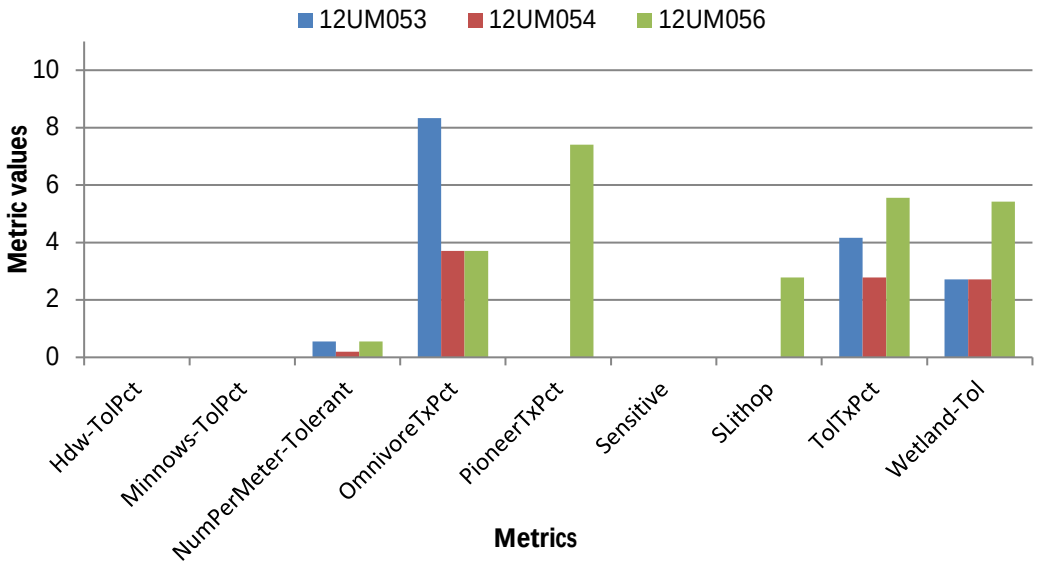

Figure 144. Fish metrics for Judicial Ditch 15 branches

Only stations 12UM056 and 12UM060 were sampled for macroinvertebrates, as the other two stations had insufficient flow. Both stations were in macroinvertebrate class 7 with scores well below the threshold of 38 (Figure 145). The highest metric score possible was 10, with a high score of five for predators at station 12UM060. Scores were uniformly low at both stations, particularly the collector-filterer, caddisfly (Tricoptera) and intolerant metrics where both stations scored zero.

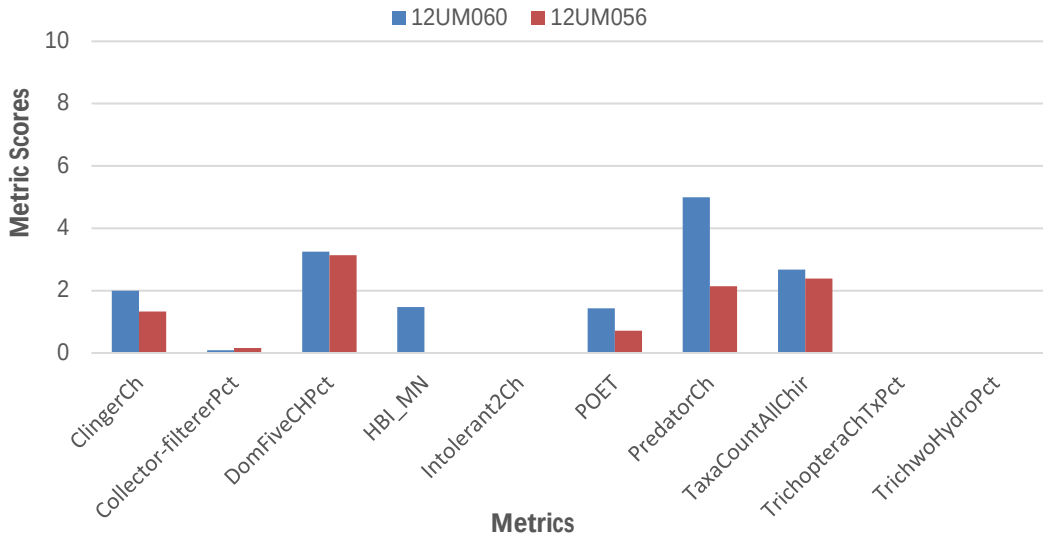

Figure 145. Macroinvertebrate metric scores

Phosphorus/Eutrophication

Phosphorus data is limited on Judicial Ditch 15 and its branches, however values were taken both after rain events and during base flow conditions. Values ranged from 0.038 mg/L to 1.33 mg/L. The highest value was collected at station 12UM056 during July. Of the 16 samples, 50% of the values were above the standard of phosphorus in the southern region is 0.150 mg/L. A tile inlet into station 12UM053 had a phosphorus value of 0.287 mg/L. Algae was thick at station 12UM053 (Figure 146), station 12UM056, and station 12UM060 (Figure 147).

Figure 146. Algae at station 12UM053 (July 11, 2012)

Figure 147. Algae at station 12UM060 (July 12, 2012)

Continuous data was collected at station 12UM060. There were no DO values below 5 mg/L or elevated DO flux during deployment, however DO values of 15.66-18.58 mg/L were collected on four different days. Elevated values this high are often an indication of DO flux. The BOD at station 12UM056 was 7.1 mg/L and 2.3 mg/L at station 12UM054 (just below the standard of 3 mg/L). Station 12UM053 had a lower BOD value at 1.7 mg/L. The daily flux of pH was all below 0.14.

All tributaries had percentages of zero sensitive fish, darters, and intolerant macroinvertebrate percentages. All of the stations were comprised of more than 70% tolerant fish species with the highest percentage at the two visits at station 12UM054. The percentage of omnivorous fish which have a positive relationship with eutrophication was 8.45 to 70%. The highest percentage was at station 12UM060 where phosphorus and BOD values were highest. The percentage of EPT individuals was low at the two stations with macroinvertebrate data, while the abundance of dominant two taxa were elevated when compared to class averages. Based on the percentage of sensitive, darter, and tolerant fish and EPT percent eutrophication is a stressor to Judicial Ditch 15 and its tributaries.

Table 48. Phosphorus related metrics

Stations	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct	Invert Taxa	EPT Pct	Dominant 2 Invert Taxa Pct
12UM060	0	18.18	72.73	45.45	28	0.33	60.33
12UM056	0	0	76.67	70	27	6.27	57.68
Average for fish class 7 streams	**8.16**	**5.21**	**70.59**	**22.40**			
12UM053	0	18.31	80.28	8.45	_	_	_
12UM054 (7-12-12)	0	0	91.07	12.50	_	_	_
12UM054 (8-8-12)	0	0	100	53.85	_	_	_
Average for fish class 6 streams	**15.13**	**6.34**	**66.59**	**16.87**			
Average for invert class 7 streams					**32.34**	**19.37**	**49.31**
Expected response to increased TP stress	↓	↓	↑	↑	↓	↑	↑

Lack of habitat

Habitat availability is lacking in Judicial Ditch 15 and its' tributaries; the MSHA scores taken during biological sampling were poor at all sampling sites. The dominance of fine sediments and lack of channel developmental and depth variability were the main contributors to the low scores. All of the stations exclusively had silt substrate and none of them had any shade cover. Cobble and gravel presence also has a positive relationship with a higher fish IBI. Stations 12UM053 and 12UM060 were filled with choking vegetation that inhibits fish movement. This relationship is mirrored by the macroinvertebrate community, where the number of clinger taxa decrease aligns with the increase in percent fines.

The slow velocity at all four stations creates a lack of enough stream power to move the sediment, which results in accumulation. Measurements with a rod averaged 56 cm of silt at station 12UM060 with measurements up to 68 cm. The lack of any coarse substrates results in the lack of simple lithophilic spawners throughout the stations. There was also a lack of darters, sculpins, riffle, and benthic insectivores. The darter and sculpin percentages are inflated at stations 12UM053 and 12UM060 due to the presence of johnny darters, a tolerant darter. The majority of fish collected were tolerant at all four stations, with stations comprised of 70% or more tolerant fish. The preponderance of evidence shows that the predominance of fine sediments and lack of habitat are a stressor to the fish community.

Table 49. Habitat related metrics

Stations	SLithophilic Spawners Pct	DarterSculpin Pct	Tolerant Fish Pct	Riffle Pct	Benthic Insectivore Pct
12UM053	0	18.31	80.28	0	18.31
12UM054 (7-12-12)	0	0	91.07	0	0
12UM054 (8-8-12)	0	0	100	0	0
Average for fish class 6 streams	**21.68**	**7.75**	**66.56**	**11.87**	**9.72**
12UM056	3.33	0	76.67	3.33	0
12UM060	0	18.18	72.73	0	18.18
Average for fish class 7 streams	**14.90**	**5.41**	**70.64**	**8.41**	**6.54**
Expected response with habitat stress	↓	↓	↑	↓	↓

Macroinvertebrate data was collected only at stations 12UM056 and 12UM060. The percentage of clingers was very low at both stations. Clingers use firm substrates as habitat, which were not available at these stations. Burrowers and sprawlers both utilize fine sediments, which are abundant at these stations. The percentages of burrowers were above average at both stations while sprawler percentages were both below average, when they would be expected to be higher. The percentage of climbers were both well above average, particularly at station 12UM060 (Figure 148). Climbers live on macrophytes, and station 12UM060 had choking vegetation providing a lot of habitat. Overhanging vegetation was also the only habitat sampled due to dominance. A lack of habitat is also a stressor to the macroinvertebrate community.

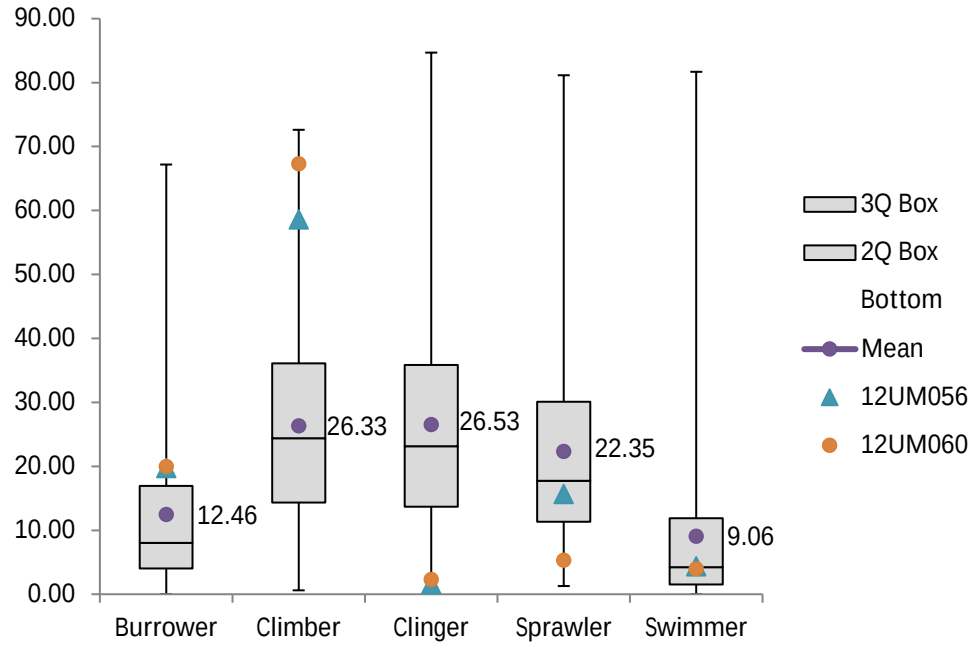

Figure 148. Habitat metrics

Altered hydrology

The tributaries to Buffalo Creek in this HUC are all channelized (Figure 149). Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency, increasing the impact of high flow events and increasing the intensity of low flow periods, both of which affect biological communities. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat.

Figure 149. Channelization at station 12UM053 (September 1, 2011)

Benthic insectivore and simple lithophilic species can decrease with channelization as bedload increases. Generalized fish species, which are adaptable to different habitats through generalized food preferences, are positively correlated with channelization. The average percentage for generalized fish in class 7 waters was 36.44%. Two of the stations were in fish class 7 and had a general percentage range of 63.64% at station 12UM060 to 75% at station 12UM060. The average for fish class 6 was 41.54% and the two stations had a range of 30.99% to 73.21%. This corresponds with the simple lithophilic spawner and benthic insectivore percentages discussed in the habitat section.

Channelization is connected to and contributing to the lack of habitat. The effects of altered hydrology seem to be contributing to the increase of generalized fish percentages, which are more adaptable to changing conditions and food sources. Other contributing factors are likely affecting the high percentage of general fish species. Altered hydrology is a contributing stressor to lack of habitat.

Ionic strength

Specific conductance values in the watershed are highest at station 12UM054, a tributary to Judicial Ditch 15. The highest specific conductance concentration was recorded in July in 2014 (1199 uS/cm). The ecoregion norm for the Western Corn Belt Plain (based on the 75th percentile of annual specific conductance values) is 820 (McCollor et. al, 1993). Station 12UM055 located upstream of the Hector WWTP had a specific conductance value of 799, while station 12UM052 downstream of the Hector WWTP had a specific conductance value of 887 on July 17, 2012. Both stations are on AUID -513 which has a class 7 use class. Both stations were sampled on August 7, 2012, and had conductance values of 933 and 931 respectively. The highest recorded value in this section was 1875 µS/cm in September of 2013. Continuous data collected at station 12UM060 over 10 days in 2014 showed specific conductance values all higher than 1060 uS/cm (Figure 150).

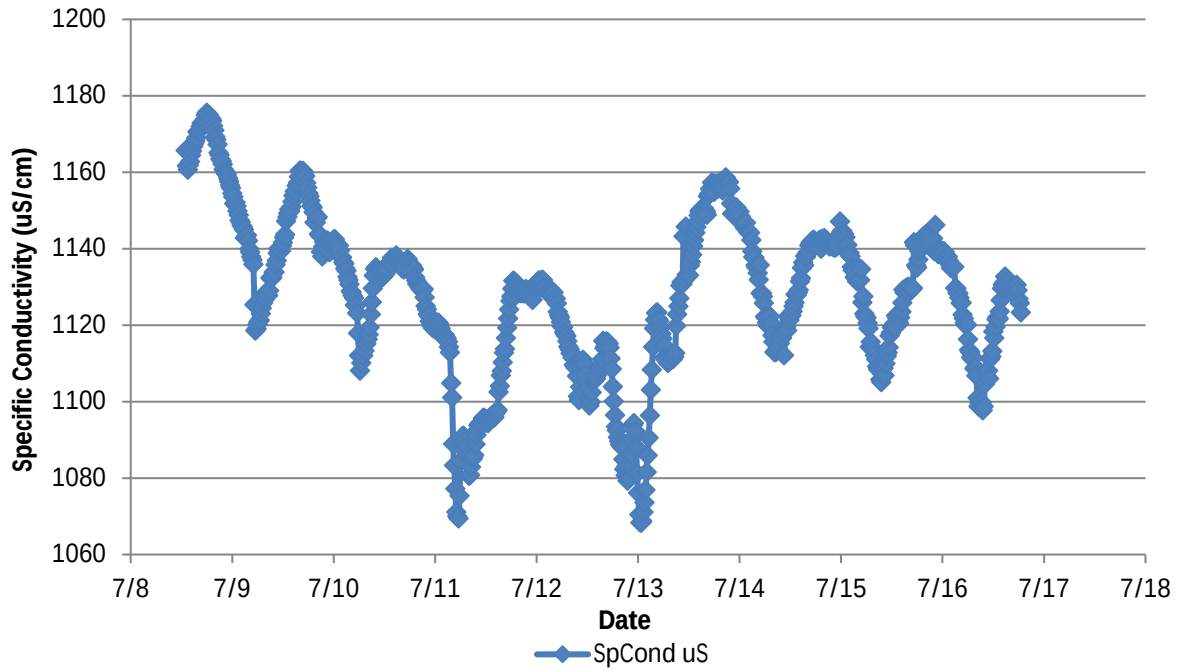

Figure 150. Continuous data at station 12UM060

Increased ionic strength can cause an increase in ion tolerant taxa and an increase in ion tolerant life stages, causing fish and invert impairments, but it is difficult to separate this effect from other stressors. As salinity increases, macroinvertebrate taxa richness and ephemeroptera has been found to decrease (Piscart et al., 2005). Echols et. al (2009) also found a reduction in EPT abundance as conductivity values increased. A study of Minnesota biological data and stressor linkages found that sites with conductivities higher than 1,000 µS/cm rarely meet the biological thresholds for general use streams (MBI, 2012). Stations 12UM054, 12UM056, and 12UM060 have all had recorded values of specific conductance of 1,000 µS/cm; all visits failed to meet the threshold. Stations 12UM056 and 12UM060 had both EPT% and taxa counts lower than average for their macroinvertebrate class. Stations 12UM053 and 12UM054 were not sampled for macroinvertebrates. While these metrics also respond to other stressors, elevated ionic strength is likely a contributing stressor to the macroinvertebrate community.

Nitrogen

Elevated values of nitrogen were sampled at all of the sites in this watershed. Values on Judicial Ditch 15 itself ranged from 6.6 mg/L in 2012 to 24 mg/L in 2014. The highest value, 24 mg/L was taken after a rain event at station 12UM060 (S008-010). The values at the tributaries ranged from 13 to 23 mg/L at station 12UM053, from 3.2 to 22 mg/L at station 12UM054, and 3.5 to 20 mg/L at station 12UM056. A tile inlet into station 12UM053 had a nitrate value of 14 mg/L.

Sensitive species have a negative relationship with nitrate, but sensitive species are also affected by DO and phosphorus. Better relationships have been made with respect to macroinvertebrate impairment and nitrate concentration. Nitrate intolerant macroinvertebrate were zero at both stations sampled for macroinvertebrates.

Nitrate tolerant individuals comprised of 0.8% (12UM056) to 97% (12UM054) of the fish communities. Nitrate intolerant taxa was zero at all stations. Nitrate tolerant macroinvertebrate individuals at the two stations sampled were 28.1% (12UM060) and 75.8% (12UM056) tolerant nitrate individuals.

Only two of the four stations were sampled for macroinvertebrates. While station 12UM056 had a high percentage of nitrogen tolerant species, they were much lower at station 12UM060. Neither site had any nitrogen intolerant species or Tricoptera individuals. The elevated nitrogen levels are of concern, but the limited biological data does not have a consistent response. Nitrate as a stressor is inconclusive, but nitrate mitigation in this area is important.

Table 50. Nitrate related metrics

Stations	Nitrogen Tolerant Pct	Nitrogen Intolerant Invert Taxa	TricopterawoHydroPct	Taxa Count
12UM060	28.1	0	0	28
12UM053	_	_	_	_
12UM054	_	_	_	_
12UM056	75.8	0	0	27
Expected response to increased nitrate stress	↑	↓	↓	↓
Average for invert class 7 streams	60.72	1.06	1.5	32.3

AUID summary

The main stressors of Judicial Ditch 15 and its tributaries upstream of Hector were eutrophication, lack of habitat, and ionic strength.

5. Conclusions and recommendations

A summary of stressors to the biological communities in the South Fork Crow River Watershed is found in Table 50. Strength of evidence analysis was completed for each AUID and parameter, and is available upon request. The main stressors to the South Fork Crow River Watershed are eutrophication and lack of physical habitat for biological communities.

Table 51. Summary of stressors in the South Fork Crow River Watershed

				Stressors						
Stream name	AUID #	10-digit HUC	Biological	Eutrophication	DO	Nitrate	TSS	Habitat	Altered hydrology	Ionic strength
South Fork Crow River	658	Headwaters South Fk Crow R	Macroinvertebrate IBI, Fish IBI	I			I	I	o	
South Fork Crow River	659	City of Hutchinson-South Fk Crow R	Macroinvertebrate IBI, Fish IBI				I		◊	
South Fork Crow River	510	City of Lester Prairie South Fk Crow R	Macroinvertebrate IBI, Fish IBI	I	I					
South Fork Crow River	511	City of Lester Prairie South Fk Crow R	Macroinvertebrate IBI, Fish IBI	I			I			
South Fork Crow River	508	South Fork Crow R	Macroinvertebrate IBI, Fish IBI	I	◊			◊	I	
Buffalo Creek	502	Judicial Ditch 28A	Macroinvertebrate IBI, Fish IBI	I	◊	I	I	I	◊	
Buffalo Creek	638	Buffalo Creek	Macroinvertebrate IBI, Fish IBI	I			I	I		
Judicial Ditch 67	504	Judicial Ditch 28A	Macroinvertebrate IBI, Fish IBI	I	I	I		I	◊	◊
Judicial Ditch 15	509	Judicial Ditch 15	Macroinvertebrate IBI, Fish IBI	I		o		I	◊	◊
Bear Creek	515	City of Lester Prairie South Fk Crow R	Macroinvertebrate IBI, Fish IBI	I	◊			I		
County Ditch 4	528	Judicial Ditch 28A	Macroinvertebrate IBI, Fish IBI	I	I	I		I	◊	◊
Unnamed Creek	533	City of Hutchinson-South Fk Crow R	Macroinvertebrate IBI, Fish IBI	I	I			I	◊	
Belle Creek	549	City of Hutchinson-South Fk Crow R	Macroinvertebrate IBI, Fish IBI	I	I			I	◊	
Judicial Ditch 18	550	City of Hutchinson-South Fk Crow R	Fish IBI	I	I			I	◊	
Judicial Ditch 1	572	City of Lester Prairie South Fk Crow R	Macroinvertebrate IBI, Fish IBI	I	◊			I		

				Stressors						
Stream name	AUID #	10-digit HUC	Biological	Eutrophication	DO	Nitrate	TSS	Habitat	Altered hydrology	Ionic strength
Unnamed Creek	585	City of Lester Prairie South Fk Crow R	Fish IBI	I	◊			I		
Judicial Ditch 8	591	Buffalo Creek	Macroinvertebrate IBI, Fish IBI	I				I	◊	
State Ditch Branch 2	608	Headwaters South Fk Crow R	Macroinvertebrate IBI, Fish IBI	I				I	o	
County Ditch 18	609	City of Hutchinson-South Fk Crow R	Macroinvertebrate IBI, Fish IBI	I	I			I	◊	
County Ditch 24A	610	Headwaters South Fk Crow R	Fish IBI	I				I	o	
County Ditch 26/27	611	City of Lester Prairie South Fk Crow R	Macroinvertebrate IBI, Fish IBI	I	◊			I		
King Creek	613	City of Hutchinson-South Fk Crow R	Fish IBI	I	I			I	◊	
Unnamed Creek	614	Buffalo Creek	Fish IBI	I	I			I	◊	
Unnamed Creek	615	Buffalo Creek	Fish IBI	I				I	◊	
Unnamed Creek	617	City of Lester Prairie South Fk Crow R	Fish IBI	I	◊			I		
Unnamed Creek	618	South Fork Crow R	Macroinvertebrate IBI, Fish IBI	I	I			I	◊	
Unnamed Creek	621	City of Hutchinson-South Fk Crow R	Macroinvertebrate IBI	I	I			I	◊	
Unnamed Creek	622	City of Lester Prairie South Fk Crow R	Fish IBI	I	◊			I		
Unnamed Creek	623	City of Hutchinson-South Fk Crow R	Macroinvertebrate IBI, Fish IBI	I	I			I	◊	
Unnamed Creek	624	South Fork Crow R	Macroinvertebrate IBI, Fish IBI	I	I			I	◊	
Judicial Ditch 9	625	Judicial Ditch 28A	Macroinvertebrate IBI, Fish IBI	I	I	I		I	◊	◊
Judicial Ditch 15 Branch	626	Judicial Ditch 15	Fish IBI	I		o		I	◊	◊
Judicial Ditch 15 Branch	627	Judicial Ditch 15	Fish IBI	I		o		I	◊	◊
Judicial Ditch 15 Branch	628	Judicial Ditch 15	Macroinvertebrate IBI, Fish IBI	I		o		I	◊	◊
Unnamed Ditch	630	Judicial Ditch 28A	Macroinvertebrate IBI, Fish IBI	I	I	I		I	◊	◊
County Ditch 7A	631	Judicial Ditch 28A	Macroinvertebrate IBI, Fish IBI	I	I	I		I	◊	◊

Stream name	AUID #	10-digit HUC	Biological	Stressors						
				Eutrophication	DO	Nitrate	TSS	Habitat	Altered hydrology	Ionic strength
Silver Creek (County Ditch 13)	641	City of Lester Prairie South Fk Crow R	Macroinvertebrate IBI, Fish IBI	I	◊			I		
Otter Creek	642	City of Lester Prairie South Fk Crow R	Fish IBI	I	◊			I		
Otter Creek	643	City of Lester Prairie South Fk Crow R	Fish IBI	I	◊			I		
County Ditch 33	645	Buffalo Creek	Macroinvertebrate IBI, Fish IBI	I				I	◊	
County Ditch 9	648	South Fork Crow R	Macroinvertebrate IBI, Fish IBI	I	I			I	◊	
Pioneer Creek	654	South Fork Crow R	Macroinvertebrate IBI, Fish IBI	I	I			I	◊	
Unnamed Creek	656	City of Hutchinson-South Fk Crow R	Macroinvertebrate IBI, Fish IBI	I	I			I	◊	

● = probable stressor; o = inconclusive stressor; ◊ = contributing; blank = not a stressor

5.1. Recommendations

The fish and macroinvertebrate communities are reflective of the effects of multiple stressors. Areas of concern throughout the watershed are streams with intense macrophytes and algae growth (Figure 151) and substrates embedded with fine sediments (Figure 152). Nutrient values are elevated, with the highest values captured from tile drains. Nutrient loading can create an increase in phytoplankton (measured as sestonic chlorophyll); along with the contributing factors of temperature, light, and residence time (Heiskary et al., 2013). Ideal conditions for nutrient enrichment exist in the watershed; streams with little shade, elevated temperatures and high nutrient loads. Phosphorus, chlorophyll-a, DO flux values are all above the proposed water quality standards in areas, and pH values exceed the standard.

Figure 151. Algae growth (July 31, 2014)

Figure 152. Fine sediments covering gravel (September 5, 2013)

Current problems include field drainage directly into waterbodies and tile drainage. Water samples were collected at nine different tile outlets, including tile lines draining into tributaries, Buffalo Creek, and the South Fork Crow River directly. The highest nitrate values were collected in June (three values above 22 mg/L). Elevated phosphorus levels were found to be draining out of tile lines during spring snowmelt (0.725 and 0.522 mg/L). Another observed problem is lack of grass waterways, where nutrients and sediment can freely flow into streams (Figure 153). Intercepting and removing nutrient inputs as much as possible should be pursued throughout the entire watershed.

Figure 153. Field runoff into Buffalo Creek (June 19, 2014)

Bedded sediment is affecting the habitat availability, and the undercutting of stream-banks is contributing to the influx of fine sediment. Areas of severe erosion were present in the watershed. The suspended sediment and bedded sediment are closely tied and need to be addressed together. The aquatic communities would benefit from a decrease in fine sediment; the multiple causes of bank erosion need to be addressed. Increased drainage creates flashy flow events; where high and low flows are amplified. During increased drainage and higher flows, water barrels through channels eroding banks as they flow downstream. Along with altered hydrology, lack of water storage, and no to poor quality vegetative buffers are drivers of bank erosion. These root causes of erosion are causing both suspended and bedded sediment. Current problems observed in the watershed include lack of buffers and cover crops, allowing sediments to be carried right into streams through wind and bank erosion (Figure 154 and Figure 155).

Figure 154. Field without cover crops next to stream (April 10, 2014)

Figure 155. Small buffer causing erosion (May 28, 2014)

Protection is needed throughout the year, not just in the summer season during rain events. Wind erosion from open fields without conservation tillage left a large swath of ditches with a dark layer of soil on top of the snow that melts right into the water once the temperature warms (Figure 156).

Figure 156. Sediment from wind erosion covering snow covered stream (March 31, 2014)

There are many areas in need of buffers (Figure 157). The new buffer law should help protect streams from runoff. Areas on Silver Creek and the South Fork Crow River upstream of Hutchinson represent healthy buffers that should be implemented throughout the watershed (Figure 158).

Figure 157. Pastureland without buffer

Figure 158. Stream reaches with good buffers May 28, 2014 (top) and August 8, 2014 (bottom)

Nutrients (nitrate, phosphorus, pH, and chlorophyll-a), DO, sediments, altered hydrology, and a lack of habitat are the main stressors to both communities and should be the primary focus of restoration efforts in the watershed. The contributing stressor of specific conductance should be addressed. The DNR recommends that restoration efforts should focus attention on sources not symptoms of watershed issues (bank stability, etc.). Important practices to implement include increasing water storage, proper culvert and bridge sizing, riparian buffers with deep roots, and restoring connectivity and natural stream channels.

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7. Appendix

7.1 Strength of evidence

Strength of evidence scoring and analysis was completed for each AUID in the watershed and is available upon request.

Table A1. Values used to score evidence in the Stressor Identification Process.

Rank	Meaning	Caveat
+++	*Convincingly supports*	*but other possible factors*
++	*Strongly supports*	*but potential confounding factors*
+	*Some support*	*but association is not necessarily causal*
0	*Neither supports nor weakens*	*(ambiguous evidence)*
-	*Somewhat weakens support*	*but association does not necessarily reject as a cause*
--	*Strongly weakens*	*but exposure or mechanism possible missed*
---	*Convincingly weakens*	*but other possible factors*
R	*Refutes*	*findings refute the case unequivocally*
NE	*No evidence available*	
NA	*Evidence not applicable*	
D	*Evidence is diagnostic of cause*	

Table A2. Strength of evidence scores for various types of evidence

Types of Evidence	Possible values, high to low
Evidence using data from case	
Spatial / temporal co-occurrence	+, 0, ---, R
Evidence of exposure, biological mechanism	++, +, 0, --, R
Causal pathway	++, +, 0, -, ---
Field evidence of stressor-response	++, +, 0, -, --
Field experiments / manipulation of exposure	+++, 0, ---, R
Laboratory analysis of site media	++, +, 0, -
Temporal sequence	+, 0, ---, R
Verified or tested predictions	+++, +, 0, -, ---, R
Symptoms	D, +, 0, ---, R
Evidence using data from other systems	
Mechanistically plausible cause	+, 0, --
Stressor-response relationships in other field studies	++, +, 0, -, --
Stressor-response relationships in other lab studies	++, +, 0, -, --
Stressor-response relationships in ecological models	+, 0, -
Manipulation of exposure experiments at other sites	+++, +, 0, --
Analogous stressors	++, +, -, --
Multiple lines of evidence	
Consistency of evidence	+++, +, 0, -, --
Explanatory power of evidence	++, 0, -

7.2 Biological metrics used in the South Fork Crow

Table A3. Biological metrics included in the SID process.

	Metric description	Explanation	Expected response to stress
Fish			
BenInsect-Tol	Relative abundance that are non-tolerant benthic insectivore species (excludes tolerant species)	Benthic insectivores feed from benthic environments and are found with clean gravel substrates	*Decrease*
Darter	Relative abundance of darter species	Darters require riffle habitat and are considered sensitive to water quality degradation	*Decrease*
DarterSculpSuc	Relative abundance that are darter, sculpin & round bodied sucker species	Darter, sculpin, and round bodied suckers require shallow riffle habitats	*Decrease*
DetNWQTX	Relative abundance of taxa that are detritivores	Detritivores are bottom feeders of detritus (dead and decomposing organic matter)	*Decrease*
DomTwo	Combined relative abundance of two most abundant taxa	Taxa richness decreases with water quality degradation and become dominated by a few species	*Increase*
Exotic	Richness of exotic species	Exotic species are often tolerant of water quality degradation	*Increase*
General	Relative abundance that are generalist species	Generalist species are tolerant of water quality degradation	*Increase*
Hdw-Tol	Relative abundance that are headwater species (excludes tolerant species)	Headwater species are sensitive to changes in flow and habitat	*Decrease*
Herbv	Relative abundance that are herbivore species	Herbivorous species eat only plants	*Decrease*
Insect-Tol	Relative abundance that are insectivorous (excludes tolerant species)	Insectivore species are dependent on a stable invertebrate food base	*Decrease*
InsectCyp	Relative abundance that are insectivorous Cyprinids	Insectivore minnows are dependent on a stable invertebrate food base	*Decrease*
MA>3 years-Tol	Relative abundance of females of mature age >=3 excluding tolerant taxa	Species that have late maturity require stable conditions	*Decrease*
Minnows-TolPct	Relative abundance that are Cyprinidae (minnows) (excludes tolerants)	Many minnow species are sensitive to water quality degradation	*Decrease*
NestGuarding	Relative abundance of nest-guarding species	Species that do not require coarse substrate for nests	Increase
NumPerMeter-Tol	Number of individuals per meter of stream sampled (excludes individuals of tolerant species)	A healthy stream system has higher levels of non-tolerant fish present	Decrease
Omnivorous	Relative abundance that are omnivore species	Omnivorous species eat both plants and animals. They are tolerant of degradation	*Increase*
Perciform	Relative abundance of the order Perciformes	The order Perciformes includes sunfish, perch, and walleye. Sediment effects the growth of smallmouth bass	*Decrease*

	Metric description	Explanation	Expected response to stress
Piscivore	Relative abundance that are piscivore species	The presence of piscivores may indicate a stable system that supports lower trophic level organisms such as benthic macroinvertebrates and fish. Proper substrate will also benefit piscivores	*Decrease*
Pioneer	Relative abundance that are pioneer species	Pioneer species are able to thrive in unstable environments and are the first to invade after disturbance	*Increase*
Riffle	Relative abundance that are riffle-dwelling species	Riffle dwelling species are important indicators of available riffle habitat	*Decrease*
Sensitive	Relative abundance that are sensitive species	Species that are sensitive to disturbance. Often the first species to disappear	*Decrease*
SLithop	Relative abundance that are simple lithophilic spawners	Simple lithophilic spawners require clean gravel or cobble substrates for reproductive success	*Decrease*
SSpnTx	Relative abundance that are serial spawning species	Species that attain reproductive maturity at a very young age. The number of fast maturing individuals increases with disturbance	*Increase*
Tol	Relative abundance that are tolerant species	Tolerant fish species are able to survive generally adverse stream conditions	*Increase*
VTolTx	Relative abundance that are very tolerant species	Species that survive the most disturbed conditions	*Increase*
Wetland-Tol	Relative abundance that are wetland species	Wetland species thrive in low gradient systems dominated by a wetland riparian zones	*Decrease*
Macroinvertebrates			
Burrower	Relative abundance of burrowers in subsample	Burrower species "burrow" in fine sediment indicating potential siltation in riffles	*Increase*
Climber	Relative abundance of climbers in subsample	Climber species use habitat such as overhanging vegetation or woody debris	*Decrease*
Clinger	Relative abundance of climbers in subsample	Clinger species attach to rock or woody debris. Clingers may decrease in stream reaches with homogeneous substrate composition, velocity, and depth.	*Decrease*
Collector-Filterer	Relative abundance of collector-filterers in subsample	Collector-Filterer species filter organic material from the water	*Decrease*
Dominant2Invert Taxa	Relative abundance of dominant two taxa in subsample	Taxa richness decreases with water quality degradation and becomes dominated by a few species	*Increase*
DomFiveCH	Relative abundance of dominant five taxa in subsample (excluding all chironomids)	Taxa richness decreases with water quality degradation	*Increase*

	Metric description	Explanation	Expected response to stress
EPT	Relative abundance of Ephemeroptera, Plecoptera & Trichoptera individuals in subsample	EPT are a sensitive group of macroinvertebrates commonly used to measure overall health	*Decrease*
HBI_MN	A measure of pollution based on tolerance values		*Increase*
Legless	Relative abundance of legless individuals in subsample	Legless macroinvertebrates are tolerant species like midges/worms, and snails	*Increase*
Odonata	Relative abundance of Odonata (dragonflies) individuals in subsample	Odonata are a good indicator of water quality	*Decrease*
Plectoptera	Relative abundance of Plecoptera (stoneflies) individuals in subsample	Presence of Plecoptera is a sign of good water quality which require high DO levels	*Decrease*
POET	Taxa richness of Plecoptera, Odonata, Ephemeroptera, & Trichoptera	Stoneflies, Dragonflies, Mayflies, and Caddisflies which are all sensitive to pollution	*Decrease*
Predator	Taxa richness of predators	Predators are an important part of a stream ecosystem that eat other animals	*Decrease*
Sprawler	Relative abundance of sprawler individuals in subsample	Sprawlers live on the surface of floating plants or fine sediments. Many are adapted to keep respiratory surfaces free of silt	*Increase or Decrease*
Swimmer	Relative abundance of swimmer individuals in subsample	Swimmers require low velocity water and their abundance or decline indicate change in water flow or pools	*Decrease*
TaxaCount	Total taxa richness of macroinvertebrates	A healthy stream system has a variety of macroinvertebrates present. The number increases with habitat availability and water quality	*Decrease*
TricopteraChTx	Relative percentage of taxa belonging to Trichoptera (caddisflies)	Presence of Tricoptera is a sign of good water quality	*Decrease*
TricopterawoHydro	Relative abundance of non-hydropsychid Trichoptera individuals in subsample	Tricoptera that do not spin nets and are most sensitive to pollution	*Decrease*