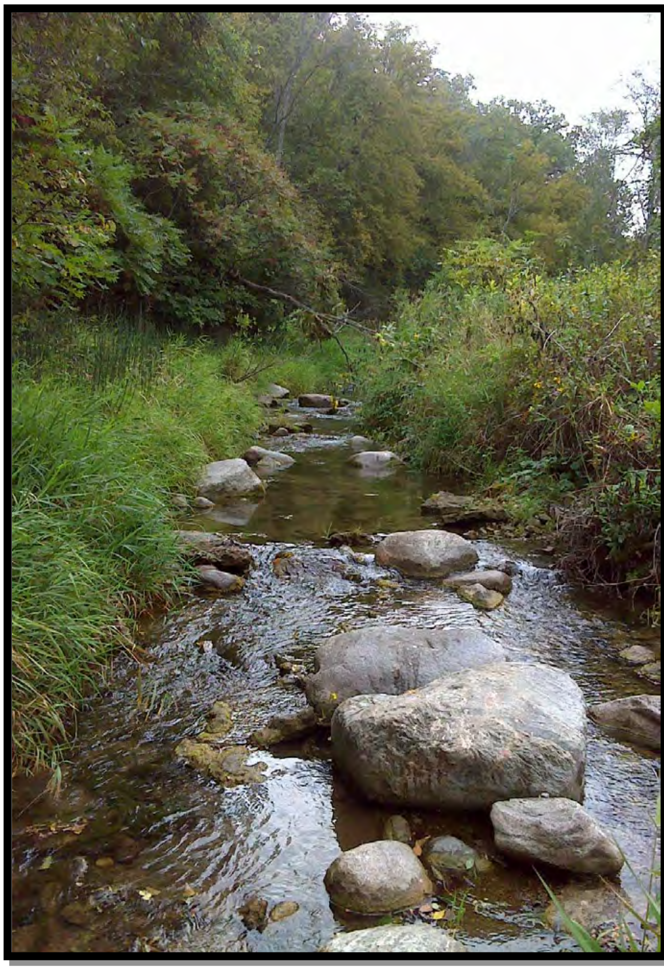
Hawk Creek Watershed Biotic Stressor Identification



Minnesota Pollution Control Agency

September 2013

Legislative Charge

Minn. Statutes § 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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Cover photo: Clockwise from left: Riffle in Smith Creek (Mike Koschak), Channelized stream section in County Ditch 119 (Mike Koschak), Algae growth in County Ditch 36 (Hawk Creek Watershed Project)

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Executive Summary

This report summarizes stressor identification work in the Hawk Creek watershed.

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

Over the past few years, the Minnesota Pollution Control Agency (MPCA) has substantially increased the use of biological monitoring and assessment as a means to determine and report the condition of rivers and streams. The basic approach is to evaluate fish and aquatic invertebrates (mostly insects), and related habitat conditions, at sites throughout a major watershed. The resulting information is used to produce an index of biological integrity (IBI). IBI scores can then be compared to standards. Segments of streams and rivers with low IBI scores are deemed "impaired."

The purpose of stressor identification is to interpret the data collected during the biological monitoring and assessment process. This analysis may provide insight as to why one stream has a low IBI score, while another has a high score. It considers causal factors – negative ones harming fish and insects, and positive ones leading to healthy biology. Stressors may be physical, chemical, or biological.

Located in west-central Minnesota, the Hawk Creek watershed encompasses approximately 659,200 acres. This watershed includes many streams that flow into Hawk Creek, but also many direct tributaries to the Minnesota River. Much of the watershed is channelized and in poor biological condition.

Four streams in this watershed were found to be impaired for aquatic life due to their biological communities. These streams include Smith Creek, County Ditch 119, County Ditch 36, and Unnamed Creek.

After examining many candidate causes for the biological impairments, the following stressors were identified for the impaired streams:

Smith Creek

- High Nitrates
- Lack of Habitat

County Ditch 119

- Low Dissolved Oxygen
- High Phosphorus
- High Nitrates
- Altered Hydrology
- High Turbidity/TSS
- Lack of Habitat

County Ditch 36

- Low Dissolved Oxygen
- High Phosphorus
- Altered Hydrology
- Lack of Habitat

Unnamed Creek

- Low Dissolved Oxygen
- High Phosphorus
- Altered Hydrology
- Lack of Habitat

Introduction

Organization framework of stressor identification

The Stressor Identification (SID) process is used in this report to weigh evidence for or against various candidate causes of biological impairment (Cormier et al., 2000). The SID process is prompted by biological assessment data indicating that a biological impairment has occurred. Through a review of available data, stressor scenarios are developed that may accurately characterize the impairment, the cause, and the sources/pathways of the various stressors (Figure 1). Confidence in the results often depends on the quality of data available to the SID process. In some cases, additional data collection may be necessary to accurately identify the stressor(s).

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

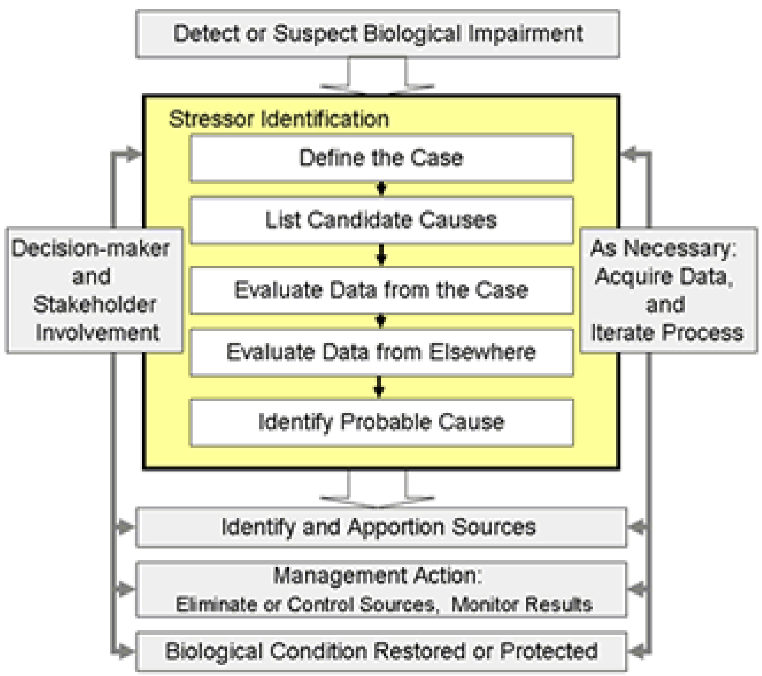


Figure 1. Conceptual model of stressor identification (SID) process

Completion of the SID process does not result in completed Total Maximum Daily Load (TMDL) allocations. The product of the SID process is the identification the stressor(s) for which the TMDL load allocation will be developed. For example, the SID process may help investigators identify 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 address and correct the impaired condition.

Elements of stream health

The elements of a healthy stream consist of five main components (Figure 2); stream connections, hydrology, stream channel assessment, water chemistry, and stream biology. The following flowchart shows the five components of a healthy stream. If one or more of the components are unbalanced, the stream ecosystem fails to function properly and is listed as an impaired water body. Table 1 shows common stream stressors of fish and invertebrate communities.

The Elements of Stream Health

Stream Health is linked to the 5 main categories below. The MPCA and local partners examine many interrelated factors to identify stressors

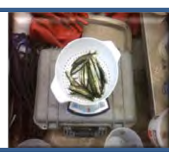
Stream Connections
Examples: dams, culverts and drainage tiles

Hydrology
Examples: stream flow and runoff

Stream Channel Assessment
Example: Bank erosion and Channel Stability

Water Chemistry
Example: Dissolved oxygen, nutrients and temperature

Stream Biology
Example: fish and bugs



What conditions stress our streams?

Several factors can stress the biological condition within streams.

Too much sediment
Soil and other particles in water can make it difficult for fish and invert to breathe, feed and reproduce. Sediment can fill pools and smoother gravel and rock habitat

Low Oxygen
Fish and macro invertebrates need dissolved oxygen in the water to breathe and survive.

Temperature
Stream temperature affects metabolism of fish, especially cold water fish species and also influences oxygen content in water.

Lack or Loss of Habitat
Habitat affects all aspects of survival for fish and macro invertebrates. Habitat encompasses places to live, food to eat, places to reproduce and means of protection.

Increased nutrients
Excess nutrients, such as phosphorus and nitrogen, cause excessive algal blooms which can lead to high daily fluctuations in dissolved oxygen concentrations. High amounts of nitrogen can be toxic to fish and macro invertebrates.

Figure 2. The five components of stream health and conditions that stress streams

Common stream stressors to biology (fish, invertebrates)

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 invertebrates 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 fate and transport of chemicals.
Stream Channel Assessment	**Loss of Habitat due to excess sediment** **Elevated levels of TSS** · Loss of dimension/pattern/profile · Bank erosion from instability · Loss of riffles due to accumulation of fine sediment · Increased turbidity and or TSS	Habitat is degraded due to excess sediment moving through system. There is a loss of clean rock substrate from embeddedness of fine material and a loss of intolerant species.
Water Chemistry	**Low Dissolved Oxygen Concentrations** **Elevated levels of TSS** · Increased nutrients from human influence · Widely variable DO levels during the daily cycle · Increased algal and or periphyton growth in stream · Increased nonpoint pollution from urban and agricultural practices · Increased point source pollution from urban treatment facilities	There is a loss of intolerant species and a loss of diversity of species, which tends to favor species that can breathe air or survive under low DO conditions. Biology tends to be dominated by a few tolerant species
Stream Biology	Fish and invertebrate communities are affected by all of the above listed stressors	If one or more of the above stressors are affecting the fish and invertebrate community, the IBI scores will not meet expectations and the stream will be listed as impaired

Table 1. The stream health component along with the associated stressor(s) and their link to biological health.

Hawk Creek Watershed

Report overview

The Hawk Creek watershed consists of 32 12-digit Hydrologic Unit Code (HUC) subwatersheds. For the purpose of this analysis the (32) 12-digit HUC subwatersheds were aggregating into 9 larger subwatersheds (Figure 3). This report describes the step-by-step analytical approach, based on the U.S. Environmental Protection Agency's (EPA) SID process, for identifying probable causes of impairment in a particular system.

This report describes the connection between the biological community and the stressor(s) causing the impairments. Stressors are those factors that negatively impact the biological community. Stressors can interact with each other and can be additive to the stress on the biota. The Minnesota River-Granite Falls Monitoring and Assessment Report is available and provides background information about the watershed and the results of recent monitoring and assessment at the 10-HUC scale.

This report includes a discussion of the data collected to support the determination of candidate stressors at the 14-digit HUC watershed level. A comprehensive review of biological, chemical, and physical data was performed to select probable causes for the impairments. The initial list of candidate causes was reduced after additional data analysis leaving seven candidate causes for final analysis in this report. The candidate causes for the biologically impaired streams in the Hawk Creek are listed below:

- Low dissolved oxygen
- High phosphorus
- High nitrates
- Altered hydrology
- High turbidity/total suspended solids
- Pesticides
- Lack of habitat

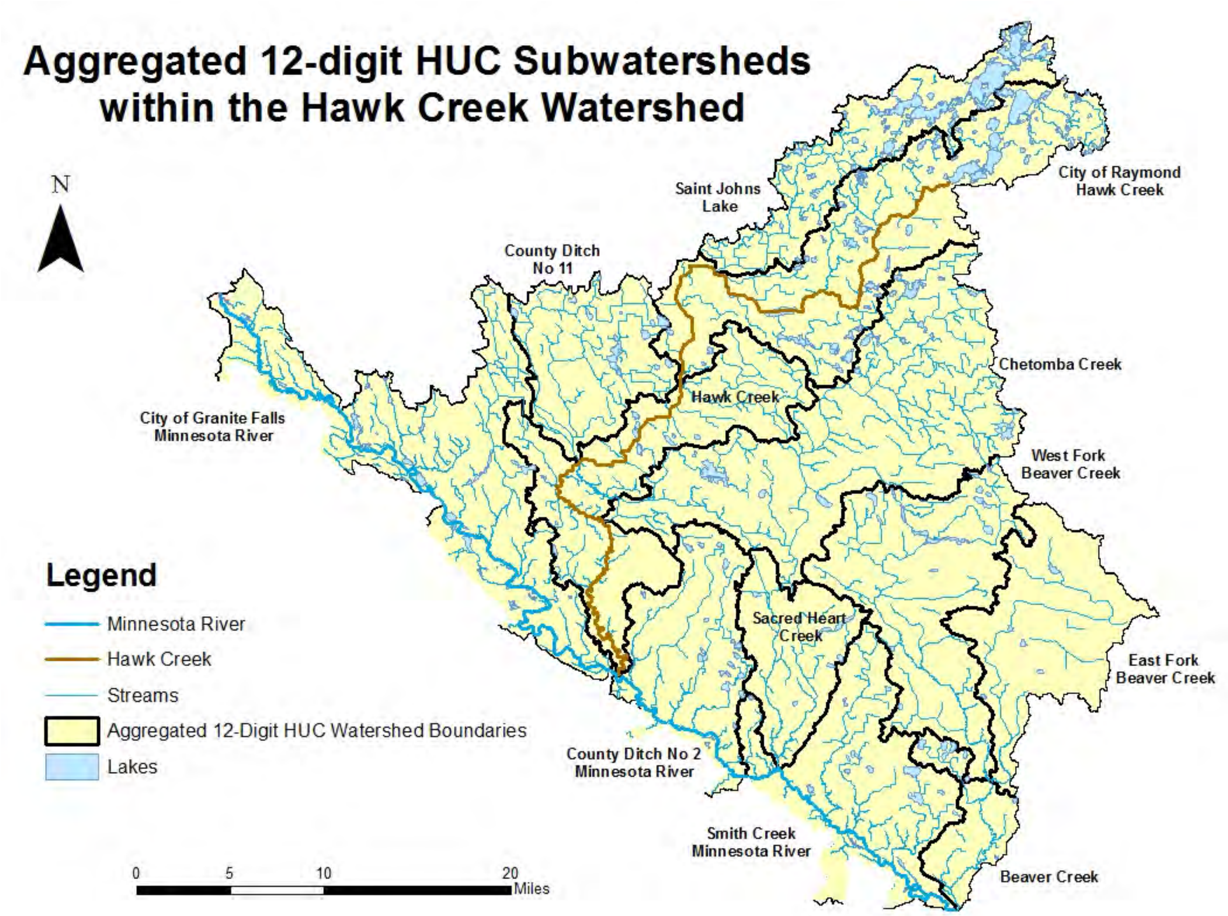


Figure 3. Map of aggregated 12-Digit HUC subwatersheds within the Hawk Creek watershed

Biological assessment

The Hawk Creek watershed was assessed in 2012 for aquatic recreation, aquatic consumption and aquatic life beneficial uses as part of the Minnesota River-Granite Falls watershed (8-Digit HUC: 07020004). Based on this investigation, it was determined that four stream reaches were determined to be impaired for fish and/or invertebrates, as part of the aquatic life use designation. Three of the impaired reaches are located on direct tributaries to the Minnesota River: Unnamed Creek, Smith Creek, and County Ditch 119. The other impairment was located on County Ditch 36 which is a tributary to Hawk Creek.

The Hawk Creek watershed had many instances where the fish and invertebrate IBI scores were below their respective threshold. However, many of these sampling stations are located on stream reaches that are more than 50 percent channelized. The MPCA does not currently assess channelized streams and these impairments are deferred until the implementation of Tiered Aquatic Life Use (TALU).

Summary of biological impairments

As part of the aquatic life use portion of the assessment, fish and invertebrates were assessed. The fish and invertebrates within each Assessment Unit Identification (AUID) were compared to a regionally developed threshold and confidence interval and utilized a weight of evidence approach. In the Hawk Creek watershed, four AUIDs are currently impaired for a lack of biological assemblage (Table 2). The data considered during the assessment process were collected from 2002-2011. Of the four listed AUIDs, three are impaired for both fish and invertebrates (County Ditch 36, County Ditch 119, and Unnamed Creek). One AUID (Smith Creek) is impaired only for invertebrates.

				Impairments	
Stream Name	**AUID #**	**HUC-12**	**Reach Description**	**Biological**	**Water Quality**
Unnamed creek	07020004-566	070200041007	Unnamed cr to Unnamed cr	Fish IBI, Invertebrate IBI	None
Smith Creek (County Ditch 125A)	07020004-617	070200041207	T113 R35W S4, north line to Minnesota R	Invertebrate IBI	None
County Ditch 119	07020004-687	070200041007	Unnamed ditch to Unnamed cr	Fish IBI, Invertebrate IBI	None
County Ditch 36	07020004-716	070200040905	Unnamed cr to Hawk cr	Fish IBI, Invertebrate IBI	None

Table 2. Biologically impaired AUIDs in the Hawk Creek watershed

The fish and invertebrate thresholds and confidence limits are shown by class for sites found in the Hawk Creek watershed in Table 3. For a complete description of the fish and invertebrate classes, please see Appendices 1.1 and 1.2.

Each IBI is comprised of a fish or invertebrate metric that is based on community structure and function and produces a metric score scaled to 100 points. The number of metrics that make up an IBI will determine the metric score scale. For example, an IBI with 8 metrics would have a scale from 0-12.5 and an IBI with 10 metrics would have a scale from 0-10.

Class	Class Name	Fish IBI Thresholds	Upper CL	Lower CL
1	Southern Rivers	39	50	28
2	Southern Streams	45	54	36
3	Southern Headwaters	51	58	44
7	Low Gradient	40	50	30
Class	**Class Name**	**Invertebrate IBI Thresholds**	**Upper CL**	**Lower CL**
2	Prairie Forest Rivers	30.7	41.5	19.9
5	Southern Streams RR	35.9	48.5	23.3
7	Prairie Streams GP	38.3	51.9	24.7

Table 3. Fish and invert classes found in the Hawk Creek watershed with their respective IBI thresholds and upper/lower confidence limits.

Table 4 shows the fish and invertebrate IBI scores for the sites studied further in this report. For a complete summary of fish and invertebrate IBI scores in the Hawk Creek watershed, see Appendices 2.1, 2.2, 3.2, and 3.3.

The impaired AUIDs are color coded by their relationship to the IBI threshold and confidence intervals in Table 4. See Table 5 for the color descriptions of the IBI scores.

AUID	Station	Year	Fish IBI Score*	Fish Class	Invertebrate IBI Score*	Invertebrate Class
07020004-566 (Unnamed Creek)	91MN050	2010	**0 0**	3	**15.9 16.3**	7
07020004-617 (Smith Creek)	10MN108	2010	**74**	3	**27.3**	5
07020004-687 (County Ditch 119)	10MN140	2010	**43**	3	**19.4 29.5**	7
07020004-716 (County Ditch 36)	10MN144	2010	**26**	3	**29.3**	5

Table 4. Fish and invertebrate IBI scores by biological station within AUID with descriptive color
*Multiple scores are a result of multiple sampling visits

At or below lower confidence limit	At or below threshold, above lower confidence limit	Above upper confidence limit

Table 5. IBI color descriptions

Hydrological Simulation Program - FORTRAN Model

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

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

The HSPF watershed model was run for the Hawk Creek watershed to predict water quality condition throughout the watershed on an hourly basis from 1995-2009. In this report, the minor watersheds with biological impairments used the model output to supplement available water quality analyses. See Figure 4 for a map of the HSPF model numbered subwatersheds. Subwatersheds included in this study are numbered 301 (Smith Creek), 270 (County Ditch 119), 201 (County Ditch 36), and 305 (Unnamed Creek).

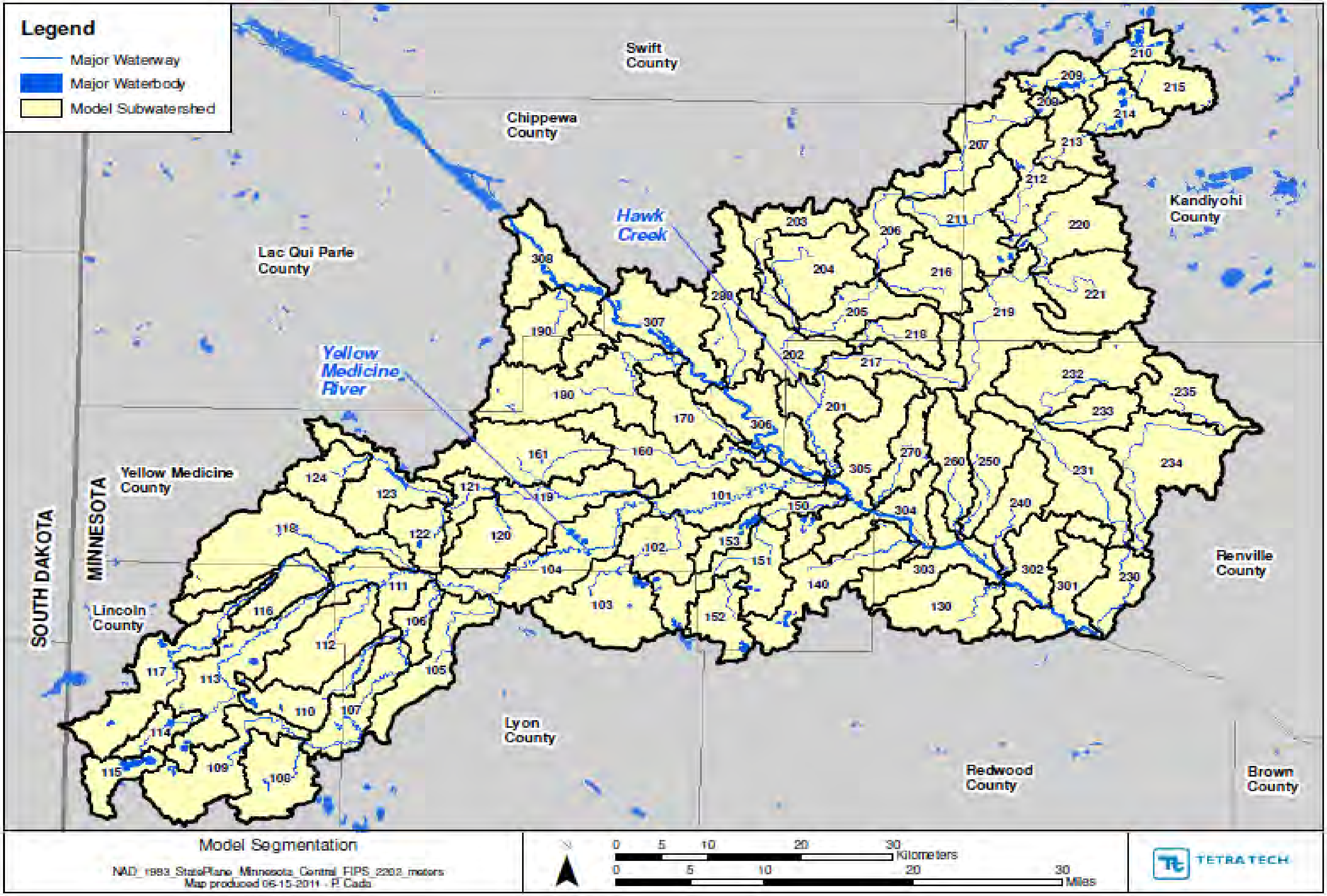


Figure 4. HSPF modeled subwatersheds in the Hawk Creek/Yellow Medicine River watersheds.

Candidate cause: Low Dissolved Oxygen

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

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

Water quality standards

In Class 2B streams, the Minnesota standard for DO is 5.0 mg/L as a daily minimum. The biologically impaired streams in the Hawk Creek watershed were all Class 2B streams.

The following is from the Guidance Manual for Assessing the Quality of Minnesota Surface Waters (MPCA, 2009):

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

Types of dissolved oxygen data

Point measurements

Instantaneous DO data is available throughout the watershed and can be used as an initial screening for low DO. These measurements represent discrete point samples, usually conducted in conjunction with surface water sample collection utilizing a Yellow Springs Instruments (YSI) sonde. Because DO concentrations can vary significantly as a result of changing flow conditions and time of sampling, instantaneous measurements need to be used with caution and are not completely representative of the DO regime at a given site.

Diurnal (continuous)

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

Overview of dissolved oxygen in the Hawk Creek watershed

The impaired reaches, when ample flow permitted, were studied continuously in 2010 with the use of a sonde, as well as many other site visits. Smith Creek remained above the minimum standard of 5 mg/L and did the daily flux never exceed 5 mg/L during all sampling events.

County Ditch 119 consistently fell below the minimum standard with most occurrences taking place before 9:00 am. The daily flux for this site was also above 8 mg/L during the majority of sonde deployment.

County Ditch 36 and Unnamed Creek both went dry during the summer months in 2012 and thus no sondes were deployed. County Ditch 36 also had one reading below the minimum standard during an invertebrate sampling visit on August 2, 2010, at 7:12 pm. At that time, the DO was 3.99 mg/L. The one other measurement at this location was above the standard at 6.32 mg/L. Unnamed Creek had one previous DO measurement of 3.31 mg/L during a fish sampling visit on August 25, 2010, at 8:00 am. Other measurements were above the standard.

Sources and causal pathways model for low dissolved oxygen

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

Candidate cause: High Phosphorus

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

Water quality standards and ecoregion norms

There is no current water quality standard for total phosphorus; however there is a draft nutrient standard for rivers of Minnesota as well as ecoregion data to show if the data is within the expected norms. The current draft standard is a maximum concentration of 0.15 mg/L. For more information, please reference the Minnesota River-Granite Falls Watershed Monitoring and Assessment Report for a summary of phosphorus and other water chemistry parameters at the 10-digit HUC subwatershed scale.

Total phosphorus concentrations in the Hawk Creek watershed

From 2000-2012, there has been 2938 phosphorus samples collected in streams in the Hawk Creek watershed. Of those samples, over 71 percent have been at or above the current draft standard of 0.15 mg/L. Many of the readings were above 7 mg/L with the highest reading at 8.05 mg/L. These extremely high readings were commonly found along the Class 7 (Limited Resource Water) section of Hawk Creek. Phosphorus in the Hawk Creek watershed is a watershed-wide issue.

Sources and causal pathways for high phosphorus

Phosphorus is delivered to streams by wastewater treatment facilities, urban stormwater, agriculture, and direct discharges of sewage. In the Hawk Creek watershed, there are 141.69 stream miles that have a Use Class 7 (Limited Value Resource) designation. These waters have much lower water quality expectations and are commonly used for wastewater discharge. The causes and potential sources for excess phosphorus in the Hawk Creek watershed are modeled at EPA's Nutrient CADDIS webpage.

Candidate cause: High Nitrate - Nitrite

Exposure to elevated nitrite or nitrate concentrations can lead to the development of methemoglobinemia. The iron site of the hemoglobin molecule in red blood cells preferentially bonds with nitrite molecules over oxygen molecules. Methemoglobinemia ultimately limits the amount of oxygen that can be absorbed by fish and invertebrates (Grabda et al., 1974). Certain species of caddisflies, amphipods, and salmonid fishes seem to be the most sensitive to nitrate toxicity according to Camargo and Alonso (2006).

Water quality standards

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

Ecoregion data

McCollor & Heiskary (1993) developed a guidance of stream parameters by ecoregion for Minnesota streams. The Hawk Creek watershed encompasses portions of two ecoregions: the majority being Western Corn Belt Plains (WCBP) and a small portion of North Central Hardwood Forest (NCHF) is located in the fair northeastern headwaters. The annual 75th percentile nitrate-N values where used for comparison (Table 6). Since most of the watershed is within WCBP (96.67 percent), this ecoregion type will be used for analysis.

Ecoregion	75 Percentile value (mg/L)
North Central Hardwood Forest (NCHF)	0.28
Western Corn Belt Plains (WCBP)	6.9

Table 6. Ecoregions in the Hawk Creek watershed with the associated annual 75 percentile nitrate-nitrite level

Collection methods for nitrate and nitrite

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

Nitrate and nitrite in the Hawk Creek watershed

From 2000-2012, there were 2687 nitrate samples collected throughout the Hawk Creek watershed. Values ranged from 0.001 mg/L up to 37.8 mg/L. In general, the months with the highest nitrate values were March through June. Many of the samples collected throughout the watershed have elevated nitrate-N concentrations.

Sources and causal pathways model for nitrate and nitrite

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

Candidate cause: Altered Hydrology

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

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

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

Flow alteration in the Hawk Creek watershed

The Hawk Creek watershed has been heavily channelized. Nearly 60 percent of the entire watershed has been identified as being altered. To get a better scope of the amount of altered waterways within the watershed, see Figure 5. Figure 6 shows examples of channelized streams located in the Hawk Creek watershed.

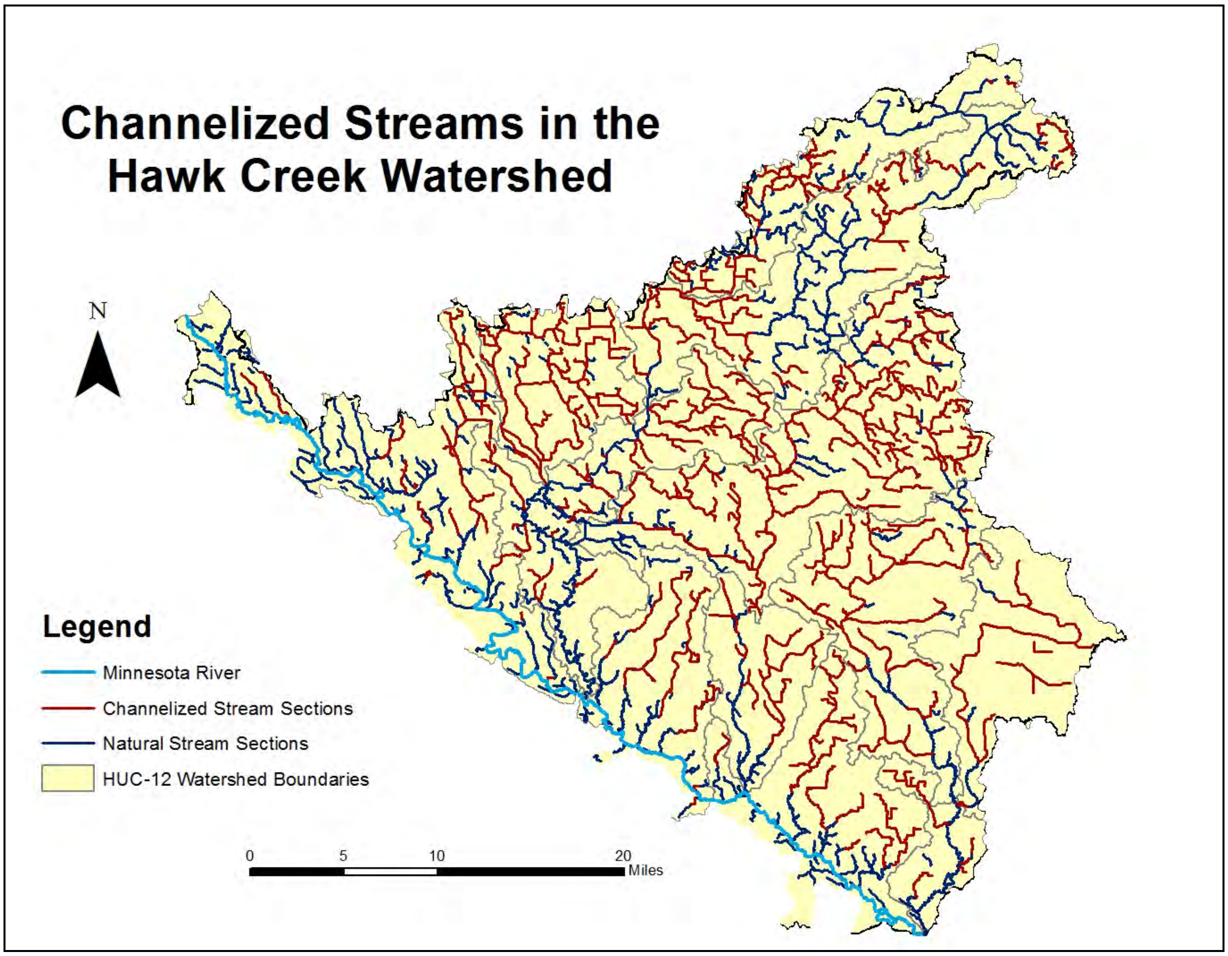


Figure 5. The Hawk Creek watershed and its many altered waterways.

Figure 6. Examples of channelized streams in the Hawk Creek watershed (left to right) - Beaver Creek, East Fork at biological station 10MN020; Hawk Creek at biological station 10MN013.

Sources and causal pathways model for altered hydrology

Channelization occurs on ditches serving as first and second order streams to larger streams and rivers as well as some of the larger rivers within this particular watershed. The channelized reaches and subsurface tiling serve to route water quickly off the landscape which alters the natural hydrologic regime of the system. The causes and potential sources for altered flow in the Hawk Creek watershed are modeled at EPA's CADDIS Flow Alteration webpage.

Candidate cause: High Turbidity/Total Suspended Solids

Increases in suspended sediment and turbidity within aquatic systems are now considered one of the greatest causes of water quality and biological impairment in the United States (U.S. EPA, 2003). Although sediment delivery and transport are important natural processes for all stream systems, sediment imbalance (either excess sediment or lack of sediment) can result in the loss of habitat in addition to the direct harm to aquatic organisms. As described in a review by Waters (1995), excess suspended sediments cause harm to aquatic life through two major pathways: (1) direct, physical effects on biota (i.e. abrasion of gills, suppression of photosynthesis, avoidance behaviors); and (2) indirect effects (i.e. loss of visibility, increase in sediment oxygen demand). Elevated turbidity levels and total suspended solids (TSS) concentrations can reduce the penetration of sunlight and thus impede photosynthetic activity and limit primary production (Munavar et al., 1991; Murphy et al., 1981).

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

Water quality standards

The water quality standard for turbidity is 25 Nephelometric Turbidity Units (NTUs) for Class 2B waters for protection of aquatic life. Turbidity is a measure of reduced transparency that can increase due to suspended particles such as sediment, algae, and organic matter. Total suspended solids and transparency tube measurements can be used as surrogate standards.

A strong correlation exists between the measurements of TSS concentration and turbidity. In 2010, MPCA released draft TSS standards for public comment (Markus). The new TSS criteria are stratified by geographic region and stream class due to differences in natural background conditions resulting from the varied geology of the state and biological sensitivity. The draft TSS standard for Hawk Creek has been set at 65 mg/L. For assessment, this concentration is not to be exceeded in more than 10 percent of samples within a 10-year data window.

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

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

Turbidity in the Hawk Creek watershed

The most recent assessments for the Hawk Creek watershed determined there were two turbidity impairments. These new impairments are located on Timms Creek (AUID: 07020004-525) and Sacred Heart Creek (AUID: 07020004-526).) Previously listed turbidity impairments still remain on Beaver Creek (AUID: 07020004-528), Beaver Creek, West Fork (AUID: 07020004-530), Hawk Creek (07020004-568), Hawk Creek (07020004-587), and Unnamed Ditch (AUID: 07020004-589).

Streams with more than 10 percent of exceedances of the turbidity standard that were not listed are due to channelization deferments or insufficient information include: Hawk Creek (AUID: 07020004-510), Palmer Creek (07020004-534), Beaver Creek, East Fork (AUID: 07020004-586), Eagle Lake Inlet (AUID: 07020004-602), Middle Creek (AUID: 07020004-615), Judicial Ditch 16 (AUID: 07020004-623), Hawk Creek (AUID: 07020004-642), County Ditch 119 (AUID: 07020004-648), and County Ditch 11 (AUID: 07020004-689).

Figure 7 provides a spatial reference of the turbidity issues in the Hawk Creek watershed.

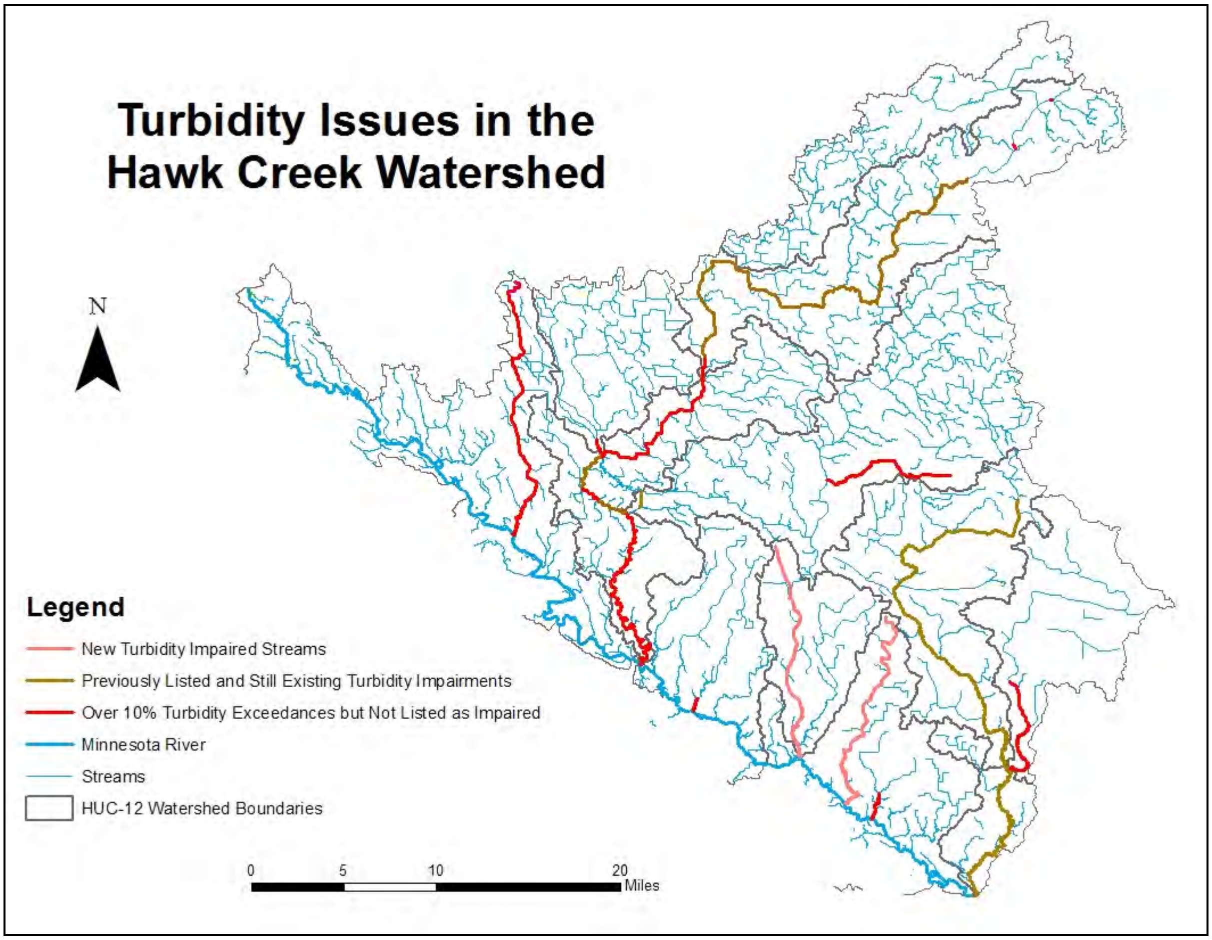


Figure 7. Hawk Creek watershed turbidity issues

Sources and causal pathways for turbidity

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

Candidate cause: Pesticides

Herbicides are chemicals used to manipulate or control undesirable vegetation. The most frequent application of herbicides occurs in row-crop farming, where they are applied before, during, or after planting to maximize crop productivity by minimizing other vegetation. In suburban and urban areas, herbicides are often applied to lawns, parks, and golf courses. Herbicides are also applied to water bodies to control aquatic weeds that impede irrigation withdrawals or interfere with recreational and industrial uses of water (Folmar et al. 1979).

Herbicides may cause biological impairments if they are present in water or sediment at sufficient concentrations. The most common pathway for herbicides to enter surface water is through runoff or leachate. Herbicides have relatively low toxicity to fish and invertebrates, therefore, acute toxicity is likely only when they are deliberately or accidentally applied directly to water bodies. Direct applications may result in direct toxicity to non-target plants and animals or indirect effects due to the death and decomposition of plants.

Impairments are also more likely when herbicides are applied together or with other pesticides resulting in additive or synergistic effects (Streibig et. al. 1998). Atrazine has been shown to increase the effects of other pesticides in mosquito larvae, fruit flies, houseflies, and midge flies (Belden and Lydy 2000, Lydy and Linck 2003). The surfactants used in herbicide solutions also can be toxic to biota and are not considered when testing active ingredients (Folmar et al. 1979).

Minnesota water quality standards

Since 1985, the Minnesota Department of Agriculture (MDA) and Minnesota Department of Health (MDH) have been monitoring the concentrations of common pesticides in groundwater near areas of intensive agricultural land-use. In 1991, these monitoring efforts were expanded to include surface water monitoring sites on select lakes and streams. To learn more about the MDA pesticide monitoring plan and results, go to the following website, http://www.mda.state.mn.us/protecting/cleanwaterfund/pesticidemonitoring.aspx

"The Minnesota Pollution Control Agency (MPCA) has developed toxicity-based (for aquatic life) or human health-based enforceable chronic standards for pollutants detected in surface water. The toxicity-based standard is designed to be protective of aquatic life exposure, and is typically based on exposure duration of four days. The human health-based standard (protective for drinking water plus fish consumption) is based on exposure duration of 30 days. For the most current MPCA water quality rules, see Chapter 7050: Standards for Protection of Waters of the State (http://www.revisor.leg.state.mn.us/rules/?id=7050)." A summary of MPCA's chronic and maximum standard values for common pesticides used in Minnesota are shown in Table 7.

	Chronic[1] and Maximum[2] Standards (µg/L)		
Pesticide Analyte	**Class 2A[3]**	**Class 2B[4]**	**Maximum Standard[4]**
Acetochlor	3.6	3.6	86
Alachlor	59	59	800
Atrazine	10	10	323
Chlorpyrifos	0.041	0.041	0.083
Metolachlor	23	23	271

Table 7. Summary of MPCA surface water standards associated with target pesticide analytes

[1] Chronic standards are defined in Minn. R. ch. 7050 as toxicity-based for aquatic organisms and is protective for an exposure duration of 4 days

[2] Maximum standard value for aquatic life & recreation as defined in Minn. R. ch.. 7050. Values are the same for all classes of surface waters.

[3] State water classification for coldwater streams and all recreation.

[4] State water classification for cool and warmwater streams and all recreation.

Pesticides in the Hawk Creek watershed

In the Hawk Creek watershed, pesticide samples were taken at the Smith Creek biological sampling site, 10MN108, and at the County Ditch 119 biological sampling site, 10MN140 (Figure 8). More detailed pesticide sampling results are presented in the Smith Creek and County Ditch 119 sections of this report.

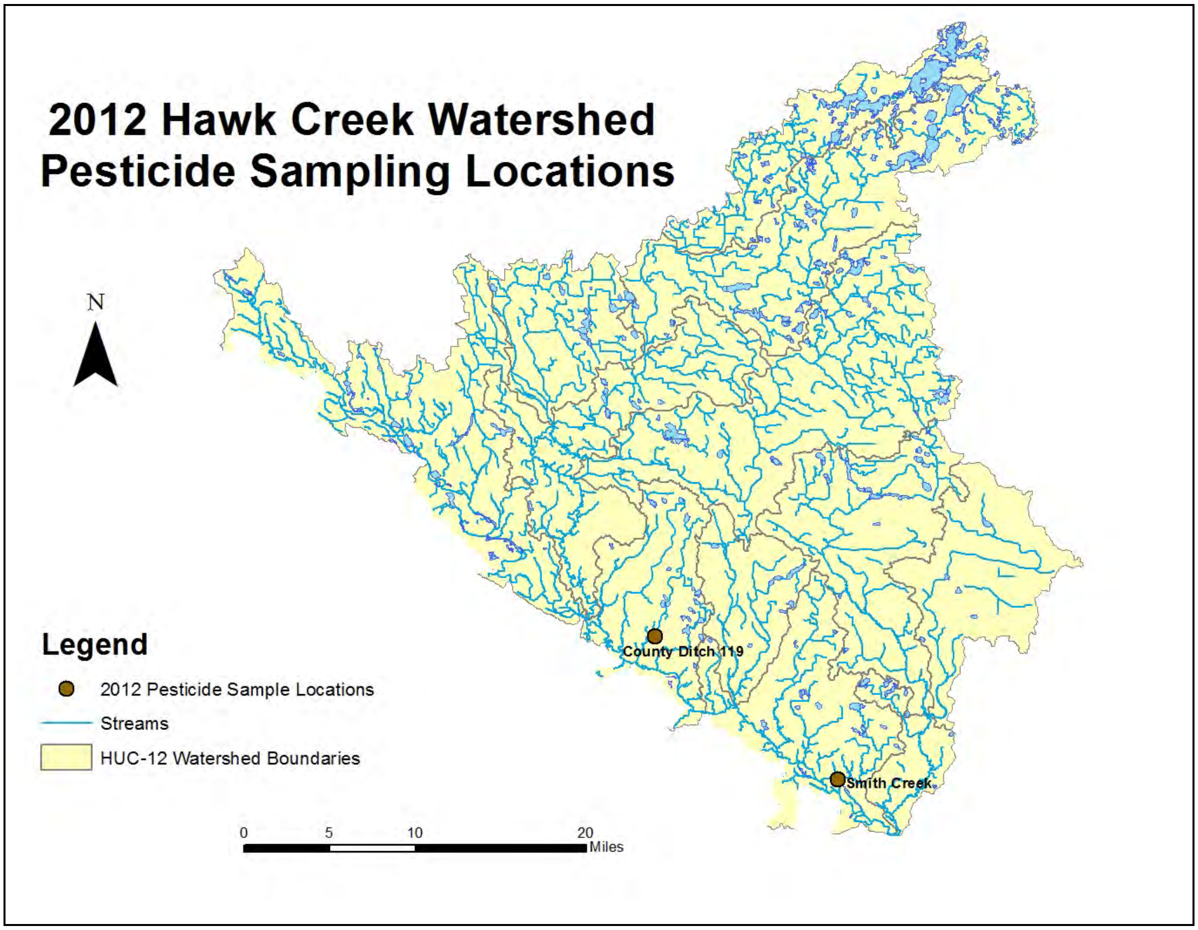


Figure 8: 2012 Pesticide sampling locations in the Hawk Creek watershed.

Sources and causal pathways model for pesticides

The conceptual model for herbicides as a candidate stressor in the Hawk Creek watershed is modeled at [EPA's CADDIS Herbicide webpage.]

Candidate cause: Lack of Habitat

Habitat is a broad term encompassing all aspects of the physical, chemical, and biological conditions needed to support a biological community. This section will focus on the physical habitat structure including geomorphic characteristics and vegetative features (Griffith et al., 2010). Physical habitat is often interrelated to other stressors (e.g., sediment, flow, DO) that are addressed separately.

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

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

Water quality standards

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

Habitat characteristics in the Hawk Creek watershed

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

In the Hawk Creek watershed, habitat scores were predominantly fair or poor upstream of the Minnesota River valley (Figure 9). Many of these areas are channelized and farmed intensively. Habitat scores generally improved in the higher gradient streams in the Minnesota River valley.

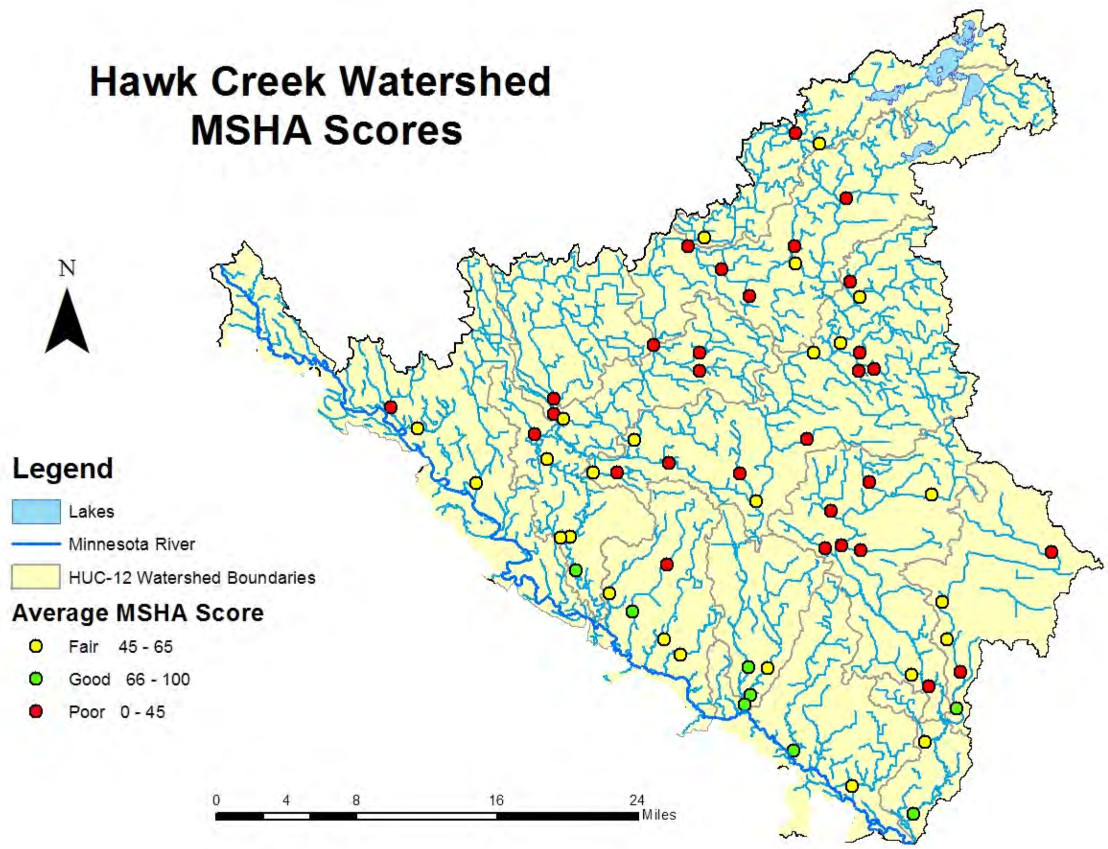


Figure 9. Average MSHA scores at biological sampling stations in the Hawk Creek Watershed

In addition, the National Fish Habitat Partnership has created a national data set measuring the amount of human disturbance on the landscape. For a spatial reference of the amount of landscape disturbance in the Hawk Creek watershed, please see Figure 10.

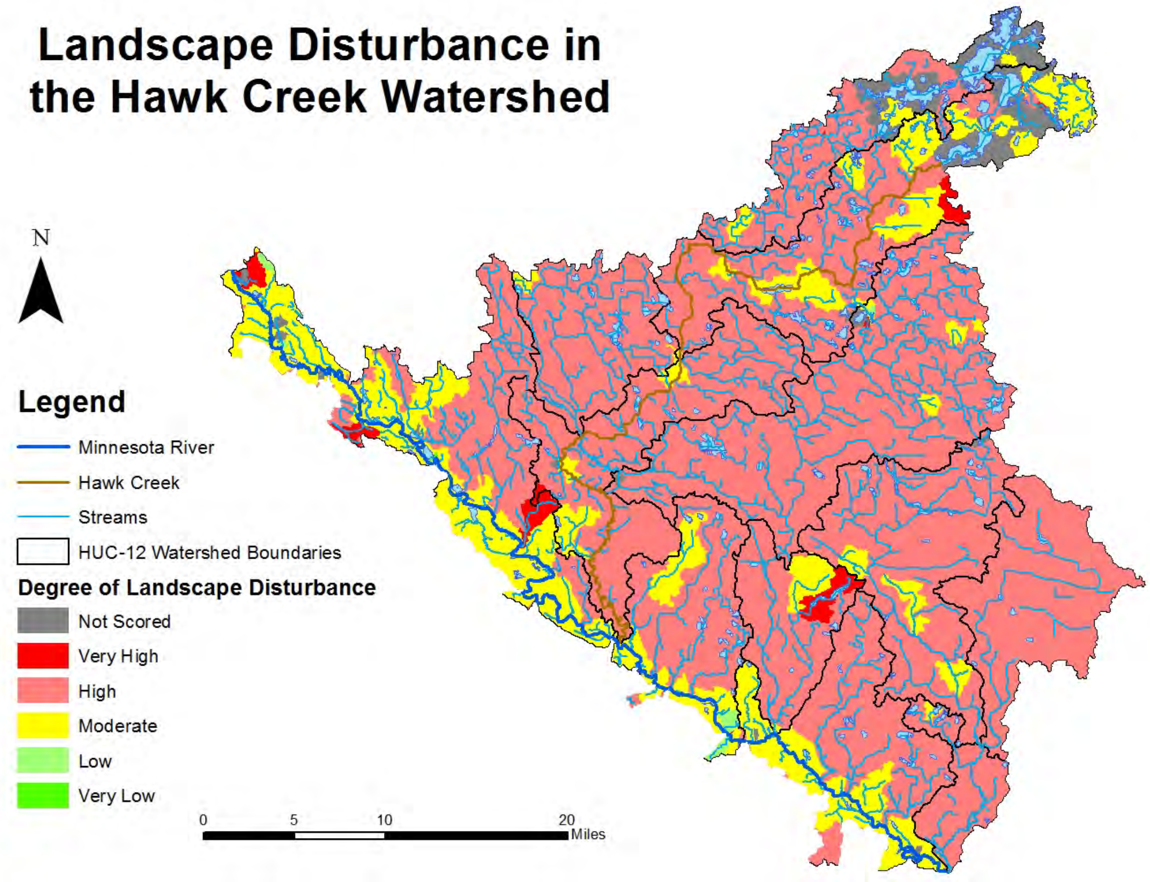


Figure 10. Human caused landscape disturbance in the Hawk Creek watershed produced by the National Fish Habitat Partnership.

Sources and causal pathways model for habitat

The causes and potential sources for lack of habitat in the Hawk Creek watershed are modeled at EPA's CADDIS Physical Habitat webpage. Many riparian areas along Hawk Creek and its tributaries as well as the direct tributaries to the Minnesota River within the watershed, are dominated by row crop agriculture, which decreases riparian and bank vegetation. Along with altered hydrology, the alteration of habitat caused by channelization and impoundments, has numerous pathways of influence affecting the biological community.

Biologically Impaired Reaches

Smith Creek watershed

Smith Creek (AUID: 07020004-617) was assessed in 2012 and determined to be impaired for aquatic invertebrates. This AUID is also impaired for Escherichia coli (E. coli). The impaired reach extends from T113 R35W S4, north line (270th Ave) to the Minnesota River. Figure 11 is a detailed map of the Smith Creek watershed.

The Smith Creek minor watershed has a landscape dominated by cultivated crops (87.7 percent). The next most prevalent land uses are developed, open space (4.25 percent) and deciduous forest (3.08 percent). Such a high density of row crop agricultural occurring in the watershed makes Smith Creek very vulnerable to harmful runoff and other damaging agricultural practices especially in the vital headwaters.

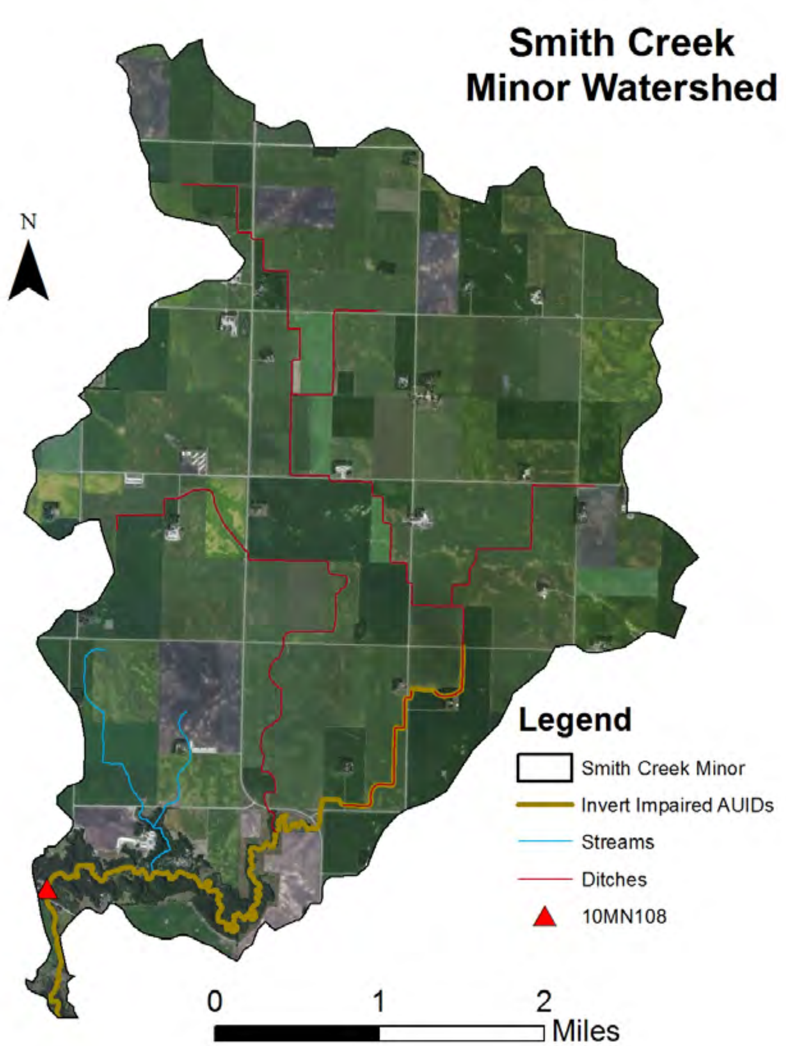


Figure 11. Smith Creek minor watershed with impaired invertebrate reach highlighted.

Biology in Smith Creek

This AUID had one invertebrate sampling event at one sampling station, 10MN108, located upstream of CSAH-15, 4.5 miles north of Redwood Falls. This site scored below the invertebrate index of biological integrity (MIBI) threshold for an Invertebrate Class 5 (Southern Streams RR) stream, but was within the confidence limit. After this site was deemed impaired, additional physical and chemical monitoring took place in 2012 by the MPCA as well as the Hawk Creek Watershed Project.

The invertebrate sample at Smith Creek was taken in 2010 from equal parts of the various habitats found within the reach (undercut banks/overhanging vegetation, riffle/run/rock, and snag/woody debris). This assemblage was dominated by Simulium (black flies), which is not uncommon for streams with degraded water quality (http://www.wlu.ca/science/biology/eschweigert/bio305/Database/Simulium.htm).

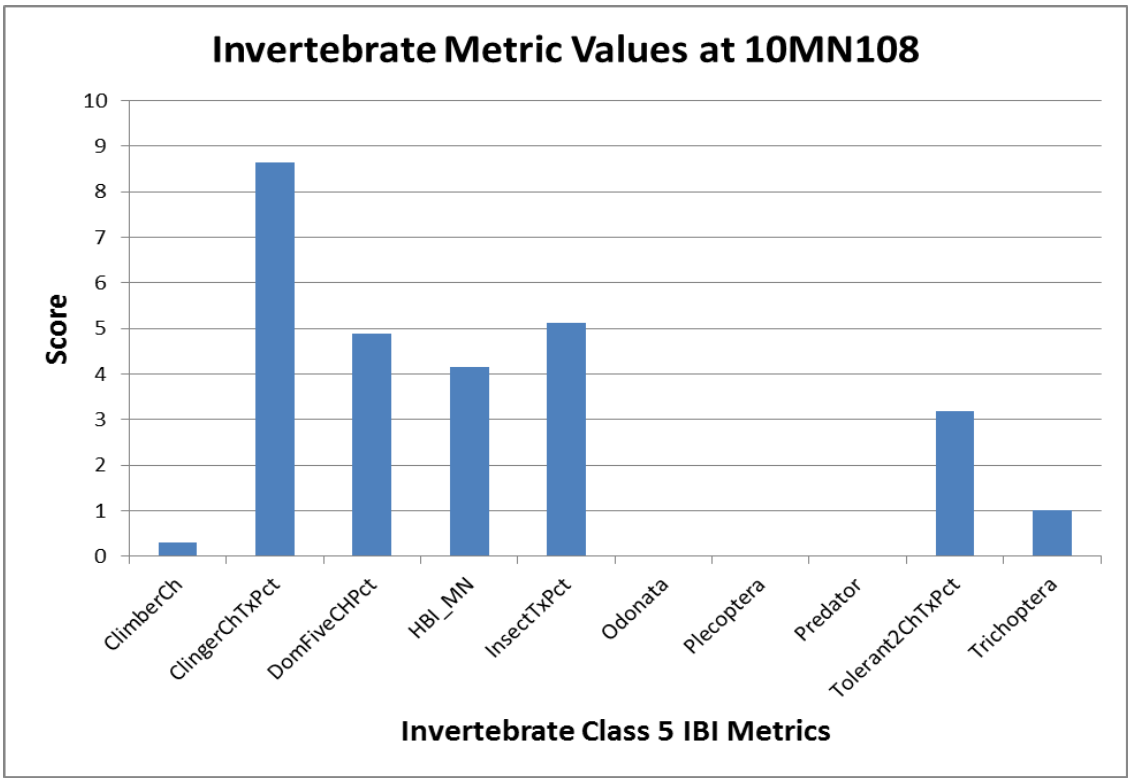


Figure 12. Individual invertebrate IBI metric scores at 10MN108 at Smith Creek.

To meet the IBI threshold for an Invertebrate Class 5 stream, each metric would need to average 3.59 points. As shown by Figure 12 above, the only metrics to do so in Smith Creek were DomFiveCHPct, ClingerChTxPct, HBI_MN, and InsectTxPct. All other metrics scored well below average especially Odonata, Plecoptera, and Predator.

Odonata, or dragon and damselflies, are a diverse group of organisms that display a wide array of sensitivities and life histories. They exploit most aquatic microhabitats, and their diversity is considered a good indicator of aquatic health (Chirhart 2003).

Plecoptera, or stoneflies, are among the most sensitive indicator organisms. They occupy the interstitial spaces between rocks, woody debris, and vegetation, and require a relatively high amount of DO in order to survive.

Candidate cause: Low Dissolved Oxygen

A sonde was placed in Smith Creek to continuously monitor DO levels for two weeks during the summer of 2012. During this time DO flux did not exceed 4.5 mg/L a day and levels never dipped below the minimum DO standard of 5mg/L. Conditions below 5 mg/L can be detrimental to biological communities. Since low values and high flux were not present, DO does not appear to be a stressor to the impaired invertebrate community in Smith Creek at this time.

Candidate cause: High Phosphorus

From 2010-2012, a total of 31 phosphorus samples were taken from Smith Creek. Values from these samples ranged from 0.015-0.106 mg/L. Since all sites are well below the proposed draft standard for phosphorus of 0.15 mg/L, it was determined that phosphorus is not a stressor to the impaired invertebrate assemblage in Smith Creek.

Candidate cause: High Nitrates

From 2010-2012, a total of 32 nitrate samples were taken in Smith Creek. A quantile regression showed with 75 percent confidence that a stream of the same invertebrate class as Smith Creek will score below the designated MIBI threshold when values are over 18 mg/. Of the 32 samples taken at Smith Creek, 11 values (34.4 percent) were at or above 18.1mg/L (Figure 13)

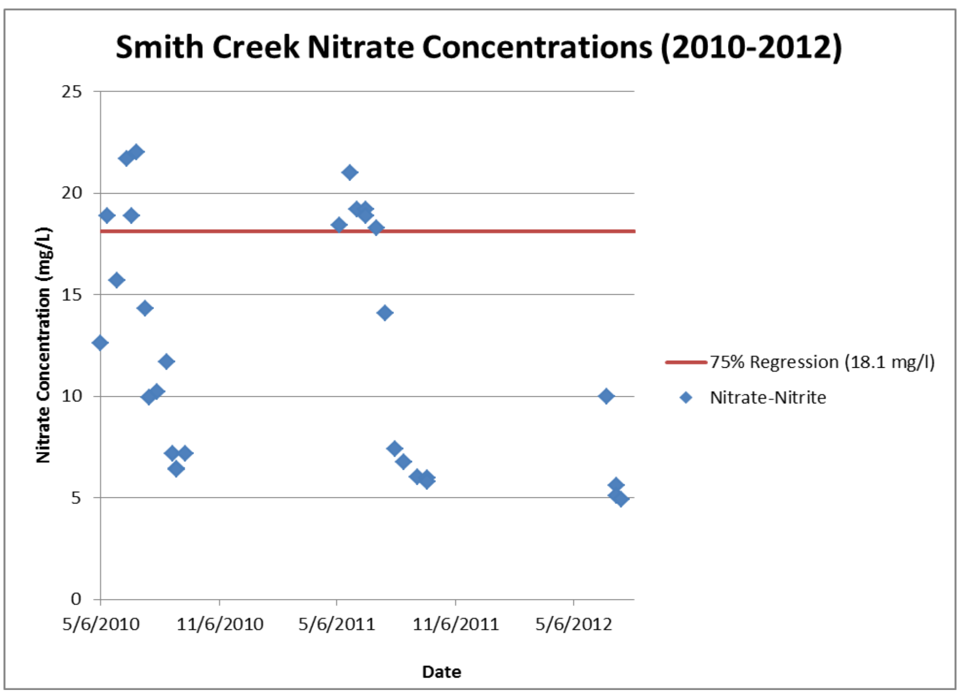


Figure 13. Observed nitrate levels in Smith Creek

Biologically, Trichoptera populations tend to decrease with increased levels of nitrate. Analyses of samples collected from Smith Creek had spikes of nitrate levels that could have led to lower numbers of Trichoptera in 2010. Also found in Smith Creek were 16 Physa individuals, which are common taxa found in degraded streams and can signify streams with excess nutrients.

With the frequent elevated nitrate values, as well as the low levels of nitrate sensitive Trichoptera species along with the high presence of nitrate tolerant Physa, nitrate is a stressor to the impaired invertebrate assemblage in Smith Creek.

Candidate cause: Altered Hydrology

The Smith Creek watershed has approximately 70 percent of its waters channelized, with the most extensive alterations in the headwaters including a small portion of the impaired AUID (Figure 11). The channelized streams and extensive tile drainage often lead to very high and extremely low flows. Often times during low flow events, the streams become intermittent and make it nearly impossible for a viable biotic community to survive.

Fortunately, Smith Creek has springs located near the biological sampling station. These springs help provide a continuous source of water that helps prevent extremely low flow conditions that are very common in relatively small watersheds throughout Minnesota.

With the presence of the springs providing a continuous base flow, altered hydrology does not appear to be a likely stressor to the impaired invertebrate community in Smith Creek.

Candidate cause: High Turbidity/TSS

The turbidity values in Smith Creek are very low. Only one sample had an observed value over the 25 NTU standard for a Class 2B stream (Figure 14). The lower reaches of Smith Creek have numerous springs and groundwater seeps. At this time, turbidity is not considered a stressor to the impaired invertebrate community in Smith Creek.

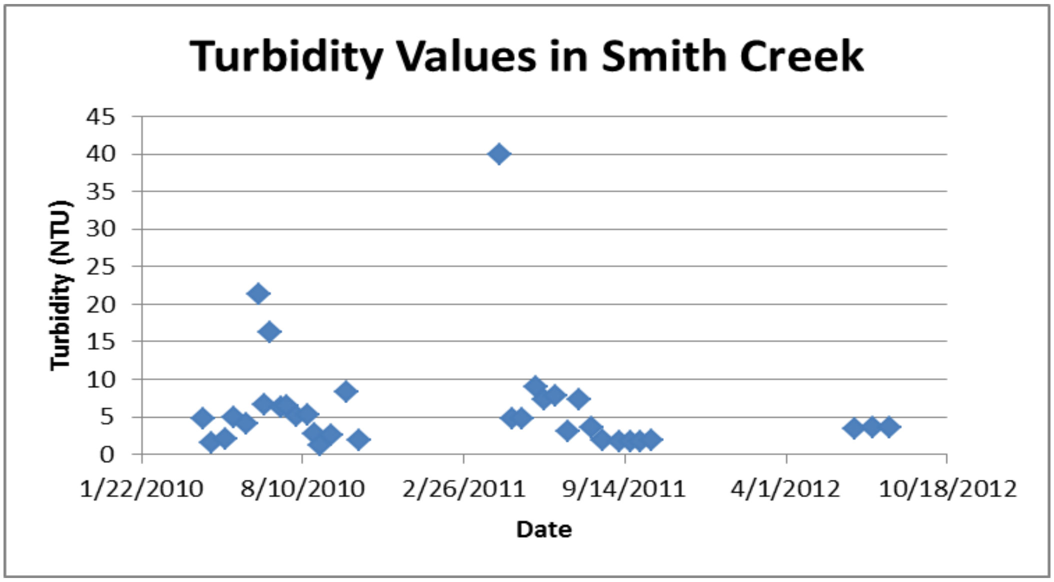


Figure 14. Turbidity values near the outlet of Smith Creek.

Candidate cause: Pesticides

Smith Creek had a pesticide sample taken on 8/14/2012. Pesticides found detected in this sample are identified in Table 8.

Smith Creek Pesticide Detections (Sample on 8/14/2012):					
Pesticide and info	**Smith Creek Result (µg/L)**	**MPCA Class 2B Chronic Standard (µg/L)[1]**	**MPCA Max Standard (µg/L)[1]**	**EPA Acute Value Aquatic Life BenchMark (µg/L)**	**EPA Chronic Value Aquatic Life Benchmark (µg/L)**
Acetochlor ESA; degradation product of the parent herbicide acetochlor, used as a herbicide on corn	**0.0508**	3.6	86	>62,500 (i)	9,900 (n)
Alachlor ESA;degradation product of the parent herbicide alachlor, used as an herbicide to control broad leafed weeds and grasses in corn and other crops.	**0.265**	5.9	59	52,000 (f, i)	-
Metolachlor ESA; degradation product of the parent herbicide metolachlor, widely used in both agricultural and non-crop areas	**0.423**	23	271	24,000 (f)	>95,100 (v)

Table 8. Pesticide sample results for Smith Creek at 10MN108.

The pesticide sample taken from Smith Creek tested positive for three different herbicides. However, the levels of these herbicides were very minimal and at this point, do not appear to be harming either the fish or invertebrate communities in Smith Creek. Further pesticide monitoring targeting stormflow events or during the peak run off periods in spring and early summer would provide a better understanding of all and any pesticides the system may hold as well as their range of values.

Candidate cause: Lack of Habitat

The habitat for site 10MN108 on Smith Creek had a MSHA score of 60.2 out of 100. This score is considered to be Fair. While no single category stood out as bringing down the overall score (Figure 15), individual factors that could be improved upon within the MSHA are: channel stability, embeddedness, bank erosion (Figure 16), the row crop land use upstream of the site, and the lack of large coarse substrates. Furthermore, immediately upstream of site 10MN108 was a very large pasture (Figure 17) with unrestricted stream access. This can limit the available habitat as well as cause elevations in other parameters.

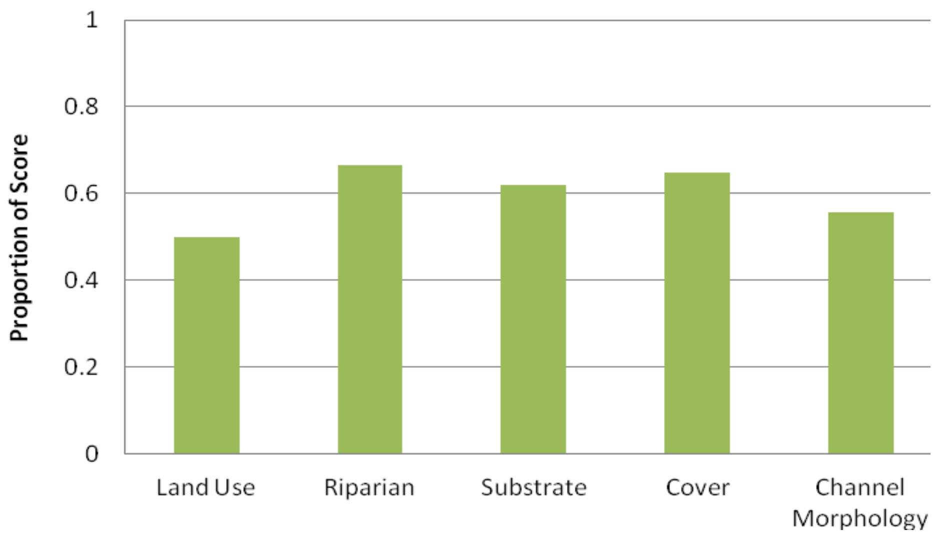


Figure 15. Proportion of possible MSHA subcategory scores in Smith Creek at site 10MN108

Figure 16. Eroded bank on Smith Creek.

Figure 17. Pasture upstream of 10MN108.

The absence of Plectoptera in Smith Creek can signify problems with embedded sediment. This order of invertebrates prefers clean substrates to use as habitat. The abundance of sand covering some of the coarse substrates in Smith Creek can prevent this order from colonizing. Sands and other fine substrates are more abundant moving upstream from 10MN108 (Figure 18). The lack of climber invertebrates can also signify habitat issues.

Figure 18. Sand dominant substrate upstream of 10MN108 on Smith Creek.

With the Fair MSHA score, and many different habitat categories in need of some improvement, it is reasonable to conclude that instream habitat is having a negative impact on the invertebrate community and should be considered a stressor.

Weight of evidence

For each likely stressor, the quantity and quality of each type of evidence is evaluated. The consistency and credibility of the evidence is also evaluated. Each step for Smith Creek was scored and summarized in Table 9. For further information on scoring, please see Appendix 1.3 and 1.4.

Smith Creek		
Types of Evidence	**Scores of Candidate Causes**	
	High Nitrates	**Lack of Habitat**
Spatial/temporal co-occurrence	+	+
Temporal sequence	+	0
Field evidence of stressor-response	+ +	0
Causal pathway	+	+
Evidence of exposure, biological mechanism	NE	NE
Field experiments /manipulation of exposure	NE	NE
Laboratory analysis of site media	NE	NE
Verified or tested predictions	+	+
Symptoms	+	0
Mechanistically plausible cause	+	NE
Stressor-response in other lab studies	NE	NE
Stressor-response in other field studies	+	+
Stressor-response in ecological models	NE	NE
Manipulation experiments at other sites	NE	NE
Analogous stressors	NE	NA
Consistency of evidence	+ + +	+
Explanatory power of evidence	+ +	+ +

Table 9. Weight of evidence table for potential stressors in Smith Creek.

Conclusions

The main stressors affecting invertebrates in Smith Creek seemed to be from elevated nitrate levels and the lack of habitat in the stream system. Within the sampling station, no issues with DO or phosphorus were detected, transparency values were all very high and only minimal amounts of pesticides were found.

The seasonal high spikes of nitrates sampled in the stream correspond to fertilizer application times. Higher amounts of precipitation are common in the months of May and June which often leads to increased amounts of runoff and ultimately higher levels of nitrogen and erosion entering Smith Creek. While the invertebrates were not sampled until late summer, the long term effects of nitrate spikes has likely led to the reduced Trichoptera populations which ultimately contributed to the poor MIBI score.

In stream habitat also likely contributed to the impairment designation. At times the substrate was primarily sand, which impacts the ability for invertebrates to carry out their life cycles. Controlling the eroding banks on Smith Creek would help reduce the amount of sediment and sand this stream reach experiences and would improve the overall habitat conditions.

Furthermore, changes in the surrounding land use, especially in the heavily channelized headwaters of this minor watershed, would help alleviate runoff issues, as well has high intensity flows that occur during hydrologic events. These high flows can lead to easy transport of nutrients, eroding stream banks, destruction of habitat, and sedimentation of the stream channel.

Continued pesticide sampling is recommended to get a better idea of how this potential stressor could be impacting the fish and invertebrate communities throughout the year. The one sample collected on Smith Creek is not enough to draw significant conclusions from at this time.

Overall, Smith Creek is a stream with great potential. Correcting the nitrate and habitat issues, along with restoring and protecting other parts of the watershed should improve the health of the invertebrate community in this stream and potentially result in the removal from the impaired water list.

County Ditch 119

County Ditch 119 (AUID: 07020004-687) was assessed in 2012 and determined to be impaired for both fish and aquatic invertebrate communities. The impaired reach extends from CSAH 9 downstream to the confluence with an unnamed tributary. Figure 19 is a detailed map of the impaired reach and the watershed.

The land use in the County Ditch 119 minor watershed is dominated by cultivated crops (86.48 percent). Other land uses with some presence are developed, open space (5.4 percent), deciduous forest (3.07 percent) and emergent herbaceous wetlands (2.82 percent). The high abundance of land used for agriculture makes the land susceptible to runoff containing nitrates, phosphorus, and pesticides. Also, the high amount of channelization taking place in the headwaters of the watershed can lead to higher erosion rates leading to excess sedimentation and turbidity problems.

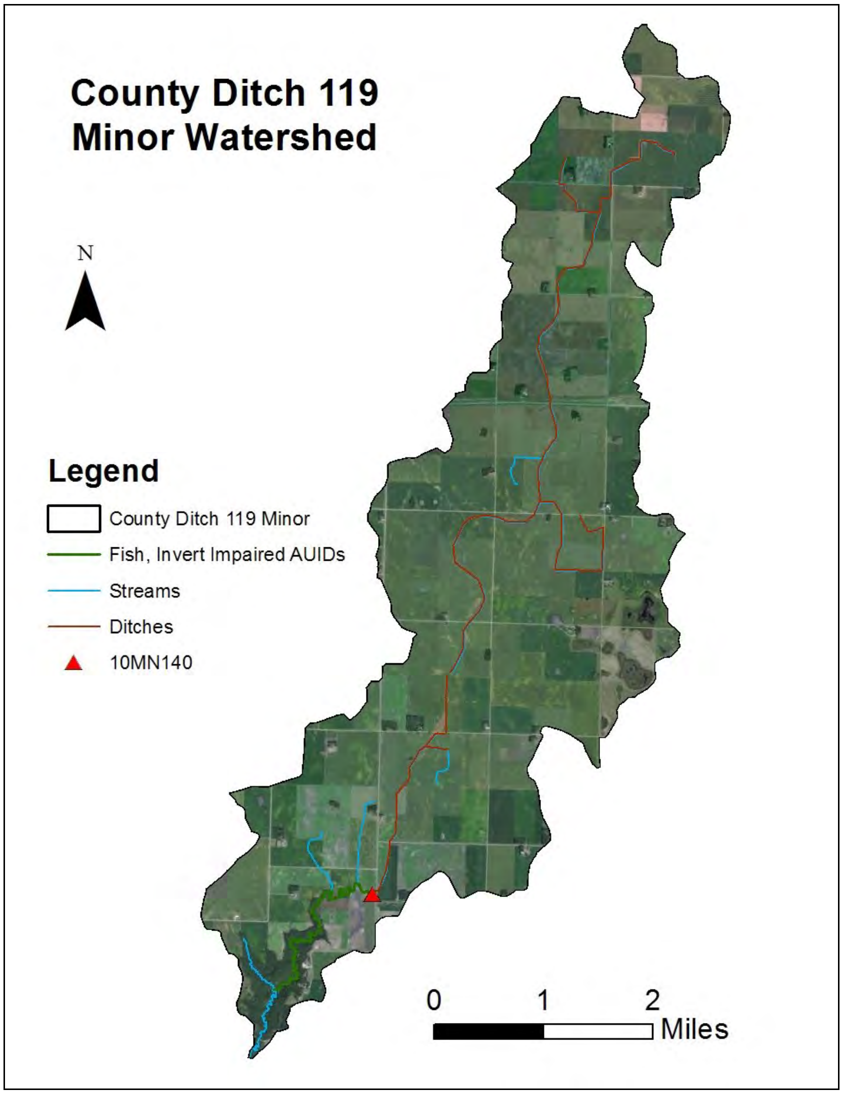


Figure 19. The County Ditch 119 watershed with the fish and invertebrate impaired AUID highlighted.

Biology in County Ditch 119

This AUID on County Ditch 119 had one fish and two invertebrate sampling events at one biological station, 10MN140, located downstream of CSAH-9, 4 miles south of Sacred Heart. This site scored below the Fish IBI threshold for a Class 3 (Southern Headwaters) stream and the confidence limit. One of the invertebrate samples scored below the MIBI threshold for a Class 7 (Prairie Streams GP) stream, but within the confidence limit, while the other sample scored below both.

After this site was deemed impaired, additional physical and chemical monitoring has taken place during 2012 by the MPCA as well as the Hawk Creek watershed project.

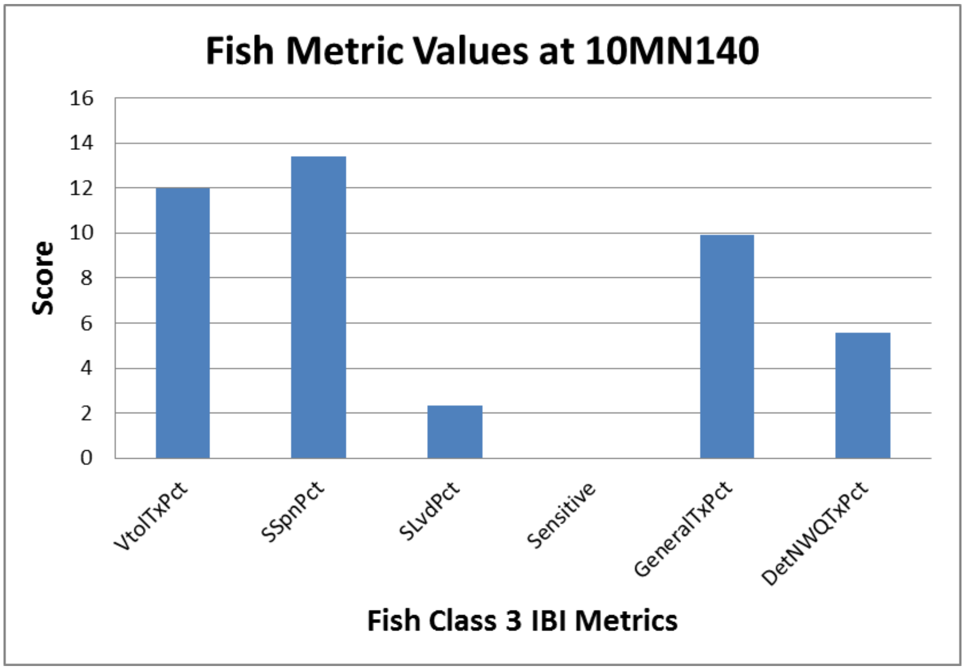


Figure 20. Fish IBI metric values in County Ditch 119 at biological sampling station 10MN140.

A metric score of 8.5 is the average score a metric would need for the site to meet the FIBI threshold for a Class 3 Southern Headwaters stream. Fish IBI metrics scoring below average in County Ditch 119 are SLvdPct, Sensitive, and DetNWQTxPct (Figure 20). This shows an abundance of short-lived, and detritivorous species, and a complete lack of sensitive species.

Sensitive species are susceptible to environmental degradation and often decline in abundance and richness following disturbance. They are not as susceptible as intolerant taxa but their presence in a stream is an indication of a high quality resource. With the conditions present, it comes as no surprise that sensitive species were absent.

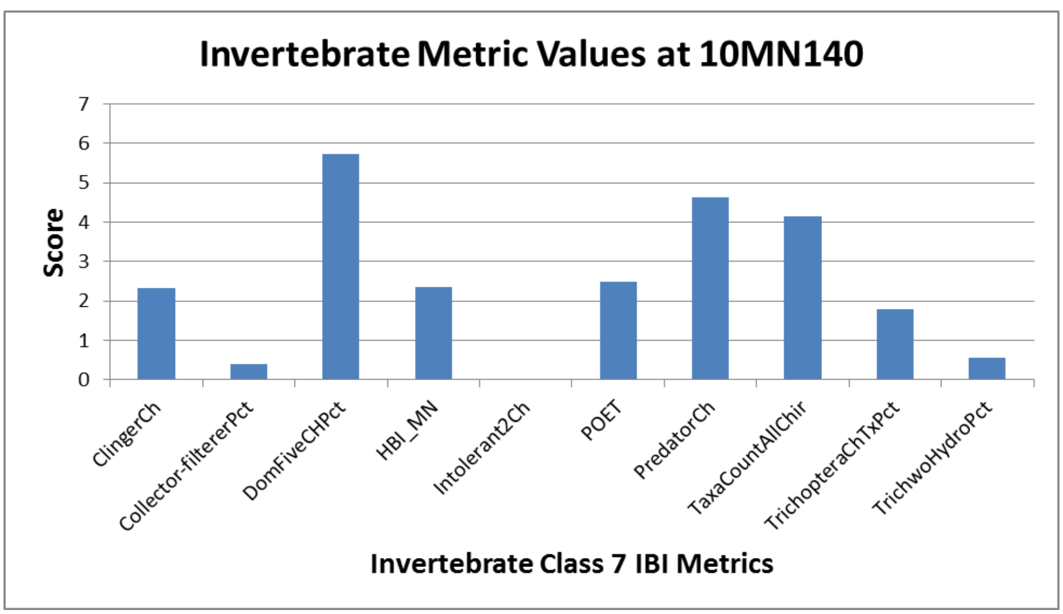


Figure 21. Individual invertebrate metric scores for 10MN140.

To meet the MIBI threshold for an Invertebrate Class 7 stream, each metric would need to average 3.83 points. As shown by Figure 21, the only metrics to do so in County Ditch 119 were DomFiveCHPct, PredatorCh, and TaxaCountAllChir. All other metrics scored well below average especially Collector-filtererPct, TrichwoHydroPct, and Intolerant2Ch. This means the invertebrate sample lacked collector-filterer species, non-hydropsychid trichoptera species, and taxa with tolerance values less than or equal to two using Minnesota Tolerance Values.

Candidate cause: Low Dissolved Oxygen

The daily minimum standard for DO in a Minnesota Class 2B stream like County Ditch 119 is 5 mg/L. Figure 22 shows that this requirement is violated very frequently. Also, a daily flux of over 4.5 mg/L is a sign that the stream is experiencing a DO problem. Exceeding these limits can cause reduced growth rates as well as fatality (Allan, 1995) (Doudoroff and Warren, 1965).

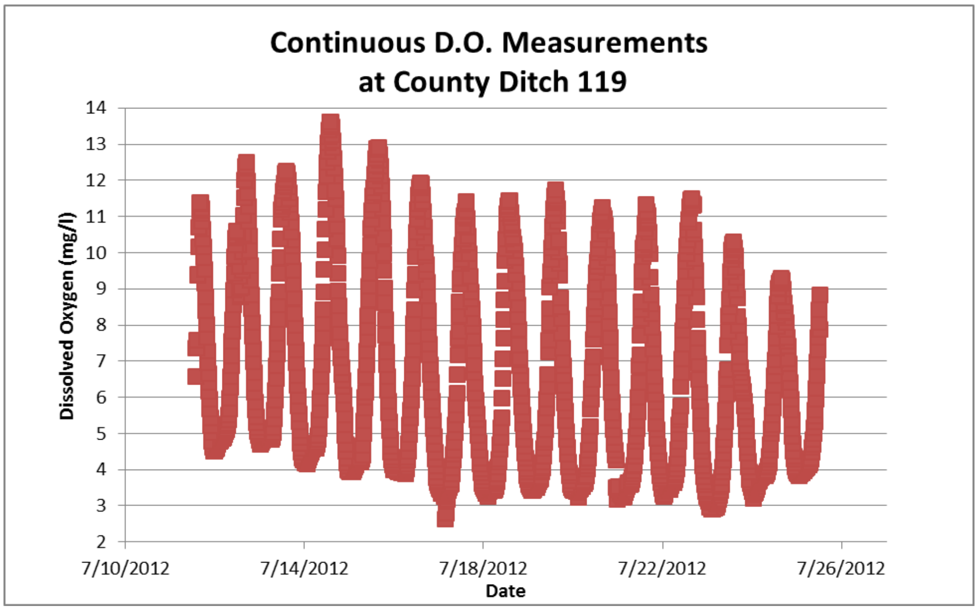


Figure 22. Diurnal DO readings taken from YSI Sonde at 10MN140.

Furthermore, nearly 70 percent of individual fish caught were either brook sticklebacks or fathead minnows. These two species are well known to be extremely tolerant of low DO conditions. The complete lack of sensitive fish species could be attributed to the large daily fluctuations in DO level resulting in the low fish IBI score.

Invertebrates in County Ditch 119 lacked Ephemeroptera, Plecoptera, and Trichoptera (EPT) species. Only (3.1 percent) of species belonged to this group which are considered sensitive to low levels of DO.

The extremely low daily minimum levels, the high daily flux, the high presence of very low DO tolerant fish and the lack of EPT invertebrate species are reasons enough to conclude that DO is a stressor to the aquatic life in County Ditch 119.

Candidate cause: High Phosphorus

A total of 95 phosphorus measurements were taken from County Ditch 119 from 2005-2012. Of these samples, 22 percent were above the proposed draft standard of 0.15 mg/L (Figure 23). The elevated levels of phosphorus can be attributed to the minimal amount of riparian buffer present throughout the County Ditch 119 watershed that easily allows nutrients to access the stream system. These high inputs of phosphorus cause increased plant and algal growth within the stream leading to an increase in DO consumption during periods of decomposition and respiration. The abundance of phosphorus entering County Ditch 119 likely had a significant impact to the DO flux being over 4.5 mg/.

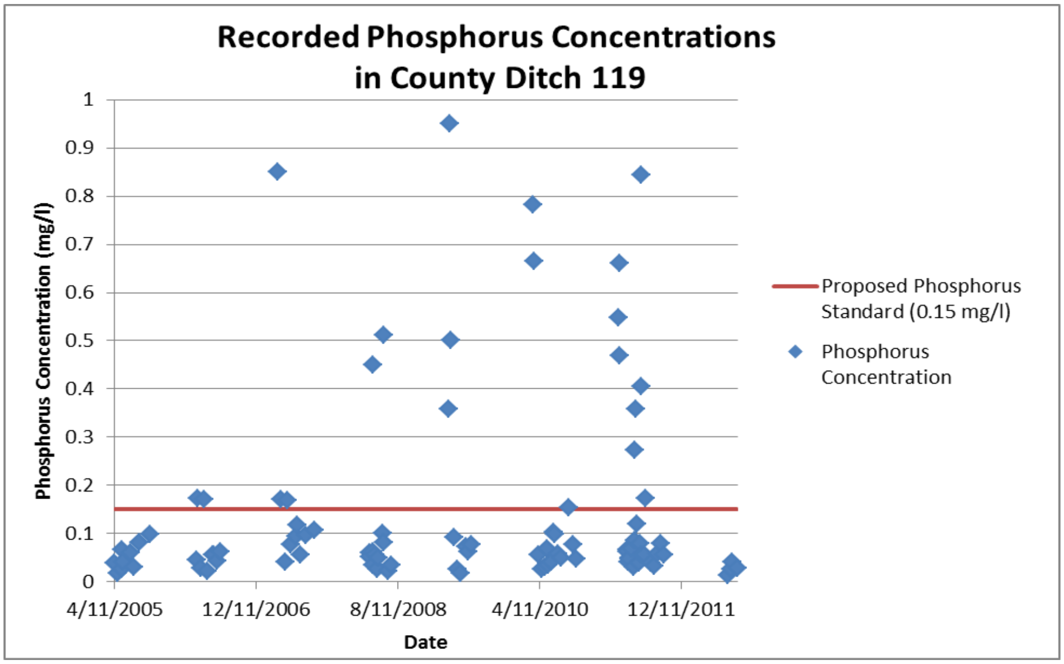


Figure 23. Phosphorus values in County Ditch 119 from 2005-2012.

With the frequent violations of the proposed draft standard, phosphorus should be considered a stressor to the impaired fish and invertebrate communities in County Ditch 119.

Candidate cause: High Nitrates

A total of 95 nitrate measurements were taken in County Ditch 119 from 2005-2012. A quantile regression of Invertebrate Class 7 streams in Minnesota shows with 90 percent confidence that if a stream has a nitrate-nitrite reading of 11.5 mg/L or higher, the MIBI score will be below the threshold for that respective class. Using measured data, County Ditch 119 had 29 of 95 (30.5 percent) measurements above 11.5 mg/L (Figure 24).

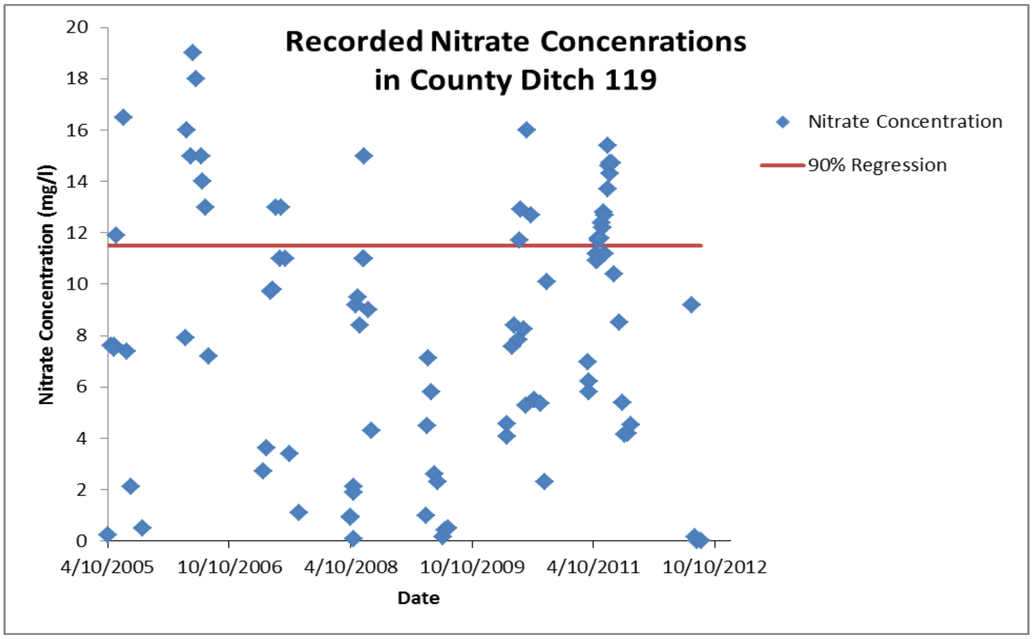


Figure 24. Recorded nitrate concentrations in County Ditch 119 from 2005-12

Biologically, the invertebrate sample collected in 2010 showed very few nitrate sensitive trichoptera species, while showing the presence of Physa (16 individuals) and Hyalella (17 individuals). These two genera are commonly present in degraded water quality conditions consistent with elevated nutrient levels as they tend to feed on organic material and detritus.

Furthermore, 32 of the 46 (69.6 percent) fish specimens captured were either brook stickleback or fathead minnows. These two species are very tolerant of high nitrate levels. Species mostly sensitive to high nitrate levels typical for this stream size and area were not found.

Taking into account the measured elevated nitrate levels as well as the fish and invertebrate species commonly found in high nitrate conditions, nitrate should be considered a stressor to the impaired biological assemblages found in County Ditch 119.

Candidate cause: Altered Hydrology

The County Ditch 119 minor watershed is approximately 68 percent channelized. Almost all of this channelization happens immediately upstream of the biological sampling station which includes the valuable headwaters (Figure 19). An example of localized channelization near the biological sampling location is found in Figure 25.

One effect of channelizing streams is the increase in flow velocity, especially following rain events. Faster moving

Figure 25. Channelized section of County Ditch 119 just upstream of sampling location.

water often times will lead to eroding banks causing an excess of fine sediments being deposited in the stream channel. This sediment covers many of the coarse substrates needed for spawning by numerous types of fish species.

The HSPF model predicted flows for County Ditch 119 from 1993 through 2009. There are many instances during the summer months that predict this stream goes under 1 cubic feet per second (CFS) and even below 0.1 CFS. These extremely low flows make it very difficult for many species of fish and invertebrates to stay and colonize in this stream. Figure 26 displays the monthly average flows in which these extremely low flows are evident in County Ditch 119.

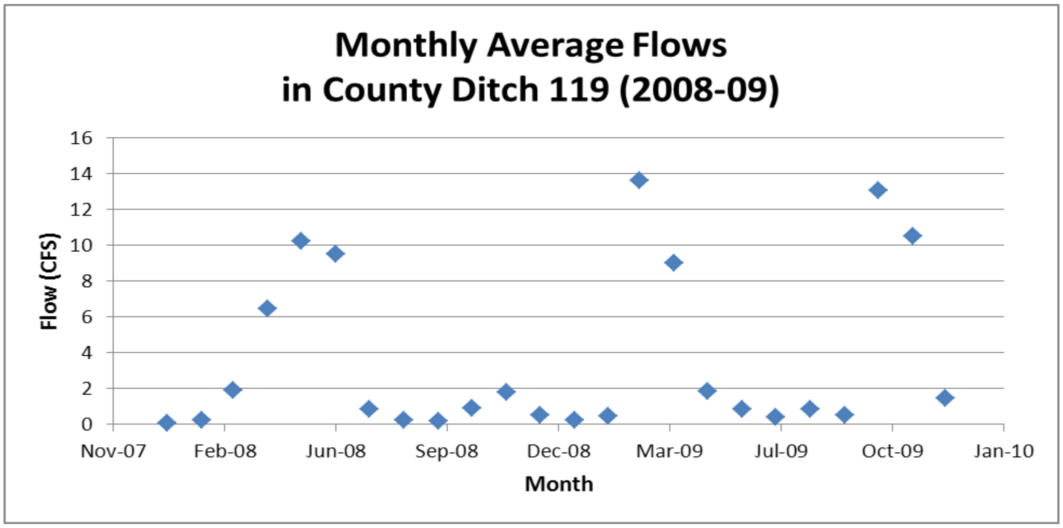


Figure 26. HSPF predicted flows in County Ditch 119 in 2008-09.

The overall lack of consistent flow makes it difficult for biological communities to survive and reproduce and therefore, altered hydrology is a stressor to the biological communities in County Ditch 119.

Candidate cause: High Turbidity/TSS

A total of 78 turbidity measurements were taken from 2005-2011 at County Ditch 119. Of these measurements 23 (29.5 percent) were above the turbidity standard of 25 NTU (Figure 27).

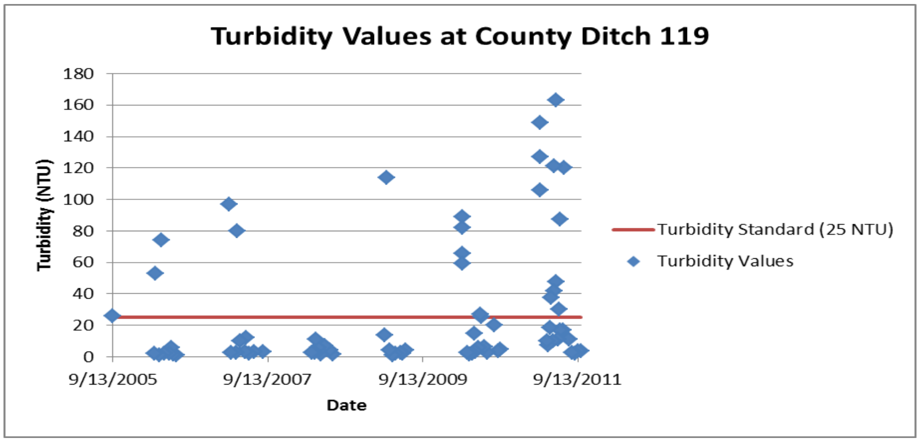


Figure 27. Measured turbidity values from County Ditch 119 from 2005-2011.

The TSS draft standard for County Ditch 119 is 65 mg/L. (Markus 2010). From 2005-2011, 92 TSS measurements were taken and 18 (19.56 percent) exceeded this draft standard (Figure 28). Seven of those readings were at levels more than three times the draft standard. These high levels were measured at times during or immediately following a rain event, or during a time of high runoff conditions in late winter/early spring.

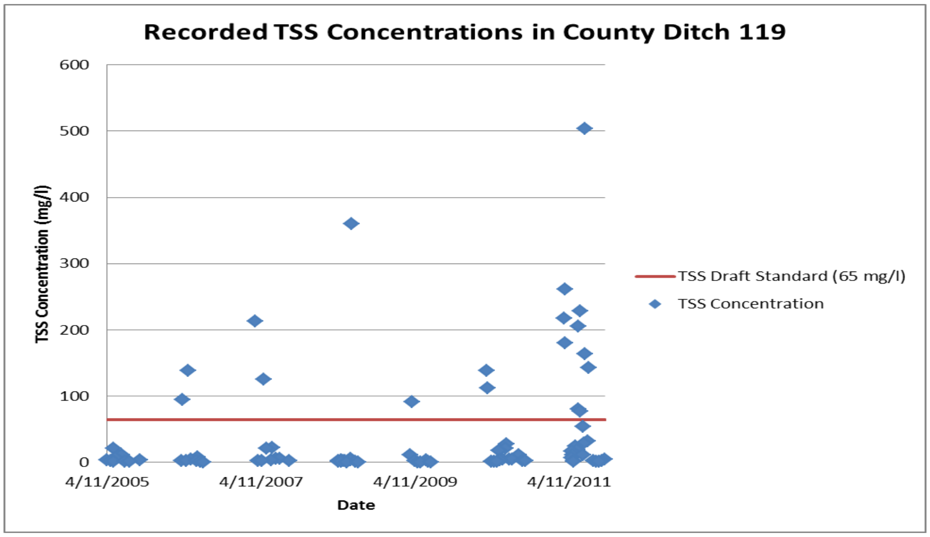


Figure 28. Recorded TSS concentrations in County Ditch 119 from 2005-2011..

Biologically, County Ditch 119 had low percentages of Ephemeroptera (3.1 percent), Trichoptera (0 percent), scraper species (6.3 percent) and collector-filterer species (6.3 percent) which can be sensitive to elevated turbidity or TSS levels.

With the frequent violations of the turbidity and TSS standards, along with the absence of turbidity/TSS sensitive invertebrate species, this parameter is a stressor to the impaired biological communities in County Ditch 119.

Candidate cause: Pesticides

County Ditch 119 had a pesticide sample taken on August 14, 2012. The pesticides detected during this sample can be seen in Table 10.

County Ditch 119 pesticide detections (sample on 8/14/2012)					
Pesticide and info	**County Ditch 119 Result (µg/L)**	**MPCA Class 2B Chronic Standard (µg/L)[1]**	**MPCA Max Standard (µg/L)[1]**	**EPA Acute Value Aquatic Life BenchMark (µg/L)**	**EPA Chronic Value Aquatic Life Benchmark (µg/L)**
Alachlor ESA;degradation product of the parent herbicide alachlor, used as an herbicide to control broad leafed weeds and grasses in corn and other crops.	**.0863**	59	800	52,000 (f, i)	-
Dimethenamid ESA; degradation product of the parent herbicide demethenamid, used as an herbicide to control weeds in corn.	**0.00991**	n/a	n/a	3150 (f)	300 (f)
Metolachlor ESA; degradation product of the parent herbicide metolachlor, widely used in both agricultural and non-crop areas	**0.234**	23	271	24,000 (f)	>95,100 (v)
Saflufenacil; herbicide used to control annual broad leaf plants in soy beans and corn	**. 0.0274**	n/a	n/a	-	-

Table 10: Pesticide sample results for County Ditch 119 at 10MN140.
[1]Parent Herbicide used for MPCA Class 2B chronic and maximum standards.

The pesticide sample taken from County Ditch 119 tested positive for four different herbicides. However, the levels of these herbicides were very minimal and at this point, do not appear to be harming either the fish or invertebrate communities in County Ditch 119. Further pesticide monitoring targeting stormflow events or during the peak run off periods in spring and early summer would provide a better understanding of the pesticides the system may hold as well as their range of values.

Candidate cause: Lack of Habitat

County Ditch 119 scored 55.4 (Fair) for the MSHA, which was taken during the fish sampling visit (6/21/2010). Categories limiting the MSHA score were Land Use, Substrate, and Channel Morphology (Figure 29).

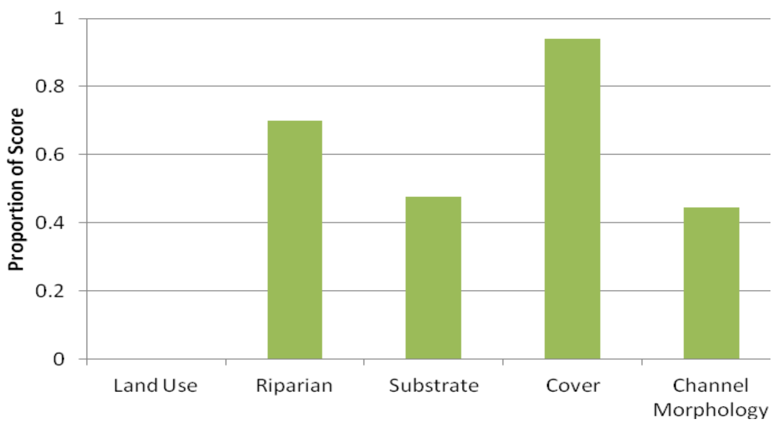


Figure 29. Proportion of possible MSHA subcategory scores in County Ditch 119 at site 10MN140.

At station 10MN140, there is an overwhelming abundance of row crop (corn) at and upstream of the sampling site. This resulted in a score of 0 out of 5 for the Land Use category. Figure 30 provides images of land use practices near County Ditch 119.

Figure 30. Surrounding land uses at 10MN140.

The Substrate category was limited by the high presence of silt. While a few coarse substrates were present, the dominance of silt (causing some embeddedness) within the sampling reach are reasons why this category lowered the overall MSHA score (12.9 of 27).

The Channel Morphology category scored 16 points out of 36 possible. Major factors resulting in a low score at 10MN140 were the lack of riffles, moderate channel stability, fair channel development, and the lack of deep pools preventing more channel depth variability.

Biologically, County Ditch 119 had a low percentage (13.04 percent) of simple lithophilic spawners present. These types of fish prefer a clean gravel substrate for their reproductive needs. Also, the high number of tolerant fish (83.3 percent) and invertebrate taxa (75 percent) as well as the complete lack of riffle-dwelling fish species suggests that habitat is stressing the biological communities.

With habitat scoring low in many categories and the biological assemblages reflecting this, improvements to the surrounding land use, riparian buffer, as well as the overall channel stability of County Ditch 119 would be beneficial to the instream habitat. At this point, habitat should be considered a stressor to the aquatic life of County Ditch 119.

Weight of evidence

For each likely stressor, the quantity and quality of each type of evidence is evaluated for consistency and credibility. Each step for County Ditch 119 was scored and summarized in Table 11. Appendix 1.3 and 1.4 contains further information on scoring.

County Ditch 119						
Types of Evidence	Scores of Candidate Causes					
	Low Dissolved Oxygen	High Phosphorus	High Nitrates	Altered Hydrology	High Turbidity/TSS	Lack of Habitat
Spatial/temporal co-occurrence	+	+	+	+	+	+
Temporal sequence	0	+	+	+	+	0
Field evidence of stressor-response	+ +	+ +	+	+	+	0
Causal pathway	+	+	+	+	+	+
Evidence of exposure, biological mechanism	NE	NE	NE	NE	NE	NE
Field experiments /manipulation of exposure	NE	NE	NE	NE	NE	NE
Laboratory analysis of site media	NE	NE	NE	NE	NE	NE
Verified or tested predictions	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +
Symptoms	+	+	+	+	+	+
Mechanistically plausible cause	+	+	+	+	+	NE
Stressor-response in other lab studies	NE	NE	NE	NE	NE	NE
Stressor-response in other field studies	+ +	+	+	+	+	+
Stressor-response in ecological models	NE	NE	NE	NE	NE	NE
Manipulation experiments at other sites	NE	NE	NE	NE	NE	NE
Analogous stressors	NE	NE	NE	NE	NE	NA
Consistency of evidence	+ + +	+ + +	+ + +	+ + +	+ + +	+
Explanatory power of evidence	+ +	+ +	+ +	+ +	+ +	+ +

Table 11. Weight of evidence table for potential stressors in County Ditch 119.

Conclusions

In County Ditch 119, low DO, high phosphorus and nitrates, altered hydrology, turbidity/TSS, and lack of habitat were all determined to be stressors causing the fish and invertebrate communities to be impaired.

Dissolved oxygen levels frequently dropped below 5 mg/L making it difficult for many fish species to complete their life cycles. The daily flux of DO often was greater than 5 mg/L. These extreme changes can be too volatile for many sensitive species of both fish and invertebrates.

Phosphorus levels were also elevated in the watershed. Excess phosphorus itself does not directly result in harm to biological communities; it does however cause imbalances in the stream system affecting other factors such as DO levels. The abundant agricultural fields are the likely pathway for these amounts of phosphorus to enter County Ditch 119.

Nitrate values in County Ditch 119 were elevated throughout the watershed. Concentrations were often above 11.5 mg/L which is a level in which the MIBI will dip below the threshold ultimately resulting in impairment. Furthermore, the biology reflected these conditions with a very small population of non-hydropsychid Trichoptera invertebrate species. The fish population was also dominated by fathead minnows and brooks sticklebacks which are found to be very tolerant of elevated nitrate levels.

Channelization of waterways is a common practice throughout this watershed. This leads to inconsistent flows of water hindering colonization of many types of biota and can result in erosion during high flow events following precipitation events. Altered waterways can also provide an easier access point for other nutrients to enter the water system.

Turbidity and TSS both had levels that were often above their current standards or proposed ecoregion standards. These results occurred frequently after rain or snowmelt runoff events. These fine sediments have settled in the stream channel and are embedding coarse substrates needed by different types of fish for reproduction.

Habitat in this stream and throughout the minor watershed has likely been affected by the current land use practices and subsequent changes in hydrology. These changes are having an effect on the biology resulting in the fish and invertebrate impairment designations. Habitat restoration and protection strategies should be considered to ensure there is enough suitable habitat available for the desirable biological assemblages to survive and carry out their respective life cycles.

County Ditch 36

County Ditch 36 (AUID: 07020004-716) was assessed in 2012 and determined to be impaired for both fish and aquatic invertebrate communities. The impaired reach extends from Unnamed Creek to Hawk Creek. Figure 31 is a detailed map of the watershed and the impaired AUID.

The land use of the County Ditch 36 minor watershed consists mainly of cultivated crops (77.69 percent), herbaceous wetlands (8.72 percent), and developed, open space (7.4 percent).

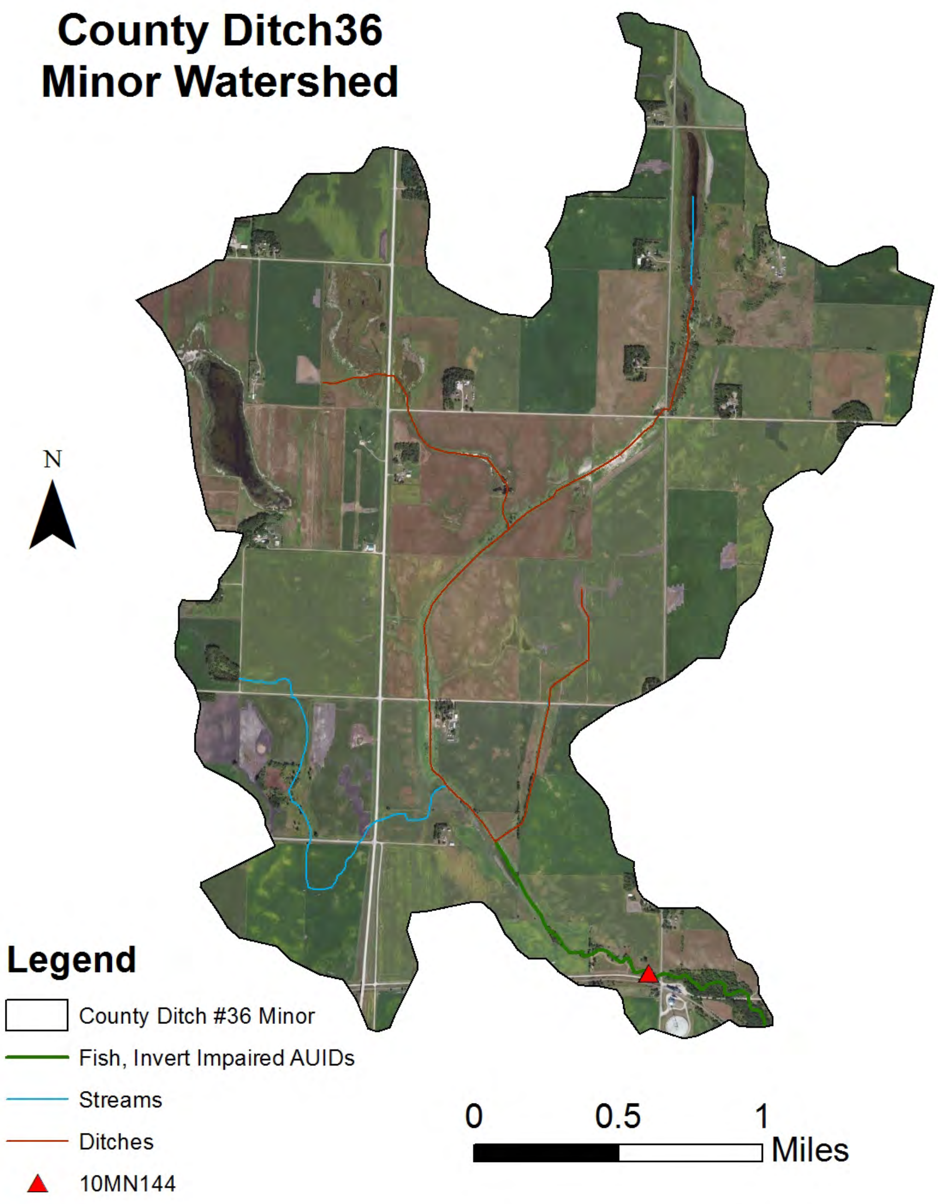


Figure 31. County Ditch 36 watershed with the fish and invertebrate impaired reach highlighted.

Biology in County Ditch 36

This AUID had one fish and one invertebrate sampling event at the one sampling station, 10MN144, located upstream of 110th St, 2 miles east of Granite Falls. This site scored below the fish IBI threshold for a Class 3 (Southern Headwaters) stream and confidence limit. During the invertebrate visit, the site scored below the MIBI threshold for a Class 5 (Southern Streams RR) stream, but above the confidence limit. After this site was deemed impaired, additional physical and chemical monitoring has taken place during 2012 by the MPCA as well as the Hawk Creek Watershed Project.

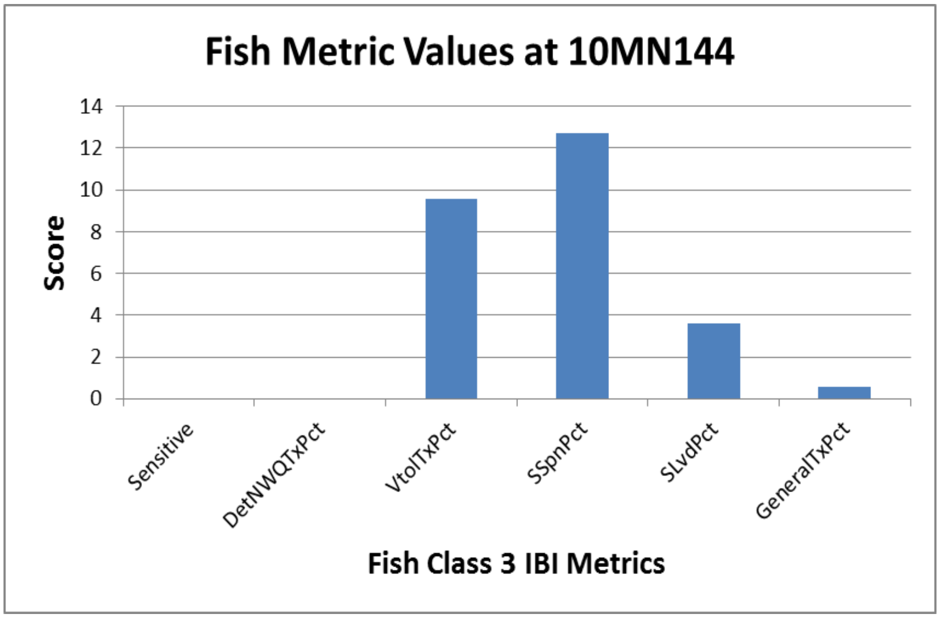


Figure 32. Fish IBI metric values in County Ditch 36 at biological sampling station 10MN144.

To reach the Fish IBI threshold for a Class 3 Southern Headwaters stream like County Ditch 36, each metric would need an average score of 8.5. Metrics scoring below average in the Fish IBI were GerneralTxPct, SLvdPct, DetNWQTxPct, and Sensitive (Figure 32). These metrics indicate an abundance of generalist fish species that can survive in most environments and are not specialized as well as short-lived species that tend to be very tolerant and can dominate a system. County Ditch 36 also had many fish species that are considered detritivorous, which feed on dead plant or animal matter.There was also a complete lack of sensitive species. These results are very similar to County Ditch 119.

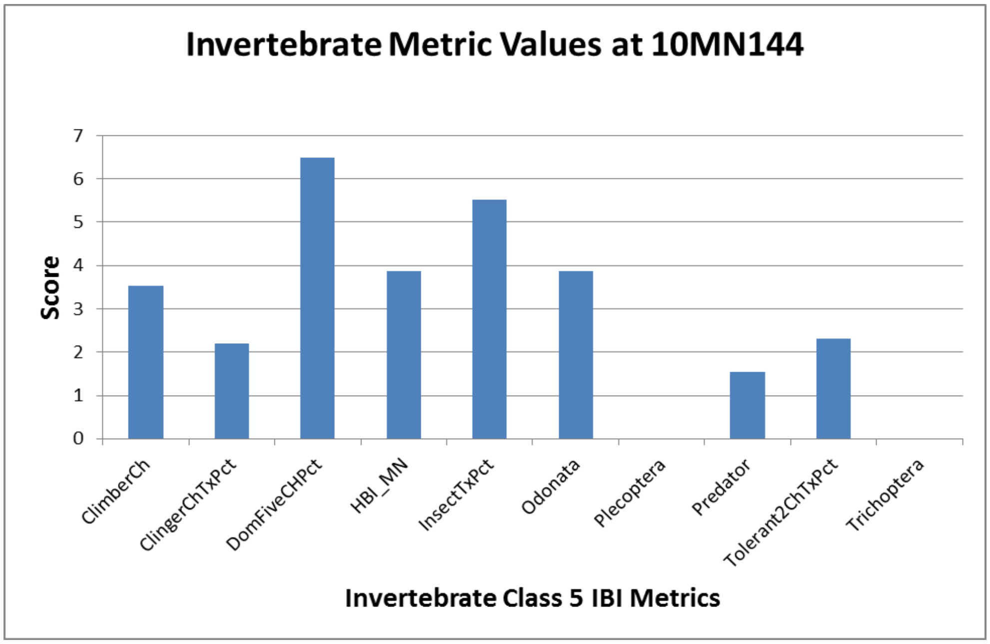


Figure 33. Individual invertebrate metric scores for 10MN144.

To meet the MIBI threshold for an Invertebrate Class 5 stream, individual metrics need to average a score of 3.59 points to reach the MIBI threshold for this type of stream. As Figure 33 shows, nearly half of the metrics met this criteria. This site was mainly limited by the Plecopteraand Trichoptera metric scores. The absence of these orders of invertebrates can indicate some DO as well as habitat problems.

Candidate cause: Low Dissolved Oxygen

The DO data in County Ditch 36 were extremely limited with measurements only coming from the biological sampling visits. The DO reading during the fish sampling event was 6.32 mg/L taken at 11:20 am and 3.99 mg/L during the invertebrate sample with the measurement taken at 7:12 pm. Low flow conditions in 2012 prevented further DO analysis.

Of the four fish species caught during the sampling event, nearly 78 percent of those individuals are considered to be tolerant of low DO conditions. This high abundance of tolerant individuals, lack of any sensitive species, and a measured value below the minimum standard signifies that DO is likely a stressor to this watershed.

Candidate cause: High Phosphorus

County Ditch 36 has had two phosphorus measurements taken from 2010-2012. The results can be seen in Table 12.

Site	Visit Date	Result (mg/L)	Proposed Draft Standard (mg/L)
10MN144	7/8/2010	0.496	0.15
10MN144	6/26/2012	0.162	0.15

Table 12. Phosphorus sampling results for County Ditch 36 at biological station 10MN144.

Biologically, the high levels of phosphorus has aided in the low percentages of Intolerant invertebrate species (0 percent), sensitive fish species (0 percent) as well as a lower than expected taxa count (22) and EPT taxa (14.3 percent) (See Minnesota River Nutrient Criteria Development for more information.) Furthermore, 100 percent of the fish sampled are considered to be tolerant.

Figure 34. County Ditch 36 likely being affected by elevated levels of phosphorus.

Both phosphorus samples had values over the proposed draft standard of 0.15 mg/L, with the sample taken in 2010 over three times the standard (0.496 mg/L). Despite the limited number of samples, photographic evidence (Figure 34), biological communities reflecting ones impacted by high levels of phosphorus and since both samples have exceeded the proposed standard, phosphorus should be considered a likely stressor to the impaired biological communities in County Ditch 36.

Candidate cause: High Nitrates

There were only two nitrate samples collected from County Ditch 36, both at biological station 10MN144 (See Table 13).

Site	Visit Date	Result (mg/L)	Proposed Draft Standard (mg/L)
10MN144	7/8/2010	0.73	n/a
10MN144	6/26/2012	1.3	n/a

Table 13. Nitrate sampling results for County Ditch 36 at biological station 10MN144.

Both nitrate readings are well below levels known to cause damage to fish and invert communities. However, more monitoring needs to be done when ample flow is present to get a better idea of the affect, if any, that nitrates are having on the biology in County Ditch 36.

Candidate cause: Altered Hydrology

Over 75 percent of the waterways in the County Ditch 36 watershed are channelized. This includes the impaired AUID, 07020004-716, which is 46 percent channelized (Figure 31). With a drainage area of only 5.74 square miles, the flashy tendencies of the stream caused by widespread channelization have a negative impact on the biological communities.

Figure 35. Dry and perched culvert in County Ditch 36 (photo taken by Hawk Creek watershed project).

Biological communities in streams that dry up or get disconnected have an extremely difficult time recovering. County Ditch 36 has been observed being disconnected and intermittent in July of 2012 (Figure 35).

Biologically, County Ditch 36 had low levels of swimmer species (5.7 percent), a complete lack of long lived fish species (0 percent) and a fish population consisting of 100 percent tolerant species. These biological assemblages are characteristics of a stream that often experiences periods of low to zero flow.

The HSPF model predicts that low flows in County Ditch 36 are fairly common. Flows well under 1 CFS routinely occurs making it challenging for healthy biological communities to establish themselves. The overall lack of consistent flow throughout the year makes altered hydrology a stressor to the biological communities in County Ditch 36.

Candidate cause: High Turbidity/TSS

Given the low amount of turbidity/TSS/transparency data collected, it is too early to rule out this parameter as a stressor. The absence of herbivorous fish and lower levels of collector-filterer invertebrate species are reasons to believe that this parameter could be a stressor. However, more sampling during base flow conditions will help determine the effect that turbidity/TSS is having on the biological communities in County Ditch 36.

Candidate cause: Lack of Habitat

County Ditch 36 scored 62.25 (Fair) for the MSHA, which was taken during the fish sampling visit (7/8/2010). Categories limiting the MSHA score the most were Land Use, Substrate, and Channel Morphology (Figure 36).

While the immediate riparian at and near the site is fairly extensive, further upstream is heavily impacted by row crop agriculture. The lack of buffer in these areas can provide an easy route for runoff and their accompanying nutrients to make their way to the stream system. Station 10MN144 scored 0 out of 5 in the Land Use category.

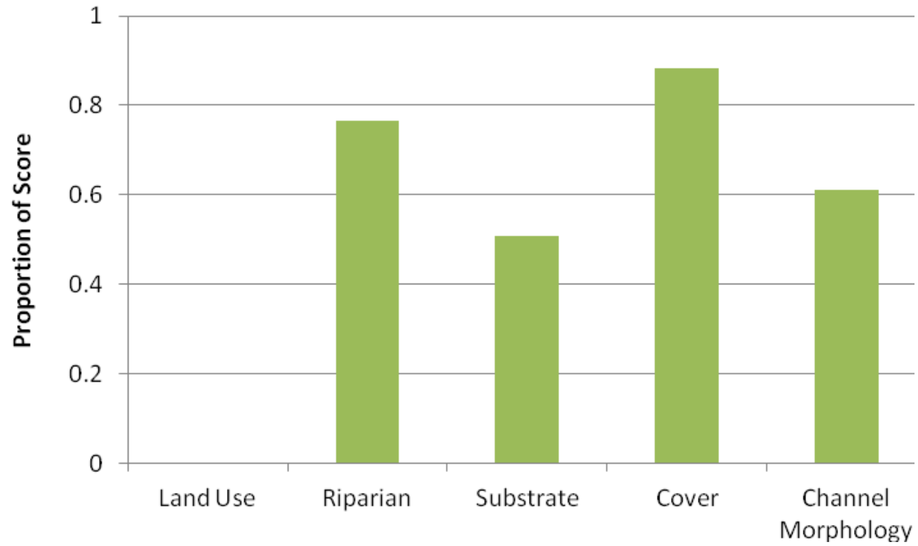


Figure 36. MSHA scores by category for County Ditch 36 at station 10MN144.

Biologically, County Ditch 36 had a low percentage (4.08 percent) of simple Lithophilic spawning fish species, and a complete lack of benthic insectivores (0 percent) and had an absence of darters, sculpins, and round bodied suckers. These types of fish are commonly absent in degraded habitat conditions. There was also a high percentage (68.6 percent) of tolerant invertebrate taxa, which can be attributed to poor habitat conditions.

While certainly not the most severe stressor to aquatic life in County Ditch 36, the overall habitat at biological station 10MN144 could still be enhanced. Improvements to the surrounding land use, increases in buffer width, and providing measures that help stabilize the stream would go a long way towards increasing the amount of suitable habitat in this stream. Until then, habitat should be considered a stressor to the impaired fish and invertebrate assemblages in County Ditch 36.

Weight of evidence

For each likely stressor, the quantity and quality of each type of evidence is evaluated for consistency and credibility. Each step for County Ditch 36 was scored and summarized in Table 14. For more information on scoring, please see Appendix 1.3 and 1.4.

County Ditch 36				
Types of Evidence	**Scores of Candidate Causes**			
	Low Dissolved Oxygen	**High Phosphorus**	**Altered Hydrology**	**Lack of Habitat**
Spatial/temporal co-occurrence	+	+	+	+
Temporal sequence	0	0	0	0
Field evidence of stressor-response	+	+	+ +	+
Causal pathway	+	+	+	+
Evidence of exposure, biological mechanism	NE	NE	NE	NE
Field experiments /manipulation of exposure	NE	NE	NE	NE
Laboratory analysis of site media	NE	NE	NE	NE
Verified or tested predictions	+	+	+ + +	+
Symptoms	+	+	D	0
Mechanistically plausible cause	+	+	+	NE
Stressor-response in other lab studies	NE	NE	NE	NE
Stressor-response in other field studies	+ +	+	+	+
Stressor-response in ecological models	NE	NE	NE	NE
Manipulation experiments at other sites	NE	NE	NE	NE
Analogous stressors	NE	NE	NE	NA
Consistency of evidence	+	+	+ + +	+
Explanatory power of evidence	+ +	+ +	+ +	+ +

Table 14. Weight of evidence table for potential stressors in County Ditch 36.

Conclusions

In County Ditch 36, low DO, high phosphorus, altered hydrology, and lack of habitat were all determined to be stressors causing the fish and invertebrate communities to be impaired.

The primary reason for these impairments is the lack of consistent base flow. When a stream frequently dries up or becomes intermittent it makes it extremely difficult for many species, especially sensitive species, of biota to re-establish themselves and complete their respective life cycles. Having a consistent base flow of water will allow this stream to be monitored more frequently for other stressors including: DO, nitrate, phosphorus, turbidity, and pesticides. Until that time, those potential stressors cannot be eliminated as factors causing the biological impairments.

Despite the limited data, phosphorus should still be considered a stressor to the fish and invertebrate communities of County Ditch 36. Both measurements were well above the proposed draft standard of 0.15 mg/L. The elevated levels of phosphorus also may be altering other parameter in County Ditch 36 such as DO, pH, water clarity, and changes in food resources.

Habitat conditions are also contributing to the fish and invertebrate impairment in County Ditch 36. Poor surrounding land use, especially in the upper headwaters of the watershed where minimal buffer areas exist, low channel stability, and the high presence of silt are all correctable issues that limit the habitat in this stream system.

Overall, there are multiple stressors to the impaired fish and invertebrate communities in County Ditch 36. Significant efforts should be made to limit phosphorus entering the water way, improve habitat conditions, and most importantly to alter the surrounding landscape to help return the flow regime back to a more consistent and less flashy system. These efforts over time will aid in the removal of this stream from the impaired waters list.

Unnamed Creek Watershed

Unnamed Creek (AUID: 07020004-566) was assessed in 2012 and determined to be impaired for aquatic invertebrate communities and reaffirmed the existing impairment for fish communities. This AUID was listed as impaired for fish during the 2004 assessment cycle. The impaired reach extends from the tributary confluence upstream of 820th Avenue to the next tributary confluence downstream of 810th Avenue. Figure 37 is a detailed map of the watershed and its impairments.

The Unnamed Creek minor watershed’s land use is primarily cultivated crops (79.19 percent). Other common land use types are emergent herbaceous wetlands (9.39 percent) and developed, open space (5.36 percent). Like much of the Hawk Creek watershed, Unnamed Creek is susceptible to the problems commonly found in areas with similar land use.

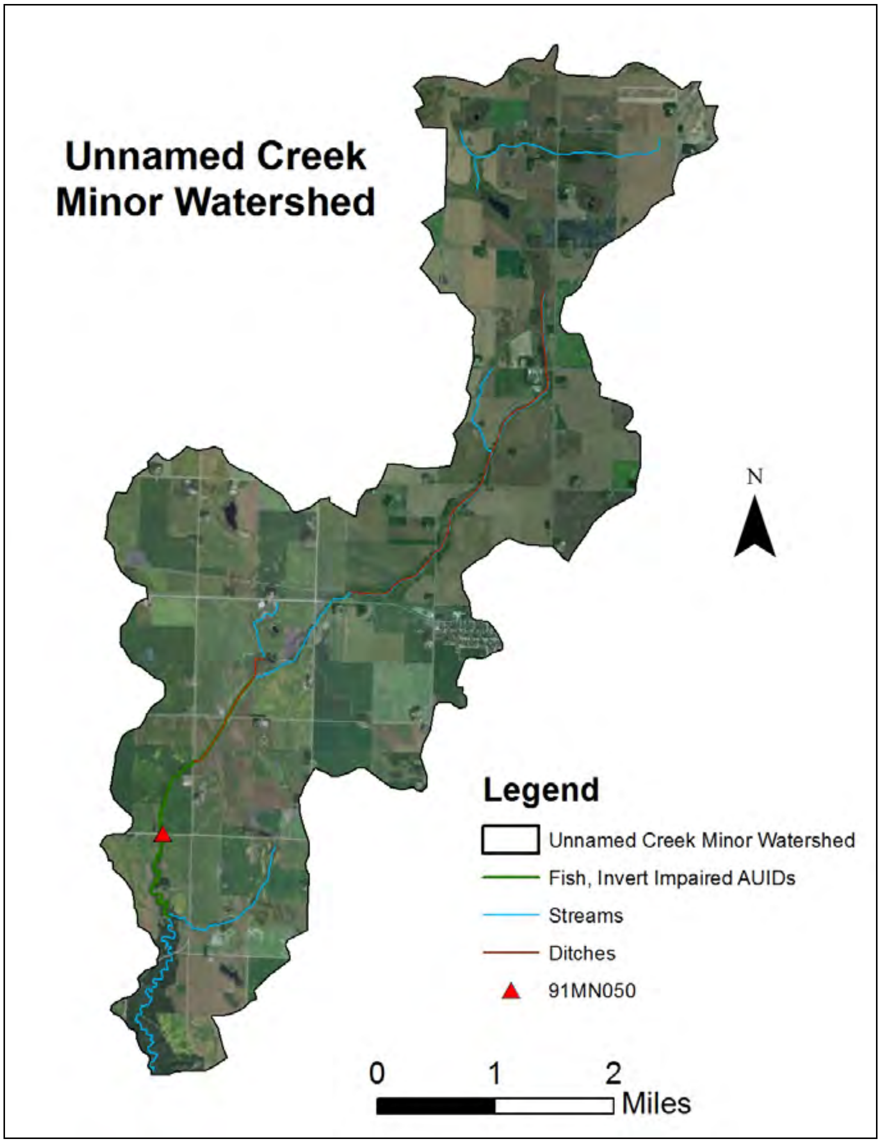


Figure 37. Unnamed Creek watershed with fish and invertebrate impaired reach highlighted.

Biology in Unnamed Creek

The biological sampling site, 91MN050, is located upstream of 810th Avenue, 2.5 miles SW of Sacred Heart. During this last assessment cycle, this location was sampled twice for fish. Each visit had an FIBI score below both the threshold and confidence limit for a Class 3 (Southern Headwaters) stream. In fact, every fish sampling event ever taken at this site (5) scored a 0 for fish IBI (Table 15).

There were two invert visits in 2010 and both were below the threshold and confidence limits for a Class 7 (Prairie Streams GP) stream. After this site was deemed impaired, additional physical and chemical monitoring has taken place during 2012 by the MPCA as well as the Hawk Creek Watershed Project.

Site 91MN050 had Invertebrate IBI scores of 15.9 and 16.3. These scores are both well below the Class 7 threshold of 38.3. These low MIBI scores can be attributed to the lack of climber and collector-filterer species present. Invertebrates belonging to the orders of Plecoptera, Odonata, Ephemeroptera, and Trichoptera were also present in low numbers. The low numbers of species in those orders can signify water quality issues.

Sample Year	Species Caught	Individuals Caught	Fish IBI
1991*	1	8	0
2001	1	21	0
2010	1	1	0
2010	1	1	0
2010*	0	0	0

Table 15. Historical fish sampling information at Unnamed Creek, 91MN050.
***** Minnesota River Assessment Project (MRAP) sampling protocols were used.

Candidate cause: Low Dissolved Oxygen

Very few DO data points exist for Unnamed Creek with the only readings taken during the biological sampling visits. A reading on 8/25/2010 at 8:00 AM was 3.31 mg/L which is below the 5 mg/L minimum standard, while other readings are close to the standard (Table 16).

Site	Visit Date	D.O. (mg/L)
91MN050	8/2/2001	5.1
91MN050	8/2/2001	6.4
91MN050	7/20/2010	7.2
91MN050	8/25/2010	3.31

Table 16. DO readings on Unnamed Creek at biological station 91MN050.

Sensitive fish species can be an indicator of DO conditions in streams. During the fish sampling events, only two fish species were captured, fathead minnows and brook sticklebacks. The DO tolerance indicator values (TIV) for these two species are both very low meaning that these species can survive in low DO conditions much easier than other more sensitive fish species in Minnesota.

Invertebrate populations in Unnamed Creek showed lower levels of EPT taxa (7.7 percent) and low taxa richness (15). These results can be linked to low DO levels that this stream likely experiences on a regular basis.

Low flow conditions during the summer of 2012 prevented further DO testing. With the measured results near and sometimes falling below the 5.0 mg/L minimum standard , combined with the total lack of sensitive fish species, low levels of EPT species, and a general lack of diverse invertebrate populations, it is likely that the DO conditions in Unnamed Creek are impeding the health of the biological communities.

Candidate cause: High Phosphorus

Unnamed Creek had four phosphorus measurements taken on it from 2001-2012 (Table 17). All four of these samples were more than double the proposed standard of 0.15 mg/L.

Site	Visit Date	Result (mg/L)	Proposed Draft Standard (mg/L)
91MN050	8/2/2001	0.408	0.15
91MN050	8/25/2010	0.342	0.15
91MN050	7/20/2010	0.487	0.15
91MN050	6/27/2012	0.318	0.15

Table 17. Phosphorus measurements taken at Unnamed Creek at 91MN050 from 2001-2012.

Biologically, Unnamed Creek had low levels of EPT taxa (7.7 percent), no intolerant invertebrates, while having higher levels of scraper species (17.9 percent) and tolerant taxa (64.3 percent). These populations are characteristics of a stream with elevated phosphorus levels.

Despite the low number of samples, the degree that the samples violated the proposed standard concludes that phosphorus is ultimately having a degrading effect on the stream (Figure 38) and the biology in Unnamed Creek. Therefore, phosphorus should be considered a stressor to the impaired biological communities.

Figure 38. Unnamed Creek experiencing algal growth likely caused by excess phosphorus.

Candidate cause: High Nitrates

Unnamed Creek had four nitrate measurements taken from 2001-2012 (Table 18).

Site	Visit Date	Result (mg/L)	Proposed Draft Standard (mg/L)
91MN050	8/2/2001	0.05	n/a
91MN050	8/25/2010	0.46	n/a
91MN050	7/20/2010	0.84	n/a
91MN050	6/27/2012	0.65	n/a

Table 18. Nitrate sampling results from Unnamed Creek at biological station 91MN050 from 2001-2012.

All four of the nitrate samples taken from Unnamed Creek were well below levels considered to be harmful of the biological communities. More sampling for nitrates is recommended during base flow conditions to fully the determine the impacts, if any, nitrate is having on the fish and invertebrate assemblages in Unnamed Creek.

Candidate cause: Altered Hydrology

Approximately 60 percent of the waterways in the Unnamed Creek watershed are channelized. This includes the impaired AUID, 07020004-566, which is 46 percent channelized (Figure 37). This widespread practice has negative effects on the biological communities.

Flows in Unnamed Creek have proven to be fairly intermittent. Significant channelization and tile drainage used in the headwaters of this watershed helps moves water off the farm fields and to the streams rather quickly. This causes the flows of this stream system to become very inconsistent. Frequent high flows can lead to large amounts of erosion, while numerous periods of intermittent or no flow reduces the connectivity and ultimately the ability for this stream to support healthy fish and invertebrate populations. Unnamed Creek has been observed dry during the fall of 2009 as well as the summer of 2012 (Figure 39). The HSPF model also predicts periods of negligible flow from 1993-2009.

Figure 39. (clockwise from top left) Biological sampling station, 91MN050, during July fish sampling in 2010; (right) dry stream bed at 91MN050 in August 2012; (bottom left) dry water sampling station located downstream of 91MN050 in 2012.

Another change in the hydrology of a stream can be the impact that beavers can have on a system. Figure 40 shows a small beaver dam on Unnamed Creek that can also contribute to the flow problems, the migration of fish and invertebrate species, as well as the habitat conditions found upstream and downstream of the impoundment.

Biologically, the fish populations in Unnamed Creek consisted of 100 percent tolerant species, while lacking any long lived and migratory fish species. Invertebrate populations lacked swimmer taxa (0 percent), which are also indicative of a stream stressed by frequent periods of low to zero flow.

Figure 40: Upstream of 91MN050, beaver activity into a wetland like environment.

The affects of channelization, the inconsistent and minimal flow, the HSPF model results, as well as the presence of beaver dams makes altered hydrology a major stressor to the impaired biological communities in Unnamed Creek.

Candidate cause: Turbidity/TSS

Unnamed Creek had three TSS measurements taken during its fish sampling events from 2001-2010 (Table 19). All three of these readings were well below the TSS draft standard of 65 mg/L.

Site	Visit Date	TSS Result (mg/L)
91MN050	02-Aug-01	27
91MN050	25-Aug-10	1.6
91MN050	20-Jul-10	1.2

Table 19. TSS sample results at Unnamed Creek.

Biologically, invertebrate populations in Unnamed Creek had low levels of Trichoptera taxa (3.6 percent), Ephemeroptera taxa (7.1 percent), and collector-filterer taxa (11.5 percent) while having high populations of Chironomid taxa (46.2 percent) and tolerant taxa (73.1 percent). These results can be partially attributed to elevated levels of turbidity/TSS. However, with the limited amount of data collected, turbidity/TSS should only be considered a potential stressor to the impaired biological communities at this time.

Candidate cause: Lack of Habitat

Unnamed Creek had MSHA scores of 53.85 (Fair) and 56(Fair) during its two fish sampling events in 2010. Categories limiting the MSHA score in this stream the most were Land Use, Substrate, and Channel Morphology (Figure 41).

This station, 91MN050, scored a 0 in the Land Use category. This is due to the abundant row crop agriculture present near the site and upstream of it.

The substrate category of the MSHA was brought down by the high amounts of embeddedness and the lack of large coarse substrates. This signals that there is likely an erosion problem upstream of this reach.

Factors limiting the Channel Morphology category were channel stability and the channel development. Unstable banks, the lack of large coarse substrates, and the lack of any different riffle/run/pool sequences contributed to the low scores for channel morphology.

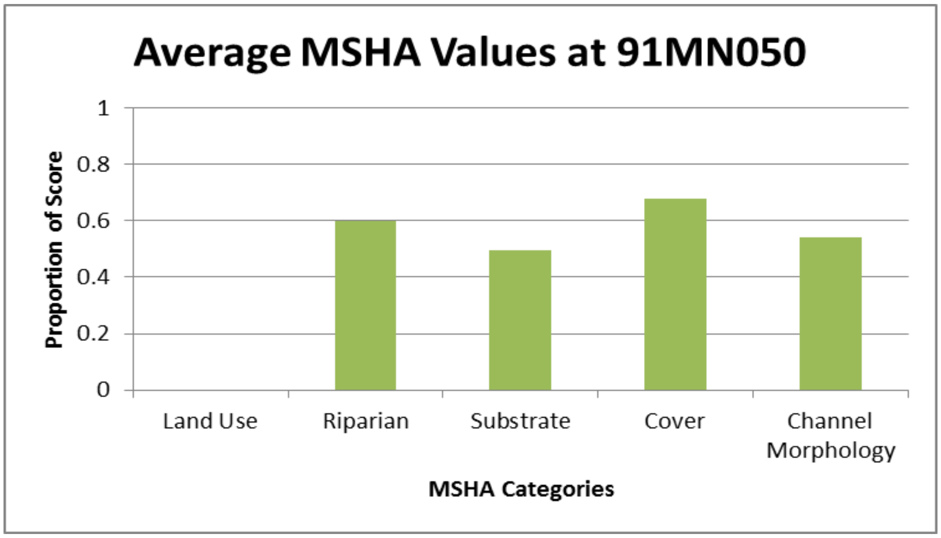


Figure 41. MSHA scores by category on Unnamed Creek at site 91MN050.

Biologically, fish populations in Unnamed Creek did not have any simple lithophilic spawners, benthic insectivores, or riffle dwelling fish species while containing 100 percent tolerant taxa. Invertebrates in Unnamed Creek had a below average amount of clinger taxa (25 percent) and an abundance of tolerant taxa (73.1 percent) All of these values reflect biological assemblages affected by less than ideal habitat conditions.

Improving habitat conditions in Unnamed Creek is an important restoration activity that needs to be considered. Altering the current land use, increasing buffer widths, and limiting the amount of sediment reaching the stream will go a long way to enhance the available habitat to the fish and invertebrates. Until then, habitat should be considered a stressor to the impaired biological communities in Unnamed Creek.

Weight of evidence

For each likely stressor, the quantity and quality of each type of evidence is evaluated as well as consistency and credibility. Each step for Unnamed Creek was scored and summarized in Table 20. For more information on scoring, please see Appendix 1.3 and 1.4.

Unnamed Creek				
	Scores of Candidate Causes			
Types of Evidence	**Low Dissolved Oxygen**	**High Phosphorus**	**Altered Hydrology**	**Lack of Habitat**
Spatial/temporal co-occurrence	+	+	+	+
Temporal sequence	+	+	+	+
Field evidence of stressor-response	+	+	+ +	+
Causal pathway	+	+	+	+
Evidence of exposure, biological mechanism	NE	NE	NE	NE
Field experiments /manipulation of exposure	NE	NE	NE	NE
Laboratory analysis of site media	NE	NE	NE	NE
Verified or tested predictions	+	+	+ + +	+
Symptoms	+	+	D	+
Mechanistically plausible cause	+	+	+	NE
Stressor-response in other lab studies	NE	NE	NE	NE
Stressor-response in other field studies	+ +	+	+	+
Stressor-response in ecological models	NE	NE	NE	NE
Manipulation experiments at other sites	NE	NE	NE	NE
Analogous stressors	NE	NE	NE	NA
Consistency of evidence	+	+	+ + +	+ + +
Explanatory power of evidence	+ +	+ +	+ +	+ +

Table 20. Weight of evidence table for potential stressors in Unnamed Creek.

Conclusions

Unnamed Creek has had an impaired fish community since being assessed for biology in 2004. The most recent assessment in 2012 revealed that this stream is still impaired for fish, but also the invertebrate community. There are many factors contributing to these impairments with the major reason being the inconsistent and lack of flow of the stream. Streams that frequently dry up make it extremely difficult for these biological communities to re-establish themselves.

The abundant channelization within the watershed can lead to flashy flows in the stream by quickly moving water following rain events into the stream system. This water moves through the system very fast disrupting normal flows that the stream may have while also contributing to increased amounts of erosion.

Despite limited DO samples, it appears that this parameter is also stressing the biological communities on this stream. The only fish species sampled over the many visits to Unnamed Creek were the fathead minnow and brook stickleback, which are two species that are very tolerant to low DO conditions.

In stream habitat is another stressor that is contributing to the impaired fish and invertebrate communities in Unnamed Creek. Problems caused by intense land use, channel morphology, and substrates are present throughout this stream reach. Improvements to these habitat categories could go a long way to bringing back a more diverse and generally healthier fish and invertebrate assemblages.

Although excess phosphorus does not directly harm fish or invertebrates, it does lead to changes in other parameters including DO, pH, water clarity, and habitat. Dissolved oxygen and habitat are considered stressors to this stream which could be partially attributed to the excess phosphorus this system receives.

While Unnamed Creek has many causes of stress to the biological communities, providing a consistent base flow to this system would go a long way towards improving both the fish and invertebrate populations. Managing the local sources and intensity of phosphorus applications would be another solution to the problems this stream faces. Until these causes are addressed, Unnamed Creek will likely remain as an impaired biological stream reach.

Summary and Recommendations

The Hawk Creek watershed is impaired for biology at four different streams: Smith Creek, County Ditch 119, County Ditch 36, and Unnamed Creek. Multiple stressors were found at all streams studied.

Dissolved oxygen is a clear stressor in County Ditch 119 as evidenced by the continuous diurnal monitoring using a sonde. Numerous daily minimums under 5 mg/L as well as daily fluctuations over 5 mg/L made it quite obvious that this system is stressed by low DO. This parameter is viewed as a potential stressor in both County Ditch 36 and Unnamed Creek. More monitoring is needed on those streams to better understand the stress this parameter has on the biological communities. The impaired invertebrate community in Smith Creek does not appear to be affected by DO at this time.

Given the high phosphorus readings watershed-wide and highlighted in the biologically impaired reaches of County Ditch 36, County Ditch 119, and Unnamed Creek; a large scale plan to reduce phosphorus amounts may be needed. Management plans focusing on the timing and intensity of the fertilizers and manure application would help reduce the amount of phosphorus in the system. These reductions would also aid in the DO problems present in the watershed.

Elevated levels of nitrates are stressing the invertebrate communities in Smith Creek and County Ditch 119 as well as the fish assemblage in County Ditch 119. With the spikes of nitrate coinciding with snowmelt and rainfall events along with the abundance of cropland in the Hawk Creek watershed, fertilizer application is the likely source of the nitrates in these waterways. Reducing the amounts of nitrates in the system can be achieved by lowering fertilizer application rates, better application times, using cover crops, wetland restorations and increasing the stream buffer width.

Altered hydrology is a major stressor to the fish and invertebrate communities at the impaired reaches within the Hawk Creek watershed. All biotic impairments have an extensively channelized headwater system in their respective minor watersheds. Drain tiles and channelized streams are designed to remove water quickly from the landscape and into the waterway. With little water retention, flows can become inconsistent resulting in extremely fast and erosive flows following rain events as well as intermittent and dry stream beds in the fall and summer when precipitation is less abundant. Specifically, County Ditch 36 and Unnamed Creek have been found to be intermittent multiple times in the last five years making it difficult for fish and invertebrate populations to thrive and recover following times of no flow. Changes to the landscape that reduce the volume, rates and timing of runoff as well as increase the base flows will be needed to prevent continued and further impairments to biological assemblages not only in the studied stream reaches, but throughout the Hawk Creek watershed.

Turbidity and TSS are issues that need to be addressed in County Ditch 119 to help improve the biological assemblages. Increasing stream buffer width, improving hydrology, as well as improving riparian conditions are activities that need to be considered to reduce turbidity values. More turbidity and TSS monitoring needs to be done at County Ditch 36 and Unnamed Creek during base flow conditions to better understand the impacts this parameter is having on the fish and invert populations. Turbidity and TSS do not appear to be stressors at Smith Creek at this time. While this report focuses on the biological impairments, turbidity and TSS are watershed wide problems and improvements need to be made on a large scale basis to prevent further impairments to the biological communities.

Habitat throughout the studied reaches had MSHA scores that fell mostly in the Fair category. In general, increases in riparian buffer width, and stabilizing stream banks would greatly help the in-stream habitat that many of these impaired streams lack. Further restoration practices and techniques would also help alleviate the stress on the biological communities in this watershed and could eventually aid in the removal of these streams from the impaired waters list.

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Appendix 1.1 – MPCA fish IBI class criteria for Hawk Creek watershed streams

Fish IBI Class	Class Name	Drainage Area	Gradient
1	Southern Rivers	> 300 mi^2	not specified
2	Southern Streams	> 30 mi^2, < 300 mi^2	not specified
3	Southern Headwaters	< 30 mi^2	> 0.50 m/km
7	Low Gradient	< 30 mi^2	< 0.50 m/km

Appendix 1.2 – MPCA invertebrate IBI class criteria for Hawk Creek watershed streams

M-IBI IBI Class	Class Name	Drainage Area	Description
2	Prairie Forest Rivers	>500 mi^2	Sites in Minnesota that are representative of the Eastern Broadleaf forest, Prairie Parklands, and Tall Aspen Parklands ecological provinces
5	Southern Streams (Riffle/Run Habitats)	<500 mi^2	Sites within this class are representative of the Eastern Broadleaf forest, Prairie Parklands, and Tall Aspen Parklands ecological provinces, as well as streams in HUC 07030005.
7	Prairie Streams (Glide/Pool Habitats)	<500 mi^2	Sites in Minnesota that are representative of the Prairie Parklands and Tall Aspen Parklands ecological provinces

Appendix 1.3 - Values used to score evidence in the stressor identification process developed by EPA

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*	

Appendix 1.4 - Strength of evidence scores for various types of evidence used in stressor ID analysis

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, -

Appendix 2.1 - Biological monitoring results – fish IBI (assessable reaches)

12-HUC	AUID	Biological Station	Stream	Drainage Area (mi^2)	Fish Class	Fish IBI	Threshold	Visit Date
070200040207	07020004-534	10MN007	Palmer Creek (County Ditch 68)	33.28	2	53	45	28-Jul-10
070200040207	07020004-610	10MN076	Brafees Creek	6.38	3	68	51	07-Jul-10
070200040207	07020004-682	10MN116	County Ditch 36A	8.54	3	65	51	07-Jul-10
070200040905	07020004-587	10MN122	Hawk Creek	494.29	1	51	46	28-Jul-10
070200040905	07020004-587	90MN017	Hawk Creek	501.16	1	71	46	14-Sep-10
070200040905	07020004-716	10MN144	County Ditch 36	5.11	3	26	51	08-Jul-10
070200041007	07020004-687	10MN140	County Ditch 119	14.42	3	43	51	21-Jun-10
070200041007	07020004-566	91MN050	Unnamed creek	13.74	3	0	51	20-Jul-10
070200041007	07020004-566	91MN050	Unnamed creek	13.74	3	0	51	25-Aug-10
070200041105	07020004-586	10MN006	Beaver Creek, East Fork	72.27	2	49	45	26-Jul-10
070200041106	07020004-528	92MN052	Beaver Creek	191.32	2	47	45	27-Jul-10
070200041106	07020004-528	92MN052	Beaver Creek	191.32	2	52	45	12-Aug-10
070200041202	07020004-526	10MN009	Sacred Heart Creek	45.28	2	55	45	14-Jul-10
070200041202	07020004-675	04MN003	County Ditch 45	21.49	3	56	51	11-Aug-10
070200041202	07020004-526	10MN021	Sacred Heart Creek	21.35	3	41	51	24-Jun-10
070200041207	07020004-525	10MN077	Timms Creek	23.74	3	84	51	21-Jul-10
070200041207	07020004-617	10MN108	Smith Creek (County Ditch 125A)	13.70	3	74	51	15-Jul-10

Appendix 2.2 - Biological monitoring results-invertebrate IBI (assessable reaches)

12-HUC	AUID	Biological Station	Stream	Drainage Area (mi^2)	Invert Class	MIBI	Threshold	Visit Date
070200040207	07020004-534	10MN007	Palmer Creek	33.28	5	34.22	35.90	03-Aug-10
070200040207	07020004-610	10MN076	Brafees Creek	6.38	7	49.60	38.30	03-Aug-10
070200040905	07020004-587	06MN002	Hawk Creek	500.14	2	40.55	30.70	02-Oct-06
070200040905	07020004-587	90MN017	Hawk Creek	501.16	2	24.52	30.70	10-Aug-10
070200040905	07020004-716	10MN144	County Ditch 36	5.11	5	29.35	35.90	02-Aug-10
070200040905	07020004-587	10MN122	Hawk Creek	494.29	5	36.43	35.90	02-Aug-10
070200040905	07020004-587	10MN122	Hawk Creek	494.29	5	52.19	35.90	02-Oct-06
070200041007	07020004-566	91MN050	Trib. to Minnesota River	13.74	7	15.91	38.30	02-Aug-10
070200041007	07020004-566	91MN050	Trib. to Minnesota River	13.74	7	16.34	38.30	24-Aug-10
070200041007	07020004-687	10MN140	County Ditch 119	14.42	7	19.40	38.30	11-Aug-10
070200041105	07020004-586	10MN006	Beaver Creek, East Fork	72.27	5	19.00	35.90	24-Aug-10
070200041106	07020004-528	92MN052	Beaver Creek	191.32	7	55.59	38.30	09-Aug-10
070200041202	07020004-675	04MN003	County Ditch 45	21.49	5	52.32	35.90	05-Oct-04
070200041202	07020004-526	10MN009	Sacred Heart Creek	45.28	5	37.43	35.90	12-Aug-10
070200041202	07020004-526	10MN021	Sacred Heart Creek	21.35	5	15.11	35.90	12-Aug-10
070200041207	07020004-525	10MN077	Timms Creek	23.74	5	29.05	35.90	11-Aug-10
070200041207	07020004-617	10MN108	Smith Creek	13.70	5	27.28	35.90	09-Aug-10

Appendix 3.1 - Good/fair/poor thresholds for biological stations on non-assessed channelized AUIDs

Ratings of Good for channelized streams are based on Minnesota's general use threshold for aquatic life (Table 2). Stations with IBIs that score above this general use threshold would be given a rating of Good. The Fair rating is calculated as a 15 point drop from the general use threshold. Stations with IBI scores below the general use threshold, but above the Fair threshold would be given a rating of Fair. Stations scoring below the Fair threshold would be considered Poor.

Class #	Class Name	Good	Fair	Poor
Fish				
1	Southern Rivers	>38	38-24	<24
2	Southern Streams	>44	44-30	<30
3	Southern Headwaters	>50	50-36	<36
4	Northern Rivers	>34	34-20	<20
5	Northern Streams	>49	49-35	<35
6	Northern Headwaters	>39	39-25	<25
7	Low Gradient Streams	>39	39-25	<25
Invertebrates				
1	Northern Forest Rivers	>51	52-36	<36
2	Prairie Forest Rivers	>31	31-16	<16
3	Northern Forest Streams RR	>50	50-35	<35
4	Northern Forest Streams GP	>52	52-37	<37
5	Southern Streams RR	>36	36-21	<21
6	Southern Forest Streams GP	>47	47-32	<32
7	Prairie Streams GP	>38	38-23	<23

Appendix 3.2 - Channelized stream reach and AUID IBI scores-FISH (non-assessed)

12-HUC	AUID	Biological Station	Stream	Drainage Area (mi^2)	Fish Class	Fish IBI	Visit Date
070200040705	07020004-508	03MN007	Hawk Creek	49.97	2	0	09-Jul-07
070200040705	07020004-508	03MN007	Hawk Creek	49.97	2	36	04-Aug-03
070200040905	07020004-510	03MN016	Hawk Creek	230.01	2	63	04-Aug-03
070200040704	07020004-524	07MN047	Unnamed creek	46.65	2	29	09-Jul-07
070200040705	07020004-508	03MN007	Hawk Creek	49.97	2	37	02-Aug-10
070200040705	07020004-508	10MN081	Hawk Creek	113.18	2	46	28-Jul-10
070200040704	07020004-578	10MN086	Unnamed creek	32.13	2	32	09-Aug-10
070200040705	07020004-510	10MN133	Hawk Creek	195.40	2	38	28-Jul-10
070200040705	07020004-508	10MN147	Hawk Creek	104.61	2	43	29-Jul-10
070200040705	07020004-510	10MN031	Hawk Creek	241.07	2	52	04-Aug-10
070200040704	07020004-524	10MN089	Unnamed creek	61.77	2	42	10-Aug-10
070200040705	07020004-508	10MN106	Hawk Creek	76.26	2	48	29-Jul-10
070200040704	07020004-524	10EM110	Unnamed creek	4.50	3	41	19-Aug-10
070200040705	07020004-733	10MN098	Unnamed ditch	5.21	3	49	19-Jul-10
070200040705	07020004-732	10MN104	Unnamed ditch	12.46	7	21	18-Aug-10
070200040805	07020004-576	07MN077	Chetomba Creek	107.78	2	24	28-Aug-07
070200040805	07020004-576	10EM046	Chetomba Creek	133.71	2	20	15-Sep-10
070200040805	07020004-576	10EM046	Chetomba Creek	133.71	2	22	19-Aug-10
070200040805	07020004-574	10MN083	County Ditch 31 (Chetomba Creek)	31.39	2	21	20-Jul-10
070200040805	07020004-576	97MN004	Chetomba Creek	114.89	2	33	27-Jul-10
070200040805	07020004-588	10MN016	Spring Creek	158.52	2	25	27-Jul-10
070200040805	07020004-522	10MN148	Chetomba Creek	76.23	2	20	11-Aug-10
070200040805	07020004-735	10MN084	Unnamed ditch	14.11	3	39	25-Aug-10
070200040805	07020004-735	10MN084	Unnamed ditch	14.11	3	40	19-Jul-10
070200040805	07020004-735	10MN084	Unnamed ditch	14.11	3	42	09-Aug-10
070200040805	07020004-734	10MN088	County Ditch 16	7.05	3	13	19-Jul-10

12-HUC	AUID	Biological Station	Stream	Drainage Area (mi^2)	Fish Class	Fish IBI	Visit Date
070200040805	07020004-683	10MN124	Spring Creek	4.13	3	0	06-Jul-10
070200040805	07020004-651	91MN016	County Ditch 18	9.54	3	19	20-Jul-10
070200040805	07020004-649	10MN082	Judicial Ditch 1	15.15	3	44	20-Jul-10
070200040805	07020004-571	10MN085	Unnamed creek	7.92	3	17	19-Jul-10
070200040805	07020004-650	10MN091	County Ditch 8	18.46	7	0	19-Jul-10
070200040805	07020004-728	10MN111	Judicial Ditch 8	4.93	7	0	06-Jul-10
070200040805	07020004-623	10MN101	Judicial Ditch 16	9.87	7	10	20-Jul-10
070200040805	07020004-623	10MN101	Judicial Ditch 16	9.87	7	10	25-Aug-10
070200040905	07020004-568	97MN006	Hawk Creek	318.06	1	47	04-Aug-10
070200040903	07020004-689	10MN032	County Ditch 11	57.71	2	50	27-Jul-10
070200040903	07020004-689	10MN032	County Ditch 11	57.71	2	65	25-Aug-10
070200040903	07020004-725	10MN138	Unnamed ditch	34.63	2	0	22-Jul-10
070200040905	07020004-731	10MN102	Unnamed ditch	8.24	3	19	19-Jul-10
070200040905	07020004-730	10MN103	Judicial Ditch 2	11.55	3	16	19-Jul-10
070200040905	07020004-724	10MN137	County Ditch 37	6.26	3	39	08-Jul-10
070200041007	07020004-719	10MN139	Unnamed creek	5.38	3	20	21-Jun-10
070200041007	07020004-719	10MN139	Unnamed creek	5.38	3	56	24-Aug-10
070200041007	07020004-614	10MN141	County Ditch 104	8.58	3	42	24-Jun-10
070200041007	07020004-684	10MN150	County Ditch 116	4.43	3	19	23-Jun-10
070200041103	07020004-530	03MN018	Beaver Creek, West Fork	98.07	2	32	16-Jul-03
070200041105	07020004-585	07MN076	Beaver Creek, East Fork	30.41	2	41	29-Aug-07
070200041105	07020004-586	10MN020	Beaver Creek, East Fork	63.34	2	22	05-Aug-10
070200041103	07020004-530	10MN033	Beaver Creek, West Fork	42.14	2	44	20-Jul-10
070200041105	07020004-586	10MN115	Beaver Creek, East Fork	66.26	2	28	26-Jul-10
070200041103	07020004-530	10MN152	Beaver Creek, West Fork	95.01	2	32	27-Jul-10
070200041105	07020004-585	10MN019	Beaver Creek, East Fork	61.02	2	30	26-Jul-10
070200041106	07020004-722	10MN095	County Ditch 117	5.96	3	43	10-Jun-10

12-HUC	AUID	Biological Station	Stream	Drainage Area (mi^2)	Fish Class	Fish IBI	Visit Date
070200041103	07020004-678	10MN110	County Ditch 17A	11.46	3	47	14-Jul-10
070200041103	07020004-677	10MN113	County Ditch 59	15.01	3	47	14-Jul-10
070200041103	07020004-721	10MN093	County Ditch 110	9.81	3	45	21-Jul-10
070200041103	07020004-530	10MN107	Beaver Creek, West Fork	9.51	3	10	23-Jun-10
070200041103	07020004-531	03MN017	County Ditch 37	5.12	7	0	22-Jul-03
070200041103	07020004-531	03MN017	County Ditch 37	5.12	7	0	07-Jun-10
070200041105	07020004-621	10MN099	County Ditch 63 (East Fork Beaver Creek)	19.96	7	23	23-Jun-10
070200041103	07020004-727	10MN105	County Ditch 31	5.53	7	0	23-Jun-10
070200041202	07020004-676	10MN092	County Ditch 45	19.50	3	52	20-Jul-10

Appendix 3.3 - Channelized stream reach and AUID IBI scores-invertebrates (non-assessed)

12-HUC	AUID	Biological Station	Stream	Drainage Area (mi^2)	Invert Class	MIBI	Visit Date
070200040905	07020004-568	97MN006	Hawk Creek	318.06	5	17.61	04-Aug-10
070200041007	07020004-719	10MN139	Unnamed creek	5.38	5	28.19	11-Aug-10
070200041202	07020004-676	10MN092	County Ditch 45	19.50	5	25.51	12-Aug-10
070200040705	07020004-508	03MN007	Hawk Creek	49.97	7	9.83	15-Aug-07
070200040705	07020004-508	03MN007	Hawk Creek	49.97	7	20.47	18-Aug-03
070200040705	07020004-508	03MN007	Hawk Creek	49.97	7	23.53	05-Aug-10
070200040705	07020004-508	10MN081	Hawk Creek	113.18	7	26.27	09-Aug-10
070200040705	07020004-508	10MN106	Hawk Creek	76.26	7	32.58	05-Aug-10
070200040705	07020004-508	10MN147	Hawk Creek	104.61	7	14.25	10-Aug-10
070200040705	07020004-736	10MN087	Unnamed ditch	8.24	7	3.86	05-Aug-10
070200040704	07020004-524	07MN047	Unnamed creek	46.65	7	25.92	15-Aug-07
070200040704	07020004-524	10EM110	Unnamed creek	4.50	7	11.34	09-Aug-10
070200040704	07020004-524	10MN089	Unnamed creek	61.77	7	7.62	09-Aug-10
070200040704	07020004-578	10MN086	Unnamed creek	32.13	7	4.07	10-Aug-10
070200040905	07020004-510	03MN016	Hawk Creek	230.01	7	27.30	18-Aug-03
070200040705	07020004-510	10MN133	Hawk Creek	195.40	7	22.20	05-Aug-10
070200040705	07020004-732	10MN104	Unnamed ditch	12.46	7	4.11	05-Aug-10
070200040705	07020004-733	10MN098	Unnamed ditch	5.21	7	13.75	10-Aug-10
070200040805	07020004-650	10MN091	County Ditch 8	18.46	7	8.28	11-Aug-10
070200040805	07020004-734	10MN088	County Ditch 16	7.05	7	0.00	11-Aug-10
070200040805	07020004-571	10MN085	Unnamed creek	7.92	7	23.59	10-Aug-10
070200040805	07020004-574	10MN083	County Ditch 31 (Chetomba Creek)	31.39	7	7.38	11-Aug-10
070200040805	07020004-735	10MN084	Unnamed ditch	14.11	7	23.31	10-Aug-10
070200040805	07020004-576	07MN077	Chetomba Creek	107.78	7	14.72	28-Aug-07
070200040805	07020004-576	10EM046	Chetomba Creek	133.71	7	10.83	25-Aug-10
070200040805	07020004-623	10MN101	Judicial Ditch 16	9.87	7	22.75	25-Aug-10

12-HUC	AUID	Biological Station	Stream	Drainage Area (mi^2)	Invert Class	MIBI	Visit Date
070200040805	07020004-649	10MN082	Judicial Ditch 1	15.15	7	31.43	04-Aug-10
070200040805	07020004-588	10MN016	Spring Creek	158.52	7	13.02	04-Aug-10
070200040805	07020004-651	91MN016	County Ditch 18	9.54	7	19.54	11-Aug-10
070200040805	07020004-576	97MN004	Chetomba Creek	114.89	7	12.37	12-Aug-10
070200040805	07020004-728	10MN111	Judicial Ditch 8	4.93	7	0.00	12-Aug-10
070200040805	07020004-522	10MN148	Chetomba Creek	76.23	7	10.55	11-Aug-10
070200040905	07020004-730	10MN103	Judicial Ditch 2	11.55	7	21.42	11-Aug-10
070200040905	07020004-731	10MN102	Unnamed ditch	8.24	7	1.27	11-Aug-10
070200040903	07020004-725	10MN138	Unnamed ditch	34.63	7	20.52	04-Aug-10
070200040903	07020004-689	10MN032	County Ditch 11	57.71	7	17.55	04-Aug-10
070200040905	07020004-724	10MN137	County Ditch 37	6.26	7	21.91	04-Aug-10
070200041007	07020004-614	10MN141	County Ditch 104	8.58	7	22.83	10-Aug-10
070200041007	07020004-684	10MN150	County Ditch 116	4.43	7	19.67	02-Aug-10
070200041103	07020004-530	03MN018	Beaver Creek, West Fork	98.07	7	27.39	18-Aug-03
070200041103	07020004-530	10MN033	Beaver Creek, West Fork	42.14	7	4.89	12-Aug-10
070200041103	07020004-727	10MN105	County Ditch 31	5.53	7	0.00	25-Aug-10
070200041103	07020004-531	03MN017	County Ditch 37	5.12	7	7.57	12-Aug-10
070200041103	07020004-531	03MN017	County Ditch 37	5.12	7	14.19	18-Aug-03
070200041103	07020004-721	10MN093	County Ditch 110	9.81	7	25.91	25-Aug-10
070200041105	07020004-621	10MN099	County Ditch 63 (East Fork Beaver Creek)	19.96	7	12.48	26-Aug-10
070200041105	07020004-585	07MN076	Beaver Creek, East Fork	30.41	7	20.55	27-Aug-07
070200041105	07020004-585	10MN019	Beaver Creek, East Fork	61.02	7	8.24	12-Aug-10
070200041105	07020004-586	10MN020	Beaver Creek, East Fork	63.34	7	8.40	12-Aug-10
070200041103	07020004-678	10MN110	County Ditch 17A	11.46	7	8.68	12-Aug-10
070200041103	07020004-677	10MN113	County Ditch 59	15.01	7	5.71	25-Aug-10
070200041103	07020004-530	10MN107	Beaver Creek, West Fork	9.51	7	25.99	26-Aug-10