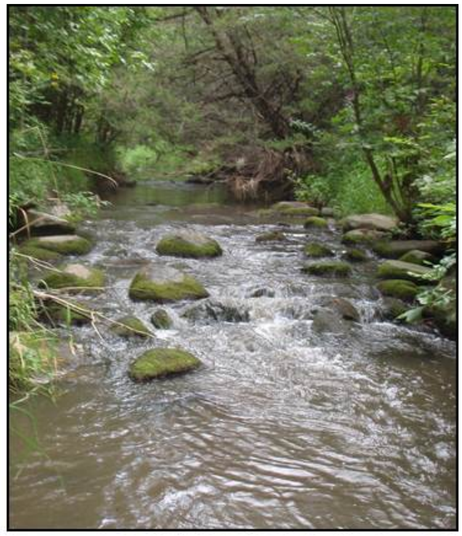
Yellow Medicine River Watershed Biotic Stressor Identification



Minnesota Pollution Control Agency

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Authors

Principal Author: Michael Koschak

Contributors / acknowledgements

Chandra Carter
Kimberly Laing
Katherine Pekarek-Scott
Darrell Schindler
Bryan Spindler
Chuck Regan
Tim Larson

Editing and Graphic Design

Administrative staff: Elizabeth Tegdesch
Cover photo: Michael Koschak
Upper left photo- (Judicial Ditch 10/Wood Lake Creek), Upper right photo-County Ditch 39 (10MN051), Bottom photo- Yellow Medicine River (90MN015)

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520 Lafayette Road North | Saint Paul, MN 55155-4194 | www.pca.state.mn.us | 651-296-6300
Toll free 800-657-3864 | TTY 651-282-5332

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Executive summary

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

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

This report summarizes stressor identification work in the Yellow Medicine River watershed.

Located in west-central Minnesota, the Yellow Medicine River watershed encompasses approximately 754,100 acres. This watershed includes many streams that flow into Yellow Medicine River, but also many are direct tributaries to the Minnesota River.

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

This report analyzed the biologically impaired Assessment Unit Identification (AUID) into two categories: Direct Tributaries to the Minnesota River and Uplands streams that are tributaries to the Yellow Medicine River. The biologically impaired AUIDs studied from the Direct Tributaries to the Minnesota River category are as follows: Judicial Ditch 10/Wood Lake Creek, Unnamed Creek (Lone Tree Lake to Minnesota River), County Ditch 39, and County Ditch 2.

Biologically impaired streams in the Uplands category are: Mud Creek, North Branch Yellow Medicine River, Unnamed Creek (Trib. to North Branch Yellow Medicine River), Unnamed Creek (Ash Lake to Yellow Medicine River) and Unnamed Creek (Tributary to South Branch Yellow Medicine River).

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

Direct Tributaries to the Minnesota River

County Ditch 39 (07020004-713)

- High phosphorus
- High nitrates
- Altered hydrology

Unnamed Creek (07020004-718)

- Low dissolved oxygen
- High phosphorus
- Altered hydrology
- Lack of habitat

County Ditch 2 (07020004-717)

- High phosphorus
- Altered hydrology

Judicial Ditch 10/Wood Lake Creek (07020004-547)

- Low dissolved oxygen
- High phosphorus
- High nitrates
- High turbidity/TSS
- Lack of habitat

Uplands

Unnamed Creek (07020004-595)

- Low dissolved oxygen
- Altered hydrology
- Lack of habitat

Unnamed Creek (07020004-694)

- Low dissolved oxygen
- Altered hydrology
- Lack of habitat

Unnamed Creek (07020004-564)

- Altered hydrology

Mud Creek (07020004-543)

- Low dissolved oxygen
- High phosphorus
- High nitrates
- High turbidity/TSS
- Altered hydrology
- Lack of habitat

Yellow Medicine River, North Branch (07020004-542)

- High phosphorus
- High turbidity/TSS
- Altered hydrology

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 (see Cormier et al., 2000). The SID process is prompted by biological assessment data indicating that a biological impairment has occurred. Through a review of available data, stressor scenarios are developed that may accurately characterize the impairment, the cause, and the sources/pathways of the various stressors (Figure 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. Strength of evidence (SOE) analysis is used to develop cases in support of, or against various candidate causes. Typically, the majority of the information used in the SOE analysis is from the study watershed, although evidence from other case studies or scientific literature can also be drawn upon in the SID process.

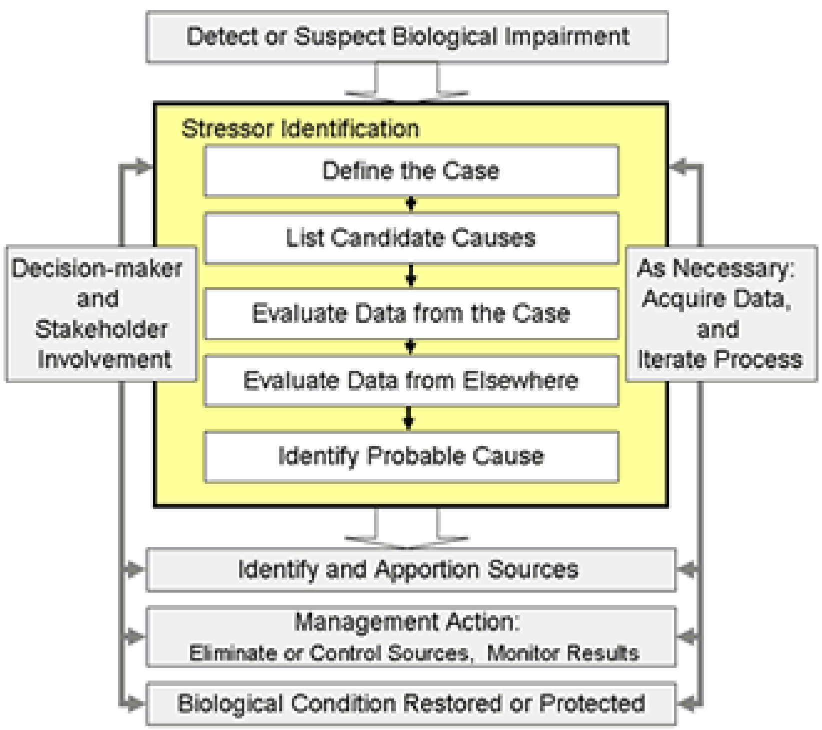

Figure 1: Conceptual model of SID process

Completion of the SID process does not result in a finished Total Maximum Daily Load (TMDL) allocation. The product of the SID process is the identification of 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. 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.

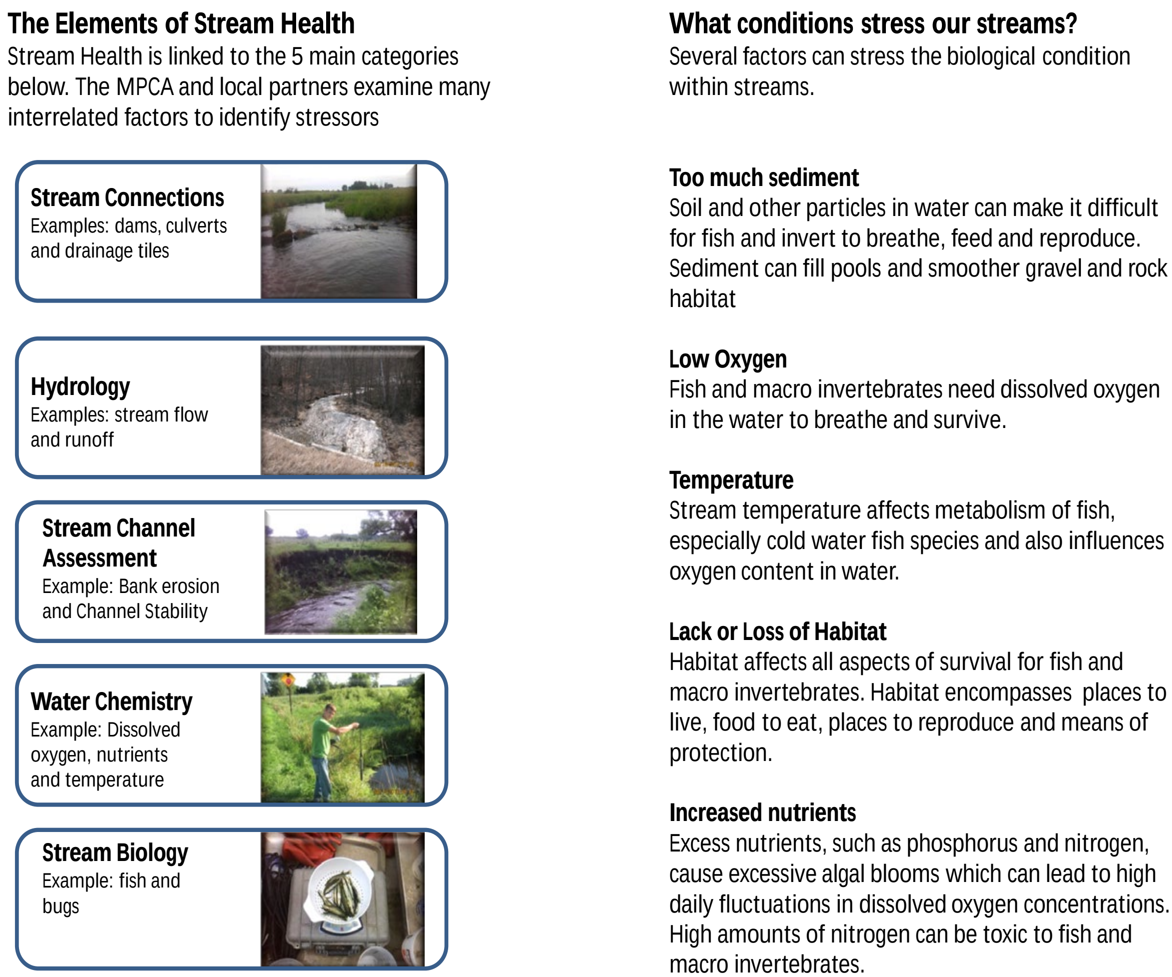

Figure 2: The five components of stream health and conditions that stress streams

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 there link to biological health

Yellow Medicine watershed

Report overview

The Yellow Medicine River watershed consists of 39 12-digit Hydrologic Unit Code (HUC) subwatersheds. For the purpose of this analysis the (39) 12-digit HUC subwatersheds were aggregated into 13 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 analyzes 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.

This report includes a discussion of the data collected to support the determination of candidate stressors at the AUID 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 narrowed down after additional data analysis leaving seven candidate causes for final analysis in this report. The candidate causes for the entire Yellow Medicine River watershed were evaluated, and have enough data to show that they are a problem, are listed below:

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

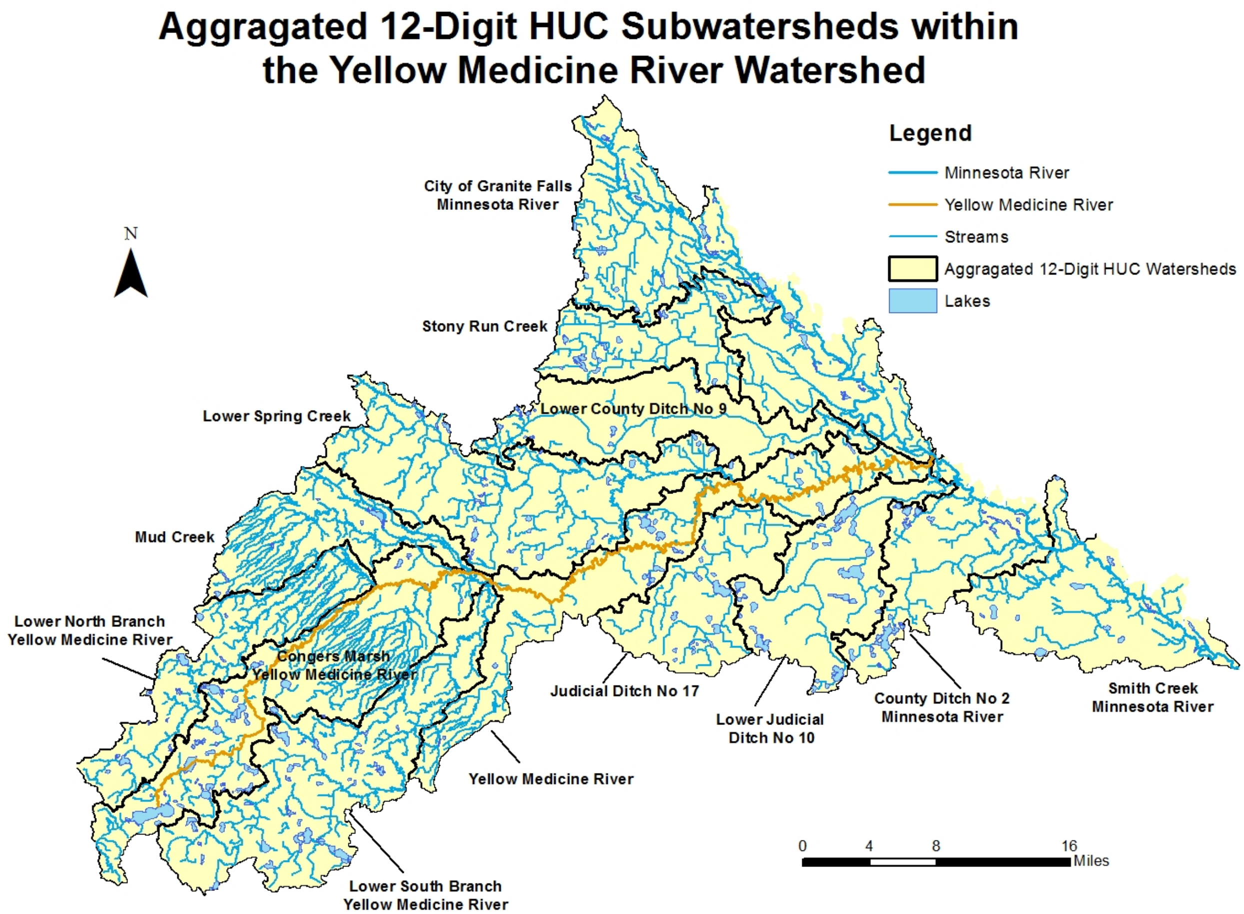

Figure 3: Map of aggregated 12-Digit HUC subwatersheds within the Yellow Medicine River watershed

Biological assessment

The Yellow Medicine River 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 nine stream reaches were impaired for biological assemblages, as part of the aquatic life use designation. The biological impairments in the Yellow Medicine River watershed have been split into two different categories, Direct Tributaries to the Minnesota River and the Uplands, to more accurately describe these impairments in two very different regions.

The four biologically impaired reaches located on Direct Tributaries to the Minnesota River category are as follows: County Ditch 39, Judicial Ditch 10/Wood Lake Creek, County Ditch 2 and Unnamed Creek (Lone Tree Lake to Minnesota River).

The five biologically impaired reaches located in the Uplands category are as follows: Mud Creek, North Branch Yellow Medicine River, Unnamed Creek (Tributary to North Branch Yellow Medicine River), Unnamed Creek (Ash Lake to Yellow Medicine River) and Unnamed Creek (Tributary to South Branch Yellow Medicine River).

The Yellow Medicine River 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% 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 AUID were compared to a regionally developed threshold and confidence interval and utilized a weight of evidence approach. In the Yellow Medicine River watershed, nine AUIDs are currently impaired for a lack of biological assemblage (Table 2). The data that was considered during the assessment process was collected from 2002-2011.

				Biological Impairments	
Stream Name	**AUID #**	**HUC-12**	**Reach Description**	**Biological**	**Water Quality**
Direct Tributaries to the Minnesota River					
County Ditch 39	07020004-713	70200040207	CD 6A to Minnesota R	Fish IBI, Invertebrate IBI	
Unnamed Creek	07020004-718	70200041007	Lone Tree Lk to Minnesota R	Fish IBI, Invertebrate IBI	
County Ditch 2	07020004-717	70200041007	Unnamed cr to Minnesota R	Fish IBI	
Judicial Ditch 10 (Wood Lake Creek)	07020004-547	70200041003	Wood Lk outlet to Minnesota R	Fish IBI, Invertebrate IBI	
Uplands					
Unnamed Creek	07020004-595	70200040404	Headwaters to Unnamed cr	Fish IBI	
Unnamed Creek	07020004-694	70200040307	Ash Lk to Yellow Medicine R	Fish IBI, Invertebrate IBI	
Unnamed Creek	07020004-564	70200040304	Unnamed cr to Unnamed cr	Invertebrate IBI	
Mud Creek	07020004-543	70200040306	Headwaters to T114 R43W S35, south line	Invertebrate IBI	Turbidity
Yellow Medicine River, North Branch	07020004-542	70200040304	CD 8 to Yellow Medicine R	Invertebrate IBI	Turbidity

Table 2: Summary of biological impairments in the Yellow Medicine River watershed

The fish and invertebrate thresholds and confidence limits are shown by class for sites found in the Yellow Medicine River watershed in Table 3. 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 Yellow Medicine River watershed, see Appendix 2.1 and 2.2.

Each IBI is made up of a fish or invertebrate metric that is based on community structure and function and produces a metric score. 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.

Fish Class	Fish 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

Invertebrate Class	Invertebrate 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 invertebrate IBI thresholds and confidence limits by class for sites located in the Yellow Medicine River watershed

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 & Reach	Station	Year	Fish IBI Score	Fish Class	Invertebrate IBI Score	Invertebrate Class
Direct Tributaries to the Minnesota River						
07020004-713 (County Ditch 39)	10MN051	2010	**40**	3	**28.8**	5
07020004-718 (Unnamed Creek)	10MN057	2010	**0, 32**	3	**30.8**	7
07020004-717 (County Ditch 2)	10MN125	2010	**25**	3	**59.6**	7
07020004-547 (Judicial Ditch 10/Wood Lake Creek)	 10MN013 12MN001	2010 2012 2012	**31**, **46** **32** **21**	2	**17.4** **18.6** **19.5**	5
Uplands						
07020004-595 (Unnamed Creek)	10MN029	2010	**15**	3	**38.6**	7
07020004-694 (Unnamed Creek)	10MN059	2010	**32**	3	**27.8**	7
07020004-564 (Unnamed Creek)	10MN065	2010	**68**	3	**31.6**	5
07020004-543 (Mud Creek)	10EM126 10MN075 10MN010	2010 2010 2010	**54** **59** **71**	2	**26.3** **35.7** **13.5**	7
07020004-542 (Yellow Medicine River, North Branch)	10EM016 10MN071 03MN042	2010 2010 2003	**51** **43** **11**	2	**28.4** **48.4** **21**	5 7

Table 4: Fish and invertebrate IBI scores by biological station within AUID with descriptive color

At or Below Lower Confidence Limit	**At or Below Threshold, Above Lower Confidence Limit**	**At or Above Threshold, Below Upper Confidence Limit**	**At or Above Upper Confidence Limit**

Table 5: IBI color descriptions

Hydrological Simulation Program - FORTRAN (HSPF) 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 Yellow Medicine River watershed to help simulate outputs used for analysis. In this report, the minor watersheds with biological impairments used the model results to supplement information that was not collected. See Figure 4 for a map of the numbered subwatersheds that the HSPF model was run for along with the biological impairments.

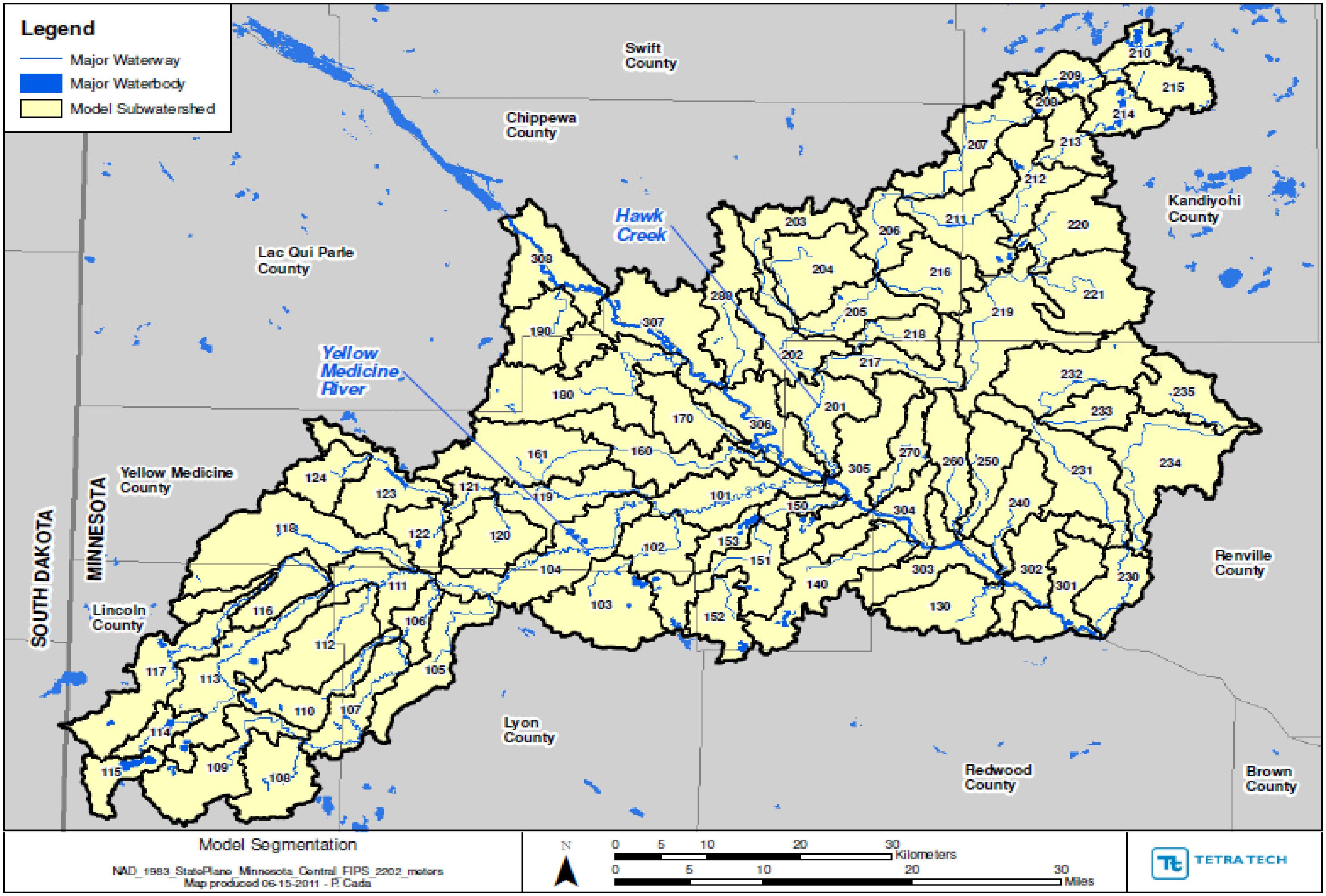

Figure 4. HSPF modeled subwatersheds in the Hawk Creek/Yellow Medicine River watersheds

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. Additional stipulations have been recently added to this standard. The following is from the Guidance Manual for Assessing the Quality of Minnesota Surface Waters (MPCA, 2009):

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

Types of dissolved oxygen data

Point measurements

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

A YSI sonde was deployed for 14 days at one location in the Yellow Medicine River watershed in late summer to capture diurnal fluctuations over the course of a number of diurnal patterns. This information was then used to look at the diurnal flux of DO along with the patterns of DO fluctuation. Hieskary et al. (2010) observed several strong negative relationships between fish and 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 Yellow Medicine River watershed

Dissolved oxygen has been measured frequently in the Yellow Medicine River watershed; however the watershed did not have enough measurements before 9AM to assess for DO in many streams. Currently, no AUIDs with a biological impairment are also impaired for DO. Spring Creek (07020004-538) is the only stream reach in this watershed listed as impaired for this parameter.

The biologically impaired reach, Judicial Ditch 10/Wood Lake Creek, had a YSI sonde deployed to record continuous DO measurements. This is the only stream with a biological impairment that had enough ample flow to record diurnal readings.

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 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 Yellow Medicine River watershed is modeled at EPA's CADDIS Dissolved Oxygen webpage.

Candidate cause: High Phosphorus

Phosphorus is an essential nutrient for all aquatic life, but elevated phosphorus concentrations can result in an imbalance which can impact stream organisms. Excess phosphorus does not result in direct harm to fish and 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 Yellow Medicine River watershed

From 2000-2012, there has been 1163 phosphorus samples collected in streams in the Yellow Medicine River watershed. Of those samples, over 52% of them have been at or above the current draft standard of 0.15 mg/L or higher. The highest reading was above 2 mg/L, with many readings above 1 mg/L. While phosphorus concentrations are not nearly as high as the neighboring Hawk Creek watershed (71% exceedances); phosphorus is still a watershed-wide issue that will need to be addressed in the Yellow Medicine River watershed.

Sources and causal pathways for excess phosphorus

Phosphorus is delivered to streams by wastewater treatment facilities, urban stormwater, agriculture, and direct discharges of sewage. The causes and potential sources for excess phosphorus in the Yellow Medicine River watershed are modeled at EPA's CADDIS Phosphorus 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 which 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-nitrogen water quality standard of 10 mg/L. At this time, none of the AUIDs in the Yellow Medicine River watershed that are impaired for biota are classified as Class 1 streams. Minnesota currently does not have a nitrate standard for other waters of the state besides for class 1.

Ecoregion data

McCollor & Heiskary (1993) developed a guidance of stream parameters by ecoregion for Minnesota streams. The Yellow Medicine River watershed encompasses portions of two ecoregions: the majority being Western Corn Belt Plains (WCBP) and a smaller portion of North Central Hardwood Forest (NCHF) is located in the southwestern portion of the watershed. The annual 75th percentile nitrate-N values where used for comparison (Table 6). Since most of the watershed is within WCBP (73.25%), this ecoregion type will be used for analysis.

Ecoregion	75 Percentile value (mg/L)
Northern Glaciated Plains (NGP)	0.28
Western Corn Belt Plains (WCBP)	6.9

Table 6: Ecoregions in the Yellow Medicine River 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 Yellow Medicine River watershed

From 2000-2012, there were 393 nitrate samples collected throughout the Yellow Medicine River watershed. Values ranged from 0.008 mg/L up to 39.8 mg/L. Generally, spring months had higher nitrate values. Nitrate levels were elevated watershed wide, but seem to be in much lower than the neighboring Hawk Creek watershed

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 Yellow Medicine River watershed, please see the EPA's CADDIS Nitrogen webpage.

Candidate cause: High Turbidity/Total Suspended Solids

Increases in suspended sediment and turbidity, which is a measure of water clarity affected by sediment, algae, and organic matter, 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 Suspend Solids (TSS) concentrations can reduce the penetration of sunlight and thus impede photosynthetic activity and limit primary production (Munavar et al., 1991; Murphy et al., 1981).

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

Water quality standards

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

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 Yellow Medicine River has been set at 65 mg/L. For assessment, this concentration is not to be exceeded in more than 10 percent of samples within a 10-year data window.

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 Yellow Medicine River watershed

The most recent assessments for the Yellow Medicine River watershed determined that the existing turbidity impairments are still present and will remain listed. These stream reaches are: Mud Creek

(AUID: 07020004-543), Yellow Medicine River (AUID: 07020004-584), Yellow Medicine River (AUID: 07020004-502), Yellow Medicine River (AUID: 07020004-513), Yellow Medicine River, North Branch (AUID: 07020004-542) and Yellow Medicine River, South Branch (AUID: 07020004-503).

For a spatial reference of turbidity issues in the Yellow Medicine River watershed, please see Figure 5 below.

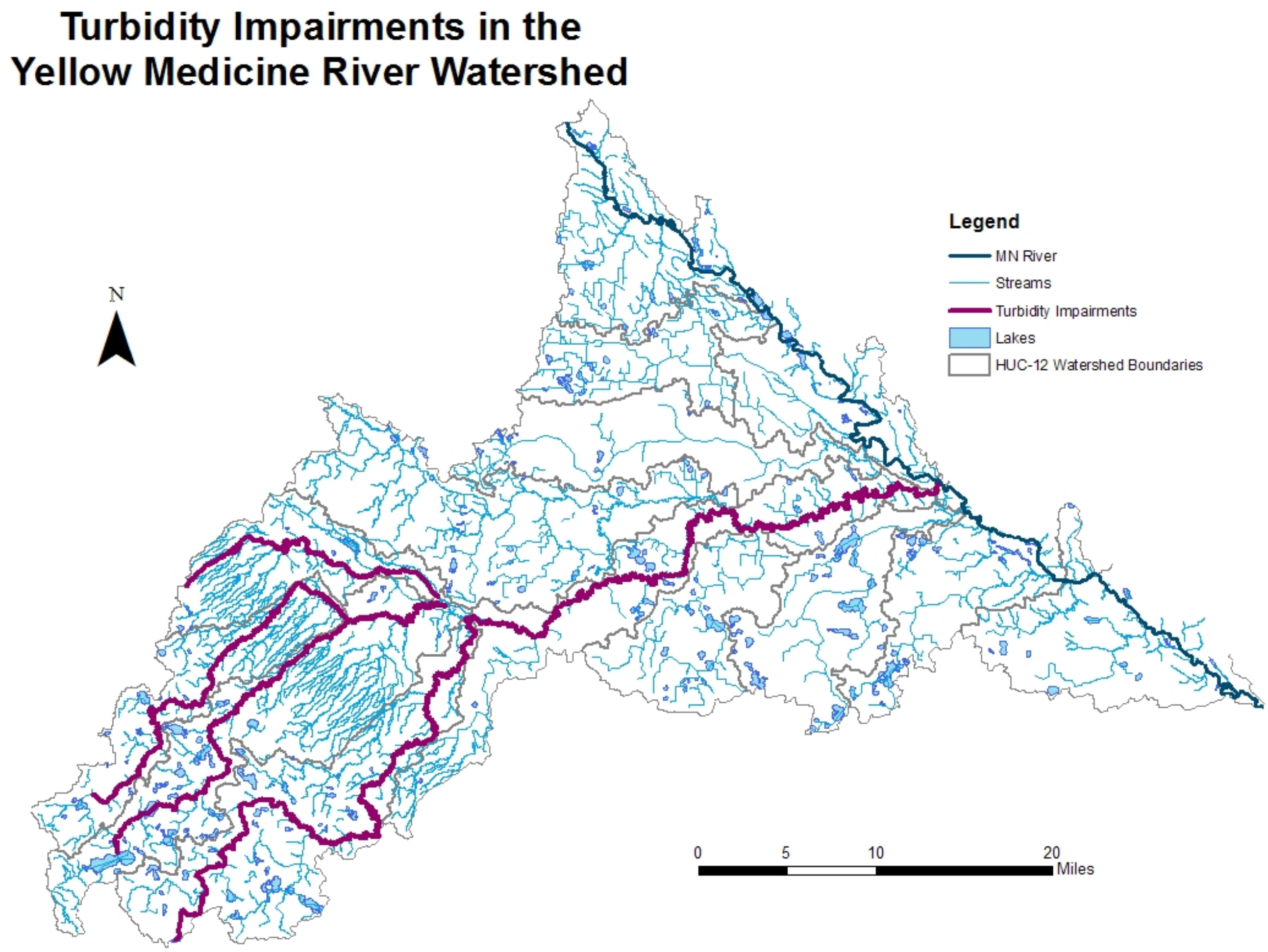

Figure 5: Yellow Medicine River watershed current turbidity impairments including: Mud Creek, North Branch Yellow Medicine River, South Branch Yellow Medicine River, and Yellow Medicine River

Sources and causal pathways for turbidity

The causes and potential sources for increases in turbidity in the Yellow Medicine 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: 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 population. 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 Yellow Medicine River watershed

The Yellow Medicine River watershed has a fair amount of channelization taking place in its streams. Approximately 27% 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 6.

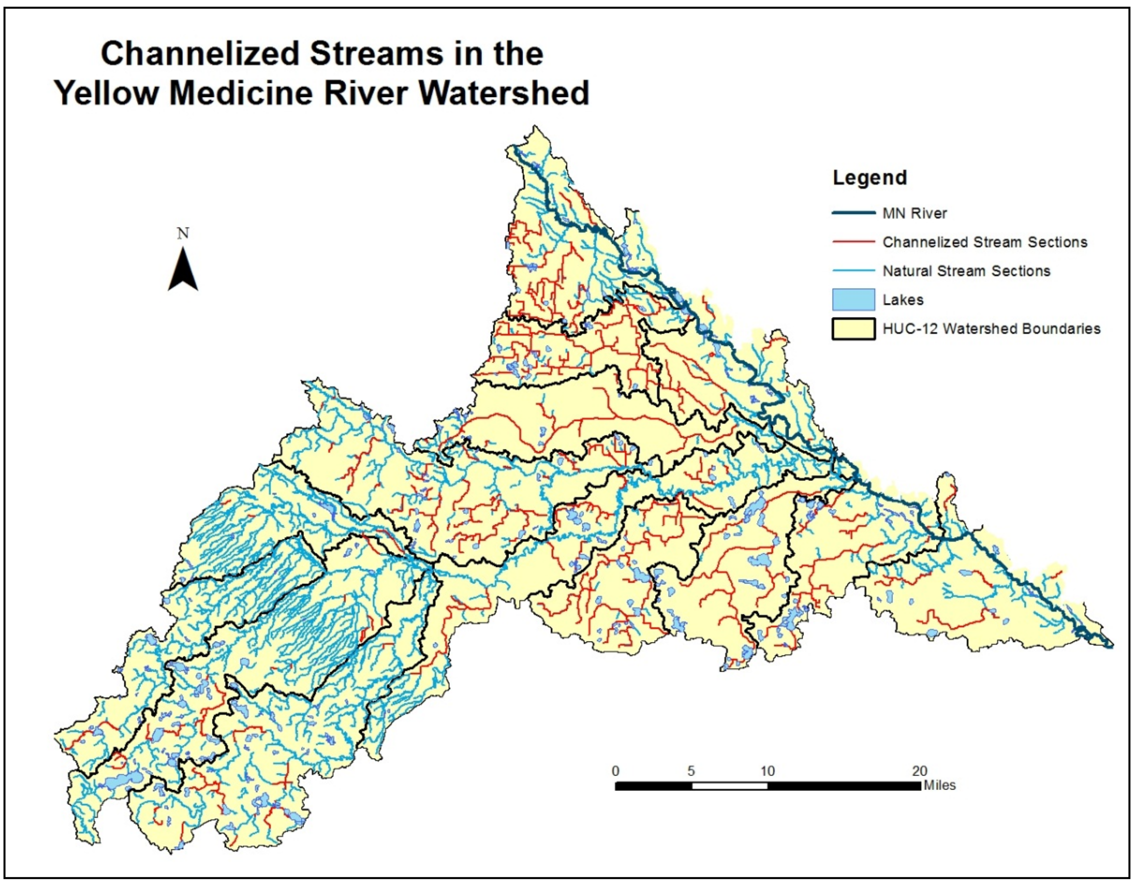

Figure 6: The Yellow Medicine River watershed and its many altered waterways

Stream channelization is prevalent throughout the Yellow Medicine watershed. See Figure 7 below for examples of stream channelization in the watershed.

Figure 7: (Left to right) Biological station 10MN047 on Hazel Creek; Judicial Ditch 17 at Biological Station 10MN012

Sources and causal pathways model for altered flow

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 Yellow Medicine River watershed are modeled at EPA's CADDIS Flow Alteration 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) and will be 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 Yellow Medicine River watershed

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

In the Yellow Medicine River watershed, habitat scores were predominantly fair or poor upstream of the Minnesota River valley (Fig. 8). Many of these areas are channelized and farmed intensively. Habitat scores generally improved in the higher gradient streams in the Minnesota River valley.

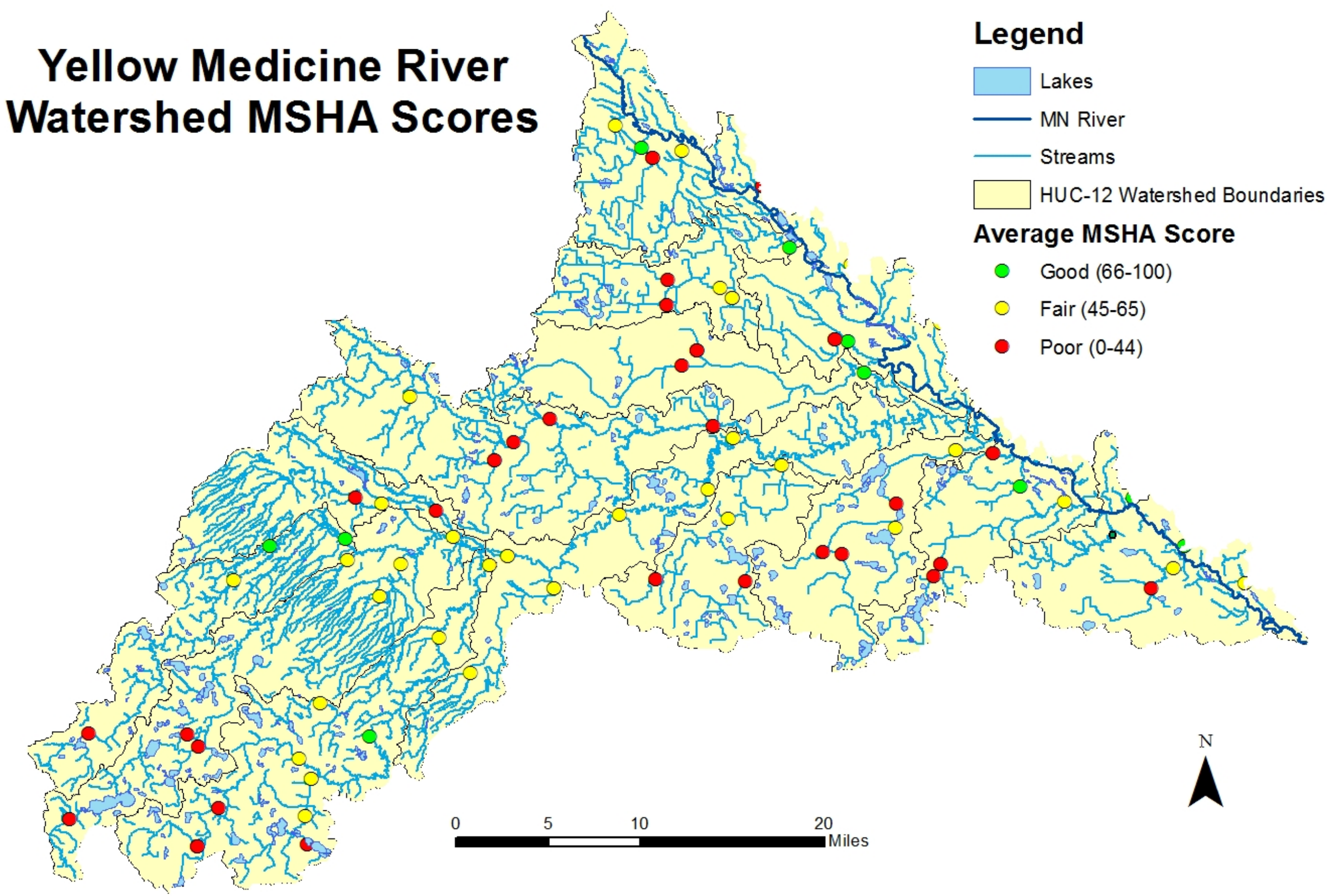

Figure 8: Average MSHA scores at biological sampling stations in the Yellow Medicine River watershed

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 Yellow Medicine River watershed, please see Figure 9.

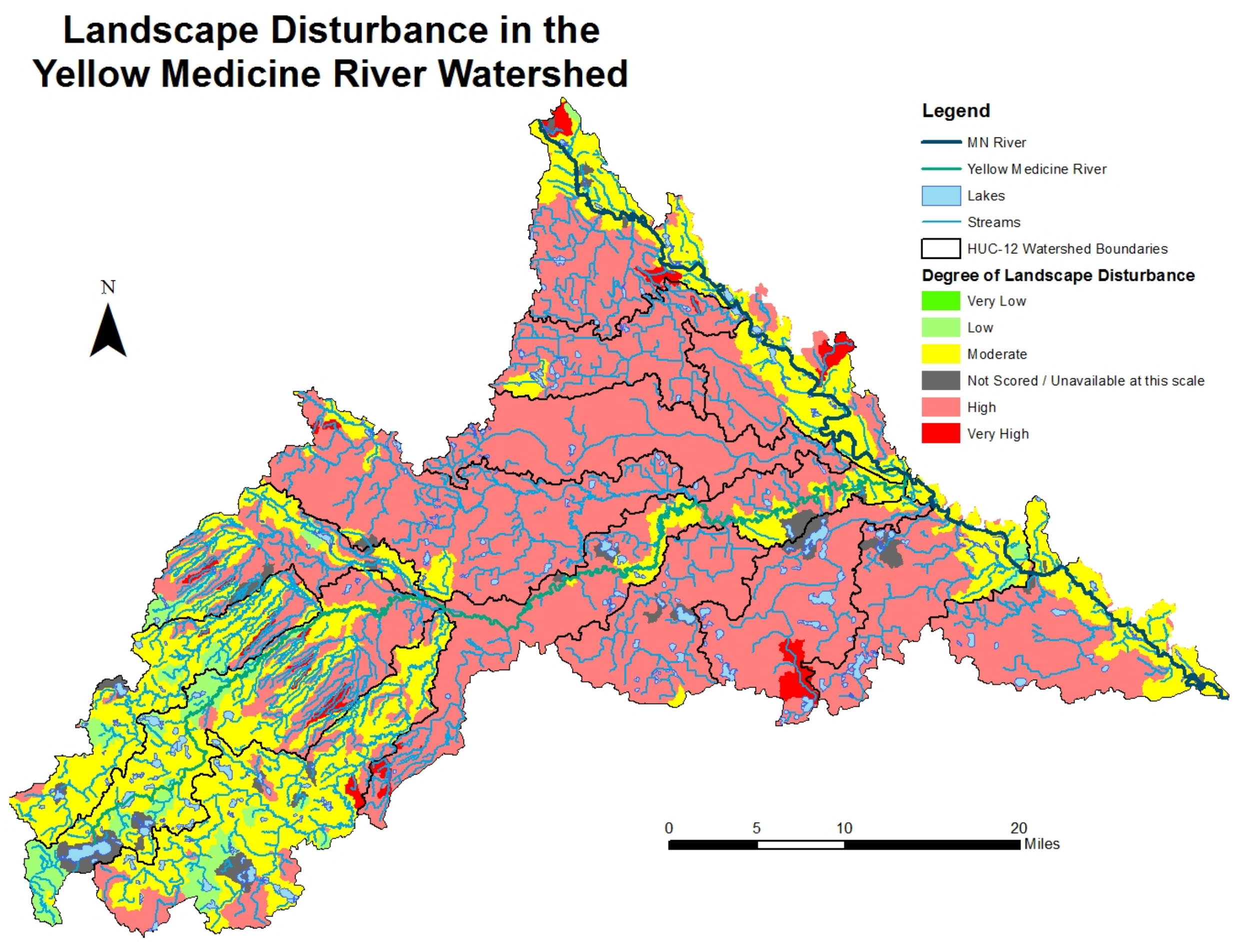

Figure 9: Human caused landscape disturbance in the Yellow Medicine River watershed produced by the National Fish Habitat Partnership

Sources and causal pathways model for habitat

The causes and potential sources for lack of habitat in the Yellow Medicine River watershed are modeled at EPA's CADDIS Physical Habitat webpage. Many riparian areas along the Yellow Medicine River 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.

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 or during 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's 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 (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 6.

	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
Metachlor	23	23	271

Table 6: Summary of MPCA surface water standards associated with target pesticide analytes

[1] Chronic standards are defined in Minn. Rule Chap. 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. Rule Chap. 7050. Values are the same for all classes of surfacewaters.

[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 Yellow Medicine River watershed

In the Yellow Medicine River Watershed, a pesticide sample was taken in Judicial Ditch 10/Wood Lake Creek at the biological sampling station 10MN013. A total of eight different pesticides were found during this sample. For more information on the quantity and types of pesticides found in Judicial Ditch 10/Wood Lake Creek, please read the pesticide section in the Direct Tributaries category. For a spatial reference of the pesticide sampling location, see Figure 10 below.

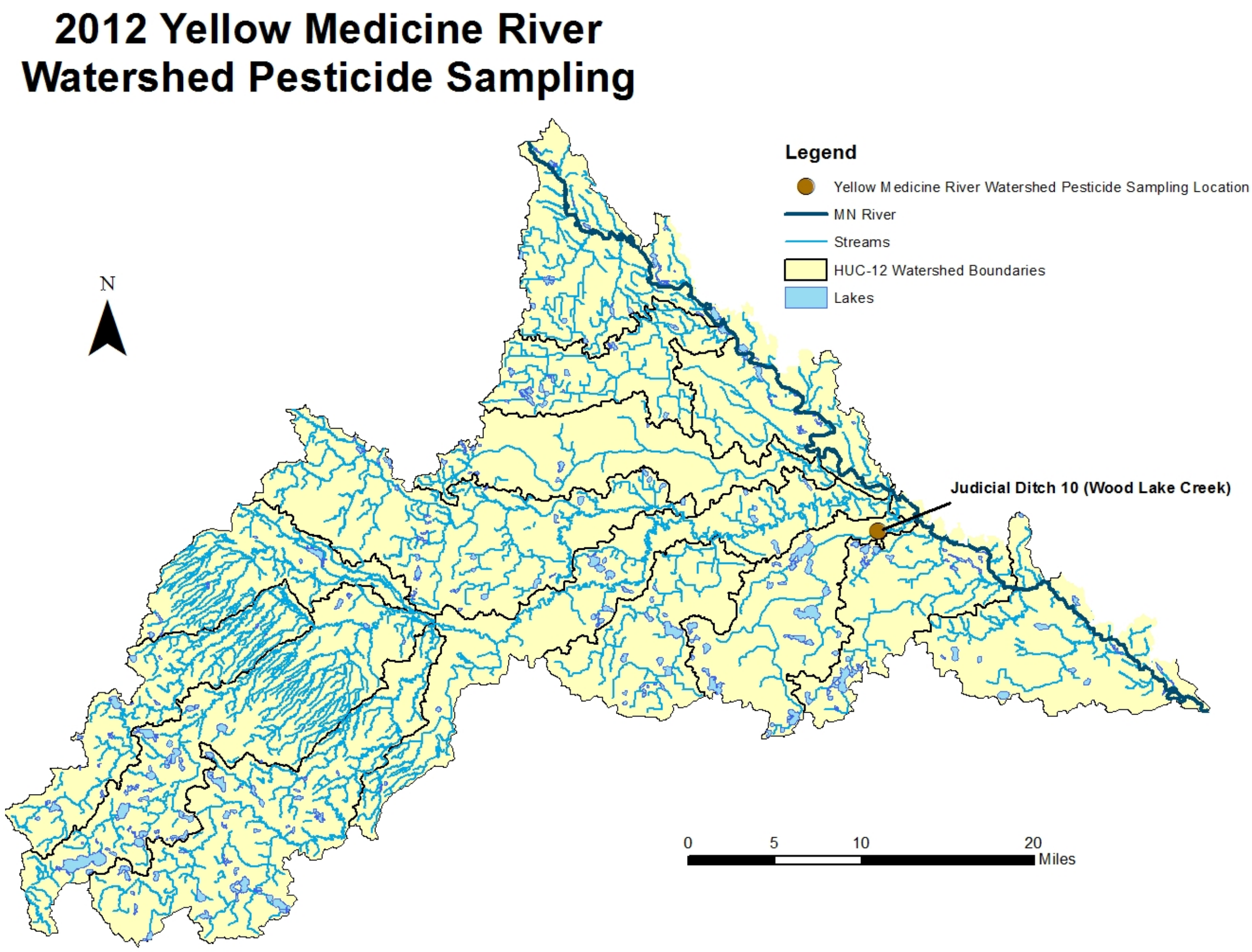

Figure10: Map of 2012 stressor identification pesticide sampling in the Yellow Medicine River watershed

Sources and causal pathways model for pesticides

The conceptual model for herbicides as a candidate stressor in the Yellow Medicine River watershed is modeled at EPA's CADDIS Herbicide webpage.

Direct tributaries to the Minnesota River

This category describes the biologically impaired reaches located in the Yellow Medicine River watershed that flow directly into the Minnesota River. These AUIDs were assessed in 2012 and include: County Ditch 39, Unnamed Creek, County Ditch 2 and Judicial Ditch 10/Wood Lake Creek.

County Ditch 39 **(07020004-713)**, County Ditch 6A to the Minnesota River, is impaired for aquatic life due to the conditions of its fish and invertebrate assemblages. This 3.89 mile reach has one biological sampling station, 10MN051, which was sampled for both fish and invertebrates in 2010. The minor watershed for County Ditch 39 drains an area of 12.9 mi^2 and has land use consisting mainly of cultivated crops (86.04%), developed open space (4.47%), and pasture/hay (4.37%).

Unnamed Creek **(07020004-718)**, Lone Tree Lake to the Minnesota River, is impaired for both its fish and invertebrate communities. This AUID is 4.98 miles long and contains one biological sampling station, 10MN057, which was sampled for fish and invertebrates in 2010. The minor watershed for Unnamed Creek drains an area of 10 mi^2 and has land use consisting mainly of cultivated crops (80.94%), open water (6.32%) and emergent herbaceous wetlands (3.87%).

County Ditch 2 **(07020004-717)**, Unnamed Creek to the Minnesota River, is impaired for aquatic life due to its fish assemblage. This 3 mile reach has one biological monitoring station, 10MN125, which was sampled for both fish and invertebrate communities in 2010. The minor watershed for County Ditch 2 drains an area of 8.1 mi^2. Land use in this subwatershed is mostly cultivated crops (85.29%), with the next most prevalent land uses being deciduous forest (5.82%) and developed open space (4.63%).

Judicial Ditch 10/Wood Lake Creek **(07020004-547)**, Wood Lake outlet to Minnesota River, is impaired for both fish and invertebrate communities. This AUID is 8.54 miles long and has two biological monitoring stations, 10MN013 and 12MN002, located on it. Two fish samples were taken at 10MN013 in 2010 and once in 2012. Invertebrates were sampled at this site once in each 2010 and 2012. Site 12MN002 had a fish and invertebrate sample collected in 2012. The minor watershed for Judicial Ditch 10/Wood Lake Creek drains an area of 8 mi^2 and has a land use comprised mainly of cultivated crops (81.33%), developed open space (4.26%), and pasture/hay (4.24%).

See Figure 11 below for a spatial reference of the Direct Tributaries to the Minnesota River category.

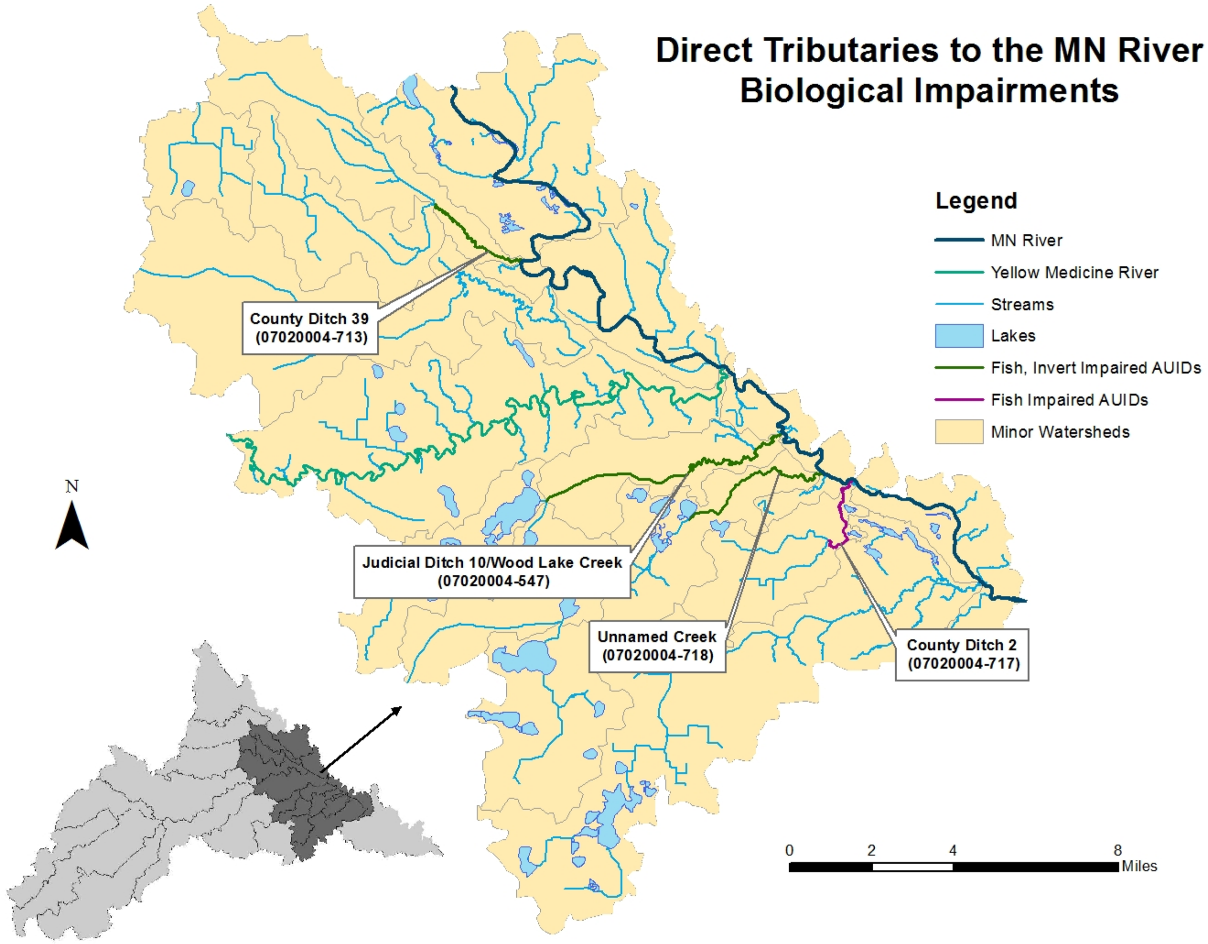

Figure 11: Spatial reference to the direct tributaries to the Minnesota River and its biological impairments

Biology in the Direct Tributaries

Fish

The Direct Tributaries to the Minnesota River category had four AUIDs impaired for fish community. Three of these streams are classified as Class 3 Southern Headwaters streams, County Ditch 39, Unnamed Creek, and County Ditch 2. All three of these streams had fish IBI scores below their class' designated threshold and confidence interval. For a breakdown of their IBI metrics, see Figure 12 below.

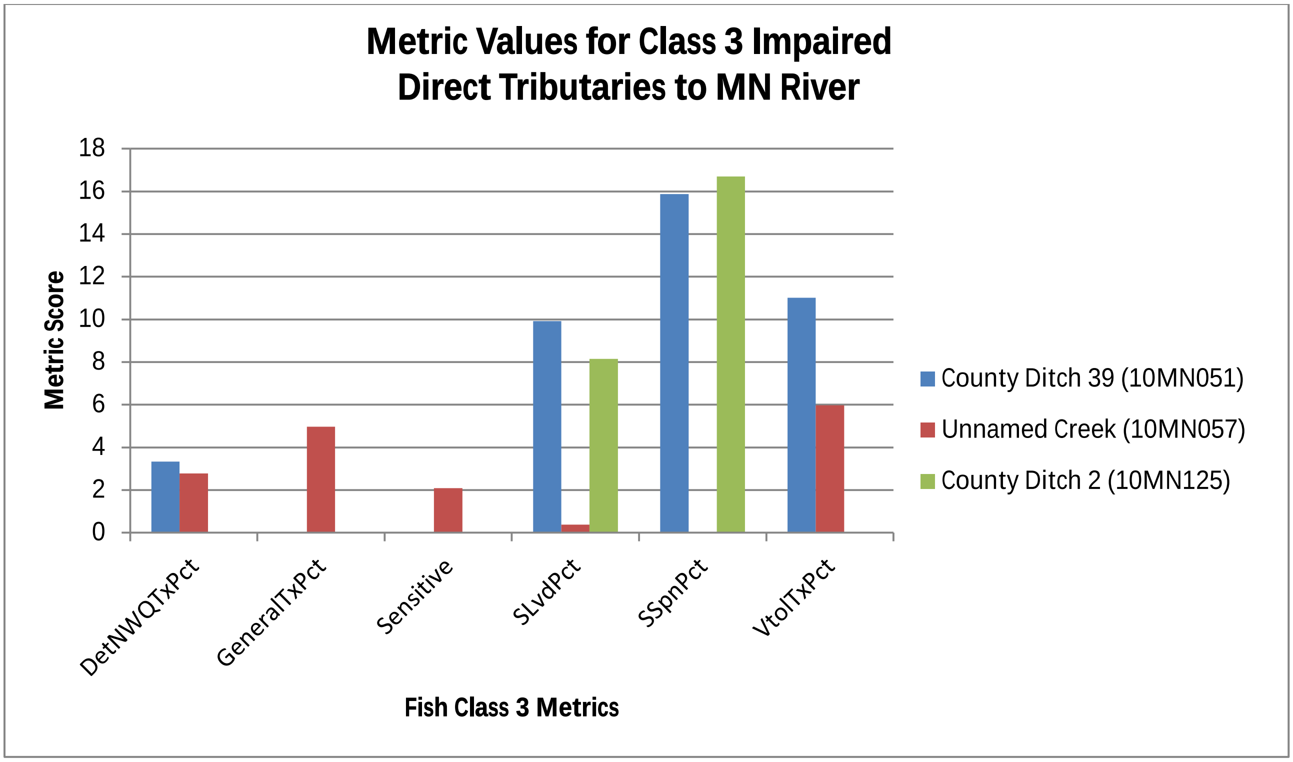

Figure 12: Individual metric scores for the impaired fish Class 3 streams in the Direct Tributaries to the Minnesota River

To reach the fish IBI threshold (51), each metric in this class would need an average score of 8.5. As Figure 12 shows, most of the metrics have values well below the average needed to reach the threshold. County Ditch 39, while scoring well for a few metrics, was brought down by its lack of sensitive species, high amount of generalist feeders (GeneralTxPct), and abundant detritivorous taxa (DETNWQTxPct). Unnamed Creek scored poorly for all metrics and County Ditch 2 scored poorly in four of the metrics.

The remaining AUID impaired for fish assemblage is Judicial Ditch 10/Wood Lake Creek. This stream has a Fish Class 2 Southern Streams classification. The most downstream site, 12MN002, was sampled in 2012 and had a fish IBI score of 21 out of 100 which is below both the threshold and confidence level. The other site, 10MN013, was sampled for fish twice in 2010. One visit scored below both the threshold and confidence level for this fish class. One visit did, however, score above the impairment threshold, but below the confidence limit. This site was also sampled in 2012 and scored a 32, which is below the impairment threshold and confidence limit. See Figure 13 for a breakdown of the metric values for Judicial Ditch 10/Wood Lake Creek.

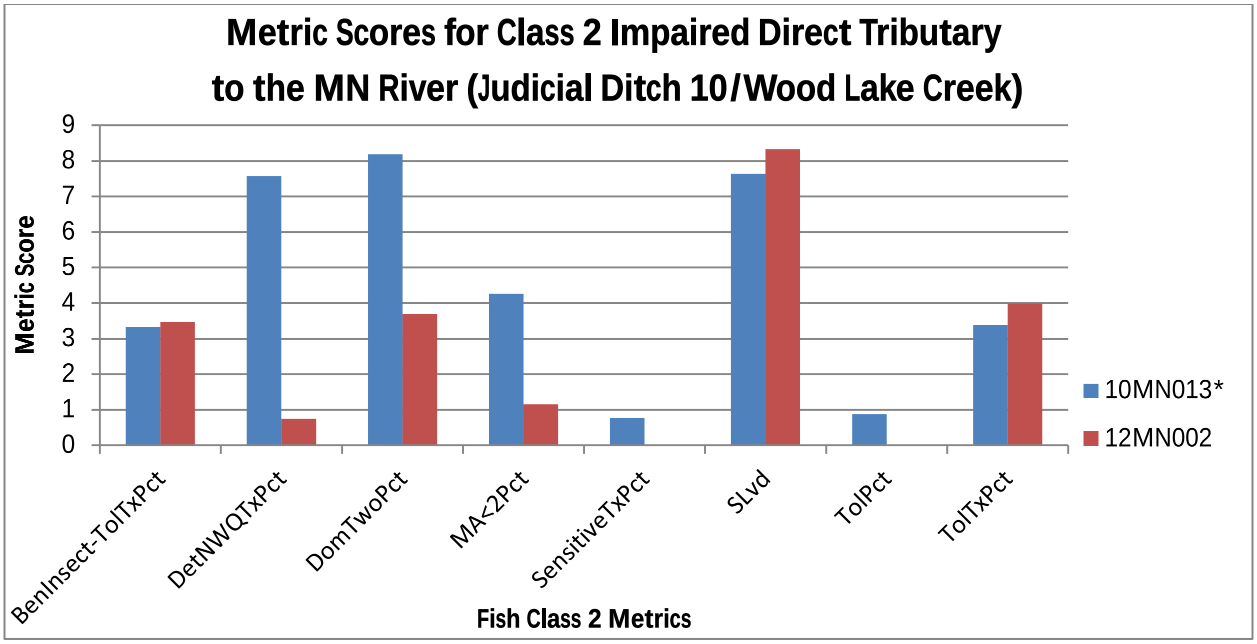

Figure13: Individual metric scores for the impaired fish Class 2 streams in the Direct Tributaries to the Minnesota River

* indicates average metric scores over 3 visits

To reach the fish IBI threshold (45), each metric in this fish Class 2 stream would need an average score of 5.63. Both sites on Judicial Ditch 10/Wood Lake Creek scored poorly in many of these metrics. Site 12MN002 only scored well in the Short Lived (SLvd) species metric. Further upstream, 10MN013, scored better in the DetNWTxPct (abundance of detritivorous taxa) and DomTwoPct (abundance of two most abundant taxa). These sites showed high amounts of undesirable tolerant taxa (TolPct) resulting in a low metric score. Low numbers of sensitive species (SensitiveTxPct) were present resulting in a low metric score as well.

Invertebrates

The Direct Tributaries to the Minnesota River category had three AUIDs impaired for invertebrate assemblage. Two of these streams have an invertebrate Class 5 Southern Streams RR classification, County Ditch 39 and Judicial Ditch 10/Wood Lake Creek. County Ditch 39 had an invertebrate IBI score that was below the Class 5 threshold, but still within the confidence limit. Judicial Ditch 10/Wood Lake Creek had two samples taken at 10MN013 and another at 12MN002 that scored below both the threshold and confidence limit. For a breakdown of their IBI metrics, see Figure 14.

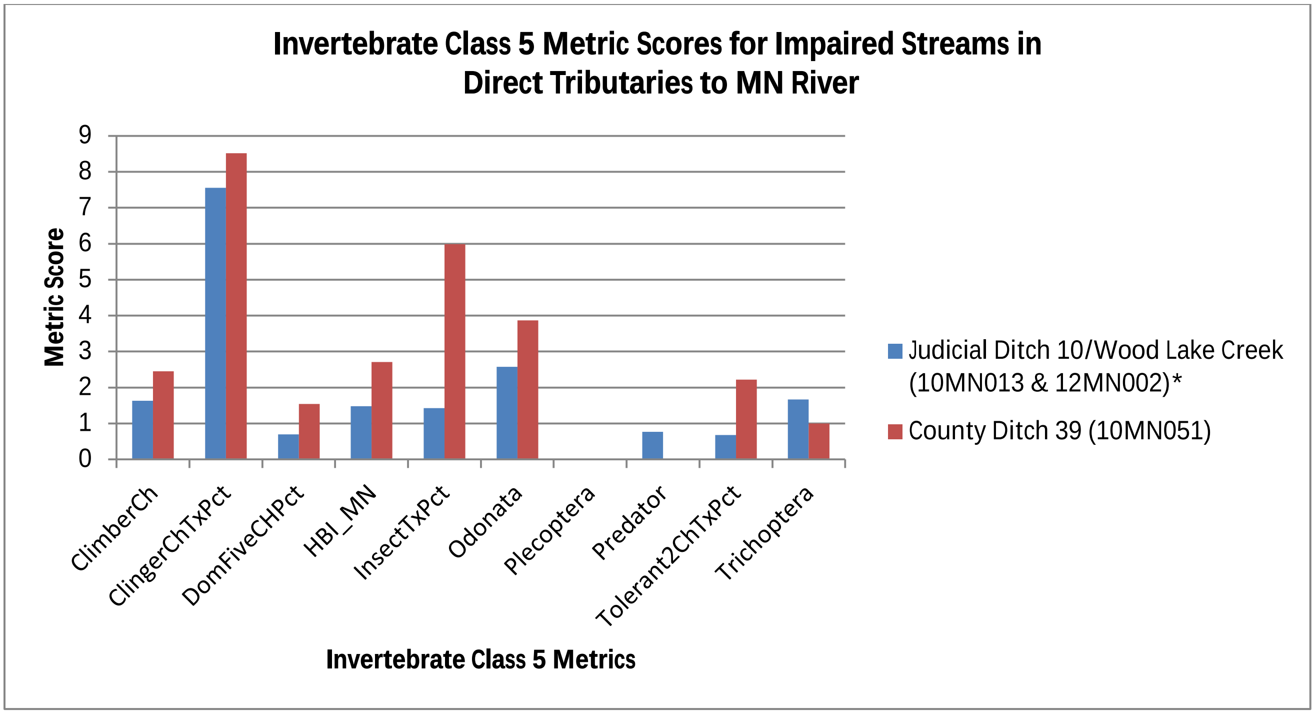

Figure14: Invertebrate Class 5 metric scores for impaired streams in the Direct Tributaries to the Minnesota River category

* Average score of two samples taken at 10MN013 and one taken at 12MN002

To reach the Class 5 macroinvertebrate IBI threshold, each metric would need an average score of 3.59. The only metric to reach this goal in Judicial Ditch 10/Wood Lake Creek was the percentage of Clinger Taxa (ClingCHTxPct) (Figure 14). Meanwhile, County Ditch 39 exceeded this goal at only 3 of the 10 metrics.

The remaining invertebrate impairment in the Direct Tributaries to the Minnesota River Category is at Unnamed Creek. The sampling station (10MN057) on this AUID has an Invertebrate Class 7 (Prairie Streams GP) classification. The MIBI on Unnamed Creek scored below the class threshold, above the lower confidence limit. See Figure 15 for a breakdown of the metric values.

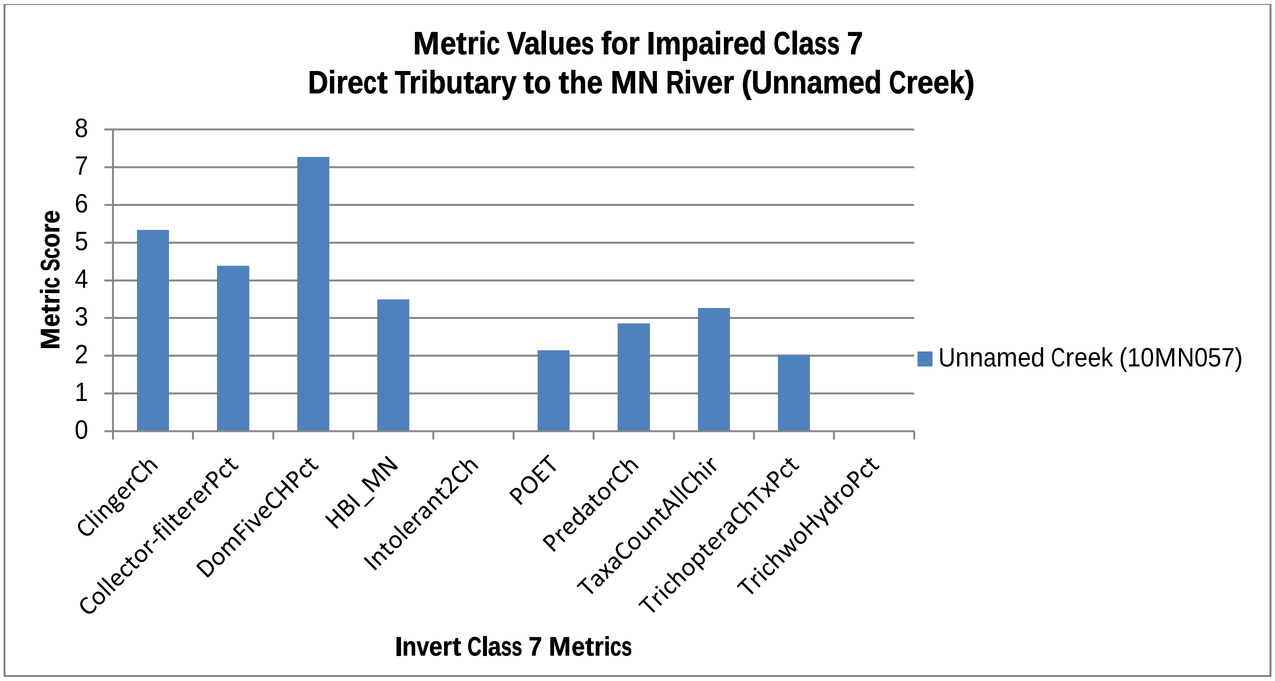

Figure 15: Individual metric scores for the impaired invertebrate Class 7 stream in the Direct Tributaries to the Minnesota River

To reach the MIBI threshold (38.1) for Invertebrate Class 7 stream, each metric in this class would need an average score of 3.81. As Figure 15 shows, the majority of the metrics did not reach this level in Unnamed Creek. The MIBI score dropped significantly due to the lack of non-hydropsychid trichoptera (TrichwoHydroPct) and the lack of taxa richness of invertebrates with a Minnesota tolerance value less than or equal to 2 (Intolerant2Ch).

Candidate cause: Low Dissolved Oxygen

The daily minimum standard for DO in Minnesota Class 2B streams is 5 mg/L. All streams in the Direct Tributaries to the Minnesota River category have this 2B classification. Also, no streams in this grouping are currently listed as impaired for DO mostly due to the lack of limited pre 9AM data.

County Ditch 39 (07020004-713) County Ditch 39 only had two DO readings taken on the AUID at the Biological Station 10MN051 (Table 7). These readings were taken during the fish and invertebrate sampling event with each value above the daily minimum standard.

Sample Location	Sample Date and Time	Result (mg/L)	Daily Minimum Standard (mg/L)
10MN051	8/4/2010 8:48 AM	6.89	5
10MN051	8/12/2010 10:20 AM	6.77	5

Table 7: Dissolved oxygen sampling results for County Ditch 39 at Biological Station 10MN051

Biologically, high numbers of low DO tolerant fish species, brook sticklebacks and fathead minnows, are present. Invertebrate populations in County Ditch 39 have a below statewide average taxa count (18), a low percentage of Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa (20%). EPT taxa have been found to decrease in streams with low DO. County Ditch 39 also had a very high amount of tolerant taxa (83.3%) which can indicate possible DO problems.

The fish and invertebrates suggest that DO could potentially be a stressor. However, with the few samples taken that are both above the minimum standard, there simply is not enough information to determine if DO is a definite stressor to the biological assemblages at this time. Continuous sampling during base flow conditions is needed to determine the effect DO is having on the fish and invertebrate populations in County Ditch 39.

County Ditch 2 (07020004-717): Dissolved oxygen measurements on County Ditch 2 at 10MN125 are limited to the two biological sampling visits (Table 8). Both readings were well above the daily minimum standard. Although the sample taken on August 5, 2010 was high and could potentially signal an issue with DO flux.

Sample Location	Sample Date and Time	Result (mg/L)	Daily Minimum Standard (mg/L)
10MN125	7/21/2010 10:45 AM	9.64	5
10MN125	8/5/2010 2:44 PM	13.27	5

Table 8: Dissolved oxygen sampling results for County Ditch 2 at Biological Station 10MN125

Biologically, the invertebrates in County Ditch 2 scored above the MIBI threshold and upper confidence limit. Their populations were diverse (26 taxa) while having an average amount of EPT taxa (22.2%). Fish in County Ditch 2 were tolerant (100%) and not very diverse with only creek chubs, blacknose dace, and brook sticklebacks captured.

With the limited data available and the mixed results from the biological monitoring, it is too early to rule out DO as a stressor to the impaired fish assemblage in County Ditch 2. Continuous DO monitoring during base flow conditons is recommended to determine how DO affects the fish populations in County Ditch 2.

Unnamed Creek (07020004-718): Dissolved oxygen readings were taken from Unnamed Creek at 10MN057 during the biological sampling visits. The two fish visits had values just above the daily minimum standard (Table 9), while the invertebrate visit had a level of 2.31 mg/L.

Sample Location	Sample Date and Time	Result (mg/L)	Daily Minimum Standard (mg/L)
10MN057	6/22/2010 1:30 PM	5.48	5
10MN057	8/10/2010 3:15 PM	2.31	5
10MN057	8/23/2010 2:20 PM	5.27	5

Table 9: Dissolved oxygen sampling results for Unnamed Creek at Biological Station 10MN057

Biologically, the fish community was dominated by DO tolerant fathead minnows and brook sticklebacks. An average of the two visits showed tolerant taxa (83.3%) and few sensitive species (8.33%). The invertebrate populations had a below average amount of EPT taxa (13.3%) and taxa count (16), and also had a high amount of tolerant taxa (70%).

Despite the low number of DO measurements, the results do suggest that there is a problem since one of the measurements was below the daily minimum standard and the other two values were just above 5 mg/L. The fish and invertebrate communites also suggest that a DO problem is present. More sampling during base flow is needed, but DO should still be considered a stressor.

Judicial Ditch 10/Wood Lake Creek (07020004-547): Routine sampling performed at site 10MN013 from 2010-2011 showed no indication of a DO issue as values were all well above the daily minimum standard. In 2012 a sonde was placed at this site to collect continuous DO readings over a three week period (Figure 16). These readings showed that the DO levels often dipped below the minimum standard during the early morning hours. The daily flux reached 10.6 mg/L on August 3rd which is much higher than the daily standard of 4.5 mg/L, which can indicate that the DO levels are stressing the biological communities.

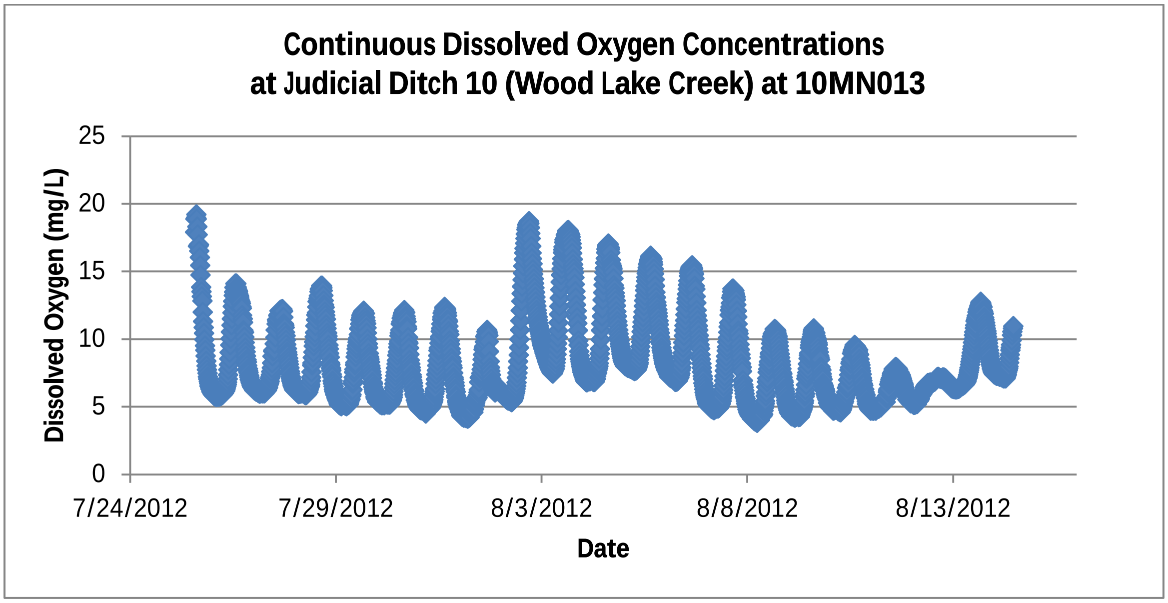

Figure 16: Continuous DO data at 10MN013 on Judicial Ditch 10/Wood Lake Creek

Biologically, the fish populations in Judicial Ditch 10/Wood Lake Creek generally lacked sensitive fish species (2.1% average of 4 visits), had 10.8% of late maturing fish, while having an increase in serial spawning fish species (26.4%). Late maturing fish need stable DO conditions to for years of growth and development. They are present in higher numbers in streams with high water quality conditions. Serial spawning fish tend to be more tolerant of low DO conditions. The invertebrates in Judicial Ditch 10/Wood Lake Creek were comprised of a below average amount of EPT taxa (22.5%) and a high amount of tolerant taxa (60%).

With the daily minimum DO level often dropping below 5 mg/L, a daily flux reaching 10.6 mg/L, and the fish and invertebrate communities reflecting stream conditions with DO issues, this parameter is a stressor to the aquatic life in Judicial Ditch 10/Wood Lake Creek.

Candidate cause: High Phosphorus

The proposed draft standard for phosphorus for streams in the Yellow Medicine River watershed is currently 0.15 mg/L. Although phosphorus is an essential nutrient for all aquatic life, elevated levels can lead to an imbalance which impacts stream ecology. In the Direct Tributaries to the Minnesota River category, phosphorus levels generally exceed the proposed standard.

County Ditch 39 (07020004-713): County Ditch 39 had three phosphorus samples taken from 2010-2012. One of the samples was over twice the proposed draft standard (See Table 10).

Sample Location	Sample Date	Result (mg/L)	Proposed Draft Standard (mg/L)
10MN051	8/12/2010	0.106	0.15
10MN051	6/25/2012	0.053	0.15
10MN051	7/18/2012	0.345	0.15

Table 10: Phosphorus sampling results on County Ditch 39 at Biological Station 10MN051

The HSPF model calculated 2991 daily phosphorus values in County Ditch 39 from 2000-2009. These estimates ranged from 0.0131 to 9.6589 mg/L and were above the proposed draft standard of 0.15 mg/L over 44% of the time. The average value during this time frame was 0.2466 mg/L.

Biologically, in County Ditch 39 EPT taxa (20%) were below average, while having an above average amount of scraper (13.33%) and tolerant (70%) taxa. Sensitive fish species were completely absent and the entire population consisted of tolerant species. These are characteristics of a stream affected by elevated phosphorus levels.

The model and limited sampling results are backed up by the biological metric results, therefore, phosphorus is a stressor to the fish and invertebrate communities in County Ditch 39.

County Ditch 2 (07020004-717): During the summer months of 2012, County Ditch 2 had three phosphorus samples taken before a beaver dam severely restricted stream flow. Two of the three samples were above the proposed draft standard (See Table 11).

Sample Location	Sample Date	Result (mg/L)	Proposed Draft Standard (mg/L)
10MN125	7/21/2010	0.095	0.15
10MN125	6/25/2012	0.071	0.15
10MN125	7/18/2012	0181	0.15
10MN125	8/9/2012	0.223	0.15

Table 11: Phosphorus sampling results on County Ditch 2 at Biological Station 10MN125

County Ditch 2 had a fish population consisting of zero sensitive species and 100% tolerant taxa. Tolerant fish and invertebrates tend to increase in streams with elevated phosphorus levels. Invertebrates in this stream had much lower tolerant taxa (53.33%), but still had a higher than statewide average amount of scraper species (15.6%). These metrics can all indicate stressors caused by an excess of phosphorus.

Despite the limited data, it appears that the phoshorus levels in County Ditch 2 frequently violate the proposed draft standard. While invertebrates are currently not impaired, the increased amount of scraper can indicate phosphorus issues. The complete lack of sensitive fish species and the dominance of tolerant taxa also suggest that there are phosphorus problems in County Ditch 2. The evidence concludes that phosphorus is a stressor to the impaired fish community in this stream.

Unnamed Creek (07020004-718): Unnamed Creek had two phosphorus samples taken. One being in 2010 during the fish sampling event. Another sample was taken in 2012 before the stream dried up. See Table 12 for the results of these samples.

Sample Location	Sample Date	Result (mg/L)	Proposed Draft Standard (mg/L)
10MN057	6/22/2010	0.183	0.15
10MN057	8/23/2010	0.224	0.15
10MN057	6/25/2012	0.15	0.15

Table 12: Phosphorus sampling results on Unnamed Creek at Biological Station 10MN057

Biologically, Unnamed Creek had only 3.3% trichoptera species and only 16 total taxa present. These numbers are both low and can signal potential problems with elevated phosphorus levels. Fish populations had low diversity (2 species), zero sensitive species, and 100% tolerant taxa.

With all of the samples being at or above the proposed draft standard and the biological populations both suggesting problems commonly found in streams with elevated phosphorus levels, phosphorus is stressing the impaired fish and invertebrate communities in Unnamed Creek.

Judicial Ditch 10/Wood Lake Creek (07020004-547): From 2010-2012 there have been 18 phosphorus samples taken on Judicial Ditch 10/Wood Lake Creek. Nine of these samples were above the proposed standard of 0.15 mg/L. See Figure 17 for the 2010 results and Figure 18 for the 2012 results.

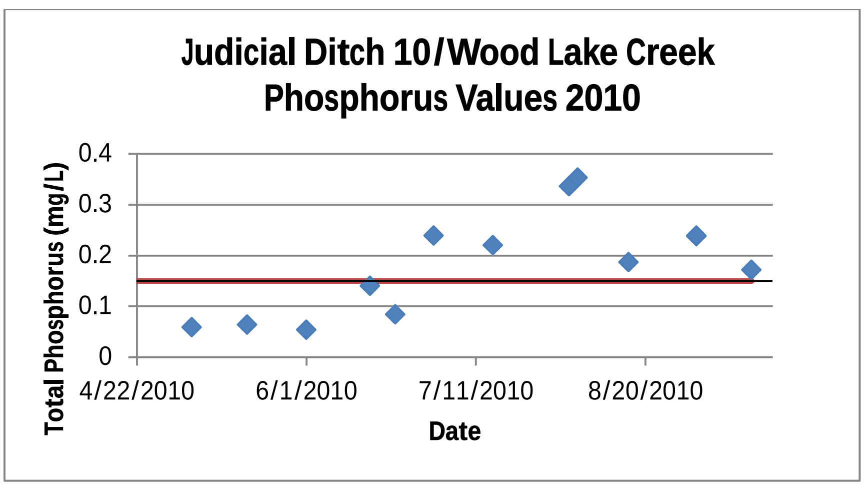

Figure 17: Phosphorus sampling results on Judicial Ditch 10/Wood Lake Creek in 2010 with the draft standard highlighted in red

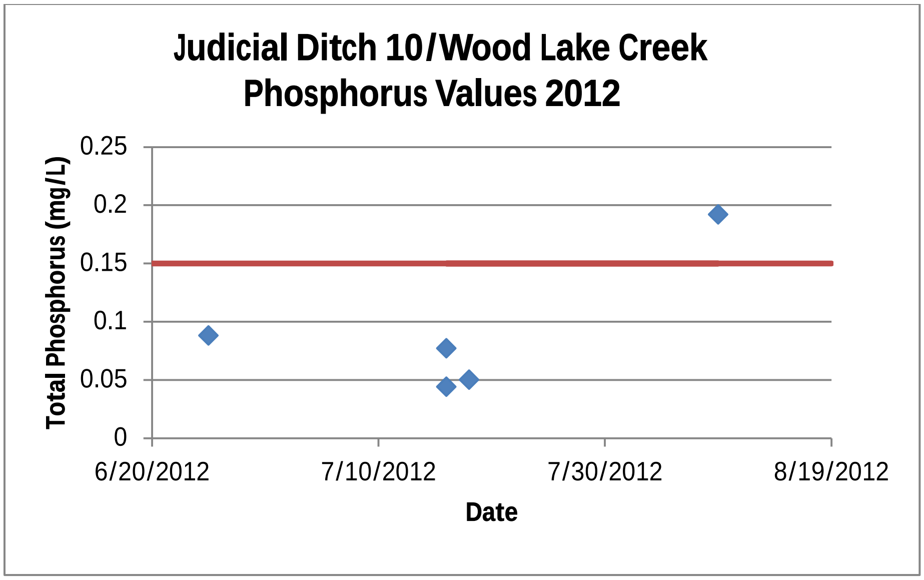

Figure 18: Phosphorus sampling results on Judicial Ditch 10/Wood Lake Creek in 2012 with the draft standard highlighted in red

The HSPF model predicted 3111 phosphorus values on Judicial Ditch 10/Wood Lake Creek from 2000-2009. Nearly 48.8% of these estimates were above 0.15 mg/L, which is a similar exceedance rate to the samples taken from 2010-2012.

Biologically, there were high numbers of tolerant invertebrates and taxa, as well as low EPT taxa and numbers. This information can signal signs of phosphorus stress on the invertebrate community.

With the high rate of exceedances with recent samplings along with the model results, as well as the low numbers of EPT taxa, it is reasonable to suggest that phosphorus is a stressor to the impaired biological communities in Judicial Ditch 10/Wood Lake Creek.

Candidate cause: High Nitrates

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

County Ditch 39 (07020004-713): County Ditch 39 had two nitrate samples taken in 2012 before the stream became intermittent. There was also a nitrate measurement taken during the fish sampling event in 2010. See Table 13 below for the results of these samples.

Sample Location	Sample Date	Result (mg/L)	Proposed Draft Standard
10MN051	8/12/2010	12	n/a
10MN051	6/25/2012	11	n/a
10MN051	7/18/2012	0.64	n/a

Table 12: Nitrate sampling results on County Ditch 39 at Biological Sampling Station 10MN125

The HSPF model predicted nitrate values to range from 0.63 to 171.86 mg/L from 2000-2009. Of these 2991 daily values, 15 calculations were over 18.1 mg/L which has a 75% chance to lead to an invertebrate impairment. The average values of the model estimates was 5.5 mg/L.

Biologically, invertebrate populations in County Ditch 39 lacked Trichoptera taxa (10%) and diversity (only 18 taxa). These metrics both tend to decrease in streams with elevated nitrate levels. Only five different fish species were sampled in this stream, with no sensitive fish species present.

With some higher nitrate measurements and estimates, as well as the lack of biological diversity and absence of nitrate sensitive species, it appears that nitrate is likely a stressor to the biological assemblages in County Ditch 39. More nitrate sampling needs to be taken during base flow conditions to better understand the impacts this parameter is having on the biological communities in this stream reach.

County Ditch 2 (07020004-717): During the summer months of 2012, County Ditch 2 had three nitrate samples taken before a beaver dam severely restricted stream flow. The highest level detected was 8.9 mg/L while the other two measurements showed minimal levels of nitrate. The nitrate sample collected during the fish sampling event in 2010 was 11 mg/L. See Table 14 below for the nitrate sampling results at County Ditch 2.

Sample Location	Sample Date	Result (mg/L)	Proposed Draft Standard (mg/L)
10MN125	7/21/2010	11	n/a
10MN125	6/25/2012	8.9	n/a
10MN125	7/18/2012	0.11	n/a
10MN125	8/9/2012	0	n/a

Table 14: Nitrate sampling results on County Ditch 2 from 2010-2012 at Biological Sampling Station 10MN125

Sensitive fish species were completely absent, while diversity was very low (3 species) in County Ditch 2. This is common for streams with elevated levels of nitrates. However, trichoptera taxa (15.6%) were found to be above average when compared to other sites statewide.

With the limited number of samples, it is likely that the impaired fish community is being mainly affected by stressors other than nitrates at this time. Further monitoring of nitrate levels during base flows are recommended to determine the full effect nitrates are having, if any, on the biological communities in County Ditch 2.

Unnamed Creek (07020004-718): Unnamed Creek has had 3 nitrate samples taken from 2010-2012. Two of these were during the fish surveys in 2010 and one other nitrate sample was taken in 2012 before the stream dried up. See Table 15 for the results of these samples.

Sample Location	Sample Date	Result (mg/L)	Proposed Draft Standard (mg/L)
10MN057	6/22/2010	3	n/a
10MN057	8/23/2010	0.78	n/a
10MN057	6/25/2012	9.4	n/a

Table 15: Nitrate sample results on Unnamed Creek at Biological Station 10MN057

Biologically, had a statewide below average amount of Trichoptera taxa (3.33%) present during the invertebrate sampling event. Trichoptera tend to decrease in streams with elevated levels of nitrates. This stream also had a statewide below average amount of overall invertebrate taxa (16). Taxa counts are likely to be higher in streams with lower levels of nitrates present.

The biological information suggests that nitrates may be stressing the aquatic life in this stream. However, more nitrate sampling needs to be done during base flow conditions to better determine the effect nitrates are having on the fish and invertebrate populations and therefore, nitrate is not considered a main stressor at this time.

***Judicial Ditch 10/Wood Lake Creek (07020004-547)*:** Judicial Ditch 10/Wood Lake Creek had some higher levels of nitrates in 2010, mostly during the spring and early summer months. A quantile regression of Invertebrate Class 5 streams in Minnesota shows with 75% confidence that if a stream has a Nitrate-Nitrite reading of 18.1 mg/L or higher, the MIBI score will be below the threshold for that respective class. While there are currently no readings at this level, nitrates in Judicial Ditch 10/Wood Lake Creek have been recorded over 12 mg/L regularly and as high as 16.2 mg/L (Figure 19 and Table 16).

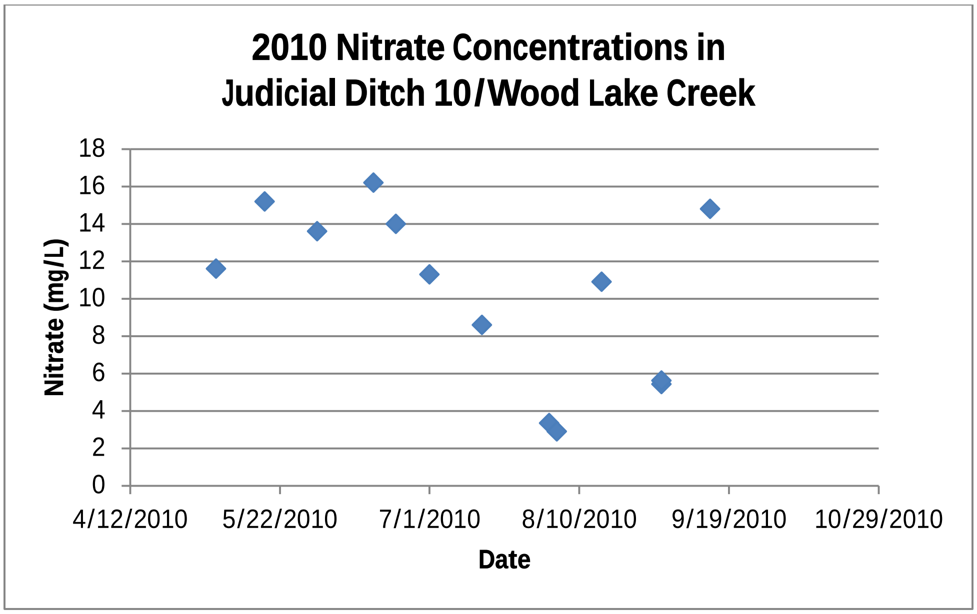

Figure 19: 2010 Nitrate levels in Judicial Ditch 10/Wood Lake Creek at Biological Station 10MN013

Sample Location	Sample Date	Result (mg/L)	Proposed Draft Standard (mg/L)
10MN013	6/25/2012	9.6	n/a
10MN013	7/16/2012	0.99	n/a
10MN013	7/18/2012	0.75	n/a
10MN013	8/9/2012	0.05	n/a

Table 13: 2012 Nitrate sampling results on Judicial Ditch 10/Wood Lake Creek at Biological Station 10MN013

The HSPF model predicted results ranging from 0.43-228.97 mg/L from 2000-2009. The model predicted nitrate values greater than 18.1 mg/L a total of 33 times. Nitrate levels this high, often indicates an invertebrate impairment. Levels over 12 mg/L were calculated 313 times during this time period.

Biologically, this AUID had very low numbers (2.1%) of sensitive fish species and overall diversity during the samples (9.5 species average). The invertebrate population also lacked diversity with an average of 17.5 different taxa sampled per visit.

Elevated levels during sampling, high predicted nitrate values, along with a lack of sensitive and overall biological diversity are all reasons to conclude that nitrates are stressing the biological assemblages in Judicial Ditch 10/Wood Lake Creek.

Candidate cause: High Turbidity/TSS

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

County Ditch 39 (07020004-713): County Ditch 39 only had one TSS sample taken, which was in 2010. It had a reading of 32 mg/L which is well below the proposed draft standard for this area. Two transparency tube readings from Biological Station 10MN051 were 17 cm and 26.5 cm respecitively. Additionally, the HSPF model was able to estimate 2991 outputs from 2000 through 2009. Of these outputs, 59 (1.87%) were projected to be above the 65 mg/L standard.

Biologically, County Ditch 39 had a small percentage of invertebrates that are scraper species, which are sensitive to high levels of turbidity. On the fish side, this stream had a complete lack of herbivores, which are also intolerant of high levels of turbidity and/or TSS.

At this point, Turbidity/TSS is not a clear stressor to the impaired biological communities of County Ditch 39. The absence of scrapers and herbivorous fish along with relatively few actual Turbidity/TSS/Transparency measurements, is not enough information to label this parameter as a major stressor to the fish and invertebrate assemblages at this time. Further data collection during base flows coupled with frequent biological samplings may eventually help determine the effect turbidity and TSS is ultimately having on these respective communities.

County Ditch 2 (07020004-717): Biological station, 10MN125, had two transparency tube readings taken during the 2010 sampling season. These values were both greater than 100 cm. The TSS reading from this stream was 1.2 mg/L, which is well below the 65 mg/L standard.

Biologically, the fish population was 100% comprised of tolerant taxa and had no herbivorous taxa. The invertebrates populations had an above average amount of collector/filterers (13.3%) and scrapers (15.6%). These metrics tend to be much lower in streams with turbidity issues.

The limited data set and conflicting biological information suggests that more turbidity/TSS monitoring needs to be done before listing it as a stressor for the impaired fish community in County Ditch 2.

Unnamed Creek (07020004-718): There were two TSS measurements taken from Unnamed Creek at Biological Station 10MN057 with results of 27 mg/L and 20 mg/L. Both of these results are well below the 65 mg/L TSS standard. There were three Transparency Tube measurements taken with readings of 20 cm, 39.5 cm, and 40 cm. All of these results are at or above the 20 cm standard for Minnesota Class 2B streams.

Biologically, Unnamed Creek possessed few numbers of ephemeroptera and trichoptera, which are two orders of invertebrates that can be fairly senstive to elevated turbidity or TSS levels. Unnamed Creek did have a statewide above average amount of scraper taxa (13.33%). Scraper species of invertebrates decrease in streams with higher turbidity and TSS levels.

There is not enough data to clearly list turbidity as a stressor to the impaired biological communities at this time. Further monitoring of this parameter is recommended to better understand its affect on the biological communities in Unnamed Creek.

Judicial Ditch 10/Wood Lake Creek (07020004-547): For Turbidity, Judicial Ditch 10/Wood Lake Creek had 19 samples taken from 2010-2011. Of these samples, three (15.8%) were over the water quality standard. For TSS, 16 samples were taken from 2010-2012. They had an average reading of 19.23 mg/L and no samples were over the proposed draft standard of 65 mg/L.

Figure 20: Turbid water in Judicial Ditch 10/Wood Lake Creek at 10MN013 on July 25, 2012. Transparency tube reading was 19 cm

While this stream is not currently listed for turbidity, it appears (Fig. 20) that it is a problem that could be having an effect on the biological communities. Judicial Ditch 10/Wood Lake Creek had low number of turibidity sensitive ephemeroptera (8.7%) and scraper (10.8%) species while also having high numbers of tolerant (71.3%) invertebrates.

With the high turbidity exceedance rate and biology also suggesting a potential problem, Turbidity/TSS should be considered a stressor to the impaired biological communities in Judicial Ditch 10/Wood Lake Creek at this time.

Candidate cause: Altered Hydrology

Altered hydrology is a problem in the Direct Tributaries to the Minnesota River area. Three of the biologically impaired streams frequently become intermittent. County Ditch 39, County Ditch 2, and Unnamed Creek have all either dried up or have been severely limited by flow.

Channelized streams are also prevalent in the minor watersheds of the impaired reaches. Many of these altered streams are in the headwaters of the watershed whose primary purpose is to move water off the abundant farm fields in to the streams rather quickly. This can cause the streams flows to be very inconsistent (Schottler 2013).

County Ditch 39 (07020004-713): The minor watershed of County Ditch 39 has 62.2% of its waterways channelized. Much of the channelization is done in the headwaters of the watershed. Altered waterways tend to have limited habitat conditions and cause inconsistent periods of flow (See Figure 21) which can deter less tolerant fish and invertebrate species.

Figure 21: County Ditch 39 becoming intermittent during the summer of 2012

The HSPF model calculated flows from 2000-2009 that ranged from 0.0069-256.95 cubic feet per second (cfs) in County Ditch 39. The model also suggests that from this time period, flows in County Ditch 39 fall below 1 cfs over 52% of the time.

The periods of low and zero flow had an impact on the fish populations in County Ditch 39. These conditions led to a fish assemblage consisting of 80% generalist species and 100% tolerant taxa. Also, no fish species caught were considered to be long lived fish. These metrics have a positive relationship with a stream that lacks a consistent base flow.

Based on observations, modeling information, as well as the biology, the lack of consistent base flow is a major stressor to the biological communities in County Ditch 39.

County Ditch 2 (07020004-717): County Ditch 2 experienced a recent alteration in hydrology. Figure 22 shows site 10MN125 dry during a visit in September 2009. It also shows that beaver activity has also restricted flow in 2012. These alterations not only limit biotic community establishment, they also prevent migration of these communities to headwater streams.

Figure 22: (From left to right) Site 10MN125 dry during visit in September of 2009; Beaver activity severely restricting flow in 2012

Furthermore, the minor watershed of County Ditch 2 has 56.3% of its streams channelized. The majority of these alterations are in the valuable headwaters.

Fish in County Ditch 2 consisted of 66.7% Generalist species, 100% tolerant taxa, and 0% short lived species. These metrics have a positive relationship with stream conditions affected by low to zero flow. When a stream dries up or becomes intermittent, the only species that typically survive or re-colonize are species not requiring specific habitat conditions.

The frequency of County Ditch 2 to dry up or become intermittent due to lack of precipitation, land use, channelization of streams, beaver activity, and the fish metrics all suggest that Altered Hydrology is a major stressor to the impaired fish community.

Unnamed Creek (07020004-718): The minor watershed of Unnamed Creek has over 59% of its streams channelized. This may be a factor in which the biological sampling station, 10MN057, has been observed dry in 2009 and 2012 (See Figure 23).

Figure23: Site 10MN057 dry in September 2009

Fish and invertebrate assemblages have a difficult time establishing themselves and completing their respective life cycles when a stream becomes intermittent or dries up altogether. Fish populations consisted of 100% tolerant species, 50% generalists, with 0% long lived taxa.

The frequency of this problem makes Altered Hydrology a significant stressor to the biological communities of Unnamed Creek.

Judicial Ditch 10/Wood Lake Creek (07020004-547): Judicial Ditch 10/Wood Lake Creek's minor watershed consists of 36.3% channelized streams. The channelization is primarily focused in the headwaters, which are vital areas for many different species. This stream was the only biologically impaired reach that did not dry up or become intermittent. However, the model has estimated that from 2000-2009 that Judicial Ditch 10/Wood Lake Creek would have flows lower than 1 cfs approximately 30% of the time.

Biologically, fish populations in this stream consisted of many generalist (58%) and tolerant (64.7%) species. Also, there was an average of 2.1% of long lived fish species. Populations of swimmer species of invertebrates tend to increase at times of low flows, however Judicial Ditch 10/Wood Lake Creek had a statewide below average amount of swimmer taxa (6.2%).

The presence of consistent base flow and biology that does not mirror the other impaired AUIDs in this category that have gone dry makes Altered Hydrology a potential stressor at this time. More monitoring of low flow and biological conditions is needed to better determine the stress this parameter is having on the fish and invertebrate populations in Judicial Ditch 10/Wood Lake Creek.

Candidate cause: Lack of Habitat

Habitat quality in the Direct Tributaries to the Minnesota River region of the Yellow Medicine River watershed varies from poor to good on the biologically impaired reaches in this category. The MSHA was the main tool used for evaluating this potential stressor and the results of these habitat scores can be seen in Figure 24 below.

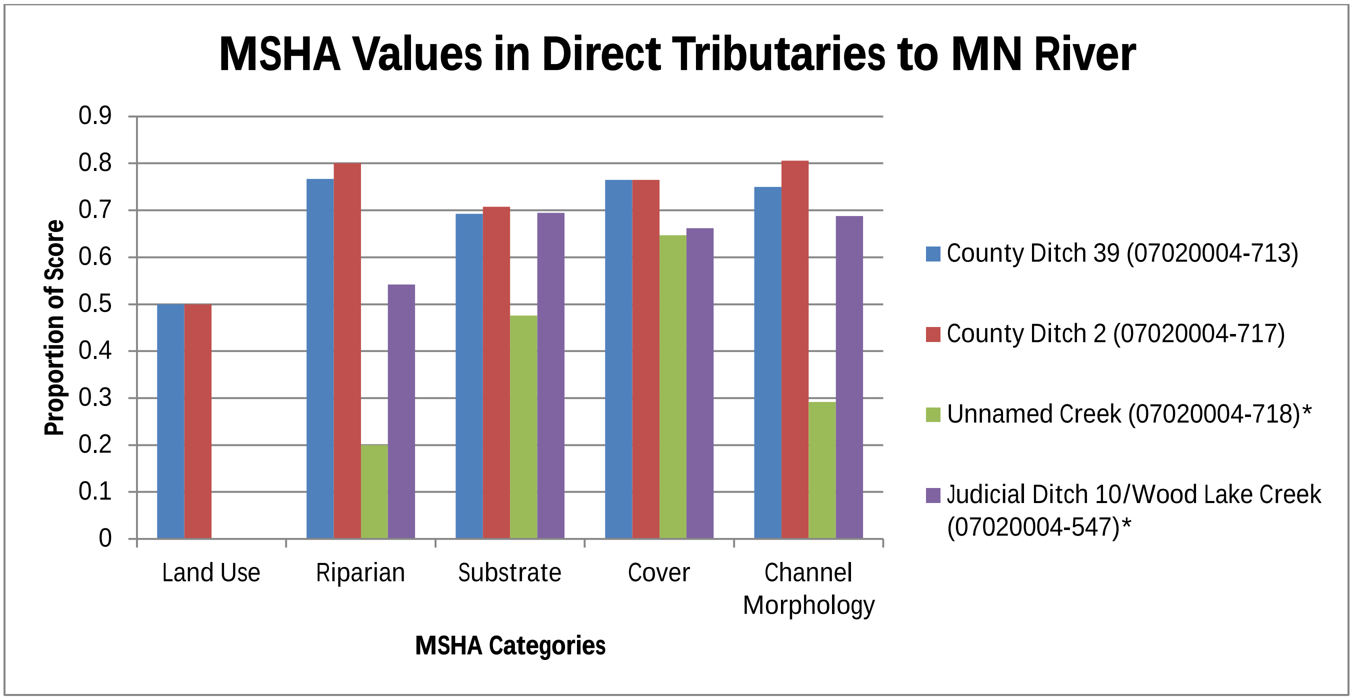

Figure 24: MSHA values at biologically impaired streams in Direct Tributaries to Minnesota River category
*Indicates the average values of multiple visits/sites on impaired AUID.

County Ditch 39 (07020004-713): County Ditch 39 had an MSHA score of 72.7 out of 100 at its biological sampling station, 10MN051. This score is considered to be good. Factors lowering this score are: the presence of row crop in the surrounding land use, some eroded banks, and some moderately embedded course substrates.

Biologically, clinger taxa were very high (43.3%). These types of invertebrates tend to decrease with poor habitat conditions. While the fish population was comprised of 100% tolerant species, 40% are also simple lithophilic spawners, which need clean gravel substrate for spawning. These types of spawners also tend to decrease in streams with degraded habitat.

At this time, the MSHA and biological information suggest that habitat is not stressing the biological communities in County Ditch 39 at this time.

County Ditch 2 (07020004-717): The MSHA score at the Biological Station (10MN125) on County Ditch 2 was 75.6. This is considered to be a good habitat score. Limiting this score was: the presence of row crop in the surrounding land use, some heavy right bank erosion (Figure 25), and some stream channel instability.

Figure 25: Severe bank erosion in County Ditch 2 at site 0MN125

Biologically, the fish community in County Ditch 2 consisted of 100% tolerant taxa and completely lacked benthic insectivores, which can indicate habitat problems. However, there was a statewide above average amount of Lithophilic spawner taxa (33.33% taxa) that are typically present in streams with good habitat conditions.

With the good MSHA score and the mixed biological results, habitat does not appear to be a stressor to the impaired fish community in this stream reach at this time.

Unnamed Creek (07020004-718): Multiple visits at the lone Biological Station (10MN057) on Unnamed Creek produced an average MSHA score of 37.35. This is a poor habitat score. Factors bringing down the MSHA score on this stream reach are: poor surrounding land use (Figure 26), no riparian buffer, severe bank erosion, limited shading, light embeddedness, and poor channel stability and development.

Biologically, Unnamed Creek had no simple lithophilic spawning fish, benthic insectivores, or darter/sculpins/round bodied suckers. These fish metrics tend to decrease when habitat becomes degraded. Invertebrates did have an above average amount of clinger taxa (33.3%), but also had a population of 70% tolerant taxa.

Due to the poor MSHA score as well as the fish and invertebrate metrics scoring poorly, the lack of habitat is a stressor to the impaired biological communities in Unnamed Creek.

Figure 26: Open pasture and minimal buffer on Unnamed Creek at 10MN057

Judicial Ditch 10/Wood Lake Creek (07020004-547): The MSHA scores at the biological sites (10MN013, 12MN002) on Judicial Ditch 10/Wood Lake Creek were 62.88 and 65.1 respectively. These are considered to be fair scores. Factors limiting the habitat scores on this stream reach are: the surrounding land use consisting of row crops, channel instability, embedded course substrates, and moderate to heavy bank erosion (Figure 27).

Figure 27: Eroded bank in Judicial Ditch 10/Wood Lake Creek at biological stations 10MN013 (left) and 12MN002 (right).

Fish inhabiting Judicial Ditch 10/Wood Lake Creek were very tolerant (68.7%), while lacking benthic insectivores (16.7%) and darters/sculpins/round bodied suckers (10.8%). Invertebrates in this stream system were tolerant (71.3%), but did have a good population of clingers (39.6%).

The biological information mainly supports the Fair condition determined by the MSHA. Therefore, habitat is stressing the fish and invertebrate populations in Judicial Ditch 10/Wood Lake Creek.

Candidate cause: Pesticides

Judicial Ditch 10/Wood Lake Creek had a pesticide sample taken on 8/14/2012. Eight different herbicides were detected in the pesticide sample. The results can be seen below in Table 17.

Judicial Ditch 10/Wood Lake Creek Pesticide Detections (Sample on 8/14/2012):					
Pesticide and info	**Gilbert Creek Result (µg/L)**	**MPCA Class 2B Chronic Standard (µg/L)**	**MPCA Max Standard (µg/L)**	**EPA Acute Value Aquatic Life BenchMark (µg/L)**	**EPA Chronic Value Aquatic Life Benchmark (µg/L)**
2,4-D; herbicide and secondary plant growth regulator, used to control broadleaf weeds in agricultural settings	0.0156	70	n/a	12,075	13.1
Acetochlor ESA; degradation product of the parent herbicide acetochlor, used as a herbicide on corn	0.0674	3.6[1]	86[1]	>62,500	9,900
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.	0.0648	59[1]	800[1]	52,000	-
Dimethenamid ESA; degradation product of the parent herbicide demethenamid, used as an herbicide to control weeds in corn.	0.00974	n/a	n/a	3150	300
Hydroxyatrazine; degradation product of the parent herbicide atrazine, used to control weeds in various agricultural crops	0.0142	n/a	n/a	-	-
Metolachlor ESA; degradation product of the parent herbicide metolachlor, widely used in both agricultural and non-crop areas	0.201	23[1]	271[1]	24,000	>95,100
Metolachlor OXA; degradation product of the parent herbicide metolachlor, widely used in both agricultural and non-crop areas	0.0243	23[1]	271[1]	7,700	-
The following were found at trace amounts					
Metolachlor; widely used herbicide for general weed control	P	23	271	550	1

Table 17: Pesticide sample results from Judicial Ditch 10/Wood Lake Creek at 10MN013

[1]Parent Herbicide used for MPCA Class 2B chronic and maximum standards.

The pesticide sample taken from Judicial Ditch 10/Wood Lake Creek tested positive for eight 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 Judicial Ditch 10/Wood Lake Creek. Further pesticide monitoring targeting stormflow events or during the peak run off periods in spring and early summer would help provide a better understanding of pesticides the system may hold as well as their range of values.

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 County Ditch 39, County Ditch 2, Unnamed Creek, and Judicial Ditch 10/Wood Lake Creek were scored and summarized in Tables 18-21. For further information on scoring please see Appendix 1.3 and 1.4.

County Ditch 39			
Types of Evidence	Scores of Candidate Causes		
	High Phosphorus	High Nitrate	Altered Hydrology
Spatial/temporal co-occurrence	+	+	+
Temporal sequence	0	0	+
Field evidence of stressor-response	+	+	+ +
Causal pathway	+	+	+
Evidence of exposure, biological mechanism	NE	NE	NE
Field experiments /manipulation of exposure	NE	NE	NE
Laboratory analysis of site media	NE	NE	NE
Verified or tested predictions	+	+	+ + +
Symptoms	+	+	D
Evidence using data from other systems			
Mechanistically plausible cause	+	+	D
Stressor-response in other lab studies	NE	NE	NE
Stressor-response in other field studies	+	+	+
Stressor-response in ecological models	NE	NE	NE
Manipulation experiments at other sites	NE	NE	NE
Analogous stressors	NE	NE	NE
Multiple lines of evidence			
Consistency of evidence	+	+	+ + +
Explanatory power of evidence	+ +	+ +	+ +

Table 18: Weight of evidence scoring at County Ditch 39

County Ditch 2		
Types of Evidence	Scores of Candidate Causes	
	High Phosphorus	Altered Hydrology
Spatial/temporal co-occurrence	+	+
Temporal sequence	0	+
Field evidence of stressor-response	+	+ +
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	+	D
Evidence using data from other systems		
Mechanistically plausible cause	+	+
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	NE
Multiple lines of evidence		
Consistency of evidence	+	+ + +
Explanatory power of evidence	+ +	+ +

Table 19: Weight of evidence scoring at County Ditch 2

Unnamed Creek				
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
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	+
Evidence using data from other systems				
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	NE
Multiple lines of evidence				
Consistency of evidence	+ + +	+ + +	+ + +	+ + +
Explanatory power of evidence	+ +	+ +	+ +	+ +

Table 20: Weight of evidence scoring at Unnamed Creek

Judicial Ditch 10/Wood Lake Creek					
Types of Evidence	**Scores of Candidate Causes**				
	Low Dissolved Oxygen	**High Phosphorus**	**High Nitrate**	**High Turbidity/TSS**	**Lack of Habitat**
Spatial/temporal co-occurrence	+	+	+	+	+
Temporal sequence	0	0	0	0	0
Field evidence of stressor-response	+ +	+ +	+ +	+	+ +
Causal pathway	+	+	+	+	+
Evidence of exposure, biological mechanism	NE	NE	NE	NE	NE
Field experiments /manipulation of exposure	NE	NE	NE	NE	NE
Laboratory analysis of site media	NE	NE	NE	NE	NE
Verified or tested predictions	+ + +	+	+	+	+ + +
Symptoms	+	+	+	+	+
Evidence using data from other systems					
Mechanistically plausible cause	+	+	+	+	NE
Stressor-response in other lab studies	NE	NE	NE	NE	NE
Stressor-response in other field studies	+ +	+	+	+	+
Stressor-response in ecological models	NE	NE	NE	NE	NE
Manipulation experiments at other sites	NE	NE	NE	NE	NE
Analogous stressors	NE	NE	NE	NE	NE
Multiple lines of evidence					
Consistency of evidence	+ + +	+ + +	+ + +	+	+ + +
Explanatory power of evidence	+ +	+ +	+ +	+ +	+ +

Table 21: Weight of evidence scoring at Judicial Ditch 10/Wood Lake Creek

Conclusions

The major stressor to the biologically impaired streams in the Direct Tributaries to the Minnesota River category in the Yellow Medicine River watershed is the lack of consistent base flow. Three of the four reaches became intermittent or dried up completely in 2012. Some of the streams were also dry in 2009, the year before the biological monitoring took place. The frequency of these streams going dry makes it very difficult for different fish and invertebrate communities to establish themselves and complete their respective life cycles. The HSPF model also predicted many instances of low flow in these biologically impaired streams. These low flow conditions are much more conducive to tolerant assemblages.

Dissolved oxygen is a stressor to the fish and invertebrate communities in Judicial Ditch 10/Wood Lake Creek. According to the continuous oxygen readings, the daily minimum standard was frequently violated and the daily flux also exceeding 5 mg/L. This stream reach also had fish populations abundant with species that are very tolerant of low DO conditions. Unnamed Creek is also being stressed by lows levels of DO. This was evident by its high number of tolerant taxa, a general lack of biological diversity, and low DO values.

As of right now, it is too early to rule out DO as a stressor to the biological communities in County Ditch 39 and County Ditch 2. However, some very low DO readings were taken and the high presence of very tolerant to low DO fish species are present. Continuous DO monitoring is recommend when ample base flow permits at these streams.

Excess phosphorus has a greater effect on fish and invertebrates through its effect on other factors such as DO, pH, water clarity, changes in food resources and habitat. Phosphorus levels at the four stream reaches in this category have all exceeded the proposed maximum standard of 0.15 mg/L. Although some sites had very few samples collected exceedance rates of the proposed standards were: County Ditch 39 (33.3%), County Ditch 2 (50%), Unnamed Creek (100%), and Judicial Ditch 10/Wood Lake Creek (47%). These high frequencies make phosphorus a likely stressor to all of the streams in this category.

Nitrate levels are elevated at County Ditch 39 and Judicial Ditch 10/Wood Lake Creek for this parameter to be considered a stressor to the impaired biological communities. Judicial Ditch 10/Wood Lake Creek especially had high observed and predicted nitrate levels. The low amounts of non-hydropsychid trichoptera species found in these three streams can be a telling sign that nitrate levels are too high for healthy invertebrate populations. Further nitrate sampling is needed at County Ditch 2 and Unnamed Creek to determine the extent nitrate is having on the fish and invertebrate assemblages in these streams.

Although lacking measurements below the set standards for Turbidity, TSS, or Transparency, this parameter should be considered a potential stressor to the impaired fish and invertebrate populations in Judicial Ditch 10/Wood Lake Creek. Small numbers of scraper species as well as members of the order Ephemeroptera and Trichoptera were all very low which is common in streams with Turbidity/TSS issues. Furthermore, Judicial Ditch 10/Wood Lake Creek did see a large amount of Turbidity tolerant invertebrates. More turbidity, TSS, and/or Transparency measurements are needed at County Ditch 39, County Ditch 2, and Unnamed Creek to determine if this parameter is indeed stressing the impaired biological communities. Controlling the amount of sediment reaching these streams is imperative for the health of the impaired biological communities.

Habitat is likely a stressor in Unnamed Creek (10MN057) as well as Judicial Ditch 10/Wood Lake Creek. These streams had MSHA scores rating either poor or fair. Common problems in these streams are poor surrounding land use with minimal buffers, large amounts of eroded banks, and poor channel stability. These factors limit the abilities of fish and invertebrates to successfully complete their respective life cycles. Alterations to the landscape, which are prevalent in these watersheds, reduce habitat availability and effectiveness. Habitat improvement projects in these impaired reaches may be an option to help reduce the stress this parameter is having on both the fish and invertebrate communities.

Uplands

This category describes the biologically impaired reaches located in the Yellow Medicine River watershed that are located in the Buffalo Ridge area of the Coteau des Plains. These impaired stream reaches were assessed in 2012 and are all tributaries to the Yellow Medicine River. More details of these AUIDs are described below:

Unnamed Creek (07020004-595), Headwaters to Unnamed Creek, is impaired for aquatic life due to its fish assemblage. This 4.74 mile reach has one biological monitoring station, 10MN029, which was sampled for both fish and invertebrate communities in 2010. The minor watershed for Unnamed Creek has a drainage area of 9.9 mi^2. Land use in this subwatershed is cultivated crops (64.09%) followed by grassland (15.21%) and pasture/hay (12.98%).

Unnamed Creek (07020004-694), Ash Lake to Yellow Medicine River, is impaired for aquatic life due to both its fish and invertebrate assemblages. This 2.76 mile AUID has one biological monitoring station, 10MN059, which was sampled for both fish and invertebrate communities in 2010. The minor watershed for Unnamed Creek has a drainage area of 5.9 mi^2. Land use in this subwatershed is cultivated crops (43.55%) followed by grassland (25.91%) and pasture/hay (12.05%).

Unnamed Creek (07020004-564), Unnamed Creek to Unnamed Creek, is impaired for aquatic life due to its invertebrate assemblage. This 4.38 mile reach has one biological monitoring station, 10MN065, which was sampled for both fish and invertebrate communities in 2010. The minor watershed for Unnamed Creek has a drainage area of 8.5 mi^2. Land use in this subwatershed is mostly cultivated crops (70.36%), but also contains larger portions of pasture/hay (11.4%) and grassland (11.38%).

Mud Creek (07020004-543), Headwaters to T114 R43W S35, south line, is impaired for aquatic life due to its poor invertebrate assemblage. This 29.2 mile AUID has three biological monitoring stations located along it, 10MN010, 10MN075, and 10EM126. These stations each had a fish and invertebrate sampling visit in 2010. The impaired stream reach extends into three minor watersheds and also has an additional three minor watersheds draining into it. The combined drainage area for these subwatersheds is 58 mi^2. The land use for the combined minor watersheds is mainly cultivated crops (67.04%) with large portions of emergent herbaceous wetlands (7.69%) and pasture/hay (7.29%).

Yellow Medicine River, North Branch (07020004-542), County Ditch 8 to Yellow Medicine River, is impaired for aquatic life due to its invertebrate assemblage. This 39.9 mile reach has three biological monitoring stations located on it, 10MN071, 10EM016, and 03MN042. Sites 10MN071 and 10EM016 each had a fish an invertebrate sample taken in 2010, while 03MN042 had two fish samples and one invertebrate sample taken in 2003. This AUID flows into three different minor watersheds and has an additional two draining into it. The combined drainage area for these subwatersheds is 68.1 mi^2. The land use for the combined minor watersheds consists mostly of cultivated crops (66.62%), grassland (11.33%), and pasture/hay (10.59%).

See Figure 28 for a spatial reference of the Uplands category.

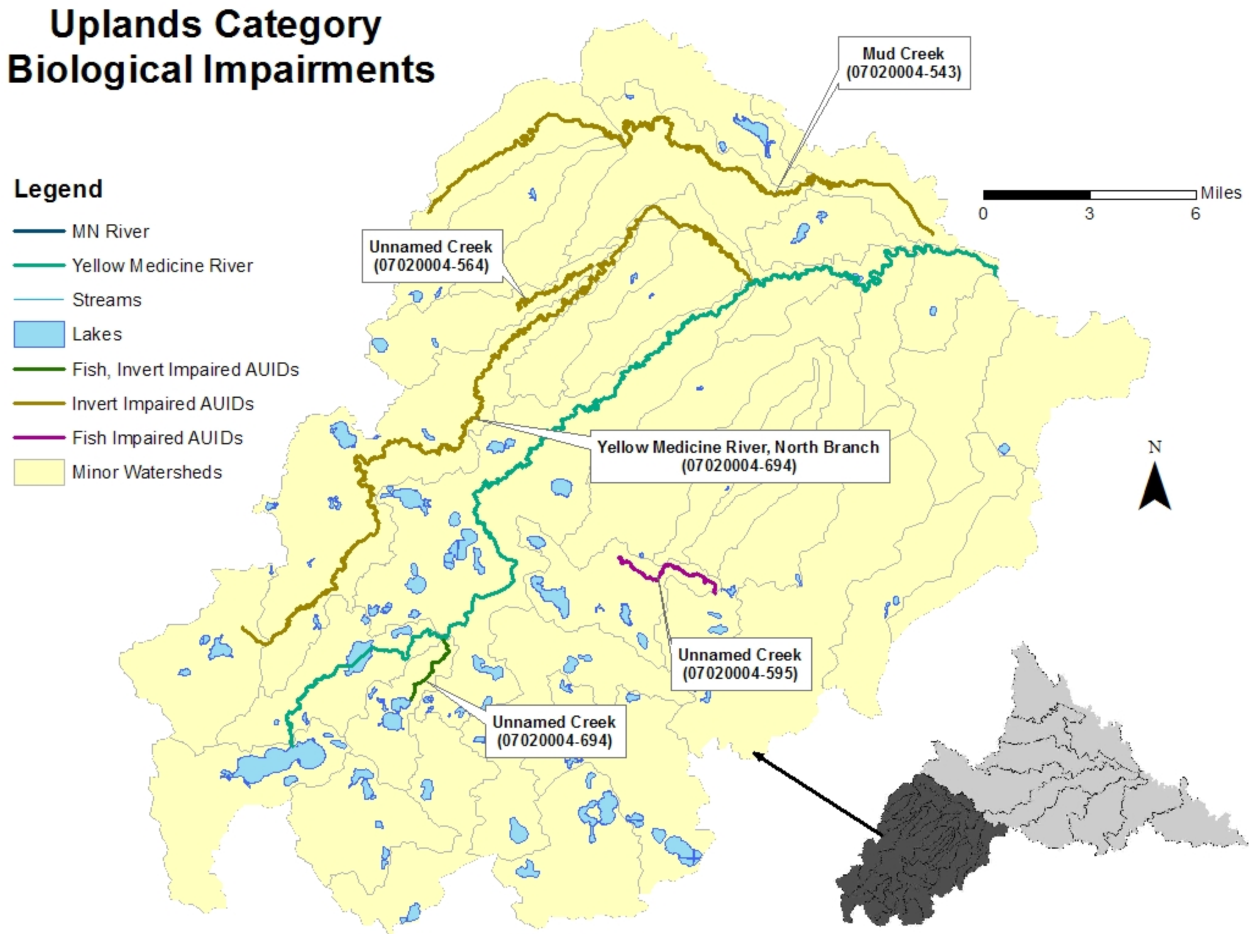

Figure28: Spatial reference to the Uplands category area and its biological impairments

Biology in the Uplands

Fish

The Uplands category has two AUIDs impaired for fish community. Both of these streams are fish Class 3 Southern Headwaters streams, Unnamed Creek (10MN029) and Unnamed Creek (10MN059). Both of these streams had Fish IBI scores below their class' designated threshold and confidence interval. For a breakdown of their IBI metrics, see Figure 29 below.

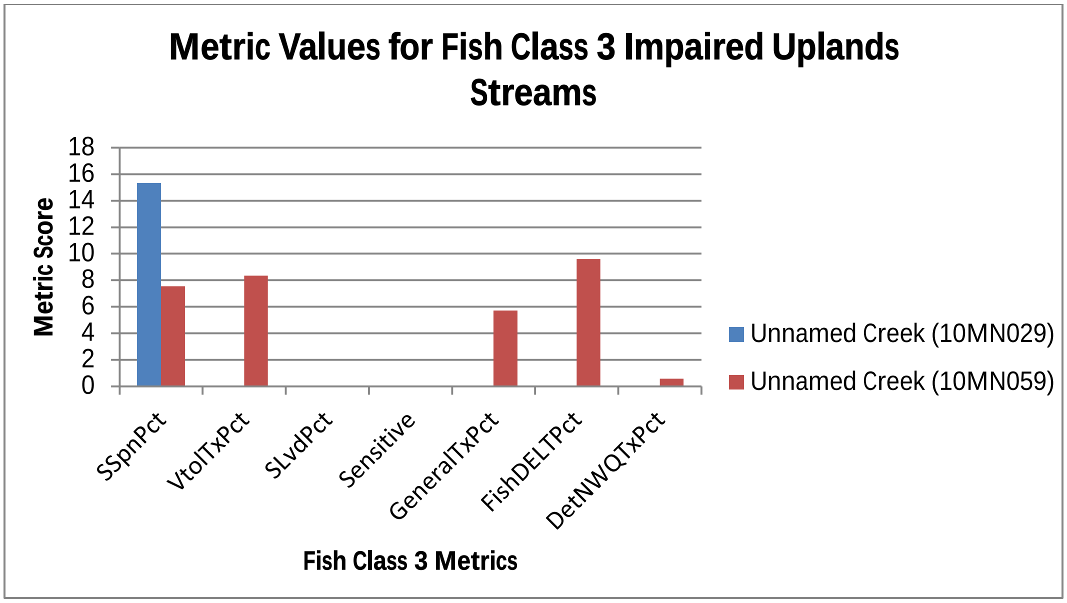

Figure 29: Individual metric scores for the impaired fish Class 3 streams in the Uplands category within the Yellow Medicine River watershed

To reach the Fish Class 3 IBI threshold, each metric would need an average value of 7.29. As Figure 21 shows, these two AUIDs scored poorly in many of the metrics. Unnamed Creek (07020004-694, Biological station- 10MN059) was brought down due to its lack of sensitive fish species, the abundance of undesirable short lived species (SLvdPct), and numerous species that feed on detritus (DetNWQTxPct). Unnamed Creek (07020004-595, Biological station-10MN029) scored well with the lack of serial spawning fish species (SSPnPct), but scored poorly in every other metric.

Invertebrates

The Uplands category has four AUIDs that are impaired for Invertebrate assemblage. Two sites on these streams have an Invertebrate Class 5 Southern Streams RR classification, 10EM016 on the North Branch Yellow Medicine River and 10MN065 on Unnamed Creek. Both of these sites had their MIBI scores below their respective threshold, but both were within the confidence interval. For a breakdown of their MIBI metrics, see Figure 30 below.

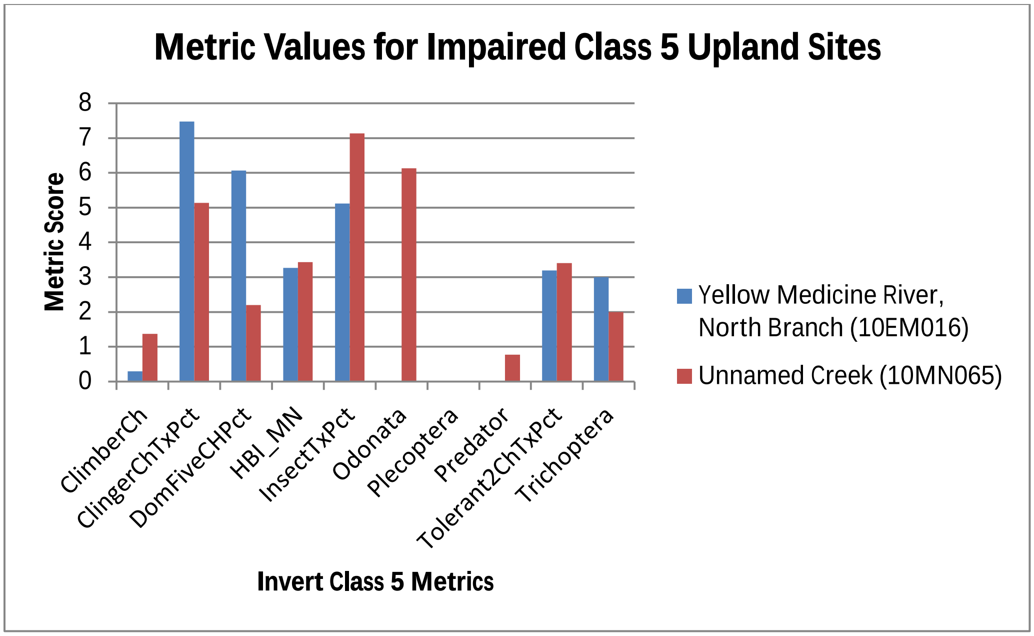

Figure 30: Invertebrate metric values for the impaired Class 5 invertebrate sites in the Uplands category

To reach the MIBI threshold for a Class 5 stream, each metric would need to have a score of 3.59. Both sites had healthy percentages of clinger taxa, dominant five taxa, and insect taxa. Metrics significantly hurting the MIBI score were the taxa richness of Climbers, Plecoptera, and Predator species. Odonata species were noticeably absent at the North Branch Yellow Medicine River site. These taxa consist largely of dragonflies and damselflies and typically exist in streams of good water quality.

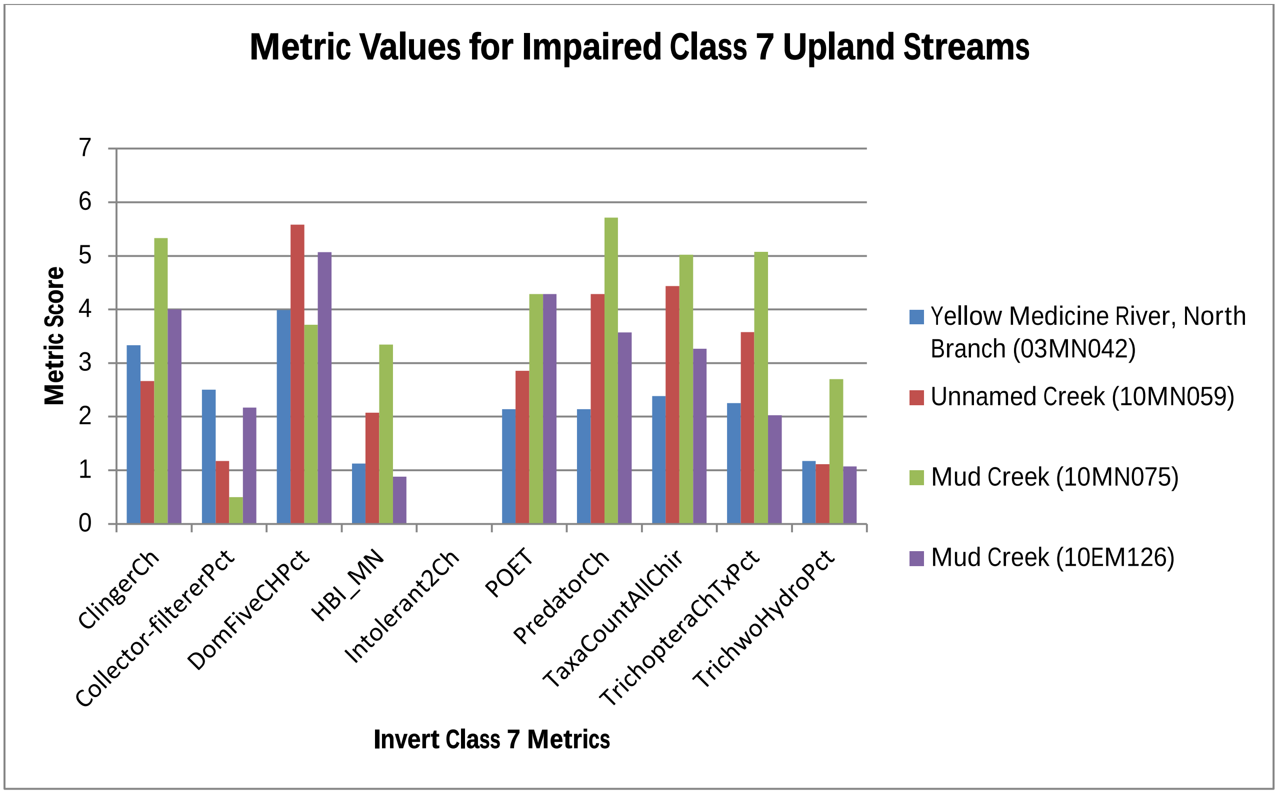

Figure 31: Invertebrate metric values for the impaired Class 7 invertebrate sites in the Uplands category

The invertebrate IBI threshold for Class 7 streams is 38.3. To achieve this, each metric would need an average score of 3.83. Site 03MN042, on the North Branch of the Yellow Medicine River, only reached this in the Dominant Five Taxa (DomFiveCHPct) category. Site 10MN059 on Unnamed Creek failed to reach the 3.83 on half of the metrics. Site 10MN075 on Mud Creek scored below the threshold goal on half of the metrics as well. Metrics particularly hurting this site were the lack of Collector-filterer species and the lack of taxa with tolerance values less than 2 (Intolerant2Ch). Site 10EM126 on Mud Creek met the threshold goal on only 3 metrics (ClingerCh, DomFiveCHPct, POET). All sites graphed above (Figure 31) had minimal collector-filterer taxa, intolerant species, and non-hydropsychid trichoptera taxa.

Candidate cause: Low Dissolved Oxygen

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

Unnamed Creek (07020004-595): A total of 32 DO readings were taken along Unnamed Creek from 2009-2010 (Fig. 32). Three of these measurements were below the 5 mg/L DO standard. The data set is currently not strong enough to list DO as an impairment to Unnamed Creek, although it appears to be non-support.

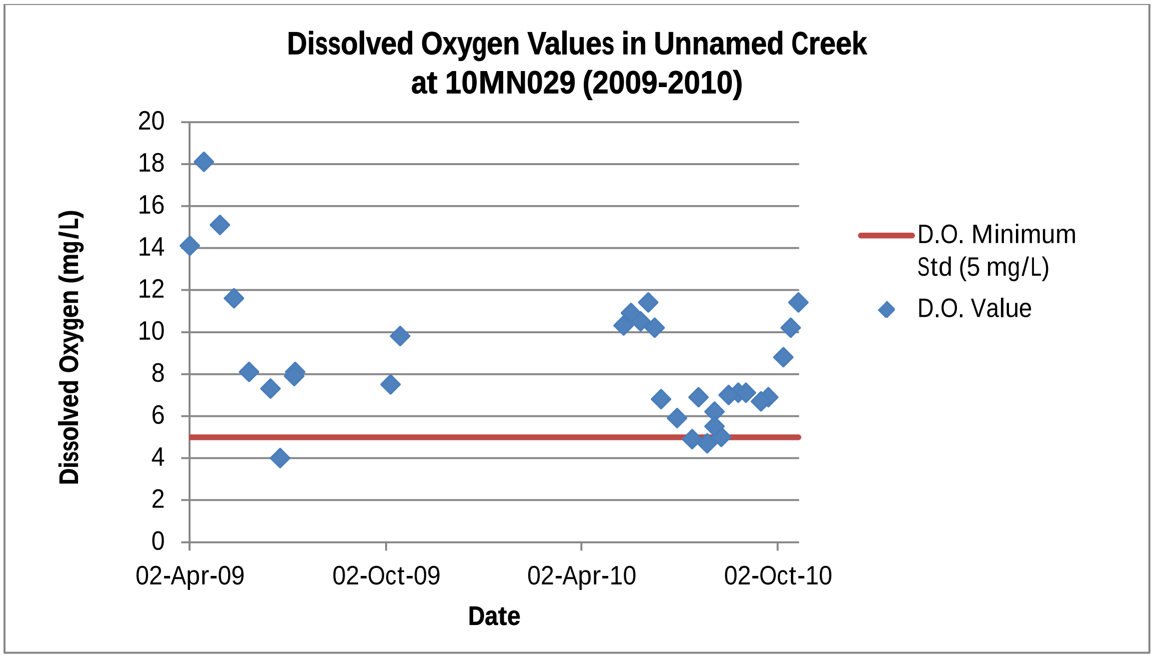

Figure 32: Dissolved oxygen values in Unnamed Creek at Biological Station 10MN029 (2009-2010)

Biologically, Fathead Minnows and Brook Sticklebacks were the only two fish species found in this stream. These two species are both extremely tolerant to low DO conditions.

The presence of EPT taxa (15.6%) was below the statewide average as was the overall invertebrate diversity (21 species).

With the frequency of the DO levels below the standard, the high amounts of tolerant fish, and invertebrates lacking diversity, DO is a stressor to the impaired fish community in Unnamed Creek. Continuous DO is recommended during base flow conditions.

Unnamed Creek (07020004-694): Unnamed Creek had two DO measurements taken at its Biological Station, 10MN059 (Table 22). These readings were taken during the biological visits and were 11.3 mg/L and 1.76 mg/L. The lower value is well below the standard of 5 mg/L.

Sample Location	Sample Date and Time	Result (mg/L)	Daily Minimum Standard (mg/L)
10MN059	6/8/2010 4:42 PM	11.3	5
10MN059	8/4/2010*	1.76	5

Table 22: Dissolved oxygen values in Unnamed Creek at Biological Station 10MN059
* Time of day not available

Biologically, over half of the fish caught were low DO tolerant Fathead Minnows. There was a noticeable decline in number of EPT taxa (14.7%) present, which can also signal a community stressed by low DO. When there is ample water present in Unnamed Creek, DO is stressing the biological communities in Unnamed Creek.

Unnamed Creek (07020004-564): Unnamed Creek at Biological Station 10MN065 had DO measurements of 6.91 mg/L and 7.02 mg/L during its fish and invertebrate sampling events (Fig. 23). These two values are both above the daily minimum standard of 5 mg/L.

Sample Location	Sample Date and Time	Result (mg/L)	Daily Minimum Standard (mg/L)
10MN065	8/3/2010 6:40 PM	6.91	5
10MN065	8/10/10 10:49 AM	7.02	5

Table 23: Dissolved oxygen values in Unnamed Creek at Biological Station 10MN065

Biologically, the fish populations in Unnamed Creek contained a large amount of serial spawning taxa (38.5%), tolerant species (61.5%), while having few late maturing fish species (7.7%). Invertebrates had a tolerant taxa population (55.6%) that was below the statewide average, while having an average amount of EPT taxa (22.2%). Diversity of invertebrate taxa (17) was also low in Unnamed Creek.

Due to the conflicting biological information and few measurements taken, more data needs to be collected in order to get a better understanding of the DO conditions and its effects on the impaired invertebrate assemblage in Unnamed Creek.

Mud Creek (07020004-543): Mud Creek had 19 measurements taken on it during 2010-2011. Of these readings, four of them were below the standard of 5 mg/L. See Figure 33 below for the DO levels taken during this time period.

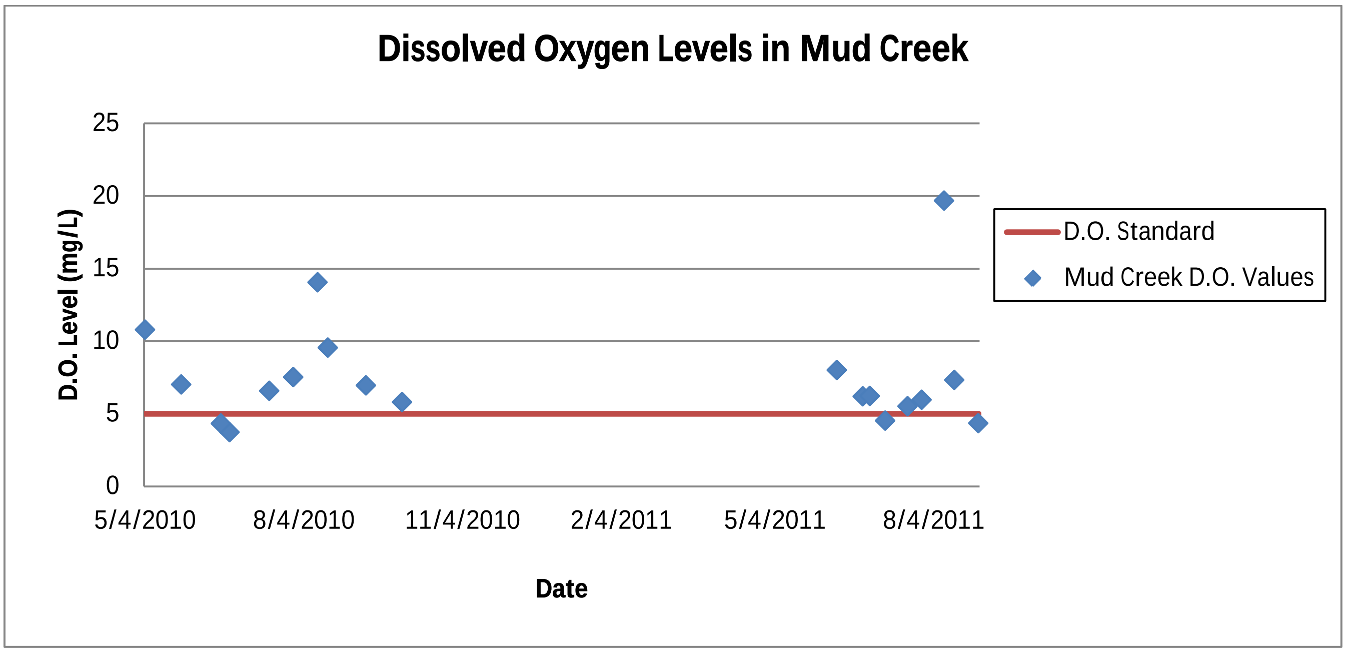

Figure33: Dissolved oxygen levels in Mud Creek from 2010-2011

Mud Creek became intermittent before a sonde could be deployed for continuous measurements. However, Mud Creek did show relatively low EPT numbers (14.1%), a population consisting of 78% tolerant species, and a below statewide average amount of diversity (19 taxa). These results can signify a DO related stress of the invertebrate assemblage.

With the high percentage of violations of the daily minimum standard as well as low diversity, EPT taxa, and high amounts of tolerant invertebrate species, DO is a stressor to the impaired invertebrate community in Mud Creek.

Yellow Medicine River, North Branch (07020004-542): Only 2 of 44 measurements was below the 5 mg/L DO standard on the North Branch Yellow Medicine River taken from 2003-2008.

Biologically, the invertebrate populations in the North Branch Yellow Medicine River had a below average amount of diversity (21 taxa), but also an above average amount of EPT taxa (29.4%). Tolerant taxa were also less abundant than average (56.5%).

The extensive sampling and biology both indicate that DO is not a stressor to the impaired invertebrate populations in this stream at this time.

Candidate cause: High Phosphorus

The proposed draft standard for Phosphorus for streams in the Yellow Medicine River watershed is currently 0.15 mg/L. Although phosphorus is an essential nutrient for all aquatic life, elevated levels can lead to an imbalance which impacts stream ecology. In the Uplands category, phosphorus levels generally exceed the proposed standard.

Unnamed Creek (07020004-595): Unnamed Creek has two phosphorus sampling records taken at Biological Station 10MN029. One was taken during the fish sampling event in 2010, while the other was taken in 2012 before the stream went dry. See Table 24 for the sampling results.

Sample Location	Sample Date	Result (mg/L)	Proposed Draft Standard (mg/L)
10MN029	6/9/2010	0.039	0.15
10MN029	6/26/2012	0.03	0.15

Table 24: Phosphorus sampling results for Unnamed Creek at site 10MN029

Biologically, fish populations in Unnamed Creek consisted of 100% tolerant species, with no sensitive taxa present. Invertebrates had a below average amount of EPT taxa (15.6%), but also had a below average amount of scraper species which tend to increase in streams with elevated phosphorus levels.

With the limited data set available phosphorus is not considered a likely stressor to the impaired fish community in Unnamed Creek at this time. Further monitoring for phosphorus will be needed during times of ample flow to determine the extent of impact, if any, that phosphorus is having on this system.

Unnamed Creek (07020004-694): Unnamed Creek has only one phosphorus sample of record, which was collected during the fish sampling event at Biological Station 10MN059. The stream reach went dry in 2012 prior to any sampling. See Table 25 below for the result.

Sample Location	Sample Date	Result (mg/L)	Proposed Draft Standard (mg/L)
10MN059	6/8/2010	0.127	0.15

Table 25: Phosphorus sample result in Unnamed Creek at 10MN059

Biologically, the fish assemblage in Unnamed Creek had zero sensitive fish species and was dominated by tolerant taxa (75%). Invertebrate populations had an average amount of scraper species (11.8%), but a higher than average amount of crustacean/mollusca species (17.6%) and tolerant taxa (73.5%) which tend to increase in streams with elevated phosphorus levels.

With the limited data set available it is too early to rule phosphorus out as a potential stressor to the impaired fish community. Further monitoring for phosphorus will be needed during times of ample flow to determine the extent of impact, if any, that phosphorus is having on this system.

Unnamed Creek (07020004-564): Unnamed Creek has only one phosphorus sample of record, which was collected during the fish sampling event. The stream reach went dry in 2012 prior to any sampling. See Table 26 below for the result.

Sample Location	Sample Date	Result (mg/L)	Proposed Draft Standard (mg/L)
10MN065	8/3/2010	0.115	0.15

Table 26: Phosphorus sample result in Unnamed Creek at 10MN065

Biologically, EPT taxa were present in average numbers. These types of taxa tend to decrease during high phosphorus levels. Very few scraper species were also present (7.1%) in Unnamed Creek. These invertebrates increase during elevated phosphorus conditions. Furthermore, mollusca/crustacea species both were present in average numbers. These types of invertebrates also tend to increase during times of high phosphorus levels.

With the limited phosphorus sampling and the mixed biological results, it is too early to list this parameter as a stressor to the biological communities at this point. Increased sampling during base flow conditions is needed to determine the extent, if any, that phosphorus is stressing the biology of this stream system.

Mud Creek (07020004-543): Mud Creek had 71 phosphorus samples taken from 2001-2012. Of these samples, 44 (61.9%) were at or above the proposed draft standard (0.15 mg/L) for Minnesota streams (Figure 34).

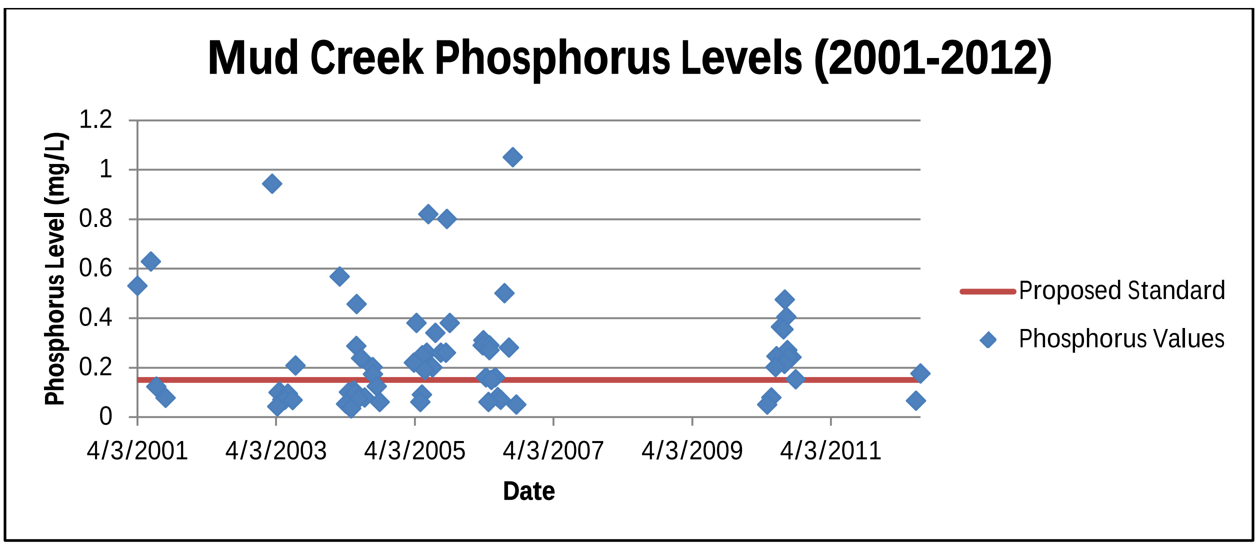

Figure 34: Mud Creek phosphorus levels (2001-2012)

The HSPF model predicted 3315 phosphorus values from 2000-2009 with a range from 0.0048-12.214 mg/L. Of these values, 1204 (36.32%) were above the proposed draft standard of 0.15 mg/L.

Figure 35: Mud Creek at Biological Station 10MN010 affected by excessive amounts of phosphorus

Biologically, invertebrate populations had low numbers of EPT taxa (14.1%), while also having above average amounts of tolerant (78%) and crustacean/Mollusca species.

These frequent elevated levels of phosphorus likely factored in the degradation of other parameters such as DO, pH, water clarity, and habitat (Figure 35). Therefore, phosphorus is a stressor to the impaired invertebrate assemblage in Mud Creek.

Yellow Medicine River, North Branch (07020004-542): The North Branch Yellow Medicine River had 59 phosphorus samples taken from 2003-2010. Of these samples, 21 (35.6%) were at or above the 0.15 mg/L proposed draft standard for phosphorus for Minnesota streams (See Figure 36).

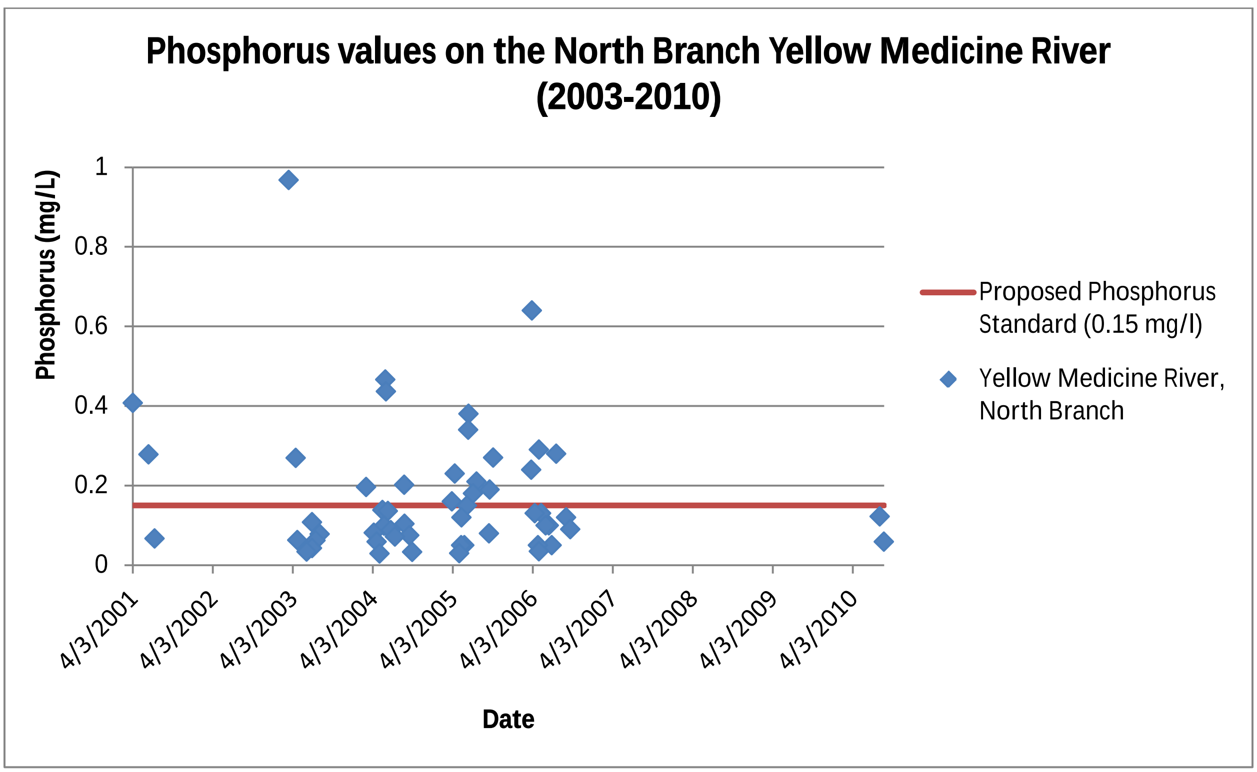

Figure 36: North Branch Yellow Medicine River phosphorus levels from 2003-2010

The HSPF model calculated 3248 phosphorus values from 2000-2009. Of these values, 1248 (39.6%) were above 0.15 mg/L.

Biologically, the invertebrate populations in the North Branch Yellow Medicine River had above average amounts of scraper species (14.8%) and crustacean/mollusca species (12.1%). Higher values for these metrics tend to indicate phosphorus problems.

The HSPF model, the sample collections and the invertebrate metrics all indicate that phosphorus is indeed a stressor to the impaired invertebrate community in the North Branch Yellow Medicine River.

Candidate cause: High Nitrates

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

Unnamed Creek (07020004-595): At site 10MN029 on Unnamed Creek, there were two nitrate samples taken (Table 27) one each in 2010 and 2012. The stream dried up before more nitrate sampling could take place in 2012.

Sample Location	Sample Date	Result (mg/L)	Proposed Draft Standard (mg/L)
10MN029	6/9/2010	9.5	n/a
10MN029	6/26/2012	8.4	n/a

Table 27: Nitrate sample results at Unnamed Creek (10MN029)

Biologically, the invertebrate community in Unnamed Creek had a statewide below average amount of trichoptera taxa (6.25%). Trichoptera taxa tend to decrease in numbers in streams with elevated nitrate levels. Fish (2) and invertebrate (21) taxa counts were both below statewide averages. Species diversity is lowers in streams with elevated nitrate levels.

With the limited data set available it is too early to rule nitrate out as a stressor to the impaired fish community in Unnamed Creek at this time. Further nitrate monitoring will be needed during times of ample flow to determine the extent of impact, if any, that nitrates are having on this system.

Unnamed Creek (07020004-694): At site 10MN059 on Unnamed Creek, there was one nitrate sample taken (Table 28). The sample result was very low and the stream went dry in 2012 before more rigorous nitrate sampling could take place.

Sample Location	Sample Date	Result (mg/L)	Proposed Draft Standard (mg/L)
10MN059	6/8/2010	0.1	n/a

Table 28: Nitrate sample results at Unnamed Creek (10MN059)

With the limited data set available, nitrate is just a potential stressor to Unnamed Creek at this time. More sampling during base flow conditions is recommended.

Unnamed Creek (07020004-564): At site 10MN065 on Unnamed Creek, there was only one nitrate sample taken (Table 29) in 2010. Unnamed Creek went dry before more sampling could take place in 2012.

Sample Location	Sample Date	Result (mg/L)	Proposed Draft Standard (mg/L)
10MN065	8/3/2010	1.7	n/a

Table 29: Nitrate sample result at Unnamed Creek (10MN065)

Invertebrate populations in Unnamed Creek had above average numbers of non-hydropsychid trichoptera (11.1%). Low levels of these species tend to signal high nitrate levels in a stream system.

There simply is not enough nitrate data at this point to determine if nitrate is indeed stressing the biological communities in Unnamed Creek. Further monitoring during base flow conditions is needed.

Mud Creek (07020004-543): From 2001-2012 there were 61 nitrate measurements taken along Mud Creek (See Figure 37). A quantile regression shows with 75% confidence that when a nitrate sample is above 1.6 mg/L during invertebrate sampling, that a Class 7 stream will be impaired for invertebrates. With 90% confidence, the MIBI score will fall below the threshold when reaching levels of 11.5 mg/L. Mud Creek had one reading over this level and 40 measurements at 1.6 mg/L or higher. Most of these higher values occurred during the spring and early summer months when fertilizer application is more common.

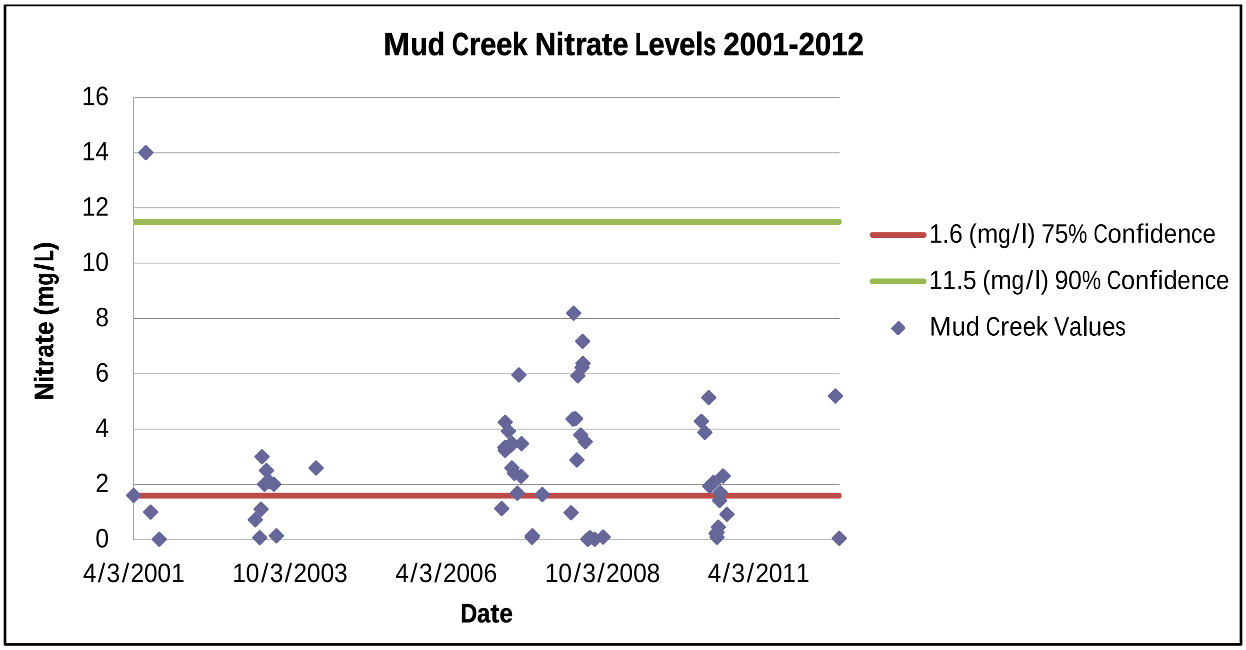

Figure 37: Measured nitrate levels in Mud Creek from 2001-2012

The HSPF model had 3315 estimated daily nitrate values for Mud Creek. Of these estimates, 20 (0.6%) were above 11.5 mg/L. Furthermore, the lack of the nitrate sensitive non-hydropsychid trichoptera is a signal that Mud Creek may be affected by the nitrate levels. At this point, it appears that nitrates are a minor stressor to the impaired invertebrate community in Mud Creek.

Yellow Medicine River, North Branch (07020004-542): The invertebrate impaired North Branch Yellow Medicine River has had 31 nitrate samples taken along the reach from 2003-10 (Figure 38). The average value of these samples was 2.03 mg/L and all of the measurements were below 5 mg/L. The highest values were during the spring months with the readings dipping below 1 mg/L during the late summer months when invertebrate sampling occurs.

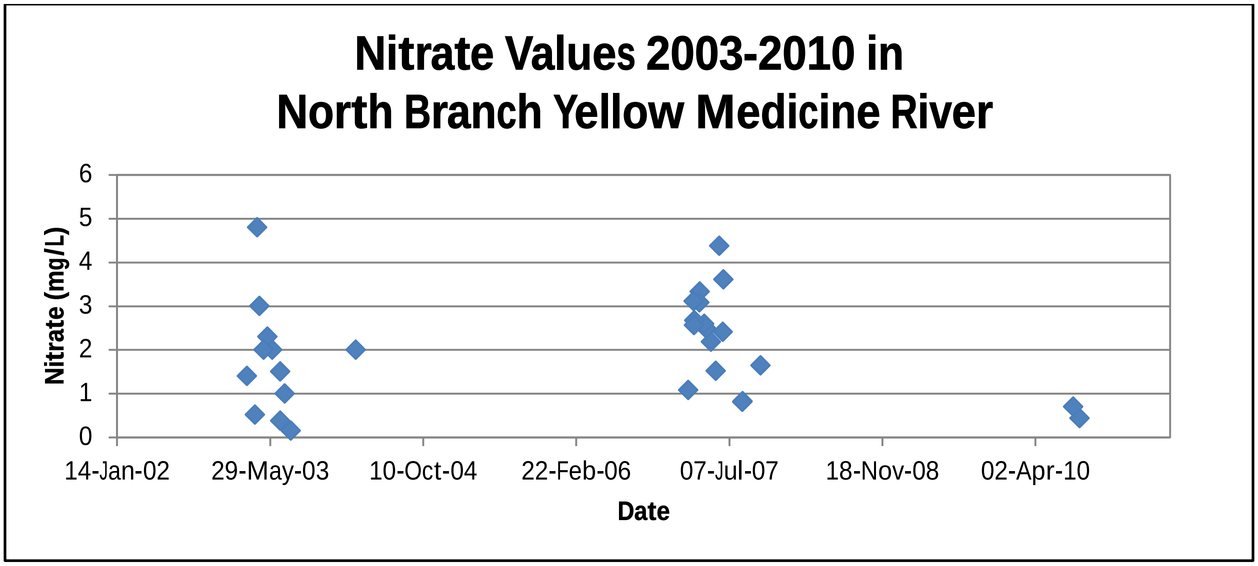

Figure 38: Observed nitrate values on the North Branch Yellow Medicine River from 2003-2010

The HSPF model calculated 3248 nitrate values on the North Branch Yellow Medicine River from 2000-2009. Of all of these calculations, 37 (1.14%) were above 11.5 mg/L, which often signifies a likely impairment to the invertebrate assemblage.

Lower numbers of non-hydropsychid trichoptera present can be a sign of a nitrate related problem, however, due to the low observed values and HSPF generated values it does not appear that nitrate is a stressor to the invertebrate community.

Candidate cause: High Turbidity/TSS

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

Two of the impaired reaches have been and currently are listed as impaired for Turbidity. Less extensive data sets on the smaller streams in this category reduces the ability to define the magnitude that elevated Turbidity/TSS values are having on these impaired stream reaches.

Unnamed Creek (07020004-595): Unnamed Creek had a total of 38 transparency tube measurements taken from 2009-2010. Only 5 of these were below the 20 cm standard for a Minnesota Class 2B stream. This stream section was assessed for Turbidity in 2012 and determined to be in full support of aquatic life.

Biologically, there was a statewide below average amount of trichoptera taxa (6.25%), ephemeroptera taxa (9.38%), and scraper species (9.38%). These species are often present in lower numbers in streams with elevated turbidity/TSS levels. Also, the fish community consisted of all tolerant species and no herbivores. Herbivorous fish are found in greater numbers in streams with low turbidity/TSS values.

In this case, the biology in Unnamed Creek is suggesting that turbidity/TSS is a problem to the impaired fish assemblage. However, the transparency data suggests that the stream is in full support of aquatic life. Both more biological and chemical sampling is recommended in Unnamed Creek to get a more clear understanding of the impact that this parameter is having on the biological communities.

Unnamed Creek (07020004-694): Biological station 10MN059 on Unnamed Creek had one TSS reading (3.6 mg/L) taken during its fish sampling event in 2010. In addition, during the fish and invertebrate sampling transparency readings were both greater than 100 cm.

Biologically, the fish population consisted of 75% tolerant taxa and completely lacked any herbivorous species. These values can potentially indicate the fish population is affected by high turbidity or TSS values. The invertebrate assemblage had high amounts of chironomid taxa (38.2%), tolerant species (73.5%), and collector-filterer species (14.7%).

The fish and invertebrate metric information does indicate stress caused by high levels of turbidity/TSS, however the limited data set does not confirm this at this time. More turbidity, TSS, and transparency samples need to be taken to know the actual effect that this parameter is having on the impaired biological communities in Unnamed Creek.

Unnamed Creek (07020004-564): Unnamed Creek had one TSS measurement taken at its biological monitoring station, 10MN065. The result of this sample was 46 mg/L, with the TSS standard for this region set at 65 mg/L.

An indicator that turbidity/TSS may be stressing the invertebrate populations was the low amounts of Scraper species captured (7.4%). However, Unnamed Creek did show high amounts of collector-filterer invertebrate species which tend to disappear in streams with turbidity/TSS problems.

With the extremely limited data set, it is assumed that turbidity/TSS is a just a potential stressor to the impaired invertebrate community in Unnamed Creek at this time.

Mud Creek (07020004-543): There were 108 transparency tube measurements taken on Mud Creek from 2003-2011. Of these measurements, 20 (18.5%) were below the 20 cm standard for class 2B streams in Minnesota. This high amount of exceedances caused this AUID to be listed as impaired for turbidity during a 2010 assessment. This assessment was confirmed during the latest round of assessments in 2012.

Sites along Mud Creek showed low numbers of ephemeroptera (7.2%) and trichoptera (4.3%), which are two orders of invertebrates sensitive to high turbidity values. These sites also had high numbers of tolerant invertebrate species (78%), which is also common for a community potentially stressed by high turbidity values. Turbidity/TSS is stressing the impaired invertebrate assemblage in Mud Creek.

Yellow Medicine River, North Branch (07020004-542): This AUID currently has a turbidity listing from a 2010 assessment. With standard exceedances of approximately 25%, the most recent assessment supports this impairment decision. The mid-site along this stream reach, 03MN042, scored especially poor in advanced Turbidity related invertebrate metrics. This location had an overwhelming number of tolerant invertebrates (95.6%), while having very few turbidity sensitive Ephemeroptera, Trichoptera, as well as Collector-Filterer species.

Turbidity is a stressor to the impaired invertebrate community in the North Branch Yellow Medicine River.

Candidate cause: Altered Hydrology

Altered hydrology is a problem in the Uplands category of the Yellow Medicine River watershed. All of the biologically impaired streams appear to be intermittent or have completely dried up at times during the past few years.

Channelized streams are also prevalent in the minor watersheds of the impaired reaches. Many of these altered streams are in the headwaters of the watershed whose primary purpose is move water off the abundant farm fields in to the streams rather quickly. This can cause the streams flows to be very inconsistent (Schottler 2013).

Unnamed Creek (07020004-595): Unnamed Creek has a history of becoming intermittent or drying up altogether (Fig. 39). The HSPF model estimates that Unnamed Creek has flow less than 1 cfs more than 48% of the time. The fish community on this reach has an extremely difficult time establishing itself on a consistent basis. An ample amount of base flow present is needed for many species to complete their respective life cycles.

Figure 39: (Left to right) Biological Station 10MN029 during a site visit in the Fall of 2009; 10MN029 during July of 2012

Furthermore, Unnamed Creek, only fathead minnows and brook sticklebacks present. Fathead minnows are generalist species and can quickly adapt to low flow and other unfavorable conditions. Another indication that the fish population is affected by the lack of flow was the complete absence of long lived species.

The biological information, the HSPF model results, and the frequent observances of intermittent flow are all reasons that altered hydrology is a stressor to the impaired fish community in Unnamed Creek.

Unnamed Creek (07020004-694): Site 10MN059 on Unnamed Creek was dry during a visit during the fall of 2009 (Figure 40) and also during the summer of 2012. This lack of a consistent base flow makes it impossible for healthy fish and invertebrate communities to survive, much less complete their life cycles.

Figure 40: Site 10MN059 on Unnamed Creek during a fall 2009 visit

The subwatershed used by the HSPF model to simulate flows has values under 1 cfs nearly 25.3% of the time. However, the minor watershed containing Unnamed Creek made up only 12.8% of this subwatershed and was located in the far headwaters. The frequency of Unnamed Creek to have flow less than 1 cfs is much greater.

Biologically, the fish population consisted of high amount of generalist species (75%) and tolerant taxa (75%). These two metrics are both typically high in cases of low to intermittent flow.

Considering the HSPF results, the biology, and the frequent observed dry conditions in Unnamed Creek, altered hydrology is a major stressor to the fish and invertebrate assemblages in Unnamed Creek.

Unnamed Creek (07020004-564): Unnamed Creek has commonly experienced periods of extremely low flow (Figure 41). The Biological Station, 10MN065, was observed to be intermittent and/or dry during the summer of 2012. Furthermore, the North Branch Yellow Medicine River often becomes intermittent. This severely limits the invertebrate communities as they search for suitable living conditions.

Figure 41: Low flow on Unnamed Creek at 10MN065 during August 2012

Biologically, Unnamed Creek had a high population of generalist taxa (46.2%) and a below average amount of long lived fish species (7.7%). Invertebrates had a high population of tolerant species (61.5%).

Unnamed Creek often dries up or becomes intermittent making it difficult for viable biological communities. In this stream, the invertebrate population was affected the most. Altered hydrology is a major stressor to the invertebrate assemblage in Unnamed Creek.

Mud Creek (07020004-543): Even with a watershed drainage area of 58 mi^2, Mud Creek has become intermittent or dried up completely at least twice in the past four years (See Figure 42).

Figure 42: (Left to right) Biological Station 10MN075 on Mud Creek during a visit in Fall of 2009; upstream side of road at site 10MN075 in July 2012

The HSPF model estimated flows on Mud Creek to be below 1 cfs over 23% of the time. The lack of consistent base flow prevents healthy invertebrates from establishing themselves on a frequent basis.

Biologically, the invertebrate assemblage in Mud Creek had an above average amount of swimmer species (9%). These species are much more common in streams that have low flow or become intermittent due to their increased mobility.

The HSPF model data, the biological information and the recurring periods of minimal flow throughout Mud Creek makes Altered Hydrology a major stressor to the impaired invertebrate communities along this stream reach.

Yellow Medicine River, North Branch (07020004-542): Despite a watershed drainage area of 68.1 mi2, the North Branch Yellow Medicine River has become intermittent or dried up completely at least twice in the past four years (See Figure 43).

Figure 43: (Left to right) Biological Station 10MN071 during a visit in Fall of 2009; Site 10MN071 in July 2012

The HSPF model estimated flows on North Branch Yellow Medicine River to be below 1 cfs over 27% of the time. The lack of consistent base flow especially in the headwaters of this stream prevents healthy invertebrates from establishing themselves on a frequent basis.

Biologically, the invertebrate populations consisted of 11.8% swimmer species. There was also a statewide above average amount of generalist species of fish (46.9%) and tolerant taxa (52.2%).

The recurring periods of minimal flow throughout North Branch Yellow Medicine River makes Altered Hydrology a major stressor to the impaired invertebrate communities along this stream reach.

Candidate cause: Lack of Habitat

Habitat quality in the Uplands region of the Yellow Medicine River watershed varies from poor to good on the biologically impaired reaches in this category. The MSHA was the main tool used for evaluating this potential stressor and the results of these habitat scores can be seen in Figure 44 below.

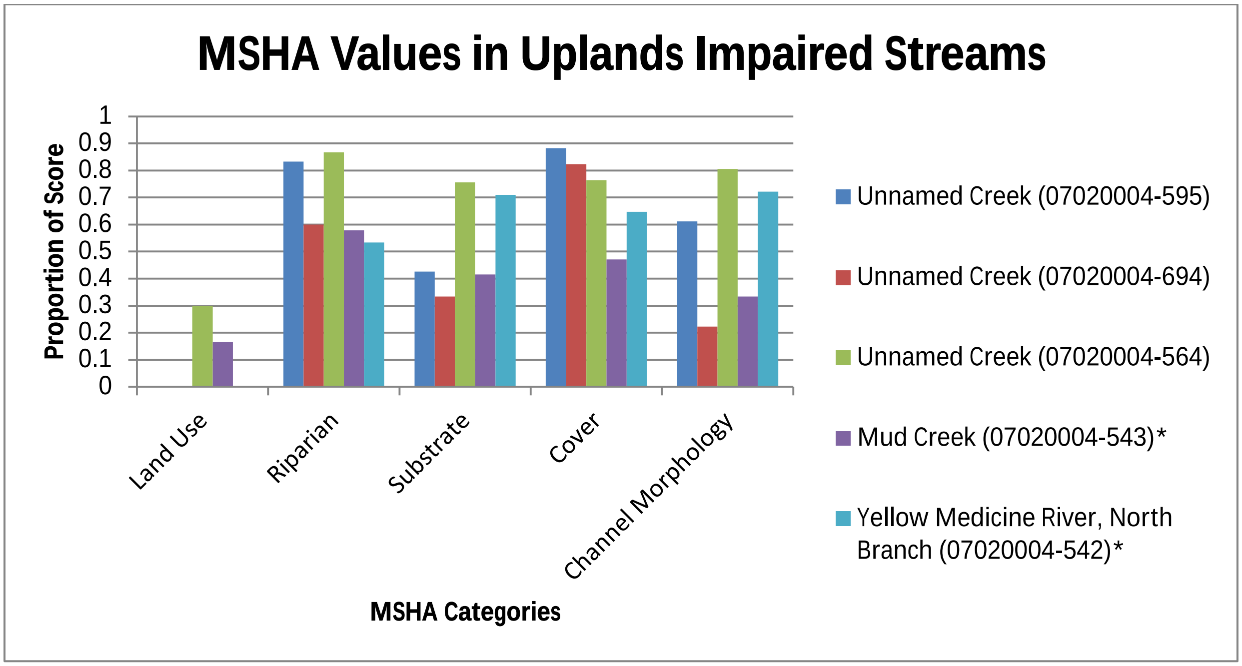

Figure 44: MSHA falues at biologically impaired streams in Uplands category.
*Indicates the average values of multiple visits/sites on impaired AUID.

Unnamed Creek (07020004-595): The MSHA score for the Biological Station, 10MN029, was 61 out of 100. This score is considered to be fair. Factors limiting habitat on Unnamed Creek are: the poor surrounding land use (Figure 45), the abundant presence of sand/ silt substrates, and the lack of channel stability and development.

Figure 45: Land use in and surrounding Unnamed Creek at 10MN029.

Biologically, Unnamed Creek had fish populations completely absent of riffle dwelling fish, benthic insectivores, Lithophilic spawners, and darters/sculpins/round bodied suckers. These metrics are typically low in degraded habitat conditions. Invertebrates had slightly below average amounts of clinger taxa (28.1%), which tend to decrease in streams lacking habitat.

With a fair MSHA score, supported by biological metrics, habitat is a stressor to the impaired fish assemblage.

Unnamed Creek (07020004-694): The habitat score for the Biological Station, 10MN059, was 40 out of 100. This value is considered to be poor. The MSHA value on Unnamed Creek was low due to: poor surrounding land use (Figure 46), an extremely minimal riparian buffer, no course substrates, poor channel stability and development, and little depth variability in the stream.

Figure 46: Land use in and surrounding Unnamed Creek at 10MN059.

Biologically, Unnamed Creek completely lacked benthic insectivores and darters/sculpins/round bodied suckers, while also having a large population of tolerant fish (75%). However, it did have a statewide above average amount of riffle dwelling taxa (12.5%) and lithophilic spawners (37.5%). The invertebrates were mostly tolerant species (73.5%) and had a below average amount of clinger taxa (17.6%).

With a poor MSHA score and most of the biological metrics reflecting degraded habitat conditions, lack of habitat is a stressor to the impaired biological communities in Unnamed Creek.

Unnamed Creek (07020004-564): Unnamed Creek had an MSHA score of 76.9 at its Biological Station, 10MN065. This is a good habitat score. The presence of row crop as a nearby land use and the moderate embeddedness from the existence of fine particles are two factors that lowered this MSHA value.

Biologically, Unnamed Creek had an above average amount of riffle dwelling fish taxa (30.8), benthic insectivores (30.7%), lithophilic spawners (23.1%), and darter/sculpin and round bodied suckers (23.1%). Invertebrates also had an above average amount of clinger species (33.3%). These results are common in streams not stressed by habitat.

With the good MSHA score and habitat related biological metrics, lack of habitat is not a stressor to the impaired invertebrate community at this time.

Mud Creek (07020004-543): The MSHA scores at the three biological stations (10MN010, 10MN075, 10EM126) were 38.8, 51.3, and 32 respectively. The middle site on the AUID, 10MN075, had the only MSHA value not considered to be poor. Limiting the habitat on this stream reach was: poor surrounding land use, sparse in-stream cover for fish, a small riparian buffer, little shade, poor channel stability and development, as well as a lack of stream depth variability.

Biologically, fish populations had below average amounts of riffle dwelling taxa (6.3%) and lithophilic spawners (8.8%). They did however have higher amounts of benthic insectivores (28.8%) and darter/sculpin/round bodied suckers (22.54%). Invertebrates in Mud Creek had high amounts of tolerant taxa (78%) and below average amounts of clinger species (27.24%).

With the poor scores at two of the three sampling locations and low scores for habitat related invertebrate metrics, lack of habitat is stressing the impaired invertebrate community in Mud Creek.

Yellow Medicine River, North Branch (07020004-542): Habitat scores at the three biological stations (10MN071, 03MN042, 10EM016) on this AUID were 66.9, 63, and 62.6. The most downstream site, 10MN071, had a MSHA value that is considered to be good, while the other two sites had fair values. Main factors limiting the MSHA on this stream reach were: poor surrounding land use, light to moderate stream shading, and some embeddedness of the course substrates.

Biologically, the impaired invertebrate community in North Branch Yellow Medicine River had above average amounts of clinger species (22.5%), while also have a below average amount of tolerant taxa (56.5%).

With the MSHA scores ranging from fair to good, and the habitat related invertebrate metrics scoring well, other factors are likely stressing the invertebrate community in this stream. The lack of habitat should not be considered a stressor at this time.

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 Unnamed Creek (07020004-595), Unnamed Creek (07020004-694), Unnamed Creek (07020004-564), Mud Creek, and North Branch Yellow Medicine River were scored and summarized in Tables 30-34. For further information on scoring please see Appendix 1.3 and 1.4.

Unnamed Creek (07020004-595)			
Types of Evidence	Scores of Candidate Causes		
	Low Dissolved Oxygen	Altered Hydrology	Lack of Habitat
Spatial/temporal co-occurrence	+	+	+
Temporal sequence	+	+	0
Field evidence of stressor-response	+	+ +	+
Causal pathway	+	+	+
Evidence of exposure, biological mechanism	NE	NE	NE
Field experiments /manipulation of exposure	NE	NE	NE
Laboratory analysis of site media	NE	NE	NE
Verified or tested predictions	+	+ + +	+
Symptoms	+	D	+
Evidence using data from other systems			
Mechanistically plausible cause	+	+	NE
Stressor-response in other lab studies	NE	NE	NE
Stressor-response in other field studies	+ +	+	+
Stressor-response in ecological models	NE	NE	NE
Manipulation experiments at other sites	NE	NE	NE
Analogous stressors	NE	NE	NE
Multiple lines of evidence			
Consistency of evidence	+ + +	+ + +	+ + +
Explanatory power of evidence	+ +	+ +	+ +

Table 30: Weight of evidence scoring at Unnamed Creek

Unnamed Creek (07020004-694)			
Types of Evidence	Scores of Candidate Causes		
	Low Dissolved Oxygen	Altered Hydrology	Lack of Habitat
Spatial/temporal co-occurrence	+	+	+
Temporal sequence	0	+	0
Field evidence of stressor-response	+	+ +	+
Causal pathway	+	+	+
Evidence of exposure, biological mechanism	NE	NE	NE
Field experiments /manipulation of exposure	NE	NE	NE
Laboratory analysis of site media	NE	NE	NE
Verified or tested predictions	+	+ + +	+
Symptoms	+	D	+
Evidence using data from other systems			
Mechanistically plausible cause	+	+	NE
Stressor-response in other lab studies	NE	NE	NE
Stressor-response in other field studies	+ +	+	+
Stressor-response in ecological models	NE	NE	NE
Manipulation experiments at other sites	NE	NE	NE
Analogous stressors	NE	NE	NE
Multiple lines of evidence			
Consistency of evidence	+ + +	+ + +	+ + +
Explanatory power of evidence	+ +	+ +	+ +

Table 31: Weight of evidence scoring at Unnamed Creek

Unnamed Creek (07020004-564)	
Types of Evidence	Scores of Candidate Causes
	Altered Hydrology
Spatial/temporal co-occurrence	+
Temporal sequence	+
Field evidence of stressor-response	+ +
Causal pathway	+
Evidence of exposure, biological mechanism	NE
Field experiments /manipulation of exposure	NE
Laboratory analysis of site media	NE
Verified or tested predictions	+ + +
Symptoms	D
Evidence using data from other systems	
Mechanistically plausible cause	+
Stressor-response in other lab studies	NE
Stressor-response in other field studies	+
Stressor-response in ecological models	NE
Manipulation experiments at other sites	NE
Analogous stressors	NE
Multiple lines of evidence	
Consistency of evidence	+ + +
Explanatory power of evidence	+ +

Table 32: Weight of evidence scoring at Unnamed Creek

Mud Creek (07020004-543)						
Types of Evidence	Scores of Candidate Causes					
	Low Dissolved Oxygen	High Phosphorus	High Nitrate	Turbidity/TSS	Altered Hydrology	Lack of Habitat
Spatial/temporal co-occurrence	+	+	+	+	+	+
Temporal sequence	0	+	+	+	+	0
Field evidence of stressor-response	+	+ +	+	+ +	+ +	+ +
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	+	+	+	+	D	+
Evidence using data from other systems						
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	NE
Multiple lines of evidence						
Consistency of evidence	+ + +	+ + +	+	+ + +	+ + +	+ + +
Explanatory power of evidence	+ +	+ +	+	+ +	+ +	+ +

Table 33: Weight of evidence scoring at Mud Creek

	Yellow Medicine River, North Branch (07020004-542)		
Types of Evidence	Scores of Candidate Causes		
	High Phosphorus	High Turbidity/TSS	Altered Hydrology
Spatial/temporal co-occurrence	+	+	+
Temporal sequence	+	+	+
Field evidence of stressor-response	+ +	+ +	+ +
Causal pathway	+	+	+
Evidence of exposure, biological mechanism	NE	NE	NE
Field experiments /manipulation of exposure	NE	NE	NE
Laboratory analysis of site media	NE	NE	NE
Verified or tested predictions	+ + +	+ + +	+ + +
Symptoms	+	+	D
	Evidence using data from other systems		
Mechanistically plausible cause	+	+	+
Stressor-response in other lab studies	NE	NE	NE
Stressor-response in other field studies	+	+	+
Stressor-response in ecological models	NE	NE	NE
Manipulation experiments at other sites	NE	NE	NE
Analogous stressors	NE	NE	NE
	Multiple lines of evidence		
Consistency of evidence	+ + +	+ + +	+ + +
Explanatory power of evidence	+ +	+ +	+ +

Table 34: Weight of evidence scoring at North Branch Yellow Medicine River

Conclusions

The Uplands category in the Yellow Medicine River watershed has five biologically impaired streams. While many factors can lead and contribute to a biological impairment, the one common stressor found in this category was altered hydrology. All reaches impaired for biology either became intermittent or dried up completely in 2012. Many of these reaches were also intermittent in 2009 and likely at times before and in between. The HSPF model estimates many of the streams to have flows less than 1 cfs from 23% to over 50% of the time. When flow does exist, the extended periods of extremely low flow make it nearly impossible for a viable biological community to exist, especially in the headwater reaches of the watershed. The recovery rate following drought like conditions for biological assemblages, especially invertebrates often take years of normal base flow conditions.

Dissolved oxygen is another stressor likely leading to the biological impairments on Unnamed Creek (07020004-595), Unnamed Creek (07020004-694), and Mud Creek. When ample flows are present on these streams, DO levels have gone below the minimum standard of 5 mg/L. When this happens, species tolerant to low levels of DO move in and begin to dominate the ecosystem.

As previously mentioned, phosphorus is an essential nutrient for aquatic life, but its presence in excess can disrupt the balance of a streams ecosystem by altering other parameters including DO, pH, water clarity and habitat. Phosphorus levels at these reaches were found to be elevated most of the time. Mud Creek and the North Branch Yellow Medicine River had extensive data sets and had violations of the proposed draft standard 35.6% (North Branch Yellow Medicine River) to 61.9% (Mud Creek) of the time. These are significant exceedances that need to be addressed. The remaining streams all need further phosphorus monitoring during consistent base flows over time to better understand the extent of the phosphorus problem in the Uplands category.

Without a current standard in place, quantifying the stress associated from nitrates can prove to be difficult, especially in streams with inconsistent flow levels like the ones found in this category. For the most part, nitrate levels did not reach extreme levels in either sampling or HSPF model outputs. Nitrate levels in Mud Creek were sometimes above 11.5 mg/L which often signifies an invertebrate impairment. The low numbers of non-hydropsychid trichoptera can also serve as an indicator of nitrate related stress to the invertebrate communities. These taxa were often present in low numbers when nitrate levels were both elevated and relatively low. This may also be attributed to the frequent intermittent and dry conditions that these streams often experience. Further nitrate sampling and analysis will be needed on these streams during ample flow conditions to determine the true extent of stress that this parameter is having on the biological communities.

Currently two of the studied stream reaches are already designated as impaired for turbidity (Mud Creek and North Branch Yellow Medicine River). The fish and invertebrate communities in these stream reaches reflect these impairments as well. Continued work to reduce the amount of fine sediments entering these systems is needed to improve both the water clarity, but also the biology. Unnamed Creek (07020004-595) had enough transparency tube measurements to be assessed. These measurements were found to be fully supporting of aquatic life. Unnamed Creek (07020004- 694) and Unnamed Creek (07020004-564)had too few measurements taken for assessment purposes and further monitoring of these two stream reaches is needed to better determine the effects turbidity is having on these systems, if any.

In-stream habitat at the biologically impaired reaches in the Uplands category ranged from Poor (MSHA -32) to Good (MSHA-76.9). Habitat was found to be a stressor at Unnamed Creek (07020004-595), Unnamed Creek (07020004-694), and Mud Creek. Embedded fine sediment, poor surrounding land use, eroded banks, and lack of cover for fish were the main habitat factors limiting diverse fish and invertebrate communities. Habitat improvement projects would help improve the impaired biological communities in these streams.

Summary and recommendations

Nine stream reaches are impaired for aquatic life due to their biological communities in the Yellow medicine River watershed. The stressors found to be affecting the biology are summarized in Table 35. The following is a general overview of conclusions and recommendations for the Yellow Medicine River watershed regarding its stressors. Please see the individual reaches in their respective categories for more specific information.

The primary stressor to the majority of the streams in this watershed is altered hydrology. Hydrology is foundational to the streams and river's well-being and when it is disturbed other aspects which are influenced or reliant on the hydrology will also be altered. Restoring the hydrology to provide a consistent base flow is imperative for the survival of the biological communities in this watershed. Too often, streams in this watershed became intermittent or dried up making it nearly impossible for viable fish and invertebrate populations to exist.

Drought conditions have been common in this watershed over the past few years. A landscape that quickly removes water from its system like the common practice of using tile drainage systems along with channelizing streams allows for extreme shifts in stream flow. Following rain events, these streams will be flowing faster and with more power than they can normally handle resulting in high amounts of stream bank erosion (Schottler 2013). Also, without water being retained by fields and slowly released into a stream, these streams will tend to become intermittent or dry up altogether. 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 Yellow Medicine River watershed.

Dissolved oxygen is a clear stressor in Unnamed Creek (07020004-718), Judicial Ditch 10/Wood Lake Creek, Unnamed Creek (07020004-595), Unnamed Creek (07020004-694), and Mud Creek as evidenced by the measured values and the biological response. Judicial Ditch 10/Wood Lake Creek had continuous diurnal monitoring using a sonde showing numerous instances below 5 mg/L and a daily flux greater than 4.5 mg/L. This parameter is viewed as a potential stressor in County Ditch 39, County Ditch 2, and Unnamed Creek (07020004-564). More monitoring is needed on those streams to better understand the stress this parameter has on the biological communities. The impaired invertebrate community in North Branch Yellow Medicine River does not appear to be affected by DO at this time. Continuous monitoring of DO during base flow conditions is recommended to better understand the extent of the stress this parameter is having on streams in the Yellow Medicine River watershed.

Given the high phosphorus readings watershed-wide and highlighted as stressors in the biologically impaired reaches of County Ditch 39, County Ditch 2, Unnamed Creek (07020004-718), Judicial Ditch 10/Wood Lake Creek, Mud Creek, and North Branch Yellow Medicine River; 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. Further monitoring is recommended watershed-wide to better understand the magnitude of stress phosphorus is causing.

Elevated levels of nitrates are stressing the impaired fish and invertebrate communities in County Ditch 39, Judicial Ditch 10/Wood Lake Creek and Mud Creek. With the spikes of nitrate coinciding with snowmelt and rainfall events along with the abundance of cropland in the Yellow Medicine River 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. Further monitoring is recommended watershed-wide to better understand the magnitude of stress nitrates causing.

Turbidity and TSS are issues that need to be addressed in Judicial Ditch 10/Wood Lake Creek, Mud Creek and North Branch Yellow Medicine River 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 the remaining streams during base flow conditions to better understand the impacts this parameter is having on the fish and invert populations. 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.

Lack of habitat is a stressor in Unnamed Creek (07020004-718), Judicial Ditch 10/Wood Lake Creek, Unnamed Creek (07020004-595), Unnamed Creek (07020004-694), and Mud Creek. MSHA scores ranged from poor to fair in these streams. 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.

		Stressors					
Stream Name	**AUID #**	Low Dissolved Oxygen	High Phosphorus	High Nitrates	High Turbidity/ TSS	Altered Hydrology	Lack of Habitat
Direct tributaries to the Minnesota River							
County Ditch 39	07020004-713		•	•		•	
Unnamed Creek	07020004-718	•	•			•	•
County Ditch 2	07020004-717		•			•	
Judicial Ditch 10 (Wood Lake Creek)	07020004-547	•	•	•	•		•
Uplands							
Unnamed Creek	07020004-595	•				•	•
Unnamed Creek	07020004-694	•				•	•
Unnamed Creek	07020004-564					•	
Mud Creek	07020004-543	•	•	•	•	•	•
Yellow Medicine River, North Branch	07020004-542		•		•	•	

Table 35: Summary of Stressors in the Yellow Medicine River Watershed.

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Appendix 1.1 - MPCA fish IBI class criteria for Yellow Medicine River watershed streams

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

Appendix 1.2- MPCA invertebrate IBI class criteria for Yellow Medicine River watershed streams

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

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
0702000401	07020004-536	10MN014	Hazel Creek	75.32	2	67	45	28-Jul-10
0702000402	07020004-713	10MN051	County Ditch 39	21.90	3	40	51	12-Aug-10
0702000402	07020004-674	10MN121	Judicial Ditch 23	22.30	3	66	51	22-Jul-10
0702000403	07020004-542	03MN042	Yellow Medicine River, North Branch	41.42	2	44	45	05-Aug-03
0702000403	07020004-542	10EM016	Yellow Medicine River, North Branch	40.80	2	51	45	24-Aug-10
0702000403	07020004-543	10EM126	Mud Creek	35.97	2	54	45	23-Aug-10
0702000403	07020004-584	10MN002	Yellow Medicine River	70.18	2	42	45	04-Aug-10
0702000403	07020004-584	10MN011	Yellow Medicine River	191.03	2	66	45	10-Aug-10
0702000403	07020004-543	10MN075	Mud Creek	39.97	2	59	45	03-Aug-10
0702000403	07020004-694	10MN059	Unnamed creek	5.60	3	32	51	08-Jun-10
0702000403	07020004-564	10MN065	Unnamed creek	8.03	3	68	51	03-Aug-10
0702000404	07020004-503	03MN038	Yellow Medicine River, South Branch (County Ditch 35)	75.74	2	61	45	26-Jun-03
0702000404	07020004-503	03MN039	Yellow Medicine River, South Branch (County Ditch 35)	84.62	2	47	45	26-Jun-03
0702000404	07020004-503	10EM062	Yellow Medicine River, South Branch (County Ditch 35)	74.92	2	61	45	18-Aug-10
0702000404	07020004-503	10MN003	Yellow Medicine River, South Branch (County Ditch 35)	122.11	2	57	45	09-Aug-10
0702000404	07020004-503	10MN030	Yellow Medicine River, South Branch (County Ditch 35)	89.56	2	53	45	10-Aug-10
0702000404	07020004-595	10MN029	Unnamed creek	9.32	3	15	51	09-Jun-10
0702000406	07020004-513	03MN048	Yellow Medicine River	438.99	1	36	46	05-Aug-10
0702000406	07020004-513	03MN048	Yellow Medicine River	438.99	1	55	46	17-Jul-03
0702000406	07020004-513	03MN048	Yellow Medicine River	438.99	1	56	46	25-Jun-03
0702000406	07020004-513	10MN038	Yellow Medicine River	379.78	1	54	46	25-Aug-10

12-HUC	AUID	Biological Station	Stream	Drainage Area (mi^2)	Fish Class	Fish IBI	Threshold	Visit Date
0702000406	07020004-513	10MN038	Yellow Medicine River	379.78	1	59	46	11-Aug-10
0702000406	07020004-513	10MN045	Yellow Medicine River	452.64	1	42	46	04-Aug-10
0702000406	07020004-513	10MN096	Yellow Medicine River	425.05	1	33	46	03-Aug-10
0702000406	07020004-502	90MN015	Yellow Medicine River	675.75	1	74	46	29-Aug-11
0702000410	07020004-555	10MN008	Boiling Spring Creek	30.22	2	62	45	13-Jul-10
0702000410	07020004-547	10MN013	Judicial Ditch 10 (Wood Lake Creek)	69.76	2	31	45	22-Jun-10
0702000410	07020004-547	10MN013	Judicial Ditch 10 (Wood Lake Creek)	69.76	2	46	45	04-Aug-10
0702000410	07020004-718	10MN057	Unnamed creek	9.06	3	0	51	22-Jun-10
0702000410	07020004-718	10MN057	Unnamed creek	9.06	3	32	51	23-Aug-10
0702000410	07020004-717	10MN125	County Ditch 2	7.47	3	25	51	21-Jul-10
0702000412	07020004-552	10MN136	County Ditch 12	30.02	2	47	45	15-Jul-10
0702000412	07020004-604	03MN057	Echo Creek	13.45	3	61	51	16-Jul-03
0702000412	07020004-604	03MN057	Echo Creek	13.45	3	66	51	02-Jul-03
0702000412	07020004-604	03MN057	Echo Creek	13.45	3	66	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
0702000401	07020004-536	10MN014	Hazel Creek	75.32	5	27.49	35.90	05-Aug-10
0702000402	07020004-674	10MN121	Judicial Ditch 23	22.30	5	39.12	35.90	03-Aug-10
0702000402	07020004-713	10MN051	County Ditch 39	21.90	5	28.77	35.90	04-Aug-10
0702000403	07020004-542	10EM016	Yellow Medicine River, North Branch	40.80	5	28.41	35.90	10-Aug-10
0702000403	07020004-564	10MN065	Trib. to Yellow Medicine River, North Br	8.03	5	31.59	35.90	10-Aug-10
0702000403	07020004-584	10MN002	Yellow Medicine River	70.18	7	54.71	38.30	11-Aug-10
0702000403	07020004-584	10MN011	Yellow Medicine River	191.03	7	42.38	38.30	11-Aug-10
0702000403	07020004-694	10MN059	Trib. to Yellow Medicine River	5.60	7	27.77	38.30	04-Aug-10
0702000403	07020004-542	03MN042	Yellow Medicine River, North Branch	41.42	7	21.05	38.30	19-Aug-03
0702000403	07020004-543	10EM126	Mud Creek	35.97	7	26.34	38.30	11-Aug-10
0702000403	07020004-543	10MN075	Mud Creek	39.97	7	35.70	38.30	11-Aug-10
0702000404	07020004-503	03MN038	Yellow Medicine River, South Branch	75.74	5	39.05	35.90	26-Aug-03
0702000404	07020004-503	03MN039	Yellow Medicine River, South Branch	84.62	5	44.02	35.90	26-Aug-03
0702000404	07020004-503	10EM062	Yellow Medicine River, South Branch	74.92	5	36.51	35.90	05-Aug-10
0702000404	07020004-503	10MN003	Yellow Medicine River, South Branch	122.11	7	47.30	38.30	11-Aug-10
0702000404	07020004-503	10MN030	Yellow Medicine River, South Branch	89.56	7	32.92	38.30	04-Aug-10
0702000404	07020004-503	10MN030	Yellow Medicine River, South Branch	89.56	7	44.89	38.30	11-Aug-10
0702000404	07020004-595	10MN029	Trib. to Yellow Medicine River, South Br	9.32	7	38.61	38.30	04-Aug-10
0702000406	07020004-502	90MN015	Yellow Medicine River	675.75	2	35.73	30.70	24-Aug-10
0702000406	07020004-513	03MN048	Yellow Medicine River	438.99	7	36.18	38.30	25-Aug-03
0702000406	07020004-513	03MN048	Yellow Medicine River	438.99	7	46.52	38.30	12-Aug-10
0702000406	07020004-513	10MN038	Yellow Medicine River	379.78	7	37.51	38.30	12-Aug-10
0702000406	07020004-513	10MN045	Yellow Medicine River	452.64	7	44.39	38.30	12-Aug-10
0702000406	07020004-513	10MN096	Yellow Medicine River	425.05	7	46.41	38.30	12-Aug-10
0702000410	07020004-547	10MN013	Judicial Ditch 10	69.76	5	17.37	35.90	05-Aug-10
0702000410	07020004-717	10MN125	County Ditch 2	7.47	7	59.58	38.30	05-Aug-10
0702000410	07020004-718	10MN057	Trib. to Minnesota River	9.06	7	30.79	38.30	10-Aug-10
0702000410	07020004-555	10MN008	Boiling Spring Creek	30.22	7	40.44	38.30	11-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 (**Appendix 4.1**). 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
070200040102	07020004-536	10MN047	Hazel Creek	42.49	2	0	28-Jul-10
070200040102	07020004-707	10MN048	Unnamed Creek	6.48	7	5	18-Aug-10
070200040102	07020004-707	10MN048	Unnamed Creek	6.48	7	8	26-Aug-10
070200040203	07020004-535	10MN123	Stony Run Creek	32.07	2	0	03-Aug-10
070200040203	07020004-535	10MN015	Stony Run Creek	53.57	2	49	22-Jul-10
070200040203	07020004-709	10MN052	Unnamed Ditch	5.33	3	26	07-Jul-10
070200040207	07020004-710	10MN058	Unnamed Creek	11.28	3	46	10-Aug-10
070200040203	07020004-708	10MN118	County Ditch 36	6.03	3	63	18-Aug-10
070200040207	07020004-711	10MN120	County Ditch 90	5.33	3	42	22-Jun-10
070200040207	07020004-714	10MN050	County Ditch 6A	9.86	3	0	22-Jun-10
070200040207	07020004-714	10MN050	County Ditch 6A	9.86	3	54	12-Aug-10
070200040207	07020004-673	10MN132	Judicial Ditch 23	14.59	3	54	10-Aug-10
070200040207	07020004-673	10MN132	Judicial Ditch 23	14.59	3	64	24-Aug-10
070200040203	07020004-580	10MN114	Stony Run Creek	19.31	7	0	22-Jul-10
070200040307	07020004-584	07MN070	Yellow Medicine River	42.07	2	35	29-Aug-07
070200040306	07020004-543	10MN010	Mud Creek	55.98	2	71	04-Aug-10
070200040307	07020004-545	10MN017	Unnamed Creek	33.96	2	54	18-Aug-10
070200040304	07020004-542	10MN071	Yellow Medicine River, North Branch	64.13	2	43	04-Aug-10
070200040307	07020004-695	10MN066	Unnamed Creek	9.12	3	58	08-Jun-10
070200040307	07020004-592	10MN022	Unnamed Creek	5.82	3	0	08-Jun-10
070200040307	07020004-584	10MN060	Yellow Medicine River	24.51	3	46	08-Jun-10
070200040304	07020004-912	10MN061	County Ditch 8	9.63	3	3	08-Jun-10
070200040404	07020004-503	03MN040	Yellow Medicine River, South Branch (County Ditch 35)	34.90	2	30	09-Jun-10
070200040404	07020004-503	03MN040	Yellow Medicine River, South Branch (County Ditch 35)	34.90	2	34	30-Jun-03
070200040404	07020004-503	03MN041	Yellow Medicine River, South Branch (County Ditch 35)	33.50	2	29	30-Jun-03
070200040404	07020004-600	10MN023	Unnamed Creek	9.80	3	0	09-Jun-10

12-HUC	AUID	Biological Station	Stream	Drainage Area (mi^2)	Fish Class	Fish IBI	Visit Date
070200040404	07020004-600	10MN023	Unnamed Creek	9.80	3	13	17-Aug-10
070200040404	07020004-549	10MN027	Judicial Ditch 29	2.50	3	15	09-Jun-10
070200040404	07020004-550	10MN028	Judicial Ditch 29	27.69	3	39	07-Jun-10
070200040404	07020004-550	10MN028	Judicial Ditch 29	27.69	3	47	13-Jul-10
070200040404	07020004-503	10MN024	Yellow Medicine River, South Branch (County Ditch 35)	20.47	3	42	09-Jun-10
070200040404	07020004-549	10MN025	Judicial Ditch 29	16.43	3	56	09-Jun-10
070200040505	07020004-538	10EM190	Spring Creek	65.65	2	24	18-Aug-10
070200040505	07020004-538	91MN014	Spring Creek	121.44	2	40	02-Aug-10
070200040505	07020004-538	10MN037	Spring Creek	73.96	2	0	03-Aug-10
070200040505	07020004-539	10MN046	Unnamed Ditch	6.02	3	0	03-Aug-10
070200040505	07020004-697	10MN068	County Ditch 48	8.52	3	0	13-Jul-10
070200040505	07020004-697	10MN068	County Ditch 48	8.52	3	0	11-Aug-10
070200040604	07020004-622	10MN012	Judicial Ditch 17	61.87	2	64	21-Jul-10
070200040604	07020004-670	10MN043	Judicial Ditch 24	40.23	2	19	05-Aug-10
070200040604	07020004-663	10MN070	County Ditch 4	7.08	3	41	07-Jun-10
070200040605	07020004-634	10MN062	County Ditch 37	7.53	3	50	08-Jun-10
070200040605	07020004-636	10MN064	Judicial Ditch 7	27.93	3	43	08-Jun-10
070200040605	07020004-636	10MN064	Judicial Ditch 7	27.93	3	47	23-Aug-10
070200040604	07020004-703	10MN130	Unnamed Creek	16.60	7	0	07-Jun-10
070200041003	07020004-546	03MN049	Judicial Ditch 10 (Wood Lake Creek)	36.00	2	8	02-Jul-03
070200041003	07020004-546	03MN049	Judicial Ditch 10 (Wood Lake Creek)	36.00	2	14	16-Jul-03
070200041003	07020004-547	07MN069	Judicial Ditch 10 (Wood Lake Creek)	64.49	2	11	29-Aug-07
070200041003	07020004-546	10MN126	Judicial Ditch 10 (Wood Lake Creek)	51.29	2	14	16-Aug-10
070200041003	07020004-737	10MN128	County Ditch 31	12.19	3	36	12-Jul-10
070200041007	07020004-620	10MN151	Boiling Spring Creek	10.74	3	0	10-Jun-10
070200041003	07020004-546	10MN056	Judicial Ditch 10 (Wood Lake Creek)	18.77	7	9	21-Jul-10
070200041003	07020004-518	10MN129	Judicial Ditch 10	11.90	7	10	21-Jul-10
070200041007	07020004-554	10MN146	Boiling Spring Creek	15.29	7	0	21-Jul-10
070200041007	07020004-554	10MN146	Boiling Spring Creek	15.29	7	0	24-Aug-10
070200041207	07020004-551	10MN135	County Ditch 12	17.46	3	53	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
070200040207	07020004-710	10MN058	Unnamed Creek	11.28	5	19.52	03-Aug-10
070200040203	07020004-535	10MN015	Stony Run Creek	53.57	5	37.49	04-Aug-10
070200040307	07020004-695	10MN066	Unnamed Creek	9.12	5	40.69	11-Aug-10
070200040404	07020004-550	10MN028	Judicial Ditch 29	27.69	5	29.02	05-Aug-10
070200040604	07020004-622	10MN012	Judicial Ditch 17	61.87	5	25.93	03-Aug-10
070200040102	07020004-536	03MN050	Hazel Creek	70.20	7	5.36	25-Aug-03
070200040102	07020004-536	10MN047	Hazel Creek	42.49	7	10.44	04-Aug-10
070200040102	07020004-707	10MN048	Unnamed Creek	6.48	7	5.57	04-Aug-10
070200040207	07020004-673	10MN132	Judicial Ditch 23	14.59	7	29.89	03-Aug-10
070200040203	07020004-535	10MN123	Stony Run Creek	32.07	7	15.68	04-Aug-10
070200040203	07020004-708	10MN118	County Ditch 36	6.03	7	10.46	04-Aug-10
070200040203	07020004-709	10MN052	Unnamed Ditch	5.33	7	10.90	04-Aug-10
070200040207	07020004-714	10MN050	County Ditch 6A	9.86	7	18.98	03-Aug-10
070200040207	07020004-711	10MN120	County Ditch 90	5.33	7	19.57	03-Aug-10
070200040203	07020004-580	10MN114	Stony Run Creek	19.31	7	9.00	04-Aug-10
070200040307	07020004-584	07MN070	Yellow Medicine River	42.07	7	5.94	28-Aug-07
070200040307	07020004-584	10MN060	Yellow Medicine River	24.51	7	32.13	04-Aug-10
070200040307	07020004-592	10MN022	Unnamed Creek	5.82	7	24.26	03-Aug-10
070200040304	07020004-542	10MN071	Yellow Medicine River, North Branch	64.13	7	48.37	10-Aug-10
070200040304	07020004-912	10MN061	County Ditch 8	9.63	7	29.50	04-Aug-10
070200040306	07020004-543	10MN010	Mud Creek	55.98	7	13.52	11-Aug-10
070200040307	07020004-545	10MN017	Unnamed Creek	33.96	7	19.44	12-Aug-10
070200040404	07020004-503	03MN041	Yellow Medicine River, South Branch (County Ditch 35)	33.50	7	15.59	19-Aug-03
070200040404	07020004-503	10MN024	Yellow Medicine River, South Branch (County Ditch 35)	20.47	7	14.33	04-Aug-10
070200040404	07020004-600	10MN023	Unnamed Creek	9.80	7	19.09	03-Aug-10

12-HUC	AUID	Biological Station	Stream	Drainage Area (mi^2)	Invert Class	MIBI	Visit Date
070200040404	07020004-549	10MN025	Judicial Ditch 29	16.43	7	30.26	05-Aug-10
070200040404	07020004-549	10MN027	Judicial Ditch 29	2.50	7	24.30	04-Aug-10
070200040404	07020004-503	03MN040	Yellow Medicine River, South Branch (County Ditch 35)	34.90	7	21.09	19-Aug-03
070200040404	07020004-503	03MN040	Yellow Medicine River, South Branch (County Ditch 35)	34.90	7	46.49	05-Aug-10
070200040505	07020004-697	10MN068	County Ditch 48	8.52	7	7.68	10-Aug-10
070200040505	07020004-538	10EM190	Spring Creek	65.65	7	11.37	10-Aug-10
070200040505	07020004-538	10MN037	Spring Creek	73.96	7	18.09	10-Aug-10
070200040505	07020004-539	10MN046	Unnamed ditch	6.02	7	6.23	10-Aug-10
070200040505	07020004-607	01MN045	Judicial Ditch 20	4.21	7	0.71	24-Sep-02
070200040605	07020004-634	10MN062	County Ditch 37	7.53	7	46.58	10-Aug-10
070200040605	07020004-636	10MN064	Judicial Ditch 7	27.93	7	44.47	03-Aug-10
070200040604	07020004-663	10MN070	County Ditch 4	7.08	7	10.27	03-Aug-10
070200040604	07020004-703	10MN130	Unnamed Creek	16.60	7	29.36	03-Aug-10
070200040604	07020004-670	10MN043	Judicial Ditch 24	40.23	7	15.10	03-Aug-10
070200041003	07020004-546	03MN049	Judicial Ditch 10 (Wood Lake Creek)	36.00	7	9.68	09-Sep-03
070200041003	07020004-546	03MN049	Judicial Ditch 10 (Wood Lake Creek)	36.00	7	14.83	25-Aug-03
070200041003	07020004-546	10MN056	Judicial Ditch 10 (Wood Lake Creek)	18.77	7	9.18	03-Aug-10
070200041003	07020004-546	10MN126	Judicial Ditch 10 (Wood Lake Creek)	51.29	7	18.55	05-Aug-10
070200041003	07020004-518	10MN129	Judicial Ditch 10	11.90	7	7.06	03-Aug-10
070200041003	07020004-547	07MN069	Judicial Ditch 10 (Wood Lake Creek)	64.49	7	11.21	28-Aug-07
070200041007	07020004-554	10MN146	Boiling Spring Creek	15.29	7	28.90	10-Aug-10
070200041003	07020004-737	10MN128	County Ditch 31	12.19	7	14.37	05-Aug-10
070200041007	07020004-620	10MN151	Boiling Spring Creek	10.74	7	13.00	10-Aug-10
070200041207	07020004-551	10MN135	County Ditch 12	17.46	7	25.54	11-Aug-10