Wapsipinicon River Watershed Stressor Identification Report

A study of local stressors limiting the biotic communities in the Wapsipinicon River Watershed.

MINNESOTA POLLUTION CONTROL AGENCY

March 2018

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Legislative charge

Minn. Stat. § 116.011 Annual Pollution Report

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

HIST: 1995 c 247 art 1 s 36; 2001 c 187 s 3

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Key Terms & Abbreviations

AUID	Assessment Unit ID
BOD	Biological Oxygen Demand
CADDIS	Causal Analysis/Diagnosis Decision Information System
CL	Confidence limits
cm	Centimeter
DELT	Deformities, Eroded fins, Lesions, and Tumors
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, and Trichoptera
FIBI	Fish Index of Biological Integrity
GP	Glide/Pool
HUC	Hydrologic Unit Code
IBI	Index of Biotic Integrity
IWM	Intensive Watershed Monitoring
µS/cm	Microsiemens per centimeter
DNR	Minnesota Department of Natural Resources
MIBI	Macroinvertebrate Index of Biological integrity
mg/L	Milligrams per liter
mgy	Million gallons per year
MPCA	Minnesota Pollution Control Agency
MSHA	MPCA Stream Habitat Assessment
SID	Stressor Identification
SOE	Strength of Evidence
SSURGO	Soil Survey Geographic Database
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSS	Total Suspended Solids
USDA	United States Department of Agriculture
USGS	United States Geological Survey

Executive Summary

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

Stressor identification (SID) is a formal and rigorous process that identifies stressors causing biological impairment of aquatic ecosystems and provides a structure for organizing the scientific evidence supporting the conclusions (Cormier et al. 2000). In simpler terms, it is the process of identifying the major factors causing harm to aquatic life. The SID 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 SID work in the Wapsipinicon River Watershed. There is only one Assessment Unit ID (AUID) currently impaired for a lack of biological assemblage. After examining many candidate causes for the biological impairment, the following stressors were identified as probable causes of stress to aquatic life:

- Nitrate
- Habitat
- Flow Alteration

1. Introduction

1.1. Monitoring and Assessment

Water quality and biological monitoring in the Wapsipinicon River Watershed has been ongoing. As part of the MPCA's Intensive Watershed Monitoring (IWM) approach, monitoring activities increased in rigor and intensity during 2015, and focused more on biological monitoring (fish and macroinvertebrates) as a means of assessing stream health. The data collected during this period, as well as historic data obtained prior to 2015, were used to identify stream reaches that were not supporting healthy fish and macroinvertebrate assemblages (Figure 1).

Once a biological impairment is discovered, the next step is to identify the source(s) of stress on the biological community. A SID analysis is a step-by-step approach for identifying probable causes of impairment in a particular system. Completion of the SID process does not result in a finished Total Maximum Daily Load (TMDL) study. The product of the SID process is the identification of the stressor(s) for which the TMDL may be developed. In other words, the SID process may help investigators nail down excess fine sediment as the cause of biological impairment, but a separate effort is then required to determine the TMDL and implementation goals needed to restore the impaired condition.

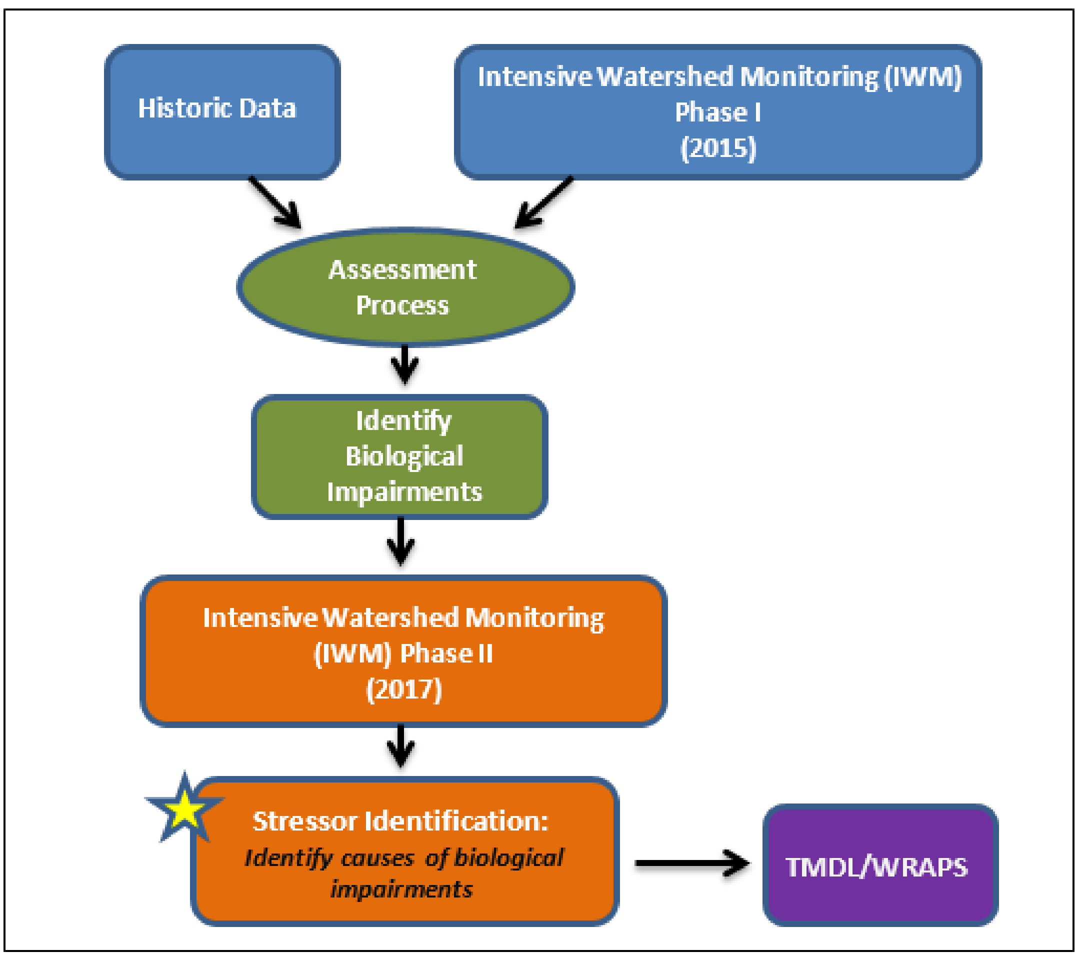

Figure 1. Process map of Intensive Watershed Monitoring, Assessment, Stressor Identification and TMDL processes.

1.2. Stressor Identification Process

The MPCA follows the Environmental Protection Agency's (EPA's) process of identifying stressors that cause biological impairment, which has been used to develop the MPCA's guidance to SID (Cormier et al. 2000 MPCA 2008). The EPA has also developed an updated, interactive web-based tool, the Causal Analysis/Diagnosis Decision Information System (CADDIS, EPA 2010). This system provides an enormous amount of information designed to guide and assist investigators through the process of SID. Additional information on the SID process using CADDIS can be found here: https://www.epa.gov/caddis-vol1/caddis-volume-1-stressor-identification-summary-tables-types-evidence.

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

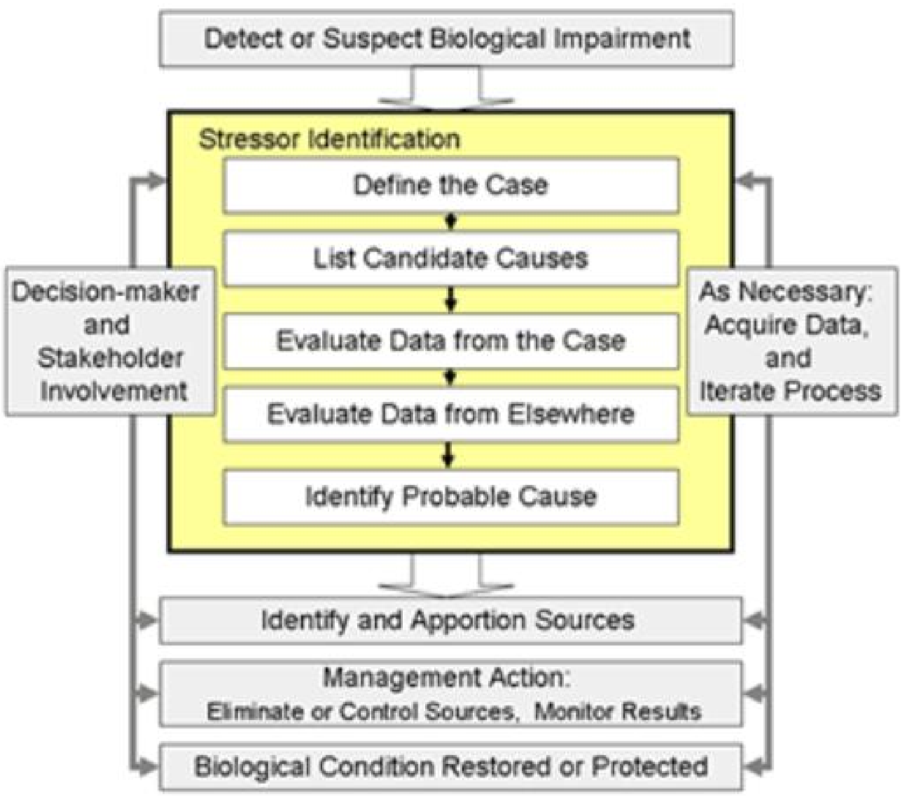

Figure 2. Conceptual model of Stressor Identification process (Cormier et al. 2000).

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

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

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

1.3. Common Stream Stressors

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

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

Stream Health	Stressor(s)	Link to Biology
Stream Connections	**Loss of Connectivity** · Dams and culverts · Lack of Wooded riparian cover · Lack of naturally connected habitats/ causing fragmented habitats	Fish and macroinvertebrates cannot freely move throughout system. Stream temperatures also become elevated due to lack of shade.
Hydrology	**Altered Hydrology** **Loss of habitat due to channelization** **Elevated Levels of TSS** · Channelization · Peak discharge (flashy) · Transport of chemicals	Unstable flow regime within the stream can cause a lack of habitat, unstable stream banks, filling of pools and riffle habitat, and affect the fate and transport of chemicals.
Stream Channel Assessment	**Loss of Habitat due to excess sediment** **Elevated levels of TSS** · Loss of dimension/pattern/profile · Bank erosion from instability · Loss of riffles due to accumulation of fine sediment · Increased turbidity and or TSS	Habitat is degraded due to excess sediment moving through system. There is a loss of clean rock substrate from embeddedness of fine material and a loss of intolerant species.
Water Chemistry	**Low Dissolved Oxygen Concentrations** **Elevated levels of Nutrients** · Increased nutrients from human influence · Widely variable DO levels during the daily cycle · Increased algal and or periphyton growth in stream · Increased nonpoint pollution from urban and agricultural practices · Increased point source pollution from urban treatment facilities	There is a loss of intolerant species and a loss of diversity of species, which tends to favor species that can breathe air or survive under low DO conditions. Biology tends to be dominated by a few tolerant species.

Stream Biology	Fish and macroinvertebrate communities are affected by all of the above listed stressors	If one or more of the above stressors are affecting the fish and macroinvertebrate community, the IBI scores will not meet expectations and the stream will be listed as impaired.

1.4. Report Format

This SID report follows a format to first summarize candidate causes of stress to the biological communities at the 8-digit Hydrologic Unit Code (HUC) scale. Within the summary (Section 3), there is information about how the stressor relates broadly to the Wapsipinicon River Watershed, water quality standards and general effects on biology. Section 4 is organized by 8-digit HUC (only one AUID in this case), and discusses the available data and relationship to fish and macroinvertebrate metrics in more detail.

2. Overview of the Wapsipinicon River Watershed

2.1. Background

See Wapsipinicon River Watershed Monitoring and Assessment Report and [Wapsipinicon River homepage]() for background information.

2.2. Monitoring Overview

The Wapsipinicon River Watershed was sampled intensively for fish and macroinvertebrates in 2015 and 2016 (Figure 3). Detailed information regarding the biological monitoring process and impairment decisions can be found in the Wapsipinicon River Watershed Monitoring and Assessment Report.

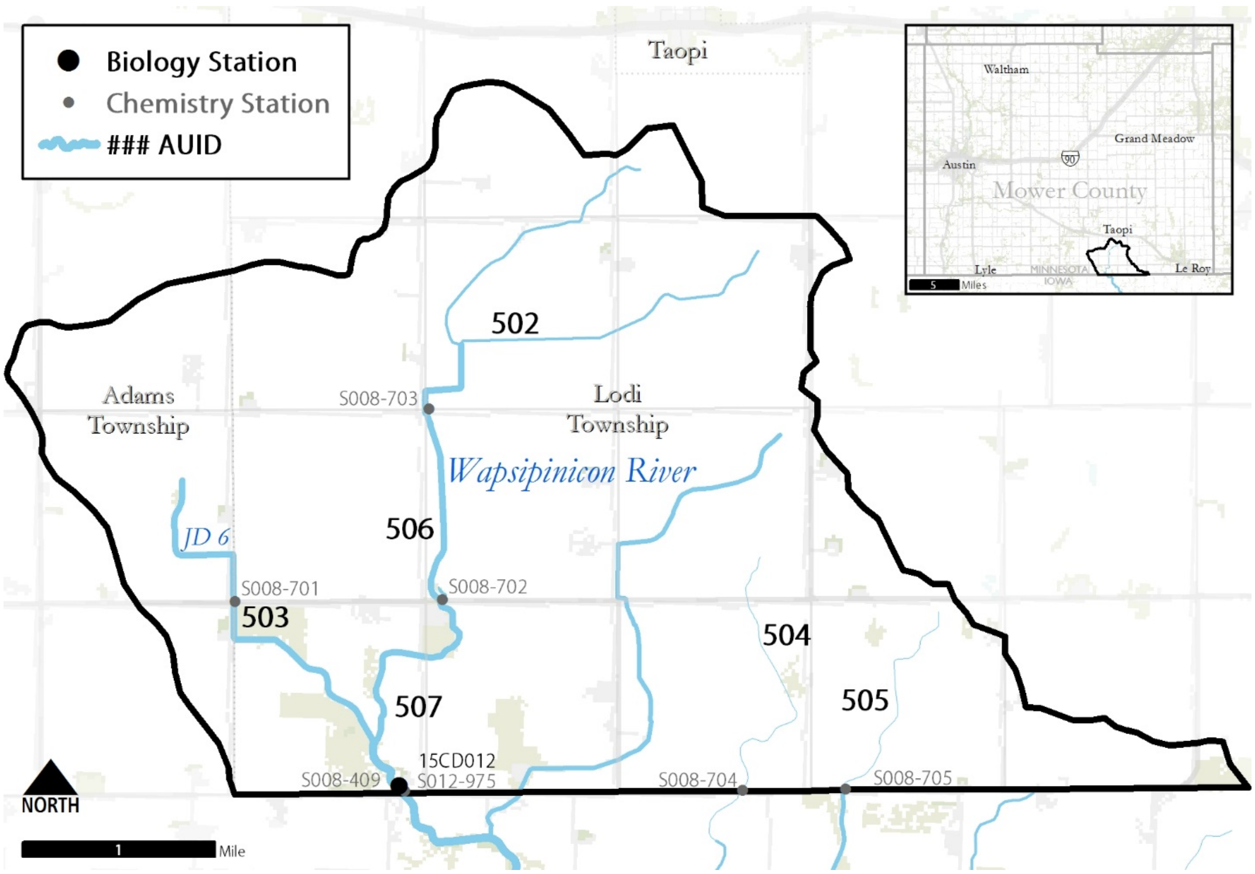

Figure 3. Biology and chemistry monitoring stations for streams in the Wapsipinicon River Watershed.

2.3. Summary of Biological Impairments

The approach used to identify biological impairments includes assessment of fish and aquatic macroinvertebrate communities and related habitat conditions at sites throughout a watershed. The resulting information is used to calculate a specific Index of Biotic Integrity (IBI) for that reach. The IBI scores can then be compared to a range of thresholds (MPCA 2016).

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

In the Wapsipinicon River Watershed, one AUID is currently impaired for a lack of biological assemblage (Table 2).

Table 2: Biologically impaired AUIDs in the Wapsipinicon River Watershed.

			Impairments	
Stream Name	**AUID #**	**Reach Description**	**Biological**	**Water Quality**
Wapsipinicon River	507	-92.6732, 43.5073 to MN/IA border	Fish and Macroinvertebrates	Bacteria

The general use IBI thresholds for stream classes sampled in the Wapsipinicon River Watershed can be found below in Table 3 and Table 4. Additional information can be found in the Wapsipinicon River Watershed Monitoring and Assessment Report and Development of Biological Criteria for Tiered Aquatic Life Uses (MPCA 2016).

Table 3: Fish classes with respective general use IBI thresholds and upper/lower CL found in the Wapsipinicon River Watershed.

Class	Class Name	IBI Thresholds	Upper CL	Lower CL
3	Southern Headwaters	55	62	48

Table 4: Macroinvertebrate classes with respective general use IBI thresholds and upper/ lower CL found in the Wapsipinicon River Watershed.

Class	Class Name	IBI Thresholds	Upper CL	Lower CL
6	Southern Forest Streams GP	43	56.6	29.4

The purpose of SID is to interpret data collected during the biological monitoring and assessment process. Trends in the IBI scores can help to identify causal factors for biological impairments. A summary of the macroinvertebrate and fish IBI scores can be found in the Wapsipinicon River Watershed Monitoring and Assessment Report.

3. Possible Stressors to Biological Communities

A comprehensive list of potential stressors to aquatic biological communities compiled by the EPA can be found here (https://www.epa.gov/caddis-vol2/caddis-volume-2-sources-stressors-and-responses-learn-about-stressors). This comprehensive list serves two purposes. First, it can serve as a checklist for investigators to consider all possible options for impairment in the watershed of interest. Second, it can be used to identify potential stressors that can be eliminated from further evaluation. In some cases, the data may be inconclusive and limit the ability to confidently determine if a stressor is causing impairment to aquatic life. It is imperative to document if a candidate cause was suspected, but there was not enough information to make a scientific determination of whether or not it is causing harm to aquatic life. In this case, management decisions can include modification of sampling plans and future evaluation of the inconclusive case. Alternatively, there may be enough information to conclude that a candidate cause is not causing biological impairment and therefore can be eliminated. The inconclusive or eliminated causes will be discussed in more detail in the following section.

3.1. Eliminated Causes

There were no causes eliminated from the Wapsipinicon River Watershed.

3.2. Inconclusive Causes (insufficient information)

Some candidate causes were unable to be considered further and therefore were determined inconclusive. These causes were inconclusive due to lack of information, lack of biological connection, and/or mixed results (water quality and/or biological). The potential causes that were inconclusive in the Wapsipinicon River Watershed were pesticides, ammonia, pH, chloride, metals, and conductivity. These causes are discussed in more detail below.

3.2.1. Overview of Pesticides in the Wapsipinicon River Watershed

There is no pesticide data available in the Wapsipinicon River Watershed.

3.2.2. Overview of Ammonia in the Wapsipinicon River Watershed

Very limited ammonia data is available in the Wapsipinicon River Watershed. Only 10 samples have been collected, and they were all collected at station S008-409 (co-located with station 15CD012). Samples were collected May through September in 2015, and ranged from 0.05 to 0.06 mg/L. The unionized fraction of these samples resulted in zero exceedances over the assessment period; unionized ammonia is meeting aquatic life standards.

3.2.3. Overview of pH in the Wapsipinicon River Watershed

Several instantaneous pH samples (61) were collected across the watershed in 2015 and 2016, ranging from 7.0 to 8.2. Zero exceedances were observed. Samples were collected at stations S008-409, S008-701, S008-702, and S008-703. In addition, there were no exceedances observed during sonde deployments in 2017; pH is meeting aquatic life standards.

3.2.4. Overview of Chloride in the Wapsipinicon River Watershed

Only 10 chloride samples have been collected, and they were collected at station S008-409 (co-located with station 15CD012) in 2015. Concentrations ranged from 16.0 to 22.3 mg/L (average of 20.2 mg/L); all samples were well below the chronic standard (230 mg/L). Chloride is meeting aquatic life standards.

3.2.5. Overview of Metals in the Wapsipinicon River Watershed

There is no metal data available in the Wapsipinicon River Watershed.

3.2.6. Overview of Conductivity in the Wapsipinicon River Watershed

Several instantaneous conductivity samples (64) were collected across the watershed in 2015 and 2016. Concentrations ranged from 76 to 661 µS/cm (average of 561 µS/cm). The average concentration is below the ecoregion average for the Western Corn Belt Plains (698 µS/cm) (McCollor et al. 1993). Although this average for the Western Corn Belt Plains was derived using an older data set (1970 through 1992), it provides some context to the concentrations documented in the Wapsipinicon River Watershed. In addition, conductivity values recorded during sonde deployments in 2017 were similar to those observed during point sampling (160 to 570 µS/cm).

3.3. Summary of Candidate Causes in the Wapsipinicon River Watershed

Fourteen candidate causes were selected as possible drivers of biological impairments in the Wapsipinicon River Watershed. The initial list of candidate/potential causes was narrowed down after the initial data evaluation/data analysis resulting in eight for final analysis in this report. The eight remaining candidate causes are:

- Temperature
- Nitrate
- Eutrophication
- DO
- TSS
- Habitat
- Fish Passage
- Flow Alteration

Background information specific to candidate causes/stressors in Minnesota can be found here. This information provides an overview of the pathway and effects of each candidate stressor considered in the biological SID process with relevant data and water quality standards specific to Minnesota. The U.S. EPA has additional information, conceptual diagrams of sources and causal pathways, and publication references for numerous stressors on its CADDIS website.

4. Evaluation of Candidate Causes

Candidate causes were evaluated in the Wapsipinicon River Watershed by individual AUID. The Minnesota portion of this watershed is very small, and only one AUID is impaired for biology. This AUID is discussed below, and this report only covers the Minnesota portion of the watershed.

4.1 Wapsipinicon River (8-digit HUC)

This section encompasses biotic impairments in the Wapsipinicon River Watershed (8-digit HUC) (Figure 4). There is only one AUID impaired for biology in the watershed; AUID 507 has a fish and macroinvertebrate impairment. The impairment is located in the headwaters of the Wapsipinicon River, ending at the Minnesota/Iowa border and extending only a short distance (0.61 miles) upstream. AUID 507 is warmwater (2B) and general use.

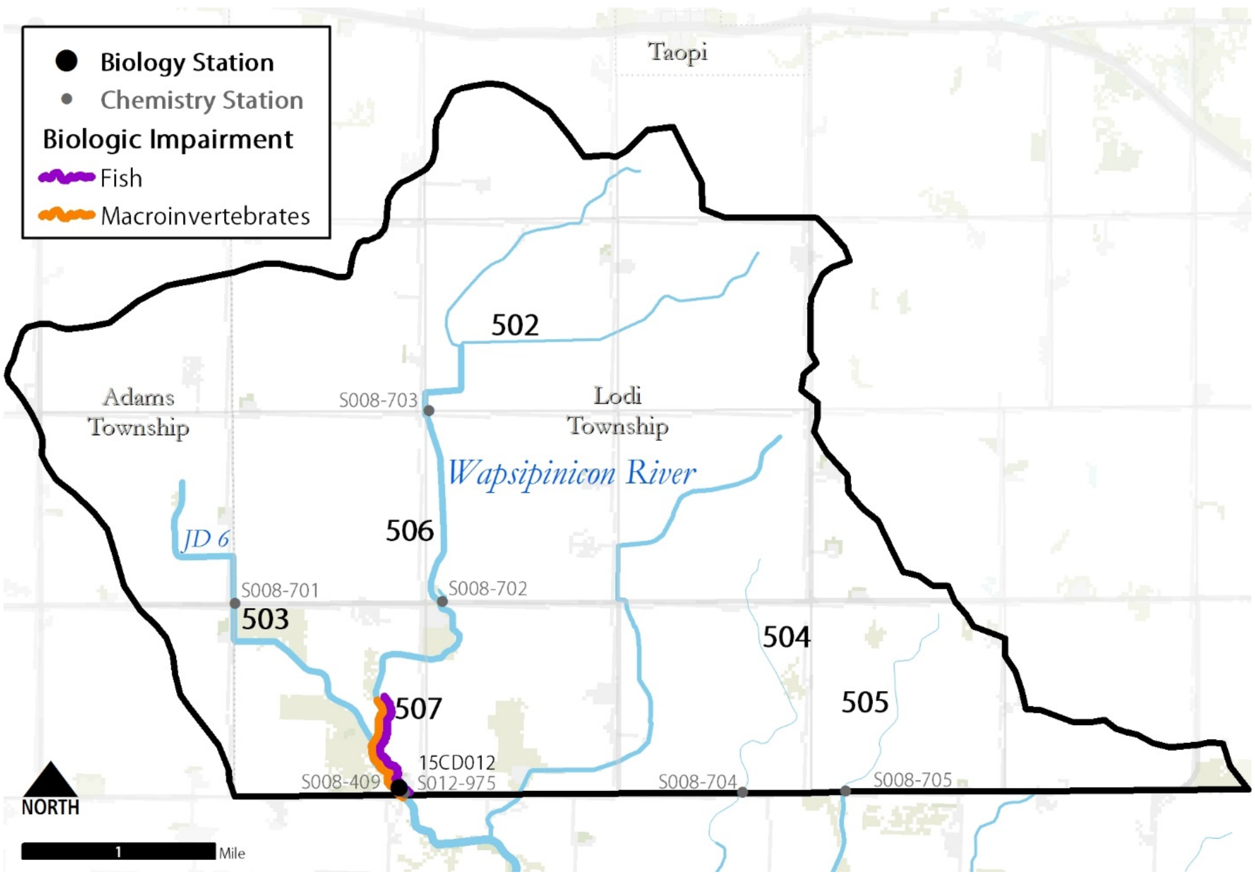

Figure 4: Wapsipinicon River Watershed biota impairments, biology stations, and chemistry stations.

Biological Communities

The Wapsipinicon River Watershed (07080102) is approximately 8,264 acres and is dominated by row crops (93%) (DNR WHAF). The entire watershed is in Mower County, and there are no cities in the watershed. All streams are warmwater (2B) and general use; worth noting is that the Wapsipinicon River is considered coldwater just downstream near McIntire, Iowa (IA DNR BioNet 2017). The Minnesota portion of this watershed is very small, containing the headwaters of the Wapsipinicon River and a few other small tributaries/ditches. The only biological impairment is for fish and macroinvertebrates on AUID 507; this reach also has a bacteria impairment. Station 15CD012, located on the Wapsipinicon River at the Minnesota/Iowa border, is the only biological station in the watershed. This station was sampled in 2015 and 2016 for fish and macroinvertebrates.

The fish community is impaired and "not supporting" the aquatic life use. Fish Index of Biological Integrity (FIBI) scores for station 15CD012 were 51 (2015) and 65 (2016). One score was below the general use threshold (55) for the Southern Headwaters fish class and one was above. The lower score was within the confidence interval, and the higher score was above the confidence interval and was positively impacted by the collection of two adult rainbow trout. These trout are considered an anomaly for this stream type, and likely migrated upstream from Iowa. In general, most FIBI metrics had adequate scores (Figure 5). Relative abundance of taxa that are detritivorous (DetNWQTxPct), relative abundance of taxa that are generalist feeders (GeneralTxPct), taxa richness of sensitive species (Sensitive), and relative abundance of taxa that are very tolerant (VtolTxPct) scored below average in 2015 and contributed to the low FIBI score. There were no deformities, eroded fins, lesions, or tumors (DELTs) in either sample; these would negatively impact the FIBI score.

The macroinvertebrate community is impaired and "not supporting" the aquatic life use. Macroinvertebrate Index of Biological integrity (MIBI) scores for station 15CD012 were 36.2 (2015) and 47.4 (2016); one sample is below the impairment threshold (43) for the Southern Forest Streams Glide/Pool (GP) macroinvertebrate class and one is above (both are within the confidence interval). Station 15CD012 has several MIBI metric scores below average (Figure 6). Collector-filterers (Collector-filtererPct), pollution scores based on tolerance values (HBI_MN), intolerant taxa (Intolerant2Ch), taxa richness of Plecoptera, Odonata, Ephemeroptera, and Trichoptera (POET), and relative abundance of Trichoptera taxa and non-hydropsychid individuals (TrichopteraChTxPct and TrichwoHydroPct) scored poorly and contributed to the impairment.

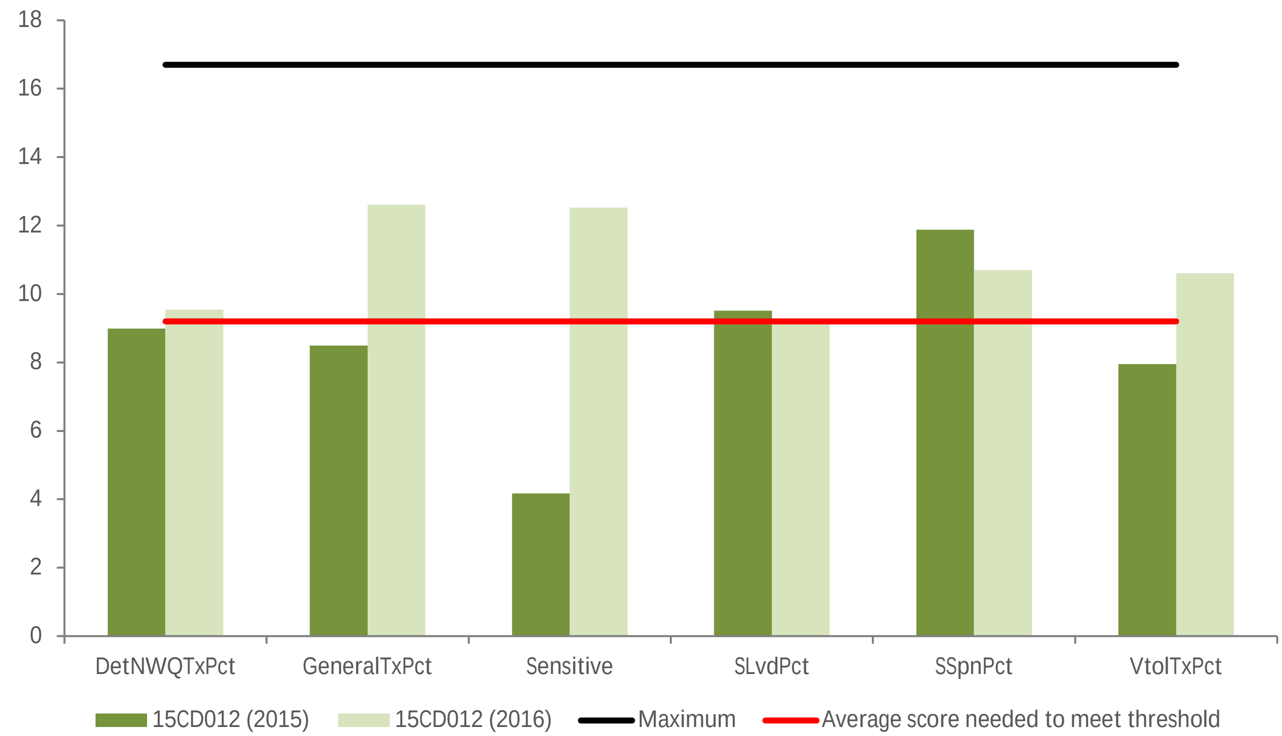

Figure 5: Fish metrics of the Southern Headwaters (class 3) IBI for the Wapsipinicon River (07080102-507), station 15CD012.

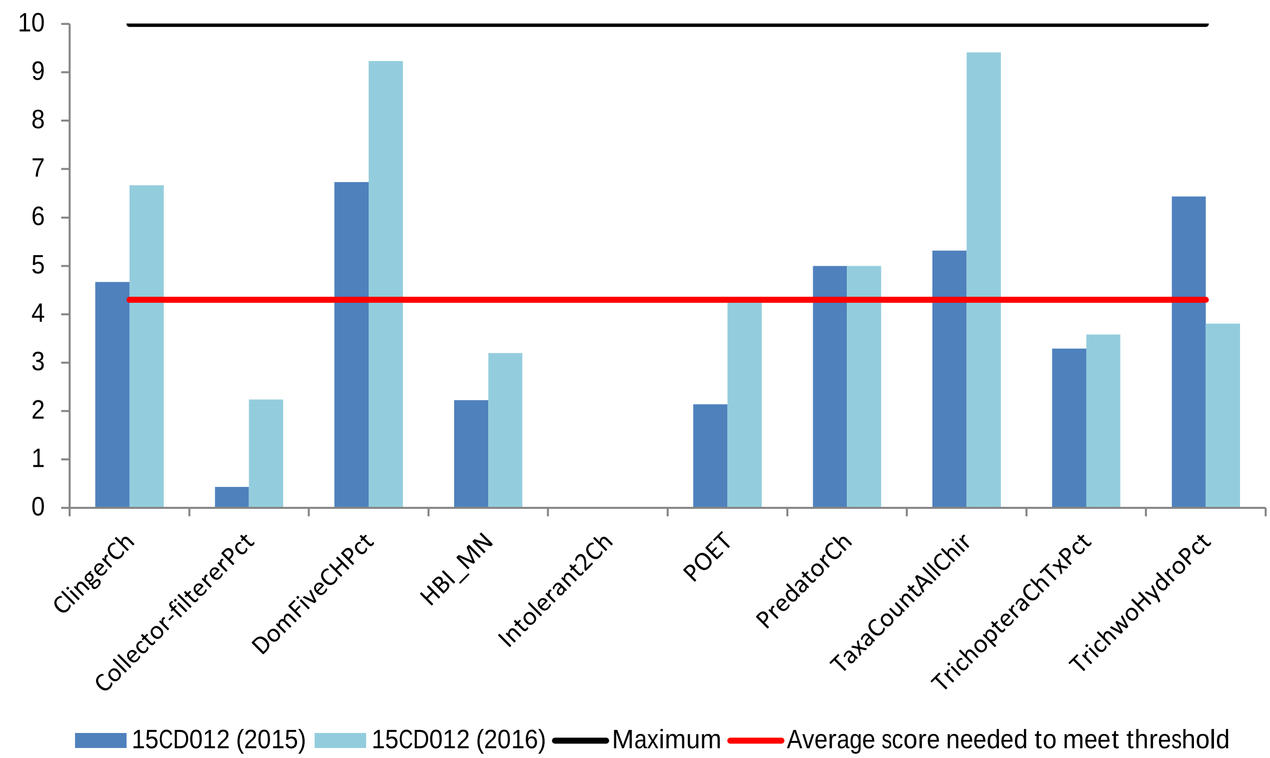

Figure 6: Macroinvertebrate metrics of the Southern Forest Streams GP (class 6) IBI for the Wapsipinicon River (07080102-507), station 15CD012.

Data Evaluation for each Candidate Cause

Temperature

Temperatures ranged from 6.3°C to 28.5°C during deployment in 2015 (Figure 7). A continuous temperature sensor was deployed at station 15CD012 from May 15, 2015 to September 9, 2015, and there were zero values greater than 30 °C (daily average warmwater standard). Temperature values from two sonde deployments in 2017 (July 18, 2017 to July 31, 2017 and August 17, 2017 and August 29, 2017) ranged from 12.9°C to 28.7°C. There were also several instantaneous (point) measurements collected throughout the watershed in 2015 and 2016, all of which were below 30°C.

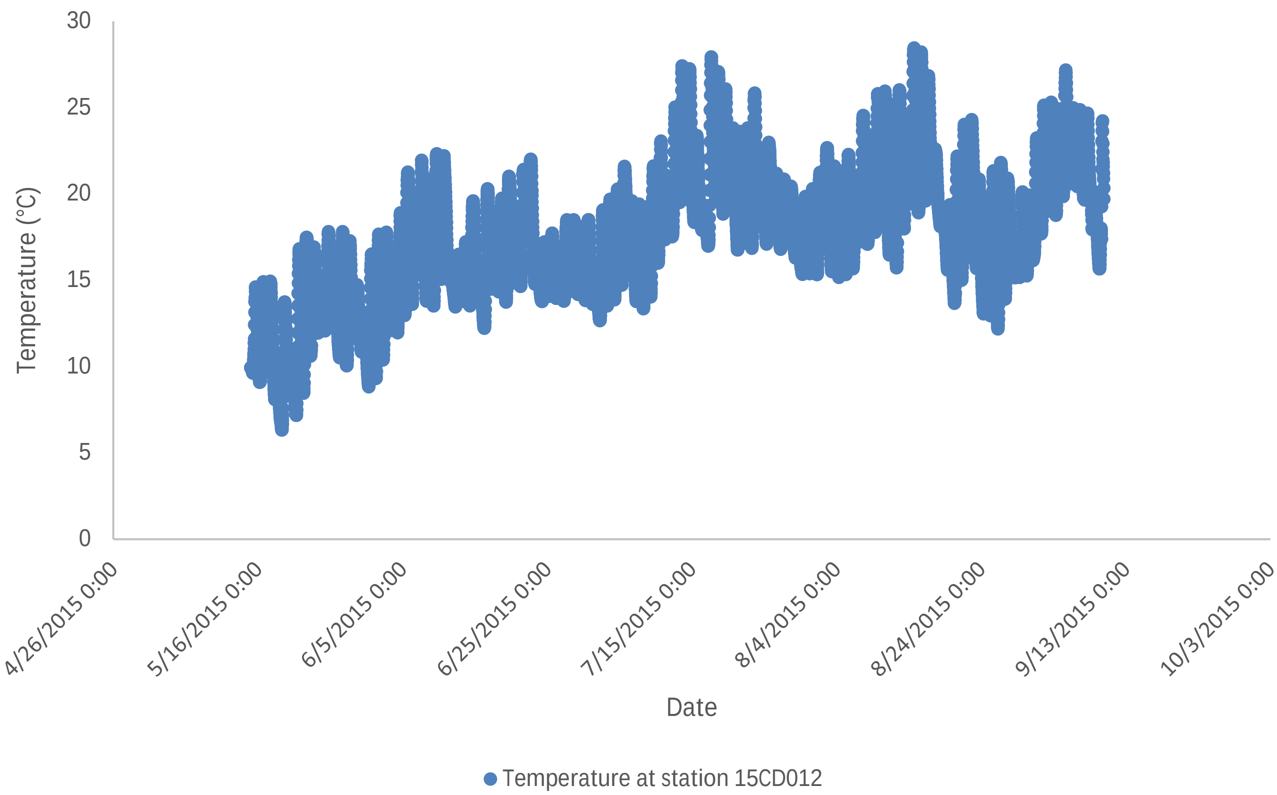

Figure 7: Temperature data at station 15CD012 from deployment in 2015.

This AUID has a continuous data set with zero exceedances, and temperature does not appear to be a stressor in the Wapsipinicon River.

Nitrate

Nitrate concentration during fish sampling on July 21, 2015 and June 29, 2016 at station 15CD012 was 18 mg/L and 14 mg/L respectively. Additional samples collected from 2015 through 2017 ranged from 5.3 to 23.8 mg/L (average of 16.0 mg/L) (Figure 8). Seventy-one samples were collected, and 63 (89%) were greater than 10 mg/L (drinking water standard). Nine samples (13%) were greater than 20 mg/L. Elevated concentrations were documented nearly year round (March through December). Six stations were sampled in close proximity, with all but two samples coming from stations S008-409, S008-701, S008-702, and S008-703.

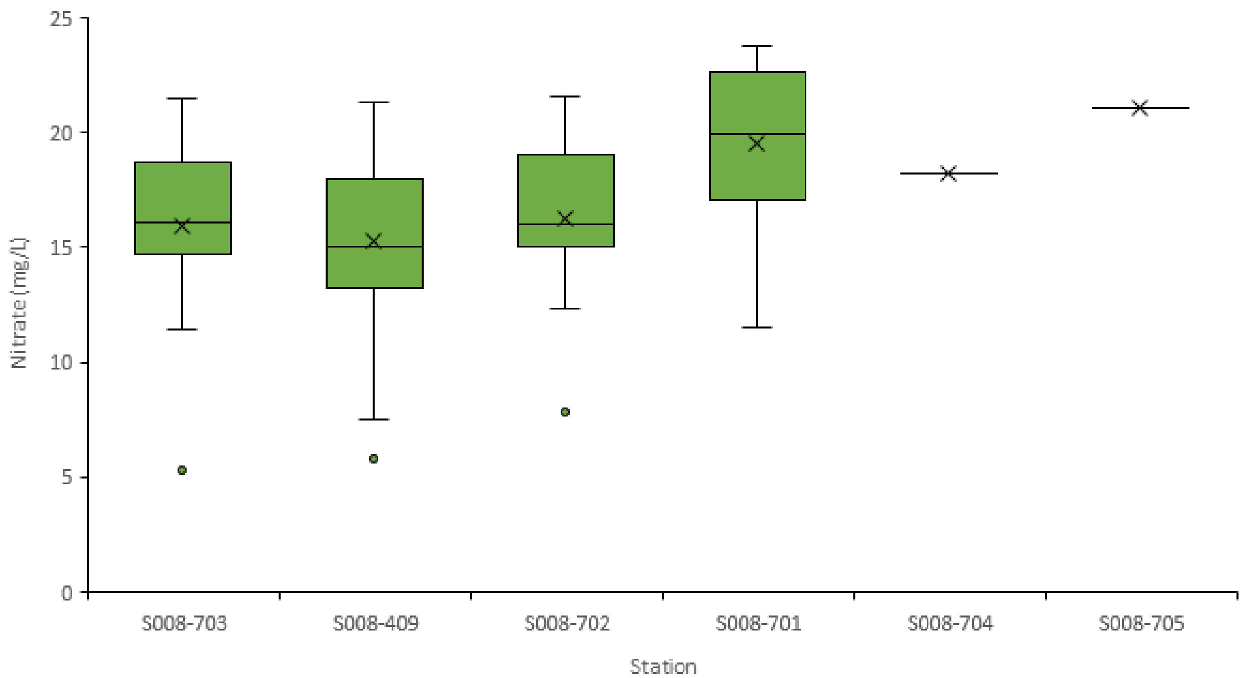

Figure 8: Nitrate concentrations (mg/L) in the Wapsipinicon River Watershed from 2015 through 2017.

Fish lack a strong biological response in relation to elevated nitrate. Better relationships have been made with respect to macroinvertebrate impairment and nitrate concentration. Taxa richness of Trichoptera (TrichopteraCh) was below the statewide median of stations meeting the MIBI threshold (Table 5). Relative abundance of non-hydropsychid Trichoptera individuals (TrichwoHydroPct) was above the median in 2015, and below in 2016. There were zero nitrate intolerant taxa, and 26 to 31 nitrate tolerant taxa comprising 67% to 76% of the community. The macroinvertebrate nitrate index scores were worse than the median, indicating a community more tolerant of nitrate. A majority of the macroinvertebrate metrics are indicative of nitrate stress.

Table 5: Macroinvertebrate metrics that respond to nitrate stress in the Wapsipinicon River compared to the statewide median of visits meeting the biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	Nitrate Index Score	Nitrate Intolerant Taxa	Nitrate Intolerant Pct	Nitrate Tolerant Taxa	Nitrate Tolerant Pct	TrichopteraCh	TrichwoHydroPct
15CD012 (2015)	**4.7**	**0**	**0.0**	**26**	**76.0**	**2**	3.9
15CD012 (2016)	**3.7**	**0**	**0.0**	**31**	**67.3**	**3**	**1.6**
Southern Forest Streams Median	*3.0*	*2*	*1.0*	*18*	*49.1*	*4*	*2.3*
Expected response to stress	↑	↓	↓	↑	↑	↓	↓

Elevated nitrate concentrations exist in the Wapsipinicon River. In addition to elevated nitrate levels, most of the macroinvertebrate metrics were worse than average, there were zero nitrate intolerant taxa, and several nitrate tolerant taxa comprising a high percentage of the overall community. Nitrate is a stressor in this AUID.

Eutrophication

Total Phosphorus (TP) concentration during fish sampling on July 21, 20157 and June 29, 2016 at station 15CD012 was 0.06 mg/L and 0.046 mg/L respectively. Additional samples collected from 2015 through 2017 ranged from 0.013 to 0.484 mg/L (average of 0.1 mg/L). Seventeen samples were collected, and three (18%) exceeded the river eutrophication standard for the South Region (0.150 mg/L). All samples were collected at station S008-409, which is co-located with biological monitoring station 15CD012. Two out of the three exceedances occurred during elevated flows.

Chlorophyll-*a* (Chl-*a*), biological oxygen demand (BOD), dissolved oxygen (DO) flux, and pH flux are also considered when evaluating eutrophication stress. Three chl-a and BOD samples were collected at station S008-409 in July and August of 2017. Chl-*a* concentrations ranged from 1.9 to 3.3 µg/L, and BOD concentrations ranged from 1.0 to 8.4 mg/L. There were no exceedances of the chl-a standard (35 µg/L), and one exceedance of the BOD standard (3 mg/L). Daily DO flux and low DO exceedances were observed during sonde deployment in 2017; daily DO flux during 2017 deployments ranged from 1.4 to 12.0 mg/L, with five days exceeding the standard (4.5 mg/L). pH flux ranged from 0.08 to 1.02 (average of 0.36). Typical daily pH fluctuations are 0.2 to 0.3 (Heiskary et al. 2013). Figure 9 below illustrates conditions in the Wapsipinicon River Watershed in August 2016.

Figure 9: Algae (left) was documented in the upstream AUID at station S008-703 on August 18, 2016; low DO (3.7 mg/L) was also documented. Conditions at station 15CD012 on the same day are pictured to the right; DO was adequate at 9.8 mg/L. Minimal to no flow was noted for both stations.

A majority of the macroinvertebrate metrics were worse than the statewide median of stations meeting the MIBI threshold (Table 6). Taxa richness of collector-filterers (Collector-filtererCh) and Ephemeroptera, Plecoptera, and Trichoptera (EPT) were below the median both years. Taxa richness of collector-gatherers (Collector-gathererCh) was below the median in 2015 and above in 2016. There was one phosphorus intolerant taxa comprising 1% of the community, and 8 to 9 phosphorus tolerant taxa comprising 15% to 18% of the community. The macroinvertebrate phosphorus index score was worse than the median in 2015 and equal to the median in 2016.

Table 6: Macroinvertebrate metrics that respond to eutrophication stress in the Wapsipinicon River compared to the statewide median of visits meeting the biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	Phosphorus Index Score	Phosphorus Intolerant Taxa	Phosphorus Intolerant Pct	Phosphorus Tolerant Taxa	Phosphorus Tolerant Pct	Collector-filtererCh	Collector-gathererCh	EPT
15CD012 (2015)	**0.131**	**1**	**1.3**	9	17.5	**3**	**13**	**2**
15CD012 (2016)	0.127	**1**	**0.6**	8	15.3	**5**	25	**5**
Southern Forest Streams Median	*0.127*	*2*	*1.9*	*10*	*18.7*	*6*	*14*	*8*
Expected response to stress	↑	↓	↓	↑	↑	↓	↓	↓

A majority of the fish metrics were better than the statewide average of stations meeting the FIBI threshold (Table 7). Relative abundance of individuals that are simple lithophilic spawners (SLithopPct) and omnivore species (OmnivorePct) were better than average both years. Relative abundance of individuals that are darter species (DarterPct) were worse than average both years, and tolerant species (TolPct) were mixed. There doesn't appear to be a strong fish signal for eutrophication stress.

Table 7: Fish metrics that respond to eutrophication stress in the Wapsipinicon River compared to the statewide average of visits meeting the biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	DarterPct	SLithopPct	OmnivorePct	TolPct
15CD012 (2015)	**8.7**	61.4	14.0	64.8
15CD012 (2016)	**10.8**	40.5	9.6	**75.4**
Southern Headwaters Average	*12.1*	*33.2*	*14.7*	*70.8*
Expected response to stress	↓	↓	↑	↑

TP, BOD, DO flux, and low DO exceedances have been documented, but some of the data and exceedances are limited and the fish and macroinvertebrate metrics are mixed. Additional monitoring is needed to determine if eutrophication is a stressor. Eutrophication is inconclusive as a stressor in the Wapsipinicon River.

Dissolved Oxygen

Sondes were deployed at station 15CD012 in 2015 and 2017 (Figure 10 and Figure 11). In 2015, DO concentrations ranged from 5.4 to 11.8 mg/L. There were zero exceedances of the warmwater standard (5 mg/L). Daily DO flux during this deployment ranged from 1.8 to 4.5 mg/L, with one value right at the standard (4.5 mg/L). In 2017, there were two deployments, and DO concentrations ranged from 0.5 to 13.2 mg/L. Minimal exceedances (1%) of the low DO standard were observed during the July deployment; a small rain event (approximately 0.5 to 1.0 inches) occurred early in the deployment and appears to have played a role in the brief low DO readings. Being that the low DO was short-lived (approximately five hours in duration) and coincided with a rain event, it's possible that a discharge (point source and/or nonpoint source) containing pollutants decreased the DO concentrations. Sampling information gathered during this sonde deployment supports this theory. Samples were collected near the end of the low DO period on July 20th, and results documented elevated TP (0.330 mg/L) and BOD (8.4 mg/L) concentrations. These concentrations are well above the standards (0.150 mg/L and 3.0 mg/L respectively), and are much higher than concentrations during two sampling events later that August (TP maximum was 0.106 mg/L and BOD maximum was 1.3 mg/L). In addition, a dead fish was documented near the sampling site (Figure 12); this watershed has experienced previous fish kills, which indicates this could be an ongoing issue. Examples of potential sources in this watershed, which is dominated by agriculture, include runoff from feedlots, feed storage areas (e.g. silage pads), and manure applied fields; all have the ability to reduce DO concentrations (and increase BOD concentrations). Other forms of organic matter (leaves, dead plants, sewage, etc.) are also potential sources. Daily DO flux during these deployments ranged from 1.4 to 12.0 mg/L, with five days exceeding the standard. There were two low DO exceedances documented during instantaneous (point) measurements; one occurred in the upstream AUID on August 18, 2016 at station S008-703 (3.7 mg/L), and the other occurred on July 20, 2017 (during the sonde deployment) at station 15CD012 (4.9 mg/L).

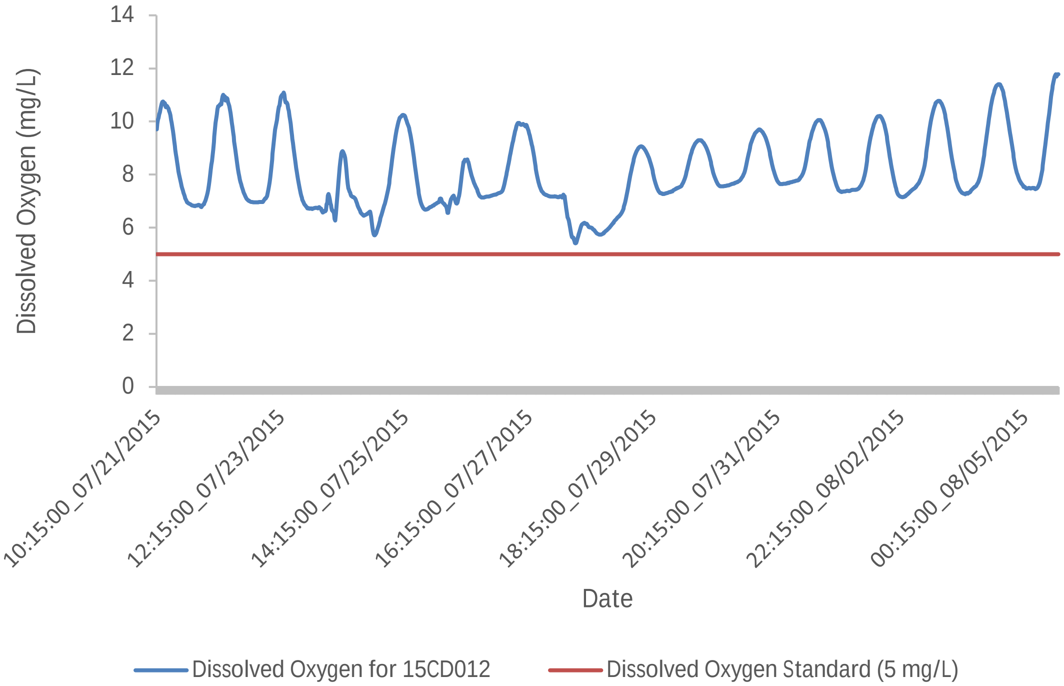

Figure 10: DO concentrations at station 15CD012 during sonde deployment in 2015.

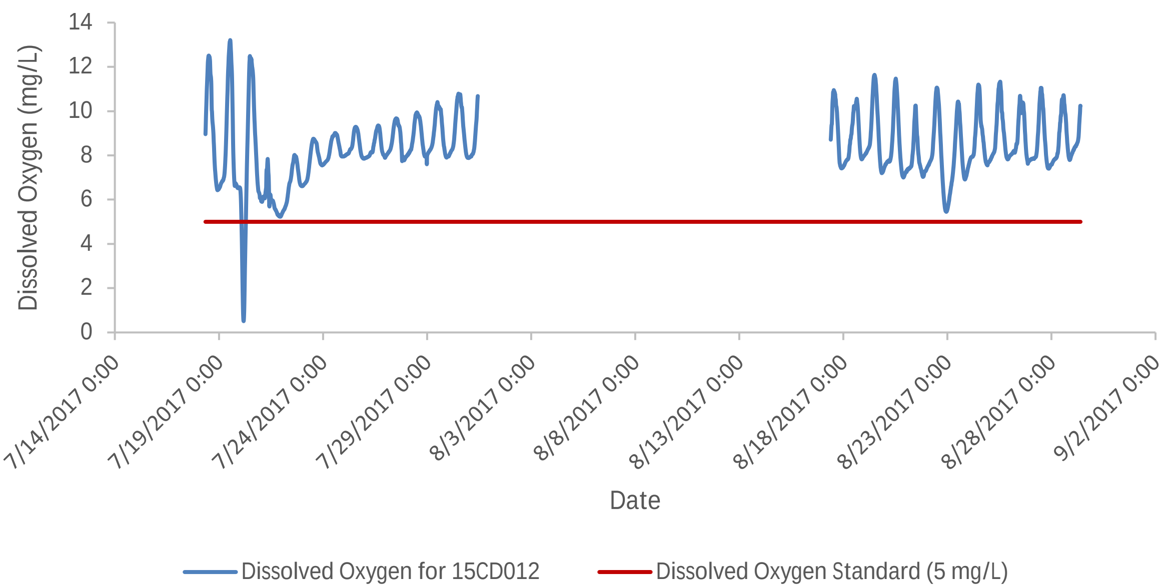

Figure 11: DO concentrations at station 15CD012 during sonde deployments in 2017. There were two deployments, one in July (7/18/17 – 7/31/17) and one in August (8/17/17 – 8/29/17).

Figure 12: Stream conditions during sonde deployment at station 15CD012 on July 20, 2017. This photo was taken near the end of the brief low DO period, and a dead fish was observed in the stream.

A majority of the macroinvertebrate metrics were worse than the statewide median of stations meeting the MIBI threshold (Table 8). Taxa richness of EPT was below the median both years. There were 3 to 8 low DO intolerant taxa comprising 6% to 7% of the community, and five low DO tolerant taxa comprising 12% to 14% of the community. The macroinvertebrate low DO index scores were worse than the median both years.

Table 8: Macroinvertebrate metrics that respond to low DO stress in the Wapsipinicon River compared to the statewide median of visits meeting the biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	Low DO Index Score	Low DO Intolerant Taxa	Low DO Intolerant Pct	Low DO Tolerant Taxa	Low DO Tolerant Pct	EPT
15CD012 (2015)	**6.2**	**3**	**7.1**	5	**12.0**	**2**
15CD012 (2016)	**6.4**	8	**5.9**	5	**14.0**	**5**
Southern Forest Streams Median	*6.9*	*5*	*9.4*	*6*	*9.0*	*8*
Expected response to stress	↓	↓	↓	↑	↑	↓

Fish metrics were mixed; some were better than the statewide average of stations meeting the FIBI threshold and some were worse (Table 9). Relative abundance of individuals with a female mature age ≥ 3 (MA>3Pct) and relative abundance of serial spawning species (SSpnPct) were worse than average both years. Tolerant species (TolPct) were just above and below the average. Low DO index scores and probability of meeting the DO standard were above average both years. The fish community does not have a strong signal for low DO stress.

Table 9: Fish metrics that respond to low DO stress in the Wapsipinicon River compared to the statewide average of visits meeting the biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	Low DO Index Score (RA)	Probability of meeting DO std.	MA>3Pct	SSpnPct	TolPct
15CD012 (2015)	7.5	0.68	**13.0**	**22.2**	64.8
15CD012 (2016)	7.5	0.68	**9.8**	**27.6**	**75.4**
Southern Headwaters Average	*7.2*	*0.45*	*13.6*	*16.5*	*70.8*
Expected response to stress	↓	↓	↓	↑	↑

Low DO and elevated DO flux have been documented, and the macroinvertebrate community shows signs of stress. It's possible the macroinvertebrate stress is due to another stressor, as low DO exceedances were minimal. Overall, it appears the DO regime is suitable for healthy warmwater communities, but additional monitoring is required to confirm. It's unclear how often brief low DO dips (like the one documented during sonde deployment in 2017) occur, but there is reason for concern. Efforts should be made to ensure best management practices are being followed in this watershed, including manure management (storage, application, etc.) and feed storage to reduce the potential for future issues (low DO, fish kills, etc.). At this time, low DO is inconclusive as a stressor.

TSS

Total Suspended Solids (TSS) concentration during fish sampling on July 21, 2015 and June 29, 2016 at station 15CD012 was 5.6 mg/L and 6 mg/L respectively. Additional samples collected from 2015 through 2017 ranged from 2.8 to 32 mg/L (average of 11.0 mg/L). Seventeen samples were collected, and there were no exceedances of the TSS standard for the South Region (65 mg/L). All samples were collected at station S008-409, which is co-located with biological monitoring station 15CD012.

A majority of the macroinvertebrate metrics were worse than the statewide median of stations meeting the MIBI threshold (Table 10). Relative abundance of collector-filterer individuals (Collector-filtererPct) was below the median both years, and relative abundance of Plecoptera individuals (PlecopteraPct) was zero both years. There were zero TSS intolerant taxa, and 6 to 11 TSS tolerant taxa comprising 29% to 35% of the community. The macroinvertebrate TSS index scores were worse than the median both years.

Table 10: Macroinvertebrate metrics that respond to TSS stress in the Wapsipinicon River compared to the statewide median of visits meeting the biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TSS Index Score	TSS Intolerant Taxa	TSS Intolerant Pct	TSS Tolerant Taxa	TSS Tolerant Pct	Collector-filtererPct	PlecopteraPct
15CD012 (2015)	**16.5**	**0**	**0.0**	6	**35.4**	**1.9**	0.0
15CD012 (2016)	**15.2**	**0**	**0.0**	11	**28.7**	**8.8**	0.0
Southern Forest Streams Median	*15.1*	*1*	*0.9*	*11*	*26.8*	*23.3*	*0.0*
Expected response to stress	↑	↓	↓	↑	↑	↓	↓

A majority of the fish metrics were worse than the statewide average of stations meeting the FIBI threshold (Table 11). Relative abundance of individuals that are non-tolerant Centrarchidae (Centr-TolPct), herbivore species (HrbNWQPct), intolerant species (IntolerantPct), long-lived (LLvdPct), individuals of the Order Perciformes excluding tolerant individuals (Percfm-TolPct), riffle dwelling species (RifflePct), and sensitive species (SensitivePct) were all below average both years. There were zero non-tolerant Centrarchidae, intolerant species, and long-lived individuals both years. Relative abundance of individuals that are exclusively benthic feeders (BenFdFrimPct) and simple lithophilic spawners (SLithFrimPct) were above average both years. TSS index scores and probability of meeting the TSS standard were better than average both years. The fish community has a somewhat mixed response to TSS stress; several metrics scored poorly but the TSS index scores and probabilities of meeting the TSS standard are indicating no issues with TSS. It's possible some of the stress observed is due to other stressors.

Table 11: Fish metrics that respond to TSS stress in the Wapsipinicon River compared to the statewide average of visits meeting the biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TSS Index Score (RA)	Probability of meeting TSS std.	BenFdFrimPct	Centr-TolPct	HrbNWQPct	IntolerantPct	LLvdPct	Percfm-TolPct	RifflePct	SensitivePct	SLithFrimPct
15CD012 (2015)	13.3	0.81	38.4	**0.0**	**18.0**	**0.0**	**0.0**	**8.7**	**21.4**	**3.4**	24.6
15CD012 (2016)	14.5	0.76	37.9	**0.0**	**18.0**	**0.0**	**0.0**	**10.8**	**20.1**	**2.6**	19.0
Southern Headwaters Average	*16.9*	*0.60*	*37.4*	*0.9*	*23.1*	*2.1*	*3.5*	*13.9*	*28.1*	*8.9*	*14.9*
Expected response to stress	↑	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓

Recent geomorphology work completed by the DNR at station 15CD012 classified this reach as an E5 stream type. These stream types have "very high sensitivity to disturbance, good recovery potential, moderate sediment supply, high streambank erosion potential, and are very reliant on riparian vegetation to retain stability" (DNR 2017). This work also noted that the "Wapsipinicon River site appears to be one of the more stable stream reaches in southern Minnesota."

A majority of the macroinvertebrate and fish metrics scored poorly, but it's possible this response is due to other stressors as all TSS concentrations were below the standard. TSS is inconclusive as a stressor due to mixed results; additional monitoring is recommended.

Lack of Habitat

The MPCA Stream Habitat Assessment (MSHA) scores at station 15CD012 ranged from 43.5 ("Poor") – 56 ("Fair") (Table 12). There were two "poor" scores and two "fair" scores. In general, all sub-categories (Land Use, Riparian, Substrate, Cover, and Channel Morphology) scored similar between visits. Land Use scores were zero due to surrounding row crops. Runs (80% to 90%) were the dominant channel type, with very few pools (10% to 20%) present (Figure 13). Gravel, sand, and silt were the main substrates; the MPCA biologists noted that the streambed was primarily fine substrate that lacked suitable coarse substrate to support organisms. Bank erosion ranged from none – moderate, embeddedness ranged from light – moderate, and cover amount ranged from sparse – moderate. Multiple cover types were present each visit. The MPCA biologists also noted variable flow conditions between the August 2015 sample and August 2016 sample; the 2015 sample had adequate flow for riffle organisms while the 2016 sample had inadequate flow for riffle organisms. Variable flows can impact habitat availability.

Table 12: MSHA scores at station 15CD012 in 2015 and 2016.

Station (Year Sampled)	Land Use (5)	Riparian (14)	Substrate (28)	Cover (18)	Channel Morphology (35)	**MSHA Total (100)**
15CD012 (2015)	0	9	17	12	18	**56 (Fair)**
15CD012 (2015)	0	8	14.1	6	17	**45.1 (Fair)**
15CD012 (2016)	0	7.5	14.4	12	11	**44.9 (Poor)**
15CD012 (2016)	0	8.5	13	11	11	**43.5 (Poor)**


Figure 13: Habitat conditions at station 15CD012 on July 21, 2015.

In general, the macroinvertebrate metrics are within an expected range (Figure 14). Most metrics fall within the middle quartiles or just outside of them. Climbers, which use overhanging vegetation and woody debris, were present in adequate numbers. However, there are signals of habitat stress with slightly elevated burrowers and legless and slightly reduced clingers. Burrowers “burrow” in fine sediment, legless species are tolerant of degraded habitat conditions, and clingers attach to rock or woody debris. The MPCA assessment database noted that both visits were “dominated by invertebrates tolerant of general stress” (MPCA CARL 2017).

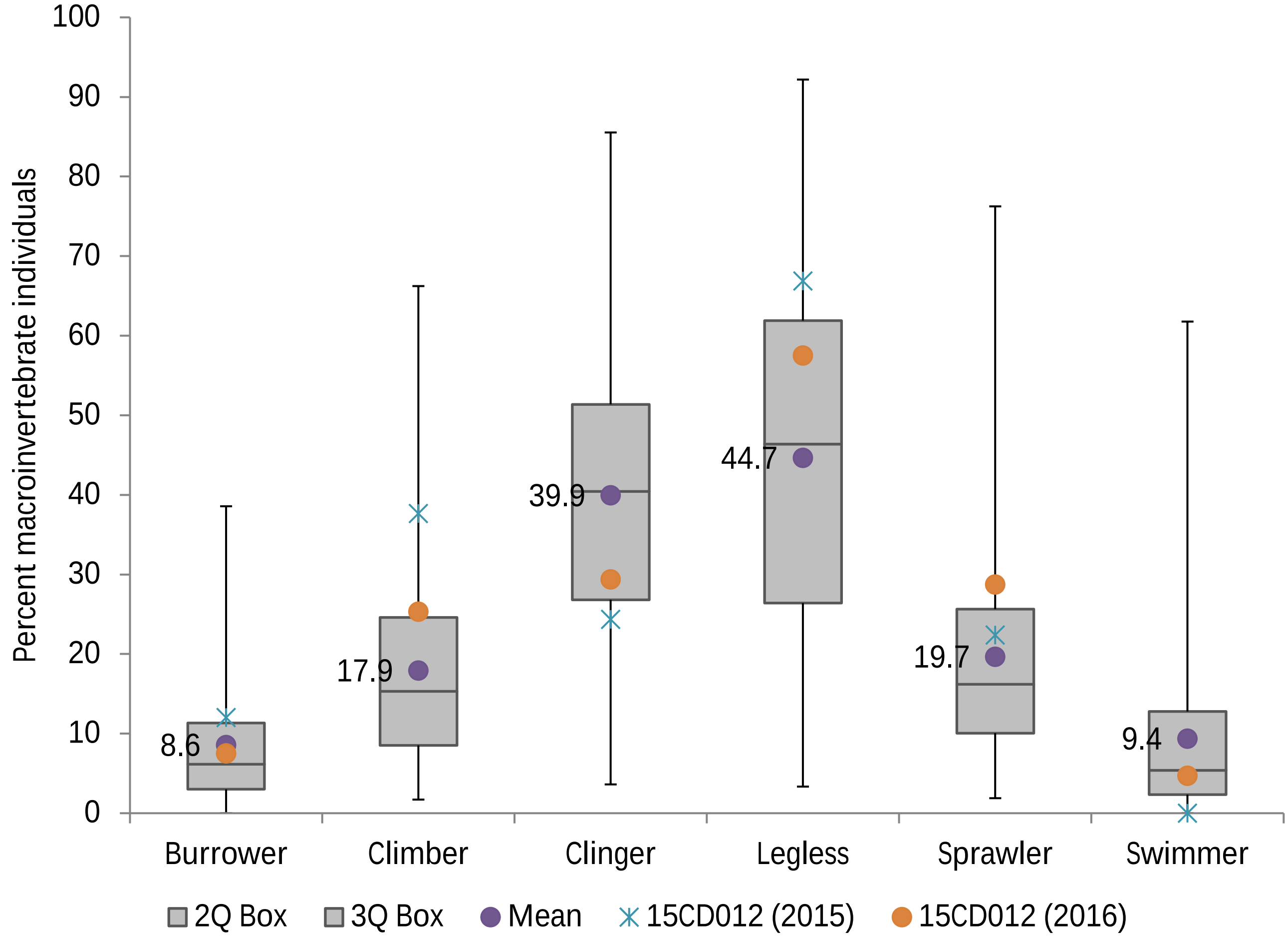

Figure 14: Macroinvertebrate habitat metrics with box plot showing range of values from Southern Forest Streams (class 6) stations meeting the bio criteria, mean of those stations, and metric values from the Wapsipinicon Watershed.

Fish metrics are mixed; some are better than the statewide average of stations meeting the FIBI threshold and some are worse (Table 13). Relative abundance of individuals that are tolerant species (TolPct) and benthic insectivore species (BenInsectPct) were above and below the average. Relative abundance of lithophilic spawners (LithFrimPct), dominant two species (DomTwoPct), and simple lithophilic spawners (SLithopPct) were better than average both years, while relative abundance of darter, sculpin, and round bodied sucker species (DarterSculpSucPct) and riffle-dwelling species (RifflePct) were worse than average both years. Overall, the fish community does not display a strong signal for habitat stress.

Table 13: Fish metrics that respond to habitat stress in the Wapsipinicon River compared to the statewide average of visits meeting the biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	TolPct	BenInsectPct	LithFrimPct	DarterSculpSucPct	DomTwoPct	RifflePct	SLithopPct
15CD012 (2015)	64.8	**11.4**	81.7	**8.7**	37.3	**21.4**	61.4
15CD012 (2016)	**75.4**	17.3	72.6	**10.8**	40.7	**20.1**	40.5
Southern Headwaters Average	*70.8*	*16.8*	*68.3*	*12.8*	*58.6*	*28.1*	*33.2*
Expected response to stress	↑	↓	↓	↓	↑	↓	↓

Recent geomorphology work completed by the DNR at station 15CD012 noted the following:

> *"The Wapsipinicon River site appears to be one of the more stable stream reaches in southern Minnesota. The dimension, pattern, and profile appear to help transport the water and sediments of its watershed without building up or cutting down. This site has a considerable amount of floodplain connectivity and riparian vegetation within the floodplain. Floodplain connectivity and riparian vegetation are major components to retain the stability of this site considering changing climate trends and a considerably altered watershed upstream of this site. This site also appeared to have quality riffle and pool habitat, and large numbers of fish were witnessed during the time of survey"* (DNR 2017).

The MSHA scores were "poor" to "fair", fine substrates were abundant, embeddedness and erosion were present, flows were variable, and the macroinvertebrate community shows signs of habitat stress (elevated burrowers and legless and reduced clingers). Although the DNR identified good channel stability, fine substrate and variable flows appear to be impacting the quality and availability of habitat in the Wapsipinicon River. All the channelization upstream is a likely source of the degraded habitat. Habitat is a stressor in this AUID.

Fish Passage

This small AUID in the headwaters of the Wapsipinicon River has a few culverts and crossings that could potentially impact fish passage (Figure 15 and Figure 16). Most notably is the culvert located in the middle of the sampling reach (Figure 15). MPCA biologists documented this culvert during fish sampling, mentioning that it may impact fish migration during low flows. It's unknown if there are any barriers downstream in Iowa impacting migration; there doesn't appear to be any permanent barriers though, as two rainbow trout were collected in the 2016 sample which are suspected to have migrated north from Iowa. A portion of the Wapsipinicon River near McIntire, IA is managed for trout, which includes the stocking of catchable rainbows (IA DNR 2017).

Relative abundance of migratory taxa (MgrTxPct) and individuals (MgrPct) was 15.4% (2015) and 28.6% (2016), and 18.0% (2015) and 19.0% (2016) respectively. The statewide average of visits meeting the biocriteria is 19.6% and 23.0% respectively; all are below average except MgrTxPct in 2016.

The Wapsipinicon River Watershed has potential fish barriers that limit migration, but the extent of stress on the fish community is uncertain. In general, migratory taxa and individuals are present in slightly reduced numbers, but fish passage is inconclusive as a stressor. Regardless, future culvert and bridge replacements should allow proper water conveyance and fish passage. In addition to limiting fish migration, improperly sized and placed culverts create channel instability, which can have negative impacts on other stressors (e.g. TSS and habitat).

Figure 15: Photos of culvert at station 15CD012. During fish sampling, it was noted that "there is a culvert in the middle of the reach that could act as a fish barrier at times of low flow or drought, but during normal flow it looks like fish should be able to pass." The photo on the left is courtesy of Google Earth.

Figure 16: Private crossings near station 15CD012; it is unclear if these locations are affecting fish passage. Some of these crossings are located on AUID 507, while others are located on neighboring AUIDs. Notice the top photo has a crossing in the upper left corner and an unkown potential barrier in the lower right corner.

Flow Alteration

Flow alteration (altered hydrology) has many components and can be a significant source of stress to biology. Hydrology is impacted by several factors, some of which include wetland drainage, tile drainage, channelization, ground water and surface water appropriation, precipitation, land use, dams, and impervious surface. All of these components alter stream flow, which in turn can negatively impact the biology and have direct or indirect effects on stressors such as temperature, nitrate, phosphorus, DO, TSS, habitat, and fish passage.

Altered (channelized) watercourses dominate the Wapsipinicon River Watershed; station 15CD012 is located in the only natural reach in the watershed (Figure 17). These channelized reaches have direct impacts on hydrology and habitat, as well as other variables. Agricultural tile drainage is a common practice used in the Wapsipinicon River Watershed (Figure 17). Although tile drainage can increase agricultural productivity, it has negative impacts on hydrology (e.g. increasing peak flows and reducing base flows) and water quality (e.g. increasing nitrogen loading). A recent study comparing changes in hydrology for 21 southern Minnesota watersheds found that "artificial drainage is a major driver of increased river flow, exceeding the effects of precipitation and crop conversion" (Schottler et al. 2013) (Figure 18). It also noted, "twentieth century crop conversions and the attendant decreases in ET from depressional areas due to artificial drainage have combined to significantly alter watershed hydrology on a very large scale, resulting in more erosive rivers." Wapsipinicon River Watershed tile calculations, which were derived using the 2009 United States Department of Agriculture (USDA) crop data layer, United States Geological Survey (USGS) National Elevation Dataset, and Soil Survey Geographic Database (SSURGO) soil drainage class, estimate that roughly 38% of the watershed is tiled.

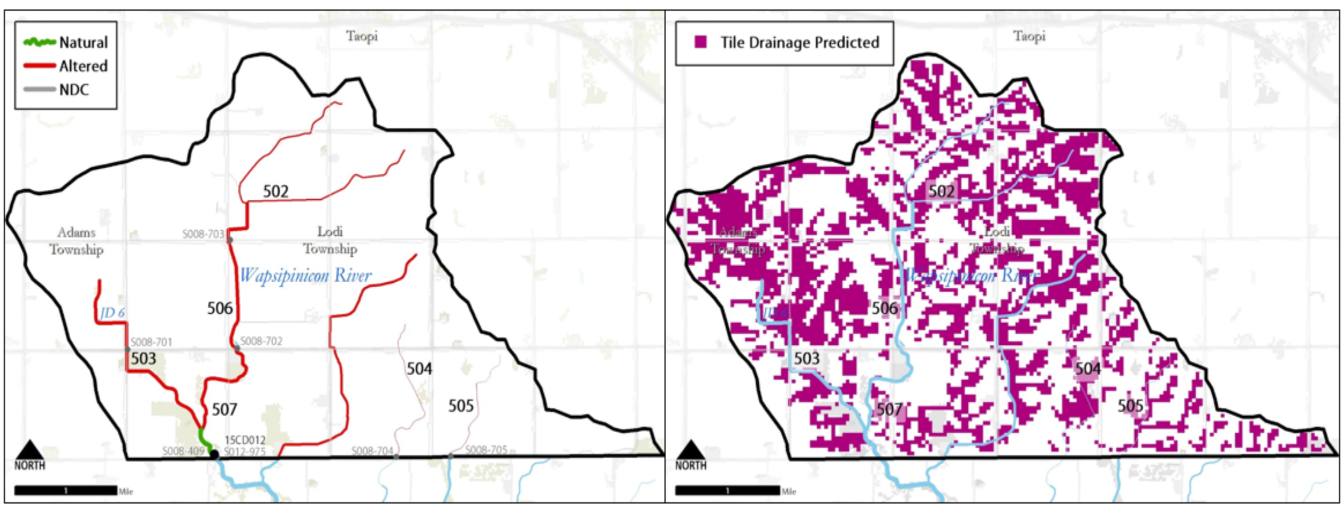

Figure 17: Altered, natural, and no definable channel watercourses in the Wapsipinicon River Watershed (left), and tile drainage estimates in the Wapsipinicon River Watershed (right).

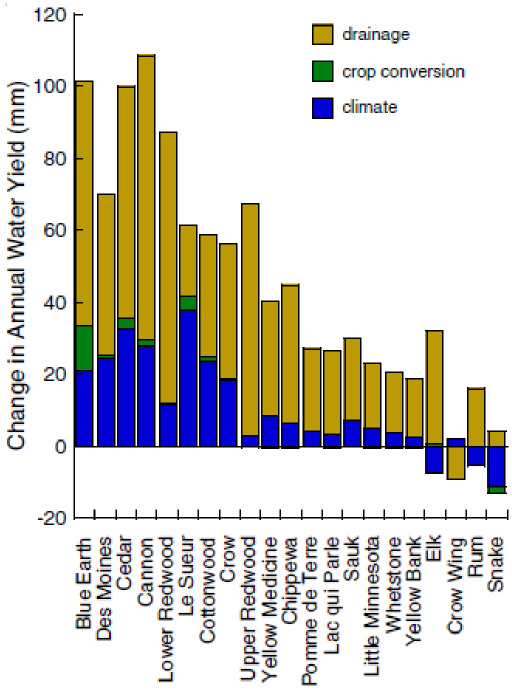

Figure 18: Apportionment of changes in mean annual water yield for each watershed. In rivers with significant changes in flow, climate and crop conversions account for less than half of the total change in water yield. Excess water yield is the portion that cannot be attributed to changes in crop ET and climate and is hypothesized to result from artificial drainage. The above figure was taken from the journal article titled "Twentieth century agricultural drainage creates more erosive rivers" (Schottler et al. 2013).

Wetland impacts on hydrology include providing water storage and reducing peak flows; anthropogenic activities such as draining wetlands alter the flows, timing, and quality of water. Today, very few wetlands remain in the Wapsipinicon River watershed (Figure 19). This decrease in storage impacts hydrology.

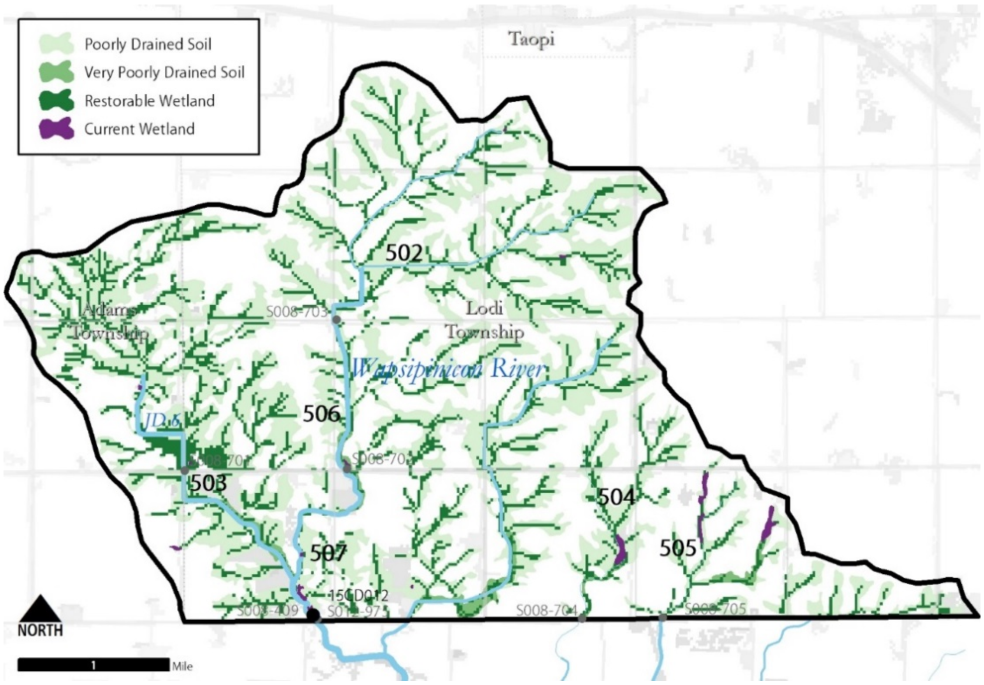

Figure 19: Current wetlands and potential wetland areas in the Wapsipinicon River Watershed. Current wetlands are from the U.S. Fish and Wildlife Service's National Wetland Inventory; potential wetland areas were derived using poorly drained and very poorly drained soils from the SSURGO data and the restorable wetland inventory from the Center for Water and the Environment Natural Resources Research Institute.

Land use in a watershed has significant impacts on the hydrology. Perennial cover, cropland, forest, wetlands, and developed (impervious) land affect hydrology in different ways, with some ultimately reducing runoff and river flows while others increase these flows. Agriculture is the dominant land use in the Wapsipinicon River Watershed (93%) (DNR WHAF); additional information regarding land use can be found in the Wapsipinicon River Watershed Monitoring and Assessment Report.

Groundwater and surface water appropriation also influence hydrology in a watershed. Currently only one appropriation permit exists. This permit is for livestock watering, and the total permit volume is five million gallons per year (mgy). Actual usage for this well in 2015 and 2016 was under two mgy each year.

A majority of the macroinvertebrate metrics were worse than the statewide median of stations meeting the MIBI threshold (Table 14). Relative abundance of EPTPct and tolerant taxa (Tolerant2ChTxPct) were worse than the median both years. However, relative abundance of long-lived individuals (LongLivedPct) was better than the median both years, and relative abundance of non-hydropsychid Trichoptera individuals (TrichwoHydroPct) and total taxa richness (TaxaCountAllChir) were mixed (above and below the median). Flow regime instability tends to limit macroinvertebrate diversity, particularly taxa that belong to the orders of EPT, and favor taxa that are shorter-lived and tolerant of environmental disturbances (Klemm et al. 2002; Poff and Zimmerman 2010; EPA 2012).

Table 14: Macroinvertebrate metrics that respond to flow alteration stress in the Wapsipinicon River Watershed compared to the statewide median of visits meeting the biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	EPTPct	LongLivedPct	TaxaCountAllChir	Tolerant2ChTxPct	TrichwoHydroPct
15CD012 (2015)	**3.9**	14.9	**37**	**82.4**	3.9
15CD012 (2016)	**11.6**	11.3	51	**86.5**	**1.6**
Southern Forest Streams Median	*27.4*	*3.9*	*40*	*75.9*	*2.3*
Expected response to stress	↓	↓	↓	↑	↓

A majority of the fish metrics were worse than the statewide average of stations meeting the FIBI threshold (Table 15). Relative abundance of individuals that are generalist species (GeneralPct), individuals with a female mature age ≤ 2 (MA<2Pct), and short-lived individuals (SLvdPct) were worse than average both years. Relative abundance of individuals of the dominant two species (DomTwoPct) and the number of individuals per meter of stream sampled excluding tolerant species (NumPerMeter-Tol) were better than average both years. Relative abundance of individuals that are pioneer species (PioneerPct) was better than average in 2015, and worse than average in 2016. Flow regime instability tends to limit species diversity and favor taxa that are trophic generalists, early maturing, pioneering, short-lived, and tolerant of environmental disturbances (Aadland et al. 2005; Poff and Zimmerman 2010).

Table 15: Fish metrics that respond to flow alteration stress in the Wapsipinicon River watershed compared to the statewide average of visits meeting the biocriteria. Bold indicates metric value indicative of stress.

Station (Year Sampled)	DomTwoPct	GeneralPct	MA<2Pct	NumPerMeter-Tol	PioneerPct	SLvdPct
15CD012 (2015)	37.3	**70.1**	**81.5**	0.8	25.1	**42.6**
15CD012 (2016)	40.7	**63.7**	**81.5**	0.7	**41.5**	**44.5**
Southern Headwaters Average	*58.6*	*59.0*	*73.9*	*0.7*	*37.9*	*24.3*
Expected response to stress	↑	↑	↑	↓	↑	↑

Flow alteration is negatively influencing the biology in the Wapsipinicon River Watershed, and is contributing to nitrate and habitat stressors. Nitrogen loading via tile lines, degraded habitat from upstream channelization, and variable flows (e.g. reduced baseflow) are examples of flow alteration impacts. Flow alteration is a stressor in the Wapsipinicon River Watershed.

Conclusion

Nitrate, habitat, and flow alteration are stressing the biological communities in the Wapsipinicon River Watershed (Table 16 and Figure 20). Flow alteration is a major source of stress and is contributing to all stressors in the watershed. Nitrate and habitat stressors are impacted by flow alteration through tile drainage and channelization. Almost the entire watershed is channelized and dominated by fine substrate, leading to reduced habitat quality and availability. Inadequate flows also appear to be affecting habitat availability. Additional monitoring is needed to determine the impacts of eutrophication, DO, TSS, and fish passage; they are all inconclusive at this time. Although DO is inconclusive, low DO has been documented and it appears that contaminated discharges (point and/or nonpoint) may be impacting DO concentrations (see DO section for more information). Temperature is suitable for warmwater fish and macroinvertebrates, and is not a stressor.

Table 16: Summary of stressors in the Wapsipinicon River Watershed (• = stressor, ○ = inconclusive stressor, blank = not a stressor). Strength of evidence analysis was completed for each AUID and parameter, and is available upon request.

Waterbody	AUID	Stations	Biological Impairment	Class	Stressors							
					Temperature	Nitrate	Eutrophication	DO	TSS	Habitat	Fish Passage	Flow Alteration
Wapsipinicon River	507	15CD012	Fish and Inverts	2B		•	○	○	○	•	○	•

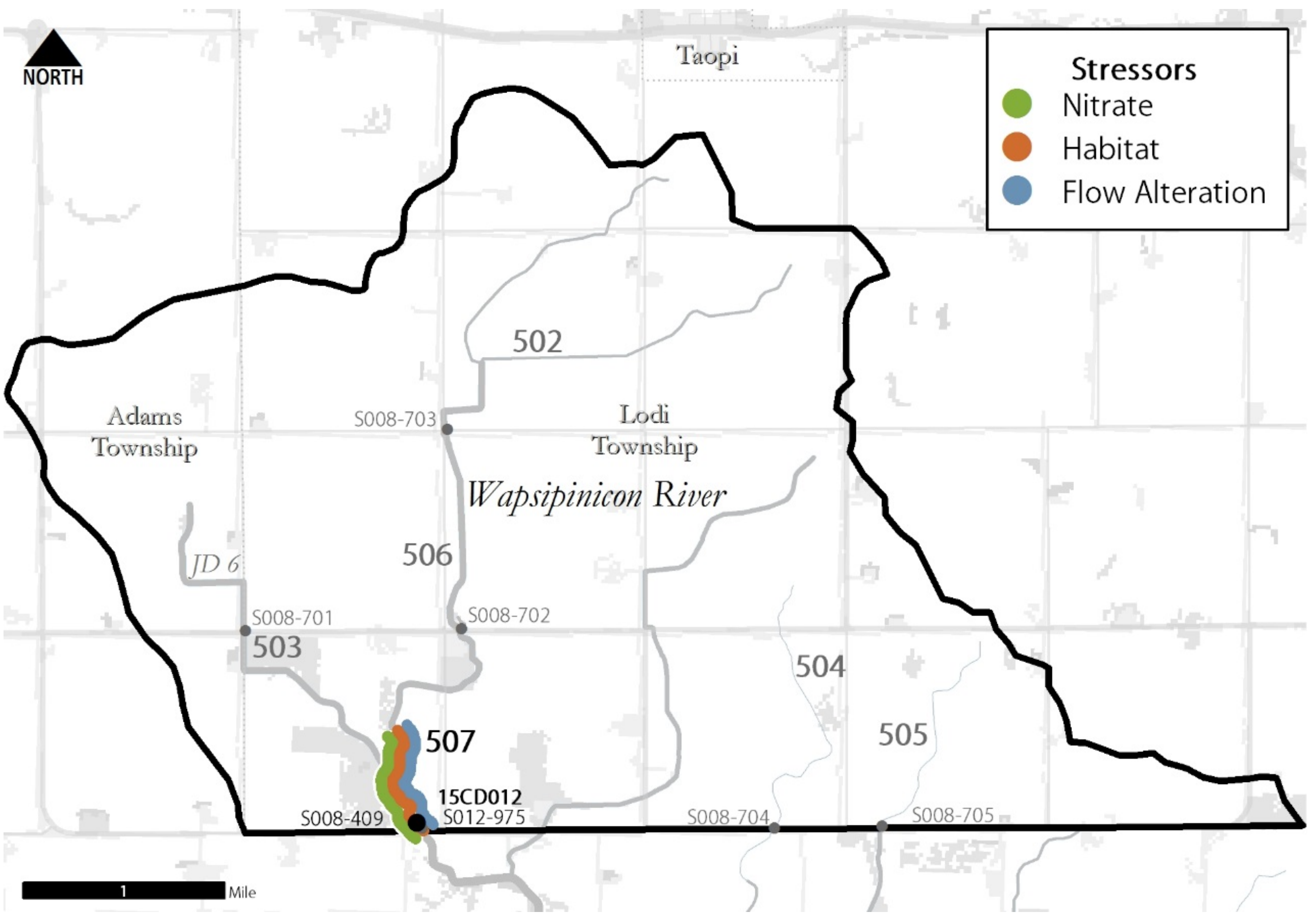

Figure 20: Map of stressors in the Wapsipinicon River Watershed.

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6. Appendix

Table 17: Fish and macroinvertebrate metrics used in stressor analysis in the Wapsipinicon River Watershed.

Metric Name	Type	Metric Description
BenFdFrimPct	Fish	Relative abundance (%) of individuals that are exclusively benthic feeders (Frimpong)
BenInsectPct	Fish	Relative abundance (%) of individuals that are benthic insectivore species
Burrower	Macroinvertebrates	Taxa richness of burrowers (excluding chironomid burrower taxa)
Centr-TolPct	Fish	relative abundance (%) of individuals that are non-tolerant Centrarchidae
Climber	Macroinvertebrates	Taxa richness of climbers (excluding chironomid climber taxa)
Clinger	Macroinvertebrates	Taxa richness of clingers (excluding chironomid clinger taxa)
ClingerCh	Macroinvertebrates	Taxa richness of clingers
Collector-filtererCh	Macroinvertebrates	Taxa richness of collector-filterers
Collector-filtererPct	Macroinvertebrates	Relative abundance (%) of collector-filterer individuals in subsample
Collector-gathererCh	Macroinvertebrates	Taxa richness of collector-gatherers
DarterPct	Fish	Relative abundance (%) of individuals that are darter species
DarterSculpSucPct	Fish	Relative abundance (%) of individuals that are darter, sculpin, and round bodied sucker species
DetNWQTXPct	Fish	relative abundance (%) of taxa that are detritivorous (NAWQA database)
DomFiveCHPct	Macroinvertebrates	Relative abundance (%) of dominant five taxa in subsample (chironomid genera treated individually)
DomTwoPct	Fish	Relative abundance (%) of individuals of the dominant two species
EPT	Macroinvertebrates	Taxa richness of Ephemeroptera, Plecoptera & Trichoptera (baetid taxa treated as one taxon)
EPTPct	Macroinvertebrates	Relative abundance (%) of Ephemeroptera, Plecoptera & Trichoptera individuals in subsample
FishDELTPct	Fish	Relative abundance (%) of individuals with DELT anomalies (deformities, eroded fins, lesions, or tumors)
GeneralPct	Fish	Relative abundance (%) of individuals that are generalist species
GeneralTxPct	Fish	Relative abundance (%) of taxa that are generalists
HBI_MN	Macroinvertebrates	A measure of pollution based on tolerance values assigned to each individual taxon developed by Chirhart

Metric Name	Type	Metric Description
HrbNWQPct	Fish	Relative abundance (%) of individuals that are herbivore species (NAWQA database)
Intolerant2Ch	Macroinvertebrates	Taxa richness of macroinvertebrates with tolerance values less than or equal to 2, using MN TVs
IntolerantPct	Fish	Relative abundance (%) of individuals that are tolerant species
Legless	Macroinvertebrates	Taxa richness of legless macroinvertebrates (chironomid taxa treated as one taxon)
LithFrimPct	Fish	Relative abundance (%) of individuals that are lithophilic spawners
LLvdPct	Fish	Relative abundance (%) of individuals that are long-lived (Frimpong)
LongLivedPct	Macroinvertebrates	Relative abundance (%) of longlived individuals in subsample
Low DO Index Score	Macroinvertebrates	Low DO index score
Low DO Index Score (RA)	Fish	Low DO Index Score (RA)
Low DO Intolerant Pct	Macroinvertebrates	Relative abundance of taxa with tolerance values in the lower 25th percentile of stressor tolerance scores
Low DO Intolerant Taxa	Macroinvertebrates	Number of taxa with tolerance values in the lower 25th percentile of stressor tolerance scores
Low DO Tolerant Pct	Macroinvertebrates	Relative abundance of taxa with tolerance values in the upper 25th percentile of stressor tolerance scores
Low DO Tolerant Taxa	Macroinvertebrates	Number of taxa with tolerance values in the upper 25th percentile of stressor tolerance scores
MA<2Pct	Fish	relative abundance (%) of individuals with a female mature age <=2 (Frimpong)
MA>3Pct	Fish	relative abundance of individuals with a female mature age >=3 (Frimpong)
MgrPct	Fish	Relative abundance (%) of individuals that are migratory species
MgrTxPct	Fish	Relative abundance (%) of taxa that are migratory
Nitrate Index Score	Macroinvertebrates	Nitrate index score
Nitrate Intolerant Pct	Macroinvertebrates	Relative abundance of taxa with tolerance values in the lower 25th percentile of stressor tolerance scores
Nitrate Intolerant Taxa	Macroinvertebrates	Number of taxa with tolerance values in the lower 25th percentile of stressor tolerance scores
Nitrate Tolerant Pct	Macroinvertebrates	Relative abundance of taxa with tolerance values in the upper 25th percentile of stressor tolerance scores
Nitrate Tolerant Taxa	Macroinvertebrates	Number of taxa with tolerance values in the upper 25th percentile of stressor tolerance scores
NumPerMeter-Tolerant	Fish	Number of individuals per meter of stream sampled (excludes individuals of tolerant species)

Metric Name	Type	Metric Description
OmnivorePct	Fish	Relative abundance (%) of individuals that are omnivore species
Percfm-TolPct	Fish	Relative abundance (%) of individuals of the Order Perciformes (excluding tolerant)
Phosphorus Index Score	Macroinvertebrates	Phosphorus Index Score
Phosphorus Intolerant Pct	Macroinvertebrates	Relative abundance of taxa with tolerance values in the lower 25th percentile of stressor tolerance scores
Phosphorus Intolerant Taxa	Macroinvertebrates	Number of taxa with tolerance values in the lower 25th percentile of stressor tolerance scores
Phosphorus Tolerant Pct	Macroinvertebrates	Relative abundance of taxa with tolerance values in the upper 25th percentile of stressor tolerance scores
Phosphorus Tolerant Taxa	Macroinvertebrates	Number of taxa with tolerance values in the upper 25th percentile of stressor tolerance scores
PioneerPct	Fish	Relative abundance (%) of individuals that are pioneer species
PlecopteraPct	Macroinvertebrates	Relative abundance (%) of Plecoptera individuals in subsample
POET	Macroinvertebrates	Taxa richness of Plecoptera, Odonata, Ephemeroptera, & Trichoptera (baetid taxa treated as one taxon)
PredatorCh	Macroinvertebrates	Taxa richness of predators
Probability of meeting DO std.	Fish	Probability of meeting DO std.
Probability of meeting TSS std.	Fish	Probability of meeting TSS std.
RifflePct	Fish	Relative abundance (%) of individuals that are riffle-dwelling species
Sensitive	Fish	Taxa richness of sensitive species
SensitivePct	Fish	Relative abundance (%) of individuals that are sensitive species
SLithFrimPct	Fish	Relative abundance (%) of individuals that are simple lithophilic spawners, as per Frimpong database
SLithopPct	Fish	Relative abundance (%) of individuals that are simple lithophilic spawners
SLvdPct	Fish	Relative abundance (%) of individuals that are short-lived
Sprawler	Macroinvertebrates	Taxa richness of sprawlers (excluding chironomid and baetid sprawler taxa)
SSpnPct	Fish	Relative abunance (%) of individuals that are serial spawning species
Swimmer	Macroinvertebrates	Taxa richness of swimmers (excluding chironomid, baetid taxa treated as one taxon)
TaxaCountAllChir	Macroinvertebrates	Total taxa richness of macroinvertebrates
Tolerant2ChTxPct	Macroinvertebrates	Relative percentage of taxa with tolerance values equal to or greater than 6, using MN TVs
TolPct	Fish	Relative abundance (%) of individuals that are tolerant species

Metric Name	Type	Metric Description
TrichopteraCh	Macroinvertebrates	Taxa richness of Trichoptera
TrichopteraChTxPct	Macroinvertebrates	Relative percentage of taxa belonging to Trichoptera
TrichwoHydroPct	Macroinvertebrates	Relative abundance (%) of non-hydropsychid Trichoptera individuals in subsample
TSS Index Score	Macroinvertebrates	TSS index score
TSS Index Score (RA)	Fish	TSS index score (RA)
TSS Intolerant Pct	Macroinvertebrates	Relative abundance of taxa with tolerance values in the lower 25th percentile of stressor tolerance scores
TSS Intolerant Taxa	Macroinvertebrates	Number of taxa with tolerance values in the lower 25th percentile of stressor tolerance scores
TSS Tolerant Pct	Macroinvertebrates	Relative abundance of taxa with tolerance values in the upper 25th percentile of stressor tolerance scores
TSS Tolerant Taxa	Macroinvertebrates	Number of taxa with tolerance values in the upper 25th percentile of stressor tolerance scores
VtolTxPct	Fish	Relative abundance (%) of taxa that are very tolerant species