Watershed health

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Cottonwood River Watershed Streams Stressor Identification Report

A study of local stressors limiting the biotic communities in the streams of the Cottonwood Watershed.

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Executive Summary

The Minnesota Pollution Control Agency (MPCA) uses biological monitoring and assessment as a means to determine and report the condition of the state's rivers and streams. This basic approach is to examine fish and aquatic macroinvertebrate communities and related habitat conditions at multiple sites throughout a major watershed. From these data, an Index of Biological Integrity (IBI) score can be developed, which provides a measure of overall community health. Stream and river reaches are assigned an Assessment Unit Identification (AUID) number and will be referred to as the AUID in this report. AUIDs with low IBI scores are determined to have a biological impairment. If biological impairments are found, stressors to the aquatic community must be identified.

Stressor identification (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). It looks at causal factors – negative ones harming fish and insects, and positive ones leading to healthy biology. Stressors may be physical, chemical, or biological. In simpler terms, it is the process of identifying the major factors causing harm to aquatic life. 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 Cottonwood Watershed. There were 30 biological impairments in the Cottonwood River Watershed. The impairments in this report are organized by 12-digit Hydrologic Unit Code (HUC). There are 13 HUCs discussed in this report.

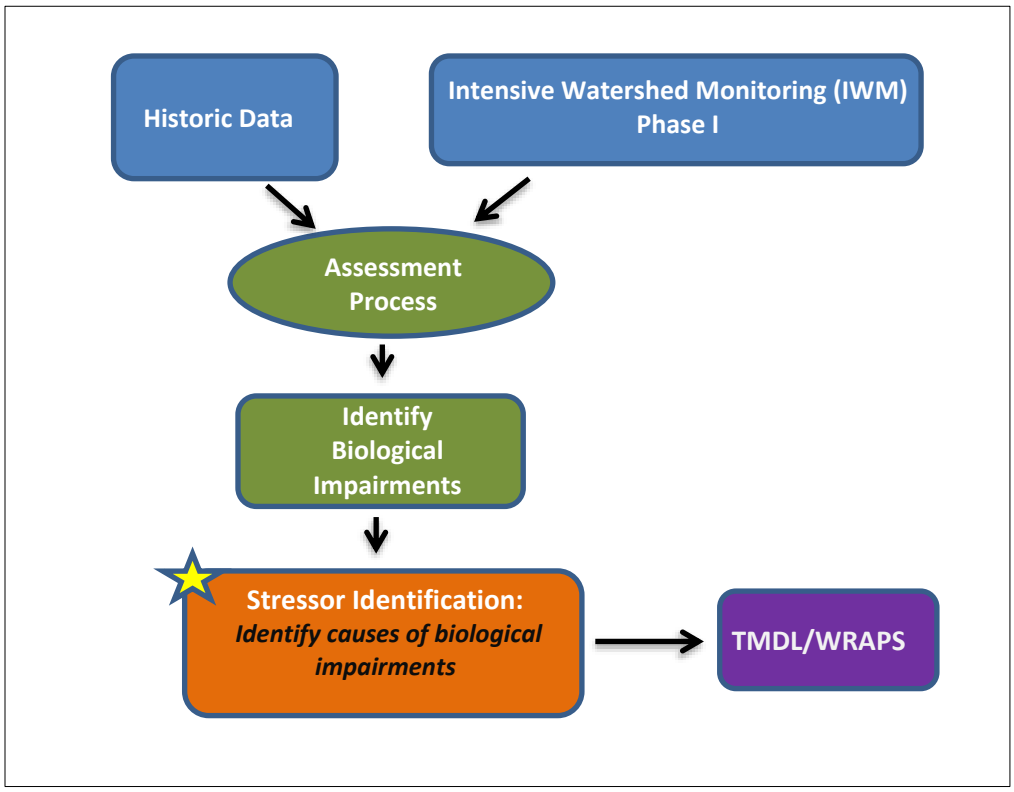
1. Introduction

Monitoring and assessment

Water quality and biological monitoring in the Cottonwood River Watershed have been ongoing for years. As part of the MPCA's Intensive Watershed Monitoring (IWM) approach, monitoring activities increased in rigor and intensity over two years, and focused on biological monitoring (fish and macroinvertebrates) as a means of assessing stream health. The data collected during this period, as well as historic data, 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, TMDL, and WRAPS processes



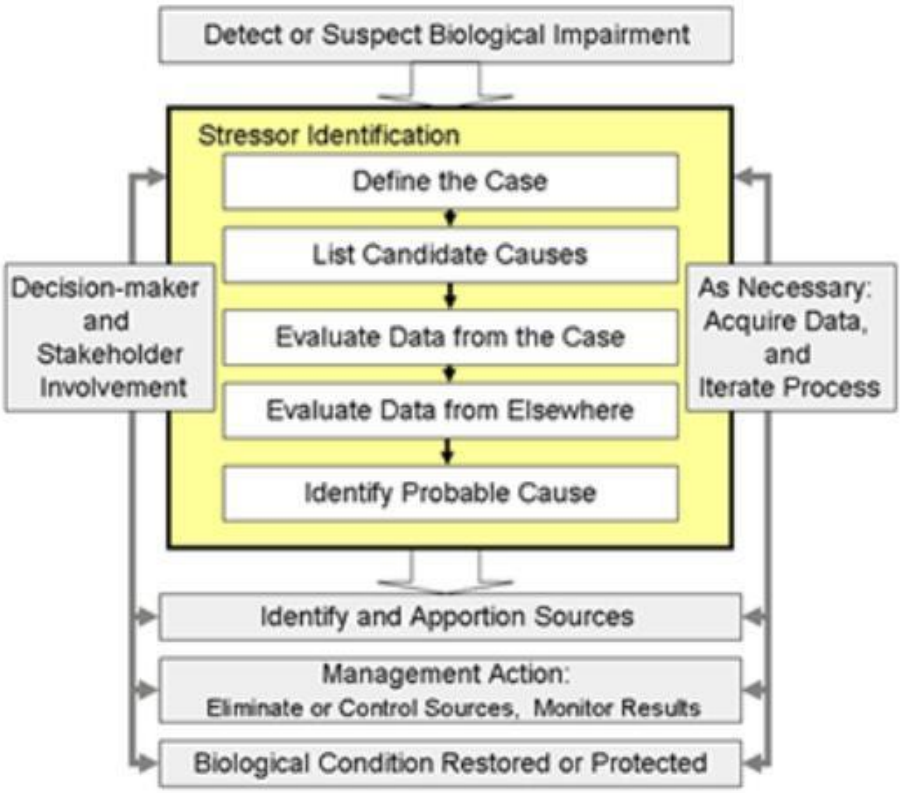
Stressor Identification Process

The MPCA follows the U.S. Enviromental Protection Agency's (EPA's) process of identifying stressors that cause biological impairment (Figure 2), (Cormier et al. 2000). 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: http://www.epa.gov/caddis/.

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.

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).

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



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.

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.

2. Overview of Cottonwood River Watershed

Background

The Cottonwood River Watershed drains an area of approximately 1,312 square miles in the southwest part of the state (MPCA 2020). The confluence of the Cottonwood River with the Minnesota River is located near the city of New Ulm. The cities of Springfield and Sleepy Eye are also located in the watershed. Major tributaries to the Cottonwood River include Sleepy Eye Creek, Dutch Charley Creek, and Plum Creek.

The watershed is located in the Western Corn Belt Plains and Northern Glaciated Plains ecoregions. The watershed was historically primarily prairie grassland, but is now dominated by cropland for agricultural use. Corn and soybeans are the most prevalent crops.

The amount of altered hydrology in the watershed has had "negative effects on the stream communities due to the lack of habitat, increased sedimentation, and increased large flow events (MPCA 2020). Throughout the watershed, only nine stations had habitat with good scores and no stations with excellent habitat scores (MPCA 2020).

The most common stressors to the biological communities in the watershed are eutrophication, lack of habitat, and flow alteration.

Report format

This report is grouped by the 13 12-digit HUCs in the Cottonwood River Watershed that contain biologically impaired streams (Figure 3). The 30 stream biological impairments are evaluated and discussed in the respective aggregated 12-digit HUC where they are located. The HUCs with impaired reaches are listed below:

- Headwaters Cottonwood River
- Meadow Creek
- Upper Cottonwood River
- Plum Creek
- Pell Creek
- Dutch Charley Creek
- Highwater Creek
- Dry Creek
- Mound Creek
- Coal Mine Creek
- Upper and Lower Sleepy Eye Creek
- Judicial Ditch 30
- Lower Cottonwood River

Monitoring overview

"During this two-year sampling period, 81 stations across 59 stream reaches were monitored for fish, macroinvertebrates, and water chemistry" (MPCA 2020). Assessment of the biological information led to 30 stream and 2 lake biological impairments; 4 fish biological stream impairments, 18 macroinvertebrate biological impairments, and 8 streams with both fish and macroinvertebrate impairments. Additional information can be found in subsequent sections of this report, in addition to the comprehensive Cottonwood River Watershed Monitoring and Assessment Report.

Chemical impairments also exist in the watershed, but this report will focus on streams with biological impairments. On streams with biological impairments, there are also chemical impairments of Turbidity, total suspended solids (TSS), and the pesticide Chloropyrifos.

Summary of biological impairments

The approach used to identify biological impairments includes assessment of fish and aquatic macroinvertebrates communities and related habitat conditions at sites throughout a watershed. The resulting information is used to develop an IBI. The IBI scores can then be compared to range of thresholds.

The fish and macroinvertebrates within each AUID were compared to a regionally developed threshold and confidence interval and utilized a weight of evidence approach. The water quality standards call for the maintenance of a healthy community of aquatic life. 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 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 water body condition involves consideration of potential stressors, and draws upon additional information regarding water chemistry, physical habitat, and land use, etc.

In the Cottonwood Watershed, 30 AUIDs are currently impaired by a lack of biological assemblage (Table 2). The purpose of SID is to interpret the data collected during the biological monitoring and assessment process. Trends in the IBI scores can help to identify causal factors for biological impairments.

Table 2. Biologically impaired AUIDs in the Cottonwood River Watershed

				Impairments	
Stream name	**AUID #**	**HUC-12**	**Reach description**	**Biological**	**Water quality**
Cottonwood	07020008-502	Headwaters Cottonwood	Headwaters to Meadow Cr	Invert, fish	TSS
Cottonwood R	07020008-503	Upper Cottonwood	Meadow Cr to Plum Cr	Invert, fish	
Dutch Charley Cr	07020008-517	Dutch Charley	Highwater Cr to Cottonwood R	Fish	Turbidity
Dutch Charley Cr	07020008-518	Dutch Charley	Headwaters to Highwater Cr	Invert, fish	Turbidity
Dry Creek	07020008-520	Dry Cr	T108 R36W S31, south line to Cottonwood R	Invert, fish	
Mound Creek	07020008-521	Mound Creek	Headwaters to Cottonwood R	Invert	
Unnamed Creek	07020008-529	Dutch Charley	Unnamed cr to Dutch Charley Cr	Invert	
County Ditch 38	07020008-537	Highwater Cr	Headwaters to T107 R37W S32, north line	Invert	
Unnamed Creek	07020008-545	Pell Cr	Unnamed cr to Unnamed cr	Fish	

				Impairments	
Stream name	**AUID #**	**HUC-12**	**Reach description**	**Biological**	**Water quality**
County Ditch 24	07020008-550	Lower Sleepy Eye	Unnamed cr to Sleepy Eye Cr	Invert, fish	
Willow Creek	07020008-551	Plum Cr	Unnamed cr to Plum Cr	Invert	
County Ditch 38	07020008-557	Lower Sleepy Eye	Headwaters to CD 85	Invert	
Unnamed creek	07020008-563	Lower Cottonwood	Unnamed ditch to Cottonwood R	Invert	
Unnamed ditch	07020008-569	Meadow Cr	Unnamed ditch to CD 44	Invert	
Unnamed creek	07020008-573	Meadow Cr	Unnamed cr to Lk Marshall	Invert	
Unnamed creek	07020008-574	Meadow Cr	Unnamed cr to Lk Marshall	Invert	
Unnamed creek	07020008-576	Meadow Cr	Heck Slough to Unnamed cr	Invert	
Unnamed creek	07020008-581	Headwaters	Unnamed cr to Cottonwood	Invert	
Unnamed creek	07020008-590	Dry Cr	Unnamed cr to Dry Cr	Invert	
Unnamed creek	07020008-593	Meadow Cr	Unnamed cr to Unnamed ditch	Invert	
County Ditch 26	07020008-597	Lower Sleepy Eye	Headwaters to Sleepy Eye Cr	Invert	
Sleepy Eye Creek	07020008-598	Upper Sleepy Eye	Headwaters to T109 R33W S6, east line	Fish	
Sleepy Eye Creek	07020008-599	Lower Sleepy Eye	T109 R33W S5, west line to Cottonwood R	Invert	Turbidity, Chlorpyrifos
Coal Mine Creek	07020008-604	Coal Mine Cr	Headwaters to T109 R35W S22, south line	Invert	
Unnamed creek	07020008-606	Mound Cr	Unnamed cr to -95.095 44.134	Invert	
Judicial Ditch 30	07020003-609	JD 30	T110 R33W S15, west line to T110 R33W S36, east line	Fish	
Unnamed creek	07020008-615	Meadow Cr	T1110 R40W S9, south line to Unnamed cr	Invert	
Judicial Ditch 22	07020008-617	Upper Cottonwood	-95.566 44.325 to Cottonwood R	Invert, fish	
Unnamed creek	07020008-619	Headwaters Cottonwood	T110 R42W S24, west line to Cottonwood R	Invert, fish	
Unnamed creek	07020008-621	Headwaters Cottonwood	-95.902 44.256 to Cottonwood R	Invert, fish	

3. Possible stressors to biological communities

Possible stressors to biological communities

There is a comprehensive list of potential stressors to aquatic biological communities compiled by the EPA (https://www.epa.gov/caddis-vol1/aquatic-stressors-can-potentially-cause-biological-impairment). This comprehensive list serves two purposes. First, it can serve as a checklist for investigators to consider all possible options for impairment in the watershed of interest. Second, it can be used to identify potential stressors that can be eliminated from further evaluation. In some cases, the data may be inconclusive and limit the ability to confidently determine if a stressor is causing impairment to aquatic life. It is imperative to document if a candidate cause was suspected, but there was not enough information to make a scientific determination. In this case, management decisions can include modification of sampling plans and future evaluation of the inconclusive case. Alternatively, there may be enough information to conclude that a candidate cause is not causing biological impairment and therefore can be eliminated. The inconclusive or eliminated causes will be discussed in more detail in the following section.

A candidate cause is defined as a "hypothesized cause of an environmental impairment that is sufficiently credible to be analyzed" (EPA 2012). Identification of a set of candidate causes is an important early step in the SID process and provides the framework for gathering key data for causal analysis. A more detailed description of possible candidate causes or stressors is provided in the document Stressors to Biological Communities in Minnesota's Rivers and Streams (MPCA 2017). 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 EPA has additional information, conceptual diagrams of sources and causal pathways, and publication references for numerous stressors on its CADDIS website. 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.

Inconclusive causes

- Ammonia
- Toxics
- Predation and interspecies competition
- Physical trampling
- Parasitism

Evaluation of candidate causes

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

- Dissolved oxygen (DO)

- Eutrophication
- Nitrate
- TSS
- Habitat
- Altered hydrology
- Connectivity
- Pesticides

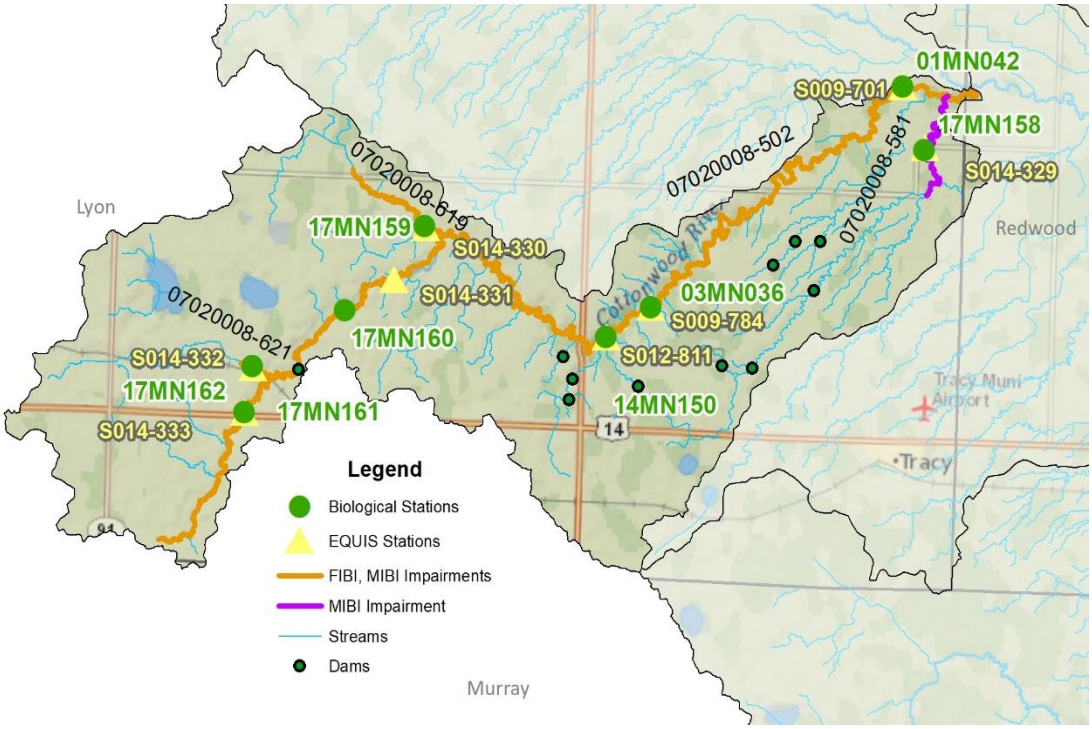
4. Evaluation of stressors to biological impairments

Headwaters Cottonwood River 12-digit HUC

This aggregated HUC includes the headwaters of the Cottonwood River that flows to the mouth of Meadow Creek and three tributaries to the river (Figure 3). The streams in this section have the following impairments:

- Cottonwood River (-502) impaired by TSS, macroinvertebrates and fish (17MN162, 17MN160, 17MN190, 14MN150, 01MN042, S014-333, S009-440)
- Unnamed creek (-621) impaired by macroinvertebrates and fish (17MN161, S014-332)
- Unnamed creek (-619) impaired by macroinvertebrates and fish (17MN159, S014-330)
- Unnamed creek (-581) impaired by macroinvertebrates (17MN158, S014-329)

Figure 3. Map of the Headwaters Cottonwood River 12-digit HUC



Candidate cause: Dissolved oxygen

Values in this HUC ranged from 3.45 mg/L to 11.65 mg/L (Table 3). The lowest values were collected at station 17MN162, located in the headwaters of the Cottonwood River (-502) and just downstream of the Hwy 14 detention dam. The detention dam is below a wetland and is further slowing the flow out of the wetland. An elevated DO value was collected at station 17MN160 on the Cottonwood River. Limited DO values were available on the unnamed tributaries to the Cottonwood River, but there were no values under 5 mg/L, the water quality standard. An elevated DO value was collected on one of the tributaries at station 17MN158.

Table 3. DO values in the Headwaters Cottonwood River HUC

Stream reach	# DO values	Range of DO values	# of values below 5 mg/L
Cottonwood River (-502)	35	3.45-11.65	2
Unnamed Creek (-581)	5	7.52-11.72	0
Unnamed Creek (-619)	3	7.76-10.15	0
Unnamed Creek (-621)	3	8.96-10.27	0

Fish species that are specifically tolerant and intolerant to DO were analyzed at each station. There were no intolerant fish at any station. DO tolerant percentages ranged from 0% (17MN158, 01MN042, and 14MN150) to 33% (17MN162).

The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. All stations had less than 3% of fish that take three years or longer to mature, indicating that fish are quick to reproduce due to short life spans from the influence of human disturbance. Low DO values also correspond with increased serial spawning fish percentage. Serial spawning occurs based on environmental stress. Serial spawners ranged from 7.8% to 34.62% (Table 4). Station 17MN159 was the only station with a serial spawning percentage higher than the class average. Reach -619 has indications of DO stress and DO stress is localized on the Cottonwood River at site 17MN162.

Table 4. Low DO fish related metrics in the Headwaters Cottonwood HUC

		DO related Fish Metrics		
Station	**WID**	MA>3years Percentage	Serial Spawning Fish Pct	Fish Taxa Count
17MN158	**-581**	1.03	7.78	15
17MN159	**-619**	0	34.62	10
17MN160	**-502**	2.38	9.05	6.5
17MN161	**-621**	0	8.33	9
17MN162	**-502**	0	20.74	8

Station	WID	DO related Fish Metrics: MA>3years Percentage	Serial Spawning Fish Pct	Fish Taxa Count
Statewide average for Class 3 Southern Headwaters stations that meet the FIBI General Use Threshold (55.0)		**2.06**	**17.09**	**12.16**
14MN150 (2014)	**-502**	0.55	18.91	17
14MN150 (2016)	**-502**	1.87	20.93	15
14MN150 (2017)	**-502**	1.57	25.39	14
01MN042	**-502**	0.71	19.48	21
Statewide average for Class 2 Southern Streams stations that meet the FIBI General Use Threshold (50.0)		**12.36**	**28.72**	**20**
Expected response to increased DO stress		↓	↑	↓

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed at each station. Intolerant macroinvertebrate taxa ranged from 1 to 9 that were collected and DO tolerant percentage ranged from 0.32 to 31.67. Sites 17MN159 and 17MN162 both had DO tolerant percentages higher than the class average (Table 5). Based on low DO values and the biological communities, low DO is a stressor to the headwaters reach of the Cottonwood River (-502) and is inconclusive on reach -519. More DO samples would be helpful on reach -519.

Table 5. Low DO macroinvertebrate related metrics in the Headwaters Cottonwood HUC

Station	WID	DO related Macroinvertebrate Metrics: Percentage DO Tolerant Macroinvertebrates	HBI_MN	Intolerant DO Macroinvertebrate Taxa	DO Tolerant Index Score
17MN158	**-581**	6.96	8.25	2	6.95
17MN159	**-619**	24.76	7.99	1	6.79
17MN162	**-502**	31.67	8.17	3	6.24
17MN190	**-502**		8.64		
01MN042	**-502**	5.31	8.10	8	6.67

Station	WID	DO related Macroinvertebrate Metrics: Percentage DO Tolerant Macroinvertebrates	HBI_MN	Intolerant DO Macroinvertebrate Taxa	DO Tolerant Index Score
Statewide average for Class 7 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**12.98**	**7.55**	**4.46**	**6.91**
14MN150 (2014)	**-502**	0.32	7.43	6	7.03
14MN150 (2016)	**-502**	2.18	7.19	8	7.62
14MN150 (2017)	**-502**	0.93	7.16	9	7.43
17MN161	**-621**	5.97	7.23	9	7.54
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**8.62**	**7.04**	**8.97**	**7.09**
Expected response to DO stress		↑	↑	↓	↑

Candidate cause: Eutrophication

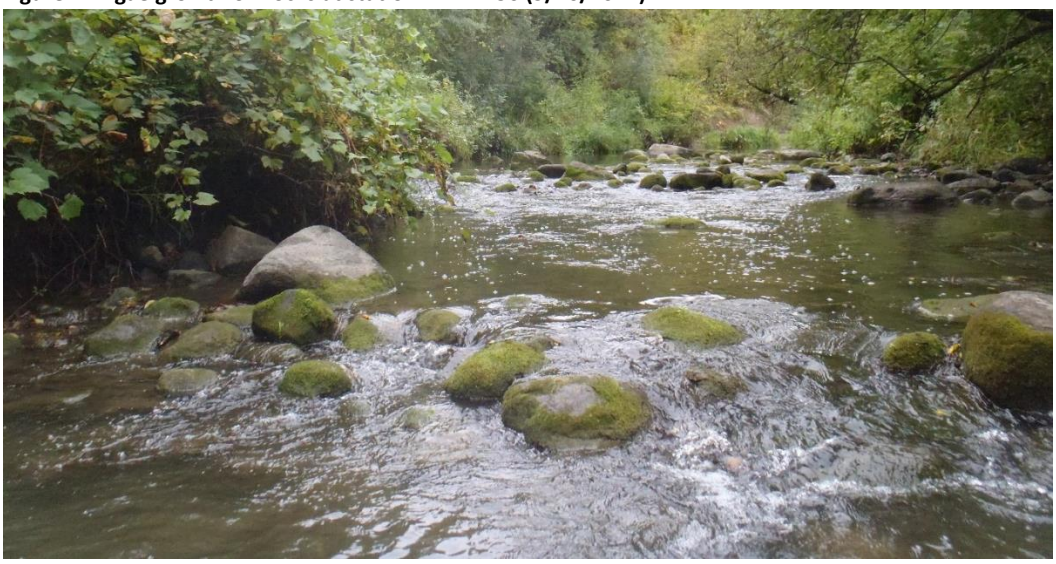
Recent phosphorus data on the upper reach of the Cottonwood River ranged from 0.033 to 0.238 mg/L (Table 6). More than 61% of the samples were above the southern water quality standard of 0.150 mg/L, with the elevated TP values located at S009-440, the most downstretion on this reach of the Cottonwood River. Limited phosphorus values were collected on the two unnad creeks, but both creeks had values above the water quality standard. Reach -619 had the highest p value in the area at 0.81 mg/L.

Table 6. Phosphorus values in the Headwaters Cottonwood HUC

Stream reach	# TP values	Range of TP values	# of values above 0.150 mg/L
Cottonwood River (-502)	26	0.033-0.238	16
Unnamed Creek (-581)	3	0.064-0.203	1
Unnamed Creek (-619)	2	0.105-0.81	1
Unnamed Creek (-621)	2	0.045-0.162	1

There were 15 chlorophyll-a (chl-*a*) values on the Cottonwood River and were all below 15.3 ug/L. The southern standard for chl-*a* is 35 ug/L. Algae was present on rocks at station 14MN150 (Figure 4).

Figure 4. Algae growth on rocks at station 14MN150 (9/10/2014)



All stations had low percentages of sensitive and darter percentages except the 2017 visit at station 14MN150 (Table 7). Darters were also above average at station 17MN159, but the darters collected were all johnny darters which are more tolerant. Fish tolerant to disturbance were higher than average at each station. Omnivorous fish have a positive relationship with nutrients. Stations 17MN159, 17MN160, and 17MN162 had higher than average percentages, with station 17MN160 the highest at 27.62%.

Table 7. Eutrophication related fish metrics in the Headwaters Cottonwood HUC

		Eutrophication related Fish Metrics			
Station	**WID**	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct
17MN158	**-581**	0	2.56	89.74	8.21
17MN159	**-619**	0	15.38	83.97	23.08
17MN160	**-502**	5.72	5.72	91.91	27.62
17MN161	**-621**	0	4.17	91.67	13.33
17MN162	**-502**	0	5.93	94.07	23.70
Statewide average for Class 3 Southern Headwater stations meeting the FIBI General Use Threshold (55.0)		**8.55**	**12.08**	**70.64**	**14.62**
14MN150 (2014)	**-502**	11.09	8.91	46	8.91
14MN150 (2016)	**-502**	17.19	9.16	49.16	10.09
14MN150 (2017)	**-502**	23.03	16.73	47.64	10.43
01MN042	**-502**	0	1.90	62.71	6.65
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**18.65**	**11.68**	**44.85**	**16.53**
Expected response to increased Eutrophication stress		↓	↓	↑	↑

EPT percentages were high at stations 14MN150 and 17MN161 but were dominated by tolerant caddisflies (Table 8). The biological communities are showing a mixed response to the elevated phosphorus. Looks to be a stressor on reach -502 but getting diurnal DO data would be helpful. Eutrophication is inconclusive as a stressor to reach -502 on the Cottonwood River and reaches (-581 and -621). Eutrophication is a stressor reach -619 based on the elevated phosphorus values and biological communities.

Table 8. Eutrophication related macroinvertebrate metrics in the Headwaters Cottonwood HUC

		Eutrophication related Macroinvertebrate Metrics		
Station	**WID**	Invert Taxa	EPT Pct	Dominant 2 Invert CH Pct
17MN158	**-581**	34	6.01	49.37
17MN159	**-619**	27	9.52	52.69
17MN162	**-502**	37	13.67	27
17MN190	**-502**	28	30.7	50.2
01MN042	**-502**	36	53.29	37.93
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**37**	**38.45**	
14MN150 (2014)	**-502**	33	48.70	30.52
14MN150 (2016)	**-502**	36	63.95	23.19
14MN150 (2017)	**-502**	31	73.52	36.14
17MN161	**-621**	31	76.42	47.48
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**42**	**43.90**	
Expected response to TP stress		↓	↓	↑

Candidate cause: Nitrates

Recent nitrate data was available on the upper reach of the Cottonwood River with samples values ranging from 0.11 to 4.6 mg/L (Table 9). Values on the three unnamed creeks ranged from 1.8 to 6.5 mg/L. The highest value collected on the unnamed creeks was at site 17MN161 on reach -621.

Table 9. Nitrate values in the Headwaters Cottonwood River HUC

Stream reach	# nitrate values	Range of values (mg/L)
Cottonwood River (-502)	9	0.11-4.6
Unnamed Creek (-581)	3	1.8-4.3
Unnamed Creek (-619)	2	2.8-6
Unnamed Creek (-621)	2	6.1-6.5

Sensitive fish species have a negative relationship with nitrate, but sensitive species are also affected by DO and phosphorus. Better relationships have been made with respect to macroinvertebrate impairment and nitrate concentration.

Nitrate tolerant individuals comprised of 25.47% to 58.9% of the macroinvertebrate communities on the Cottonwood River and 22.64% to 91.14% on the unnamed creeks (Table 10). Station 14MN150 had a population of 58.9% of nitrogen tolerant macroinvertebrate individuals during sampling in 2014 and decreased to 25.5% during the 2017 sample. The intolerant taxa were zero at all stations.

Increasing nitrate concentrations also have a negative relationship with nonhydropsychid Trichoptera (caddisfly) individual percentages. Nonhydropsychid Trichoptera are all caddisflies that do not spin nets. Values were above the class average of sites meeting the threshold on reach -581 and two of the visits on -502. Based on the lack of elevated nitrate values and the preponderance of metric values, nitrate is not a stressor to the headwaters of the Cottonwood River. Reaches -581 and -619 had indications of nitrate stress based on the tolerant taxa and the nitrate TIV score. However, based on the lack of elevated nitrogen values, nitrate is inconclusive as a stressor.

Table 10. Nitrates values in the Headwaters Cottonwood

		Nitrate related Macroinvertebrate metrics			
Station	**WID**	TrichwoHydroPct	N % Tolerant Taxa	N Intolerant Taxa	Nitrogen TIV
17MN158	**-581**	6.33	91.14	0	4.75
17MN159	**-619**	2.54	83.17	0	5.89
17MN162	**-621**	0.33	72.33	0	4.24
17MN190	**-502**	2.2			
01MN042	**-502**	2.51	63.44	0	3.90
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**4.02**	**54.87**	**3.18**	**3.23**
14MN150 (2014)	**-502**	4.22	58.90	0	3.14
14MN150 (2016)	**-502**	8.15	47.04	0	3.04
14MN150 (2017)	**-502**	9.66	25.47	0	2.60
17MN161	**-621**	0.31	22.64	0	2.67
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**5.94**	**47.60**	**2.92**	**2.95**
Expected response to Nitrate stress		↓	↑	↓	↑

Candidate cause: Sediment

This reach of the Cottonwood River has a TSS impairment. Recent TSS data ranged in value from 2.4 to 215 mg/L, with 11 concentrations above the southern standard of 65 mg/L (Table 11). All the elevated TSS values were located at station S009-440, which is located near the mouth of Meadow Creek. Additionally, secchi tube measurements ranged from 8- >100, with two values below the standard of 10. Limited TSS values were available on the unnamed creeks, all values below 22 mg/L. Secchi measurements at the three unnamed creeks ranged from 9.5->100 cm. The only station with a value below the water quality standard was station 17MN158. Site 17MN158 was also turbid during sampling (Figure 5).

Table 11. TSS values on the Headwaters Cottonwood HUC

Stream reach	# TSS values	Range of values (mg/L)	# of values above 65 mg/L
Cottonwood River (-502)	30	2.4-215	11
Unnamed Creek (-581)	1	14	0
Unnamed Creek (-619)	1	22	0
Unnamed Creek (-621)	1	3.2	0

Fish species that are specifically tolerant and intolerant to TSS were analyzed at each station. Intolerant fish on the Cottonwood River were 0, with tolerant fish ranging from 0% (14MN150) to 52% (17MN160). TSS tolerant species at 01MN042 decreased from 21% in 2001 to less than 1% in 2017. Intolerant species were also 0 on the unnamed creeks, with tolerant species ranging from 0% (17MN158) to 55.8% (17MN159). Herbivore species of fish decrease as TSS values increase. The stations all had herbivore percentages higher than the average of sites meeting the IBI thresholds. Perciforms species (smallmouth bass, walleye, etc.) have been demonstrated to decrease as TSS increases. Perciform percentages were low at all stations except 17MN159 (Table 12).

Figure 5. Station 17MN158 was turbid during sampling (5/22/2019)

Table 12. TSS related fish metrics in the Headwaters Cottonwood HUC

		TSS related Fish Metrics					
Station	**WID**	BenFdFrimPct	Centr-tolPct	HerbvPct	Percfm-tolPct	IntolerantPct	Longlived pct
17MN158	**-581**	20.51	0	13.33	3.59	0	1.03
17MN159	**-619**	20.51	0	7.05	15.38	0	0
17MN160	**-502**	25.24	0	1.43	8.09	0	4.76
17MN161	**-621**	10	0	0.83	4.17	0	0
17MN162	**-502**	9.63	0	0	5.93	0	0
Statewide average for Class 3 Southern Headwaters stations meeting the FIBI General Use Threshold (55.0)		**37.83**	**0.89**	**13.33**	**13.93**	**1.95**	**3.56**
14MN150 (2014)	**-502**	29.27	0.18	14	9.09	0	0.55
14MN150 (2016)	**-502**	29.53	0	10.28	9.16	0	1.49
14MN150 (2017)	**-502**	39.96	0	11.42	16.73	0	1.57
01MN042	**-502**	27.32	0	24.47	1.90	0	1.43
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**37.38**	**4.89**	**9.61**	**18.66**	**4.97**	**11.68**
Expected response to TSS stress		↓	↓	↓	↓	↓	↓

TSS intolerant macroinvertebrates were absent at all stations, and all stations had higher than average TSS tolerant percentages except for station 17MN162 (Table 13). The long-lived percentage were lower than average at stations 17MN158, 17MN159, and the 2014 visit of 14MN150. Collector-filterer percentages were lowered at all sites except 14MN150 and 17MN161. Plecoptera percentages were lowered at all stations except 01MN042. The preponderance of evidence supports TSS is a stressor on the Cottonwood River (-502) and unnamed creeks (-581 and -619).

Table 13. TSS Macroinvertebrate metrics in the Headwaters Cottonwood HUC

		TSS related Macroinvertebrate metrics					
Station	**WID**	TSS Index Score	TSS Intolerant Taxa	TSS Tolerant Pct	Collector Filterer Pct	Plectoptera Pct	Long-lived Pct
17MN158	**-581**	18.83	0	59.49	4.75	0	2.22
17MN159	**-619**	19.75	0	55.56	2.22	0	0.32
17MN162	**-502**	16.82	0	33.67	9.0	0	9.67
17MN190	**-502**				0.6	0	39.2
01MN042	**-502**	22.89	0	70	7.84	0.63	14.42
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI General Use Threshold (41.0)		**17.78**	**1.33**	**48.28**	**19.13**	**0.22**	**7.99**
14MN150 (2014)	**-502**	15.89	0	39.16	29.55	0	5.52
14MN150 (2016)	**-502**	16.34	0	36.45	42.95	0	9.09
14MN150 (2017)	**-502**	16.34	0	42.86	53.59	0.31	14.95
17MN161	**-621**	16.46	0	41.83	70.13	0	5.35
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**15.87**	**3**	**35.23**	**4.56**	**0.54**	**8.99**
Expected response to stress		↑	↓	↑	↓	↓	↓

Candidate cause: Lack of habitat

Habitat conditions were shown to be poor according to MSHA scores on unnamed creeks -581 and -619. Stations 17MN158 and 17MN159 were both in active pastures (Figure 6) and had MSHA scores of 31.4 and 19 respectively. Contributing to the low scores was a lack of a riparian buffer and a lack of channel development. Station 17MN158 also had moderate embeddedness and sparse cover. Excess sediment in the stream created sand bars (Figure 7). Station 17MN159 also had heavy bank erosion and a lack of depth variability. Station 17MN161 on reach -621 had a good MSHA score of 64, with a lack of sinuosity and channel development bringing down the score.

Figure 6. Bank trampling at station 17MN159 (8/19/2017)

Figure 7. Excess sand deposition at station 17MN158 (8/29/19)

The Cottonwood River had a range of MSHA scores; poor scores at station 17MN160 (31) and 17MN190 (36) fair scores at station 01MN042 (50) and 17MN162 (54), and good scores at station 14MN150 with a range of 67 to 72. Stations 17MN160 and 17MN162 had no riparian buffer, stations 17MN160 and 17MN190 had a lack of depth variability, lack of channel development, no riffles and station 17MN190 also had no coarse substrates. DNR collected geomorphic data at Deer Lane WMA, downstream of station 17MN190. The stability at station 17MN190 was determined to be fair (DNR 2020). Station

01MN042 had a lack of channel development and no riffle. A lack of a riparian buffer was also observed upstream of station 01MN042 (Figure 8).

Figure 8. Eroding banks upstream of station 01MN042 (5/22/2019)

Station 14MN150 also had geomorphic work by the DNR, where the stability was found to be fair. “This reach had well distinguishable riffle and pool features... Large stream bed particles and woody debris provide diverse microhabitats that complement the bed features noted in the longitudinal profile” (DNR 2020).

Simple lithophilic spawners, which require coarse substrate for spawning, typically decrease in numbers with limited habitat. Percentages were much lower than average except at station 14MN150 on the Cottonwood River and station 17MN161 on reach -621. Benthic insectivores, darter, sculpin, and sucker, and Piscivore individuals were lowered at all sites on the Cottonwood River except for the most recent visit at station 14MN150 (Table 14). Metrics were also lower on the unnamed creeks except for reach -619, but the only darters collected were johnny darters which are a tolerant darter. Darters are sensitive to siltation and riffle species tend to decrease due to lack of habitat. Riffle species were above average on the Cottonwood River, and below average on the unnamed creeks. The percentage of tolerant species were above average at all sites.

Table 14. Habitat related fish metrics in the Headwaters Cottonwood HUC

		Habitat related Fish Metrics							
Station	**WID**	BenInsect-TolPct	SLithopPct	DarterSculpSucPct	RiffPct	PiscivorePct	LithFrimPct	TolPct	PioneerPct
17MN158	**-581**	2.56	22.56	2.56	18.46	0	86.15	89.74	56.92
17MN159	**-619**	16.03	3.21	15.38	4.49	0	14.74	83.97	48.72
17MN160	**-502**	5.71	29.52	5.71	25.23	0	62.86	91.90	49.52
17MN161	**-621**	4.17	39.17	4.17	5.83	0	83.33	91.67	59.17
17MN162	**-502**	5.93	20.74	5.93	3.70	0	61.48	94.07	69.63
Statewide average for Class 3 Southern Headwaters stations meeting the FIBI General Use Threshold (55.0)		**14.22**	**33.71**	**12.55**	**28.33**	**1.62**	**69.21**	**70.64**	**37.79**
14MN150 (2014)	**-502**	9.45	57.64	9.45	33.27	0.18	84.55	46	9.64
14MN150 (2016)	**-502**	11.03	58.50	10.65	38.69	0	87.48	49.16	9.91
14MN150 (2017)	**-502**	18.31	55.12	18.31	45.28	0	79.33	47.64	8.07
01MN042	**-502**	2.61	35.63	2.61	30.88	0.24	82.42	62.71	23.04
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**20.39**	**39.38**	**18.18**	**32.49**	**5.24**	**58.26**	**44.85**	**19.02**
Expected response to Habitat stress		↓	↓	↓	↓	↓	↓	↑	↑

Clingers need coarse substrates and decrease with the increase in percent fines. The percentages of clingers were below average at all sites except stations 14MN150 and 17MN161 (Table 15). Burrowers and legless individuals are a signal of high levels of sedimentation. Burrowers and legless percentages were increased at sites 17MN158, 17MN162, and 01MN042. A high number of Tricorythodes were present at 01MN042 which are tolerant to sedimentation. EPT percentages were below class average at station 17MN190 and the unnamed creeks. Based on the poor habitat conditions and preponderance of evidence, lack of habitat is stressor to reaches -581, -619, and the upper reach of the Cottonwood River (-502).

Table 15. Invert metrics related to habitat in the Headwaters Cottonwood HUC

		Habitat related Macroinvertebrate Metrics				
Station	**WID**	BurrowerPct	ClimberPct	ClingerPct	EPTPct	LeglessPct
17MN158	**-581**	10.13	57.91	7.28	12.34	85.13
17MN159	**-619**	2.86	54.60	13.33	12.38	74.92
17MN162	**-502**	9.67	35.33	22.33	13.67	62.67
17MN190	**-502**				30	
01MN042	**-502**	8.78	13.16	26.96	53.29	24.14
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI General Use Threshold (41.0)		**7.51**	**21.59**	**38.50**	**38.45**	**39.76**
14MN150 (2014)	**-502**	7.47	12.01	70.45	48.70	42.21
14MN150 (2016)	**-502**	3.45	9.72	68.03	63.95	21.32
14MN150 (2017)	**-502**	3.43	4.36	82.55	73.52	9.97
17MN161	**-621**	3.46	2.83	81.45	76.42	11.95
Statewide average for Class 5 Southern Streams RR stations meeting the MIBI General Use Threshold (41.0)		**7.54**	**14.71**	**49.54**	**42.46**	**36.03**
Expected response to Habitat stress		↑	↓	↓	↓	↑

Candidate cause: Altered hydrology

Portions of two of the unnamed creeks have been channelized; station 17MN161 and upstream of station 17MN159. Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency, increasing the impact of high flow events and increasing the intensity of low flow periods, both of which affect biological communities. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat. Habitat availability can be scarce when flows are interrupted, or low for a prolonged duration. Flows that are reduced beyond normal baseflow decrease living space for aquatic organisms and increase competition for resources.

Generalist fish species, which are adaptable to different habitats through generalized food preferences, are correlated with channelization. The two reaches had a population of generalist fish ranging from 37% to 94%. The numbers of nest guarder species are also positively correlated with increased low flows. The nest guarder species had a population ranging from 15% to 65%. Long-lived macroinvertebrates decrease with flow changes as they are not able to stay in one place as conditions change. The range of long-lived macroinvertebrates ranged from 0.3% to 5%. The channelization is likely contributing to the lack of habitat on reach -619 and is a contributing stressor to the biological communities.

Candidate cause: Connectivity

Connectivity is an important aspect of hydrology. Fish migration is dependent on-stream connectivity. There is an old detention dam (Figure 9) and a perched culvert (Figure 10) preventing migration along the river. There are no known dams or connectivity issues on the unnamed creeks.

Figure 9. Old impoundment on the upper headwaters of the Cottonwood River (5/22/2019)

Figure 10. Culvert on the upper headwaters of the Cottonwood River (5/22/19)

Summary and recommendations

The Headwaters Cottonwood HUC contains four biologically impaired reaches. DO, eutrophication, suspended sediments, lack of habitat, altered hydrology, and connectivity were all stressors in this watershed (Table 16).

The predominant land use in this subwatershed, row crop agriculture, is a contributor to the stressors found in these reaches. Utilizing a variety of nutrient and sediment reducing Best Management Practices (BMPs) including: cover crops, nutrient management, saturated buffers, etc. will help in reducing stress to the biological communities.

Table 16. Stressors in the Headwaters Cottonwood HUC

	Stressors:						
Stream name	**Dissolved oxygen**	**Eutrophication**	**Nitrate**	**Suspended sediment**	**Habitat**	**Altered hydrology**	**Connectivity**
Cottonwood River (-502)	●	o	---	●	●	---	●
Unnamed Creek (-581)	---	o	o	●	●	---	---
Unnamed Creek (-619)	o	●	o	●	●	●	---
Unnamed Creek (-621)	---	o	---	o	---	●	---

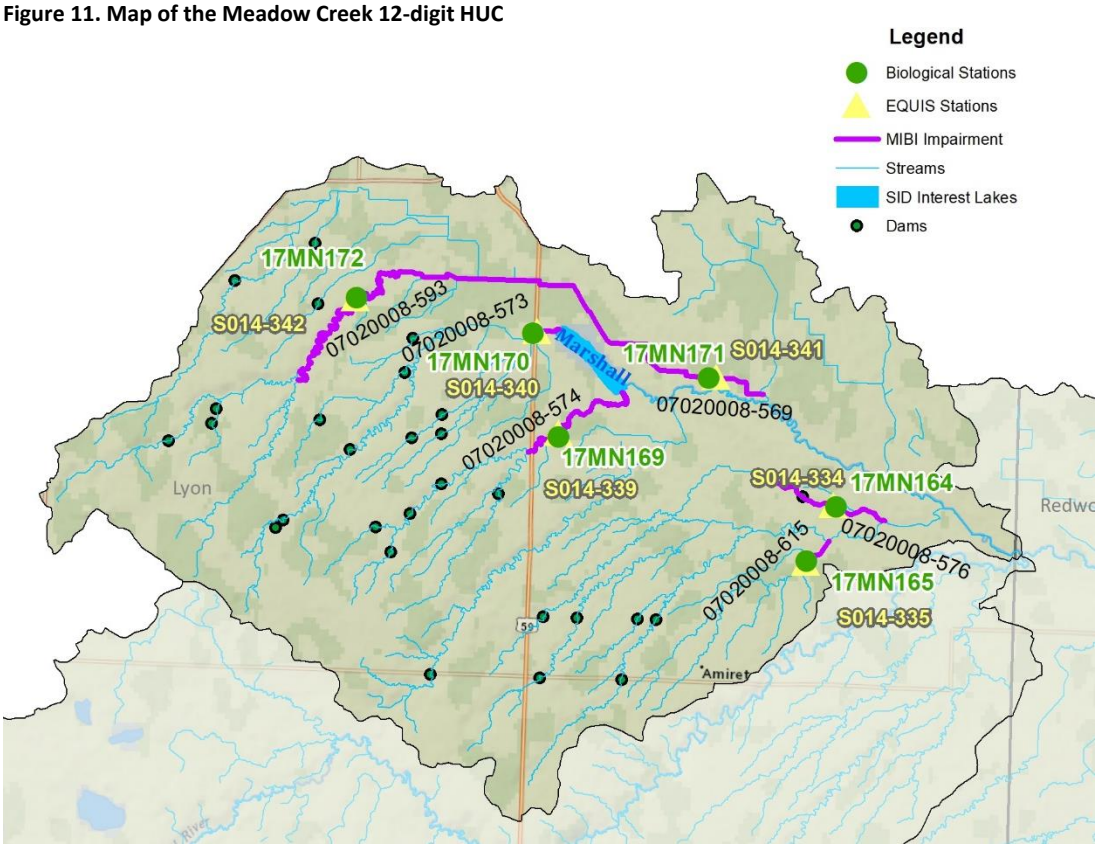
● = stressor; o = inconclusive stressor; --- = not an identified stressor

Meadow creek 12-digit HUC

This aggregated HUC includes the entirety of Meadow Creek and its watershed (Figure 11). Meadow Creek is supporting for both fish and macroinvertebrate communities. The below tributaries to Meadow Creek in this section have the following impairments:

- Unnamed creek (-593) impaired by macroinvertebrates (17MN172, S014-342)
- Unnamed ditch (-569) impaired by macroinvertebrates (17MN171, S014-341)
- Unnamed creek (-573) impaired by macroinvertebrates (17MN170, S014-340)
- Unnamed creek (-574) impaired by macroinvertebrates (17MN169, S014-339)
- Unnamed creek (-576) impaired by macroinvertebrates (17MN164, S014-334)
- Unnamed creek (-615) impaired by macroinvertebrates (17MN165, S014-335)

Figure 11. Map of the Meadow Creek 12-digit HUC



Candidate cause: Dissolved oxygen

Values in this HUC ranged from 0.74 mg/L to 17.02 mg/L (Table 17). The lowest values were collected at station 17MN164, located downstream of a wetland. Elevated DO values was collected at stations 17MN165, 17MN171, and 17MN172.

Continuous data at station 17MN164 over a twenty day period were all below 5.25 mg/L, with a low of 0.96 mg/L. There is a riparian wetland along the station. Continuous data at 17MN165 had a low of 5.11 mg/L, station 17MN169 had a low of 5.15 mg/L, and station 17MN171 had a low of 6.14 mg/L.

Table 17. DO data in the Dry Creek HUC

Stream reach	# DO values	Range of DO values	# of values below 5 mg/L
Unnamed Creek (-569)	5	8.07-17.02 mg/L	0
Unnamed Creek (-573)	4	5.4-10.16 mg/L	0
Unnamed Creek (-574)	5	5.34-9.39 mg/L	0
Unnamed Creek (-576)	5	0.74-7.76 mg/L	4
Unnamed Creek (-593)	4	8.24-17.02	0
Unnamed Creek (-615)	5	7.63-11.49 mg/L	0

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed at each station. Intolerant macroinvertebrate taxa ranged from 0 (17MN171) to 8 (17MN165) and DO tolerant percentage ranged from 4.7% (17MN172) to 83% (17MN164). Sites 17MN164, 17MN169, 17MN170, and 17MN171 had DO tolerant percentages higher than the class average (Table 18). Based on low DO values and the biological communities, low DO is a stressor to the reach -576. There are indications of

DO stress on reaches -569, 573, and -574 and low DO values right around 5 mg/L on reaches -569, -574, and -615. DO is inconclusive on these reaches along with reach -593, where more data would be useful.

Table 18. DO related macroinvertebrate metrics in the Meadow Creek HUC

		DO related Macroinvertebrate Metrics			
Station	**WID**	Percentage DO Tolerant Macroinvertebrates	HBI_MN	Intolerant DO Macroinvertebrate Taxa	DO Tolerant Index Score
17MN171	**-569**	64.54	8.68	0	
17MN170	**-573**	52.73	8.35	1	6.34
17MN164	**-576**	83.43	8.27	0	4.12
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**31.37**	**8.00**	**1.78**	**6.19**
17MN169	**-574**	31.05	7.79	4	6.76
Statewide average for Class 7 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**12.98**	**7.55**	**4.46**	**6.91**
17MN172	**-593**	4.70	7.49	5	7.18
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**8.62**	**7.04**	**8.97**	**7.09**
17MN165	**-615**	12.27	7.93	8	6.92
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI Modified Use Threshold (24.0)		**18.23**	**7.57**	**4.51**	**6.75**
Expected response to DO stress		↑	↑	↓	↑

Candidate cause: Eutrophication

Recent phosphorus data on tributaries to Meadow Creek ranged from 0.03 to 0.416 mg/L (Table 19). Even with limited phosphorus data, five of the six reaches had values above the southern water quality standard of 0.150 mg/L. Reach -574 had the highest phosphorus value in the area at 0.416 mg/L.

Table 19. Phosphorus values on the Meadow Creek HUC

Stream reach	# TP values	Range of TP values	# of values above 0.150 mg/L
Unnamed Creek (-569)	3	0.085-0.180 mg/L	1
Unnamed Creek (-573)	2	0.105-0.232mg/L	1
Unnamed Creek (-574)	3	0.034-0.416 mg/L	1
Unnamed Creek (-576)	3	0.051-0.156 mg/L	1
Unnamed Creek (-593)	2	0.052-0.068 mg/L	0
Unnamed Creek (-615)	3	0.03-0.161 mg/L	1

Algae growth was observed at 17MN164 (Figure 12). Chl-*a*, BOD, and DO fluctuations values are a proximate measurement of eutrophication and have more direct impacts on biology than phosphorus.

Daily fluctuations were above the southern standard of 4.5 mg/L at two of the four sites. Continuous data collected at station 17MN164 had a DO flux range from 0.95 to 2.6 mg/L, 17MN169 had a high flux of 2.39 mg/L, site 17MN165 had a range from 1.9 to 5.41, and 17MN171 had a range of flux 8.06 to 13.34 mg/L.

Figure 12. Algal growth at station 17MN164 (8/8/2019)

Stations 17MN171 and 17MN164 had macroinvertebrate communities dominated by two species; dragonflies and midges at station 17MN171 and amphipods and midges at station 17MN164 (Table 20). The EPT percentage were lowered at each site. Based on the elevated DO flux and biological metrics, eutrophication is a stressor to the macroinvertebrate communities at site 17MN171 (reach -569). While site 17MN164 (reach -576) had algal growth and some indications of stress, eutrophication is inconclusive as a stressor. Reaches -573 and -574 had elevated phosphorus values and indications of metric stress but are inconclusive for eutrophication stress at this time.

Table 20. Eutrophication related metrics on the Meadow Creek HUC

		Eutrophication related macroinvertebrate metrics		
Station	**WID**	Invert Taxa	EPT Pct	Dominant 2 Invert Ch Pct
17MN171	**-569**	23	2.88	47.92
17MN170	**-573**	24	2.77	41.38
17MN164	**-576**	21	0	76.67
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**34**	**20.58**	
17MN169	**-574**	28	6.54	47.39

Station	WID	Eutrophication related macroinvertebrate metrics: Invert Taxa	EPT Pct	Dominant 2 Invert Ch Pct
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**37**	**38.45**	
17MN172	**-593**	42	38.36	21.38
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**42**	**43.90**	
17MN165	**-615**	34	7.72	41.98
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI Modified Use Threshold (24.0)		**36.82**	**33.60**	
Expected response to TP stress		↓	↓	↑

Candidate cause: Nitrates

Limited data was available on the tributaries with values ranging from 0.05 to 14 mg/L (Table 21). The highest value collected on the unnamed creeks was at site 17MN171 on reach -569.

Table 21. Nitrate values in the Meadow Creek HUC

Stream reach	# Nitrate values	Range of values (mg/L)
Unnamed Creek (-569)	3	5.5-14
Unnamed Creek (-573)	1	4.5
Unnamed Creek (-574)	2	1.1-1.8
Unnamed Creek (-576)	2	0.05-0.42
Unnamed Creek (-593)	2	3.2-4.5
Unnamed Creek (-615)	3	5.6-8.3 mg/L

Nitrate tolerant individuals comprised of 3.01% to 90.18% of the macroinvertebrate communities on the unnamed creeks. A community of macroinvertebrates with a percentage of nitrate tolerant individuals greater than 78% has only a 25% chance of meeting the MIBI. The intolerant taxa were zero at all stations except for one collected at station 17MN164 (Table 22).

Increasing nitrate concentrations also have a negative relationship with nonhydropsychid Trichoptera (caddisfly) individual percentages. Nonhydropsychid Trichoptera are all caddisflies that do not spin nets. Values were below the class average of sites meeting the threshold at all the stations. Reach -569 looks to be stressed, more data would be helpful to confirm. However, based on the lack of elevated nitrogen values, nitrate is also inconclusive as a stressor to reaches -574 and -593.

Table 22. Nitrate related metrics on the Meadow Creek HUC

		Nitrate related Macroinvertebrate Metrics			
Station	**WID**	TrichwoHydroPct	N % Tolerant taxa	N Intolerant taxa	Nitrogen TIV
17MN170	**-569**	0.15	56.77	0	4.37
17MN171	**-573**	1.28	59.42	0	4.13
17MN164	**-576**	0	3.01	1	1.59
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**2.16**	**59.41**	**1.95**	**3.32**
17MN169	**-574**	0.98	87.58	0	4.54
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**4.02**	**54.87**	**3.18**	**3.23**
17MN172	**-593**	5.03	64.26	0	3.88
Statewide average for Class 5 Southern Streams RR stations meeting the MIBI General Use Threshold (37.0)		**5.94**	**47.60**	**2.92**	**2.95**
17MN165	**-615**	3.08	90.18	0	5.57
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI Modified Use Threshold (24.0)		**11.14**	**56.71**	**1.88**	**3.22**
Expected response to Nitrate stress		↓	↑	↓	↑

Candidate cause: Sediment

Limited TSS data ranged in value from 2.4 to 46 mg/L, with 0 concentrations above the southern standard of 65 mg/L on (Table 23). Additionally, secchi tube measurements ranged from 6.5 to >100, with values below the standard of 10 at sites 17MN170, 17MN169, and 17MN172. Sites 17MN169 and 17MN172 were turbid during sampling (Figure 13 and Figure 14).

Table 23. TSS values on the Meadow Creek HUC

Stream reach	# TSS values	Range of values (mg/L)	# of values above 65 mg/L
Unnamed Creek (-569)	1	46 mg/L	0
Unnamed Creek (-573)	0		0
Unnamed Creek (-574)	1	6 mg/L	0
Unnamed Creek (-576)	1	2.4 mg/L	0
Unnamed Creek (-593)	2	10-22 mg/L	0
Unnamed Creek (-615)	2	2.4-6.4 mg/L	0

Figure 13. Turbid conditions at site 17MN172 (5/22/2019)

Figure 14. Turbid conditions at site 17MN169 (8/8/2019)

TSS intolerant macroinvertebrates were absent at all stations, and all stations had higher than average TSS tolerant percentages except for stations 17MN164 and 17MN169 (Table 24). The long-lived percentage were lower than average at all stations. Collector-filterer percentages were lowered at all sites except 17MN172. Plecoptera percentages were lowered at all stations except 17MN169. While there are indications of TSS as a stressor on the tributaries, more TSS data would be helpful. TSS is inconclusive as a stressor on all the reaches.

Table 24. TSS related metrics in the Meadow Creek HUC

		TSS related Macroinvertebrate metrics					
Station	**WID**	TSS Index Score	TSS Intolerant Taxa	TSS Tolerant Pct	Collector Filterer Pct	Plectoptera Pct	Long-lived Pct
17MN170	**-573**	18.75	0	50.95	0	0	2.30
17MN171	**-569**	18.16	0	54.95	1.59	0	0
17MN164	**-576**	12.68	0	4.52	0.61	0	0
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**16.25**	**0.6**	**35.60**	**9.91**	**0.02**	**5.59**
17MN169	**-574**	14.23	0	13.39	0.98	0.33	0.33
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**17.78**	**1.33**	**48.28**	**19.13**	**0.22**	**7.99**
17MN172	**-593**	16.61	0	42.0	26.73	0	1.26
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**15.87**	**3**	**35.23**	**4.56**	**0.54**	**8.99**
17MN165	**-615**	17.61	0	46.63	6.48	0	0
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI Modified Use Threshold (24.0)		**16.10**	**1.16**	**36.67**	**22.05**	**0.10**	**6.46**
Expected response to stress		↑	↓	↑	↓	↓	↓

Candidate cause: Lack of habitat

Habitat conditions ranged between poor and fair on the reaches according to MSHA scores. Sites 17MN164, 17MN170, and 17MN171 had no coarse substrates, poor channel development, and no depth variability. Station 17MN164 also had no connectivity to the floodplain, was entrenched and seems overwidened. Sites 17MN165 and 17MN171 had eroding banks (Figure 15 and Figure 16) and poor sinuosity. Site 17MN169 had moderate to severe embeddedness and poor channel development with no riffles present. The score at 17MN172 was lowered by location in an open pasture, and moderate to heavy erosion.

Figure 15. Eroding bank along site 17MN165 (5/22/2019)

Figure 16. Eroding bank at site 17MN171 (8/8/2019)

Clingers need coarse substrates and decrease with the increase in percent fines. The percentages of clingers were below average at all sites except stations (Table 25). Burrowers and legless individuals are a signal of high levels of sedimentation. Burrowers and legless percentages were increased at sites 17MN164, 17MN165, and 17MN169. EPT percentages were below class average at each station. Based on the poor habitat conditions and preponderance of evidence, lack of habitat is stressor on all the reaches.

Table 25. Habitat related metric in the Meadow Creek HUC

		Habitat related Macroinvertebrate metrics				
Station	**WID**	BurrowerPct	ClimberPct	ClingerPct	EPTPct	LeglessPct
17MN170	**-569**	19.99	52.33	11.23	2.77	65.72
17MN171	**-573**	11.18	56.55	21.09	4.15	58.15
17MN164	**-576**	49.09	3.03	1.82	0	64.24
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI Modified Use Threshold (22.0)		**14.12**	**27.47**	**23.07**	**20.58**	**55.79**
17MN169	**-574**	19.28	46.73	16.67	6.54	83.66
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI General Use Threshold (41.0)		**7.51**	**21.59**	**38.50**	**38.45**	**39.76**
17MN165	***-615***	12.65	46.29	18.21	7.72	91.67
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI Modified Use Threshold (24.0)		**8.99**	**21.49**	**39.23**	**33.60**	**45.53**
17MN172	**-593**	4.09	23.58	47.48	38.36	54.72
Statewide average for Class 5 Southern Streams RR stations meeting the MIBI General Use Threshold (41.0)		**7.54**	**14.71**	**49.54**	**42.46**	**36.03**
Expected response to Habitat stress		↑	↓	↓	↓	↑

Candidate cause: Altered hydrology

Three of the unnamed tributaries have been channelized; stations 17MN164, 17MN170, and 17MN171 (Figure 17 and Figure 18). Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency, increasing the impact of high flow events and increasing the intensity of low flow periods, both of which affect biological communities. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting species that rely on clean substrate for habitat. Habitat availability can be scarce when flows are interrupted, or low for a prolonged duration. Flows that are reduced beyond normal baseflow decrease living space for aquatic organisms and increase competition for resources.

Generalist fish species, which are adaptable to different habitats through generalized food preferences, are correlated with channelization. The two reaches had a population of generalist fish ranging from 21% to 73%. The numbers of nest guarder species are also positively correlated with increased low flows. The nest guarder species had a population ranging from 40% to 96%. Long-lived macroinvertebrates decrease with flow changes as they are not able to stay in one place as conditions change. The range of long-lived macroinvertebrates ranged from 0% to 3%. The channelization is likely contributing to the lack of habitat and is a contributing stressor to the biological communities.

Figure 17. Channelization at site 17MN170 (5/22/2019)

Figure 18. Channelization at site 17MN164 (5/22/2019)

Candidate cause: Connectivity

Connectivity is another important aspect of hydrology. Fish migration is dependent on stream connectivity. Perched culverts were present at sites 17MN171, 17MN170, and 17MN164 and are barriers to fish migration (Figure 19, Figure 20, and Figure 21). Connectivity is a stressor on reaches -569, 573, and -576.

Figure 19. Perched culvert at site 17MN171 (8/8/2019)

Figure 20. Perched culvert at site 17MN170 (8/29/2019)

Figure 21. Perched culvert at site 17MN164 (5/22/2019)

Summary and recommendations

The Meadow Creek HUC contains five biologically impaired reaches. DO, eutrophication, lack of habitat, altered hydrology, and connectivity were all stressors in this watershed (Table 26).

The predominant land use in this subwatershed, row crop agriculture, is a contributor to the stressors found in these reaches. Utilizing a variety of nutrient and sediment reducing BMPs including: cover crops, nutrient management, saturated buffers, etc. will help in reducing stress to the biological communities. Fixing the perched culverts would be helpful to restore stream connectivity.

Table 26. Stressors in the Meadow Creek HUC

	Stressors:						
Stream name	Dissolved oxygen	Eutrophication	Nitrate	Suspended sediment	Habitat	Altered hydrology	Connectivity
Unnamed Creek (-569)	o	●	o	o	●	●	●
Unnamed Creek (-573)	o	o	---	o	●	●	●
Unnamed Creek (-574)	o	o	o	o	●	---	---
Unnamed Creek (-576)	●	o	---	o	●	●	●
Unnamed Creek (-593)	o	---	o	o	●	---	---
Unnamed Creek (-615)	---	o	o	o	●	●	---

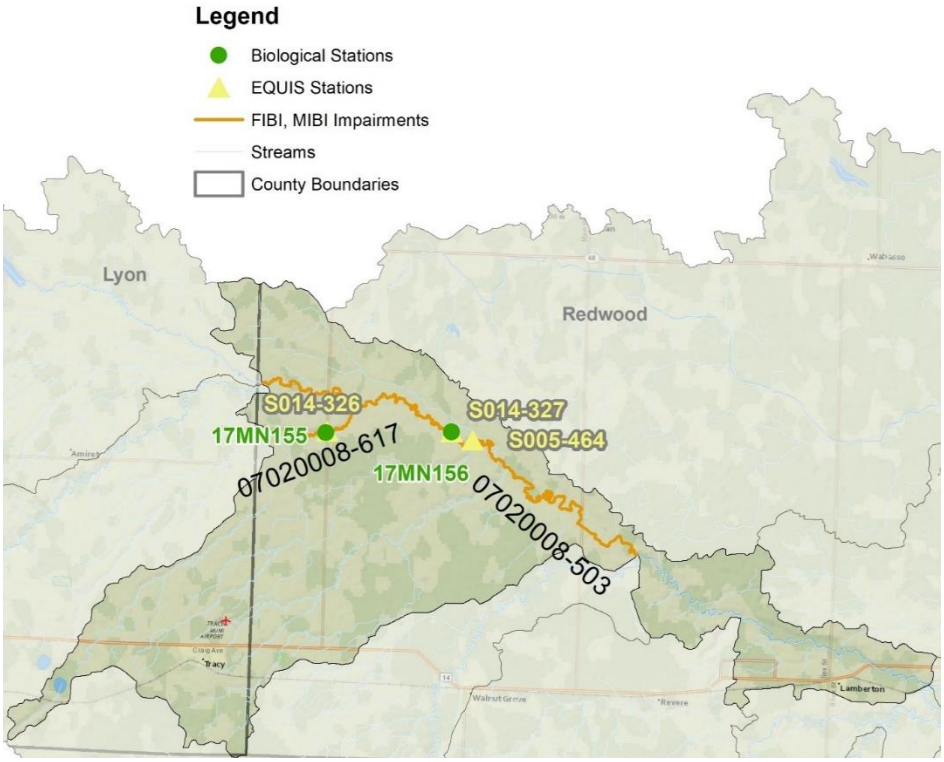
● = stressor; o = inconclusive stressor; --- = not an identified stressor

Upper Cottonwood River 12-digit HUC

This aggregated HUC includes the Cottonwood River from Meadow Creek to Plum Creek and Judicial Ditch 22 (Figure 22). The streams in this HUC have the following impairments:

- Cottonwood River (-503) impaired by macroinvertebrates and fish (17MN156, S005-464, S014-327)
- Judicial Ditch 22 (-617) impaired by macroinvertebrates and fish (17MN155, S014-326)

Figure 22. Map of the Upper Cottonwood HUC



Candidate cause: Dissolved oxygen

There was limited DO data available in this HUC, ranging from 8.11 mg/L to 10.98 mg/L (Table 27). There were no values under 5 mg/L, the water quality standard.

Table 27. DO values in the Upper Cottonwood HUC

Stream reach	# DO values	Range of DO values	# of values below 5 mg/L
Cottonwood River (-503)	2	8.11-9.33 mg/L	0
Judicial Ditch 22 (-617)	3	8.28-10.98	0

Fish species that are specifically tolerant and intolerant to DO were analyzed at both stations. There were no intolerant fish at either station. The DO tolerant percentage was 0% at site 17MN155 and 22% at site 17MN156.

The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. Site 17MN155 had zero fish that take three years or longer to mature, indicating that fish are quick to reproduce due to short life spans from the influence of human disturbance. Site 17MN156 had higher than average mature fish. Low DO values also correspond with

increased serial spawning fish percentage. Serial spawning occurs based on environmental stress. Station 17MN156 had a serial spawning percentage higher than the class average (Table 28).

Table 28. DO related fish metrics in the Upper Cottonwood HUC

		DO Related Fish Metrics		
Station	**WID**	MA>3 years Percentage	Serial Spawning Fish Pct	Fish Taxa Count
17MN155	**-617**	0	9.72	10
Statewide average for Class 3 Southern Headwaters stations that are meeting the FIBI General Use Threshold (55.0)		**2.06**	**17.09**	**12.16**
17MN156	**-503**	17.95	58.97	13
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**12.36**	**28.72**	**20**
Expected response to increased DO stress		↓	↑	↓

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed at each station. Seven intolerant macroinvertebrate taxa were collected at site 17MN155 and two were collected at site 17MN156 (Table 29). Both sites had DO tolerant percentages lower than the class average. Based on the limited DO values and the mixed metrics, low DO is inconclusive as a stressor to both reaches.

Table 29. DO related macroinvertebrate metrics in the Upper Cottonwood HUC

		DO related Macroinvertebrate metrics			
Station	**WID**	Percentage DO Tolerant Macroinvertebrates	HBI_MN	Intolerant DO Macroinvertebrate Taxa	DO Tolerant Index Score
17MN155	**-617**	2.22	7.79	7	7.11
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**8.62**	**7.04**	**8.97**	**7.09**
17MN156	**-503**	0.32	8.33	2	7.21
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**12.98**	**7.55**	**4.46**	**6.91**
Expected response to DO stress		↑	↑	↓	↑

Candidate cause: Eutrophication

Limited phosphorus values were collected on the two reaches (Table 30). All values were below the water quality standard of 0.150 mg/L. DO flux, chl-*a*, and BOD data was not available.

Table 30. Phosphorus values in the Upper Cottonwood HUC

Stream reach	# TP values	Range of TP values	# of values above 0.150 mg/L
Cottonwood River (-503)	1	0.109	0
Judicial Ditch 22 (-617)	2	0.098-0.098	0

Both stations had low percentages of sensitive and darter percentages (Table 31). Fish tolerant to disturbance were higher than average at each site 17MN155. Omnivorous fish have a positive relationship with nutrients. Stations 17MN156 had a higher than average omnivorous percentage.

Table 31. Eutrophication related fish metrics in the Upper Cottonwood HUC

		Eutrophication related Fish Metrics			
Station	**WID**	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct
17MN155	**-617**	0	4.17	86.11	6.94
Statewide average for Class 3 Southern Streams stations that are meeting the FIBI General Use Threshold (55.0)		**8.55**	**12.08**	**70.64**	**14.62**
17MN156	**-503**	0	0	41.03	20.51
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**18.65**	**11.68**	**44.85**	**16.53**
Expected response to increased Eutrophication stress		↓	↓	↑	↑

EPT percentages were high at both stations (Table 32), but the most common EPT species collected were tolerant including Cheumatopsyche, which can be abundant in eutrophic conditions. Based on the limited DO values and the mixed metrics, low DO is inconclusive as a stressor on the Cottonwood River (-503). Eutrophication is not a stressor to reach -617.

Table 32. Eutrophication related metrics in the Upper Headwaters

		Eutrophication related Macroinvertebrate metrics		
Station	**WID**	Invert Taxa	EPT Pct	Dominant 2 Invert CH Pct
17MN155	**-617**	34	52.53	28.48
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**42**	**43.90**	
17MN156	**-503**	27	72.35	57.23
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**37**	**38.45**	
Expected response to TP stress		↓	↓	↑

Candidate cause: Nitrates

Limited nitrate data was available ranging from 5.2 to 8.9 mg/L (Table 33). The highest value was collected on Judicial Ditch 22.

Table 33. Nitrate samples collected in the Upper Cottonwood River HUC

Stream reach	# nitrate values	Range of values (mg/L)
Cottonwood River (-503)	1	5.2
Judicial Ditch 22 (-617)	2	8.7-8.9

Sensitive fish species have a negative relationship with nitrate, but sensitive species are also affected by DO and phosphorus. Better relationships have been made with respect to macroinvertebrate impairment and nitrate concentration. Nitrate tolerant individuals comprised of 59.18% on the ditch and 76.6% of the macroinvertebrate communities on the Cottonwood River (Table 35). The intolerant taxa were 0 at both stations.

Increasing nitrate concentrations also have a negative relationship with nonhydropsychid Trichoptera (caddisfly) individual percentages. Nonhydropsychid Trichoptera are all caddisflies that do not spin nets. Values were below the class average of sites meeting the threshold on both sites. Based on the lack of elevated nitrate values and the preponderance of metric values, nitrate is not a stressor to the headwaters of the Cottonwood River. Both reaches had indications of nitrate stress. However, based on the lack of elevated nitrogen values, nitrate is inconclusive as a stressor.

Table 34. Nitrate related metrics in the Upper Cottonwood HUC

		Nitrate related Macroinvertebrate metrics			
Station	**WID**	TrichwoHydroPct	N % Tolerant Taxa	N Intolerant Taxa	Nitrogen TIV
17MN155	**-617**	3.79	59.18	0	3.98
Statewide average for Class 5 Southern Streams RR stations meeting the MIBI General Use Threshold (37.0)		**5.94**	**47.60**	**2.92**	**2.95**
17MN156	**-503**	2.89	76.60	0	3.86
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**4.02**	**54.87**	**3.18**	**3.23**
Expected response to Nitrate stress		↓	↑	↓	↑

Candidate cause: Sediment

Limited TSS values were available on the unnamed creeks, all values below 56 mg/L (Table 35). Additionally, secchi tube measurements ranged from 5 to 45, with 10 values (55%) below the standard of 10. Secchi measurements on the Judicial Ditch ranged from 19->100 cm.

Table 35. Suspended sediment values in the Upper Cottonwood HUC

Stream reach	# TSS values	Range of values (mg/L)	# of values above 65 mg/L
Cottonwood River (-503)	1	46	0
Judicial Ditch 22 (-617)	1	56	0

Fish species that are specifically tolerant and intolerant to TSS were analyzed at each station. Intolerant fish were absent from both sites. DO tolerant species were less than 1% at site 17MN155 and were 47% at site 17MN156. Herbivore species of fish decrease as TSS values increase. Both sites had herbivore percentages lower than the average of sites meeting the IBI thresholds. Perciforms species (smallmouth bass, walleye, etc.) have been demonstrated to decrease as TSS increases. Perciform percentages were also low at both stations (Table 36).

Table 36. TSS related fish metrics in the Upper Cottonwood HUC

		TSS related fish metrics					
Station	**WID**	BenFdFrimPct	Centr-TolPct	HerbvPct	Percfm-TolPct	IntolerantPct	Longlived Pct
17MN155	**-617**	16.67	0	6.94	4.17	0	0
Statewide average for Class 3 Southern Streams stations meeting the FIBI General Use Threshold (55.0)		**37.83**	**0.89**	**13.33**	**13.93**	**1.95**	**3.56**
17MN156	**-503**	11.54	0	0	2.56	0	16.67
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**37.38**	**4.89**	**9.61**	**18.66**	**4.97**	**11.68**
Expected response to TSS stress		↓	↓	↓	↓	↓	↓

TSS intolerant macroinvertebrates were absent at both stations and both stations had higher than average TSS tolerant percentages (Table 37). The long-lived percentage were lower than or near average at both sites. Collector-filterer percentages were lowered at site 17MN155 but not site 17MN156. Plecoptera were lowered absent at both stations. Based on the limited TSS data and the mixed metrics, TSS is inconclusive as a stressor on the Cottonwood River (-503) and JD 22 (-617).

Table 37. TSS related macroinvertebrate metrics in the Upper Cottonwood HUC

		TSS related Macroinvertebrate metrics					
Station	**WID**	TSS Index Score	TSS Intolerant Taxa	TSS Tolerant Pct	Collector Filterer Pct	Plectoptera Pct	Long-lived Pct
17MN155	**-617**	3.98	0	59.18	45.23	0	6.01
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**15.87**	**3**	**35.23**	**4.56**	**0.54**	**8.99**
17MN156		3.86	0	76.60	18.00	0	8.04
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)	**-503**	**17.78**	**1.33**	**48.28**	**19.13**	**0.22**	**7.99**
Expected response to stress		↑	↓	↑	↓	↓	↓

Candidate cause: Lack of habitat

The MSHA score at station 17MN156 was poor at 33, and fair at station 17MN155 with a score of 51. The score was lowered at station 17MN155 by heavy erosion, moderate embeddedness of coarse substrates with fine sediments, and low channel stability. The score was lowered at station 17MN156 by severe bank erosion, a lack of different substrates, and poor channel development with no riffles present. Comment during invert visit, “Extensive erosion and aggradation, unstable channel”. “Site is in much worse condition than upstream site 01MN042, silt-dominated rather than sand-dominated substrate.”

Simple lithophilic spawners, which require coarse substrate for spawning, typically decrease in numbers with limited habitat. Percentages were lower than average at both sites. Benthic insectivores, darter, sculpin, and sucker, and Piscivore individuals were lowered at both sites also (Table 38). Darters are sensitive to siltation and riffle species tend to decrease due to lack of habitat. Riffle species were below average at both sites.

Table 38. Habitat related fish metrics on the Upper Cottonwood HUC

		Habitat Related Fish Metrics							
Station	**WID**	BenInsect-TolPct	SLithopPct	DarterSculpSucPct	RiffePct	PiscivorePct	LithFrimPct	TolPct	PioneerPct
17MN155	**-617**	4.17	25	4.17	12.5	0	86.11	86.11	62.5
Statewide average for Class 3 Southern Streams stations meeting the FIBI General Use Threshold (55.0)		**14.22**	**33.71**	**12.55**	**28.33**	**1.62**	**69.21**	**70.64**	**37.79**
17MN156	**-503**	15.38	30.77	15.38	6.41	0	33.33	41.03	21.79
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**20.39**	**39.38**	**18.18**	**32.49**	**5.24**	**58.26**	**44.85**	**19.02**
Expected response to Habitat stress		↓	↓	↓	↓	↓	↓	↑	↑

Clingers need coarse substrates and decrease with the increase in percent fines. The percentages of clingers were below average at sites 17MN156 (Table 39). Burrowers and legless individuals are a signal of high levels of sedimentation. Burrowers and legless percentages were only slightly increased at site 17MN155. EPT percentages were above class average at both stations, however the highest number of EPT were Tricorythodes at site 17MN156 which are tolerant to sediment. Based on the lowered habitat scores and preponderance of evidence, lack of habitat is stressor on both reaches.

Table 39. Habitat related macroinvertebrate metrics in the Upper Cottonwood HUC

		Habitat related Macroinvertebrate metric				
Station	**WID**	BurrowerPct	ClimberPct	ClingerPct	EPTPct	LeglessPct
17MN155	**-617**	2.85	31.01	53.48	52.53	38.61
Statewide average for Class 5 Southern Streams RR stations meeting the MIBI General Use Threshold (41.0)		**7.54**	**14.71**	**49.54**	**42.46**	**36.03**
17MN156	**-503**	3.86	9.00	28.62	72.35	17.36
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI General Use Threshold (41.0)		**7.51**	**21.59**	**38.50**	**38.45**	**39.76**
Expected response to Habitat stress		↑	↓	↓	↓	↑

Candidate cause: Altered hydrology

Reach -617 is altered upstream of station 17MN155 on Judicial Ditch 22. Generalist fish species, which are adaptable to different habitats through generalized food preferences, are correlated with channelization. Site 17MN155 had a population of generalist fish of 83.3%. The numbers of nest guarder

species are also positively correlated with increased low flows. The nest guarder species had a population of 8.3%. Long-lived macroinvertebrates decrease with flow changes as they are not able to stay in one place as conditions change. The range of long-lived macroinvertebrates was 6.01%. The channelization is likely contributing to the lack of habitat and is a contributing stressor to the biological communities.

Candidate cause: Connectivity

There are two impoundments upstream of station 17MN155, but connectivity exists between the tributary and the Cottonwood River. Headwater species were present at 9.72%, which is below class average and could be affected by the barriers to fish migration. Connectivity is not a stressor on the ditch.

In 2016, the DNR began the process of removing three dams along the Cottonwood River; one in Kuhar Park north of Lamberton (located in this HUC), and two downstream near Sanborn (in the Middle Cottonwood HUC where the Cottonwood is not impaired). The dams will be replaced with more natural structures that will allow for fish migration. Construction on Kuhar Park dam began January 2020.

Summary and recommendations

The Upper Cottonwood HUC contains two biologically impaired reaches. Habitat and altered hydrology were stressors in this watershed (Table 40). Further DO, TSS, and nutrient data would help further determine their impacts.

Table 40. Stressors in the Upper Cottonwood HUC

	Stressors:						
Stream name	**Dissolved oxygen**	**Eutrophication**	**Nitrate**	**Suspended sediment**	**Habitat**	**Altered hydrology**	**Connectivity**
Cottonwood River (-503)	o	o	o	o	●	---	---
Judicial Ditch 22 (-617)	o	---	o	o	●	●	---

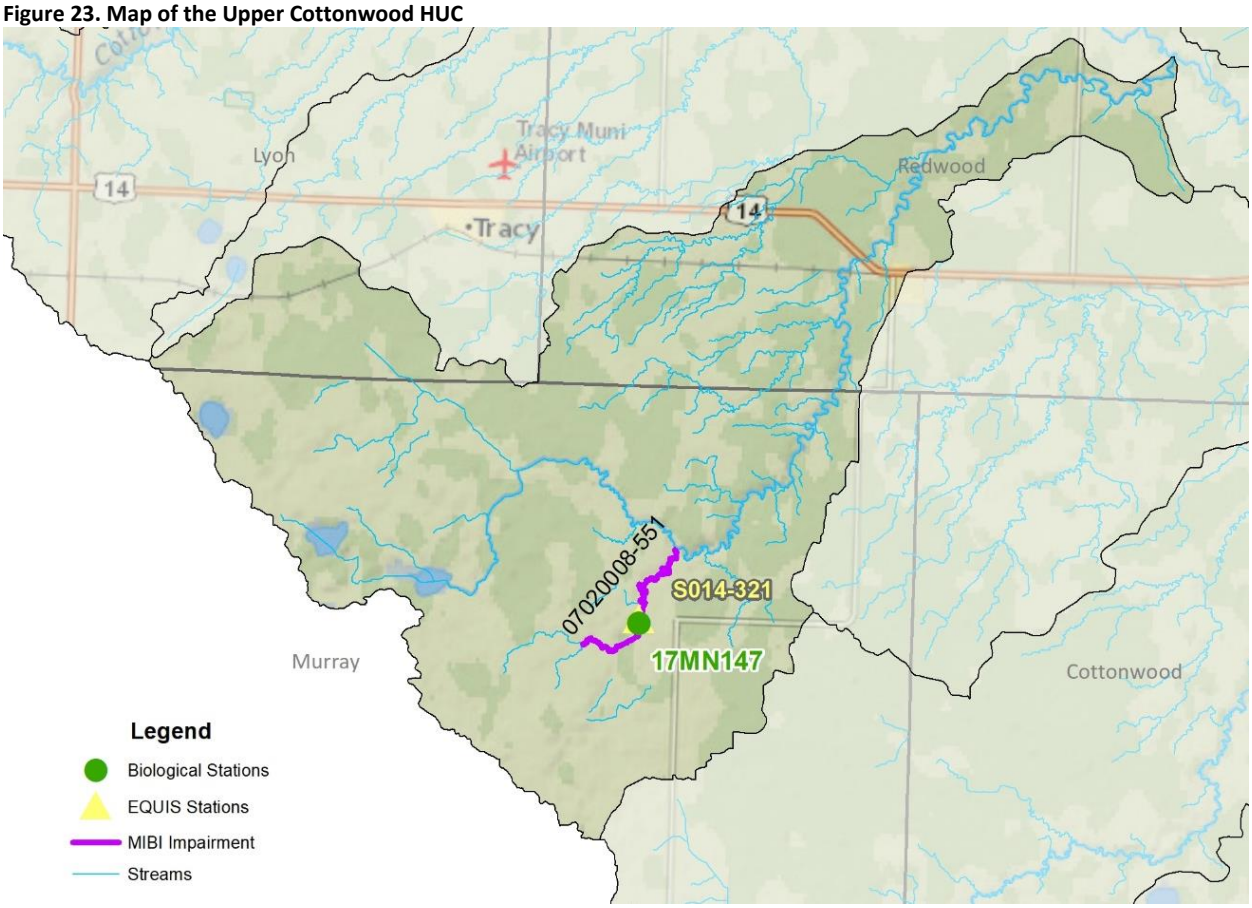
● = stressor; o = inconclusive stressor; --- = not an identified stressor

Plum Creek 12-digit HUC

This aggregated HUC includes Plum Creek and its watershed (Figure 23). The watershed has the following impairment:

- Willow Creek (-551) impaired by macroinvertebrates (17MN147, S014-321)

Figure 23. Map of the Upper Cottonwood HUC



Candidate cause: Dissolved oxygen

Limited DO values on Willow Creek ranged from 8.26 mg/L to 10.28 mg/L (Table 41), all above the water quality standard of 5 mg/L.

Table 41. DO data in the Plum Creek HUC

Stream reach	# DO values	Range of DO values	# of values below 5 mg/L
Willow Creek (-551)	3	8.26-10.28	0

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed. Six intolerant macroinvertebrate taxa were collected, and the DO tolerant percentage was 17.6 (Table 42). The intolerant taxa were below average, and the tolerant percentage was above average. There were some indications of DO is a stressor to the biological metrics, but more DO data would be helpful. Low DO is inconclusive as a stressor.

Table 42. DO related metrics in the Plum Creek HUC

		DO Related Macroinvertebrate Metrics			
Station	**WID**	Percentage DO Tolerant Macroinvertebrates	HBI_MN	Intolerant DO Macroinvertebrate Taxa	DO Tolerant Index Score
17MN147	**-551**	17.57	7.32	6	7.19
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**8.62**	**7.04**	**8.97**	**7.09**
Expected response to DO stress		↑	↑	↓	↑

Candidate cause: Eutrophication

Limited phosphorus values on Willow Creek were below 0.100 mg/L (Table 43). Both values were below the water quality standard of 0.150 mg/L. DO flux, chl-*a*, and BOD data was not available.

Table 43. Phosphorus data in the Plum Creek HUC

Stream reach	# TP values	Range of TP values	# of values above 0.150 mg/L
Willow Creek (-551)	2	0.066-0.071	0

The EPT percentage was higher than the class average but there were high numbers of species tolerant to eutrophic conditions (Table 44). The number of macroinvertebrate taxa were lower than average, but the site was not dominated by two species. More phosphorus data would be useful, eutrophication is not a stressor at this time.

Table 44. Eutrophication related metrics in the Plum Creek HUC

		Eutrophication Related Macroinvertebrate Metrics		
Station	**WID**	Invert Taxa	EPT Pct	Dominant 2 Invert CH Pct
17MN147	**-551**	35	47.60	31.31
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**42**	**43.90**	
Expected response to TP stress		↓	↓	↑

Candidate cause: Nitrates

The limited phosphorus values on Willow Creek were both below 6.5 mg/L (Table 45).

Table 45. Nitrate samples collected in the Plum Creek HUC

Stream reach	# nitrate values	Range of values (mg/L)
Willow Creek (-551)	2	3.3-6.5

Nitrate tolerant individuals comprised of 34.5% of the macroinvertebrate community and no intolerant taxa were collected (Table 46). Increasing nitrate concentrations also have a negative relationship with nonhydropsychid Trichoptera (caddisfly) individual percentages. Nonhydropsychid Trichoptera are all caddisflies that do not spin nets. The percentage was below the class average of sites meeting the threshold. More nitrate values would be helpful, but nitrate is not a stressor at this time.

Table 46. Nitrate related metrics in the Plum Creek HUC

		Nitrate related Macroinvertebrate Metrics			
Station	**WID**	TrichwoHydroPct	N % Tolerant Taxa	N Intolerant Taxa	Nitrogen TIV
17MN147	**-551**	0.96	34.50	0	3.03
Statewide average for Class 5 Southern Streams RR stations meeting the MIBI General Use Threshold (37.0)		**5.94**	**47.60**	**2.92**	**2.95**
Expected response to Nitrate stress		↓	↑	↓	↑

Candidate Cause: Sediment

Only one TSS value is available on the reach, with a value of 10 mg/L (Table 47). Three secchi measurements ranged from 46 to 82 cm, all above the water quality standard of 10 cm.

Table 47. TSS values in the Plum Creek HUC

Stream reach	# TSS values	Range of values (mg/L)	# of values above 65 mg/L
Willow Creek (-551)	1	10	0

No TSS intolerant macroinvertebrates were absent and the TSS tolerant percentage was slightly higher than average of sites meeting the threshold (Table 48). The long-lived percentage were lower than average. Collector-filterer percentages was much higher than average and Plecoptera numbers were zero. While there are indications of TSS as a stressor on the tributaries, more TSS data would be helpful. TSS is inconclusive as a stressor.

Table 48. TSS related metrics in the Plum Creek HUC

		TSS related Macroinvertebrate metrics					
Station	**WID**	TSS Index Score	TSS Intolerant Taxa	TSS Tolerant Pct	Collector Filterer Pct	Plectoptera Pct	Long-lived Pct
17MN147	**-551**	16.02	0	36.10	47.28	0	4.47
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**15.87**	**3**	**35.23**	**4.56**	**0.54**	**8.99**
Expected response to stress		↑	↓	↑	↓	↓	↓

Candidate cause: Lack of habitat

Habitat conditions were shown to be good with a MSHA score of 69. Limits to the habitat included fair sinuosity and an eroding bank (Figure 24).

Figure 24. Eroding bank at site 17MN147

Clingers need coarse substrates and decrease with the increase in percent fines. The percentages of clingers were above average (Table 49). Burrowers and legless individuals are a signal of high levels of sedimentation. Burrowers and legless percentages were both below average. EPT percentages were above class average but were dominated by tolerant species. Reach -551 had a good MSHA score but there were some indications of stress from a lack of habitat. Lack of habitat is inconclusive as a stressor.

Table 49. Habitat related metrics in the Plum Creek HUC

		Habitat related Macroinvertebrate Metrics				
Station	**WID**	BurrowerPct	ClimberPct	ClingerPct	EPTPct	LeglessPct
17MN147	**-551**	3.83	9.59	61.66	47.60	20.77
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**7.54**	**14.71**	**49.54**	**42.46**	**36.03**
Expected response to Habitat stress		↑	↓	↓	↓	↑

Candidate cause: Altered hydrology

The upstream reach is natural, but station 17MN147 was channelized. Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency, increasing the impact of high flow events and increasing the intensity of low flow periods, both of which affect biological communities. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting species that rely on clean substrate for habitat. Flows that are reduced beyond normal baseflow decrease living space for aquatic organisms and increase competition for resources.

Long-lived macroinvertebrates decrease with flow changes as they are not able to stay in one place as conditions change. The percentage of long-lived macroinvertebrates was 4.48%. Altered hydrology is a stressor to the macroinvertebrate community.

Summary and recommendations

The Plum Creek HUC contains one biologically impaired reach. Altered hydrology is the stressor in this watershed (Table 50). Further DO, TSS, and nutrient data would help further determine their impacts.

Table 50. Stressors in the Plum Creek HUC

	Stressors:						
Stream name	**Dissolved oxygen**	**Eutrophication**	**Nitrate**	**Suspended sediment**	**Habitat**	**Altered hydrology**	
Willow Creek (-551)	o	---	---	o	o	●	

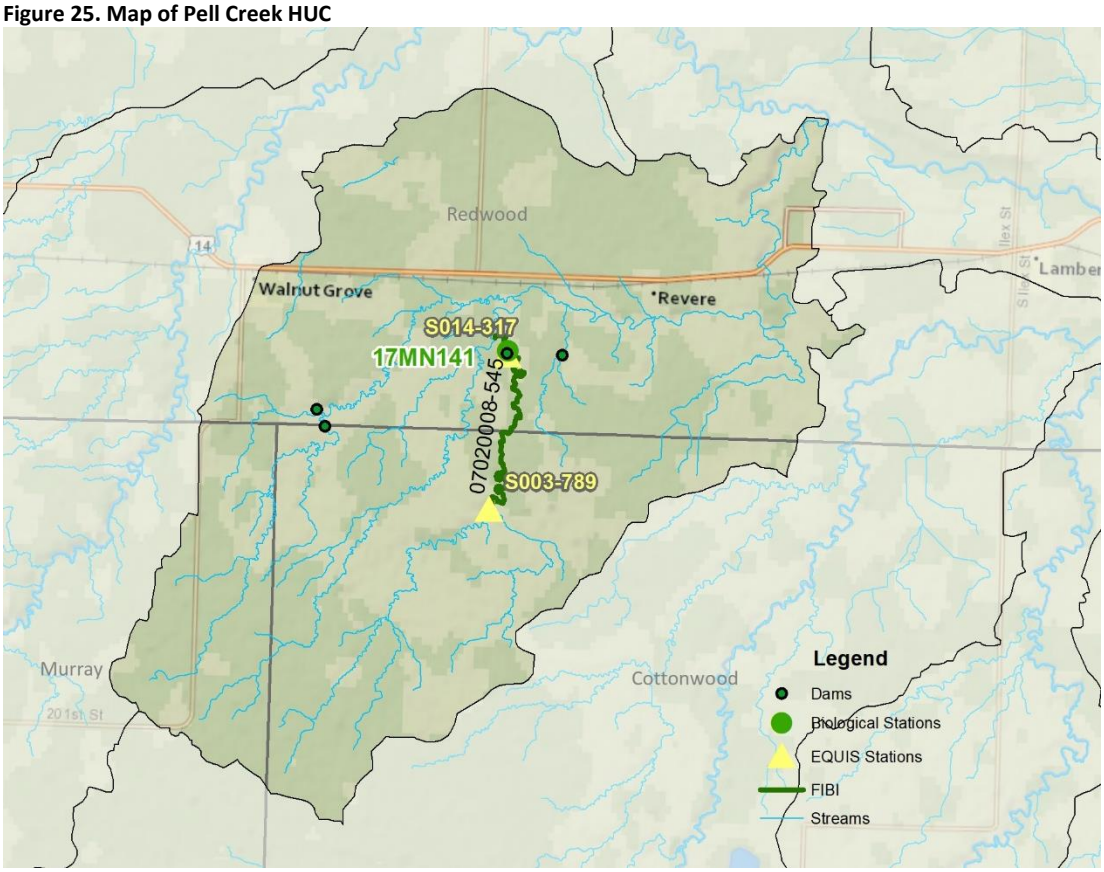
● = stressor; o = inconclusive stressor; --- = not an identified stressor

Pell Creek 12-digit HUC

This aggregated HUC includes Pell Creek and its watershed (Figure 25). The watershed has the following impairment:

- Unnamed creek (Tributary to Pell Creek) (-545) impaired by macroinvertebrates and fish (17MN141, S003-789, S014-317)

Figure 25. Map of Pell Creek HUC



Candidate cause: Dissolved oxygen

Limited DO values on the tributary to Pell Creek ranged from 9.46 mg/L to 12.3 mg/L (Table 51), all above the water quality standard of 5 mg/L.

Table 51. DO data in the Pell Creek HUC

Stream reach	# DO values	Range of DO values	# of values below 5 mg/L
Unnamed Creek (-545)	3	9.46-12.3 mg/L	0

Fish species that are specifically tolerant and intolerant to DO were analyzed. There were no intolerant fish at either station, but the DO tolerant percentage was less than 1% at site.

The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. Site 17MN141 had 0 fish that take three years or longer to mature, indicating that fish are quick to reproduce due to short life spans from the influence of human disturbance. Low DO values also correspond with increased serial spawning fish percentage. Serial spawning occurs based on environmental stress. Station 17MN141 had a serial spawning percentage lower than the class average (Table 52).

Table 52. DO related fish metrics in the Pell Creek HUC

		DO Related Fish Metrics		
Station	**WID**	MA>3 years Percentage	Serial Pawning Fish Pct	Fish Taxa Count
17MN141	**-545**	0	13.30	10
Statewide average for Class 3 Southern Headwaters stations that are meeting the FIBI General Use Threshold (55.0)		**2.06**	**17.09**	**12.16**
Expected response to increased DO stress		↓	↑	↓

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed. Six intolerant macroinvertebrate taxa were collected, and the DO tolerant percentage was 17.6 (Table 53). The intolerant taxa were below average, and the tolerant percentage was above average. There were some indications of DO is a stressor to the biological metrics, but more DO data would be helpful. Low DO is inconclusive as a stressor.

Table 53. Eutrophication related macroinvertebrate metrics in the Pell Creek HUC

		DO Related Macroinvertebrate Metrics			
Station	**WID**	Percentage DO Tolerant Macroinvertebrates	HBI_MN	Intolerant DO Macroinvertebrate Taxa	DO Tolerant Index Score
17MN141	**-545**	5.96	7.91	5	6.89
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**12.98**	**7.55**	**4.46**	**6.91**
Expected response to DO stress		↑	↑	↓	↑

Candidate cause: Eutrophication

Limited phosphorus values on the creek were both below 0.100 mg/L (Table 54). Both values were also below the water quality standard of 0.150 mg/L. DO flux, chl-*a*, and BOD data was not available.

Table 54. Phosphorus values in the Pell Creek HUC

Stream reach	# TP values	Range of TP values	# of values above 0.150 mg/L
Unnamed Creek (-545)	2	0.055-0.057	0

Site 17MN141 had low percentages of sensitive and darter percentages (Table 55). Fish tolerant to disturbance were higher than average. Omnivorous fish have a positive relationship with nutrients. Site 17MN141 had a lower-than-average omnivorous percentage.

Table 55. Eutrophication related fish metrics in the Pell Creek HUC

		Eutrophication related Fish Metrics			
Station	**WID**	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct
17MN141	**-545**	**0**	**4.43**	**94.09**	**4.93**
Statewide average for Class 3 Southern Streams stations that are meeting the FIBI General Use Threshold (55.0)		**8.55**	**12.08**	**70.64**	**14.62**
Expected response to increased Eutrophication stress		↓	↓	↑	↑

The EPT percentage was higher than the class average but there were high numbers of species tolerant to eutrophic conditions (Table 56). The second most sampled macroinvertebrate was in the genus *Cheumatopsyche,* which is fairly tolerant and could show high numbers in a eutrophication situation. The number of macroinvertebrate taxa were lower than average, but the site was not dominated by two species. More phosphorus data would be useful, eutrophication is not a stressor at this time.

Table 56. Eutrophication related macroinvertebrate metrics in the Pell Creek HUC

		Eutrophication Related Macroinvertebrate Metrics		
Station	**WID**	Invert Taxa	EPT Pct	Dominant 2 Invert CH Pct
17MN141	**-545**	32	42.71	36.09
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**37**	**38.45**	
Expected response to TP stress		↓	↓	↑

Candidate cause: Nitrates

The limited nitrate values on the creek ranged from 4 to 9.1 mg/L (Table 57).

Table 57. Nitrate samples collected in the Mound Creek HUC

Stream reach	# nitrate values	Range of values (mg/L)
Unnamed Creek (-545)	2	4-9.1

Sensitive fish species have a negative relationship with nitrate, but sensitive species are also affected by DO and phosphorus. Better relationships have been made with respect to macroinvertebrate impairment and nitrate concentration. Nitrate tolerant individuals comprised of 72.19% of the macroinvertebrate community (8). There were zero intolerant taxa.

Increasing nitrate concentrations also have a negative relationship with nonhydropsychid Trichoptera (caddisfly) individual percentages. Nonhydropsychid Trichoptera are all caddisflies that do not spin nets. The percentage was below the class average of sites meeting the threshold. The reach had indications of nitrate stress, but more nitrate values would be helpful. Nitrate is inconclusive as a stressor.

Table 58. Nitrate related metrics in the Pell Creek HUC

		Nitrate related Macroinvertebrate Metrics			
Station	**WID**	TrichwoHydroPct	N % Tolerant Taxa	N Intolerant Taxa	Nitrogen TIV
17MN141	**-545**	2.98	72.19	0	3.93
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**4.02**	**54.87**	**3.18**	**3.23**
Expected response to Nitrate stress		↓	↑	↓	↑

Candidate cause: Sediment

Only one TSS value is available on the creek, with a value of 8 mg/L (Table 59). Secchi measurements ranged from 23 to 76 cm. No secchi measurements were below the standard of 10 cm.

Table 59. Sediment values in the Pell Creek HUC

Stream reach	# TSS values	Range of values (mg/L)	# of values above 65 mg/L
Unnamed Creek (-545)	1	8	0

Fish species that are specifically tolerant and intolerant to TSS were analyzed at each station. Intolerant fish were absent from both sites. However, DO tolerant species were also absent. Herbivore species of fish decrease as TSS values increase. The herbivore percentage was lower than the average of sites meeting the IBI threshold. Perciforms species (smallmouth bass, walleye, etc.) have been demonstrated to decrease as TSS increases. Perciform percentages were also low (Table 60).

Table 60. TSS related fish metrics in the Pell Creek HUC

		TSS related Fish Metrics					
Station	**WID**	BenFdFrimPct	Centr-TolPct	HerbvPct	Percfm-TolPct	IntolerantPct	Longlived Pct
17MN141	**-545**	9.85	0	4.43	4.43	0	0
Statewide average for Class 3 Southern Streams stations meeting the FIBI General Use Threshold (55.0)		**37.83**	**0.89**	**13.33**	**13.93**	**1.95**	**3.56**
Expected response to TSS stress		↓	↓	↓	↓	↓	↓

TSS intolerant macroinvertebrates were absent and the TSS tolerant percentage was higher than average of sites meeting the threshold (Table 61). The long-lived percentage were lower than average. The collector-filterer percentages was higher than average and Plecoptera numbers were zero. While there are indications of TSS as a stressor on the tributaries, more TSS data would be helpful. TSS is inconclusive as a stressor.

Table 61. TSS related macroinvertebrate metrics in the Pell Creek HUC

		TSS related Macroinvertebrate Metrics					
Station	**WID**	TSS Index Score	TSS Intolerant Taxa	TSS Tolerant Pct	Collector Filterer Pct	Plectoptera Pct	Long-lived Pct
17MN141	**-545**	18.09	0	59.27	31.13	0	4.97
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**17.78**	**1.33**	**48.28**	**19.13**	**0.22**	**7.99**
Expected response to stress		↑	↓	↑	↓	↓	↓

Candidate cause: Lack of habitat

Site 17MN141 had a MSHA score of 53, a fair rating of the habitat conditions. The score was lowered by moderate erosion, sparse cover amount (Figure 26) and only moderate stability. The macroinvertebrate samplers noted there was not much habitat to sample.

Figure 26. Lack of habitat at site 17MN141 (8/15/2017)

Simple lithophilic spawners, which require coarse substrate for spawning, typically decrease in numbers with limited habitat. Percentages were lower than average. Benthic insectivores, darter, sculpin, and

sucker, and Piscivore individuals were all lowered (Table 62). Darters are sensitive to siltation and riffle species tend to decrease due to lack of habitat. Riffle species were below average.

Table 62. Habitat related fish metrics in the Pell Creek HUC

		Habitat Related Fish Metrics							
Station	**WID**	BenInsect-TolPct	SLithopPct	DarterSculpSucPct	RiffePct	PiscivorePct	LithFrimPct	TolPct	PioneerPct
17MN141	**-545**	4.43	21.67	4.43	5.91	0	82.76	94.09	64.53
Statewide average for Class 3 Southern Streams stations meeting the FIBI General Use Threshold (55.0)		**14.22**	**33.71**	**12.55**	**28.33**	**1.62**	**69.21**	**70.64**	**37.79**
Expected response to Habitat stress		↓	↓	↓	↓	↓	↓	↑	↑

Clingers need coarse substrates and decrease with the increase in percent fines. The percentages of clingers were slightly above average (Table 63). Burrowers and legless individuals are a signal of high levels of sedimentation. The legless individuals were above average. EPT percentages were above class average. Based on the fair MSHA score and the preponderance of evidence, lack of habitat is a stressor.

Table 63. Habitat related macroinvertebrate metrics in the Pell Creek HUC

		Habitat related Macroinvertebrate Metrics				
Station	**WID**	BurrowerPct	ClimberPct	ClingerPct	EPTPct	LeglessPct
17MN141	**-545**	6.62	29.47	39.40	42.72	47.35
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI General Use Threshold (41.0)		**7.51**	**21.59**	**38.50**	**38.45**	**39.76**
Expected response to Habitat stress		↑	↓	↓	↓	↑

Candidate Cause: Altered hydrology

The reach is completely natural with a few small channelized tributaries (Figure 27). In October of 2020, the creek was intermittent. The numbers of nest guarder species are also positively correlated with increased low flows. Nest guarder individuals comprised 7.88% of the population. Long-lived macroinvertebrates decrease with flow changes as they are not able to stay in one place as conditions change. Long lived macroinvertebrate individuals comprised 4.97% of the community. The lack of flow is a stressor to the biological communities.

Figure 27. Intermittent flow at site 17MN141 (10/16/2020)

Candidate cause: Connectivity

Connectivity is another important aspect of hydrology. Fish migration is dependent on stream connectivity. An inverted culvert at the road crossing is preventing fish migration based on flow velocity (Figure 28 and Figure 29).

Figure 28. Culvert on downstream side of road (5/22/2019)

Figure 29. Culvert on upstream side of road (5/22/2019)

Summary and recommendations

The Pell Creek HUC contains one biologically impaired reach. Habitat, altered hydrology, and connectivity are the stressors in this watershed (Table 64). Further DO, TSS, and nutrient data would help further determine their impacts. Fixing the road culvert would fix the fish migration barrier.

Table 64. Stressors in the Pell Creek HUC

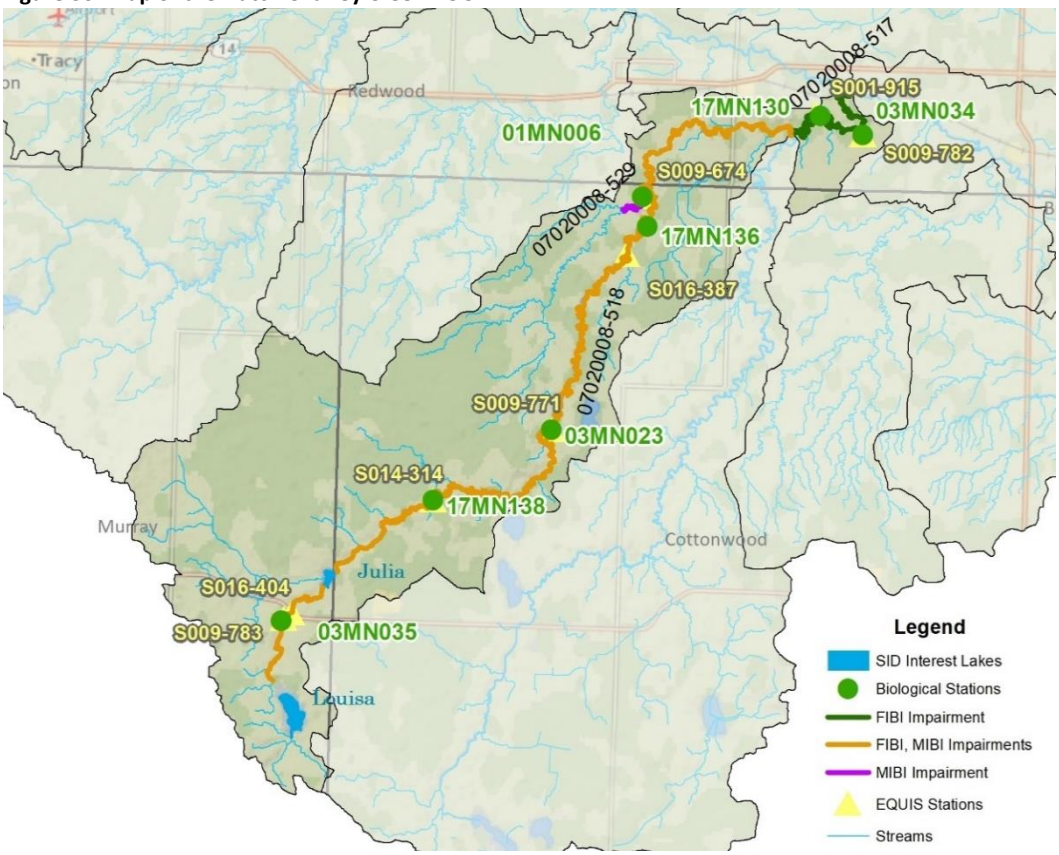
	Stressors:						
Stream name	**Dissolved oxygen**	**Eutrophication**	**Nitrate**	**Suspended sediment**	**Habitat**	**Altered hydrology**	**Connectivity**
Unnamed Creek (-545)	---	---	o	o	●	●	●

● = stressor; o = inconclusive stressor; --- = not an identified stressor

Dutch Charley Creek 12-digit HUC

- This aggregated HUC includes Dutch Charley Creek and its tributaries (Figure 30). The watershed has the following impairments:
- Dutch Charley Creek (-518) impaired by macroinvertebrates and fish (03MN023, 03MN035, 17MN136, 17MN138) and Turbidity
- Dutch Charley Creek (-517) impaired by fish (17MN130, S001-915, S009-782) and Turbidity
- Unnamed creek (-529) impaired by macroinvertebrates (01MN006, S009-674, S015-365)

Figure 30. Map of the Dutch Charley Creek HUC



Candidate cause: Dissolved oxygen

Values in this HUC ranged from 1.50 mg/L to 12.47 mg/L (Table 65). The lowest values were collected at stations S016-404 and S009-783, located in the headwaters of the creek and downstream of a wetland complex (Figure 31). Elevated DO values were collected both on Dutch Charley Creek and its tributaries.

Table 65. DO values in the Dutch Charley HUC

Stream reach	# DO values	Range of DO values	# of values below 5 mg/L
Dutch Charley Creek (-517)	23	7.30-12.47 mg/L	0
Dutch Charley Creek (-518)	15	1.50-9.55	4
Unnamed creek (-529)	3	8.29-12.27 mg/L	0

Figure 31. Wetland plants growing near Hwy 30 in the headwaters of the creek (7/10/2020)

Fish species that are specifically tolerant and intolerant to DO were analyzed. There were no intolerant fish at any of the stations, and the DO tolerant percentages ranged from 10% to 98%. DO tolerant fish increased from 67% in 2003 to 98% in 2017 at site 03MN035. They also increased from less than 1% in 2001 to 24% in 2017 at site 01MN006.

The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. All sites had lower than average fish that take three years or longer to mature, indicating that fish are quick to reproduce due to short life spans from the influence of human disturbance. Low DO values also correspond with increased serial spawning fish percentage. Serial spawning occurs based on environmental stress. Sites 03MN035 and 17MN130 had serial spawning percentage higher than the class averages (Table 66).

Table 66. DO related fish metrics in the Dutch Charley HUC

		DO Related Fish Metrics		
Station	**WID**	MA>3 years Pct	Serial Spawning Fish Pct	Fish Taxa Count
03MN035	**-518**	0	41.67	9
01MN006	**-529**	0	2.70	9
Statewide average for Class 3 Southern Headwaters stations meeting the FIBI General Use Threshold (55.0)		**2.06**	**17.09**	**12.16**
17MN138	**-518**	0	8.89	12
17MN136	**-518**	1.60	12	14
17MN130	**-517**	2.26	49.22	27
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**12.36**	**28.72**	**20**
Expected response to increased DO stress		↓	↑	↓

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed. Intolerant macroinvertebrate taxa ranged from 0 to 11, and the DO tolerant percentages ranged from 1.5 to 71.3 (Table 67). Based on the DO values and metrics, DO is a limited stressor to the headwaters of Dutch Charley Creek near station 03MN035 (-518). DO is not a stressor to the tributary or the lower reach of Dutch Charley Creek (-517).

Table 67. DO related macroinvertebrate metrics in the Dutch Charley Creek HUC

		DO Related Macroinvertebrate Metrics			
Station	**WID**	Percentage DO Tolerant Macroinvertebrates	HBI_MN	Intolerant DO Macroinvertebrate Taxa	DO Tolerant Index Score
01MN006	**-529**	1.25	7.80	7	7.52
03MN035	**-518**	71.25	7.63	0	5.93
17MN136	**-518**	13.0	7.93	6	6.54
17MN130	**-517**	1.86	7.35	11	6.97
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**12.98**	**7.55**	**4.46**	**6.91**
17MN138	**-518**	1.54	7.70	3	7.51
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**8.62**	**7.04**	**8.97**	**7.09**
Expected response to DO stress		↑	↑	↓	↑

Candidate cause: Eutrophication

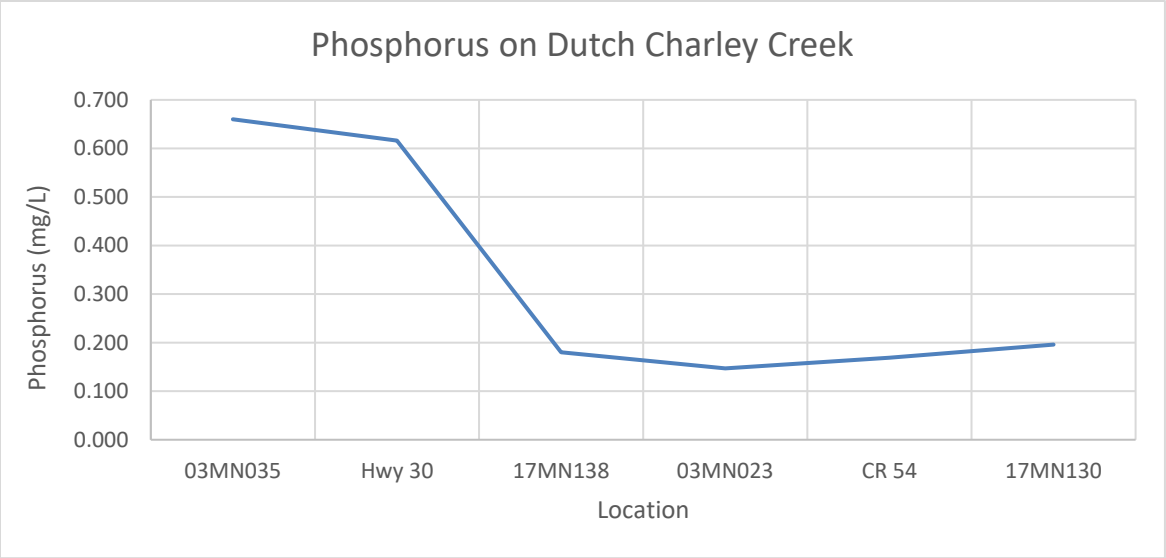
Recent phosphorus data on tributaries to Dutch Charley Creek ranged from 0.039 to 0.674 mg/L (Table 68). The limited phosphorus data on the unnamed creek was below the southern water quality standard of 0.150 mg/L. The highest phosphorus values were collected in the headwaters at site 03MN035. Longitudinal sampling had five of the six samples above the water quality standard (Figure 32).

Chl-*a*, BOD, and DO fluctuations values are a proximate measurement of eutrophication and have more direct impacts on biology than phosphorus. Fifteen chl-*a* values were available, with one value (49) above the southern standard of 35 on reach -517. There was no BOD or DO flux data available.

Table 68. Phosphorus data in the Dutch Charley Creek HUC

Stream reach	# TP values	Range of TP values	# of values above 0.150 mg/L
Dutch Charley Creek (-517)	21	0.039-0.284	9
Dutch Charley Creek (-518)	12	0.106-0.674	9
Unnamed creek (-529)	2	0.05-0.057	0

Figure 32. Longitudinal phosphorus sampling



Sensitive and darter percentages were low at all the stations (Table 69). Fish tolerant to disturbance were higher than average at each site. Omnivorous fish have a positive relationship with nutrients. All sites had higher than average omnivorous percentages except for sites 17MN130 and 17MN138.

Table 69. Eutrophication related fish metrics in the Dutch Charley Creek HUC

		Eutrophication related Fish Metrics			
Station	**WID**	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct
03MN035	**-518**	2.78	2.22	97.22	42.78
01MN006	**-529**	1.35	1.35	91.89	16.22
Statewide average for Class 3 Southern Headwater stations meeting the FIBI General Use Threshold (55.0)		**8.55**	**12.08**	**70.64**	**14.62**
17MN138	**-518**	4.44	6.67	83.33	6.67
17MN136	**-518**	4	4.80	63.20	19.20
17MN130	**-517**	3.96	5.52	65.21	2.55
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**18.65**	**11.68**	**44.85**	**16.53**
Expected response to increased Eutrophication stress		↓	↓	↑	↑

The EPT percentage was higher than the class average at stations 01MN006, 17MN130, and 17MN138, however the most common species were Cheumatopsyche, which is fairly tolerant and can show high numbers in an eutrophication situation. The number of macroinvertebrate taxa were lower than average at sites 01MN006, 03MN035, and 17MN138. Sites 01MN006 and 03MN035 were dominated by two species (Table 70). Based on elevated phosphorus values and the biological response, eutrophication is a stressor in the upper reach of Dutch Charley on reach -518. Eutrophication is inconclusive as a stressor on the lower reach (-517) and the unnamed creek (-529).

Table 70. Eutrophication related macroinvertebrate metrics in the Dutch Charley HUC

		Eutrophication Related Macroinvertebrate Metrics		
Station	**WID**	Invert Taxa	EPT Pct	Dominant 2 Invert CH Pct
01MN006	-529	29	86.52	61.76
03MN035	-518	22	0.31	68.13
17MN136	-518	49	46.13	30.34
17MN130	-517	43	57.19	19.06
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		37	38.45	
17MN138	-518	28	68.42	43.65
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		42	43.90	
Expected response to TP stress		↓	↓	↑

Candidate Cause: Nitrates

Limited data was available near the mouth of Dutch Charley Creek with ten values available on the upper reach of the creek (Table 71). All available values on Dutch Charley Creek were below 7.3 mg/L. The tributary had little nitrate data available, with values ranging from 1 to 9.6 mg/L.

Table 71. Nitrate samples collected in the Dutch Charley Creek HUC

Stream reach	# nitrate values	Range of values (mg/L)
Dutch Charley Creek (-517)	2	5.7-7.3
Dutch Charley Creek (-518)	10	0.09-6.3
Unnamed creek (-529)	2	1-9.6

Sensitive fish species have a negative relationship with nitrate, but sensitive species are also affected by DO and phosphorus. Better relationships have been made with respect to macroinvertebrate impairment and nitrate concentration. Nitrate tolerant individuals ranged from 39.06% to of 79.31% of the macroinvertebrate community (Table 72). A community of macroinvertebrates with a percentage of nitrate tolerant individuals greater than 78% has only a 25% chance of meeting the MIBI. The sites also had a lack of intolerant taxa.

Increasing nitrate concentrations also have a negative relationship with nonhydropsychid Trichoptera (caddisfly) individual percentages. Nonhydropsychid Trichoptera are all caddisflies that do not spin nets. The percentage was below the class average of sites meeting the threshold except for sites 17Mn130 and 17MN138. The three reaches had indications of nitrate stress, but more nitrate values would be helpful. Nitrate is inconclusive as a stressor.

Table 72. Nitrate related metrics in the Dutch Charley Creek HUC

		Nitrate related Macroinvertebrate Metrics			
Station	**WID**	TrichwoHydroPct	N % Tolerant Taxa	N Intolerant Taxa	Nitrogen TIV
01MN006	**-529**	0.31	79.31	1	3.96
03MN035	**-518**	0	39.06	0	2.88
17MN136	**-518**	5.57	65.33	1	3.43
17MN130	**-517**	6.56	52.94	0	3.62
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**4.02**	**54.87**	**3.18**	**3.23**
17MN138	**-518**	4.33	57.10	0	3.22
Statewide average for Class 5 Southern Streams RR stations meeting the MIBI General Use Threshold (37.0)		**5.94**	**47.60**	**2.92**	**2.95**
Expected response to Nitrate stress		↓	↑	↓	↑

Candidate Cause: Sediment

Both reaches of Dutch Charley (-517 and -518) have turbidity impairments. Recent TSS data ranged in value from 2 to 534 mg/L, with 15 concentrations above the southern standard of 65 mg/L on (Table 73). The elevated TSS values were located at station S004-879 near Lamberton and S001-919, which is located near the mouth of the creek. Additionally, secchi tube measurements ranged from 5 to >100, with three values below the standard of 10. Only one TSS value was available on the unnamed creek. Secchi measurements at the unnamed creek ranged from 30 to 54 cm.

Table 73. TSS values in the Dutch Charley Creek HUC

Stream reach	# TSS values	Range of values (mg/L)	# of values above 65 mg/L
Dutch Charley Creek (-517)	43	3-534	12
Dutch Charley Creek (-518)	26	2-304	4
Unnamed creek (-529)	1	12	0

Intolerant fish on Dutch Charley Creek were 0, with tolerant fish ranging from 0% (03MN035) to 20% (17MN130). Intolerant species were also 0 on the unnamed creek, with tolerant species less than 1%. Herbivore species of fish decrease as TSS values increase. The herbivore percentages were higher than the average of sites meeting the IBI threshold except at site 17MN136. Perciforms species (smallmouth bass, walleye, etc.) have been demonstrated to decrease as TSS increases. Perciform percentages were lowered at all sites (Table 74).

Table 74. TSS related fish metrics in the Dutch Charley Creek HUC

		TSS related fish metrics					
Station	**WID**	BenFdFrimPct	Centr-TolPct	HerbvPct	Percfm-TolPct	IntolerantPct	Longlived Pct
03MN035	**-518**	1.11	0	39.44	2.22	0	0
01MN006	**-529**	31.08	0	37.84	1.35	0	0
Statewide average for Class 3 Southern Streams stations meeting the FIBI General Use Threshold (55.0)		**37.83**	**0.89**	**13.33**	**13.93**	**1.95**	**3.56**
17MN138	**-518**	17.78	0	30	6.67	0	0
17MN136	**-518**	26.40	0	8	4.80	0	4
17MN130	**-517**	8.63	0.57	13.01	6.22	0.14	3.54
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**37.38**	**4.89**	**9.61**	**18.66**	**4.97**	**11.68**
Expected response to TSS stress		↓	↓	↓	↓	↓	↓

TSS intolerant macroinvertebrates were absent at all stations on Dutch Charley Creek, and only one intolerant macroinvertebrate was collected on the unnamed creek. The unnamed creek was the only site with a higher-than-average TSS tolerant percentage (Table 75). The long-lived percentage were lower than average at all stations except 17MN138. Collector-filterer percentages were lowered at all sites except 03MN035 and 17MN136. Plecoptera percentages were absent at all stations except 01MN006. High numbers of Tricorythodes were collected at stations 01MN006, 17MN130, and 17MN136 which are tolerant to sedimentation. The preponderance of evidence supports TSS is a stressor on Dutch Charley Creek (-517) and is inconclusive on the headwaters of Dutch Charley Creek (-518). TSS is not a stressor on the unnamed creek (-529).

Table 75. TSS related macroinvertebrate metrics in the Dutch Charley Creek HUC

		TSS related Macroinvertebrate Metrics					
Station	**WID**	TSS Index Score	TSS Intolerant Taxa	TSS Tolerant Pct	Collector Filterer Pct	Plectoptera Pct	Long-lived Pct
01MN006	**-529**	20.02	1	67.39	62.38	1.25	2.82
03MN035	**-518**	14.19	0	3.44	3.44	0	0.94
17MN136	**-518**	19.42	0	48.29	4.33	0	7.74
17MN130	**-517**	18.99	0	42.11	25	0	6.56
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**17.78**	**1.33**	**48.28**	**19.13**	**0.22**	**7.99**
17MN138	**-518**	17.10	0	33.33	50.15	0	16.72
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**15.87**	**3**	**35.23**	**4.56**	**0.54**	**8.99**
Expected response to stress		↑	↓	↑	↓	↓	↓

Candidate Cause: Lack of Habitat

The tributary scored poorly (45) in the MSHA. The score was lowered by a lack of channel development, sparse cover amount, and moderate embeddedness of coarse substrates with fine sediment (Figure 33). Stations on reach -518 of Dutch Charley Creek ranged from 46 (17MN136) to 52(17MN138). No riffles were present at stations 03MN035 or 17MN136 and there was a lack of depth variability at 03MN035. Station 17MN136 had moderate embeddedness and sparse cover amount. Station 17MN138 had heavy erosion. The station near the mouth of the creek, 17MN130 was noted to have an overwidened channel. The score was also poor (41), lacking channel development, stability, sinuosity, depth variability and moderate embeddedness.

Figure 33. Excess sediment at site 01MN006

Simple lithophilic spawners, which require coarse substrate for spawning, typically decrease in numbers with limited habitat. Percentages were lower than average except at station 17MN136. Benthic insectivores, darter, sculpin, and sucker, and Piscivore individuals were lowered at all sites (Table 76). Darters are sensitive to siltation and riffle species tend to decrease due to lack of habitat. Riffle species were below average at all sites except for site 01MN006 on the unnamed creeks. The percentage of tolerant species were above average at all sites.

Table 76. Habitat related fish metrics in the Dutch Charley HUC

		Habitat Related Fish Metrics							
Station	**WID**	BenInsect-TolPct	SLithopPct	DarterSculpSucPct	RiffePct	PiscivorePct	LithFrimPct	TolPct	PioneerPct
01MN006	**-529**	1.35	22.97	1.35	31.08	0	74.32	91.89	37.84
03MN035	**-518**	2.22	1.11	2.22	1.11	0	2.22	97.22	53.89
Statewide average for Class 3 Southern Streams stations meeting the FIBI General Use Threshold (55.0)		**14.22**	**33.71**	**12.55**	**28.33**	**1.62**	**69.21**	**70.64**	**37.79**
17MN130	**-517**	7.64	27.72	7.21	6.65	0.85	33.24	65.21	13.86
17MN136	**-518**	6.40	48.79	6.40	25.60	0	83.19	63.20	28.79
17MN138	**-518**	6.67	35.56	6.67	15.56	0	61.11	83.33	22.22
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**20.39**	**39.38**	**18.18**	**32.49**	**5.24**	**58.26**	**44.85**	**19.02**
Expected response to Habitat stress		↓	↓	↓	↓	↓	↓	↑	↑

Clingers need coarse substrates and decrease with the increase in percent fines. The percentages of clingers were below average at all sites except stations 01MN006 and 17MN136 (Table 77). Burrowers and legless individuals are a signal of high levels of sedimentation. Burrowers and legless percentages were increased at all sites except 01MN006 and 17MN138. EPT percentages were below class average at stations 03MN035 and 17MN130. Based on the lowered MSHA scores and the preponderance of evidence, habitat is a stressor to Dutch Charley Creek. Habitat is a stressor on -518 but is having more of an impact in the upper section. Habitat is also a stressor to the tributary, but seems to impacting the fish community more than the macroinvertebrate community.

Table 77. Habitat related macroinvertebrate metrics in the Dutch Charley Creek HUC

		Habitat related Macroinvertebrate Metrics				
Station	**WID**	BurrowerPct	ClimberPct	ClingerPct	EPTPct	LeglessPct
01MN006	**-529**	2.82	4.08	77.12	86.52	10.66
03MN035	**-518**	8.125	15.63	14.38	0.31	43.44
17MN136	**-518**	12.69	13.93	16.09	46.13	38.69
17MN130	**-517**	8.13	15.63	14.38	0.31	43.44
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI General Use Threshold (41.0)		**7.51**	**21.59**	**38.50**	**38.45**	**39.76**
17MN138	**-518**	0.31	8.05	85.45	68.42	13.0
Statewide average for Class 5 Southern Streams RR stations meeting the MIBI General Use Threshold (41.0)		**7.54**	**14.71**	**49.54**	**42.46**	**36.03**
Expected response to Habitat stress		↑	↓	↓	↓	↑

Candidate Cause: Altered hydrology

Both reaches of Dutch Charley Creek are predominantly natural with some channelized tributaries. The creek was channelized upstream of site 03MN035 There were a few small areas of channelization on the tributary. Generalist fish species, which are adaptable to different habitats through generalized food preferences, are correlated with channelization. The site had a population of generalist fish ranging from 56% (03MN035) to 74% (17MN136). The tributary had a generalist percentage of 59% (01MN006) and 35% on reach -517. The numbers of nest guarder species are also positively correlated with increased low flows 13% on -517, 3% on -529, and 0 (17MN138)-56% (03MN035) on -518. Long-lived macroinvertebrates decrease with flow changes as they are not able to stay in one place as conditions change; 2.82% on -529, 6.56% on -517, and a range of 0.94 (03MN035) to 16.72% (17MN138). Generalization are increased and long lived decreased at -517 and -529, but likely due to other stressors based on a small amount of channelization on the reach. The upstream channelization is likely contributing to the lack of habitat and is a contributing stressor to the biological communities on the upper reach of -518 at station 03MN035.

Candidate Cause: Connectivity

Connectivity is another important aspect of hydrology. Fish migration is dependent on stream connectivity. An inverted culvert at the Highway 30 road crossing is preventing fish migration based on the improper slope and flow of the culvert (Figure 34). The DNR also found **"**40 crossings that are either significant or seasonal barriers in the Dutch Charley Creek Watershed (DNR 2020).

Figure 34. Incorrect slope on culvert on Dutch Charley Creek

Summary and recommendations

The Dutch Charley Creek HUC contains three biologically impaired reaches. Eutrophication, TSS, lack of habitat, altered hydrology, and connectivity are the stressors in this watershed (Table 78). Fixing the road barriers on Dutch Charley Creek would help with fish migration.

Table 78. Stressors in the Dutch Charley Creek HUC

	Stressors:						
Stream name	**Dissolved oxygen**	**Eutrophication**	**Nitrate**	**Suspended sediment**	**Habitat**	**Altered hydrology**	**Connectivity**
Dutch Charley Creek (-517)	---	o	o	●	●	---	---
Dutch Charley Creek (-518)	●	●	o	o	●	●	●
Unnamed creek (-529)	---	o	o	---	●	---	---

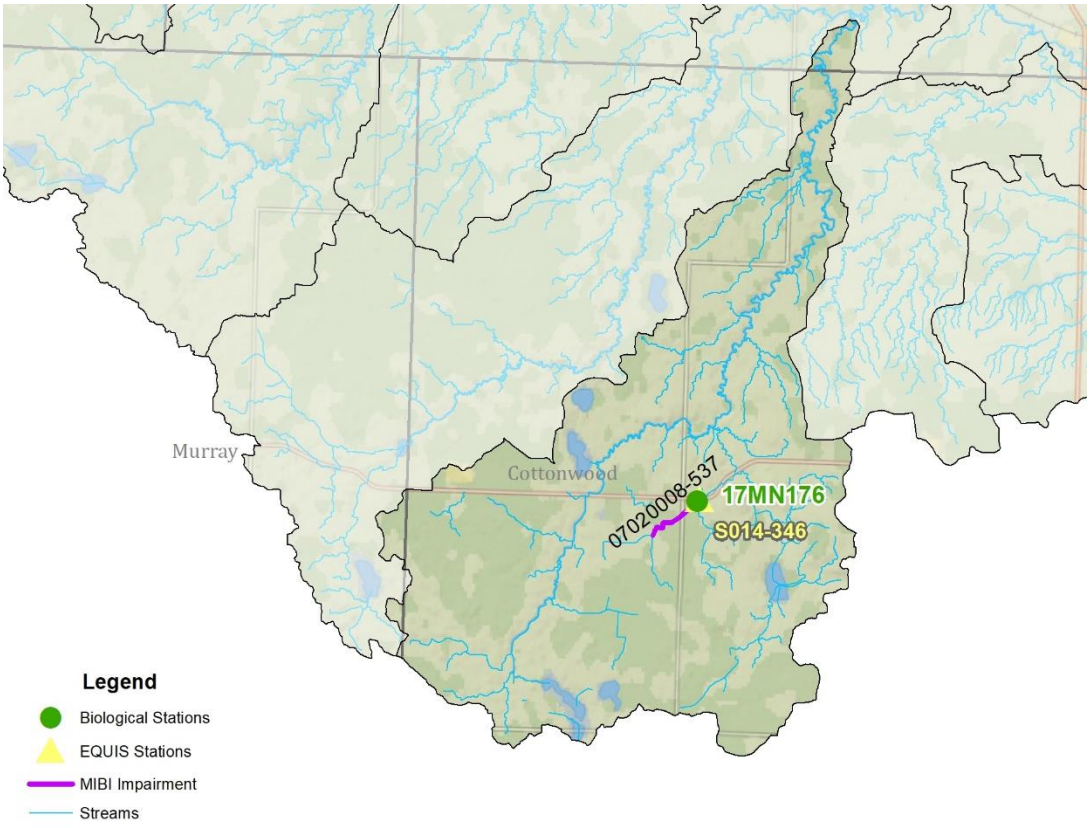
● = stressor; o = inconclusive stressor; --- = not an identified stressor

Highwater Creek 12-digit HUC

This aggregated HUC includes Highwater Creek and its watershed (Figure 35). The watershed has the following impairment:

- County Ditch 38 (-537) impaired by macroinvertebrates (17MN176, S014-346)

Figure 35. Map of Highwater HUC



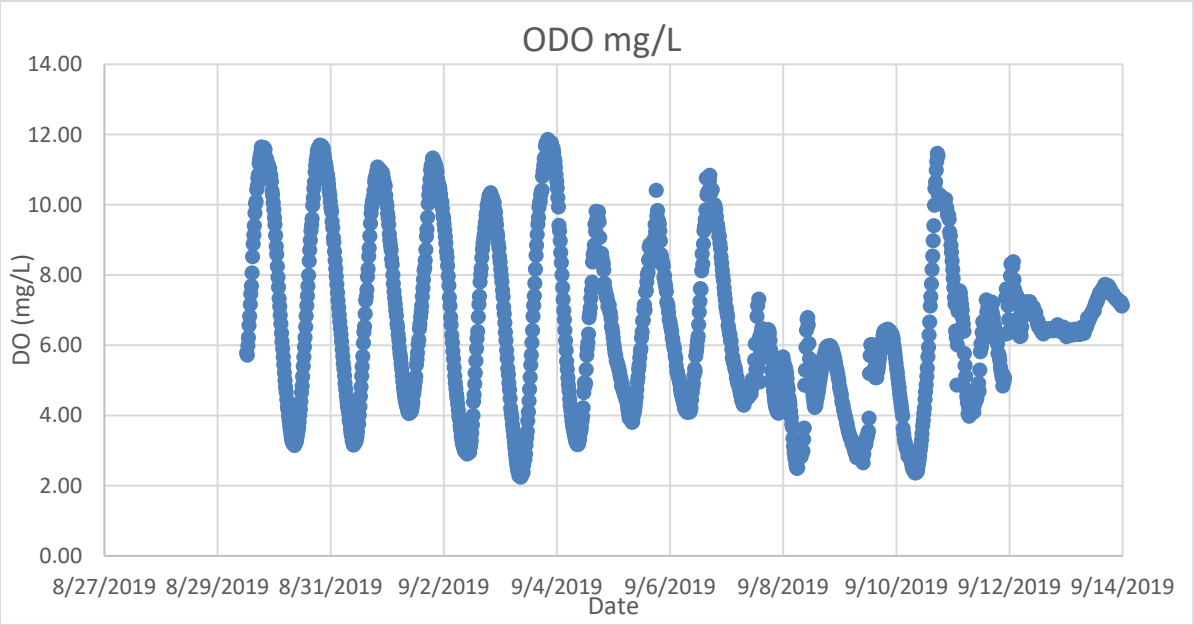
Candidate cause: Dissolved oxygen

Only three values were collected on County Ditch 38, ranging from 5.55 mg/L to 10.47 mg/L (Table 79). Continuous data was collected at station in 2019, where the recorded minimum was 2.24 mg/L, and where DO values almost daily fell below 5 mg/L (Table 79).

Table 79. DO values in the Highwater Creek HUC

Stream reach	# DO values	Range of DO values	# of values below 5 mg/L
County Ditch 38 (-537)	3	5.55-7.18 mg/L	0

Figure 36. Continuous DO data



Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed (Table 80). Zero intolerant macroinvertebrates were collected. The percentage of DO tolerant individuals was 25.08%. While continuous data shows daily lowered DO values, the metrics are not indicative of DO stress. DO is inconclusive as a stressor.

Table 80. DO related macroinvertebrate metrics in the Highwater Creek HUC

		DO Related Macroinvertebrate Metrics			
Station	**WID**	Percentage DO Tolerant Macroinvertebrates	HBI_MN	Intolerant DO Macroinvertebrate Taxa	DO Tolerant Index Score
17MN176	**-537**	25.08	6.87	0	3.32
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**31.37**	**8.00**	**1.78**	**6.19**
Expected response to DO stress		↑	↑	↓	↑

Candidate Cause: Eutrophication

There was limited phosphorus data available on the CD 38, with both values below 0.100 mg/L (Table 81). Chl-*a*, BOD, and DO fluctuations values are a proximate measurement of eutrophication and have more direct impacts on biology than phosphorus. Continuous data collected in 2019 at site 17MN176 had a DO flux range of 3.23 to 9.36 mg/L. Ten days of the deployment had fluctuations above 4.5 mg/L, the southern standard.

Table 81. Phosphorus values in the Highwater Creek HUC

Stream Reach	# TP values	Range of TP values	# of values above 0.150 mg/L
County Ditch 38 (-537)	2	0.06-0.097	0

The macroinvertebrate sample was comprised of two species comprising more than 60% of the (Table 82). EPT species and total taxa collected were below average of sites meeting the threshold. The biological communities are showing the effects of the diurnal fluctuations. Eutrophication looks to be a stressor, but more phosphorus values would be helpful to confirm. Eutrophication is inconclusive as a stressor.

Table 82. Eutrophication related macroinvertebrate metrics in the Highwater Creek HUC

		Eutrophication Related Macroinvertebrate Metrics		
Station	WID	Invert Taxa	EPT Pct	Dominant 2 Invert CH Pct
17MN176	**-537**	26	0.67	66.33
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**34**	**20.58**	
Expected response to TP stress		↓	↓	↑

Candidate cause: Nitrates

County Ditch 38 had little nitrate data available, with values ranging from 7 to 9.2 mg/L (Table 83).

Table 83. Nitrate samples collected in the Mound Creek HUC

Stream reach	# nitrate values	Range of values (mg/L)
County Ditch 38 (-537)	2	1.5-1.8

Nitrate tolerant individuals comprised 23.10% of the macroinvertebrate community (Table 84). No intolerant taxa were collected. Increasing nitrate concentrations also have a negative relationship with nonhydropsychid Trichoptera (caddisfly) individual percentages. Nonhydropsychid Trichoptera are all caddisflies that do not spin nets. The percentage was below the class average of sites meeting the threshold. Nitrate is not a stressor to the County Ditch 38.

Table 84. Nitrate related metrics in the Dry Creek HUC

		Nitrate related Macroinvertebrate Metrics			
Station	WID	TrichwoHydro Pct	N % Tolerant Taxa	N Intolerant Taxa	Nitrogen TIV
17MN176	**-537**	0.67	23.10	0	2.45
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**2.16**	**59.41**	**1.95**	**3.32**
Expected response to Nitrate stress		↓	↑	↓	↑

Candidate cause: Sediment

Only one TSS value is available on the reach, with a value of 1.6 mg/L (Table 85). The available secchi measurements were 28 and >100 cm. The ditch was very silty during sampling (Figure 37).

Table 85. Sediment related macroinvertebrate metrics in the Highwater Creek HUC

Stream reach	# TSS values	Range of values (mg/L)	# of values above 65 mg/L
County Ditch 38 (-537)	1	1.6	0

Figure 37. Turbid water during sampling (8/29/19)

There was one TSS intolerant taxa present and tolerant macroinvertebrate individuals comprised less than the class average (Table 86). The gully is a pathway for silt and corn and should be addressed, but TSS is not a stressor to the macroinvertebrate community at this time.

Table 86. TSS related macroinvertebrate metrics in the Dry Creek HUC

		TSS related Macroinvertebrate Metrics					
Station	**WID**	TSS Index Score	TSS Intolerant Taxa	TSS Tolerant Pct	Collector Filterer Pct	Plectoptera Pct	Long-lived Pct
17MN176	**-537**	9.06	1	22.44	5.33	0	0
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**16.25**	**0.6**	**35.60**	**9.91**	**0.02**	**5.59**
Expected response to stress		↑	↓	↑	↓	↓	↓

Candidate Cause: Lack of Habitat

Habitat conditions were shown to be poor by the MSHA score of 29.5. Station 17MN176 had a small riparian buffer, no coarse substrates, a lack of channel development, sinuosity, and depth variability. During stressor ID work, a pathway from the adjacent corn field ran through a gully into the stream, which was full of silt and corn plant debris (Figure 38 and Figure 39).

Figure 38. Gully along the ditch (8/29/19)

Figure 39. Corn downstream of the gully in the ditch (8/29/19)

Clingers need coarse substrates and decrease with the increase in percent fines. The percentages of clingers were below average. Burrowers and legless individuals are a signal of high levels of sedimentation. Burrowers percentages were higher than average (Table 87). The EPT percentage was only below class average. Based on the preponderance of evidence of the macroinvertebrate communities, habitat is a stressor.

Table 87. Habitat related metrics in the Highwater Creek HUC

		Habitat related Macroinvertebrate Metrics				
Station	**WID**	BurrowerPct	ClimberPct	ClingerPct	EPTPct	LeglessPct
17MN176	**-537**	52.33	20.67	3.67	0.67	76
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI Modified Use Threshold (22.0)		**14.12**	**27.47**	**23.07**	**20.58**	**55.79**
Expected response to Habitat stress		↑	↓	↓	↓	↑

Candidate cause: Altered hydrology

Site 17MN176 and reach -537 are completely channelized. Generalist fish species, which are adaptable to different habitats through generalized food preferences, are correlated with channelization. Site 17MN176 had a population of generalist fish of 64%. The numbers of nest guarder species are also positively correlated with increased low flows. The nest guarder species had a population of 18.67%. Long-lived macroinvertebrates decrease with flow changes as they are not able to stay in one place as conditions change. The range of long-lived macroinvertebrates was 0%. The channelization is likely contributing to the lack of habitat and is a contributing stressor to the biological communities.

Candidate cause: Connectivity

Connectivity is another important aspect of hydrology. Fish migration is dependent on-stream connectivity. A perched culvert is preventing fish migration (Figure 40).

Figure 40. Perched culvert at site 17MN176

Summary and recommendations

The Highwater Creek HUC contains one biologically impaired reach. Habitat, altered hydrology, and connectivity are the stressors in this watershed (Table 88). Further DO, TSS, and nutrient data would help further determine their impacts. Fixing the perched culvert would fix the fish migration barrier.

Table 88. Stressors in the Highwater Creek HUC

	Stressors:						
Stream name	**Dissolved oxygen**	**Eutrophication**	**Nitrate**	**Suspended Sediment**	**Habitat**	**Altered hydrology**	**Connectivity**
County Ditch 38 (-537)	o	o	---	---	●	●	●

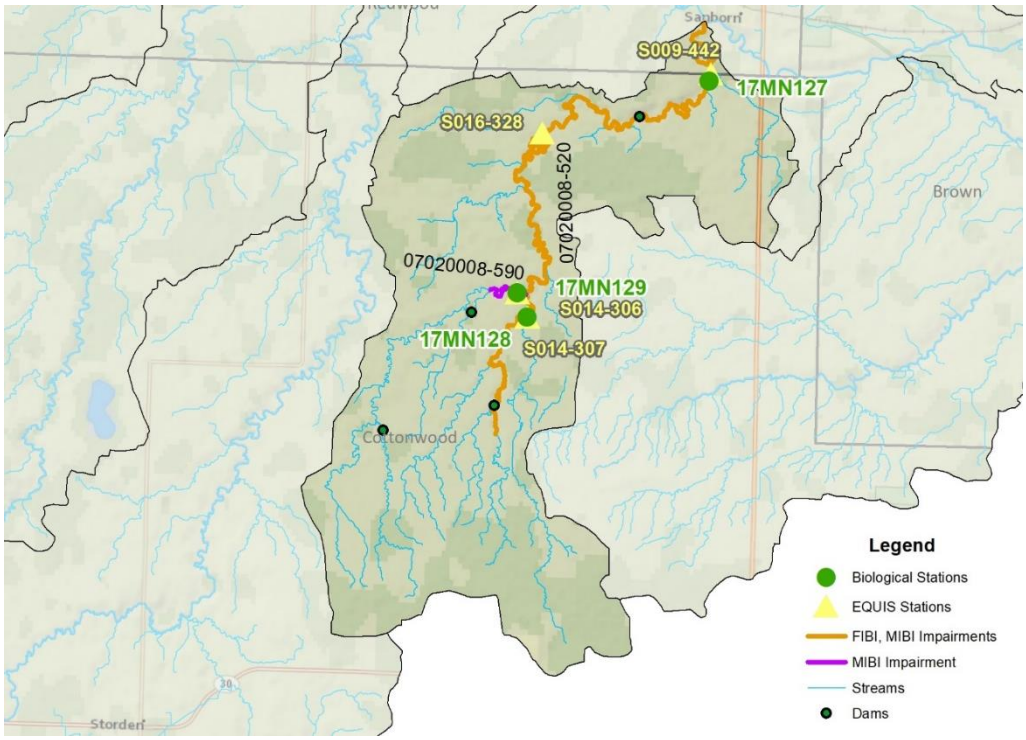
● = stressor; o = inconclusive stressor; --- = not an identified stressor

Dry Creek 12-digit HUC

This aggregated HUC includes Dry Creek and its watershed (Figure 41). The watershed has the following impairments:

- Dry Creek (-520) impaired by macroinvertebrates and fish (17MN127, 17MN129, S009-442, S014-307)
- Unnamed creek (-590) impaired by macroinvertebrates (17MN128, S014-306, S016-388)

Figure 41. Map of Dry Creek HUC



Candidate cause: Dissolved oxygen

Values on Dry Creek ranged from 5.55 mg/L to 10.47 mg/L (Table 89). The lowest value was collected at station 17MN127, the station near the mouth of the creek. Only two DO values were collected on the unnamed creek, and both were above 5 mg/L.

Table 89. DO data in the Dry Creek HUC

Stream reach	# DO values	Range of DO values	# of values below 5 mg/L
Dry Creek (-520)	24	5.55-10.47 mg/L	0
Unnamed Creek (-590)	2	9.37-10.14 mg/L	0

Fish species that are specifically tolerant and intolerant to DO were analyzed. There were no intolerant fish at any of the stations. However the DO tolerant percentages were all less than 1%.

The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. All sites had less than 1% of fish that take 3 years or longer to mature, indicating that fish are quick to reproduce due to short life spans from the influence of human disturbance. Low DO values also correspond with increased serial spawning fish percentage. Serial spawning occurs based on environmental stress. The three sites did not have increased serial spawning percentages higher than the class averages (Table 90).

Table 90. DO related fish metrics in the Dry Creek HUC

		DO Related Fish Metrics		
Station	**WID**	MA>3 years Pct	Serial Spawning Fish Pct	Fish Taxa Count
17MN127	**-520**	0.55	10.29	21
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**12.36**	**28.72**	**20.38**
17MN128	**-590**	0	8.57	9
17MN129	**-520**	0	0	5
Statewide average for Class 3 Southern Streams stations that are meeting the FIBI General Use Threshold (55.0)		**2.06**	**17.09**	**12.16**
Expected response to increased DO stress		↓	↑	↓

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed (Table 91). Zero intolerant macroinvertebrates were collected on the unnamed creek, while slightly less than average were found at stations on Dry Creek. The percentage of DO tolerant individuals ranged from 6.92% to 14.15%. The DO tolerant percentage was higher than average on the unnamed creek. While there is evidence that the unnamed creek macroinvertebrate community is experiencing DO stress, more DO samples would help to confirm. DO is not a stressor to either community.

Table 91. DO related macroinvertebrate metrics in the Dry Creek HUC

		DO Related Macroinvertebrate Metrics			
Station	**WID**	Percentage DO Tolerant Macroinvertebrates	HBI_MN	Intolerant DO Macroinvertebrate Taxa	DO Tolerant Index Score
17MN127	**-520**	6.92	7.25	7	7.52
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (41.0)		**8.62**	**7.04**	**8.97**	**7.09**
17MN129	**-520**	14.15	8.42	4	6.95
17MN128	**-590**	8.59	8.06	1	6.74
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**12.98**	**7.55**	**4.46**	**6.91**
Expected response to DO stress		↑	↑	↓	↑

Candidate cause: Eutrophication

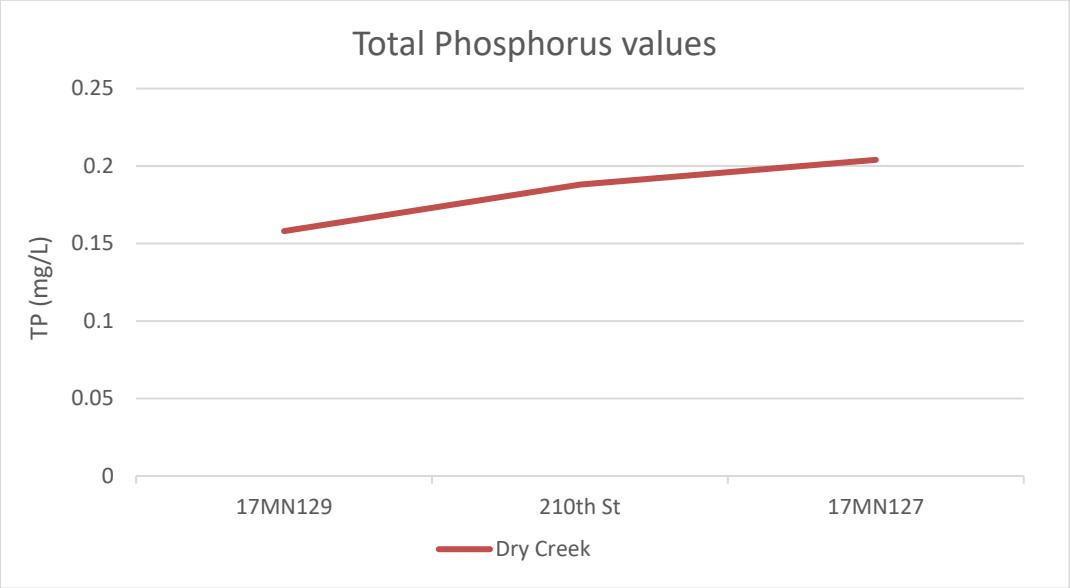
Recent phosphorus data on Dry Creek ranged from 0.046 to 0.205 mg/L (Table 92). The highest values were taken at station 17MN127. The highest value on a longitudinal survey was also sampled at station 17MN127, near the mouth of the river (Figure 42).

Table 92. Phosphorus values in the Dry Creek HUC

Stream reach	# TP values	Range of TP values	# of values above 0.150 mg/L
Dry Creek (-520)	17	0.05-0.205	6
Unnamed Creek (-590)	2	0.083-0.105	0

Chl-*a*, BOD, and DO fluctuations values are a proximate measurement of eutrophication and have more direct impacts on biology than phosphorus. Chl-*a* data on Dry Creek had a range of values from 1.0 to 20.6 ug/L, all below the southern standard of 40 ug/L.

Figure 42. Longitudinal phosphorus values on Dry Creek



All stations had low percentages of sensitive and darter percentages (Table 93). Fish tolerant to disturbance were higher than average at each station. Omnivorous fish have a positive relationship with nutrients. Only station 17MN127 had a higher-than-average omnivorous percentage.

Table 93. Eutrophication related fish metrics in the Dry Creek HUC

		Eutrophication related Fish Metrics			
Station	**WID**	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct
17MN127	**-520**	**2.21**	**1.29**	**69.85**	**38.79**
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**18.65**	**11.68**	**44.85**	**16.53**
17MN128	**-590**	**0**	**4.29**	**92.86**	**11.43**
17MN129	**-520**	**0**	**0**	**94.64**	**14.29**
Statewide average for Class 3 Southern Streams stations that are meeting the FIBI General Use Threshold (55.0)		**8.55**	**12.08**	**70.64**	**14.62**
Expected response to increased Eutrophication stress		↓	↓	↑	↑

EPT percentages were high at station 17MN127 but were dominated by species tolerant to eutrophic conditions. Sites 17MN127 and 17MN128 were dominated by two species, showing a lack of diversity (Table 94). Eutrophication is a stressor on Dry Creek based on the elevated phosphorus values and biological communities. Eutrophication is inconclusive as a stressor on the unnamed creek.

Table 94. Eutrophication related macroinvertebrate metrics in the Dry Creek HUC

		Eutrophication Related Macroinvertebrate Metrics		
Station	**WID**	Invert Taxa	EPT Pct	Dominant 2 Invert CH Pct
17MN127	**-520**	33	79.57	49.85
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (41.0)		**42**	**43.90**	
17MN129	**-520**	41	15.43	39.23
17MN128	**-590**	32	0.64	90.73
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**37**	**38.45**	
Expected response to TP stress		↓	↓	↑

Candidate cause: Nitrates

Recent nitrate data was available on Mound Creek with samples values ranging from 0.43 to 9.2 mg/L (Table 95). The highest value was collected at site 17MN129. The tributary to Dry Creek had little nitrate data available, with values ranging from 7 to 9.2 mg/L.

Table 95. Nitrate samples collected in the Mound Creek HUC

Stream reach	# nitrate values	Range of values (mg/L)
Dry Creek (-520)	5	0.43-9.2
Unnamed Creek (-590)	2	7-9.2

Sensitive fish species have a negative relationship with nitrate, but sensitive species are also affected by DO and phosphorus. Better relationships have been made with respect to macroinvertebrate impairment and nitrate concentration. Nitrate tolerant individuals comprised a range of 39.32% to 92.86% of the macroinvertebrate community (Table 96). A community of macroinvertebrates with a percentage of nitrate tolerant individuals greater than 78% has only a 25% chance of meeting the MIBI. No intolerant taxa were collected at sites 17MN127 and 17MN128, while two were collected at 17MN129.

Increasing nitrate concentrations also have a negative relationship with nonhydropsychid Trichoptera (caddisfly) individual percentages. Nonhydropsychid Trichoptera are all caddisflies that do not spin nets. Values ranged from 0% to 1.93%. Metric data shows some indications of stress on both Dry Creek and the Unnamed Creek, but more nitrate data would be helpful. Nitrate is inconclusive as a stressor to Dry Creek and the Unnamed Creek.

Table 96. Nitrate related metrics in the Dry Creek HUC

		Nitrate related Macroinvertebrate Metrics			
Station	**WID**	TrichwoHydroPct	N % Tolerant Taxa	N Intolerant Taxa	Nitrogen TIV
17MN127	**-520**	0	39.32	0	2.99
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (41.0)		**5.94**	**47.60**	**2.92**	**2.95**
17MN129	**-520**	1.93	86.82	2	4.74
17MN128	**-590**	0	92.36	0	8.34
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**4.02**	**54.87**	**3.18**	**3.23**
Expected response to Nitrate stress		↓	↑	↓	↑

Candidate cause: Sediment

Recent TSS samples on Dry Creek ranged in value from 2 to 100 mg/L, with two concentrations above the southern standard of 65 mg/L (Table 97). The value of 100 mg/L was taken at station S009-442 near station 17MN127, and the mouth of Dry Creek. Additionally, secchi tube measurements ranged from 9.5 to 100 cm. Of these measurements, one sample at station S016-328 was just below the 10 cm standard for transparency. Only one recent TSS samples and one secchi readings are available on reach -590. The secchi reading was 65 cm. Dry Creek was turbid after a rainfall (Figure 42). A small clear tributary shows the difference in clarity.

Table 97. TSS data in the Dry Creek HUC

Stream reach	# TSS values	Range of values (mg/L)	# of values above 65 mg/L
Dry Creek (-520)	22	2-100	2
Unnamed Creek (-590)	1	28	0

Figure 43. Turbidity on Dry Creek (6/27/19)

Fish species that are specifically tolerant and intolerant to TSS were analyzed at each station. There were zero intolerant fish at any of the stations. However, there were also less than 1% of TSS tolerant individuals at each site. Herbivore species of fish decrease as TSS values increase (Table 98). Herbivore percentages were lower than average at all stations. Perciforms species (smallmouth bass, walleye, etc.) decrease as TSS increases. Perciform percentages were also below average at all stations. Intolerant, Centrarchid, and long-lived species were below average at all sites. Based on the TSS data and the biological response, TSS is inconclusive as a stressor to the fish community on Dry Creek.

Table 98. TSS related fish metrics in the Dry Creek HUC

		TSS Related Fish Metrics					
Station	**WID**	BenFdFrimPct	Centr-TolPct	HerbvPct	Percfm-TolPct	IntolerantPct	Longlived Pct
17MN127	**-520**	37.87	0.37	2.39	1.65	0	1.29
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI General Use Threshold (50.0)		**37.38**	**4.89**	**9.61**	**18.66**	**4.97**	**11.68**
17MN128	**-590**	15.71	0	1.43	4.29	0	0
17MN129	**-520**	19.64	0	5.36	0	0	0
Statewide average for Class 3 Southern Streams stations meeting the FIBI General Use Threshold (55.0)		**37.83**	**0.89**	**13.33**	**13.93**	**1.95**	**3.56**
Expected response to TSS stress		↓	↓	↓	↓	↓	↓

There were no TSS intolerant taxa present at any of the stations. However tolerant macroinvertebrate individuals comprised 1% or less of each of the macroinvertebrate communities also (Table 99). While there were some elevated TSS samples at the mouth of the creek, TSS response is mixed. TSS is inconclusive as a stressor on Dry Creek and the unnamed creek.

Table 99. TSS related macroinvertebrate metrics in the Dry Creek HUC

		TSS related Macroinvertebrate Metrics					
Station	**WID**	TSS Index Score	TSS Intolerant Taxa	TSS Tolerant Pct	Collector Filterer Pct	Plectoptera Pct	Long-lived Pct
17MN127	**-520**	16.89	0	<1	58.51	0	4.64
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (41.0)		**15.87**	**3**	**35.23**	**4.56**	**0.54**	**8.99**
17MN129	**-520**	18.32	0	0	1.93	0	28.29
17MN128	**-590**	23.09	0	0	0.96	0	1.28
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**17.78**	**1.33**	**48.28**	**19.13**	**0.22**	**7.99**
Expected response to stress		↑	↓	↑	↓	↓	↓

Candidate cause: Lack of habitat

Habitat conditions were shown to be poor by MSHA scores at station 17MN129 (46), and fair at stations 17MN128 (54) and 17MN127 (57). The downstream section including station 17MN127 had heavy erosion (Figure 44) and only fair sinuosity. Station 17MN128 had poor sinuosity and slow flow, and station 17MN129 had fair channel development and severe embeddedness of coarse substrates by fines. Station 17MN129 is located in a cow pasture (Figure 44).

Figure 44. Erosion at CSAH 11 (between stations 17MN129 and 17MN127)

Figure 45. excess sediment a station 17MN129

Simple lithophilic spawners, which require coarse substrate for spawning, typically decrease in numbers with limited habitat. The percentage was lower than average at site 17MN129. Benthic insectivores, darter, sculpin, sucker, and Piscivore individuals were low at all sites (Table 100). Darters are sensitive to siltation and riffle species tend to decrease due to lack of habitat. Riffles species were above average at the downstream site (17MN127) and below average at the upstream site (17MN129). The percentage of tolerant species were elevated and above average at all sites.

Table 100. Habitat related fish metrics in the Dry Creek HUC

		Habitat Related Fish Metrics							
Station	**WID**	BenInsect-TolPct	SLithopPct	DarterSculpSucPct	RiffePct	PiscivorePct	LithFrimPct	TolPct	PioneerPct
17MN127	**-520**	1.65	64.34	1.65	38.60	0.18	87.68	69.85	25.74
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**20.39**	**39.38**	**18.18**	**32.49**	**5.24**	**58.26**	**44.85**	**19.02**
17MN128	**-590**	5.71	50	4.29	11.43	0	87.14	92.86	47.14
17MN129	**-520**	0	30.63	0	19.64	0	100	94.64	64.29
Statewide average for Class 3 Southern Streams stations meeting the FIBI General Use Threshold (55.0)		**14.22**	**33.71**	**12.55**	**28.33**	**1.62**	**69.21**	**70.64**	**37.79**
Expected response to Habitat stress		↓	↓	↓	↓	↓	↓	↑	↑

Clingers need coarse substrates and decrease with the increase in percent fines. The percentages of clingers were below average at sites 17MN128 and 17MN129. Burrowers and legless individuals are a signal of high levels of sedimentation (Table 101). Burrowers percentages were higher than average at

stations 17MN128 and 17MN129. EPT percentages were above class average at site 17MN127. Habitat is a stressor on the reaches on both reaches and is concentrated in the upper reach of Dry Creek.

Table 101. Habitat related macroinvertebrate metrics in the Dry Creek HUC

		Habitat related Macroinvertebrate Metrics				
Station	**WID**	BurrowerPct	ClimberPct	ClingerPct	EPTPct	LeglessPct
17MN127	**-520**	1.24	1.24	82.66	79.57	8.98
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (41.0)		**7.54**	**14.71**	**49.54**	**42.46**	**36.03**
17MN128	**-590**	5.11	83.07	6.07	0.64	95.21
17MN129	**-520**	8.04	39.23	29.26	15.43	52.73
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI General Use Threshold (41.0)		**7.51**	**21.59**	**38.50**	**38.45**	**39.76**
Expected response to Habitat stress		↑	↓	↓	↓	↑

Candidate cause: Altered hydrology

Dry Creek is a natural stream with some channelized tributaries, and the unnamed creek has some channelized sections. Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency, increasing the impact of high flow events and increasing the intensity of low flow periods, both of which affect biological communities. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat. Habitat availability can be scarce when flows are interrupted, or low for a prolonged duration. Flows that are reduced beyond normal baseflow decrease living space for aquatic organisms and increase competition for resources.

Generalist fish species, which are adaptable to different habitats through generalized food preferences, are correlated with channelization. The reaches had a population of generalist fish ranging from 90% to 95%. The numbers of nest guarder species are also positively correlated with increased low flows. The nest guarder species had a population ranging from 0% to 11%. Long-lived macroinvertebrates decrease with flow changes as they are not able to stay in one place as conditions change. The range of long-lived macroinvertebrates ranged from 1% to 28%. The channelization is likely contributing to the lack of habitat and is a contributing stressor to the biological communities on the unnamed creek (-590).

Candidate cause: Connectivity

Connectivity is another important aspect of hydrology. Fish migration is dependent on stream connectivity. A dam is present upstream of 17MN129 in the headwaters of Dry Creek. A rock dam was also present at site 17MN129 (Figure 46). Both are acting as fish barriers. Connectivity is a stressor on Dry Creek (-520).

Figure 46. Rock dam at site 17MN129(6/27/19)

Summary and recommendation

The Dry Creek HUC contains one biologically impaired reach. Eutrophication, habitat, and connectivity are the stressors in this watershed (Table 102). Further DO, TSS, and nutrient data would help further determine their impacts. Removing the rock dam would fix the fish migration barrier and a buffer would help prevent sediment from entering Dry Creek.

Table 102. Stressors in the Dry Creek HUC

	Stressors:						
Stream name	**Dissolved oxygen**	**Eutrophication**	**Nitrate**	**Suspended sediment**	**Habitat**	**Altered hydrology**	**Connectivity**
Dry Creek (-520)	---	●	o	o	●	o	●
Unnamed Creek (-590)	---	o	o	o	●	●	---

● = stressor; o = inconclusive stressor; --- = not an identified stressor

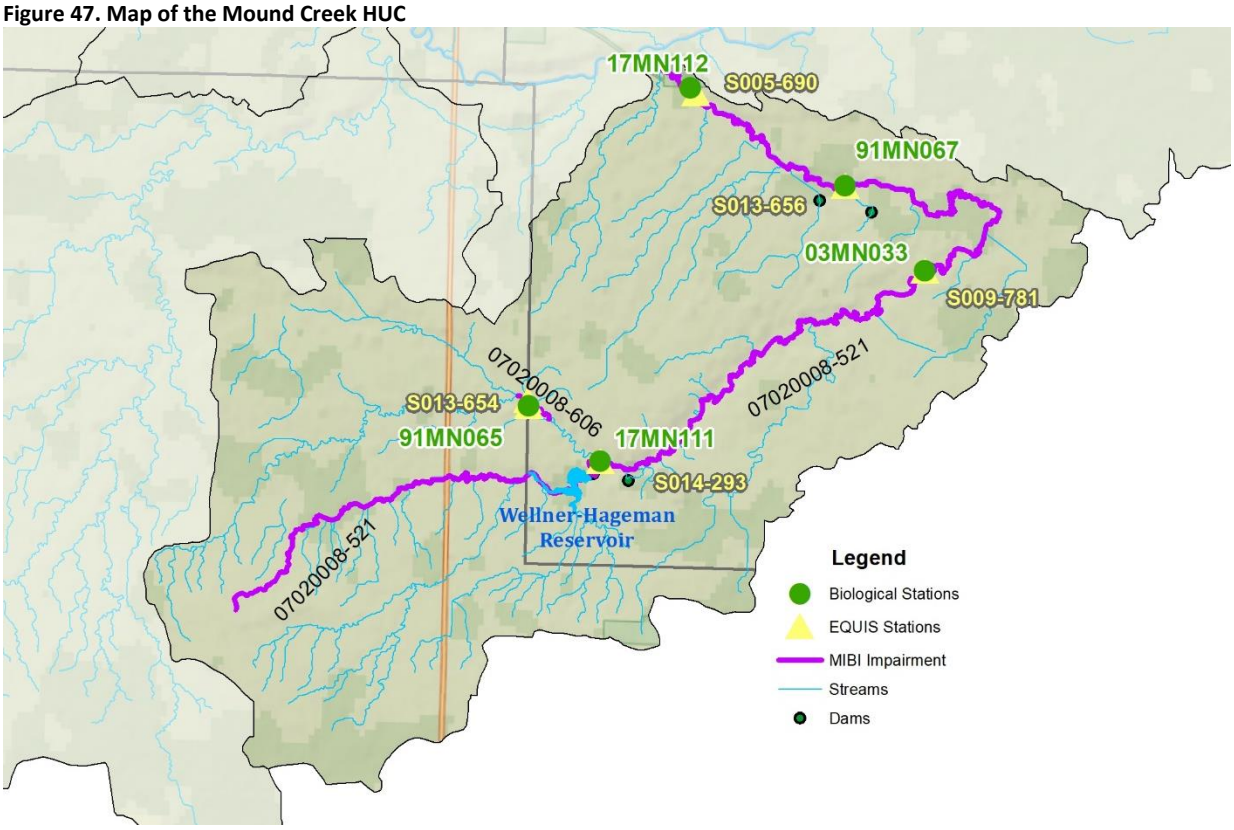
Mound Creek 12-digit HUC

This aggregated HUC includes Mound Creek and its watershed (Figure 47). The watershed has the following impairments:

- Mound Creek (-521) impaired by macroinvertebrates (91MN067, 17MN111, 17MN112)

- Unnamed creek (-606) impaired by macroinvertebrates (91MN065, S013-654)

Figure 47. Map of the Mound Creek HUC



Candidate cause: Dissolved oxygen

Values on Mound Creek ranged from 5.0 mg/L to 14.79 mg/L (Table 103). The maximum values were collected at station 17MN112. The wide range of DO values was indicative of possible eutrophication. Only three DO values collected on the unnamed creek, and all were above 5 mg/L.

Table 103. DO data in the Mound Creek HUC

Stream reach	# DO values	Range of DO values	# of values below 5 mg/L
Mound Creek (-521)	77	5-14.79 mg/L	0
Unnamed Creek (-606)	3	7.16-10.28 mg/L	0

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed (Table 104). Zero intolerant macroinvertebrates were collected on the unnamed creek, while less than three were found at all stations on Mound Creek. The percentage of DO tolerant individuals ranged from 3.14% to 76.80%. While there is evidence that the unnamed creek macroinvertebrate community is experiencing DO stress, more DO samples would help to confirm. DO is inconclusive as a stressor on reach -606. There is a mixed metric response on Mound Creek (-521), DO stress seems to be concentrated at station 17MN111. Station 17MN111 is located just downstream of the Wellner-Hageman reservoir impoundment on Mound Creek. DO is currently inconclusive as a stressor on reach -521.

Table 104. DO related metrics in the Mound Creek HUC

		DO Related Macroinvertebrate Metrics			
Station	**WID**	Percentage DO Tolerant Macroinvertebrates	HBI_MN	Intolerant DO Macroinvertebrate Taxa	DO Tolerant Index Score
91MN065	**-521**	76.80	8.99	0	6.09
91MN067	**-521**	4.75	7.83	3	7.09
17MN111	**-521**	75.08	8.22	1	5.93
17MN112	**-521**	3.14	7.81	3	7.15
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**12.98**	**7.55**	**4.46**	**6.91**
Expected response to DO stress		↑	↑	↓	↑

Candidate cause: Eutrophication

Recent phosphorus data on Mound Creek ranged from 0.054 to 0.398 mg/L (Table 105). The highest values were taken at station 17MN112 near the mouth of the creek. The highest value on a longitudinal survey was also sampled at station 17MN112.

Table 105. Phosphorus data in the Mound Creek HUC

Stream reach	# TP values	Range of TP values	# of values above 0.150 mg/L
Mound Creek (-521)	39	0.043-0.297	18
Unnamed Creek (-606)	3	0.072-1.1	1

A longitudinal sample of TP after a rainfall at five locations on Mound Creek showed four of the five locations above the southern phosphorus standard of 0.150 mg/L (Figure 48). The phosphorus concentration was highest at the most downstream station 17MN112. Algae was also noted during sampling at stations 91MN067 and 91MN065 (Figure 49 and Figure 50).

Figure 48. Longitudinal survey on Mound Creek

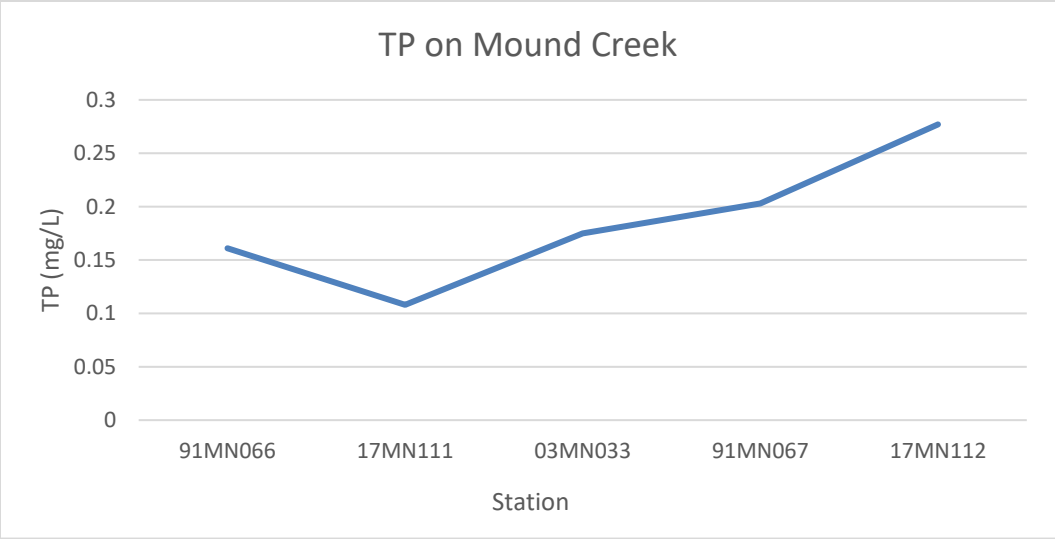


Figure 49. Algal growth on rocks a station 91MN067 (6/27/19)

Figure 50. Algal growth on rocks at station 91MN066 (8/22/19)

All stations on Mound Creek had macroinvertebrate samples comprised of more than 40% of the community dominated by two species (Table 106), while station 91MN065 on the unnamed creek had two species comprising 69.09% of the community. EPT species were below average at each station except 17MN112. Tolerant mayfly (baetis) species were at stations 91MN067 and 17MN112, increasing the EPT percentages at both sites. EPT percentage lowered from 36.19 in 2001 to 24.84 in 2010 at 91MN067. The number of taxa were all below the class average of sites meeting the threshold. The biological communities are showing the effects of the elevated phosphorus and DO values. Eutrophication is a stressor to the macroinvertebrate communities on Mound Creek (-521) and the unnamed creek (-606).

Table 106. Eutrophication related metrics in the Mound Creek HUC

		Eutrophication related Macroinvertebrate metrics		
Station	**WID**	Invert Taxa	EPT Pct	Dominant 2 Invert CH Pct
91MN065	**-606**	27	3.15	69.09
91MN067	**-521**	39	24.84	40.45
17MN111	**-521**	33	3.11	55.76
17MN112	**-521**	24	38.68	46.86
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**37**	**38.45**	
Expected response to TP stress		↓	↓	↑

Candidate cause: Nitrates

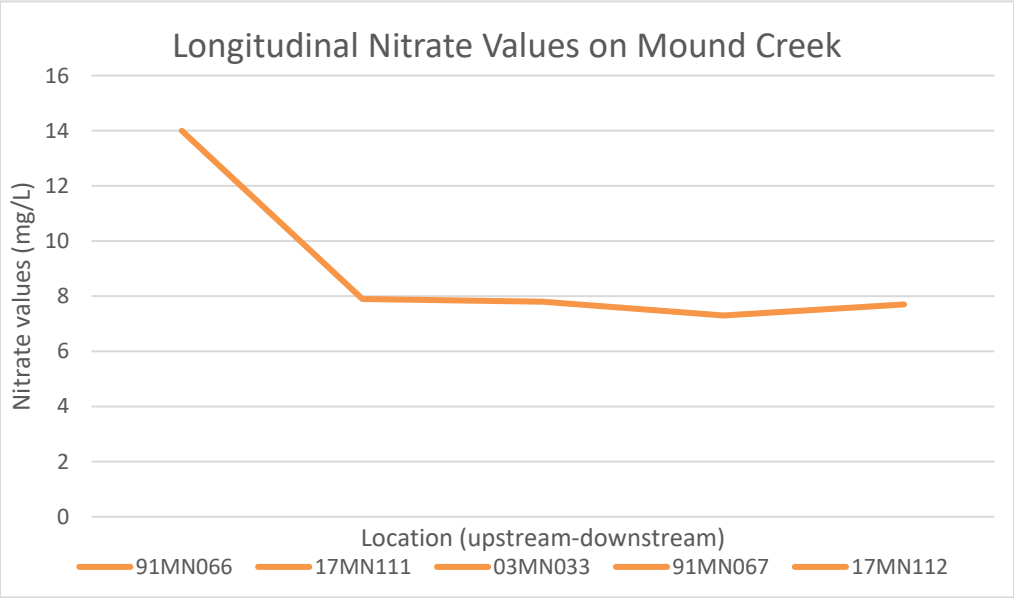
Recent nitrate data was available on Mound Creek with samples values ranging from 0.47 to 16 mg/L (Table 107). The highest values were located at site S005-690 (17MN112), near the mouth of the river before it flows into the Cottonwood River. The tributary to Mound Creek had little nitrate data available, with values ranging from 0.05 to 8.6 mg/L.

Table 107. Nitrate samples collected in the Mound Creek HUC

Stream reach	# nitrate values	Range of values (mg/L)
Mound Creek (-521)	26	0.47-16
Unnamed Creek (-606)	3	0.05-8.6

A longitudinal sample of nitrate values after a rainfall at five locations on Mound Creek showed the highest value was at the most upstream site (Figure 51). Station 91MN066, the most upstream site is located just upstream of the Wellner-Hageman dam.

Figure 51. Longitudinal nitrate samples on Mound Creek



Nitrate tolerant individuals comprised 25% (17MN111) to 75% (91MN065) of the macroinvertebrate communities (Table 108). Nitrate intolerant macroinvertebrate taxa were absent at every site. Increasing nitrate concentrations also have a negative relationship with nonhydropsychid Trichoptera (caddisfly) individual percentages. Nonhydropsychid Trichoptera are all caddisflies that do not spin nets. Values range from 0% to 10.69%, half below the class average of sites meeting the threshold. High nitrate values were collected both in the headwaters and near the mouth and metric data shows some indications of stress on both Mound Creek and the unnamed creek. Based on inconsistent metric response, nitrate is inconclusive stressor to Mound Creek and the unnamed Creek.

Table 108. Nitrate related metrics in the Mound Creek HUC

		Nitrate related Macroinvertebrate Metrics			
Station	**WID**	TrichwoHydroPct	N % Tolerant Taxa	N Intolerant Taxa	Nitrogen TIV
91MN065	**-606**	0	75.24	0	3.69
91MN067	**-521**	4.14	74.05	0	3.59
17MN111	**-521**	0.93	24.61	0	2.59
17MN112	**-521**	10.69	69.18	0	3.58
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**4.02**	**54.87**	**3.18**	**3.23**
Expected response to Nitrate stress		↓	↑	↓	↑

Candidate cause: Sediment

Recent TSS samples on Mound Creek ranged in value from 10 to 158 mg/L, with three concentrations above the southern standard of 65 mg/L (Table 109). The value of 158 mg/L was taken at station S005-690 near station 17MN112, and the mouth of Mound Creek. Additionally, secchi tube measurements ranged from 10 to 60 cm. Of these measurements, zero samples were below the 10 cm standard for transparency. Only two recent TSS samples and two secchi readings are available on the unnamed creek. Both TSS samples were below 8 mg/L and both secchi readings were greater than 100 cm. Mound Creek was turbid at both stations 17MN111 and 17MN112 (Figure 52 and Figure 53).

Table 109. TSS values in the Mound Creek HUC

Stream reach	# TSS values	Range of values (mg/L)	# of values above 65 mg/L
Mound Creek (-521)	13	10-158	3
Unnamed Creek (-606)	2	2.8-7.2	0

Figure 52. Turbidity at site 17MN111

Figure 53. Turbidity at site 17MN112

There were no TSS intolerant taxa present except as station 91MN067, where one intolerant taxa was collected. Tolerant macroinvertebrate individuals comprised slightly higher than the class average at stations 91MN067 and 17MN111 and below at stations 17MN112 and 91MN065 (Table 110). While there were some elevated TSS samples at the mouth of the creek, TSS response is mixed. TSS is not a stressor on Mound Creek or the tributary.

Table 110. TSS related macroinvertebrate metrics in the Mound Creek HUC

		TSS related Macroinvertebrate Metrics					
Station	**WID**	TSS Index Score	TSS Intolerant Taxa	TSS Tolerant Pct	Collector Filterer Pct	Plectoptera Pct	Long-lived Pct
91MN065	**-606**	17.03	0	34.48	1.89	0	2.52
91MN067	**-521**	18.33	1	52.53	15.29	0	8.92
17MN111	**-521**	17.47	0	43.61	6.54	0	2.49
17MN112	**-521**	17.07	0	52.83	29.56	0	5.35
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI General Use Threshold (41.0)		**17.78**	**1.33**	**48.28**	**19.13**	**0.22**	**7.99**
Expected response to stress		↑	↓	↑	↓	↓	↓

Candidate cause: Lack of habitat

Habitat conditions were shown to be poor by MSHA scores at station 91MN067 (48), fair at station 17MN111 (57), and good at station 17MN112 (68) the downstream reach. Station 91MN067 had sparse cover amount and embeddedness of coarse substrates by fines. and fair at station 91MN065 (27 in 2017, 47 in 2010). Station 17MN111 was located in an active cattle pasture resulting in bank trampling and siltation (Figure 54). Station 17MN112 had a large prairie riparian but was located just downstream of a cattle pasture.

Figure 54. Cattle pasture along Mound Creek (6/27/19)

Clingers need coarse substrates and decrease with the increase in percent fines. The percentages of clingers were below average at sites 91MN067 and 17MN111. Burrowers and legless individuals are a signal of high levels of sedimentation (Table 111). Burrowers percentages were higher than average at stations 17MN111 and legless percentages were higher than average at all sites except 17MN111. EPT percentages were above class average at all sites except 17MN112. Habitat is a stressor on both reaches and is concentrated in the upper reach of Dry Creek.

Table 111. Habitat related metrics in the Mound Creek HUC

		Habitat related Macroinvertebrate Metrics				
Station	**WID**	BurrowerPct	ClimberPct	ClingerPct	EPTPct	LeglessPct
91MN065	**-606**	3.47	34.07	56.78	3.15	73.50
91MN067	**-521**	4.78	42.99	30.25	24.84	64.97
17MN111	**-521**	9.35	33.33	19.00	3.11	36.13
17MN112	**-521**	5.35	35.53	53.14	38.68	52.52
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI General Use Threshold (41.0)		**7.51**	**21.59**	**38.50**	**38.45**	**39.76**
Expected response to Habitat stress		↑	↓	↓	↓	↑

Candidate cause: Altered hydrology

Mound Creek is a natural stream with a channelized section in the headwaters and channelized tributaries. The unnamed creek is predominantly channelized. Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency, increasing the impact of high flow events and increasing the intensity of low flow periods, both of which affect biological communities. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat. Habitat availability can be scarce when flows are interrupted, or low for a prolonged duration. Flows that are reduced beyond normal baseflow decrease living space for aquatic organisms and increase competition for resources.

Generalist fish species, which are adaptable to different habitats through generalized food preferences, are correlated with channelization. The reaches had a population of generalist fish ranging from 44% to 90%. The numbers of nest guarder species are also positively correlated with increased low flows. The nest guarder species had a population ranging from 11% to 43%. Long-lived macroinvertebrates decrease with flow changes as they are not able to stay in one place as conditions change. The range of long-lived macroinvertebrates ranged from 2% to 9%. The channelization is likely contributing to the lack of habitat and is a contributing stressor to Mound Creek and the tributary.

Candidate cause: Connectivity

Connectivity is another important aspect of hydrology. Fish migration is dependent on stream connectivity. Station 17MN111 is located just downstream of the Wellner-Hageman reservoir impoundment on Mound Creek. Perched culverts were also present at sites 91MN067 on Mound Creek and 91MN065 on the tributary (Figure 55 and Figure 56). All are acting as fish barriers. Connectivity is a stressor on Mound Creek and its tributary.

Figure 55. Culvert at site 91MN067 (6/27/19)

Figure 56. Perched culvert at site 91MN065 (8/22/19)

Summary and recommendations

The Mound Creek HUC contains two biologically impaired stream reaches; on Mound Creek and a tributary to Mound Creek. Eutrophication, habitat, altered hydrology, and connectivity are the stressors in this watershed (Table 112).

The predominant land use in this subwatershed, row crop agriculture, is a contributor to the stressors found in these reaches. Utilizing a variety of nutrient reducing BMPs including: cover crops, nutrient management, saturated buffers, etc., will also help both in phosphorus reduction. Fixing the perched culverts would help fish migration.

Table 112. Stressors on streams in the Coal Mine Creek HUC

Stream name	Stressors:						
	Dissolved oxygen	Eutrophication	Nitrate	Suspended sediment	Habitat	Altered hydrology	Connectivity
Mound Creek (-521)	o	●	o	---	●	●	●
Unnamed Creek (-606)	o	●	o	---	●	●	●

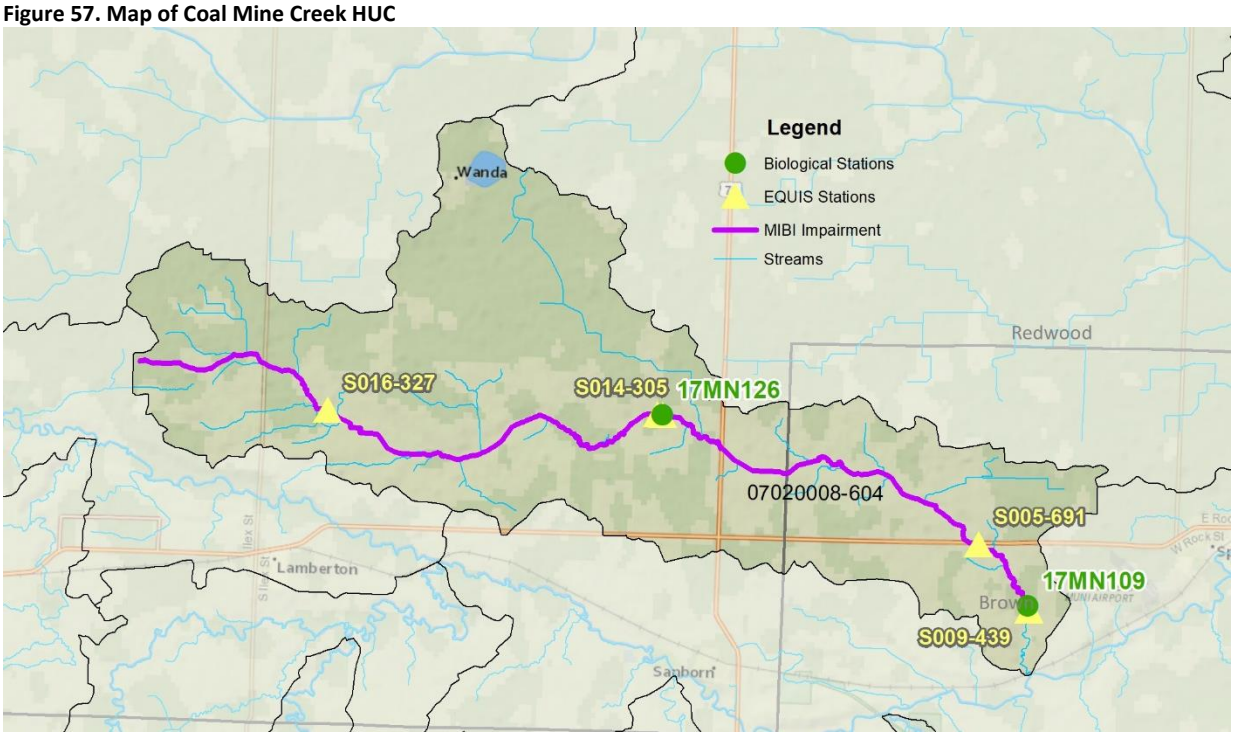
● = stressor; o = inconclusive stressor; --- = not an identified stressor

Coal Mine Creek 12-digit HUC

This aggregated HUC includes Coal Mine Creek and its watershed (Figure 57). The watershed has the following impairments:

- Coal Mine Creek (-604) impaired by macroinvertebrates (17MN109, 17MN126, S005-691, S009-439, S014-305)

Figure 57. Map of Coal Mine Creek HUC



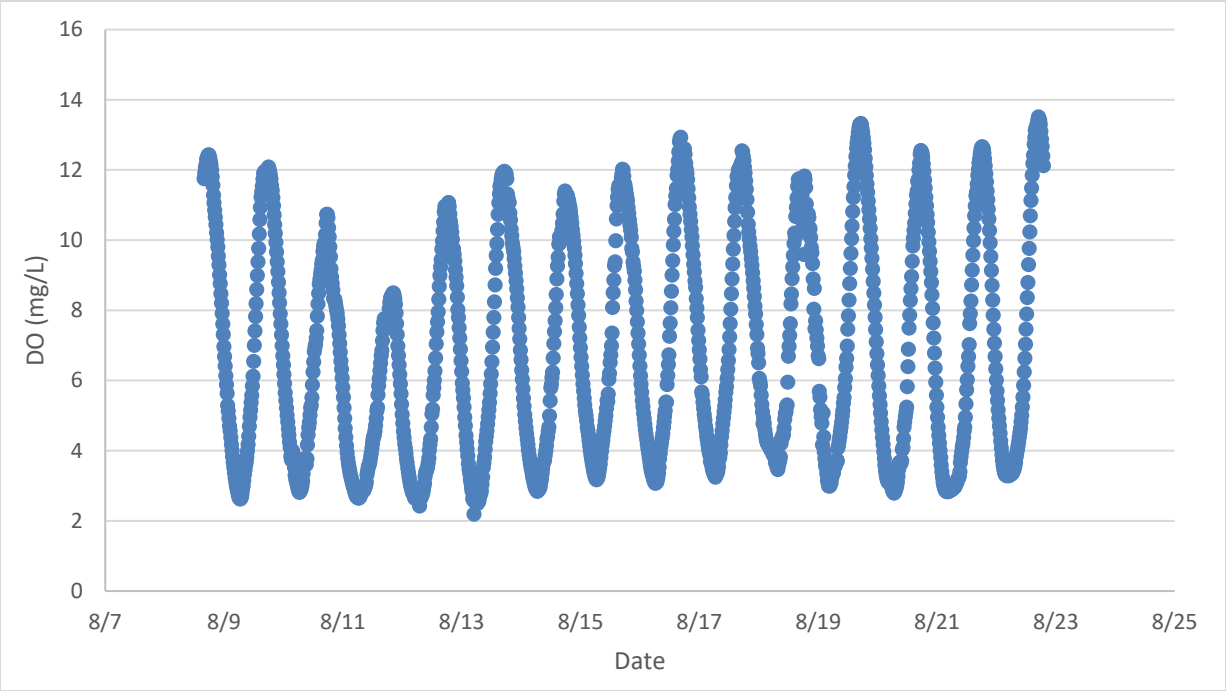
Candidate cause: Dissolved oxygen

Values in this HUC ranged from 3.04 mg/L to 13.37 mg/L (Table 113). The minimum and maximum values were collected at station S005-691 near the mouth of the creek. The wide range of DO values was indicative of possible eutrophication. Three values were below 5 mg/L. Continuous data was collected at station 17MN126 in 2019, where the recorded minimum was 2.19 mg/L, and where DO values daily fell below 5 mg/L (Figure 58).

Table 113. DO data in the Coal Mine Creek HUC

Stream reach	# DO values	Range of DO values	# of values below 5 mg/L
Coal Mine Creek (-604)	60	3.04-13.37 mg/L	3

Figure 58. Continuous DO data at station 17MN126 on Coal Mine Creek



Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed (Table 114). One taxa of intolerant macroinvertebrates were collected at both stations. The percentage of DO tolerant individuals ranged from 31.68% to 67.99%. Based on the daily low DO values collected, DO intolerant fish and macroinvertebrates, and preponderance of evidence DO is a stressor to the biological communities on Coal Mine Creek.

Table 114. DO related macroinvertebrate metrics in the Coal Mine Creek HUC

		DO related macroinvertebrate metrics			
Station	**WID**	Percentage DO tolerant macroinvertebrates	HBI_MN	Intolerant DO macroinvertebrate taxa	DO tolerant index score
17MN109	-604	31.68	8.42	1	6.56
17MN126	-604	67.99	7.71	1	6.21
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**31.37**	**8.00**	**1.78**	**6.19**
Expected response to DO stress		↑	↑	↓	↑

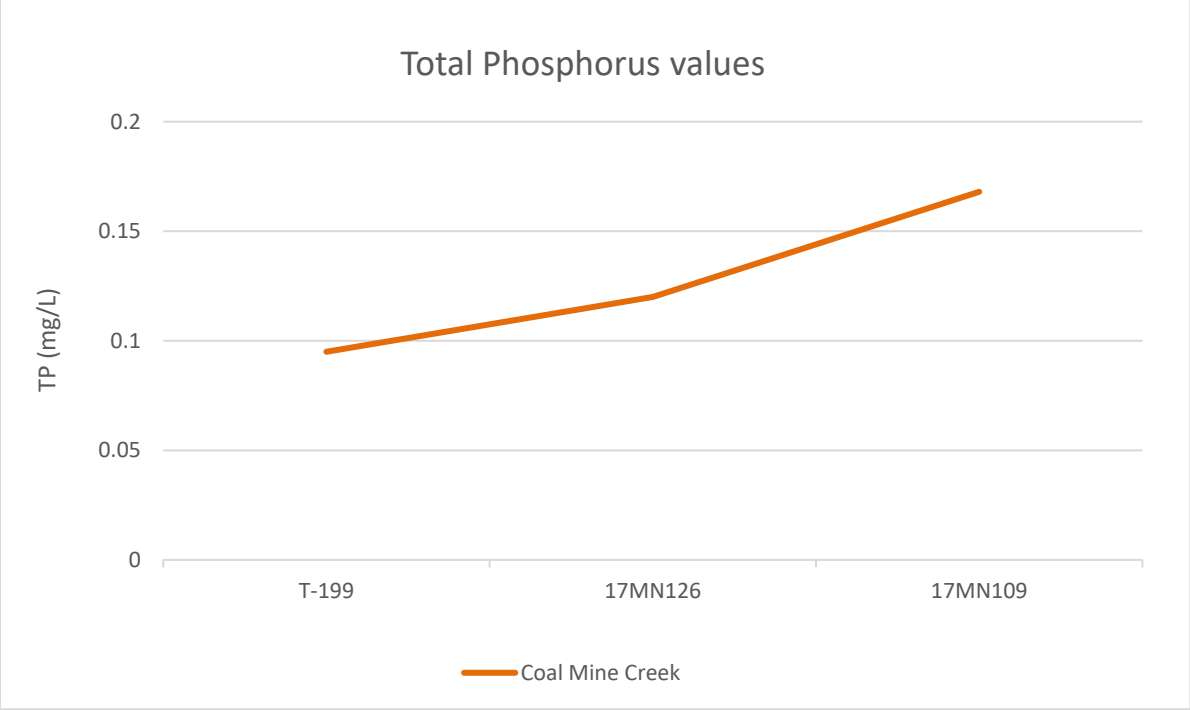
Candidate cause: Eutrophication

Recent phosphorus data on Coal Mine Creek ranged from 0.054 to 0.398 mg/L (Table 115). The highest values were taken at station S005-691 near the mouth of the creek. The highest value on a longitudinal survey was sampled just downstream of station S005-691 at station 17MN109 (Figure 59).

Table 115. Phosphorus values in the Coal Mine Creek HUC

Stream reach	# TP values	Range of TP values	# of values above 0.150 mg/L
Coal Mine Creek (-604)	33	0.054-0.398	18

Figure 59. Longitudinal samples on Coal Mine Creek



Chl-*a*, BOD, and DO fluctuations values are a proximate measurement of eutrophication and have more direct impacts on biology than phosphorus. Chl-*a* data had a range of values from 1 to 32.6 ug/L, all below the southern standard of 40 ug/L. Continuous data collected in 2019 at site 17MN126 had a DO flux range of 5.84 to 10.33 mg/L. Of the 13 deployment days, all of the daily fluctuations were above 4.5 mg/L, the southern standard. Algae was also noted during sampling at station 17MN126 (Figure 60).

Figure 60. Algal growth at site 17MN126

Station 17MN126 had a macroinvertebrate community dominated by two species; snails and Hyalella (a crustacean) (Table 116). Snails increase as their food source algae increases. The EPT percentage was high at station 17MN109, however EPT species tolerant to disturbance were the most commonly collected EPT taxa. Based on the elevated DO flux and biological metrics, eutrophication is a stressor to the macroinvertebrate community.

Table 116. Eutrophication related metrics in the Coal Mine Creek HUC

		Eutrophication Related Macroinvertebrate Metrics		
Station	**WID**	Invert Taxa	EPT Pct	Dominant 2 Invert CH Pct
17MN109	**-604**	32	21.49	38
17MN126	**-604**	19	1.23	81.23
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**34**	**20.58**	
Expected response to TP stress		↓	↓	↑

Candidate cause: Nitrates

Recent nitrate data available on Coal Mine Creek with samples values ranging from 0.47 to 15 mg/L (Table 117). The highest values were located at site S005-691, near the mouth of the river before it flows into the Cottonwood River.

Table 117. Nitrate samples collected in the Coal Mine Creek HUC

Stream reach	# nitrate values	Range of values (mg/L)
Coal Mine Creek (-604)	25	0.17-15

Nitrate intolerant macroinvertebrate taxa were absent at both sites. Nitrate tolerant individuals comprised 26% to 75% of the macroinvertebrate communities (Table 118). Increasing nitrate concentrations also have a negative relationship with nonhydropsychid Trichoptera (caddisfly) individual percentages. Nonhydropsychid Trichoptera are all caddisflies that do not spin nets. Values range from 0% to 4.67%. High nitrate values were collected near the mouth and metric data shows some indications of stress on Coal Mine Creek, however nitrate is currently inconclusive as a stressor to Coal Mine Creek.

Table 118. Nitrate related metrics in the Coal Mine Creek HUC

		Nitrate related Macroinvertebrate Metrics			
Station	**WID**	TrichwoHydroPct	N % Tolerant Taxa	N Intolerant Taxa	Nitrogen TIV
17MN109	**-604**	4.67	74.53	0	4.87
17MN126	**-604**	0	26.22	0	3.82
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**2.16**	**59.41**	**1.95**	**3.32**
Expected response to Nitrate stress		↓	↑	↓	↑

Candidate cause: Sediment

Recent TSS samples on Coal Mine Creek ranged in value from 3 to 58 mg/L, with zero concentrations above the southern standard of 65 mg/L (Table 119). Additionally, secchi tube measurements ranged from 1 to 100 cm. Of these measurements, two samples were below the 10 cm standard for transparency. Eroding banks were present in the headwaters of the stream (Figure 61).

Table 119. TSS values in the Coal Mine Creek HUC

Stream reach	# TSS values	Range of values (mg/L)	# of values above 65 mg/L
Coal Mine Creek (-604)	12	2.8-58	0

Figure 61. Erosion along Coal Mine Creek (6/26/19)

There were no TSS intolerant taxa present, while tolerant macroinvertebrate individuals comprised higher than the class average at one of the two stations (Table 120). There are some indications of sediment stress to the macroinvertebrate community. However, the response is possibly due to suspended organic matter as seen in thick algae at station 17MN126. TSS is inconclusive as a stressor to Coal Mine Creek.

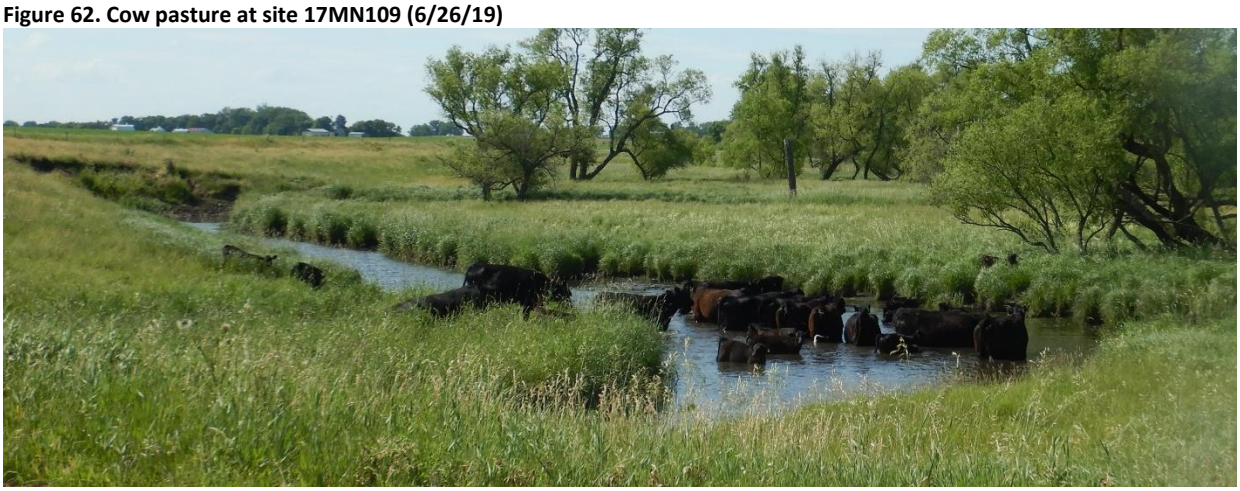
Table 120. TSS related metrics in the Coal Mine Creek HUC

		TSS related Macroinvertebrate metrics					
Station	**WID**	TSS Index Score	TSS Intolerant Taxa	TSS Tolerant Pct	Collector Filterer Pct	Plectoptera Pct	Long-lived Pct
17MN109	**-604**	20.34	0	66.15	2.18	0	1.56
17MN126	**-604**	17.88	0	33.23	1.53	0	0
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**16.25**	**0.6**	**35.60**	**9.91**	**0.02**	**5.59**
Expected response to stress		↑	↓	↑	↓	↓	↓

Candidate cause: Lack of habitat

Habitat conditions were shown to be poor by MSHA scores at both stations. Both stations had a lack of channel development, moderate embeddedness and station 17MN126 had no depth variability or coarse substrates and had choking vegetation present. Station 17MN109 was in an active cattle pasture (Figure 62).

Figure 62. Cow pasture at site 17MN109 (6/26/19)



Clingers need coarse substrates and decrease with the increase in percent fines. The percentages of clingers were below average at both sites (Table 121). Burrowers and legless individuals are a signal of high levels of sedimentation. Burrowers percentages were lower than average at both stations while legless percentages were only higher than average at site 17MN109. EPT percentages were above class average at 17MN109. Based on the poor MSHA scores and the preponderance of evidence, habitat is a stressor to Coal Mine Creek.

Table 121. Habitat related metrics in the Coal Mine Creek HUC

		Habitat related Macroinvertebrate metrics				
Station	**WID**	BurrowerPct	ClimberPct	ClingerPct	EPTPct	LeglessPct
17MN109	**-604**	6.23	53.89	12.15	21.49	57.94
17MN126	**-604**	0.92	36.81	2.15	1.22	30.06
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI Modified Use Threshold (22.0)		**14.12**	**27.47**	**23.07**	**20.58**	**55.79**
Expected response to Habitat stress		↑	↓	↓	↓	↑

Candidate cause: Altered hydrology

Coal Mine Creek is an almost completely altered waterway. “In the Coal Mine Creek Watershed, only 4.07% of stream length is considered natural, while nearly 60% is considered altered or channelized” (DNR 2020). Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency, increasing the impact of high flow events and increasing the intensity of low flow periods, both of which affect biological communities. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat. Habitat availability can be scarce when flows are interrupted, or low for a prolonged duration. Flows that are reduced beyond normal baseflow decrease living space for aquatic organisms and increase competition for resources.

Long-lived macroinvertebrates decrease with flow changes as they are not able to stay in one place as conditions change. The range of long-lived macroinvertebrates ranged from 01.56% to 9% at the two sites The channelization is likely contributing to the lack of habitat and is a contributing stressor to Coal Mine Creek.

Summary and recommendations

The Coal Mine Creek HUC contains one biologically impaired stream reach on Coal Mine Creek. Eutrophication, habitat, and altered hydrology are the stressors in this watershed (Table 122).

The predominant land use in this subwatershed, row crop agriculture, is a contributor to the stressors found in these reaches. Utilizing a variety of nutrient reducing BMPs including: cover crops, nutrient management, saturated buffers, etc., will also help both in phosphorus reduction

Table 122. Stressors on streams in the Coal Mine Creek HUC

	Stressors					
Stream name	**Dissolved oxygen**	**Eutrophication**	**Nitrate**	**Suspended sediment**	**Habitat**	**Altered hydrology**
Coal Mine Creek (-604)	●	●	o	o	●	●

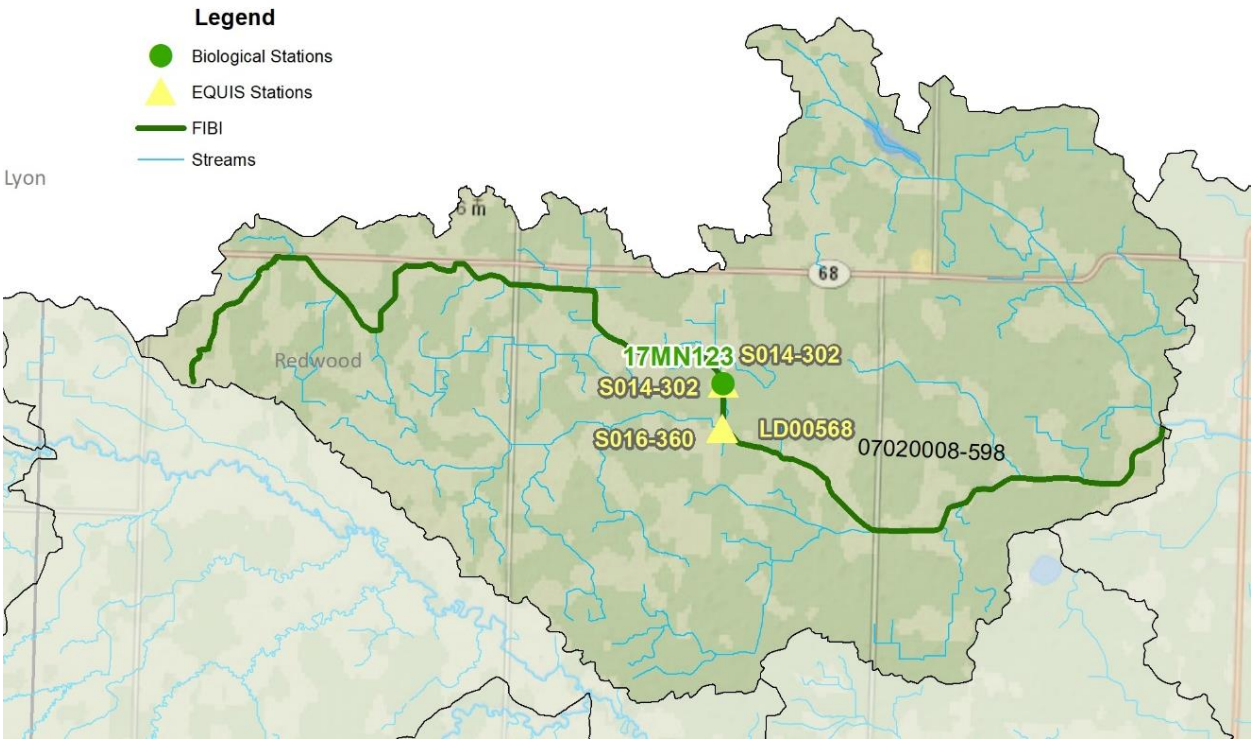
● = stressor; o = inconclusive stressor; --- = not an identified stressor

Upper and Lower Sleepy Eye Creek 12-digit HUC

The Upper and Lower Sleepy Eye HUCs were combined for this report. These aggregated HUCs include Sleepy Eye Creek and three tributaries to the river (Figure 63). The streams in this section have the following impairments:

- Sleepy Eye Creek (-598) impaired by fish (17MN123, 17MN119, 17MN115, 97MN014, S001-916, S009-441, S010-492, S014-302, S014-475)
- Sleepy Eye Creek (-599) is impaired by macroinvertebrates (03MN032, S001-919, S005-378, S009-780) and Turbidity and Chlorpyrifos
- County Ditch 26 (-597) is impaired by macroinvertebrates (17MN118, S014-298)
- County Ditch 38 (-557) is impaired by macroinvertebrates (10EM007, 17MN116, S006-656, S011-266, S014-296)
- County Ditch 38 (-550) is impaired by fish and macroinvertebrates (07MN073, 17MN114, S010-493, S014-295)

Figure 63. Map of the Upper and Lower Sleepy Eye Creek HUC



Candidate Cause: Dissolved Oxygen

Values on Sleepy Eye Creek ranged from 4.57 mg/L to 17.5 mg/L (Table 123). The minimum value was collected at site 17MN119 and the maximum was collected at site 03MN032 near the mouth of the creek. The wide range of DO values was indicative of possible eutrophication. Values on the ditches ranged from 1.35 to 15.66 mg/L with four values below the water quality standard of 5 mg/L. Three of the lowered values occurred on reach -557.

Table 123. DO values in the Upper and Lower Sleepy Eye Creek HUC

Stream reach	# DO values	Range of DO values	# of values below 5 mg/L
County Ditch 38 (-550)	4	5.6- 15.66 mg/L	0
County Ditch 38 (-557)	6	1.35 – 11.39 mg/L	3
County Ditch 26 (-597)	2	4.94- 14.43 mg/L	1
Sleepy Eye Creek (-598)	23	4.57-16.45 mg/L	1
Sleepy Eye Creek (-599)	295	5.2-17.5 mg/L	0

Fish species that are specifically tolerant and intolerant to DO were analyzed at each station. There were no intolerant fish at any station except one intolerant fish at one of the three visits at site 03MN032. DO tolerant percentages ranged from less than 1% (03MN032) to 56% (17MN115) on Sleepy Eye Creek and 41% (17MN114) to 64% (10EM007) on the ditches.

The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. The ditch reaches and three of the four stations on reach -598 of Sleepy Eye Creek had less than 5% of fish that take 3 years or longer to mature, indicating that fish are quick to reproduce due to short life spans from the influence of human disturbance. Low DO values also correspond with increased serial spawning fish percentage. Serial spawning occurs based on

environmental stress. Serial spawners ranged from 3.39 to 77.63% (Table 124). One visit on station 10EM007 was the only visit with a serial spawning percentage lower than the class average.

Table 124. DO related fish metrics in the Upper and Lower Sleepy Eye Creek HUC

		DO Related Fish Metrics		
Station	**WID**	MA>3years Percentage	Serial Spawning Fish Pct	Fish Taxa Count
03MN032 (2012)	**-599**	37.35	36.44	26
03MN032 (2016)	**-599**	36.14	30.92	25
03MN032 (2017)	**-599**	25.22	42.98	26
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**12.36**	**28.72**	**20.38**
97MN014	**-598**	19.23	57.69	22
17MN115	**-598**	4.37	61.65	17
17MN119	**-598**	0.14	77.63	18
17MN123	**-598**	0	60	5
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI Modified Use Threshold (35.0)		**15.09**	**25.34**	**14.5**
10EM007 (2010)	**-557**	0	23.24	9
10EM007 (6/9/2015)	**-557**	0	3.39	6
10EM007 (8/5/2015)	**-557**	0	11.26	9
17MN114 (7/24/2017)	**-550**	0	31.03	10
17MN114 (8/15/2017)	**-550**	0	40.35	8
17MN116	**-557**	0	47.63	9
Statewide average for Class 3 Southern Streams stations meeting the FIBI Modified Use Threshold (55.0)		**1.43**	**10.56**	**10**
Expected response to increased DO stress		↓	↑	↓

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed at each station. Intolerant macroinvertebrate taxa were lower than average at all sites except for the two most downstream sites on Sleepy Eye Creek (Table 125). DO tolerant percentages were higher than the class average on reach -550, -597, and two of the three reaches on -557. DO tolerant percentages were lower than average on the lower reach of Sleepy Eye Creek (-599) and were higher than average at four of the six visits on the upper reach (-598). Based on the lowered DO values and the biological response, low DO is a stressor to both reaches -557 and -597. DO is inconclusive as a stressor on reaches -550 and -598 and is not a stressor on reach -599.

Table 125. DO related macroinvertebrate metrics in the Upper and Lower Sleepy Eye Creek HUC

		DO related macroinvertebrate metrics			
Station	**WID**	Percentage DO Tolerant Macroinvertebrates	HBI_MN	Intolerant DO Macroinvertebrate Taxa	DO Tolerant Index Score
97MN014	**-598**	29.57	8.03	6	6.76
03MN032 (2016)	**-599**	9.51	7.58	5	7.43
03MN032 (2017)	**-599**	3.38	7.61	6	7.71
17MN115	**-598**	13.31	7.94	4	6.84
17MN119	**-598**	25.86	7.93	3	6.21
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI Modified Use Threshold (24.0)		**18.23**	**7.57**	**4.51**	**6.75**
10EM007 (2010)	**-557**	38.75	8.31	0	6.32
10EM007 (2015)	**-557**	66.67	7.70	0	4.49
17MN114	**-550**	48.76	8.44	0	6.50
17MN116	**-557**	19.12	7.91	0	6.30
17MN118	**-597**	65.15	7.73	0	4.48
17MN123	**-598**	18.89	8.68	1	6.74
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**31.37**	**8.00**	**1.78**	**6.19**
Expected response to DO stress		↑	↑	↓	↑

Candidate Cause: Eutrophication

Recent phosphorus data on Sleepy Eye Creek ranged from 0.021 to 1.56 mg/L (Table 126). The highest value was taken at site. A phosphorus value taken near site 17MN123 from a tile drain was 0.141 and the stream measured 0.55 mg/L. A sample from a tile at site 07MN073 was 0.086 and stream value was 0.064 mg/L.

More than 33% of the samples were above the southern water quality standard of 0.150 mg/L, with the highest values located at 03MN032, the most downstream station. Limited phosphorus values were collected on the ditches, with values ranging from 0.04 to 0.718 mg/L. Reach -557 had the highest phosphorus value of the tributaries with a value of 0.718 mg/L.

Table 126. Phosphorus data in the Upper and Lower Sleepy Eye Creek HUC

Stream reach	# TP values	Range of TP values	# of values above 0.150 mg/L
County Ditch 38 (-550)	3	0.04-0.064	0
County Ditch 38 (-557)	4	0.072-0.718	2
County Ditch 26 (-597)	2	0.081-0.182	1
Sleepy Eye Creek (-598)	22	0.049-0.402 mg/L	5
Sleepy Eye Creek (-599)	425	0.021-1.56	146

Algae growth was observed at sites 07MN073 and 17MN118 (Figure 64 and Figure 65). Chl-*a*, BOD, and DO fluctuations values are a proximate measurement of eutrophication and have more direct impacts on biology than phosphorus. Chl-*a* values on the upstream reach (-598) ranged from 2.1-50.4 ug/L, with one value above the southern water quality standard of 35 ug/L. Values on the downstream reach (-599) ranged from 2.9-98.5 ug/L with two values over the standard. BOD and DO fluctuation data was not available.

Figure 64. Algal growth at site 07MN073 (8/29/2019)

Figure 65. Algal growth at site 10EM007 (8/4/2010)

All stations had low percentages of sensitive percentages except sites 97MN014 and 17MN123 (Table 127). Darters were also below average except at stations 17MN114, 17MN123, and one visit of 03MN032 but the darters collected at site 17MN114 were all johnny darters which are more tolerant.

Fish tolerant to disturbance were higher than average at each station except 03MN032, 17MN114, 17MN115, and 17MN123. Omnivorous fish have a positive relationship with nutrients. Stations 17MN114 and 17MN116 had higher than average percentages.

Table 127. Eutrophication related fish metrics in the Upper and Lower Sleepy Eye Creek HUC

		Eutrophication related Fish Metrics			
Station	**WID**	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Pct
03MN032 (2012)	**-599**	0	3.28	27.13	3.93
03MN032 (2016)	**-599**	0	14.86	22.89	6.02
03MN032 (2017)	**-599**	14.47	10.96	39.91	9.87
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**18.65**	**11.68**	**44.85**	**16.53**
97MN014	**-598**	17.95	13.46	54.49	22.44
17MN115	**-598**	4.37	1.35	45.15	22.33
17MN119	**-598**	0.43	6.20	67.53	11.54
17MN123	**-598**	20	40	40	0
Statewide average for Class 2 Southern Streams stations meeting the FIBI Modified Use Threshold (35.0)		**8.38**	**13.57**	**46.38**	**25.54**
10EM007 (2010)	**-557**	0	2.07	85.89	29.46
10EM007 (6/9/2015)	**-557**	0	6.78	93.22	3.39
10EM007 (8/5/2015)	**-557**	0	0.66	94.04	7.28
17MN114 (7/24/2017)	**-550**	0	20.69	68.97	34.48
17MN114 (8/15/2017)	**-550**	0	54.63	47.37	22.81
17MN116	**-557**	0	0.96	97.29	47.63
Statewide average for Class 3 Southern Headwaters stations that are meeting the FIBI Modified Use Threshold (33.0)		**6.02**	**10.56**	**76.69**	**19.80**
Expected response to increased eutrophication stress		↓	↓	↑	↑

EPT percentages were lower than average except at stations 03MN032, 17MN114, 17MN115 and 97MN014 but sites 03MN032 and 17MN115 were dominated by tolerant caddisflies (Table 128). Eutrophication is inconclusive as a stressor to reach -550, more phosphorus data would be useful. Based on phosphorus data, chl-*a* data, and the preponderance of the biological response, eutrophication is a stressor to both reaches of Sleepy Eye Creek. Eutrophication is also a stressor to the ditches on reaches -557 and -597.

Table 128. Eutrophication related macroinvertebrate metrics in the Upper and Lower Sleepy Eye Creek HUC

		Eutrophication related Macroinvertebrate Metrics		
Station	**WID**	Invert Taxa	EPT Pct	Dominant 2 Invert CH Pct
97MN014	**-598**	39	53.23	43.38
03MN032 (2016)	**-599**	32	72.37	38.49
03MN032 (2017)	**-599**	28	87.35	70.99
17MN115	**-598**	35	47.20	40.37
17MN119	**-598**	35	20.94	55.94
Statewide average for Class 5 Southern Streams RR stations that are meeting the MIBI General Use Threshold (37.0)		**42**	**43.90**	
10EM007 (2010)	**-557**	26	0.96	92.5
10EM007 (2015)	**-557**	23	0	66.24
17MN114	**-550**	32	21.74	57.45
17MN116	**-557**	30	7.52	57.99
17MN118	**-597**	28	1.64	57.38
17MN123	**-598**	30	19.19	69.04
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**34**	**20.58**	
Expected response to TP stress		↓	↓	↑

Candidate Cause: Nitrates

Recent nitrate data was available on Sleepy Eye Creek with samples values ranging from 0.05 to 30 mg/L (Table 129). The highest values on Sleepy Eye Creek were collected at site 03MN032. Values on the three ditches creeks ranged from 0.09 to 28 mg/L. The highest value collected on the unnamed creeks was at site 10EM007 on reach -557. A tile line near site 17MN123 had a nitrate concentration of 6.9 and the creek had a concentration of 5.8 mg/L. A tile line near site 07MN073 had a nitrate concentration of 3.2 and the creek had a concentration of 7.4 mg/L.

Table 129. Nitrate values in the Upper and Lower Sleepy Eye Creek HUC

Stream reach	# nitrate values	Range of values (mg/L)
County Ditch 38 (-550)	3	1.7-7.9
County Ditch 38 (-557)	5	0.09-28
County Ditch 26 (-597)	2	0.79-14
Sleepy Eye Creek (-598)	7	1.6-13
Sleepy Eye Creek (-599)	300	0.05-30.4

Sensitive fish species have a negative relationship with nitrate, but sensitive species are also affected by DO and phosphorus. Better relationships have been made with respect to macroinvertebrate impairment and nitrate concentration.

Nitrate tolerant individuals comprised 39.69 to 87.93% of the macroinvertebrate communities on Sleepy Eye Creek and 12.70% to 93.44% on the unnamed creeks (Table 130). A community of macroinvertebrates with a percentage of nitrate tolerant individuals greater than 78% has only a 25% chance of meeting the MIBI. The intolerant taxa were zero at all stations except for one visit at 03MN032.

Increasing nitrate concentrations also have a negative relationship with nonhydropsychid Trichoptera (caddisfly) individual percentages. Nonhydropsychid Trichoptera are all caddisflies that do not spin nets. Values were below the class average of sites meeting the threshold on reaches -557, 597, and 599. Based on the elevated nitrate values and the preponderance of metric values, nitrate is a stressor to Sleepy Eye Creekthe ditches on reaches -557 and -597. Based on the lack of elevated nitrogen values and mixed biological response, nitrate is inconclusive as a stressor on reach -550.

Table 130. Nitrate related metrics in the Upper and Lower Sleepy Eye Creek HUC

		Nitrate related macroinvertebrate metrics			
Station	**WID**	TrichwoHydroPct	N % tolerant taxa	N intolerant taxa	Nitrogen TIV
97MN014	**-598**	18.46	71.34	0	3.89
03MN032 (2016)	**-599**	7.24	61.64	1	3.22
03MN032 (2017)	**-599**	0.93	39.69	0	4.66
17MN115	**-598**	7.45	66.56	0	3.73
17MN119	**-598**	5	67.60	0	4.34
Statewide average for Class 5 Southern Streams RR stations meeting the MIBI Modified Use Threshold (24.0)		**11.14**	**56.71**	**1.88**	**3.22**
10EM007 (2010)	**-557**	0	93.44	0	4.15
10EM007 (2015)	**-557**	0	25.64	0	2.57
17MN114	**-550**	3.11	77.64	0	4.81
17MN116	**-557**	0.63	72.41	0	5.61
17MN118	**-597**	0	12.70	0	2.07
17MN123	**-598**	4.64	87.93	0	3.88
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**2.16**	**59.41**	**1.95**	**3.32**
Expected response to Nitrate stress		↓	↑	↓	↑

Candidate cause: Sediment

Recent TSS data ranged in value from 2 to 648 mg/L, with 58 concentrations above the southern standard of 65 mg/L on Sleepy Eye Creek (Table 131). All the elevated TSS values were located at station S001-919, which is located near the mouth of Sleepy Eye Creek. Additionally, secchi tube measurements ranged from 2-100, with 25 values below the standard of 10. Limited TSS values were available on the ditches, but County Ditch 38 had an extremely elevated value at 660 mg/L. Secchi measurements at the ditches ranged from 62 to 100 cm. Site 03MN032 was turbid during sampling (Figure 66).

Table 131. TSS data in the Upper and Lower Sleepy Eye Creek HUC

Stream Reach	# TSS values	Range of values (mg/L)	# of values above 65 mg/L
County Ditch 38 (-550)	2	2.8-5.2	0
County Ditch 38 (-557)	3	3.6-660	1
County Ditch 26 (-597)	0	--	-
Sleepy Eye Creek (-598)	25	3-64	0
Sleepy Eye Creek (-599)	266	2-648	58

Figure 66. Turbid conditions at site 03MN032 (6/26/19)

Fish species that are specifically tolerant and intolerant to TSS were analyzed at each station. Intolerant fish on Sleepy Eye Creek were absent, with tolerant fish ranging from 0% (17MN123) to 26% (03MN032). Intolerant species were also absent on the unnamed creeks, with tolerant species all less than 1%. Herbivore species of fish decrease as TSS values increase. The stations all had herbivore percentages lower than the average of sites meeting the IBI thresholds. Perciforms species (smallmouth bass, walleye, etc.) have been demonstrated to decrease as TSS increases. Perciform percentages were low at all stations except 17MN114, 17MN123, and two of the visits at site 03MN032 (Table 132). Centrarchids (sunfish), herbivores, Perciforms, intolerant, and long-lived species all decreased between 2012 and 2017 at site 03MN032 while sunfish, perciforms, intolerant species, and long-lived species all increased at site 97MN014 between 1997 and 2017.

Table 132. TSS related fish metrics in the Upper and Lower Sleepy Eye Creek HUC

		TSS related fish metrics					
Station	**WID**	BenFdFrimPct	Centr-TolPct	HerbvPct	Percfm-TolPct	IntolerantPct	Longlived Pct
03MN032 (2012)	**-599**	25.43	16.12	1.18	19.79	11.14	23.59
03MN032 (2016)	**-599**	16.87	24.49	0.80	39.36	0.40	9.64
03MN032 (2017)	**-599**	30.04	6.14	0.88	17.54	1.32	17.98
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		37.38	4.89	9.61	18.66	4.97	11.68
97MN014	**-598**	25	7.69	0	6.47	0.64	13.46
17MN115	**-598**	55.83	4.37	1.94	6.79	0	0.97
17MN119	**-598**	29	0.14	1.73	6.35	0	0.58
17MN123	**-598**	60	0	0	40	0	0
Statewide average for Class 2 Southern Streams stations meeting the FIBI Modified Use Threshold (35.0)		**30.08**	**6.17**	**2.88**	**28.69**	**0.86**	**21.25**
10EM007 (2010)	**-557**	7.47	0	1.24	2.07	0	0
10EM007 (6/9/2015)	**-557**	6.78	0	5.08	6.78	0	0
10EM007 (8/5/2015)	**-557**	0.66	0.66	0.66	1.32	0	0.66
17MN114 (7/24/2017)	**-550**	27.59	0	0	20.69	0	3.45
17MN114 (8/15/2017)	**-550**	54.39	0	0	52.63	0	1.75
17MN116	**-557**	3.61	0	4.51	1.35	0	0
Statewide average for Class 3 Southern Headwaters stations meeting the FIBI Modified Use Threshold (33.0)		**31.38**	**1.00**	**10.83**	**12.43**	**0.52**	**4.91**
Expected response to TSS stress		↓	↓	↓	↓	↓	↓

TSS intolerant macroinvertebrates were absent at all stations except where one intolerant taxa were collected at stations 03MN032 and 17MN119 (Table 133). All stations had lower than average TSS tolerant percentages except for stations 17MN114, 17MN115, and 17MN116. The long-lived percentage were lower than average at all stations except 17MN115, 17MN116, 17MN119, and 17MN123. Collector-filterer percentages were lowered at all sites except 03MN032 and 17MN115. Collector-filterer percentages increased from 2003 to 2016 at site 03MN032. Plectoptera percentages were lowered at all stations except 97MN014, 03MN032, and 17MN115. Based on the increased TSS values and the preponderance of evidence, TSS is a stressor on the lower reach of Sleepy Eye Creek (-599). More data would be helpful on reaches as a stressor reaches -550, -557, and -597, where TSS is inconclusive. TSS is also inconclusive as a stressor on the upper reach of Sleepy Eye Creek (-598).

Table 133. TSS related macroinvertebrate metrics in the Upper and Lower Sleepy Eye Creek HUC

		TSS related macroinvertebrate metrics					
Station	**WID**	TSS index score	TSS intolerant taxa	TSS tolerant pct	Collector filterer pct	Plectoptera pct	Long-lived pct
97MN014	**-598**	18.43	0	31.09	14.15	0.62	4.92
03MN032 (2016)	**-599**	18.35	1	34.43	33.88	0	2.30
03MN032 (2017)	**-599**	21.36	0	32.31	55.56	0.31	0.62
17MN115	**-598**	17.11	0	41.49	29.19	0.62	6.83
17MN119	**-598**	16.32	1	33.33	11.25	0	7.81
Statewide average for Class 5 Southern Streams RR stations meeting the MIBI Modified Use Threshold (24.0)		**16.10**	**1.16**	**36.67**	**22.05**	**0.10**	**6.46**
10EM007 (2010)	**-557**	13.38	0	10.63	3.13	0	0
10EM007 (2015)	**-557**	13.63	0	1.28	1.61	0	0
17MN114	**-550**	18.92	0	81.06	3.42	0	0.93
17MN116	**-557**	18.19	0	47.02	2.19	0	10.34
17MN118	**-597**	11.83	0	9.45	1.97	0	0.98
17MN123	**-598**	17.59	0	23.53	3.09	0	47.99
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI Modified Use Threshold (22.0)		**16.25**	**0.6**	**35.60**	**9.91**	**0.02**	**5.59**
Expected response to stress		↑	↓	↑	↓	↓	↓

Candidate cause: Lack of habitat

Habitat conditions were shown to be poor according to MSHA scores on the three ditches and at station 97MN014 on Sleepy Eye Creek. The scores at stations 17MN114 and 17MN118 were lowered by a lack of channel development, depth variability, and a lack of coarse substrates. Stations 97MN014, 17MN115, and 17MN118 all had heavy bank erosion (Figure 67, Figure 68, and Figure 69).

Stations 17MN115 and 17MN119 on the upper reach of Sleepy Eye Creek had fair MSHA ratings. A DNR survey location in the upper Sleepy Eye Creek (-598) lacked floodplain connectivity, had a poor stability rating, and had very little instream habitat (DNR 2020). The lower reach (-599) of Sleepy Eye Creek had a good MSHA score. A DNR survey in the lower part of the creek found that "The lower Sleepy Eye Creek has relatively good habitat quality for southern Minnesota" (DNR 2020).

Figure 67. Bank erosion at site 97MN014 (6/26/2019)

Figure 68. Bank erosion at site 17MN118 (6/26/2019)

Figure 69. Bank erosion at site 17MN115 (6/26/2019)

Simple lithophilic spawners, which require coarse substrate for spawning, typically decrease in numbers with limited habitat. Percentages were much lower than average at all stations on the ditches and two sites on Sleepy Eye Creek (17MN123 and 17MN119). Benthic insectivores, darter, sculpin, and sucker, and Piscivore individuals were lowered on reach -557 (Table 134). Darter, sculpin, and sucker, and Piscivore individuals were also lowered on the upper reach at sites 17MN115 and 17MN119. Darters are sensitive to siltation and riffle species tend to decrease due to lack of habitat. Riffle species were near average or below average at all sites. The percentage of tolerant species were above average on reaches -550, -557, and sites 97MN015, 17MN119on the upper reach Sleepy Eye Creek. The percentage of tolerant fish increased between 2012 and 2017 on the lower reach of Sleepy Eye Creek.

Table 134. Habitat related fish metrics in the Upper and Lower Sleepy Eye Creek HUC

		Habitat related fish metrics							
Station	**WID**	BenInsect-TolPct	SLithopPct	DarterSculpSucPct	RiffePct	PiscivorePct	LithFrimPct	TolPct	PioneerPct
03MN032 (2012)	**-599**	23.85	44.29	23.19	19.53	16.51	49.80	27.13	9.04
03MN032 (2016)	**-599**	26.51	37.35	26.10	19.68	26.10	42.57	22.89	14.46
03MN032 (2017)	**-599**	26.97	41.45	26.75	20.18	7.89	39.04	39.91	23.90
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**20.39**	**39.38**	**18.18**	**32.49**	**5.24**	**58.26**	**44.85**	**19.02**
97MN014	**-598**	23.08	34.62	23.08	20.51	10.25	25.64	54.48	45.51
17MN115	**-598**	44.17	24.27	2.43	12.14	4.37	27.67	45.15	19.42
17MN119	**-598**	26.98	10.39	6.20	2.45	0.14	14.57	67.53	25.83
17MN123	**-598**	60	0	40	20	0	20	40	20
Statewide average for Class 2 Southern Streams stations meeting		**19.05**	**26.17**	**16.45**	**19.54**	**8.02**	**35.59**	**46.38**	**23.58**

Station	WID	Habitat related fish metrics: BenInsect-TolPct	SLithopPct	DarterSculpSucPct	RiffPct	PiscivorePct	LithFrimPct	TolPct	PioneerPct
the FIBI Modified Use Threshold (50.0)									
10EM007 (2010)	**-557**	2.07	26.97	2.07	5.39	0	55.60	85.89	56.94
10EM007 (6/9/2015)	**-557**	6.78	8.47	6.78	0	0	28.81	93.22	30.51
10EM007 (8/5/2015)	**-557**	0.66	18.54	0.66	0	0	70.86	94.04	60.26
17MN114 (7/24/2017)	**-550**	27.59	10.34	20.69	0	0	24.14	68.97	55.17
17MN114 (8/15/2017)	**-550**	52.63	3.51	52.63	1.75	0	3.51	47.37	85.96
17MN116	**-557**	1.35	26.19	1.35	2.26	0	47.86	97.29	68.85
Statewide average for Class 3 Southern Headwaters stations meeting the FIBI Modified Use Threshold (33.0)		**10.91**	**30.09**	**10.59**	**22.62**	**1.97**	**57.98**	**76.69**	**32.54**
Expected response to Habitat stress		↓	↓	↓	↓	↓	↓	↑	↑

Clingers need coarse substrates and decrease with the increase in percent fines. The percentages of clingers were below average at sites 17MN114, 17MN116, and 17MN118 (Table 135). Burrowers and legless individuals are a signal of high levels of sedimentation. Legless percentages were increased at sites 17MN114, 17MN116, and 17MN119. EPT percentages were below class average at sites 10EM007, 17MN116, and 17MN118. Based on the poor habitat conditions and preponderance of evidence, lack of habitat is stressor to reaches -550, -557, -597, and the upper reach of Sleepy Eye Creek (-598).

Table 135. Habitat related macroinvertebrate metrics in the Upper and Lower Sleepy Eye Creek HUC

Station	WID	Habitat related Macroinvertebrate Metrics: BurrowerPct	ClimberPct	ClingerPct	EPTPct	LeglessPct
97MN014	**-598**	4.31	12.92	40.62	53.23	29.84
03MN032 (2016)	**-599**	2.63	6.25	52.96	72.37	22.37
03MN032 (2017)	**-599**	3.70	2.47	62.04	87.35	10.80
17MN115	**-598**	2.48	23.91	53.11	47.20	37.27
17MN119	**-598**	15	28.13	34.38	20.94	59.38
Statewide average for Class 5 Southern Streams RR stations meeting the MIBI Modified Use Threshold (24.0)		**8.99**	**21.49**	**39.23**	**33.60**	**45.53**
10EM007 (2010)	**-557**	14.69	9.32	7.07	0.96	27.65
10EM007 (2015)	**-557**	12.54	42.19	38.75	0	98.44
17MN114	**-550**	7.14	43.79	11.49	21.74	58.39
17MN116	**-557**	3.13	45.77	15.67	7.52	60.50
17MN118	**-597**	10.82	21.97	4.59	1.64	32.13

		Habitat related Macroinvertebrate Metrics				
Station	WID	BurrowerPct	ClimberPct	ClingerPct	EPTPct	LeglessPct
17MN123	**-598**	4.33	18.26	53.56	19.19	25.08
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI Modified Use Threshold (22.0)		**14.12**	**27.47**	**23.07**	**20.58**	**55.79**
Expected response to Habitat stress		↑	↓	↓	↓	↑

Candidate cause: Altered hydrology

"The Sleepy Eye Creek Watershed is the most significantly altered large (i.e. >200 square mile drainage area) watershed surveyed by DNR staff in southern Minnesota" (DNR 2020). All of the upper reach of Sleepy Eye Creek has been altered while the lower reach (-599) is natural. County Ditch 24 (-550), County Ditch 38 (-557), and County Ditch 26 (-597) are 100% channelized. Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency, increasing the impact of high flow events and increasing the intensity of low flow periods, both of which affect biological communities. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat.

Habitat availability can be scarce when flows are interrupted, or low for a prolonged duration. Flows that are reduced beyond normal baseflow decrease living space for aquatic organisms and increase competition for resources. The loss of wetlands in this subwatershed have also altered hydrology by limiting the amount of water storage capacity on the landscape. "Thousands of historic wetlands exist throughout the (Cottonwood) watershed, especially in the Sleepy Eye Creek Subwatershed." (DNR 2020).

Generalist fish species, which are adaptable to different habitats through generalized food preferences, are correlated with channelization. Sleepy Eye Creek had a population of generalist fish ranging from 20% to 59% and the ditches had a population ranging from 32% to 94%. The numbers of nest guarder species are also positively correlated with increased low flows. The nest guarder species had a population ranging from 23% to 43% on Sleepy Eye and 25% to 88% on the ditches. Long-lived macroinvertebrates decrease with flow changes as they are not able to stay in one place as conditions change. The range of long-lived macroinvertebrates ranged from 5% to 62% on Sleepy Eye and 0% to 10% on the ditches. The channelization is likely contributing to the lack of habitat on the reaches and is a contributing stressor to the biological communities. While the downstream reach of Sleepy Eye is natural the upstream channelization, wetland removal, and tile drainage has altered the hydrology of the creek.

Candidate cause: Connectivity

Connectivity is another important aspect of hydrology. Fish migration is dependent on-stream connectivity. There were no known dams or connectivity issues on Sleepy Eye Creek. A perched culvert was present at site 17MN116 on County Ditch 38 and is acting as a fish barrier (Figure 70). Connectivity is a stressor on County Ditch 38.

Figure 70. Perched culvert at site 17MN116 (6/26/2019)

Candidate cause: Pesticides

Sleepy Eye Creek has a Chloropyrifos pesticide impairment on the lower reach of the creek (-599). Eighty-one samples were collected on the creek and five were over the standard of 0.41 ug/L with a high concentration of 0.121 ug/L. Insecticides can lead to changes in condition, growth, and susceptibility to other stressors (EPA 2022). Low DO or high temperature can exacerbate effects (EPA 2022). Further macroinvertebrate sampling would be helpful to check for invertebrate community drift. Pesticides are currently inconclusive as a stressor to the lower reach of Sleepy Eye Creek.

Summary and recommendations

The Upper and Lower Sleepy Eye Creek HUC contains five biologically impaired stream reaches; two on Sleepy Eye Creek and three ditches that are tributaries to Sleepy Eye Creek. DO, eutrophication, nitrate, TSS, habitat, altered hydrology, and connectivity are the stressors in this watershed (Table 136).

The predominant land use in this subwatershed, row crop agriculture, is a contributor to the stressors found in these reaches. Utilizing a variety of nutrient reducing BMPs including: cover crops, nutrient management, saturated buffers, etc., will also help both in phosphorus reduction. Erosion control efforts on the upper reach of Sleepy Eye Creek would help both with sediment and phosphorus reduction to the creek.

The loss of wetlands in this subwatershed has limited the amount of water storage capacity on the landscape. Finding ways to increase the storage and infiltration of water throughout the watershed will help mitigate this issue.

Table 136. Stressors in the Upper and Lower Sleepy Eye Creek HUC

Stream name	Stressors:							
	Dissolved oxygen	Eutrophication	Nitrate	Suspended sediment	Habitat	Altered hydrology	Connectivity	Pesticides
County Ditch 38 (-550)	o	o	●	o	●	●	---	NA
County Ditch 38 (-557)	●	●	●	o	●	●	●	NA
County Ditch 26 (-597)	●	●	---	---	●	●	---	NA
Sleepy Eye Creek (-598)	o	●	●	o	●	●	---	NA
Sleepy Eye Creek (-599)	---	●	●	●	●	●	---	o

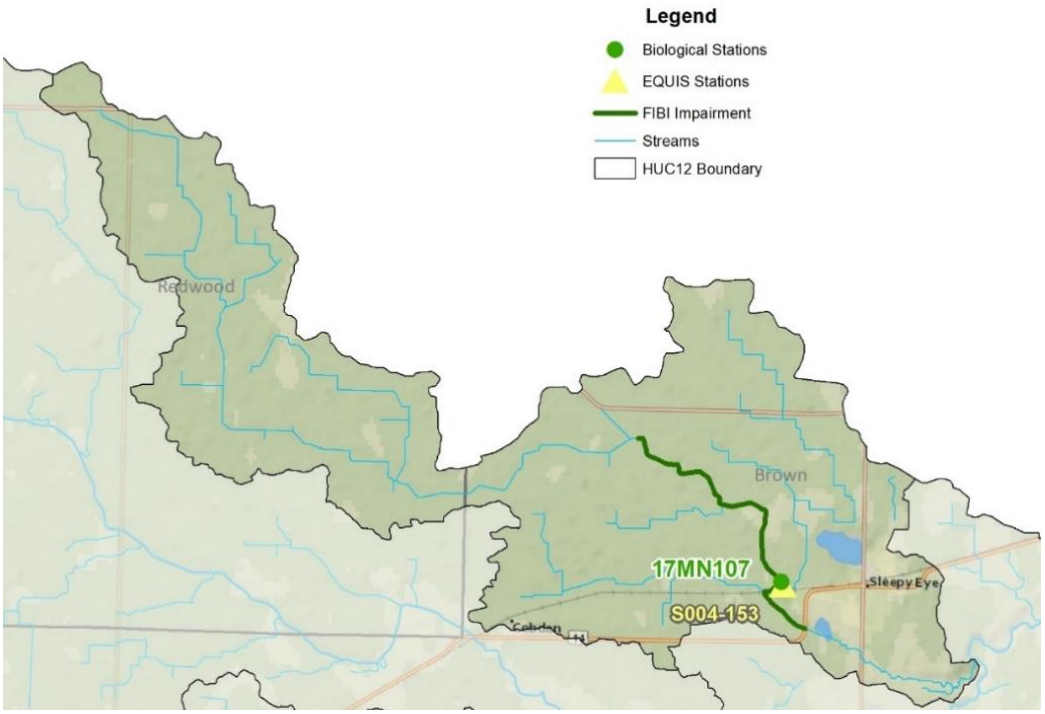
● = stressor; o = inconclusive stressor; --- = not an identified stressor

Judicial Ditch 30

This aggregated HUC includes Judicial Ditch (JD) 30 and its watershed (Figure 71). The watershed has the following impairment:

- Judicial Ditch 30 (-609) impaired by fish (17MN107, S004-153, S005-688)

Figure 71. Map of the Judicial Dich 30 HUC



Candidate cause: Dissolved oxygen

Values on Judicial Ditch 30 ranged from 3 mg/L to 19.29 mg/L (Table 137). One value was below the water quality standard. The minimum and maximum values were both collected downstream of site 17MN107. The wide range of DO values was indicative of possible eutrophication.

Table 137. DO values in the Judicial Ditch 30 HUC

Stream reach	# DO values	Range of DO values	# of values below 5 mg/L
Judicial Ditch 30 (-609)	42	3-19.29 mg/L	1

Fish species that are specifically tolerant and intolerant to DO were analyzed. There were no intolerant fish while the DO tolerant percentage was 19%. The abundance of fish individuals where females mature at greater than three years in age decreases with low DO conditions. Site 17MN107 was absent of fish that take three years or longer to mature, indicating that fish are quick to reproduce due to short life spans from the influence of human disturbance. Low DO values also correspond with increased serial spawning fish percentage. Serial spawning occurs based on environmental stress. Serial spawners were slightly higher than class average (Table 138). While there are some indications of DO stress, early morning DO data would help to conform the stressor. DO is inconclusive as a stressor.

Table 138. DO related fish metrics in the Judicial Ditch 30 HUC

		DO Related Fish Metrics		
Station	**WID**	MA>3 years percentage	Serial spawning fish pct	Fish taxa count
17MN107	**-609**	0	31.25	5
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI Modified Use Threshold (35.0)		**15.09**	**25.34**	**14.5**
Expected response to increased DO stress		↓	↑	↓

Candidate cause: Eutrophication

Recent phosphorus data on Judicial Ditch 30 ranged from 0.044 to 0. mg/L (Table 139). The highest values were taken near the town of Sleepy Eye. No continuous data DO data was available, but a range of DO values from 3 to 19.29 mg/L indicate diurnal fluctuations. Chl-*a* values ranged from 1 to 112 with 13.6% of values over the southern standard of 35 ug/L.

Table 139. Eutrophication values in the Judicial Ditch 30 HUC

Stream reach	# TP values	Range of TP values	# of values above 0.150 mg/L
Judicial Ditch 30 (-609)	24	0.044-0.264	14

Station 17MN107 were lacking sensitive species. Darters were higher than average, but they were all johnny darters which is a more tolerant darter (Table 140). Fish tolerant to disturbance were higher than average. Omnivorous fish have a positive relationship with nutrients. Omnivores were not increased. Based on elevated phosphoruus values, elevated chl-*a* values, and the preponderance of evidence, eutrophication is a stressor.

Table 140. Eutrophication related fish metrics in Judicial Ditch 30 HUC

		Eutrophication related Fish Metrics			
Station	**WID**	Sensitive Pct	Darter Pct	Tolerant Fish Pct	Omnivorous Fish Pct
17MN107	**-609**	0	43.75	56.25	18.75
Statewide average for Class 2 Southern Streams stations that are meeting the FIBI Modified Use Threshold (35.0)		**8.38**	**13.57**	**46.38**	**25.54**
Expected response to increased TP stress		↓	↓	↑	↑

Candidate cause: Nitrates

Recent nitrate data ranged from 0.2-20.1 mg/L (Table 141). High values were collected at both sites 17MN107 and S005-688.

Table 141. Nitrate samples collected on Judicial Ditch 30

Stream reach	# nitrate values	Range of values (mg/L)
Judicial Ditch 30 (-609)	24	0.2-20.1

While this reach has a fish impairment, better relationships have been made with respect to macroinvertebrate impairment and nitrate concentration. Nitrate tolerant individuals comprised 59.81% of the macroinvertebrate community and intolerant taxa were absent (Table 142).

Increasing nitrate concentrations also have a negative relationship with nonhydropsychid Trichoptera (caddisfly) individual percentages. Nonhydropsychid Trichoptera are all caddisflies that do not spin nets. The value was above class average of sites meeting the threshold. While there were elevated nitrate values, the preponderance of metric values indicates nitrate is inconclusive as a stressor.

Table 142. Nitrate related metrics in the Judicial Ditch 30 HUC

		Nitrate related Macroinvertebrate metrics			
Station	**WID**	TrichwoHydroPct	N % Tolerant Taxa	N Intolerant Taxa	Nitrogen TIV
17MN107	**-609**	13.08	59.81	0	3.51
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**2.16**	**59.41**	**1.95**	**3.32**
Expected response to Nitrate stress		↓	↑	↓	↑

Candidate cause: Sediment

Only one TSS value was available on JD 30, with a value of 14 mg/L (Table 143). Secchi tube measurements ranged from 4 to 100, with seven values below the standard of 10. Site 17MN107 had turbid conditions during sampling (Figure 72).

Table 143. TSS data in the Judicial Ditch 30 HUC

Stream reach	# TSS values	Range of values (mg/L)	# of values above 65 mg/L
Judicial Ditch 30 (-609)	1	14	0

Figure 72. Site 17MN107 turbid during sampling (6/26/2019)

Fish species that are specifically tolerant and intolerant to TSS were analyzed. Both TSS tolerant and intolerant fish species were absent. Herbivore species of fish decrease as TSS values increase. Herbivore species were also absent (Table 144). From site 17MN107. Perciforms species (smallmouth bass, walleye, etc.) have been demonstrated to decrease as TSS increases. The Perciform percentage was well above the average of sites meeting the class threshold. Centrarchids (sunfish) and long-lived species were also absent. Based on limited TSS data and mixed biological response, TSS is inconclusive as a stressor.

Table 144. TSS related metrics in the Judicial Ditch 30 HUC

		TSS Related Fish Metrics						
Station	**WID**	BenFdFrimPct	Centr-TolPct	HerbvPct	Percfm-TolPct	IntolerantPct	Longlived Pct	TSS Index Score (RA)
17MN107	**-609**	43.75	0	0	43.75	0	0	
Statewide average for Class 2 Southern Streams stations meeting the FIBI Modified Use Threshold (35.0)		**30.08**	**6.17**	**2.88**	**28.69**	**0.86**	**21.25**	
Expected response to TSS stress		↓	↓	↓	↓	↓	↓	↑

Candidate cause: Lack of habitat

Habitat conditions were shown to be poor with a MSHA score of 31. The score was lowered by a narrow riparian zone, light shade, severe embeddedness of coarse substrates by fine sediments, sparse cover amount, a lack of channel development, and a lack of depth variability.

Simple lithophilic spawners, which require coarse substrate for spawning, typically decrease in numbers with limited habitat. The percentage was lower than average. Benthic insectivores and darter, sculpin, and sucker were higher than average, but all the darters were johnny darters which are a more tolerant darter (Table 145). Darters are sensitive to siltation and riffle species tend to decrease due to lack of habitat. Riffles and Piscivore species were absent while tolerant and pioneer species were both above class averages. Based on the poor MSHA score and the preponderance of evidence, lack of habitat is a stressor to Judicial Ditch 30.

Table 145. Habitat related metrics in the Judicial Ditch 30 HUC

		Habitat Related Fish Metrics							
Station	**WID**	BenInsect-TolPct	SLithopPct	DarterSculpSucPct	RifflePct	PiscivorePct	LithFrimPct	TolPct	PioneerPct
17MN107	**-609**	43.75	12.5	43.75	0	0	25	56.25	87.5
Statewide average for Class 2 Southern Streams stations meeting the FIBI General Use Threshold (50.0)		**20.39**	**39.38**	**18.18**	**32.49**	**5.24**	**58.26**	**44.85**	**19.02**
Expected response to Habitat stress		↓	↓	↓	↓	↓	↓	↑	↑

Candidate cause: Altered hydrology

Reach -609 is completely channelized. Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency, increasing the impact of high flow events and increasing the intensity of low flow periods, both of which affect biological communities. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat. Habitat availability can be scarce when flows are interrupted, or low for a prolonged duration. Flows that are reduced beyond normal baseflow decrease living space for aquatic organisms and increase competition for resources.

Generalist fish species, which are adaptable to different habitats through generalized food preferences, are correlated with channelization. Site 17MN107 had a population of generalist fish of 56%. The numbers of nest guarder species are also positively correlated with increased low flows. The nest guarder species had a population of 75%. The channelization is likely contributing to the lack of habitat and is a contributing stressor Judicial Ditch 30.

Candidate cause: Connectivity

Connectivity is another important aspect of hydrology. Fish migration is dependent on-stream connectivity. Located just downstream of station 17MN107 is an old fence placed across the ditch

(Figure 73). The fence acts as a physical barrier during low flow and high velocity over the fence acts as a barrier during higher flows (Figure 74). Connectivity is a stressor to the fish community. The fence is preventing migration up from the Cottonwood River.

Figure 73. Barrier during low flow (9/25/2020)

Figure 74. Barrier at 17MN107 (6/26/2019)

Summary and recommendations

The Judicial Ditch HUC contains one biologically impaired stream reach. Eutrophication, habitat, altered hydrology, and connectivity are the stressors in this watershed (Table 146).

The predominant land use in this subwatershed, row crop agriculture, is a contributor to the stressors found in these reaches. Utilizing a variety of nutrient reducing BMPs including: cover crops, nutrient management, saturated buffers, etc., will also help both in phosphorus reduction. Removing the fence downstream of 17MN107 would improve fish migration.

Table 146. Stressors in the Judicial Ditch 30 HUC

Stream name	Stressors: Dissolved oxygen	Eutrophication	Nitrate	Suspended sediment	Habitat	Altered hydrology	Connectivity
Judicial Ditch 30 (-609)	o	●	o	o	●	●	●

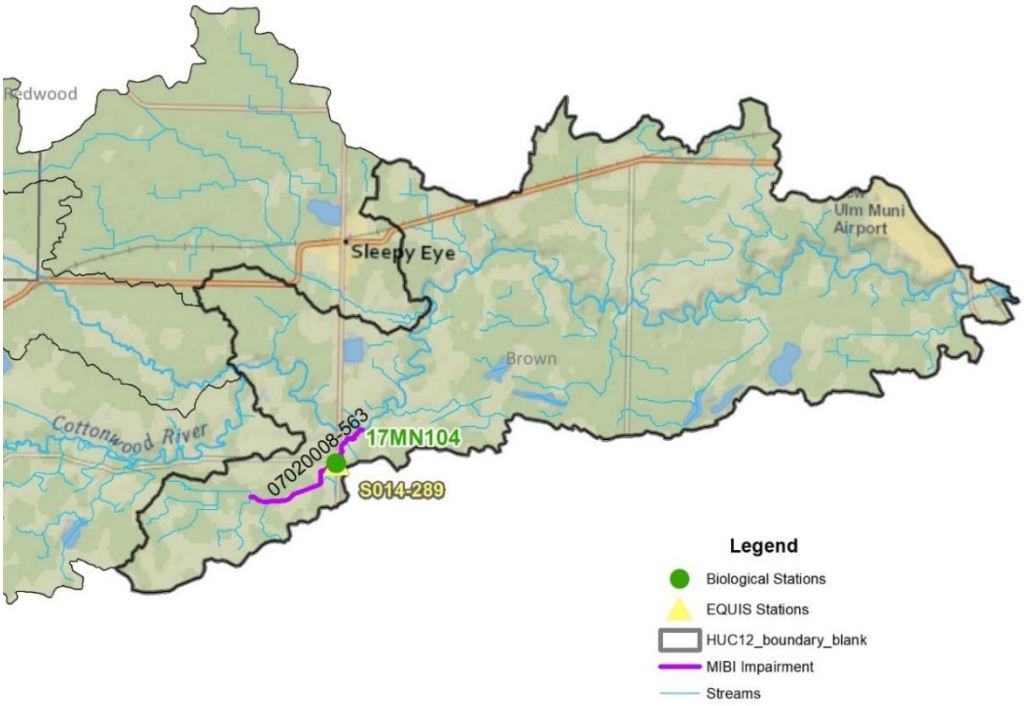
● = stressor; o = inconclusive stressor; --- = not an identified stressor

Lower Cottonwood River 12-digit HUC

This aggregated HUC includes the Cottonwood River from Sleepy Eye Creek to the mouth of the river, and its surrounding watershed (Figure 75). The watershed has the following impairment:

- Unnamed Creek (-563) impaired by macroinvertebrates (17MN104, S014-289)

Figure 75. Map of the Lower Cottonwood HUC



Candidate cause: Dissolved oxygen

Limited DO data was available, ranging from 5.11 mg/L to 7.72 mg/L (Table 147). One value taken in the early morning was near the water quality standard of 5 mg/L. Site 17MN104 was downstream of wetland influence.

Table 147. DO data in the Lower Cottonwood River HUC

Stream reach	# DO values	Range of DO values	# of values below 5 mg/L
Unnamed creek (-563)	4	5.11-7.72 mg/L	0

Macroinvertebrate species that are specifically tolerant and intolerant to DO were analyzed. Six intolerant macroinvertebrate taxa were collected, while less than 1% of DO tolerant taxa were collected (Table 148). While there were some indications of DO stress, DO is inconclusive as a stressor. More early morning DO data would be helpful.

Table 148. DO related metrics in the Lower Cottonwood HUC

		DO Related Macroinvertebrate Metrics			
Station	**WID**	Percentage DO Tolerant Macroinvertebrates	HBI_MN	Intolerant DO Macroinvertebrate Taxa	DO Tolerant Index Score
17MN104	**-563**	0.64	8.32	6	7.24
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**12.98**	**7.55**	**4.46**	**6.91**
Expected response to DO stress		↑	↑	↓	↑

Candidate cause: Eutrophication

Limited phosphorus data was available on the unnamed creek, ranging from 0.059 to 0.084 mg/L (Table 149). All data was below the water quality standard of 0.150 mg/L. Continuous DO, chl-*a*, and BOD data was not available.

Table 149. Phosphorus data in the Lower Cottonwood River HUC

Stream reach	# TP values	Range of TP values	# of values above 0.150 mg/L
Unnamed creek (-563)	3	0.059-0.084	0

The EPT percentage was lower than average. The macroinvertebrate community was not dominated by two species (Table 150). Eutrophication is inconclusive as a stressor to reach -550, more phosphorus data would be useful.

Table 150. Eutrophication related metrics in the Lower Cottonwood HUC

		Eutrophication related Macroinvertebrate Metrics		
Station	**WID**	Invert Taxa	EPT Pct	Dominant 2 Invert Ch Pct
17MN104	**-563**	26	11.58	24.85
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**37**	**38.45**	
Expected response to TP stress		↓	↓	↑

Candidate cause: Nitrates

Limited nitrate data was available, ranging from 0.53 to 0.73 mg/L (Table 151). No elevated values were collected.

Table 151. Nitrate samples collected on Judicial Ditch 30

Stream reach	# nitrate values	Range of values (mg/L)
Unnamed creek (-563)	3	0.53-0.73

Nitrate tolerant individuals comprised 55.13% of the macroinvertebrate community (Table 152). Intolerant taxa were absent. Increasing nitrate concentrations also have a negative relationship with nonhydropsychid Trichoptera (caddisfly) individual percentages. Nonhydropsychid Trichoptera are all caddisflies that do not spin nets and were also absent. Based on the low nitrate values available and the mixed biological response, nitrate is not a stressor to the unnamed creek.

Table 152. Nitrate related metrics in the Lower Cottonwood HUC

		Nitrate related Macroinvertebrate Metrics			
Station	**WID**	TrichwoHydroPct	N % Tolerant Taxa	N Intolerant Taxa	Nitrogen TIV
17MN104	**-563**	0	55.13	0	3.70
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI General Use Threshold (41.0)		**4.02**	**54.87**	**3.18**	**3.23**
Expected response to Nitrate stress		↓	↑	↓	↑

Candidate cause: Sediment

Only two TSS values were available, ranging from 6.8 to 8.8 mg/L (Table 153). Three secchi tube measurements ranged from 96-100 cm, well above the water quality standard of 10 cm.

Table 153. TSS data in the Lower Cottonwood HUC

Stream reach	# TSS values	Range of values (mg/L)	# of values above 65 mg/L
Unnamed creek (-563)	2	6.8-8.8	0

TSS intolerant macroinvertebrates were absent at site 17MN104, while TSS tolerant taxa were not higher than average (Table 154). The long-lived and Plectoptera percentages were lower than average, while the collector-filterer percentages was higher than average. Based on the low TSS and secchi tube values and the preponderance of evidence, TSS is not a stressor on the unnamed creek.

Table 154. TSS related metrics in the Lower Cottonwood HUC

		TSS related Macroinvertebrate Metrics					
Station	**WID**	TSS Index Score	TSS Intolerant Taxa	TSS Tolerant Pct	Collector Filterer Pct	Plectoptera Pct	Long-lived Pct
17MN104	**-563**	14.39	0	16.67	37.62	0	1.61
Statewide average for Class 7 Prairie Streams GP stations meeting the MIBI General Use Threshold (41.0)		**17.78**	**1.33**	**48.28**	**19.13**	**0.22**	**7.99**
Expected response to stress		↑	↓	↑	↓	↓	↓

Candidate cause: Habitat

Station 17MN104 had a MSHA score of 53, which rates as fair. The score was lowered due to moderate to severe embeddedness and fair channel development (no riffles present in the reach).

Clingers need coarse substrates and decrease with the increase in percent fines. The percentage of clingers were above average (Table 155). Burrowers and legless individuals are a signal of high levels of sedimentation. Neither burrowers or legless percentages were increased. EPT percentages were below class average at sites. Based on the poor habitat conditions and preponderance of evidence, lack of habitat is stressor.

Table 155. Habitat related metrics in the Lower Cottonwood HUC

Station	**WID**	BurrowerPct	ClimberPct	ClingerPct	EPTPct	LeglessPct
17MN104	**-563**	6.43	17.04	54.66	11.58	37.94
Statewide average for Class 7 Prairie Streams GP stations that are meeting the MIBI Modified Use Threshold (22.0)		**14.12**	**27.47**	**23.07**	**20.58**	**55.79**
Expected response to Habitat stress		↑	↓	↓	↓	↑

Candidate cause: Altered hydrology

The unnamed creek was channelized but has gotten some sinuosity back. The upstream reach is completely channelized. Channelization and tile drainage alters the natural flow regime by moving water through the system at a higher frequency, increasing the impact of high flow events and increasing the intensity of low flow periods, both of which affect biological communities. Increased flow events can cause increased bank erosion and bedload sedimentation, affecting fish species that rely on clean substrate for habitat. Habitat availability can be scarce when flows are interrupted, or low for a prolonged duration. Flows that are reduced beyond normal baseflow decrease living space for aquatic organisms and increase competition for resources. Long-lived macroinvertebrates decrease with flow changes as they are not able to stay in one place as conditions change. The percentage of long-lived macroinvertebrates was 1.61%. The channelization is likely contributing to the lack of habitat and is a contributing stressor to the biological communities.

Summary and recommendations

The Lower Cottonwood HUC contains one biologically impaired stream reach. Habitat and altered hydrology are the stressors in this watershed (Table 156). Letting the stream continue to regain its sinuosity would help the hydrology and habitat of the stream.

Table 156. Stressors in the Lower Cottonwood HUC

Stream name	Stressors:					
	Dissolved oxygen	Eutrophication	Nitrate	Suspended sediment	Habitat	Altered hydrology
Unnamed creek (-563)	o	o	---	---	●	●

● = stressor; o = inconclusive stressor; --- = not an identified stressor

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