Stressor Identification

May 2023

Crow Wing River Watershed Stressor Identification Update 2023

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

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

Author

Chuck Johnson

Contributors/acknowledgements

Jonathon Newkirk
Bonnie Goshey
Jinny Fricke (5.30.23)

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520 Lafayette Road North | Saint Paul, MN 55155-4194 |

651-296-6300 | 800-657-3864 | Or use your preferred relay service. | Info.pca@state.mn.us

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Key terms and abbreviations

AUID	Assessment Unit Identification
DO	Dissolved Oxygen
EPA	U.S. Environmental Protection Agency

HUC	Hydrologic Unit Code
IBI	Index of Biotic Integrity
MIBI	Macroinvertebrate Index of Biotic Integrity
MPCA	Minnesota Pollution Control Agency
MSHA	Minnesota Stream Habitat Assessment
SID	Stressor Identification
TALU	Tiered Aquatic Life Use
TIV	Tolerance Index Value
TP	total phosphorus
TSS	Total Suspended Solids
UAA	Use Attainability Analysis
WID	waterbody identification

Introduction

Since 2008, the Minnesota Pollution Control Agency (MPCA) has substantially increased the use of biological monitoring and assessment as a means to determine and report the condition of the state's rivers and streams. This basic approach is to examine fish and aquatic macroinvertebrate communities and related habitat conditions at multiple sites throughout a major watershed. From these data, an Index of Biological Integrity (IBI) score can be developed, which provides a measure of overall community health. These scores are then compared to the appropriate IBI thresholds (stream class), which are determined by the type and location of the stream or river that was sampled. If the fish or macroinvertebrate IBI score fails to meet the standards set by the stream class, it is termed a "biological impairment" and is placed on the U.S. Environmental Protection Agency's (EPA's) impaired wasters list. If biological impairments are found, stressors to the aquatic community must be identified.

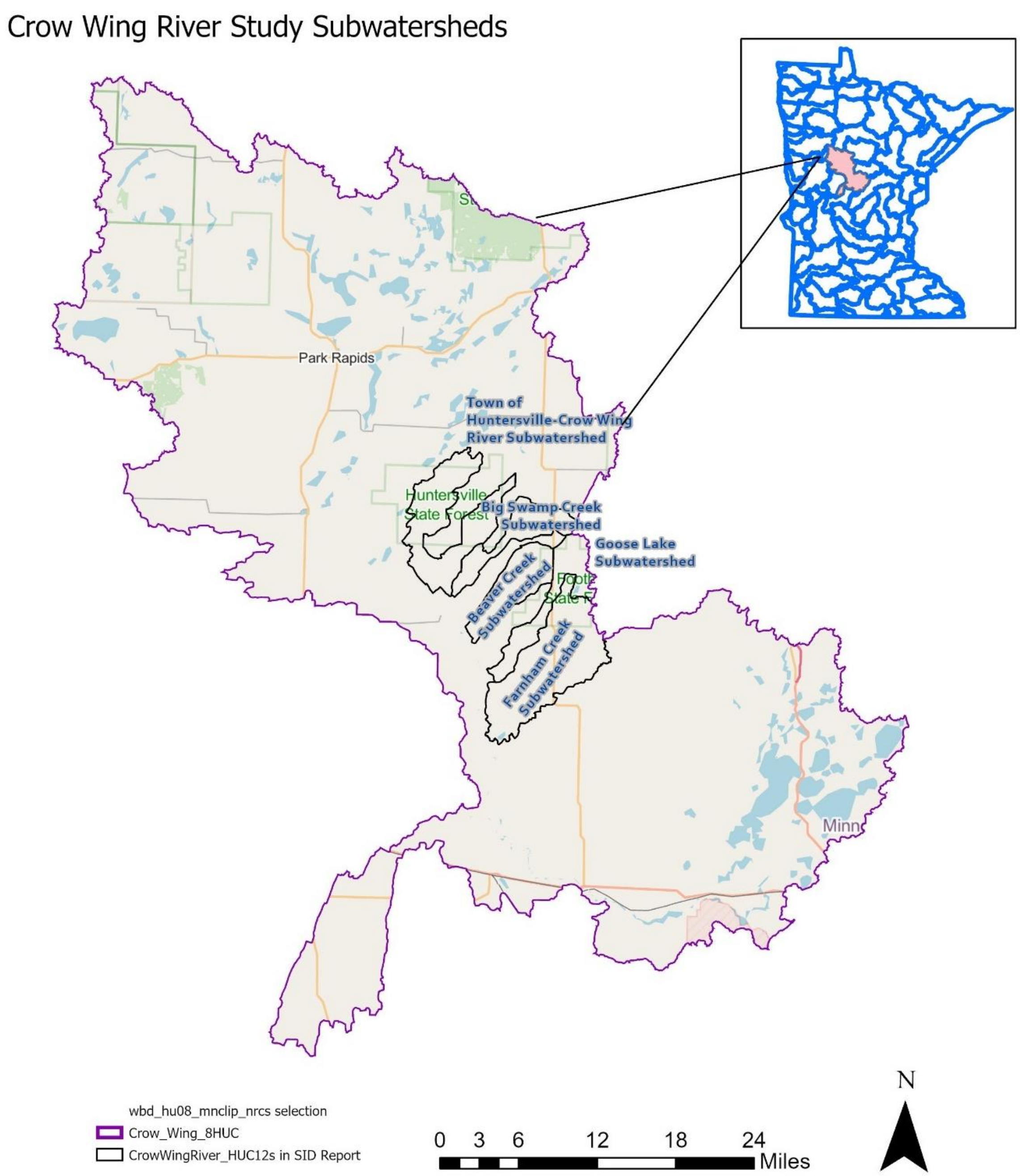
Stressor identification (SID) is a formal and rigorous process that identifies stressors causing biological impairment of aquatic ecosystems and provides a structure for organizing the scientific evidence supporting the conclusions (Cormier et al. 2000). In simpler terms, it is the process of identifying the probable 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. Information on the SID process can be found on the EPA website http://www.epa.gov/caddis/. Specific information on Minnesota's processes for SID in streams can be found on MPCA's webpage "stressor identification" at https://www.pca.state.mn.us/water/your-water-stressed. DNR has a similar webpage for lakes - "Stressors to Biological Communities in Minnesota's Lakes" https://www.dnr.state.mn.us/waters/surfacewater_section/lake_ibi/index.html.

This report details the SID process for the Crow Wing River Watershed, following the second cycle of biological monitoring. This report also contains SID work that was completed after the first cycle of watershed monitoring, on stations that were channelized. Until the Tiered Aquatic Life Use (TALU) assessment process was written into rule in 2014, the MPCA did not have the tools to assess channelized streams. Stations that were sampled in 2010 on channelized streams, were not assessed until TALU criteria were finalized; as a result, these Assessment Unit Identification (AUIDs) were not included in the cycle I SID report (MPCA 2014).

Overview of the Crow Wing River Watershed

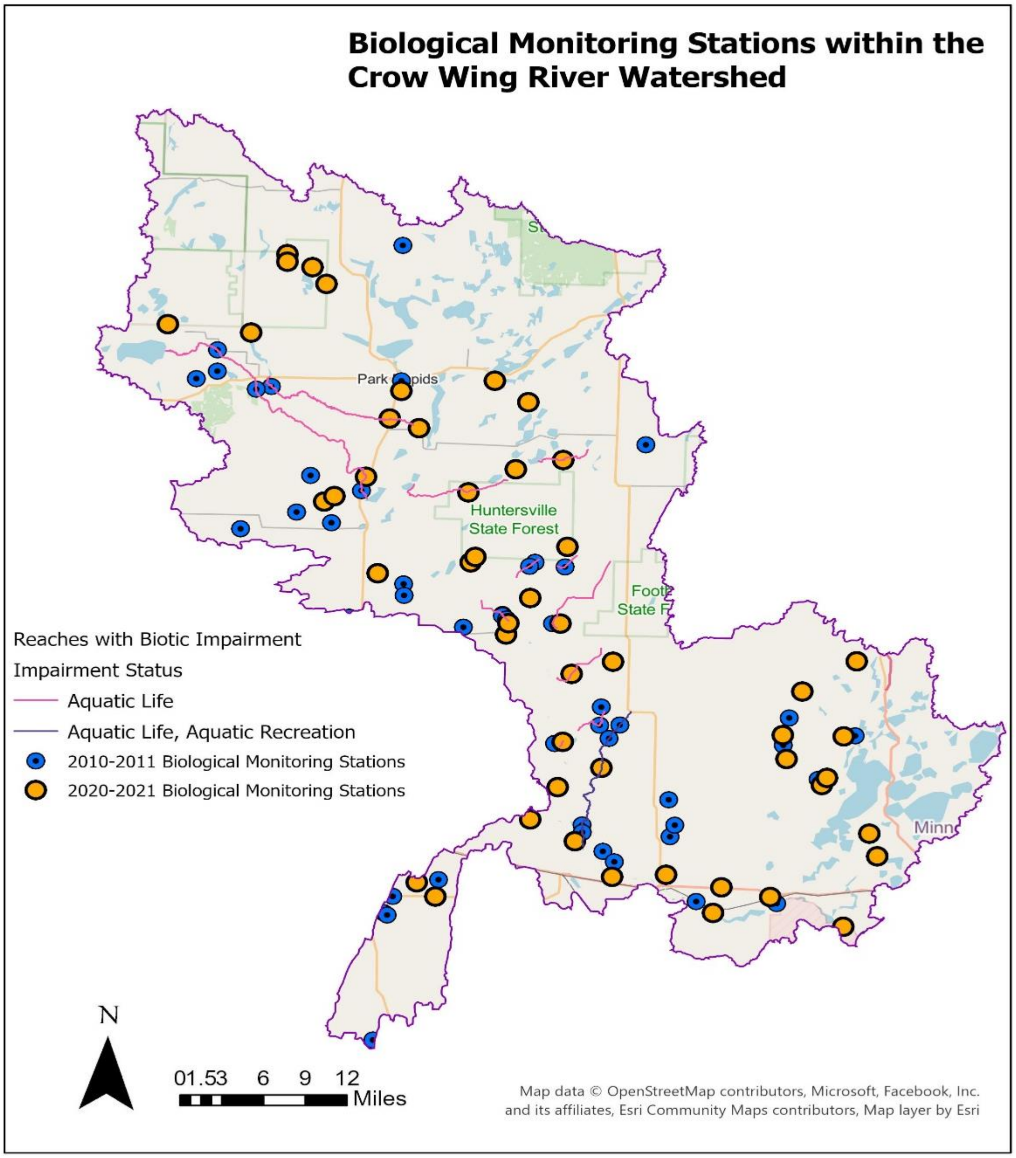
The Crow Wing River Hydrologic Unit Code (HUC)-8 watershed (07010106) is divided into 59 HUC-12 subwatersheds and 5 were studied in this report (Figure 1). HUC-12 subwatersheds that were previously studied can be found in the Cycle 1 Crow Wing River Watershed SID Report https://www.pca.state.mn.us/sites/default/files/wq-ws5-07010106.pdf.

Figure 1: Crow Wing River Stressor Identification Study 12 HUC's



Within the first cycle of watershed monitoring, a biological station was placed at the outlet of the HUC-14, 12, 10, and 8 levels in an attempt to monitor each HUC-8 watershed in an unbiased manner. As the MPCA moved into the second cycle of monitoring, efforts were scaled back in an attempt to provide the ability to sample stations that were local priorities, while still monitoring at a sufficient level to detect change. Biological monitoring stations are placed at the outlet of each of the HUC-12 subwatersheds, with a preference for stations that have existing data from the cycle I monitoring efforts (Figure 2).

Figure 2: Biological Monitoring Stations and Biological Impairments within the Crow Wing River Watershed



Biologically impaired streams

Biological sampling from the cycle II monitoring effort resulted in one stream reach being assessed as having impaired fish and/or macroinvertebrate communities. In addition to the one new impairment from the cycle II monitoring, four stream reaches that were sampled in the first cycle, but were deferred due to being channelized, were also assessed as impaired. These reaches were brought into the SID update process. These reaches are listed below (Table 1).

Table 1: Summary of aquatic life impairments and stressors in the Crow Wing River Watershed.

Denotes Cass County

Denotes Wadena County

Stream	AUID	Aquatic Life Impairment	Monitoring Data Source Year	Dissolved Oxygen	Phosphorus	TSS	Connectivity	Hydrology / Geomorphology	Habitat	Flow
Farnham Creek	-702	Fish	Coldwater Reach from 2010 and 2021 Sampling					x	x	
Tributary to Beaver Creek*	-688	Macroinvertebrates	Channelized Stream from 2010 Sampling	x	X			x	x	x
Tributary to Big Swamp Creek*	-683	Macroinvertebrates	Channelized Stream from 2010 Sampling	x	X				x	
Tributary to Crow Wing River*	-689	Macroinvertebrates	Channelized Stream from 2010 Sampling					x	x	x
Unnamed Ditch*	-555	Macroinvertebrates	Channelized Stream from 2010 Sampling	x	X			x	x	x

x = direct stressor (stressor directly contributing to the biological impairment), X = secondary stressor (stressor that is not the direct stressor, but is still contributing to the biological impairment), ◊ = Possible contributing root cause (stressor that is not a direct or secondary stressor, but may be contributing to other stressors, causing stress to the biological communities, ? = Inconclusive

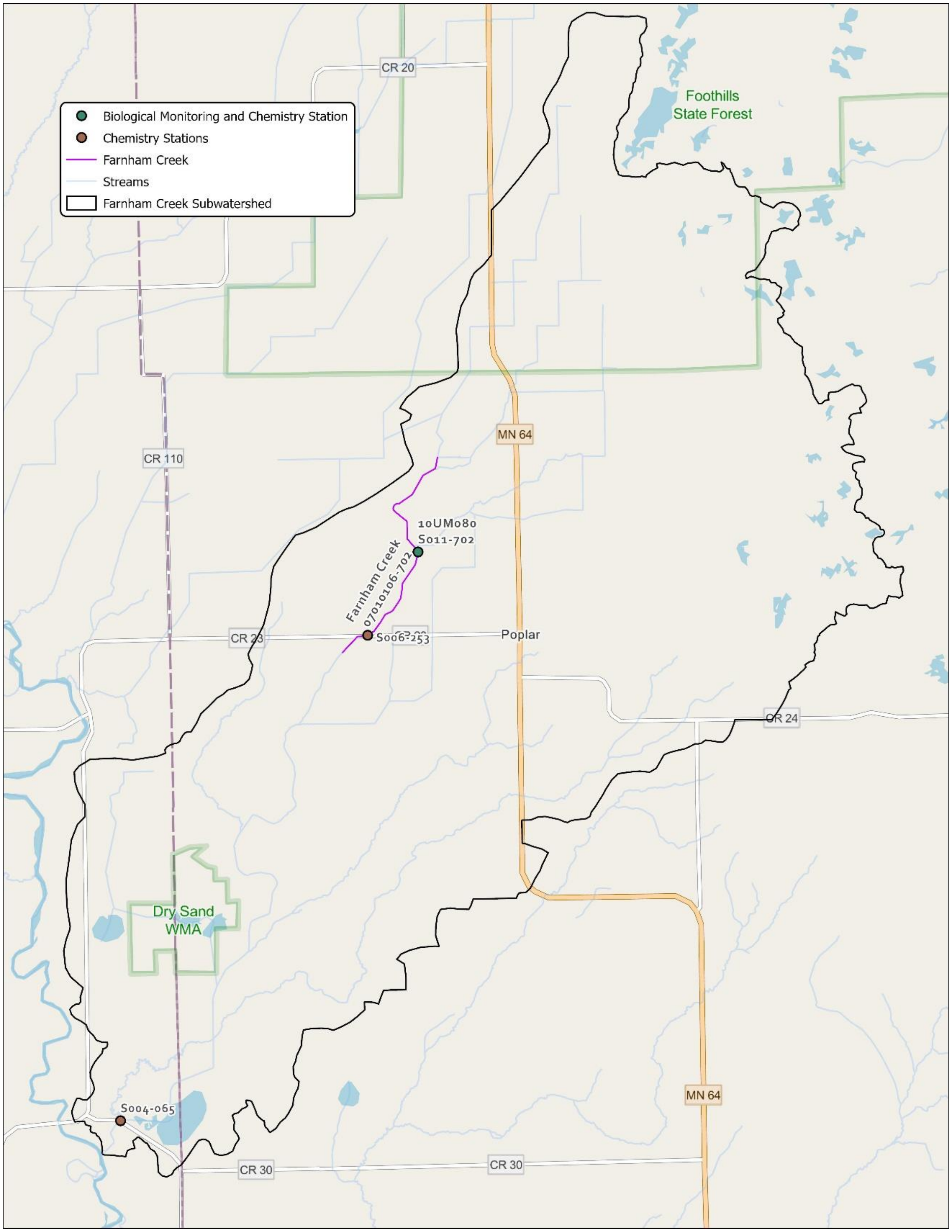
*Denotes channelized streams that may be part of a Judicial or County ditch system.

The SID data collection, analysis, and recommendations for each of these impaired AUIDS will be discussed and sorted into HUC-12 subwatersheds for the duration of this report.

Farnham Creek Subwatershed

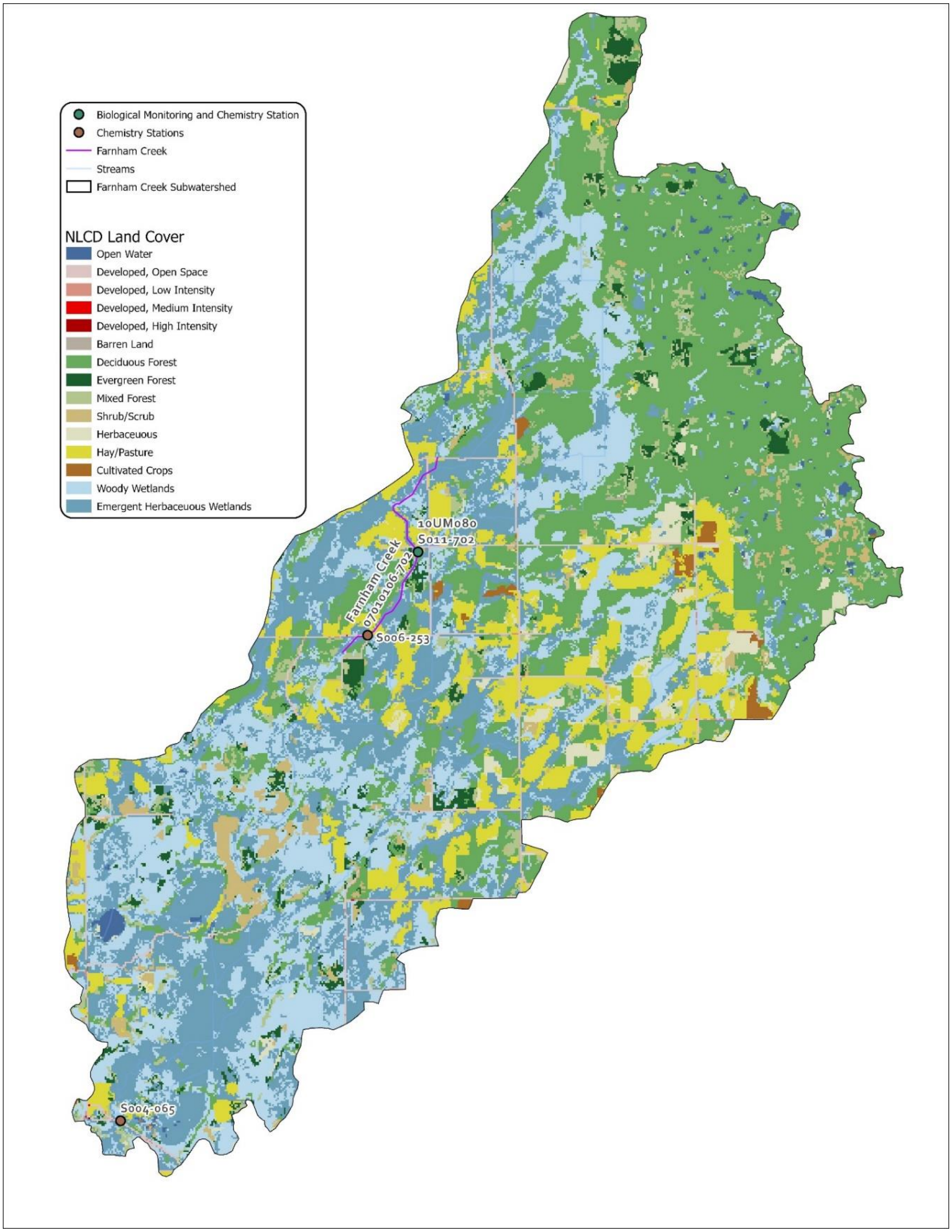
The Farnham Creek Subwatershed covers 34,685 acres, located just North of Staples (Figure 3). Over half of the streams within the subwatershed have been straightened.

Figure 3: Monitoring stations in the Farnham Creek Subwatershed.



The land use within the Farnham Creek Subwatershed is dominated by wetlands (45.0%), followed by forestland (39.6%), and rangeland (12.5%) (Figure 4).

Figure 4: Land use in the Farnham Creek Subwatershed



Farnham Creek (07010106-702)

Impairment: Farnham Creek (AUID -702) flows for 2.96 miles. This waterbody identification (WID) is the headwaters of Farnham Creek and is fed by WID 655 and WID 652, both are unnamed tributary creeks that meet to form Farnham Creek. WID 702 and the upstream tributaries are all channelized. There is one biological monitoring stations (10UM080) that was sampled on Farnham Creek (Figure 3). Fish were sampled at 10UM080 in 2010 and 2021 and macroinvertebrates were sampled in 2010 and 2020. The data indicated that the fish within Farnham Creek were not meeting standards and resulted in a new fish impairment for the 2024 Impaired waters list. The fish class at 10UM080 is fish class 11 (Northern Coldwater). The macroinvertebrate class at 10UM080 is class 8 (Northern Coldwater). The macroinvertebrate sample was not assessed and is considered inconclusive.

Data and Analyses

Chemistry

Extensive water chemistry data has been collected on Farnham Creek from 2010-2011 and 2021-2022 at two monitoring locations (S006-253 and S011-702) (Table 2).

Table 2: Water chemistry data collected on Farnham Creek from 2010-2011 and 2021-2022. Data available at https://webapp.pca.state.mn.us/surface-water/search.

Parameter	Sample Count	Applicable Standard	Average Result	Min Result	Max Result	% exceeding standard
Temperature, water	41		13.93	0.46	25.3	
Specific conductance	41	N/A	425.3	199.7	492	
pH	39	N/A	7.78	6.35	8.84	
Dissolved Oxygen	41	7.0 mg/L	9.47	6.24	14.8	8.89
Inorganic nitrogen (nitrate and nitrite)	18	10	0.12	0.10	0.197	0
Phosphorus	27	0.10	0.09	0.07	0.325	29.63
Ortho Phosphorus	4					
Total suspended solids	30	30	5.04	1.0	39	3.33

Nutrients – Phosphorus

Phosphorus values from the dataset on Farnham Creek (Table 2), shows that the average TP is near the Central Region River Nutrient standard (0.100 mg/L) with an average value of 0.09 mg/L. However, although the average phosphorus value is low, there is evidence that TP can become elevated during the summer months, as 29.6% of the samples were above the standard. Overall, due to 70.4% of the phosphorus values meeting the standard, phosphorus is not considered to be a stressor in Farnham Creek, but additional monitoring should be conducted every few years to track the amount of phosphorus in the stream.

Dissolved Oxygen

Extensive dissolved oxygen (DO) data has been collected on Farnham Creek (Table 2), which indicated that the DO levels are good within the creek with 91% of the values occurring above the standard. Since this AUID is in the Northern Coldwater class the applicable standard is 7.0 mg/L. DO is not considered to be a stressor within Farnham Creek.

Total Suspended Solids

The TSS dataset for Farnham Creek indicates that TSS values are low within the creek, with 97% of the values occurring below the standard of 30 mg/L (Table 2). TSS is not considered to be a stressor to the aquatic life in Farnham Creek.

Conductivity

Specific conductivity values were within range on Farnham Creek (Table 2) and is not considered to be a stressor within Farnham Creek.

Temperature

Temperature values were within range on Farnham Creek (Table 2) and is not considered to be a stressor within Farnham Creek.

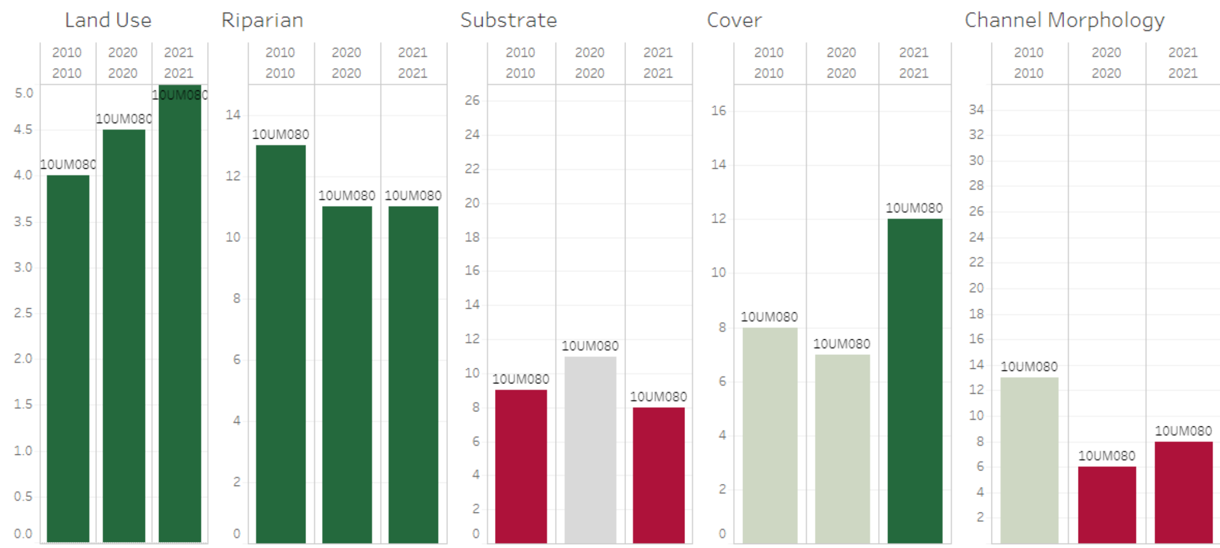
Habitat

Habitat was classified as fair/poor on Farnham Creek, through the Minnesota Stream Habitat Assessment (MSHA) evaluations during the fish and macroinvertebrate samples (Figure 9). During water quality sampling events in 2021 it was observed that there were beaver impoundments downstream of 56^{th} St SW near 10UM080. Field observations from 2010 also noted beaver impoundments during the 2010 biological sampling events. This section of stream has been historically ditched and flows through a large woody wetland, perfect habitat for beaver activity. Stream substrate was dominated by sand, silt and some clay during the 2010 and 2020 site visit.

Figure 5: MSHA Habitat scores for Farnham Creek

MSHA Scores

Field Num	Month of Visit Date	Day of Visit Date	Year of Visit Date	Total Score
10UM080	June	9	2021	44
	July	26	2010	47
	August	11	2020	39.5



In general, the MSHA evaluations score poor on Farnham Creek; however, there is a stark difference in the habitat availability between the upstream biological monitoring station (10UM080) and the downstream station (99UM022) (Figure 5). The most significant differences between the two stations can be seen in the cover and channel morphology categories. The substrate at 10UM080 was dominated by sand and silt, with the presence of clay also noted. The substrate at 99UM022 was dominated by sand, with the presence of silt noted. In 1999 there was boulder, cobble, gravel and sand at 99UM022. All the later substrate notes on sand and silt at this location. Sand being supplied by failing stream banks is covering any coarse substrate. Healthy fish communities need coarse substrate in order to build nests and spawn. Excessive fine sediment also affects juvenile fishes, as the sediment is stirred into the water column creating TSS, it can easily tear sensitive juvenile fish gills. Similarly, many sensitive macroinvertebrates also have specialized gills that are used to breathe DO. Excessive fine sediments can damage these gills, similar to juvenile fishes, making the creek inhabitable for sensitive species. In addition to the differences in substrate between the two biological monitoring stations, channel morphology also changed between the two stations. The channel morphology score at 10UM080 indicated that the channel development was poor (shallow pools, slow velocity runs, and no riffles). In contrast, the channel morphology score at 99UM022 was fair, as no riffles were present within the reach, and the pools were small (10% of the reach). Sensitive fish and macroinvertebrates require well defined pools, riffles, and runs to feed, spawn, and to use as refuge during high precipitation events. Lack of habitat is a stressor to the aquatic life within 10UM080 and 99UM022 due to poor channel morphology and substrate.

Hydrology and geomorphology

Over time, there have been many changes on the landscape that have changed the natural hydrology and geomorphology of Farnham Creek, and the entire subwatershed. The most significant historical changes to the landscape have been land conversion from mature forests to hay/pasture and woody wetlands and the channelization of the natural streams and wetlands. Farnham Creek has been straightened along the entire length of the AUID. Historically, Farnham Creek was comprised of multiple wetlands and small stream channels. The channel was altered to drain the landscape, starting from the Northeast and ending downstream of Farnham Lake where Farnham Creek flows into the Crow Wing River. This new channel cut through multiple wetlands, creating a direct connection throughout the subwatershed. This channel alteration accelerates stream flow, resulting in higher flows during precipitation events which achieves the agricultural land use drainage goals, but causes instability. Water leaves the landscape quickly, resulting in periods of higher flow than what would have naturally occurred. As the landscape drains, water that was once held in the upstream wetlands is flushed downstream, carrying low DO water throughout the reach. Then, as these flows quickly drain, the flow regime quickly transitions to slow moving groundwater inflow, reaching very low conditions starting early in the summer. Although 2021 was a dry summer, Farnham Creek was already mostly very slow and low by the end of May. This reach is very low gradient and has very slow stream velocities for large portions of the summer.

Sand deposition observed downstream of road crossing. 06/10/2021

DS 7/14/2021 very low flow

US 07/14/2021 cattle in pasture

Due to the channelization of Farnham Creek, the creek does not have a natural stream pattern that can be assessed for stability. Utilizing the biological monitoring sampling pictures and MSHA evaluations of stream bank condition, the banks appear to be stable and not actively eroding. The current channel size is most likely much larger than the historic stream channels that existed prior to the channelization and is showing signs that the channel is receiving excess sediment from the banks or the landscape, as sand was the only substrate noted within the MSHA evaluation. It is possible that this excess sediment would have historically settled out within the wetlands that made up most of the riparian pre-settlement, but due to the channelization, the sediment is flushed downstream during precipitation events. Therefore, due to the altered hydrology and geomorphology of Farnham Creek causing the channel to get very low flow, it is considered to be the primary stressor within Farnham Creek.

Connectivity

The culvert crossing by 10UM080 off 56th St SW does not appear to be a fish barrier. The road crossing downstream at 60th St SW also does not appear to be a fish barrier.

Stressor signals from biology

Fish

Fish were sampled in 2009 as part of the cycle I monitoring effort. A total of three fish species were collected, with the Central Mudminnow being the most dominate. The Central Mudminnow is one of the most pollution tolerant fish species within the State of Minnesota. All of the other fish species that were collected are also considered tolerant of pollutants.

Tolerance index values (TIV) were calculated for Plum Creek using the fish community. The total suspended solids (TSS) TIV found that the fish community has an 87% probability of coming from a stream that is meeting the TSS standard. No fish species that are considered to be tolerant or sensitive of elevated TSS were found within any of the fish samples, indicating a weak TSS signal from the biology. Therefore, the fish community response to TSS is weak, and therefore, is inconclusive at this time.

DO TIV scores were also calculated for Farnham Creek using the fish communities. This calculation indicated that the fish community has an average probability of only 7% of coming from a stream that was meeting the DO standard. Most of the fish collected within the sample are considered to be either tolerant or very tolerant of low DO, indicating that low DO has the potential to be a stressor to the fish community within Farnham Creek.

Phosphorous tolerance of the fish community was also investigated in Farnham Creek using the fish species characteristics. Three of the fish collected within the sample were considered to be tolerant of elevated phosphorous. As for sensitive species, one fish that are sensitive or intolerant of elevated phosphorous were found in the sample. The presence of elevated phosphorus tolerant species and the absence of intolerant species indicates that phosphorus may be a stressor to the fish community within Farnham Creek.

Macroinvertebrates

Macroinvertebrates were not able to be assessed during the 2010 or 2020 monitoring effort due to dry stream conditions.

Composite conclusion from biology

The fish TIVs are indicating that low DO is a potential stressor to the aquatic life within Farnham Creek; however, the extensive DO dataset indicates that DO is at healthy levels. TSS does not appear to be stressor to the aquatic life within Farnham Creek. Elevated phosphorus levels may be a stressor to the aquatic life in Farnham Creek. The habitat and geomorphology are heavily altered within Farnham Creek, and are the primary stressors to the aquatic life within Farnham Creek.

Conclusions about stressors

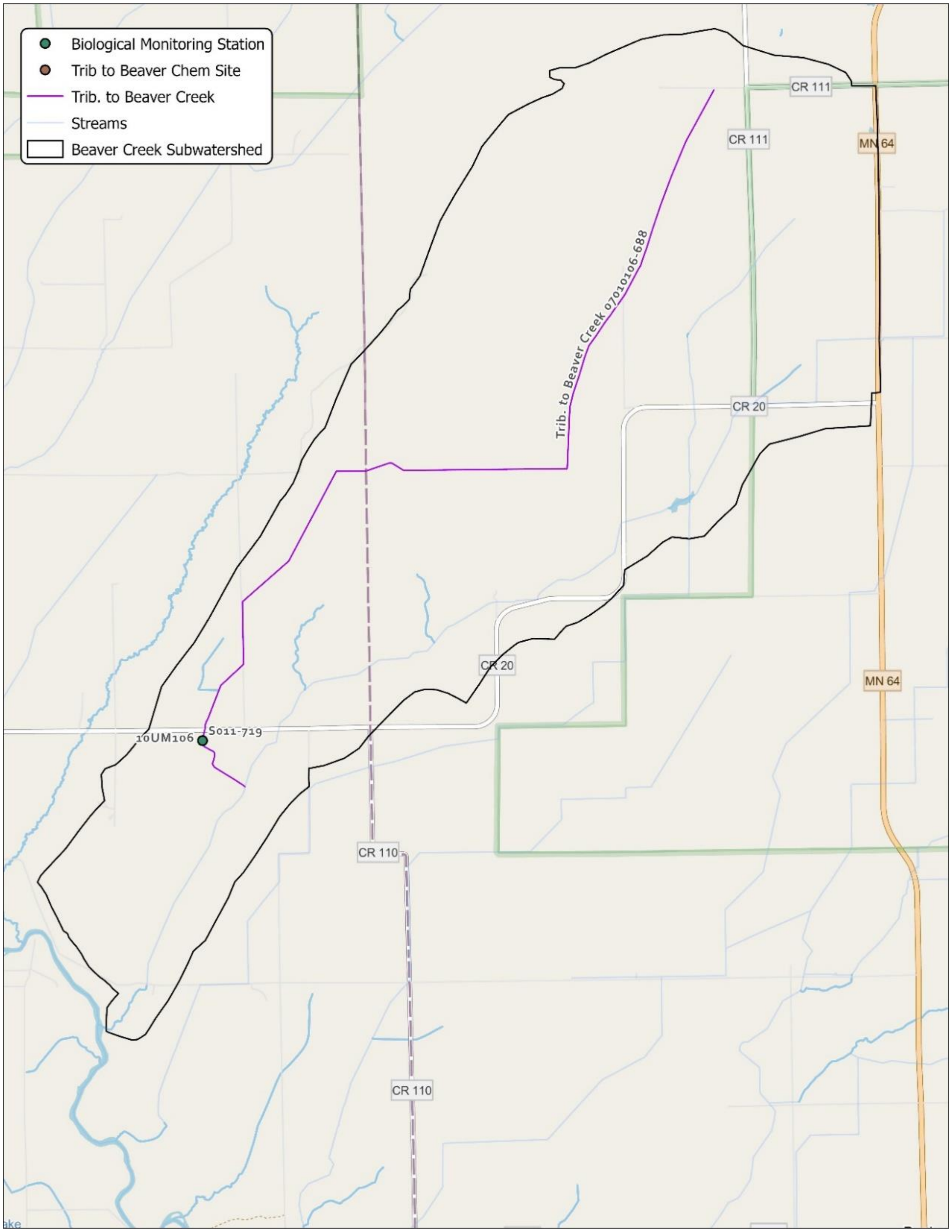
The fish TIVs indicate that DO is a potential stressor to the fish community within Farnham Creek; however, this may be the result of the low DO tolerant fish species also having the ability to survive in streams with poor habitat and altered hydrology. Therefore, altered hydrology is the primary stressor to the biology in Farnham Creek. Poor sinuosity, poor channel development, and fine sediment were noted within the MSHA assessment. These are the result of channel over widening and the creation of a new channel through large wetlands. Sensitive fish and macroinvertebrates require coarse substrate and good channel morphology to survive and reproduce. However, good sinuosity and the pools and riffles that naturally occur within streams and rivers, do not exist in Farnham Creek by design. As for the substrate in Farnham Creek, due to creating a channel through several wetlands, sand has covered all of the coarse substrates that would exist naturally.

The geomorphology and habitat of Farnham Creek have impeded intolerant species from surviving in the creek, due to the channelization.

Beaver Creek Subwatershed

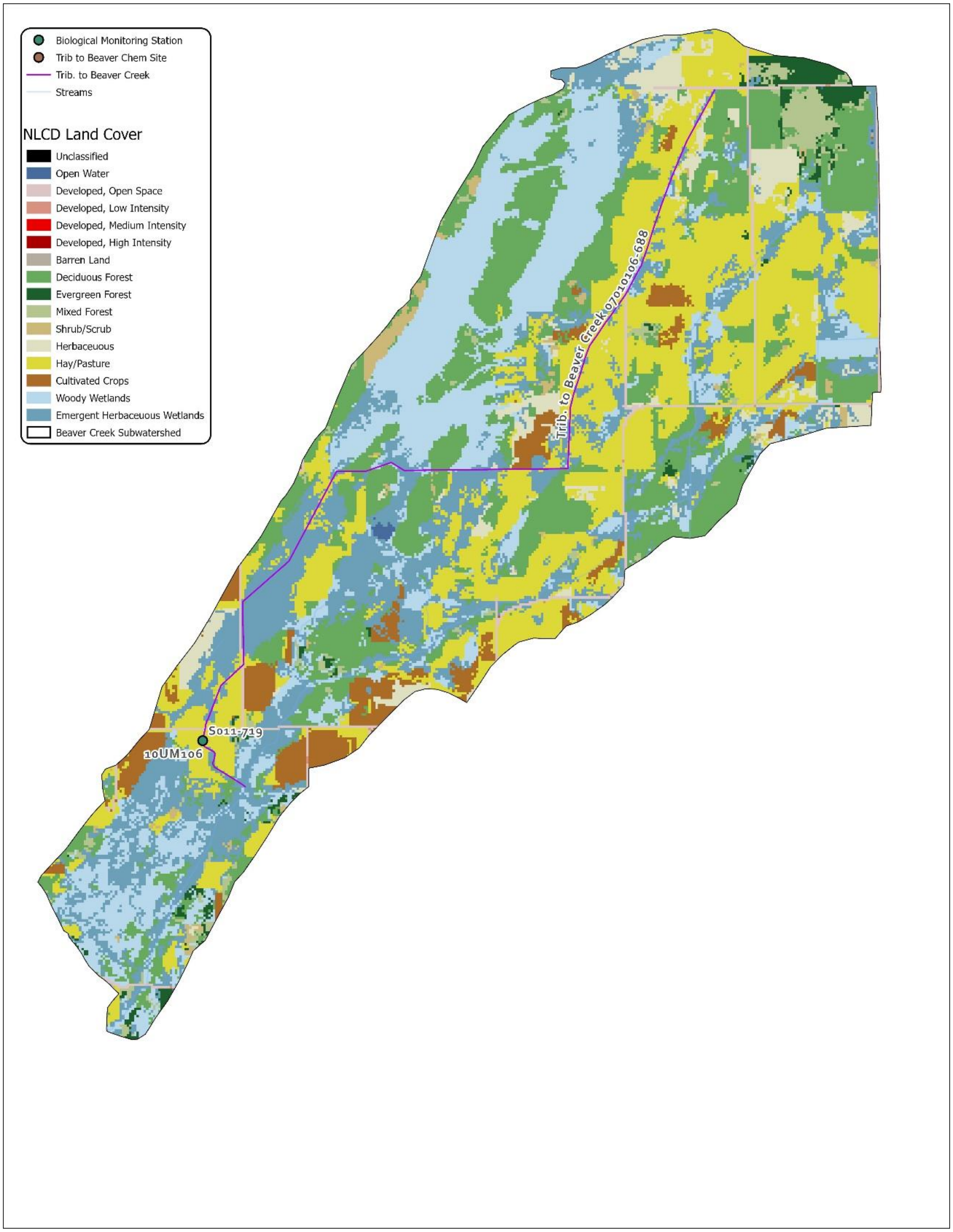
The Beaver Creek Subwatershed covers 12,799 acres, located 19 miles north of Staples, Minnesota. Over 95% of the streams within the subwatershed have been straightened (Figure 6).

Figure 6: Monitoring locations in Tributary to Beaver Creek Subwatershed



The land use within the Beaver Creek Subwatershed is dominated by wetlands (83.7.0%), followed by rangeland (29.1%), and forestland (25.8%) (Figure 7).

Figure 7: Tributary to Beaver Creek land use



Tributary to Beaver Creek (07010106-688)

The Tributary to Beaver Creek Subwatershed covers 6,080 acres. The AUID 688 was initially listed as impaired for aquatic life use based on benthic macroinvertebrate bioassessments in 2020. The macroinvertebrate IBI score was 29 during the 9/2/2010 sampling event, which is 22 points below the general use threshold. Site 10UM106 was only sampled during the Cycle 1 event in 2010. Macroinvertebrate samplers noted excess sediment in pools, animal access to stream, animal trampling of banks, low DO (0.99 mg/L) and mid channel bars. The macroinvertebrate sample was dominated by a tolerant scud with few caddisflies and Odonates present. The fish were sampled at site 10UM106 on 6/17/2010 and scored an IBI of 76 which was well above the general use threshold. The fish sample included 3 sensitive dace species, along with burbot and blacknose shiner, which are also sensitive species. This score listed AUID 688 as a general use stream. As a general use stream the expectation is that the biological life in the stream will meet the associated IBI score in order to be removed from the impaired waters list.

Data and Analysis

Chemistry

Water chemistry data has been collected on Tributary to Beaver Creek in 2021 and 2022 at monitoring station S011-719 (Table 3).

Table 3: Water chemistry data collected on Tributary to Beaver Creek from 2010;2021-2022. Data available at https://webapp.pca.state.mn.us/surface-water/search.

Parameter	Sample Count	Applicable Standard	Avg. Result	Min. Result	Max. Result	% Exceeding standard
Temperature, water	13		12.78	2.04	27.7	
Specific conductance	13		193	108	428	
pH	12		7.024	6.82	7.36	
Dissolved Oxygen	13	5.0	7.60	0.99	13.41	28.57
Inorganic nitrogen (nitrate and nitrite)	8		0.231	0.022	0.7	
Total Phosphorus	8	0.100	0.173	0.055	0.375	75
Ortho Phosphorus	4	0.100	0.11	0.064	0.149	75
Total suspended solids	5	30	8.32	4.4	18.8	0

Nutrients – Phosphorus

Phosphorus values from the dataset on Tributary to Beaver Creek (Table 4) shows that the average TP value is well above the Central region River Nutrient standard (0.100 mg/L) with an average value of 0.173 mg/L. This reach has animals pasturing throughout both the upstream and downstream sections. Cattle have been documented in the stream and there is minimal tall grass that can buffer the channel. This allows cattle manure to freely enter the stream during rain fall events (Figure 8). Elevated phosphorus is a potential stressor to the macroinvertebrates. Elevated phosphorus occurred in 75% of the eight phosphorus samples collected.

Figure 8: Tributary to Beaver Creek biological monitoring site 10UM106 and Equis site S011-719. Photo taken on 6/17/2021 when stream was a flowing at a trickle. Cattle have direct access to stream allowing sediment and nutrients to freely access stream.

Nutrients – Inorganic Nitrogen

Inorganic nitrogen measured as nitrate-nitrite is well below the 10 mg/L drinking water standard. The average concentration from 8 samples collected was 0.256 mg/L (Table 3). Inorganic nitrogen is not a stressor to the biology within Tributary to Beaver Creek.

Dissolved Oxygen

If DO is below 5mg/L for extended periods of time, biological communities can be severely impacted. DO was collected 13 times in 2021 and 2022. The average DO concentration was 7.606 mg/L. Twenty three percent of the collected DO concentrations were below the 5 mg/L standard for 2B waters (Table 3). The low DO readings occurred during the late summer months when water levels were below normal. DO is a stressor to the stream biology during periods of below normal flow. When the flow is greater than 0.75 cfs the DO concentrations appear to be above 5 mg/L. In both 2021 and 2022 DO concentrations were below 5 mg/L in July during low flow periods. During both years the channel went dry or had less than one inch of water in the culvert under the road. Low DO caused by low flow conditions is a stressor to the macroinvertebrate community.

Conductivity

Specific conductivity values were within range on Tributary to Beaver Creek (Table 3) and is not considered to be a stressor within Tributary to Beaver Creek.

Temperature

Temperature values were within range on Tributary to Beaver Creek (Table 3) and is not considered to be a stressor within Tributary to Beaver Creek.

Total Suspended Solids

TSS data is limited to five samples (Table 3). The average concentration was 8.32 mg/L for TSS and is well below the state standard of 30mg/L in the central TSS zone. Elevated TSS is not considered to be a stressor to the macroinvertebrate community.

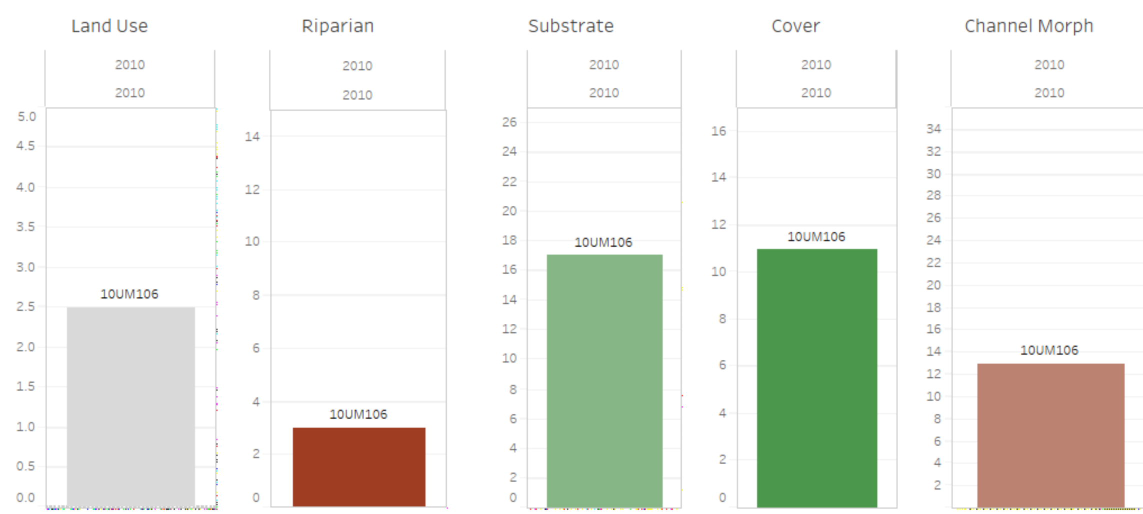
Habitat

Habitat was classified as fair on Tributary to Beaver Creek, through the MSHA evaluations during the fish and macroinvertebrate samples (Figure 9).

Figure 9: MSHA habitat scores for Tributary to Beaver Creek.

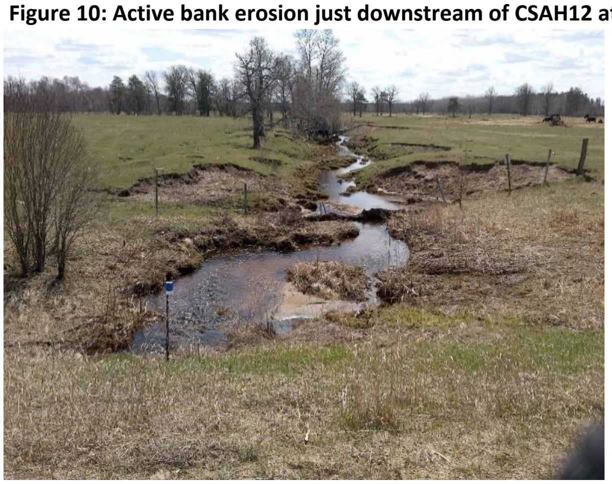
MSHA Scores

Station Id	Month of Visit Date	Day of Visit Date	Year of Visit Date	Total Score
10UM106	June	17	2010	46.6



There was one habitat assessment conducted at 10UM106 on 6/17/2010 during the fish visit. This site scores poorly in riparian cover and channel morphology. There are active cattle pastures both upstream and downstream side of CSAH12 near water quality station S011-719. The entire reach shows signs of active bank erosion from cattle access along with mid channel bar formation from excess sediment entering the stream due to bank erosion from cattle trampling of banks. The substrate was dominated by sand with small gravel exposed in riffle areas. Stream pools were determined to be >4 times deeper than the shallowest depth and sinuosity was considered poor. Cover type during the 2010 site visit was determined to moderate with 25% to 50% of the reach having cover from 4 types of cover types. During 2021 and 2022 site visits it was documented that the stream was actively eroding along its banks, mainly due to cattle access to the stream banks and limited vegetation growth along the banks due to overgrazing. The active bank erosion is causing the formation of mid channel bars, filling of pools and general lack of in-stream depth diversity. Figure 10 shows the active erosion on the downstream side of CSAH 12. Photo on the left was taken on 4/28/2021 and the photo on the right was taken on 6/08/2022.

Figure 10: Active bank erosion just downstream of CSAH12 at S011-719.



Lack of habitat is a stressor to the aquatic life within 11UM106 due to poor channel morphology and substrate.

Hydrology and geomorphology

Over time, there have been many changes on the landscape that have changed the natural hydrology and geomorphology of Tributary to Beaver Creek, and the entire subwatershed. The most significant historical changes to the landscape have been land conversion from mature forests to pasture and the channelization of the natural streams and wetlands. Tributary To Beaver Creek has been partially straightened along the entire length of the AUID. Historically, Tributary to Beaver Creek was comprised of multiple wetlands and small stream channels. It appears that the upper reaches of the ditch were cut through wetlands in an effort to drain wetlands and convert the land for agricultural purposes. This channel alteration accelerates stream flow, resulting in higher flows during precipitation events, which achieves the agricultural land drainage goals, but causes channel instability. Water leaves the landscape quickly, resulting in periods of higher flow than what would have naturally occurred. As the landscape drains, water that was once held in the upstream wetlands is flushed downstream, carrying low DO water throughout the reach. Then, as these flows quickly drain, the flow regime quickly transitions to intermittent, reaching stagnant conditions starting early in the summer (Figure 11). Channelization and the corresponding flow alteration are stressors to the biological community.

Figure 11: Tributary to Beaver Creek at S011-719 on 9/9/2021. Most of the summer of 2021 streamflow was less than 0.5 cfs.

Connectivity

The culvert crossing by 10UM106 off CSAH 12 does not appear to be a fish barrier.

Stressor signals from biology

Fish

Fish were sampled in 2010 as part of the cycle I monitoring effort. A total of 13 fish species were collected, with Northern redbelly dace being the most dominate. Northern redbelly dace are tolerant of low DO, sensitive to nitrogen and TSS. White sucker was the second most dominant fish species sampled. White sucker are tolerant of many pollutants.

TIV were calculated for Tributary to Beaver Creek using the fish community. The TSS TIV found that the fish community has an average of 82% probability of coming from a stream that is meeting the TSS standard. No fish species that are considered to be tolerant or sensitive of elevated TSS were found within any of the fish samples, indicating a weak TSS signal from the biology. Therefore, the fish community response to TSS is weak, and therefore, is inconclusive at this time.

DO TIV scores were also calculated for Tributary to Beaver Creek using the fish communities. This calculation indicated that the fish community has an average probability of 16% of coming from a stream that was meeting the DO standard. Six of the fish species collected is tolerant of low DO, while the other seven species do not have a documented sensitivity to low DO. Therefore, the fish community response to DO is weak, and therefore, is inconclusive currently.

Macroinvertebrates

Macroinvertebrates were also sampled in 2010 as part of the cycle I watershed monitoring effort. Sixty-nine percent of the macroinvertebrate community that was sampled in 2010 was comprised of taxa that are considered to be tolerant of pollutants, and 22% of the community was considered to be very tolerant of pollutants. *Hyalella (scuds)* and *Pisidiidae* dominated the sample and are both considered to be tolerant taxa.

TSS taxa tolerance was investigated using the macroinvertebrate communities. In the 2010 sample, one intolerant taxa, five tolerant taxa, and two very tolerant taxa were collected (Table 4). Overall, the macroinvertebrate community within Tributary to Beaver Creek indicates that TSS is not a stressor to the macroinvertebrate community.

DO tolerance was also investigated using the macroinvertebrate communities. In 2010, three very tolerant and nine tolerant taxa were collected (5). Although there are no intolerant taxa present, tolerant and very tolerant taxa dominated the sample, and indicate that low DO has the potential to be a stressor to the macroinvertebrate community within Tributary to Beaver Creek.

The final tolerance indicator that was investigated within the macroinvertebrate community was phosphorous tolerance. In the 2010 sample, one intolerant taxa, thirteen tolerant taxa and eight very tolerant taxa were collected (5). These tolerance indicators within the macroinvertebrate community indicate that phosphorous is a stressor to the macroinvertebrate community within Tributary to Beaver Creek and may further suggest the elevated phosphorus is a stressor to the fish community.

Table 4: Macroinvertebrate tolerance index values for Tributary to Beaver Creek.

Parameter	Taxa Tolerance	2010 Sample
DO	# Intolerant	0
	# Tolerant	9
	# Very Intolerant	0
	# Very Tolerant	3
Phosphorus	# Intolerant	1
	# Tolerant	13
	# Very Intolerant	0
	# Very Tolerant	8
TSS	# Intolerant	1
	# Tolerant	5
	# Very Intolerant	0
	# Very Tolerant	2

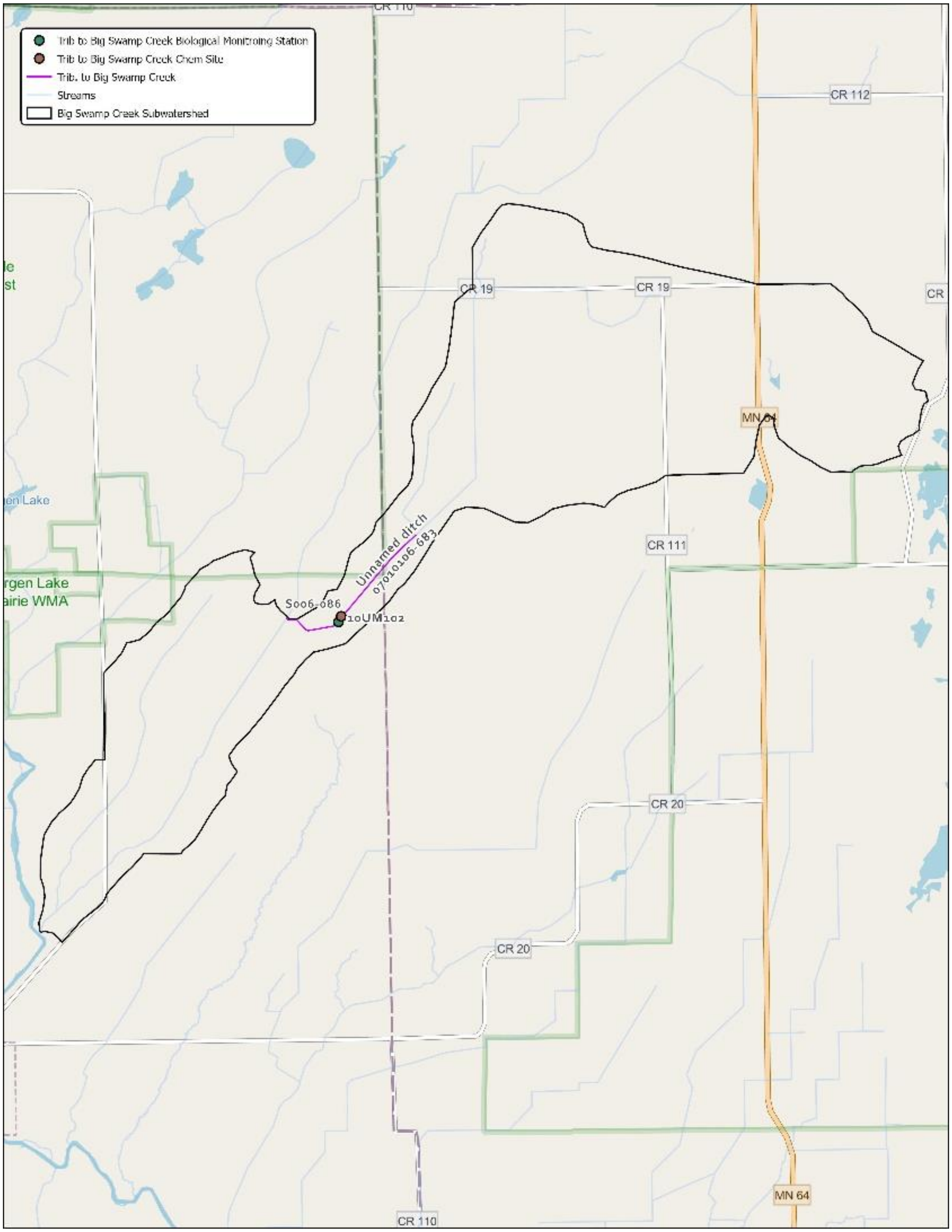
Conclusions about stressors

Fish score really well. The culvert just upstream of the sampling site is slightly perched and may be causing a barrier to fish migration. This may in part be why the fish score was high just downstream as most fish species were probably stuck in the downstream reach. The macroinvertebrates scored poorly and the main issue appears to be bank failure and a lack of quality habitat caused by the bank erosion and the poor channel conditions, along with a lack of baseflow in periods of low precipitation. This was evident in 2021 and 2022 as the channel dried out in August and September of both years. The year 2021 was a drought year so limited water samples were collected; however, the 4/8/2021 TP concentration was 0.181 mg/L (above state standard). Water samples collected in 2022 indicated that phosphorus concentrations are routinely above the 0.100 mg/L standard in late May through August. The main stressors to the macroinvertebrate community are fine sediment smothering hard substrates, a lack of flow in the late summer months, elevated phosphorus concentrations and periods of low DO concentrations.

Big Swamp Creek Subwatershed

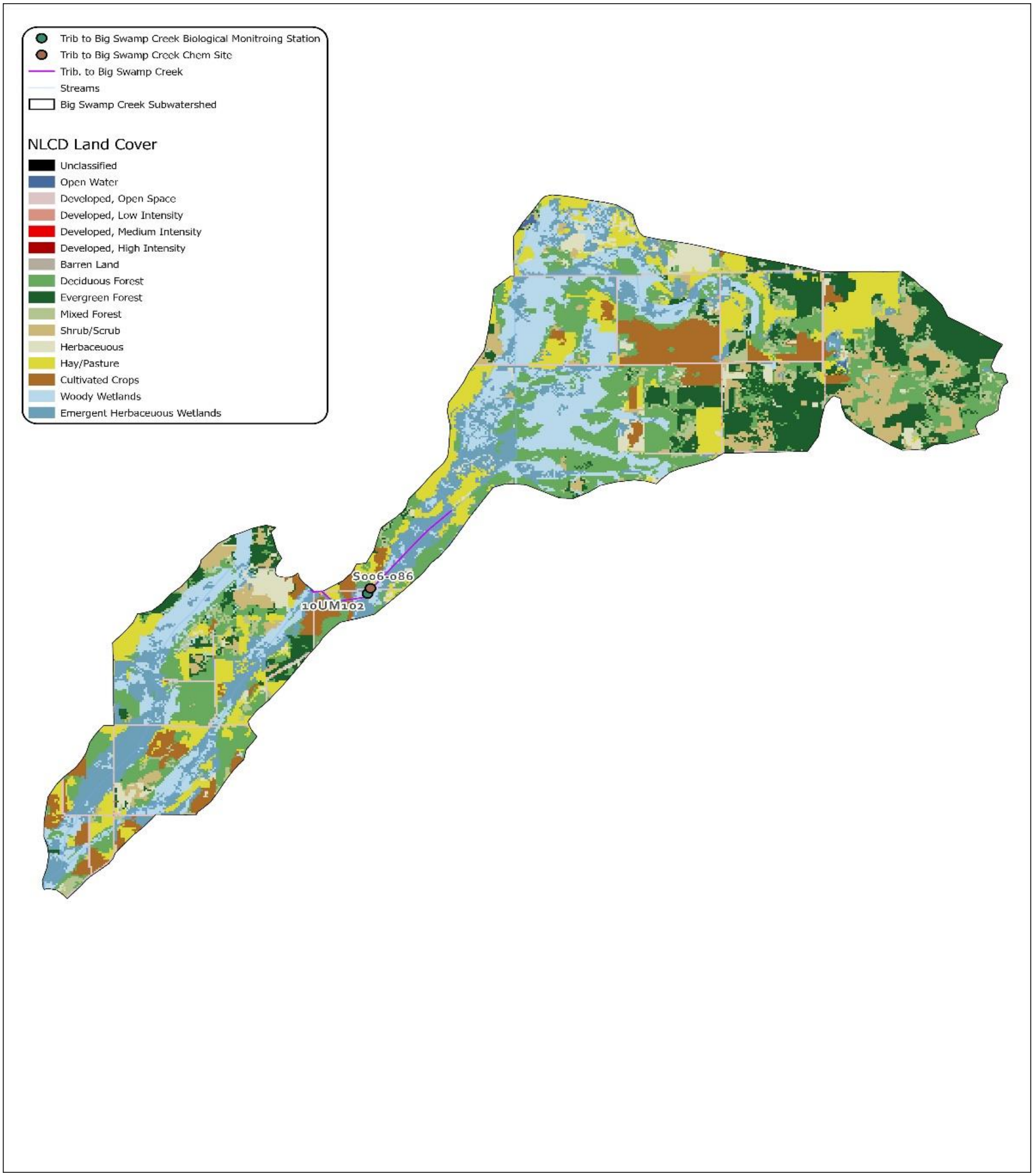
The big Swamp Creek Subwatershed covers 11,615 acres, located 22 miles North of Staples, Minnesota (Figure 12). All of the streams within the subwatershed have been straightened.

Figure 12: Monitoring stations in the Tributary to Big Swamp Creek Subwatershed.



The land use in the Trib to Big Swamp Creek Subwatershed is dominated by Mixed Forest (43.1%), Wetland (30.4%), Rangeland (17.0%), and cultivated crops (7.0%) (Figure 13).

Figure 13: Land use in the Tributary to Big Swamp Creek Subwatershed



Tributary to Big Swamp Creek (07010106-683)

Impairment: Trib to Big Swamp Creek (AUID-683) flows for 1.87 miles and is entirely channelized. There is one biological monitoring station (10UM102) that was sampled for fish and macroinvertebrates in 2010 (Figure 12). Tributary To Big Swamp Creek was assessed in 2020 as part of the TALU assessment process for assessing channelized streams. The Use Attainability Analysis (UAA) process determined that Tributary to Big Swamp Creek should be assessed under the general use criteria, which resulted in a new macroinvertebrate impairment. The macroinvertebrate class is class 4 (Northern Forest Streams-Glide/Pool). During the 2010 macroinvertebrate sampling event, samplers collected only bank habitat. Samplers observed bank issues, beaver dams and wetland riparian characteristics. The fish stream class is class 7 (Low Gradient), and the fish passed with an IBI score of 51.9. This ditch was actively cleaned out in June of 2021. After the cleanout, what little habitat was there has been eliminated.

Data and Analyses

Chemistry

Water chemistry data is limited to the samples that were collected during 2021 and 2022 (Table 5).

Table 5: Water chemistry data collected on Tributary to Big Swamp Creek.

Parameter	Sample Count	Applicable Standard	Avg. Results	Min. Results	Max. Results
Temperature, water	14		13.634	1.4	26.1
Specific conductance	14		222	105.9	392
pH	13		7.219	6.96	7.41
Dissolved oxygen	14	5.0	7.746	0.92	12.26
Inorganic nitrogen (nitate and nitrite)	8		0.223	0.05	1
Total phosphorus	8	0.100	0.184	0.061	0.397
Ortho phosphorus	4		0.108	0.059	0.148
Total suspended solids	4	30	8.6	4	15

Nutrients – Phosphorus

Phosphorus values from the dataset show that the average phosphorus concentration is 0.184 mg/L which is nearly double the Central Region River Nutrient standard of 0.100 mg/L (Table 5). This reach is channelized through an area of hydric soil. This channelization is allowing for groundwater inputs and the low DO groundwater is causing phosphorus to bind to the iron precipitate as seen in the Figure 14 below.

Figure 14: Big Swamp Creek with iron floc in stream channel.

Dissolved Oxygen

If DO is below 5mg/L for extended periods of time, biological communities can be severely impacted. DO was collected 14 times in 2021 and 2022 (Table 6). The average DO concentration was 7.74 mg/L. Seven percent of the collected DO concentrations were below the 5 mg/L standard for 2B waters. The low DO readings occurred during the late summer months when water levels were below normal during active ditch maintenance activity. DO is not a stressor to the stream biology.

Total Suspended Solids

TSS data is limited to four samples in 2022 (Table 5). The values were well below the standard. The iron precipitate can cause elevated TSS values and strips DO out of the water column. TSS is not considered a stressor to the macroinvertebrates.

Conductivity

Specific conductivity values are within range on Tributary to Big Swamp Creek (Table 5) and is not considered to be a stressor within Tributary to Big Swamp Creek.

Temperature

Temperature values were within range on Tributary to Big Swamp Creek (Table 5) and is not considered to be a stressor within Tributary to Big Swamp Creek.

Habitat

Habitat was classified as fair on Tributary to Big Swamp Creek, through the MSHA evaluation at the fish sample (Figure 15).

Figure 15: MSHA habitat scores for Tributary to Big Swamp Creek.

Due to the historic channelization of Tributary to Big Swamp Creek, and fair MSHA score, the assessment of Tributary to Big Swamp Creek was brought into the UAA process. It was determined that the habitat of Tributary to Big Swamp Creek has the ability to support good quality habitat for aquatic life, as a result of the MSHA score. Therefore, Tributary to Big Swamp Creek was assessed using the General Use TALU criteria.

Although the MSHA score was fair overall, substrate and channel morphology scored particularly low as noted in Figure 15. Substrate was the first low scoring component of the MSHA score, as indicated by the dominance of sand and silt. Healthy fish communities need coarse substrate in order to build nests and spawn. Excessive fine sediment also affects juvenile fishes, as the sediment is stirred into the water column creating TSS, it can easily tear sensitive juvenile fish gills. Similarly, many sensitive macroinvertebrates also have specialized gills that are used to breathe DO. Excessive fine sediments can damage these gills, similar to juvenile fishes, making the creek inhabitable for sensitive species.

Channel morphology was another low scoring component of the MSHA evaluation. The MSHA indicated that there was minimal channel depth variability, fair sinuosity, and no channel development (no riffles or pools). Fish and macroinvertebrates need channel depth variability to use as cover from predation and refuge during high precipitation events. No change in the channel depth combined with fair sinuosity and poor channel development impedes the fish and macroinvertebrate's ability to inhabit the creek throughout the summer, especially during high flow events, which can flush these communities downstream. The lack of good channel morphology is caused by the channelization of the creek, as the manipulation of the channel has been designed to move water quickly, by mechanically removing channel sinuosity, pools, and riffles. Lack of habitat is a stressor to the aquatic life in Tributary to Big Swamp Creek.

Hydrology and geomorphology

Over time, there have been many changes on the landscape that have changed the natural hydrology and geomorphology of Tributary to Big Swamp Creek, and the entire subwatershed. The most significant historical changes to the landscape have been land conversion from mature forests and woody wetlands to cultivated fields and pastures along with the channelization of the natural streams and wetlands. Tributary to Big Swamp Creek has been straightened along the entire length of the AUID. Historically, Tributary to Big Swamp Creek was comprised of multiple woody wetlands and small stream channels.

As the channel was altered to drain the landscape, a new channel was cut through mixed forest and woody wetlands, creating a direct connection to Big Swamp Creek. This channel alteration accelerates stream flow, resulting in higher flows during precipitation events, which achieves the agricultural land use drainage goals, but causes instability. Water leaves the landscape quickly, resulting in periods of higher flow than what would have naturally occurred. As the landscape drains, water that was once held in the upstream wetlands is flushed downstream, carrying low DO water throughout the reach. Then, as these flows quickly drain, the flow regime quickly transitions to intermittent, reaching stagnant conditions starting early in the summer (Figure 17, Figure 18). Although 2021 was a dry summer, Tributary to Big Swamp Creek was already mostly dry by early June. The water that was present in the channel was very shallow groundwater seeping into the newly cleaned out channel.

Figure 16: Tributary to Big Swamp Creek on September 2, 2010. Prior to the repair of the channel the channel was narrow and there was some bank habitat to sample for macroinvertebrates.

Figure 17: Tributary to Big Swamp Creek on 6/04/21, showing an almost dry channel with only 1 in of water in the channel. Channel had just been maintained in this section.

Figure 18: Tributary to Big Swamp Creek intermittent flow in the middle of July 2021.

In May of 2021, a ditch maintenance project was occurring along the stream reach. This maintenance removed any available habitat that was in the stream prior to spring of 2021. The maintenance effort has enlarged the channel capacity and will promote sediment buildup and a lack of stream depth variability for the future. The current channel size is most likely much larger than the historic stream channels that existed prior to the channelization, and is showing signs that the channel is receiving excess sediment from the banks or the landscape, as sand was the only substrate noted within the MSHA evaluation. It is possible that this excess sediment would have historically settled out within the wetlands that made up most of the riparian pre-settlement, but due to the channelization, the sediment is flushed downstream during precipitation events. Therefore, due to the altered hydrology and geomorphology of Tributary to Big Swamp Creek causing the channel to dry up, it is considered to be the primary stressor within Tributary to Big Swamp Creek.

Connectivity

The culvert crossing by 10UM102 off 336th St. does not appear to be a fish barrier. The culvert on Bunny Hill Rd was replaced in the spring of 2022 with a new 36 inch cmp culvert. This culvert does not appear to be a barrier to fish movement.

Stressor signals from biology

Macroinvertebrates

Macroinvertebrates were also sampled in 2010 as part of the cycle I watershed monitoring effort. Seventy-one percent of the macroinvertebrate community that was sampled in 2010 was comprised of taxa that are considered to be tolerant of pollutants, and 5.8% of the community was considered to be very tolerant of pollutants. *Simulium (blackfly)* and *Baetis* (mayfly) dominated the sample and are both considered to be tolerant taxa.

TSS taxa tolerance was investigated using the macroinvertebrate communities. In the 2010 sample, no intolerant taxa, three tolerant taxa, and no very tolerant taxa were collected (Table 6). Overall, the macroinvertebrate community within Tributary to Big Swamp Creek indicates that TSS is not a stressor to the macroinvertebrate community.

DO tolerance was also investigated using the macroinvertebrate communities. In 2010, two very intolerant, five intolerant taxa, four tolerant taxa, and zero very tolerant taxa were collected (Table 6). Although there are a few tolerant taxa present, intolerant and very intolerant taxa dominated the sample, and indicate that low DO most likely is not a stressor to the macroinvertebrate community within Tributary to Big Swamp Creek. This low DO signature by the macroinvertebrate community may further suggest that low DO is a stressor to the fish community.

The final tolerance indicator that was investigated within the macroinvertebrate community was phosphorous tolerance. In the 2010 sample, one intolerant taxa, five tolerant taxa and one very tolerant taxa were collected (Table 7). These tolerance indicators within the macroinvertebrate community indicate that phosphorous is a possible stressor to the macroinvertebrate community within Tributary to Big Swamp Creek.

Table 6: Macroinvertebrate tolerance index values for Tributary to Big Swamp Creek.

Parameter	Taxa Tolerance	2010 Sample
DO	# Intolerant	5
	# Tolerant	4
	# Very Intolerant	2
	# Very Tolerant	0
Phosphorus	# Intolerant	1
	# Tolerant	5
	# Very Intolerant	0
	# Very Tolerant	1
TSS	# Intolerant	0
	# Tolerant	3
	# Very Intolerant	0
	# Very Tolerant	0

Composite conclusion from biology

The TSS and DO TIVs were inconclusive for macroinvertebrates, but did indicate that Phosphorus is a potential stressor to the macroinvertebrate community.

The habitat and geomorphology are heavily altered within Tributary to Big Swamp Creek and are the primary stressors to the aquatic life within the ditch.

Conclusions about stressors

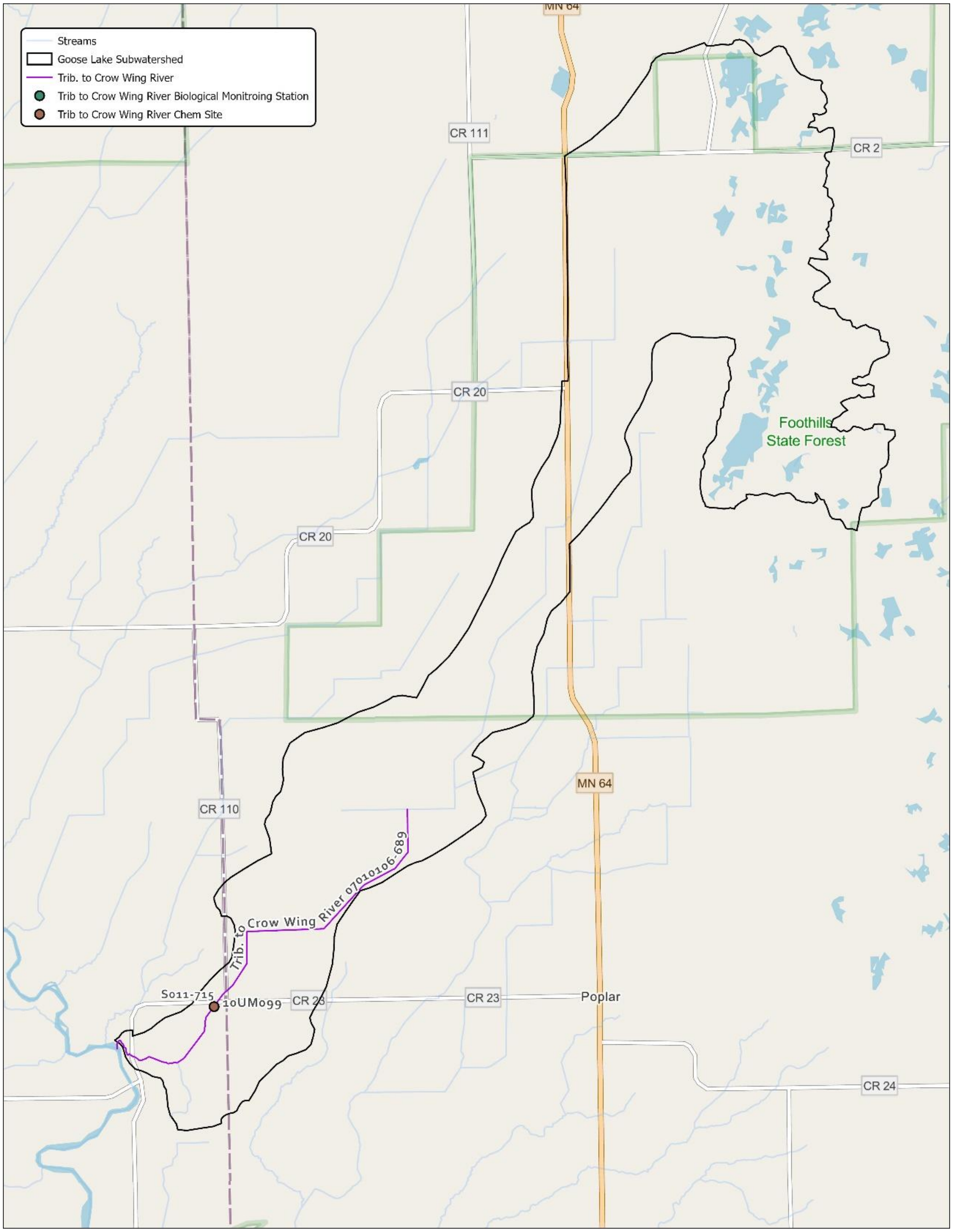
The fish sample from 2010 passed the IBI with a score of 51.9 and had 7 species sampled. The fish sample showed a high probability of low DO as a stressor when reviewing the fish TIV data. The macroinvertebrate TIVs were able to be used, which indicated that Phosphorus has the potential to be a stressor to the aquatic life within Tributary to Big Swamp Creek, with DO and TSS not appearing to be stressors. The elevated TP and unstable DO levels within the chemistry dataset collected on Tributary to Big Swamp Creek further indicate that TP and DO are stressors to the aquatic life within the ditch.

Altered hydrology and geomorphology have also impacted the aquatic life within Tributary to Big Swamp Creek, by removing habitat, increasing the amount of nutrients drained from the landscape, and altering the historic flow conditions. Good quality habitat such as coarse substrate, good channel development, and good depth variability are critical for the survival of sensitive fish and macroinvertebrates. Sensitive fish species like the Hornyhead Chub utilize coarse substrate to build nests for spawning. Similarly, sensitive macroinvertebrate taxa use coarse substrate, aquatic vegetation, and woody debris as attachment surfaces to avoid floating downstream, which allows them to feed. These important habitat types have been removed by the ditching process. Any habitat that was available before 2021 was lost during the ditch cleaning process that occurred in May and June of 2021.

Tributary to Crow Wing River Subwatershed

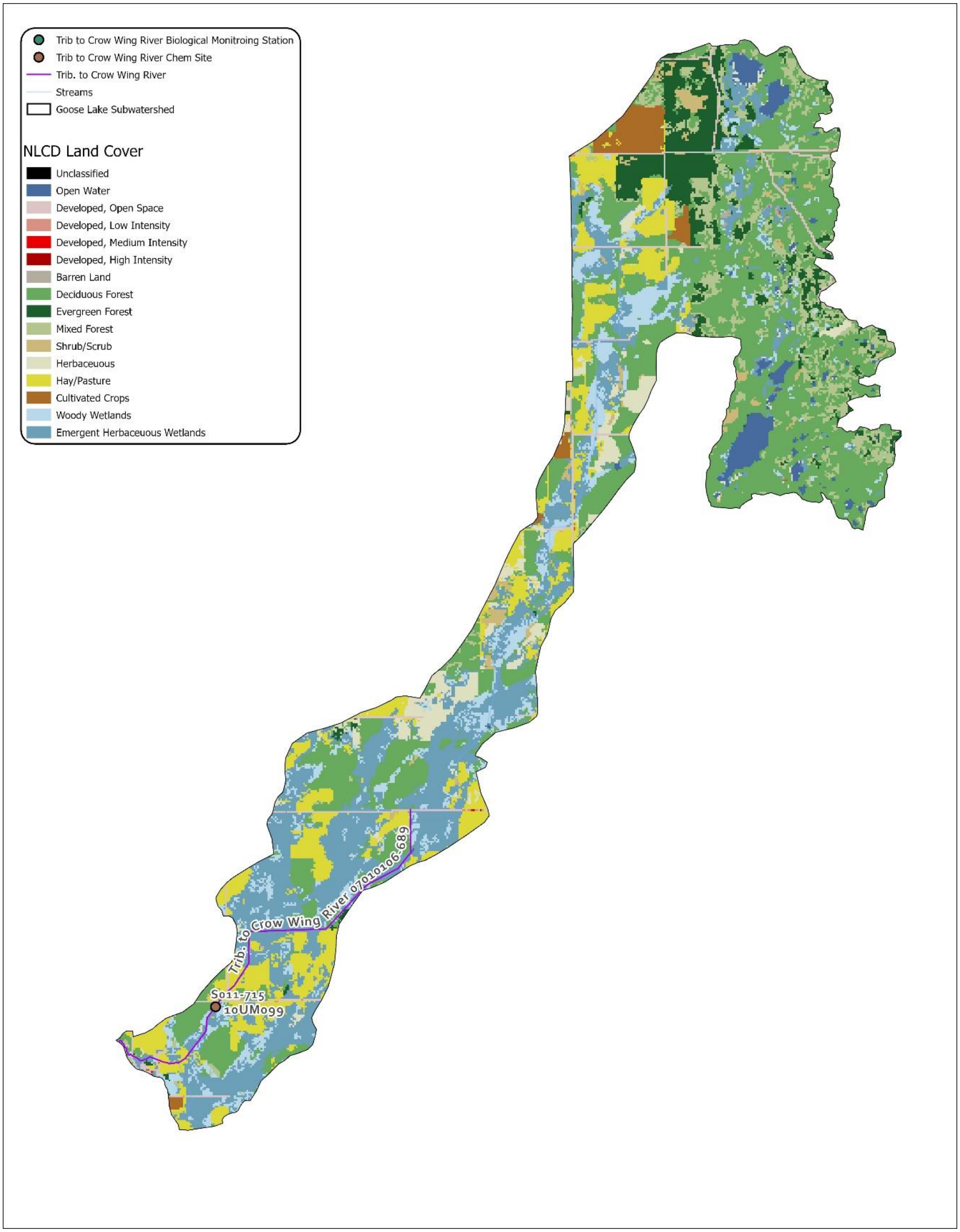
The Tributary to Crow Wing River Subwatershed covers 19520 acres, located 22 miles North of Staples, Minnesota (Figure 19). All of the streams within the subwatershed have been partially straightened.

Figure 19: Tributary to Crow Wing River Subwatershed area along with monitoring site names and locations.



The land use in the Tributary to Crow Wing River Subwatershed is dominated by Mixed Forest (47.9%), Wetland (29.6%) Rangeland (16.1%) and barrenland (7.9%; Figure 20).

Figure 20: Tributary to Crow Wing River Subwatershed land use map



Tributary to Crow Wing River (07010106-689)

Impairment: Trib to Crow Wing River (AUID-689) flows for 5.03 miles and is partially channelized. There is one biological monitoring station (10UM099) that was sampled for fish and macroinvertebrates in 2010 (Figure 19). Tributary To Crow Wing River was assessed in 2020 as part of the TALU assessment process for assessing channelized streams. The UAA process determined that Tributary to Crow Wing River should be assessed under the general use criteria, which resulted in a new macroinvertebrate impairment. The macroinvertebrate class is class 3 (Northern Streams-riffle/run). The 2010 sample had noted that the stream contains intermittent flow sections. The 2010 sample was 16 points below the GU threshold. During the 2010 macroinvertebrate sampling event, samplers collected only rock and wood habitat. Samplers noted that collector-filterer caddisflies were prevalent. During the 2020 macroinvertebrate sampling event, samplers noted baseball size rock and the MIBI score was nine points below the threshold. The fish stream class is class 6 (Northern Headwaters), and the fish passed with an IBI score of 52.8.

Data and Analyses

Chemistry

Water chemistry data is limited to the samples that were collected during 2010 through 2022 (Table 7).

Table 7: Water chemistry data collected on Tributary to Crow Wing River.

Paramter	Sample Count	Applicable Standard	Avg. Results	Min. Results	Max. Results
Temperature, water	11		15.287	1.79	26.02
Specific conductance	11		337	145	421
pH	10		7.837	7.22	8.09
Dissolved oxygen	11	5.0	9.02	6.59	11.15
Inorganic nitrogen (nitrate and nitrite)	5	8.0	0.087	0.02	0.13
Total phosphorus	7	0.100	0.091	0.052	0.161
Total suspended solids	3	30	9.73	6	13.4

Nutrients – Phosphorus

Phosphorus values from the dataset show that the average phosphorus concentration is 0.091 mg/L, which is near the Central Region River Nutrient standard of 0.100 mg/L (Table 7). This reach is partially channelized and is flowing through a series of pastures located upstream. Currently there is not enough information to assess if phosphorus is a stressor to the biology.

Dissolved Oxygen

If DO is below 5mg/L for extended periods of time, biological communities can be severely impacted. DO was collected 11 times between 2010 and 2022 (Table 7). The average DO concentration was 9.02 mg/L. None of the collected DO concentrations were below the 5 mg/L standard for 2B waters. DO is not a stressor to the stream biology.

Total Suspended Solids

TSS data is limited to 3 samples in 2022 (Table 7). The values were well below the standard of 30 mg/L. TSS is not considered a stressor to the macroinvertebrates.

Conductivity

Specific conductivity values are within range on Tributary to Crow Wing River (Table 7) and is not considered to be a stressor within Tributary to Crow Wing River.

Temperature

Temperature values were within range on Tributary to Crow Wing River (Table 7) and is not considered to be a stressor within Tributary to Crow Wing River.

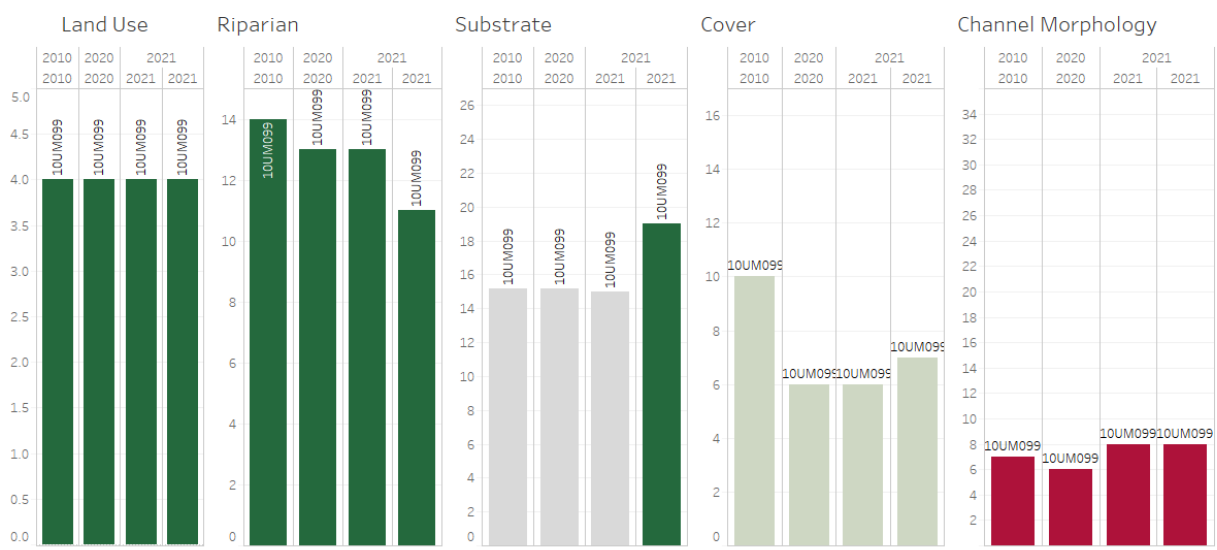
Habitat

Habitat was classified as fair on Tributary to Crow Wing River, through the MSHA evaluation at the biological sample dates (Figure 21).

Figure 21: MSHA habitat scores for Tributary to Crow Wing River.

MSHA Scores

Field Num	Month of Visit Date	Day of Visit Date	Year of Visit Date	Total Score
10UM099	June	17	2021	46
		29	2010	50.200000763
	July	8	2021	49
	August	11	2020	44.200000763



Due to the historic channelization of Tributary to Crow Wing River, and fair MSHA score, the assessment of Tributary to Crow Wing River was brought into the UAA process. It was determined that the habitat of Tributary to Crow Wing River has the ability to support good quality habitat for aquatic life, as a result of the MSHA score. Therefore, Tributary to Crow Wing River was assessed using the General Use TALU criteria.

Although the MSHA score was fair overall, cover and channel morphology scored particularly low as noted in Figure 21. Cover was the first low scoring component of the MSHA score, as indicated by the lack of deep pools, boulders, and overhanging vegetation. Healthy fish communities need cover to escape predation. Excessive fine sediment also affects juvenile fishes, as the sediment is stirred into the water column creating TSS, it can easily tear sensitive juvenile fish gills. Similarly, many sensitive macroinvertebrates also have specialized gills that are used to breathe DO. Excessive fine sediments can damage these gills, similar to juvenile fishes, making the creek inhabitable for sensitive species.

Channel morphology was another low scoring component of the MSHA evaluation. The MSHA indicated that there was minimal channel depth variability, poor sinuosity, and no channel development (no riffles or pools). Fish and macroinvertebrates need channel depth variability to use as cover from predation and refuge during high precipitation events. No change in the channel depth combined with fair sinuosity and poor channel development impedes the fish and macroinvertebrate's ability to inhabit the creek throughout the summer, especially during high flow events which can flush these communities downstream. The lack of good channel morphology is caused by the channelization of the creek, as the manipulation of the channel has been designed to move water quickly, by mechanically removing channel sinuosity, pools, and riffles. Lack of habitat is a stressor to the aquatic life in Tributary to Crow Wing River.

Hydrology and geomorphology

Over time, there have been many changes on the landscape that have changed the natural hydrology and geomorphology of Tributary to Crow Wing River, and the entire subwatershed. The most significant historical changes to the landscape have been land conversion from mature forests and woody wetlands to cultivated fields and pastures along with the channelization of the natural streams and wetlands. Tributary to Crow Wing River has been straightened along the entire length of the AUID. Historically, Tributary to Crow Wing River was comprised of multiple woody wetlands and small stream channels.

This channel alteration accelerates stream flow, resulting in higher flows during precipitation events which achieves the agricultural land use drainage goals, but causes instability. Water leaves the landscape quickly, resulting in periods of higher flow than what would have naturally occurred. As the landscape drains, water that was once held in the upstream wetlands is flushed downstream. Then, as these flows quickly drain, the flow regime quickly transitions to intermittent, reaching stagnant conditions starting in the summer (Figure 22). Although 2021 was a dry summer, Tributary to Crow Wing River was already mostly dry by the early July. The water that was present in the channel was very shallow groundwater seeping into the channel.

Figure 22: Tributary to Crow Wing River experienced low flows during the summer of 2021.

June 28,2021 low flow (upstream)

October 8, 2021, low flow (downstream

Connectivity

The culvert crossing downstream of 10UM099 off CR23 is a fish barrier. There is a drop structure in the culvert on the upstream side of the CR23 crossing located just upstream of the confluence with the Crow Wing River (Figure 23).

Figure 23: 5/13/2021 manhole drop structure at road crossing CR110 (CR7). Top of emergency spillway. Complete fish barrier

The culvert with the drop structure is located on the farthest downstream end of the stream and appears to be a grade control structure to help prevent erosion on the downstream outlet of the culvert. The gradient in this stretch of stream is high and prior to this recently installed structure the downstream section of stream was eroded. Aerial photo analysis shows that the structure was installed between 2013 and 2016 as seen in the photos below.

April 11, 2013. photo from Google Earth

August 30, 2016. Photo from Google Earth

Stressor signals from biology

Macroinvertebrates

Macroinvertebrates were also sampled in 2010 as part of the cycle I watershed monitoring effort. Sixty-four percent of the macroinvertebrate community that was sampled in 2010 was comprised of taxa that are considered to be tolerant of pollutants, and 18% of the community was considered to be very tolerant of pollutants. *Ceratopsyche (caddisfly)* and *Hydropsyche* (caddisfly) dominated the sample and are both considered to be tolerant taxa.

TSS taxa tolerance was investigated using the macroinvertebrate communities. In the 2010 sample, three intolerant taxa, five tolerant taxa, and no very tolerant taxa were collected (Table 8). Overall, the macroinvertebrate community within Tributary to Crow Wing River indicates that TSS is not a stressor to the macroinvertebrate community.

DO tolerance was also investigated using the macroinvertebrate communities. In 2010, three very intolerant, eight intolerant taxa, three tolerant taxa, and zero very tolerant taxa were collected (Table 8). Although there are a few tolerant taxa present, intolerant and very intolerant taxa dominated the sample, and indicate that low DO most likely is not a stressor to the macroinvertebrate community within Tributary to Crow Wing River.

The final tolerance indicator that was investigated within the macroinvertebrate community was phosphorous tolerance. In the 2010 sample, four intolerant taxa, three tolerant taxa and zero very tolerant taxa were collected (Table 8). These tolerance indicators within the macroinvertebrate community indicate that phosphorous is a possible stressor to the macroinvertebrate community within Tributary to Crow Wing River. Further sampling of phosphorus would need to be conducted to determine the seasonal phosphorus concentrations of the stream reach. Currently phosphorus as a stressor is inconclusive.

Table 8: Macroinvertebrate tolerance index values for Tributary to Crow Wing River.

Parameter	Taxa Tolerance	2010 Sample
DO	# Intolerant	8
	# Tolerant	3
	# Very Intolerant	3
	# Very Tolerant	0
Phosphorus	# Intolerant	4
	# Tolerant	3
	# Very Intolerant	0
	# Very Tolerant	0
TSS	# Intolerant	3
	# Tolerant	5
	# Very Intolerant	0
	# Very Tolerant	0

Composite conclusion from biology

The TSS and DO TIVs were inconclusive for macroinvertebrates but did indicate that Phosphorus is a potential stressor to the macroinvertebrate community but remains inconclusive at this time.

The habitat and geomorphology are heavily altered within Tributary to Crow Wing River and are the primary stressors to the aquatic life within the ditch.

Conclusions about stressors

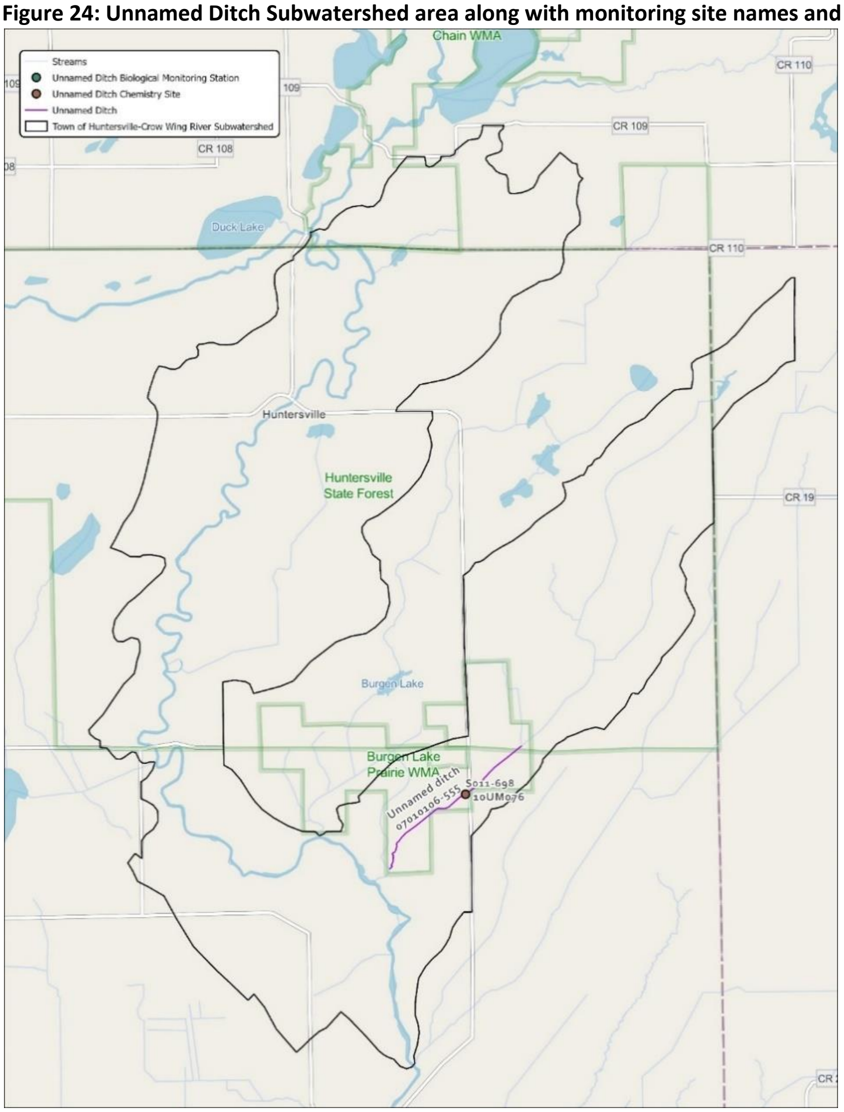
The fish sample from 2010 passed the IBI with a score of 52.8 and had 6 species sampled. The macroinvertebrate TIVs were able to be used, which indicated that Phosphorus has the potential to be a stressor to the aquatic life within Tributary to Crow Wing River, with DO and TSS not appearing to be stressors.

Altered hydrology and geomorphology have also impacted the aquatic life within Tributary to Crow Wing River, by removing habitat, increasing the amount of nutrients drained from the landscape, and altering the historic flow conditions. Good quality habitat such as coarse substrate, good channel development, and good depth variability are critical for the survival of sensitive fish and macroinvertebrates. Sensitive fish species like the Hornyhead Chub utilize coarse substrate to build nests for spawning. Similarly, sensitive macroinvertebrate taxa use coarse substrate, aquatic vegetation, and woody debris as attachment surfaces to avoid floating downstream, which allows them to feed. These important habitat types have been removed by the historical ditching process. Lack of stream flow throughout the summer months is also affecting the macroinvertebrate communities as many habitats are dry during various times of the season. Water levels were extremely low during 6/17/2021 fish sample. My notes indicate standing water with a very minimal amount of flow. Since there was virtually no rainfall after the 4/8/2021 1 inch rain event, the stream was being fed with groundwater for most of the summer is my guess. Majority of this WID is channelized historically. There are a few sections of natural channel left. There are also a bunch of active pastures located along this WID with free access to channel. There is a drop structure in the culvert on the upstream side of the CR23 crossing located just upstream of the confluence with the Crow Wing River.

Town of Huntersville-Crow Wing River Subwatershed

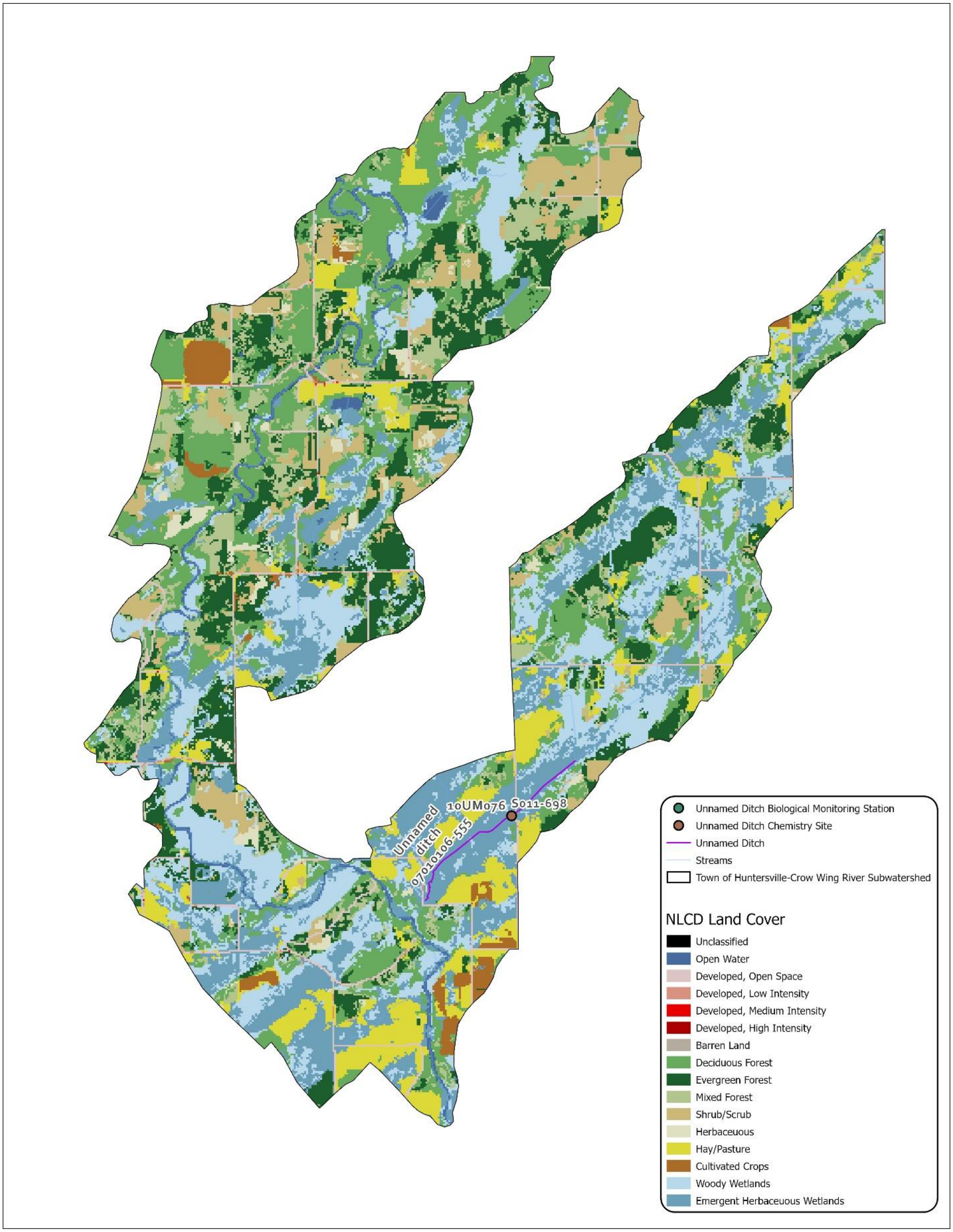
The Town of Huntersville-Crow Wing River Subwatershed covers 25,519 acres, located in Huntersville, MN (Figure 24). While the Crow Wing River remains natural, all of the tributary streams within the subwatershed have been straightened.

Figure 24: Unnamed Ditch Subwatershed area along with monitoring site names and locations.



The land use within the Town of Huntersville-Crow Wing River Subwatershed is dominated by forestland (49.7%), followed by wetlands (34.5%), and rangeland (10.1%; Figure 25).

Figure 25: Town of Huntersville-Crow Wing River Subwatershed land use map



Unnamed Ditch (07010106-555)

Impairment: Unnamed Ditch (AUID -555) flows for 3.81 miles Southwest and enters the Crow Wing River just north of Huntersville. Unnamed ditch has been channelized throughout the entire reach. There is one biological monitoring station (10UM076) that was sampled for fish and macroinvertebrates in 2010 (Figure 24). Unnamed ditch was assessed in 2020 as part of the TALU assessment process for assessing channelized streams. The UAA process determined that Unnamed ditch should be assessed under the general use criteria, due to fair habitat scores. This assessment resulted in a new macroinvertebrate impairment. The fish stream class is class 7 (low gradient) and scored a 52.1, which is 10 points above the threshold. The macroinvertebrate stream class is class 4 (Northern Streams glide/pool) and scored a 22.8, which is 18 points below the threshold. During the macroinvertebrate sampling event in 2010 it was noted that the stream was full of iron precipitate, bank cutting below the root zone, groundwater influence and wetland characteristics. Sampling in June of 2021 and July of 2022 also documented high iron concentrations as iron floc was very evident. The macroinvertebrate sample was dominated by fingernail clams with very little diversity overall (13 species in total).

Data and Analyses

Chemistry

Water chemistry data has been collected in one location (S011-698) on unnamed ditch (Table 9Table 10). The dataset ranges throughout various years from 2010 through 2022. Three samples were collected in 2010 and used to aid in SID process of the biological impairment from the 2010 sampling effort on unnamed ditch.

Table 9: Water chemistry data collected on Unnamed Ditch from 2010-2022. Data available at https://webapp.pca.state.mn.us/surface-water/search.

Parameter	Count of Samples	Applicable Standard	Avg. Result	Min. Result	Max. result	% Exceedance
Temperature, water	12		14.17	3.30	25.4	
Specific Conductance	12		296.6	121	502	
pH	12		7.03	6.75	7.31	
Dissolved Oxygen	12	5	5.47	0.24	11.49	41.67
Total Phosphorus	9	0.100	0.216	0.042	0.622	66.67
Ortho Phosphorus	4		0.057	0.034	0.084	
Inorganic nitrogen (nitrate and nitrite)	9		0.05	<0.02	0.12	
Total suspended solids	6	30	17.23	1.4	48.8	33.33

Nutrients – Phosphorus

Phosphorus values from the dataset show that the average phosphorus concentration is 0.216 mg/L, which is double the Central Region River Nutrient standard of 0.100 mg/L (Table 9). This reach is channelized through an area of hydric soil. This channelization is allowing for groundwater inputs and the low DO groundwater is causing phosphorus to bind to the iron precipitate as seen in the Figure 26 below. As stream flow gets low the iron starts to precipitate and binds phosphorus. DO concentrations crash during these low flow iron floc events causing an environment that is not favorable to the macroinvertebrate community.

Figure 26: June 10, 2021, photo on upstream side of culvert. Showing iron in water and iron precipitate along stream edges.

Dissolved Oxygen

If DO is below 5mg/L for extended periods of time, biological communities can be severely impacted. DO was collected 10 times in 2021 and 2022. The average DO concentration was 6.402 mg/L. Thirty percent of the collected DO concentrations were below the 5 mg/L standard for 2B waters (Table 9). The low DO readings occurred during the late summer months when water levels were below normal. In both 2021 and 2022 stream flow was documented as very low (less <0.05 cfs) and in August and September of both years the channel was dry on the upstream side of the road. During the low flow periods iron precipitates and DO concentrations drop immediately. DO is a stressor to the stream biology during periods of below normal flow.

Total Suspended Solids

TSS data is limited to 6 samples with both samples in 2010 being well above the 30 mg/L standard (Table 9). The 2022 values were well below the standard but in 2022 there was more flow in the stream than in 2010. The iron precipitate can cause elevated TSS values and strips DO out of the water column. TSS is considered a secondary stressor to the macroinvertebrates.

Conductivity

Specific conductivity values are within range on Unnamed Ditch (Table 9) and is not considered to be a stressor within Unnamed Ditch.

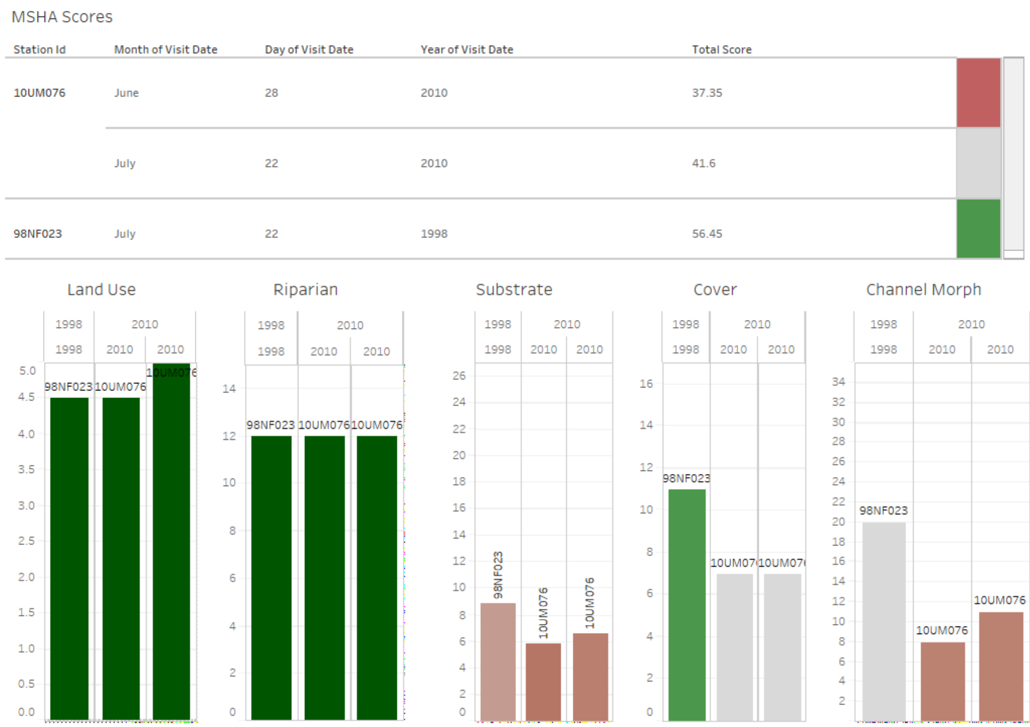
Temperature

Temperature values were within range on Unnamed Ditch (Table 9) and is not considered to be a stressor within Unnamed Ditch.

Habitat

Habitat was classified as fair on Unnamed Ditch, through the MSHA evaluations (Figure 27).

Figure 27: MSHA habitat scores for Unnamed Ditch.



Due to the historic channelization of Unnamed Ditch, and fair MSHA score, the assessment of Unnamed Ditch was brought into the UAA process. It was determined that the habitat of Unnamed Ditch has not degraded to a point where it cannot support good quality habitat for aquatic life, as a result of channelization. Therefore, Unnamed Ditch was assessed using the General Use TALU criteria. Although the average MSHA score was fair overall, substrate and channel morphology scored particularly low, which lowered the overall MSHA score (Figure 27). Substrate was the first low scoring component of the MSHA score, as indicated by the dominance of clay and silt. Healthy fish communities need coarse substrate to build nests and spawn. Excessive fine sediment also affects juvenile fishes, as the sediment is stirred into the water column creating TSS, it can easily tear sensitive juvenile fish gills. Similarly, many sensitive macroinvertebrates also have specialized gills that are used to breathe DO. Excessive fine sediments can damage these gills, like juvenile fishes, making the ditch inhabitable for sensitive species. Gravel was not present within the channel. Since this channel appears to be nearly 100% created in the upstream reaches, there was probably never any coarse substrate available.

Channel morphology was another low scoring component of the MSHA evaluation. The MSHA indicated that there was fair channel depth variability, poor sinuosity, and moderate channel stability. Fish and macroinvertebrates need channel depth variability to use as cover from predation and refuge during high precipitation events. Minimal change in the channel depth combined with fair sinuosity impedes the fish and macroinvertebrate’s ability to inhabit the creek throughout the summer, especially during high flow events which can flush these communities downstream. The lack of good channel morphology is caused by the channelization of the creek, as the manipulation of the channel has been designed to move water quickly, by mechanically removing channel sinuosity, pools, and riffles. Lack of habitat is a stressor to the aquatic life in Unnamed Ditch.

Hydrology and geomorphology

Over time, there have been many changes on the landscape that have changed the natural hydrology and geomorphology of Unnamed Ditch, and the entire subwatershed. The most significant historical changes to the landscape have been land conversion from mature forests to agricultural fields and the channelization of the natural streams and wetlands. Unnamed Ditch has been straightened along the entire upper ¾ length of the AUID. Historically, the stream channel that now makes up Unnamed Ditch, did not exist. As the landscape drains, the flow regime quickly transitions to low flow, reaching stagnant conditions starting early in the summer (Figure 28).

Figure 28: Unnamed Ditch. Channel was dry on 7/14/2021. Channel stayed dry through September of 2021 and dried out again in August and September of 2022.

Due to the channelization of Unnamed Ditch, the ditch does not have a natural stream pattern that can be assessed for stability. Utilizing the biological monitoring sampling pictures and MSHA evaluations of stream bank condition, the banks appear to be stable and not actively eroding. The current channel size is most likely similar in size to the historic stream channels that existed prior to the channelization, but the new channel is much shorter, which drains the channel quickly. Due to these hydrologic and geomorphic alterations of the historical stream channel, altered hydrology is a stressor to the aquatic life within Unnamed Ditch. During the September 2010 macroinvertebrate sampling event, water levels were also very low, and the stream was full of iron precipitate (Figure 29). This shows that the stream frequently goes dry or nearly dry. Lack of baseflow in the late summer and fall is the greatest stressor to the macroinvertebrates.

Figure 29: Macroinvertebrate sampling event on September 2, 2010. Water levels are low, and the channel is full of iron precipitate and has very low DO concentrations.

Connectivity

The culvert crossing by 10UM076 off Huntersville Road Ave does not appear to be a fish barrier.

Stressor signals from biology

Macroinvertebrates

Macroinvertebrates were also sampled in 2010 as part of the cycle I watershed monitoring effort. Seventy-five percent of the macroinvertebrate community that was sampled in 2010 was comprised of taxa that are tolerant of pollutants, and 26.8% of the community was considered to be very tolerant of pollutants. *Pisisiisae* and *Chironomus* dominated the sample and are both considered to be tolerant taxa.

TSS taxa tolerance was investigated using the macroinvertebrate communities. In the 2010 sample, no intolerant taxa, three tolerant taxa, and two very tolerant taxa were collected (Table 10). Overall, the macroinvertebrate community within Unnamed Ditch indicates that TSS is a stressor to the macroinvertebrate community. This is probably a function of the iron flocculant that appears to develop every year as low flows occur in the channel.

DO tolerance was also investigated using the macroinvertebrate communities. In 2010, zero very intolerant, zero intolerant taxa, four tolerant taxa, and four very tolerant taxa were collected (Table 10). Tolerant and very tolerant taxa dominated the sample and indicate that low DO has the potential to be a stressor to the macroinvertebrate community within Unnamed Ditch.

The final tolerance indicator that was investigated within the macroinvertebrate community was phosphorous tolerance. In the 2010 sample, zero intolerant taxa, five tolerant taxa and three very tolerant taxa were collected (Table 10). These tolerance indicators within the macroinvertebrate community indicate that phosphorous is a stressor to the macroinvertebrate community within Unnamed Ditch.

Table 10: Macroinvertebrate tolerance index values for Unnamed Ditch.

Parameter	Taxa Tolerance	2010 Sample
DO	# Intolerant	0
	# Tolerant	4
	# Very Intolerant	0
	# Very Tolerant	4
Phosphorus	# Intolerant	0
	# Tolerant	5
	# Very Intolerant	0
	# Very Tolerant	3
TSS	# Intolerant	0
	# Tolerant	3
	# Very Intolerant	0
	# Very Tolerant	2

Conclusions about stressors

The main stressor to the macroinvertebrate community in Unnamed Ditch is a lack of baseflow and the channel going dry. During late summer of both 2021 and 2022 the channel went dry upstream of the road. As the streamflow drops the channel has elevated iron floc, low DO and elevated phosphorus concentrations. A lack of suitable habitat is also a stressor to the macroinvertebrates as the channel has fine sediment along with a lack of pools, riffles and runs.