Watershed

July 2025

Big Fork River Watershed Stressor Identification Report

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

MINNESOTA POLLUTION CONTROL AGENCY

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Cover photo: Caldwell Brook in Pine Island State Forest, Koochiching County, MN - MPCA photo

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Acronyms and term definitions

BFRW	Big Fork River Watershed, the USGS HUC-8-scale watershed and this report's focus.
BMPs	Best Management Practices
CADDIS	Causal Analysis/Diagnosis Decision Information System, an EPA developed methodology
CSAH	County State Aid Highway
DO	Dissolved Oxygen
DNR	Minnesota Department of Natural Resources
FIBI	Fish-based lake Index of Biological Integrity; an index developed by the DNR that compares the types and numbers of fish observed in a lake to what is expected for a healthy lake (range from 0–100). More information can be found at the DNR Lake Index of Biological Integrity website
GIS	Geographic Information System
GLA	Glacial Lake Agassiz
HUC	Hydrologic Unit Code (a multi-level coding system of the U.S. Geological Survey, with levels corresponding to scales of geographic region size)
IBI	Index of Biological Integrity – a multi-metric index used to score the condition of a biological community.
Intolerant species	A species whose presence or abundance decreases as human disturbance increases.
IWM	MPCA's Intensive Watershed Monitoring, which includes chemistry, habitat, and biological sampling. Some watersheds have had two IWM efforts (10 years apart), while some have only had the first IWM so far.
MFRC	Minnesota Forest Resources Council
mg/L	Milligrams per liter
MnDOT	Minnesota Department of Transportation
MPCA	Minnesota Pollution Control Agency
NLCD	National Land Cover Database, a GIS layer
Natural background	An amount of a water chemistry parameter coming from natural sources, or a situation caused by natural factors.
SID	Stressor Identification – The process of determining the factors (stressors) responsible for causing a reduction in the health of aquatic biological communities.
SWCD	Soil and Water Conservation District. This is a county-level management office.

TALU	Tiered Aquatic Life Uses, a framework of setting biological standards for different categories of streams
TMDL	Total Maximum Daily Load
TP	Total Phosphorus (measurement of all forms of phosphorus combined)
TSS	Total Suspended Solids (i.e. all particulate material in the water column)
EPA	U.S. Environmental Protection Agency
WID	Waterbody Identification number - a three digit number following the 8 digit HUC-8 major watershed number. It is a reach that receives an assessment.
WPLMN	Watershed Pollutant Load Monitoring Network - long-term flow and chemistry monitoring stations with frequent sampling.
WRAPS	Watershed Restoration and Protection Strategy, with watershed at the 8-digit Hydrological Unit Code scale

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Executive summary

This report documents the efforts that were taken to identify the causes, and to some degree the source(s) of impairments to aquatic biological communities in streams in the Big Fork River Watershed (BFRW). Though the BFRW has undergone two rounds of intensive watershed monitoring (IWM), this is the first Stressor Identification (SID) Report for the BFRW. The first IWM (IWM-1, in 2010) results are described in the IWM and Assessment Report (MPCA, 2013). An IWM Report Update was created for IWM-2 (MPCA, 2024).

In general, the BFRW's flowing water systems are in healthy condition, with many of them found to have biological communities classified as "Exceptional", particularly the mainstem of the Big Fork River. Exceptional biological communities are little changed from their historical, pre-settlement condition. No new biological impairments were found in IWM-2. The SID effort for IWM-2 began in 2019, when a Minnesota Pollution Control Agency (MPCA) assessment team met to discuss three biological impairments that had been deferred in IWM-1 because they were ditched channels. These stream reaches are remote ditches through peatlands or have such ditching upstream. The team determined that the wetland setting of these ditches, in combination with these being unnatural channels, belong in the "Impairment, nonpollutant" category of stream impairments, meaning no total maximum daily load (TMDL) gets written. In addition, three other biological impairments were determined to be due to natural background conditions related to wetland characteristics of the sites.

One stream (Caldwell Brook) was investigated because the biological monitoring staff had assigned a "vulnerable" assessment to the reach, as the fish community barely passed the Fish-based Lake Index of Biological Integrity (FIBI) threshold, and field staff noted seemingly unnatural channel erosion. The SID staff took on an investigation of this stream in 2023 for protection reasons, based on the vulnerable status assigned during the assessment process. Field observations by SID staff found some notable signs of channel instability and requested the Minnesota Department of Natural Resources (DNR) Clean Water Legacy staff to conduct a geomorphic survey/assessment at the MPCA biological monitoring site's reach. DNR conducted the fieldwork in fall 2023 and fall 2024 with MPCA and Soil and Water Conservation District (SWCD) field assistance. The DNR produced a report that found the channel is indeed unstable, having incised significantly from its original elevation, meaning a loss of connectivity to the floodplain. This results in high flows not being able to spill out onto the floodplain and dissipate energy. This channel-containment of flood flows exerts much energy instead on the bed and banks, resulting in excessive erosion. Additionally, a determination was made that fish habitat (and likely macroinvertebrate habitat) has been degraded. Thus, habitat degradation is likely the cause of the barely-passing fish community FIBI score. The fish community is not as robust as it would naturally be in Caldwell Brook, and the stream contributes much more sediment to the Big Fork River than it would be if in healthy condition.

Stream aquatic life impairments (Natural Background)

- Rice River (WID 09030006-539) - Dissolved Oxygen
- Popple River (WID 09030006-517) - Fish

- Gale Brook (WID 09030006-547) - Macroinvertebrates

Stream aquatic life impairments (Non-pollutant)

- Unnamed Ditch (WID 09030006-681) - Fish and Macroinvertebrates
- Hay Creek (WID 09030006-679) - Fish and Macroinvertebrates
- Unnamed Creek (WID 09030006-676) - Fish and Macroinvertebrates

Stream Geomorphology investigations

- Caldwell Brook (WID 09030006-510) - Vulnerable fish community

The stressors of aquatic biological communities in the BFRW are either natural or related to altered hydrology. The natural stressors are low dissolved oxygen (DO), due to the extensive wetlands that supply water to streams, and beaver dams, which can cause lowered DO levels and can also block fish passage, preventing repopulation of smaller streams in spring from downstream overwintering habitat. The altered hydrology (increased flow volumes) has caused channel instability, habitat degradation, and excess sediment export in Caldwell Brook. Two other streams near Caldwell Brook (Plum Creek and Bowerman Brook) also look like they may be incised. Land cover (i.e., vegetation) changes alter the water-retentive capabilities of landscapes, resulting in greater runoff of melting snow and rain. Some of this alteration goes back in time to the era of the original logging at European settlement, when vast areas of old-growth forests were clear-cut across northern Minnesota. In modern times, forest alteration has continued as very significant amounts of logging for the paper and wood products industries has occurred in the second and third growth forests. In parts of the BRFW, significant forest cover has been converted from the original pine to poplar, as it is the dominant species that naturally arises from forest disturbance/logging, as well as the predominant species utilized in the region for paper production. Even changes in tree species in a forest can change the hydrology of that area.

Additional stream issues that are not linked with an impairment that were observed while in the field were documented and discussed in this report as potential protection projects. These mostly involved erosional issues, some at recreational access points. Infrastructure stressors included culverts that were installed such that fish passage is difficult or not possible, which is a common issue all across Minnesota. SWCD staff of both Itasca and Koochiching Counties did assessments of culverts at a number of stream crossings.

Koochiching County SWCD staff conducted a reconnaissance of the mainstem of the Big Fork River, including at recreational points (campsites and boat/canoe accesses). Issues predominantly involving erosion were documented for potential restoration.

Information on the SID process can be found on the U.S. Environmental Protection Agency's (EPA) website http://www.epa.gov/caddis/. Specific information on Minnesota's processes for SID in streams can be found on MPCA's webpage "Is Your Stream Stressed". The DNR has a similar webpage for lakes - "Stressors to Biological Communities in Minnesota's Lakes".

Introduction

Background information

The BFRW was first sampled as part of MPCA's IWM process in 2010. For several reasons, a SID effort was not completed for the cycle 1 watershed restoration and protection strategy (WRAPS) process. This report discusses findings in both the cycle 1 and cycle 2 (2021) IWM efforts in the BFRW, associated stressors to the aquatic biological communities, and opportunities for stream protection work. Much information about the characteristics of the BFRW can be found in the IWM assessment report for the BFRW (MPCA, 2013) and the IWM cycle 2 Update Report (MPCA, 2024). These reports can be found on the MPCA website page: https://www.pca.state.mn.us/watershed-information/big-fork-river. Information on MPCA's SID Program for impaired streams and rivers can be found on the following webpage: https://www.pca.state.mn.us/business-with-us/stressor-identification.

Stream impairment status after IWM cycle 1 (2010)

Stream reaches with failing aquatic life use standards

Three water body identification numbers (WIDs) that were found to not be meeting aquatic life use standards were further investigated and determined to no longer be impaired reaches. These included Rice River (WID 09030006-539, DO), Popple River (WID 09030006-517, Fish), and Gale Brook (WID 09030006-547, Macroinvertebrates). Because these impairments were determined to be caused by natural conditions, no SID was conducted.

Deferred assessments of IWM cycle 1 biological data

In the early years of MPCA's assessment process for IWM data, streams that were channelized were deferred from assessment decisions. Three such stream segments with biological communities that did not meet the passing IBI thresholds for fish and/or macroinvertebrates from cycle 1 IWM sampling (2010) were brought forward later for assessment, and proper assessment categorization, meaning consideration of moving the impairments from the default 303(d) impairment category to another 303(d) category (Table 1). The proposed category shift was from category 5, which associates the impairment with an anthropogenic water pollutant, to one of the category 4 options, which associates the impairment with a natural background water quality condition or a non-pollutant anthropogenic issue, for which a TMDL is not the proper means of restoration.

Table 1. List of biological stream impairments from IWM cycle 1 brought up for impairment recategorization.

WID	Stream name	WID length (mi)	Subwatershed name	Impairment	New 303(d) use class
09030006-681	Unnamed ditch	3.83	Bear River	Fish, MI	4C
09030006-679	Hay Creek	2.23	Bear River	Fish, MI	4C
09030006-676	Unnamed Creek	2.45	Sturgeon River	Fish, MI	4C

The three stream segments were either a ditch cut through extensive, remote peatland areas many decades ago or have such ditching in their connected headwaters area. All reaches have low DO, which is common for waters that emerge from within peatlands. The bacterial decay occurring in the saturated organic riparian soils deprives these source waters of much of their oxygen.

The MPCA team that reviewed the arguments for changing the 303(d) category assignment agreed with the supporting documentation that was submitted for review, and these stream segments were moved to 303(d) impairment category 4c (natural background).

Also, two stream reaches were assessed prior to Cycle 2, using Cycle 1 data that had been deferred at that point because the channels were not natural within the reach sampled (i.e., were straightened) (Table 2).

Table 2. Stream assessments from IWM cycle 1 that had been deferred previously.

WID	Stream name	WID length (mi)	Subwatershed name	Assessment
09030006-516	Bear River	34.52	Bear River	Meets Aquatic Life Use (ALU) standards
09030006-626	Pancake Creek	1.79	Caldwell Brook	Fish meets ALU, MI inconclusive

Stream assessments from IWM cycle 2 (2021)

The results of biological and chemistry monitoring in IWM cycle 2 found no biological stream impairments. One stream, Caldwell Brook was flagged as vulnerable regarding its fish community, with a narrowly-passing FIBI score, and some seasonally-high TSS has been found on the more downstream sections of the Big Fork River. Both are further discussed below.

Stressors in the BFRW

No anthropogenic water pollution was found to be causing impairments to the biological communities in the BFRW. However, there is potential for current human activities on the landscape to reduce the health of biological communities, and also a recognition/documentation that past human activities have created stress on biological life in some BFRW streams. Work toward alleviating these stressors in this case would be considered "protection" activities, which is the "P" in the acronym WRAPS. These potential stressors are discussed immediately below.

Altered Hydrology - Introduction

The hydrology of a watershed is about how water received via precipitation moves through the watershed's landscape as it makes its way out of that watershed downstream into a different watershed. This involves many processes, including surface runoff, infiltration, movement into the groundwater aquifer, springs that release groundwater, stream flow, interactions with other features such as lakes and wetlands, and interaction with landscape vegetation. Some of the water received via precipitation never makes it to the watershed outlet but returns to the atmosphere through evaporation or evapotranspiration (release of water vapor by plants).

Human activities on the landscape can change (alter) the way water moves through the landscape's systems, including the speed at which it moves through and the amount that moves through. One of the main ways that humans alter hydrology patterns is by changing the vegetation on the land. Permanently removing forest changes evapotranspiration, evaporation, and infiltration generally in negative ways. Changing the type of forest will also change these things. Another common way that humans have altered hydrology is by straightening streams and adding ditches in wetlands. These will change the peak flows in streams during precipitation events, generally speeding up the movement of water. The construction of impervious surfaces (building roofs, driveways, roads) creates more surface runoff by decreasing infiltration.

The primary way that altered hydrology harms water resources is by the addition of pollutants from enhanced surface runoff (e.g., soil erosion) and by damaging stream channels by creating incised streams leading to bank erosion and sedimentation of the stream bed. This too causes degradation of water quality and also the physical habitat of streams for aquatic biological life (e.g., fish and macroinvertebrates).

European settlement led to numerous changes to land cover. First, the old-growth pine forests were clearcut in a massive logging effort across central and northern Minnesota in the late 1800s and early 1900s. Forest fires were common following this logging. Logs were transported down streams and rivers, which damaged their channels. The forest that returned is different from the original forest. Tree species composition is different (same species but in very different amounts), as is the age of the forest. Subsequent cutting of the second-growth forest continues to be a major industry in northern Minnesota.

Some lands were permanently changed via conversion to farm fields and pastures. Roads and settlements created impervious surfaces. In the early 1900s, large areas of Minnesota's vast peatlands were ditched in effort to create farmland for newcomers. All of these things happened in the BFRW. Things such as impervious surfaces (roads and urban areas) and farmland are however less significant than in some other Minnesota watersheds due to the relatively small population in northern Itasca and Koochiching Counties. So there are legacy influences and current activities that have and are altering the original hydrology of the BFRW.

In addition to these landscape factors, precipitation has been trending upward (DNR, 2023). The increase in precipitation may be exacerbating the other factors that have altered hydrology. The individual influences on current day water resources in the BFRW are discussed next.

Altered Hydrology - Peatland legacy ditches

Wetland restoration is considered a positive practice to help improve water quality, including for sequestering nutrients. In many parts of Minnesota, a large percentage of wetlands have been drained, and many opportunities exist to do restorations to improve water quality. Northern Minnesota has fortunately retained the great majority of its original natural wetlands. However, in past times, the peatlands (a unique type of wetland) which are extremely abundant in northern Minnesota were commonly trenched in major efforts to try to drain them. Those efforts, though largely not successful in creating farmable lands, are still functioning, and have the potential for negative effects on water resources.

History of Peatland ditching in Minnesota

Northern Minnesota has vast areas of peatlands, where the water table lies just inches below the ground surface and deep organic soils exist. This includes the largest patterned peat bog in the lower 48 states, known as the "Big Bog". During the period when European settlers were arriving in northern Minnesota, attempts were made by counties to drain the peatlands to create farmland for the settlers to homestead. A number of counties, including Koochiching, nearly bankrupted themselves due to the cost of ditching projects, and eventually were bailed out by the state, who took ownership of the land. A presentation of the history of ditching in Koochiching County is on the county's website (see References). Another good description of this era and these drainage projects is presented on a DNR interpretive sign at Big Bog State Recreation Area, near Washkish, just north of Upper Red Lake. The text of this sign can be found at this website: https://www.hmdb.org/m.asp?m=191353. The BFRW contains the eastern portion of the Big Bog, as well as numerous other large bogs. The majority of BFRW ditches, especially ones where no original, natural channel existed, are associated with organic (hydric) soils.

Current functionality of legacy peatland ditches

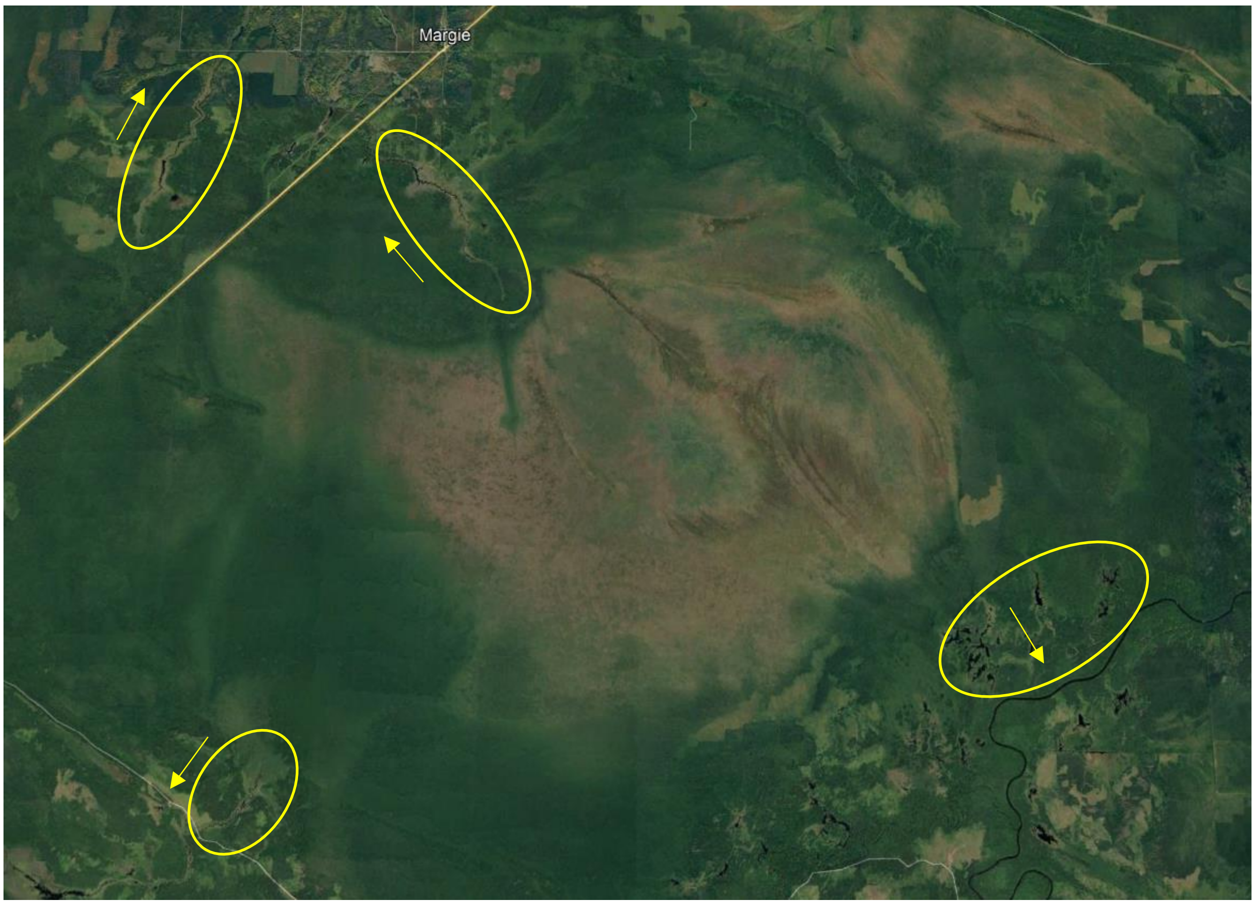
Though these legacy ditches generally did not have the desired effect of creating farmable land, they did, and still do, function to drain some of the water from the peatlands. A DNR study south of Lake of the Woods, at the Winter Road Scientific and Natural Area, found that ditches in the study peatland did draw down the water table along the ditches laterally to a distance of 370 feet, or about 113 meters (Walker, 2015). These drier corridors in the peatlands result in faster decomposition of organic soils because more oxygen is present for the decomposer bacteria. This results in land subsidence in these corridors (Krause et al., 2021). It is very common for beavers to create dams in these peatland ditches, which does impound some water, but the study found that the ditches do continue to enhance the water movement out of the peatlands. Additionally, the study found that drainage effects of the ditches depend on the direction of the ditch relative to the groundwater movement in the peatland.

Problems associated with legacy peatland ditches

There are a variety of negative effects of peatland ditches, which include alteration/loss of specialist wetland plant species, potential barriers to movement of certain wildlife species, importantly for our time, the loss of stored/sequestered carbon, and water-related issues including contributing to downstream flooding, creation of unstable stream channels downstream, stream habitat degradation, and a degradation of water quality. Water and land managers are recognizing the multiple benefits of restoring the hydrology of peatlands. A recent publication by The Nature Conservancy (2025), with the assistance of numerous federal, state, and tribal agencies, universities, and other nongovernmental organizations, documents the benefits of natural, unmodified peatlands.

Water does gradually seep or slowly drain from peatlands, where small channels have naturally developed near the edge of the peatland (Figure 1). This drainage of the peat soils is slow because these natural channels don't extend far into the peatland. On the other hand, the legacy ditches extend throughout a peatland, creating much, much greater surface area for water to emerge from the peat into a transmitting channel. Because these legacy ditches are still draining wetlands, in addition to the impacts to wetland vegetation within the peatland, there are downstream effects from the drained water. These effects include greater peak flows in downstream channels (altered hydrology that leads to bank erosion and stream habitat loss) and export of chemical constituents from the peat soils to streams (three of note are phosphorus, dissolved organic carbon, and methylmercury).

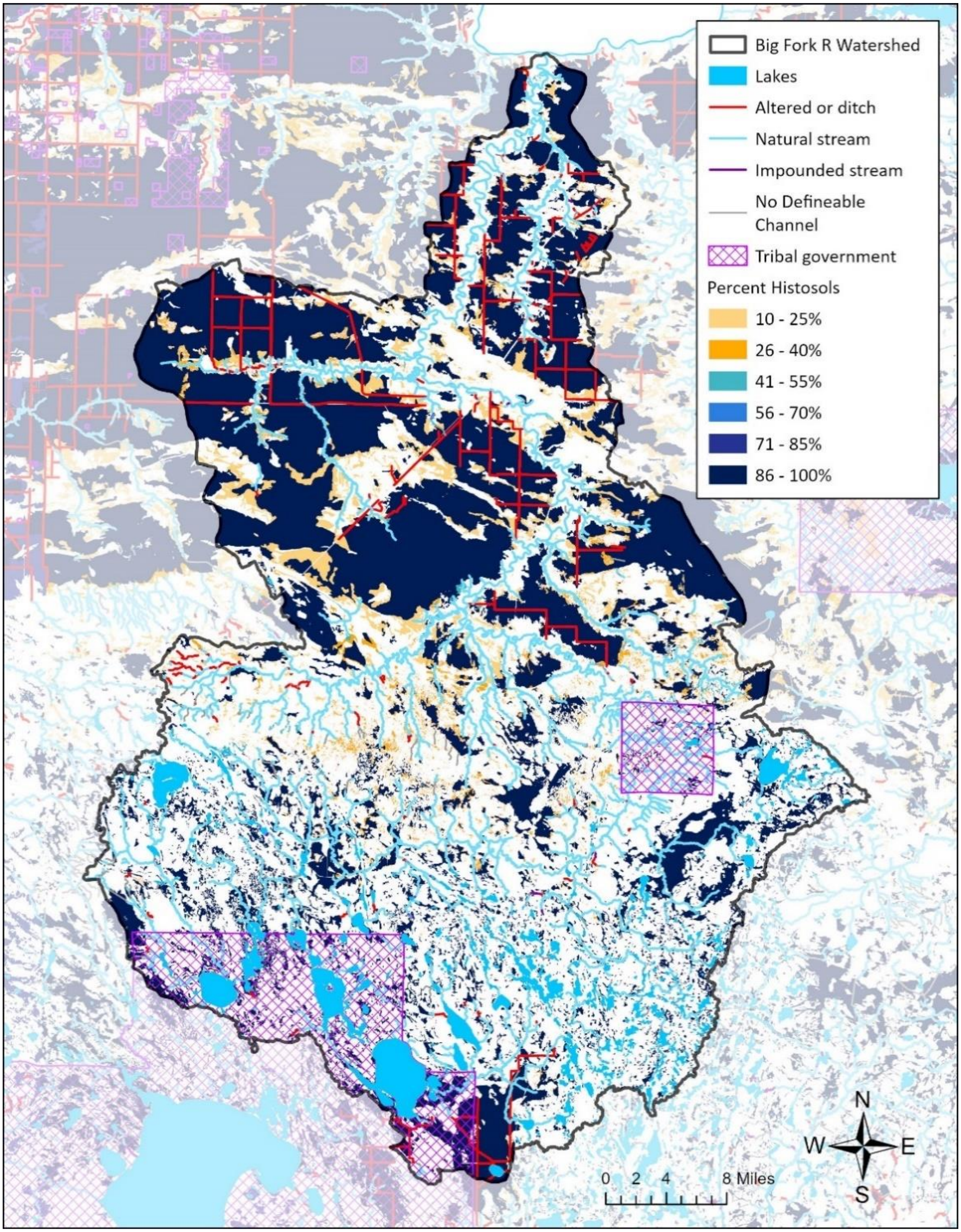
Figure 1. Natural drainage from an undisturbed peatland. Yellow circles surround the emerging natural channels that are on the periphery of the peatland and which flow in the direction of the arrows. Highway 71 is in the upper left corner - the channels there are the headwaters of Dinner Creek. In the lower right corner, the outlet channels flow to the Big Fork River.



The peatland ditches of the BFRW are especially prominent in the northern half of the BFRW where hydric soils subsequently formed on the land that previously was inundated by Glacial Lake Agassiz (GLA; Figure 2). Underlying the peat is clay that was deposited on the lakebed. This is also the part of the Big Fork River that experiences elevated TSS in spring. Some of the elevated TSS is natural, as greater flow volumes (such as during snowmelt) have greater erosive ability. During these higher flows, fine sediment is either stirred up from the river bed or eroded from river banks. Phosphorus is bound to soil particles, so its erosion also brings phosphorus into the stream system. Theoretically, a reduction in the amount of high flow volumes would reduce the suspension of fine sediments and reduce erosion of soil into the river from the river's banks. There are notable large, steep eroding banks at several locations on the Big Fork River, mostly downstream from Big Falls.

One way to reduce peak flow volumes in the Big Fork River would be to abandon and plug/fill peatland ditches that contribute unnatural amounts of water to the river. This should also reduce phosphorus transport downstream to the Rainy River and ultimately to Lake of the Woods, which has a phosphorus problem and is impaired for excess nutrients. Such peatland restorations are few to date in Minnesota, and lessons on techniques, challenges, and solutions are currently being learned. There are many hundreds of miles of peatland ditch reaches in northern Minnesota, including in the BFRW, that are not providing any kind of benefit to residents or landowners and are just remnants of the original drainage effort in the area. These would be the first targets for restoration, most likely. DNR has begun working on peatland restoration on state-owned lands (DNR, 2025a). Opportunities are now open for private landowners who are farming high-organic (previously peatland) soils via a program recently instituted by the Minnesota Board of Soil and Water Resources (BWSR, 2024 and 2025) through the Reinvest in Minnesota (RIM) program.

Figure 2. Big Fork River Watershed stream channels, highlighting ditched waterways. The background is hydric soils, classified by their percent organic content.



Growing support and proficiency for peatland hydrology restoration

Peatlands have come to be recognized for the vast amount of carbon they store and their ability to continue to be natural carbon sequestration landscape features. Alteration of peatlands (such as ditching) can actually result in peatlands being a source of carbon to the atmosphere. In recent years, there has been a quickly-growing recognition of the multiple benefits of restoring the natural hydrology of peatlands, particularly where they have been ditched or where high organic-content soils are drained and farmed. An early restoration study project was conducted in 2011 through 2015 by DNR at the Winter Road Scientific and Natural Area (Walker, 2015), where important hydrological factors were assessed (groundwater influence, water table drawdown of ditches, etc.).

The nonprofit organization, The Nature Conservancy, convened a peatland symposium in 2023, which brought together a wide range of government natural resource agencies including state (DNR, MPCA, BWSR), federal (USFS, USFWS, NOAA), tribal resource agencies, academia (University of Minnesota and Michigan Tech), and other nonprofit groups together to begin considering collaborative efforts to restore Minnesota peatlands.

Following the first symposium, several subgroup teams formed to continue the discussion of various aspects of potential restorations. Another broader workshop occurred in fall 2024. The Nature Conservancy produced a document titled “Playbook for Minnesota Peatlands” with assistance from these other participating agencies (TNC, 2025). This document describes peatland types and locations in Minnesota, historic alteration, quantifies benefits of restoration (particularly regarding carbon sequestration), and feasibility of implementation, among other related topics. The multi-agency group has formed several sub-groups, and one is currently working on solving multiple technical restoration issues and details and will produce a technical restoration guidance document to facilitate future restoration projects.

Additionally, the MPCA has found several water quality problems associated with streams that have peatland ditching within their systems. Three such stream systems are currently being studied by MPCA for water quality aspects, one in the St. Louis River Watershed, and two in the Mississippi River - Grand Rapids Watershed. Particular water quality parameters being sampled are DO, phosphorus, and dissolved organic carbon. Two of the sites are measuring water flow volumes with automated, continuous measurement gages, with a goal of learning more about the influence of ditching on these parameters affecting downstream water resources.

BFRW ditches that have best potential for elimination to restore natural hydrology

An aerial photo review of BFRW ditches was done as an initial attempt at locating ditches that could be eliminated to reduce downstream flow volumes. The first criteria are to find locations that provide no benefit and would not affect any landowners or property near the ditch. Second, priority elimination locations are at the headwaters of ditch systems. That is, elimination of ditches would have to start at the upstream end of the systems and proceed in the downstream direction. Note that this is only a very preliminary effort for any discussion on this topic, and there are no current plans to do any elimination. It is important to note that blocking/eliminating bog ditches does not cause flooding. Rather, the area of the channel where the original peat was removed is filled back in to the natural elevation. The water table within the peatland (within about a 370 foot width on each side of the ditch) then rises back to the level it naturally was pre-ditching. Such a restoration does not impound water on the surface or create a surficial water body (e.g. marsh, pond or lake).

In the following graphics that show ditches having perhaps the best restoration potential, the red lines are ditches (or sometimes straightened streams), blue lines are natural stream channels, and yellow-green lines are catchment boundaries (Hydrologic Unit Code [HUC-12] scale watersheds).

Headwaters of the Sturgeon River

The headwaters of the Sturgeon River begin in a large, remote peatland. Ditches were dug through this large peatland and these drain to the Sturgeon River (Figure 3). There is no developed land adjacent to or upstream of these ditches. Land ownership of the affected peatland is almost all state or county-administered state land (Figure 4). The ditch running along Pine Island Road would perhaps need to remain for road protection purposes. Because some of this system of ditches cross watershed (or subwatershed - the green lines) boundaries, the direction of flow in these areas would likely need to be determined in the field. The opaque area along the top of the figure lies in the Lower Rainy River Watershed.

Figure 3. Incoming bog ditches from the north into the headwaters of the Sturgeon River.

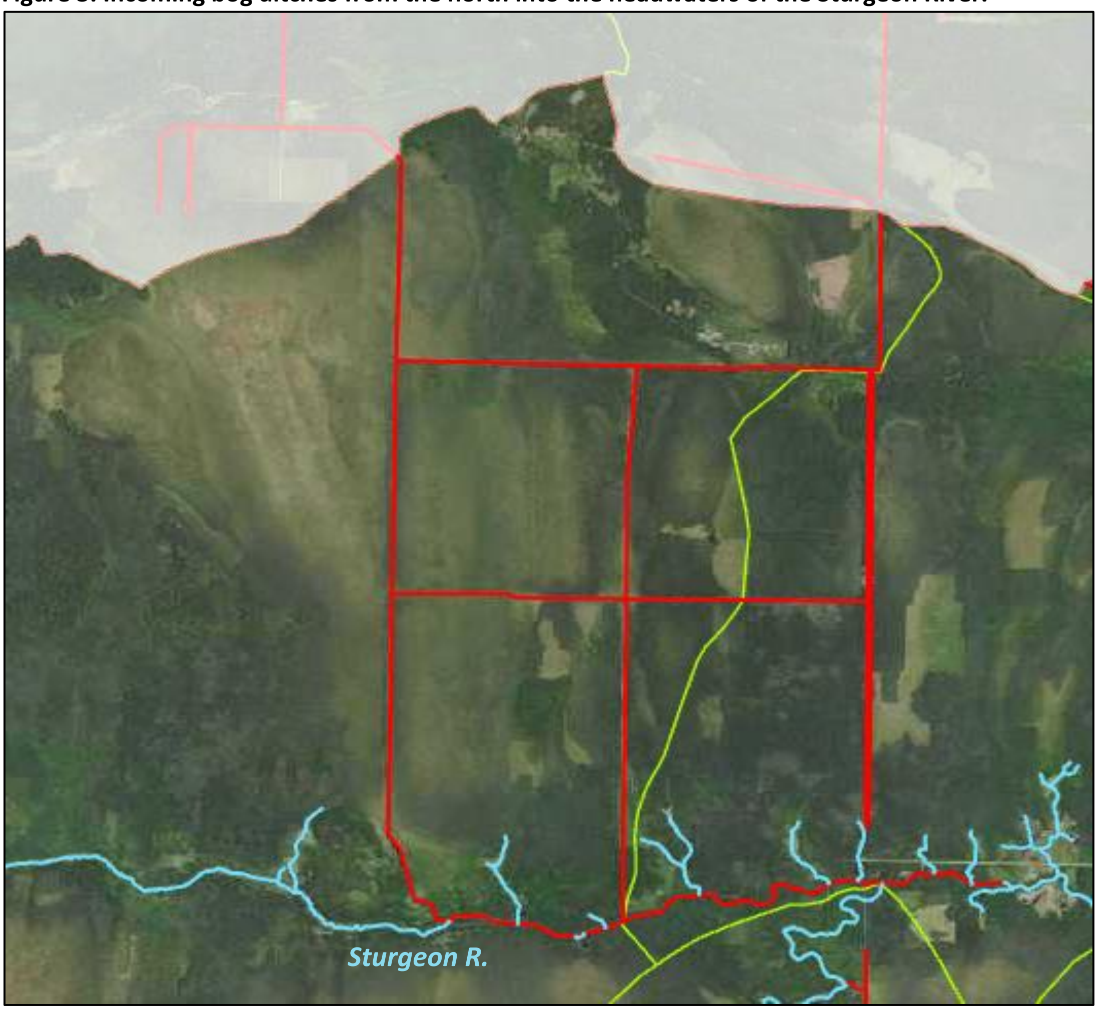
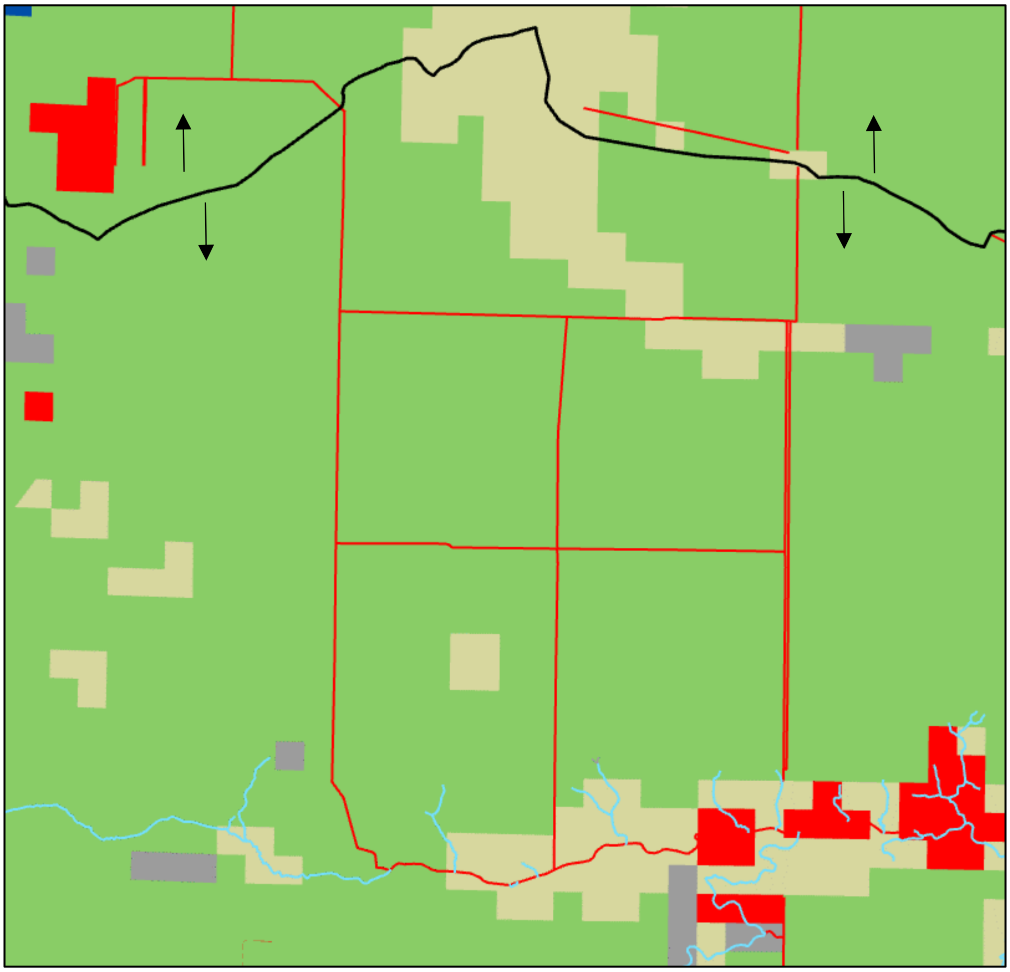


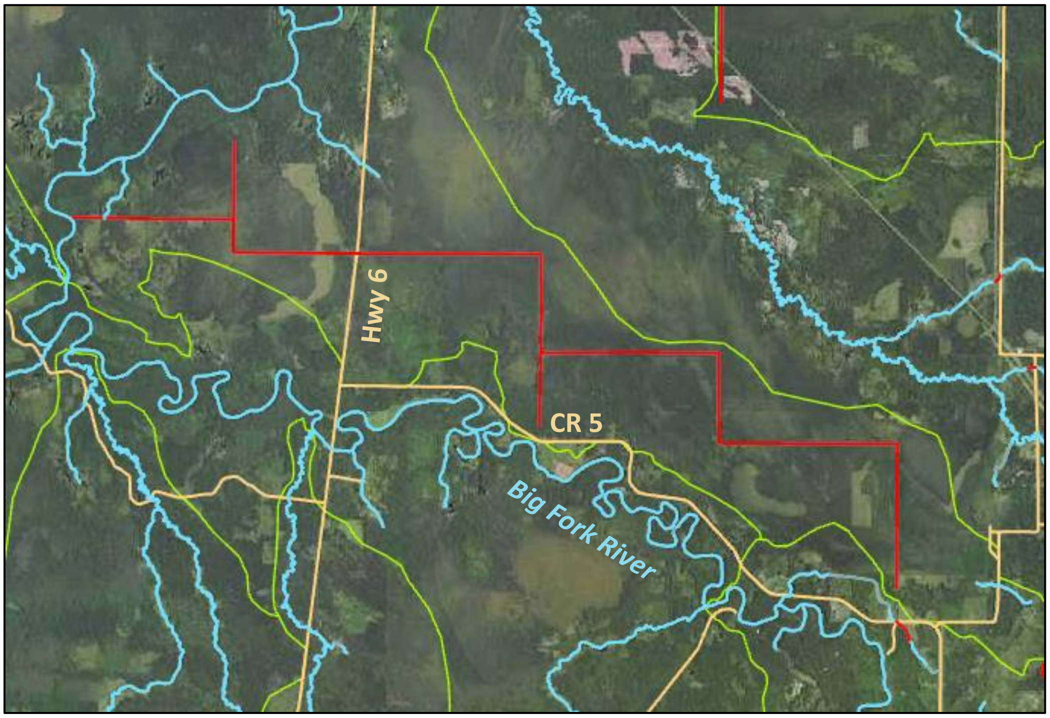
Figure 4. Land ownership in the approximate area shown in Figure 3 having ditches that flow to the headwaters of the Sturgeon River. Ownership is State (green), County/State (khaki), Private industrial (gray), Private (red). Arrows show surface flow direction.



Peatland ditch to Big Fork River

A ditch system (flowing west) runs through an undeveloped bog area between (and parallel to) the Big Fork River and Reilly Brook, north of CSAH-5, about seven miles north of Effie. Elimination of this ditch system could potentially eliminate a culvert crossing under State Hwy 6, which may be a maintenance cost benefit. Road access for bog-restoration machinery is pretty good along this ditch. No developed land would be affected by a hydrologic restoration of this legacy ditch system. The great majority of the watershed of this ditch system is state-owned, with a small amount of private industrial in an unditched area.

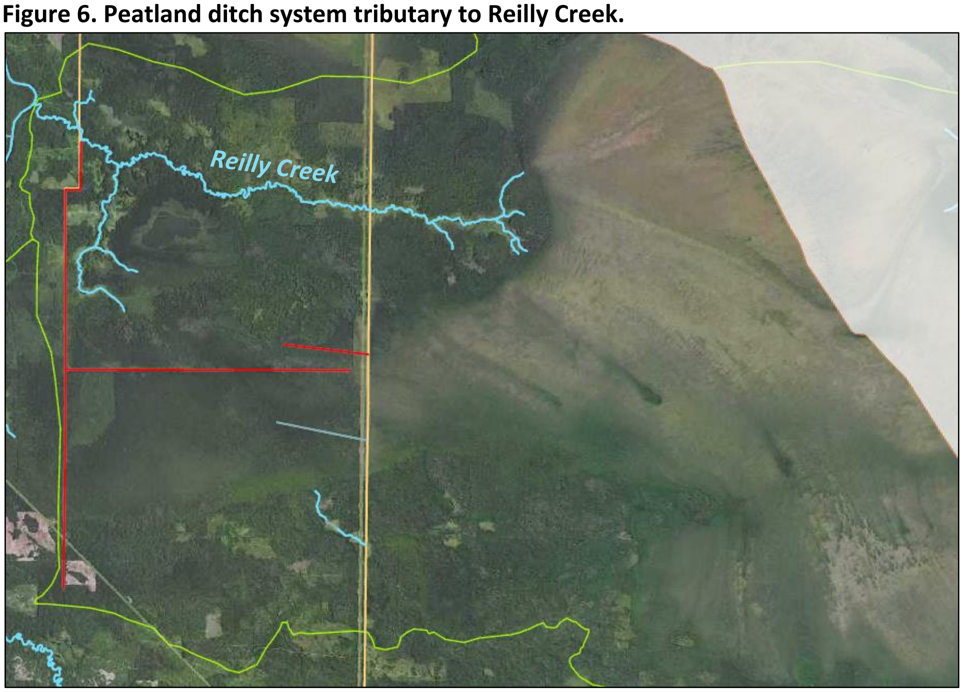
Figure 5. The peatland ditch system between the Big Fork River and Reilly Brook, which drains to the Big Fork River.



Peatland ditch to Reilly Creek

A remote ditch system enters Reilly Creek from the south (Figure 6). This area is predominantly state-owned land, especially adjacent to the ditches. The opaque area in the upper right corner is in the Little Fork River Watershed.

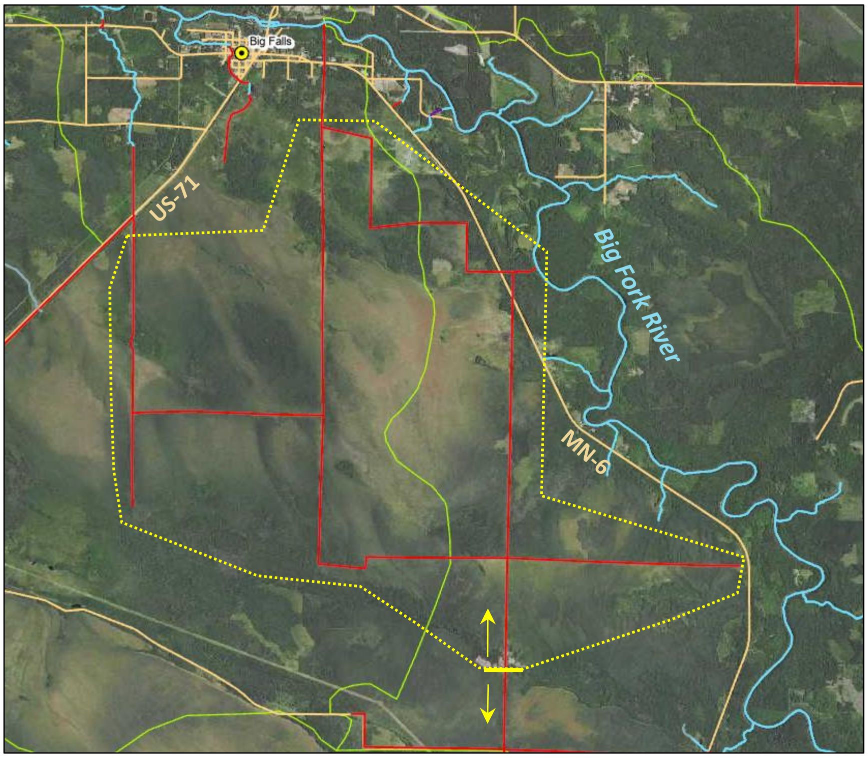
Figure 6. Peatland ditch system tributary to Reilly Creek.



Peatland ditches to the Big Fork River at Big Falls

A peatland ditch system with no development exists between US-71 and State Hwy 6, just southeast of Big Falls (Figure 7). Focus perhaps on the ditches within the yellow-dotted line. Based on vegetation, it looks like the ditch near the bottom of the scene may have a divide in flow, represented by the arrows. Nearly all of the land associated with this ditch system is state-owned.

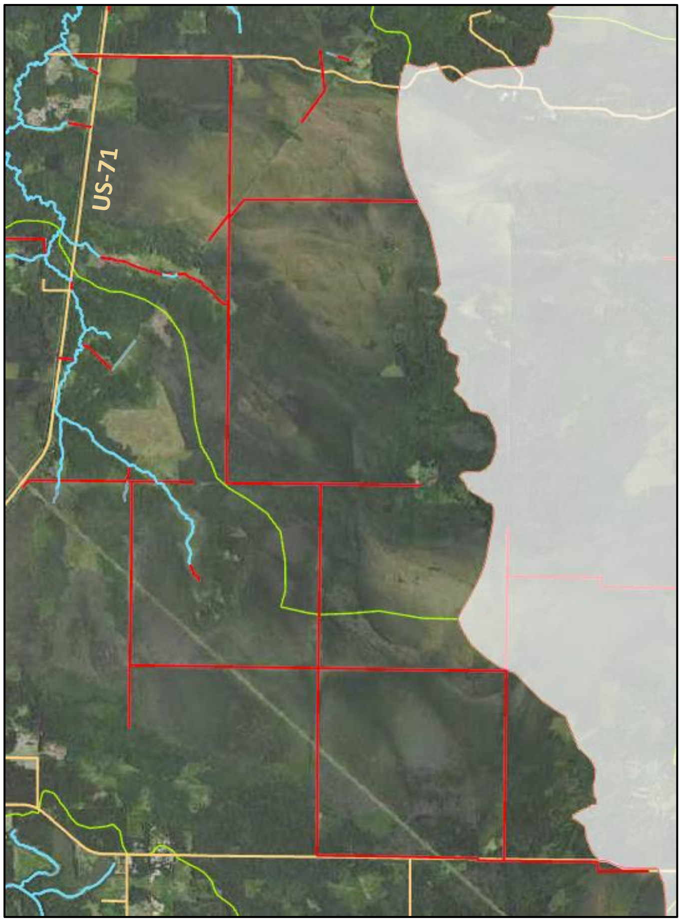
Figure 7. Ditch complex southeast of Big Falls. The area within the yellow dotted line looks potentially restorable. Some of the downstream ditch reaches near Big Falls may need to remain. Yellow arrows show flow divide.



Peatland ditches to Bear River northeast of Big Falls

A complex of peatland ditch channels in a remote area with no development exists to the northeast of Big Falls, just east of US-71 (Figure 8). These ditches enter the headwaters of the Bear River at multiple locations. The opaque area to the left is in the Little Fork River Watershed. Nearly 100% of the land being drained by this ditch system is state-owned. A very small amount of private industrial land exists but is far from any ditch.

Figure 8. Ditched peatland northeast of Big Falls that flow into the Bear River.



There is some visual evidence of channel incision and overwidening farther downstream in the Bear River, which is likely at least in part due to the addition of several miles of ditch segments to the headwaters area, creating higher peak flow volumes in the river. Photos from the biological monitoring visit at site 10RN048, at CSAH-1 show trees leaning into the channel on both sides of the river (Figure 9), and the channel eroding under the root zone of woody riparian vegetation (Figure 10).

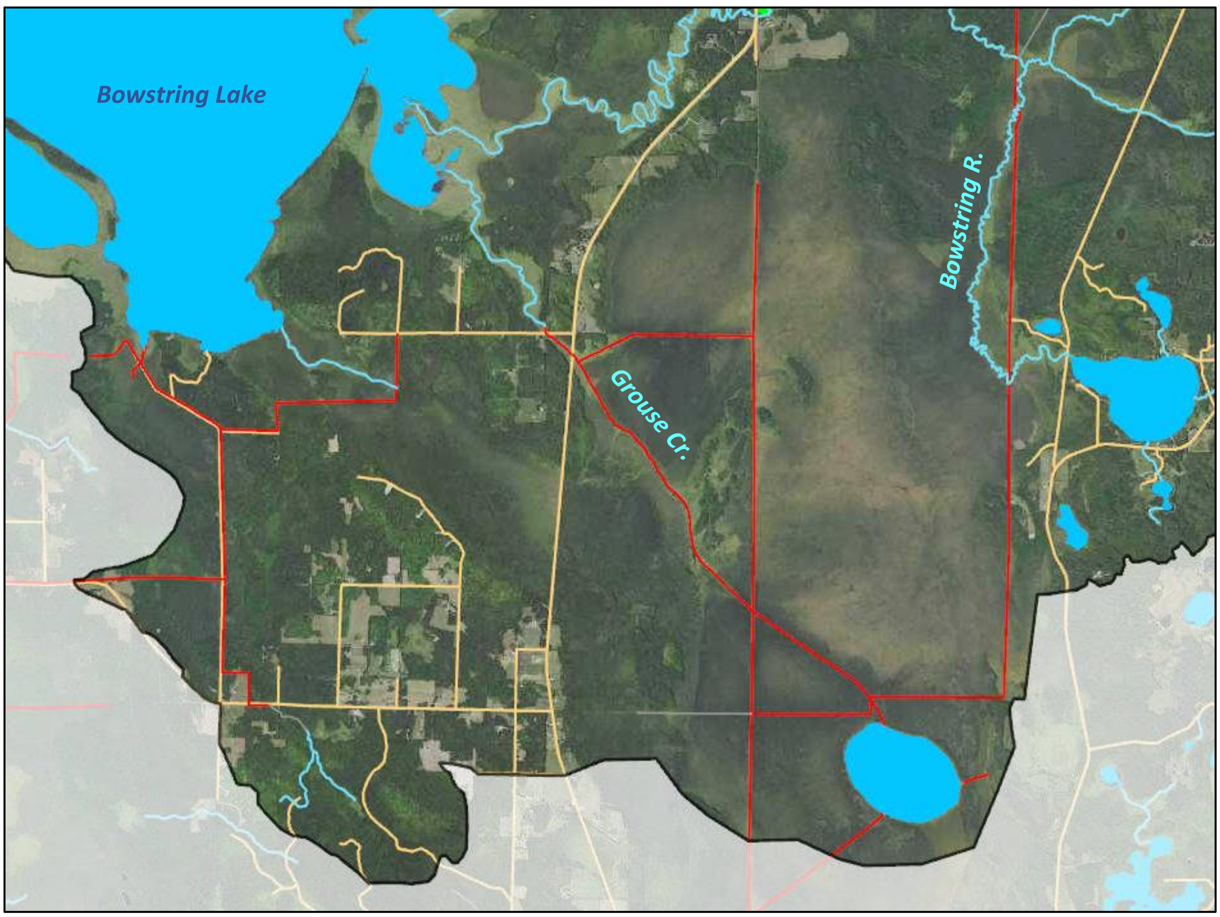
Figure 9. Trees leaning into the Bear River channel (at CR-1) from both sides of the river, a symptom of bank erosion.

Figure 10. There is undercutting of the woody shrub root zone along the bank, a sign that the channel has incised and is now over widening due to altered hydrology (excess flow volumes).

Peatland ditches south of Bowstring Lake

For the protection of Bowstring Lake, restoring the ditched peatlands entering Grouse Creek (and eventually Grouse Bay of Bowstring Lake), Bowstring R., and/or the ditches directly south of Bowstring Lake may be helpful in reducing some of the loading of phosphorus into the lake (Figure 11). The ditches associated with Grouse Cr./Bowstring R. may be easier to accomplish due to there being little infrastructure or developed land associated with them. However, they appear to be small ditches, and thus may not convey much if any water in the summer, when more of the phosphorus leaks from the peatlands. The ditches that are associated with the very southern tip of Bowstring Lake are mostly associated with roads, which may make abandoning those ditches more difficult. The LLBO resources staff are monitoring Grouse Creek and at a location of the southern ditch system in 2025, including for phosphorus. The Bowstring River at Hwy - 6 has a multi-year record of phosphorus sampling, and total phosphorus (TP) is most often at a fairly low concentration relative to streams that have associations with wetlands/peatlands.

Figure 11. Wetland/peatland ditches to the south and southeast of Bowstring Lake.



Conclusions regarding legacy peatland ditching

There is no shortage of locations which could be chosen to work on peatland hydrology restoration. The above are just some of the most obvious locations in the BFRW where other land development does not exist, and where the great majority of the land ownership is public (and most of that being state-owned). These are just some initial suggestions. Peatland restoration can lead to multiple benefits, including water quality and water storage, and others such as carbon sequestration, plant ecology, wildlife habitat, and so it is good to involve multiple natural resource and land managers in deciding on a restoration location to achieve these various benefits and potentially partner in funding restorations.

Altered Hydrology - Legacy forest harvest

The BFRW was part of the lumbering boom that occurred in the late 1800s and early 1900s across a large part of northern Minnesota, where old growth pine forests were clear cut to provide lumber to the rapidly expanding cities in the Midwest. Much of the forest in the BFRW now consists of much younger forest, with somewhat different tree species composition. Fewer pine trees grow now, and large areas of land are in a rotating poplar harvest cycle, cut every 45 to 65 years, depending on the intended use of the poplar trees. Locations that have not been cut since the original logging days are returning somewhat to their original character, though are still only half or less years old than some of the original forest stands were. Forests of pines have had difficulty regenerating due to the dense regrowth of poplar following clearcutting of pines, the short logging cycle that keeps the forest in predominantly poplar, deer browsing of white pine seedlings, and white pine blister rust.

Interestingly, one of Minnesota's best original forest remnants is in the BFRW, between (and slightly north of) Alvwood and Wirt, Minnesota. The tract of land is known as "The Lost 40", a 114-acre forest of old-growth red pine and white pine that was never logged due to an early mapping mistake. The acreage is partly managed by DNR as the Lost 40 Scientific and Natural Area and part federally-owned within the Chippewa National Forest. More information is found at the following webpage: https://www.dnr.state.mn.us/snas/detail.html?id=sna01063.

The original forest was clear-cut and the open areas, containing the downed trees' branches, often burned following logging. This left a very different landscape setting in the years following, which substantially changed the hydrology of the region (Figure 12). Much more runoff occurred, meaning flow volumes of rivers increased. This increased flow damaged streams, causing the streams to cut deeper into the land and erode their banks, creating wider streams with unstable banks and higher sediment loads. It is difficult to know the full extent of the change of river channels that occurred back then, but since stream channels are slow to restabilize, it is likely that some streams are still in an unstable condition. An additional amount of channel damage was caused during log drives in rivers. Waters were dammed and logs placed behind the dams during winter, and the following spring, the dams were breached, and a large pulse of water carried the logs downstream to mills.

Altered Hydrology - Modern logging

Logging of BFRW has continued to be an important industry in the BFRW. This more recent/current logging of second and third growth forest also affects hydrology, causing greater runoff, but the more recent alteration of hydrology should be less than the original logging since the land areas cut are not as extensive as that original harvest. For poplar forest clearcuts that are allowed to regenerate, hydrology (run-off) remains altered for approximately 15 years (Verry, 1987). Though less than the original cutting, the alteration of river flow from modern logging may still have negative consequences for stream channels. Forest management that minimizes the extent of new and recent clearcutting in a stream's watershed by rotating cuts over a widespread area will reduce the harmful effects of altered hydrology. This can be a challenge because there can be multiple forest owners/managers within a watershed including federal, state, county, and private citizens. The Minnesota Forest Resources Council (MFRC) has created guidelines for best management practices (BMPs) on lands that are undergoing a harvest (MFRC, 2012). These are site-scale (rather than watershed-scale) guidelines and focus more on water quality in the locality of the harvest rather than water quantity issues at a larger geographical scale. MFRC has recently done a review of these guidelines to determine if any should be modified and a recommendations report has been completed (MFRC, 2022).

Additionally, MFRC has put in place a program to evaluate forester adoption of the BMP guidelines on a HUC-8 watershed scale. Several watersheds are field-evaluated each year on a rotating basis. In 2018, the BFRW was assessed by MFRC staff (DNR/MFRC, 2020). On that report's page 33, a summary of the monitoring of BMP adoption/practice is presented. Not all assessed metrics pertain to water quality, but of those that do, notable places for improvement in the BFRW include "infrastructure management" and "riparian management along streams".

Figure 12. An example of the change that occurred with original logging as well as change with current forest management - an old white pine, like those composing the pre-settlement forest of this area, stands in a recently harvested area, with mostly deciduous trees among the re-growth.

Altered Hydrology - Changed vegetation and landscapes

The BFRW does have some lands that have been long-time farming operations, though much of it is pasture/hay, which has significantly less potential for water resource concerns than where soils are tilled and exposed soil occurs, as well these areas not receiving fertilizer application as row crops do. Per DNR (2023) analysis through 2016, farm use of land has declined to the lowest levels since 1920, with almost zero BFRW acres used for row crops or small grains since the mid-1980s and a substantial reduction of hay harvest since about 1990 (though at its peak it was only about 6% of land area). Thus this open land area should have less of an effect than it did years ago (regarding the watershed as a whole).

Even so, these lands do alter hydrology to an extent and may still be influential locally in areas that have a greater density of open land acreage. Utilization of farmland BMPs would be beneficial to water resources in areas where these open lands are denser, particularly those that temporarily store runoff and release it slowly to streams. Fields that are no longer used could be considered for reforestation.

Altered Hydrology - Caldwell Brook channel instability

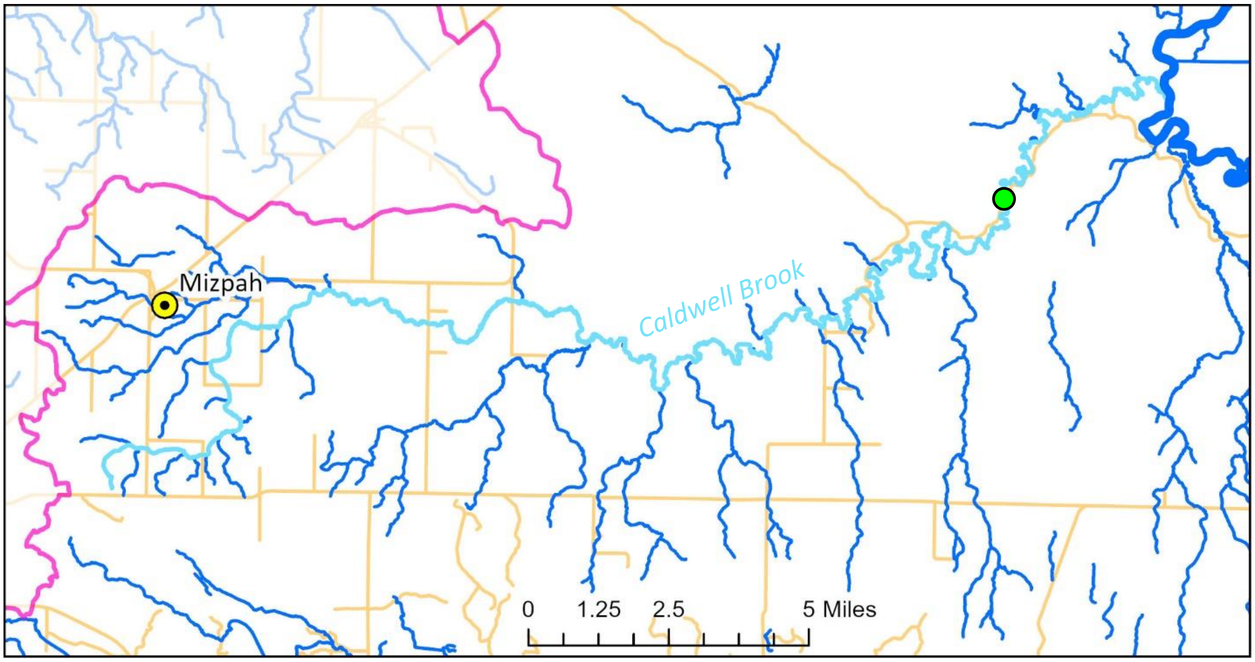
DNR geomorphology study

During the MPCA visits to monitor biological communities in Caldwell Brook in 2021-2022, staff biologists observed that there appeared to be excessive bank erosion. This was documented in the notes recorded for the 2023 assessment review of the 2021 IWM data. The assessment team chose to give Caldwell Brook a rating of "vulnerable" regarding the fish community, which was slightly below the passing threshold score, and found a majority of fish species present that are "generalists", with fewer "sensitive" species present, and no "intolerant" species collected. It was suggested that channel instability may be degrading fish habitat.

SID staff made a visit to Caldwell Brook to further look into the possibility and degree of channel/bank instability subsequent to the assessment process. SID staff, trained in geomorphological condition assessment, concluded that based on visual observation at several locations along the stream channel, the stream appeared to be incised, resulting in high, steep, poorly vegetated or raw banks and telling sediment deposition features in the channel. At this point, the MPCA requested DNR stream geomorphology staff to conduct a quantitative measurement assessment, using Rosgen (1996) methodology, to make a more data-driven determination of incision/instability.

In the fall of 2023, two DNR geomorphology staff and the MPCA BFRW SID lead visited one of the biological monitoring sites (10RN024) and made observations and set up monumented cross-sections for long term monitoring of channel morphology changes (Figure 13).

Figure 13. Caldwell Brook (light blue) and its tributaries (darker blue) with the location of the DNR/MPCA geomorphology study reach (green dot) on Caldwell Brook.



In August 2024, DNR, MPCA, and Itasca County SWCD staff returned to do surveying of the channel using Rosgen (1996) methodology. The DNR staff then analyzed the survey measurements and wrote up their findings in a report (DNR, 2025). The analysis concluded that there is active channel instability ongoing at this location. Symptoms of this instability found at Caldwell Brook noted in the report were:

- A Pfankuch Stability Index score of 130, with a condition rating of “Poor”.
- High, steep, unvegetated sloughing banks (Figure 15).
- Unstable channel bottom that is in a frequent state of flux.
- Excessive tree toppling into the stream channel, including creation of large debris jams (Figure 16 and Figure 17).
- Measurements that classify the stream as an “F” channel type (Rosgen, 1996).
- Disconnection of the channel from its floodplain, leading to more erosive conditions in the channel.
- Accelerated lateral channel migration.
- Gravel in riffles is embedded by sand and fine particles.

The report concludes that the smothering of important bed features with fine sediment (due to the excessive erosion resulting from bank instability) has created a channel that lacks diverse habitat features, leading to a reduced diversity of fish species. Additionally, an estimate of sediment export was made using Rosgen methodology, which found that stream bank erosion from the study reach is approximately 214 tons. If the stream was in an un-incised condition, able to dissipate high flows onto the floodplain, only an estimated 47 tons of sediment would be coming from the reach’s banks. Thus, there is about 4.6 times more sediment in the channel and moving downstream due to its unstable condition. This has implications for the Big Fork River too, which receives flow and sediment directly from Caldwell Brook.

The report's conclusion is that original logging of the old-growth forest in the 1900s initiated the instability that still exists today. Some evidence exists that the stream is trying to evolve to a more stable state (i.e., narrow within-channel floodplain benches were seen in some places). A very informative factsheet discusses the causes of streambank erosion and restoration options (DNR, 2010). The full Caldwell Brook geomorphology report is available from DNR - Grand Rapids Office.

It is interesting to note that the upper portion of the Caldwell Brook subwatershed was not part of GLA, while the lower portion was. The DNR geomorphology site is a short distance from where the Minnesota Geological Survey map (2019) shows the edge of GLA was located (Figure 14). At the studied location, near the uppermost shoreline of GLA, there is still a significant component of sand in the bank material, which is less cohesive than some other soil types, such as clay, which may have made non-GLA area of Caldwell Brook more vulnerable to incision and instability. Downstream of the GLA shoreline, the brook is more sinuous. Banks here likely have more clay content, but this part of the channel has difficult access and was not observed from the ground.

Figure 14. Shaded LiDAR elevation map of a portion of Caldwell Brook and the locations of the approximate of the highest shoreline of Glacial Lake Agassiz (blue line) and the DNR geomorphology site (red oval, approximately 2 stream miles downstream).

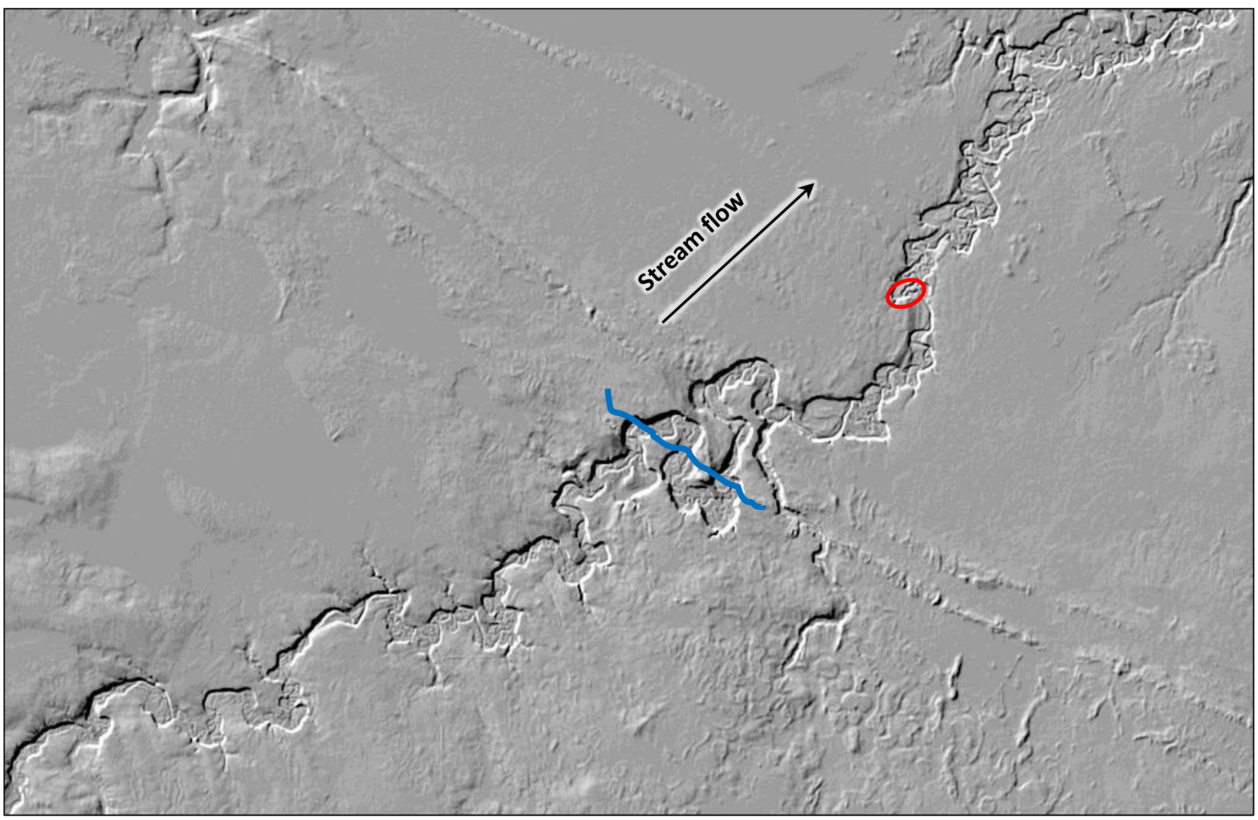


Figure 15. Actively eroding raw vertical stream bank within the geomorphology study reach.

Figure 16. A bank tree that has been completely undermined by erosion and is now down in the stream channel with most of its roots exposed, soon to be a contributor to one of the many log jams seen on aerial photos.

Figure 17. As a consequence of un-naturally fast erosion of stream banks of Caldwell Brook, trees along the channel are undermined and topple into the channel and form log jams. Many log jams were documented in Caldwell Brook. This aerial photo is from 7/18/2016. This logjam is still present in 2023 aerial photos.

Caldwell Brook Subwatershed Land Use/Land Cover assessment

In addition to the large and abrupt hydrology change that occurred after the original logging of area forests, current land use/land cover in the Caldwell Brook Subwatershed may be influencing the stability of Caldwell Brook's channel. A Geographic Information System (GIS) analysis was done of recent land use/land cover, covering the full subwatershed (Table 3 and Figure 17). The land cover is overwhelmingly forest (87.1%, all types combined), though there are significant amounts of very young forest from new forest harvest parcels. Land classified as developed is a very low percentage (0.18%), with almost all of that being classified as "Low Intensity". The "Developed - Open Space" is about 1.0% and is mostly roadways. There is about 5.6% of the full subwatershed that is "Hay/Pasture/Cropland".

The portion of the Caldwell Brook Subwatershed that contributes to the flow at the point where the instability was measured has a somewhat different composition due to the developed and agricultural lands primarily being in the upper area of the watershed and a very large area of forested wetlands not contributing to the flow at the geomorphology site. A recalculation of land use/land cover was done for the geomorphology site subwatershed (Table 3 and Figure 18). The land cover is still overwhelmingly forest (83.4%, all types combined). Land classified as developed up slightly but is still a very low percentage (0.24%), and still almost all of that being classified as "Low Intensity". The "Developed - Open Space" is about 1.3%. About 7.7% of this partial subwatershed is "Hay/Pasture/Cropland".

Table 3. Percentages of area coverage of the 2016 NLCD land use/land cover types depicted in Figure 17 and Figure 18.

Class of land areas	Percent of Area Full Subwatershed	Percent of Area Partial Subwatershed
Open Water	0.30	0.34
Developed Open Space	1.05	1.28
Developed Low Intensity	0.17	0.23
Developed Med Intensity	0.01	0.01
Developed High Intensity	0.00	0.00
Barren Land	0.00	0.00
Deciduous Forest	24.43	32.44
Evergreen Forest	0.45	0.39
Mixed Forest	5.28	5.70
Shrub/Scrub	0.60	0.73
Herbaceous	0.83	1.10
Hay/Pasture	2.74	3.75
Cultivated Crops*	2.84	3.90
Woody Wetlands	56.98	44.85
Emergent Wetlands	4.33	5.27

*In some cases these can be mis-classified and are actually hay.

Land ownership and thus management oversight in the Caldwell Brook Subwatershed is quite mixed. There is private, industrial, city, county, county-managed state, state, and federal land within the subwatershed, with no one entity being the dominant owner/manager (Table 4 and

Figure 19). The two largest owners/managers are Koochiching County (as administrator of State land) and private landowners. The State (DNR administered State Forest land) is the other large landholder in the Caldwell Brook Subwatershed (for the Brook's Subwatershed that contributes to the location where DNR did the stream geomorphology survey. The remaining land that drains to the stream at the mouth is State Forest Land. Other ownership classes manage small amounts of land in the Caldwell Brook Subwatershed.

Figure 18. Land use/cover in the Caldwell Brook Watershed, from the 2016 NLCD GIS layer.

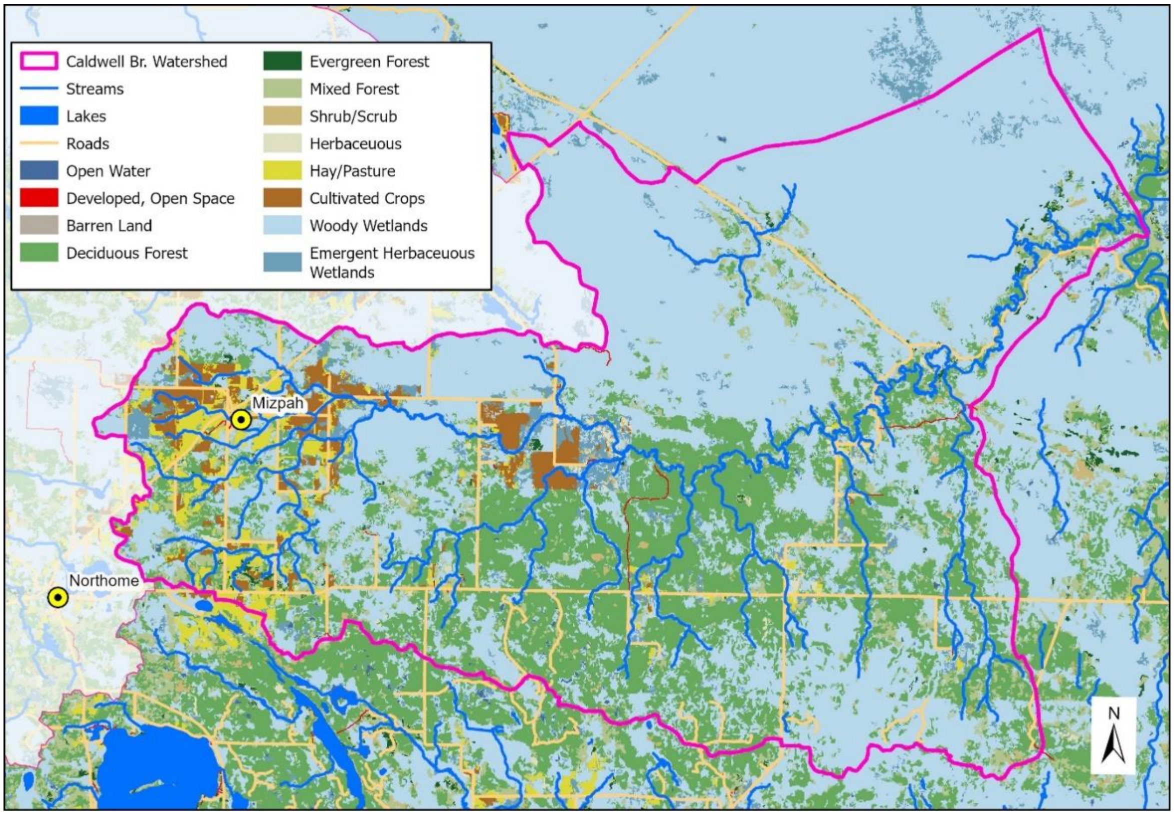


Figure 19. The Caldwell Brook Subwatershed land area contributing flow to the DNR geomorphology site (green dot).

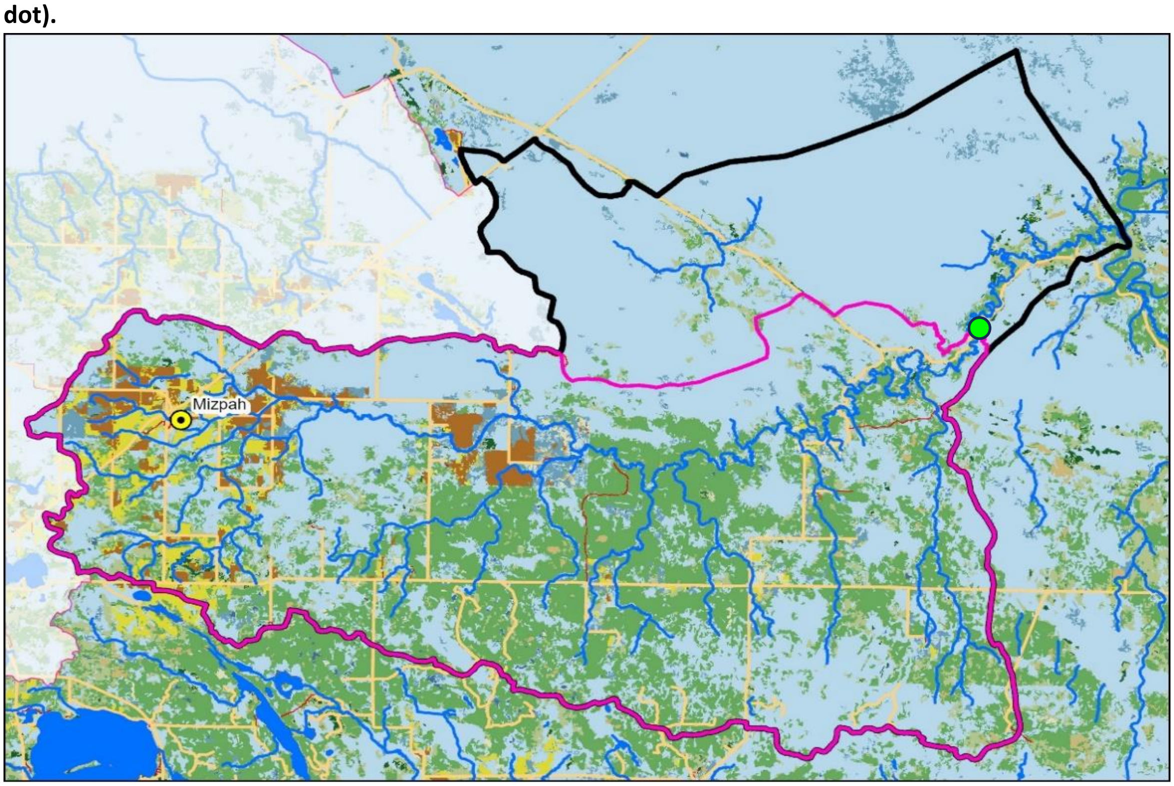
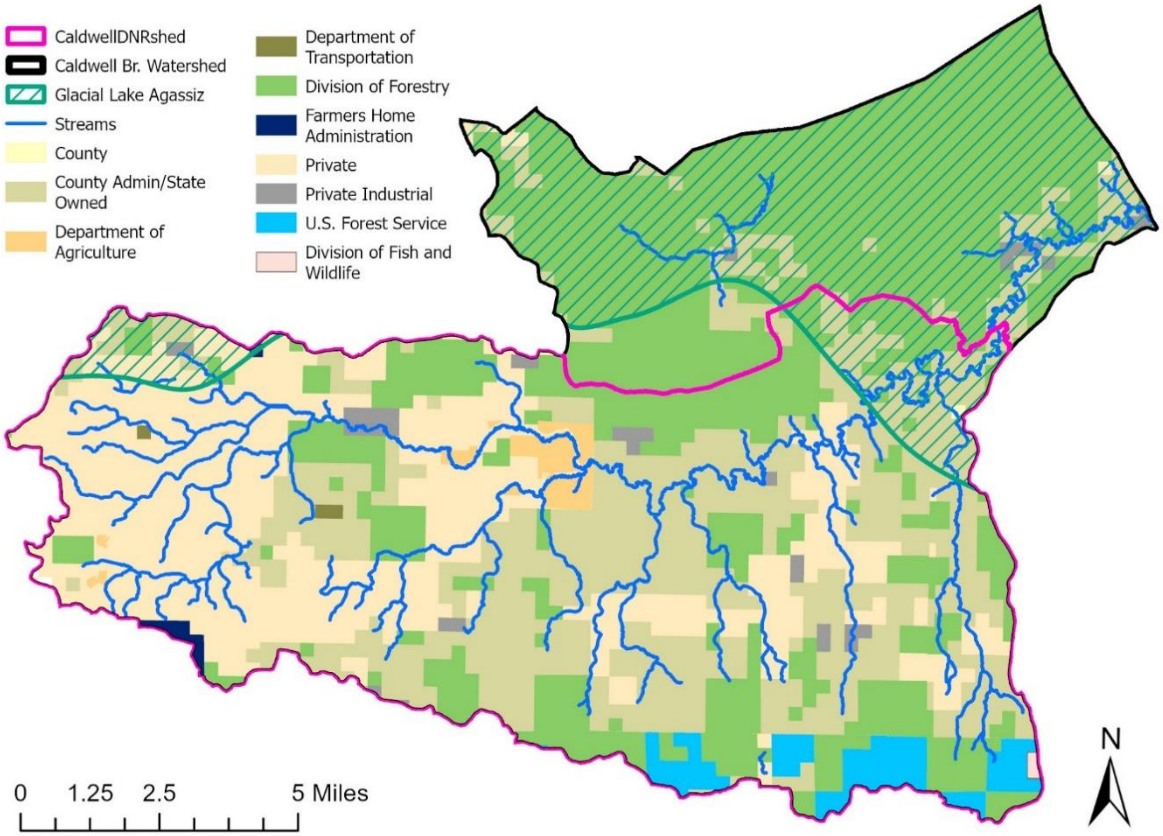


Table 4. Ownership of land in the Caldwell Brook Subwatershed for the drainage area at the DNR geomorphology site.

Specific Class	General Ownership	Sq km	Percent	Summed % by ownership
Koochiching County	County	0.2	0.1	0.1
Farmers Home Administration	Federal	1.2	0.4	3.9
Chippewa National Forest	Federal	11.3	3.6	
City of Northome	Other Public	0.1	0.0	0.1
Village of Northome	Other Public	0.0	0.0	
CRP Lands	Private	4.8	1.5	35.4
Private	Private	107.1	33.8	
Boise Cascade Corporation	Private Industrial	4.4	1.4	1.4
County Miscellaneous	State	111.6	35.3	35.4
Gravel Pits	State	0.5	0.1	
Division of Forestry	State (DNR)	1.6	0.5	23.8
Pine Island State Forest	State (DNR)	61.9	19.6	
Big Fork State Forest	State (DNR)	11.8	3.7	

Figure 20. Land ownership in the Caldwell Brook Subwatershed.



Improving Caldwell Brook

The instability of Caldwell Brook has been in the making for many decades. The process originally started, and may have primarily happened, just after the original logging of old-growth forests in the early 1900s. Some areas along the upstream third of the brook have had a long-term conversion of landscape vegetation from forest to hay and/or pasture, increasing flow in the stream compared to if those lands were still forested.

Restoring incised channels is difficult. Stabilizing streambanks along the length of Caldwell Brook would be cost prohibitive due to its length. Some methods are available that would assist in helping the stream bed elevation rise, moving in the direction of being un-incised. This requires geomorphological expertise, such as exists in DNR. Guidance or detailed information is available on the internet (for example, Fischenich and Morrow, 2000, Rosgen 1997). It is more likely to be cost-effective to work on reducing peak flows in the river using land management BMPs. This will reduce the erosivity of flows and help the river evolve to a more stable condition. Efforts to make restoration progress in Caldwell Brook would be a long-term process. Removal of some of the large log jams may be of some benefit to improving the health of Caldwell Brook. It is advised to consult DNR stream managers before such work. Also, DNR permits may be required.

Because much of the land ownership is public (i.e., state), work toward restoring a large part of the stream probably would need state involvement. Local government land managers could look at the upper part of the watershed where there is more private land and more of the converted land use occurring and assess whether there are applicable hydrological BMPs that could be applied by private landowners (perhaps with financial assistance) to slow the movement of runoff to downstream locations. Reducing the peak flows in the stream will reduce erosion and sediment export to the Big Fork River, and potentially improve fish and macroinvertebrate habitat in Caldwell Brook.

Altered Hydrology - Changes in precipitation and runoff

An analysis of long-term precipitation and flow volume (both 1929 - 2020) trends has been conducted by the DNR (2023). The report can be found online at the link provided in the Reference section. Over that long time period, there has been on average a 7% increase in precipitation (2.9 inches), and 6% increase in runoff (the latter as measured at the gaging station located at Big Falls [USGS gage 05132000]) between pre- and post-1961 periods. There has been a 25.9% increase in the average annual discharge between pre- and post-1961 measurements (DNR Figure 23), however, the 30-year running average shows a declining trend since about 2000 (DNR figure 3). The 30-year running average for annual peak discharge shows a declining trend since about 1970 (DNR figure 4). Runoff per unit of precipitation has increased 12.5% post-1961 (their table 5). This time period does coincide with the time that logging of second-growth forest began (50 to 60 years following the original harvest), though more detailed evaluation of logging activity since 1961 would need to be done to substantiate the second round of logging as a reason for this increased runoff.

The analysis found that peak flows have not changed since 1929. However, there has been some increase in the 1.5-year recurrence level flow (15% higher) since 1961. This is important because flows of this approximate frequency are those that create a stream's channel dimensions.

It is important to consider that the start year of the analysis of the change in runoff was at the tail end of the intense logging period in the BFRW. Thus, it only partially takes into consideration the alterations to runoff that occurred prior to 1929. By then, some recovery (i.e., reduced runoff) may have occurred as forests had started to re-grow. While it is not possible to get back to a pre-1850s landscape and forest composition, it is still important to consider the changes that have occurred because the stream and river channels developed their dimensions during that pre-disturbance period, and human-caused increases in runoff cause channel instability due to greater flow volumes. DNR hydrology and geomorphology experts could be consulted for further assessment of how the noted hydrological changes may have affected or still be affecting channel stability.

Altered Hydrology - Effects on the Big Fork River

Bank failure

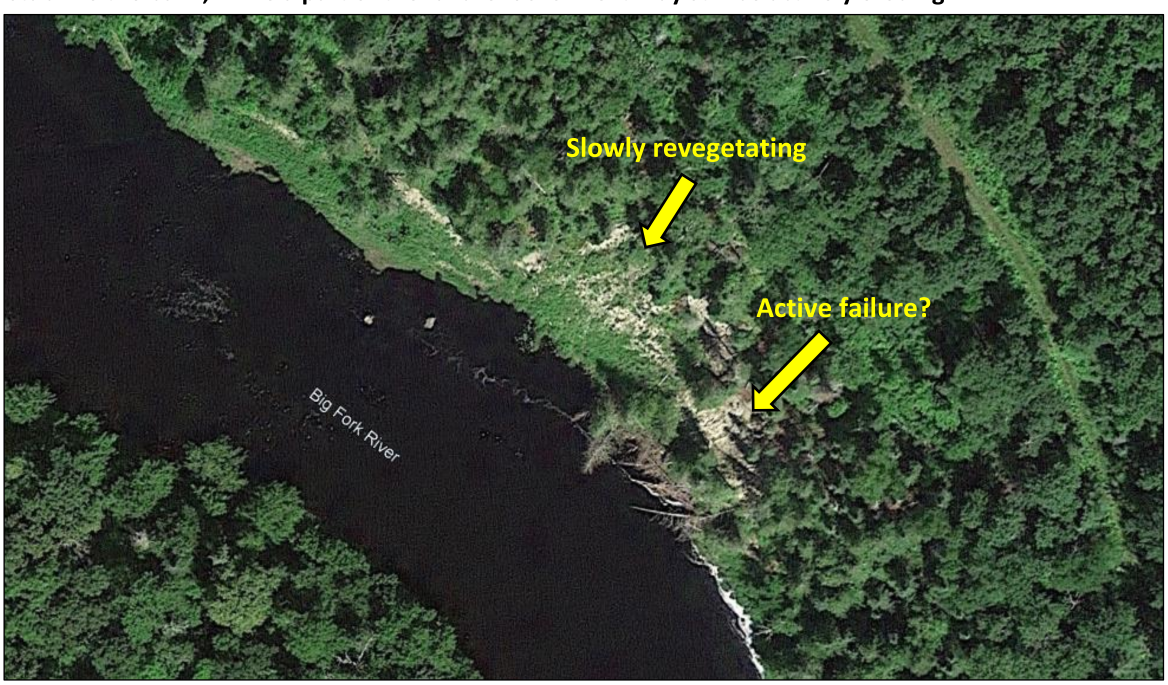
The Big Fork River, in its lower reaches, has a number of locations of significant erosion, with high, steep, unvegetated banks (Figure 20, Figure 22, and Figure 23). They seem to be mostly in a section of the river downstream a short way from Big Falls. The origin of these erosion hotspots is not known. They are not in locations where tree-clearing along the river had occurred. These may be related to a large-precipitation event or other natural situation, such as a high wind velocity storm. Or, altered hydrology from original logging may have altered the channel in ways that enabled this to occur more easily. These situations do not look to be decades old. Some appear to be healing themselves with young trees growing at the bank failures (Figure 21) or vegetation beginning to cover the bare soil (Figure 23). Local soil and water managers should be aware of the occurrence of these bank slumps and could utilize future aerial photographs to see if new erosion areas have developed and perhaps can then determine whether they were caused by a substantial storm event or not.

Figure 21. Young trees are growing at both the top and toe of the eroded bank. A small floodplain also helps protect against lower flows being able to scour at the base of the bank failure.

Figure 22. Two nearby bank erosion locations, about 3.6 miles downstream of Big Falls. Collapsed dead trees can be seen at the base of both bank slides.

Figure 23. Another example of bank failure on the Big Fork River. The trees that toppled from the bank can be seen below the failure in the water.

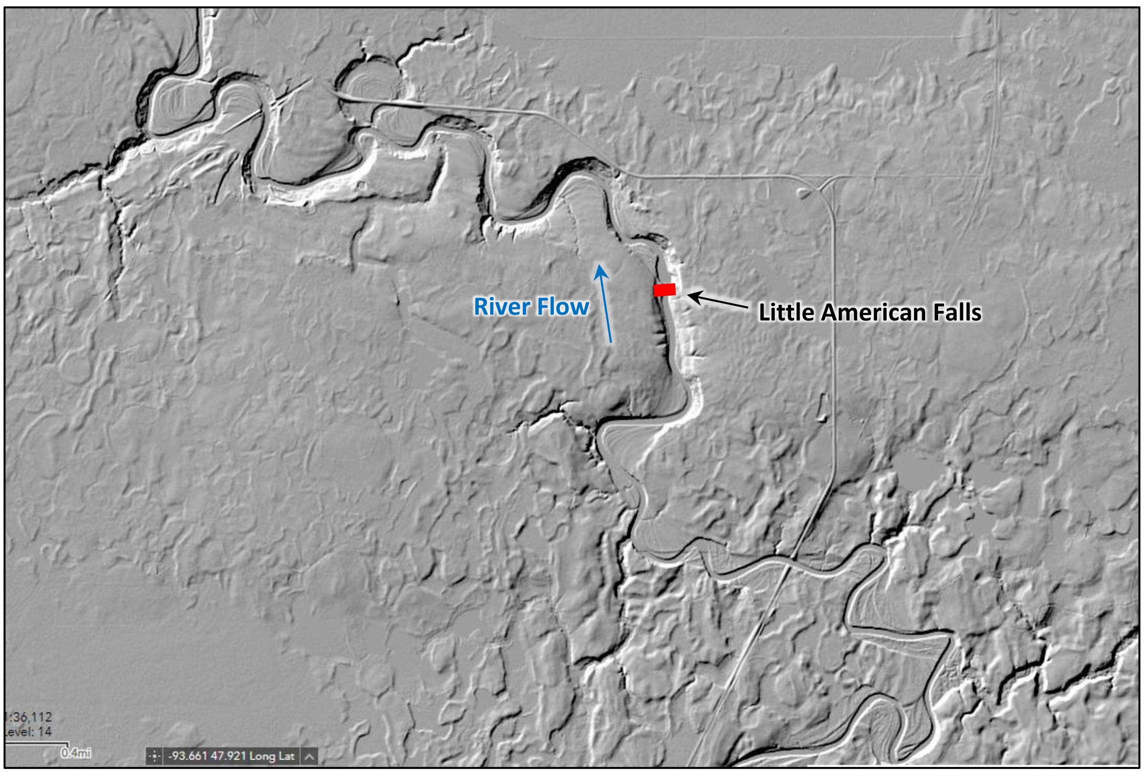
Figure 24. At this bank failure, it appears as though part of it is healing via new vegetation growth helping to stabilize the bank, while a part of the failure looks like it may still be actively eroding.



It may be possible to do some bio-engineering solutions on these slumps to enable them to heal, including possibly planting some seedlings and using some erosion control products (e.g., coconut bales) to speed up natural healing processes. Boat access to at least some of these sites to bring in supplies looks manageable.

Some places along the river have banks that are much more susceptible to eroding than others, in part because of natural grade control rock formations that do not allow the channel bed to incise upstream for some distance. An example of this is Little American Falls, a bedrock formation the river flows over. Above the falls, river banks are fairly low and appear to allow the river to access its floodplain during high flows. Immediately downstream of the falls the banks become high and quite steep, and the river is incised and quite entrenched (i.e., there is little floodplain that the river can overflow onto) (Figure 24). Stream power in this reach is higher and more able to cause erosion of banks. From Little American Falls upstream to Muldoon Rapids, the river channel has low banks, and the river is vertically stable from being bookended by two rock structures/rocky rapids in the channel.

Figure 25. Big Fork River entrenchment upstream versus downstream of Little American Falls.

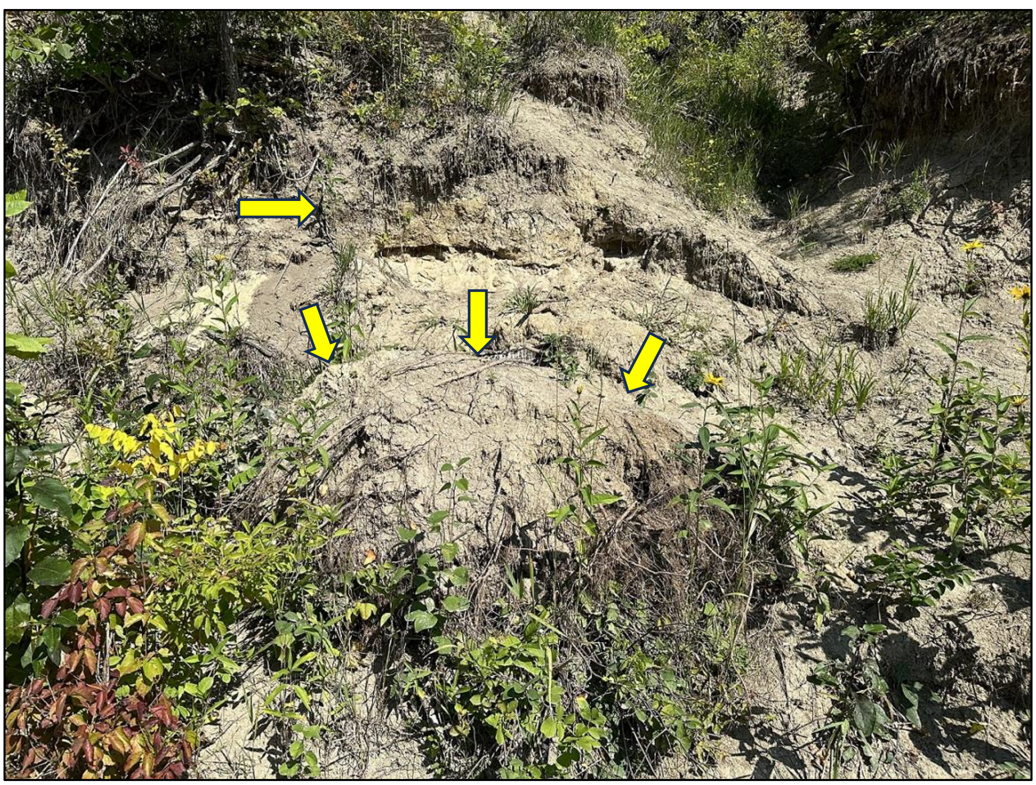


Direct human influence leading to bank erosion

One location along the Big Fork River that has become unstable and has had significant erosion is the park area at Little American Falls. Foot traffic up and down the steep banks near the picnic and camping areas has caused gully erosion and raw banks that are composed of fine sand, which is more susceptible to erosion than more cohesive soil types (Figure 26 and Figure 27). Bio-engineered stabilization of banks enabling new vegetation to establish on the raw, exposed areas may be an effective solution to stabilizing this area. Restoration specialists should be consulted to help ensure an effective solution.

Figure 26. Gullies and bare soil eroding down to the river's edge at Little American Falls.

Figure 27. Steep slopes adjacent to the campground/picnic area at Little American Falls have been destabilized over the years by recreation at the site. Active erosion and sloughing is occurring on these banks along the river. Arrows point to a large chunk of soil that has broken off and slid down the bank.



Suspended Sediment

The lower portion of the BFRW was covered by GLA. During those long years, clay accumulated on the bottom of the lake, forming the clay soils that now exist in this part of the BFRW. While clay soils are very cohesive and therefore somewhat resistant to erosion, when they do erode, the particles stay suspended in the water column for an extended time, creating a cloudiness (reduced transparency) to the water. The MPCA measures total suspended solids (TSS) as an aspect of water quality. Minnesota's TSS standard for the northern region is 15 mg/L.

The MPCA has three long-term monitoring stations on the Big Fork River, known as Watershed Pollutant Load Monitoring Network (WPLMN) stations: near Bigfork at Hwy-6, near Craigville (northwest of Effie) at Hwy-6, and at Big Falls, Minnesota, measuring flow volumes and several water chemistry parameters. The latter two sites are in the GLA lake plain, while the site near Bigfork is above the surface elevation GLA reached (Figure 25). The longest-running monitoring site is the one at Big Falls (also the farthest downstream of the three) and data collected over the 2003-2023 period has shown no statistically significant trend in TSS concentration in the river. However, measurements in the Big Fork River are high at times. There are differences in the TSS levels at different locations of the river, and there is also a seasonal pattern to TSS concentrations in the river with the high TSS levels generally occurring in the late winter to late spring (Figure 28 and Figure 29). This correlates to the normal flow patterns in the river (and Minnesota rivers in general) of higher flow volumes at snowmelt and during spring, gradually tapering off into later summer. The lowest levels of TSS typically occur in August and September, which are almost always below the state's northern region TSS standard unless there has been a large precipitation event.

Figure 28. The three WPLMN stations on the Big Fork River and their positions relative to Glacial Lake Agassiz and showing their EQuIS S-code identifier. The two more northern stations are within the land area previously covered by Glacial Lake Agassiz (hatched area).

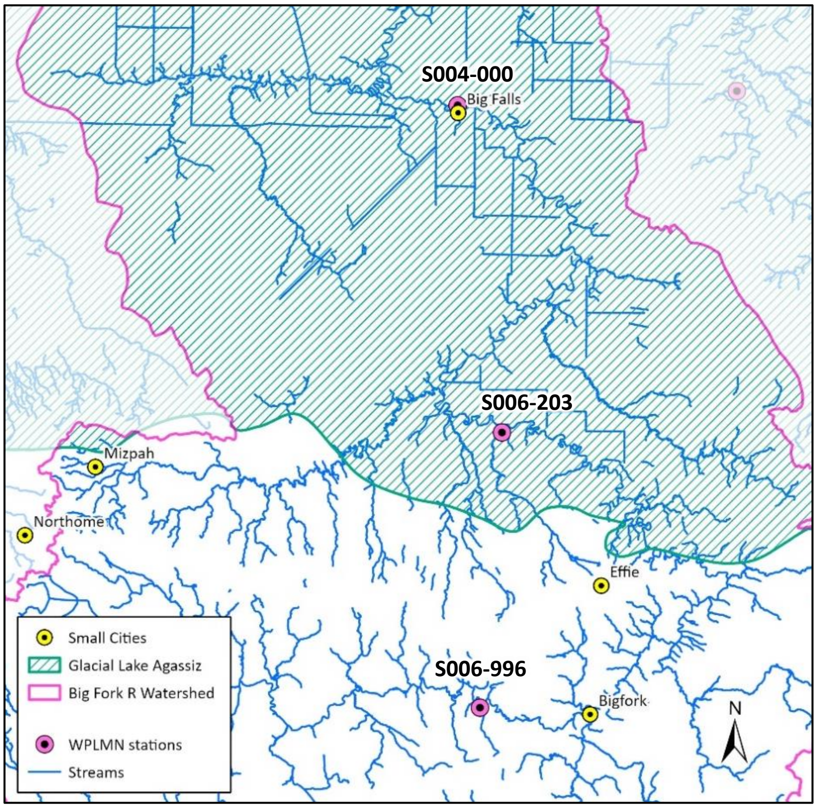


Figure 29. Measured TSS values (2010 - 2024) during open water seasons in the Big Fork River near Craigville, MN, EQuIS station S006-203. A 3rd order polynomial regression has been applied, with R^2 value shown. The red line is the Minnesota Northern TSS Standard.

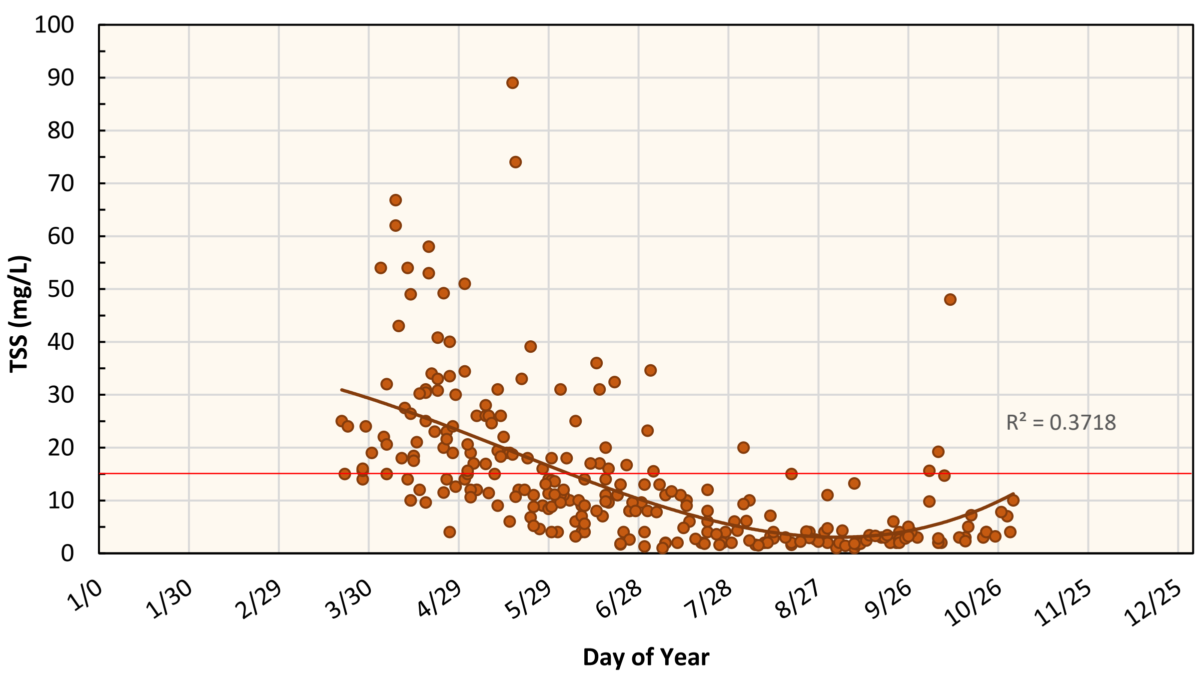
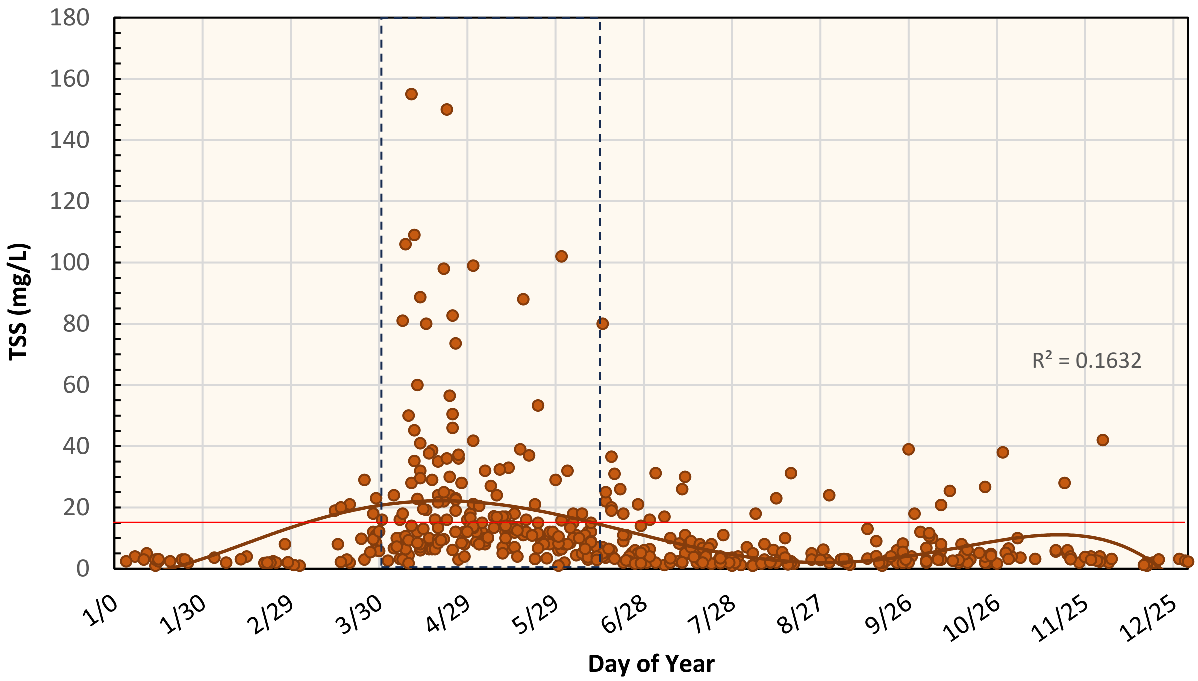
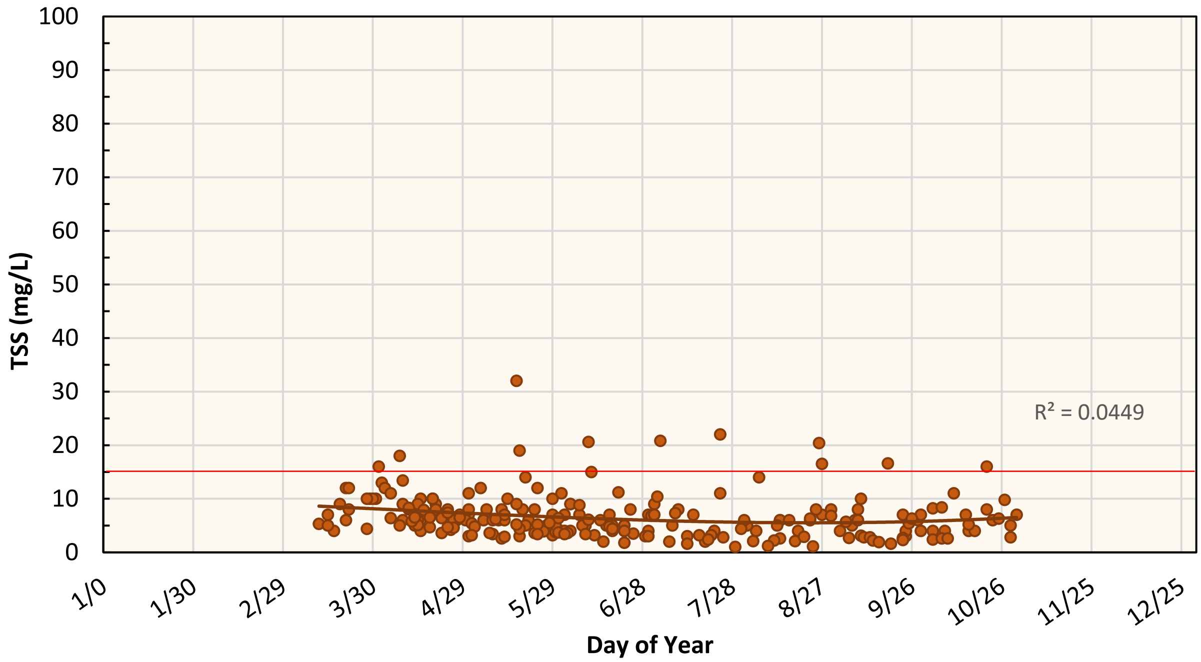


Figure 30. Measured TSS values (2006 - 2024) during the full year in the Big Fork River at Big Falls, MN, EQuIS station S004-000. A 4th order polynomial regression has been applied, with R^2 value, showing the seasonal TSS concentration pattern. The dashed box contains April 1 - June 15 samples. The red line is the Minnesota Northern TSS Standard. Note the y-axis scale is different for this graph than the other two.



The TSS concentrations at the WPLMN station upstream of the GLA shoreline (less clay in the soils) has much lower TSS during snowmelt/spring than at either the Craigville or Big Falls WPLMN stations (Figure 30). The seasonal pattern of TSS in this area is very subtle, with just slightly higher TSS in the spring than at other times of the year (excluding bigger rain events), contrasting with the other two WPLMN sites that have much higher early-season TSS concentrations. The difference in TSS levels in the river at different locations seems to be related to whether the location is within the old GLA lake bed or not, and thus related to the difference in soil types in and out of the Lake Agassiz lake plain.

Figure 31. Measured TSS values (2012 - 2024) during open water seasons in the Big Fork River near Bigfork, MN, EQuIS station S006-996. A 3rd order polynomial regression has been applied, with R^2 value shown. The red line is the Minnesota Northern TSS Standard.



Because TSS levels are generally correlated with flow volumes, reducing flow volumes should help reduce TSS concentrations. Efforts to store water on the landscape or slow its entry into larger streams and rivers can help to reduce gully and bank erosion and sediment movement in the streams.

The neighboring Little Fork River Watershed also has high TSS levels, again more so in late winter and spring. USGS research (in publication) studying where neighboring Little Fork River sediment was coming from on the landscape found that most of it was from near-channel gullies and the banks of the river (see Figure 31). Big Fork River sediment levels are lower than the Little Fork's, but there is potential for similar sources of sediment in the two watersheds, as both have areas that were under GLA.

Based on viewing aerial photos, the Big Fork River has healthier river banks (i.e., more gently sloping and more vegetated) than the Little Fork River does, but there are places where Big Fork River banks are sloughing too (see bank failure section above). A review of the LiDAR elevation map for the Big Fork River does show some short, deep near-channel gullies as are found along the Little Fork River, though they seem generally smaller and less deep than at the Little Fork River (Figure 32). It would be useful for water managers to visit some of the gullies to see if there is active erosion occurring in them. Again, reducing overland runoff and the higher, more erosive flows of water in the river and tributaries should reduce bank erosion. Some of these gullies; however, are draining natural areas that have little or no human disturbance (e.g., un-ditched peatlands), and therefore there aren't options for changing management of those areas to reduce erosion in those particular gullies. A number of these have had nearby logging, and those with road crossings may be more vulnerable for eroding as they likely receive road ditch runoff (Figure 33). Deposition of sediment from these gullies can be seen in aerial photos (Figure 34), though the extent of any unnatural amounts would require on-the-ground investigation of the gullies. Caldwell Brook is one tributary to the Big Fork River that is producing much more sediment in its current unstable condition (DNR, 2025; also discussed in this report).

Figure 32. LiDAR elevation map showing a section of the Little Fork River and the many short, near channel gullies (examples circled) which have been shown to be a substantial source of sediment to the Little Fork River.

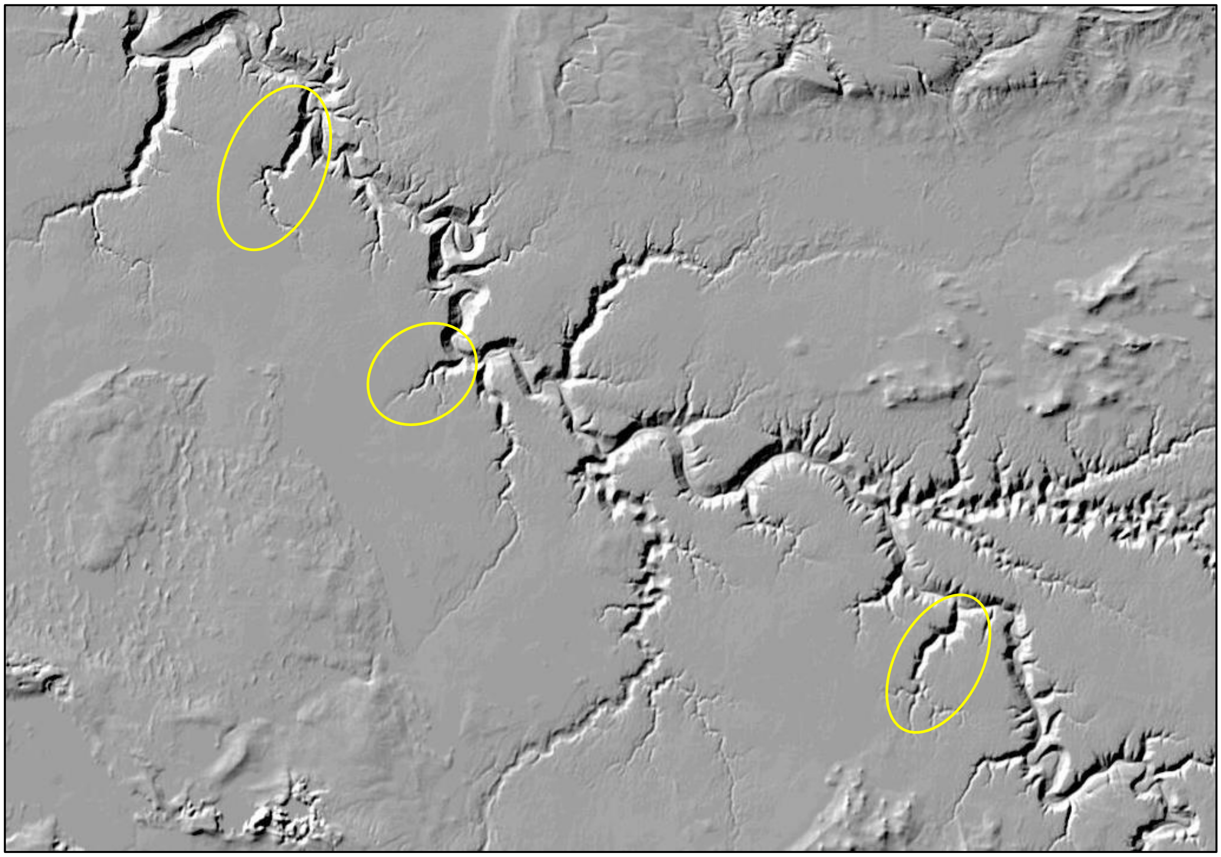
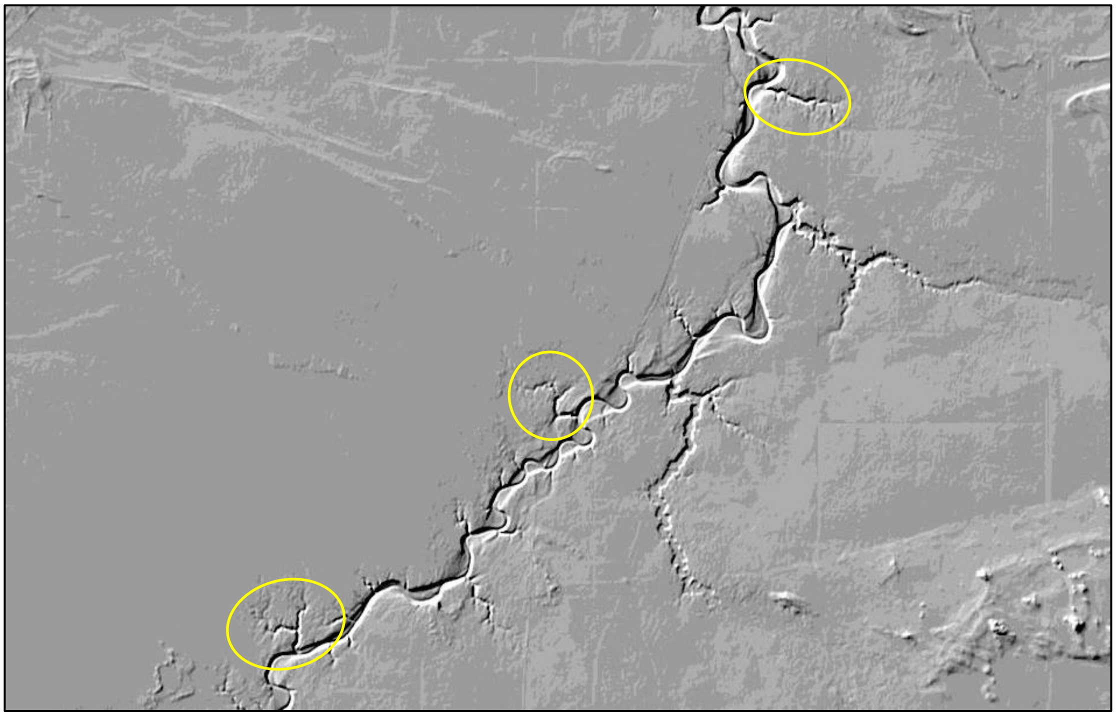


Figure 33. LiDAR elevation map showing a section of the Big Fork River and numerous short, near channel gullies (examples circled) The gullies along the Big Fork River appear to be smaller and less incised than those along the Little Fork River.



Flow levels in the BFRW have been changing. The annual peak discharge flows have been trending lower in the last several decades, according to an analysis of the hydrology of the BFRW; however, the channel-forming flow volume (which is the flow volume with a recurrence interval of approximately 1.5 years) has been increasing, as has average annual precipitation and the annual runoff (DNR, 2023). The additional flow volume creates greater sheer stress on the river bed and banks leading to increased erosion, though a statistically-significant increase in TSS concentration has not occurred over the period of 2003 through 2023 as assessed by the MPCA WPLMN program.

Figure 34. Example of short near-river-mainstem streams/gullies that are produced from natural drainage of peatlands. This area is a close-up of the center yellow circle in the previous figure: recently logged areas and re-growing previously logged plots can be seen, as well as MN Hwy 6 that likely contributes runoff to the steeper part of the gully near the river.

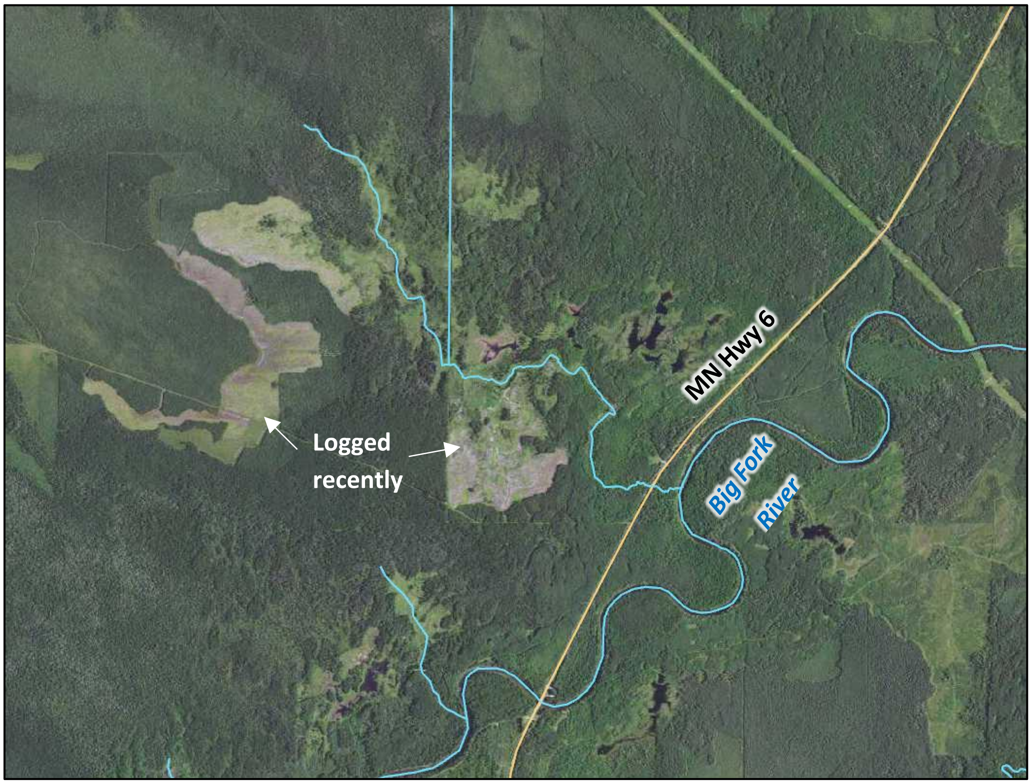


Figure 35. Deposited sediment (circled in yellow) can be seen in the Big Fork River immediately downstream of where the short tributary from Figure 23 enters the river.

Connectivity blockages for aquatic organisms

One common stressor to streams and their aquatic life happens at their intersections with roads. The infrastructure associated with a road can interfere with stream processes. In some cases, the infrastructure of the crossing becomes a barrier to the migration of fish species along the stream corridor, especially when fish are trying to move upstream to access their spawning areas and summer habitats after moving downstream to overwinter in larger streams, or when fish need to find important refuge areas during stressful periods (e.g., colder water locations during hot spells). Barriers can lead to impairments of a stream's aquatic life use standard.

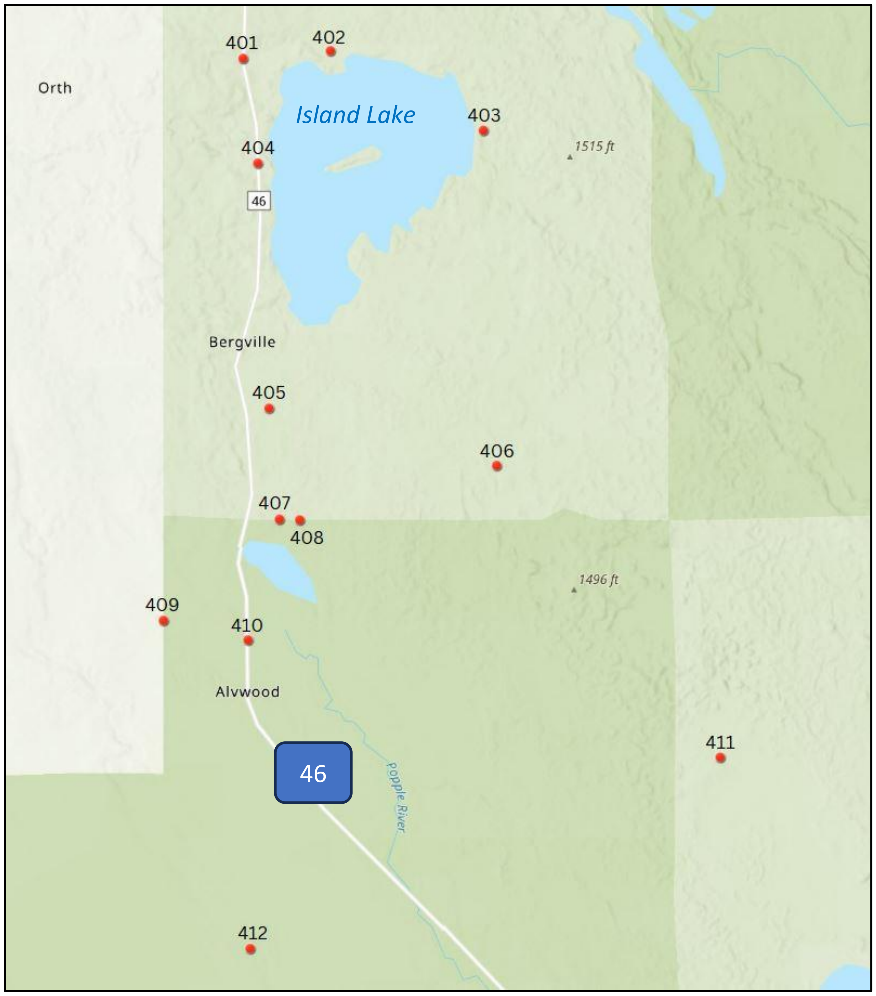
The construction of roads can also interfere with the stream's physical characteristics. The constructed road grade within the floodplain can act like a dam up on the floodplain, funneling flow through a narrow space under the road. It is quite common to find that culverts installed in the past are undersized. This can cause stream bed aggradation/sedimentation upstream of the culvert, water current within the culvert to be too fast/strong for smaller species to navigate, and erosion of stream banks on the downstream side of the culvert. Other common problems of culverts occur when they are not set at a low enough elevation, so that they are perched above the downstream water level, and also do not have natural bed materials on the culvert bottom, which aid fish passage through the culvert by providing current breaks.

Certain crossing designs can compensate for the road's influence. In recent years, more attention has been paid to fish passage when culverts have been installed, and newer designs for construction have been developed for that purpose. A generalization is that bridges are less problematic than culverts, and in some cases, culverts are being replaced with bridges. The Minnesota Department of Transportation (MnDOT) has created a very helpful guidance document discussing designs of road crossings that allow for normal functioning of streams and good fish passage, while simultaneously protecting the road better (MnDOT, 2019).

DNR has created survey methods to assess road crossings for these potential issues (DNR, 2015). These assessments are most often done at crossings that use culverts, which are more numerous than bridges, and which are also more likely to be barriers. Local water resource managers (SWCD staff) were provided training in this assessment methodology by Grand Rapids DNR staff. Itasca and Koochiching County SWCD staff completed assessments at a number of road crossings in two portions of the BFRW, around Island and Shallow Pond lakes in Itasca County, and along the Sturgeon River in Koochiching County.

Itasca County SWCD staff visited and assessed 12 culverts in the Popple River HUC-10 subwatershed (0903000602), in far northwestern Itasca County (Figure 35). These assessments found that a number of the stream crossings have undersized culverts, showing signs of upstream pooling and downstream scouring, which likely contribute to bank erosion and increased sediment and phosphorus levels in the water bodies, and potential fish passage barriers at some flows. None of the culverts inventoried showed immediate signs of failure. Those assessed as relatively the most problematic were #409 and #410. Though #408 (on Forest Road 3346) was assessed to be a somewhat lesser problem, it, along with #410, is on a somewhat larger stream and may therefore be more important to fix from a fish barrier perspective (i.e., there is more fish habitat available). The assessment information collected for these culverts has been entered into the DNR online culvert database but needs to be reviewed before obtaining public availability status.

Figure 36. Upper Popple River/Island Lake area culvert assessment.



Koochiching County SWCD staff visited and assessed 15 culverts in the Sturgeon River HUC-10 Subwatershed (0903000608), just west of Big Falls in Koochiching County (Figure 36), though time constraints didn't allow the full DNR protocol assessment to be completed for some. Two culverts were considered high priority due to not being properly aligned, being barriers to fish passage at some flow levels, and not containing natural substrate in the culvert. Three culverts were considered medium to high priority due to not being properly aligned. Two culverts were considered low-medium priority, one due to not being properly aligned, and the other culvert being highly impacted by beaver activity.

Figure 37. Sturgeon River HUC-10 culvert assessment locations.

Eight culverts were considered low priority relative to the others, because there were no obvious problems. The assessment information collected for these culverts has been entered into the DNR online culvert database but needs to be reviewed before obtaining public availability status.

The findings of problematic road crossings should be shared with the appropriate road authorities so that at some point in the future, the problem culverts get replaced using appropriate sizing and designs (DOT, 2019). A particularly good time to do replacements is when other work (e.g., road re-surfacing) is planned at that location, and it helps road managers to know ahead of time where problematic culvert are located so they can incorporate replacements as part of related projects.

Overall conclusions

In general, the streams and rivers of the BFRW are in very good condition. Much of the Big Fork River itself has biological communities that place these reaches in the "Exceptional Use" category of Minnesota's Tiered Aquatic Life Use (TALU) biological standards, which are the streams with the most outstanding, healthiest fish and macroinvertebrate communities.

Some legacy human alterations that have had lasting negative effects on the watershed. The original clear-cut logging of the forest in the late 1800s and early 1900s caused channel instability in some streams (e.g., Caldwell Brook). Attempts during the homesteading period to drain peatlands to create farmland have altered hydrology in the lower half of the BFRW, also causing channel instability. These alterations likely contribute to the elevated TSS concentrations that occur in the lower reaches of the Big Fork River, though natural characteristics (clay glacial lakebed soils) also play a part. Forest harvest still occurs at a significant scale in the BFRW and has the potential to also alter the hydrology of streams.

Opportunities may exist in the coming years for restoration of drained peatlands, particularly because there is a carbon sequestration/climate benefit to doing so. This will have a simultaneous benefit in storing water on the landscape to reduce historical changes to hydrology. Ensuring that harvested forest parcels are spread out to reduce local effects of the harvesting on runoff to streams and adoption of forest harvest BMPs will be important to protect the future health of BFRW streams. And as will all watersheds in Minnesota, there is road crossing infrastructure (especially culverts) that can be improved by designs that take into consideration fish passage needs.

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