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Skunk Creek Section 319 EPA Nine Element Plan

MINNESOTA POLLUTION CONTROL AGENCY

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1. Introduction

The Skunk Creek Section 319 Small Watershed Focus Program Grant Workplan (Skunk Creek Workplan) developed by compiling and synthesizing information from previous studies and planning documents conducted in the watershed. Much of the text and concepts in this Workplan are derived from the various existing studies and plans in the watershed. Additional information is provided when necessary to address all of the U.S. Environmental Protection Agency's (EPA) nine key elements of a watershed-based plan. Key documents include:

- Nemadji River Watershed Monitoring and Assessment Report, 2014, assessed three stream segments in the Skunk Creek Watershed (Skunk Creek from the headwaters to Elim Creek confluence, Skunk Creek downstream of the Elim Creek confluence, and Elim Creek) for compliance with water quality standards.
- Nemadji River Stressor Identification Report, 2014, evaluated the biotic impairment in Elim Creek that included new monitoring data, evaluation of potential stressors to the biota, and identified potential restoration activities.
- Nemadji River Watershed Total Maximum Daily Load, 2017, includes a total suspended solids total maximum daily load (TMDL) for Skunk Creek along with watershed information, a summary of water quality data, and implementation strategy.
- Nemadji River Watershed Restoration and Protection Strategy, 2017, addresses all three of the assessed stream segments in the Skunk Creek watershed and includes a summary of water quality, restoration and protection strategies, and recommended monitoring activities.
- Phase 1 Red Clay Dam Project: Skunk Creek Red Clay Dams Assessment, 2014, identifies high risk of failure dam structures for future projects and funding opportunities and provided landowners with relevant information regarding the structures on their property.
- Nemadji River Watershed Culvert Inventory for Fish Passage 2011-2014, 2014, provides an inventory of culverts acting as road/trail stream crossings and their ability to provide for fish passage.
- Nemadji River Habitat Assessment Using Lidar, 2018, identifies priority restoration and protection sites in the watershed. A multi-criteria feasibility matrix was developed to prioritize and direct actions based on factors such as watershed needs, available funding, local planning, land ownership, historic and predicted climate patterns and habitat location.

The Skunk Creek Workplan is a living, working document that serves as a guide and starting point for local stakeholders to achieve water quality goals through implementation of nonpoint source pollution control measures. An adaptive management approach is taken to allow for change, reaction, and course correction throughout implementation.

1.1 Document overview

The intent of the Skunk Creek Workplan is to concisely address the nine elements identified in EPA's *Handbook for Developing Watershed Plans to Restore and Protect our Waters* (EPA 2008) that EPA feels are critical to preparing effective watershed plans to address nonpoint source pollution. EPA emphasizes the use of watershed-based plans containing the nine elements in Section 319 watershed projects in its guidelines for the Clean Water Act Section 319 program and grants (EPA 2013). The nine elements are listed in Table 1 along with the section of this report in which each element can be found.

Table 1. Nine elements and report section(s)

Section 319 Nine Elements	Applicable report section
Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve needed load reductions, and any other goals identified in the watershed plan.	Sections 4.0
An estimate of the load reductions expected from management measures.	Section 7.0
A description of the nonpoint source management measures that will need to be implemented to achieve load reductions in element b, and a description of the critical areas in which those measures will be needed to implement this plan.	Sections 5.0 and 7.0
An estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan.	Sections 7.0 and 10.0
An information and education component used to enhance public understanding of the project and encourage the public's early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented.	Sections 8.0
Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.	Section 7.0
A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.	Section 7.0
A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards.	Sections 6.0, 7.0, and 9.0
A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item h immediately above.	Section 9.0

1.2 Planning purpose and process

The purpose of this plan effort is to build upon the existing foundation of work that has been completed in the Skunk Creek Watershed. The plan builds on the past efforts to inform the details of this plan. Implementing the actions in this plan will achieve the water quality goals for the streams and lakes in the watershed. The goals include meeting the water quality standards for the waterbodies.

This plan incorporates detailed work for specific waterbodies. It builds off of the existing work of the watershed partners described in Section 1.3. Considerable cross interactions between various programs makes it difficult to single out any one document/plan as the complete picture for the watershed plan that fully meets EPA's nine key elements for every waterbody in the watershed. Instead, each of these plans, studies, and efforts brings more information to the table to inform the actions needed to obtain improved water quality and to ultimate reach water quality standards.

Part of the development of this plan includes synthesizing and compiling the information from these multiple scale planning efforts. Circumstances in the watershed will continue to change. Land use will change, BMPs will be implemented, the climate will continue to change, etc., and the needs of the watershed will change based on these inputs. The milestones and intentional monitoring of progress will guide the changes needed to this plan throughout the implementation process.

1.3 Watershed management team

Several agencies and organizations have been active in one or more watershed management-related activities in the Skunk Creek Watershed. These entities can form the basis of the watershed management team for the Skunk Creek Workplan. A list of these with a brief description of their involvement is given in Table 2.

Table 2. Agencies and organizations participating in watershed activities in the Skunk Creek watershed

Entity	Description of Activities
Carlton Soil and Water Conservation District	Work with private landowners to implement conservation projects. Coordinate with partners to improve water quality
Carlton County	Manage county forest land, Soo line Trail, County Roads and Clear Creek Township Roads. Enforce wetland, shoreline and SSTS ordinances.
Minnesota Trout Unlimited	Support fish habitat projects
Minnesota Department of Natural Resource	Manage the Blackhoof WMA. Issue public water permits. Manage fish resources. Provides financial assistance for private forestry project implementation and planning. Implement fishing easements of trout streams.
Minnesota Pollution Control Agency	Collect water quality data and assess water quality. Identify stressors to water quality. Coordinates citizen monitoring program
Blackhoof Township	Manage Township roads
Volunteer Water Monitors	Collect water quality data
Minnesota Department of Agriculture	Implement the Minnesota Agricultural Water Quality Certification Program which helps producers implement practices to improve water quality
USDA – NRCS	Provide financial and technical assistance to implement conservation practices including forestry.
Minnesota Land Trust	Provide support to private landowners who want to protect their land.
Pheasants Forever	Support habitat improvement projects.
Ruffed Grouse Society	Support habitat improvement projects.
Wisconsin Wetlands Association	Provide technical assistance to support the protection, restoration and enjoyment of wetlands
American Bird Conservancy	Provides technical assistance to private landowners to improve forest habitat
The Nature Conservancy	Provides assistance for land protection.
Area schools (Barnum, Carlton, Wrenshall)	Assist with water quality monitoring
Area secondary education institutions: Fond Du Lac Tribal Community College and University of Minnesota - Duluth	Assist with primary research
Fond Du Lac Band of Lake Superior	Provide technical assistance/advice
Private Landowners	Implement conservation practices to improve water quality. Influence other land owners to do similar work.

1.4 Nonpoint source (NPS) pollution management in the Skunk Creek Watershed

Many partners have been active in watershed management and restoration in the Skunk Creek Watershed. In the 1970s, the Red Clay Project (Andrews et al.1980) included a study of erosion and sedimentation throughout the Nemadji River Watershed and resulted in the construction of sixteen sediment retention structures, referred to as red clay dams, in the Skunk Creek watershed as well as numerous agricultural practices, woodland improvements, amongst others. The purpose of these projects was to reduce sediment loading to the Nemadji River. Following implementation of the Red Clay Project, 95% of the Skunk Creek Watershed was adequately providing water quality treatment (Andrews et al. 1980).

The Nemadji River Basin Project includes a detailed summary of the greater Nemadji River Basin, a sediment budget, and detailed description of the issues and concerns, and recommendations that would lead to watershed restoration (NRCS 1998).

In 2006, an EPA Section 319 Grant funded Carlton County to inventory the sediment retention structures. Photos were taken of the pond, inlets, and outlets of each structure and linked to a GIS database with coordinates for each structure. The survey showed a wide range of conditions including breached embankments, perched outlets, and failing spillways. The state of these structures impacts sedimentation in the Nemadji River basin, which relates to both the St. Louis River AOC and impaired waters listings.

Figure 1. Example of Elim Creek restoration, Dam 3 before and after

In 2011, a Clean Water Fund grant was secured by the Carlton SWCD to restore a series of three red clay dams over 1/3 mile on Elim Creek and a complete an inventory of the red clay dams to establish a prioritization schedule for future project phases to restore the stream corridor from the unmaintained dams. The inventory was completed in 2013 and the red clay dam restoration project was completed in 2014. This project is referred to as Red Clay Dams Phase 1, or the Elim Creek Restoration through Aging Sediment Retention Structure Removal.

In 2014, a Great Lakes Commission grant was secured by the Carlton SWCD to develop five erosion control design plans for the highest prioritized sites in Phase I. The project will utilize field surveying and GIS analysis to develop options for erosion control actions landowners may pursue with future funding. Each site features 30+ year old Red Clay Dams that have exceeded their life expectancy and are at varying stages of failure. The sediment retained by these structures over the last decade presents a massive sediment load into Lake Superior should the dams fail. The erosion control design plans will provide landowners options to either repair the erosion damage to the dams or restore the streams to natural channel design.

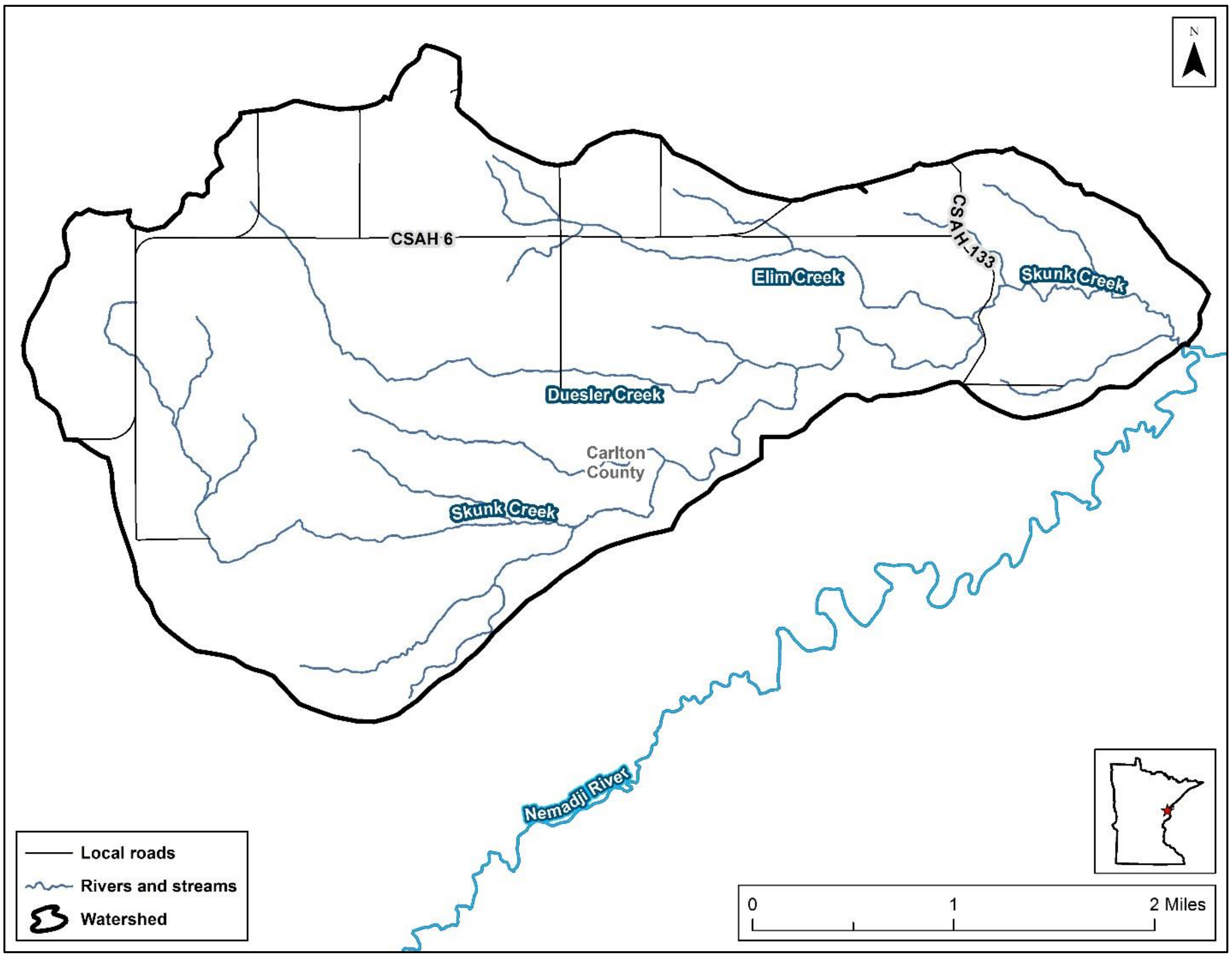
In 2011 the Carlton SWCD was awarded grant funding from the U.S. Fish and Wildlife Service Fish Passage Program to conduct a watershed-wide culvert assessment. In 2014 the culvert inventory was completed, with assistance from Carlton County Zoning & Environmental Services, focusing primarily on perennial streams for fish passage barriers in the Nemadji River watershed. The inventory includes a final prioritization element to guide future restoration funds to increase fish passage within the watershed. The assessment and prioritization of potential future culvert projects will increase the valuable fish habitat in the watershed and aid in the restoration of old infrastructure.

In addition, the state of Minnesota has adopted the Minnesota Watershed Approach to address the state's major watersheds. The approach incorporates water quality assessment, watershed analysis, public participation, planning, implementation, and measurement of results into a 10-year cycle that addresses both restoration and protection needs. A key aspect of this effort is to develop and use watershed-scale models and other tools to identify strategies for addressing point and nonpoint source pollution that will cumulatively achieve water quality targets. Several documents have been developed that are applicable to the Skunk Creek watershed as part of this process including the Nemadji River Watershed Monitoring and Assessment Report (MPCA 2014), Nemadji River Stressor Identification (EOR 2014), Nemadji River Watershed Total Maximum Daily Load (Tetra Tech 2017a), and the Nemadji River Watershed Restoration and Protection Strategy Report (Tetra Tech 2017b). The process used to develop these reports included significant stakeholder involvement; these reports provide much of the background information and inform selection of management activities.

2. Watershed prioritization

Skunk Creek is located within the Nemadji River Watershed in southeastern Carlton County and includes portions of Blackhoof, Clear Creek, and Barnum townships. The watershed is in the Northern Lakes and Forests ecoregion. Skunk Creek is 8.94 miles in length from the headwaters to its confluence with the Nemadji River and has a watershed area of 6,560 acres. The two named tributaries to Skunk Creek are Elim Creek and Duesler Creek. The three creeks are located in the Skunk Creek-Nemadji River HUC12 (040103010203) watershed. There are no lakes in the Skunk Creek watershed. Skunk and Elim Creeks are the priority waterbodies for this plan with the drainage area shown in Figure 2.

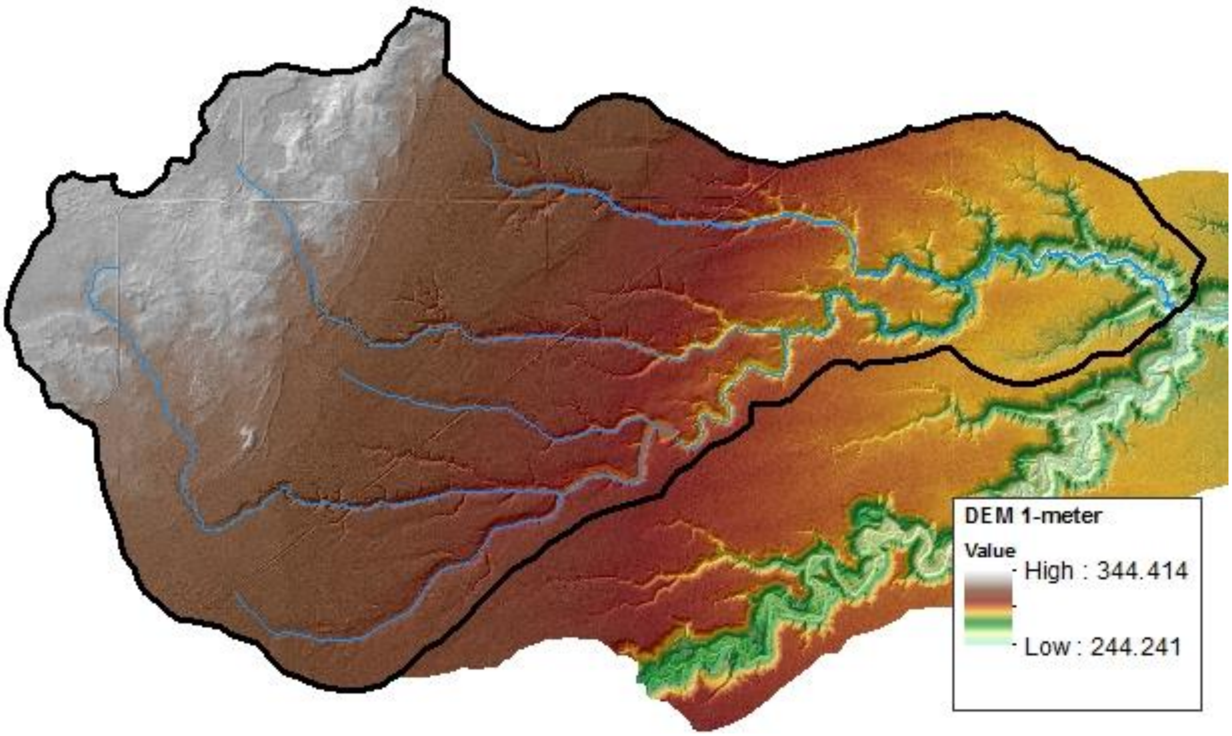
Figure 2. Skunk Creek Watershed



2.1 Topography and drainage

Skunk Creek drains a 10.7 square mile (6,560 acre) watershed. Major tributaries include Elim Creek and Duesler Creek. As described in the Red Clay Project (Andrews et al. 1980), elevation in the Skunk Creek Watershed ranges from almost 805 feet at the east end to 1,090 feet above sea level at the extreme west end (Figure 3). Skunk Creek and its tributaries are entrenched up to more than 100 feet at the lower end. The central and upper end of the watershed is gently sloping to rolling. A significant component affecting drainage in the Skunk Creek Watershed is a series of sediment retention structures.

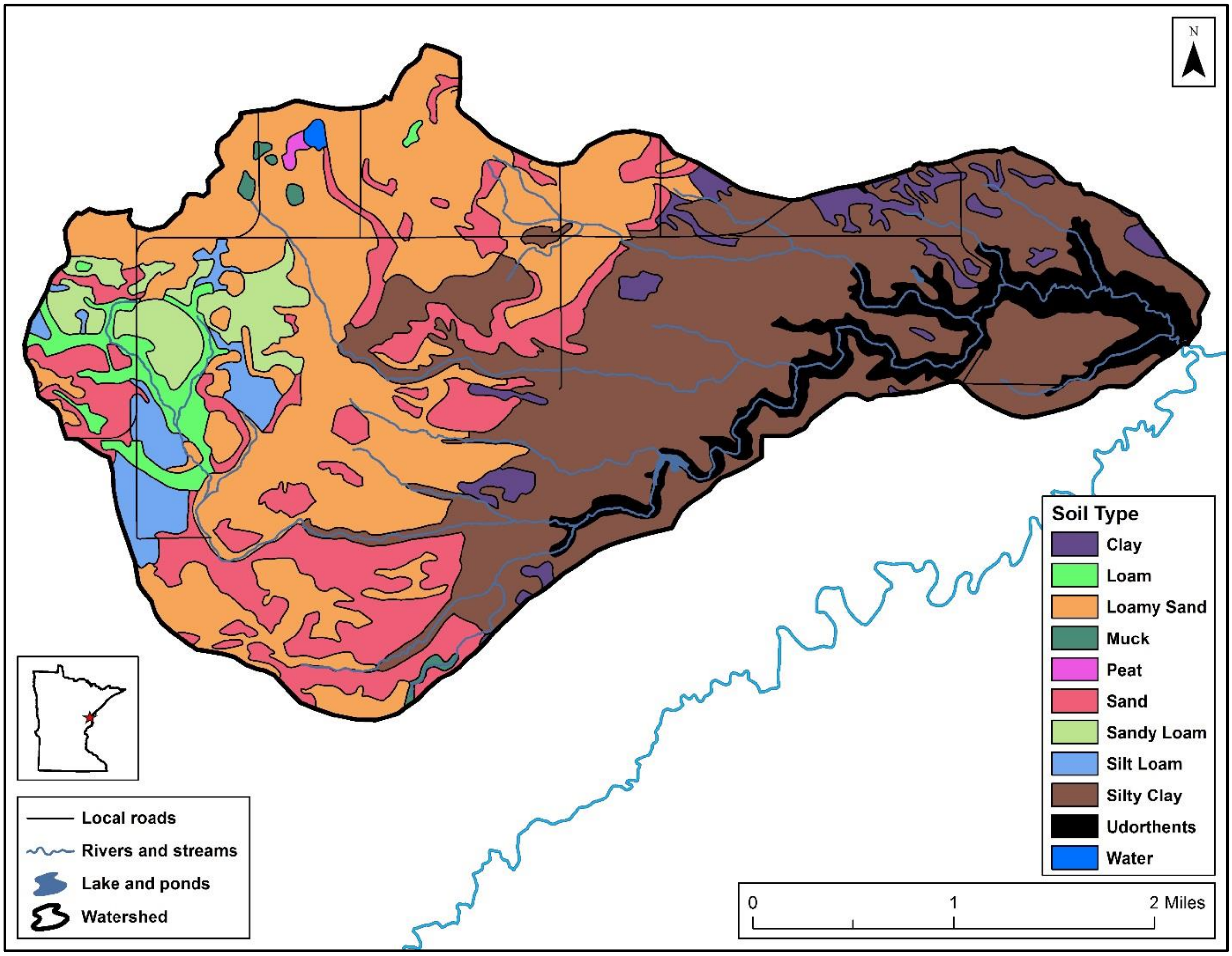
Figure 3. Skunk Creek Watershed topography



2.2 Geology and soils

The geology of the watershed includes deep bedrock units overlain by glacial deposits. The underlying bedrock is primarily igneous and sedimentary rocks of the Precambrian Age, specifically sandstone, siltstone and conglomerate. Overlying the bedrock is a series of Quaternary deposits. The headwater areas of the Skunk Creek watershed consist of coarse grained, sandy till deposits. The lower portion of the watershed is clay and clayey silt lacustrine deposits. This area is referred to as the red clay zone and has a substantial impact on water quality in the Nemadji River watershed as the red-clay is highly erodible and is prone to extensive mass wasting or "slumping". In addition, clayey soils consist of fine particles that do not readily settle out of the water column, leading to naturally high turbidity and suspended sediment (Figure 4).

Figure 4. Soil types in the Skunk Creek Watershed



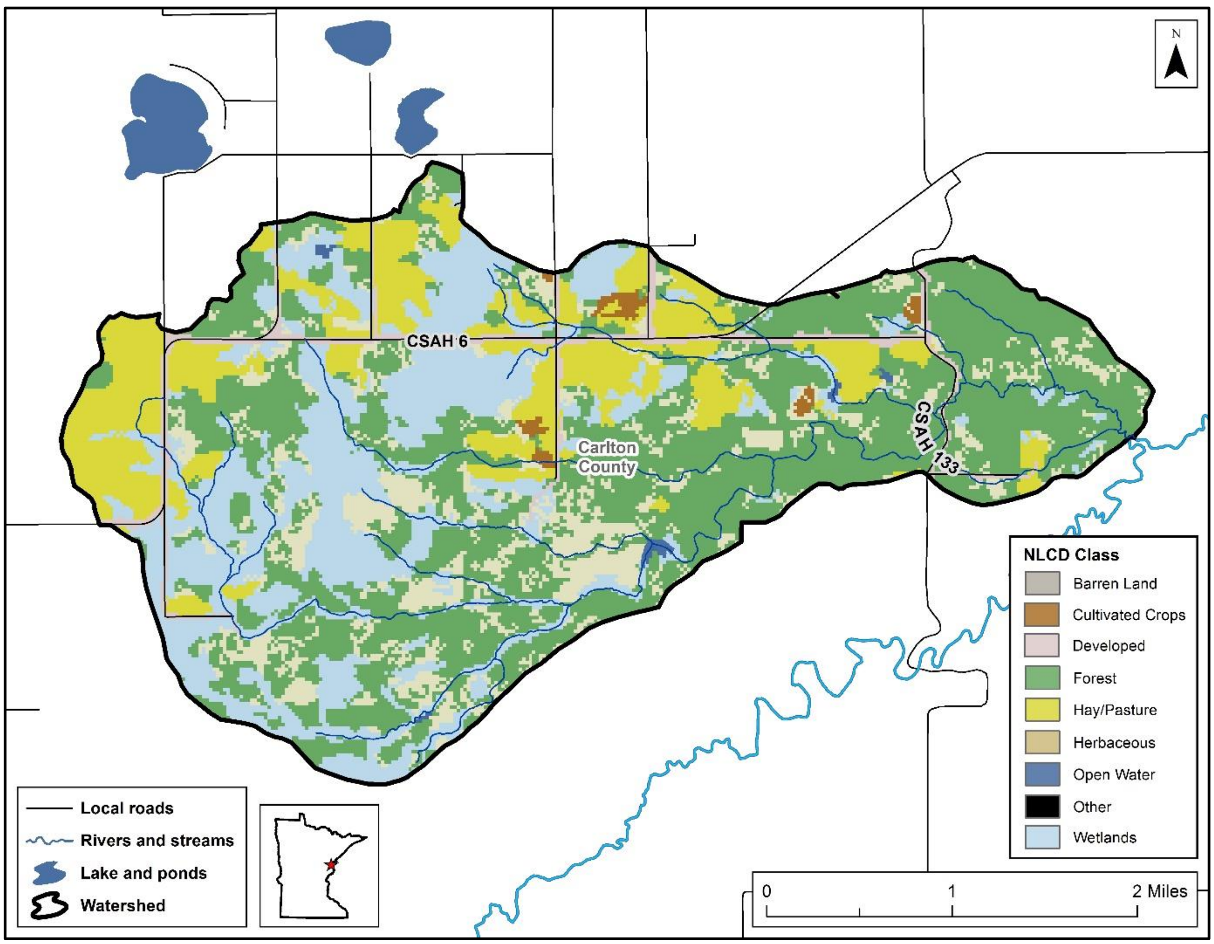
2.3 Land use

Historically, the Skunk Creek Watershed was mostly coniferous forest. Upon human settlement was heavily logged and people attempted to farm. The 6,560-acre Skunk Creek Watershed is currently 54% (3,542 acres) forest land cover classification. The next two dominant land use types include wetlands (24%) and hay/pasture (18%). Table 3 and Figure 5 displays the 2016 NLCD classification cover acreage and percent with the watershed.

Table 3. Land use breakdown for the Skunk Creek watershed (NLCD 2016)

Land use classification	Acres	Percent
Cultivated Crops	66	1%
Developed	131	2%
Forest	3,542	54%
Hay/Pasture	1,181	18%
Herbaceous	66	1%
Open Water	<1	<1%
Wetlands	1,574	24%
Total	**6,560**	**100%**

Figure 5. Land use and land cover for Skunk Creek watershed (NLCD 2016)

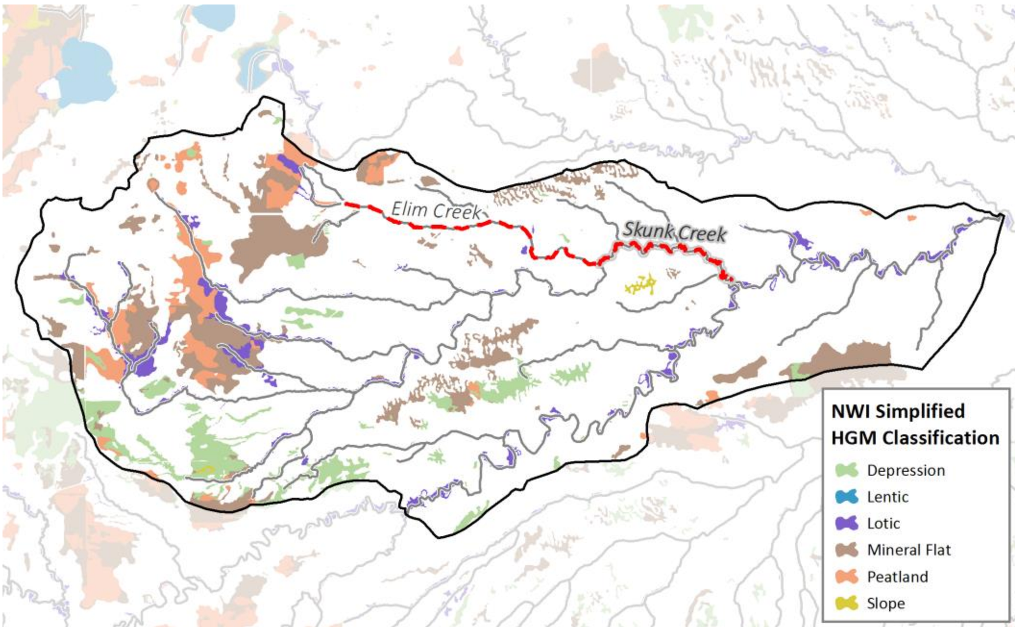


2.4 Aquatic habitat and wetlands

Wetlands and open water make up 24% of the Skunk Creek Watershed. Large wetland complexes form the headwaters of Skunk and Elim creeks (Figure 5). These wetlands are primarily forested. A functional assessment of the wetlands indicated that over 80% of the wetlands provide moderate to high value function for stream flow maintenance and nearly all provide functional value in storing runoff that can then reduce downstream peak flows (Benck et al. 2018). The wetlands provided lower functional values for sediment retention and shoreline stabilization primarily due to their location in the landscape.

Benck et al. (2018) estimated that there are 875 acres of potentially restorable wetland in the Skunk Creek Watershed. Even though the quality of the wetlands is good, there are still good opportunities for wetland restoration with further analysis, especially with riparian wetlands.

Figure 6. Wetlands in the Skunk Creek Watershed (impaired streams in red)



2.5 Climate and precipitation

The climate of the Skunk Creek Watershed is typical of east central Minnesota. The long-term average annual precipitation is 28 inches per year based on records from the Minnesota State Climatology Office for the Nemadji River HUC-8 watershed. Most of the precipitation (81%) occurs between March and October with the remainder (19%) falling between November and February as mostly snow. The average annual snowfall is about 60 inches. The normal average annual temperature in the watershed is 40 degrees Fahrenheit (F) with the winter and summer normal average temperatures being 8 degrees and 62 degrees F, respectively. The average minimum and maximum temperatures are -6 degrees and 75 degrees F, respectively.

There have been three rainfall events in the past three years that have exceeded the 200-year storm event planning framework. These extraordinarily heavy and increasingly characteristic rain events have increased the sediment loading and stress on the system.

3. Watershed description

3.1 Water quality standards

The federal Clean Water Act requires states to designate beneficial uses for all waters and develop water quality standards to protect each use. Water quality standards consist of several parts:

- Beneficial uses — Identify how people, aquatic communities, and wildlife use our waters
- Numeric criteria — Amounts of specific pollutants allowed in a body of water and still protects it for the beneficial uses
- Narrative criteria — Statements of unacceptable conditions in and on the water
- Antidegradation protections — Extra protection for high-quality or unique waters and existing uses

Together, the beneficial uses, numeric and narrative criteria, and antidegradation protections provide the framework for achieving Clean Water Act goals. Minnesota's water quality standards are provided in Minn. R. ch. 7050 and 7052. All current state water rules administered by the Minnesota Pollution Control Agency (MPCA) are available on the Minnesota water rules page (https://www.pca.state.mn.us/water/water-quality-rules).

3.1.1 Beneficial uses

The beneficial uses for waters in Minnesota are grouped into one or more classes as defined in Minn. R. 7050.0140. The classes and associated beneficial uses are:

- Class 1 – domestic consumption
- Class 2 – aquatic life and recreation
- Class 3 – industrial consumption
- Class 4 – agriculture and wildlife
- Class 5 – aesthetic enjoyment and navigation
- Class 6 – other uses and protection of border waters
- Class 7 – limited resource value waters

The aquatic life use class now includes a tiered aquatic life uses framework for rivers and streams. The framework contains three tiers—exceptional, general, and modified uses. All surface waters are protected for multiple beneficial uses.

3.1.2 Numeric criteria and state standards

Narrative and numeric water quality criteria for all uses are listed for four common categories of surface waters in Minn. R. 7050.0220. The four categories are:

- Cold water aquatic life and habitat, also protected for drinking water: classes 1B; 2A, 2Ae, or 2Ag; 3A or 3B; 4A and 4B; and 5
- Cool and warm water aquatic life and habitat, also protected for drinking water: classes 1B or 1C; 2Bd, 2Bde, 2Bdg, or 2Bdm; 3A or 3B; 4A and 4B; and 5
- Cool and warm water aquatic life and habitat and wetlands: classes 2B, 2Be, 2Bg, 2Bm, or 2D; 3A, 3B, 3C, or 3D; 4A and 4B or 4C; and 5
- Limited resource value waters: classes 3C; 4A and 4B; 5; and 7

The narrative and numeric water quality criteria for the individual use classes are listed in Minn. R. ch. 7050.0221 through 7050.0227. The procedures for evaluating the narrative criteria are presented in Minn. R. 7050.0150.

The MPCA assesses individual water bodies for impairment for class 2 uses—aquatic life and recreation. Class 2A waters are protected for the propagation and maintenance of a healthy community of cold water aquatic life and their habitats. Class 2B waters are protected for the propagation and maintenance of a healthy community of cool or warm water aquatic life and their habitats.

Protection of aquatic life entails the maintenance of a healthy aquatic community as measured by fish and macroinvertebrate indices of biotic integrity (IBIs). Fish and invertebrate IBI scores are evaluated against criteria established for individual monitoring sites by water body type and use subclass (exceptional, general, and modified).

Both class 2A and 2B waters are also protected for aquatic recreation activities including bathing and swimming, and the consumption of fish and other aquatic organisms. In streams, aquatic recreation is assessed by measuring the concentration of Escherichia *(E.) coli* in the water, which is used as an indicator species of potential waterborne pathogens. To determine if a lake supports aquatic recreational activities, its trophic status is evaluated using total phosphorus, Secchi depth, and chlorophyll-a as indicators.

The ecoregion standards for aquatic recreation protect lake users from nuisance algal bloom conditions fueled by elevated phosphorus concentrations that degrade recreational use potential.

3.1.3 Antidegradation policies and procedures

The purpose of the antidegradation provisions in Minn. R. ch. 7050.0250 through 7050.0335 is to achieve and maintain the highest possible quality in surface waters of the state. To accomplish this purpose:

- Existing uses and the level of water quality necessary to protect existing uses are maintained and protected.
- Degradation of high water quality is minimized and allowed only to the extent necessary to accommodate important economic or social development.
- Water quality necessary to preserve the exceptional characteristics of outstanding resource value waters is maintained and protected.
- Proposed activities with the potential for water quality impairments associated with thermal discharges are consistent with section 316 of the Clean Water Act, United States Code, title 33, section 1326.

3.1.4 Skunk Creek Watershed water quality standards

The streams in the Skunk Creek watershed are primarily designated as class 2A waters. The water quality standards used in assessing the streams and lakes include the following parameters:

- E. coli – not to exceed 126 organisms per 100 milliliters as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than ten percent of all samples taken during any calendar month individually exceed 1,260 organisms per 100 milliliters. The standard applies between April 1 and October 31.
- Dissolved oxygen – daily minimum of 7 mg/L.
- pH – to be between 6.5 and 8.5 pH units.

- Total suspended solids – 10 mg/L (class 2A streams) not to be exceeded more than 10% of the time between April 1 and October 31.
- Stream eutrophication – based on summer average concentrations for the North River Nutrient Region
  - Total phosphorus concentration less than or equal to 50 µg/L and
  - Chlorophyll-a (seston) concentration less than or equal to 7 µg/L or
  - Diel dissolved oxygen flux less than or equal to 3.0 mg/L or
  - Five-day biochemical oxygen demand concentration less than or equal to 1.5 mg/L.
  - If the total phosphorus criterion is exceeded and no other variable is exceeded, the eutrophication standard is met.
- Biological indicators – The basis for assessing the biological community are the narrative water quality standards and assessment factors in Minn. R. 7050.0150. Attainment of these standards is measured through sampling of the aquatic biota and is based on impairment thresholds for IBI that vary by use class. Appendix 5 in the Nemadji River Watershed Monitoring and Assessment Report (MPCA 2014) provides the IBI numeric thresholds.

3.2 Streamflow

Streamflow in Skunk and Elim Creeks has been monitored by various entities at various times dating back to 1976. Historical streamflow data exists at the USGS stream gauges for Elim Creek near Holyoke, MN (05023022) and for Skunk Creek below Elim Creek near Holyoke, Minnesota (05013001) spanning January of 1976 to October of 1978. Streamflow data was also monitored at Skunk Creek near Pleasant Valley, CR 103 (05013003) between May 2009 to October of 2013. Peak flows were observed near 900 cfs in June of 2012 and an average flow of 9 cfs has been recorded across the monitoring period (Figure 7). Streamflow was continuously monitored in Elim Creek during 2013 to inform the Nemadji River Stressor Identification (EOR 2014). As shown in Figure 6, Elim Creek maintained a baseflow near 2 cfs during May and June but was then reduced to almost 0 cfs for much of the summer. Flow data indicate that flows are reduced to almost 0 cfs especially during dry periods in late summer. The Minnesota Department of Natural Resources (DNR) has also collected stream discharge measurements through the low flow summer months to identify the low flow habitat suitability for trout in the Nemadji River Watershed (Figure 8, Tetra Tech 2017b). Very low flow conditions were observed in Skunk and Elim Creeks upstream of their confluence; whereas, streamflow downstream of the confluence are much higher and able to support trout.

Figure 7. Streamflow in Elim Creek, 2013 (EOR 2014)

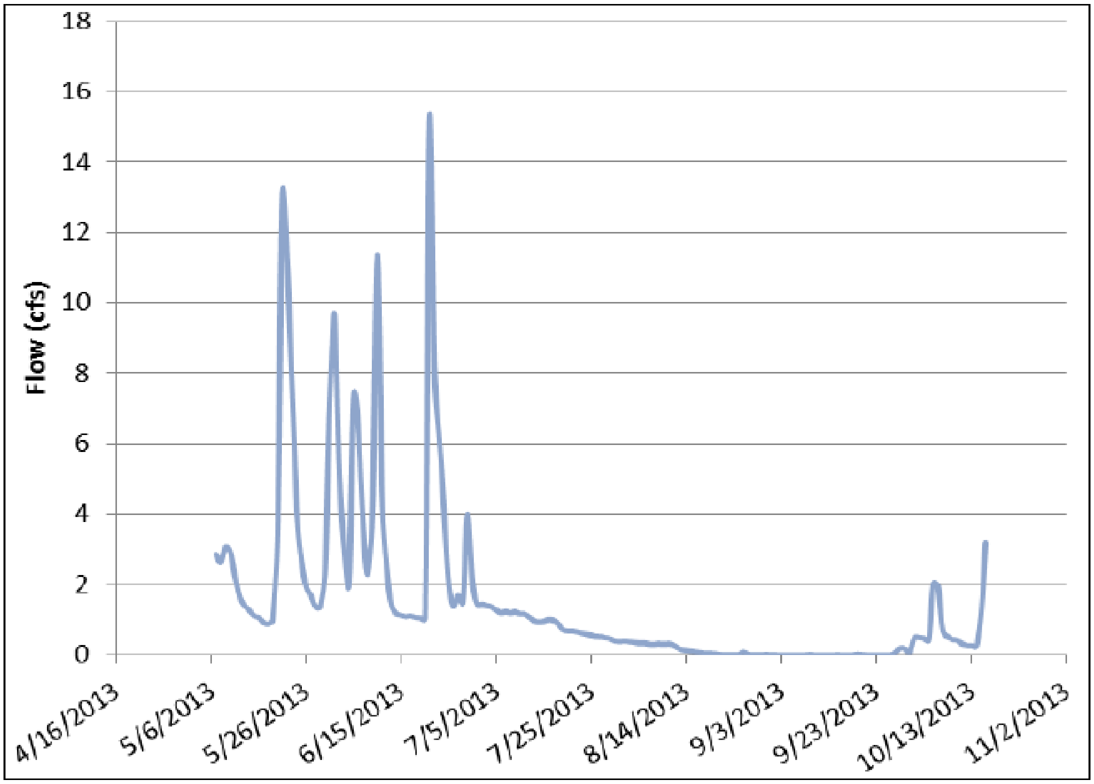


Figure 8. Streamflow at Skunk Creek near Pleasant Valley, 2009-2013

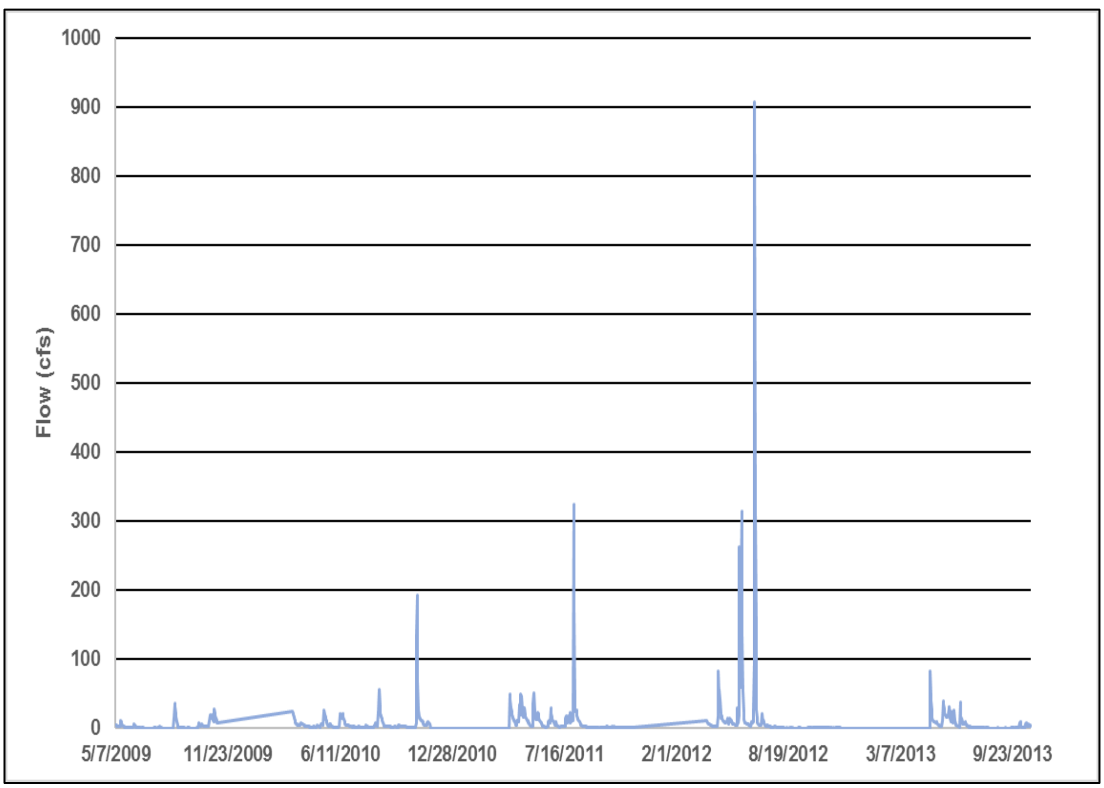
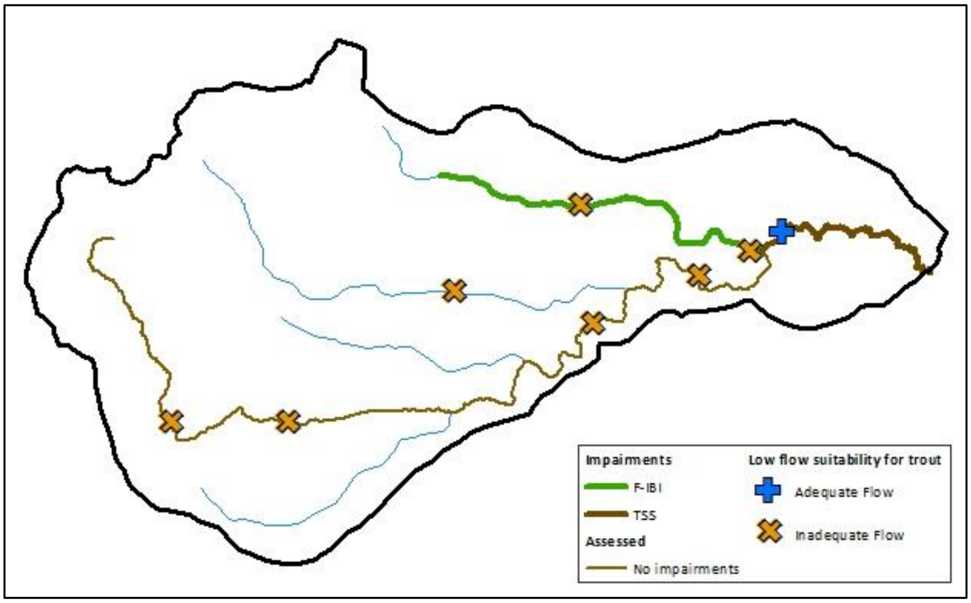


Figure 9. Low flow trout habitat suitability



3.3 Water quality data summaries

A summary of water quality data has been developed for Elim Creek (EOR 2014) and the lower reach of Skunk Creek downstream of the confluence with Elim Creek (Tetra Tech 2017a). No water quality data is available for Duesler Creek.

3.3.1 Elim Creek

As described in EOR 2014, mean total suspended solids concentrations on Elim Creek over a 10-year period between 2003 and 2012 exceeded the total suspended solids (TSS) coldwater standard of 10 mg/L for every month during the growing season except September (Table 4). Overall, August had the highest TSS concentrations with up to 100 mg/L of TSS. TSS data collected on Elim Creek in 2013 followed a similar seasonal trend in TSS concentrations compared to long-term records. A portion of Elim Creek passes through the clay zone which is likely contributing TSS. However, TSS concentrations are not as high as compared to other impaired reaches in the Nemadji River Watershed.

Table 4. TSS concentration summary for Elim Creek (2003-2012; EOR 2014)

Station	Month	Mean	#	Min	Max
S007-453	May	21	1	21	21
	June	47	2	18	76
	August	56	2	12	100
	September	5.2	2	4	6.4
	October	16	1	16	16

3.3.2 Skunk Creek below Elim Creek Confluence

As described in Tetra Tech 2017a, annual average TSS concentrations in the lower portion of Skunk Creek have fluctuated from 23 mg/L to 116 mg/L (Table 5). On average, 62% of the measurements exceed the 10 mg/L standard, and the standard was exceeded every year where there are monitoring data. On average, TSS concentrations are greatest in the months of May and August and lowest in September (Table 6). The majority of samples taken during very high and high flow conditions exceed the standard, whereas the majority of samples taken during low and very low flow conditions are below the standard (Figure 10).

Table 5. Summary of TSS data for Skunk Creek (S005-617), between April through September

Values in red indicate years in which the numeric criteria of 10 mg/L was exceeded.

Year	Sample count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances (%)
2009	16	23	5	105	9	56
2010	17	116	4	890	10	59
2011	20	48	3	380	14	70
2012	13	110	5	740	9	69

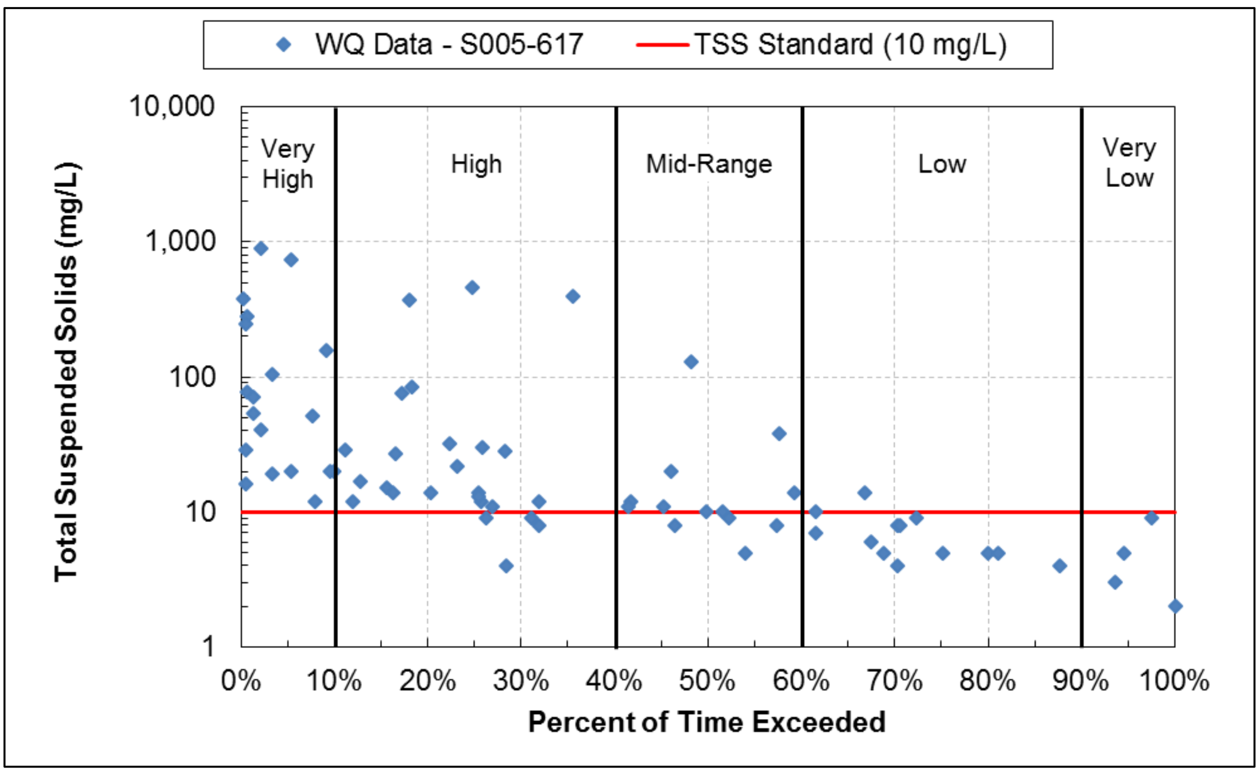
Table 6. Monthly summary of TSS data for Skunk Creek (S005-617), 2009–2012

Values in red indicate months in which the numeric criteria of 10 mg/L was exceeded.

Month	Sample count	Mean (mg/L)	Minimum (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
March	3	39	16	71	NA	NA
April	8	37	5	130	6	75
May	14	118	8	740	13	93
June	14	71	9	400	12	86
July	6	24	9	85	3	50
August	13	121	5	890	8	62
September	11	6	3	9	0	0
October	5	102	2	461	NA	NA

NA: not applicable because the TSS standard does not apply during this month.

Figure 10. TSS water quality duration curve, Skunk Creek



3.4 Water quality impairment assessments

The MPCA assesses the use support of individual water bodies in Minnesota.

Three reaches in the Skunk Creek watershed were assessed by the MPCA (MPCA 2014). Elim Creek (04010301-501) and the segment of Skunk Creek downstream of Elim Creek (04010301-502) are identified as impaired for aquatic life based on Fish IBI and TSS (turbidity), respectively (Table 7). The reach of Skunk Creek (04010301-504) above its confluence with Elim Creek was identified as fully supporting for aquatic life based on fish and macroinvertebrate IBIs even though a barrier was located just upstream of Skunk Creek's confluence with the Nemadji River that prevented migration of trout species into available habitat found in Elm and Skunk Creeks. The barrier was removed in 2019 to increase the stream connectivity. The reach was not assessed for the other water quality standards. The downstream reach of Skunk Creek was not assessed for fish and macroinvertebrate IBIs given that data was not available. Table 8 shows the Minnesota Stream Habitat Assessment (MSHA) overall rating and associated scores for land use, riparian, substrate, fish cover and channel morphology categories.

Table 7. Assessment status of stream reaches (MPCA, 2014)

AUID (Last 3 digits)	Stream	Reach Description	Aquatic Life							Aquatic Rec.	Protection or Restoration Focus
			Fish IBI	Macroinvertebrate IBI	Dissolved Oxygen	Turbidity/TSS	Chloride	pH	Ammonia	*E. coli* Bacteria (fecal pollution)	
501	Unnamed creek (Elim Creek)	Unnamed cr to Skunk Cr	Imp	Sup	NA	NA	NA	NA	NA	NA	Restoration
504	Skunk Creek	Headwaters to Unnamed cr	Sup	Sup	NA	NA	NA	NA	NA	NA	Protection
502	Skunk Creek	Unnamed cr to Nemadji R	NA	NA	Sup	Imp	NA	Sup	NA	NA	Restoration

Sup = found to meet the water quality standard and therefore is supportive of the designated use, Imp = does not meet the water quality standard and therefore is impaired, NA = not assessed

Table 8. Average Minnesota Stream Habitat Assessment results (MPCA, 2014)

Aggregated HUC-12	Land use	Riparian	Substrate	Fish cover	Channel morph.	MSHA score	MSHA rating
	(0-5)	(0-15)	(0-27)	(0-17)	(0-36)	(0-100)	
Skunk Creek	5	13	19.7	9.5	26.5	73.7	Good

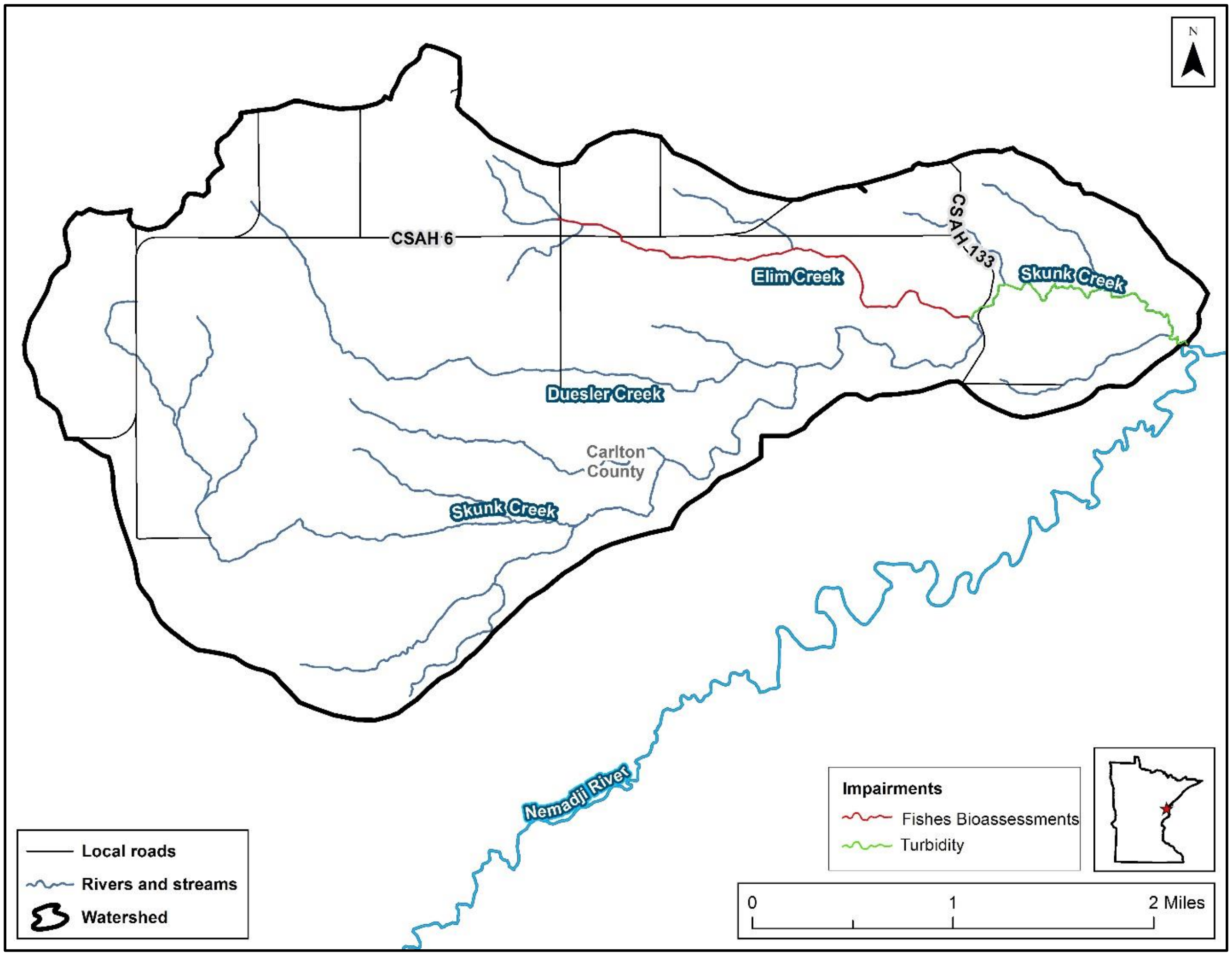
3.5 Impairment 303(d) listings

Water quality impairments are identified in the Minnesota's 303(d) list. The most recent approved updates of the 303(d) list occurred in 2018; however, the Skunk Creek Watershed has listed impairments dating back to 2014. Figure 11 shows the impairments and Table 9 describes the criteria, date of listing and the current status of TMDL development.

Table 9. Impaired streams in the Skunk Creek Watershed (MPCA 2018)

Reach name	Reach description	Classification	Year listed	River AUID	Affected designated use	Pollutant or stressor	Status of TMDL
Skunk Creek	Unnamed cr to Nemadji R	2A	2014	502	Aquatic Life	TSS	Approved
Unnamed creek (Elm Creek)	Unnamed cr to Skunk Cr	2A	2014	501	Aquatic Life	Fishes Bioassessments	None

Figure 11. Impairments in the Skunk Creek Watershed



3.6 Stressor identification for biological impairments

Biological stressor identification is the process of identifying the major factors causing harm to fish, macroinvertebrates and other aquatic organisms. The MPCA conducts a stressor identification process to identify the likely stressors causing either fish or macroinvertebrate biota impairments. This process encompasses both evaluation of pollutants and non-pollutant-related (e.g., altered hydrology, fish passage, habitat) factors as potential stressors. The Nemadji River Stressor Identification Report (EOR 2014) evaluated the potential stressors of the fish bioassessment impairment in Elim Creek, a tributary to Skunk Creek.

Habitat fragmentation was identified as the primary stressor to the fish community in Elim Creek. The fragmentation was primarily due to a large red clay dam on Elim Creek and a red clay structure located below the confluence of Elim Creek with Skunk Creek and downstream of the biological monitoring site on Skunk Creek. The red clay structure was removed in 2019 and is no longer a barrier to fish movement.

Past and recent flow alteration are potential stressors to the fish community in Elim Creek. Past land use changes such as logging and others caused by human activities have resulted in increased volumes and rates of runoff and stream-flow that have altered the channel stability and evolution of Elim Creek. Numerous dams and culverts also impact flow in Elim Creek. The Elim Dam, initially constructed to manage channel incision in the clay zone, is likely leading to flow alterations. The red clay dam structures likely restrict some of the spring-fed base flow sources to Elim Creek. The physical habitat of Elim Creek is another potential stressor to the fish community in Elim Creek. While the channel is stable at the fish monitoring site, the channel upstream is incising.

While TSS concentrations exceed the TSS coldwater standard of 10 mg/L, TSS is not likely driving the low invertebrate and fish IBI scores in Elim Creek relative to the more pronounced impacts that low stream flows, physical habitat quality, and habitat fragmentation are having on the health of the biological community. It is also important to note that water quality standards are based on a range of acceptable conditions that support a beneficial use (such as aquatic life), with the standard chosen to be conservatively protective.

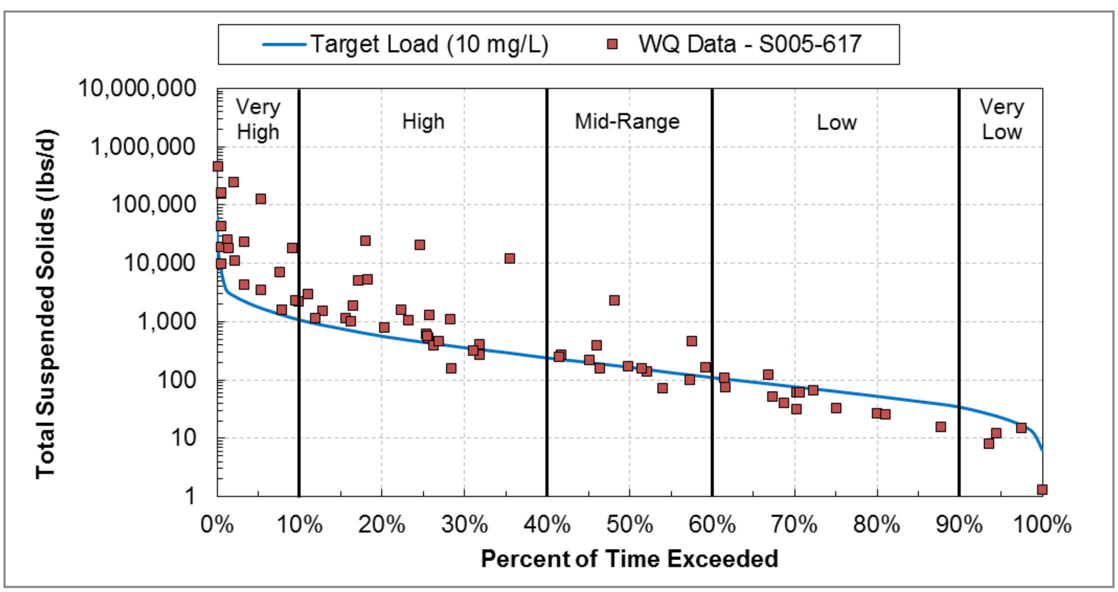
3.7 TMDLs

A TSS TMDL was approved in 2017 for Skunk Creek (-502) as part of the Nemadji River Watershed TMDLs (Tetra Tech 2017a). The TMDL requires high levels of TSS load reductions, focused on the mid-range and higher flow conditions (Table 10).

Table 10. Skunk Creek (04010301-502) TSS TMDL summary

TMDL Parameter	**Flow Regime**				
	Very High	**High**	**Mid-Range**	**Low**	**Very Low**
	TSS Load (lbs/day)				
Construction Stormwater WLA (NPDES permit #MNR100001)	0.37	0.094	0.035	0.013	0.0048
Load Allocation	1,600	400	149	57	20
MOS	178	44	17	6.4	2.3
Loading Capacity	**1,778**	**444**	**166**	**63**	**22**
Existing Load	202,354	5,270	444	102	14
Percent Load Reduction	99	92	63	38	0

Figure 12. Load duration curve for Skunk Creek (Tetra Tech 2017b)



4. Pollutant source assessments

Pollutant source assessments are conducted for typical pollutants and where a biological stressor identification report process identifies a pollutant as a stressor. Sources of pollutants to waterbodies include point sources or nonpoint sources. There are no point sources in the Skunk Creek watershed with the exception of development activities which fall under the General Stormwater Construction Permit. The primary pollutant of concern in the Skunk Creek watershed is sediment. In addition to sediment, limitations to fish passage due to habitat fragmentation and low flows is a primary concern in the Skunk Creek Watershed (as summarized in Section 3.6).

Sediment loads in the Skunk Creek Watershed are dominated by near-channel sources as is commonly found throughout the Nemadji River Watershed (Tetra Tech 2017b). The highest level of near-channel loading occurs downstream of the confluence with Elim Creek. According to CCSWCD (2014a), hydrologic changes caused by historic logging and other human activities have resulted in increased volumes and rates of runoff and stream-flow. These changes have resulted in higher stream-flow energies that, in turn, have increased stream bank and bluff erosion and slumping.

A significant threat of near-channel sediment load is associated with the deterioration of the red clay dams along the stream. The dams were originally built to address the sedimentation problems in the Nemadji River but are now becoming significant contributors as they fail. Each of these dams could contribute a very large one-time contribution to sediment loading at the failure, but also continue to increase sediment loading following the failure of the dams. Additionally, these failing dams continue to impede fish passage and contribute to sediment loading as they erode into the streams. Erosion from area roads and incorrectly sized/perched culverts add to the sediment loading.

The watershed has experienced 200-year rainfall events each year for the past three years. The additional precipitation has increased the threat of dam failure, increased loading from culverts and road erosion, and will continue to increase the streamflow to further alter the hydrology and speed up streambank erosion.

Sources of sediment to Skunk Creek were modeled in the Nemadji River Watershed TMDL (Tetra Tech 2017a) and summarized in Table 11.

Table 11. TSS loads by source to Skunk Creek (Tetra Tech 2017a)

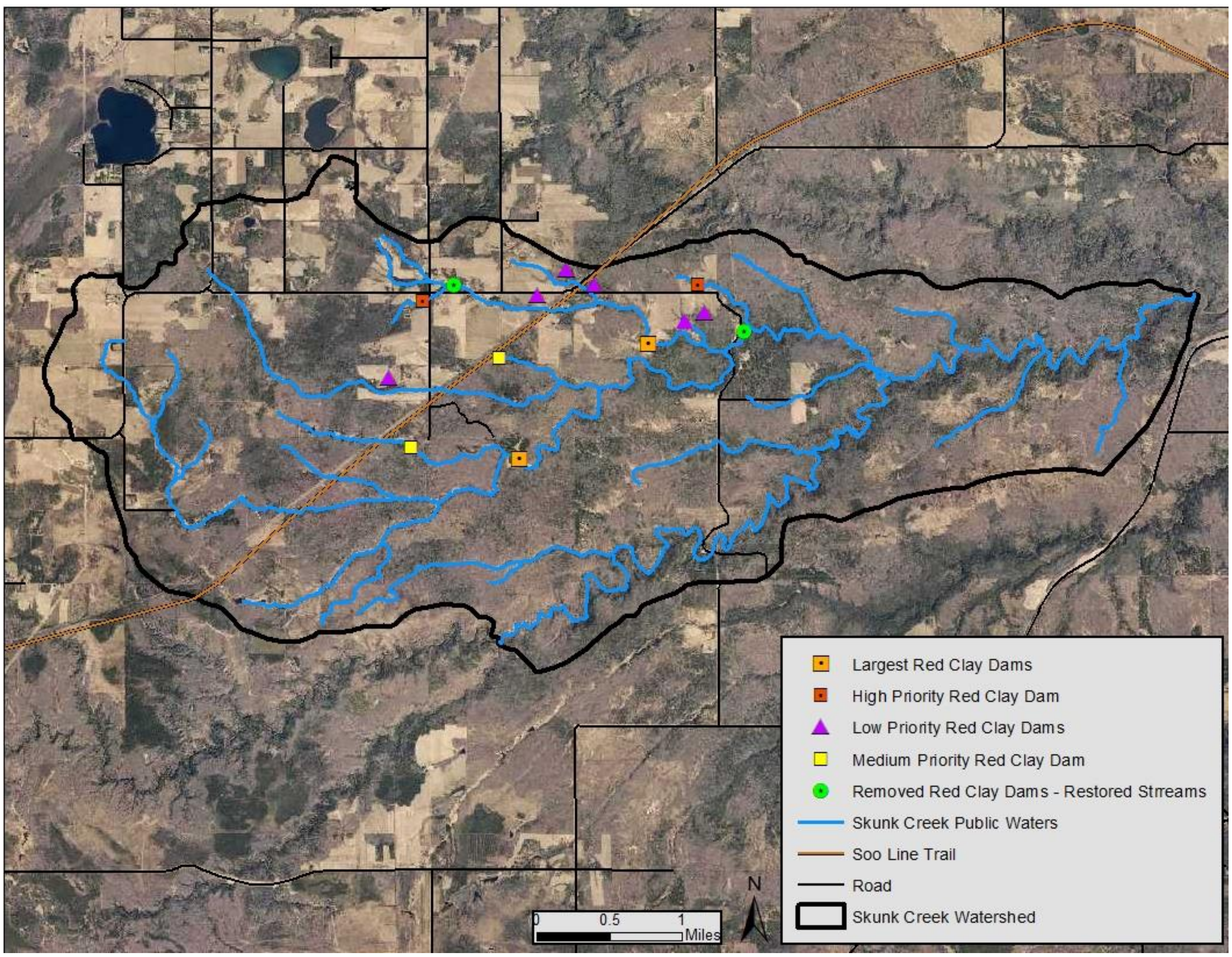
Sources		**TSS load**	
		ton/yr	**%**
Watershed	Forest	142	6
	Shrub	16	<1
	Pasture	109	5
	Crop	34	1
	Developed	56	2
	Roads	7	<1
	Wetlands	53	2
Near-channel		1,965	86
Total TSS Load		2,283	100

5.0 Watershed critical areas

The Nemadji River system is a high priority in the Lake Superior Basin given its numerous native brook trout streams. It is also a high priority with its extremely high sediment loading to Lake Superior and its significance as a primary hatchery for the non-native Lake Superior steelhead fishery. The sediment load from the Nemadji River is visible from space as large red plumes. Skunk Creek was determined to be a priority in the Nemadji River Watershed given its failing red clay dams.

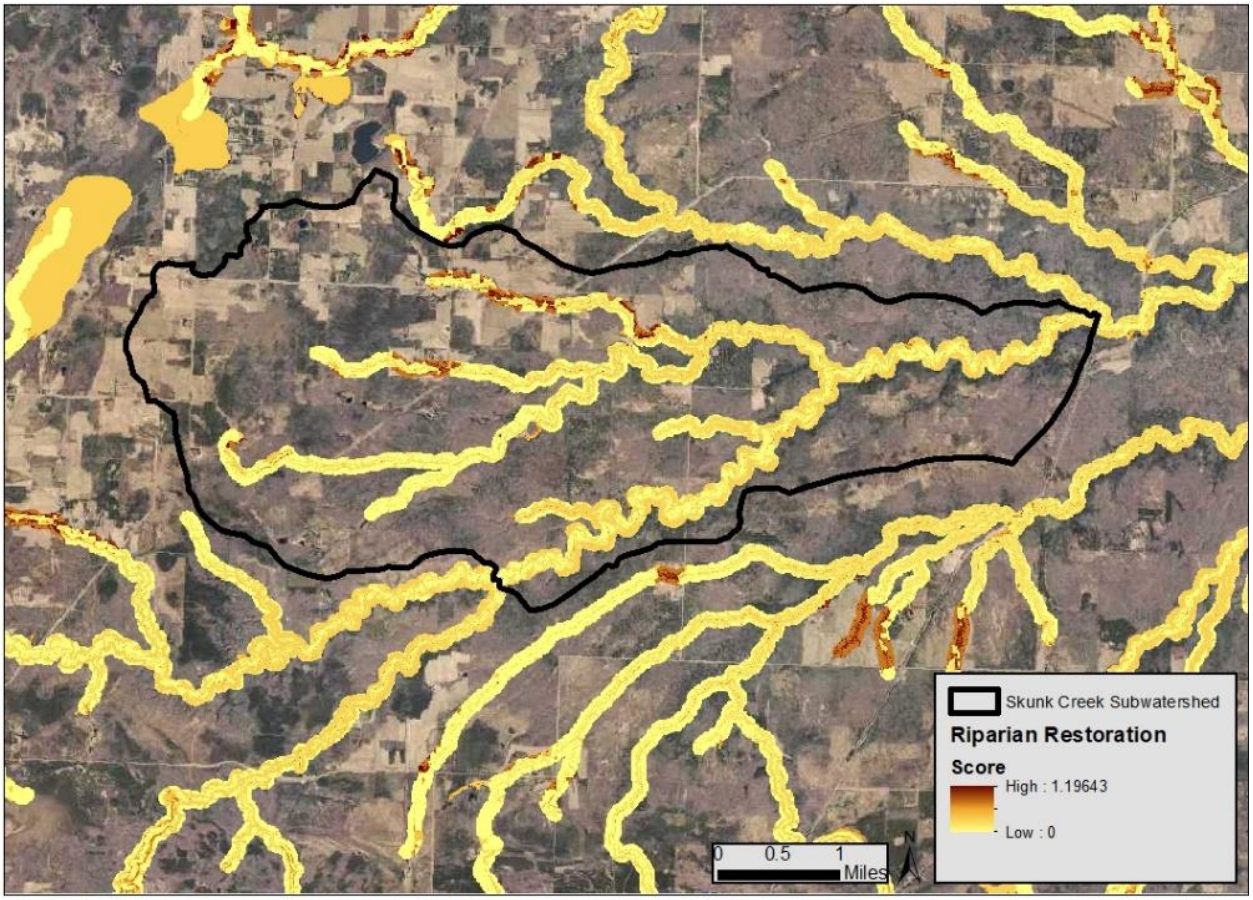
Critical areas contributing to the elevated TSS concentrations and loads in the stream include the failing red clay dams, near-channel erosion, and the road/stream interface areas along the streams. Red clay dams create sediment loading and fish passage problems and also threaten infrastructure and private property. The red clay dams were inventoried and assessed for condition. The inventory also identified the priority in which to restore or replace the dams. The table includes the assessment results along with comments and recommended actions for each dam.

Figure 13. Map of dams needing removal in the Skunk Creek Watershed.



Near-channel sources of sediment include streambank erosion areas and riparian ravines and gullies. The streams are susceptible to significant erosion given their location in the red clay zone of the Lake Superior Lacustrine Clay Plain. Benck et al. (2018) identified critical streambank and riparian areas for restoration as part of the *Nemadji River Watershed Habitat Assessment using LiDAR Data* (Remedial Action Plan Project 9-13) project for the St. Louis River Area of Concern (Figure 14).

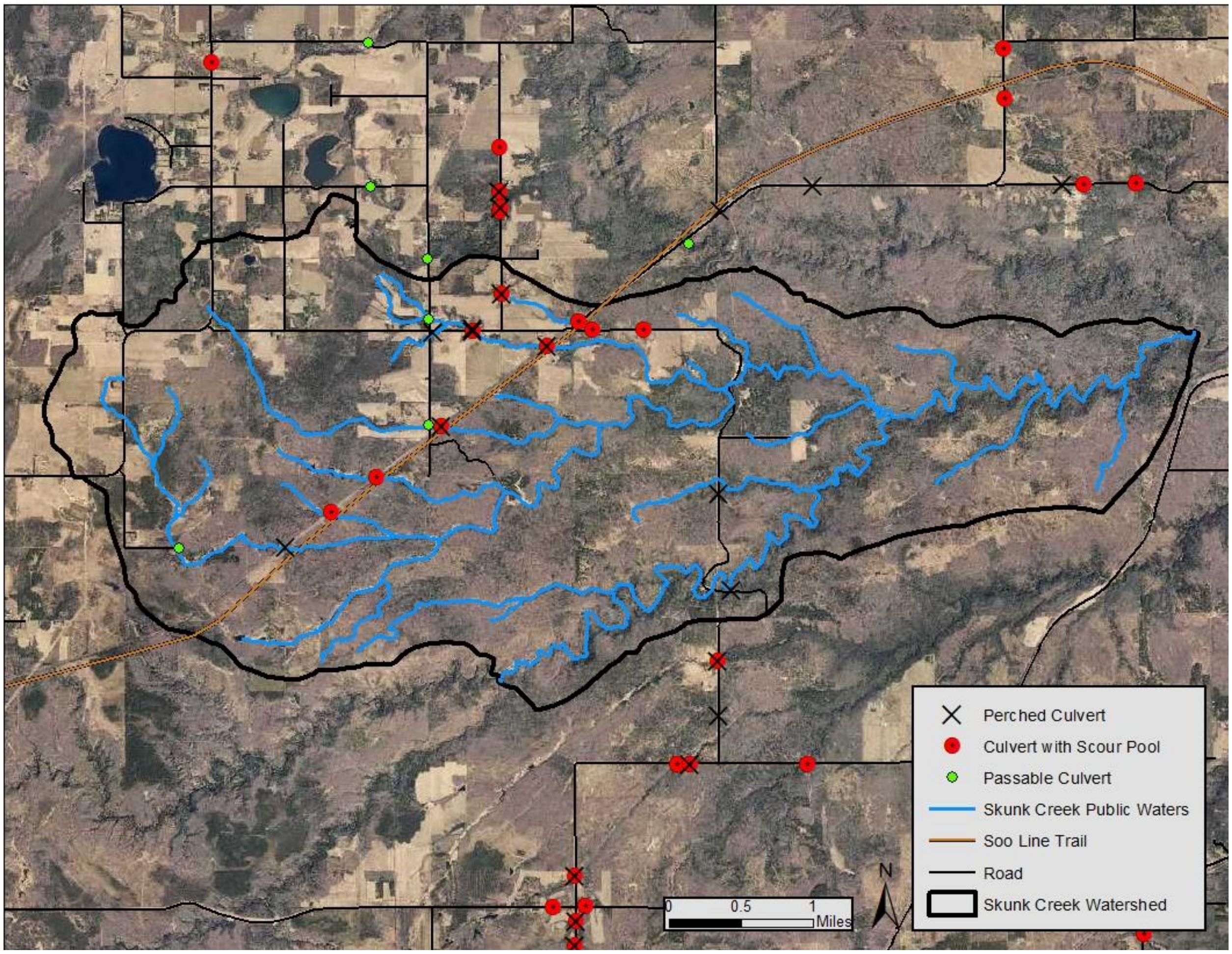
Figure 14. Streambank and riparian restoration areas



Data source: Nemadji River Watershed Habitat Assessment
Saint Mary's University of Minnesota

In addition to the high priority for reducing sediment contributions to the stream with the resulting critical areas for load reductions, a high priority in the watershed is to decrease habitat fragmentation by improving connectivity and habitat in the streams. Connectivity problems are primarily associated with the red clay dams and perched culverts that limit fish passage. Many of the culverts are also under-sized which increased the risks of being blown out and contributing large amounts of sediment to the system. Culvert replacement priorities include the following crossings: Elim Creek South of Pioneer Road, Soo Line Trail crossing of Elim Creek, Elim Creek at CSAH 6, and Soo Line Trail along Tributary #2 to Skunk Creek.

Figure 15. Map of Carlton County road culverts needing replacement in the Skunk Creek Watershed.



6.0 Watershed goals

There are both restoration and protection goals for the Skunk Creek Watershed. Restoration goals are developed for impairments within the Skunk Creek watershed and are derived from existing TMDLs and planning documents. Protection goals are established for issues of concern.

The following restoration goals have been identified for the Skunk Creek Watershed:

- **Meet TSS water quality standards for Skunk Creek:** attainment of the water quality standard is measured by the percent of time that TSS concentrations exceed 10 mg/L.
- **Maintain water temperature for Skunk Creek:** continue to maintain temperatures in line with Class 2A cold water quality streams standards.
- **Meet water quality standards for fish communities in Elim Creek**: Elim Creek is impaired for aquatic life based on fish IBI due to habitat fragmentation from fish passage barriers. The current condition Fish IBI of 20 has to increase to above the Northern Coldwater Streams threshold of 37.
- **Reduced sediment loading in upper reaches of the Skunk Creek Watershed:** reduction in sediment loading in the upper reaches of Skunk Creek which are not currently impaired but do have somewhat elevated TSS concentrations. This segment of Skunk Creek is currently meeting the standards for both fish and macroinvertebrates.
- **Increase watershed storage and reduce peak flows:** Increase the use of forest management plans, buffers, conservation easements, wetland restorations, and land trusts to provide lower peak stream flows and restore floodplain connectivity, thus reducing erosion and sediment loading.

7.0 Management strategies and activities

In the Skunk Creek Watershed, there are many sources of sediment that have been discovered as discussed in Section 4. Sediment loading is incredibly high, especially during very high flow events. The nature of the soil in this area has made it difficult for this stream to meet the water quality standard simply because of the high erodibility of the landscape; however, targeting the critical loading sites will be a large step in the direction of WQS.

There are two layers of threats of significant sediment loading in this watershed that reach beyond the "general" sediment and erosion loading in most areas. The failure of red clay dams located in the watershed and excessive erosion due to inadequate road infrastructure following extreme precipitation events are unique to the region. The dams have reached the end of their design life and are beginning to fail. It is estimated that the largest, and most critical dam for replacement, could release over 100,000 tons upon failure. The imminent failure of this and other dams makes dam replacement a high priority for the watershed partners. This threat will be directly dealt with and reductions discussed in Section 7.1. The sediment loading occurring from erosion at the dams throughout the year along with the other watershed sources is addressed through stream restoration and riparian management activities discussed in Section 7.3. The ongoing reductions from these activities are included in the tables of management activities.

The second layer of threat is the large loading events from large rain events causing significant erosion from gravel roads, erosion at road crossings, and erosion due to undersized and damaged culverts in the watershed. Sediment contribution from this erosion is ongoing, but it is estimated that the now-common torrential rainfalls can contribute as much as 600 tons of sediment to the stream from a single culvert acting as a "firehose" in eroding downstream banks during the rain event. It is estimated that the repair and restructure of five areas in the next ten-years will reduce sediment loading by 19,400 t/large rain event. These event-based loading numbers are estimated based on the watershed partners' observations of the road washouts, culvert damage, and downstream streambank scouring following large events. In the case of the road washout, the estimated amount was based on how much material was used to repair the road washout. These loads are not necessarily reflected in the load estimates from models because the models may not capture extreme events. The critical loads are event-related and the activities to address these problems will be described in Section 7.2.

Addressing the two large storm event-related threats takes care of an immediate and pressing threat. However, the loading to Skunk Creek will remain high, with an estimated 86% of the loading coming from near-channel sources. This will be addressed through stream restoration, riparian management, and addressing altered hydrology through increasing water storage in the watershed. These tasks and activities will be described fully in in 7.3 and 7.4, including estimated costs and reductions. In addition to the restoration activities in the next ten years, efforts will be made to refine and target stream channel restoration, reducing peak flows, and increasing base flows with water storage opportunities.

The goals, milestones, and assessments of implementation for Skunk Creek are provided for each of the implementation practice suites below. More information about each strategy or activity is provided in the following sections.

The FIBI impairment will be addressed by improving the habitat—including removing the significant fish passage barriers created by the red clay dams and the perched culverts. All of the management activities to follow have an element of habitat improvement and will be discussed in each section below. The following practices address connectivity, peak flows, and low base flows to help mitigate this stressor.

7.1 Red clay dam removal and stream restoration

Several red clay dams located in the Elim and Skunk Creek Watersheds have exceeded their planned design life and have begun to fail, resulting in dam breaches and sediment loading to the streams (Table 12). Carlton SWCD has led previous projects to remove three of the dams and restore the channel along Elim Creek. Elim Creek is a tributary to Skunk Creek and is part of the watershed. The restoration work has resulted in approximately 2,200 feet of streambank restoration and contributed 146 t/yr to the overall TSS load reduction. In 2019, the Carlton SWCD and Carlton County Highway Department collaborated on the Skunk Creek Sediment Reduction Project. The removal of this red clay structure resulted in 1,873 feet of streambank restoration and 244 t/yr of sediment reduction.

Additional work is needed to complete the removal and restoration of the remaining failing red clay dams including feasibility studies, design, and construction. The red clay dams are discrete sources of sediment typically located in the upper reaches of the watershed.

The estimated load reductions in Table 13 is to demonstrate the severity of potential failures and are not included in the estimated reductions needed to achieve water quality standards. This is only a demonstration of the catastrophic loading based on failure event. Streambank restoration, which will occur after the dams are removed, is included per dam project as a separate milestone. These reductions, the “day-to-day” reductions, will be described in Section 7.5.

An assessment of the red clay dams was completed by Carlton County SWCD in 2011. The assessment included a primary assessment of all the structures in the Skunk Creek Watershed to identify high risk of failure dam structures for future projects and funding opportunities as shown in Figure 13. This assessment also focused on providing landowners relevant information regarding the structures on their property because all of the dams are on private property. The Skunk Creek Dam Assessment notes that all of the dams have exceeded their life expectancy, so even the ‘low’ priority sites should consider dam breaching and failure in the near future. Three structures along Elim Creek have been removed (CCSWCD 2014a).

Table 12. Skunk Creek dam assessment results (CCSCWD 2014a)

Priority Status	Site	Comments	Recommended Future Actions
High	Elim Dam	Removal will be very expensive, and result in significant number of stream miles reconnected, SWCD financially responsible for maintenance as long as structure is in place.	Seek assistance from other agencies, project will be very expensive and require significant engineering assistance, possibly consultants and contractors to assist with removal method.
High	Dam 2	Recent breach and failure, landowner used to access property.	Design options may include low water ford.
High	Dam 3	Beaver continue to dam spillway structure, overtopping regularly over 2014. A township road lies not far downstream, along with the recently completed Dam 6 removal/stream restoration.	Communicate with landowner regarding dam removal and stream restoration. High likelihood of failure and subsequent damage to infrastructure make this a high priority.
Medium	Dam 4	Dam in good condition, however SWCD is financially responsible for maintenance. Long term solution will need to be found.	Continue to communicate with landowner regarding options of removing dam or taking over maintenance responsibilities.

Priority Status	Site	Comments	Recommended Future Actions
Medium	Dam 5	Dam is used as driveway to access house, is in failing condition for now.	Continue to communicate with landowner and monitor condition of dam.
Medium	Dam 6	Dam is in moderate condition, rust apparent on infrastructure.	Continue to communicate with landowner and monitor condition of dam.
Low	Dam 7	Dam is difficult to assess due to overgrowth. Not much flow.	Continue to communicate with landowner and monitor condition of dam.
Low	Dam 8	Dam is in moderate condition, used for vehicle access.	Continue to communicate with landowner and monitor condition of dam.
Low	Dam 9	Dam is in moderate condition, some rusting by is used regularly for wildlife and recreation by landowner.	Continue to communicate with landowner and monitor condition of dam.
Low	Dam 10	Had the second highest sediment contribution from 2012 flood, already breached.	Could be a fairly low cost project to reduce the most sediment contribution.
Low	Dam 11	Dam is mostly breached, would be good candidate for restoration.	Communicate with landowners and secure funding to stabilize erosion.

There are six dams that are identified as critical areas—these are the ones that are directly influencing an impaired water, on public waters, and have the highest risk of failure. Failure of these dams will result in significant sediment loading. Additionally, these dams are contributors to the fish bioassessment impairment and must be addressed to enable fish passage. Removing the standing/ponding water behind the dams will decrease water temperature, making the conditions better to reintroduce trout. The largest dam to be removed, Elim Dam, will address the habitat fragmentation for Elim Creek. The stressor identification indicates that this remaining dam is the primary barrier to fish.

It is conservatively estimated that the two largest dams could contribute over 200,000 tons/event should they fail. These six dams are ranked as high and moderate in Table 12.

There are an additional six dams that should be replaced; however, they are less critical due to less impact, off the public waters, or may have already failed. Continued monitoring of the dams is necessary to capture any significant changes that occur. The Watershed partners are fully aware of the current conditions of the dams; however, this is subject to change based on many factors.

The red clay dams also inhibit fish passage, contributing to the habitat stressors. Removal of these dams will increase connectivity in the stream. The restoration will also help restore the hydrology of the stream, including near-channel subsurface storage that will likely support better base flows.

The 10-year targeted implementation practices for the remediation of the red clay dams in the Skunk Creek Watershed is detailed in Table 13. The table describes the activities, milestones, goals, assessment criteria, estimated reductions, and costs per practice. The reductions in the table are assumed at a catastrophic failure rate and are labeled as a “per event” unit. These are not included as part of the reductions estimated to achieve the water quality standard for TSS. The general TSS contribution that occurs on a continuous basis is addressed in Section 7.3 Stream channel and riparian activities.

Table 13. Red clay dam removal strategies, milestones, goals, costs, and expected reductions

Treatment type	Milestones					Long-Term Goals	Assessment	Catastrophic sediment reductions	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)				
Dam removals (milestones related to all dams)	Direct contact of landowners with dams avg. 2 landowners	Direct contact of landowners with dams avg. 2 landowners	Direct contact of landowners with dams avg. 2 landowners	Direct contact of landowners with dams avg. 2 landowners	Direct contact of landowners with dams avg. 2 landowners	Develop and sustain landowner relationships	# of landowners contacted		$5,000
	Continue to monitor/observe dam conditions and reassess potential failure	Continue to monitor/observe dam conditions and reassess potential failure	Continue to monitor/observe dam conditions and reassess potential failure	Continue to monitor/observe dam conditions and reassess potential failure	Continue to monitor/observe dam conditions and reassess potential failure	To have the most up-to-date information on the continually deteriorating dams			
	Continue to work with permitting agencies to mitigate dam.	Reassess approach and potential solutions				Develop and sustain agency relationships Develop mutually agreeable solutions	# of contacts with permitting agencies		$5,000
						Focus on re-establishment of brook trout on this restored stream. A total of 11 dams/barriers removed.	# of barriers		
						Meet FIBI water quality standard by 2035	Meet water quality standards met FIBI >37		

Treatment type	Milestones					Long-Term Goals	Assessment	Catastrophic sediment reductions	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)				
Removal Elim Dam (largest dam)	Feasibility study--request for proposals for an engineering firm preliminary conceptual plan to remove the red clay dams	Survey and design--actual project placements (including permitting, EAWs, etc.)	Construction Phase I	Construction Phase II	Assessment of practice, lessons learned	To improve FIBI Remove sediment loading risk (failure) Increase fish passage Reduces potential thermal loading	# of FIBI # feet of stream reconnected Cold water temperatures maintained	50,000 cu yds or 100,000 T/event of failure *	$2 million
	Work with landowner(s) with peer experience of other dam removals	Classroom to look at the MIBI	Use this as demonstration project, both complete and in progress				# of events		$10,000
				4,000 feet of streambank restoration reducing TSS		Streambank restoration conducted following the dam removal	# of feet streambank	See Section 7.5	
Stream flow monitoring/gauges and turbidity sensors	Develop baseline data of peak flows and turbidity above and below the Elim Dam	Continue monitoring	Continue monitoring	Begin effectiveness monitoring of peak flows and turbidity above and below Elim Dam	Continue effectiveness monitoring of peak flows and turbidity above and below Elim Dam	Reduce stream flow flashiness immediately after rain events	Stream flow data Turbidity data before and after removal		$30,000
Develop citizens' monitoring program	Determine outreach to involved partners to develop network of citizen monitors	Encourage outreach to less-involved watershed residents to monitor (min. 4 new monitors)	Evaluate the effectiveness of outreach Evaluate the collected data	Make program adaptations according to evaluations		Develop an additional source of data and engage/educate citizens	# of participants # of data points collected		$10,000

Treatment type	Milestones					Long-Term Goals	Assessment	Catastrophic sediment reductions	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)				
	Sign up and train new monitors (min 2)								
	Develop goals for peak flow reduction as part of the 1W1P process					To have a quantitative reduction of stream flow	stream flow reduction goal developed		$500
#2 Dam removal	Continue to work with landowner(s) and permitting agencies to mitigate dam.	Reassess approach and potential solutions			Remove dam	To improve FIBI Remove sediment loading risk (failure) Increase fish passage Reduces potential thermal loading	Relationship with landowner(s) # of FIBI # feet of stream reconnected Cold water temperatures maintained	2300 cubic yards or 3500 T/event *	$500
	Determine the thermal loading from the pond.	Propose new solutions to the pond and thermal loads					Thermal differences of the pond		$500
	Design/feasibility study of potential wetland restoration	Restore wetland 1.28 acres			600 feet of streambank restoration	Increase water storage by restoring small wetland	# acres restored # feet restored		$20,000
#3 Dam removal	Initiate communication with absentee landowner(s)	Provide landowner with conceptual plan	Design dam removal project	Remove dam and 600 linear feet of streambank restoration	Assessment of practice, lessons learned	To improve FIBI Remove sediment loading risk (failure) Increase fish passage	Relationship with landowner(s) # of FIBI # feet of stream reconnected	2300 cubic yards or 3500 T/event *	$275,000

Treatment type	Milestones					Long-Term Goals	Assessment	Catastrophic sediment reductions	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)				
						Reduces potential thermal loading	Cold water temperatures maintained # feet restored		
#6 Dam removal	Continue to work with landowner(s)		Provide landowner(s) with conceptual plan	Design dam removal project	Remove dam and restore 600 linear feet of streambank	To improve FIBI Remove sediment loading risk (failure) Increase fish passage Reduces potential thermal loading	Relationship with landowner(s) # of FIBI # feet of stream reconnected Cold water temperatures maintained # feet restored	50,000 cu yds or 100,000 T/event of failure *	$300,000
#11 dam removal	Reach out to build relationship with new landowner(s)	Reach out to build relationship with new landowner(s)	Feasibility study--request for proposals for an engineering firm preliminary conceptual plan to remove the red clay dams	Survey and design--actual project placements (including permitting, EAWs, etc.)	Construction Phase and 600 linear feet of streambank restoration	To improve FIBI Remove sediment loading risk (failure) Increase fish passage Reduces potential thermal loading	Relationship with landowner(s) # of FIBI # feet of stream reconnected Cold water temperatures maintained # feet restored	2300 cubic yards or 3500 T/event *	$200,000
#4 Dam	Build relationship with landowner.		Complete feasibility study for the removal of this dam on Skunk Creek	Design work	Remove dam and restore 4,000 linear feet of streambank	To improve FIBI Remove sediment loading risk (failure) Increase fish passage Reduces	Relationship with landowner(s) # of FIBI # feet of stream reconnected Cold water temperatures maintained	50,000 cu yds or 100,000 T/event of failure *	$2 million

Treatment type	Milestones					Long-Term Goals	Assessment	Catastrophic sediment reductions	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)				
						potential thermal loading			
Stream flow monitoring/gauges and turbidity sensors				Develop baseline data of peak flows and turbidity above and below the Skunk Creek Dam	Begin effectiveness monitoring of peak flows and turbidity above and below the Skunk Creek Dam		Stream flow data Turbidity data before and after removal		
#5 Dam	Reach out to build relationship with new landowner(s)	Reach out to build relationship with new landowner(s)	Feasibility study--request for proposals for an engineering firm preliminary conceptual plan to remove the red clay dams	Survey and design--actual project placements (including permitting, EAWs, etc.)	Construction Phase including 600 linear feet of streambank restoration	To improve FIBI Remove sediment loading risk (failure) Increase fish passage Reduces potential thermal loading	Relationship with landowner(s) # of FIBI # feet of stream reconnected Cold water temperatures maintained # feet of streambank restoration	2300 cubic yards or 3500 T/event *	$300,000
#7 Dam	Reach out to build relationship with new landowner(s)	Reach out to build relationship with new landowner(s)	Feasibility study--request for proposals for an engineering firm preliminary conceptual plan to remove the red clay dams	Survey and design--actual project placements (including permitting, EAWs, etc.)	Construction Phase including 600 linear feet of streambank restoration	To improve FIBI Remove sediment loading risk (failure) Increase fish passage Reduces potential thermal loading	Relationship with landowner(s) # of FIBI # feet of stream reconnected Cold water temperatures maintained # feet of streambank restoration	2300 cubic yards or 3500 T/event *	$200,000

Treatment type	Milestones					Long-Term Goals	Assessment	Catastrophic sediment reductions	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)				
#8 Dam	Reach out to build relationship with new landowner(s)	Reach out to build relationship with new landowner(s)	Feasibility study--request for proposals for an engineering firm preliminary conceptual plan to remove the red clay dams	Survey and design--actual project placements (including permitting, EAWs, etc.)	Construction Phase including 600 linear feet of streambank restoration	To improve FIBI Remove sediment loading risk (failure) Increase fish passage Reduces potential thermal loading	Relationship with landowner(s) # of FIBI # feet of stream reconnected Cold water temperatures maintained # feet of streambank restoration	2300 cubic yards or 3500 T/event *	$200,000
#9 Dam	Reach out to build relationship with new landowner(s)	Reach out to build relationship with new landowner(s)	Feasibility study--request for proposals for an engineering firm preliminary conceptual plan to remove the red clay dams	Survey and design--actual project placements (including permitting, EAWs, etc.)	Construction Phase including 600 linear feet of streambank restoration	To improve FIBI Remove sediment loading risk (failure) Increase fish passage Reduces potential thermal loading	Relationship with landowner(s) # of FIBI # feet of stream reconnected Cold water temperatures maintained # feet of streambank restoration	2300 cubic yards or 3500 T/event *	$200,000
#10 Dam	Reach out to build relationship with new landowner(s)	Reach out to build relationship with new landowner(s)	Feasibility study--request for proposals for an engineering firm preliminary conceptual plan to remove the red clay dams	Survey and design--actual project placements (including permitting, EAWs, etc.)	Construction Phase including 600 linear feet of streambank restoration	To improve FIBI Remove sediment loading risk (failure) Increase fish passage Reduces potential thermal loading	Relationship with landowner(s) # of FIBI # feet of stream reconnected Cold water temperatures maintained # feet of streambank restoration	2300 cubic yards or 3500 T/event *	$200,000

* Reductions in this context are the catastrophic sediment loading from a dam failure. Estimated reductions for the dam removal will be described in Section 7.5.

7.2 Infrastructure management

A continued consideration for the Skunk Creek Watershed is the ongoing contribution of sediment from the various road crossings and failing culverts in the system. These contributions are augmented by the increased size of rainfall events in recent years.

CCSWCD (2014b) conducted an inventory of county culverts and assessment of fish passage in the Nemadji River watershed, including Skunk Creek. The Carlton County Highway Department conducted additional inspections of road crossings and identified several crossings as being barriers to native fish due to infrastructure failure. Some culverts were identified as critical erosion sites (Figure 15). Repairing the erosion sites will decrease TSS loading. Removing the fish barriers will alleviate the stressor of fragmented habitat in the system. The county roads have been an ongoing problem, with massive amounts of repair work and replacement of road surfaces and fill materials. The evidence of these washing out after storm events are the basis for the event-based loading estimates included in Table 14. These are found in the "Torrential Rain Sediment Reduction" column. It could be argued that these significant events are rare; however, the large rain events have been happening consistently over the past several years. There are 11 township road crossings in Skunk Creek that will be evaluated for problems; however, there are no specific fish barriers identified at this time with most of the problem being erosion sites.

In addition to the extreme loads from significant events described in 7.0, general sediment contributions occur on an ongoing basis. The installation of properly-sized culverts will minimize downstream bank erosion and provide fish passage. Road surface management will reduce sediment loading from washouts during storms. Ongoing sediment load reductions are estimated in Section 7.5. It is estimated that there will be a reduction of 176 t/yr of TSS by replacing with five adequately designed and sized culverts. One culvert on County Road 103 was recently replaced with a bridge, reducing sediment by an estimated 67 t/yr.

The culvert under the crossing of the Soo Line Trail at Elim Creek is pictured in Figure 16. The culvert is damaged and estimated to be perched 5 feet, inhibiting the fish passage.

Figure 16. High-priority Soo Line Trail Crossing of Elim Creek

The 10-year targeted implementation practices for the remediation of the infrastructure in the Skunk Creek Watershed is detailed in Table 14. The table describes the activities, milestones, goals, assessment criteria, estimated reductions, and costs per practice. Reductions in Table 14 are based on a torrential rain event and are labeled as t/event.

Table 14. Infrastructure management strategies, milestones, goals, costs, and expected reductions

Treatment Groups	Treatment type	Milestones					Long-Term Goals	Assessment	Torrential rain sediment reductions	Costs
		2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)				
Culvert and road management	Overall goals					Upgrade 4 identified fish passage barriers on mainstem and tributaries	Re-establishment of brook trout on this restored stream. Fully restored stream connectivity Reduce sediment loading (Section 7.5)	# feet of stream reconnected	N/A	
	Collection and evaluation of data to determine effects of TSS reductions and stream connectivity above and below the culvert/road crossing restorations	SWCD evaluation monitoring for effectiveness of BMPs on TSS in Elim and Skunk Creeks	SWCD evaluation monitoring for effectiveness of BMPs on TSS in Elim and Skunk Creeks	SWCD evaluation monitoring for effectiveness of BMPs on TSS in Elim and Skunk Creeks	SWCD evaluation monitoring for effectiveness of BMPs on TSS in Elim and Skunk Creeks	SWCD evaluation monitoring for effectiveness of BMPs on TSS in Elim and Skunk Creeks	Determine the effectiveness of implementation activities	# of samples, inventories, and evaluations TSS data		$1,000
		Start IWM cycle with MPCA to repeat in 10 years	Complete IWM cycle				Meet water quality standards met FIBI >37 by 2035	FIBI		
Specific projects	Replace Elim Creek culvert at Pioneer Road				Engineering/design year one, installation year two			# of culverts fixed # feet of stream reconnected	600 T/event *	$200,000

Treatment Groups	Treatment type	Milestones					Long-Term Goals	Assessment	Torrential rain sediment reductions	Costs
		2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)				
					200 feet of streambank restoration (part of culvert replacement)			# feet restored		
	Replace Soo Line Trail culvert at crossing of Elim Creek			Engineering/design year one, installation year two		Monitor for effectiveness		# of culverts fixed # feet of stream reconnected	600 T/event *	$350,000
				200 feet of streambank restoration (part of culvert replacement)				# feet restored		
	Replace Elim Creek culvert at County State Aid Highway 6	Engineering/design year one, installation year two		Monitor for effectiveness		Connect the streams to restored area first		# of culverts fixed # feet of stream reconnected	600 T/event *	$550,000
		200 feet of streambank restoration (part of culvert replacement)						# feet restored		

Treatment Groups	Treatment type	Milestones					Long-Term Goals	Assessment	Torrential rain sediment reductions	Costs
		2-year (2023)	**4-year (2025)**	**6-year (2027)**	**8-year (2029)**	**10 year (2031)**				
	Soo Line Trail along Tributary #2 to Skunk Creek		Engineering/design year one (in house), installation year two		Monitor for effectiveness	Connect the streams to restored area first		# of culverts fixed # feet of stream reconnected	600 T/event *	$100,000
			200 feet of streambank restoration (part of culvert replacement)					# feet restored		
	11 township road crossings	Inventory and mitigate erosion at all 11 road crossings for township roads	Identify all erosion sites	Maintain inventory of erosion	Replace and upgrade 50% of culverts (150 ft stream each)		Knowledge of all town road and trail crossings in Skunk Creek Watershed	# of miles replaced # of inventories # feet restored		$45,000/mile
	Road surface stabilization CR 103 crossing Skunk Creek and culvert replacement	Road surface stabilization (1/4 mile)	Continue to identify sites	Monitor for effectiveness					17,000 T/event *	
		200 feet of streambank restoration (part of culvert replacement						# feet restored		
	Six remaining county road and Soo Line trail crossings with culvert problems		Design work completed	Construction of 2 culvert repair/replace	Construction of 2 culvert repair/replace	Construction of 2 culvert repair/replace	All culverts are properly sized	# of culverts fixed	600 T/event x 6 culverts *	$200,000 per crossing

Treatment Groups	Treatment type	Milestones					Long-Term Goals	Assessment	Torrential rain sediment reductions	Costs
		2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)				
				300 feet streambank restoration	300 feet streambank restoration	300 feet streambank restoration		# feet of stream reconnected		

* Reductions in this context are the massive loading from increasingly common torrential rain events. For reductions from culvert replacements see Section 7.5

7.3 Stream channel restoration and riparian management

Near-channel and streambank erosion is considered to be the primary contributing source of sediment in the watershed. The WRAPS identified the need for stream channel restoration and stabilizing of ravines, banks, headcuts, and shoreland along Skunk Creek. A long-term goal to restore 15,000-20,000 linear feet of streambank to address TSS loading in the stream was established. The initial activity for the stream channel restoration and management strategies involves the completion of an in-depth geomorphic assessment of the stream (e.g., Rosgen Level III analysis or some portion of a WARSSS approach) and inventory of slumps and bank failures. This will identify, prioritize, and provide data to identify cost-effective restoration opportunities and provide for restoration design planning for the most critical portions of the channel. The geomorphic assessment will be completed by the DNR. Initial critical areas are shown in Figure 14. Subsequent implementation activities will include extensive streambank restoration of critical eroding banks and increased tree cover shading the stream along currently stable reaches of the streams.

Stream channel restoration will provide sediment reduction on a continual basis. The Skunk Creek Watershed Partners are conducting a study and assessment to determine the most critical stream banks to target and repair. The assessment and implementing 15,060 linear feet of stream bank restoration are the goals for the first ten years. Targeted placement and further implementation goals will be added following the study. In addition, there are approximately 17,500 linear feet of streambank restoration that will coincide with the dam removals discussed in Section 7.1 and 1,900 feet of stream bank restoration that will coincide with the culvert replacements discussed in Section 7.2. Past work has also included 25,500 ft of past streambank restoration.

Considering the loading and the soil types in this area, streambank restoration will be critical to achieving the significant reductions needed to achieve water quality standards. Understanding the effectiveness of the practices implemented is critical to achieving water quality standards in any plan; however, it is even more significant in this case. Monitoring will be conducted to determine the effectiveness of the BMPs implemented at the edge-of-field and in-stream. The watershed partners will determine if these BMPs will meet the significant reductions necessary to reach water quality standards and will adjust the plan accordingly during year five.

The combination of streambank restoration and riparian vegetation management will provide multiple benefits to the system through reduced sediment loading, maintenance of water temperatures, and improving fish habitat in the stream through channel stabilization. Restoration of the streams also addresses connectivity, habitat, and hydrology. Areas for streambank and riparian restoration areas are identified in Figure 14. The 10-year targeted implementation practices for the stream channel and riparian area strategies in the Skunk Creek Watershed are detailed in Table 15. The table describes the activities, milestones, goals, assessment criteria, estimated reductions, and costs per practice.

Table 15. Stream channel restoration and riparian management strategies milestones, goals, assessment criteria, estimated reductions, and costs

Treatment type	Milestones					Long-Term Goals	Assessment	Costs
	2-year (2023)	**4-year (2025)**	**6-year (2027)**	**8-year (2029)**	**10 year (2031)**			
Stream geomorphic study and assessment	Complete geomorphic assessment of streams (e.g., Rosgen Level III analysis or some portion of a WARSSS approach) by the DNR	Develop channel and riparian area restoration plan to address findings from assessment				Develop an understanding of stream conditions for stabilizing the streambanks	Assessment completed Channel restoration plan developed	$15,000
Stream bank restoration	Determine restoration opportunities based on assessment and inventory	Build relationships with landowner(s) and educate about potential co benefits of restoration	Restore 5,020 linear feet of stream bank	Restore 5,020 linear feet of stream bank	Restore 5,020 linear feet of stream bank	Restore identified incised streams and failing banks along 15,060 linear feet within the Skunk Creek Watershed	# of linear feet restored	$250 /linear foot
Improve riparian vegetation	Increase shade in riparian corridor to achieve <1% of summer days with water temperatures lethal to trout	Build relationships with landowner(s) and educate about potential co benefits of restoration	Plant vegetation	Ensure establishment of vegetation		Plant 450 linear feet of riparian vegetation	# of linear feet restored	$2,500

Treatment type	Milestones					Long-Term Goals	Assessment	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)			
Grassed buffers	Establish relationship with landowners and 130 ft of buffer installed (grass, 35 ft wide)	Establish relationship with landowners and 130 ft of buffer installed (grass, 35 ft wide)	Establish relationship with landowners and 130 ft of buffer installed (grass, 35 ft wide)	Establish relationship with landowners and 130 ft of buffer installed (grass, 35 ft wide)	Establish relationship with landowners and 130 ft of buffer installed (grass, 35 ft wide)	650 ft of grassed buffers on riparian land	# ft of grassed buffers	$3,000
Early successional habitat development management	Work with landowners; Implement 100 acres of early successional habitat	Work with landowners; Implement 100 acres of early successional habitat	Work with landowners; Implement 100 acres of early successional habitat	Work with landowners; Implement 100 acres of early successional habitat	Work with landowners; Implement 100 acres of early successional habitat	Plant and develop 500 acres of land to create and manage early habitat	# of acres	$10,000
Cover crops	Work with landowners/ Producers to understand the need for cover crops	Implement cover crops on 66 acres of ag land within Skunk Creek	Follow up with farmers, evaluating the use and effectiveness of cover crops	Monitor cover crop usage, update outreach as necessary		All 66 acres of cropland utilizing cover crops	# of acres	$2,000
Evaluation of the plan		Collect data of BMP effectiveness, including "edge-of-field" monitoring	Analysis of all BMP monitoring data collected to date to determine changes in this plan	Change and/or add BMPs to ensure that the BMPs selected are effective.	Implement additional BMPs, continue monitoring BMP effectiveness	TSS standard met within 10 years; understanding of the success of the plan and the adaptations necessary to meet goals	# of T/yr reduced of TSS	$5,000

7.4 Water storage activities to reduce peak flows

It is a goal of Skunk Creek Watershed partners to slow the speed of the water and improve the water storage in the upland areas of the watershed. AS part of the development of the 1W1P for the entire Nemadji, numeric water storage/flow reduction numbers will be developed specifically for Skunk Creek Watershed as identified in Table 16. The goal of water storage and curbing peak flows is part of the larger two-state initiative to 'Slow the Flow' in the Nemadji River Watershed as a component of the St. Louis River Estuary Area of Concern. Until these numbers are developed, TSS reductions will be used as a surrogate measure in this plan.

Currently, there are about 1,575 acres of wetlands in the watershed. A concern of the partners is to gain an understanding of wetland function in the watershed through an assessment of the current wetlands and identification of potentially restorable wetlands in the watershed. Understanding the level of function in the existing wetlands will help prioritize and target implementation. While there will be reductions captured from specific activities, such as restored wetlands, the bulk of the benefits will be met by slowing the stream flow to reduce near-channel and stream erosion, reducing the TSS loading to the stream. Further, the restoration of wetlands and increasing water storage on the land, will help to increase base flows, addressing one of the habitat stressors. Figure 17 and

Figure 18 identify areas for potential wetland restoration based on wetland habitat value, value for restoring lost water storage, and value for reducing peak stream flows based on a watershed habitat assessment completed for the Nemadji River Watershed (Benck et al. 2018).

Forest management activities will also provide benefits to the watershed system by protecting, managing, and restoring the forest cover in the watershed. A primary benefit will be to help reduce stream flows by reducing overland runoff with increased infiltration, temporary water holding capacity, and evapotranspiration. Increased water storage activities will help increase base flow to address habitat stressors. Critical areas for forest protection and management are shown in Figure 19.

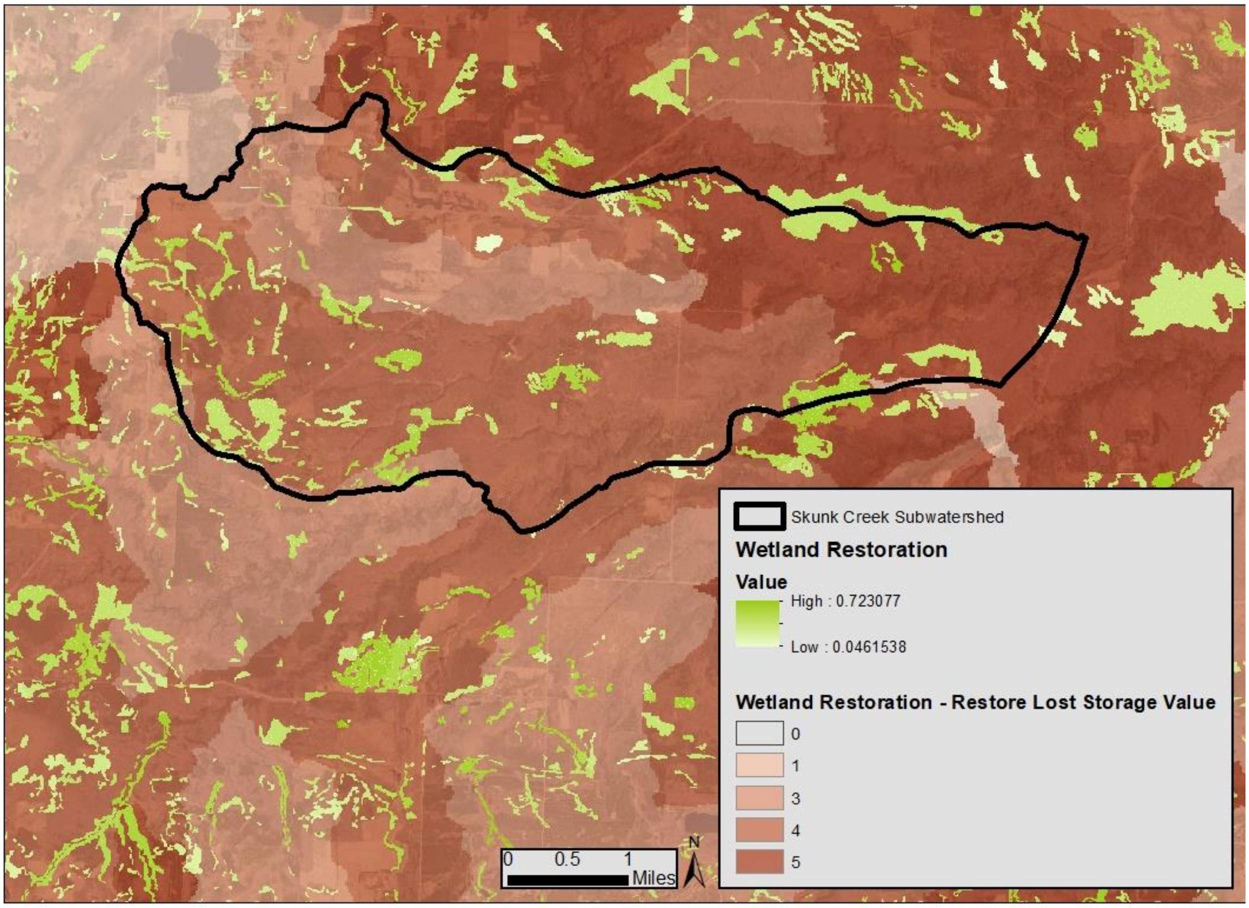
The DNR administers forest management programs. The DNR Forest Stewardship Program helps woodland owners manage their woods through advice and education, cost-share programs, and Woodland Stewardship Plans. A Woodland Stewardship Plan registered with the DNR qualify landowners a cost-share program for improving woodlands and a property tax incentive program through the Minnesota Sustainable Forest Incentive Act (https://www.dnr.state.mn.us/foreststewardship/sfia/index.html). The SFIA provides annual incentive payments to encourage private landowners to keep their wooded areas undeveloped. Management practices that are likely included in the Woodland Stewardship Plans are described in Table 17.

The Minnesota Forest Resources Council provides timber harvesting and forest management guidelines that address the management, use, and protection of historic and cultural resources, riparian areas, soil productivity, water quality and wetlands, wildlife habitat, and visual quality. These guidelines are:

- Comprehensive—address a wide variety of forest resource issues.
- Science-based—grounded in the best available scientific information.
- Voluntary—all landowners apply the guidelines according to their management objectives.
- Integrated—guidelines protecting various forest functions and values are contained in one cohesive package.
- Flexible—accommodate a range of site-level conditions and management objectives.
- Stakeholder based—involve the full spectrum of interests in guidelines development, education, and monitoring.

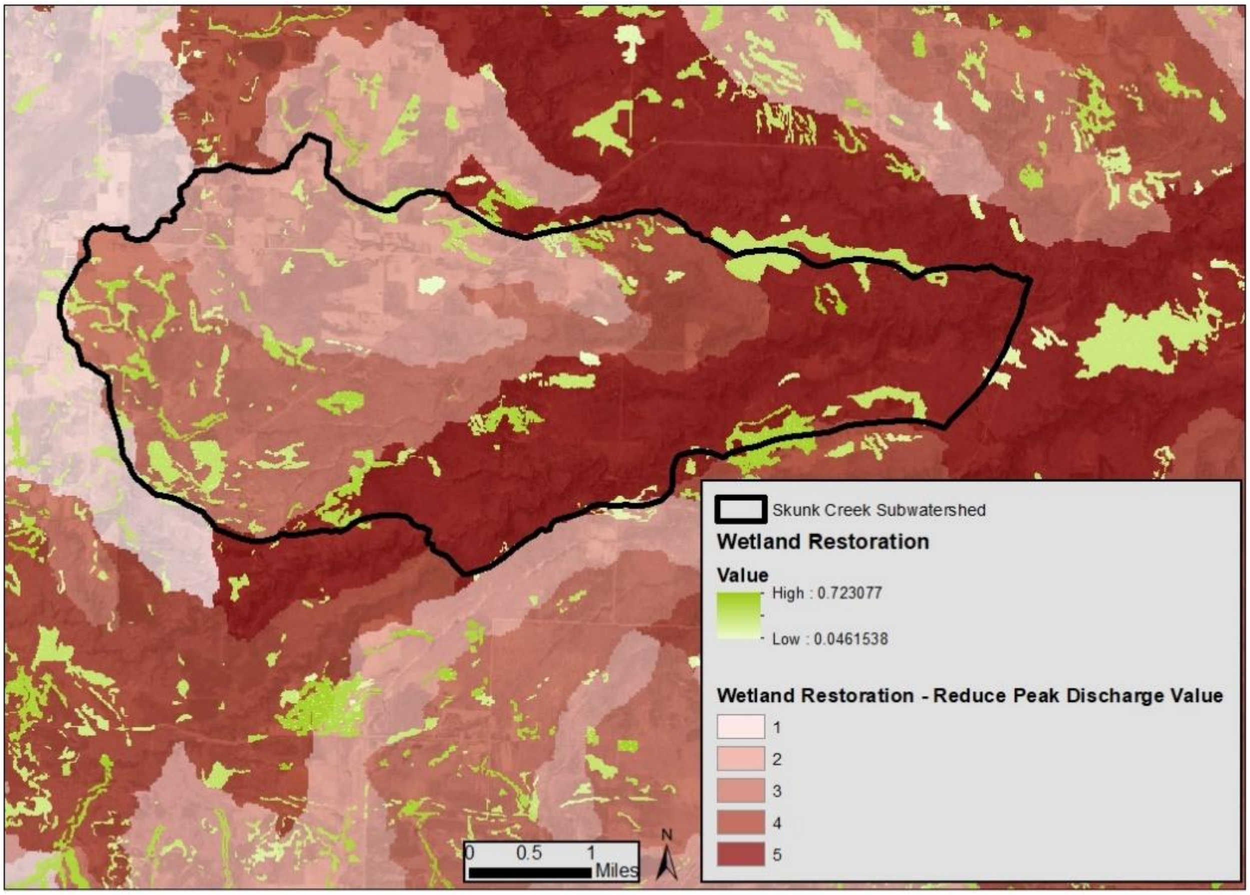
The 10-year targeted implementation practices for the water storage activities in the Skunk Creek Watershed are detailed in Table 16. The table describes the activities, milestones, goals, assessment criteria, and costs per practice.

Figure 17. Wetland restoration to recover lost storage



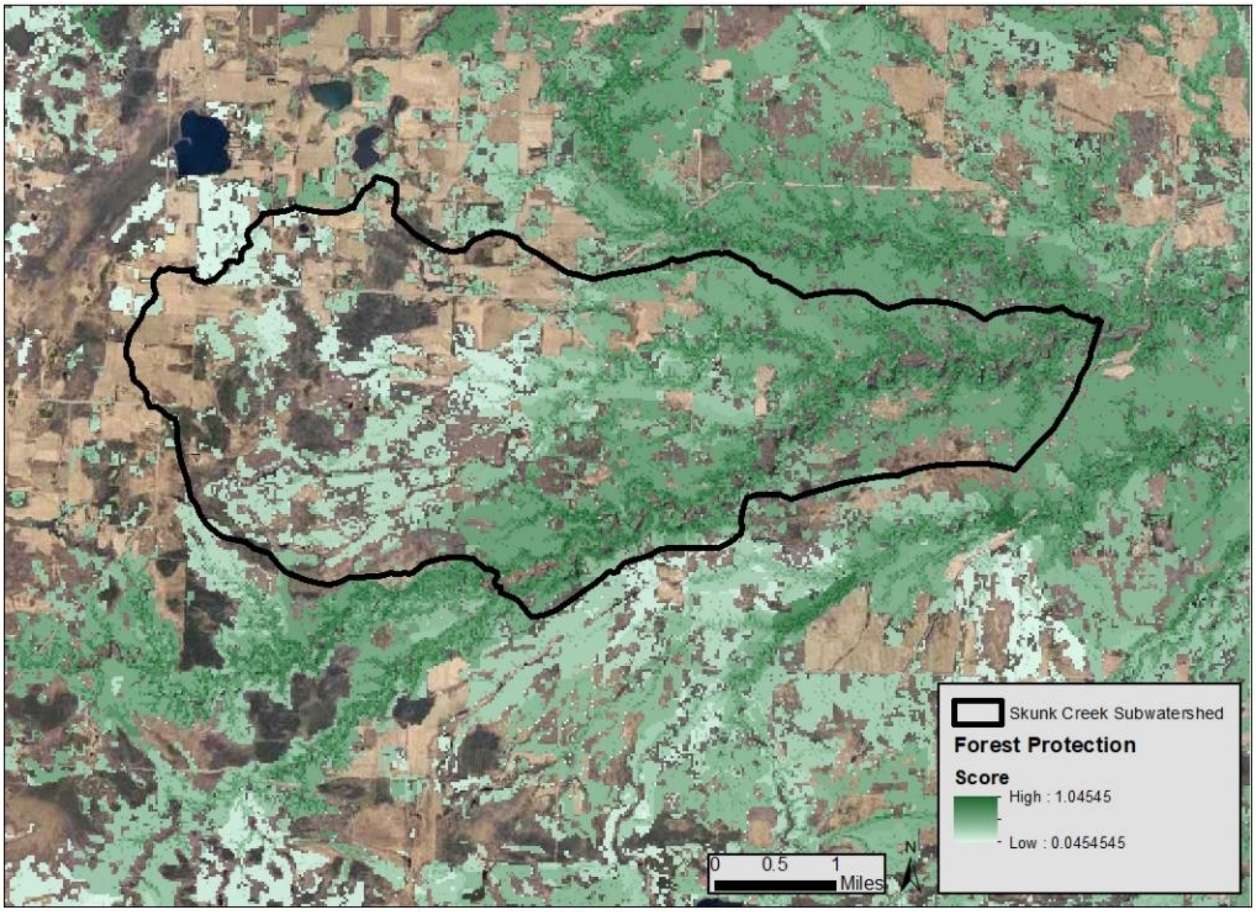
Data source: Nemadji River Watershed Habitat Assessment
Saint Mary's University of Minnesota

Figure 18. Restorable wetland to help reduce peak flow.



Data source: Nemadji River Watershed Habitat Assessment
Saint Mary's University of Minnesota

Figure 19. Forestry protection areas



Data source: Nemadji River Watershed Habitat Assessment
Saint Mary's University of Minnesota

Table 16. Water storage activities to reduce peak flows milestones, goals, assessment criteria, and costs

Treatment type	Milestones					Long-Term Goals	Assessment	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)			
	Develop an acre/feet storage goal for water storage in the 1W1P process					Increase water storage in Skunk Creek Watershed	# of acre/feet of water storage needed	
	Develop goals for peak flow reduction as part of the 1W1P process	Develop implementation strategy(ies) for peak flow reduction	Following development, add milestones for the strategies			Estimated reduction needed by flow regime	Goals developed Implementation strategy complete Milestones added	
Wetland restoration	Assessment of wetland function in Skunk Creek Watershed; Identify sites, number of acres, and targeted restoration priorities	Restore 375 acres of wetlands	Restore 375 acres of wetlands	Restore 375 acres of wetlands	Restore 375 acres of wetlands	Restore 1,500 acres of wetlands at the end of ten years	# of wetlands and # of acres of wetland restored	$10,000/acre
Public outreach	Educate public about wetlands	Educate public about wetlands; engage 3 landowners about wetland restoration	Educate public about wetlands; engage 3 landowners about wetland restoration	Educate public about wetlands; engage 3 landowners about wetland restoration	Educate public about wetlands; engage 3 landowners about wetland restoration	Educated and engaged public	# of events # of engaged landowners	$10,000
	Develop wetland banking program	Promote banking program	Promote banking program	Promote banking program	Promote banking program	Create and support the wetland	Program exists	$5,000

Treatment type	Milestones					Long-Term Goals	Assessment	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)			
						banking program in the area		
Forestry practices	Develop and implement an education and outreach program that uses multiple forms of media to result in increased participation in forest stewardship. The goal will be to link forest management actions to the health of the watershed.	Continue the education and outreach program that uses multiple forms of media to result in increased participation in forest stewardship. The goal will be to link forest management actions to the health of the watershed.	Continue the education and outreach program that uses multiple forms of media to result in increased participation in forest stewardship. The goal will be to link forest management actions to the health of the watershed.	Continue the education and outreach program that uses multiple forms of media to result in increased participation in forest stewardship. The goal will be to link forest management actions to the health of the watershed.	Continue the education and outreach program that uses multiple forms of media to result in increased participation in forest stewardship. The goal will be to link forest management actions to the health of the watershed.	# of mailings, articles, social media posts # of responses to outreach efforts		$1,000
Forest protections and management	Develop 2 Forest Stewardship Plans	Develop 2 Forest Stewardship Plans	Develop 2 Forest Stewardship Plans	Develop 2 Forest Stewardship Plans	Develop 10 Forest Stewardship Plans in the watershed	Develop 124 Forest Stewardship Plans in the watershed	# of Forest Stewardship Plans	$500/plan ($5,000)
Implement practices in forest stewardship plans	Implement 10 projects from suite of practices (Table 17)	Implement 10 projects from suite of practices (Table 17)	Implement 10 projects from suite of practices (Table 17)	Implement 10 projects from suite of practices (Table 17)	Implement 50 identified forestry projects from suite of	Implement 150 identified projects	# BMP projects implemented	

Treatment type	Milestones					Long-Term Goals	Assessment	Costs
	2-year (2023)	4-year (2025)	6-year (2027)	8-year (2029)	10 year (2031)			
					practices (Table 17)			
Timber harvest BMP workshops	Biennial workshop with 10 attendees	Biennial workshop increase attendees by 2	Biennial workshop increase attendees by 2	Biennial workshop increase attendees by 2	Biennial workshop increase attendees by 2	Biennial workshop attended by 20 attendees	# landowners	$3,000
	Increase acres enrolled in Sustainable Forest Incentive Act (SFIA) by 200 acres	Increase acres enrolled in SFIA by 200 acres	Increase acres enrolled in SFIA by 200 acres	Increase acres enrolled in SFIA by 200 acres	1,000 acres in SFIA (or similar easement)	Protect 2,400 acres of forest land in SFIA (or similar easement)		$15/acre ($15,000)

Table 17. Suite of BMPs likely in forest stewardship plans

Timber stand improvement
Tree and shrub planting
Invasive species control
Prescribed burning
Forest and trails and landings
Critical area planting
Conservation cover
Riparian forest buffer
Early successional habitat management

7.5 Load reduction summary

The use of the Spreadsheet Tool for Estimating Pollutant Loads (STEPL) load and load reduction estimates provide a means of evaluating progress in reducing the amount of sediment getting into the stream. The annual sediment load without BMPs was estimated with STEPL is 3,368 t/yr with 236 and 3,132 t/yr from upland and near-channel sources, respectively. The implementation activities in this plan are estimated to provide a 90% reduction in the annual sediment load in Skunk Creek (Table 18). Section 7.6 describes that the 90% reduction will achieve the water quality standard. The table provides the STEPL load reduction estimates for TSS for the ten-year milestones in Tables 13 – 16. STEPL BMPs were assumed and assigned for the treatment practices to calculate reductions and are described in Appendix A. The catastrophic loading from dam failure or the torrential rains are not included in Table 18 and are outlined separately in Table 13 and Table 14.

Table 18. STEPL sediment loads, load reductions, and percent reductions for BMP implementations

Watershed	TSS load (no BMP) t/yr	TSS reduction t/yr	TSS load (with BMP) t/yr	TSS %
Skunk Creek	3367.8	3032.2	335.5	90.0

7.6 Achieving TSS water quality standard

The NKE plan is a reasonable approach to achieve the goals of the watershed partners that include achieving the TSS water quality standard and improving stream habitat and connectivity through streambank restoration and removal of fish barriers. The removal of the red clay dams and the upgrades and replacements of the culverts will restore connectivity and are estimated to improve the fish habitat. The ten-year implementation will result in significant reduced loading, as well as to remove the threat of the catastrophic event loading from dam failure and the excessive loading from the infrastructure problems combined with snowmelt and high rainfall. Elimination of the sources of extreme sediment loads will greatly reduce the TSS load and concentration in individual storm events; thereby, reducing the number of days with TSS concentrations greater than 10 mg/L.

The very significant reduction at very high flow of 98% may not be met with the NKE plan, if implemented as modeled today. It is the stated intent of the watershed partners to closely monitor and analyze the data collected from monitoring and adapt the plan as necessary in year five. This will determine which BMPs are yielding higher TSS reductions and allow for more targeted implementation. Intensive monitoring and analysis may also reveal that these reductions are sufficient to reach the water quality standard in Skunk Creek.

Continuous water quality monitoring combined with water sampling and laboratory analysis will be initiated in the watershed to enable the direct evaluation of the TSS standard being met with the implementation of this plan. Daily TSS concentrations will be computed using a site specific regression analysis between the continuous turbidity and discreet TSS concentration data.

Progress toward achieving the TSS standard will be assessed every two years and additional implementation activities will be incorporated into the plan, as necessary.

7.7 Achieving connectivity, habitat, and hydrology goals

The milestones, goals, and activities described in previous sections will also address the connectivity, habitat, and streamflow issues identified as stressors to aquatic life. These issues have been identified as necessary aspects in achieving overall watershed health by the Skunk Creek Watershed partners. The removal of the fish barriers (red clay dams, perched culverts) will restore the streams' connectivity, hydrology (base flows, reduce peak flows), along with achieving the TSS water quality standard.

8.0 Education and outreach

As described in Carlton County (2014), information and education activities are based on a focused effort to have a citizen-led civic engagement strategy. It includes a framework determined by citizen volunteers to extend outreach and education throughout the Nemadji Watershed. The end goal is to extend the scientific data to the land users to improve the Nemadji Watershed and find local solutions to the local water quality issues. Special focus will be on coordinating with local schools, creating a Red Clay Landowners' Guide, increasing public access and use to public lands, hosting technical workshops with natural resource professionals and landowners. Activities will also include citizen monitoring (transparency, macroinvertebrate events, and possibly flow/temperature), forestry and wetland outreach/education, and working with groups (e.g., Audubon Society, Trout Unlimited) to connect water quality with benefits to habitat.

Other information and education activities identified in existing planning documents include:

- Continued implementation of a watershed and water quality education and outreach program focused on:
  - Riparian users/owners (lakes and streams)
  - Municipal operations
  - Recreational trail users
  - Forestry activities
  - Septic system maintenance and compliance
  - Animal agriculture producers and hobby farmers
  - Stakeholders and residents
- Annual watershed newsletter, 1-2 outreach events each year, education and information for lakeshore residents on septic systems and lake quality, outreach and information for animal agriculture producers and hobby farmers in shoreland areas

9.0 Monitoring

Monitoring in the context of this plan will include elements of various on-going programs and Skunk Creek watershed-specific activities.

Regular monitoring of the condition of the failing red clay dams will be conducted to identify changes in the risk of failure to allow time for adapting the dam removal plans to minimize infrastructure damage from dams that may become imminent risks for failure.

A stream flow and water quality monitoring site at the downstream road crossing of Skunk Creek will be re-established. The site will provide the data needed to determine progress toward and eventual achievement of the TSS water quality standard. The site will include continuous water level, turbidity, and temperature monitoring, development and maintenance of a streamflow rating curve, routine field measurements, and discrete water sampling and laboratory analysis. Twenty to thirty samples will be collected each year, with an emphasis with storm event monitoring. Monitoring plan and costs are estimated in Table 19.

Turbidity sensors will also be installed at six sites along Elim and Skunk Creeks to provide up-and down-stream monitoring of the red clay dam removal sites and the streambank restoration sites, including some at the road crossing and culvert replacement sites. Sensors will be operated collecting 15 minute interval data. Water quality samples will be collected for TSS concentrations to develop a turbidity/TSS relationship for use in calculating TSS concentrations from the continuous turbidity data. Approximately 30 samples will be collected per year, across the flow spectrum. A statistical analysis will evaluate whether or not individual site relationships will require sampling. If the TSS/turbidity relationships are approximately the same across sites, fewer sites will need to be sampled. Ongoing TSS analysis will be used to make sure that the relationship between turbidity and TSS is maintained.

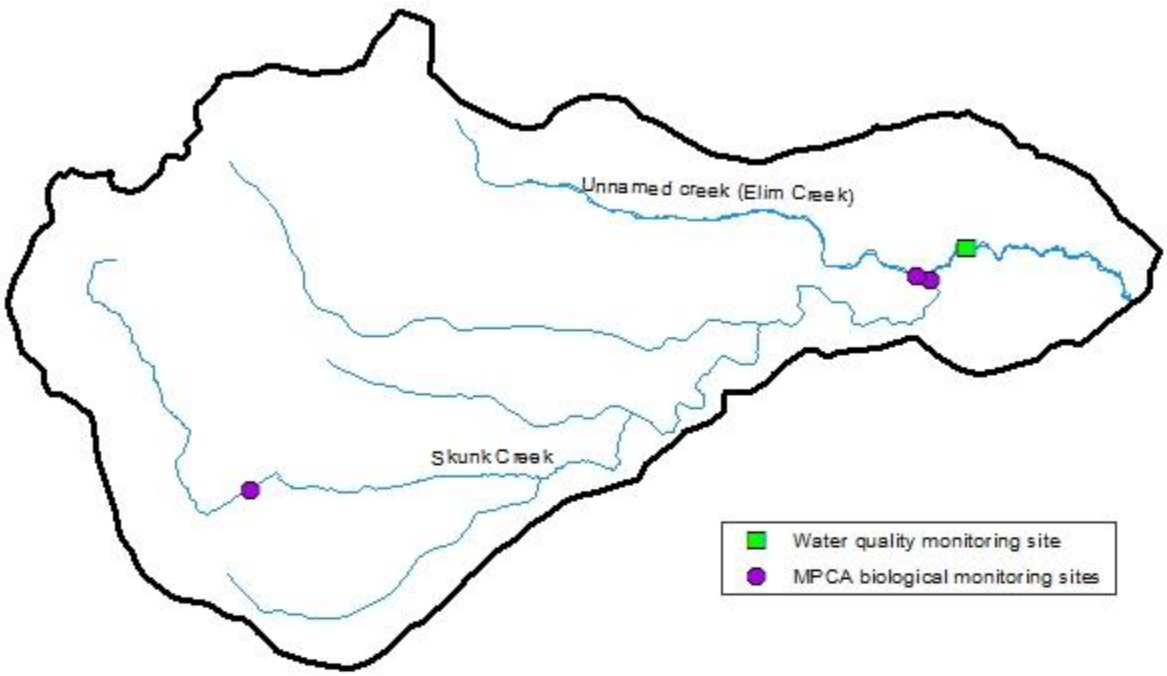
In addition to monitoring above and below the dam removal sites, there will be monitoring sensors placed above and below three road crossing restoration sites. Biological monitoring for FIBI and MIBI will occur every other year at four sites.

Table 19. Monitoring costs

Monitoring type	Description	Unit cost (annual)	Total (10-years)
Streamflow and water quality sampling and analysis	0.1 FTE for 6 sites 0.1 FTE for data analysis Lab costs Equipment: Gage site Other sites	$10,000 $10,000 $2,000 $5,000/gage site $1,000/other sites	$320,000
Biological monitoring	0.05 FTE for 4 sites 2-4 person crew and data analysis	$5,000	$50,000
Habitat and stream geomorphology	0.1 FTE (2 times per 10-year period)	$10,000	$20,000
Total			**$390,000**

The MPCA will begin its second cycle of HUC8-scale intensive watershed monitoring (IWM) in the Nemadji River Watershed in 2021. The HUC8 monitoring is conducted on a ten-year cycle. The MPCA biological monitoring sites in the Skunk Creek Watershed will be sampled for fish, macroinvertebrates, habitat, and water chemistry (Figure 20). At least one water chemistry monitoring site will be sampled as part of IWM with the potential of additional sites being selected through the state and local need selection process conducted prior to IWM monitoring. The IWM monitoring is conducted to provide data for the assessment of aquatic life and recreation uses once every 10 years and to eventually provide long-term data for trend analysis.

Figure 20. MPCA IWM monitoring sites



The DNR conducts various monitoring in its role of fishery management in the state. Monitoring includes fish surveys, habitat surveys, water temperature, and streamflow. The watershed partners will coordinate with the DNR so that their monitoring will be completed as implementation activities are completed and beyond to evaluate the quality of the fishery.

Implementation activities will be tracked using the BWSR eLink database for state and Section 319-funded activities. Implementation activities funded by the USDA are tracked using their database. Field measurements, preliminary and final engineering designs, as-built plans, and photographs will be used to document the improvement in streambank and connectivity activities. Field measurements will include streambank and streambed profile measurements and geomorphic analyses to track streambank changes over time due to accelerated streambank erosion and subsequent restoration activities. Changes in land cover and land use not associated with BMP implementation will be tracked using visual observations, field measurements, and aerial imaging.

The Citizen Stream Monitoring Program will be encouraged and expanded to increase the number of volunteers (https://www.pca.state.mn.us/water/citizen-water-monitoring). Volunteers measure water clarity at least twice a month each summer at designated locations using a Secchi tube. The data can then be correlated with TSS concentrations and be used as an indicator of sediment in the stream. The goal for the watershed partners is to get four volunteer monitoring sites established in the watershed.

10.0 Financial and technical resources

Implementation of this watershed plan will require additional financial and technical resources.

The cost for SWCD, county, and state staff that will implement this plan will largely come from county and state funds provided through existing funding sources. Carlton SWCD receives operational funds from Carlton County and various BWSR grant programs designed to support SWCDs in the state. The SWCD Technical Service Area #3 joint powers board provides engineering and other technical services through state general funds administered by BWSR and funds from NRCS.

A list of existing funding sources available to support implementation is provided in Table 20.

Table 20. Partial list of funding sources

Sponsor or Information Source	Program Description
MPCA	**Section 319 Grants:** Federal grant funding from the EPA as part of the Clean Water Act, Section 319. Grants awarded by MPCA to local governmental units address nonpoint source pollution through implementation projects. **Clean Water Partnership Loan**: The state funded Clean Water Partnership Program awards no-interest loans to local governmental units for work on projects that address nonpoint source pollution.
BWSR	BWSR administers several state funded grant programs that support the operation and functions of soil and water conservation districts, including Carlton SWCD (https://bwsr.state.mn.us/swcd-grants). It also administers several implementation grant programs, including the State Cost Share, Buffer Cost Share, Conservation Delivery, and Clean Water Fund Programs. The primary CWF program is the Watershed-Based Implementation Funding Program that will provide the Carlton SWCD as base funding for BMP implementation upon completion of the One Water One Plan for the Nemadji River Watershed.
Minnesota Department of Agriculture (MDA)	**AgBMP Loan Program:** This program encourages implementation of practices that prevent or reduce pollution problems, such as runoff from feedlots, erosion from farm fields and shoreline, and noncompliant septic systems and wells. MDA provides a wide array of other information from their agency as well as other state and federal agencies on conservation programs addressing agriculture and other land uses.
Minnesota DNR	**DNR grants** are available for a variety of programs relating to land preservation, wildlife and habitat, native prairie, forestry and wetlands.
USDA NRCS	**Environmental Quality Incentives Program:** Voluntary program to implement conservation practices, or activities, such as conservation planning, that address natural resource concerns for agricultural producers. **Conservation Reserve Program – Continuous Signup:** A USDA Farm Service Agency-funded voluntary program designed to help farmers restore and protect environmentally sensitive land—particularly wetlands, wildlife habitat and water quality buffers. **Conservation Stewardship Program:** Voluntary program to improve resource conditions such as soil quality, water quality, water quantity, air quality, habitat quality, and energy.

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Tetra Tech. 2017b. Nemadji River Watershed Restoration and Protection Strategy. Prepared for the Minnesota Pollution Control Agency. Document Number: wq-ws4-30a.

Appendix A STEPL Assumptions

The reductions for BMPs identified in the ten-year milestone table calculated as combined efficiencies and the BMP calculator in STEPL. Reduction efficiencies for *E. coli* were assumed from MPCA (2011) and Wright Water Engineers, Inc. (2010) and added to the "BMPList" worksheet in STEPL. The practices and assumed reduction efficiencies are shown in Table 21. The treatment efficiencies for the BMPs that are not in the original list of BMPs and reduction efficiencies (BMPList) in STEPL were assigned based on the similarity of the treatment processes with selected BMPList practices.

Table 21. Land use, BMPs, and efficiencies for STEPL (added all *E. coli* efficiencies)

Landuse	BMP & efficiency	TSS	Assumptions and additions
Cropland			
Cropland	Cover Crop 3 (Group A Traditional Early Planting Time) (High Till only for TP and Sediment)	0.2	
Pastureland			
Pastureland	Critical Area Planting	0.42	
Pastureland	Early Successional Habitat Development/Management	0.42	Added Early Successional Habitat Development/Management, assuming same efficiencies as pastureland STEPL practice Critical Area Planting
Pastureland	Fencing and Watering Projects	0.62	Added pastureland Fencing and watering projects, assuming same efficiencies as STEPL practice Livestock Exclusion Fencing
Pastureland	Forest Buffer (minimum 35 feet wide)	0.533	
Pastureland	Grass Buffer (minimum 35 feet wide)	0.648	
Pastureland	Livestock Pipeline	0.187	
Forest			
Forest	Forest Stand Improvement	0.5	
Forest	Wetland Restoration	0.95	Added Wetland Restoration, assuming same efficiencies as STEPL practice Land retirement assuming 40 acres treated per acre of wetland
User_Defined			
User_Defined	Combined BMPs-Calculated	0	
User_Defined	Early Successional Habitat Development/Management	0.95	Added Early Successional Habitat Development/Management, assuming same efficiencies as pastureland STEPL practice Critical Area Planting
Urban			
Urban	Vegetated Filter Strips	0.73	

The combined efficiencies of the practices are described in **Error! Reference source not found.**. The forestry combined reductions were calculated using the STEPL BMP calculator module. The pasture combined efficiencies were calculated using the combined efficiency worksheet in STEPL.

Table 22. Combined efficiencies for BMPs

Area (ac)	Select a BMP type	TSS
Combined efficiencies Pastureland		
202	0 No BMP	0
66	Early Successional Habitat Development Management	0.42
800	Fencing and Watering Projects	0.62
113	Livestock Pipeline	0.187
1181	Total acres and combined TSS efficiency	0.461347
Combined efficiencies Forestry		
3000	Forest Road Dry Seeding	0.62
80	Forest-Road Grass and Legume Seeding	0.5
3080	Total acres and combined TSS efficiency	0.617

Assumptions for the use and calculations of the BMPs are described in Table 23. Streambank restoration efficiencies, number feet of restoration, and reduction estimates are described in Table 24.

Table 23. Assumptions and inputs for STEPL and outputs

Treatment	Amount treated (acres)	Percent treated	Assumptions
Upland practices			
Cover crops	66	100%	Assume that all crop land acres will use cover crops
Early successional habitat development management	500	42%	
Road runoff protection using vegetated filter strips	125	95%	Assume that the urban land is all roads, assume vegetated filter strips in Urban BMPs, and 95% of the allotted roads
Riparian vegetation planting	500	42%	Assume buffer forested for the riparian vegetation, assume applied on 42% pastureland (open land)
Forestry practices	3,000	83%	Assume as site preparation/ steep slope, seeder/ transplant, with 20 acres treated per practice, total of 150 practices (3,000 acres treated total)
Grassed buffers in pastures	650	55%	
Wetland restorations	1,500	42%	Wetland restoration, 1,500 acres of wetlands restored

Table 24. BMP streambank loads and treatment efficiencies in STEPL

Activity	Length (ft)	Hgt (ft)	Lateral recession	Rate range (ft/yr)	Rate (ft/ yr)	Efficiency (0-1)	Soil Class	Soil dry wgt (ton/ft^3)	Annual load (ton)	Load reduction (ton)
Skunk Cr Sed Red Proj	1873	9	3. Severe	0.3 - 0.5	0.4	0.95	Clay	0.035	235.9980	224.1981
Elim Dam	4000	5	3. Severe	0.3 - 0.5	0.4	0.95	Clay	0.035	280.0000	266.0000
4 small dams	2400	5	3. Severe	0.3 - 0.5	0.4	0.95	Clay	0.035	168.0000	159.6000

Large dam	4000	5	3. Severe	0.3 - 0.5	0.4	0.95	Clay	0.035	280.0000	266.0000
5 remaining dams	3000	5	3. Severe	0.3 - 0.5	0.4	0.95	Clay	0.035	210.0000	199.5000
County culverts	900	9	3. Severe	0.3 - 0.5	0.4	0.95	Clay	0.035	113.4000	107.7300
Township culverts	750	5	3. Severe	0.3 - 0.5	0.4	0.95	Clay	0.035	52.5000	49.8750
Strmbk restoration	4500	5	3. Severe	0.3 - 0.5	0.4	0.95	Clay	0.035	315.0000	299.2500
Strmbk restoration	9000	5	3. Severe	0.3 - 0.5	0.4	0.95	Clay	0.035	630.0000	598.5000
Strmbk restoration	1560	5	2. Mod	0.06 - 0.2	0.13	0.95	Clay	0.035	35.4900	33.7155
Prior work	2200	5	3. Severe	0.3 - 0.5	0.4	0.95	Clay	0.035	154.0000	146.3000
Prior culvert work	200	9	3. Severe	0.3 - 0.5	0.4	0.95	Clay	0.035	25.2000	23.9400
PstWrkHealt hWat	25494	5	2. Mod	0.06 - 0.2	0.13	0.95	Clay	0.035	579.9885	550.9891