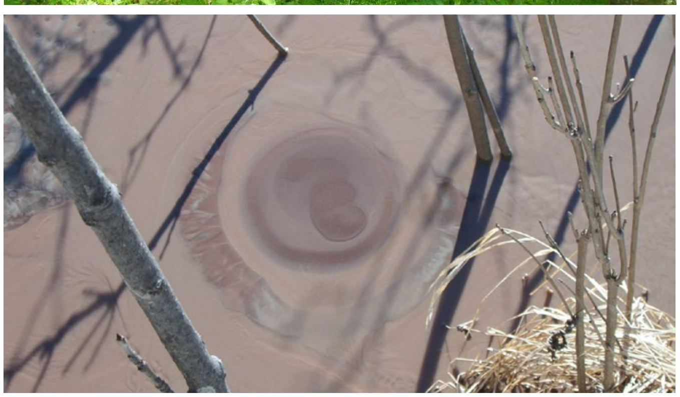
Nemadji River Watershed Restoration and Protection Strategy Report








TETRA TECH

CLEAN WATER LAND & LEGACY AMENDMENT

Minnesota Pollution Control Agency

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June 2017

Project Contributors

Nemadji Watershed Stakeholders and Citizen Representatives

A special thanks to James Scheetz and Christine Carlson for securing boats, volunteers and organizing lake sediment core field days.

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Carlton County Highway Department

Carlton County Land Commissioner

Carlton County Soil and Water Conservation District

Carlton County Zoning and Environmental Services

Chub Lake Association

Fond du Lac Band of Lake Superior Chippewa

Minnesota Department of Agriculture

Minnesota Department of Natural Resources

Minnesota Pollution Control Agency

St Croix River Watershed Research Station

Tetra Tech

U.S. Department of Agriculture Natural Resources Conservation Service

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Key Terms

Assessment Unit Identifier (AUID): The unique water body identifier for each river reach comprised of the USGS eight-digit HUC plus a three-character code unique within each HUC.

Aquatic life impairment: The presence and vitality of aquatic life is indicative of the overall water quality of a stream. A stream is considered impaired for impacts to aquatic life if the fish Index of Biotic Integrity (IBI), macroinvertebrate IBI, dissolved oxygen, turbidity, or certain chemical standards are not met.

Aquatic recreation impairment: Streams are considered impaired for impacts to aquatic recreation if *E. coli* standards are not met. Lakes are considered impaired for impacts to aquatic recreation if total phosphorus, chlorophyll-a, or Secchi disc depth standards are not met.

Hydrologic Unit Code (HUC): A Hydrologic Unit Code (HUC) is assigned by the USGS for each watershed. HUCs are organized in a nested hierarchy by size.

Impairment: Water bodies are listed as impaired if water quality standards are not met for designated uses including: aquatic life, aquatic recreation, and aquatic consumption.

Index of Biotic Integrity (IBI): A method for describing water quality using characteristics of aquatic communities, such as the types of fish and invertebrates found in the waterbody. It is expressed as a numerical value between 0 (lowest quality) to 100 (highest quality).

Protection: This term is used to characterize actions taken in watersheds of waters not known to be impaired to maintain conditions and beneficial uses of the waterbodies.

Restoration: This term is used to characterize actions taken in watersheds of impaired waters to improve conditions, eventually to meet water quality standards and achieve beneficial uses of the waterbodies.

Source (or Pollutant Source): This term is distinguished from 'stressor' to mean only those actions, places or entities that deliver/discharge pollutants (e.g., sediment, phosphorus, nitrogen, pathogens).

Stressor (or Biological Stressor): This is a broad term that includes both pollutant sources and non-pollutant sources or factors (e.g., altered hydrology, dams preventing fish passage) that adversely impact aquatic life.

Total Maximum Daily Load (TMDL): A calculation of the maximum amount of a pollutant that may be introduced into a surface water and still ensure that applicable water quality standards for that water are met. A TMDL is the sum of the wasteload allocation for point sources, a load allocation for nonpoint sources and natural background, an allocation for future growth (i.e., reserve capacity), and a margin of safety as defined in the Code of Federal Regulations.

Executive Summary

The Nemadji River Watershed is located in northeastern Minnesota and northwestern Wisconsin in the Lake Superior Basin, within the Northern Lakes and Forests ecoregion. The Minnesota portion of the watershed is 276 square miles and covers portions of Carlton County and Pine County. In this report, "Nemadji River Watershed" refers to the portion of the watershed within Minnesota. The lakes, streams and landscape found in this watershed support unique and rare species like remnant stands of hemlock, the rare wood turtle and golden winged-warbler.

Dominant land cover in the Nemadji River Watershed is forest, followed by woody wetlands, hay/pasture, and shrub/scrub lands. Cultivated crops, developed lands, emergent herbaceous wetlands, herbaceous and open water areas each make up less than 5% of the watershed land cover/land use as a whole. A small portion of the city of Wrenshall is within the watershed, along with the communities of Holyoke, Pleasant Valley, and Duesler. The Nemadji State Forest encompasses much of the southeast Carlton County and Pine County portions of the watershed.

Stream biology, water chemistry, and flow monitoring data collection for the Watershed Restoration and Protection Strategies (WRAPS) effort began in the watershed in 2011. This WRAPS report summarizes those data and culminates in a table of implementation strategies designed to help restore areas where pollutants violate standards and/or help protect those areas that currently meet water quality standards.

Of the 22 streams and 8 lakes evaluated, 12 streams and 2 lakes do not meet water quality standards for sediment, bacteria, and nutrient levels, and fish and invertebrate populations. They are the focus of restoration activities. Ten streams and six lakes meet all criteria for healthy conditions and are the focus of protection efforts.

While primarily forested and rural, mass wasting processes and down-cutting of streams into fine-grained red clay deposits is common. Excess sediment in Nemadji streams is based in part on human activities that can accentuate erosive forces and natural processes. Sediment loading and habitat fragmentation are both key issues being addressed in priority watersheds over the next 10 years.

Lac La Belle, Net Lake, Deer Creek, Elim Creek, Mud Creek, Skunk Creek, the mainstem of the Nemadji River and the South Fork Nemadji, are water bodies within the watershed that are "impaired," or polluted by high levels of sediment or bacteria. The highest concentrations of sediment-impaired streams are typically found in the lower portion of the watershed. The sediment from these streams is a major source of sediment to Lake Superior. The Nemadji River and its tributaries in the upper regions of the watershed generally have lower sediment concentrations.

Six lakes meet lake nutrient standards and will be the focus of protection efforts. Chub Lake was given a high priority for protection efforts followed by Hay Lake, Sand Lake, and Lake Venoah as medium priorities. Streams that meet biological criteria, but have somewhat elevated Total Suspended Solids (TSS) or Total Phosphorus (TP) concentrations should be managed for protection. The streams with elevated TSS concentrations include Net River, Little Net River, Anderson Creek, State Line Creek and a portion of Skunk Creek. Elevated TP concentrations are found in Deer Creek, Rock Creek, Nemadji River, and the South Fork of the Nemadji River. Blackhoof River is a high value trout stream also worthy of protection efforts.

The Minnesota Pollution Control Agency (MPCA), the Nemadji River Watershed stakeholders group and the Carlton County Soil and Water Conservation District (SWCD), recommended a number of actions to restore and protect water bodies in the watershed. Some of these actions are: culvert inventories and replacement, septic system assessments and replacement, livestock/animal stream access improvements, streambank and lakeshore buffer improvements, natural stream channel restoration where appropriate, ravine, channel bank and stream headcut stabilization, improved forestry management, conservation easements where appropriate, and low impact development design to maintain natural hydrology.

What is the WRAPS Report?

The state of Minnesota has adopted a “watershed approach” to address the state’s 80 “major” watersheds (denoted by 8-digit hydrologic unit code or HUC). This watershed approach incorporates **water quality assessment, watershed analysis, civic engagement, planning**, **implementation**, and **measurement of results** into a 10-year cycle that addresses both restoration and protection (Figure 1).

As part of the watershed approach, waters not meeting state standards are listed as impaired and Total Maximum Daily Load (TMDL) studies are performed, as they have been in the past. In addition, the watershed approach process facilitates a more cost-effective and comprehensive characterization of multiple waterbodies and overall watershed health. A key aspect of this effort is to develop and utilize watershed-scale models and other tools to identify strategies and actions for point and nonpoint source pollution that will cumulatively achieve water quality targets. For nonpoint source pollution, this report informs local planning efforts, but ultimately the local partners decide what work will be included in their local plans. This report also serves as a watershed plan addressing the U.S. Environmental Protection Agency’s (EPA’s) Nine Minimum Elements to qualify applicants for eligibility for Clean Water Act (CWA) Section 319 implementation funds (see Appendix C).

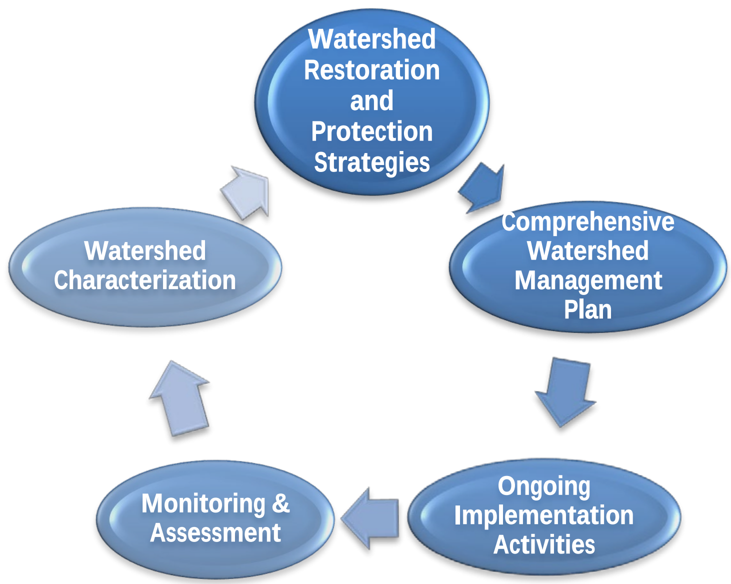


Figure 1. Minnesota’s Watershed Approach

Purpose

- Support local working groups and jointly develop scientifically-supported restoration and protection strategies to be used for subsequent implementation planning
- Summarize Watershed Approach work done to date including the following reports:
  - *Nemadji River Watershed Monitoring and Assessment*
  - *Nemadji River Watershed Biotic Stressor Identification*
  - *Nemadji River Watershed Total Maximum Daily Load*
  - *A Paleolimnological Study of Net Lake and Lac La Belle, Carlton and Pine Counties, Minnesota*

Scope

- Impacts to aquatic recreation and impacts to aquatic life in streams
- Impacts to aquatic recreation in lakes
- Protection of watershed and downstream resources

Audience

- Local working groups (local governments, SWCDs, lake associations, residents)
- State agencies (MPCA, DNR, BWSR, etc.)
- Federal agencies (NRCS, USDA, Forest Service, etc.)
- University researchers
- Fond du Lac Band of Lake Superior Chippewa

1. Watershed Background & Description

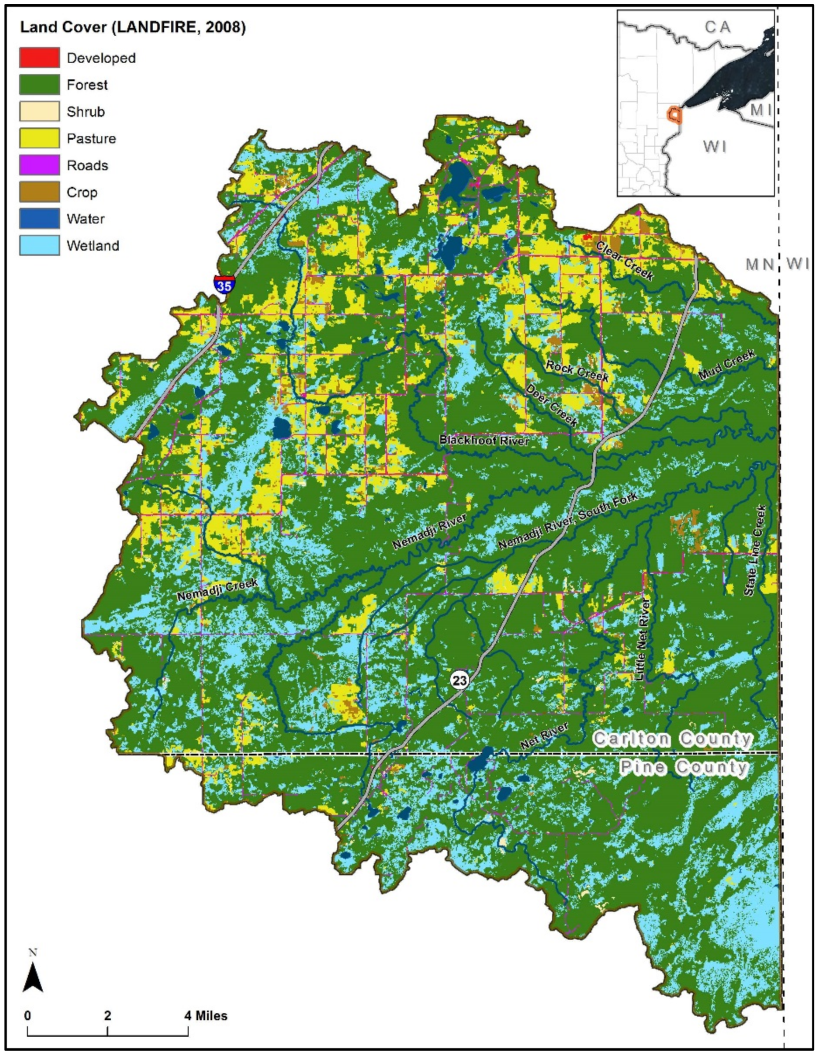


Figure 2. Nemadji River Watershed land cover

The Nemadji River Watershed is located in northeastern Minnesota and northwestern Wisconsin in the Lake Superior Basin, in the Northern Lakes and Forests ecoregion. The Minnesota portion of the watershed is 276 square miles and covers portions of Carlton County and Pine County. In this report, "Nemadji River Watershed" refers to the portion of the watershed within Minnesota. The dominant land cover in the Nemadji River Watershed is forest, followed by woody wetlands, hay/pasture, and shrub/scrub. Cultivated crops, developed, emergent herbaceous wetlands, herbaceous, and open water each make up less than 5% of the watershed as a whole. The watershed is rural in nature; a small portion of the city of Wrenshall is within the watershed along with Holyoke, Pleasant Valley, and Duesler. The Nemadji State Forest encompasses much of the southeast Carlton County and Pine County portion of the watershed.

Additional Nemadji River Watershed Resources

The MPCA information and reports on assessment, restoration, protection, and implementation in the Nemadji River Watershed: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/watersheds/nemadji-river.html

USDA Natural Resources Conservation Service (NRCS) Rapid Watershed Assessment for the Nemadji River Watershed: http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_021796.pdf

Minnesota Department of Natural Resources (DNR) Watershed Assessment Mapbook for the Nemadji River Watershed: http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/wsmb5.pdf

2. Watershed Conditions

The Nemadji River Watershed is dominated by a stream network, with several lakes in the northwest and southern portions. The central portion of the Nemadji River Watershed is known as the geologic red clay zone, which has gently sloping topography with some steep ravines. The red clay zone has a substantial impact on water quality in the Nemadji River; the clayey soils consist of fine particles that do not readily settle out of the water column, leading to naturally high turbidity and suspended sediment.

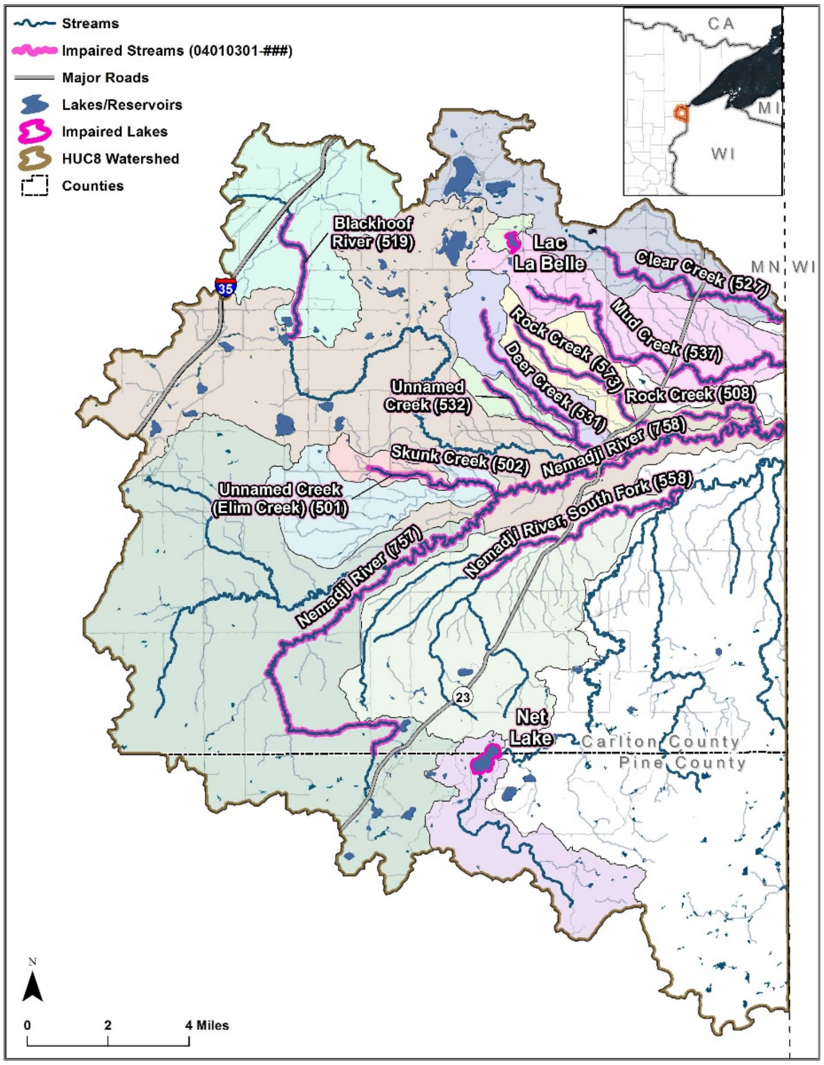


Figure 3. Nemadji River Watershed impairments

2.1 Condition Status

The Minnesota Pollution Control Agency (MPCA) assesses the water quality of streams and lakes based on each waterbody's ability to support aquatic life (e.g., fish and macroinvertebrates) and aquatic recreation (e.g., fishing and swimming). Data from the waterbodies are compared to state standards. Waterbodies that meet standards are evaluated for protection efforts; waterbodies that do not meet standards are listed as impaired and become the focus of restoration efforts (Figure 3). Waters that are not yet assessed may continue through a process of data collection and evaluation and can be candidates for protection or restoration work.

Some of the waterbodies in the Nemadji River Watershed are impaired by mercury; however, this report does not cover toxic pollutants. For more information on mercury impairments, see the statewide mercury TMDL at http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/special-projects/statewide-mercury-tmdl-pollutant-reduction-plan.html.

Streams

Twenty-two stream segments in the Nemadji River Watershed were assessed by the MPCA to identify impaired waters and waters in need of protection. Waters that do not meet targets for fish assemblage, macroinvertebrate assemblage, dissolved oxygen, turbidity, chloride, pH, or ammonia do not meet the aquatic life beneficial use. Waters that do not meet the targets for fecal indicator bacteria do not meet the aquatic recreation beneficial use; levels of the bacteria *Escherichia coli* (*E. coli*) are used to approximate the amount of fecal contamination in surface waters. Waters that meet water quality standards and provide the beneficial uses will be the focus of protection efforts. Of the assessed streams, 12 are the focus of restoration efforts and 10 are the focus of protection efforts (Table 1).

Table 1. Assessment status of stream reaches in the Nemadji River Watershed

HUC-10 Subwatershed	AUID (Last 3 digits)	Stream	Reach Description	Aquatic Life							Aquatic Rec	Protection or Restoration Focus
				Fish Index of Biotic Integrity	Macroinvertebrate Index of Biotic Integrity	Dissolved Oxygen	Turbidity/TSS	Chloride	pH	Ammonia	*E. coli* Bacteria (fecal pollution)	
Middle Nemadji River	537	Mud Creek	T47 R16W S6, west line to MN/WI border	Imp	Sup	NA	Imp	Sup	NA	Sup	NA	Restoration
	527	Clear Creek	T48 R16W S33, west line to MN/WI border	Imp	Imp	NA	Imp	NA	NA	NA	NA	Restoration
Upper Nemadji River	534	Hunters Creek	Headwaters to Nemadji Cr	Sup	Sup	NA	IF	Sup	NA	NA	NA	Protection
	545	Nemadji Creek	Headwaters to Nemadji R	Sup	Sup	NA	IF	NA	NA	NA	NA	Protection
	757	Nemadji River	T46 R17W S33, south line to Unnamed cr	Sup	Sup	NA	Imp	NA	Sup	NA	NA	Restoration
	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
	519	Blackhoof River	Unnamed cr to Ellstrom Lk	Imp	Imp	NA	NA	NA	NA	NA	NA	Restoration
	756	Unnamed creek	Unnamed cr to Ellstrom Lk	Sup	NA	NA	NA	NA	NA	NA	NA	Protection
	762	Blackhoof River	Co Rd 105 to Spring Lk outlet	NA	NA	Sup	Sup	NA	Sup	NA	NA	Protection

HUC-10 Subwatershed	AUID (Last 3 digits)	Stream	Reach Description	Aquatic Life							Aquatic Rec	Protection or Restoration Focus
				Fish Index of Biotic Integrity	Macroinvertebrate Index of Biotic Integrity	Dissolved Oxygen	Turbidity/TSS	Chloride	pH	Ammonia	*E. coli* Bacteria (fecal pollution)	
	510	Blackhoof River	Spring Lk outlet to Unnamed cr	Sup	Sup	NA	NA	NA	NA	NA	NA	Protection
	758	Nemadji River	Unnamed cr to MN/WI border	Sup	Sup	Sup	Imp	Sup	Sup	Sup	Imp	Restoration
	532	Unnamed creek	Headwaters to Deer Cr	NA	NA	Sup	Imp	NA	Sup	NA	NA	Restoration
	531	Deer Creek	Headwaters to Nemadji R	Imp	Sup	Sup	Imp	Sup	Sup	Sup	NA	Restoration
	573	Rock Creek	Headwaters to Unnamed cr	NA	NA	IF	Imp	Sup	Sup	Sup	NA	Restoration
	508	Rock Creek	Unnamed cr to Nemadji R	Imp	Imp	NA	NA	NA	NA	NA	NA	Restoration
South Fork Nemadji River	516	Anderson Creek	T46 R17W S26, south line to T46 R17W S14, north line	Sup	Sup	NA	IF	Sup	NA	NA	NA	Protection
South Fork Nemadji River	569	Little Net River	T46 R16W S34, south line to Net R	Sup	Sup	NA	IF	Sup	NA	NA	NA	Protection
South Fork Nemadji River	760	Net River	T46 R16W S29, N boundary of SE quarter to S Fk Nemadji R	Sup	Sup	Sup	IF	Sup	NA	NA	NA	Protection
South Fork Nemadji River	558	Nemadji River, South Fork	Stony Bk/Anderson Cr to Net R	Sup	Sup	Sup	Imp	Sup	Sup	Sup	Imp	Restoration
South Fork Nemadji River	564	State Line Creek	Headwaters to S Fk Nemadji R	Sup	Sup	NA	IF	Sup	Sup	NA	NA	Protection

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, IF = the data collected were insufficient to make a finding, NA = not assessed

Lakes

Lakes are assessed for their ability to support aquatic recreation based on the level of eutrophication in the lake. Water transparency and levels of phosphorus and chlorophyll are used to evaluate eutrophication. Phosphorus is a nutrient that plants and algae need to grow, and chlorophyll is a measure of the amount of algae in the water. Eight lakes in the Nemadji River Watershed were assessed for their ability to support aquatic recreation (Table 2). Six lakes were found to meet the eutrophication standards and will be the focus of protection efforts. Two lakes do not meet the standards and will be the focus of restoration efforts.

Table 2. Assessment status of lakes in the Nemadji River Watershed

HUC-10 Subwatershed	Lake ID	Lake Name	Aquatic Recreation	Protection or Restoration Focus
Middle Nemadji River	09-0008-00	Chub	FS	Protection
	09-0009-00	Venoah	FS	Protection
	09-0011-00	Lac La Belle	Imp	Restoration
Upper Nemadji River	09-0005-00	Bear	FS	Protection
	09-0007-00	Spring	FS	Protection
	09-0010-00	Hay	FS	Protection
	09-0016-00	Sand	FS	Protection
South Fork Nemadji River	58-0038-00	Net	Imp	Restoration

Imp = impaired for impacts to aquatic recreation, FS = fully supporting aquatic recreation

2.2 Water Quality Evaluation and Trends

Streams

Streams in the Nemadji River Watershed are generally high in TSS (Figure 4). The highest concentrations typically are seen in the lower portion of the watershed. The river and its tributaries in the upper regions of the watershed generally have lower TSS concentrations. Stream reaches with a sufficient amount of turbidity and TSS data were assessed for impairment, but several streams, including Net River, Little Net River, Anderson Creek, Skunk Creek (-504), and State Line Creek, had an insufficient amount of data to be assessed. Other streams had no turbidity or TSS data and, therefore, were not assessed.

Phosphorus concentrations are also high in the watershed relative to the river eutrophication standard (Table 3). Phosphorus in surface water is often attached to sediment particles. The highest average concentrations are found in the red clay zone of the lower watershed (Figure 5). High phosphorus does not appear to fuel excessive plant and algae production, likely due to high turbidity that limits light penetration and primary productivity. High phosphorus concentrations are potentially a concern for downstream receiving watersheds (e.g., Lake Superior) and may provide insight to bacteria and sediment sources in the watershed. All of the measured nitrate concentrations in the watershed are below the state standard for drinking water protection.

Table 3. North River Nutrient Region river eutrophication standards

Parameter	River Eutrophication Standard
Total phosphorus	50 µg/L
Chlorophyll-*a*	7 µg/L
Dissolved oxygen flux	3.0 mg/L
Biochemical oxygen demand	1.5 mg/L

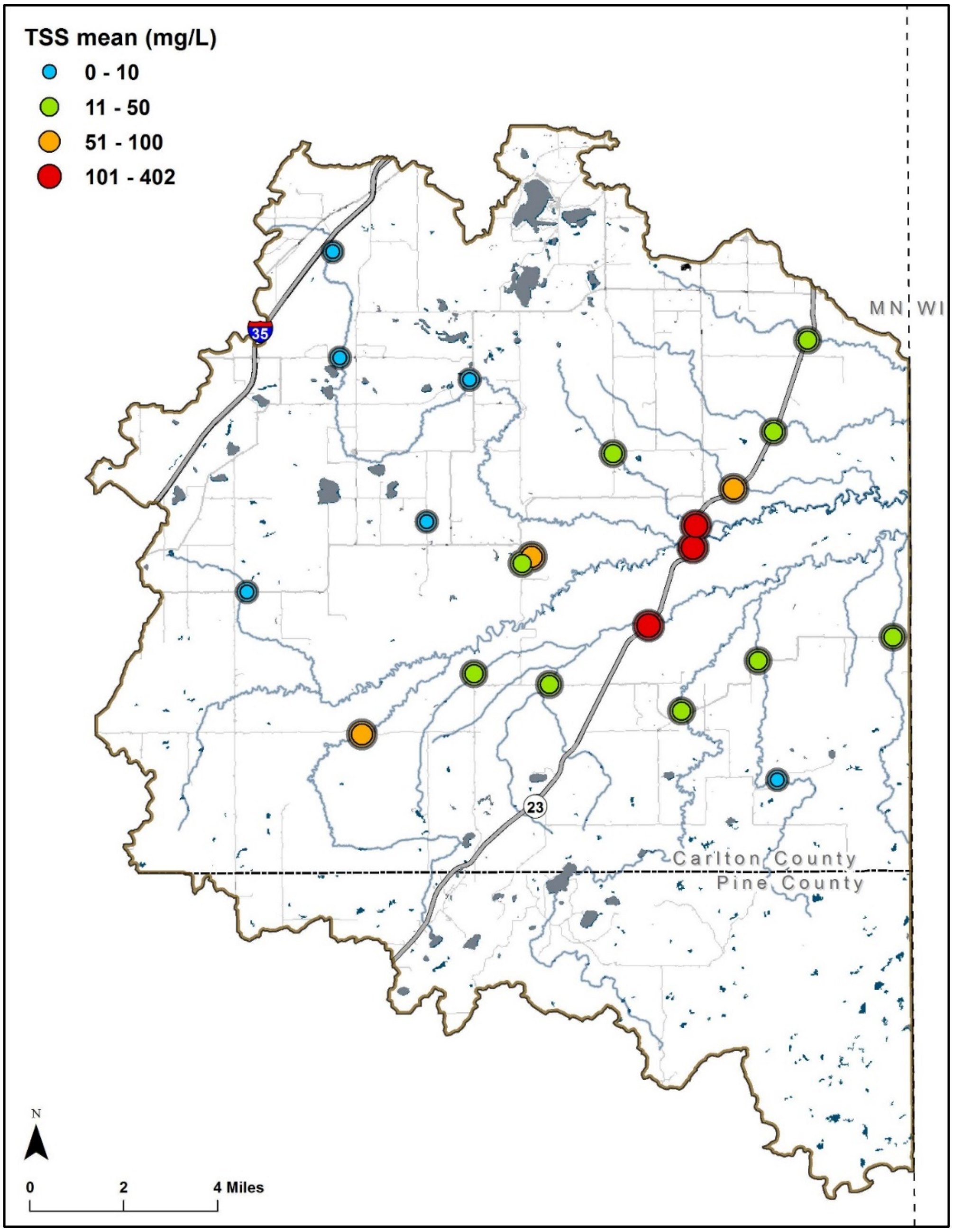


Figure 4. Mean TSS concentration by site (Apr–Sep, 2003–2014)

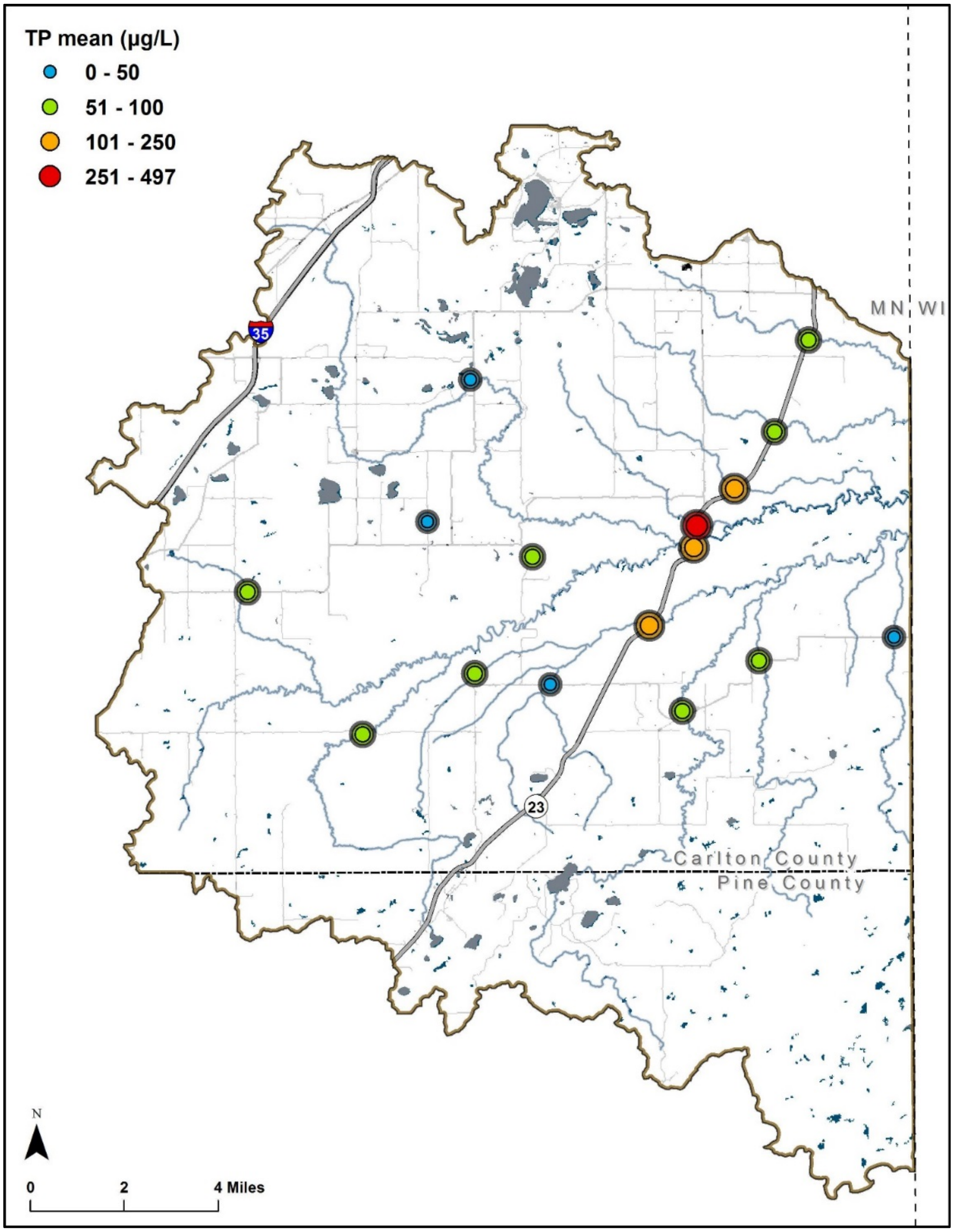


Figure 5. Mean phosphorus concentration by site (Jun–Sep, 2003–2014)

Two sites were evaluated for trends in TSS and total phosphorus over time including the Nemadji River by Wrenshall (site S000-110) and Deer Creek (S003-250). These sites were selected because they have the longest data record within the time period of interest. Sediment and phosphorus concentrations have fluctuated over the last 14 years in the Nemadji River by Wrenshall (Figure 6). The highest concentrations were observed in 2012, which was the year with record high flows. Sediment and phosphorus concentrations in Deer Creek decreased between the first half of the time period of interest and the second half (Figure 7). No trends were identified.

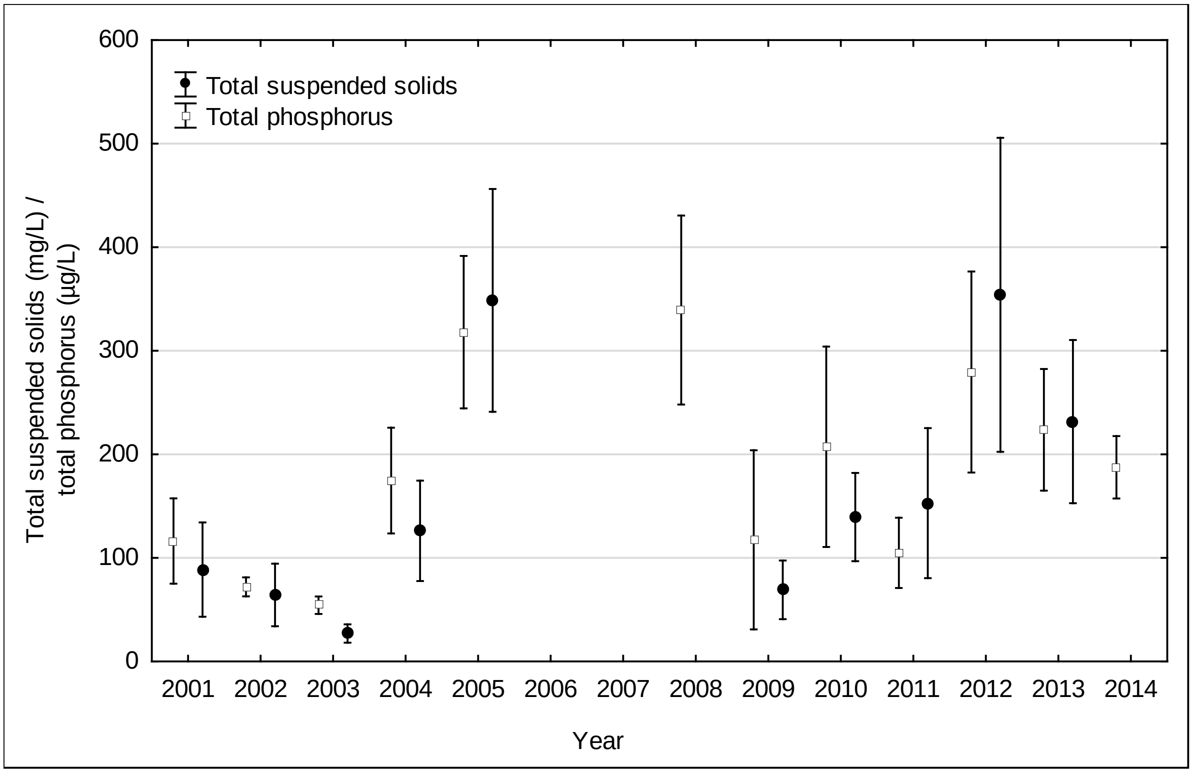


Figure 6. TSS and phosphorus at Nemadji River North Fork by Wrenshall (site S000-110), annual mean concentration +/- standard error

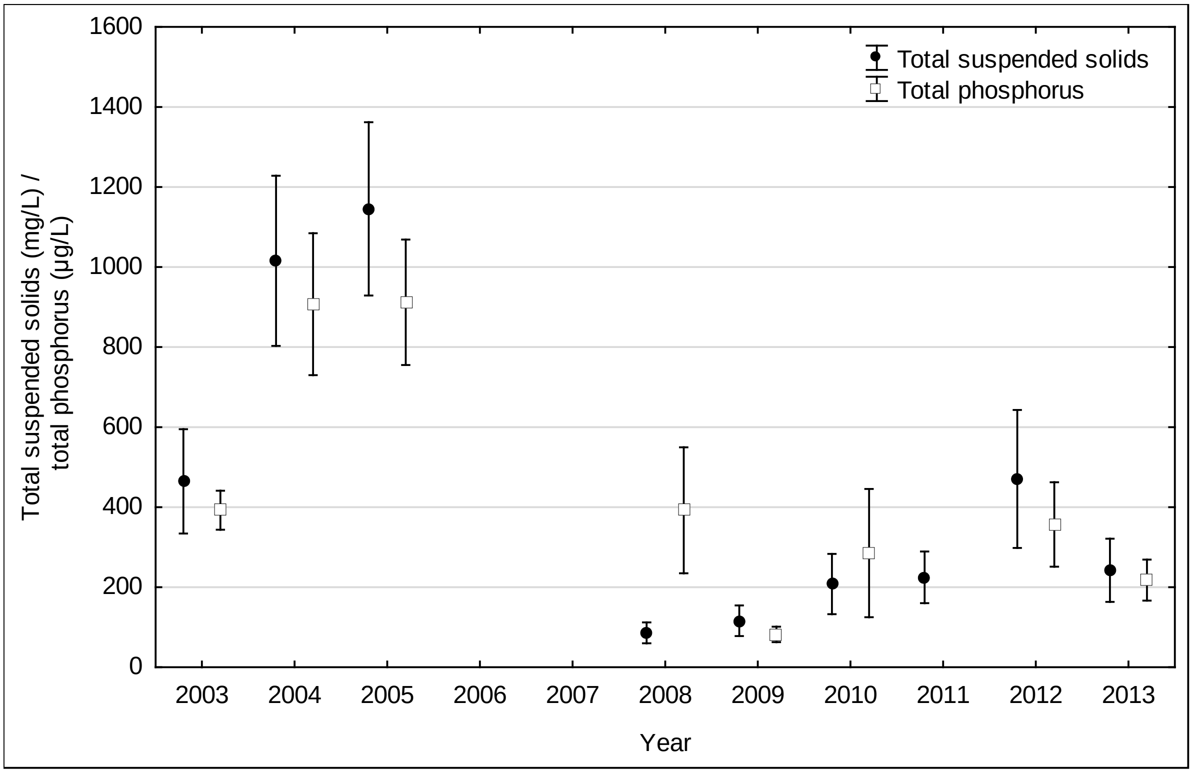


Figure 7. TSS and phosphorus at Deer Creek (site S003-250), annual mean concentration +/- standard error

E. coli concentrations in the impaired reaches are moderately high, with one sample taken on the same day in 2010 on each reach exceeding the individual sample standard (Figure 8 and Figure 9). The high samples were measured under higher flow conditions, with 0.75 inches of combined precipitation on the day before and day of sampling.

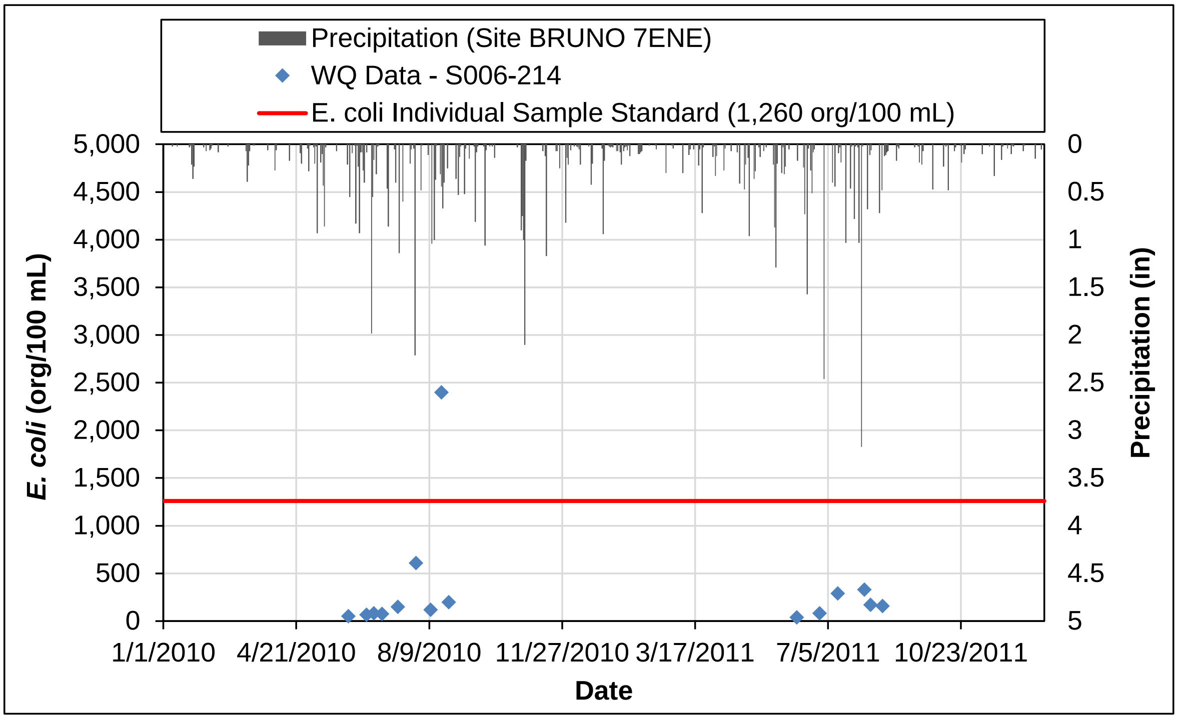


Figure 8. *E. coli* concentrations and precipitation over time in the impaired reach of the South Fork Nemadji River

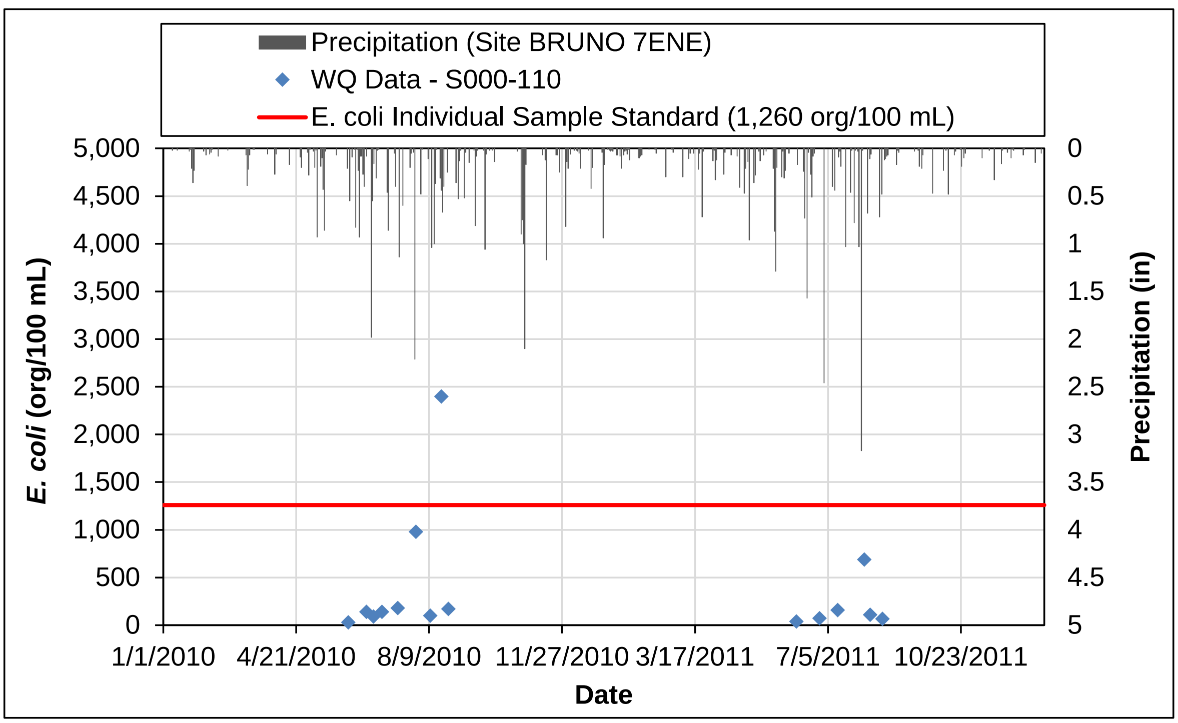


Figure 9. *E. coli* concentrations and precipitation over time in the impaired reach of the Nemadji River

Lakes

Lake water quality and the response of the lakes to nutrients varies within the watershed. For example, Net Lake has high phosphorus concentration yet low algal growth and poor transparency. This is likely due to high dissolved organics in the lake that decrease transparency but do not frequently lead to excessive algal growth. Lac La Belle also has high phosphorus and dissolved organics, but has high algal growth as well, as evidenced by recent chlorophyll data. The potential for internal loading is lower in Lac La Belle than in Net Lake (Edlund et al. 2016). Whereas the phosphorus levels in Net Lake have increased since European settlement, the phosphorus in Lac La Belle likely has not changed substantially (Edlund et al. 2016).

Three lakes (Bear, Spring, and Venoah) meet all three components of the lake standards (Table 4). Figure 10 through Figure 12 present the data over time for all lakes. Several lakes are very near the phosphorus standard or are exceeding the chlorophyll-a and Secchi targets. There are not enough data for trend analysis.

Table 4. Lake growing season means

Lake Name	Total Phosphorus		Chlorophyll-*a*		Secchi Transparency	
	Mean	Number of Years of Data	Mean	Number of Years of Data	Mean	Number of Years of Data
Bear	23	2	8.8	2	3.2	2
Spring	25	2	5.5	2	3.2	2
Chub	23	3	11.1	3	3.9	5
Venoah	16	2	3.0	2	3.3	2
Hay	28	2	7.0	2	1.6	4
Lac La Belle	58	2	40.4	2	1.6	2
Sand	29	2	6.5	2	1.3	2
Net	40	4	8.7	4	0.8	9

Notes: Standards for lakes in the Northern Lakes and Forests ecoregion: 30 µg/L total phosphorus, and response variable limits at 9 µg/L chlorophyll-*a*, and 2.0 meters Secchi transparency. Red indicates TP not meeting standard (impaired) or response variables exceeding a target.

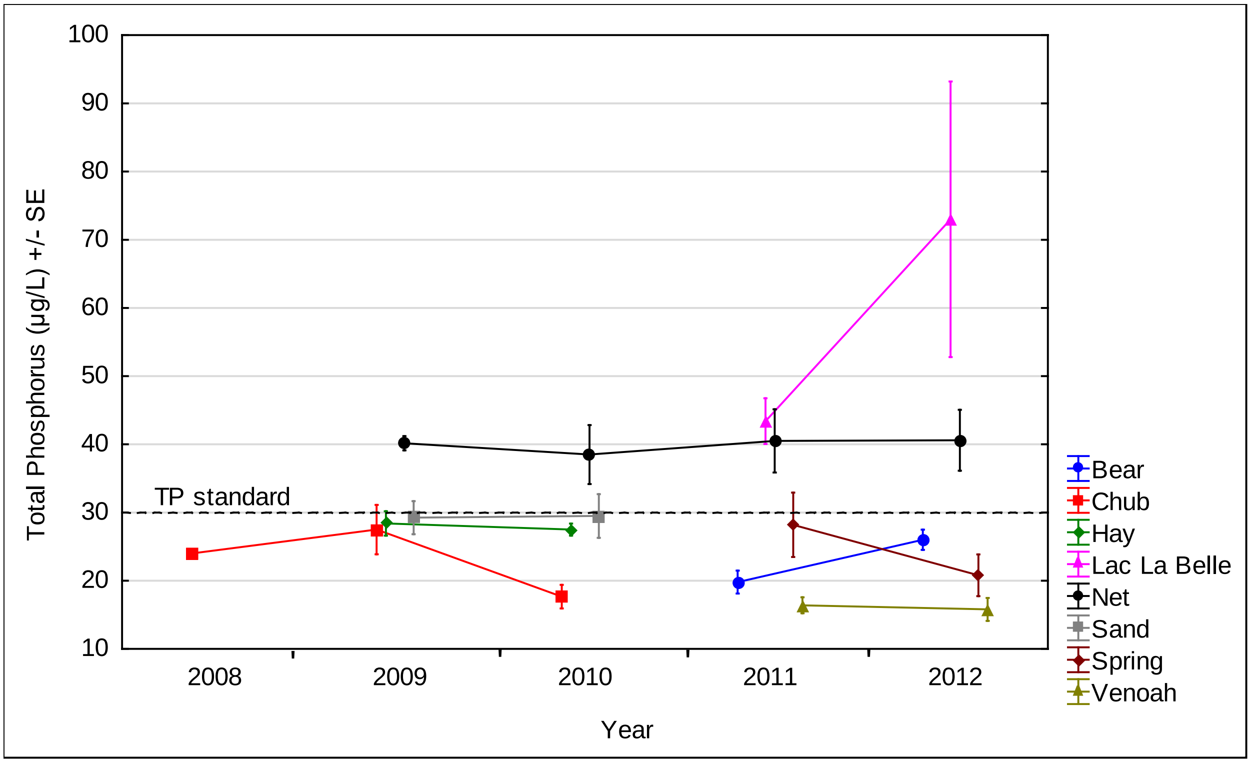


Figure 10. Average growing season total phosphorus, +/- standard error, all lakes for which there are data

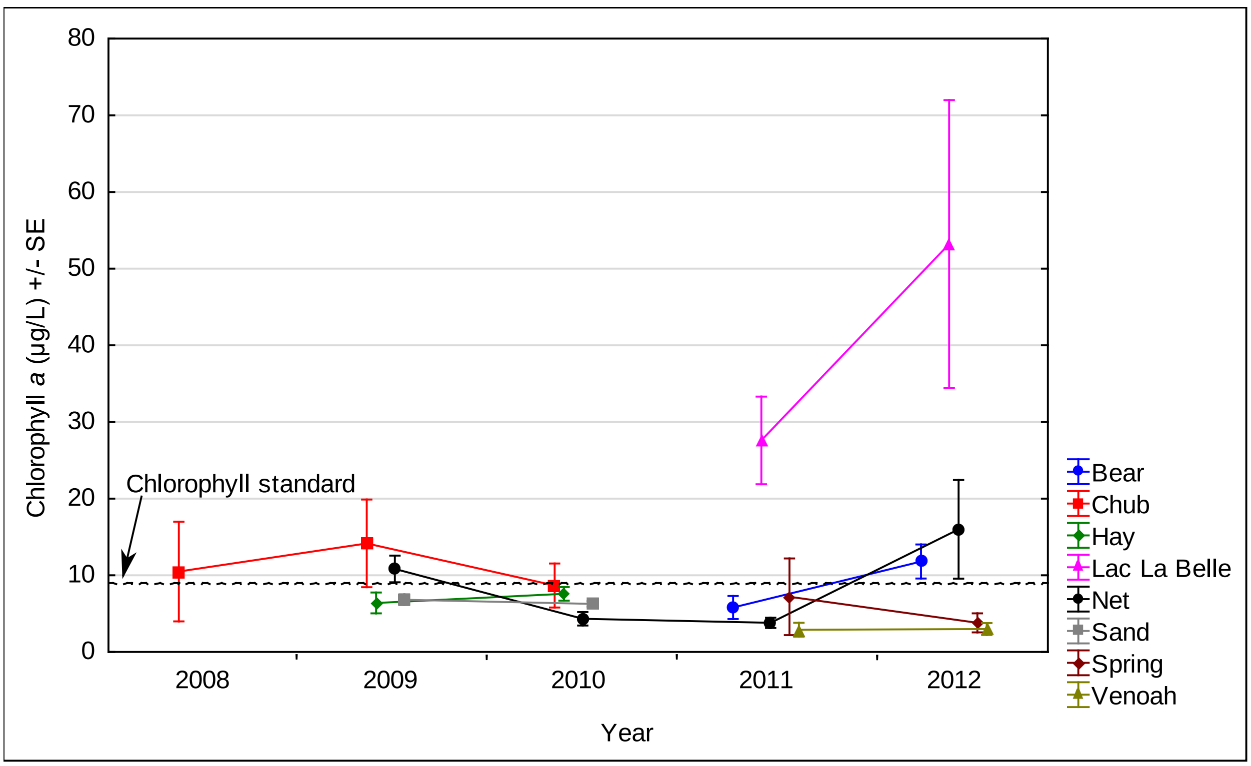


Figure 11. Average growing season chlorophyll-*a*, +/- response variable standard error, all lakes for which there are data

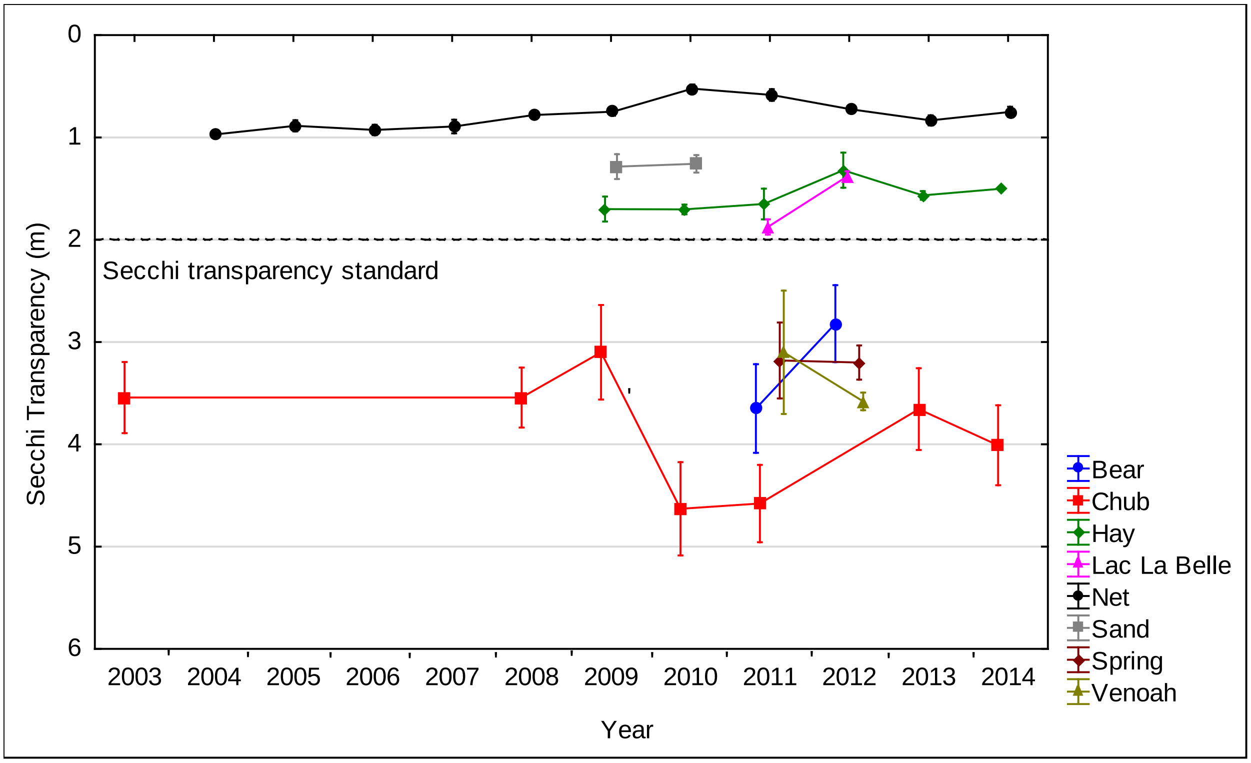


Figure 12. Average growing season Secchi transparency, +/- response variable standard error, all lakes for which there are data

2.3 Stressors and Sources

In order to develop appropriate strategies for restoring or protecting waterbodies, the stressors and/or sources impacting or threatening the waterbodies must be identified and evaluated. Biological stressor identification (SID) is done for streams with either fish or macroinvertebrate biota impairments. It evaluates both pollutants and non-pollutant (e.g., altered hydrology, fish passage, habitat) factors as potential stressors. Pollutant source assessments are done where a biological SID process identifies a pollutant as a stressor, as well as for the typical pollutant impairment listings.

Stressors of Biologically-Impaired Stream Reaches

The *Nemadji River Watershed SID Report* evaluated the stressors to the biological assemblages in the streams with fish or macroinvertebrate biota impairments. The following excerpt from the SID report explains the factors that act as primary stressors to the biotic assemblages:

- Historic flow alteration: Historic flow alteration was included as an underlying cause of several other candidate causes, including physical habitat quality, bedded sediment, habitat fragmentation, and suspended sediment/turbidity. Historical logging led to increased runoff that destabilized streams and initiated a channel evolution process.
- Recent flow alteration: Recent flow alteration refers to climate changes, impoundments, and land use changes over the past several decades that are impacting stream flow, natural stream processes, and the availability of aquatic life habitat.
- Physical habitat quality: Habitat is a broad term encompassing all aspects of the physical, chemical and biological conditions needed to support a biological community. Degraded

physical habitat quality can impact the ability of fish and macroinvertebrates to spawn, forage, or find refuge.

- Habitat fragmentation: Habitat fragmentation refers to the lack of connectivity in a stream that prevents fish passage, and is caused by dams, incorrectly sized or perched culverts, or flow barriers.
- Water temperature: Optimal growth of many fish species occurs in a specific range of water temperature. Many of the impaired streams in the Nemadji River Watershed support coldwater fish species (namely trout) whose optimal growth occurs at lower temperatures than other fish species, with high water temperatures resulting in stressful or even lethal conditions.
- Suspended solids/turbidity: Excess suspended solids (turbidity) can harm aquatic life through direct, physical effects on biota such as abrasion of gills, suppression of photosynthesis, and avoidance behaviors, or through indirect effects such as loss of visibility.

Historic flow alteration and suspended solids were the most common primary stressors to the biota in the Nemadji River Watershed (Table 5); the four streams with these primary stressors are all located in the red clay zone. The remaining two biotic impairments are located outside of the red clay zone and are caused by barriers including a pipe barrier (in Elim Creek) and beaver dams (in the Blackhoof River) that limit fish movement throughout the stream. Impairments not caused by a pollutant do not require a TMDL per the EPA Consolidated Assessment Listing Methodology.

Table 5. Primary stressors to aquatic life in biologically impaired reaches in the Nemadji River Watershed

HUC-10 Subwater -shed	AUID (Last 3 digits)	Stream	Reach Description	Biological Impairment	Primary Stressor					
					Historic Flow Alteration	Recent Flow Alteration	Physical Habitat	Habitat Fragmentation	Water Temperature	Total Suspended Solids/Turbidity
Middle Nemadji River	537	Mud Creek	T47 R16W S6, west line to MN/WI border	Fish	•					•
	527	Clear Creek	T48 R16W S33, west line to MN/WI border	Fish and macroinvertebrates	•					•
Upper Nemadji River	501	Unnamed creek (Elim Creek)	Unnamed cr to Skunk Cr	Fish				•		
	519	Blackhoof River	Unnamed cr to Ellstrom Lk	Fish and macroinvertebrates				•		
	531	Deer Creek	Headwaters to Nemadji R	Fish	•		•			•
	508	Rock Creek	Unnamed cr to Nemadji R	Fish and macroinvertebrates	•	•			•	•

Pollutant Sources

The majority of the pollutants in the Nemadji River Watershed are from nonpoint sources, which include watershed runoff, channel erosion, and septic systems. Table 6, Table 7, and Table 8 summarize the relative loading from the nonpoint pollutant sources of sediment, phosphorus, and pathogens to the impaired waterbodies, respectively. The summaries are based on data presented in the *Nemadji River Watershed TMDL* (Tetra Tech 2017a) and the *Deer Creek Watershed TMDL Report: Turbidity Impairments* (Barr 2013a).

Sediment (e.g., TSS) in the Nemadji River is associated with highly erodible lacustrine clay deposits and steep near-channel slopes. The Nemadji Watershed has been identified as the largest source of sediment load to Lake Superior (Stortz and Sydor 1976), transporting an average of 120,000 tons of sediment per year (NRCS 1998). The Nemadji River is well known for elevated turbidity and high sediment loads, estimated to be 6.5 times larger than all of Minnesota's North Shore Lake Superior streams combined (Magner and Brooks 2008). Riedel et al. (2005) discuss the erosional response of the Nemadji and show that it is in part due to the combination of active glacial rebound and lowering of the base level in Lake Superior, which causes steep channel slopes in the Nemadji, but that naturally high erosion rates have been more than doubled by human activities. These include forest harvesting in the 1850s, major forest fires in 1894 and 1918, and agricultural expansion on the uplands in the 1930s and 1950s. The harvest of the native mature white pine and red pine forest was of particular importance as it not only removed cover but also resulted in increased water yield and bankfull discharge (Riedel et al. 2005). These changes were further exacerbated by direct impacts on channel geomorphology. As was common practice in the industry, the river channel was used to float logs downstream, a process that was enhanced by removing snags, straightening river meanders, and pulsing of flow through creation and subsequent dynamiting of temporary dams, setting off a chain reaction of geomorphological instability (NRCS 1998).

The detailed study by NRCS (1998) concluded that the majority of sediment exported from the Nemadji is generated from mass wasting processes, due to slumps of valley walls as the streams down cut into erodible lacustrine sediment (Magner and Brooks 2008). Stream reaches with mass wasting are present throughout the watershed except on the relatively flat terrain of the headwaters area.

Turbidity problems are further exacerbated by the presence of numerous springs and seeps in the lower Nemadji that yield turbid, clay-rich water. The hydrogeological phenomena that lead to this condition are summarized by Magner and Brooks (2008). The ridgeline at the north and west of the basin is occupied by the Thompson Moraine, which consists of highly permeable sands. In the lower Nemadji, permeable glacial beach sands are overlain by a cap of fine-grained clay, resulting in artesian conditions with potentiometric heads 10 m above stream water surfaces (Andrews et al. 1980). Thus, deeper groundwater originating in the Thompson Moraine discharges gradually through fractures in the clay material of the lower portions of the basin. This behavior is evident in the two flow gages operated on Deer Creek, in which flow at the lower gage is substantially greater than flow at the upper gage, with increases more than would be expected due to the incremental drainage area, presumably due to the resurfacing of artesian groundwater. Mass wasting is enhanced by artesian pressure and groundwater discharges into the stream. In some locations, direct seepage into the stream is associated with sediment "volcanoes" that actively pump fine sediment into suspension as artesian groundwater discharges through the stream bed (Mooers and Wattrus 2005; EOR 2014).

Phosphorus sources to the two impaired lakes were quantified and are similar to the sediment sources, but also include septic systems. Systems that are functioning properly (conforming) contribute less phosphorus than failing systems or systems that are considered an imminent public health threat (IPHT). Failing systems do not protect groundwater from contamination, and IPHT systems discharge partially treated sewage to the surface. For septic systems located in close proximity to surface waters, both failing and conforming systems contribute phosphorus to surface waters.

Pollutant sources of *E. coli* include livestock, septic systems, domestic pets, and wildlife. *E. coli* from livestock, pets, and wildlife enters surface waters through direct deposition either on the water surface or through deposition and runoff from upland areas. Loads from septic systems are from IPHT systems. Other human sources of *E. coli* in the watershed include straight pipes and earthen pit outhouses. Straight pipe systems are sewage disposal systems that transport raw or partially settled sewage directly to a lake, stream, drainage system, or the ground surface. There are two unsewered communities identified in the watershed: Holyoke and Duesler. No compliance information is available for these areas. Livestock represent the largest source of *E. coli* load in the watersheds of both impaired streams. Human wastewater and domestic pets contribute relatively moderate loads to the impaired streams, and wildlife contribute relatively low loads.

The sediment and phosphorus source assessments are primarily based on a Hydrologic Simulation Program--Fortran (HSPF) watershed model (Tetra Tech 2016b). The *E. coli* source assessment is based on an inventory of the source types in the watershed, *E. coli* production rates per source type, and relative delivery of *E. coli* loads to surface waters.

Table 6. Sediment sources and relative magnitudes in the Nemadji River Watershed

HUC-10 Subwatershed	Stream/Reach (AUID) or Lake (ID)	Pollutant	Pollutant Sources	
			Watershed Runoff	Near Channel [a]
Middle Nemadji River	Mud Creek (537)	Sediment	™	˜
	Clear Creek (527)	Sediment	™	˜
Upper Nemadji River	Nemadji River (757)	Sediment	™	˜
	Skunk Creek (502)	Sediment	™	˜
	Nemadji River (758)	Sediment	™	˜
	Unnamed creek (532)	Sediment	™	˜
	Deer Creek (531)	Sediment	™	˜
	Rock Creek (573)	Sediment	›	›
	Rock Creek (508)	Sediment	›	›
South Fork Nemadji River	Nemadji River, South Fork (558)	Sediment	™	˜

Key: ˜ = High › = Moderate ™ = Low a. Near-channel sources include baseflow sources.

Table 7. Phosphorus sources and relative magnitudes in the Nemadji River Watershed

HUC-10 Subwatershed	Stream/Reach (AUID) or Lake (ID)	Pollutant	Pollutant Sources		
			Watershed Runoff	Near Channel [a]	Septic Systems
Middle Nemadji River	Lac La Belle (09-0011-00)	Phosphorus	›	--	›
South Fork Nemadji River	Net Lake (58-0038-00)	Phosphorus	˜	›	™

Key: ˜ = High › = Moderate ™ = Low
a. Near-channel sources include baseflow sources as provided in the watershed model.

Table 8. *E. coli* sources and relative magnitudes in the Nemadji River Watershed

HUC-10 Subwatershed	Stream/Reach (AUID) or Lake (ID)	Pollutant	Pollutant Sources			
			Septic Systems	Livestock [a]	Wildlife	Domestic Pets
Upper Nemadji River	Nemadji River (758)	*E. coli*	›	›	™	›
South Fork Nemadji River	Nemadji River, South Fork (558)	*E. coli*	›	›	™	›

Key: ˜ = High › = Moderate ™ = Low

a. Livestock adjusted to moderate based on input obtained during WRAPS development.

Construction stormwater is the only, though minor, pollutant source in the Nemadji River Watershed that is regulated through a National Pollutant Discharge Elimination System (NPDES) Permit (Permit) (Table 9). Stormwater from construction sites often carries sediment and other pollutants to surface waterbodies. Coverage under the NPDES Construction Stormwater General Permit requires erosion control measures that reduce stormwater pollution during and after construction activities.

Table 9. Point sources in the Nemadji River Watershed

Point Source	Pollutant Reduction Needed Beyond Current Permit Conditions/Limits?	Relevant Pollutants
Construction stormwater (permit #MNR100001)	No	Sediment, phosphorus

2.4 TMDL Summary

The Clean Water Act and EPA regulations require that TMDLs be developed for waters that do not support their designated uses. In simple terms, a TMDL is a plan to attain and maintain water quality standards in waters that are not currently meeting them. There are 12 impaired stream reaches (Table 1) and 2 impaired lakes (Table 2) in the Nemadji River Watershed. *E. coli* TMDLs were developed for the aquatic recreation impairments that are indicated by high *E. coli* concentrations. TSS TMDLs were developed for aquatic life impairments for which flow alteration and suspended solids were identified as primary stressors. TMDLs were not developed for the two streams that are impaired due to habitat fragmentation (Table 5); these streams do not require TMDLs because the causes are not due to a pollutant. Phosphorus TMDLs were developed for the lakes with aquatic recreation impairments. Table 10 lists the waterbodies with completed TMDLs, and Appendix A provides the current pollutant loading, load reductions needed, and load and wasteload allocations from the TMDLs.

Table 10. Completed TMDLs in the Nemadji River Watershed

HUC-10 Subwater-shed	Stream/Reach (AUID) or Lake (ID)	Affected Designated Use	Cause/Indicator of Impairment	TMDL Pollutant
Middle Nemadji River	Mud Creek (537)	Aquatic Life	Fishes Bioassessments, TSS[a]	TSS
	Clear Creek (527)	Aquatic Life	Aquatic Macroinvertebrate and Fishes Bioassessments, TSS	TSS
	Lac La Belle (09-0011-00)	Aquatic recreation	Nutrient/Eutrophication Biological Indicators	Phosphorus
	Nemadji River (757)	Aquatic Life	TSS	TSS

HUC-10 Subwater-shed	Stream/Reach (AUID) or Lake (ID)	Affected Designated Use	Cause/Indicator of Impairment	TMDL Pollutant
Upper Nemadji River	Skunk Creek (502)	Aquatic Life	TSS	TSS
	Nemadji River (758)	Aquatic Recreation	*Escherichia coli*	TSS
		Aquatic Life	TSS	*E. coli*
	Unnamed creek (532)	Aquatic Life	TSS	TSS
	Deer Creek (531)	Aquatic Life	Turbidity	TSS
	Rock Creek (573)	Aquatic Life	TSS	TSS
	Rock Creek (508)	Aquatic Life	TSS	TSS
South Fork Nemadji River	Nemadji River, South Fork (558)	Aquatic Recreation	*Escherichia coli*	*E. coli*
		Aquatic Life	TSS	TSS
	Net Lake (58-0038-00)	Aquatic recreation	Nutrient/Eutrophication Biological Indicators	Phosphorus

a. All TSS impairments are listed as turbidity impairments in the 2014 303(d) impaired waters list.

2.5 Protection Considerations

Protecting healthy watersheds and water bodies is the state's most cost effective approach to insure that the economic and ecosystem services provided by heathy waters remain intact and provide Minnesotans with quality waters to enjoy for generations to come. All waterbodies that currently meet water quality standards will be managed for protection; however, waterbodies must be prioritized for management recognizing that limited implementation funds will be available. Despite the high sediment in waters throughout the central watershed, there are waters in the Nemadji River Watershed that meet the aquatic life and recreation beneficial uses. These waters will be the focus of protection efforts.

Six lakes in the watershed currently meet the lake eutrophication standards for the region. The lakes were ranked for protection priority using a risk-based approach developed by state resource agencies to prioritize lakes for protection. This process was followed by a discussion and evaluation of local priorities by the Nemadji River Watershed stakeholders group. The risk-based approach considers each lake's sensitivity to increased phosphorus loading, proximity to the water quality standard, the percent of disturbed land use in the watershed, lake size, existing phosphorus levels, and whether the lake shows a declining trend in water clarity. From these components, a ranking is created. The preliminary ranking was then considered by the stakeholder group along with whether the lake had an active lake association, public water access, presence of wild rice, presence of invasive species, or a threat from development. The results for each indicator and the final priority given for each lake are shown in Appendix B. Chub Lake was given a high priority for protection efforts followed by Hay Lake, Sand Lake, and Lake Venoah as medium priorities. Bear Lake and Spring Lake were assigned low priorities for protection (Table 11).

Table 11. Priority ranking for unimpaired lakes

Lake Name	Existing TP (µg/L) 2003–2012	Target TP (µg/L)	Load Reduction to Meet Target (%)	WRAPS Protection Priority
Bear	23	19	15	Low
Chub	23	20	27	High
Hay	28	28	0	Medium
Sand	29	19	29	Medium
Spring	25	21	16	Low
Venoah	16	16	0	Medium

Streams that meet biological criteria, but have somewhat elevated TSS or TP concentrations should be managed for protection. The streams with elevated TSS concentrations include:

- Net River
- Little Net River
- Anderson Creek
- State Line Creek
- Skunk Creek (-504)

The streams with elevated TP concentrations include:

- Deer Creek
- Rock Creek
- Nemadji River
- South Fork of the Nemadji River

Lake Superior, the ultimate receiving water of the Nemadji River Watershed, is also identified as an important protection consideration due to its high value and exceptional water quality.

3. Prioritizing and Implementing Restoration and Protection

The Clean Water Legacy Act (CWLA) requires that WRAPS reports summarize priority areas for targeting actions to improve water quality, and identify point sources and nonpoint sources of pollution with sufficient specificity to prioritize and geographically locate watershed restoration and protection actions. In addition, the CWLA requires including an implementation table of strategies and actions that are capable of cumulatively achieving needed pollution load reductions for point and nonpoint sources.

This section of the report provides the results of such prioritization and strategy development. Because much of the nonpoint source strategies outlined in this section rely on voluntary implementation by landowners, land users and residents of the watershed, it is imperative to create social capital (trust, networks and positive relationships) with those who will be needed to voluntarily implement best management practices (BMPs). Thus, effective ongoing civic engagement is fully a part of the overall plan for moving forward.

The implementation strategies, including associated scales of adoption and timelines, provided in this section are the result of technical analyses and professional judgment based on what is known at this time and, thus, should be considered approximate. Furthermore, many strategies are predicated on needed funding being secured. As such, the proposed actions outlined are subject to adaptive management—an iterative approach of implementation, evaluation and course correction.

3.1 Targeting of Geographic Areas

The approach used to target critical geographic areas was stakeholder-based and developed over a series of meetings. Various tools were discussed for use in targeting critical areas. Tables 12 and 13 provide a summary of tools and data used by stakeholders. Table 12 shows the tools that were used to prioritize the streams for protection and restoration strategies, and Table 13 shows the data reviewed to prioritize implementation strategies.

The tool outputs reviewed by stakeholders included model outputs from the HSPF model, map and score outputs from the Minnesota Department of Natural Resources' (DNR's) Watershed Health Assessment Framework, map and score outputs from the Environmental Benefits Index (EBI), and a map and risk score for a LiDAR derived slope analysis in near-channel areas. In addition, an intensive review and evaluation of datasets provided by the DNR, MPCA, Carlton SWCD and Carlton Highway Department was completed. Data sets reviewed included: sediment and red clay dam locations; failing dams; fish passage barriers and culvert conditions at watershed crossings; trails network for ATVs, snowmobiles and other recreational trails; road crossing infrastructure risk map; forested/open lands percentages by harvest and percent open lands in subwatersheds; near channel slump inventories; stream Index of Biotic Integrity (IBI); trout populations; stream temperatures and baseflow; lake phosphorus risk analysis; and lake protection ranking (see Section 2.5 Table 11). Summaries of these data sets are depicted on map Figures 13 through 25.

The work group also reviewed aerial photography and identified priority areas based on local knowledge, known stressors and potential improvement projects. The stakeholder consensus was to use present data collected by agencies and others (EBI, IBI, trout abundance, stream temperature, and baseflow) in the WRAPS (Table 12; Figure 13 through Figure 18) along with the lake protection work described in Section 2.5.

3.2 Priority Critical Areas

After the targeting process described in the previous section, priority critical areas were identified by local managers. Selection of these subwatershed critical areas will help inform further targeting of geographic areas for project-based work. The priority watersheds for implementation include Skunk Creek, Blackhoof River, and Deer Creek. By selecting these three streams, there is also good representation of the range of sediment impairment, from the high sediment loading rates of Deer Creek, to mid-level loading representative of several streams (Skunk Creek), to the lesser sediment input associated with Blackhoof. Three lakes were identified as priority areas: Net Lake, Lac La Belle and Chub Lake. In addition, assessing and prioritizing streambank slump and bank failures was considered an important watershed wide need.

Skunk and Deer Creeks are impaired by a combination of issues, including poor biotic scores and too much sediment. Blackhoof River is primarily a protection watershed, meeting all water quality standards and biotic scores. One small area of the upper Blackhoof Watershed is impacted with poor habitat. The lower Blackhoof meanders through the clay plain and shows evidence of near channel erosion and sediment input to the stream. Most of this portion of the watershed is managed by the DNR as a wildlife management area and consistently used by sportsmen. The selection of these three watersheds will allow for a variety of BMP work in addressing the combination of issues, land managers and ownerships.

Social readiness to implement projects was also a factor in the selection of critical areas. Landowners and organizations are active in each of the stream watersheds selected. BMPs have been completed in all three of the stream watersheds and continue. Net Lake and Lac La Belle are nutrient impaired and, of the two, Net has an area association. Chub Lake has a higher seasonal total phosphorus average, but meets water quality standards. An active lake association manages Eurasian milfoil and other lake issues. Overall, this makes it a good candidate for protection work.

3.3 Priority Implementation Strategies

Below is the short list of the primary strategies to occur over the first 10-year period (2017 through 2027) of WRAPS implementation. They are organized by general categories with bullets describing specific BMPs. More detailed information can be found in the strategies table, Table 14, and the key to strategies, Table 15.

Engagement and Information Sharing

- Annual educational newsletter and two outreach events each year

Regulatory management – general

- Implement county and state regulations for any new development
- Review ordinances for water quality protection and identify needed revisions (if any)
- Feasibility analysis for site specific standards (TSS watershed-wide and TP for Lac La Belle)

Forest management

- Develop and implement a forestry education and outreach program
- Education materials developed and distributed in state forest
- Develop 10 Forest Stewardship Plans in the watershed and implement 40 projects
- Target forest restoration in subwatersheds with greater than 60% open lands in Hunters and Skunk Creek Watersheds

Septic system management

- Septic system upgrades (as needed) for 50% of all lakeshore owners on Chub, Net, and Lac La Belle lakes
- Septic upgrades at point of sale

Animal/agriculture management

- Education and outreach for animal producers and animal hobby farm owners within a shoreland corridor
- Livestock/feedlot/hobby farm inventory

Lake focused management

- Education and outreach for lakeshore residents
- Shoreland inventory/inspection of two lakes to identify critical shore areas
- Ongoing management of Eurasian milfoil in Chub Lake
- Evaluate opportunities to obtain riparian conservation easements on Venoah Lake
- Shoreland/riparian corridor vegetation management

Stream focused management

- Conservation easements along 2,000 feet of stream
- Complete two stream restoration projects using natural channel design
- Shoreland/riparian corridor vegetation management

Infrastructure projects

- Remove eight fish passage barriers
- Three red clay dam removals and associated stream and fishery restoration
- Recreational trail assessment and project work identification

3.4 Future Targeting via Local Water Planning

The efforts completed via this process should not be considered final priorities. The information and strategies discussed via the WRAPS process will be helpful to the next local water planning process. For example, more questions can be asked of the datasets, or a specific set of data may be teased out that will help define future project work. Other factors like social momentum, accessibility, and comparative costs could be considered. Questions could include:

- Are IBI scores above or very near the threshold and what variables may interact with those scores?
- Does the temperature data support the desired species? What influences temperature throughout the critical life stages or seasonal critical conditions?
- Is there sufficient baseflow to support the desired species?
- Are there abundant trout currently present?
- Does infrastructure provide adequate connectivity for fish and streamflows?
- How, where, to what degree do unstable channels interact with other key data sets like IBI scores, temperature data, infrastructure issues, current and future forest composition, etc.?

The following pages describe the tools and data sets reviewed and show examples, via Figures 19 through 25, of the output used to complete a prioritization and targeting process.

Table 12. Tools to prioritize streams for protection and restoration

Tool	Description	How can the tool be used?	Notes	Link to Information
Environmental Benefit Index	Three GIS layers containing soil erosion risk, water quality risk, and habitat quality. The higher the score, the higher the value in applying restoration or protection.	Any one of the three layers can be used separately or the sum of the layers (EBI) can be used to identify areas that are in line with local priorities.	GIS layers are available on the BWSR website.	Figure 13
Fish IBI	Indicator of the overall health of the fish community along a stream reach. Based on 2011 monitoring data collected as part of the Nemadji River Watershed Monitoring and Assessment Report (2014).	Fish IBI scores above the upper confidence limit and threshold assigned to a given stream reach can be used to prioritize protection. Scores below the lower confidence limit and threshold can be used to prioritize restoration.	See Appendix 6 within the Nemadji River Watershed Monitoring and Assessment Report for additional information.	Figure 14
Macroinvertebrate IBI	Indicator of the overall health of the macroinvertebrate community along a stream reach. Based on 2011 monitoring data collected as part of the Nemadji River Watershed Monitoring and Assessment Report (2014).	Macroinvertebrate IBI scores above the upper confidence limit and threshold assigned to a given stream reach can be used to prioritize protection. Scores below the lower confidence limit and threshold can be used to prioritize restoration.	See Appendix 7 within the Nemadji River Watershed Monitoring and Assessment Report for additional information.	Figure 15
Trout Abundance	Representative trout abundance for all species as surveyed by DNR Fisheries at various locations along stream reaches from 1981 to 2009.	Trout abundance information can be used to guide protection along stream reaches with large populations. Differences in abundance from upstream or downstream survey locations or lack of trout can indicate stream reaches for restoration.	Abundance survey data, categories and symbology provided by DNR Fisheries, 2016. Link to additional information.	Figure 16
Water Temperature	Representative water temperature as surveyed by DNR Fisheries at various locations along stream reaches from 2000 to 2013.	Water temperature information can be used to guide protection along stream reaches with a low percentage of months with temperature lethal to trout. Stream reaches with a high percentage of months with temperatures lethal to trout could be prioritized for restoration.	Water temperature data, categories and symbology provided by DNR Fisheries, 2016. Link to additional information.	Figure 17

Low Flow Trout Habitat Suitability	Stream discharge measurements collected during low flow summer months by DNR Fisheries at various locations along stream reaches from 1966 to 2013. Measurements categorized in terms of the minimum flow required to sustain trout habitat.	Low flow conditions along individual stream reaches can be used to identify and prioritize areas with year-round sustained trout habitat for protection or restoration if flow is markedly lower at specific points along a reach.	Stream discharge data and categories provided by DNR Fisheries, 2016. Link to additional information.	Figure 18

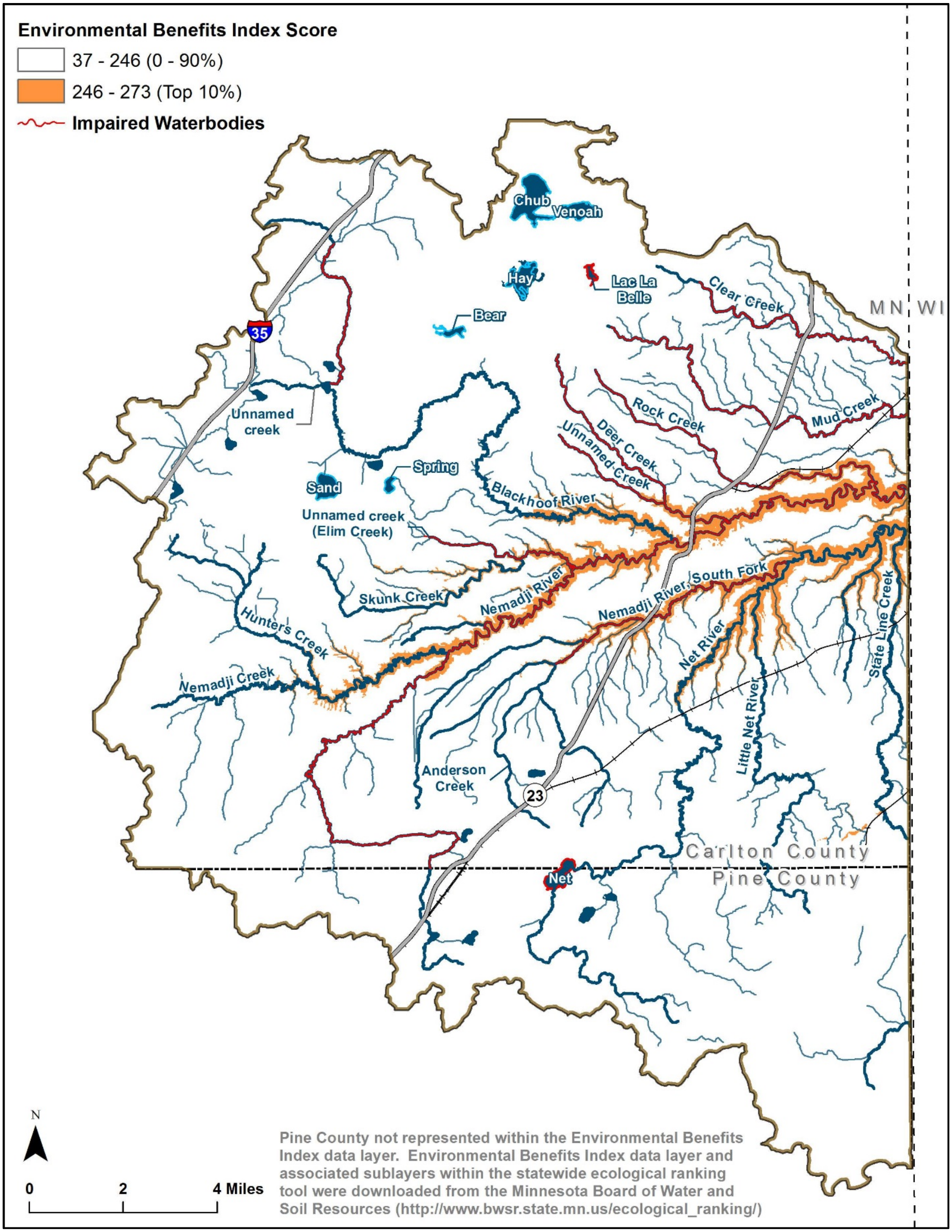


Figure 13. Environmental Benefits Index ranking

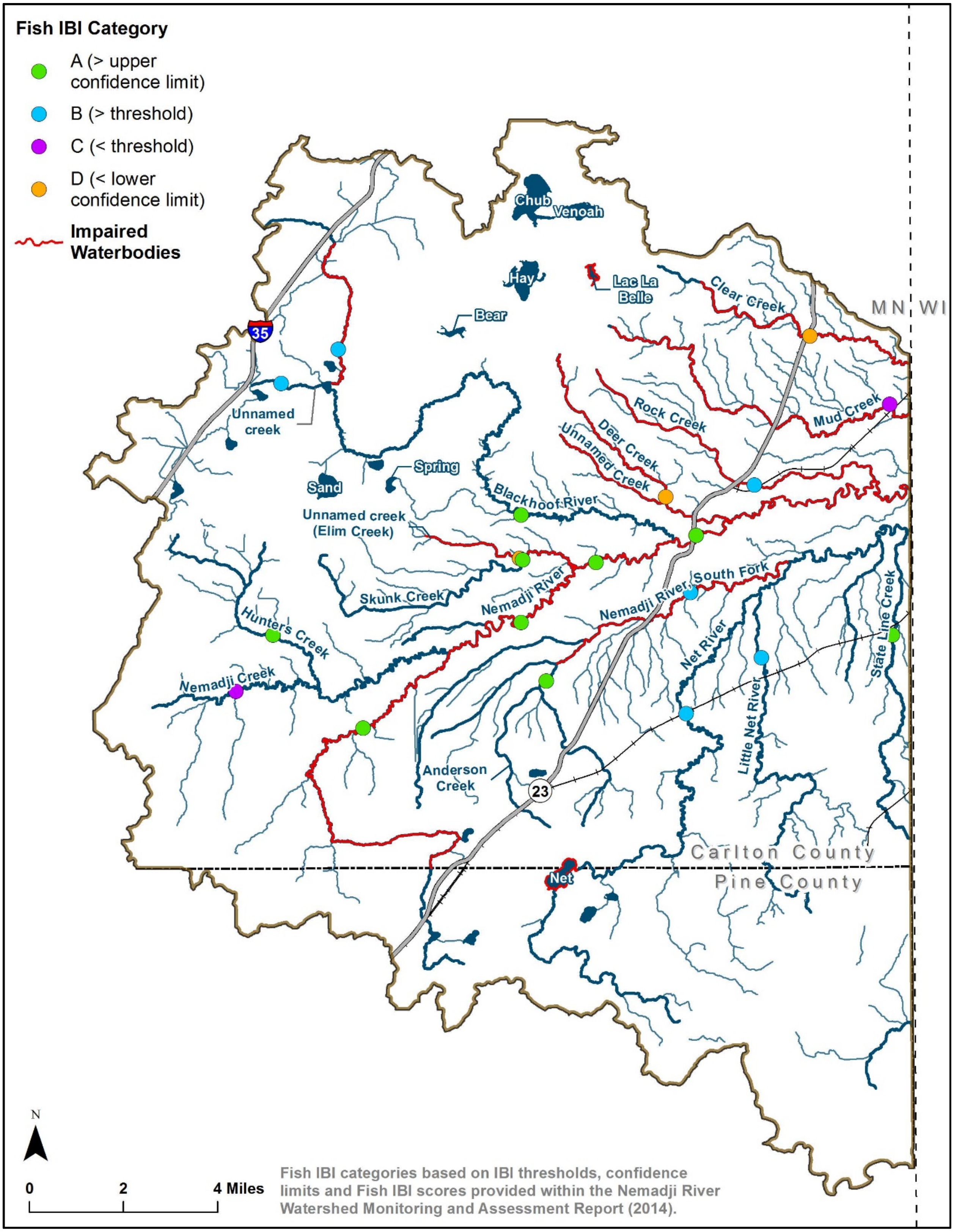


Figure 14. Fish IBI scores

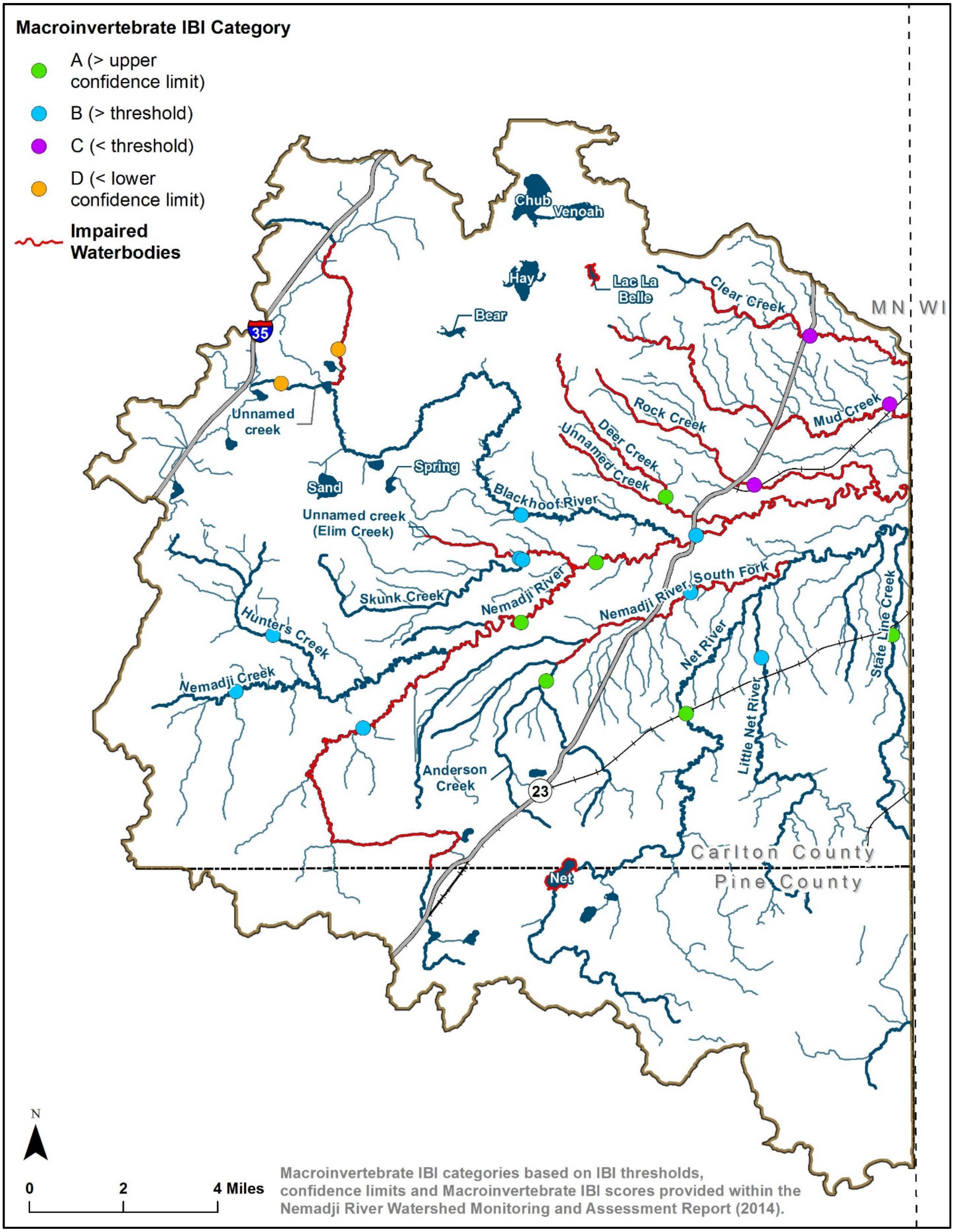


Figure 15. Macroinvertebrate IBI scores

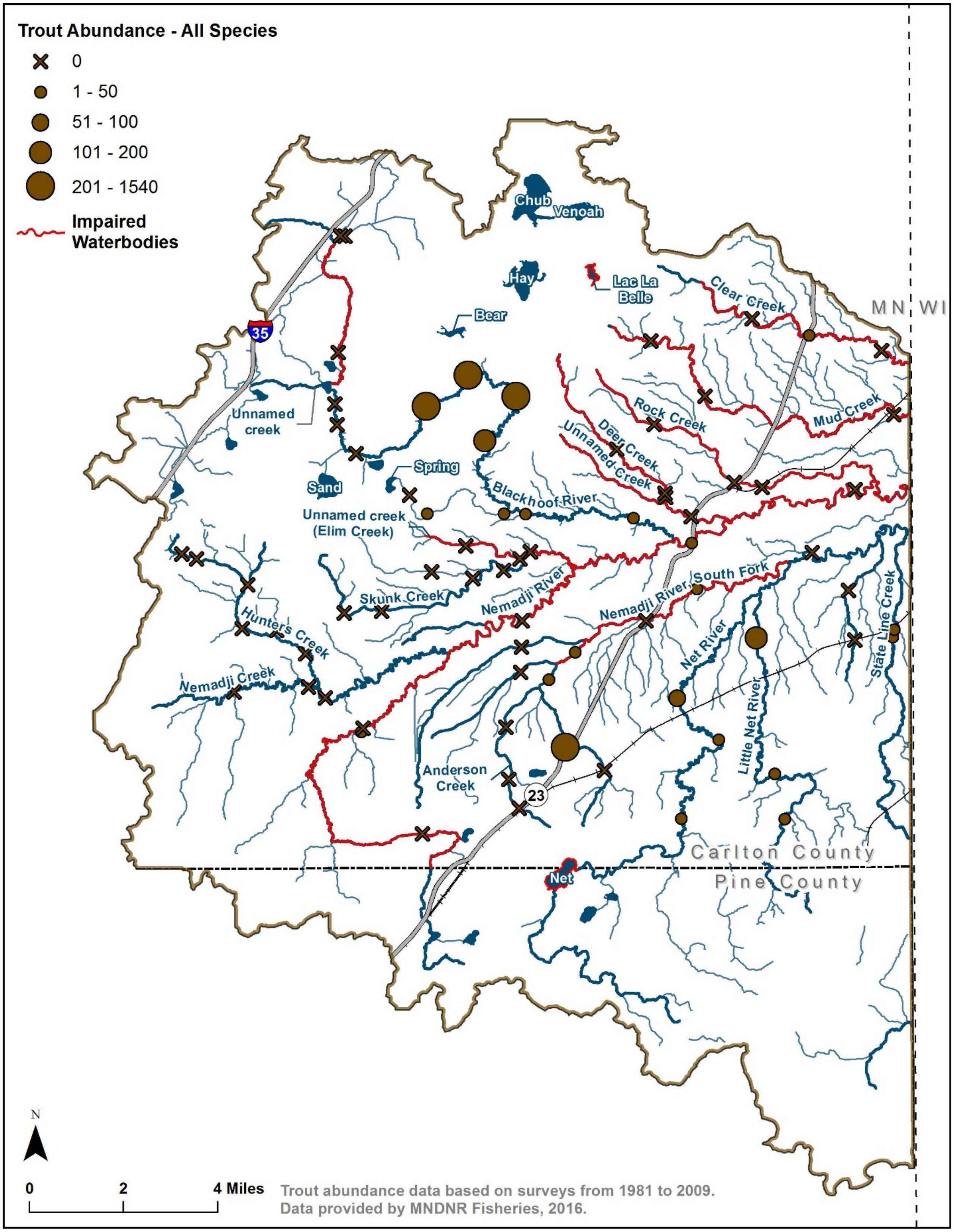


Figure 16. Trout abundance

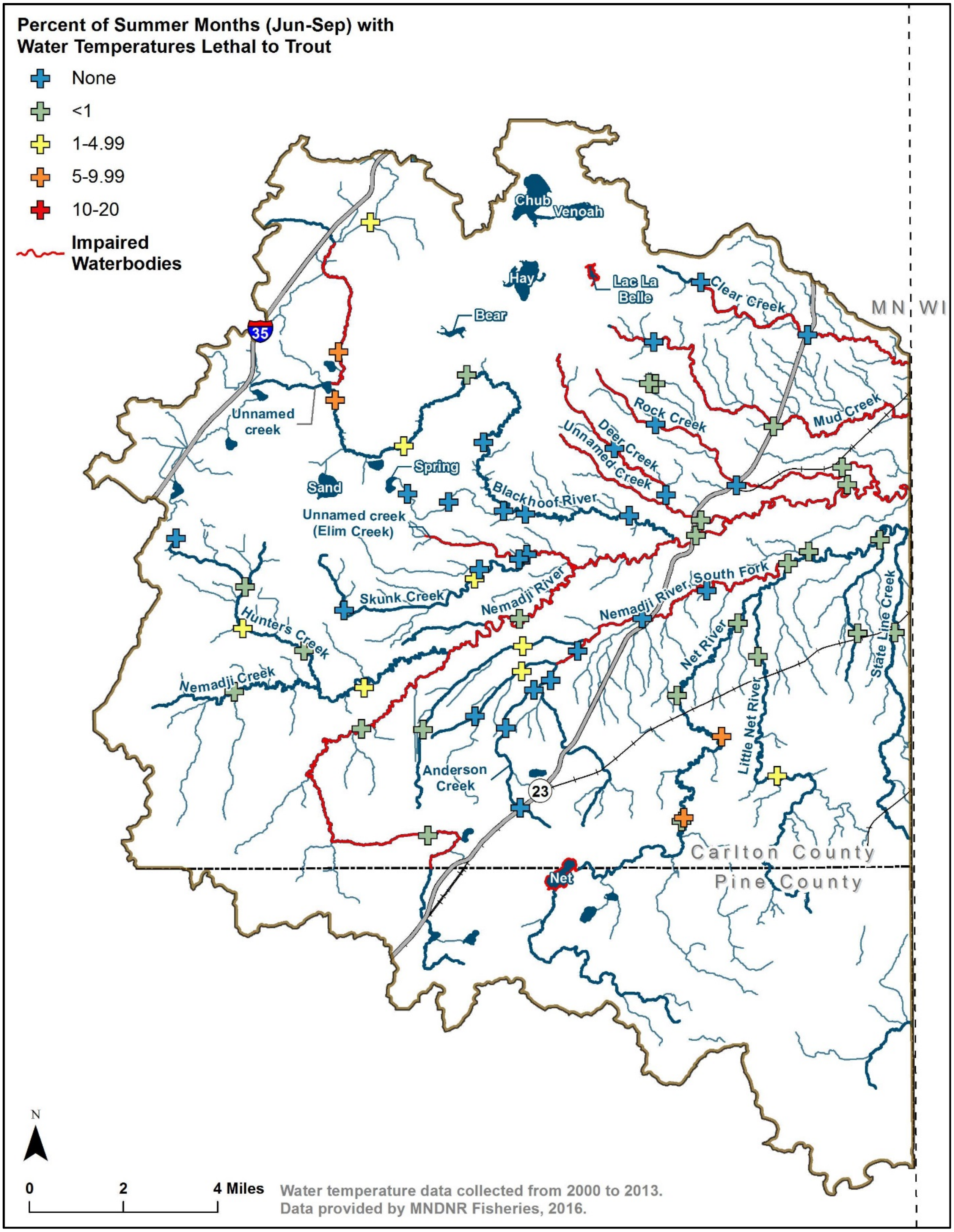


Figure 17. Water temperature

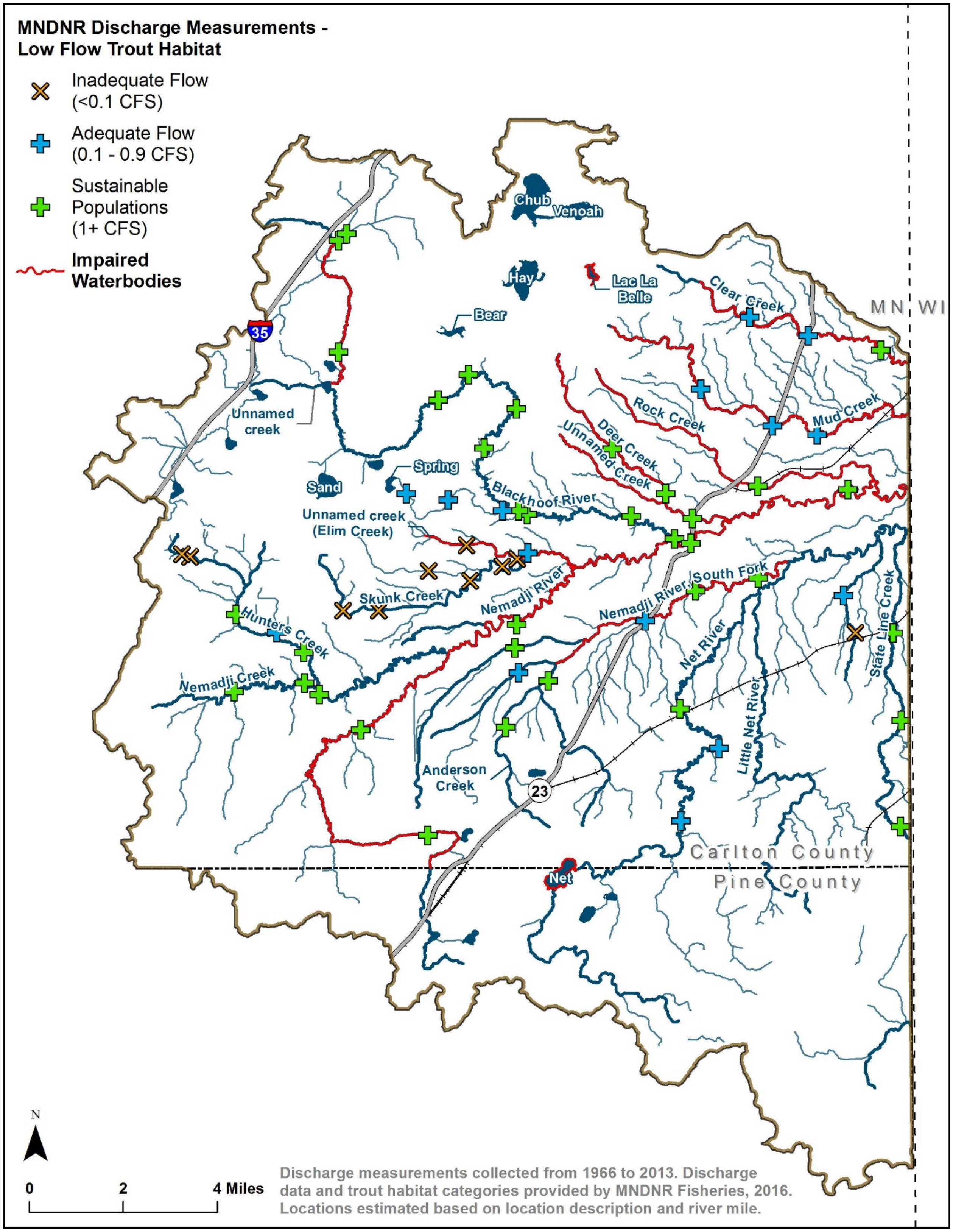


Figure 18. Low flow trout habitat suitability

Table 13. Tools to target strategy implementation

Tool	Description	How can the tool be used?	Notes	Link to Information and data
Red Clay Dams	Location of red clay dams and the priority level for restoration as identified by Carlton County SWCD during Phase I of the Red Clay Dam Project.	Priority scheme for restoration of red clay dam sites.	See http://carltonswcd.org/watersheds/nemadji-river-watershed-guide/watershed-projects/ for additional information.	Figure 19
Sediment Volcanoes	Location of known sediment volcanoes.	General mapping of known sources of sediment.	Locations inferred from Mossberger 2010. To download full report: http://conservancy.umn.edu/handle/11299/93289	Figure 19
Fish Passage Barriers	Location of fish passage barriers as provided by Carlton County SWCD and Carlton County Transportation Department.	In combination with information on fish populations and other habitat data, identify potential project locations for culvert or crossing upgrades to address fish passage barriers. Priority project locations can take into account the length of stream that will opened for fish following restoration.	See http://carltonswcd.org/watersheds/nemadji-river-watershed-guide/watershed-projects/ for additional information.	Figure 20
Infrastructure Risk	Location of culvert and overlying road infrastructure at risk of failing as provided by Carlton County SWCD and Carlton County Transportation Department..	Identify potential project locations for culvert or crossing upgrades to address potential infrastructure failures and associated sediment loading.	For in-depth culvert information and current condition, contact the Carlton County Transportation Department Engineering Division (http://www.co.carlton.mn.us/index.asp?SEC=7C970593-365F-47D7-A4B2-1D8CF2AC6CBE&Type=B_BASIC)	Figure 21
Trails	Location of state forest roads and trail systems including ATV, off-road vehicle trails, and snowmobile trails.	Identify stream crossing and potential locations for education and outreach opportunities with trail users. Target areas to improve or eliminate stream crossings.	State trails and forest roads GIS layers can be downloaded from the Minnesota Geospatial Commons (https://gisdata.mn.gov/).	Figure 22

Open Lands	Percent of open lands as determined through a long-term open lands inventory (1999-2014) conducted by Community GIS Services, 2014. Open land defined as 0 to 15 year harvested forest, agricultural land and urban land uses.	Small catchments with greater than 60% open lands are at risk for watershed degradation. Land management opportunities could be targeted towards areas with a high percentage of open land.	Open lands assessment available through Carlton SWCD. Funding for the open lands assessment provided by the Clean Water Fund.	Figure 23
Harvested Lands	Percent of harvested lands as determined through a long-term open lands inventory (1999-2014) conducted by Community GIS Services, 2014. Harvest land defined as 0 to 15 year harvested forest.	Lands that have been harvested in the past 15 years can be contributing to altered hydrology in the watershed. This map, or the inverse, can be used to focus education and outreach efforts.	Open lands inventory available through Carlton SWCD. Funding for the open lands assessment provided by the Clean Water Fund.	Figure 24
Slump Inventories	Spatial locations of inventoried slumps derived from: · Deer Creek TMDL, 2013 · DNR slump inventory completed in 2008 · Nemadji Watershed slump inventory provided by Carlton SWCD.	Identify locations for stream restoration or streambank stabilization projects. Prioritize streams based on density or occurrence of slumps.	Contact Carlton SWCD for additional information.	Figure 25

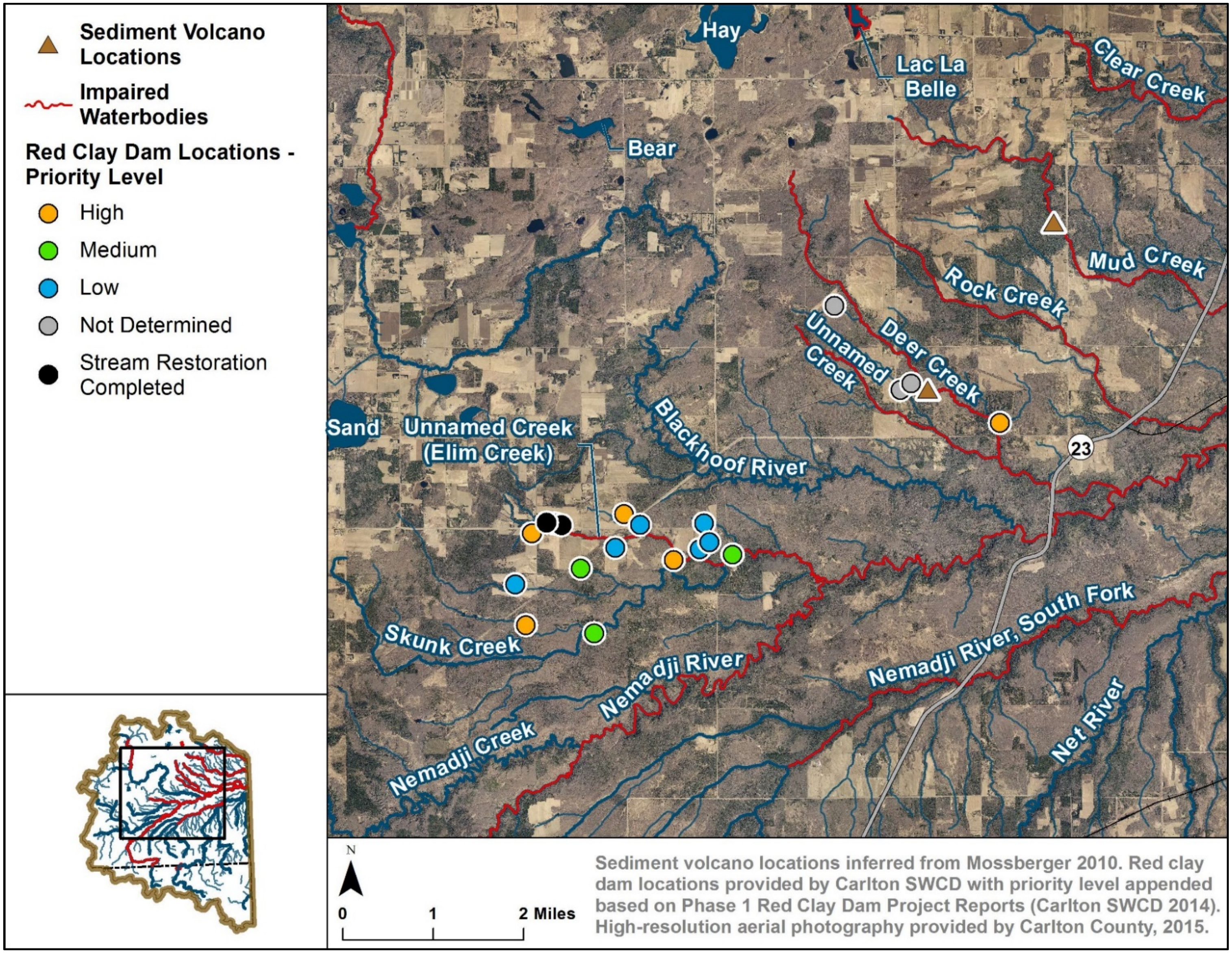


Figure 19. Red clay dams and sediment volcanoes

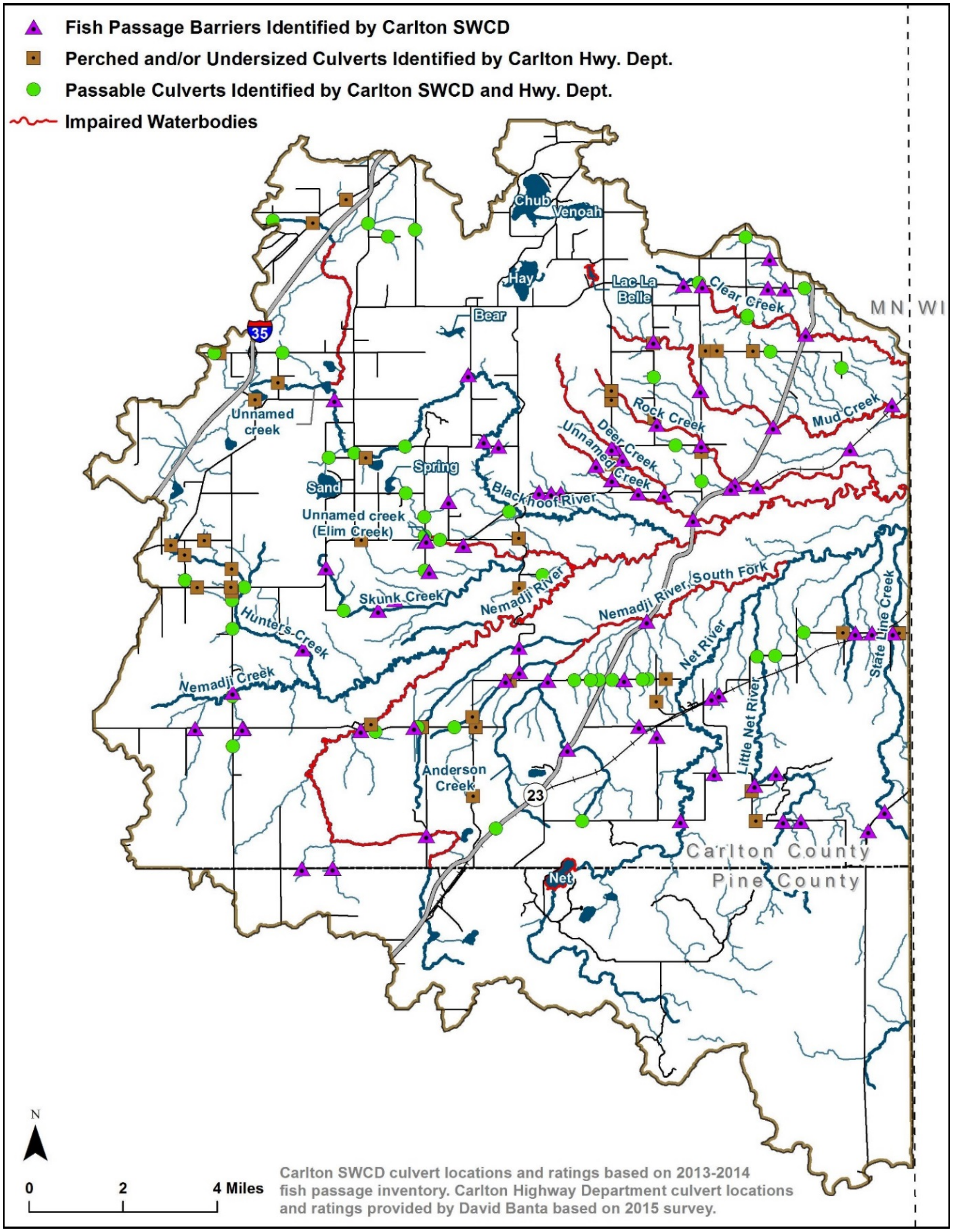


Figure 20. Fish passage barriers

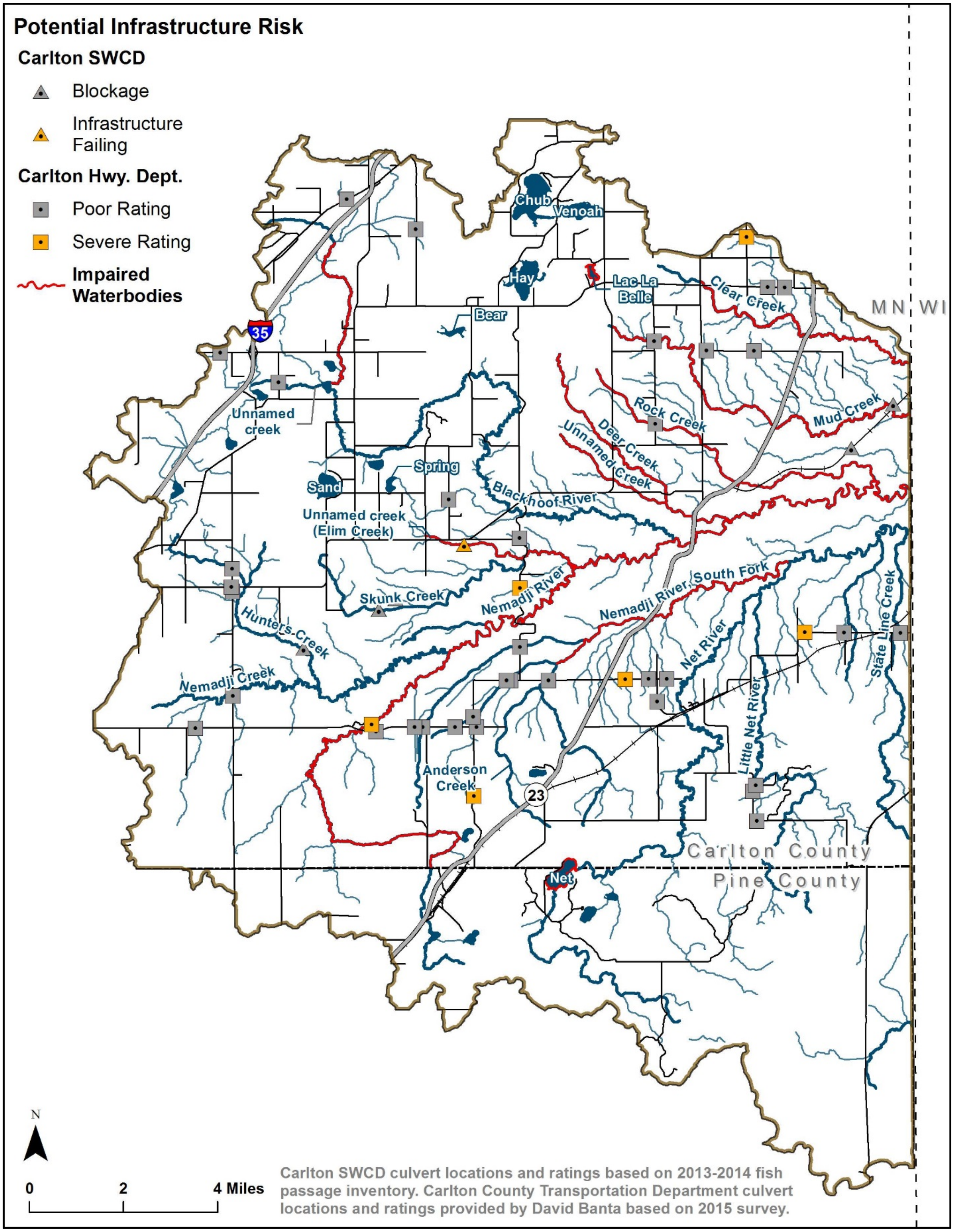


Figure 21. Infrastructure risk

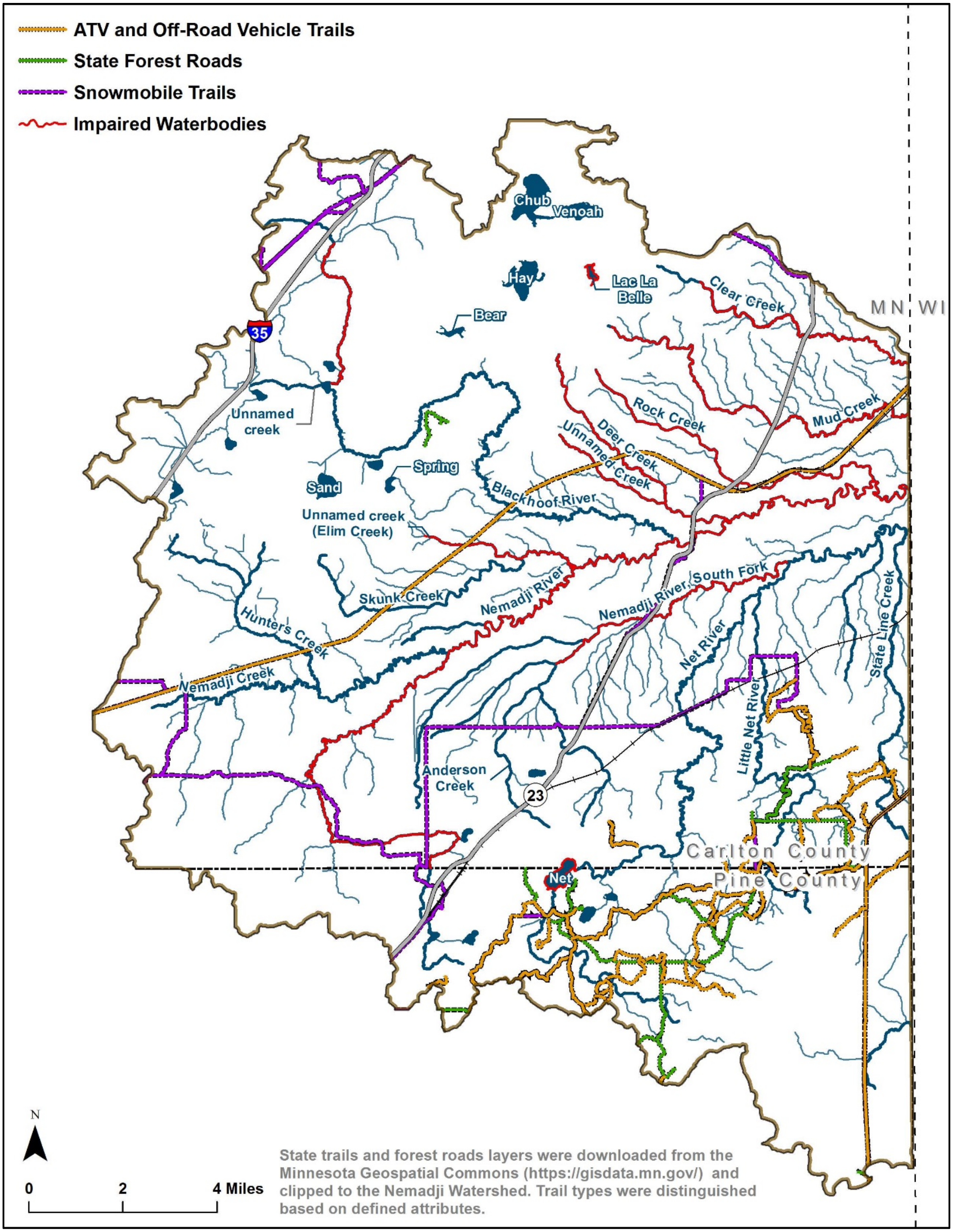


Figure 22. Trails

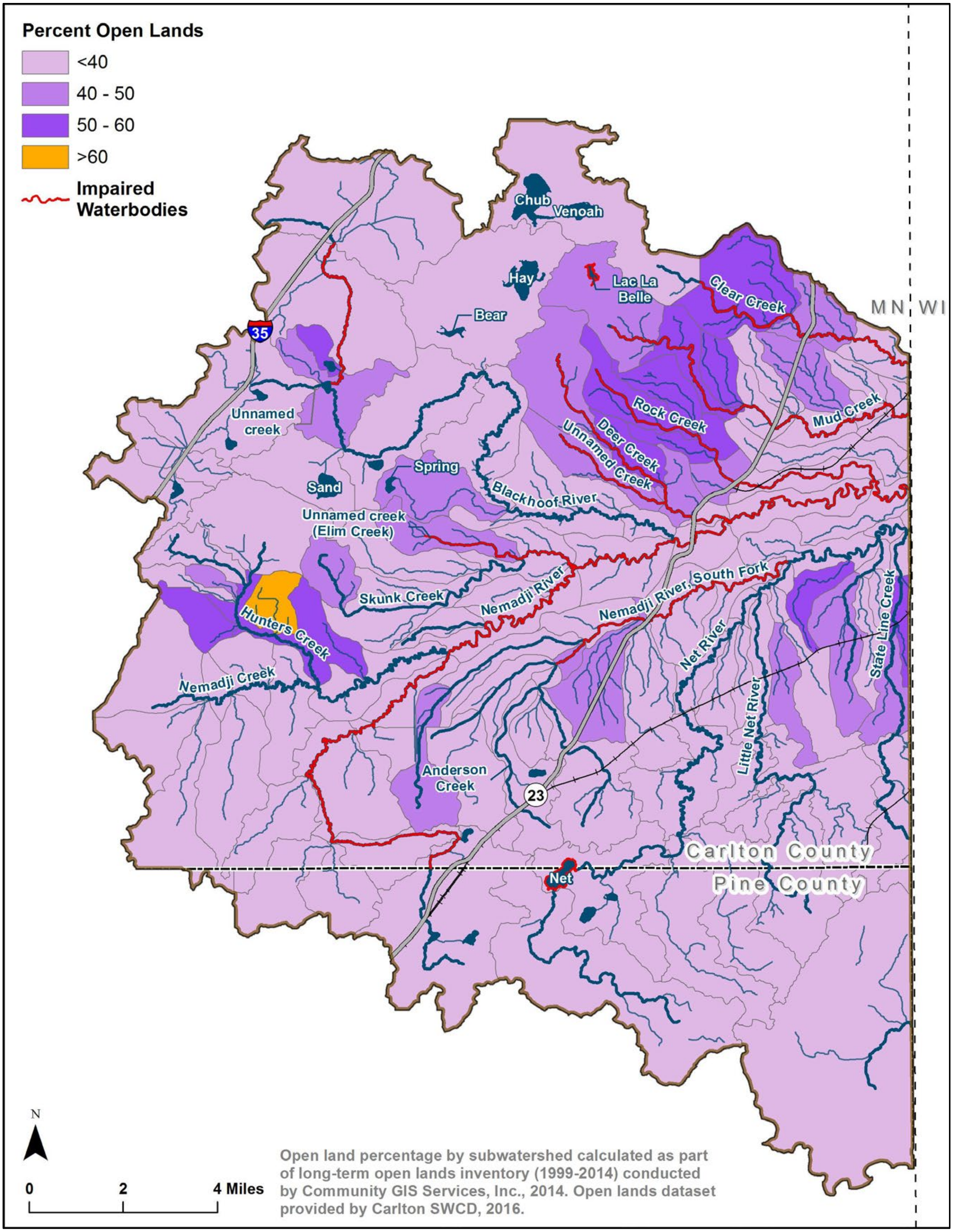


Figure 23. Percent open lands

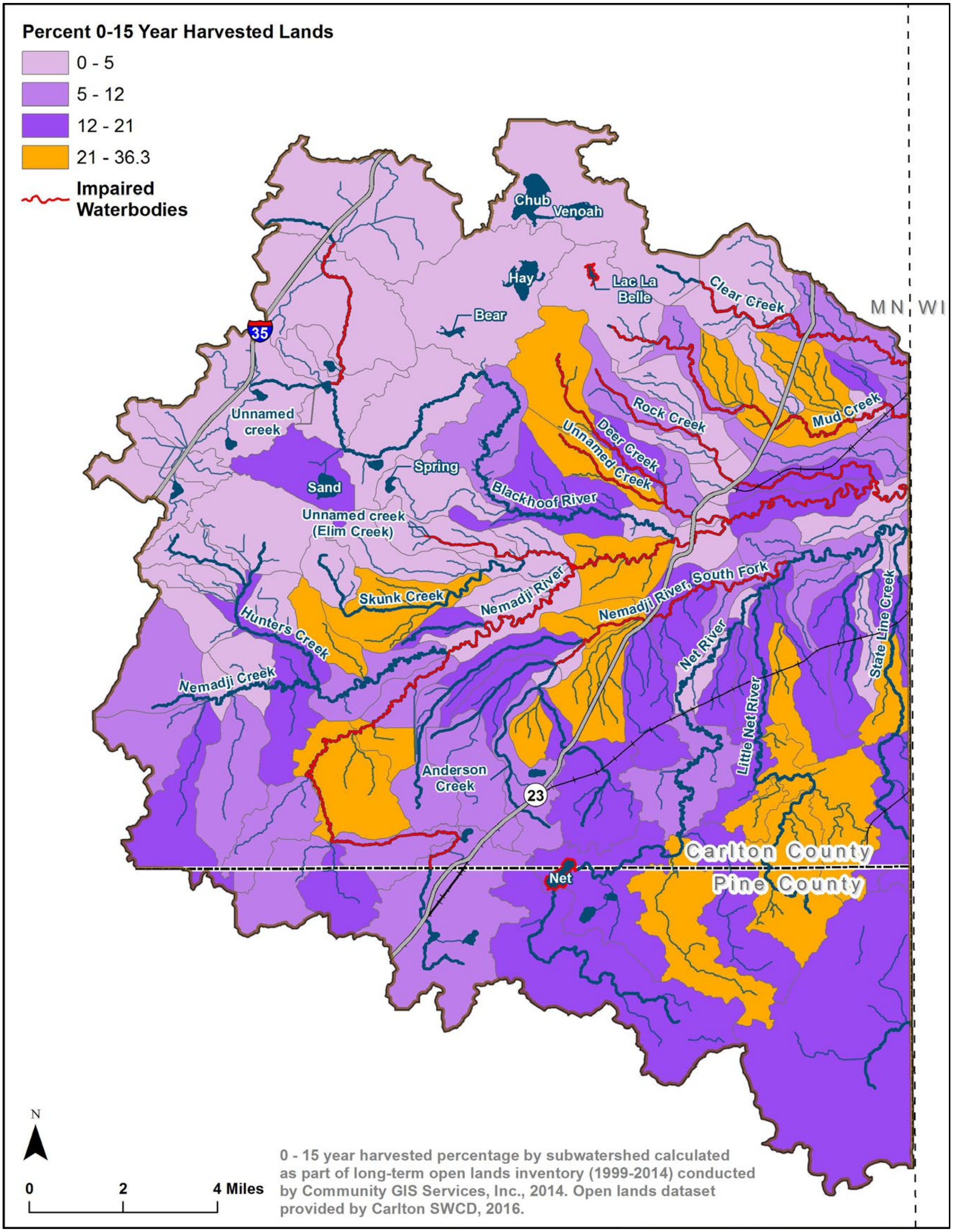


Figure 24. Recent (in the past 15 years) harvested lands

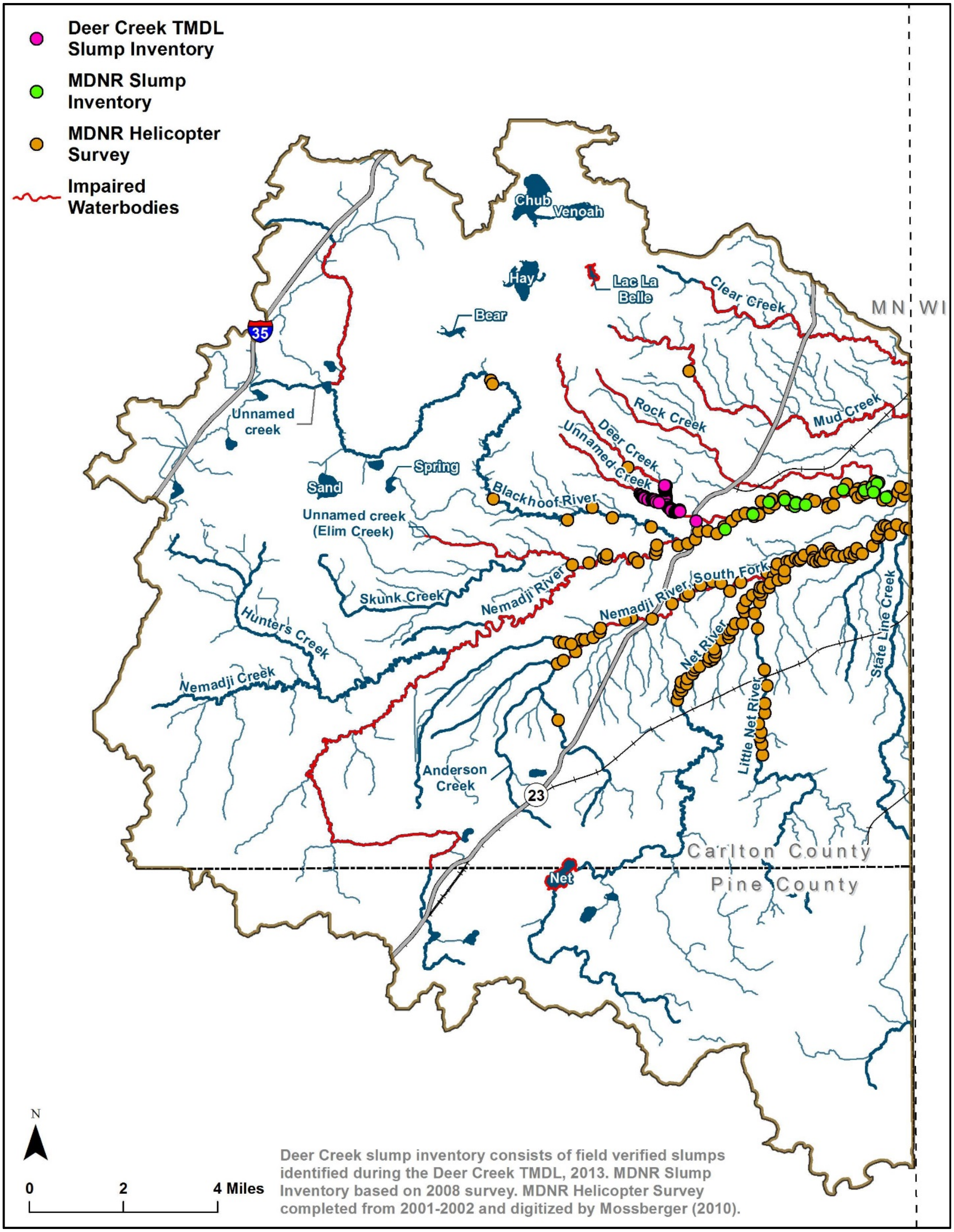
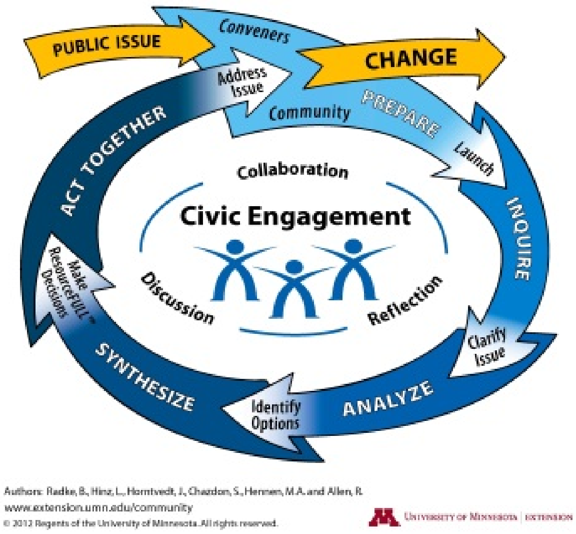


Figure 25. Available slump inventories

3.5 Civic Engagement



A key prerequisite for successful strategy development and on-the-ground implementation is meaningful civic engagement. This is distinguished from the broader term 'public participation' in that civic engagement encompasses a higher, more interactive level of involvement. Specifically, the University of Minnesota Extension's definition of civic engagement is "Making 'resourceFULL' decisions and taking collective action on public issues through processes that involve public discussion, reflection, and collaboration." A resourceFULL decision is one based on diverse sources of information and supported with buy-in, resources (including human), and competence. Further information on civic engagement is available at http://www1.extension.umn.edu/community/civic-engagement/.

Accomplishments and Future Plans

A volunteer task force consisting of agency staff, county representatives, and stakeholders met in 2014 to develop a civic engagement plan that would support WRAPS development and implementation. The task force identified three primary objectives for a civic engagement process:

- Provide opportunities for watershed residents to learn about the health of watershed streams and lakes and stay informed on recent studies, investigations, work projects, etc.
- Provide opportunities for watershed residents to share their observations and give input to natural resource managers
- Provide opportunities for watershed residents to become more actively involved in watershed work through various programs, support at meetings and events, projects on their land, volunteer data collection, etc.

Carlton SWCD along with other local partners have been leading the civic engagement process. The following are examples of civic engagement activities that have taken place since 2014 in the Nemadji River Watershed:

- Nemadji Water Fest (2016)
- School Presentation at Carlton Elementary School (2016)
- Elim Church Stream Restoration Tour (2016)
- River Watch Congress presentation (2016)
- Arrowhead Fly Fishers/Trout Unlimited Joint meeting (2016)
- Gichi Manidoo Giizis Traditional Pow Wow (2014)
- Hosted "Historic Nemadji" event at Chub Lake local park (2014)

Page 4 STAR☆GAZETTE COMMENT Thursday, August 28, 2014

Improving Nemadji watershed through sharing

Kim L. Samuelson
Carlton County SWCD
Supervisor, District 4

On Saturday, August 2 at Chub Lake, the Historic Nemadji Community Potluck brought together a variety of people from the area — homeowners, landowners, representatives from state agencies and local organizations and interested persons. The event was organized by Neva Widner, the water resource technician for the Carlton County Soil and Water Conservation District (SWCD), and was designed to give people a chance to hear and share memories, concerns and perceptions about the changes that have occurred in the Nemadji River and Watershed.

I was there not only as an SWCD supervisor, but also as an "interested person." My family is one of hundreds who recently received a newsletter from the SWCD about similar work that will be starting in the Kettle River watershed. So, I definitely wanted to get an idea of what projects and opportunities may be coming our way in the future.

Those present shared their stories of what the Nemadji watershed was like years ago, where the "big fish" were caught, what bridges and dams were replaced, and where special events (natural and manmade) happened. They poured over maps to pinpoint locations. They shared pictures and information. They laughed at funny remembrances and lamented "then and now" comparisons. In essence, they all agreed the Nemadji River watershed "ain't what it used to be."

Among those sharing what was important to them about the watershed was Mary Munn who has lived in the area since 1979. A biologist by training, Mary wanted to help improve the watershed, so years ago she joined the citizens' board for the Red Clay projects. In addition, she has been a citizen stream monitor on the State Line Creek for over three years.

Mary shared some of her remembrances of an event that happened about 15 years ago that made "big news." During an excavation project near Skank Creek, a spring was unearthed about 50 feet from a home. Enough water flowed from that spring to supply a whole town. Because of the limited demand for the water and possible danger to the home, a way to deal with the unearthed spring had to be devised quickly. A retaining pond was built with the overflow water gently eased into the creek.

To Mary, protecting and improving the natural resources of the watershed are of top importance.

Although Karen Evens is not a local landowner, she is an integral part in organizing events such as this. In her job at the Minnesota Pollution Control Agency (MPCA), Karen has worked with the local communities for many years on watershed projects in the Nemadji watershed. She knows that this watershed, especially with the red clay ravines, is a sensitive area that has a deep impact on the greater Lake Superior watershed.

Karen believes that a successful watershed project not only works with the area's natural resources, but also takes into consideration the local history and culture.

Among her many stories of the Nemadji watershed, one of Karen's most cherished memories is of an old bridge that has been replaced. However, Karen is still amazed that this old bridge for many decades was able to handle the sometimes high and chaotic water flowing through that area.

Another attendee there to share her love of the watershed and of local history was Christine Carlson of Nickerson Township. A researcher and historian who has self-published two books of historical research in Carlton and Pine counties, Christine shared some of her many years of local history gathered from the stories of the old-timers as well as newspaper research.

With her love of the area's waters and natural resources, Christine is happy to see the public outreach and education about the watershed, especially with recognition of the history and stories. She expressed gratitude to the group or organization that placed the Nemadji River watershed signs on Highway 23 near Nickerson as it helps to raise awareness in local citizens and travelers that they are in the watershed. Christine is also thankful to the Carlton County SWCD for their outreach and education.

To Christine, the emphasis on the history and stories of the past are important.

Craig Sterle of Blackhoof is a retired DNR forester who serves with Neva on the committee working in the Nemadji River watershed. Craig was there to answer questions and share information about the watershed as well as to gather the information, stories and concerns people wanted to share about the watershed from the past and present.

To Craig, it is important to educate people, including children, about the watershed and how each of us can help to protect and improve the natural resources.

Like many, improving the fishing in the watershed is of top importance. According to Ed Christian of Blackhoof and Bob Wait of Scanlon, fishing in the Nemadji is not nearly as good as it was 25 years ago. Both Ed and Bob shared stories of the "big fish" that used to be caught in the watershed's rivers and streams years ago. They both shared their longing to see the fish come back, as well as their desires to find out what's going on to improve the watershed and how they can help.

Bob remembered the days in the 1950s when he and his brother fished with a worm and a willow branch during their breaks from watering the horses their father used to cut the hay in the pastures along the river. According to Bob, even in the mid-1960s his brother was catching large trout in the Blackhoof River. Bob, who owns acreage along the Blackhoof River, also expressed his dismay at the number of beaver dams in that area. He felt these beaver dams were partly responsible for the increased buildup of black silt that is bad for fish, and he is looking for help to control the numbers of beaver dams.

No matter what the main concerns or most important issues are about the Nemadji River watershed, I'm sure we all agree — whether we live in the watershed or not — education is important. We all need to learn as much as we can about this watershed (or our own watershed) to help improve the rivers to bring back the "big fish" and the other natural resources we remember from years ago.

If you want to learn more about your watershed, contact the Carlton County SWCD at (218) 384-3891. Neva and the rest of the SWCD staff will be happy to inform you about what they are doing and how you can help.

The Carlton County Soil and Water Conservation District held a community event August 2 where those attending shared a common goal — to work to make the Nemadji watershed in Carlton County the best it can be.

Photo courtesy Carlton SWCD

In addition, articles have been provided in local newspapers and a watershed-focused newsletter has been developed and distributed to area residents.

A series of meetings were also held to specifically obtain input on TMDL and WRAPS development. Representatives from Carlton County, Carlton County SWCD, NRCS, DNR, Wisconsin DNR, MDA, MPCA, industry (forestry) and from the public participated. Meetings were held on the following dates:

- June 16, 2015 - This meeting kicked off TMDL and WRAPS development and included an overview of watershed modeling work being conducted, water quality assessment, and an approach to source assessments. Attendees shared information on current projects and efforts in the watershed.
- October 21, 2015 - This meeting focused on pollutant source assessments, TMDLs, and needed reductions. Attendees shared information on current projects and efforts in the watershed.
- December 17, 2015 - This meeting focused on the results of watershed modeling efforts being concurrently completed by the MPCA. Additional information on TMDL development was discussed and feedback was requested on monitoring priorities and implementation strategies.
- February 3, 2016 - This meeting focused on review of the WRAPS template, discussion on protection measures, presenting various options for targeting and prioritization tools, and introducing potential strategies.
- March 24, 2016 - This meeting focused on review of initial WRAPS chapters, discussion of strategies for inclusion in the WRAPS, and selection of strategies for select waterbodies.
- April 13, 2016 - The work group provided input on the various tools and datasets available for use in targeting and prioritization and further discussed restoration and protection strategies.

- May 11, 2016 – The paleolimnology report for Net Lake and Lac La Belle was presented and discussed with the work group.

The implementation strategies table and associated narrative describe opportunities for continued engagement.

Public Notice for Comments

An opportunity for public comment on the draft TMDL report was provided via a public notice in the State Register from February 13, 2017 through March 15, 2017. Six comments were received. The comments remarked on the TMDL and the WRAPS documents. Commenters suggested improvements to the documents text and improvements or concerns regarding the BMPs identified in the WRAP strategies for future work in the watershed. Some comments provided additional context or detail as to how a BMP might be managed more effectively while going forward with watershed work. Commenters received a response letter. Edits were made to the text of the TMDL document and the WRAPS document where appropriate.

3.6 Technical and Financial Assistance

Technical Assistance

Governmental units with primary implementation responsibility include:

- NRCS/MDA
- MPCA
- DNR
- Carlton County
- Carlton County SWCD

Section 3.4 (Table 14) provides the relevant governmental unit lead(s) for each proposed strategy.

A Technical Work Group is also recommended to assist in implementation and local water planning efforts. It is anticipated that this work group will be a subgroup of the TMDL and WRAPS stakeholder group and will include representatives from state and local agencies along with interested stakeholders. The primary purposes of the work group will be to provide technical oversight and identify opportunities for coordination and engagement with land managers, landowners and water resource-focused groups.

The role of the Work Group could include:

- Creating a master plan to prioritize implementation activities
- Reviewing available monitoring data and prioritizing ongoing monitoring needs
- Refining strategies and identifying specific projects
- Providing technical support for grant applications and local water planning initiatives

An initial task for this work group could include prioritizing future implementation projects and coordinating implementation efforts. Coordination of planned implementation activities by public works departments, state and local agencies, and others can lead to improved ecological benefits and create enhanced projects with water quality benefits. A second priority task for the group could be to define and further develop stream restoration approaches used in the watershed. Guidance and oversight will be needed to prioritize and plan for these projects.

In addition, this work group can support local water planning efforts expected to take place in the next ten years. This watershed-based local planning effort will further develop implementation strategies and recommend specific projects at the local scale. It is expected that the Carlton SWCD will lead and facilitate this work group. Additional local capacity will be needed to support this effort.

Financial Assistance

The proposed WRAPS will rely upon available funding sources to fund projects and programs as described in Section 3.4. The level of implementation proposed for the first ten years is significantly higher than existing efforts and will require new sources of funding for local capacity and capital improvement projects.

Potential funding sources for implementation activities in the Nemadji River Basin include:

- Clean Water Fund, part of the Clean Water, Land, and Legacy Amendment
- Outdoor Heritage Fund, part of the Clean Water, Land, and Legacy Amendment
- Legislative-Citizen Commission on Minnesota Resources
- Local government cost-share and loan programs
- Federal grants and technical assistance programs
- Conservation Reserve Program and NRCS cost-share programs
- Federal CWA Section 319 program
- Great Lakes Restoration Initiative
- MPCA Clean Water Partnership Loan Program (particularly for SSTS upgrades)

3.7 Restoration and Protection Strategies

This section provides a summary of implementation strategies and actions for both restoration and protection (Table 14). The summary table is sorted by HUC10 watershed (Figure 26) and includes all assessed waterbodies in the watershed (Figure 27).

The Nemadji River Basin is primarily forested and rural but is also experiencing mass wasting processes and down-cutting of streams into fine-grained red clay deposits. Erosion in the watershed is based in part on human activities in the watershed and natural processes. The combination creates a unique challenge for implementation. Sediment loading and habitat fragmentation are both key issues being addressed in priority watersheds over the next 10 years. The two maps, Figures 26 and 27, provide visual orientation for the HUC 10 subwatersheds and strategies table that follows.

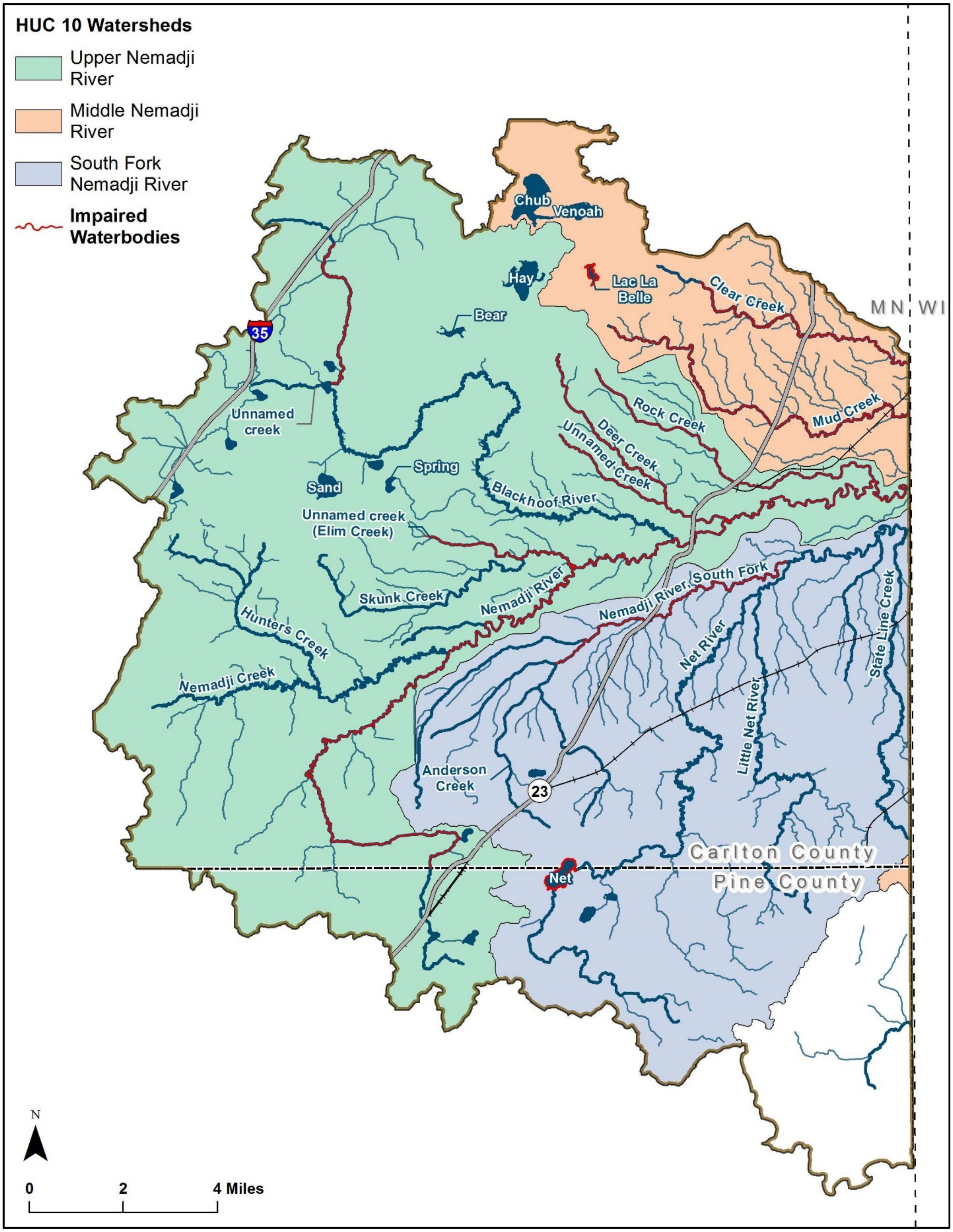


Figure 26. HUC10 Watersheds

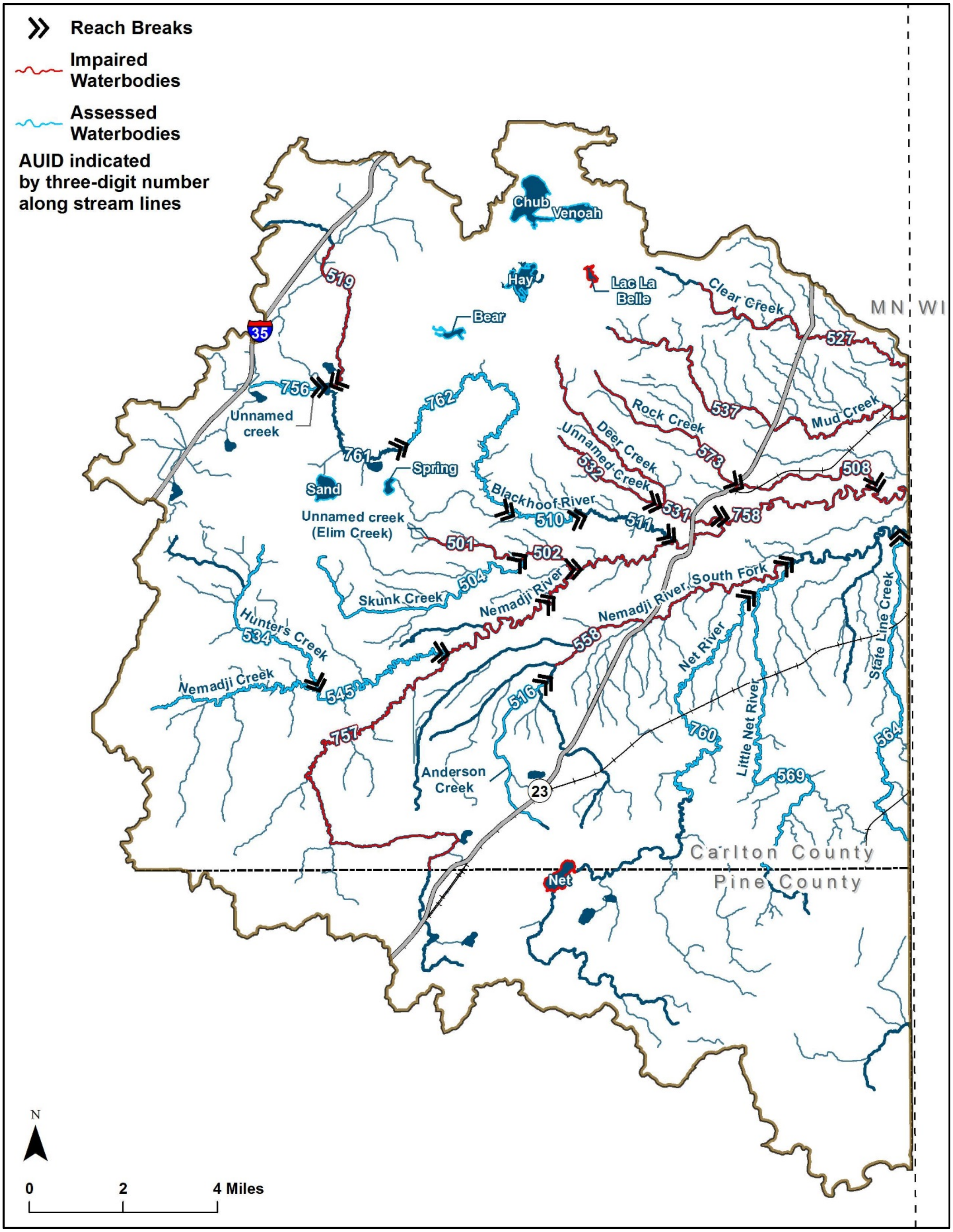


Figure 27. Assessed waters in Nemadji River Watershed

Strategies and Implementation Table

The following pages are the more detailed strategies table laid out by HUC 10 subwatersheds showing both protection and restoration measures. The table begins with a short list of measures to be applied across all watersheds. During stakeholder discussions, these strategies were deemed valuable, ongoing BMPs that should be enhanced over time and applied to all watersheds. Following these “watershed wide” strategies are the more specific strategies reflecting protection and restoration goals for both the targeted subwatersheds and all evaluated subwatersheds of the Nemadji system.

Note also in the strategies text that project work is described as high or low priority. Priorities have been given to address limited resource availability as project work continues in the watershed. As high priority work is completed, the remaining project needs will be evaluated and re-assigned a priority status.

The strategy table includes the following information:

- ***Water Quality – Current Conditions:*** “Current” condition is interpreted as the baseline condition over the evaluation period for the pollutant or non-pollutant stressor identified in the previous column. Current loads are presented as concentration and load, when applicable, and represents available data sources.
- ***Water Quality – Goals / Targets:*** Includes a water quality concentration target that is derived from water quality standards or through the lake prioritization process presented in Section 2.5.
- ***Water Quality – Estimated % and Load Reduction by Flow Regime:*** Expressed in the same terms as Current Conditions and includes a load reduction and/or percent reduction of pollutant needed to meet water quality goal/target.
- ***Strategies:*** This column provides the high-level strategies to be used for both protection and restoration as described in Table 15. Strategies outline the method, approach or combination of approaches that could be taken to achieve water quality goals.
- ***Strategy Type and Estimated Scale of Adoption Needed to Meet Final Water Quality Target:*** This column ties to the strategies column and generally describes the magnitude of effort that it will take to achieve the water quality target. This estimate is meant to describe approximately “what needs to happen” but does not detail precisely “how” goal attainment will be achieved (the latter is left to subsequent planning steps). This is an approximation only and subject to adaptive management.
- ***Interim 10-yr Milestones:*** Describes progress to be made toward implementing the strategy in the first 10 years from completion of the WRAPS report. Note that some waterbodies do not have any planned activity during the first 10 years. These waterbodies are lower priority and activities are expected to take place during the second 10 years.
- ***Governmental Units with Primary Responsibility:*** Identifies the governmental unit with primary responsibility. Other government entities as well as stakeholders, non-profits, and non-governmental units will likely support these strategies.
- ***Estimated Year to Achieve Water Quality Targets:*** This applies to the waterbody, specifically the year it is reasonably estimated that applicable water quality targets will be achieved. It is not possible to estimate a year for those waterbodies that are 2050+.

Table 14. Strategies and actions proposed for the Nemadji River Watershed

HUC-10 Subwatershed	Waterbody	AUID (Last 3 digits)	Location and Upstream Influence Counties	Water Quality: Parameter (incl. non-pollutant stressors)	Water Quality: Current Conditions: Concentration (load)	Water Quality: Goals / Targets	Water Quality: Estimated % and Load Reduction by Flow Regime	Strategies (see key below)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Governmental Units with Primary Responsibility: NRCS	MPCA	DNR	Carlton County	Carlton SWCD	Estimated Year to Achieve Water Quality Target
All	All	All	Carlton, Pine	Parameters cited in permit	Meeting all standards/ needs restoration	Sustain or improve conditions	-	Construction and Industrial Stormwater permittees -- compliance with general permits				x				-
				All				Implement limited-impact development	· Apply to all projects when developing land to provide no net increase in runoff volume and pollutant concentrations and loads · Review county ordinances and determine if revisions are needed to protect water quality	Implement county and state regulations for any new development, ordinance review		x		x		-
								Trail management	· Assess all trail crossings and develop priority list for improvements, provide education materials to trail users · Identify opportunities for and construct controlled stream crossings and exclusion fencing that minimize the impact of recreation vehicles	Education materials developed and distributed in state forest			x	x	x	-
							-	Education and outreach	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					x	-
								Improve forestry management	· Encourage compliance with MN Forest Resources Council Forest Management Guidelines · Develop and implement Forest Stewardship Plans watershed-wide · Forest road management (active and inactive) · Education, outreach and training (e.g., Nemadji Forest Day event) · On-site training · Develop public-private partnerships to promote forest stewardship · Encourage Reinvest in Minnesota-type activities (e.g., conservation easements) in forested areas	Develop 10 Forest Stewardship Plans in the watershed and implement 40 identified projects, develop and implement an education and outreach program			x		x	-
				TSS	-	-	-	Site-specific standard	· Evaluate the feasibility of developing site-specific TSS standard(s) in the watershed · Depending on outcome of feasibility analyses, develop site-specific standard(s)	Complete analysis of site-specific standard feasibility		x				-

HUC-10 Subwatershed	Waterbody	AUID (Last 3 digits)	Location and Upstream Influence Counties	Water Quality				Strategies (see key below)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Governmental Units with Primary Responsibility					Estimated Year to Achieve Water Quality Target
				Parameter (incl. non-pollutant stressors)	Current Conditions: Concentration (load)	Goals / Targets	Estimated % and Load Reduction by Flow Regime				NRCS	MPCA	DNR	Carlton County	Carlton SWCD	
Middle Nemadji River	Mud Creek	537	Carlton	Turbidity/TSS, historic flow alteration	TSS load varies by flow condition: Very High = 135 mg/L (31,168 lb/d) High = 30 mg/L (1,792 lb/d) Mid-range = 11 mg/L (260 lb/d) Low = 12 mg/L (114 lb/d) Very Low = No data	TSS standard <10 mg/L > 90% of the time, April – Sept	Very High = 93% (28,894 lb/d) High = 70% (1,263 lb/d) Mid-range = 27% (71 lb/d) Low = 33% (38 lb/d) Very Low = No data	Sediment volcano stabilization	Locate and determine impact of sediment volcano(s) and mitigate source(s) as needed	Low priority, no activity planned			X	X	X	2050
								Culvert and road management	· Upgrade 4 identified fish passage barriers on main stem of Mud Creek · Inventory and mitigate erosion at all road crossings							
								Stream channel restoration Stabilize ravines, banks, headcuts, and shoreland	· Geomorphic assessment of stream (e.g., Rosgen Level III analysis or some portion of a WARSSS approach) · Inventory slumps and bank failures · Determine restoration opportunities based on assessment and inventory · Restore 3,000 - 5,000 feet of incised streams and failing banks							
	Clear Creek	527	Carlton	Turbidity/TSS, historic flow alteration	TSS load varies by flow condition: Very High = 232 mg/L (49,706 lb/d) High = 49 mg/L (4,143 lb/d) Mid-range = 25 mg/L (796 lb/d) Low = 9.4 mg/L (170 lb/d) Very Low = No data	TSS standard <10 mg/L > 90% of the time, April – Sept	Very High = 96% (47,725 lb/d) High = 85% (3,507 lb/d) Mid-range = 66% (525 lb/d) Low = 36% (61 lb/d) Very Low = No data	Culvert and road management	· Upgrade 6 identified fish passage barriers (3 on main stem, 3 on tributaries) · Inventory and mitigate erosion at all road crossings	Complete geomorphic assessment and inventory of slumps and bank failures			X	X	X	2050
								Stream channel restoration Stabilize ravines, banks, headcuts, and shoreland	· Geomorphic assessment of stream (e.g., Rosgen Level III analysis or some portion of a WARSSS approach) · Inventory slumps and bank failures · Determine restoration opportunities based on assessment and inventory · Restore 5,000 - 7,000 feet of incised streams and failing banks							
	Chub Lake	09-0008-00	Carlton	-	Mean TP = 23 µg/L Mean chl-*a* = 11 µg/L Mean transparency = 3.9 m	Mean TP = 20 µg/L	27% reduction 114 lb/yr	Address septic systems	Identify and upgrade 100% of failing septic systems in riparian areas	**High Priority** 50% of failing systems upgraded, shoreland inventory/inspection to identify critical management areas, ongoing management of milfoil			X	X	X	-
								Stabilize ravines, banks, headcuts, and shoreland	Ensure entire shoreland is protected and well vegetated							
								Reduce in-water loading	Aquatic plant management							
	Venoah Lake	09-0009-00	Carlton	-	Mean TP = 16 µg/L Mean chl-*a* = 3.0 µg/L Mean transparency = 3.3 m	Mean TP = 16 µg/L	0% reduction 0 lb/yr	Improve riparian vegetation	Conservation easements to protect riparian areas	Evaluate opportunities to obtain riparian conservation easements			X		X	-
								Stabilize ravines, banks, headcuts, and shoreland	Ensure entire shoreland is protected and well vegetated							
	Lac La Belle	09-0011-00	Carlton	Nutrients	Mean TP = 58 µg/L	Mean TP = 30 µg/L	60% reduction, 71 lb/yr	Address septic systems	Identify and upgrade 100% of failing septic systems in riparian areas	**High Priority** 50% of failing systems upgraded, complete feasibility analysis for site-specific standard		X		X	X	2035
								Site specific standard	Evaluate the feasibility of developing site-specific eutrophication standard for Lac La Belle							
								Stabilize ravines, banks, headcuts, and shoreland	Ensure entire shoreland is protected and well vegetated							

Restoration   Protection

HUC-10 Subwatershed	Waterbody	AUID (Last 3 digits)	Location and Upstream Influence Counties	Water Quality				Strategies (see key below)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Governmental Units with Primary Responsibility					Estimated Year to Achieve Water Quality Target
				Parameter (incl. non-pollutant stressors)	Current Conditions: Concentration (load)	Goals / Targets	Estimated % and Load Reduction by Flow Regime				NRCS	MPCA	DNR	Carlton County	Carlton SWCD	
Upper Nemadji River	Hunters Creek	534	Carlton	-	Mean TSS = 5 mg/L; Mean TP = 73 µg /L	-	-	Culvert and road management	· Upgrade 2 identified fish passage barriers on the main stem · Inventory and mitigate erosion at all road crossings	Target forest restoration in subwatersheds with >60% open lands, increase shade along 1,000 feet of main stem			X	X	X	-
								Improve forestry management	Decrease % open lands in riparian areas, work with public and private landowners to decrease the % open lands to less than 40%							
								Improve riparian vegetation	Increase shade in riparian corridor to achieve <1% of summer months with water temperatures lethal to trout							
	Nemadji Creek	545	Carlton	-	No TSS data	-	-	Culvert and road management	· Upgrade 3 identified fish passage barriers on main stem and tributaries · Inventory and mitigate erosion at all road crossings	Low priority, no activity planned				X	X	-
								Improve riparian vegetation	Increase shade in riparian corridor to achieve <1% of summer months with water temperatures lethal to trout							
	Nemadji River	757	Carlton, Pine	Turbidity/TSS,	TSS load varies by flow condition: Very High = 291 mg/L (752,134 lb/d) High = 137 mg/L (41,517 lb/d) Mid-range = 66 mg/L (5,280 lb/d) Low = 14 mg/L (714 lb/d) Very Low = 6.6 mg/L (148 lb/d)	TSS standard <10 mg/L > 90% of the time, April – Sept	Very High = 99% (742,512 lb/d) High = 94% (38,943 lb/d) Mid-range = 81% (4,278 lb/d) Low = 45% (324 lb/d) Very Low = No reduction needed	Culvert and road management	· Upgrade 2 identified fish passage barriers on the main stem · Inventory and mitigate erosion at all road crossings	Upgrade 1 identified fish passage barrier at CSAH 8			X	X	X	2050+
								Stream channel restoration Stabilize ravines, banks, headcuts, and shoreland	· Geomorphic assessment of stream (e.g., Rosgen Level III analysis or some portion of a WARSSS approach) · Determine restoration opportunities based on assessment · Restore greater than 25,000 feet of incised streams and failing banks							
	Unnamed creek (Elim Creek)	501	Carlton	Habitat Fragmentation	No TMDL, no reductions needed	-	-	Red clay dam restoration	Remove all failing or high priority red clay dams (3 identified) and restore stream, monitor 4 other functioning red clay dams for signs of failure	Focus on re-establishment of brook trout on this restored stream. A total of 6 dams/barriers removed.			X	X	X	2035
								Culvert and road management	· Upgrade 3 identified fish passage barriers on main stem and tributaries · Inventory and mitigate erosion at all road crossings							
	Skunk Creek	504	Carlton	-	Mean TSS = 71 mg/L; Mean TP = 78 µg/L	-	-	Red clay dam restoration	Remove all failing or high priority red clay dams (2 identified) and restore stream, monitor 3 other functioning red clay dams for signs of failure	**High Priority Watershed for 10 year timeline:** Remove 2 high priority or failing red clay dams and complete restoration			X		X	-
								Stream channel restoration Stabilize ravines, banks, headcuts, and shoreland	· Geomorphic assessment of stream (e.g., Rosgen Level III analysis or some portion of a WARSSS approach) · Inventory slumps and bank failures · Determine restoration opportunities based on assessment and inventory · Restore incised streams and failing banks along 15,000 - 20,000 linear feet within the Skunk Creek (502) and upstream watersheds							
								Improve riparian vegetation	Increase shade in riparian corridor to achieve <1% of summer months with water temperatures lethal to trout							

Restoration Protection

HUC-10 Subwatershed	Waterbody	AUID (Last 3 digits)	Location and Upstream Influence Counties	Water Quality: Parameter (incl. non-pollutant stressors)	Water Quality: Current Conditions: Concentration (load)	Water Quality: Goals / Targets	Water Quality: Estimated % and Load Reduction by Flow Regime	Strategies (see key below)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Governmental Units with Primary Responsibility: NRCS	MPCA	DNR	Carlton County	Carlton SWCD	Estimated Year to Achieve Water Quality Target
Upper Nemadji River	Skunk Creek	502	Carlton	Turbidity/TSS	TSS load varies by flow condition: Very High = 560 mg/L (202,354 lb/d) High = 84 mg/L (5,270 lb/d) Mid-range = 34 mg/L (444 lb/d) Low = 9.9 mg/L (102 lb/d) Very Low = 8.2 mg/L (14 lb/d)	TSS standard <10 mg/L > 90% of the time, April – Sept	Very High = 99% (200,576 lb/d) High = 92% (4,826 lb/d) Mid-range = 63% (279 lb/d) Low = 38% (38 lb/d) Very Low = No reduction needed	Red clay dam restoration	Remove 1 medium priority red clay dam on mainstem and restore stream	2 stream restoration projects, complete geomorphic assessment and inventory of slumps and bank failures			X		X	2040
								Stream channel restoration Stabilize ravines, banks, headcuts, and shoreland	· Geomorphic assessment of stream (e.g., Rosgen Level III analysis or some portion of a WARSSS approach) · Inventory slumps and bank failures · Determine restoration opportunities based on assessment and inventory · Restore incised streams and failing banks along 15,000 - 20,000 linear feet within the Skunk Creek (502) and upstream watersheds							
	Blackhoof River	519	Carlton	Habitat Fragmentation	No TMDL, no reductions needed	-	Improved IBI score	Plan for and mitigate effects of mining	Sand and gravel mining assessment in headwater areas, determine need for additional ordinances to protect baseflow conditions	**High Priority Watershed:** Upgrade 3 fish barriers (on downstream segments), 1,000 feet of conservation easements			X	X	X	2045
								Culvert and road management	Upgrade 3 identified fish passage barriers on the main stem downstream in Blackhoof segments 761 and 762							
								Improve riparian vegetation	· Increase shade in riparian corridor to achieve <1% of summer months with water temperatures lethal to trout for both segment 519 and downstream in segment 761 · Conservation easements to create connections between CR105 and upper boundary of segment (519)							
	Unnamed creek	756	Carlton	-	Mean TSS = 3.87 mg/L	-	-	Culvert and road management	Upgrade 1 identified fish passage barrier	Lower priority, no activity planned				X	X	-
	Blackhoof River	762	Carlton	-	Mean TSS = 7 mg/L; Mean TP = 37 µg/L	-	-	Culvert and road management	Upgrade 2 identified fish passage barriers on the main stem	**High Priority Watershed:** Upgrade 2 fish passage barriers, 1,000 feet of conservation easements			X	X	X	-
								Improve riparian vegetation	Conservation easements to create connections between CR105 and lower boundary of segment (519)							
								Stream channel restoration Stabilize ravines, banks, headcuts, and shoreland	· Geomorphic assessment of stream (e.g., Rosgen Level III analysis or some portion of a WARSSS approach) · Inventory slumps and bank failures · Determine restoration opportunities based on assessment and inventory							
								Plan for and mitigate effects of mining	Sand and gravel mining assessment in headwater areas, determine need for additional ordinances to protect baseflow conditions							
	Blackhoof River	510	Carlton	-	Mean TSS = 7 mg/L; Mean TP = 37 µg/L	-	-	Stream channel restoration Stabilize ravines, banks, headcuts, and shoreland	· Geomorphic assessment of stream (e.g., Rosgen Level III analysis or some portion of a WARSSS approach) · Inventory slumps and bank failures · Determine restoration opportunities based on assessment and inventory	Low priority, no activity planned			X		X	-

Restoration Protection

HUC-10 Subwatershed	Waterbody	AUID (Last 3 digits)	Location and Upstream Influence Counties	Water Quality				Strategies (see key below)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Governmental Units with Primary Responsibility					Estimated Year to Achieve Water Quality Target
				Parameter (incl. non-pollutant stressors)	Current Conditions: Concentration (load)	Goals / Targets	Estimated % and Load Reduction by Flow Regime				NRCS/MDA	MPCA	DNR	Carlton County	Carlton SWCD	
Upper Nemadji River	Nemadji River	758	Carlton, Pine	*E. coli*	*E. coli* load varies by flow condition: Very High = 359 org/100 mL (4,058 B org/d) High = 108 org/100 mL (326 B org/d) Mid-range = 145 org/100 mL (151 B org/d) Low = No data Very Low = No data	Geometric mean ≤ 126 org/100mL	Very High = 73% (2,963 B org/d) High = No reduction needed Mid-range = 7% (11 B org/d) Low = No data Very Low = No data	Address septic systems, feedlot and livestock management	· Identify and upgrade 100% of failing septic systems in riparian areas · Complete livestock and feedlot inventory · Eliminate/mitigate livestock access to streams · Ensure pasture management does not contribute to erosion or sediment loading · Develop a plan if needed to address feedlots and livestock at the county level · Monitor and evaluate *E. coli* sources and patterns in the watershed, taking into consideration growth and die-off of pathogens	Septic upgrades at point of sale, 100% of animal producers/animal hobby farm owners within a shoreland corridor are contacted and informed of available programs, livestock and feedlot inventory completed	X	X		X	X	2040
				Turbidity/TSS	TSS load varies by flow condition: Very High = 1,215 mg/L (16,618,086 lb/d) High = 206 mg/L (126,155 lb/d) Mid-range = 332 mg/L (90,818 lb/d) Low = 10 mg/L (1,215 lb/d) Very Low = 11 mg/L (640 lb/d)	TSS standard <10 mg/L > 90% of the time, April – Sept	Very High = 100% (16,598,943 lb/d) High = 95% (120,377 lb/d) Mid-range = 97% (88,371 lb/d) Low = 18% (215 lb/d) Very Low = 23% (148 lb/d)	Stream channel restoration Stabilize ravines, banks, headcuts, and shoreland	· Geomorphic assessment of stream (e.g., Rosgen Level III analysis or some portion of a WARSSS approach) · Inventory and prioritize slumps and bank failures for restoration activities · Determine feasibility of restoration and restoration opportunities based on assessment and inventory Inventory and mitigate erosion at all road crossings	Low priority, no activity planned			X	X	X	2050+
	Unnamed creek	532	Carlton	Turbidity/TSS	No TSS data	TSS standard <10 mg/L > 90% of the time, April – Sept	No TSS data	Culvert and road management	· Upgrade 3 identified fish passage barriers on main stem of Unnamed Creek and 1 fish passage barrier downstream on Deer Creek · Inventory and mitigate erosion at all road crossings	Low priority, no activity planned			X	X	X	2050+
								Stream channel restoration Stabilize ravines, banks, headcuts, and shoreland	· Geomorphic assessment of stream (e.g., Rosgen Level III analysis or some portion of a WARSSS approach) · Inventory slumps and bank failures · Determine restoration opportunities based on assessment and inventory							
	Deer Creek	531	Carlton	Historic flow alteration, turbidity/TSS, physical habitat	TSS load varies by flow condition: Very High = 13,314 lb/d High = 810 lb/d Mid-range 94 lb/d Low = 228 lb/d Very Low =(128 lb/d	TSS standard <10 mg/L > 90% of the time, April – Sept	Very High = 97% (12,885 lb/d) High = 91% (737 lb/d) Mid-range = 57% (54 lb/d) Low = 82% (188 lb/d) Very Low = 79% (101 lb/d)	Red clay dam restoration	Remove all failing red clay dams (three identified as failing, one is unknown) and restore stream, monitor 1 other functioning red clay dam for signs of failure	**High Priority Watershed:** Assess mud volcano site for solutions and pursue funding for construction. Upgrade stream crossing at Highway 23 and mitigate fish passage barrier. Restore 1 red clay dam.			X	X	X	2050+
								Culvert and road management	· Upgrade 5 identified fish passage barriers · Inventory and mitigate erosion at all road crossings							
								Sediment volcano stabilization	Reduce sediment load from sediment volcanoes to reduce baseflow sediment concentrations at CSAH 6 by 50 percent, if feasible.							
								Stream channel restoration Stabilize ravines, banks, headcuts, and shoreland	· Restore over 25,000 feet of incised streams and failing banks within the Deer Creek (531) and Unnamed Creek (532) watersheds. · Follow slump and streambank restoration recommendations included in the Deer Creek TMDL Implementation Plan (2013).							

HUC-10 Subwatershed	Waterbody	AUID (Last 3 digits)	Location and Upstream Influence Counties	Water Quality				Strategies (see key below)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Governmental Units with Primary Responsibility					Estimated Year to Achieve Water Quality Target
				Parameter (incl. non-pollutant stressors)	Current Conditions: Concentration (load)	Goals / Targets	Estimated % and Load Reduction by Flow Regime				NRCS	MPCA	DNR	Carlton County	Carlton SWCD	
Upper Nemadji River	Rock Creek	573	Carlton	Turbidity/TSS	TSS load varies by flow condition: Very High = 360 mg/L (61,107 lb/d) High = 128 mg/L (4,115 lb/d) Mid-range = 96 mg/L (618 lb/d) Low = 20 mg/L (70 lb/d) Very Low = 21 mg/L (15 lb/d)	TSS standard <10 mg/L > 90% of the time, April – Sept	Very High = 99% (60,323 lb/d) High = 96% (3,940 lb/d) Mid-range = 90% (555 lb/d) Low = 66% (47 lb/d) Very Low = 49% (7.3 lb/d)	Culvert and road management	· Upgrade 3 identified fish passage barriers on main stem · Inventory and mitigate erosion at all road crossings	Complete geomorphic assessment and inventory of slumps and bank failures	X		X	X	X	2050
								Reduce watershed loading	Assess need for agricultural BMPs to mitigate erosion and sediment loading, work with landowners to install recommended practices							
								Stream channel restoration Stabilize ravines, banks, headcuts, and shoreland	· Geomorphic assessment of stream (e.g., Rosgen Level III analysis or some portion of a WARSSS approach) · Inventory slumps and bank failures · Determine restoration opportunities based on assessment and inventory · Restore incised streams and failing banks along 6,000 - 8,000 feet							
	Rock Creek	508	Carlton	TSS/ turbidity, historic flow alteration, recent flow alteration, water temperature	TSS load varies by flow condition: Very High = 360 mg/L (81,447 lb/d) High = 128 mg/L (5,485 lb/d) Mid-range = 96 mg/L (824 lb/d) Low = 20 mg/L (93 lb/d) Very Low = 21 mg/L (20 lb/d)	TSS standard <10 mg/L > 90% of the time, April – Sept	Very High = 99% (80,401 lb/d) High = 96% (5,252 lb/d) Mid-range = 90% (740 lb/d) Low = 66% (62 lb/d) Very Low = 49% (9.7 lb/d)	Culvert and road management	· Upgrade 1 identified fish passage barriers on main stem · Inventory and mitigate erosion at all road crossings	Complete geomorphic assessment and inventory of slumps and bank failures			X	X	X	2050
								Stream channel restoration Stabilize ravines, banks, headcuts, and shoreland	· Geomorphic assessment of stream (e.g., Rosgen Level III analysis or some portion of a WARSSS approach) · Inventory slumps and bank failures · Determine restoration opportunities based on assessment and inventory · Restore incised streams and failing banks along 2,000 - 3,000 feet							
	Bear Lake	09-0005-00	Carlton	-	Mean TP = 23 µg/L Mean chl-*a* = 8.8 µg/L Mean transparency = 3.2 m	Mean TP = 19 µg/L	15% reduction 59 lb/yr	Address septic systems	Identify and upgrade 100% of failing septic systems in riparian areas	Low priority, no activity planned		X		X	X	-
								Stabilize ravines, banks, headcuts, and shoreland	Ensure entire shoreland is protected and well vegetated							
	Spring Lake	09-0007-00	Carlton	-	Mean TP = 25 µg/L Mean chl-*a* = 5.5 µg/L Mean transparency = 3.2 m	Mean TP = 21 µg/L	16% reduction 280 lb/yr	Address septic systems	Identify and upgrade 100% of failing septic systems in riparian areas	Low priority, no activity planned		X		X	X	-
								Stabilize ravines, banks, headcuts, and shoreland	Ensure entire shoreland is protected and well vegetated							
	Hay Lake	09-0010-00	Carlton	-	Mean TP = 28 µg/L Mean chl-*a* = 7.0 µg/L Mean transparency =1.6 m	Mean TP = 28 µg/L	0% reduction 0 lb/yr	Address septic systems	Identify and upgrade 100% of failing septic systems in riparian areas	Low priority, no activity planned		X		X	X	-
								Stabilize ravines, banks, headcuts, and shoreland	Ensure entire shoreland is protected and well vegetated							
	Sand Lake	09-0016-00	Carlton	-	Mean TP = 29 µg/L Mean chl-*a* = 6.5 µg/L Mean transparency = 1.3 m	Mean TP = 19 µg/L	29% reduction 20 lb/yr	Address septic systems	Identify and upgrade 100% of failing septic systems in riparian areas	Low priority, no activity planned		X		X	X	-
								Stabilize ravines, banks, headcuts, and shoreland	Ensure entire shoreland is protected and well vegetated							

Restoration   Protection

HUC-10 Subwatershed	Waterbody	AUID (Last 3 digits)	Location and Upstream Influence Counties	Water Quality				Strategies (see key below)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones	Governmental Units with Primary Responsibility					Estimated Year to Achieve Water Quality Target
				Parameter (incl. non-pollutant stressors)	Current Conditions: Concentration (load)	Goals / Targets	Estimated % and Load Reduction by Flow Regime				NRCS/MDA	MPCA	DNR	Carlton County	Carlton SWCD	
South Fork Nemadji River	Anderson Creek	516	Carlton	-	Mean TSS = 32 mg/L; Mean TP = 50 µg/L	-	-	Culvert and road management	· Upgrade 1 identified fish passage barrier · Inventory and mitigate erosion at all road crossings	Low priority, no activity planned				X	X	-
	Little Net River	569	Carlton, Pine	-	Mean TSS = 30 mg/L; Mean TP = 74 µg/L	-	-	Culvert and road management	· Upgrade 3 identified fish passage barriers on main stem · Inventory and mitigate erosion at all road crossings	Low priority, no activity planned			X	X	X	-
								Improve riparian vegetation	Increase shade in riparian corridor to achieve <1% of summer months with water temperatures lethal to trout							
								Stream channel restoration Stabilize ravines, banks, headcuts, and shoreland	· Geomorphic assessment of stream (e.g., Rosgen Level III analysis or some portion of a WARSSS approach) · Inventory slumps and bank failures · Determine restoration opportunities based on assessment and inventory							
	Net River	760	Carlton, Pine	-	Mean TSS = 25 mg/L; Mean TP = 60 µg/L	-	-	Culvert and road management	· Upgrade 1 identified fish passage barrier on main stem · Inventory and mitigate erosion at all road crossings	Low priority, no activity planned			X	X	X	-
								Improve riparian vegetation	Increase shade in riparian corridor to achieve <1% of summer months with water temperatures lethal to trout							
								Stream channel restoration Stabilize ravines, banks, headcuts, and shoreland	· Geomorphic assessment of stream (e.g., Rosgen Level III analysis or some portion of a WARSSS approach) · Inventory slumps and bank failures · Determine restoration opportunities based on assessment and inventory							
	Nemadji River, South Fork	558	Carlton, Pine	*E. coli*	*E. coli* load varies by flow condition: Very High = 326 org/100 mL (705 B org/d) High = 111 org/100 mL (73 B org/d) Mid-range = 156 org/100 mL (27 B org/d) Low = No data Very Low = No data	Geometric mean ≤ 126 org/100mL	Very High = 63% (446 B org/d) High = 9% (6.6 B org/d) Mid-range = 8% (2.2 B org/d) Low = No data Very Low = No data	Address septic systems	Identify and upgrade 100% of failing septic systems in riparian areas	Septic upgrades at point of sale, 100% of animal producers/ animal hobby farm owners within a shoreland corridor are contacted and informed of available programs, livestock and feedlot inventory completed	X	X		X	X	2050
								Feedlot and livestock management	· Complete livestock and feedlot inventory · Eliminate/mitigate livestock access to streams · Ensure pasture management does not contribute to erosion or sediment loading · Develop a plan if needed to address feedlots and livestock at the county level · Monitor and evaluate *E. coli* sources and patterns in the watershed, taking into consideration growth and die-off of pathogens							
				Turbidity/TSS	TSS load varies by flow condition: Very High = 1,163 mg/L (3,077,901 lb/d) High = 54 mg/L (12,552 lb/d) Mid-range = 17 mg/L (647 lb/d) Low = 12 mg/L (157 lb/d) Very Low = 9.0 mg/L (40 lb/d)	TSS standard <10 mg/L > 90% of the time, April – Sept	Very High = 100% (3,073,380 lb/d) High = 91% (11,387 lb/d) Mid-range = 33% (215 lb/d) Low = No reduction needed Very Low = No reduction needed	Improve riparian vegetation	Increase riparian shade in tributaries to achieve <1% of summer months with water temperatures lethal to trout	Restore 1,000 feet of riparian vegetation along Clear Creek (tributary), upgrade 1 identified fish passage barrier at UT-1105			X	X	X	2050+
								Culvert and road management	· Upgrade more than 10 identified fish passage barriers in tributaries · Inventory and mitigate erosion at all road crossings							
								Stream channel restoration Stabilize ravines, banks, headcuts, and shoreland	· Geomorphic assessment of stream (e.g., Rosgen Level III analysis or some portion of a WARSSS approach) · Inventory slumps and bank failures · Determine restoration opportunities based on assessment and inventory · Restore incised streams and failing banks along greater than 25,000 feet of main channel and tributaries							
	State Line Creek	564	Carlton, Pine	-	Mean TSS = 24 mg/L; Mean TP = 46 µg/L	-	-	Culvert and road management	· Upgrade 2 identified fish passage barrier · Inventory and mitigate erosion at all road crossings	Low priority, no activity planned				X	X	-
	Net Lake	58-0038-00	Carlton, Pine	Nutrients	Mean TP = 40 µg/L Mean chl-*a* = 8.7 µg/L Mean transparency =0.8 m	Mean TP = 30 µg/L	23% reduction, 365 lb/yr	Address septic systems	Identify and upgrade 100% of failing septic systems in riparian areas	**High Priority** 50% of failing systems upgraded, shoreland inventory/inspection		X		X	X	2035
								Reduce watershed loading	Assess sources of watershed loading (e.g., wetlands, land disturbance), mitigate anthropogenic sources of nutrients.							
								Stabilize ravines, banks, headcuts, and shoreland	Ensure entire shoreland is protected and well vegetated							

Table 15. Key for strategies column

Strategy	Practices
Red clay dam restoration	· Removal of failing red clay dams and restoration of natural stream channel
Sediment volcano stabilization	· Inventory of springs and sediment volcanoes · Sediment volcano monitoring and feasibility study · Artesian pressure and sediment volcano control, if applicable
Culvert and road management	· Address road crossings (direct erosion) and floodplain cut-offs · Replace or repair priority fish barriers identified by the Carlton County SWCD and Carlton County culvert inventory and fish passage study · Accurately size bridges and culverts to improve stream stability · Design standards and training workshops for culvert replacement focused on recognizing and maintaining stream channel grade control and providing long-term channel stability · Utilize climate change tools like HSPF watershed model, etc.
Trail management	· Assess and improve trail crossings to prevent erosion and mitigate activities leading to streambank failures · Education and outreach program focused on no impact/low impact recreational use and management
Stream channel restoration: Use natural channel design principle to restore or stabilize incised streams and reconnect the floodplain.	· Holistic restoration approach to create a stable channel that may include dissipating energy, creating diversity of habitats and reconnecting the floodplain to channel, step pool morphology, and planting of vegetation · Restore natural meander and complexity · Geomorphic assessments (e.g., Rosgen Level III or some portion of a WARSSS approach (Level I, II, and III))
Stabilize ravines, banks, headcuts, and shoreland: Reduce erosion by dispersing runoff, earthwork/regrading and revegetation.	· Stream channel grade stabilization, constructed rock riffles to stabilize migrating knickpoints · Controlled/managed stream crossings (livestock, ATV, forest roads, forest activities, other) · Streambank and shoreline protection/stabilization · Lake shoreland revegetation · Inventory slumps and bank failures · Education program for lakeshore residents and stream riparian owners
Improve riparian vegetation: Plant and improve perennial vegetation in riparian areas to stabilize soil, filter pollutants, and deter waterfowl.	· Improve/increase natural habitat in riparian corridor, control invasive species · Tree planting to increase shading · Wild rice management · Conservation easements
Improve forestry management	· Continue/increase compliance with MN Forest Resources Council Forest Management Guidelines · Develop and implement Forest Stewardship Plans · Improve forest road management (active and inactive) · Education, outreach and training on forest mgmt. specifics · Develop public-private partnerships to promote forest stewardship · Encourage Reinvest in Minnesota (RIM) activities (e.g., conservation easements) in forested areas · Encourage conversion to long lived conifer
Plan for and mitigate effects of mining: Actions to decrease the risk of groundwater impacts	· Sand and gravel mining assessment in headwater areas

Strategy	Practices
Livestock management: Prevent manure from entering streams by keeping it in storage or below the soil surface and by limiting/managing access of animals to streams	· Animal agriculture producers and animal hobby farm owners outreach · Updated feedlot and livestock inventory (riparian and watershed-wide) · Grazing and pasture management · Riparian corridor survey for livestock exclusion · Implement livestock exclusion · Based on information obtained as part of the updated inventory: o Adherence with 7020 Rules o Improved field manure (nutrient) management o Improve feedlot runoff control o Increase application setbacks o Improve manure storage in ways that prevent runoff o Revisit county delegation authority, county ordinance
Address septic systems: Fix septic systems to ensure no on-site sewage is released to surface waters. Includes eliminating straight pipe discharges.	· Landowner focused education and outreach on septic system maintenance and compliance · Support increased compliance inspections (in addition to current point of sale inspections) · Support septic system improvements (education, programmatic, funding, other) · Eliminate straight pipes and surface seepages · Identify opportunities for cluster systems and work with landowners to implement
Reduce in-water loading: Address internal phosphorus loading in lakes.	· Aquatic plant management · Fisheries management · Minimize resuspension of sediment from bottom waters · Improve low oxygen conditions in lakes
Reduce watershed loading: Address watershed loading to lakes and streams.	· Monitor and assess tributaries to lakes · Assess wetlands for phosphorus contributions · Implement agricultural BMPs to mitigate erosion and sediment loading · Encourage/promote conversion to long lived conifer. Promote/employ efforts to sustain forest cover.
Implement limited-impact development: Manage development to provide no net increase in rate or volume of pollutants and maintain natural hydrology.	· Stormwater management – See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php · Ensure compliance with MPCA's Construction Stormwater Permit · Ordinance development/revision (e.g., shoreland ordinance revision, possible development of conservation overlay district or open land ordinance, local stormwater ordinance) · Ordinance workshops (lake associations, shoreland owners, contractors/developers, citizen decision-making boards etc.) · Explore wetland banking and develop opportunities for wetland mitigation efforts within the watershed · Land use planning and implementation of county water plans · Conservation easements, development limiting strategies in sensitive areas, land purchase in sensitive areas

4. Monitoring Plan

It is the intent of the implementing organizations in this watershed to make steady progress in terms of pollutant reduction. As a general guideline, progress benchmarks are established for this watershed that assume improvements will occur resulting in a water quality pollutant concentration decline each year equivalent to approximately 2% to 4% of the starting (i.e., long-term) pollutant load. More detail is provided below:

Impaired lakes (Net Lake and Lac La Belle) need a 2% to 3% reduction in total phosphorus load per year to meet water quality standards by 2035.

E. coli impaired streams (South Fork Nemadji River and Nemadji River (-758) need to reduce pathogen loading by 2% to 3% each year in order to meet water quality standards in 2050 and 2040, respectively.

All other impaired streams that require TSS load reductions over the next 19 to 34 years will need 3% to 4% reduction in TSS loads per year to meet water quality standards within the timeframe defined in Table 14. For those streams that have timeframes beyond 2050 (i.e., Deer Creek, Nemadji River (-758), and South Fork Nemadji River), no specific rate of TSS load reduction is provided.

Factors that may mean slower progress include limits in funding or landowner acceptance, challenging fixes (e.g., large unstable bluffs, banks and ravines, invasive species, accessibility) and unfavorable climatic factors. Conversely, there may be faster progress for some impaired waters, especially where high-impact fixes are slated to occur, such as red clay dam restoration.

This section outlines a plan for ongoing water quality monitoring to fill data gaps, determine changing conditions, and gage implementation effectiveness.

4.1 Existing Monitoring Efforts

Several entities have conducted monitoring in the Nemadji River Watershed. Sites that have been monitored for streamflow are shown in Figure 28 with the period of record for each site. Figure 29 shows sites where TSS data is present by number of samples collected, and represents the locations for most of the other parameters measured in the watershed as provided by the DNR and the MPCA databases accessed in May 2016. In addition, the USGS has operated a long-term continuous flow gage on the main stem of the Nemadji in Wisconsin. Maintaining this station is critical for long-term tracking of progress and water quality improvement. Other shorter-term continuous monitoring stations are scattered throughout the watershed.

Intensive watershed monitoring occurred throughout the watershed during 2011 and 2012 as part of the statewide Watershed Approach. The monitoring consisted of fish and macroinvertebrates sampling at several sites in the watershed, along with chemistry sampling at selected sites. Other ancillary data relative to habitat and stream stability were also collected. The next round of intensive monitoring is scheduled to begin in 2021.

Long-term streamflow and water quality monitoring is being conducted at two sites on the Nemadji River as part of the state's Watershed Pollutant Load Monitoring Network (WPLMN). The sites include the USGS flow gage in Wisconsin, combined with sampling near the mouth of the river and a DNR/MPCA site at Highway 23 in the mid-portion of the watershed. WPLMN measures and compares data on pollutant loads from Minnesota's rivers and streams and tracks water quality trends. WPLMN data will be used to assist with assessing impaired waters, watershed modeling, determining pollutant source contributions, developing watershed and water quality reports, and measuring the effectiveness of water quality restoration efforts. There is also one Long Term Biological Monitoring station (11LS062) on the Blackhoof River that is sampled bi-annually for fish, macroinvertebrates, flow and chemistry. Monitoring began in 2011 at this site and is expected to continue.

DNR Fisheries staff collect various data in support of fishery management including stream temperature, flow, and trout abundance monitoring. It is anticipated that new data will be collected into the future.

Carlton County SWCD anticipates a targeted monitoring program beginning in 2017 that may include the following:

- Lake sampling – two lakes over two years for chlorophyll-*a* and phosphorus
- Stream sampling – six different sites sampled over two years for *E. coli*, TSSs, total suspended volatile solids, and phosphorus

The watershed has also long been a project area for University of Minnesota researchers and citizen organizations such as Trout Unlimited and the Arrowhead Fly Fisherman organization. In addition, volunteer transparency monitoring is conducted throughout the watershed using T-tubes. Carlton County has also acquired a turbidity probe and plans to monitor various locations.

4.2 Monitoring Needs

Monitoring of flow and water quality are needed throughout the Nemadji River Basin to refine modeling and source assessments and inform implementation. In addition, monitoring is needed to better understand channel evolution and critical areas for sediment loss in the watershed. Data gaps have also been identified as part of the TMDL and associated modeling work. Table 16 summarizes recommended new monitoring activities in the watershed.

Table 16. Summary of monitoring needs

Pollutant	Type	Location
Pathogens (i.e., *E. coli*)	Grab samples	Main stem Nemadji River, tributaries
	Longitudinal profile/synoptic sampling	Main stem Nemadji River
Phosphorus (also chlorophyll-*a* and Secchi disk transparency for lakes)	Grab samples	Impaired and priority lakes
		Inputs to Net Lake
Sediment	Grab samples	Tributaries (Blackhoof River, Nemadji Creek, others)
	Longitudinal profile/synoptic sampling	Main stem Nemadji River
	Bank erosion and channel migration	All streams
Flow	Continuous monitoring	Inputs to Net Lake
		All water quality monitoring sites; identify new long-term continuous flow sites (on one or more tributaries)

As implementation activities are conducted in the watershed, an evaluation of the before and after conditions can be useful to aid in future project planning. In addition to flow and water quality monitoring, a broader assessment of ecological function and restoration could be used to assess various components of the stream system and overall effectiveness of the implementation activity.

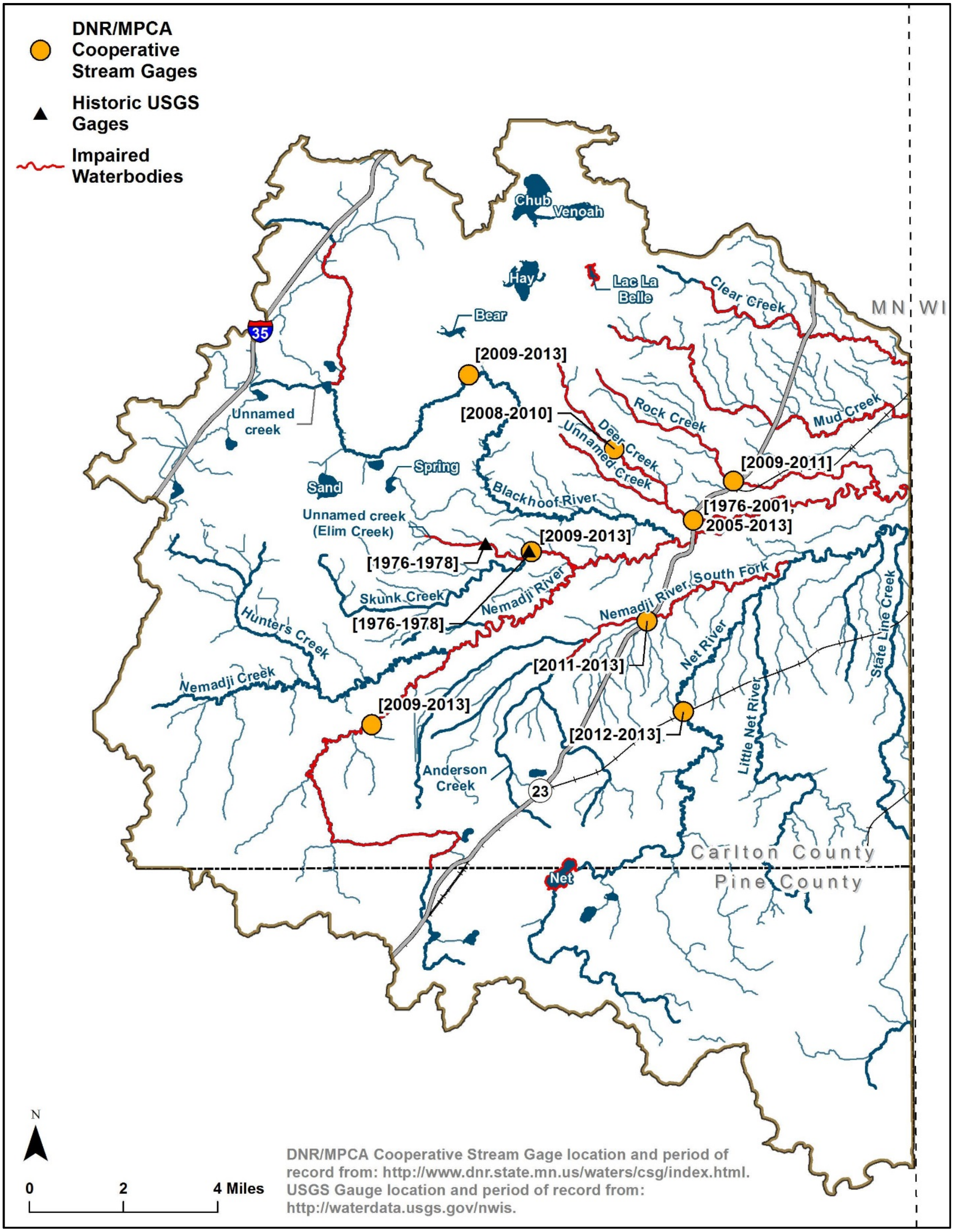


Figure 28. Inventory of flow monitoring

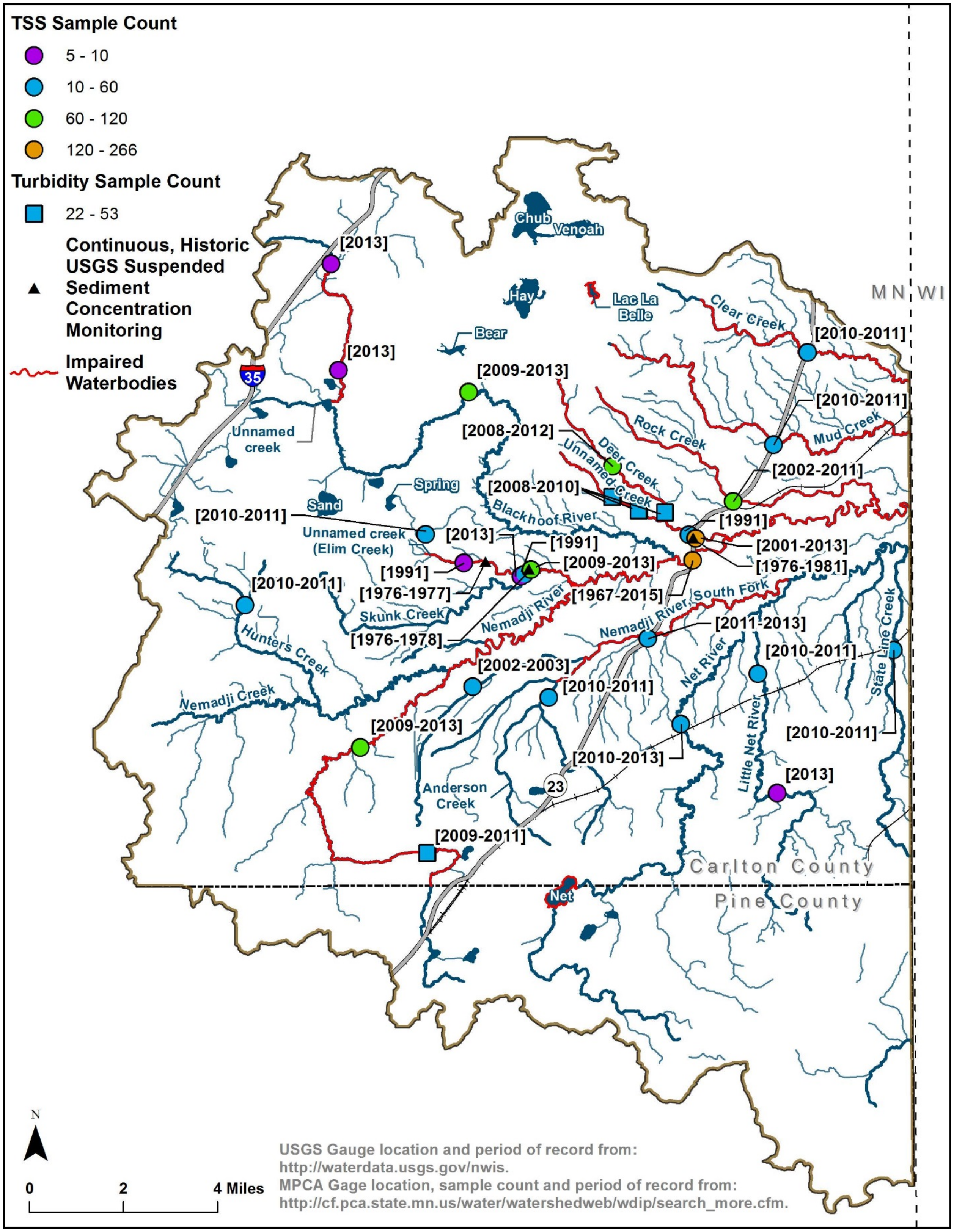


Figure 29. Inventory of TSS monitoring

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Nemadji River Watershed Reports

Many Nemadji River Watershed reports referenced in this watershed report are available at the Nemadji River Watershed webpage: *http://www.pca.state.mn.us/index.php/water/water-types-and-programs/watersheds/nemadji-river.html*

Appendices

Appendix A. TMDL Summaries

The following tables summarize the existing TMDLs for impaired waterbodies in the Nemadji River Watershed. The Deer Creek TMDL summary is from *Deer Creek Watershed TMDL Report: Turbidity Impairments* (Barr 2013a). The remaining TMDL summaries are from the *Nemadji River Watershed TMDL* (Tetra Tech 2016a).

Total Suspended Solids

Table 17 through Table 26 summarize the TSSs pollutant load allocations, wasteload allocations, current loading, and load reductions needed to meet water quality standards.

Table 17. Skunk Creek (04010301-502) total suspended solids TMDL summary

TMDL Parameter	
	Very High
Construction Stormwater WLA (NPDES permit #MNR100001)	0.37
Load Allocation	1,600
MOS	178
Loading Capacity[a]	**1,778**
Existing Load	202,354
Percent Load Reduction	99

a. Loading capacities are rounded to whole numbers.

Table 18. Rock Creek (04010301-508) total suspended solids TMDL summary

TMDL Parameter	Flow Regime				
	Very High	High	Mid-Range	Low	Very Low
	TSS Load (lbs/day)				
Construction Stormwater WLA (NPDES permit #MNR100001)	0.22	0.049	0.018	0.0066	0.0022
Load Allocation	941	210	75	28	9.3
MOS	105	23	8.4	3.1	1.0
Loading Capacity[a]	**1,046**	**233**	**83**	**31**	**10**
Existing Load	81,447	5,485	824	93	20
Percent Load Reduction	99	96	90	67	50

a. Loading capacities are rounded to whole numbers.

Table 19. Clear Creek (04010301-527) total suspended solids TMDL summary

TMDL Parameter	Flow Regime				
	Very High	High	Mid-Range	Low	Very Low
	TSS Load (lbs/day)				
Construction Stormwater WLA (NPDES permit #MNR100001)	0.42	0.13	0.057	0.023	0.011
Load Allocation	1,782	572	243	98	46
MOS	198	64	27	11	5.1
Loading Capacity [a]	**1,980**	**636**	**270**	**109**	**51**
Existing Load	49,706	4,143	796	170	-
Percent Load Reduction	96	85	66	36	-

a. Loading capacities are rounded to whole numbers.

Table 20. Deer Creek (04010301-531) total suspended solids TMDL summary

TMDL Parameter	Flow Regime				
	Very High	High	Mid-Range	Low	Very Low
	TSS Load (lbs/day)				
Construction Stormwater WLA	0.43	0.07	0.04	0.04	0.03
Load Allocation	385.8	65.8	35.8	35.8	24.4
MOS	42.9	7.3	4.0	4.0	2.7
Loading Capacity[a]	**429**	**73**	**40**	**40**	**27**
Existing Load	13,314	810	94	228	128
Percent Load Reduction [b]	97	91	57	82	79

a. Loading capacities are rounded to whole numbers.

b. Not provided in Deer Creek TMDL report (Barr Engineering 2013a); calculated from loading capacity and existing load.

Table 21. Unnamed Creek (04010301-532) total suspended solids TMDL summary

TMDL Parameter	Flow Regime				
	Very High	High	Mid-Range	Low	Very Low
	TSS Load (lbs/day)				
Construction Stormwater WLA (NPDES permit #MNR100001)	0.052	0.013	0.0052	0.0021	0.00093
Load Allocation	222	55	22	9.0	3.6
MOS	25	6.1	2.5	1.0	0.4
Loading Capacity[a]	**247**	**61**	**25**	**10**	**4**

a. Loading capacities are rounded to whole numbers.

TSS data are not available on this reach; therefore, the existing load and the percent load reduction are not calculated.

Table 22. Mud Creek (04010301-537) total suspended solids TMDL summary

TMDL Parameter	Flow Regime				
	Very High	High	Mid-Range	Low	Very Low
	TSS Load (lbs/day)				
Construction Stormwater WLA (NPDES permit #MNR100001)	0.48	0.11	0.040	0.016	0.0051
Load Allocation	2,046	476	170	68	22
MOS	227	53	19	7.6	2.4
Loading Capacity[a]	**2,273**	**529**	**189**	**76**	**24**
Existing Load	31,168	1,792	260	114	-
Percent Load Reduction	93	70	27	33	-

a. Loading capacities are rounded to whole numbers.

Table 23. Nemadji River, South Fork (04010301-558) total suspended solids TMDL summary

TMDL Parameter	Flow Regime				
	Very High	High	Mid-Range	Low	Very Low
	TSS Load (lbs/day)				
Construction Stormwater WLA (NPDES permit #MNR100001)	0.95	0.25	0.091	0.034	0.012
Load Allocation	4,068	1,048	389	147	52
MOS	452	116	43	16	5.8
Loading Capacity[a]	**4,521**	**1,164**	**432**	**163**	**58**
Existing Load	3,077,901	12,552	647	157	40
Percent Load Reduction	100	91	33	0	0

a. Loading capacities are rounded to whole numbers.

Table 24. Rock Creek (04010301-573) total suspended solids TMDL summary

TMDL Parameter	Flow Regime				
	Very High	High	Mid-Range	Low	Very Low
	TSS Load (lbs/day)				
Construction Stormwater WLA (NPDES permit #MNR100001)	0.17	0.037	0.013	0.0050	0.0016
Load Allocation	706	157	57	21	7.0
MOS	78	17	6.3	2.4	0.77
Loading Capacity[a]	**784**	**174**	**63**	**23**	**8**
Existing Load	61,107	4,115	618	70	15
Percent Load Reduction	99	96	90	67	47

a. Loading capacities are rounded to whole numbers.

Table 25. Nemadji River (04010301-757) total suspended solids TMDL summary

TMDL Parameter	Flow Regime				
	Very High	High	Mid-Range	Low	Very Low
	TSS Load (lbs/day)				
Construction Stormwater WLA (NPDES permit #MNR100001)	1.9	0.52	0.20	0.08	0.034
Load Allocation	8,658	2,316	901	351	152
MOS	962	257	100	39	17
Loading Capacity[a]	**9,622**	**2,574**	**1,001**	**390**	**169**
Existing Load	752,134	41,517	5,280	714	148
Percent Load Reduction	99	94	81	45	0

a. Loading capacities are rounded to whole numbers.

Table 26. Nemadji River (04010301-758) total suspended solids TMDL summary

TMDL Parameter	Flow Regime				
	Very High	High	Mid-Range	Low	Very Low
	TSS Load (lbs/day)				
Construction Stormwater WLA (NPDES permit #MNR100001)	3.9	1.2	0.50	0.21	0.10
Load Allocation	17,225	5,199	2,202	900	443
MOS	1,914	578	245	100	49
Loading Capacity[a]	**19,143**	**5,778**	**2,448**	**1,000**	**492**
Existing Load	16,618,086	126,155	90,818	1,215	640
Percent Load Reduction	100	95	97	18	23

a. Loading capacities are rounded to whole numbers.

Total Phosphorus

Table 27 and Table 28 summarize the total phosphorus pollutant load allocations, wasteload allocations, current loading, and load reductions needed to meet water quality standards.

Table 27. Net Lake (58-0038-00) total phosphorus TMDL summary

TMDL Parameter	TP Load (lbs/yr)	TP Load (lbs/day)
Construction Stormwater WLA (NPDES permit #MNR100001)	0.25	0.00069
Load Allocation	1,076	3.0
MOS	120	0.33
Loading Capacity[a]	**1,196**	**3.3**
Existing Load	1,561	4.3
Percent Load Reduction	23%	23%

a. Loading capacities are rounded to whole numbers (annual load) or one decimal place (daily load).

Table 28. Lac La Belle (09-0011-00) total phosphorus TMDL summary

TMDL Parameter	TP Load (lbs/yr)	TP Load (lbs/day)
Construction Stormwater WLA (NPDES permit #MNR100001)	0.0097	0.000027
Load Allocation	41.6	0.114
MOS	4.6	0.013
Loading Capacity[a]	**46**	**0.127**
Existing Load	115	0.315
Percent Load Reduction	60%	60%

a. Loading capacities are rounded to whole numbers (annual load) or three decimal places (daily load).

Pathogens (*Escherichia coli*)

Table 29 and Table 30 summarize the *E. coli* pollutant load allocations, wasteload allocations, current loading, and load reductions needed to meet water quality standards.

Table 29. Nemadji River, South Fork (04010301-558) *E. coli* TMDL summary

TMDL Parameter	Flow Regime				
	Very High	High	Mid-Range	Low	Very Low
	E. coli Load (billion org/day)				
Load Allocation	233	60	22	8	2.7
MOS	26	7	2	1	0.3
Loading Capacity	**259**	**67**	**24**	**9**	**3**
Existing Load	705	73	27	-	-
Percent Load Reduction	63%	8%	11%	-	-

Table 30. Nemadji River (04010301-758) *E. coli* TMDL summary

TMDL Parameter	Flow Regime				
	Very High	High	Mid-Range	Low	Very Low
	E. coli Load (billion org/day)				
Load Allocation	985	297	126	51	25
MOS	109	33	14	6	3
Loading Capacity	**1,094**	**330**	**140**	**57**	**28**
Existing Load	4,058	326	151	-	-
Percent Load Reduction	73%	0%	7%	-	-

Appendix B. Prioritization of Lake Protection Efforts

Name	Lake ID	Lake Type	Lake Area (ac)	Watershed Area (ac)	% Disturbed Land Use	Mean Secchi Transparency (m)	# Years with TP Measured	TP Data, All Years		TP Data, 2003-2012	
								Growing Season Mean TP (µg/L)	# TP Samples	Growing Season Mean TP (µg/L)	# TP Samples
Bear	09-0005-00	Lake	50	4,599	21%	3.2	2	23	10	23	10
Chub	09-0008-00	Lake	313	2,511	23%	3.4	5	28	21	23	15
Hay	09-0010-00	Shallow lake	140	2,303	14%	1.4	2	28	17	28	16
Sand	09-0016-00	Lake	128	445	9%	2.2	16	26	26	29	8
Spring	09-0007-00	Lake	36	33,851	23%	3.7	3	42	11	25	10
Venoah	09-0009-00	Lake	110	10,480	31%	3.3	2	16	10	16	10

Name	Lake ID	Target TP (µg/L)	TP Load Reduction Target (lb/yr)	Percent Load Reduction to Meet Target	Priority (Risk Assessment)	Lake Association	Public Water Access (Ownership)	Wild rice lake (DNR)	Presence of Invasive Species	Development Threat	WRAPS Protection Priority
Bear	09-0005-00	19	59	15	L	N	N				L
Chub	09-0008-00	20	114	27	H	Y	Y (county)		Eurasian watermilfoil		H
Hay	09-0010-00	28	5	2	M	N	Y (county)	Y			M
Sand	09-0016-00	19	20	29	M	N	Y (township)				M
Spring	09-0007-00	21	280	16	L	N	Y (county)				L
Venoah	09-0009-00	16	0	0	M	N	N			High threat	M

Appendix C. EPA 319 Plan Elements - Crosswalk

The EPA requires that applications for 319 grants be based on watershed plans that address the nine key elements. The following table crosswalks the EPA's nine elements and the applicable WRAPS section(s).

EPA's Nine Key Elements of a Watershed Plan	Applicable Section of the WRAPS or TMDL Report
1. 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.	Section 2.3 Stressors and Sources Section 3.4 Restoration and Protection Strategies
2. Estimate of the **load reductions expected from management measures**.	Section 3.4 Restoration and Protection Strategies
3. Description of the **BMPs** that will need to be implemented to **achieve load reductions** in item (2) and a description of the **critical areas** in which those measures will be needed to implement this plan.	Section 3.1 Targeting of Geographic Areas Section 3.2 Priority Critical Areas Section 3.4 Restoration and Protection Strategies
4. 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 these plans.	Section 3.3 Technical and Financial Assistance
5. An **information, education, and public participation component** used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the nonpoint source management measures that will be implemented.	Section 3.2 Civic Engagement
6. **Schedule** for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.	Section 3.4 Restoration and Protection Strategies
7. A description of **interim measurable milestones** for determining whether nonpoint source management measures or other control actions are being implemented.	Section 3.4 Restoration and Protection Strategies
8. 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, and if not, the **criteria for determining whether the WMP needs to be revised**.	Section 4 Monitoring Plan
9. A **monitoring component to evaluate the effectiveness of the implementation efforts** over time, measured against the criteria established under item (8) above.	Section 4 Monitoring Plan