Watershed

September 2019

Mississippi River - Grand Rapids Watershed Restoration and Protection Strategy Report

MINNESOTA POLLUTION CONTROL AGENCY

wq-ws4-61a

CLEAN WATER LAND & LEGACY AMENDMENT

Authors and Contributors

Emmons & Olivier Resources, Inc.:

Meghan Funke, PhD

Paula Kalinosky

Joe Pallardy

Pat Conrad

Etoile Jensen

Minnesota Pollution Control Agency:

Anna Bosch

Ben Lundeen

Isaac Martin

Kevin Stroom

Aitkin County Soil and Water Conservation District:

Janet Smude

Steve Hughes

Mitch Lundeen

Itasca County Soil and Water Conservation District:

Kim Yankowiak

Carlton County Soil and Water Conservation District:

Melanie Bomier

Brad Matlack

Cass County Soil and Water Conservation District:

Kelly Condiff

Minnesota Department of Natural Resources:

Erika Herr

Karl Koller

Danielle McNeil

Ben Nicklay

Rian Reed

Minnesota Department of Health:

Chris Parthun

Board of Water and Soil Resources:

Jeff Hrubes

Editing and graphic design

PIO staff

Graphic design staff

Contents

Key terms and abbreviations

Assessment Unit Identifier (AUID): The unique waterbody identifier for each river reach comprised of the U.S. Geological Survey (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 fecal bacteria standards are not met. Lakes are considered impaired for impacts to aquatic recreation if total phosphorus and either chlorophyll-a or Secchi disc depth standards are not met.

Civic Engagement: The process of collecting public and stakeholder input for the development of restoration and protection strategies.

Hydrologic Unit Code (HUC): A HUC is assigned by the USGS for each watershed. HUCs are organized in a nested hierarchy by size. For example, the Upper Mississippi River Basin is assigned a HUC-4 of 0701 and the Mississippi River-Grand Rapids Watershed is assigned a HUC-8 of 07010103.

Impairment: Waterbodies 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).

Monitoring: The collection of water quality data in lakes and streams to assess their condition.

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.

Water Quality: The chemical and biological condition of lakes and streams that affects our ability to recreate and the ability of lakes and streams to support aquatic life, such as fish and macroinvertebrates.

Executive summary

This Watershed Restoration and Protection Strategy (WRAPS) for the Mississippi River–Grand Rapids Watershed (MRGRW) is, in essence, a well-researched 10-year recipe for maintaining healthy lakes and streams within the watershed. It walks through the characteristics and trends of important resources in the watershed and lays out strategies for restoration and protection that ultimately assists in sustaining a healthy and prosperous environment for Minnesota. It should be used to guide local water planning, the allocation of funds and efforts toward conservation practices.

Located in the north central region of Minnesota, the MRGRW drains more than 1.3 million acres of land from the Laurentian Continental divide to the Mississippi River near the city of Palisade. It crosses through Aitkin, Cass, Carlton, Itasca, and St. Louis counties and sustains many valuable resources throughout its expanse. It is home to the communities of Grand Rapids (population 10,866), McGregor (Population 390), and Remer (Population 370), among many others.

The watershed maintains around 2,000 miles of streams and rivers and 625 lakes larger than 10 acres. Of these lakes, 79 produce wild rice, a unique resource that Minnesota produces more of than any other state, and 48 are cold water fisheries, beneficial to supporting healthy trout populations in the watershed. These beautiful lakes make the watershed an attractive destination for recreation. Forest land makes up most of the watershed (56%), providing many excellent ecosystem services such as water filtration and habitat for diverse species.

From 2015 to 2017, Intensive Watershed Monitoring (IWM) was conducted by the Minnesota Pollution Control Agency (MPCA) to collect data across this watershed for the purpose of assessing the quality of its natural water resources. Overall, the MRGRW has much healthier streams and lakes in comparison to most other watersheds in the state. Its waters are supporting sensitive species such as the Mottled Sculpin and sensitive macroinvertebrate taxa including six unique species of insects (*Amphinemura, Demicryptochironomus, Hagenius brevistylus, Micrasema sprulesi, Neophylax oligius,* and *Ophiogomphus rupinsulensis*) that were recorded for the first time in this watershed as part of the IWM effort. Twenty percent of the lakes assessed for aquatic life were identified as exceptional fish communities, which indicates the presence of favorable land use management patterns. That being said, the watershed also has some challenges that will need to be addressed in the coming years.

Twenty-five percent of the streams and rivers have been altered, which is low compared to many other watersheds, but provides a premise for the source of its impairments. Within this watershed, 216 lakes were reviewed for impairments, and of these lakes 117 had enough water quality information to conduct a formal assessment of aquatic recreation; 106 were found to meet Northern Lakes and Forests (NLF) standards and fully support aquatic recreation. Of those lakes, 49 had sufficient data to assess aquatic life. Forty-four of the 49 lakes that were assessed for aquatic life supported the use; 1 lake (Lower Island Lake, near the city of Cromwell) failed to meet the aquatic life standards. Of the 73 assessed stream/river reaches, 23 (32%) streams do not support aquatic life and/or recreation. Of those, 17 do not adequately support aquatic life and 6 do not adequately support aquatic recreation.

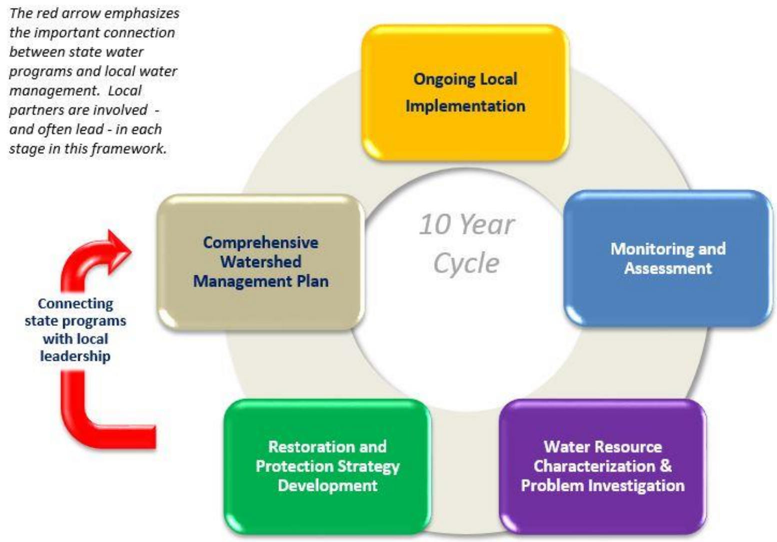
A major conclusion from the MRGRW Stressor Identification (SID) Study was that the most common stressor causing fish and macroinvertebrate community impairments involves historical ditching of peatlands, which are an extensive landscape feature of the MRGRW. This ditching has caused and is causing subsequent stressors, including low dissolved oxygen (DO), water highly-stained with dissolved organic compounds, physical damage to the channel via increased erosion, and degradation of habitat by sedimentation and instability of channel features. Another stressor found in multiple locations is road infrastructure; culverts that are not adequately designed to allow good fish passability. In a few cases, cattle pastured in riparian areas have caused channel instability and habitat degradation. These stressors provide a backdrop for the targeting of restoration and protection strategies in the watershed.

Priority areas for this watershed were determined based on input from local partners, output from Zonation – a value-based model, Hydrological Simulation Program-Fortran (HSPF) – a water quality computer model, and input from the MRGRW WRAPS Technical Advisory Committee and Ambassadors (interested citizens in the watershed). Seven high priority subwatersheds, six medium priority subwatersheds, and five low priority subwatersheds were selected using results from the targeting exercise.

Strategies for addressing the identified issues in the MRGRW include promoting shoreland protection, implementing programs for forest protection, management of lake levels, in-lake plant and fish communities, and/or sediment phosphorus release, restoring altered stream hydrology, and restoring ditched wetlands, primarily in peatlands due to the substantial ditching that has occurred in the watershed's peatlands. Specific locations of resource vulnerability are identified in this report and should be used to guide this process.

As an accompaniment to the implementation of these strategies, it is recommended that a well-executed monitoring program is developed. Monitoring strategies should include: increasing the monitoring of DO in streams to better assess if they are supporting aquatic life; prioritizing lake monitoring in impaired lakes, lakes with decreasing transparency trends, and lakes that are close to being impaired; and monitoring best management practices (BMPs). Monitoring does not need to take place on all BMPs, but should focus on practices with similar criteria and scenarios to others in the watershed. This limited monitoring will provide the necessary information for evaluating the success of conservation efforts in the watershed and to determine future prioritization needs for restoration and protection.

What is the WRAPS Report?



Minnesota has adopted a watershed approach to address the state's 80 major watersheds. The Minnesota watershed approach incorporates **water quality assessment, watershed analysis, public participation, planning, implementation, and measurement of results** into a 10-year cycle that addresses both restoration and protection.

Along with the watershed approach, the MPCA developed a process to identify and address threats to water quality in each of these major watersheds. This process is called Watershed Restoration and Protection Strategy (WRAPS) development. WRAPS reports have two parts: impaired waters have strategies for restoration, and waters that are not impaired have strategies for protection.

Waters not meeting state standards are listed as impaired and Total Maximum Daily Load (TMDL) studies are developed for them. TMDLs are incorporated into WRAPS. In addition, the watershed approach process facilitates a more cost-effective and comprehensive characterization of multiple water bodies and overall watershed health, including both protection and restoration efforts. A key aspect of this effort is to develop and utilize watershed-scale models and other tools to identify strategies for addressing 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 the basis for addressing the U.S. Environmental Protection Agency's (EPA) Nine Minimum Elements of watershed plans, to help qualify applicants for eligibility for Clean Water Act Section 319 implementation funds.

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: •*Mississippi River-Grand Rapids Watershed Monitoring and Assessment* •*Mississippi River-Grand Rapids Watershed Biotic Stressor Identification* •*Mississippi River-Grand Rapids Watershed Total Maximum Daily Load*
Scope	•Impacts to aquatic recreation and impacts to aquatic life in streams •Impacts to aquatic recreation in lakes
Audience	•Local working groups (counties, SWCDs, watershed management groups, etc.) •State agencies (MPCA, DNR, BWSR, etc.)

1. Watershed background and description

The MRGRW straddles the stretch of the Mississippi River as it flows from the Laurentian Continental divide near the city of Nashwauk, then generally south to the city of Palisade in Aitkin County, draining over 1.3 million acres within the Northern Lakes and Forest Ecoregion. The watershed comprises parts of Aitkin, Carlton, Cass, Itasca, and St. Louis Counties. The watershed contains almost 2,000 miles of stream/rivers and 625 lakes larger than 10 acres. The watershed contains numerous heavily developed lakes, 79 wild rice lakes and 48 cold water fishery lakes. The majority of the lakes are important recreational resources and economic benefits to the watershed. The profusion of beautiful lakes and streams make the watershed an important recreational destination. It is also home to unique plant and animal species, along with an abundance of healthy forests.

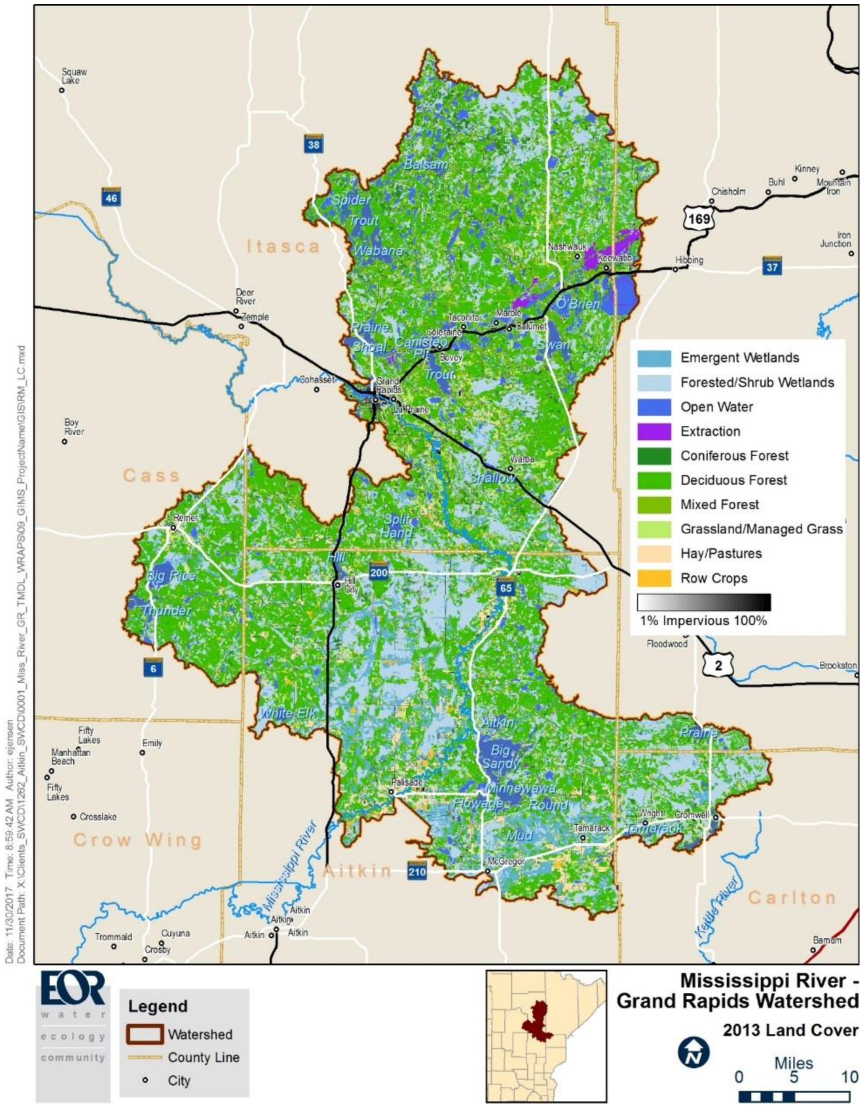


Figure 1. Land use in the MRGRW

The watershed has a long history of iron ore, taconite and aggregate mining, timber harvesting, and peat mining. Much of the work to move the large quantities of felled trees to the Mississippi River was done via the watershed's streams, which ultimately resulted in the channelization and alteration of a number of stream channels. Furthermore, in the early 1900s, peatlands were seen as having potential to be used as cropland, with the exception that they were far too wet. Subsequently, a large number of ditches were dug, especially in the center and southern edge of the watershed. Approximately 25% of the streams and rivers in the watershed have been altered. The MRGRW scored 59/100 for Altered Streams according to the Minnesota Department of Natural Resources (DNR) Watershed Health Assessment Framework. A score of 100 indicates the best condition or least amount of risk; a score of 0 indicates an unhealthy condition or the highest health risk. There are several subwatersheds in MRGRW with a score of 0.

Historically, the watershed was dominated by a mixture of hardwoods and white pine forests. Today, land use consists of 56% forested, 27% grass and wetland, 7% agricultural, 7% water, and 3% urban (Figure 1). The majority of the soils in this watershed are relatively nutrient-poor glacial soils that are not conducive to supporting agricultural practices. Some of the major cities in the watershed are Grand Rapids, McGregor, and Remer. According to the 2008 Gap Analysis Project (GAP) Ownership data, 51% of the land is privately owned. The abundance of forests continue to provide habitat for a diversity of species, a valuable resource for industry, and help to promote good water quality. Because the watershed is minimally impacted, the numerous lakes and streams that dot the landscape are clearer, at a lower trophic state, and less productive in comparison with watersheds to the south.

Additional Mississippi River-Grand Rapids Watershed Resources

Aitkin County Water Management Plan:

https://aitkincountyswcd.org/PDF-Docs/WaterPlan6-24-09.pdf

Carlton County Comprehensive Local Watershed Management Plan: http://www.co.carlton.mn.us/ArchiveCenter/ViewFile/Item/58

Carlton Soil and Water Conservation District Upper Mississippi River Watershed Story Map: https://carltonswcd.maps.arcgis.com/apps/Cascade/index.html?appid=7d6c02c66fd145d2bde9f4ae887528de

Itasca County Local Water Management Plan: https://www.co.itasca.mn.us/DocumentCenter/View/2870/Local-Water-Management-Plan

Minnesota Department of Natural Resources (DNR) Watershed Context Report: http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/context_report_major_9.pdf

Minnesota Department of Natural Resources (DNR) Watershed Health Assessment Framework Report Card: http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/ReportCard_Major_9.pdf

Minnesota Nutrient Planning Portal: https://mrbdc.mnsu.edu/mnnutrients/watersheds/mississippi-river-grand-rapids

Minnesota Nutrient Reduction Strategy: https://www.pca.state.mn.us/water/nutrient-reduction-strategy

Mississippi River – Grand Rapids HSPF Model Recalibration: https://www.pca.state.mn.us/sites/default/files/wq-iw8-58n.pdf

Mississippi River-Grand Rapids Watershed Monitoring and Assessment Report: https://www.pca.state.mn.us/sites/default/files/wq-ws3-07010103b.pdf

Mississippi River-Grand Rapids Stressor Identification Report

Mississippi River-Grand Rapids Total Maximum Daily Load (TMDL) Study for Total Phosphorus, Total Suspended Solids, and Bacteria

St. Louis County, Minnesota Comprehensive Water Management Plan: https://files.dnr.state.mn.us/lands_minerals/northmet/water-approp/references/mn-comprehensive-water-mgmt-plan-2010-2020.pdf

Upper Mississippi River Large River and Basin Restoration and Protection Strategies: https://www.pca.state.mn.us/sites/default/files/wq-ws4-38b.pdf

USDA Natural Resources Conservation Service (NRCS) Rapid Watershed Assessment: https://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/technical/dma/rwa/?cid=nrcs142p2_023584

2. Watershed conditions

The MRGRW contains high value water resources. Lakes and streams in this watershed generally have good or excellent water quality derived from well managed forestlands, grasslands, and agricultural lands. Nearly all lakes assessed for aquatic life met standards, with 20% of those lakes identified as having exceptional fish communities. Aquatic recreation use – swimming, wading, etc. was supported in many lakes in the watershed. Many of the lakes are deep and often without considerable development. Impairments were identified primarily in the Big Sandy Lake (outlet) and Tamarack River subwatersheds.

The majority of the streams in the watershed are supportive of aquatic recreation uses. Biological communities in most rivers and streams in the watershed are generally good, with only 19% of stream segments failing to meet aquatic life standards. In 2015 and 2016, the MPCA staff captured 51, or 68%, of the 75 fish species that have ever been documented in the entire Upper Mississippi River Basin. Mottled Sculpin, a sensitive species, was observed at 20 sites throughout the central and western portions of the watershed, but was noticeably absent in the Prairie River despite suitable habitat, potentially as a result of historic logging practices.

Over 10,500 individual macroinvertebrates representing 376 unique taxa were collected and identified, including six sensitive taxa that were recorded for the first time in this watershed (*Amphinemura, Demicryptochironomus, Hagenius brevistylus, Micrasema sprulesi, Neophylax oligius,* and *Ophiogomphus rupinsulensis*). The Prairie River, West Fork Prairie River, Tamarack River, and Willow River Ditch were identified as having excellent fish and macroinvertebrate communities, resulting in these streams being designated as Exceptional Use. The habitat in these streams are rated as good to exceptional. Several streams have impaired aquatic life based on poor fish and/or macroinvertebrate communities. These impairments are likely a result of non-point source sources, such as mining, agricultural activities, or areas of more dense residential development (i.e. around lakeshores), or habitat fragmentation due to alterations of streams, low DO and elevated nutrients, and/or loss of connectivity with upstream resources.

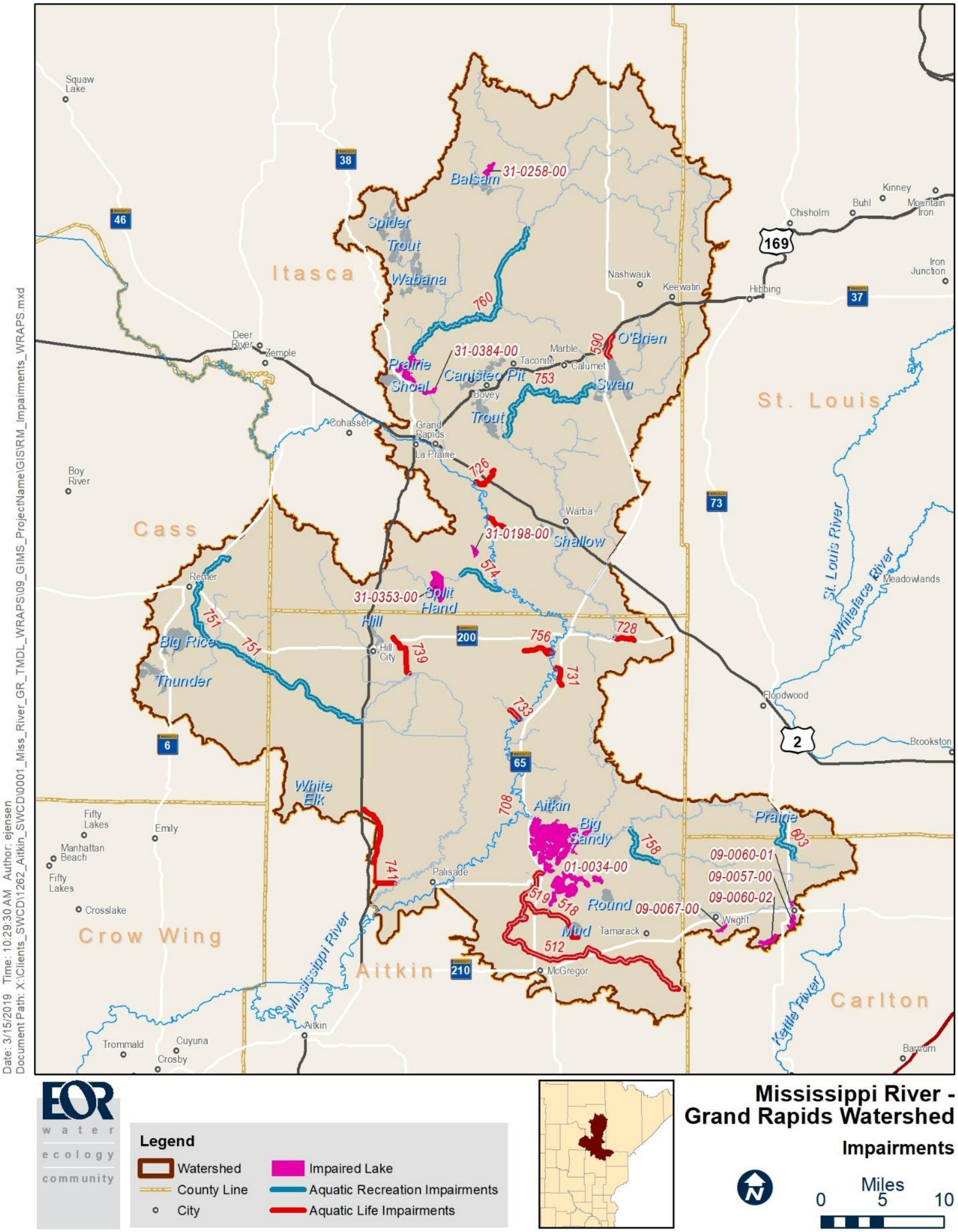


Figure 2. Mississippi River Grand Rapids Watershed Impairments

2.1 Condition status

Beginning in 2015, the MPCA initiated IWM effort of rivers, streams and lakes within the MRGRW. Then in 2017, all waterbodies with sufficient data (73 streams and 216 lakes) were assessed for aquatic life, aquatic recreation, and/or aquatic consumption use support. In general, results from the study found that most of the lakes and streams in the watershed are in good condition. The results of the monitoring and assessment are summarized in the following sections. Please refer to the MRGRW Monitoring and Assessment Report (MPCA 2018) for full monitoring and assessment details. The MPCA also developed a SID Report for the watershed. Results from the SID were incorporated into this report in an effort to fully capture the existing condition of the watershed, as well as the primary stressors to watershed resources.

The most widespread impairment found in the watershed is high levels of mercury in fish tissue. The Mississippi River and 37 lakes are currently listed as impaired by mercury. Most of the polychlorinated biphenyl (PCB) concentrations in fish tissue were near or below the reporting limit (0.01 - 0.05 mg/kg). The highest PCB concentration was 0.12 mg/kg in a lake trout taken in 1990 from Trout Lake (31-0410). A value of 0.12 mg/kg is below the threshold for impairment (0.2 mg/kg). All results of PFOS were less than the reporting limits except for a black crappie from Tamarack Lake in 2007, which had a measured PFOS concentration of 1.95 µg/kg. This report does not cover toxic pollutants. For more information on mercury impairments, see the statewide mercury TMDL on the MPCA website at: MPCA Statewide Mercury TMDL.

Streams

Seventy-three of the 203 uniquely identified stream/river reaches in the watershed have been assessed through 2017 (Table 1). Forty-three streams fully support aquatic life, and 12 streams fully support aquatic recreation. Eight stream assessments found individual stream reaches met standards for one intended use but not the other (e.g. fully supporting aquatic life and not supporting aquatic recreation, or vice versa).

Throughout the watershed, 23 streams do not support aquatic life and/or recreation. Of those, 17 do not support aquatic life and 6 do not support aquatic recreation (Table 1). The streams that do not support recreation all show chronically elevated bacteria concentrations.

Table 1. Assessment summary for stream water quality in the Mississippi River – Grand Rapids Watershed (Based on 2019 CARL database information).

		Supporting		Non-supporting		Insufficient Data	
HUC-12 Watershed	#Assessed AUIDs	Aquatic Life	# Aquatic Recreation	Aquatic Life	# Aquatic Recreation	Aquatic Life	# Aquatic Recreation
07010103	**73**	**43**	**12**	**17**	**6**	**12**	**0**
0701010301-01	8	5	1	1	0	2	0
0701010301-02	4	3	1	1	0	0	0
0701010302-01	4	3	1	1	1	0	0
0701010302-02	1	1	0	0	0	0	0
0701010302-03	2	1	0	0	0	1	0
0701010303-01	2	0	0	2	0	0	0
0701010303-02	2	2	0	0	1	0	0
0701010304-01	8	6	1	1	0	1	0
0701010304-02	4	3	0	1	1	0	0
0701010305-01	5	4	2	0	1	1	0
0701010305-02	5	4	0	0	1	1	0
0701010306-01	3	0	1	2	0	1	0
0701010306-02	1	0	1	1	0	0	0
0701010307-01	6	4	1	1	0	1	0
0701010308-01	6	1	1	1	0	4	0
0701010308-02	4	4	1	0	1	0	0
0701010308-03	1	0	1	1	0	0	0
0701010309-01	7	2	0	4	0	1	0

Lakes

The MRGRW has a high density of lakes with good to excellent water quality. All lakes were assessed against standards for aquatic recreation that are designed to protect lakes in the NLF Ecoregion; lakes with stream trout or lake trout populations were held to standards that are more stringent to protect those sensitive fish populations.

Two hundred-sixteen lake basins had at least one water quality measurement available. Of these lake basins, 117 had enough water quality information to conduct a formal assessment of aquatic recreation and 49 had enough information to conduct aquatic life assessments (Table 2). One hundred and six lakes fully supported aquatic recreation and 11 did not support aquatic recreation. Forty-four of the 49 lakes that were assessed for aquatic life supported the use; 1 lake (Lower Island Lake, near the city of Cromwell) failed to meet the aquatic life standards. See the MRGRW Monitoring and Assessment Report for detailed lake assessment results.

Table 2. Assessment summary for lake water quality in the Mississippi River – Grand Rapids Watershed.

			Supporting		Non-supporting		Insufficient Data	
HUC -12 Watershed	Area (acres)	Lakes >10 Acres	# Aquatic Life	# Aquatic Recreation	# Aquatic Life	# Aquatic Recreation	# Aquatic Life	# Aquatic Recreation
07010103	**1,332,798**	**625**	**44**	**106**	**1**	**11**	**82**	**92**
0701010301-01	96,256	53	4	12	0	0	11	17
0701010301-02	43,088	20	1	4	0	0	0	1
0701010302-01	113,219	71	5	18	0	0	10	8
0701010302-02	39,665	62	5	13	0	0	4	17
0701010302-03	32,772	52	5	11	0	1	4	3
0701010303-01	62,088	24	2	7	0	0	6	5
0701010303-02	35,526	12	0	2	0	2	3	2
0701010304-01	115,610	36	3	7	0	0	4	4
0701010304-02	94,543	86	5	13	0	0	11	9
0701010305-01	71,108	24	0	1	0	1	3	2
0701010305-02	65,878	10	0	0	1	4	6	3
0701010306-01	64,328	33	7	6	0	3	6	3
0701010306-02	60,534	20	0	1	0	0	6	4
0701010307-01	93,371	23	0	2	0	0	4	2
0701010308-01	77,009	5	0	0	0	0	1	1
0701010308-02	118,622	48	5	6	0	0	2	5
0701010308-03	41,352	25	0	0	0	0	0	3
0701010309-01	107,830	21	2	3	0	0	1	3

2.2 Water quality trends

Year-to-year weather variations affect water quality observation data; for this reason, interpreting long-term data trends minimizes year-to-year variation and provides insight into changes occurring in a water body over time.

The MPCA completes annual trend analysis on lakes and streams across the state based on long-term transparency measurements. The data collection for this work relies heavily on volunteers across the state, and incorporates any relevant agency and partner data submitted to EQuIS. The water clarity trends are calculated using a Seasonal Kendall statistical test for sites with a minimum of eight years of transparency data; Secchi disk measurements in lakes and Secchi tube measurements in streams. Of the lake sites that are monitored by volunteers, 21 show an improving trend, and 13 show a declining trend observed in water clarity (Table 3). The lone stream site and 36 lake sites show no long-term trend. See Appendix A for specific waterbodies and their trends.

Table 3. Water clarity trends at citizen stream monitoring sites.

Miss. R.-Grand Rapids (07010103)	Citizen Stream Monitoring Program	Citizen Lake Monitoring Program
Number of sites w/ increasing trend	0	21
Number of sites w/ decreasing trend	0	13
Number of sites w/ no trend	1	36

In June 2014, the MPCA published its final trend analysis of river monitoring data located statewide based on the historical Milestones Network. The period of record is generally more than 30 years, through 2010, with monitoring at some sites going back to the 1950s.

Starting in 2017, the MPCA switched to the Watershed Pollutant Load Monitoring Network (WPLMN). There are four long-term monitoring locations in the MRGRW. Users can access this data via the WPLMN browser, which shows the location of long-term monitoring sites throughout the state. It includes links to the MPCA's Environmental Data Access portal that contains all monitoring data for the entire period of record, including more recent data through 2018. As shown in Figure 3 through Figure 5, average flow weighted mean total phosphorus (TP), total nitrogen (TN), and total suspended solids (TSS) concentrations from 2007 through 2015 at monitoring locations in the MRGRW were low relative to other areas in the state.

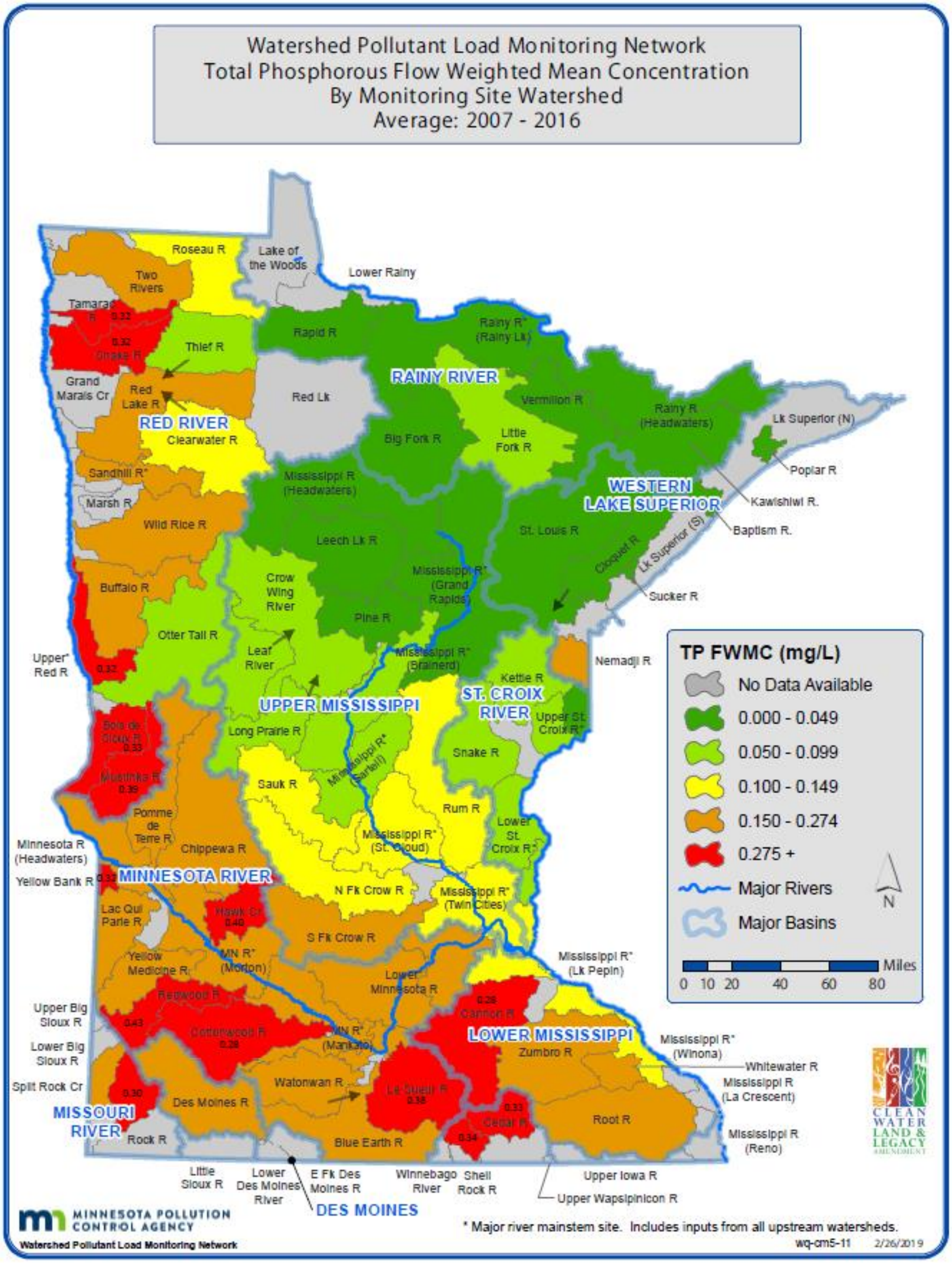


Figure 3. Watershed Pollutant Load Monitoring Network – Average Total Phosphorus Flow Weighted Mean Concentration from 2007-2015.

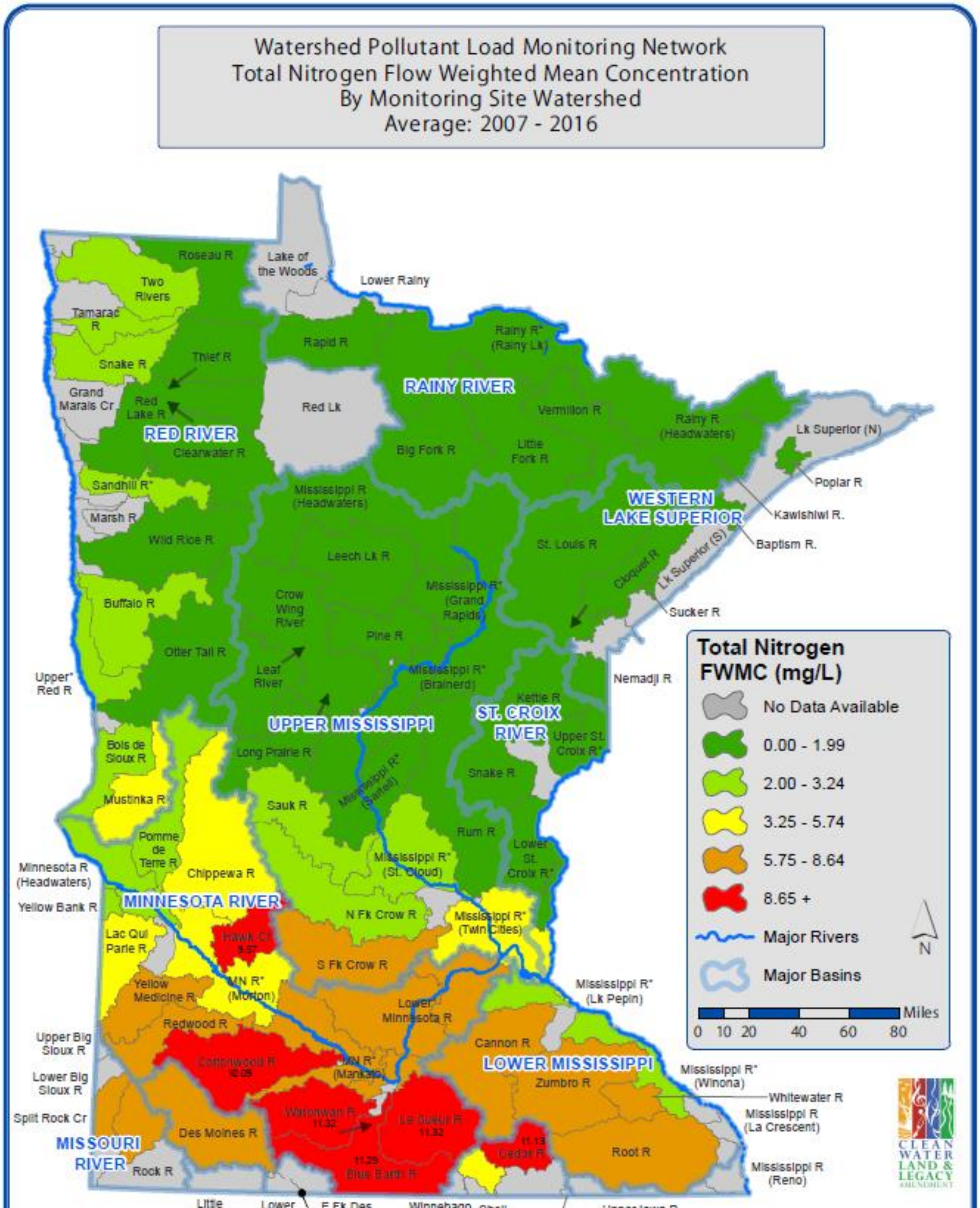


Figure 4. Watershed Pollutant Load Monitoring Network – Average Total Nitrogen Flow Weighted Mean Concentration from 2007-2015.

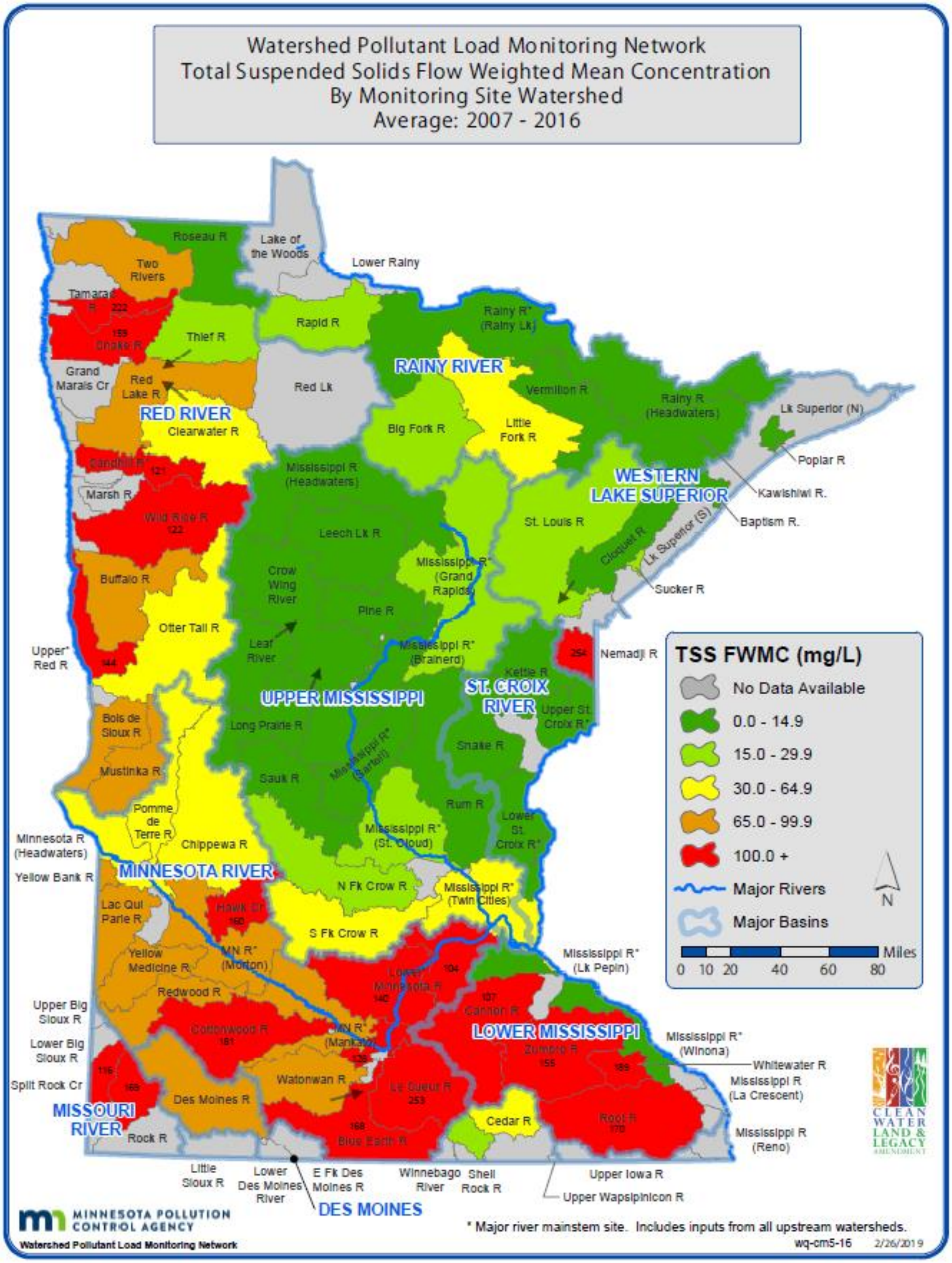


Figure 5. Watershed Pollutant Load Monitoring Network – Average Total Suspended Solids Flow Weighted Mean Concentration from 2007-2015.

2.3 Stressors and sources

In order to develop appropriate strategies for restoring or protecting waterbodies, the stressors and/or sources impacting or threatening them must be identified and evaluated.

A **stressor** is something that adversely impacts or causes fish and/or macroinvertebrate communities in streams to become unhealthy. Biological SID is conducted for streams with either fish or macroinvertebrate biota impairments, and encompasses the evaluation of both pollutants (such as nitrate-N, phosphorus, and/or sediment) and non-pollutant-related (such as altered hydrology, fish passage, or habitat) factors as potential stressors.

Pollutant source assessments are completed where a biological SID process identifies a pollutant as a stressor, as well as for the typical pollutant impairment listings such as TSS. Pollutants to lakes and streams include point sources (such as wastewater treatment plants) or nonpoint sources (such as runoff from the land).

Stressors of biologically-impaired stream reaches

SID is a key component of the major watershed restoration and protection projects being carried out under Minnesota's Clean Water Legacy Act (CWLA). A SID study was conducted in 2018 to identify the factors (i.e., stressors) that are causing the fish and macroinvertebrate community impairments in the MRGRW. For more details on the MRGRW stressors and the process used to identify the stressors causing the biological impairments, please consult the 2019 MRGRW SID Report.

Figure 6 provides a summary of the primary stressors identified for each biologically-impaired reach in the MRGRW. Fourteen Assessment Unit (AUID) reaches from 13 different streams were brought into the SID process because they were determined to have substandard biological communities via the 2015 IWM and the subsequent 2017 Waterbody Assessment process. Two other biological impairments on small, wetland-influenced streams in the far northern part of the MRGRW were determined by an assessment committee to be due to natural background conditions of low DO (AUIDs 717 and 719), and are categorized as 4D. As such, they do not require a TMDL.

The biological impairments found in the MRGRW are on small streams. This suggests that there are not widespread, systematic stressors throughout the Watershed, but rather ones that are more local in both cause and effect. No point-source effluents contribute to any of the biological impairments. The most common stressor involves historical ditching of peatlands, which are an extensive landscape feature of the MRGRW. There are places within the watershed where these local stressors are more concentrated. For peatland ditching, this is along the southern edge between the cities of Cromwell and McGregor, and in the central area near the cities of Jacobsen and Hill City. This ditching contributes to many stressors, including low DO, water highly-stained with dissolved organic compounds, physical damage to the channel via increased erosion, and degradation of habitat by sedimentation and instability of channel features. Another stressor found in multiple locations is road infrastructure; namely culverts that are not adequately designed to allow good fish passage. In a few cases, cattle pastured in riparian areas have caused channel instability and habitat degradation.

Figure 6. Stressors to aquatic life in biologically-impaired reaches in the MRGRW

Stream	AUID Last 3 digits	Biological Impairment	Stressor								
			Dissolved Oxygen	Phosphorus	Conductivity	TSS	Connectivity	Altered Hydrology	Channel alteration	Temperature	Habitat
Sandy River	512	Fish and MI	●			●		●	●		●
Minnewawa Creek	518	Fish and MI	●			?		◆			
Minnewawa Creek	519	Fish	●					◆	◆		●
Split Hand Creek	574	None							●		●
Pickerel Creek	590	Fish and MI	●		?					●	x
Trib. to Bray Lake	722	Fish				?					
Trib. to Mississippi	726	Fish and MI						?		?	
Trib. to Mississippi	727	Fish	●					◆	◆		●
Trib. to Swan River	728	Fish	●					◆			●
Trib. to Mississippi	730	Fish					●	●			●
Trib. to Unnamed Cr	731	Fish					●	●			●
Pokegama Creek	733	Fish and MI	●					◆	●		●
Trib. to Hill R Ditch	739	Fish	●				?	◆	◆		●
White Elk Creek	741	Fish	?				●		?		?
Unnamed Ditch	756	Fish and MI	●			x	●	◆	●		●

◆ A "root cause" stressor, which causes other consequences that become the direct stressors

● A direct stressor

x A secondary stressor

? Inconclusive

Pollutant sources

This section summarizes the sources of pollutants (such as phosphorus, bacteria or sediment) to lakes and streams in the MRGRW. HSPF model results were used to evaluate the relative magnitude of non-point versus point sources in the MRGRW as demonstrated in Table 4. In general, non-point source pollution represents the dominant pathway for nutrient export to the majority of water resources in the watershed.

A detailed breakdown of phosphorus loading from the subwatershed of HSPF Reach 470 (Mississippi River near the city of Palisade) is provided in Figure 7. The breakdown of pollutant sources from the Reach 470 subwatershed is representative of the MRGRW as a whole. More information about the HSPF model is provided in Section 3.2 of this document.

The 2019 MRGRW TMDL Study identified the relative contribution of point and non-point phosphorus sources to the watershed's impaired lakes. The TMDL study also identified point and non-point bacteria sources to the watershed's impaired streams.

Table 4. Percent contribution to total phosphorus load leaving the subwatershed for major water resources in the Upper Mississippi Grand Rapids Watershed.

Water Resource	HSPF Reach #	Upland Non-Point	Feedlot	Septics	Point Source	Atm. Dep.	Stream bank/bed
Prairie River	20	29.0%	0.0%	0.8%	0.0%	0.0%	70.2%
Wabana Lake	162	9.4%	0.0%	0.2%	89.3%	0.0%	1.0%
Swan Lake	282	91.4%	0.0%	0.9%	3.0%	0.0%	4.7%
Canisteo Lake	286	96.0%	0.0%	1.1%	0.0%	0.0%	2.8%
Trout Lake	288	95.2%	0.0%	1.5%	0.0%	0.0%	3.2%
Prairie Lake	404	83.8%	0.0%	0.4%	0.0%	0.0%	15.8%
Big Sandy Lake	462	84.5%	0.0%	1.0%	0.0%	0.0%	14.5%
Mississippi River	470	98.3%	0.0%	1.4%	0.0%	0.0%	0.3%
N. Fork Willow River	490	59.8%	0.0%	1.0%	6.9%	0.0%	32.3%
S Fork Willow River	510	96.9%	0.0%	2.1%	0.0%	0.0%	1.0%
Hill R Ditch	630	98.0%	0.0%	1.4%	0.0%	0.0%	0.6%
Willow R	670	92.7%	0.0%	1.7%	0.0%	0.0%	5.7%
Moose-Willow R Ditch	690	58.4%	0.0%	1.0%	0.0%	0.0%	40.6%

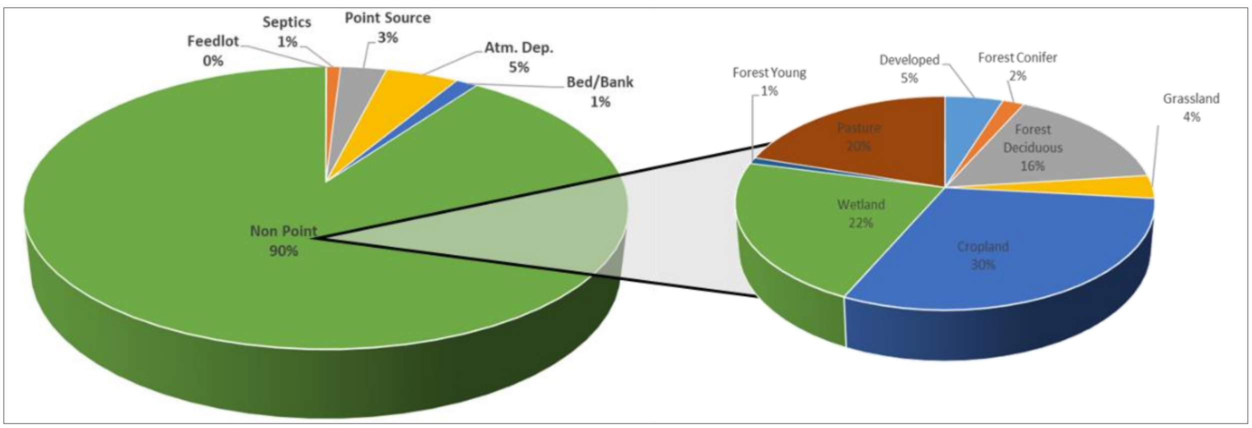


Figure 7. Breakdown of phosphorus sources for HSPF Reach 470 – Mississippi River at MRGRW outlet.

POINT SOURCES

Point sources are defined as facilities that discharge stormwater or wastewater to a lake or stream and have a National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit (Permit). There are 14 municipal wastewater treatment facilities (WWTF) and 16 industrial WWTFs that require NPDES/SDS permits located in the MRGRW (Table 5). Figure 8 shows all permitted point sources in the MRGRW; there are no active NPDES/SDS permitted feedlots located within the MRGRW.

There are four NPDES/SDS permitted WWTFs whose surface discharge stations fall within an *E. coli* impaired stream subwatershed. An individual WLA was provided for all NPDES/SDS permitted WWTFs that have fecal coliform discharge limits (200 org/100ml, April 1 through October 31) and whose surface discharge stations fall within an impaired stream subwatershed as part of the MRGRW TMDL Study. The WLAs are based on *E. coli* loads even though the WWTFs discharge limits are based on fecal coliform. If a discharger is meeting the fecal coliform limits of their NPDES/SDS permit, it is assumed that they are also meeting the *E. coli* WLA in these TMDLs.

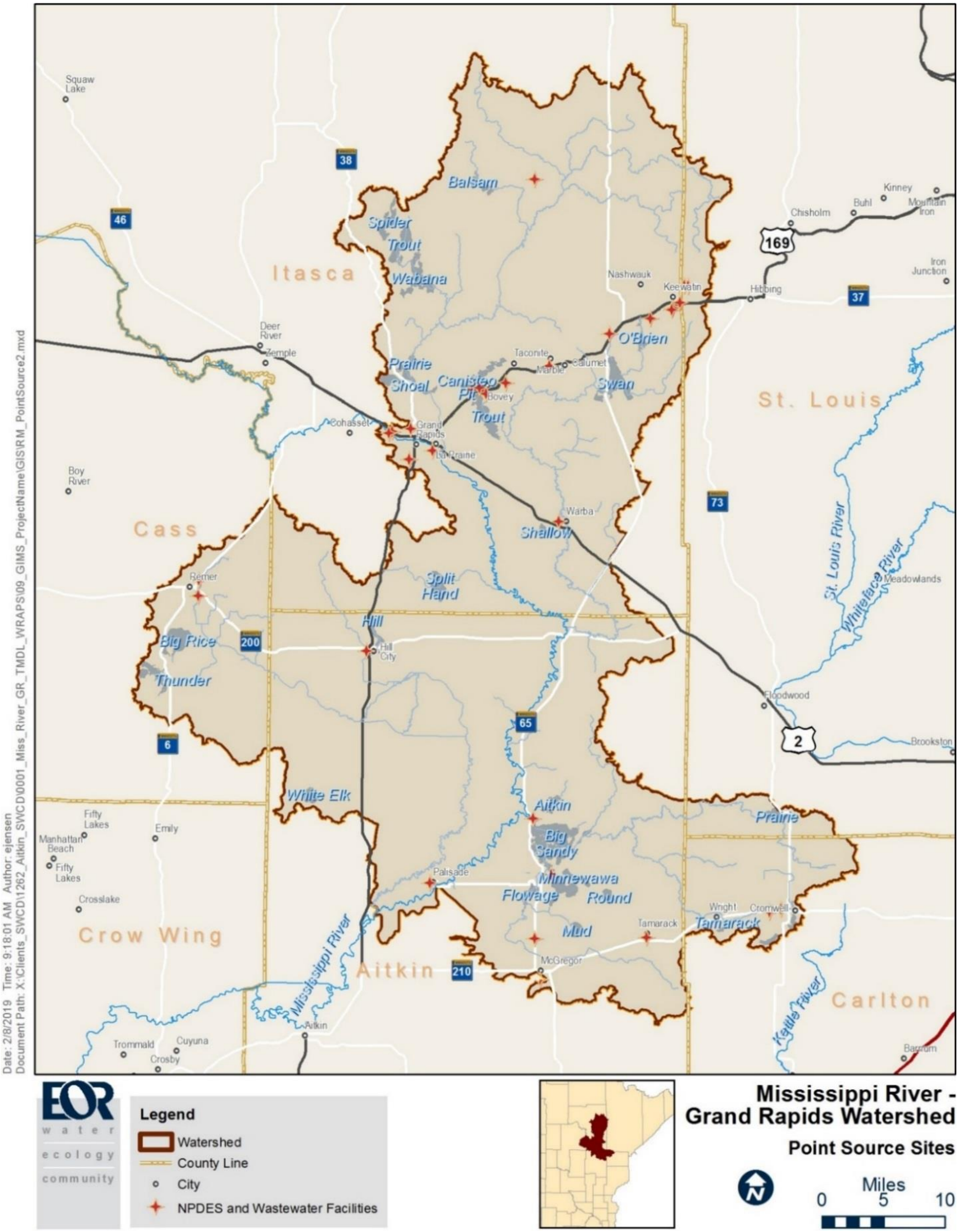


Figure 8. NPDES Industrial and Domestic Wastewater Point Source Sites.

Table 5. Point sources in the Mississippi River-Grand Rapids Watershed.

Aggregated HUC-12 Subwatershed	Point source			Pollutant reduction needed?
	Name	Permit #	Type	
Big Sandy Lake Outlet (0701010306-01)	Big Sandy Lodge and Resort	MN0067300	Domestic	No
	Tamarack WWTP	MN0064564	Domestic	No
	USCOE Sandy Lake	MN0110035	Domestic	No
City of Palisade-Mississippi River (0701010309-01)	Palisade WWTP	MN0050997	Domestic	No
Hill River (0701010307-01)	Hill City WWTP	MNG585182	Domestic	No
Lower Swan River (0701010304-01)	Coleraine-Bovey-Taconite Joint WWTP	MN0053341	Domestic	No
	Warba WWTP	MN0020974	Domestic	No
	Bovey WTP	MNG640018	Industrial	No
	ERP Iron Ore LLC - Plant 2	MN0069868	Industrial	No
	UMD - Coleraine Minerals Research Lab	MN0051802	Industrial	No
Sandy River (0701010306-02)	McGregor WWTP	MN0024023	Domestic	No
	Aitkin Agri-Peat Inc - McGregor	MN0062375	Industrial	No
Split Hand Creek-Mississippi River (0701010303-01)	Grand Rapids WWTP	MN0022080	Domestic	No
	ERP Iron Ore LLC - Plant 4	MN0070378	Industrial	No
	Hammerlund Construction	MNG490279	Industrial	No
	Hawkinson Construction Co Inc.	MNG490048	Industrial	No
	Wm J Schwartz & Sons Inc	MNG490141	Industrial	No
Tamarack River (0701010305-02)	Cromwell WWTP	MN0051101	Domestic	No
	Premier Horticulture Inc - Black Lake Site	MN0055115	Industrial	No
Upper Prairie River (0701010304-02)	Mesabi Metallics Co LLC	MN0068241	Industrial	No
Upper Swan River (0701010304-02)	Keewatin WWTP	MN0022012	Domestic	No
	Marble WWTP	MN0020214	Domestic	No
	Nashwauk WWTP	MNG580184	Domestic	No
	ERP Iron Ore LLC - Plant 1	MN0069221	Industrial	No
	Mesabi Metallics Co LLC	MN0020249	Industrial	No
	US Steel Corp - Keetac	MN0031879	Industrial	No
	US Steel Corp - Tailings	MN0055948	Industrial	No
Upper Willow River (0701010308-02)	Remer WWTP	MNG585210	Domestic	No
	MDNR Spire Valley Hatchery	MN0069710	Industrial	No

NON-POINT SOURCES

Nonpoint pollution, unlike pollution from industrial and municipal WWTFs, comes from many different sources. Nonpoint-source pollution is carried by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-caused pollutants and deposits them into lakes and streams. Significant non-point and natural pollutant sources identified in the MRGRW include:

- **Watershed runoff:** The HSPF model was used to estimate watershed runoff volumes and TP loads for all 158 individual subwatersheds in the MRGRW based on land cover and soil type, and was calibrated using meteorological data from 2001 through 2015.
- **Wetland export:** Phosphorus export from wetlands is a well-known phenomenon in northern Minnesota wetlands (O'Brien et al. 2013; Fristedt 2004; Dillon and Molot 1997; Banaszuk et al. 2005). Three of the impaired lakes in the watershed (Horseshoe, Split Hand, and Big Sandy Lakes) are located in watersheds with wetland-dominated tributaries.
- **Upstream lakes and streams:** Some lakes receive most of their phosphorus from upstream lakes and streams. For these lakes, restoration and protection efforts should focus on improving the water quality of the upstream lakes and streams.
- **Runoff from feedlots:** Fertilizer and manure contain high concentrations of phosphorus, nitrogen, and bacteria that can run off into lakes and streams when not properly managed.
- **Failing septic systems:** Septic systems that are not maintained or are failing near a lake or stream can contribute excess phosphorus, nitrogen, and bacteria.
- **Atmospheric deposition:** Atmospheric deposition represents the phosphorus that is bound to particulates in the atmosphere and is deposited directly onto surface waters.
- **Lake internal loading:** Lake sediments and macrophytes contain large amounts of phosphorus that can be released into the lake water through physical mixing or under certain chemical conditions or during the senescence of macrophytes.
- **Artificial drainage and stream morphometry:** An increase in artificial drainage combined with stream channelization can lead to streambank instability, reduced base flow, and longer periods of intermittent flow.
- **Timber harvesting**: Forest harvest has been and currently is a major activity within the MRGRW. Historical large-scale forest removal occurred in the watershed which may have created legacy effects still being experienced by streams today.
- **Fecal runoff**: Sources of fecal contamination can originate from septic systems, manure, or dense/localized populations of wildlife, such as beavers or geese. The MRGRW TMDL did not find conclusive evidence for the source of most fecal contamination to bacteria impaired streams. Microbial Source Tracking should be conducted in bacteria-impaired streams to identify sources of fecal contamination prior to project implementation.

Mining in the Mississippi River-Grand Rapids Watershed

The Mesabi Iron Range is a geologic feature that extends more than 120 miles across northern Minnesota from near the cities of Babbitt to Grand Rapids. Its western extent stretches across the northern portion of the MRGRW from the west near the city of Grand Rapids to just east of the city of Keewatin. Over 100 years of iron ore and taconite mining on the Mesabi Iron Range has altered the landscape in this portion of the watershed, changing both surface and subsurface hydrology.

The creation of open pit mines impacts hydrology by severing headwater watersheds and reducing downstream baseflow. This can lead to stream aggradation and changes in water quality, which has the potential to impact biological integrity and species richness and diversity, and decrease ecological function in the watershed. Additional hydrologic impacts occur from water withdrawals, surface water discharges, water reuse and routing, and seepage from open pits and tailings basins to groundwater and/or surface waters. Monitoring at most active mine sites is ongoing and includes macroinvertebrate, geomorphology, ground- and surface water levels and streamflow monitoring.

Open pit mines act as hydrologic sinks for both surface and groundwater and as such, they must be dewatered during active mining. When pits are no longer being mined and dewatering stops, mine pits fill with water. Hydrologic equilibrium may occur before overflow occurs or the pit may continue to fill until the water level reaches the low pit rim elevation and outflows. If hydrologic equilibrium does occur and no surface water outflows from the pit, it means that the severed watershed is permanently pirated of water. Even if the mine pit does fill with water and outflows at the low pit rim elevation, it is likely that the watershed has suffered a permanent loss of some of its water supply. Additionally, if outflow occurs it must be determined if the receiving water can handle the additional flow. As pits fill, other impacts may result from an increase in pit surface water levels as groundwater outflow may increase, which can lead to an increase in the down-gradient water table elevation and a change in groundwater chemistry. In the MRGRW, data gathering is ongoing for two large mine pit complexes for the purpose of determining which nearby waters may be receiving waters in various designed outlet scenarios, if needed.

Another type of mining occurring in the MRGRW is the surface mining of peat. There are currently two active peat mining operations and one proposed operation in the southern portion of the watershed. Though peat mining impacts are at a smaller scale than open pit mining, the operations do impact local hydrology. In order to mine peat, vegetation is removed at the site and dewatering occurs through a series of ditches. Water table drawdown from ditching can impact adjacent wetland areas. Ditched water usually leaves the site after passing through a settling pond and can increase off-site discharges. Water quality changes can also occur as nutrients, suspended solids, and trace metals may be released to surface-water systems.

2.4 TMDL summary

A TMDL is a calculation of how much pollutant a lake or stream can receive before it does not support recreational or aquatic life uses. These studies are required by the CWA for all impaired lakes and streams. There are nine impaired lakes and six impaired streams in the MRGRW with completed TMDL Studies (Table 5). See Appendix B for the existing pollutant loading, wasteload and load allocations, load reductions needed to meet water quality goals, and pollutant source summaries for each impaired stream or lake.

Table 6. Mississippi River-Grand Rapids Watershed Impaired Streams and Lakes with Completed TMDLs

Affected Use: Pollutant/ Stressor	Stream AUID/ Lake ID	Name	Location/ Reach Description	Designated Use Class	Listing Year	Target Start/ Completion	Impairment addressed by:
Aquatic Recreation: Nutrient/ Eutrophication Biological Indicators (Phosphorus)	01-0062-00	Big Sandy Lake	14 mi N of McGregor	2B, 3C	2002	2011	Completed TP TMDL[1]
	01-0033-00	Lake Minnewawa	7 mi NE of McGregor	2B, 3C (s)	2002	2011	Completed TP TMDL[1]
	09-0057-00	Eagle Lake	4 mi SW of Wright	2B, 3C	2002	2019	2019 MRGRW TMDL
	01-0034-00	Horseshoe Lake	7 mi N of Tamarack	2B, 3C (s)	2010	2019	2019 MRGRW TMDL
	09-0060-01	Upper Lake: North Island	At Cromwell	2B, 3C	2010	2019	2019 MRGRW TMDL
	09-0060-02	Lower Lake: South Island	At Cromwell	2B, 3C	2008	2019	2019 MRGRW TMDL
	31-0258-00	King Lake	16 mi N of Coleraine	2B, 3C	2018	2019	2019 MRGRW TMDL
	31-0198-00	Little Cowhorn Lake	9 mi SE of Grand Rapids	2B, 3C (s)	2018	2019	2019 MRGRW TMDL
	31-0353-00	Split Hand Lake	11 mi S of Grand Rapids	2B, 3C	2010	2019	2019 MRGRW TMDL
Aquatic Recreation: Escherichia coli	07010103-574	Split Hand Creek	T53 R24W S18, W line to Miss R	2Bg, 3C	2018	2019	2019 MRGRW TMDL
	07010103-603	Hasty Brook	Unnamed ditch to Prairie Lk	1B, 2Bg, 3B	2018	2019	2019 MRGRW TMDL
	07010103-751	Willow River	S Fk Willow R to Willow R ditch	2Bg, 3C	2018	2019	2019 MRGRW TMDL
	07010103-753	Swan River	Swan Lk to Trout Cr	2Bg, 3C	2018	2019	2019 MRGRW TMDL
	07010103-758	Tamarack River	Little Tamarack R to Prairie R	2Be, 3C	2018	2019	2019 MRGRW TMDL
	07010103-760	Prairie River	Balsam Cr to Prairie Lk	2Bg, 3C	2018	2019	2019 MRGRW TMDL

[1] Big Sandy Lake and Lake Minnewawa TMDL Report: https://www.pca.state.mn.us/sites/default/files/wq-iw8-24e.pdf

XXX – Impairment addressed by 2019 MRGRW Pollutant TMDL

DO, turbidity and macroinvertebrate/fish bioassessment impairments can sometimes be linked back to a pollutant, such as phosphorus or sediment. However, a pollutant link could not be found for some impaired reaches in the MRGRW. A list of the aquatic life use impairments not addressed by TMDL calculations in this report are provided in Table 7. These impairments will be addressed through restoration strategies identified in Section 3.3 of this WRAPS report.

Table 7. Mississippi River-Grand Rapids Watershed aquatic life use impairments not addressed by TMDLs

Waterbody Name (AUID)	Listed Pollutant/ Stressor				Reason
	Aquatic Recreation: Nutrient/ Eutrophication (Phosphorus)	Aquatic Life: Dissolved oxygen	Aquatic Life: Macroinvertebrate Bioassessments	Aquatic Life: Fish Bioassessments	
Prairie Lake (31-0384-02)	✓				List Correction
Moose River (07010103-749)		✓			Natural Background
Sandy River (07010103-512)			✓	✓	Non-pollutant based stressor
Minnewawa Creek (07010103-518)			✓	✓	Non-pollutant based stressor-proposed list re-categorization
Minnewawa Creek (07010103-519)				✓	Non-pollutant based stressor
Pickerel Creek (07010103-590			✓	✓	Non-pollutant based stressor
Unnamed Creek (07010103-717)				✓	Natural background
Unnamed creek (07010103-719)			✓		Natural Background
Unnamed Creek (07010103-722)				✓	Deferred until next assessment cycle
Unnamed creek (07010103-726)			✓	✓	Non-pollutant based stressor
Unnamed Creek (07010103-727)				✓	Non-pollutant based stressor
Unnamed Creek (07010103-728)				✓	Non-pollutant based stressor-proposed list re-categorization
Unnamed Creek (07010103-730)				✓	Non-pollutant based stressor
Unnamed Creek (07010103-731)				✓	Deferred until next assessment cycle
Pokegama Creek (07010103-733)			✓	✓	Non-pollutant based stressor-proposed list re-categorization
Unnamed Ditch (07010103-739)				✓	Non-pollutant based stressor
White Elk Creek (07010103-741)				✓	Non-pollutant based stressor
Unnamed ditch (07010103-756)			✓	✓	Non-pollutant based stressor-proposed list re-categorization

2.5 Protection considerations

This section provides a short description of the major protection considerations in the MRGRW that were developed based on input from local partners and the public. Protection strategies were identified in Section 3.3 for each of the specific areas and/or water resources listed below.

Protection Lakes

There are 642 lakes or bays larger than 10 acres in the MRGRW. The objective of this section was to prioritize those 642 lakes into a smaller subset of lakes that will be the focus of restoration and protection efforts in the watershed.

Prioritization Criteria

Twenty-six priority lakes for protection (Figure 9 and Table 8) were chosen based on the criteria of having one or more of the following attributes:

- One of the top 25 largest lakes by surface area
- Identified as a priority lake by the Ambassadors
- DNR lake of biological significance
- DNR lake benefit: cost assessment lakes that provide the greatest return on investment
- DNR designated tullibee refuge (cisco) lake
- DNR designated wild rice lake
- Lake located in a Zonation hotspot
- MPCA-DNR lake phosphorus sensitivity
- Decreasing water clarity trends
- Near water quality standards
- DNR Level 8 Subwatershed Habitat Strategy (Figure 10)

Descriptions, data sources, and categories of lake characteristics used to prioritize the lakes in the MRGRW are summarized in Table 8.

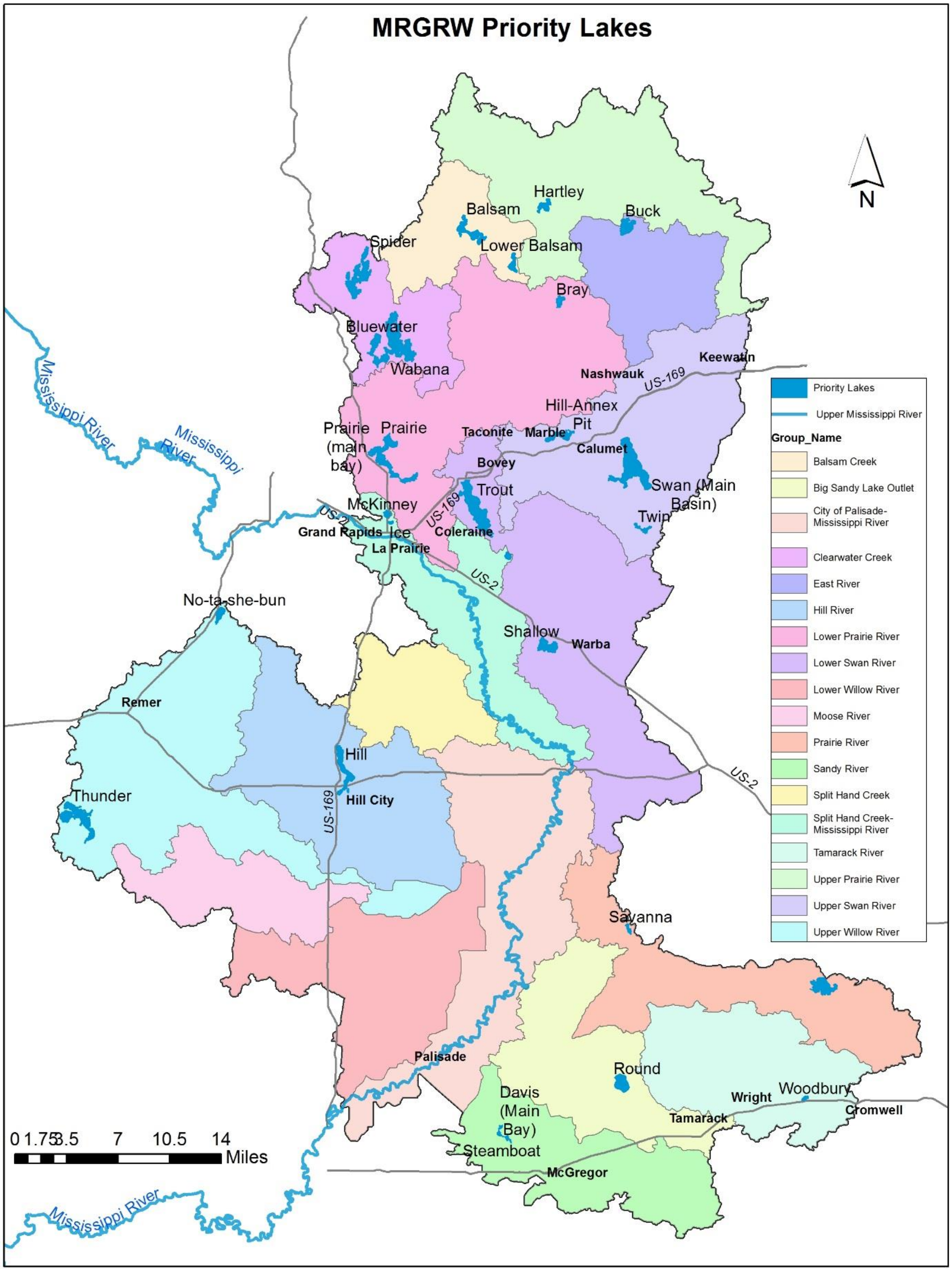


Figure 9. MRGRW Priority Lakes

Table 8. Protection Lake Prioritization Criteria

Aggregated HUC12 Name	Lake ID	Lake Name	Mean TP (ppb)	Lake Area (acres)	Top 25 in Area	Ambassador's Priority Lake	Lake of Biological Significance	Cisco Refuge Lake	Wild Rice Lake	Lake Located in a Zonation Hotspot	Phosphorus Sensitivity	Cost Benefit Analysis Ranking	Clarity Trend	Proximity to WQ Std	DNR Level 8 Subshed Habitat Strategy
Balsam Creek	31025900	Balsam	15	714	Y			Y			Higher	High	No evidence of trend		Protection
	31024700	Lower Balsam	18	259			High	Y			High	High	Insufficient data		Protection
Big Sandy Lake Outlet	01002300	Round	11	554		Y				Y	Highest	Highest	No evidence of trend		Protection
Clearwater Creek	31039500	Bluewater	8	364		Y	Outstanding	Y		Y	Highest	Highest	Improving trend		Protection
	31053800	Spider	11	1,392	Y	Y				Y	Higher	Higher	Improving trend		Vigilance
	31039200	Wabana	10	2,221	Y	Y	Outstanding	Y		Y	Highest	Higher	Improving trend		Protection
East River	31006900	Buck	17	495							Highest	Highest	No evidence of trend		Protection
Hill River	01014200	Hill	21	792	Y	Y				Y	Higher	High	No evidence of trend		Protection
Lower Prairie River	31014700	Bray	14	177				Y			High	High	Insufficient data		Protection
	31038400	Prairie	26	1,331	Y	Y	Outstanding	Y	Y	Y	High	High	No evidence of trend		Protection
Lower Swan River	31008400	Shallow	10	539			Outstanding	Y			Highest	Highest	No evidence of trend		Protection
	31021600	Trout	33	1,854	Y	Y	Outstanding	Y		Y	Highest	Higher	Improving trend		Protection
Prairie River	69084800	Prairie	28	794	Y	Y	Outstanding	Y	Y	Y	High	High	No evidence of trend	Y	Protection
	01001400	Savanna	33	86			Moderate		Y		Impaired	High	Insufficient data	Y	Vigilance
Sandy River	01007101	Davis (Main Bay)	65	77					Y		High	High	Insufficient data		
	01007102	Steamboat	80	60					Y		High	High	Insufficient data		
Split Hand Creek-Mississippi River	31037200	Ice	13	39			Moderate				Highest	High	No evidence of trend		
	31037000	McKinney	27	106							High	High	No evidence of trend		Protection
	31020900	Round	28	101		Y					Higher	High	No evidence of trend	Y	Protection
Tamarack River	09006300	Woodbury	36	60		Y	Moderate		Y	Y	Highest	High	Declining trend		
Upper Prairie River	31015400	Hartley	12	288				Y			Higher	High	No evidence of trend		Vigilance
Upper Swan River	31006700	Swan	20	2,456	Y	Y	Outstanding	Y	Y	Y	Higher	High	Improving trend		Protection
	31002600	Twin	#N/A	147							High	High	Insufficient data		Vigilance
Upper Willow River	31077500	No-ta-she-bun	7	239			Outstanding	Y			Highest	Highest	Insufficient data		Protection
	11006200	Thunder	12	1,347	Y	Y	Outstanding	Y	Y	Y	Highest	Higher	Improving trend		Protection

Table 9. Lake characteristic description, data source, and categories

Characteristic	Description	Data Source	Categories
Top 25 in Area	The surface area of each individual lake in acres	Minnesota Geospatial Commons	None
Ambassador's Priority Lake	Ambassador's prioritized lakes within Zonation hotspot	December 17, 2017 Ambassador meeting	Yes or no
Lake of Biological Significance	Lakes were identified and classified by DNR subject matter experts on objective criteria for four community types (aquatic plants, fish, amphibians, birds).	Minnesota Geospatial Commons	Outstanding, High and Moderate
Trout Lake	Legally designated trout lakes as identified in Minnesota Rules Chapter 6264.0050. These are inland lakes managed by DNR Fisheries for trout species (not including lake trout).	Minnesota Geospatial Commons	Yes or no
Cisco Refuge Lake	Lakes that support populations of tullibee (cisco or lake herring). These coldwater fish provide excellent forage for trophy walleye, northern pike, muskellunge, and lake trout. They require cold, well-oxygenated water of deep, high water quality lakes.	The Minnesota DNR Fisheries Research Unit, in conjunction with the University of Minnesota, has identified tullibee refuge lakes in Minnesota that are deep and clear enough to sustain tullibees even after climate warming occurs.	Yes or no
Lake Benefit: Cost Assessment	This dataset was formulated to rank lakes as they relate to the state's priority of focusing on high-quality, high-value lakes that likely provide the greatest return on investment. For each lake, a benefit: cost assessment priority score was calculated. This score is a function of phosphorus sensitivity, lake size, and catchment disturbance. Lakes were then grouped based on this score and assigned a priority rating.	Minnesota Geospatial Commons	High, Higher, Highest
Wild Rice Lake	DNR designated wild rice lake	Minnesota DNR statewide inventory of wild rice waters (2008-02-15)	Yes or no
Lake Located in a Zonation Hotspot	Lake is located in an area identified by zonation as being a high priority area	Minnesota DNR	Yes or no
Phosphorus Sensitivity	Prioritization of lakes as they relate to MPCA's policy objective of focusing on high quality, unimpaired lakes at greatest risk of becoming impaired. The phosphorus sensitivity significance index is a function of phosphorus sensitivity, lake size, lake TP concentration, proximity to MPCA's phosphorus impairment thresholds, and watershed disturbance.	Minnesota Geospatial Commons	High, Higher, Highest
Clarity Trend	Long-term trend of lake water transparency	Mann Kendall Trend Analysis of >8 years of MPCA Secchi transparency depth data with 4 or more readings per season reported by RMB Environmental Laboratories in the Cass County and Crow Wing County Large Lake Assessment reports.	**Improving trend** No evidence of trend **Declining trend** IF: insufficient data for trend analysis
Proximity to WQ Standard	Lakes that barely meet/exceed Northern Lakes and Forest Ecoregion nutrient standards	MPCA Monitoring and Assessment Report	Yes or no
DNR Level 8 Subshed Habitat Strategy	Suggested approaches for watershed protection and restoration of DNR managed fish lakes in Minnesota	Peter Jacobson and Michael Duval, DNR Fisheries Research Unit	**Vigilance**: Watershed disturbance < 25% and watershed protection > 75%. Sufficiently protected. Water quality supports healthy and diverse fish communities. Keep public lands protected. **Protection**: Watershed disturbance < 25% and watershed protection < 75%. Excellent candidates for protection. Water quality can be maintained in a range that supports healthy and diverse native fish communities. Disturbed lands should be limited to less than 25%. **Restoration**: Watersheds with moderate level of disturbance (25%-60%) have realistic chances for full restoration.

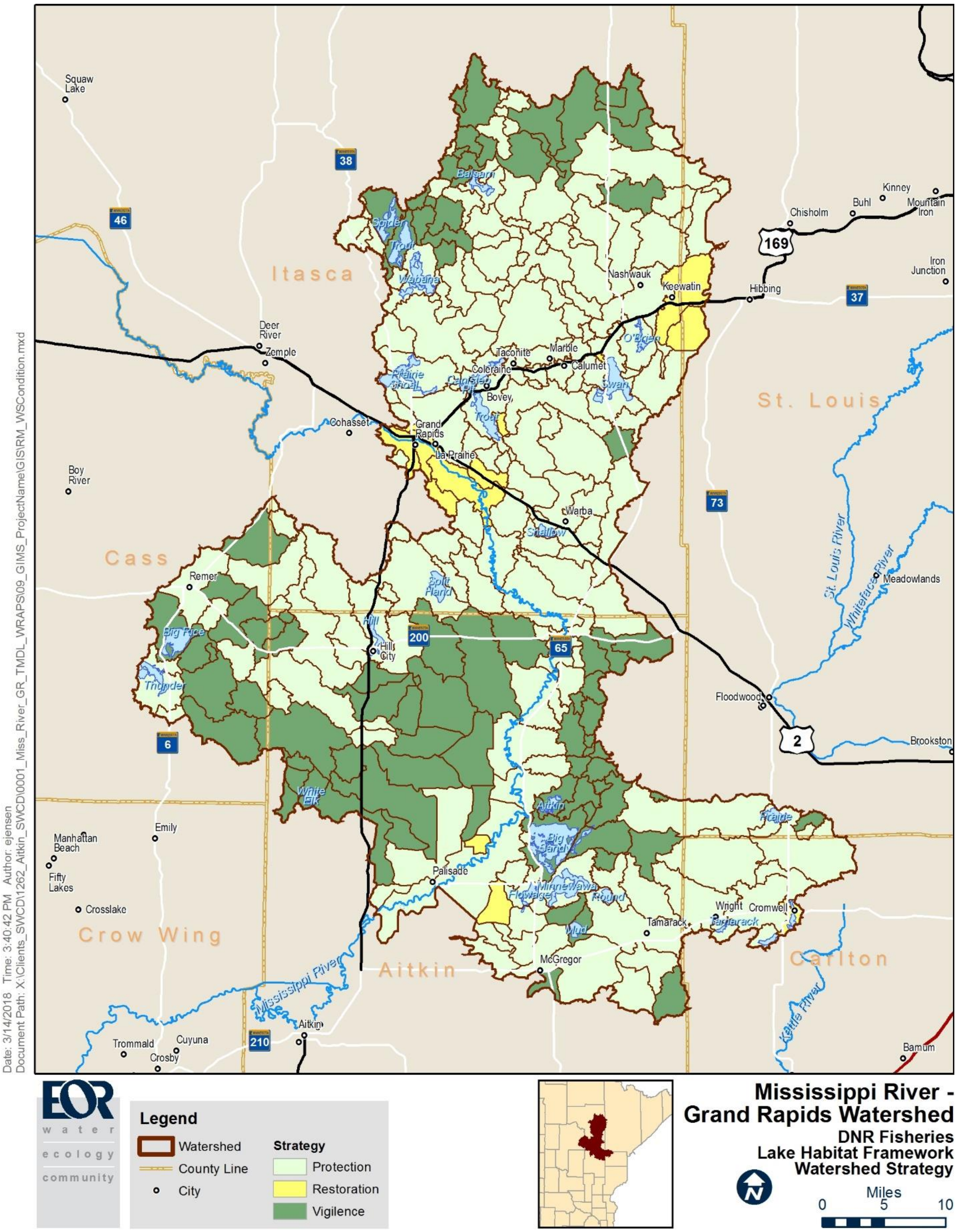


Figure 10. DNR Fisheries Lake Habitat Framework Watershed Strategy

High-Level State Priorities

In 2013, the Minnesota Legislature added accountability language to the CWLA. This new language aimed to increase accountability for the public funds used to clean up our water. The CWLA now defines WRAPS and requires the BWSR to prepare a Nonpoint Priority Funding Plan (NPFP).

The NPFP is a criteria-based process to prioritize Clean Water Fund investments. It provides state agencies with a coordinated, transparent and adaptive method to ensure that Clean Water Fund implementation allocations are targeted to cost-effective actions with measurable water quality results. The process may also help agencies identify gaps in programming to accelerate progress toward meeting water management goals. The plan can be reviewed at the BWSR website.

In the NPFP, state agencies identified the following three high-level state priorities for investing Clean Water Fund nonpoint implementation money in FY 2016-2017, based on the principles of asset preservation and risk-opportunity assessment:

- Restore those impaired waters that are closest to meeting State water quality standards
- Protect those high-quality unimpaired waters at greatest risk of becoming impaired
- Restore and protect water resources of public use and public health, including drinking water

The MPCA developed a Nearly Impaired/Barely Impaired list of lakes that are in close proximity to water quality standards in the MRGRW (Table 10). Those lakes with water quality closest to water quality standards will be the most cost-effective to improve.

Table 10. MPCA 2017 Nearly/Barely List of lakes in close proximity to water quality standards

Aggregated HUC 12	Lake ID	Lake Name
Balsam Creek	31-0258-00	King
	31-0271-00	Marble
Big Sandy Lake Outlet	01-0077-00	Rat
East River	31-0048-00	Libby
Hill River	01-0111-00	Washburn
Prairie River	01-0014-00	Savanna
	69-0848-00	Prairie
Sandy River	01-0072-00	Rock
Split Hand Creek-Mississippi River	31-0209-00	Round
Tamarack River	09-0057-00	Eagle
	09-0060-01	Upper (North) Island
	09-0060-02	Lower (South) Island
Upper Prairie River	31-0054-00	Twenty Four
	31-0057-00	Sherry

Aggregated HUC 12	Lake ID	Lake Name
	31-0265-00	Bluebill
Upper Swan River	31-0111-00	Upper Panasa

Protection Streams

The MPCA and DNR have worked together to prioritize the 44 streams in the MRGRW that were found to be supportive of designated aquatic life uses. The goal of this prioritization exercise was to identify and prioritize streams that are 1) currently healthy but near the impairment threshold or 2) currently healthy and are indicating good water quality. For those streams that are currently healthy, further prioritization exercises were performed to identify watersheds that are largely protected versus those that are at risk for being developed.

The stream protection and prioritization exercise identified two main landscape risks to biological condition including 1) percent disturbed land, and 2) density of roads. Each risk factor was assessed at two different scales including the riparian scale (200m buffer on each side of stream) and the stream's watershed scale.

The exercise then identified the amount of land in public ownership or permanent easement at both the riparian scale and watershed scale. Next, each stream was assessed to determine the number of communities (fish, macroinvertebrates, or both) that were near the impairment threshold (Figure 11). Each risk factor was assessed relative to a statewide database for fully supporting streams. The final Protection Priority Rank was calculated as follows:

Protection Priority Rank =

[(IBI Threshold Proximity) x (Riparian Risk + Watershed Risk + Current Protection)].

As an example, a stream with biological communities (fish and macroinvertebrates) that were near the IBI impairment threshold, with a large number of roads in the stream's watershed, and a low percentage of land in protection (e.g., public lands) would result in a high risk or Priority A stream. Five Priority A streams were identified in the MRGRW (Table 11; Figure 12); these five streams were identified as being near the tipping point towards one or more impairments and therefore represent the highest priority for protection efforts. Twenty Priority B streams were identified in the MRGRW; these streams represent a secondary priority for protection based efforts.

The Prairie River, West Fork Prairie River, Tamarack River, and Willow River Ditch were identified through the IWM as having excellent fish and macroinvertebrate communities, resulting in an Exceptional Use waterbodies designation. Furthermore, the near-channel habitat in these streams is rated as good to exceptional. Therefore, they were also considered as being a high priority for protection in the watershed.

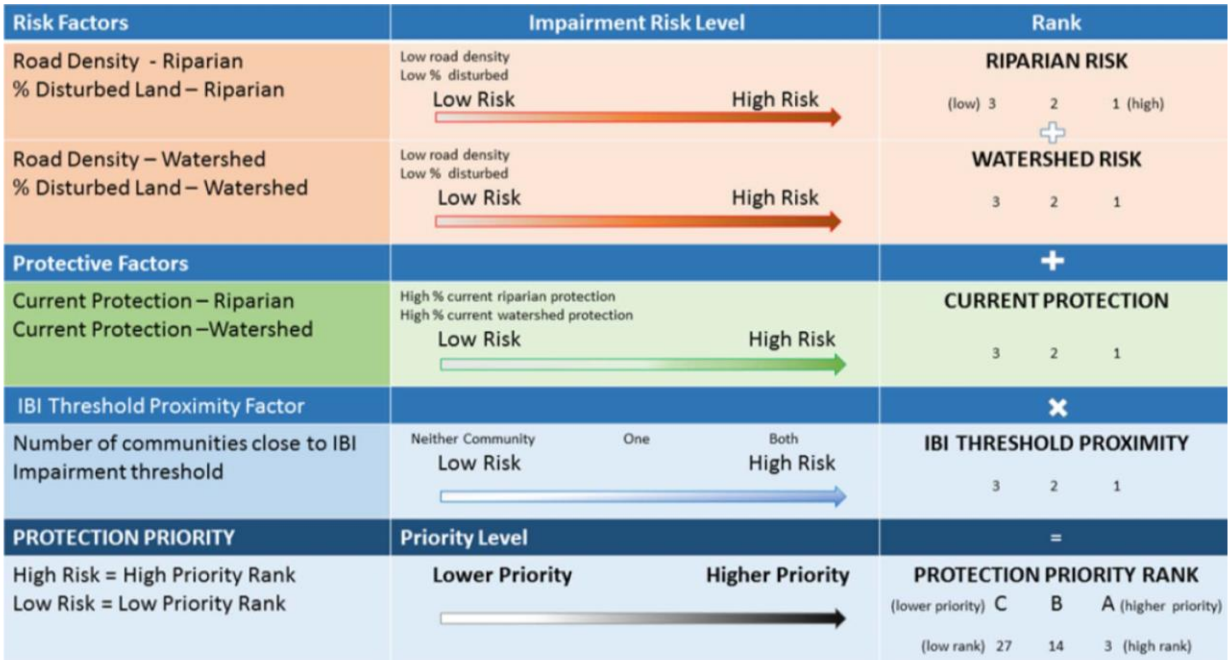


Figure 11. Stream protection and prioritization matrix.

Table 11. Stream protection and prioritization results

Aggregated HUC-12	AUID	Stream Name	Reach Length (miles)	TALU	Cold/Warm	Fish or Macroinvertebrate Community Impaired	Riparian Risk	Watershed Risk	Current Protection Level	Final Protection Prioritization Rank	Protection Prioritization Class
0701010309-01	07010103-602	Libby Brook	2.72	General	warm	both	med/high	medium	medium	**5.5**	**A**
0701010307-01	07010103-761	Morrison Brook	3.59	General	cold	both	medium	medium	high	**7**	**A**
0701010308-02	07010103-554	Unnamed creek	3.42	General	warm	both	low	med/low	high	**8.5**	**A**
0701010304-01	07010103-689	Bruce Creek	0.23	General	cold	one	high	medium	med/low	**9**	**A**
0701010309-01	07010103-623	Two Rivers Springs	1.34	General	warm	one	medium	medium	med/low	**11**	**A**
0701010304-02	07010103-753	Swan River	18.97	General	warm	one	medium	medium	medium	**12**	**B**
0701010305-02	07010103-735	Unnamed creek	3.5	General	warm	one	medium	medium	medium	**12**	**B**
0701010301-01	07010103-542	Day Brook	23.77	General	warm	one	med/low	medium	medium	**13**	**B**
0701010301-01	07010103-721	Deer Creek	5.76	General	warm	one	low	med/low	low	**13**	**B**
0701010307-01	07010103-762	Morrison Brook	2.8	General	warm	one	medium	medium	med/high	**13**	**B**
0701010301-01	07010103-571	Prairie River, West Fork	2.31	Exceptional	warm	one	med/high	medium	high	**13**	**B***
0701010308-02	07010103-716	Willow River Ditch	3.3	Exceptional	warm	one	med/high	medium	high	**13**	**B***
0701010301-02	07010103-712	East River	1.62	General	warm	one	medium	low	medium	**14**	**B**
0701010304-02	07010103-545	Hay Creek	9.99	General	warm	one	low	med/low	med/low	**14**	**B**
0701010305-02	07010103-758	Tamarack River	7.52	Exceptional	warm	one	low	medium	medium	**14**	**B***
0701010303-02	07010103-574	Split Hand Creek	6.34	General	warm	neither	high	med/low	med/low	**15**	**B**
0701010302-01	07010103-618	Sucker Brook	5.32	General	warm	one	med/low	med/low	high	**16**	**B**
0701010303-02	07010103-732	Unnamed creek	2.4	General	warm	one	medium	low	high	**16**	**B**
0701010304-01	07010103-595	Warba Creek	4.81	General	warm	one	med/low	med/low	high	**16**	**B**
0701010307-01	07010103-526	Hill River	8.64	General	warm	neither	med/high	medium	medium	**16.5**	**B**
0701010302-01	07010103-508	Prairie River	7.16	General	warm	neither	med/high	medium	medium	**16.5**	**B**
0701010305-01	07010103-603	Hasty Brook	6.75	General	warm	neither	med/high	medium	med/high	**18**	**B**
0701010304-02	07010103-583	O'Brien Creek (Welcome Creek)	1.78	General	warm	neither	med/high	med/low	medium	**18**	**B**
0701010302-01	07010103-760	Prairie River	24.23	General	warm	neither	medium	medium	medium	**18**	**B**
0701010305-02	07010103-757	Tamarack River	18.3	General	warm	neither	medium	medium	medium	**18**	**B**
0701010304-01	07010103-608	Bruce Creek	3.53	General	warm	neither	med/low	medium	medium	**19.5**	**C**
0701010302-02	07010103-587	Clearwater Creek	2.13	General	warm	neither	med/low	medium	medium	**19.5**	**C**

Aggregated HUC-12	AUID	Stream Name	Reach Length (miles)	TALU	Cold/Warm	Fish or Macroinvertebrate Community Impaired	Riparian Risk	Watershed Risk	Current Protection Level	Final Protection Prioritization Rank	Protection Prioritization Class
0701010301-01	07010103-759	Prairie River	11.31	Exceptional	warm	neither	med/low	medium	medium	**19.5**	**C***
0701010304-01	07010103-754	Swan River	51.73	General	warm	neither	med/low	medium	medium	**19.5**	**C**
0701010308-02	07010103-751	Willow River	31.34	General	warm	neither	medium	medium	med/high	**19.5**	**C**
0701010302-03	07010103-696	Balsam Creek	1.42	General	warm	neither	med/low	medium	med/high	**21**	**C**
0701010305-02	07010103-734	Little Tamarack River	4.03	General	warm	neither	med/low	med/low	medium	**21**	**C**
0701010305-01	07010103-516	Prairie River	25	General	warm	neither	low	medium	medium	**21**	**C**
0701010308-01	07010103-748	Willow River	37.88	General	warm	neither	med/low	medium	med/high	**21**	**C**
0701010301-02	07010103-714	East River	1.97	General	warm	neither	low	medium	med/high	**22.5**	**C**
0701010307-01	07010103-738	Little Hill River	9.22	General	warm	neither	med/low	med/low	med/high	**22.5**	**C**
0701010305-01	07010103-515	Prairie River	8.46	General	warm	neither	low	medium	med/high	**22.5**	**C**
0701010304-01	07010103-729	Unnamed creek	0.86	General	warm	neither	medium	low	med/high	**22.5**	**C**
0701010304-01	07010103-594	Sand Creek	8.66	General	warm	neither	med/low	med/low	high	**24**	**C**
0701010305-01	07010103-514	West Savanna River	14.45	General	warm	neither	low	medium	high	**24**	**C**
0701010301-02	07010103-718	East River	7.62	General	warm	neither	low	low	med/high	**25.5**	**C**
0701010308-03	07010103-749	Moose River	24.28	General	warm	neither	low	med/low	high	**25.5**	**C**
0701010301-01	07010103-543	Prairie River	14.55	General	warm	neither	med/low	low	high	**25.5**	**C**
0701010308-02	07010103-525	Willow River, North Fork	7.92	General	warm	neither	low	low	high	**27**	**C**

* These waterbodies were identified as high quality waters with fish and invertebrate communities at or near undisturbed conditions. These streams are considered a high priority for future protection efforts.

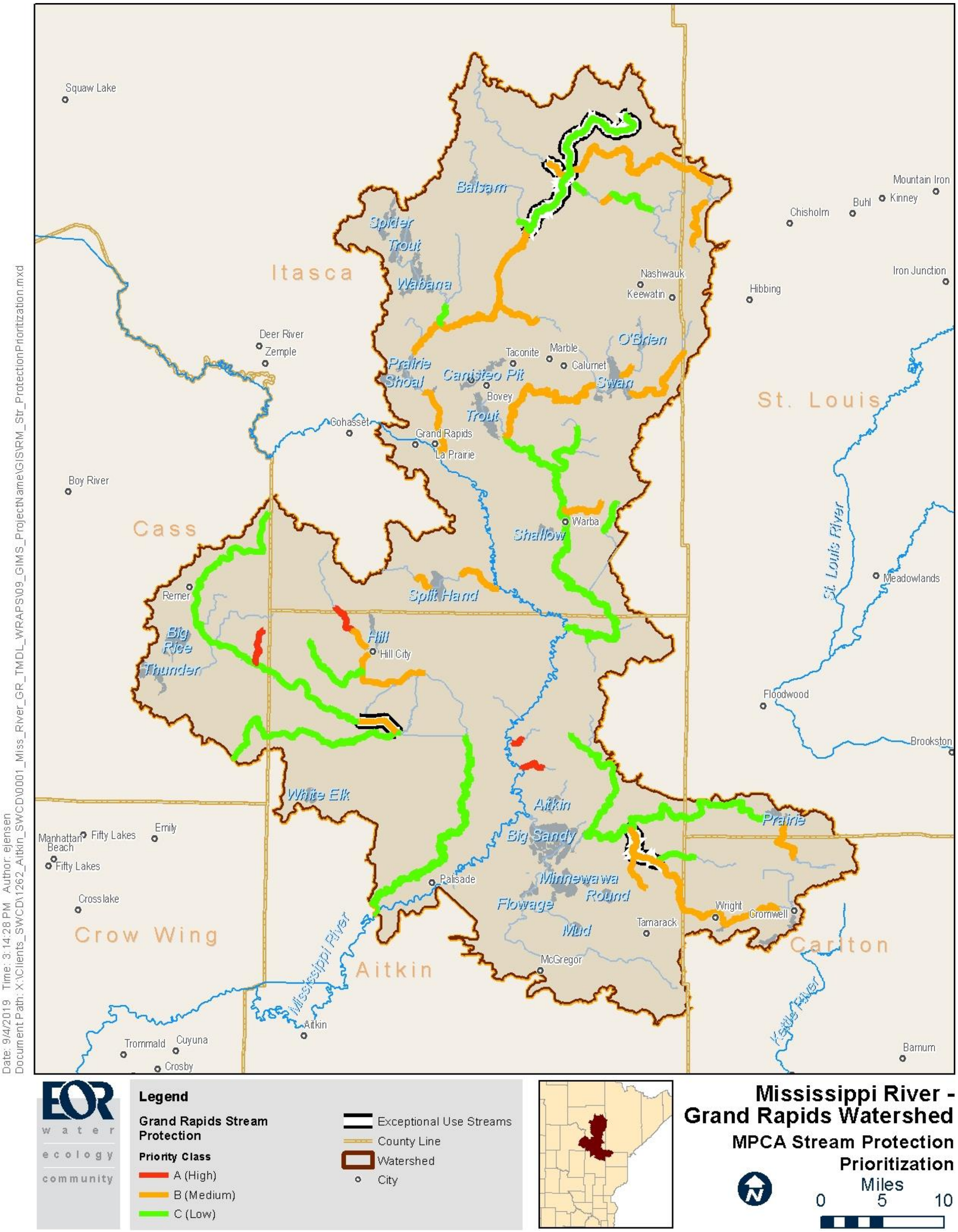


Figure 12. Stream protection and prioritization results

Drinking Water Protection

Drinking water protection considerations in the MRGRW are based on the findings from the June 2009 USDA Forest Service study titled, **Forests, Water and People: Drinking water supply and forest lands in the Northeast and Midwest United States** (https://www.fs.usda.gov/treesearch/pubs/15257). The study used a GIS-based process and a series of maps to create a watershed condition index based on physical and biological attributes. Using a multi-step process, this index was then used to compare watersheds across the 20 state study area of the Northeast and Midwest and District of Columbia, in terms of their ability to produce clean water. Through regional maps, this analysis also accomplishes the following: quantifies the magnitude and scope of forest-dependent drinking water supplies and their dependence on private forests; and identifies watersheds that are threatened by land use change or that are in need of forest management to sustain and improve forests that protect water supplies.

A description of the four indices developed for each watershed as reported in the 2009 study, and the MRGRW score (0-10, with higher scores indicating higher probability) for each index are summarized below:

1. Ability to produce clean drinking water (0-10): MRGRW score = 10

Water quality is a function of biophysical conditions as well as the nature and intensity of land use in a watershed. Watersheds with a large proportion of forest land are more likely to be associated with good water quality. Forests provide the best land cover when it comes to protecting soil, moderating streamflow, supporting healthy aquatic systems, and sustaining good water quality. In the absence of mitigating actions, conversion of forest to other land uses leads to reduced water quality via a net increase in runoff, soil erosion, downstream flooding, and the flow of nutrients and other pollutants into rivers and streams (de la Cretaz and Barten 2007).

Land uses that tend to dramatically alter natural hydrologic and biological processes also have the greatest potential to negatively influence the flow and quality of water from these watersheds. For example, areas that contain a high percent of forested riparian buffers contribute positively to the ability to produce clean water, while higher amounts of cropland or development are expected to have a negative influence on watershed function and the ability to produce clean water.

The index of the ability to produce clean water indicates the probability of finding surface waters of high quality in a watershed. Six GIS-based layers were used to develop the index of ability to produce clean drinking water: percent forest land by watershed, percent agricultural land by watershed, percent riparian forest cover by watershed, road density, soil erodibility, and 2000 housing density. Higher scores indicate higher probability.

2. Importance for drinking water supply (2-20): MRGRW score = 16

This index combines the index of Ability to Produce Clean Water with the total number of drinking water consumers served by that watershed to highlight those areas that provide high quality water to the largest population. Watersheds scoring high on this map are important forested watersheds and highlight the location of leading municipal water providers, both public and private. Areas scoring highest are likely to be forested watersheds near large population centers.

3. **Dependence on unprotected private forest land for drinking water supply (3-30): MRGRW score = 20**

It is a common misconception that all or most lands that supply public drinking water are publicly owned or otherwise protected. Some highly valued drinking water supplies do come from public or other lands that are protected from future development or land-use impacts. Other water supply system lands have limited protection zones, often surrounding reservoirs, lakes, or intakes, while the remainder of the watershed is vulnerable to land-use change. Many small watershed supplies, however, contain only private lands with little or no protective agreements or special land-use provisions.

This index combines the results of the Ability to Produce Clean Water, number of surface drinking water consumers served, and the percent private forest land, to illustrate the important role that private forest lands play in protecting water supplies. Watersheds that scored high in their ability to produce high quality water for the largest population also scored high in the amount of private forested land they encompassed.

4. **Threat of forest conversion or need for management, to sustain and improve forest conditions to protect drinking water supply (4-37): MRGRW Score = 17**

The fact that watersheds are protected predominantly by private forest lands means that those watersheds are vulnerable to land-use change if they fall within areas of projected future growth. According to the EPA, more than 60% of U.S. water pollution comes from runoff from lawns, farms, cities, and highways, as well as leachate from septic systems (EPA 2007). The loss of forest lands to development affects not only the quality of drinking water, and therefore the cost of treating it, but the quantity as well. While it increases demand and water use, development also reduces the ability of water to infiltrate and recharge water supplies, and reduces supply as well.

In this analysis, housing density data, derived from U.S. Census (2000) block data, served as an indicator of development pressure. Projections of housing density change from 2000 to 2030 (Theobold 2005) that were developed as part of the Forests on the Edge project (Stein and others 2005) were combined with private land to illustrate those unprotected forest areas where housing density is likely to increase. Areas where housing density increased were extracted and reclassified as "development pressure." The acreage subject to development pressure was then calculated for each watershed and divided by the acreage of the watershed. This "development pressure per unit area" was then used to assign a value from low to high. Watersheds with the highest scores and the highest risk of future development are near major cities and metropolitan areas.

3. Prioritizing and implementing restoration and protection

The 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 many 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 BMPs. Thus, effective ongoing civic engagement is 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 watershed modeling efforts 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 following section describes the specific tools that were used by the MRGRW stakeholders to identify, locate and prioritize watershed restoration and protection strategies. Follow-up field reconnaissance will be the next part of the process to validate the identified areas potentially needing work.

Critical Area Identification

Hydrologic Simulation Program-FORTRAN (HSPF)

HSPF is a large-basin, watershed model that simulates non-point source runoff and water quality in urban and rural landscapes. The MRGRW HSPF model incorporates real-world meteorological data and is calibrated to real-world stream flow data. HSPF model development includes the addition of point source data in the watershed, including both domestic and industrial WWTFs.

HSPF was used to predict the relative magnitude of TSS, TP, and TN pollution generated in each subwatershed of the MRGRW. The HSPF model was also used to evaluate the extent of contributions from point, nonpoint, and atmospheric sources where necessary. Development of the HSPF model helps to better understand existing water quality conditions and predict how water quality might change under different land management practices and/or climatic changes at the subwatershed scale. HSPF also provides a means to evaluate the impacts of alternative management strategies to reduce these loads and improve water quality conditions. TSS, TP, and TN yields predicted from the HSPF model in the MRGRW are mapped in Figure 13 through Figure 15.

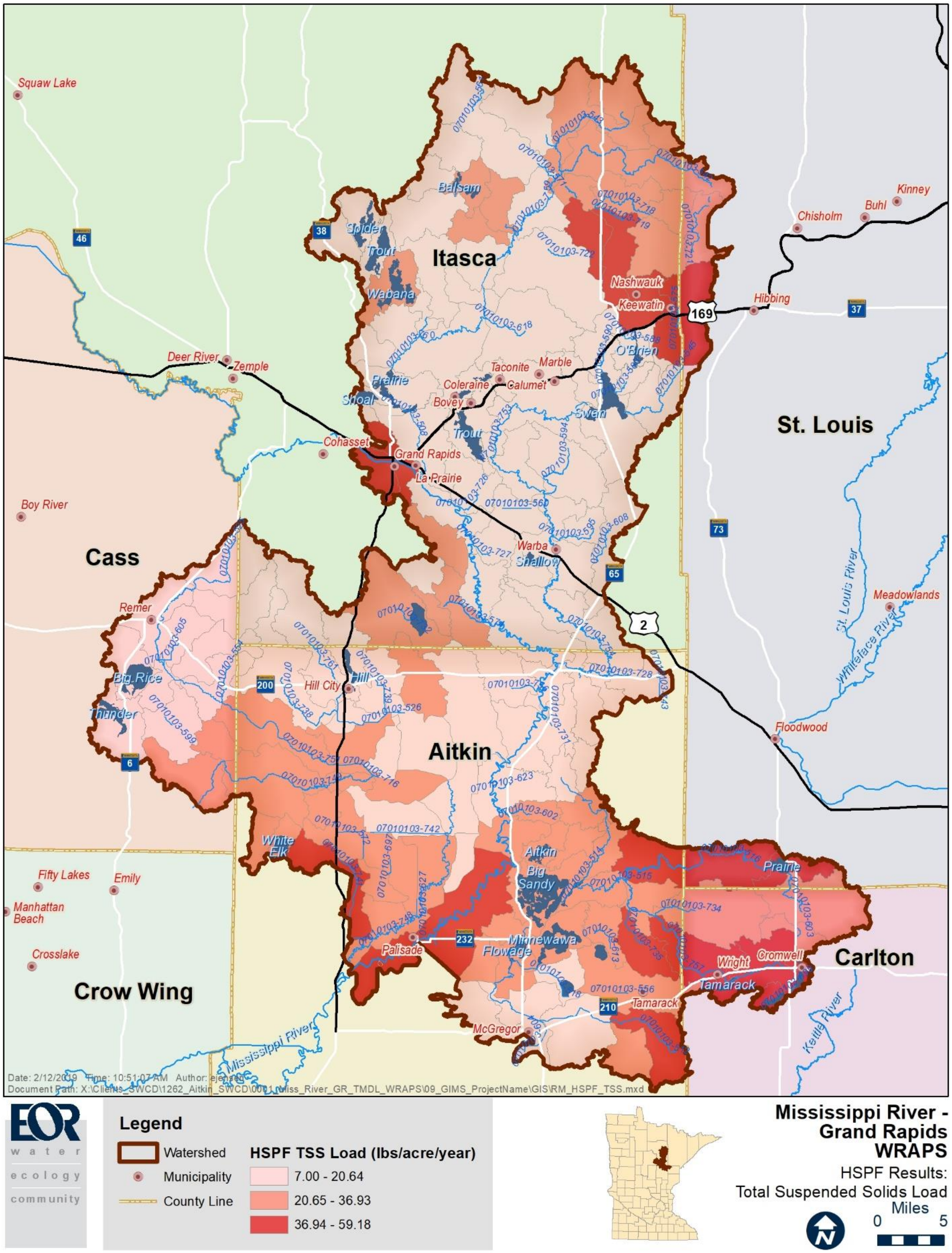


Figure 13. HSPF Total Suspended Solids Load (lbs/acre/year)

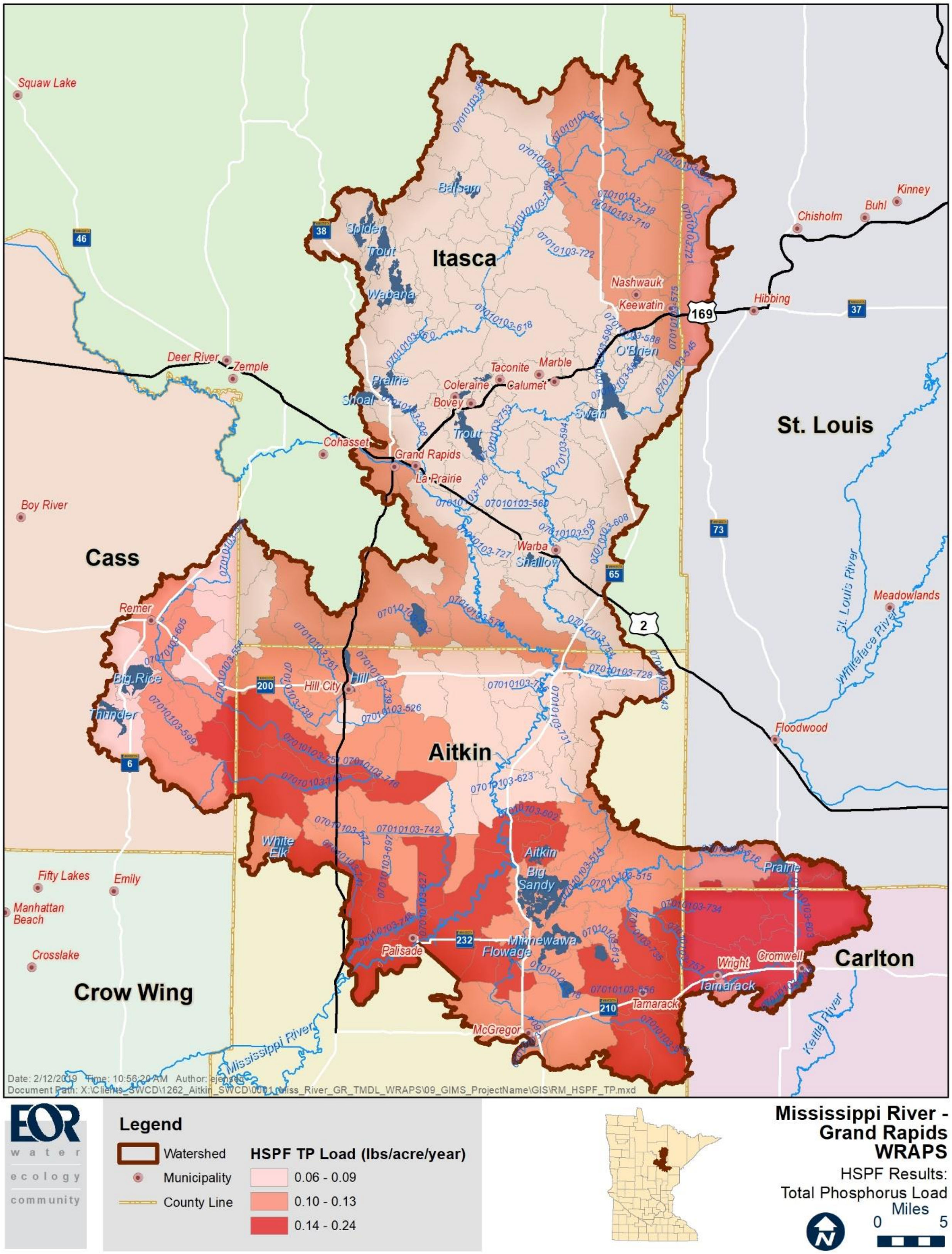


Figure 14. HSPF Total Phosphorus Load (lbs/acre/year)

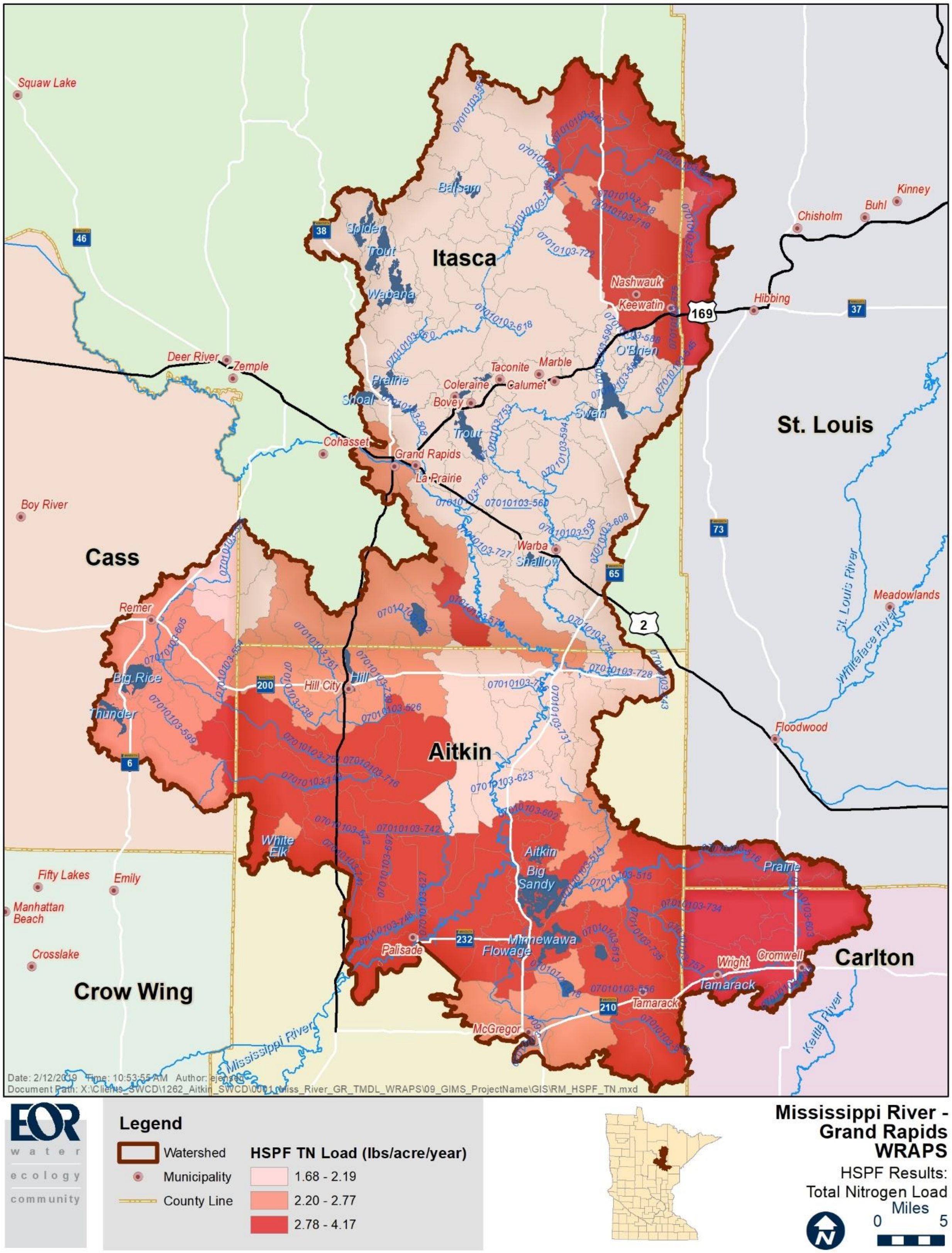


Figure 15. HSPF Total Nitrogen Load (lbs/acre/year)

Zonation

As threats to Minnesota's watersheds continue to mount, it is becoming increasingly important to identify and conserve high-priority areas. Identification of these priority areas, including sources of point and non-point pollution, will be crucial for targeting actions to improve water quality. There are multiple opportunities for protection or restoration in any watershed. Identifying which practices to implement and where in the landscape to implement them can help more effectively target efforts and more efficiently utilize limited resources.

To prioritize land within the MRGRW, we used a process that included the values-based model Zonation. This process began with the identification of valued conservation features and concluded with a review and synthesis of the results. The identification of priority areas was based on the quantitative analysis (using Zonation) of a suite of 30 data layers. Planning team members decided on what landscape features were included in the model and set the weights on those features via a pairwise questionnaire survey. The process was framed within the DNR's healthy watershed conceptual model and included biology, hydrology, water quality, geomorphology, and connectivity components. An additional component, designed to capture "unique resources" within the watershed was also included.

This approach recognized that attempts to solve clean water needs within the watershed are not separate from other natural resource needs; each priority area should provide multiple benefits. The model used in this process helps achieve this goal by identifying areas that provide multiple benefits while incorporating data valued by the community. See Appendix C for details on methods.

After the weights were determined via the pairwise survey, the Zonation model was run and a hotspot analysis was completed. This entailed using an algorithm to identify large contiguous areas where several prioritized features overlapped. This was followed by a synthesis of results, whereby the priority map and areas were edited and finalized. The final Zonation output map ranked lands as to their importance for land management activities that would provide greater protection of ecosystem functions, especially water quality, and to their importance for application of various land BMPs.

Zonation Results

The pairwise questionnaire survey results identified the *Protect/Restore Unique Resources* component of the value model inputs as the highest weight, followed by *Protect/Improve Fish & Wildlife Habitat*. The *Protect/Improve Lands of Concern* component was assigned the lowest weight (Figure 16 and Table 12).

The Zonation process identified several priority areas, which were further refined with stakeholder and partner input. These high priority areas include (Figure 18 and Figure 19):

- Lands near the city of Cromwell.
- Lands within the catchments surrounding Big Sandy Lake.
- Near the city of Hill City, the riparian areas of Morrison Brook as well as lands to the southeast of the city.
- South of the city of Remer, the areas around Big Rice and Thunder lakes.
- Lands near Prairie Lake, north of the city of Grand Rapids, as well as near Canisteo Pit and Trout Lake.

- Northeast and southwest of the city of Nashwauk.
- Spider, Trout, and Wabana lakes area in the Chippewa National Forest
- Catchment around King Lake

Table 12. Component and feature weights used in the Zonation model. Weights were obtained from a questionnaire using the analytic hierarchy process (AHP; weights sum to 100).

Component/Feature	Weight	Weight Used in Model
Component (broad-scale) Prioritization		
Protect/Improve Waters of Concern	17.3	
Reduce Erosion & Runoff	15.6	
Protect/Improve Fish & Wildlife Habitat	17.7	
Protect/Restore Unique Resources	19.2	
Protect Groundwater	16.1	
Protect/Improve Lands of Concern	14.1	
Feature (fine-scale) Prioritization		
Impaired waters	11	1.8
Catchments with higher pollution	16	2.7
Lakes with declining water quality	18	3.2
Catchments of lakes vulnerable to nutrient loading	19	3.3
Shoreland	24	4.1
Catchments with high altered hydrology	13	2.2
Areas with high erosive potential	15	2.3
Areas close to water	22	3.4
Existing wetlands	18	2.8
Stream riparian areas	32	5.0
Soil erosion risk	14	2.2
Trout stream catchments	20	3.6
Sites of biodiversity significance	24	4.2
Sensitive lakeshore	30	5.3
High value forests	26	4.6
Lakes of biological significance	44	8.5
Ecological connections	34	6.5
Rare features	22	4.2

Component/Feature	Weight	Weight Used in Model
Groundwater of private wells	19	3.1
Drinking water supply management areas	19	3.1
Groundwater contamination susceptibility	31	5.0
Areas with high groundwater recharge	30	4.9
BMPs on Pasture/hay lands	12	1.7
BMPs on Cultivated croplands	28	3.9
BMPs on valuable timber lands	24	3.4
Lands close to protected lands	17	2.4
Lands in urban growth or ag conversion areas	19	2.7

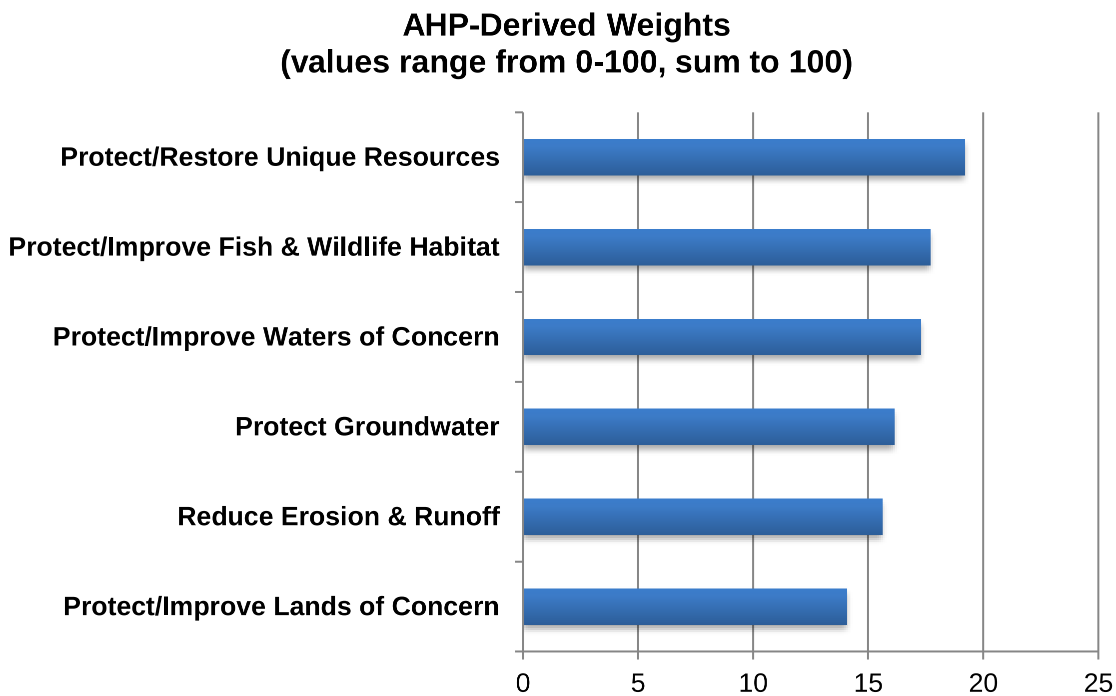


Figure 16. The component (broad-scale) weights used in the Zonation model. Weights were obtained from a questionnaire using the analytic hierarchy process (AHP; weights sum to 100).

In order to include citizens and policy makers in the Zonation process, a second survey regarding "Watershed Activities" was administered. That survey identified Improve Technical Assistance and Incentive Programs, Protect/Restore Riparian Vegetation, and Improve Education, Outreach, and Civic Engagement as the three most important activities for this watershed (Figure 17). Activities with the lowest preference included protecting areas with conservation easements or acquisition.

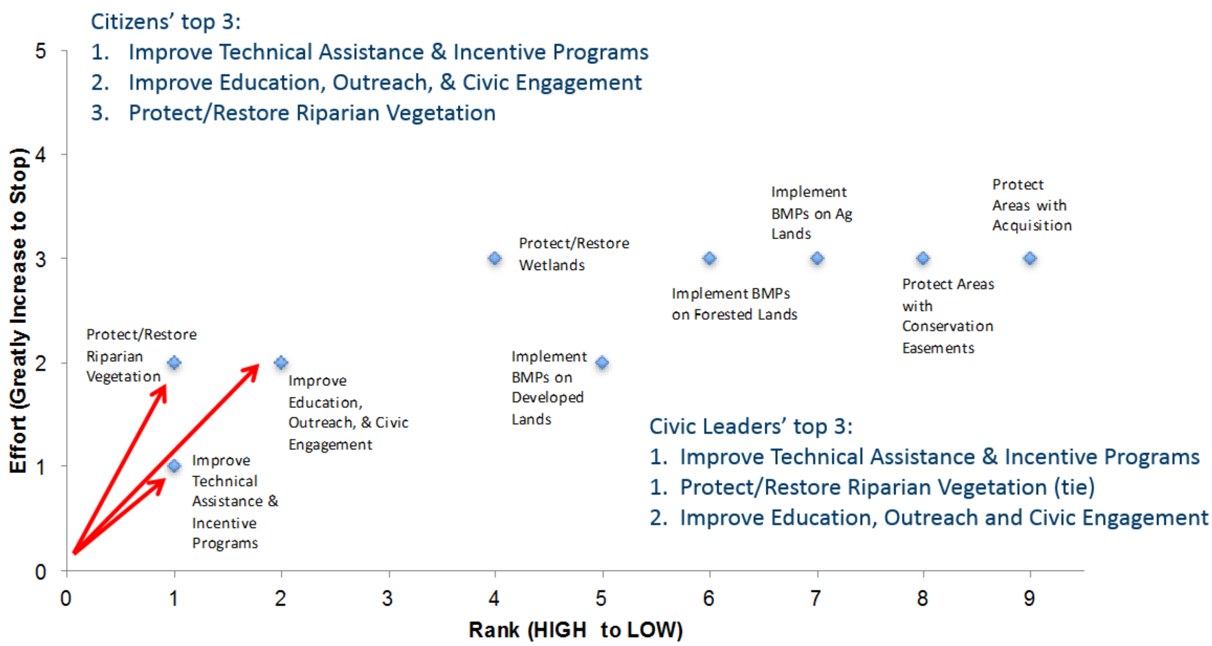
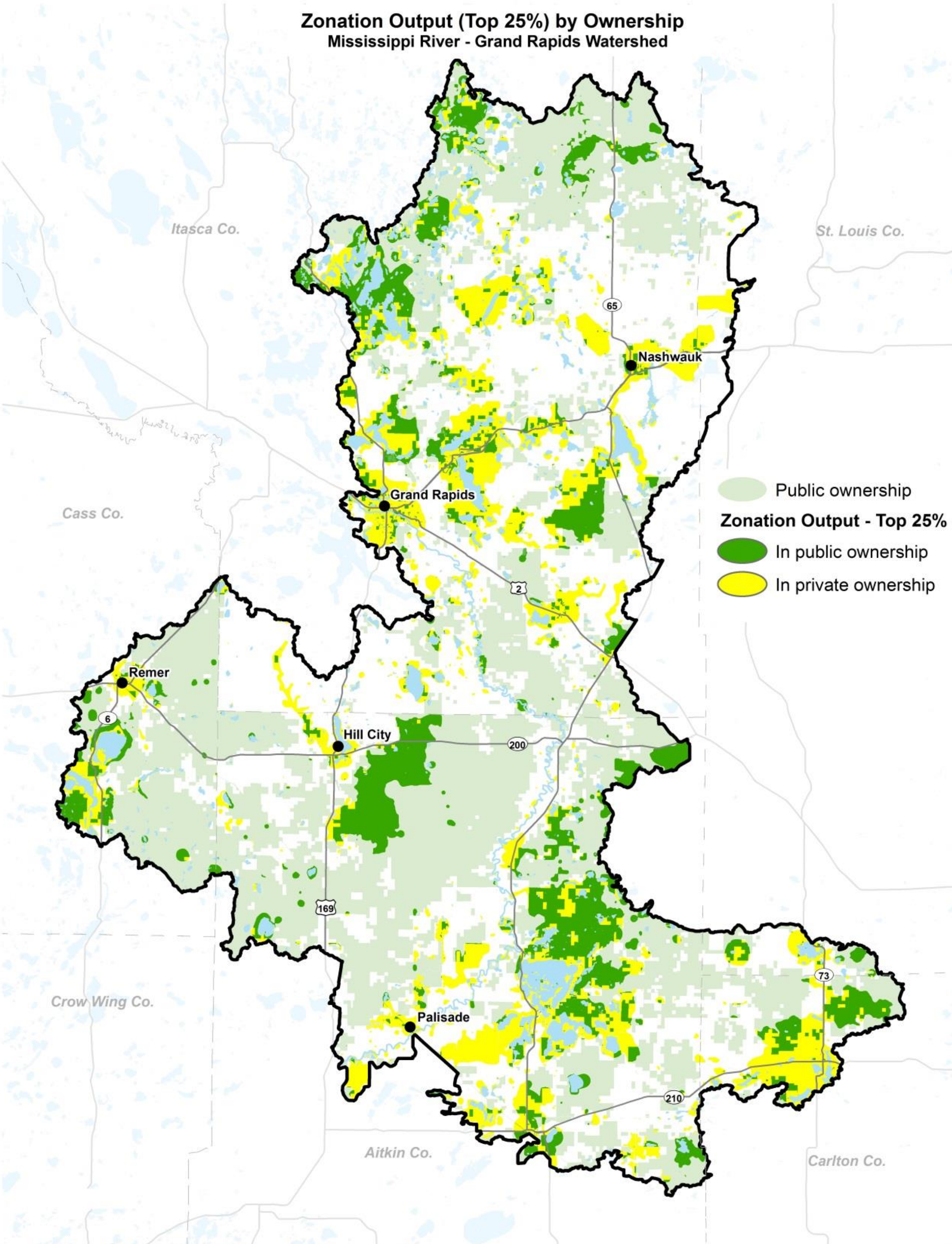


Figure 17. Results from survey used to identify preferences about watershed activities.



ty

Figure 18. Priority map from Zonation analysis and land ownership.

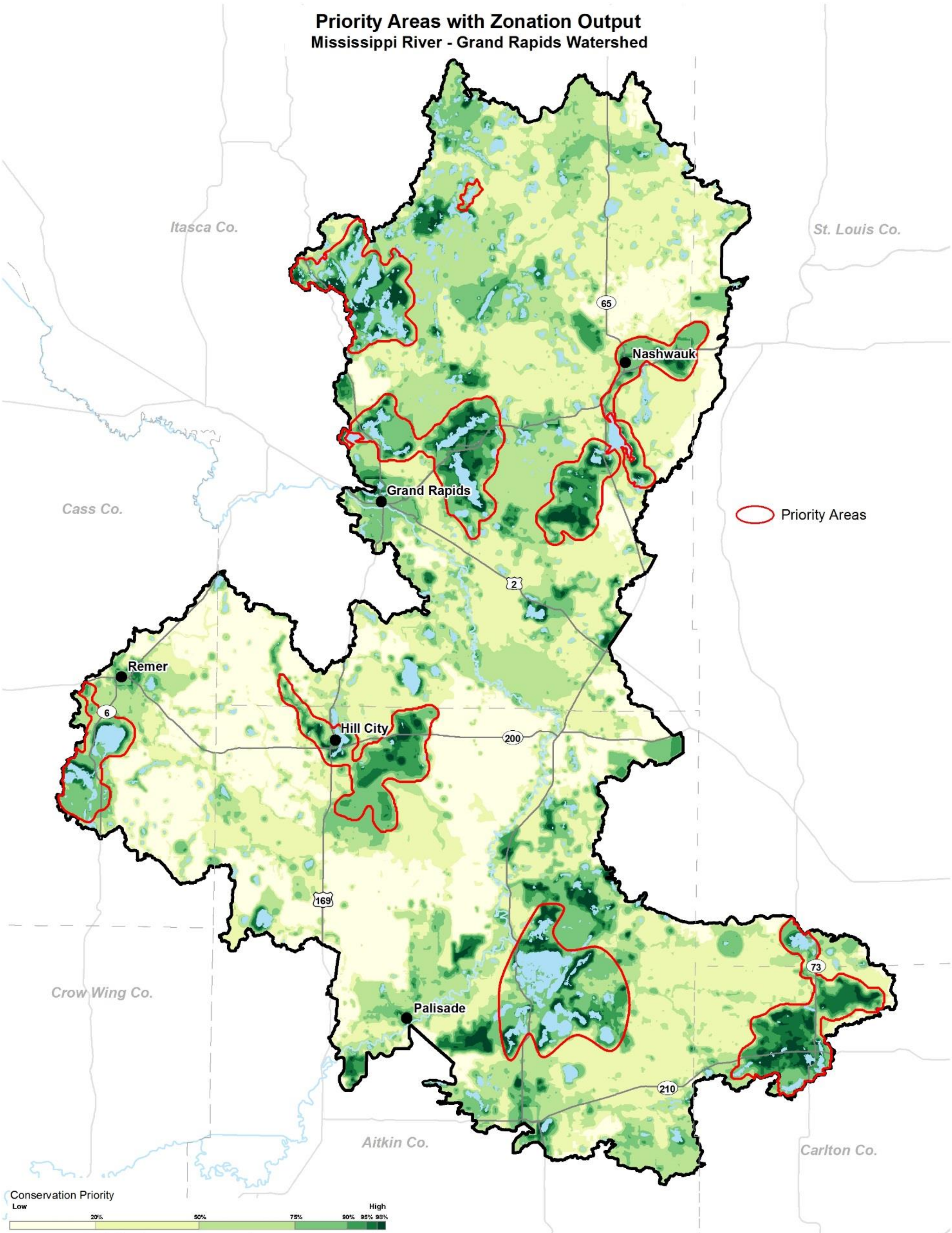


Figure 19. Priority map from Zonation analysis.

Aggregated HUC 12 Subwatershed Priority Ranking

Based on the output from Zonation, HSPF and input from the MRGRW WRAPS TAC and Ambassadors, subwatershed implementation was ranked as follows (Figure 20):

1. **<u>High Priority Subwatersheds</u>**:
    a. Balsam Creek (02-09)
    b. Lower Swan River (04-01)
    c. Split Hand Creek-Mississippi River (03-01)
    d. Split Hand Creek (03-02)
    e. Tamarack River (05-02)
    f. Big Sandy Outlet (06-01)
    g. City of Palisade-Mississippi River (09-01)
2. **<u>Medium Priority Subwatersheds</u>**:
    a. Clearwater Creek (02-02)
    b. Lower Prairie River (02-01)
    c. Upper Swan River (04-02)
    d. Sandy River (01-01)
    e. Hill River (07-01)
    f. Upper Willow River (08-02)
3. **<u>Low Priority Subwatersheds</u>**:
    a. Upper Prairie River (01-01)
    b. East River (01-02)
    c. Prairie River (05-01)
    d. Lower Willow River (08-01)
    e. Moose River (08-03)

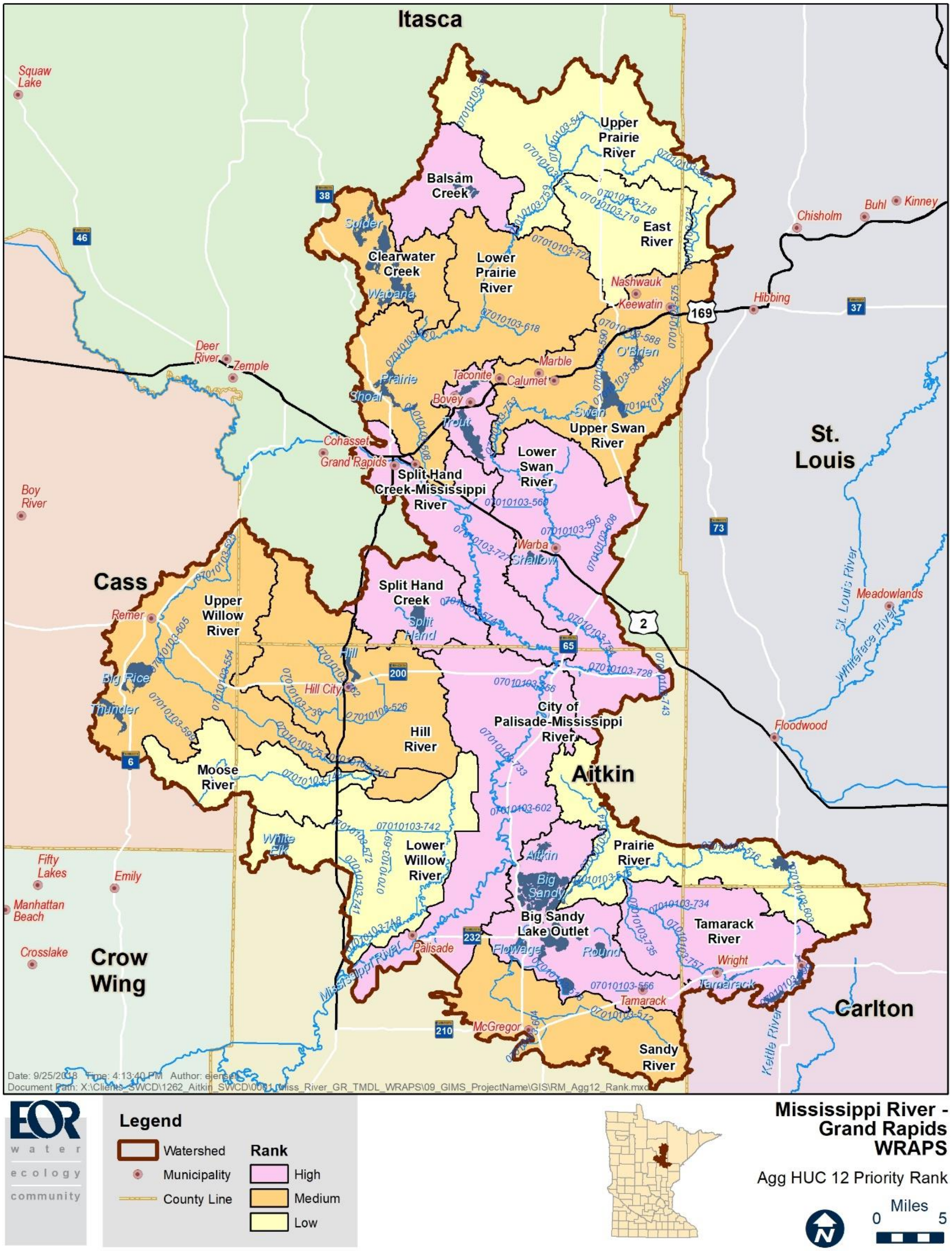


Figure 20. Mississippi River-Grand Rapids Watershed Implementation Priority Ranking

3.2 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. The MPCA has coordinated with the University of Minnesota Extension Service for years on developing and implementing civic engagement approaches and efforts for the watershed approach. 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." Extension defines a resourceFULL decision as one based on diverse sources of information and supported with buy-in, resources (including human), and competence. Further information on civic engagement is available on the University of Minnesota Extension website at: https://extension.umn.edu/community-development/leadership-and-civic-engagement.

Core Team Meetings

Quarterly, monthly, or bi-monthly working meetings were held with the watershed Core Team to discuss civic engagement and development of the WRAPS plan (Table 13). The Core Team was comprised of representatives from the Soil and Water Conservation Districts (SWCDs) and state agencies. The MRGRW Core Team engaged with various stakeholders to guide the informing and development of this Restoration and Protection Plan. A team of 'Ambassadors" was developed as part of the process. The intention was for Ambassadors to represent their group (lake association, community, etc) at a series of round table meetings throughout the WRAPS process. They were able to provide input on the group's water quality concerns, important lakes and streams, and implementation ideas. We also wanted the Ambassadors to serve as a two-way communication route, so that they would share updates with their group during the WRAPS process. These Ambassadors gained a greater understanding of water quality in the watershed, networking water resource connections with other groups, and new implementation ideas, as well as a stake in the development of the WRAPS Report and strategies that will guide future grant funding applications.

Core team members partnered with staff from the University of Minnesota Extension Service to learn civic engagement tools and strategies that could be used to fully engage citizen partners on this effort. Several training sessions were held, resulting in the development of a Civic Engagement Plan for this watershed. Two sessions of "Convening Community Conservation That Engage" were held in Grand Rapids. This workshop offered information on hosting conversations the encourage participation, and develop meaningful dialogue. Community members and core team members attended the meetings and worked to build the relationships that would carry this project forward.

A summary of public meetings hosted by the Core Team is listed in Table 14.

Table 13. Mississippi River-Grand Rapids Watershed Core Team Meetings

Date	Location	Meeting Focus
3/26/2014	Grand Rapids DNR	Preliminary Organizational Meeting
9/11/2015	Forest History Center, Grand Rapids	Civic Engagement Strategic Planning
10/20/2015	Forest History Center, Grand Rapids	Civic Engagement Strategic Planning
12/16/2015	Forest History Center	Phase II Contract Development
2/4/2016	Sawmill Inn, Grand Rapids	Civic Engagement Communication Network Development
2/17/2016	Conference Call	Civic Engagement Plan Implementation Check In
3/23/2016	Grand Rapids DNR	Biological Monitoring, Stressor ID, Zonation
5/24/2016	Conference Call	Civic Engagement Plan Implementation Check In
9/27/2016	Grand Rapids DNR	Zonation, Groundwater, Tech Update, C&E
10/5/2016	Conference Call	Zonation Survey planning
11/16/2016	Conference Call	Zonation Survey planning
12/1/2016	Brainerd MPCA	Stressor ID needs
1/10/2017	Grand Rapids DNR	Tech Team Zonation Survey
1/20/2017	Conference Call	Zonation Survey Planning
2/16/2017	Brainerd MPCA	Standard Deliverables-Miss- Brainerd and GR
3/22/2017	Brainerd MPCA	Watershed Assessment Team-Stream assessment
3/28/2017	Long Lake Conservation Center	Zonation Results, Planning
4/3/2017	Brainerd MPCA	WAT for Lakes
5/2/2017	Long Lake Conservation Center	Professional Judgement Group Meeting
6/16/2017	Long Lake Conservation Center	Zonation Synthesis
6/26/2017	Conference Call	Civic Engagement planning
6/29/2017	Aitkin SWCD	Zonation Synthesis
7/6/2017	Brainerd MPCA	Cass County Update/Zonation
8/1/2017	BWSR	1W1P & WRAPS integration
8/28/2017	Conference Call	WRAPS Ambassador Meeting Planning
9/14/2017	Hill City	Lakes Protection, Land Use Management and Shoreland Ordinance Strategies, EOR involvement
1/11/2018	Webex	Core- Project Status Update 2018 Planning, Lake Prioritization
2/27/2018	Long Lake Conservation Center	Stream and Lake Prioritization, WRAPS content and strategy
4/16/2018	WebEx	Reports Update, Stream Protection, Subwatershed forested/protection map, Lakes list-data check
6/4/2018	WebEx	Subwatershed Source Assessment/Characterization
6/11/2018	WebEx	Subwatershed Source Assessment/Characterization
7/24/2018	DNR Grand Rapids	Subwatershed Prioritization
9/17/2018	Long Lake Conservation Center	Review HUC 12 and Lakes Priorities, strategy table intro
11/13/2018	Big Sandy Army Corps of Engineers	USACE, Review lake and stream TMDL results, plan public meetings
12/12/2018	Carlton SWCD	Storymap creation
1/9/2019	WebEx	WRAPS preview and assignments
2/5/2019	Skype	WRAPS check in, Mining in the watershed, Hydroelectric
3/5/2019	Skype	WRAPS check in, Hydroelectric

Table 14. Mississippi River-Grand Rapids Watershed Public Meetings and Communication

Date	Location	Meeting Focus
5/29/2015	Sawmill Inn, Grand Rapids	Kick – Off Meeting
2/4/2016	Sawmill Inn, Grand Rapids	Convening Community Conversations That Engage
2/5/2016	Sawmill Inn, Grant Rapids	Convening Community Conversations That Engage
2/29/2016	Long Lake Conservation Center, Palisade	Zonation Overview
6/18/2016	Aitkin High School	Rivers & Lakes Fair – WRAPS Information Sharing
7/16/2016	Tamarack Sno-Fliers Clubhouse	Big Sandy Area Lakes Watershed Management Project – WRAPS Overview
11/18/2016	KKIN Radio Station	WRAPS discussion
12/15/2016	Itasca County Courthouse	Zonation Survey
2/8/2017	Cromwell Park Pavilion	Big Sandy Area Lakes Watershed Management Project-WRAPS overview and zonation survey administration
4/21/2017	Red Rock Radio Station	Radio
6/17/2017	Aitkin High School	Rivers & Lakes Fair – WRAPS/Monitoring Information Sharing
7/19/2017	Aitkin Utilities	Aitkin Water Planning-WRAPS Ambassador Solicitation
9/14/2017	Hill City	WRAPS Ambassador Kickoff
10/11/2017	Cromwell Park Pavilion	Big Sandy Area Lakes Watershed Management Project – Tour of Tamarack River Watershed, Monitoring, S ID, Impairments
11/9/2017	Grand Rapids Blandin	303d 2018 List Public meeting
12/7/2017	Itasca County Courthouse	WRAPS Ambassador- Zonation overview/Lakes Prioritization
1/24/2018	Carlton SWCD	Carlton County Planning and Zoning
2/12/2018	Aitkin SWCD	Aitkin County Planning and Zoning
2/15/2018	Itasca County Courthouse	Itasca County Planning and Zoning
3/6/2018	Long Lake Conservation Center-Palisade	Ambassador-Lake prioritization finalization
6/16/2018	Aitkin High School	Rivers and Lakes Fair – WRAPS Information Sharing
6/26/2018	Long Lake Conservation Center-Palisade	Ambassador-WRAPS Overview, Connection between Forests and Water Quality, Impairment Source Assessment, Common Stream Stressors
9/26/2018	Blandin Foundation-Grand Rapids	WRAPS Overview, HUC 12 map comments
12/6/2018	Cromwell Pavilion	TMDL overview
12/6/2018	Blandin Foundation-Grand Rapids	TMDL overview
3/13/2019	Cromwell Pavilion	Ditch abandonment education sessions
5/8/2019	Cromwell Pavilion	WRAPS overview
7/10/2019	Tamarac Sno-Flyers Clubhouse	TMDL and WRAPS Open House
7/10/2019	Blandin Foundation-Grand Rapids	TMDL and WRAPS Open House

Accomplishments and Future Plans

Future Plans and Accomplishments

The SWCDs and other local government units will continue conducting the public outreach efforts that were initiated during the WRAPS process. Measurable goals, and possible steps to reach these goals, for future civic engagement efforts in the MRGRW include:

1. Increase volunteer participation in natural resource monitoring.
    - Citizen volunteers throughout the watershed will be encouraged to participate in the Citizen Lake Monitoring Program and Citizen Stream Monitoring Program through the MPCA.
    - Technical support will be provided to lake associations and citizen groups interested in monitoring water bodies.
    - Educational opportunities will be provided regarding a variety of natural resource management topics including forestry, aquatic invasive species, stormwater management and more. Citizens will be provided with the tools they need to monitor watershed resources for future impacts to water quality.
2. Increase the number of watershed residents participating in water quality discussions.
    - Meetings of the Ambassador Group will continue, with a goal of increasing participation
    - Lake Association/Lake Advocate Sharing Sessions will be continued in an effort to build relationships between area groups involved with resource management.
3. Find effective ways to engage citizens in a meaningful way. Continuing to build relationships with and between citizens throughout the watershed will support implementation activities. Successful opportunities will be continued, and new opportunities sought.
    - Community events such as the Aitkin County Rivers and Lakes Fair and County Fairs will be participated in.
    - Technical staff will participate in meetings of Lake Associations and Watershed Management Groups.
    - Outreach opportunities to existing community and natural resource management groups (sportsmen's clubs, civic groups, local governments, etc…) will be sought.
    - Engage youth through educational opportunities such as Envirothon and the Itasca Youth Water Summit.
4. Increase the resources utilized to communicate water quality activities within the watershed.
    - Continue to utilize successful communication strategies such as radio, newspapers, and websites.
    - The use of communication tools such as Facebook and story maps will be increased.
    - Social media platforms such as Twitter and Instagram will be explored.
5. Create a document with contact information for local resources, specific to certain water quality concerns or funding sources. This will be shared among local partners and the public. Relationships

between government staff will be key to moving the watershed protection and restoration strategies forward and these should be fostered into the future. This document will make it easier to keep that connection and carry partnerships forward with a cohesive watershed identity.

If the solutions in the WRAPS report are promoted with input from local land managers, the likelihood of implementation will increase. In addition, implementation activities will be streamlined due to the collaboration between landowners, local agencies, and funding sources. Strategies identified in the WRAPS will also increase the benefit to the watershed through prioritization and targeting, and success will be measurable.

Public notice for comments

An opportunity for public comment on the draft WRAPS report was provided via a public notice in the State Register from July 15, 2019 through August 14, 2019. There were no comment letters received as a result of the public comment period.

3.3 Restoration and protection strategies

This section includes watershed-wide restoration and protection strategies, as well as customized tables identifying restoration and protection strategies that are specific to each Aggregated Hydrologic Unit Code (HUC) 12. These projects include the following information:

- ✓ County location
- ✓ Water quality conditions and goals - Current conditions for lake TP based on TMDL for impaired lakes or the 2018 DNR Lake Phosphorus Sensitivity Significance/Cost Benefit Analysis spreadsheet for unimpaired lakes. Current conditions for stream *E. coli* based on MRGRW TMDL, and for stream IBI scores from the 2018 MRGRW Monitoring and Assessment Report. Goals are based on water quality standards for impaired water bodies, and based on improving or maintaining existing water quality for all other water bodies.
- ✓ Strategies
- ✓ Estimated scale of adoption needed for each strategy to achieve the water quality goal
- ✓ Governmental units with primary responsibility
- ✓ Estimated timeline for full implementation of strategy
- ✓ Interim 10-year milestones for implementation of strategy

Strategy Prioritization & Identification

3.3.1 Key Watershed-Wide Strategies

The following watershed-wide strategies were identified by the local partners as a priority to the predominantly protection focused MRGRW:

Shoreland Protection

Minnesota's buffer law requires perennial vegetative buffers along public ditches, lakes, rivers, and streams. Buffers along lakes, rivers, and streams are to be 50 feet in width, and buffers along public ditches are to be 16.5 feet wide or more. These buffers help filter out phosphorus, nitrogen, and sediment. Buffers are critical to protecting and restoring water quality and healthy aquatic life, natural stream functions and aquatic habitat due to their immediate proximity to the water.

The law provides some flexibility for landowners to install alternative practices if they provide equal or better water quality benefits. An example of an alternative practice could be a narrower buffer if the land slopes away from the water body. This is not uncommon with some ditches, rivers, and streams. Alternative practices must be approved by the local governmental unit that implements the buffer law. It should be noted that this law defines a buffer as any type of perennial cover, including turf grass. However, buffers that are most effective at protecting water quality and habitat are characterized by native, deep rooted vegetation.

In the MRGRW, most of the private lands are well vegetated with forests, grasslands, and wetlands. Most of the privately owned lands are managed for wildlife habitat, forest management, or recreational purposes. These lands are almost always covered by permanent vegetation. The buffer requirement sometimes is not met on agricultural lands, depending on the current crop or tillage methods. The majority of lands where buffers are not in place are being used for agricultural purposes, either livestock, or crop production.

The Aitkin County SWCD implements the buffer law for Aitkin County; landowners and the SWCD work together to bring the riparian area into compliance. Itasca County reviews, implements, and enforces all buffer compliance parcels. Tracking of all parcels for compliance is done every three years. Random spot checks are also completed each year for parcel compliance. In St. Louis and Carlton County, the SWCD evaluates and determine compliance with the buffer law. If a violation occurs in either Aitkin, Itasca, or Carlton counties, the respective counties serve a Corrective Action Notice to the landowner. If a violation occurs in St. Louis county, BWSR enforces compliance. Contact Cass SWCD if there are questions about buffer law enforcement in that county.

The Board of Water and Soil Resources (BWSR) compiles compliance estimates into a statewide Buffer Compliance Map based on data provided by SWCDs. A review of BWSR's Buffer Compliance Map suggest 95% to 100% compliance for all counties in the watershed. Buffer compliance in Aitkin County is currently at 99%, and St. Louis, Carlton and Itasca Counties are at 100% compliance on all parcels. SWCD staff from Aitkin, Carlton, Itasca, Cass, and St. Louis will continue to use aerial imagery to evaluate compliance with the buffer.

Forest Protection Programs

Water quality in this watershed is currently in good shape, its quality derived from well-managed forestlands, grasslands, and agricultural lands. Forestland ranks among the best land cover in providing clean water by absorbing rainfall and snow melt, slowing storm runoff, recharging aquifers, sustaining stream flows, filtering pollutants from the air and runoff before they enter the waterways, and providing critical habitat for fish and wildlife. In addition, forested watersheds provide abundant recreational opportunities, help support local economies, provide an inexpensive source of drinking water, and improve the quality of our lives.

Minnesotans have strong conservation values. Citizens of Minnesota have long since recognized the value of forests and clean water by creating various legislative conservation programs to help conserve working land forests. There are many groups dedicated to help protect water quality in this watershed including the Big Sandy Area Lakes Watershed Management Project, Itasca Coalition of Lake Associations, Big Sandy Lake Association, Lake Minnewawa Association, the Prairie Lake Association, and others.

Fortunately, many minor watersheds are already forested in the MRGRW and are protected by public ownership (federal, state, and county). Forest protection programs play a major role in ensuring private forest lands stay working forest lands to provide optimal ecosystem services such as wildlife habitat, enhanced water quality, carbon sequestration, and many other benefits, while providing landowners with a monetary incentive to keep the land forested. Table 15 outlines applicable forest protection programs that will best allow the MRGRW to continue to maintain its biological integrity and provide healthy waters by promoting forestland stewardship. See the DNR Forest Stewardship webpage for additional information: https://www.dnr.state.mn.us/foreststewardship/index.html.

Table 15. Forest protection programs for the Mississippi River Grand Rapids Watershed

Forest Protection Program	Applicability to Mississippi River Grand Rapids Watershed
Forest Stewardship Plan	An instrumental plan for family forest landowners who own 20 acres or more of forestland. This voluntary plan offers land management recommendations to landowners based on their goals for their property from a natural resource professional. Plans are updated every 10 years to stay current with your needs and your woods. A Forest Stewardship Plan registered with the DNR qualifies you for woodland tax and financial incentive programs.
Sustainable Forest Incentive Act (SFIA)	SFIA is a tax incentive program available for landowners that have a registered Forest Stewardship Plan. This program offers an annual tax incentive payment per acre based off the amount of forest stewardship acres you have. Payments per acre range from the $9-$16.50, based off the length of covenant the landowner decides to enroll into. SFIA restricts land use conversion and subdivision of the parcel(s). A minimum of 3 acres must be excluded from the SFIA program if there is a residential structure present, landowners can exclude more acres if they plan to make future improvements on the land.
Conservation Easements	Most, but not all conservation easements are perpetual. Some landowners want to ensure their land will never be developed or converted to another use by selling or donating a conservation easement. Conservation easements serve a variety of conservation purposes and are generally intended to protect important features of the property. They are voluntary, legally binding agreements by the landowner to give up some of the rights associated with their property such as the right to develop, divide, mine, or farm the land to protect the conservation features such as wildlife habitat, water quality, and forest health, to name a few
Land Acquisition	Land acquisition is an option to permanently protect the land by selling the land to a conservation organization, agency, or other land trust. Once purchased land is restored or maintained to perpetually protect important natural resource values.

Watershed Management Framework for Minnesota Lakes

Lake water quality depends largely on land use in their watersheds. Agricultural and urban runoff contains significantly more nutrients such as phosphorus and nitrogen than undisturbed forests, grasslands, and wetlands. These nutrients increase algal growth, which is a primary driver for water quality in lakes. Catchments with undisturbed lands lie primarily in the forested ecoregions and generally provide good water quality. Fisheries research has shown that healthy watersheds with intact forests are fundamental to good fish habitat. Modeling of over 1,300 lakes by the Minnesota DNR Fisheries Research Unit (Cross and Jacobsen 2013 – Lake and Reservoir Management 29: 1-12) has revealed that phosphorus concentrations in lakes are directly related to land use disturbance in the watershed. Phosphorus concentrations start to become elevated when land use disturbance reaches 25% of the lake's watershed and are greatly elevated when land use disturbances exceed 60% (Figure 19). If land in the watershed is less than 25% disturbed and the remaining 75% is permanently protected forest, the lakes and streams in the watershed will have a high probability of sustaining a healthy ecosystem. Using land use disturbance and protection status allows for the categorization of lakes into a protection vs. restoration framework:

Vigilance (Dark Green): Lakes with watershed disturbance less the 25% and protection greater than 75% can be considered sufficiently protected. (Vigilance status is largely due to keeping public lands forested)

Protection (Light Green): Lakes with watershed disturbances less than 25%, but levels of protection less than 75% are excellent candidates for protection efforts.

Full Restoration (Yellow): Lakes with watersheds that have moderate levels of disturbance (25% to 60%) have realistic chances for full restoration of water quality to natural levels.

Partial Restoration (Red): Restoration of lake with intensive urban and agricultural watersheds (>60% disturbance) to natural levels may not be realistic. The suggested approach for these lakes is partial restoration of water quality that restores some degree of ecological integrity.

Figure 23 indicates that most of the MRGRW is currently in protection mode, meaning there is the opportunity to reach or exceed 75% protection threshold to make this watershed sufficiently protected. Figure 24 shows the percentage of protection each subwatershed (HUC 10) currently provides. Most of the subwatersheds could reach or exceed 75% protected, while a few require partial or full ecological restoration.

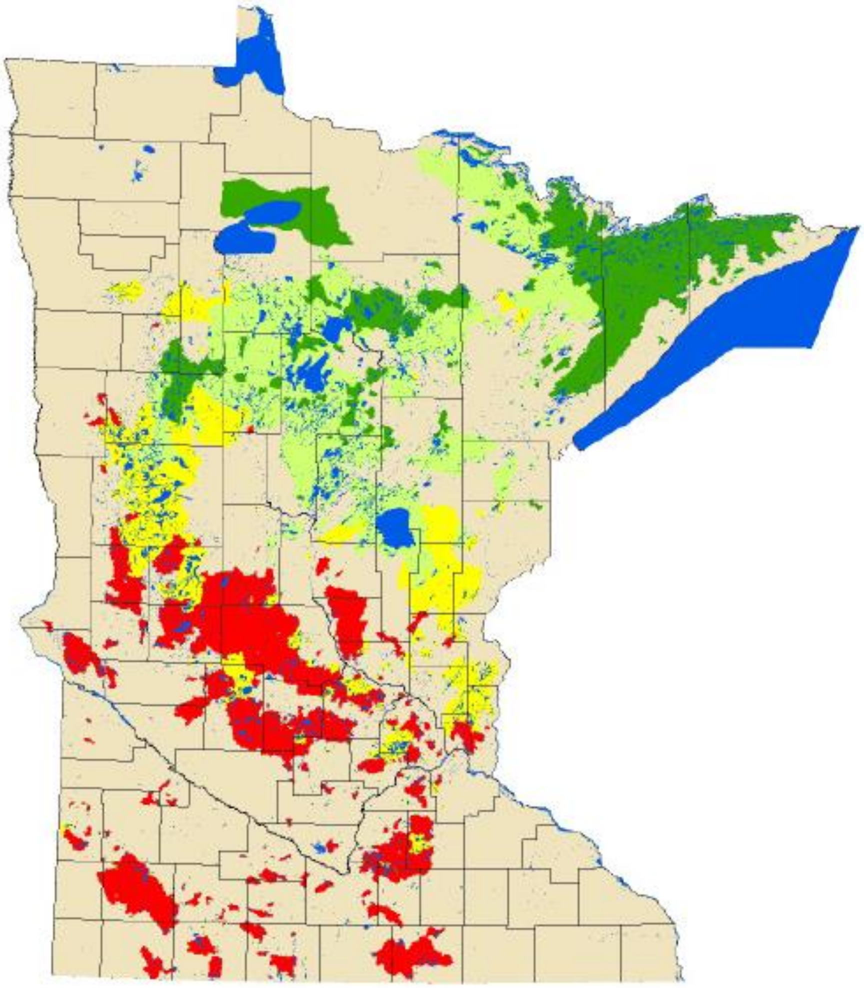


Figure 21. Lakes Watershed Condition Map. This map roughly describes the distribution of watersheds in need of varying level of protection and restoration. Dark green generally represents vigilance, light green indicates additional protection needed, yellow indicates potential for full restoration, and red represents partial restoration possible. Includes only lake watersheds contained completely within Minnesota.

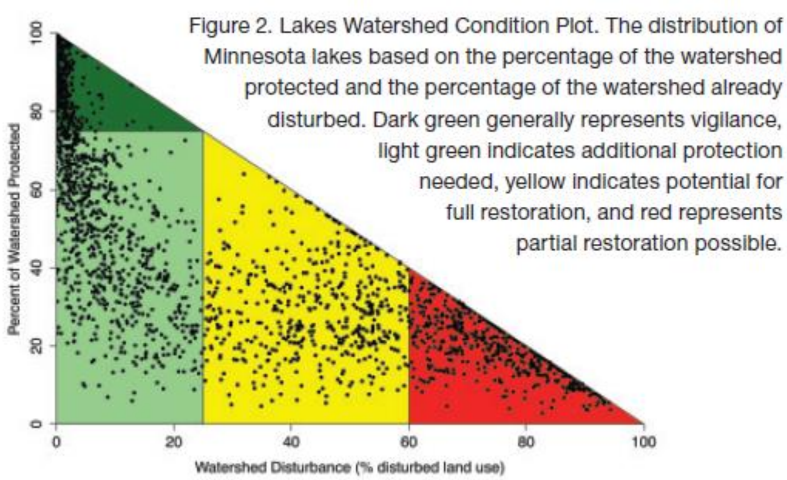


Figure 22.Watershed disturbance (DNR-Fisheries Division)

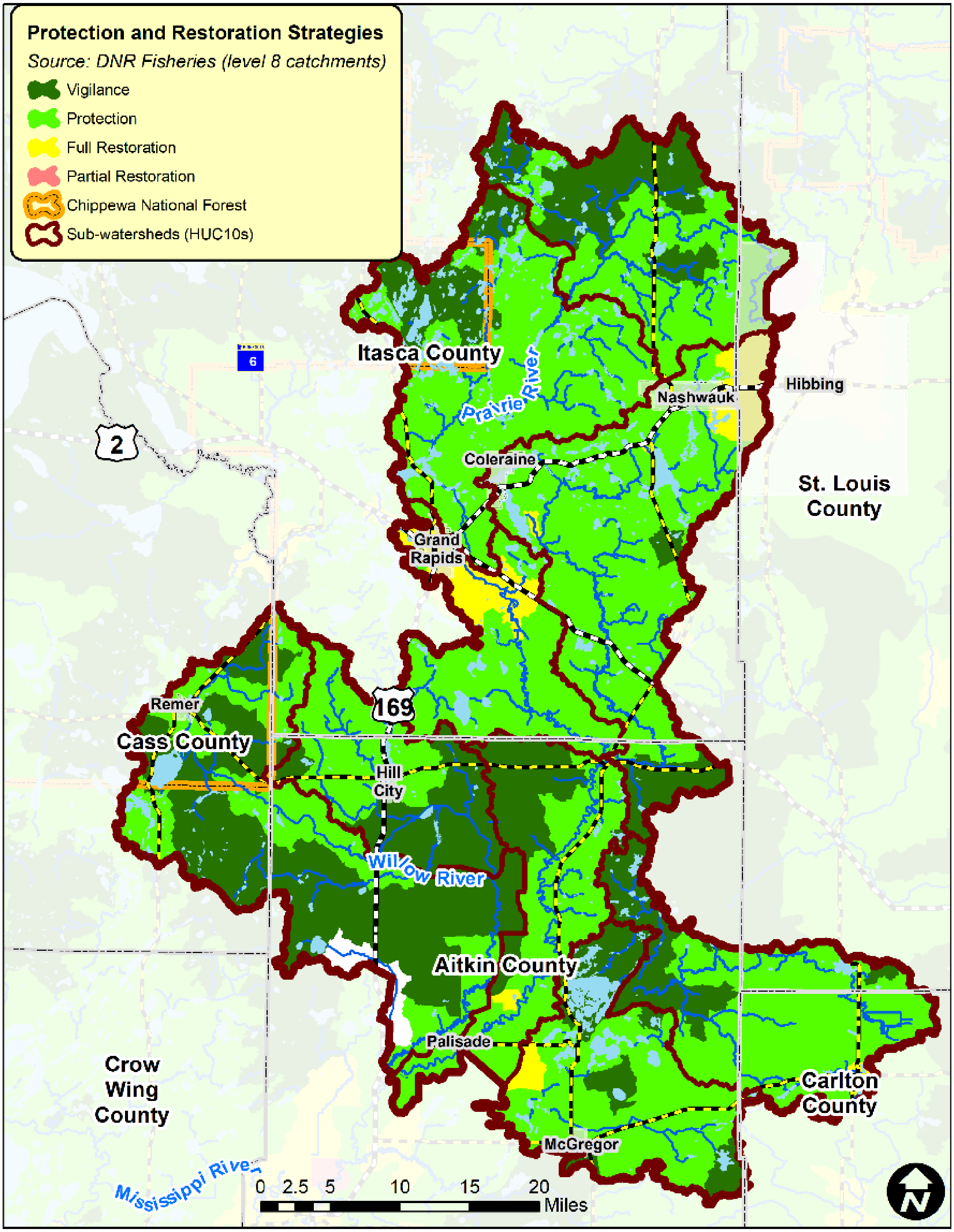


Figure 23. DNR Level 8 Protection and Restoration Strategies.

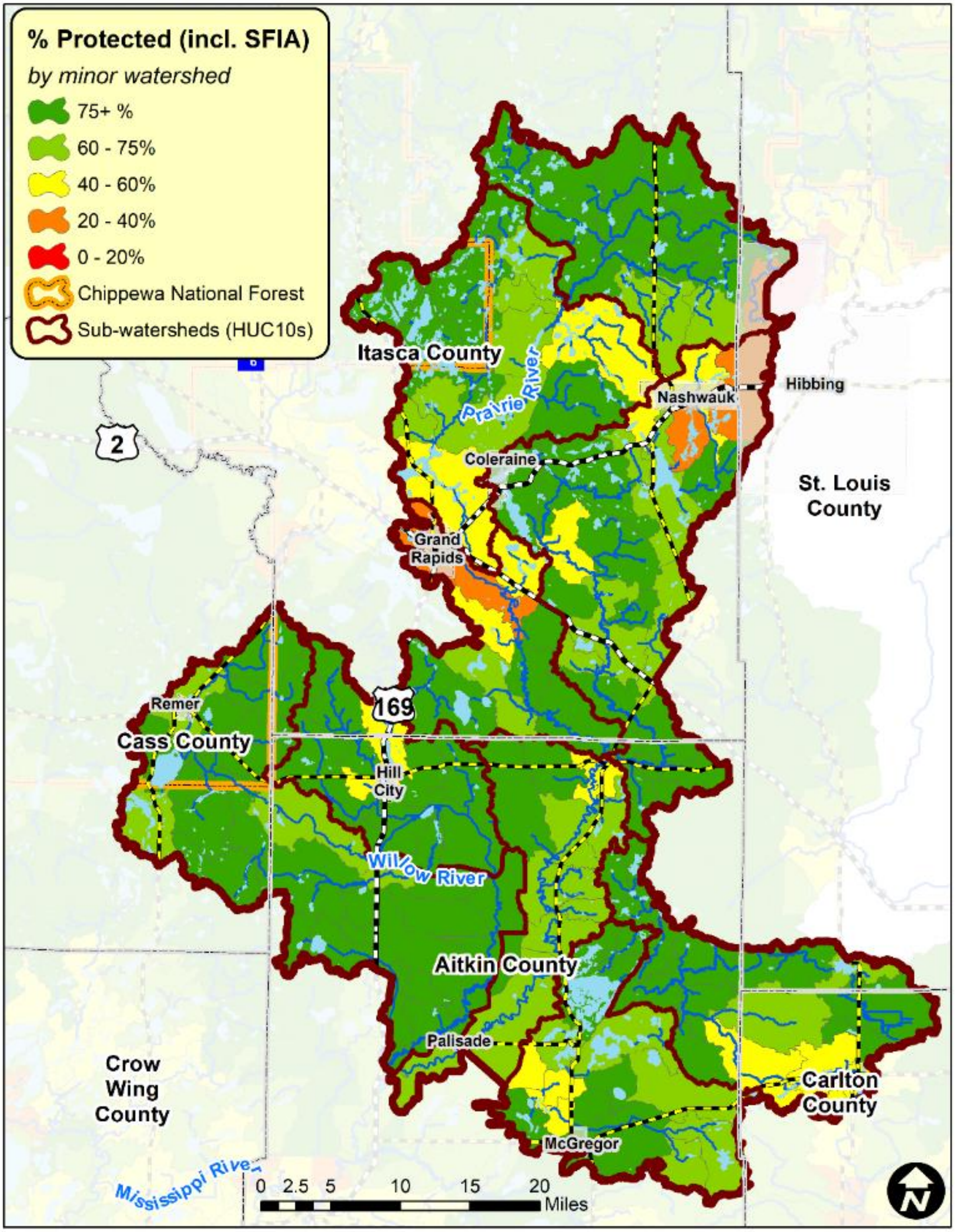


Figure 24. Percentage of protection each subwatershed (HUC 10) currently provides.

Maintaining our Wild and Scenic Lakes

An emerging concept, wild and scenic lake shorelines may be defined as places where there is minimal or no development. The importance of wild and scenic shorelines and what it means to Minnesotan's, our visitors, wildlife, and ecology is not always measureable, but is very central to our identity. We have obviously lost many wild and scenic lakes over time, but several, mainly smaller, waters endure. Currently wild due to remoteness or landowner choice, these relatively undeveloped lakes are at risk, especially as transportation routes improve.

Opportunities to provide improved long term or perpetual protection for wild and scenic lakes remain in areas of northern Minnesota where there is either no development, or a mix of private and public ownership at varying levels. Forest Stewardship Planning along with State Forest Incentive Act (SFIA) enrollment provide covenants to maintain lands in working forests within terms of 10, 20, and up to 50 years. As these are not permanent easements, they still may keep lands forested for longer time periods. However, landowners may choose to maintain their undeveloped lakeshore or intend to build a cabin/home, so SFIA may not be what they desire. A better fit may be to permanently protect their property through a conservation easement or land acquisition to a conservation organization.

The DNR and other public agency partners have recently identified important riparian and lake habitats. These include wild rice, cisco, phosphorus sensitive (PS) lakes, sensitive shorelines, lakes of biological significance, and designated wildlife lakes, among others. Ongoing DNR efforts to characterize and identify wild lakes aim to provide additional opportunities to protect important lake habitat. The case could be made to maintain a diverse number of lakes wild for studying baseline water quality, fisheries, wildlife or climate change effects.

Wild Rice Lakes

BWSR and local SWCDs, via Outdoor Heritage funding, have recently offered conservation easement incentives on wild rice lakes to preserve them for current and future generations of wildlife and outdoor enthusiasts. Even though many wild lakes would not necessarily be designated wild rice lakes, they still may provide waterfowl use, hunting or related types of recreation. What is missing is a similar type program to maintain our diminishing wild and scenic northern Minnesota lakes.

Desired Outcome

While offering local land use planning assistance for local governments, DNR identified high conservation value features as areas to prioritize in terms of risk from development, as well as developing model policies and actions for local land use planning which include zoning, easements and site design. The goal for wild lakes is easements and forest protection, however a mix of zoning and site design cannot be completely disregarded as an additional future protection opportunity. Zoning alone will be unsuccessful in adequately protecting wild lakes in most cases. However, there may be other reasons for implementing zoning restrictions based on specific biological or lake water quality conditions.

The current focus is lakes; however, rivers could also be a part of the wild and scenic protection effort. The idea is to help protect larger blocks of shorelines permanently or for long periods through Conservation Easements and/or Forest Stewardship Planning.

Stream Restoration Strategies

Several streams in the MRGRW have impaired biology due to habitat degradation from altered hydrology. In particular, Pokegama Creek (07010103-733), Sandy River (07010103-512), a Tributary to the Swan River (07010103-728), and an unnamed Ditch to the Mississippi River (07010103-756) all have extensive ditching within their subwatershed and would benefit most from a combination of ditch and/or stream restoration. The following discussion provides strategies to restore these streams and thereby improve biological function. Keep in mind that developing site-specific restoration plans will require further assessment to determine the optimal extent, methods, and locations for restorations. In addition, the length of ditched and incised reaches, local constraints, and project costs may restrict the restoration options available.

Legacy ditching efforts to drain bogs and straighten channels in the headwaters of these streams altered their hydrologic regimes. In response, the downstream channels adjusted to the new hydrologic conditions through channel evolution (Figure 25). Evolving streams often go through predictable changes in form involving periods of accelerated erosion, deposition, and lateral migration. Each stream reacts differently depending on watershed characteristics such as valley shape and slope, substrate, and vegetation composition and density. The impaired MRGRW streams have all incised, lowering the local water table and causing their floodplain to become inaccessible at bankfull flows. Without floodplain access, higher flows stay concentrated within the channel increasing sheer stress on the bed and banks, leading to accelerated bank erosion. The resulting instability has created excess sediment, a lack of variable bed form, and minimal quality habitat for all life stages of biota. Restoring these streams would stabilize the channel, reconnect them with their floodplain, and immediately provide better habitat.

The DNR recommends using a holistic approach for stream restoration planning and implementation that addresses the five components of stream health. Rather than fixing isolated symptoms, a holistic approach seeks to alleviate the driver of instability while implementing a stable channel that improves functions within the five components. Since the impacted streams have ditching in their headwaters, addressing the hydrologic impacts there can be a good place to start. Restoration of ditched wetlands opportunities are discussed separately below. However, stream function may not rapidly improve by just restoring headwaters ditches. The degraded channels downstream could still take significant time to recover without additional channel restoration.

Restoration projects that apply natural channel design (NCD) to implement multistage channels to reconnect bankfull flows to their historic floodplain can provide channel stability and improve ecological function. Site-specific restraints such as land ownership and local risks from a wider floodplain will not always allow for that ideal restoration, but NCD allows for flexibility. The methodology uses a holistic approach that incorporates pattern, profile, and channel dimensions from a stable reference reach of the same stream type under similar morphologic and hydrologic conditions (Rosgen 1998).

There are four priority methods for restoring incised channels, with priority one being the most preferred and priority four being the least (Figure 26, Rosgen 1997). Priority one reconnects the stream to its historic floodplain by either putting the stream into a relic channel or building a new channel. It cost-effectively creates the best long-term results by raising the water table, reconnecting the floodplain, restoring channel morphology, and increasing habitat diversity. Priority two restoration builds a new channel within the degraded channel, but does not raise the water table. It typically involves excavating a wider floodplain, which can have high costs. Priority three restoration converts an incised meandering channel to a step-pool type channel with a narrow floodplain at approximately the current elevation. Priority four involves armoring the channel in place and should only be used when outside restrictions affect the project. It also has the highest risk because it does not address flood sheer stress. The impaired streams are currently incised, two stage channels that lack an inner berm and require higher flows to reach their bankfull and floodplain elevations. Whichever priority method is used for restoration, a multistage channel should be constructed to increase sediment passage, increase water depth at low flows, and to reduce sheer stress at higher flows.

NCD often incorporates several types of structures needed to hold grade and prevent future incision, create aquatic habitat, or protect susceptible banks. However, careful selection is needed since not all structures are appropriate in every situation. Structures must maintain sediment transport capacity, be compatible with the stream type, and be placed in the correct stream features. If the morphological characteristics of the stream have not been stabilized, structures will often fail or even make conditions worse. Consequently, whether implementing a Priority one or two restoration, grade control will be a part of the solution due to the incision and the predominance of small particles in the impaired streams. Cross-vane structures can be installed to hold grade and be constructed with either rock or logs. Since NCD emphasizes the use of native materials, logs make the most sense for these streams. The benefits of cross vanes include grade control, decreased near bank stress, and enhanced fish habitat. Log J-hook vanes are similar, but are positioned at the beginning of stream bends and direct the flow away from the outside bank through the meander. These are useful when protecting newly constructed banks until vegetation can establish or to move flow away from existing eroding banks. Lastly, toe wood can be place on the outside of meanders to protect banks, maintain deep pools, and enhance aquatic habitat. Utilizing local materials can help to make these structures cost effective and keep project budgets lower. Tactics such as hard armoring banks in place only delay negative outcomes or push the problem downstream. Holistic stream restoration is not cheap, but the benefits of incorporating suitable structures with NCD can recreate healthy stable streams.

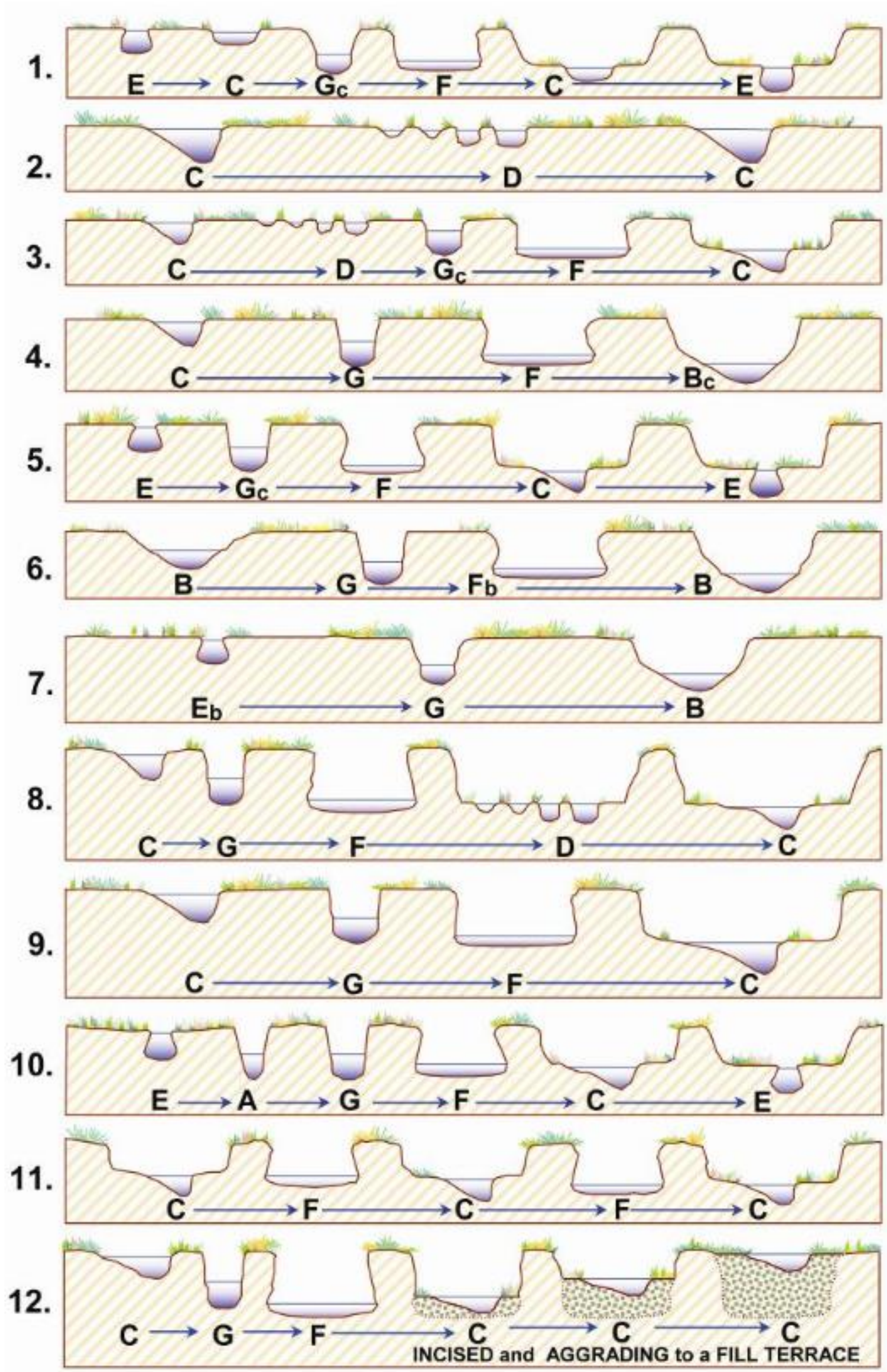


Figure 25. Some of the stream evolution scenarios documented in actual rivers (Rosgen 2011).

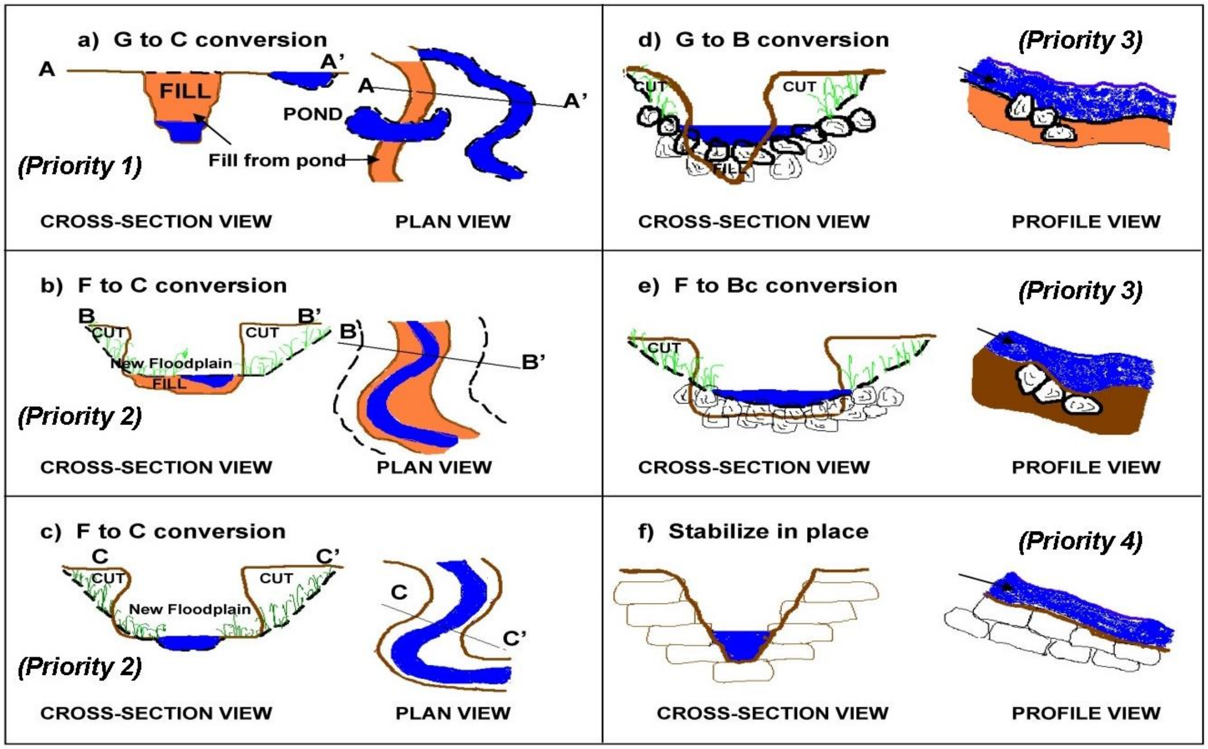


Figure 26. Priority methods for restoring incised rivers (Updated image provided by Wildland Hydrology (Rosgen 1997)).

Restoration of Ditched Wetlands Opportunities

Background

In the early 1900s, peatlands were seen as having potential to be used as cropland, with the exception that they were far too wet. A vast amount of work was done to dig trenches through large areas of northern Minnesota's abundant peatlands in hopes of drying them out enough to grow crops. For the most part, this effort failed, and Minnesota is left with ditch systems in undeveloped lands that are headwaters for a large number of streams and rivers. The MRGRW is one of the major watersheds with particularly high amounts of this type of ditching, especially along the southern edge, and in the center of the watershed. Approximately 25% of the streams and rivers in the watershed have been altered. In some instances, ditching was used to expedite log drives down some of the larger streams.

There are two primary scenarios of ditch construction related to draining wetlands in northern Minnesota. One was the trenching of peatlands in areas where no stream channel naturally existed. The second was straightening stream channels downstream of the peatlands to speed the transport of water coming from the upstream trenched areas. Sometimes this straightening occurred by cutting a ditch through the meandering stream channel (Figure 27). Other times a straight ditch was constructed a short distance from the original channel and parallel to it within the same stream valley. In still other situations, large parts of channels that had a major bend in the valley were cut off by creating a "short cut" ditch. All three of these situations can be found in the MRGRW.

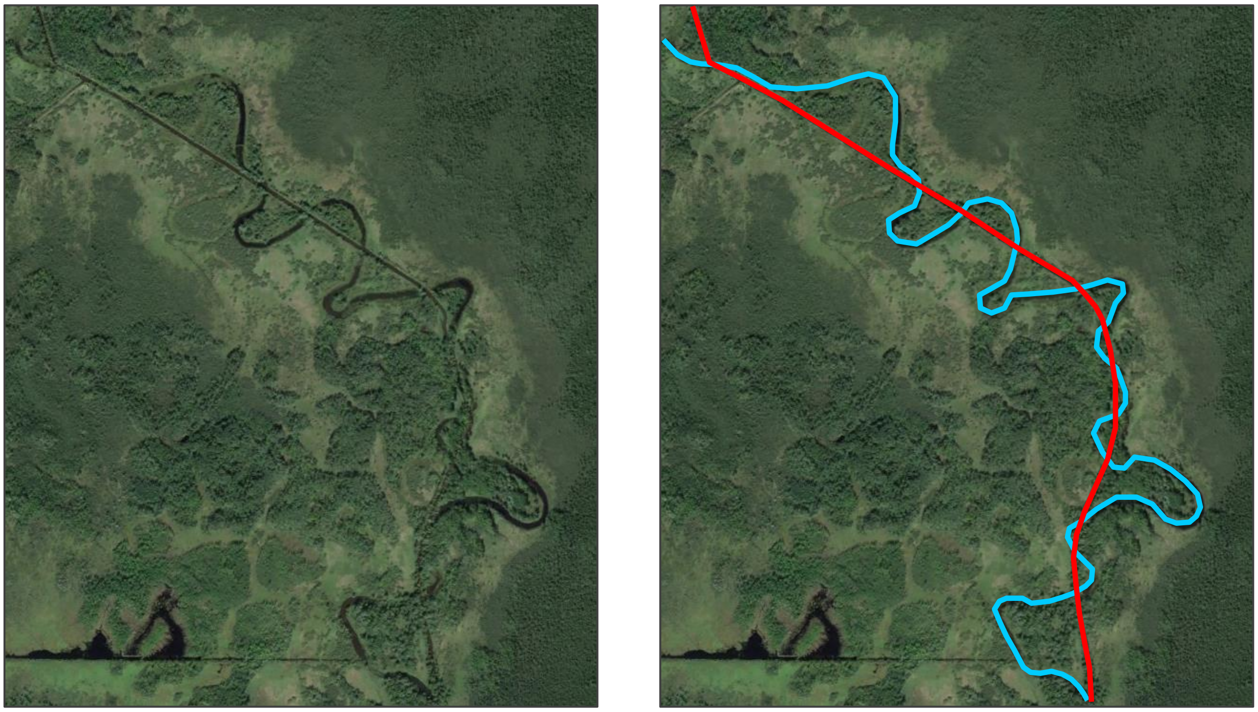


Figure 27. Ditch cutting off stream meanders - a location along the Hill River. The drawing at right points out the original channel (blue) and the current ditch (red).

Alteration of peatland hydrology by ditching can cause numerous consequences. One possible result of peatland hydrologic alterations is an increase in peak flows in downstream channel reaches. This result was found in a number of studies in fairly analogous situations in European ditched peatlands (Holden et al. 2004). In some cases, ditched peatlands seemed to reduce the peak flows due to greater storage for rain due to a lowered water table. There are numerous variables that can influence how downstream hydrology is affected by ditching, and these factors are still being studied (Holden et al. 2004). Results of altered hydrology include channel instability involving bank erosion and stream bed material alteration, leading to poor biological habitat. In the case of peatland ditching, the export of water quality parameters can be altered in a negative way. Phosphorus export from organic peat soils may increase and create nutrient excesses downstream. Dissolved organic carbon export can be increased (Strack et al. 2008), meaning the ditching is causing a loss of carbon storage, which contributes to climate change. These consequences have either been found, or existing evidence strongly supports their likelihood, in the MRGRW. Channel instability was found at several streams with upstream peatland ditches in the MRGRW. Increasing the flow from peatlands can also lead to flooding downstream. The ditched peatlands in the MRGRW add flow to the Mississippi River, which increases flooding to downstream areas such as the city of Aitkin.

Identifying Stream Restoration Opportunities

In order to assess the widespread nature and abundant quantity of ditched peatland channels in the MRGRW, an exercise was done by the MPCA, which tried to determine which ditches were probably not contributing any positive benefit to private landowners, by reviewing aerial photography and looking at ditch proximity to residences, hay fields, or other non-natural land use. The exercise ascertained that over 200 miles of ditch are currently providing little benefit to the watershed and may be causing problems. There are not currently official proposals to close/fill these ditches. Each would need further assessment before any decision to do so would be made. These determinations were made conservatively, and many more miles of ditch closure may be possible with no harm to landowners. However, this analysis shows there are numerous ditches that appear to no longer serve the function they were constructed for and are likely causing negative consequences on downstream water quality and potentially to downstream landowners (Figure 28). This exercise is meant to be a conversation starter to bring attention to this issue of legacy ditches and point to areas that warrant consideration for restoration.

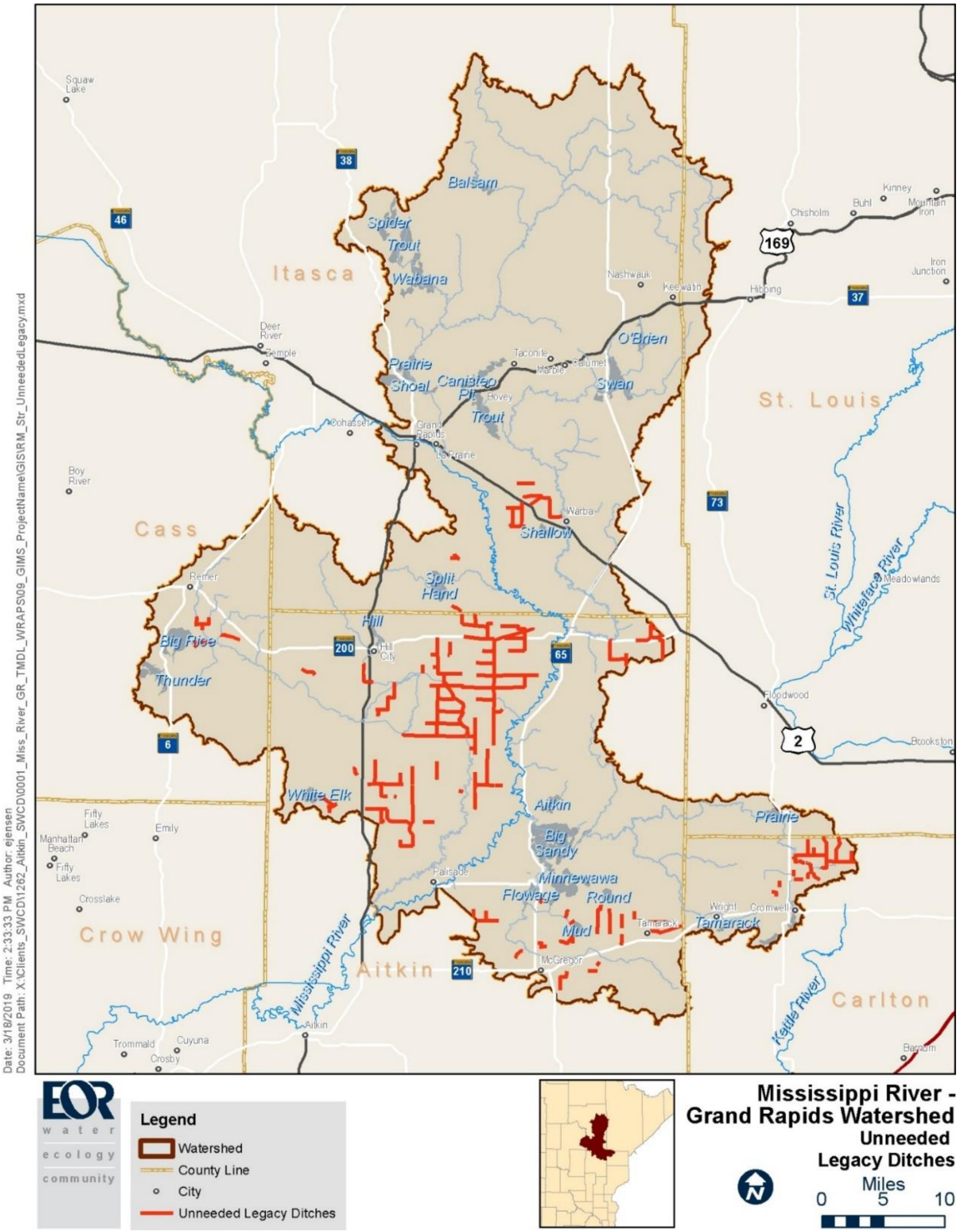


Figure 28. Tentative assessment of un-needed legacy ditches through peatlands.

The remedy for downstream impacts would seem to be a restoration of peatland hydrology where ditching has occurred. Restorations of peatlands are a complex task, and a standard template of peatland restoration does not exist currently (Price et al. 2003). Efforts to restore natural hydrology to stream channels by restoring upstream peatland hydrology should be done in consultation with experienced hydrologists, and it should be realized that attempts at the current time are not fully guaranteed to succeed since peatland hydrology and impacts of ditching are still being researched. Restoration decisions and attempts likely will involve public and local governmental participation, depending on land ownership. Ditch law may also come into play, depending on the jurisdiction of particular ditches.

Restoration of hydrology in ditched areas is not purely a speculative or hypothetical thing. In recent years, hydrology restoration projects involving ditched wetlands have begun to be completed in Minnesota, mostly in the northwest (e.g., Lawndale Creek near Rothsay, Minnesota- Aadland 2012), as well as a very large project just reaching completion in northeastern Minnesota, the Sax-Zim Bog restoration (Myers 2015). These completed projects from the region could be used as examples for new projects. Aitkin County government has expressed interest in a peatland restoration in the Wawina area of the MRGRW and is seeking funding. Some projects have also re-routed streams back into their previous channels. If this creates a local flooding concern, there are ways to put the flow back into the original channel and still use the ditch to carry excess high flow volumes. The project at Lawndale Creek is an example of such a design, as is the larger-scale Mississippi River diversion at the city of Aitkin.

In addition to the bog hydrology restoration, there are also numerous areas where stream/habitat restoration (i.e., returning flow back into the original stream channel) of substantial length could be achieved for ecological benefit (Figure 29 through Figure 32). This type of project adds habitat in two ways: by providing a more diverse set of habitat features in the channel (these features, such as better depth variability, develop naturally due to sinuosity), as well as increasing stream channel length (between two points, a meandering channel is longer than a straight channel).

Since the topic of bog hydrology restoration still lacks a full understanding, it would be beneficial to study a ditched peatland situation in the MRGRW to determine downstream effects of the peatland ditching in the setting of northern Minnesota. The very undeveloped Pokegama Creek Subwatershed may be a great opportunity for such a study. Effects could be determined by scientifically studying those downstream areas by use of flow monitoring stations in combination with water table monitoring in the peatlands and water chemistry parameter monitoring in both locations. Such a study would improve knowledge of how hydrology is quantitatively altered in ditched Minnesota peatlands and how that alteration has affected habitat and water quality in and downstream of these peatlands. Better knowledge of drainage effects would benefit the management of many peatland-containing subwatersheds across the northern region of Minnesota, as similar peatland ditching is common across that area.

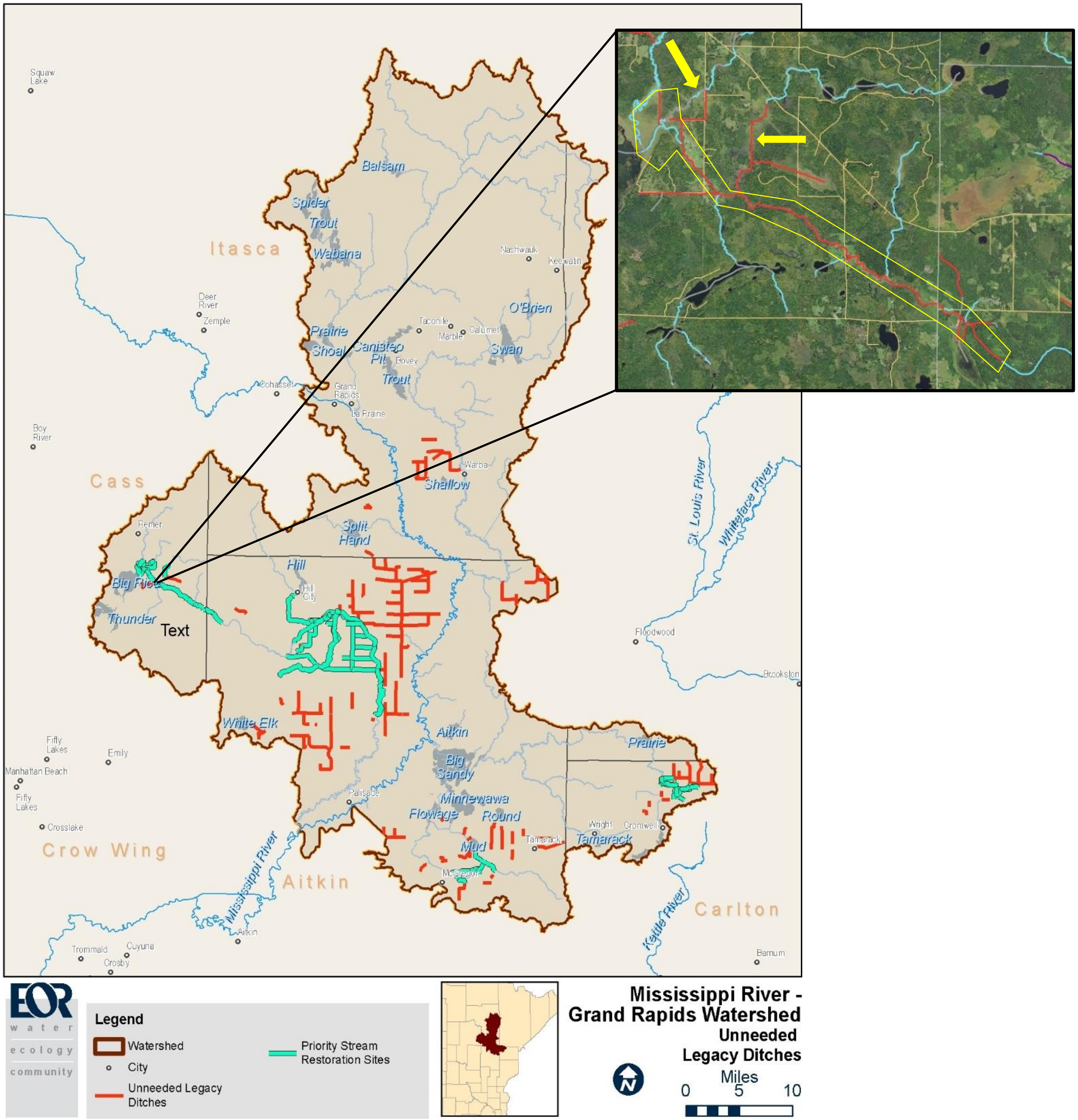


Figure 29. Reaches where significant stream channel straightening or abandonment has occurred on Birch Brook/Foley Brook/Willow River near Remer, which are areas for potential stream restoration. The arrows point to potential restoration reaches on Birch and Foley Brooks, and the yellow-boxed area is a possible stream restoration area on the Willow River.

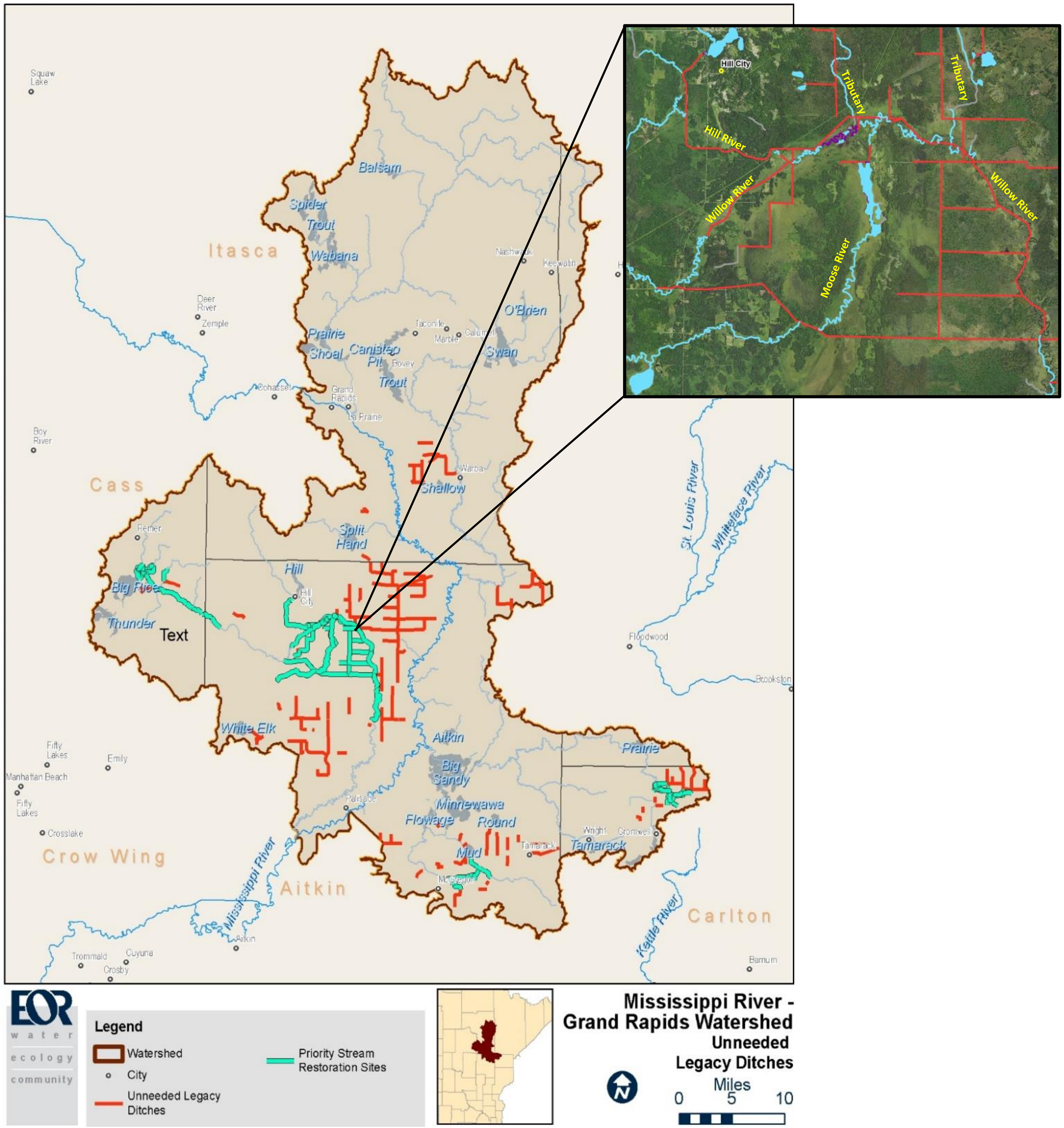


Figure 30. The Hill River/Willow River/Moose River (and several tributaries) river system near Hill City has many opportunities for both ditch abandonment/wetland restoration and stream restoration. A long reach of the Willow River particularly could be restored to natural condition.

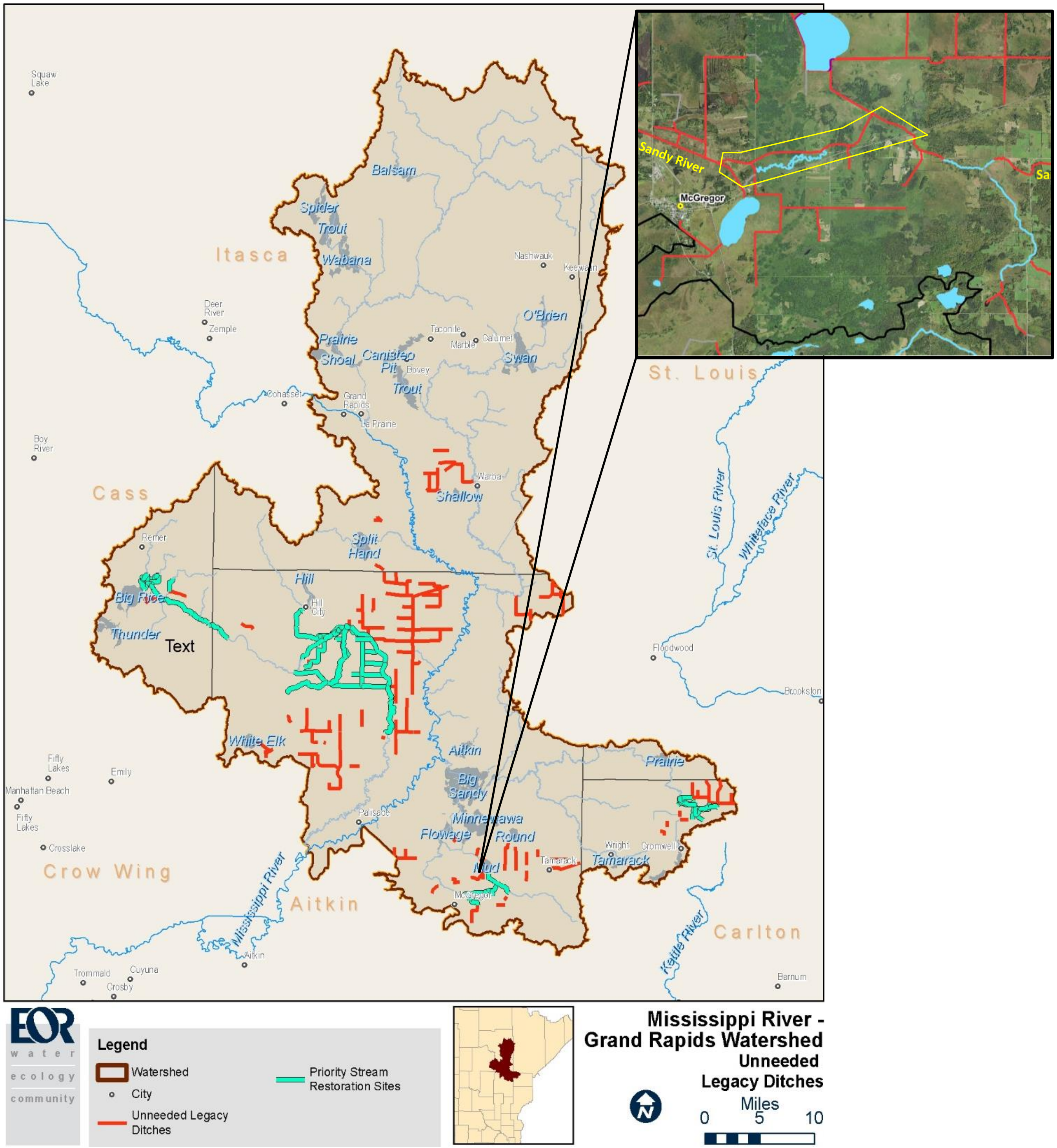


Figure 31. The Sandy River system in the Tamarack/McGregor area has many opportunities both ditch abandonment/wetland restoration and stream restoration. Red lines are ditches. The best opportunity to restore the stream channel of the Sandy River is within the yellow-boxed area.

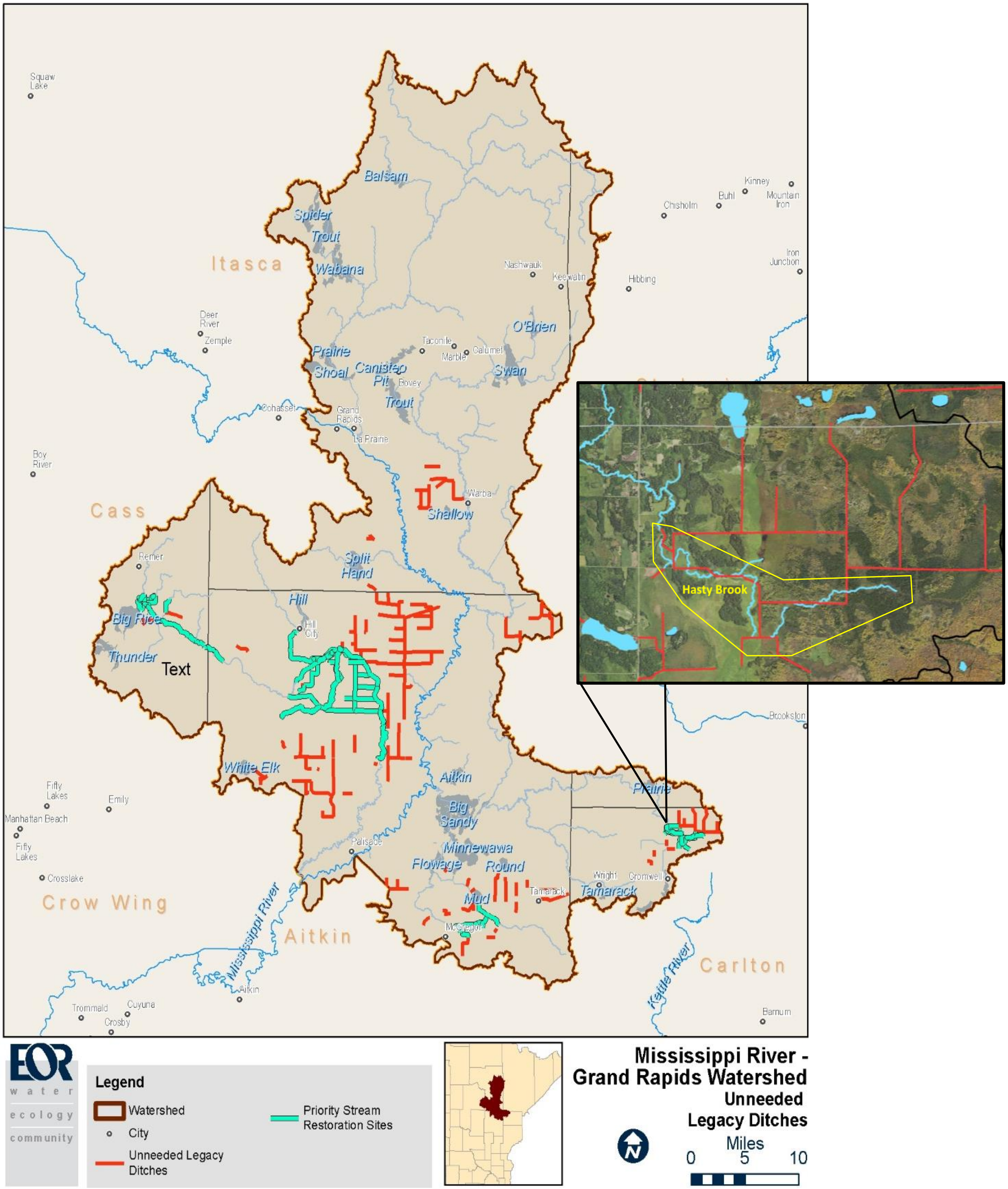


Figure 32. The Hasty Brook system in the Cromwell area has many opportunities both ditch abandonment/wetland restoration and stream restoration. Red lines are ditches. The opportunity for stream channel restoration is in the yellow-boxed area. Other ditches could be considered for abandonment/filling.

Culvert Replacement Opportunities

In the MRGRW there are numerous old failing culverts that are undersized and perched. These culverts are widespread throughout the watershed on impaired and Public Water streams, and vary from public to private ownership. For public road crossings such as county and state highways, culverts are being replaced correctly as road upgrades occur. Culvert replacements on crossings under other ownership take longer and funding is often an issue. Examples of culvert issues in the MRGRW are illustrated in Figure 33.

Figure 33. Examples of culvert issues in the MRGRW (Rian Reed 2019)

3.3.2 County-Specific Lake Protection Strategies

The following county-specific strategies were identified during meetings held in January and February of 2018 with the county and SWCD staff of Carlton, Aitkin and Itasca Environmental Services. The goal of these meetings was to work with the DNR and MPCA to incorporate county specific lake protection strategies into the WRAPS process as a proactive measure, rather than waiting until the watershed’s high quality lakes have deteriorated.

Additional goals behind the creation of county specific lake protection strategies include 1) preventing degradation, 2) understanding which lakes may be the highest priority for protection, and 3) having a set of tools to maintain them through various combinations of zoning as well as best management and conservation practices can help resource professionals accomplish multiple objectives.

The following paragraphs provide examples on a county by county basis of important ordinances and other strategies being used to better protect lakes. These county specific strategies protect lakes that go beyond just shoreland (SL) zoning. They have also developed SL ordinance standards that are equal to or beyond state minimums for protection.

Itasca County

Lake Classifications and Overlays

The County has several additional lake classifications beyond the General Development (GD), Recreational Development (RD) and Natural Environment (NE) classes. Two unique classes were developed specifically to protect water quality and include an NE3 Class developed in 1991, which identified 136 land locked lakes and also a PS Overlay developed in 2005, which selected lakes most sensitive to phosphorus increases from shoreline development. Both groups were developed in cooperation with the Itasca County Environmental Services, Itasca County SWCD, and DNR and provide standards to reduce nutrient export from lakeshore residences and are described below.

NE3 Classification. A re-classification identifying lakes that were land-locked, meaning no surface water inlet or outlet. These lakes were deemed more sensitive to nutrient inputs due to reduced ability to exchange water. Larger lot size (3 acres), sanitation setbacks (150 feet) and reduced impervious surface coverage (12%) limits were established.

Phosphorus Sensitive (PS) lakes. PS lakes are lakes exhibiting the greatest potential for water quality impairment as determined by the Minnesota Lake Eutrophication Analysis Procedure (MNLEAP Itasca, W. Walker 2005). MNLEAP uses readily available information (*i.e.*, watershed area, lake area, mean depth, and lakeshore land use inputs) to provide a simple screening tool for predicting natural versus fully developed lake water quality conditions. The sanitation setbacks and impervious surface coverage requirements on PS lakes were amended to match NE lakes.

Some notable changes have also been incorporated into all lake classifications.

- All classes have larger lot sizes and RD lakes are split into two classes (RD1 and RD2) with both exceeding state minimum dimensional standards.
- The county classifies and has zoning authority on lakes down to 10 acres, instead of the state's 25 acre minimum.
- On all lakes, livestock uses shall be setback 150 feet from the Ordinary High Water Level (OHWL).
- There was also little overlap in county zoning authority with cities or townships except on a few larger lakes in Itasca County. When there was overlap, other LGU's (except for one case) either followed County standards or were consistent with state minimums.

Carlton County

- Carlton County Ordinance #27 is more restrictive for lot area by lake type for duplex, triplex, and quads for sewered RD lakes and GD lakes.
- Shoreland Mitigation Plans are a required condition when requesting a variance from the setback from the OHWL of a classified lake, river or stream.

Aitkin County

- ○ All lakes have a maximum structure coverage of 15% of the lot area.
- ○ Impervious surfaces include any surface that sheds water, so it includes any driving surface.
- ○ Shore impact zone is 50% of the required building setback distance or 50 feet, whichever is greater.
- ○ There are standards and requirements for vacation/private home rentals. An Interim use permit and license are required. Not allowed on NE lakes.
- ○ Adopted setback distance requirements for structures and septic systems on public water wetlands.
- ○ The minimum septic system setback distance on a GD lake is 75 feet.
- ○ Maximum size of a water oriented accessory structure is 120 square feet and must be located in the center 1/3 of the lot or 50 feet from the property line, whichever is less.
- ○ Patios are included as structures and have specific regulations for building them within the building setback.
- ○ Performance standards are applied to variances when granted that require revegetation of the shore impact zone, creation of rain gardens and other water quality improvements.
- ○ Rip rap is only allowed on shorelines if the erosion problem can't be fixed with coir logs or other bioengineering methods.
- ○ Reduced the density increase multiplier for Planned Unit Developments and Conservation Subdivisions to a maximum of 25% and do not allow a density increase multiplier to be used on lands that have slopes greater than 18%.
- ○ Restrict boat access ramps to lakes that do not have a public access or an improved public access.

Funding Sources

There are a variety of funding sources to help cover some of the cost to implement practices that reduce pollutants from entering surface waters and groundwater. There are several programs listed below that contain web links to the programs and contacts for each entity. The contacts for each grant program can assist in the determination of eligibility for each program, as well as funding requirements and amounts available.

- Agriculture BMP Loan Program (MDA)
- Agricultural Water Quality Certification Program (MDA)
- Clean Water Fund Grants (BWSR)
- Clean Water Partnership Loans (MPCA)
- Environment and Natural Resources Trust Fund (Legislative-Citizen Commission on Minnesota Resources)
- Environmental Assistance Grants Program (MPCA)
- Phosphorus Reduction Grant Program (Minnesota Public Facilities Authority)
- Clean Water Act Section 319 Grant Program (MPCA)

- Small Community Wastewater Treatment Construction Loans & Grants (Minnesota Public Facilities Authority)
- Source Water Protection Grant Program (Minnesota Department of Health)
- Surface Water Assessment Grants (MPCA)
- Wastewater and storm water financial assistance (MPCA)
- Conservation Partners Legacy Grant Program (DNR)
- Environmental Quality Incentives Program (Natural Resources Conservation Service)
- Conservation Reserve Program (USDA)
- Clean Water State Revolving Fund (EPA)

3.3.3 High Priority Aggregated HUC 12 Strategies

Balsam Creek (02-03)

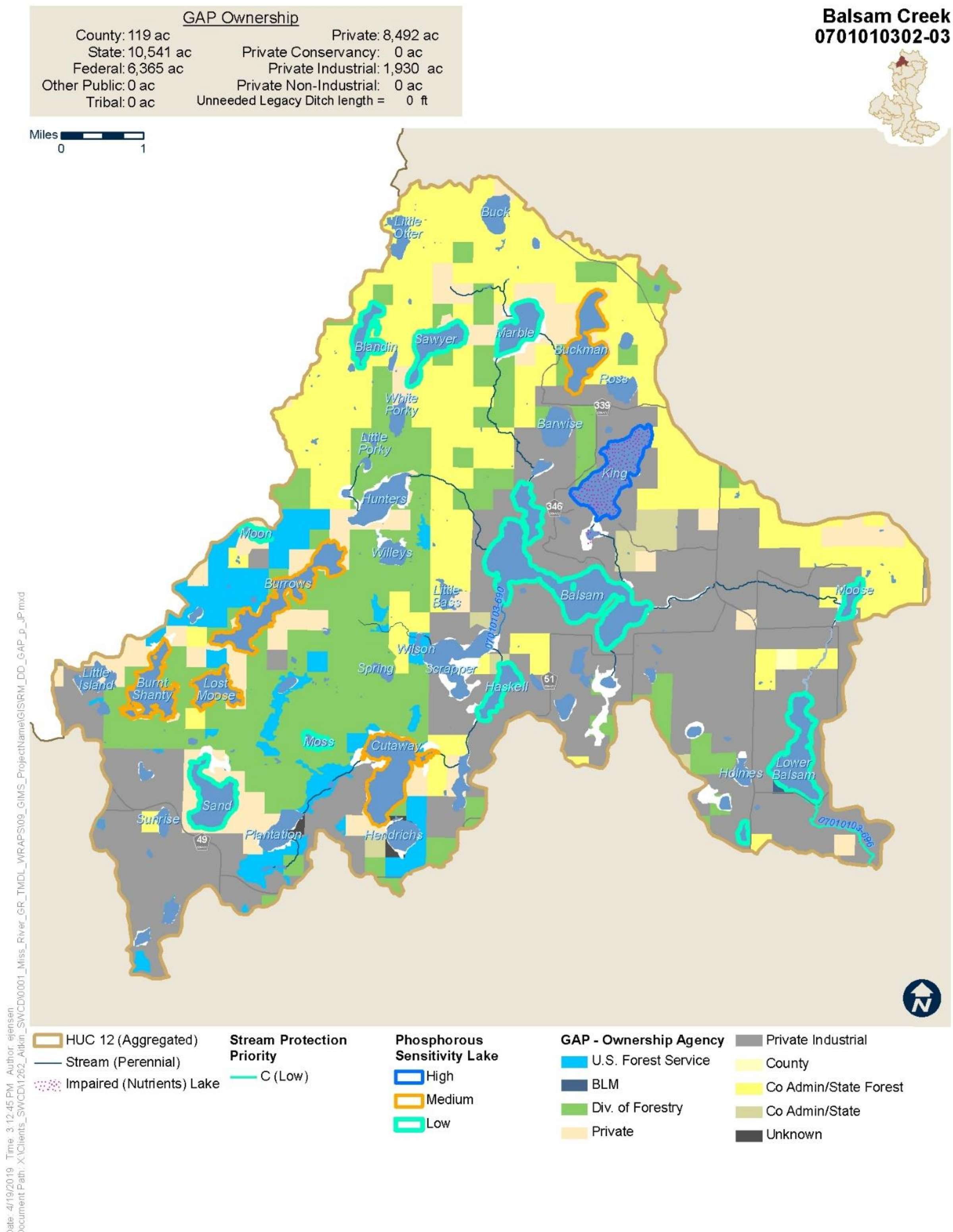


Table 16. Strategies and actions proposed for Balsam Creek (0701010302-03) Aggregated HUC 12 subwatershed.

Agg HUC 12 Rank	Agg HUC 12	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets.					Governmental Units with Primary Responsibility									Estimated Year to Achieve Water Quality Target
		Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction		Specific implementation strategy	Estimated Adoption Rate: Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	BWSR	SWCD	NRCS	MPCA	DNR	Itasca County	Cities	Landowners	Non-Profit/ Lk. Assoc.	
High	Balsam Creek (0701010302-03)	**King Lake (31-0258-00)**	**Itasca**	**Phosphorus (TP)**	286 lb TP/yr 33 ppb TP June-Sept Avg	243 lb TP/yr <30 ppb TP June-Sept Avg	Wildlife management	Dam Management	0	100%	100%	% of beaver dams eliminated					•	•		•		2025
							Improve shoreline management	Lakeshore buffers/vegetation	70%	90%	100%	% of Shoreline with adequate buffers	•	•			•	•	•	•	•	2035
							Address failing septics	Septic system inspections and maintenance education	N/A	Convert 75%	Convert 100% and maintain compliance	% of noncompliant systems				•		•		•		2040
							Reduce wastewater inputs	Grey water removal systems - install in most populated areas, 100 feet lakeshore, seasonal owners	0%	30%	75%	Percent of homes with gray water removal systems				•		•		•	•	2040
							Improve forestry management	Forest Protection Programs (Table 15 in Section 3.3.1)	60%	75%	>75%	% of watershed in protected public lands	•	•	•		•	•				2030
							Manage lake levels	Clemson leveler	0	1	1	Clemson leveler installed.	•	•			•			•		2020
							In-lake management	Hydrology study or paleo core	0	1	1	Identify strategies to reduce internal nutrient loading				•	•					2025
		Balsam Lake (31-0259-00)	**Itasca**	**Phosphorus (TP)**	15 ppb TP June-Sept Avg	Maintain or improve existing water quality	Improve forestry management	Forest Protection Programs (Table 15 in Section 3.3.1)	60%	75%	>75%	% of watershed in protected public lands	•	•	•		•	•				2030
							Address failing septics	Septic system inspections and maintenance education	N/A	Convert 75%	Convert 100% and maintain compliance	% of noncompliant systems				•		•		•	•	2040
		Lower Balsam Lake (31-0247-00)	**Itasca**	**Phosphorus (TP)**	18 ppb TP June-Sept Avg	Maintain or improve existing water quality	Improve forestry management	Forest Protection Programs (Table 15 in Section 3.3.1)	60%	75%	>75%	% of watershed in protected public lands	•	•			•	•				2030

Lower Swan River (04-01)

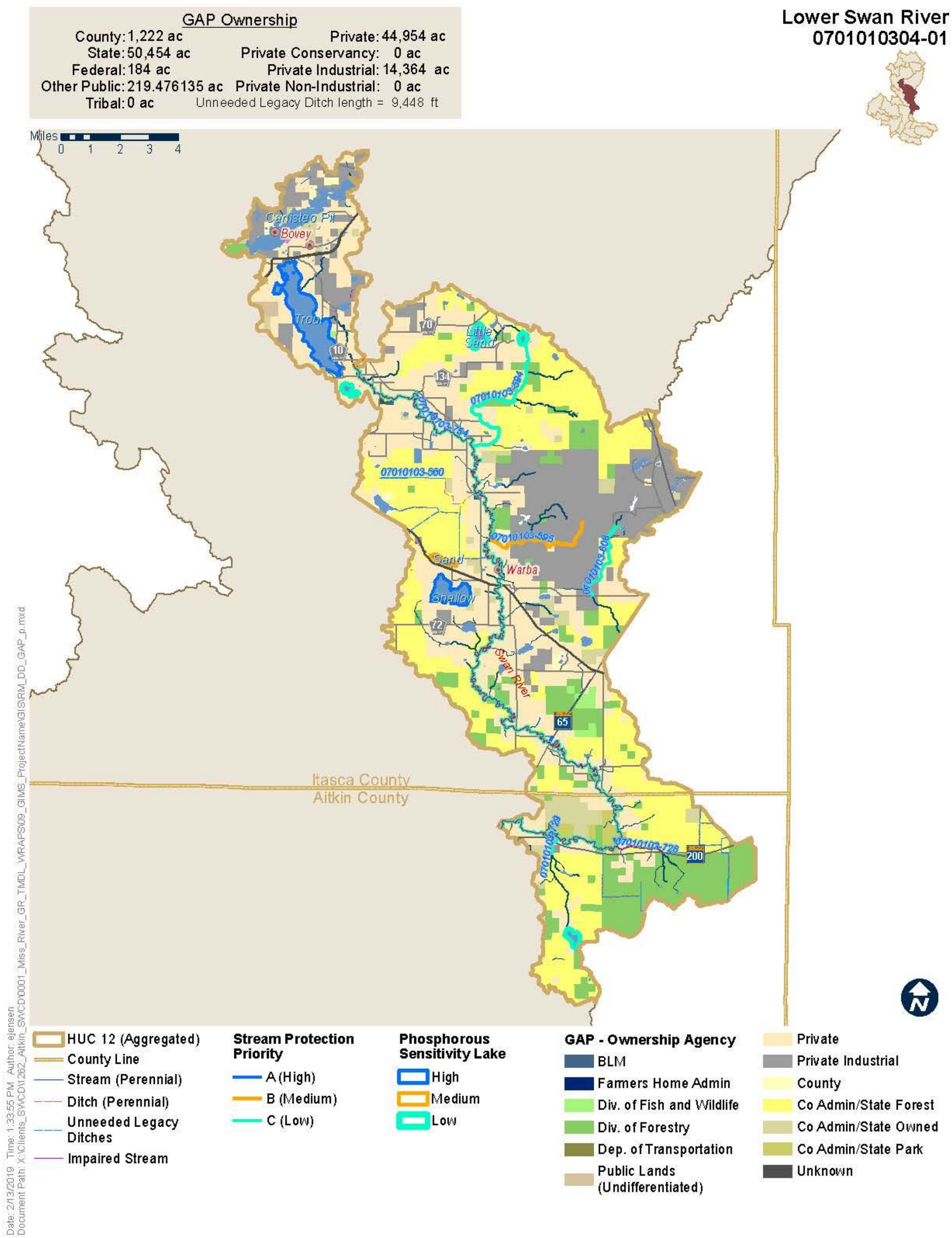


Table 17. Strategies and actions proposed for Lower Swan River (0701010304-01) Aggregated HUC 12 subwatershed.

Agg HUC 12 Rank	Agg HUC 12	Waterbody and Location: Waterbody (ID)	Waterbody and Location: Location and Upstream Influence Counties	Parameter (incl. non-pollutant stressors)	Water Quality: Current Conditions (load or concentration)	Water Quality: Goals / Targets and Estimated % Reduction	Strategy Type (see key below)	Specific implementation strategy	Estimated Adoption Rate: Current strategy adoption level, if known	Estimated Adoption Rate: Interim 10-year Milestone	Estimated Adoption Rate: Suggested Goal	Units	BSWR	SWCD	NRCS	MPCA	DNR	Aitkin/ Itasca County	Cities	Landowners	Non-Profit/ Lk. Assoc.	Estimated Year to Achieve Water Quality Target
High	Lower Swan River (0701010304-01)	**Swan River (07010103-754)**	**Itasca,** Aitkin	***E. coli***	Monthly geomeans ranged from 40-175 cfu/100 mL with samples collected during July exhibiting the highest monthly geomean	126 cfu/100 mL seasonal geomean	Improve livestock and manure management	Horse exclusion from river	N/A	Increase by at-least 500 sq. ft.	Increase by at-least 1,000 sq. ft.	Exclusion area (Sq. Ft)		•	•			•		•		2025
							Monitoring	Microbial Source Tracking to identify fecal contamination sources	N/A	Conduct Microbial Source Tracking before project implementation	*E.coli* sources identified on impaired streams	*E.coli* source assessment report identifies sources to impaired streams		•		•						2025
							Improve riparian vegetation	Riparian buffers	70%	90%	100%	% of riparian buffers with adequate buffer		•				•		•		2035
		Trib to Swan River (07010103-728)	**Aitkin**	**Fish IBI**	Fish IBI = 0, 37.7	Fish IBI > 42	Altered hydrology (alterations in streamflow)	Peatland restoration - nonfunctional (County owns land, wants to put in wetland bank, need money, crosses watershed into St. Louis Watershed, worried about AIS crossing watershed divide)	25%	Reduce by 5%	Reduce by 10%	% of altered streams in the watershed		•		•	•	•				2040
								Floodplain reconnection	N/A	50%	100%	% of stream restored.		•	•	•	•	•				2040
		Trout Lake (31-0216-00)	**Itasca**	**Phosphorus (TP)**	16 ppb TP June-Sept Avg	Maintain or improve existing water quality	Improve urban stormwater management	Stormwater management practices (see HR Green report): stormwater planters in subwatersheds 3 & 7, golf course assessment, ditch check dams along HWY 169 in subwatershed 9, detention ponds near civic center, improve stormwater ponds	N/A	15%	30%	TP load reduction as % of current load		•				•	•			2025
							In-lake management	Alum treatment (to address historic discharge from WWTP)	N/A	50%	60%	Internal TP load reduction as % of current load	•			•	•	•	•	•	•	2040
							Address failing septics	Septic system inspections and maintenance education	N/A	Convert 50%	Convert 100% and maintain compliance	% of noncompliant systems				•		•		•	•	2040

Split Hand Creek-Mississippi River (03-01)

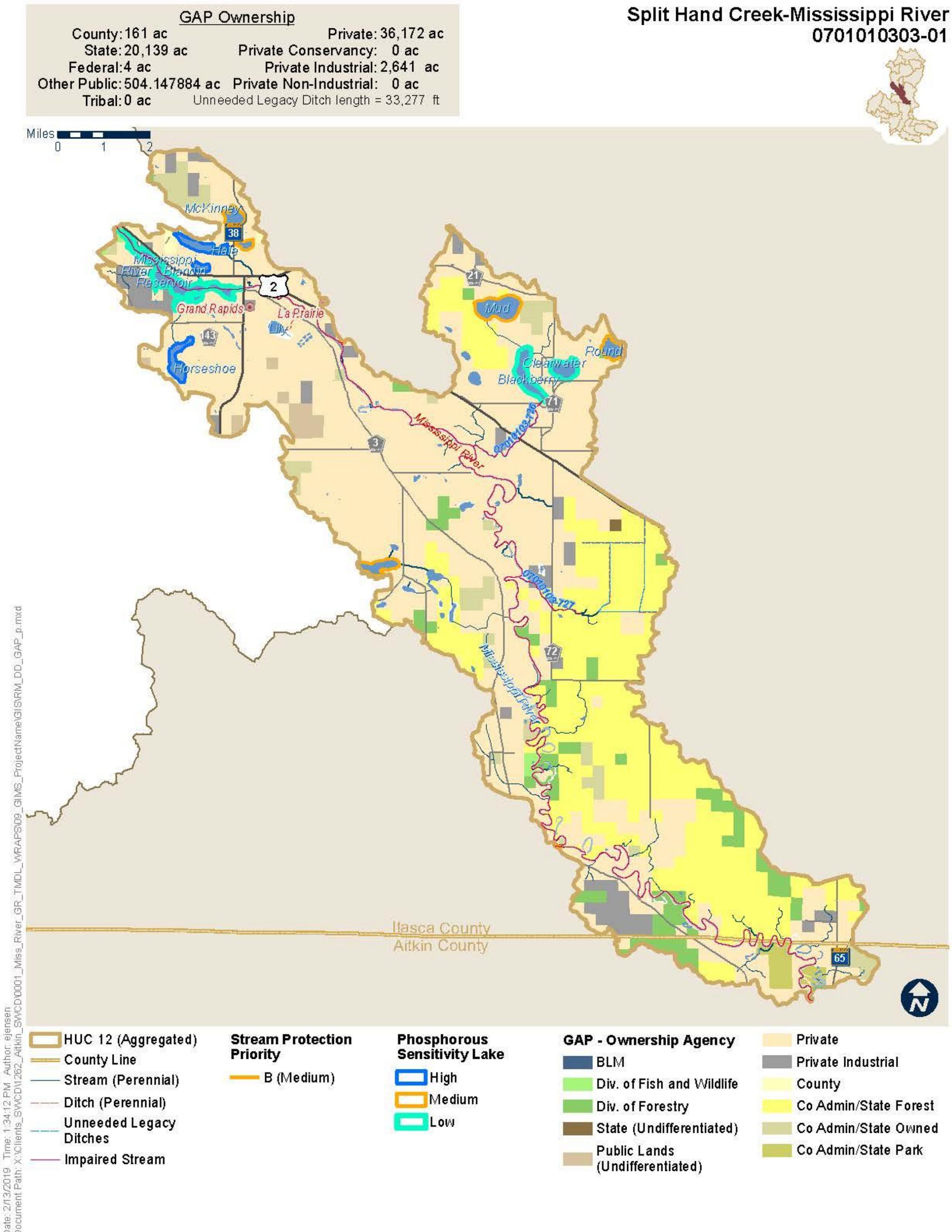


Table 18. Strategies and actions proposed for Split Hand Creek-Mississippi River (0701010303-01) Aggregated HUC 12 subwatershed.

Agg HUC 12 Rank	Agg HUC 12	Waterbody and Location: Waterbody (ID)	Waterbody and Location: Location and Upstream Influence Counties	Parameter (incl. non-pollutant stressors)	Water Quality: Current Conditions (load or concentration)	Water Quality: Goals / Targets and Estimated % Reduction	Strategy Type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets: Specific implementation strategy	Estimated Adoption Rate: Current strategy adoption level, if known	Estimated Adoption Rate: Interim 10-year Milestone	Estimated Adoption Rate: Suggested Goal	Estimated Adoption Rate: Units	BSWR	SWCD	NRCS	MPCA	DNR	Itasca County	Cities	Landowners	Non-Profit/ Lk. Assoc.	Estimated Year to Achieve Water Quality Target
High	Split Hand Creek-Mississippi River (0701010303-01)	Unnamed Creek (07010103-726)	Itasca	Fish IBI Invert IBI	Fish IBI = 35.6 Invert IBI = 49	Fish IBI > 42 Invert IBI > 53	Improve dam management	Reduce peak flows by managing dam operations	Dam is not managed	Assess feasibility of modifying or replacing dam	Modify or replace dam to allow fish passage, natural flows, and water level fluctuations	Improved Dam Management		•		•	•	•		•		2025
		Unnamed Creek (07010103-727)	Itasca	Fish IBI	Fish IBI = 0	Fish IBI > 42	Altered hydrology (alterations in streamflow)	Nonfunctional ditch decommissioning	25%	Reduce by 5%	Reduce by 10%	% of stream length that is altered – currently 33,277 LF		•		•	•	•		•		2040
		Round Lake (31-0209-00)	Itasca	Phosphorus (TP)	28 ppb TP June-Sept Avg	Maintain or improve existing water quality	Improve forestry management	Forest Protection Programs (Table 15 in Section 3.3.1)	N/A	75%	>75%	% of watershed in protected public lands	•	•			•	•				2030
							Address failing septics	Septic system inspections and maintenance education	N/A	Convert 50%	Convert 100% and maintain compliance	% of noncompliant systems				•		•		•	•	2040
							Improve stormwater management	Implement stormwater management/ shoreline buffers	N/A	Identify priority areas for stormwater BMPs/ shoreline buffers	Implement at least one stormwater BMP/ shoreline buffer restoration	Stormwater BMPs/ Shoreline Buffer		•			•		•	•	•	2040
		Blandin Reservoir (31-0533-00)	Itasca	Phosphorus (TP)	unknown	Maintain or improve existing water quality	Aquatic Invasive Species Management	Zebra mussel management	AIS Decontamination BMPS	Evaluate Zebra mussel abatement/risk reduction options	Reduce invasion pathways to downstream resources	Risk of downstream spread of Zebra Mussels		•			•			•	•	Ongoing
		Ice Lake (31-0372-00)	Itasca	Phosphorus (TP)	13 ppb TP June-Sept Avg	Maintain or improve existing water quality	Improve stormwater management	Implement stormwater management/ riparian buffers	N/A	Identify priority areas for stormwater BMPs/ riparian buffers	Implement at least one stormwater BMP/ riparian buffer restoration	Stormwater BMPs/ Riparian Buffer		•			•		•	•	•	2040
		McKinney Lake (31-0370-00)	Itasca	Phosphorus (TP)	27 ppb TP June-Sept Avg	Maintain or improve existing water quality	Nutrient management	Reduce watershed phosphorus loads by 5%	Current Watershed Load = 220lbs	Develop plan to target and implement BMP,	5% (11 lbs)	TP load reduction	•	•						•		2040
		Mississippi River mainstem (07010103-707)	Itasca	All	Fully supporting of aquatic life and aquatic recreation uses.	Maintain or improve existing water quality	Improve Riparian Vegetation	Bank revegetation, Riparian buffers	Recent 162.3 Acre Easement	Identify willing landowners needed to secure 300 acres adjacent to sensitive shorelines	Conservation Easements/ land acquired on >300 acres adjacent to sensitive shorelines	Sensitive shoreline stream miles		•	•					•	•	2030
							Streambank stabilization	Bank stabilization or restoration. Include map of key sites	N/A	A few in one key subwatershed	A few in two key subwatersheds	Degraded Stream Channels Stabilized		•	•			•		•		2040
								Coordination with ACOE on ROP	N/A	Review ACOE operating plans	Identify opportunities to improve ACOE ROP	N/A				•	•		•			2025
							Improve Urban Stormwater Management	Refer to Grand Rapids SW study - address increasing	N/A	Improve Grand Rapids SW system so less water is directly	1 Project	# of projects from Grand Rapids SW		•				•	•			2040

Agg HUC 12 Rank	Agg HUC 12	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets.					Governmental Units with Primary Responsibility									Estimated Year to Achieve Water Quality Target
									Estimated Adoption Rate													
		Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction		Specific implementation strategy	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	BSWR	SWCD	NRCS	MPCA	DNR	Itasca County	Cities	Landowners	Non-Profit/ Lk. Assoc.	
								development pressure along Hwy 169 corridor		discharged into the Mississippi River		study that are implemented										
							Education and outreach	Engage landowners through canoe trips on shoreline BMPs	N/A	10% of landowners	50% of landowners	# of educated riparian landowners		•					•	•	•	2040

Split Hand Creek (03-02)

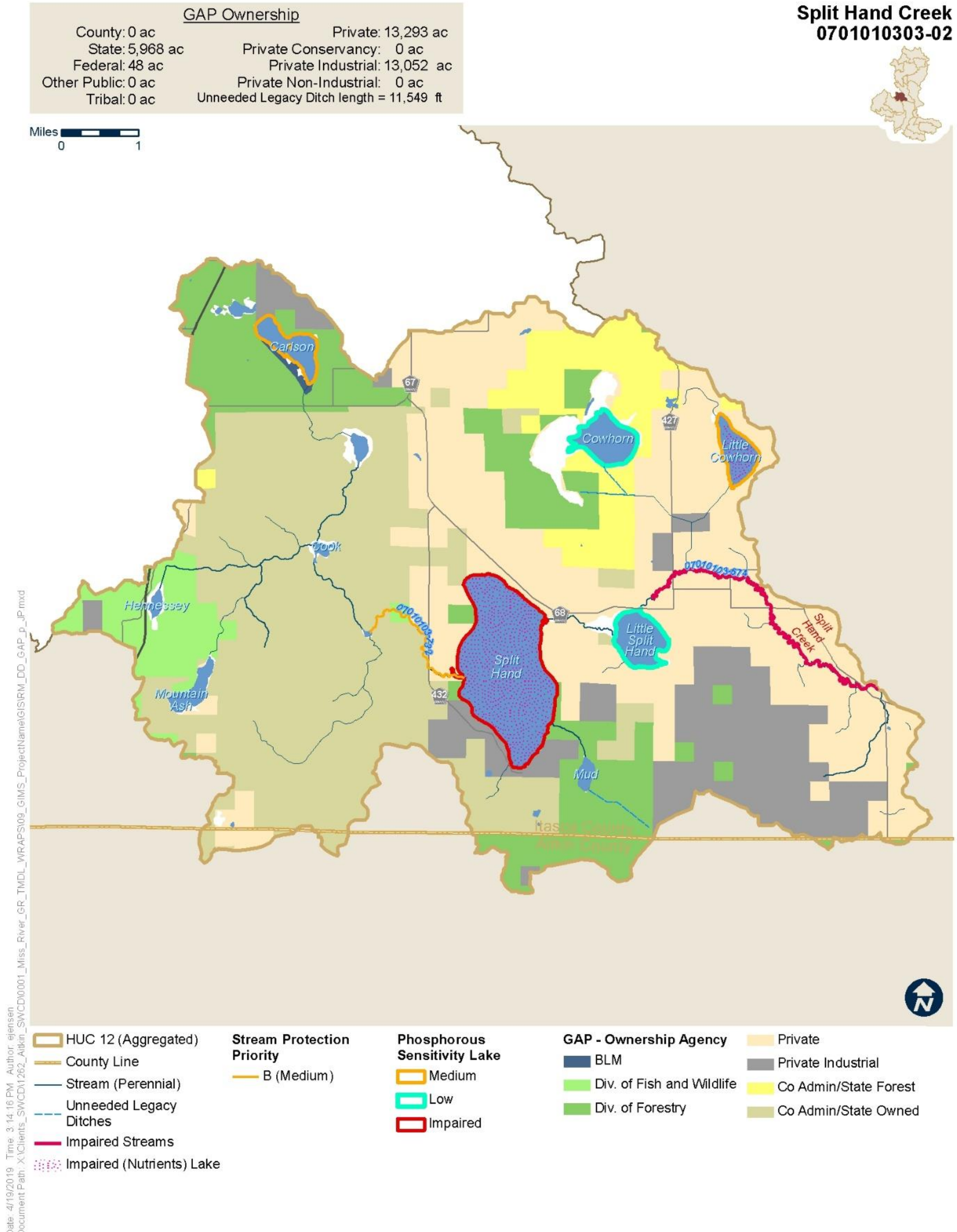


Table 19. Strategies and actions proposed for Split Hand Creek (0701010303-02) Aggregated HUC 12 subwatershed.

Agg HUC 12 Rank	Agg HUC 12	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets.					Governmental Units with Primary Responsibility									Estimated Year to Achieve Water Quality Target
									Estimated Adoption Rate													
		Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction		Specific implementation strategy	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	BSWR	SWCD	NRCS	MPCA	DNR	Itasca County	Cities	Landowners	Non-Profit/ Lk. Assoc.	
High	Split Hand Creek (0701010303-02)	**Little Cowhorn Lake (31-0198-00)**	**Itasca**	**Phosphorus (TP)**	234 lb TP/yr 46 ppb TP June-Sept Avg	127 lb TP/yr <30 ppb TP June-Sept Avg conc	Fisheries and aquatic plant management	In-lake fish and aquatic plant management	At risk for internal loading due to shallow nature of lake	Assess in-lake biological health and identify internal loading risks	Develop plan to identify, target and implement in-lake BMPs	N/A	•			•	•			•	•	2040
		Split Hand Lake (31-0353-00)	**Itasca**	**Phosphorus (TP)**	3601 lb TP/yr 41 ppb TP June-Sept Avg	2269 lb TP/yr <30 ppb TP June-Sept Avg	Improve forestry management	Forest Protection Programs (Table 15 in Section 3.3.1)	60%	75%	>75%	% of watershed in protected public lands	•	•	•		•	•				2030
							Improve shoreline management	Lakeshore buffers/vegetation	70%	90%	100%	% of Shoreline with adequate buffers	•	•			•	•	•	•	•	2035
							Address failing septics	Septic system inspections and maintenance education	N/A	Convert 75%	Convert 100% and maintain compliance	% of noncompliant systems				•		•		•		2040
		Split Hand Creek (07010103-574)	**Itasca**	***E. coli***	135 - 264 cfu/100 mL seasonal geomean	126 cfu/100 mL seasonal geomean	Improve livestock and manure management	Livestock exclusion from stream	N/A	Increase exclusion area by at-least 1,000 sq. ft.	Increase exclusion area by at-least 3,000 sq. ft.	Exclusion Area (Sq. Ft)		•				•		•		2030
							Improve livestock and manure management	Manure spreading management	N/A	Conduct windshield survey to identify manure problems	Address 50% of identified problems with manure management BMPs	% of manure management problems		•						•		2035
							Monitoring	Microbial Source Tracking to identify fecal contamination sources	N/A	Conduct Microbial Source Tracking before project implementation	*E.coli* sources identified on impaired streams	*E.coli* source assessment report identifies sources to impaired streams		•		•						2025
							Improve Riparian Vegetation	Bank revegetation, Riparian buffers	N/A	Increase riparian buffers on sensitive shorelines by 20%	Increase riparian buffers on sensitive shorelines by at least 50%	Sensitive shoreline stream miles		•						•	•	2030
							Altered hydrology (alterations in streamflow)	Nonfunctional ditch decommissioning including ditches owned by DNR	11,549 feet	Reduce non-functional ditches by 5%	Reduce non-functional ditches by 5%	% of altered streams in the watershed		•			•					2040
							Reduce bank/bluff/stream erosion	Stabilize streambanks	N/A	Increase bank stabilization by 25%	Increase bank stabilization by 50%	% of stream banks stabilized		•				•		•		2040

Tamarack River (05-02)

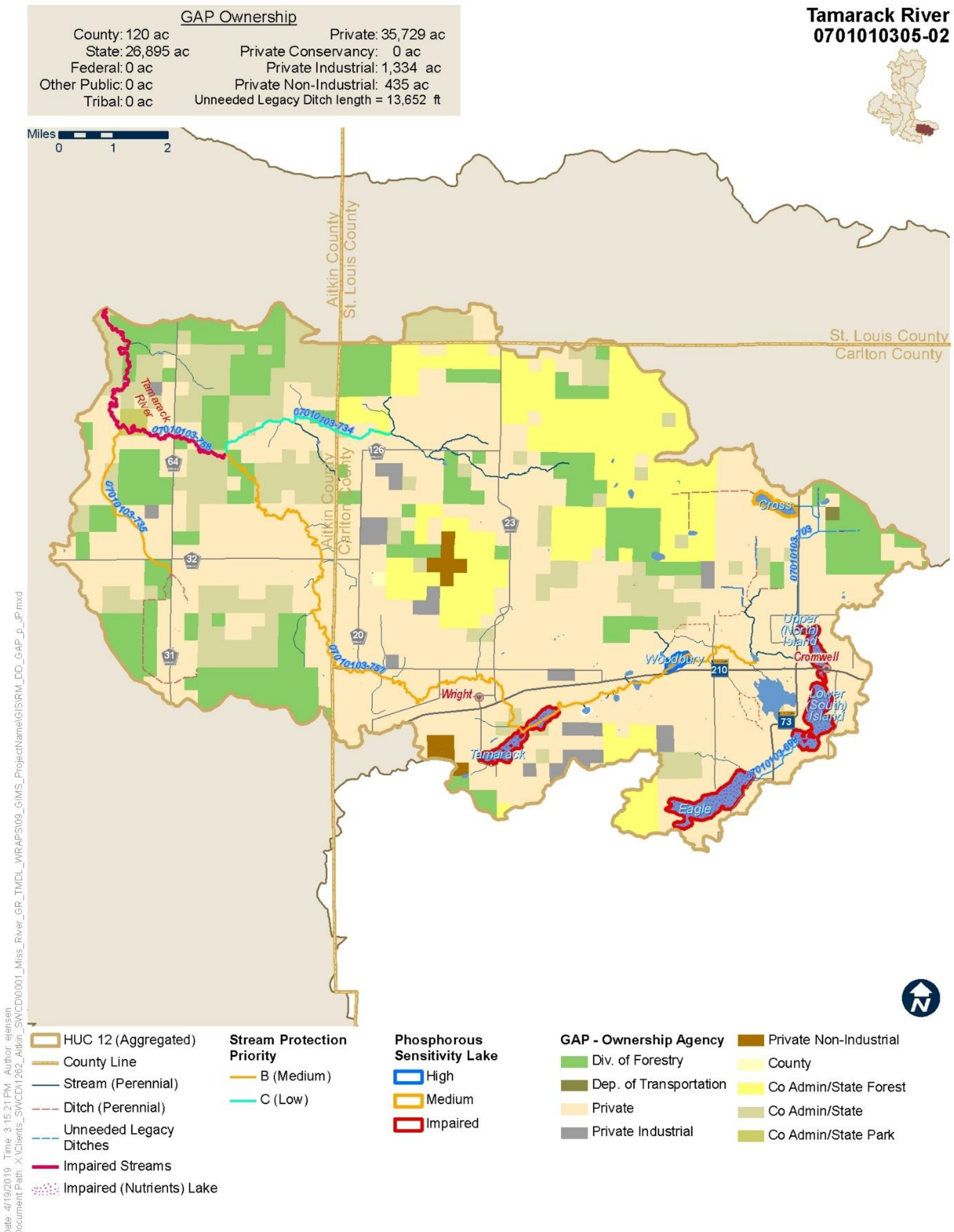


Table 20. Strategies and actions proposed for Tamarack River (0701010305-02) Aggregated HUC 12 subwatershed.

Agg HUC 12 Rank	Agg HUC 12	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets.					Governmental Units with Primary Responsibility									Estimated Year to Achieve Water Quality Target
									Estimated Adoption Rate													
		Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction		Specific implementation strategy	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	BWSR	SWCD	NRCS	MPCA	Cities	County	DNR	Landowners	Non-Profit/ Lk. Assoc.	
High	Tamarack River (0701010305-02)	**Tamarack River (07010103-758)**	**Aitkin,** Carlton	***E. coli***	57 - 163 cfu/100 mL seasonal geomean	126 cfu/100 mL seasonal geomean	Improve livestock and manure management	Livestock exclusion from streams	N/A	80%	100%	Feedlot compliance with Ag. feedlot rules	•	•	•	•		•				2030
							Monitoring	Microbial Source Tracking to identify fecal contamination sources	N/A	Conduct Microbial Source Tracking before project implementation	*E.coli* sources identified on impaired streams	*E.coli* source assessment report identifies sources to impaired streams		•		•						2025
		Eagle Lake (09-0057-00)	**Carlton**	**Phosphorus (TP)**	462 lb TP/yr 28 ppb TP June-Sept Avg	402 lb TP/yr <30 ppb TP June-Sept Avg	Improve Riparian Vegetation	Lakeshore buffers/vegetation	70%	90%	100%	% of Shoreline with adequate buffers	•	•	•			•		•	•	2040
							Address failing septics	Septic system inspections and maintenance education	N/A	Convert 75%	Convert 100% and maintain compliance	% of noncompliant systems		•				•		•	•	2040
							Improve upland/field surface runoff controls	Reduce watershed phosphorus loads by 5%	Current Watershed Load = 75.8lbs	Develop plan to target and implement BMPs,	5% (4 lbs)	TP load reduction	•	•					•			2040
		Lower (South) Island Lake (09-0060-02)	**Carlton**	**Phosphorus (TP)**	407 lb TP/yr 29 ppb TP June-Sept Avg	368 lb TP/yr <30 ppb TP June-Sept Avg	Improve Riparian Vegetation	Lakeshore buffers/vegetation	70%	90%	100%	% of Shoreline with adequate buffers	•	•			•	•	•	•	•	2040
							Address failing septics	Septic system inspections and maintenance education	N/A	Convert 75%	Convert 100% and maintain compliance	% of noncompliant systems		•				•		•	•	2040
		Upper (North) Island Lake (09-0060-01)	**Carlton**	**Phosphorus (TP)**	530 lb TP/yr 27 ppb TP June-Sept Avg	478 lb TP/yr <30 ppb TP June-Sept Avg	Improve livestock and manure management	Livestock exclusion from tributaries/shoreline	N/A	80%	100%	Feedlot compliance with Ag. feedlot rules	•	•	•	•		•		•	•	2030
							Improve livestock and manure management	Manure spreading management	N/A	Conduct windshield survey to identify manure problems or facilities w/o nutrient management BMPs	Address 50% of identified problems with manure management BMPs	% of livestock facilities following nutrient management plans		•						•		2035

Agg HUC 12 Rank	Agg HUC 12	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets.					Governmental Units with Primary Responsibility									Estimated Year to Achieve Water Quality Target
		Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction		Specific implementation strategy	Estimated Adoption Rate				BWSR	SWCD	NRCS	MPCA	Cities	County	DNR	Landowners	Non-Profit/ Lk. Assoc.	
									Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units										
							Improve Urban Stormwater Management	Cromwell SW Management	N/A	Work w/ MNDOT to implement stormwater BMPs during Hwy. 210 reconstruction.	1 or more projects installed	Number of stormwater BMPs installed		•			•					2035
							Improve Riparian Vegetation	Lakeshore buffers/vegetation	70%	90%	100%	% of Shoreline with adequate buffers	•	•			•	•	•	•	•	2040
							Address failing septics	Septic system inspections and maintenance education	N/A	Convert 75%	Convert 100% and maintain compliance	% of noncompliant systems		•				•		•	•	2040
		Tamarack Lake (09-0067-00)	**Carlton**	**Phosphorus (TP)**	30 ppb TP June-Sept Avg	<30 ppb TP June-Sept Avg	Altered hydrology (alterations in streamflow)	Nonfunctional ditch decommissioning	N/A	Feasibility studies on 100% of ditches	All feasible ditches decommissioned	% nonfunctional ditches decommissioned		•				•	•			2040
							Improve forestry management	Forest Protection Programs (Table 15 in Section 3.3.1)	60%	75%	>75%	% of watershed in protected public lands	•	•	•		•	•				2030
							Improve Riparian Vegetation	Riparian buffers	70%	90%	100%	% of riparian buffers with adequate buffer		•				•		•		2035
							Improve Urban Stormwater Management	Wright SW Management	N/A	Implement at least one stormwater BMP	Work w/ MNDOT to implement stormwater BMPs during street reconstruction projects	Number of stormwater BMPs installed		•			•					2035
							Address failing septics	Septic system inspections and maintenance education	N/A	Convert 75%	Convert 100% and maintain compliance	% of noncompliant systems		•				•		•	•	2040
		Woodbury Lake (09-0063-00)	**Aitkin, Carlton**	**Phosphorus (TP)**	36 ppb TP June-Sept Avg	<30 ppb TP June-Sept Avg	Altered hydrology (alterations in streamflow)	Nonfunctional ditch decommissioning	N/A	Feasibility studies on 100% of ditches	All feasible ditches decommissioned	% nonfunctional ditches decommissioned		•				•	•			2035
							Improve forestry management	Forest Protection Programs (Table 15 in Section 3.3.1)	60%	75%	>75%	% of watershed in protected public lands	•	•	•		•	•				2030

Big Sandy Outlet (06-01)

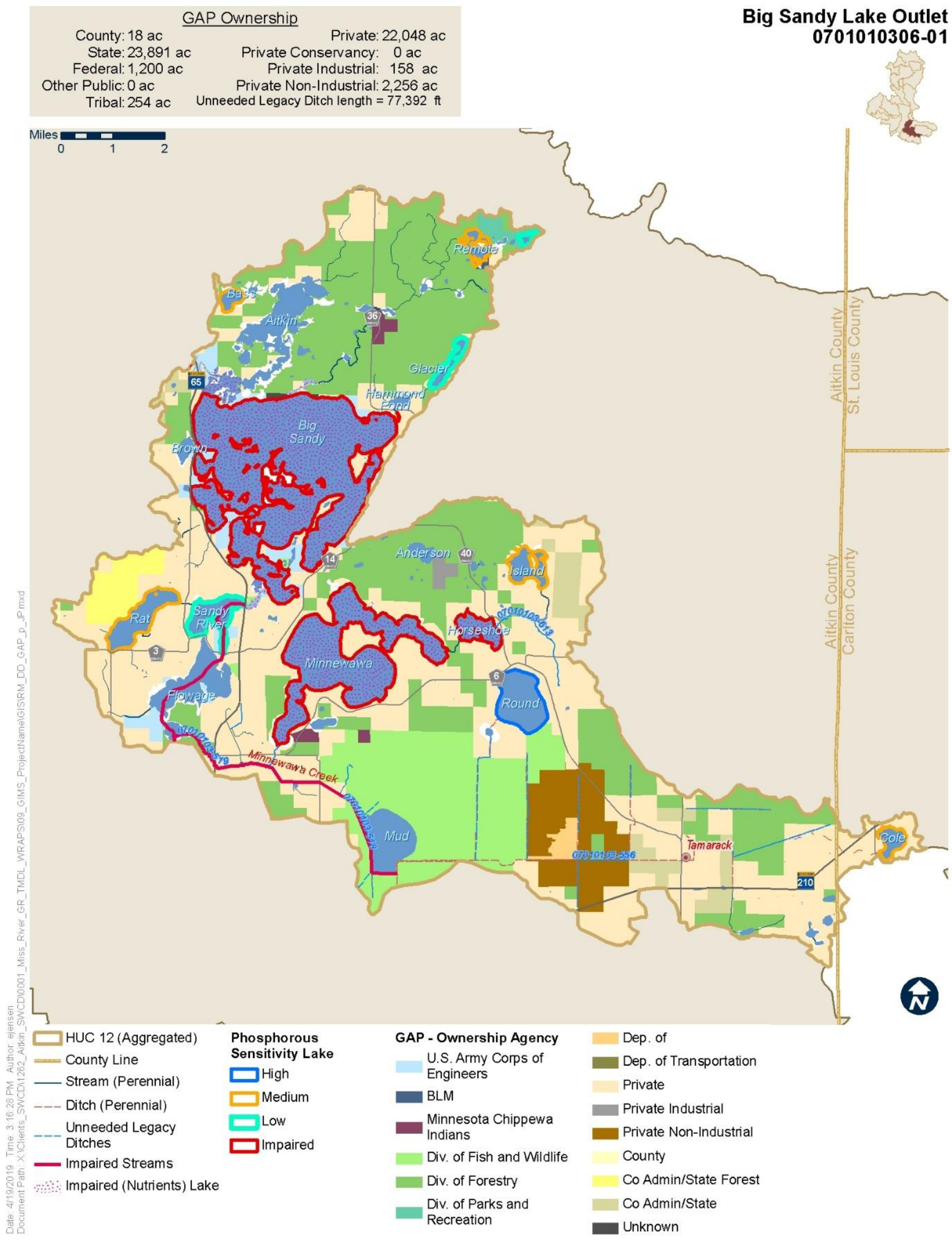


Table 21. Strategies and actions proposed for Big Sandy Outlet (0701010306-01) Aggregated HUC 12 subwatershed.

Agg HUC 12 Rank	Agg HUC 12	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets.					Governmental Units with Primary Responsibility									Esti-mated Year to Achieve Water Quality Target
		Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction		Specific implementation strategy	Estimated Adoption Rate: Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	BWSR	SWCD	NRCS	MPCA	Cities	County	DNR	Landowners	Non-Profit/ Lk. Assoc.	
High	Big Sandy Outlet (0701010306-01)	**Horseshoe Lake (01-0034-00)**	**Aitkin**	**Phosphorus (TP)**	756 lb TP/yr 43 ppb TP June-Sept Avg	487 lb TP/yr <30 ppb TP June-Sept Avg	Improve Urban Stormwater Management	Development stormwater management plan	N/A	Stormwater management plan with prioritized list of BMP locations	Implement at least one high priority stormwater BMP	Number of high-priority stormwater BMPs implemented	•	•			•	•		•	•	2025
							Improve Riparian Vegetation	Riparian buffers	70%	90%	100%	% of riparian buffers with adequate buffer		•	•			•		•		2035
							Address failing septics	Septic system inspections and maintenance education	N/A	Convert 75%	Convert 100% and maintain compliance	% of noncompliant systems				•		•		•		2040
							Fisheries and aquatic plant management	In-lake fish and aquatic plant management	At risk for internal loading due to shallow nature of lake	Assess in-lake biological health and identify internal loading risks	Develop plan to identify, target and implement in-lake BMPs	N/A	•			•	•			•	•	2040
		Big Sandy Lake (01-0062-00)	**Aitkin**	**Phosphorus (TP)**	45,398 lb TP/yr 35 ppb TP June-Sept Avg	32,878 lb TP/yr <30 ppb TP June-Sept Avg	Mississippi River Backflow Study	Minimize water quality impacts associated with Mississippi River backflow	N/A	Review outlet management protocol(s)	Evaluate whether the system could be managed in a way that would reduce water quality impacts	TP load reduction from periodic backflow events							•		•	2025
							Internal Load Reduction Feasibility Study	In-lake sediment, fish, and aquatic plant management	At risk for internal loading due to shallow nature of lake	Develop plan to assess, identify, target and implement in-lake BMPs.	93% reduction	TP load reduction from internal sources	•			•	•			•	•	2040
	Big Sandy Outlet (0701010306-01)						Treatment of Stormwater Sources / Runoff Management	Low-impact design principles incorporated into new design, redevelopment, or expansion	N/A	Implement at least one LID/stormwater BMP project	50% reduction	TP load reduction from developed land use areas		•							•	Ongoing
							Lake Management Planning	Develop lake management plans that identify goals and prioritize restoration / protection efforts	Lake management plans have been developed for several watershed lakes.	Plans are developed for 75% of upstream lakes	Plans are developed for 100% of upstream lakes	% of upstream lakes with lake management plans		•		•					•	Ongoing
							Lakeshore Erosion Management:	Control lakeshore erosion	Initial inventory of actively eroding sites already identified	assessment and inventory of eroding sites	25% reduction	TP load reduction from lakeshore erosion		•	•						•	Ongoing
							Address failing septics	Septic system inspections and maintenance education	N/A	Convert 75%	Convert 100% and maintain compliance	% of noncompliant systems				•		•		•		2040

Agg HUC 12 Rank	Agg HUC 12	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets.					Governmental Units with Primary Responsibility									Esti-mated Year to Achieve Water Quality Target
		Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction		Specific implementation strategy	Estimated Adoption Rate: Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	BWSR	SWCD	NRCS	MPCA	Cities	County	DNR	Landowners	Non-Profit/ Lk. Assoc.	
							Environmental Planning for Urban, Rural and/or Seasonal Development:	Support planning and zoning efforts, enforce existing regulations and zoning ordinances	Established minimum set-back distances from shorelines for new developments to prevent significant disturbances.	Enforce existing regulations, identify and prioritize locations for conservation easements	Establishment at least one conservation easement on high priority sites	N/A	•	•			•	•	•	•	•	Ongoing
							Stream Channel Erosion Control	Identify opportunities for correcting existing stream channel erosion sources.	N/A	Assess all-terrain vehicle (ATV) traffic as a source of erosion.	25% reduction	TP load reduction from streambank erosion	•	•	•		•	•	•	•	•	Ongoing
							Ditch System Monitoring / Maintenance	Assessment of current and planned ditch cleaning activities	N/A	Prioritize stream reaches and drainage ditches for stabilization based on apparent sediment/nutrient loading and likely cost to stabilize the system	25% reduction	TP load reduction from streambank erosion		•			•	•	•	•		Ongoing
							Agricultural BMPs	Agricultural BMP opportunities are identified and implemented in appropriate situations	N/A	At least three agricultural BMPs are installed	25% reduction	TP load reduction from agriculture/ pasture land use areas		•				•		•		2030
	Big Sandy Outlet (0701010306-01)						Wild Rice Farm BMPs	Monitor TP export from wild rice farm north of McGregor	N/A	Identify opportunities to minimize TP export and manage short/long term drainage.	93% reduction	TP load reduction from wild rice farms		•	•				•			2035
							Silviculture BMPs	Work with landowners to develop forest stewardship plans	N/A	Develop forest stewardship plans for 5 or more landowners	1% reduction	TP load reduction from forested lands		•				•	•	•	•	Ongoing
		Minnewawa Lake (01-0033-00)	**Aitkin**	**Phosphorus (TP)**	2,077 lb TP/yr 35 ppb TP June-Sept Avg	1,786 lb TP/yr <30 ppb TP June-Sept Avg	Treatment of Stormwater Sources / Runoff Management	Low-impact design principles incorporated into new design, redevelopment, or expansion	N/A	Implement at least one LID/stormwater BMP project	50% reduction	TP load reduction from developed land use areas		•							•	Ongoing
							Lake Management Planning	Develop lake management plans that identify goals and prioritize restoration / protection efforts	Lake management plans have been developed for several watershed lakes.	Plans are developed for 75% of upstream lakes	Plans are developed for 100% of upstream lakes	% of upstream lakes with lake		•		•					•	Ongoing

Agg HUC 12 Rank	Agg HUC 12	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets.					Governmental Units with Primary Responsibility									Esti-mated Year to Achieve Water Quality Target
		Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction		Specific implementation strategy	Estimated Adoption Rate: Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	BWSR	SWCD	NRCS	MPCA	Cities	County	DNR	Landowners	Non-Profit/ Lk. Assoc.	
												management plans										
							Lakeshore Erosion Management:	Control lakeshore erosion	Initial inventory of actively eroding sites already identified	assessment and inventory of eroding sites	25% reduction	TP load reduction from lakeshore erosion		•							•	Ongoing
							Address failing septics	Septic system inspections and maintenance education	N/A	Convert 75%	Convert 100% and maintain compliance	% of noncompliant systems				•		•		•		2040
							Environmental Planning for Urban, Rural and/or Seasonal Development:	Support planning and zoning efforts, enforce existing regulations and zoning ordinances	Established minimum set-back distances from shorelines for new developments to prevent significant disturbances.	Enforce existing regulations, identify and prioritize locations for conservation easements	Establishment at least one conservation easement on high priority sites	N/A	•	•			•	•	•	•	•	Ongoing
	Big Sandy Outlet (0701010306-01)						Stream Channel Erosion Control	Identify opportunities for correcting existing stream channel erosion sources.	N/A	Assess all-terrain vehicle (ATV) traffic as a source of erosion.	25% reduction	TP load reduction from streambank erosion	•	•	•		•	•	•	•	•	Ongoing
							Ditch System Monitoring / Maintenance	Assessment of current and planned ditch cleaning activities	N/A	Prioritize stream reaches and drainage ditches for stabilization based on apparent sediment/nutrient loading and likely cost to stabilize the system	25% reduction	TP load reduction from streambank erosion		•			•	•	•	•		Ongoing
							Agricultural BMPs	Agricultural BMP opportunities are identified and implemented in appropriate situations	N/A	At least three agricultural BMPs are installed	25% reduction	TP load reduction from agriculture/ pasture land use areas		•				•		•		2030
							Silviculture BMPs	Work with landowners to develop forest stewardship plans	N/A	Develop forest stewardship plans for 5 or more landowners	1% reduction	TP load reduction from forested lands		•				•	•	•	•	Ongoing
		Minnewawa Creek (071010103-518)	**Aitkin**	**Fish IBI Invert IBI**	Fish IBI = 17 Invert IBI = 18, 35	Fish IBI > 23 Invert IBI > 37	Altered hydrology (alterations in streamflow & nutrient export)	Nonfunctional ditch decommissioning	25%	Reduce by 5%	Reduce by 10%	% of stream length that is altered		•		•	•	•		•		2040
							Altered hydrology	WMA outlet restoration (close the outlet)	N/A	Evaluate options for improving D.O. and	Shut off flow from some of the	N/A		•		•			•			

Agg HUC 12 Rank	Agg HUC 12	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets.					Governmental Units with Primary Responsibility									Esti-mated Year to Achieve Water Quality Target
		Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction		Specific implementation strategy	Estimated Adoption Rate: Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	BWSR	SWCD	NRCS	MPCA	Cities	County	DNR	Landowners	Non-Profit/ Lk. Assoc.	
							(alterations in streamflow)			biological communities	upstream reaches (Grayling WMA)											
							Improve Urban Stormwater Management	Tamarack City storm sewer system/stormwater management	N/A	Implement at least one stormwater BMP	Identify opportunities for implementing stormwater BMPs (e.g., street reconstruction projects)	Number of stormwater BMPs installed		•			•					2035
	Big Sandy Outlet (0701010306-01)						Improve livestock and manure management	Limit livestock access (headwater ditches)	N/A	Increase exclusion area by at-least 1,000 sq. ft.	Increase exclusion area by at-least 3,000 sq. ft.	Exclusion Area (Sq. Ft)		•				•		•		2030
		Minnewawa Creek (07010103-519)	**Aitkin**	**Fish IBI**	Fish IBI = 34.3, 33.4	Fish IBI > 47	Altered hydrology (alterations in streamflow & nutrient export)	Nonfunctional ditch decommissioning	25%	Reduce by 5%	Reduce by 10%	% of stream length that is altered		•		•	•	•		•		2040
							Altered hydrology (alterations in streamflow)	WMA outlet restoration (close the outlet)	N/A	Evaluate options for improving D.O. and biological communities	Shut off flow from some of the upstream reaches (Grayling WMA)	N/A		•		•			•			
							Improve Urban Stormwater Management	Tamarack City storm sewer system/stormwater management	N/A	Implement at least one stormwater BMP	Identify opportunities for implementing stormwater BMPs (e.g., street reconstruction projects)	Number of stormwater BMPs installed		•			•					2035
							Improve livestock and manure management	Limit livestock access (headwater ditches)	N/A	Increase exclusion area by at-least 1,000 sq. ft.	Increase exclusion area by at-least 3,000 sq. ft.	Exclusion Area (Sq. Ft)		•				•		•		2030
		Round Lake (01-0023-00)	**Aitkin**	**Phosphorus (TP)**	11 ppb TP June-Sept Avg	Maintain or improve existing water quality	Improve shoreline management	Identify potential causes for increased water levels	N/A	Maintain water levels at or below OHWL	Maintain water levels at or below OHWL	OHWL = 1253.6 ft				•		•			•	2040
							Address failing septics	Septic system inspections and maintenance education	N/A	Convert 75%	Convert 100% and maintain compliance	% of noncompliant systems				•		•		•		2040

City of Palisade-Mississippi River (09-01)

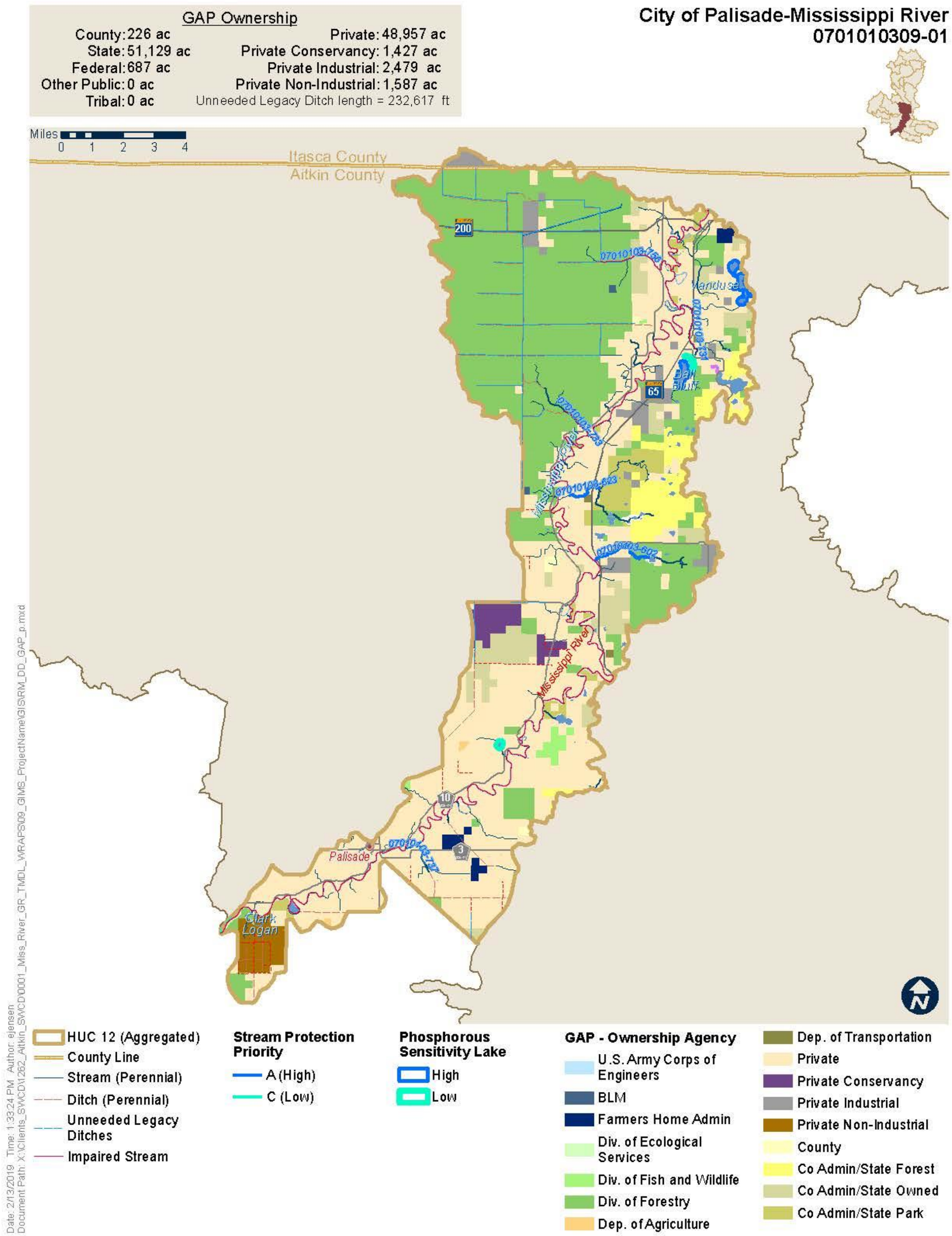


Table 22. Strategies and actions proposed for City of Palisade-Mississippi River (0701010309-01) Aggregated HUC 12 subwatershed.

Agg HUC 12 Rank	Agg HUC 12	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets.					Governmental Units with Primary Responsibility									Estimated Year to Achieve Water Quality Target
									Estimated Adoption Rate													
		Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction		Specific implementation strategy	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	BWSR	SWCD	NRCS	MPCA	Cities	County	DNR	Landowners	Non-Profit/ Lk. Assoc.	
High	City of Palisade-Mississippi River (0701010309-01)	**Mississippi River mainstem (07010103-708)**	**Aitkin**	**TSS**	Concentration exceeds Central Region TSS standard (30 mg/L) 62.3% of the time	30 mg/L met 90% of time Apr-Sep	Increase vegetative cover/root duration	Bank revegetation	N/A	Increase perennial vegetation that maximizes vegetative cover/minimizes erosion by 20%	Increase perennial vegetation that maximizes vegetative cover/minimizes erosion by 50%	% of Sensitive shoreline stream miles		•	•					•	•	2040
							Improve Riparian Vegetation	Bank revegetation, Riparian buffers	N/A	Increase riparian buffers on sensitive shorelines by 20%	Increase riparian buffers on sensitive shorelines by at least 50%	% of Sensitive shoreline stream miles		•	•					•	•	2040
							Improve upland/field surface runoff controls	Reduce watershed TSS loads through implementation of Ag. BMPs	Current Watershed TSS Load = 75.8lbs	Develop plan to target and implement BMPs,	5% (4 lbs)	TP load reduction	•	•					•			2040
							Improve Urban Stormwater Management	Development City of Palisade SWM Plan	N/A	Stormwater management plan with prioritized list of BMP locations	Implement at least one high priority stormwater BMP	Number of high-priority stormwater BMPs implemented	•	•			•	•		•	•	2025
							Improve forestry management	Forest Protection Programs (Table 15 in Section 3.3.1)	60%	75%	>75%	% of watershed in protected public lands	•	•	•		•	•				2030
		Pokegama Creek (07010103-733)	**Aitkin**	**Fish IBI Invert IBI**	Fish IBI = 11.1 Invert IBI = 22.5	Fish IBI > 42 Invert IBI > 53	Altered hydrology (alterations in streamflow)	Nonfunctional ditch decommissioning	N/A	Feasibility studies on 100% of ditches including studies of MeHg export from peatlands	All feasible ditches decommissioned	% nonfunctional ditches decommissioned		•				•	•			2030

3.3.4 Medium Priority Aggregated HUC 12 Strategies

Clearwater Creek (02-02)

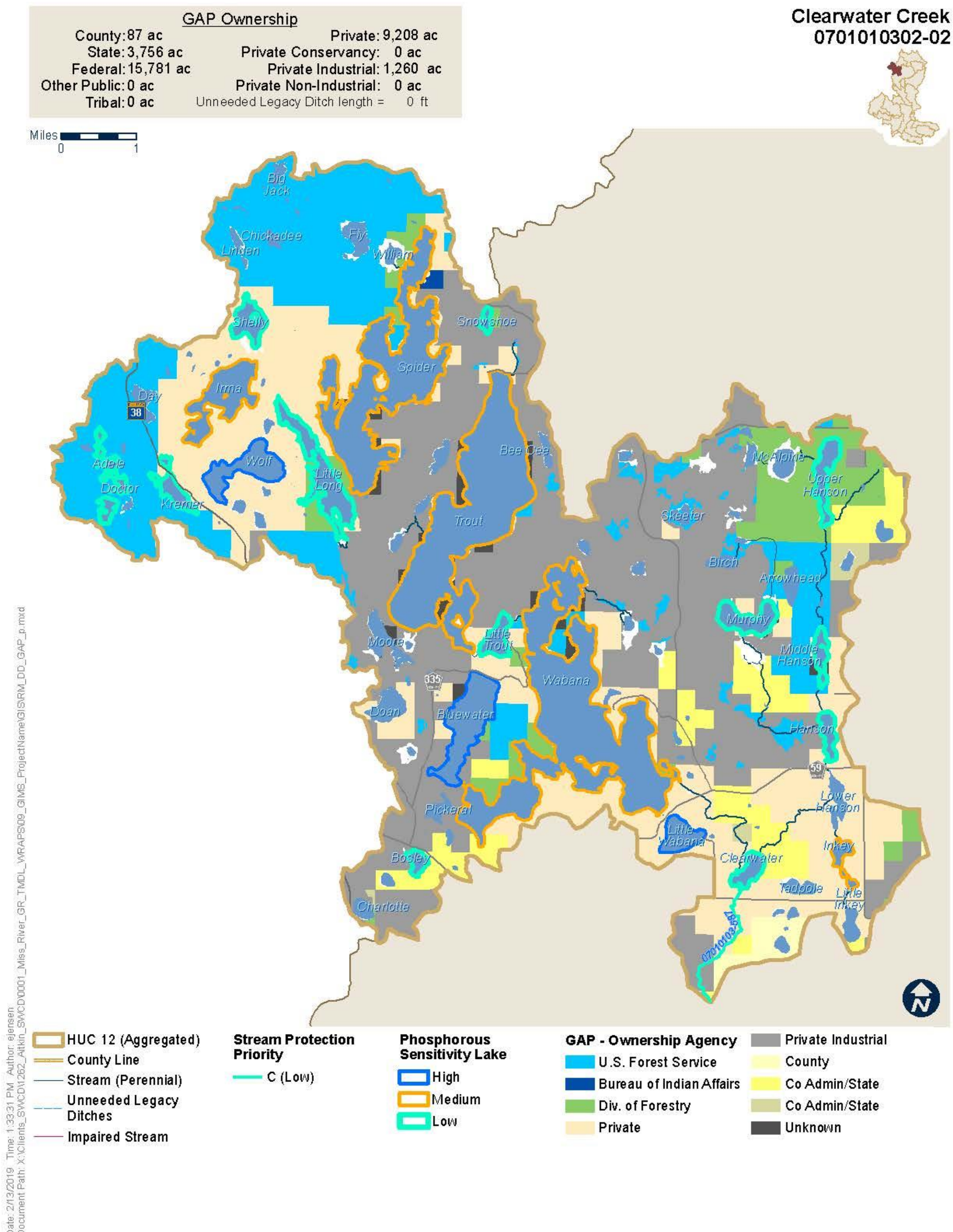


Table 23. Strategies and actions proposed for Clearwater Creek (0701010302-02) Aggregated HUC 12 subwatershed.

Agg HUC 12 Rank	Agg HUC 12	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets.					Governmental Units with Primary Responsibility									Estimated Year to Achieve Water Quality Target
									Estimated Adoption Rate													
		Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction		Specific implementation strategy	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	BWSR	SWCD	NRCS	MPCA	Cities	County	DNR	Landowners	Non-Profit/ Lk. Assoc.	
Medium	Clearwater Creek (0701010302-02)	**Wabana Lake (31-0392-00)**	**Itasca**	**Phosphorus (TP)**	10 ppb TP June-Sept Avg	Maintain or improve existing water quality	Improve shoreline management	Outreach regarding shoreline protection/ management with Lake Association	N/A	Send out educational shoreline management materials to shoreline owners	100%	% of shorelines with sufficient buffers installed		•					•	•	•	2040
		Spider Lake (31-0538-00)	**Itasca**	**Phosphorus (TP)**	11 ppb TP June-Sept Avg	Maintain or improve existing water quality	Improve shoreline management	Outreach regarding shoreline protection/ management with Lake Association	N/A	Send out educational shoreline management materials to shoreline owners	100%	% of shorelines with sufficient buffers installed		•					•	•	•	2040
		Bluewater Lake (31-0395-00)	**Itasca**	**Phosphorus (TP)**	8 ppb TP June-Sept Avg	Maintain or improve existing water quality	Improve shoreline management	Outreach regarding shoreline protection/ management with Lake Association	N/A	Send out educational shoreline management materials to shoreline owners	100%	% of shorelines with sufficient buffers installed		•					•	•	•	2040
		All	**Itasca**	N/A	N/A	Maintain or improve existing water quality	Improve shoreline management	Shoreline conservation easements on Private Forest	N/A	Send out educational shoreline management materials to shoreline owners	100%	% of shorelines with sufficient buffers installed		•					•	•	•	2040
							Improve forestry management	Forest Protection Programs (Table 15 in Section 3.3.1)	60%	75%	>75%	% of watershed in protected public lands	•	•	•		•	•				2030

Lower Prairie River (02-01)

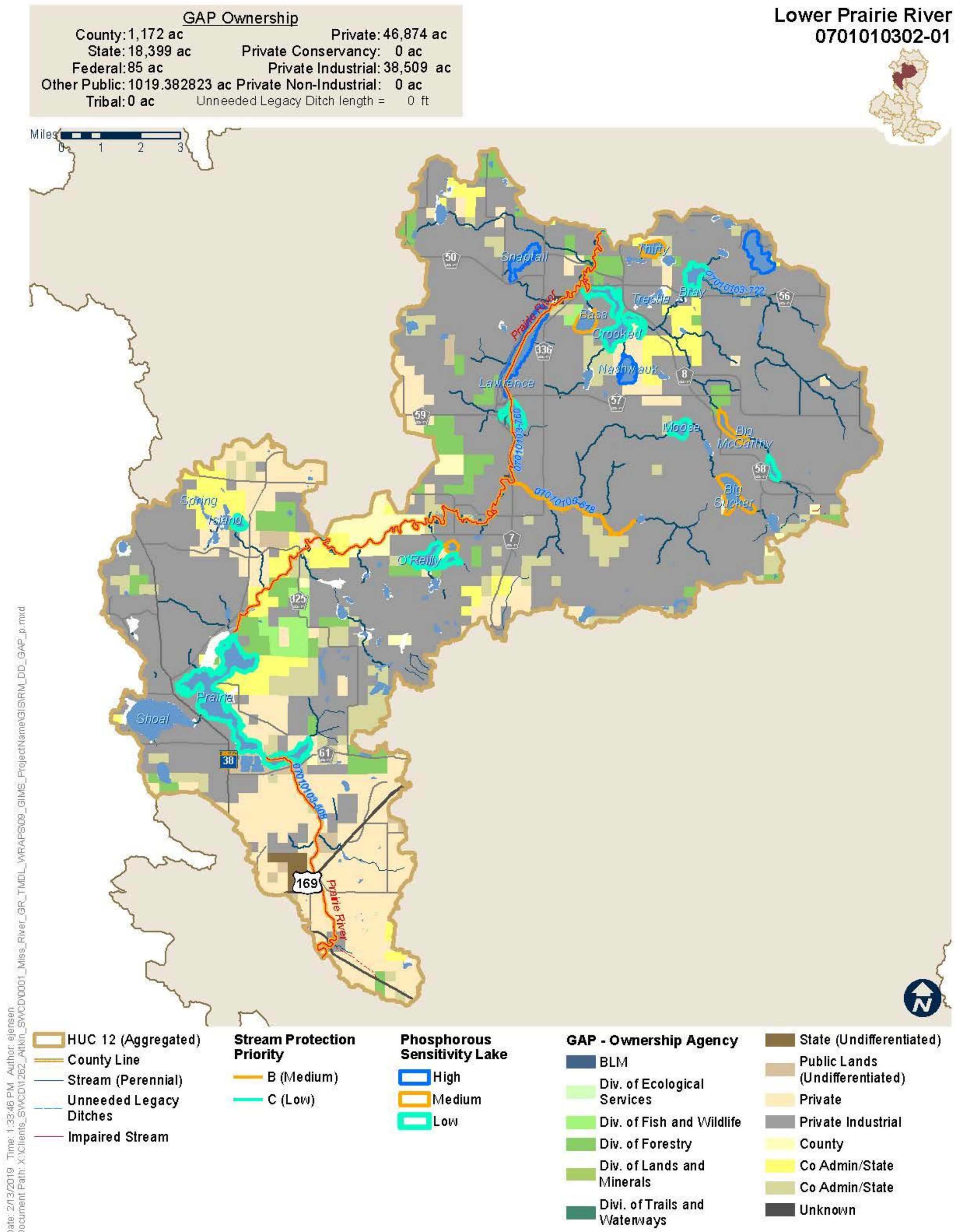


Table 24. Strategies and actions proposed for Lower Prairie River (0701010302-01) Aggregated HUC 12 subwatershed.

Agg HUC 12 Rank	Agg HUC 12	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets.					Governmental Units with Primary Responsibility									Estimated Year to Achieve Water Quality Target
		Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction		Specific implementation strategy	Estimated Adoption Rate: Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	BWSR	SWCD	NRCS	MPCA	Cities	County	DNR	Landowners	Non-Profit/ Lk. Assoc.	
Medium	Lower Prairie River (0701010302-01)	**Prairie River (07010103-541)**	**Itasca**	***E. coli***	23 - 187 cfu/100 mL seasonal geomean	126 cfu/100 mL seasonal geomean	Improve livestock and manure management	Livestock exclusion from stream	13,500 sq. ft. fence and buffer installed in 2018	Increase exclusion area by at-least 10,000 sq. ft.	Increase exclusion area by at-least 20,000 sq. ft.	Exclusion Area (Sq. Ft)		•				•		•		2030
							Monitoring	Microbial Source Tracking to identify fecal contamination sources	N/A	Conduct Microbial Source Tracking before project implementation	*E.coli* sources identified on impaired streams	*E.coli* source assessment report identifies sources to impaired streams		•		•						2025
		Trib to Bray Lake (07010103-722)	**Itasca**	**Fish IBI**	Fish IBI = 18.5, 31.4	Fish IBI > 35	Fisheries Management	Trout stocking	DNR has not managed this stream for trout	Preserve existing in-stream habitat	Maintain viable trout fishery through stocking.	N/A							•			2030
		Bray Lake (31-0147-00)	**Itasca**	**Phosphorus (TP)**	14 ppb TP June-Sept Avg	Maintain or improve existing water quality	Improve forestry management	Forest Protection Programs (Table 15 in Section 3.3.1)	40-60%	75%	>75%	% of watershed in protected public lands	•	•	•		•	•				2030
		Tullibee Lakes (various)	**Itasca**	**Phosphorus (TP)**	Fully supporting of aquatic recreation use	Maintain or improve existing water quality	Improve forestry management	Forest Protection Programs (Table 15 in Section 3.3.1)	N/A	75%	>75%	% of watershed in protected public lands	•	•	•		•	•				2030
							Improve riparian vegetation	Riparian buffer establishment	N/A	90%	100%	% of riparian buffers with adequate buffer		•				•		•		2035

Upper Swan River (04-02)

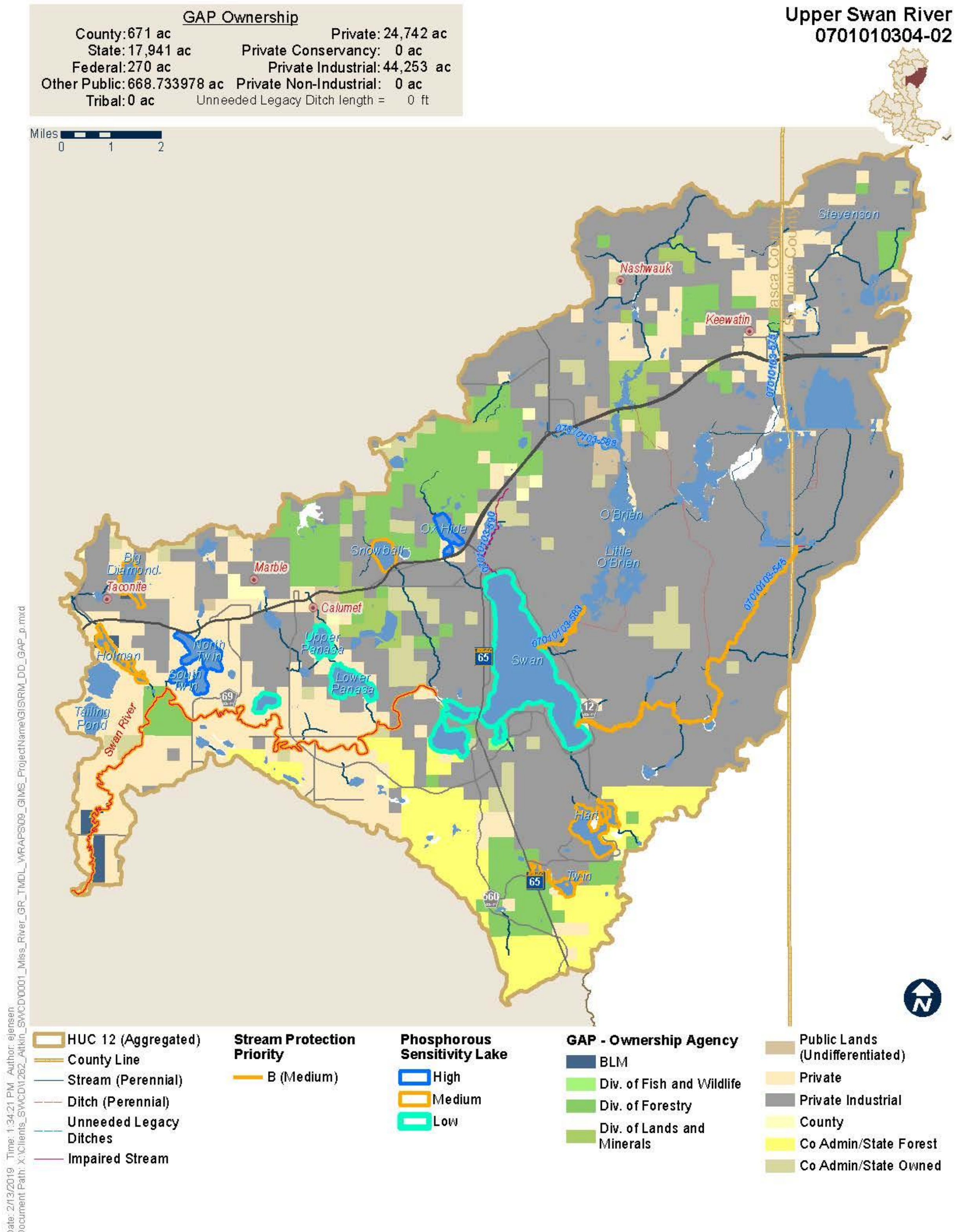


Table 25. Strategies and actions proposed for Upper Swan River (0701010304-02) Aggregated HUC 12 subwatershed.

Agg HUC 12 Rank	Agg HUC 12	Waterbody and Location: Waterbody (ID)	Waterbody and Location: Location and Upstream Influence Counties	Parameter (incl. non-pollutant stressors)	Water Quality: Current Conditions (load or concentration)	Water Quality: Goals / Targets and Estimated % Reduction	Strategy Type (see key below)	Specific implementation strategy	Estimated Adoption Rate: Current strategy adoption level, if known	Estimated Adoption Rate: Interim 10-year Milestone	Estimated Adoption Rate: Suggested Goal	Estimated Adoption Rate: Units	BWSR	SWCD	NRCS	MPCA	Cities	County	DNR	Landowners	Non-Profit/ Lk. Assoc.	Estimated Year to Achieve Water Quality Target
Medium	Upper Swan River (0701010304-02)	**Swan River (07010103-753)**	Itasca	*E. coli*	Monthly geomeans ranged from 40-175 cfu/100 mL with samples collected during July exhibiting the highest monthly geomean	126 cfu/100 mL seasonal geomean	Improve livestock and manure management	Horse exclusion from river	N/A	Increase exclusion area by at-least 250 sq. ft.	Increase exclusion area by at-least 500 sq. ft.	Exclusion Area (Sq. Ft)		•	•			•		•		2025
							Monitoring	Microbial Source Tracking to identify fecal contamination sources	N/A	Conduct Microbial Source Tracking before project implementation	*E.coli* sources identified on impaired streams	*E.coli* source assessment report identifies sources to impaired streams		•		•						2025
							Improve Riparian Vegetation	Riparian buffers	70%	90%	100%	% of riparian buffers with adequate buffer		•				•		•		2025
							Address failing septics	Septic system inspections and maintenance education	N/A	Convert 75%	Convert 100% and maintain compliance	% of noncompliant systems				•		•		•		2040
		Pickerel Creek (07010103-590)	Itasca	**Fish IBI Invert IBI**	Fish IBI = 17.2, 37.3 Invert IBI = 25.1, 16.6, 21.9	Fish IBI > 35 Invert IBI > 32	Wildlife Management	Beaver dam management	N/A	100%	100%	% of beaver dams eliminated					•	•		•		2025
		Hill Annex Pit (31-1328-02)	Itasca	**Hydrology**	N/A	N/A	WQ Monitoring	Hill Annex GW inflow monitoring, Mesabi Mining Board	N/A	Conduct groundwater level and WQ monitoring	Share data for decision making on future groundwater management	N/A		•						•		2040
		Swan Lake (31-0067-00)	Itasca	**Phosphorus (TP)**	20 ppb TP June-Sept Avg	Maintain or improve existing water quality	Aquatic Invasive Species Management	Aquatic invasive species management (curly leaf pond weed)	15%	Reduce existing coverage by 80%	Reduce existing coverage by 90%	Curly-leaf pondweed coverage		•					•	•	•	2025
							Improve forestry management	Forest Protection Programs (Table 15 in Section 3.3.1)	>80%	75%	>75%	% of watershed in protected public lands	•	•	•		•	•				2030
							Improve riparian vegetation	Riparian buffer establishment	Score the shore survey scores slightly below the statewide avg.	90%	100%	% of riparian buffers with adequate buffer		•				•		•		2035

Agg HUC 12 Rank	Agg HUC 12	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets.					Governmental Units with Primary Responsibility									Estimated Year to Achieve Water Quality Target
		Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction		Specific implementation strategy	Estimated Adoption Rate: Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	BWSR	SWCD	NRCS	MPCA	Cities	County	DNR	Landowners	Non-Profit/ Lk. Assoc.	
		Twin Lake (31-0026-00)	**Itasca**	**Phosphorus (TP)**	Fully supporting of aquatic recreation use	Maintain or improve existing water quality	Aquatic Invasive Species Management	Reduce aquatic invasive species, restore native species	N/A	Reduce existing coverage by 80%	Reduce existing coverage by 90%	Eurasian watermilfoil coverage		•					•	•	•	2025
		Hay Creek (07010103-545)	**Itasca, St. Louis**	**All**	Fully supporting of aquatic life	Maintain or improve existing water quality	Improve Riparian Vegetation	Vegetation management possibly as an add on requirement for future mining permits	40-60%	90%	100%	% of riparian buffers with adequate buffer		•				•		•		2025
							WQ Monitoring	Hay Creek	N/A	Conduct WQ monitoring	Share data for decision making on future groundwater management	N/A		•						•		2025
							Reduce upland erosion	ATV trail management	N/A	Assess all-terrain vehicle (ATV) traffic as a source of erosion.	25% reduction	TSS load reduction from streambank erosion	•	•	•		•	•	•	•	•	Ongoing
		O'Brien Creek (07010103-583)	**Itasca, St. Louis**	**All**	Fully supporting of aquatic life	Maintain or improve existing water quality	Improve Riparian Vegetation	Vegetation management possibly as an add on requirement for future mining permits	40-60%	90%	100%	% of riparian buffers with adequate buffer		•				•		•		2025
							Reduce Municipal	WWTP Improvements (Nashwauk WWTP, Keewatin WWTP, Lone Pine and Greenway Twps)	N/A	Upgrades/expansion of existing WWTP as necessary to ensure compliance with effluent turbidity standards	No change in effluent turbidity conc.	N/A				•	•	•				Ongoing
							Reduce upland erosion	ATV trail management	N/A	Assess all-terrain vehicle (ATV) traffic as a source of erosion.	25% reduction	TSS load reduction from streambank erosion	•	•	•		•	•	•	•	•	Ongoing

Sandy River (06-02)

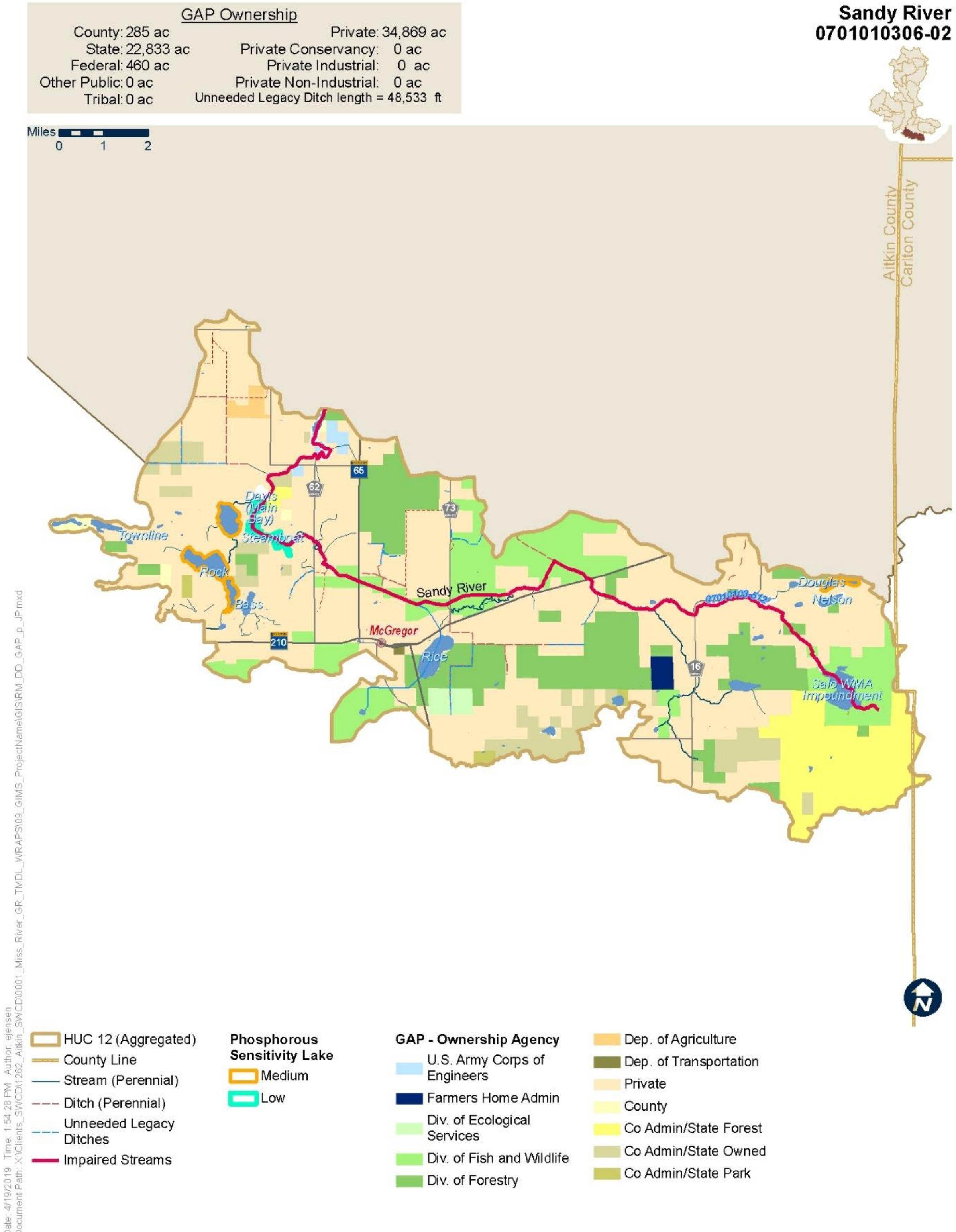


Table 26. Strategies and actions proposed for Sandy River (0701010301-01) Aggregated HUC 12 subwatershed.

Agg HUC 12 Rank	Agg HUC 12	Waterbody and Location: Waterbody (ID)	Waterbody and Location: Location and Upstream Influence Counties	Parameter (incl. non-pollutant stressors)	Water Quality: Current Conditions (load or concentration)	Water Quality: Goals / Targets and Estimated % Reduction	Strategy Type (see key below)	Specific implementation strategy	Estimated Adoption Rate: Current strategy adoption level, if known	Estimated Adoption Rate: Interim 10-year Milestone	Estimated Adoption Rate: Suggested Goal	Estimated Adoption Rate: Units	BWSR	SWCD	NRCS	MPCA	Cities	County	DNR	Landowners	Non-Profit/ Lk. Assoc.	Estimated Year to Achieve Water Quality Target
Medium	Sandy River (0701010301-01)	**Sandy River (07010103-512)**	**Aitkin**	**Fish IBI Invert IBI**	Fish IBI = 26.3 Invert IBI = 46.8, 50.0	Fish IBI > 47 Invert IBI > 51, 53	Altered hydrology (alterations in streamflow)	Nonfunctional ditch decommissioning	N/A	Feasibility studies on 100% of ditches	All feasible ditches decommissioned	% nonfunctional ditches decommissioned		•				•	•			2040
							Altered hydrology (alterations in streamflow)	Natural channel reconnection	N/A	50%	100%	% of natural stream channels restored/ ditches abandoned.		•	•	•	•	•				2040
							Improve upland/field surface runoff controls	Reduce watershed phosphorus loads by 5%	N/A	Develop plan to target and implement BMPs,	5%	TP load reduction	•	•					•			2040
							Improve Urban Stormwater Management	City of McGregor SW management Plan	N/A	Stormwater management plan with prioritized list of BMP locations	Implement at least one	High-priority stormwater BMPs implemented	•	•			•	•		•	•	2025
		Davis Lake (01-0071-01)	**Aitkin**	**Phosphorus (TP)**	65 ppb TP June-Sept Avg, Not assessed	<30 ppb TP June-Sept Avg	Improve Riparian Vegetation	Lakeshore buffers/vegetation	70%	90%	100%	% of Shoreline with adequate buffers	•	•			•	•	•	•	•	2035
							Monitoring	Engage citizen volunteers to conduct bimonthly monitoring of TP, Chl-a and Secchi depth during the open water season	Insufficient WQ data collected.	Collect 2 years of bi-monthly TP, Chl-a, and Secchi depth	Evaluate in-lake water quality to NLF WQ standard	N/A				•				•	•	2035
		Steamboat Lake (01-0071-02)	**Aitkin**	**Phosphorus (TP)**	80 ppb TP June-Sept Avg, Insufficient data for assessment	<30 ppb TP June-Sept Avg	Improve Riparian Vegetation	Lakeshore buffers/vegetation	70%	90%	100%	% of Shoreline with adequate buffers	•	•			•	•	•	•	•	2035
							Monitoring	Engage citizen volunteers to conduct bimonthly monitoring of TP, Chl-a and Secchi depth during the open water season	Insufficient WQ data collected.	Collect 2 years of bi-monthly TP, Chl-a, and Secchi depth	Evaluate in-lake water quality to NLF WQ standard	N/A				•				•	•	2035

Hill River (07-01)

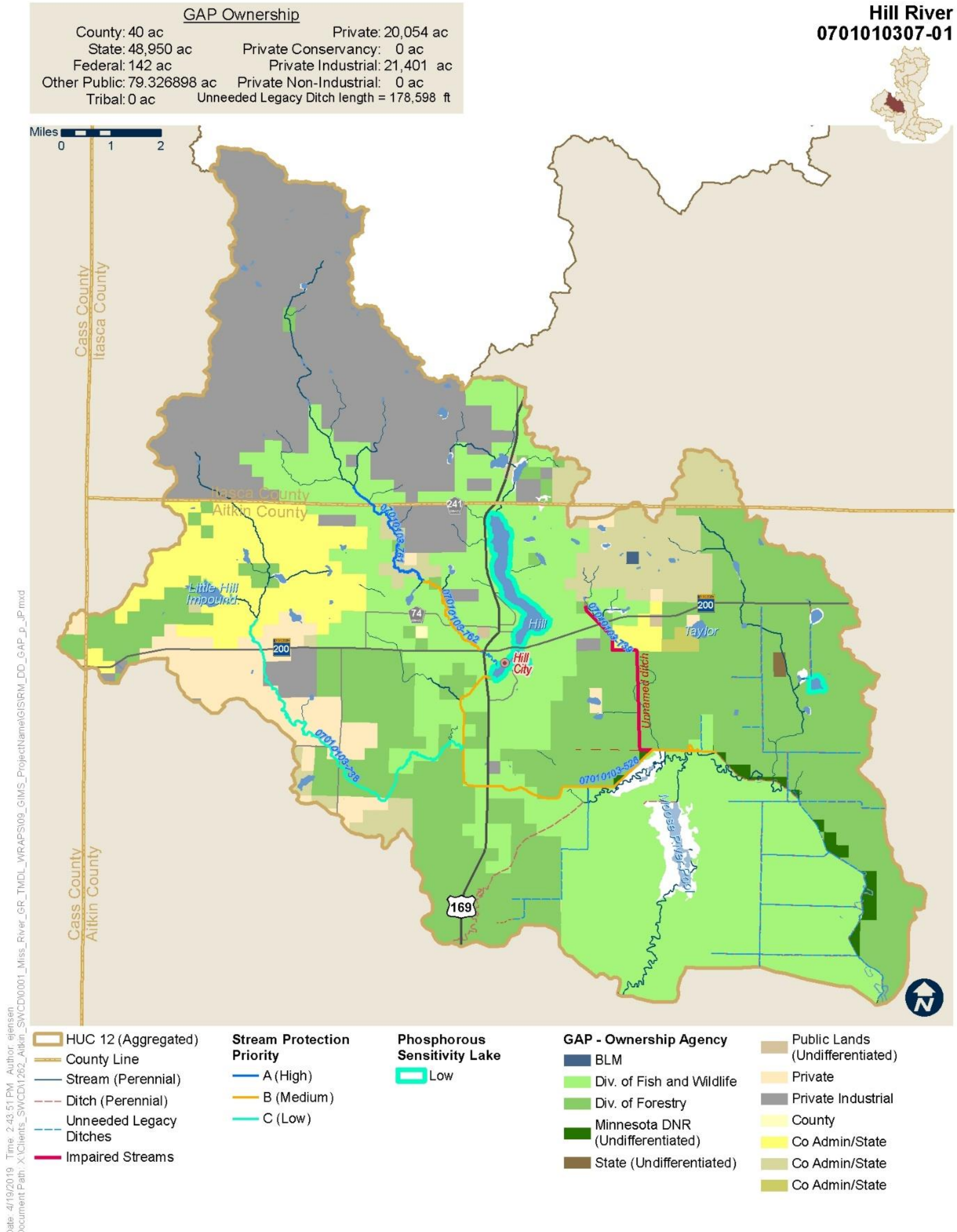


Table 27. Strategies and actions proposed for Hill River (0701010307-01) Aggregated HUC 12 subwatershed.

Agg HUC 12 Rank	Agg HUC 12	Waterbody and Location: Waterbody (ID)	Waterbody and Location: Location and Upstream Influence Counties	Parameter (incl. non-pollutant stressors)	Water Quality: Current Conditions (load or concentration)	Water Quality: Goals / Targets and Estimated % Reduction	Strategy Type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets: Specific implementation strategy	Estimated Adoption Rate: Current strategy adoption level, if known	Estimated Adoption Rate: Interim 10-year Milestone	Estimated Adoption Rate: Suggested Goal	Estimated Adoption Rate: Units	BWSR	SWCD	NRCS	MPCA	Cities	County	DNR	Landowners	Non-Profit/ Lk. Assoc.	Estimated Year to Achieve Water Quality Target
Medium	Hill River (0701010307-01)	**Unnamed Ditch (07010103-739)**	**Aitkin**	**Fish IBI**	Fish IBI = 15.9, 29.6	Fish IBI > 42	Protect/stabilize banks/bluffs	Ditch channel restoration	N/A	50%	100%	% of natural stream restored		•	•	•	•	•				2040
		Hill Lake (01-0142-00)	**Aiktin, Itasca**	**Phosphorus (TP)**	21 ppb TP June-Sept Avg	Maintain or improve existing water quality	Improve Urban Stormwater Management	Hill City SW management plan	N/A	Stormwater management plan with prioritized list of BMP locations	Implement at least one	High-priority stormwater BMPs implemented	•	•			•	•		•	•	2025
							Improve shoreline management	Lakeshore buffers/vegetation	70%	90%	100%	% of shoreline with adequate buffers	•	•			•	•	•	•	•	2035
							Land Management/Conservation	Protect springs along east side	N/A	Identify willing landowners needed to secure potential easements along east side of Lake	At least one conservation easement	Conservation easements secured adjacent to springs along east side of lake	•	•						•		2035
							Improve forestry management	Forest Protection Programs (Table 15 in Section 3.3.1)	60%	75%	>75%	% of watershed in protected public lands	•	•			•	•				2030
		Hill River (07010103-526	**Aitkin**	**All**	Fully supporting of aquatic life and aquatic recreation use	Maintain or improve existing water quality	Restore/enhance channel	Channel restoration	The Hill River/Willow River/Moose River (and several tributaries) near Hill City have many opportunities for both ditch abandonment/ wetland restoration and stream restoration	50%	100%	% of natural stream channels restored/ ditches abandoned	•	•	•	•	•	•		•		2040

Upper Willow River (08-02)

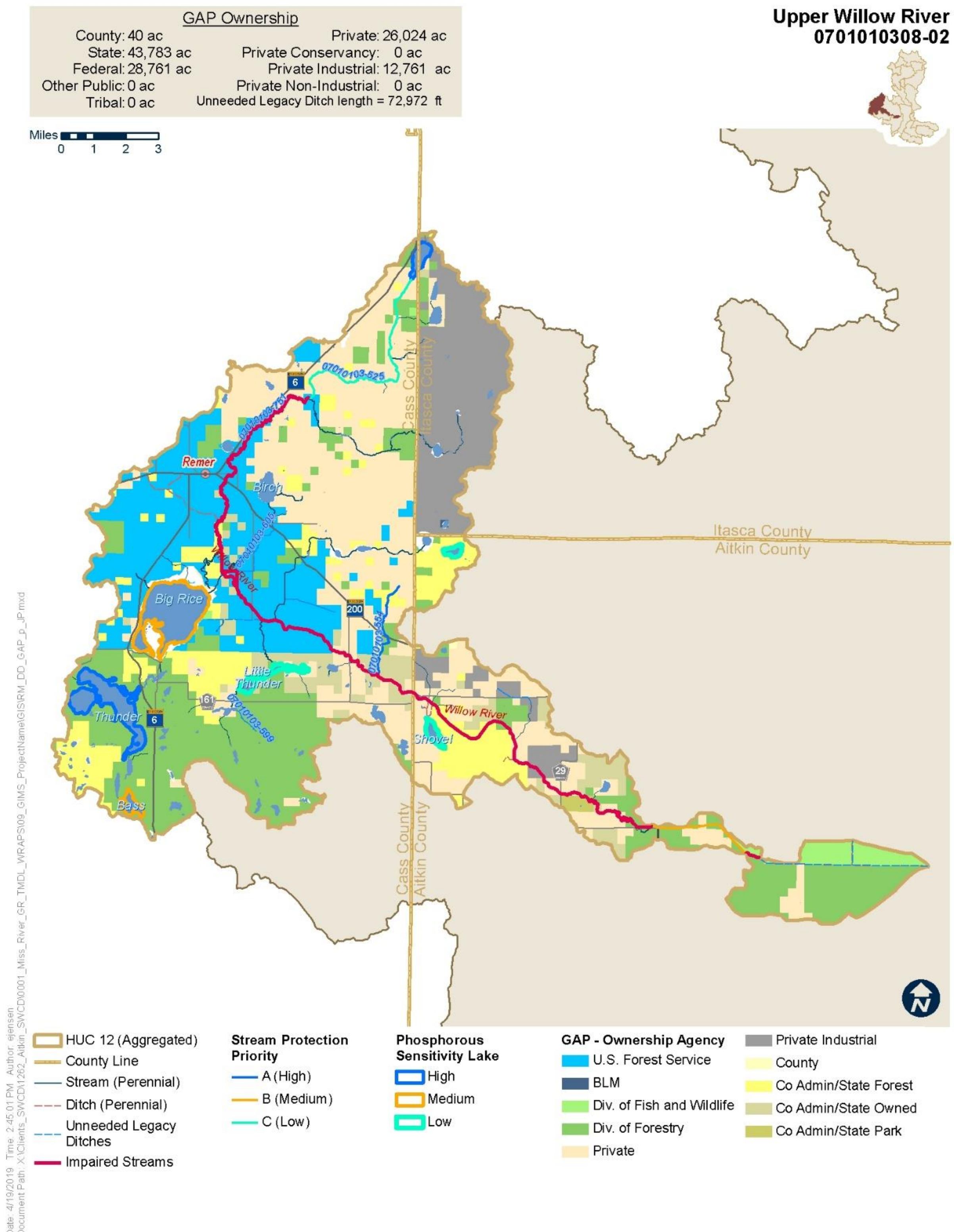


Table 28. Strategies and actions proposed for Upper Willow River (0701010308-02) Aggregated HUC 12 subwatershed.

Agg HUC 12 Rank	Agg HUC 12	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets.					Governmental Units with Primary Responsibility									Estimated Year to Achieve Water Quality Target
									Estimated Adoption Rate													
		Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction		Specific implementation strategy	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	BWSR	SWCD	NRCS	MPCA	Cities	County	DNR	Landowners	Non-Profit/ Lk. Assoc.	
Medium	Upper Willow River (0701010308-02)	**Willow River (07010103-751)**	**Cass, Aitkin**	***E. coli***	73 - 187 cfu/100 mL seasonal geomean	126 cfu/100 mL seasonal geomean	Improve Riparian Vegetation	Bank revegetation, Riparian buffers	N/A	Increase riparian buffers on sensitive shorelines by 20%	Increase riparian buffers on sensitive shorelines by at least 50%	Sensitive shoreline stream miles		●						●	●	2030
							Monitoring	Microbial Source Tracking to identify fecal contamination sources	N/A	Conduct Microbial Source Tracking before project implementation	*E.coli* sources identified on impaired streams	*E.coli* source assessment report identifies sources to impaired streams		●		●						2025
							Improve Urban Stormwater Management	Stormwater management in Remer	N/A	Stormwater management plan with prioritized list of BMP locations	At least one	High priority stormwater BMPs installed		●			●					2035
		Willow River Ditch (07010103-716)	**Cass, Aitkin**	**All**	Fully supporting of aquatic life and aquatic recreation use	Maintain or improve existing water quality	Restore/enhance channel	Channel restoration	The Willow River Ditch has many opportunities for both ditch abandonment/ wetland restoration and stream restoration	50%	100%	% of natural stream channels restored/ ditches abandoned.	●	●	●	●		●		●		2040

3.3.5 Low Priority Aggregated HUC 12 Strategies

Upper Prairie River (01-01)

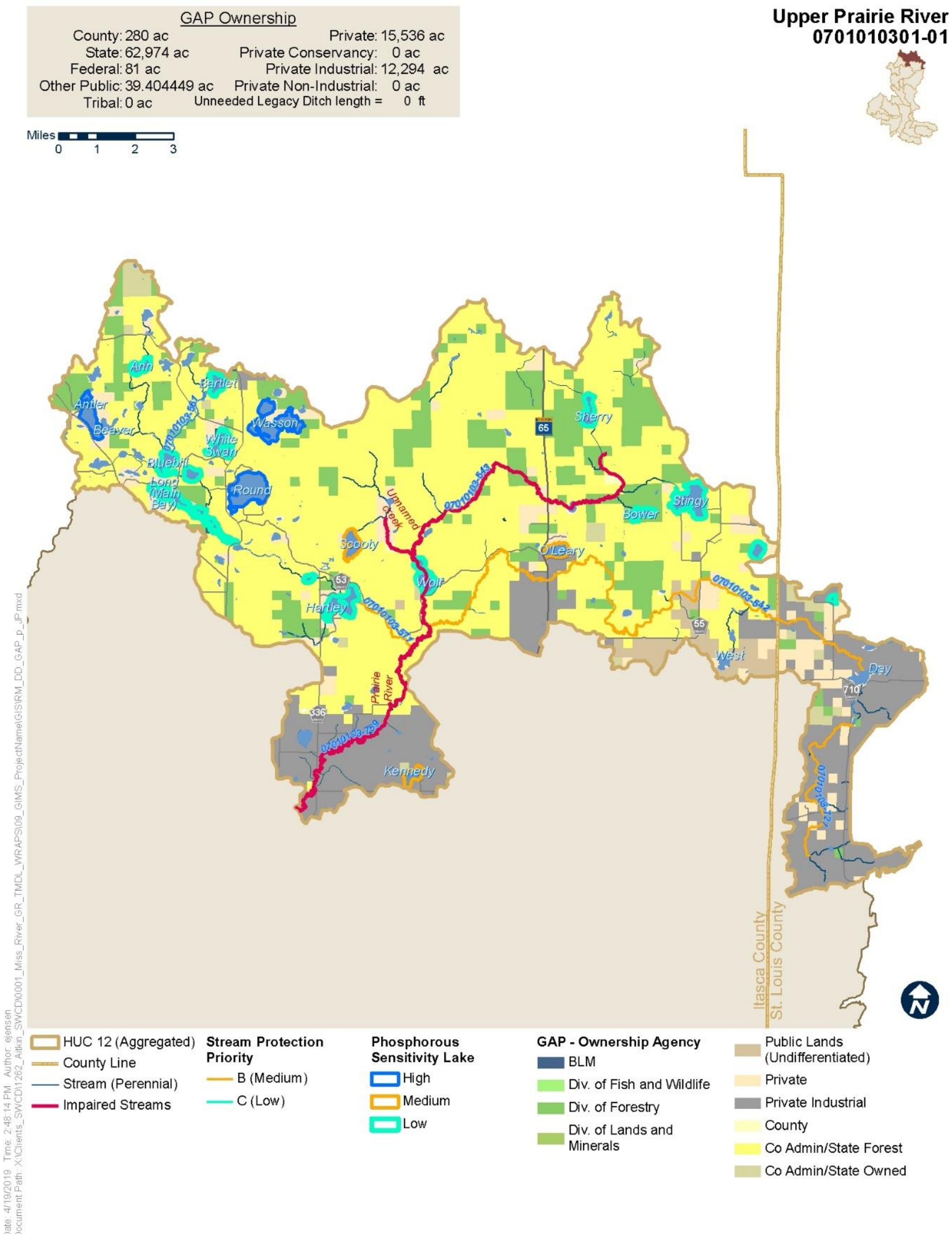


Table 29. Strategies and actions proposed for Upper Prairie River (0701010301-01) Aggregated HUC 12 subwatershed.

Agg HUC 12 Rank	Agg HUC 12	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets.					Governmental Units with Primary Responsibility									Estimated Year to Achieve Water Quality Target
								Specific implementation strategy	Estimated Adoption Rate													
		Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction			Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	BWSR	SWCD	NRCS	MPCA	Cities	County	DNR	Landowners	Non-Profit/ Lk. Assoc.	
Low	Upper Prairie River (0701010301-01)	**Unnamed Creek (07010103-717)**	**Itasca**	**Fish IBI**	Fish IBI = 25.2, 34.1	Fish IBI > 42	WQ Monitoring	Conduct additional WQ monitoring to verify impairment is due to natural background conditions	N/A	Conduct WQ monitoring	Share data for decision making on future groundwater management	N/A				•						2025
		Deer Creek (07010103-721)	**St. Louis**	**N/A**	Fully supporting of aquatic life	Maintain or improve existing water quality	Improve forestry management	Forest Protection Programs (Table 15 in Section 3.3.1)	60-75%	75%	>75%	% of watershed in protected public lands	•	•			•	•				2030
		Prairie River West Fork (-571)	**Itasca**	**N/A**	Fully supporting of aquatic life	Maintain or improve existing water quality	Improve forestry management	Forest Protection Programs (Table 15 in Section 3.3.1)	60-75%	75%	>75%	% of watershed in protected public lands	•	•			•	•				2030
		Hartley Lake (31-0154-00)	**Itasca**	**Phosphorus (TP)**	12 ppb TP June-Sept Avg	Maintain or improve existing water quality	Improve shoreline management	Re-vegetate clear cut banks	70%	90%	100%	% of clear cut nearshore areas revegetated with adequate buffers		•				•		•		2035

East River (01-02)

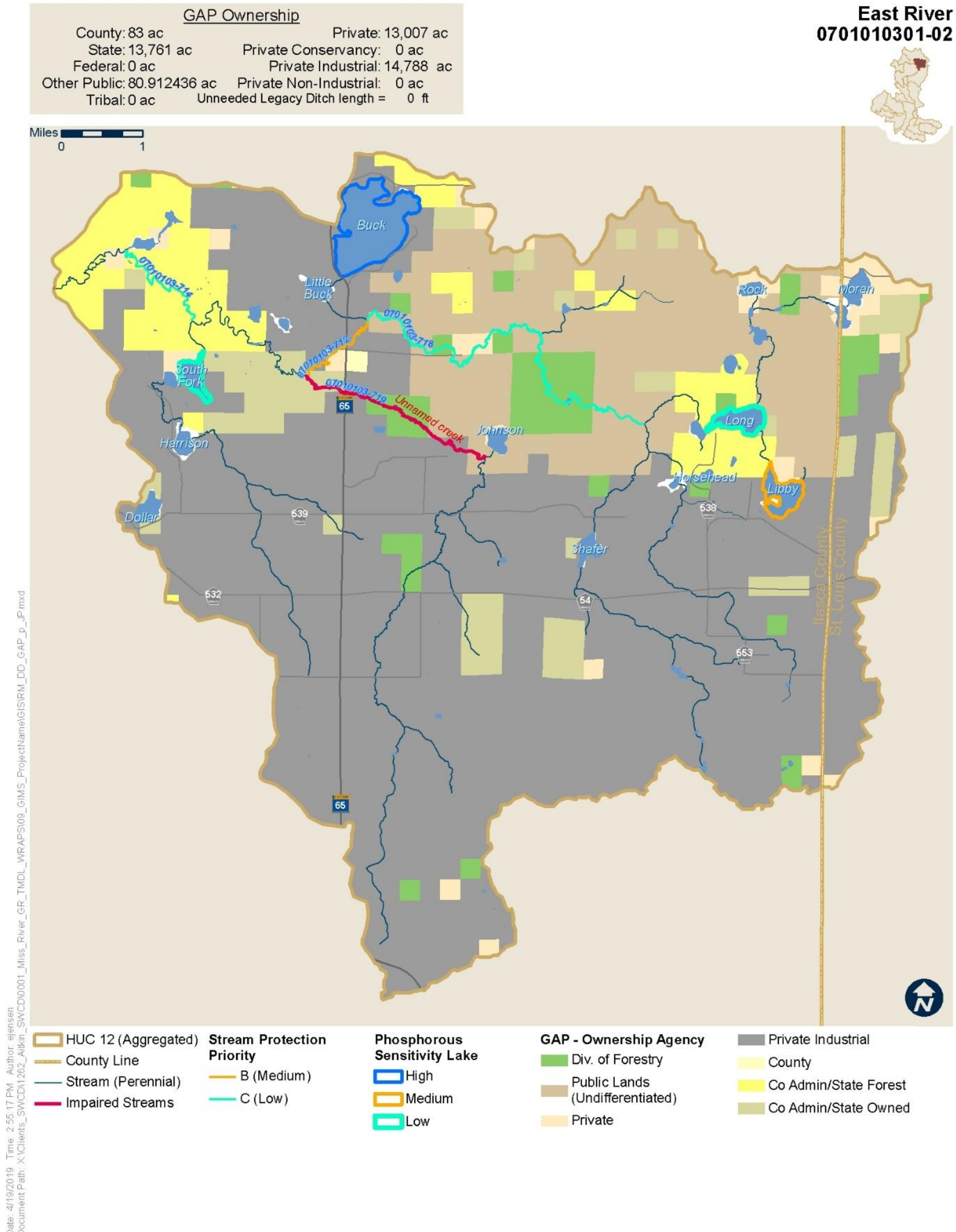


Table 30. Strategies and actions proposed for East River (0701010301-02) Aggregated HUC 12 subwatershed.

Agg HUC 12 Rank	Agg HUC 12	Waterbody and Location: Waterbody (ID)	Waterbody and Location: Location and Upstream Influence Counties	Parameter (incl. non-pollutant stressors)	Water Quality: Current Conditions (load or concentration)	Water Quality: Goals / Targets and Estimated % Reduction	Strategy Type (see key below)	Specific implementation strategy	Estimated Adoption Rate: Current strategy adoption level, if known	Estimated Adoption Rate: Interim 10-year Milestone	Estimated Adoption Rate: Suggested Goal	Estimated Adoption Rate: Units % of watershed area	BWSR	SWCD	NRCS	MPCA	Cities	County	DNR	Landowners	Non-Profit/ Lk. Assoc.	Estimated Year to Achieve Water Quality Target
Low	East River (0701010301-02)	**Unnamed Creek (-719)**	**Itasca**	**Invert IBI**	Invert IBI = 34.18	MIBI > 51	WQ Monitoring	Conduct additional WQ monitoring to verify impairment is due to natural background conditions	N/A	Conduct WQ monitoring	Share data for decision making on future groundwater management	N/A				•						2025
		Buck Lake (31-0069-00)	**Itasca**	**Phosphorus (TP)**	17 ppb TP June-Sept Avg	Maintain or improve existing water quality	Address failing septics	Septic system inspections and maintenance education	N/A	Convert 75%	Convert 100% and maintain compliance	% of noncompliant systems				•		•		•		2040

Prairie River (05-01)

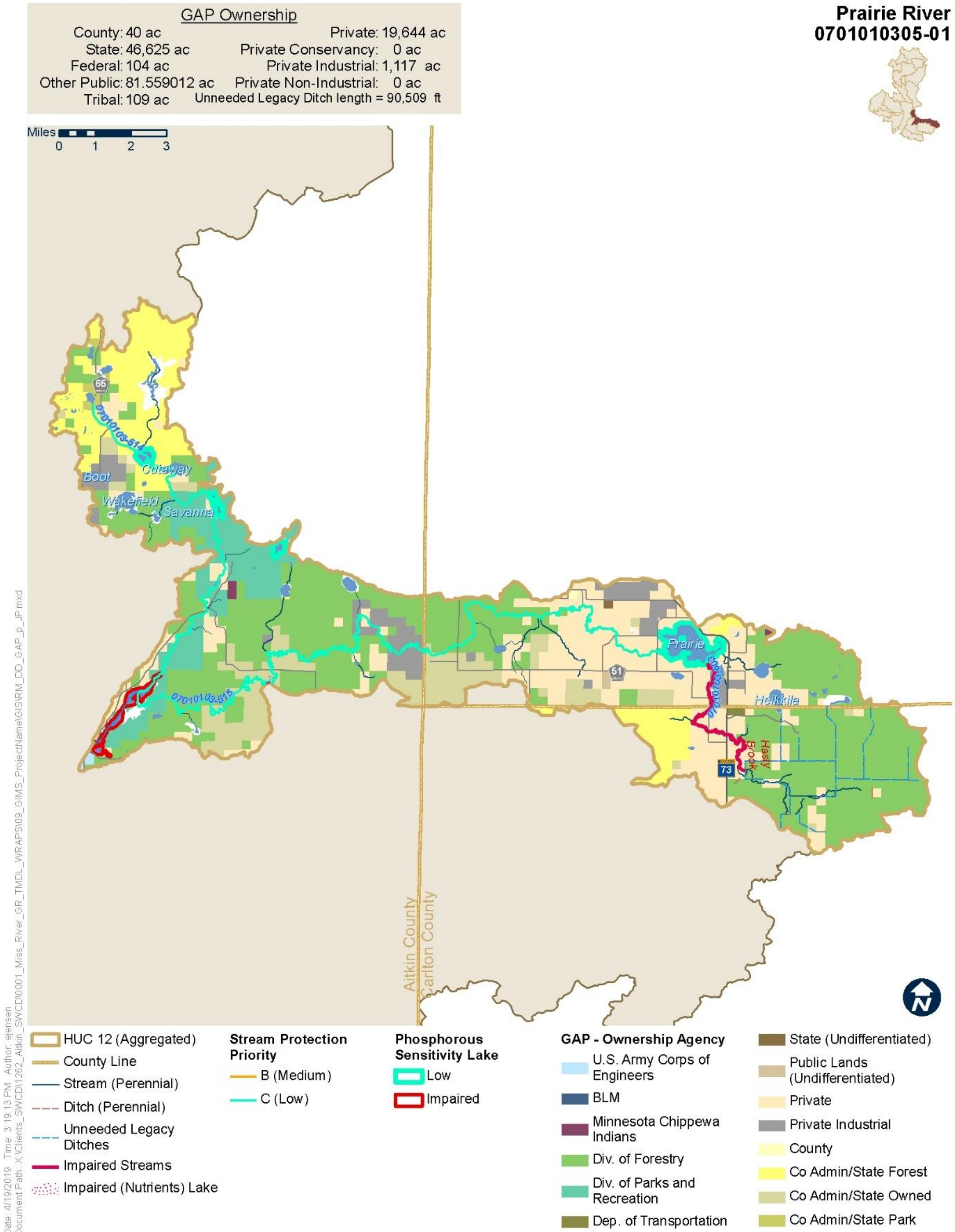


Table 31. Strategies and actions proposed for Prairie River (0701010305-01) Aggregated HUC 12 subwatershed.

Agg HUC 12 Rank	Agg HUC 12	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets.					Governmental Units with Primary Responsibility									Estimated Year to Achieve Water Quality Target
									Estimated Adoption Rate													
		Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction		Specific implementation strategy	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	BWSR	SWCD	NRCS	MPCA	Cities	County	DNR	Landowners	Non-Profit/ Lk. Assoc.	
Low	Prairie River (0701010305-01)	**Hasty Brook (07010103-603)**	**Carlton, St. Louis**	***E. coli***	109 - 292 cfu/100 mL seasonal geomean	126 cfu/100 mL seasonal geomean	Monitoring	Microbial Source Tracking to identify fecal contamination sources	N/A	Conduct Microbial Source Tracking before project implementation	*E.coli* sources identified on impaired streams	*E.coli* source assessment report identifies sources to impaired streams		•		•						2025
							Altered hydrology (alterations in streamflow)	Nonfunctional ditch decommissioning	N/A	Feasibility studies on 100% of ditches	All feasible ditches decommissioned	% nonfunctional ditches decommissioned		•				•	•			2040
							Improve livestock and manure management	Livestock exclusion from stream	N/A	Increase exclusion area by at-least 5,000 sq. ft.	Increase exclusion area by at-least 10,000 sq. ft.	Exclusion Area (Sq. Ft)		•				•		•		2030
							Address failing septics	Septic system inspections and maintenance education	N/A	Convert 75%	Convert 100% and maintain compliance	% of noncompliant systems				•		•		•		2040
							Improve Riparian Vegetation	Bank revegetation, Riparian buffers	N/A	Increase riparian buffers on sensitive shorelines by 20%	Increase riparian buffers on sensitive shorelines by at least 50%	Sensitive shoreline stream miles		•						•	•	2030
		Prairie Lake (69-0848-00)	**St. Louis, Carlton**	**Phosphorus (TP)**	Growing Season TP. Conc 27.0 ppb	Maintain or improve existing water quality	Improve shoreline management	Outreach regarding shoreline protection/ management with Lake Association	N/A	Send out educational shoreline management materials to shoreline owners	100%	% of shorelines with sufficient buffers installed		•					•	•	•	2040
							Wildlife Management	Beaver dam management	N/A	100%	100%	% of beaver dams eliminated					•	•		•		2025
		Savanna Lake (01-0014-00)	**Aitkin**	**Phosphorus (TP)**	Growing Season TP. Conc 31.5 ppb	Maintain or improve existing water quality	WQ Monitoring	Conduct additional WQ	Impaired due to natural causes	Develop site specific standard	Share data for decision making on future lake management	N/A				•						2025

Lower Willow River (08-01)

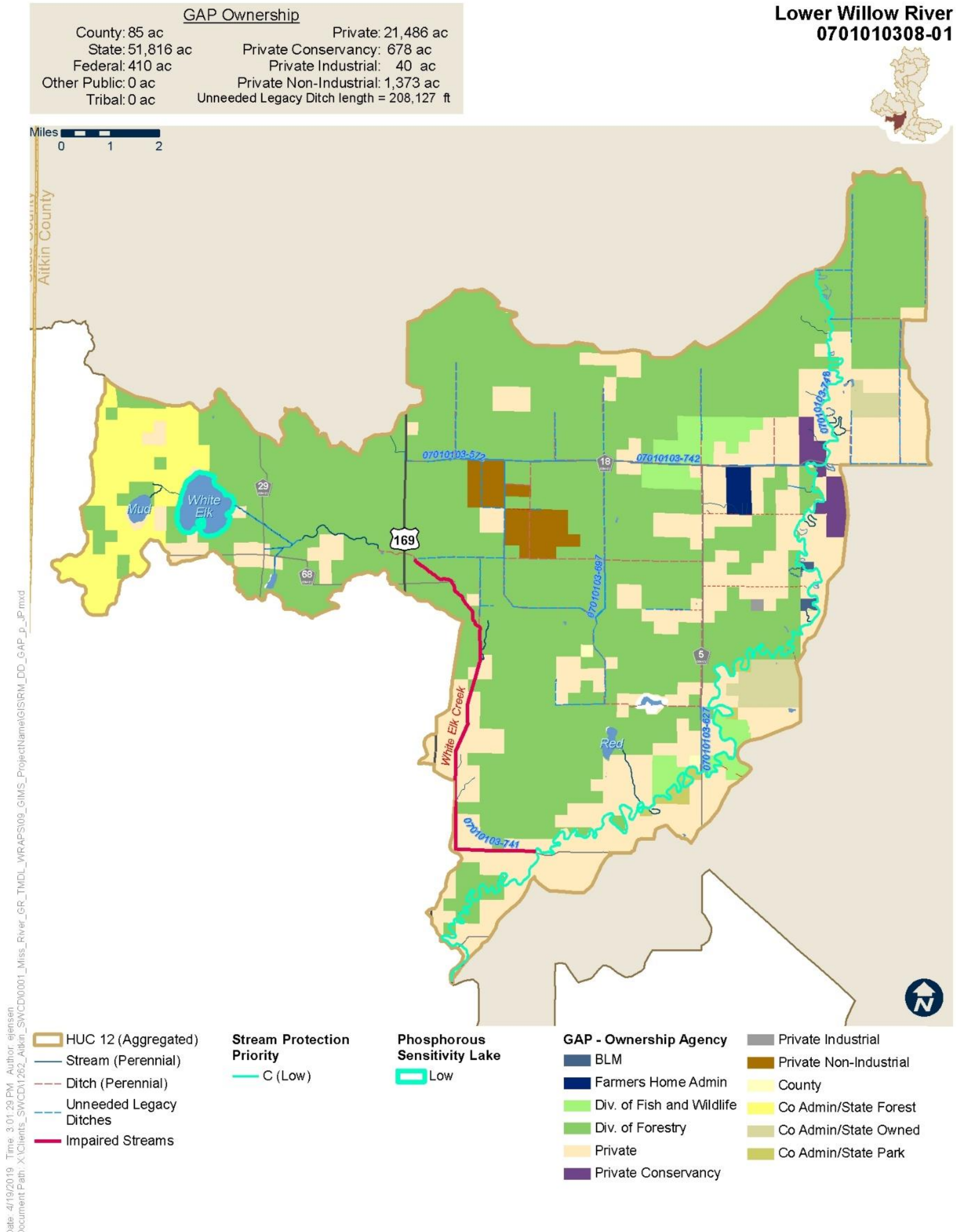


Table 32. Strategies and actions proposed for Lower Willow River (0701010308-01) Aggregated HUC 12 subwatershed.

Agg HUC 12 Rank	Agg HUC 12	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets.					Governmental Units with Primary Responsibility									Estimated Year to Achieve Water Quality Target
								Specific implementation strategy	Estimated Adoption Rate													
		Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction			Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	**Units** % of watershed area	BWSR	SWCD	NRCS	MPCA	Cities	County	DNR	Landowners	Non-Profit/ Lk. Assoc.	
Low	Lower Willow River (0701010308-01)	**White Elk Creek (07010103-741)**	**Aitkin**	**Fish IBI**	Fish IBI = 0, 30	Fish IBI > 42	Altered hydrology (alterations in streamflow)	Nonfunctional ditch decommissioning	N/A	Feasibility studies on 100% of ditches	All feasible ditches decommissioned	% nonfunctional ditches decommissioned		•				•	•			2040

Moose River (08-03)

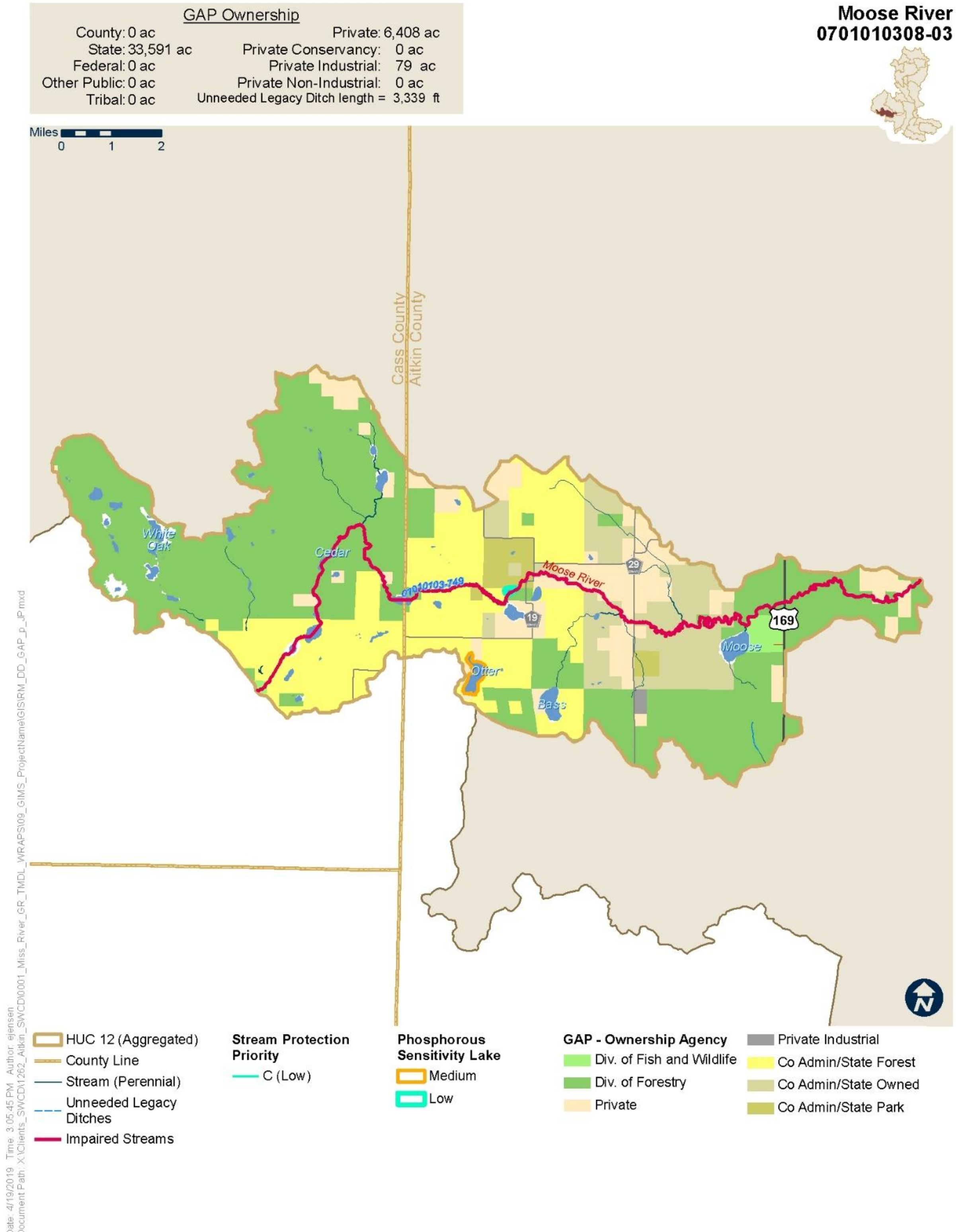


Table 33. Strategies and actions proposed for Moose River (0701010308-03) Aggregated HUC 12 subwatershed.

Agg HUC 12 Rank	Agg HUC 12	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategy Type (see key below)	Strategy scenario showing estimated scale of adoption to meet 10 yr milestone and final water quality targets.					Governmental Units with Primary Responsibility									Estimated Year to Achieve Water Quality Target
									Estimated Adoption Rate													
		Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions (load or concentration)	Goals / Targets and Estimated % Reduction		Specific implementation strategy	Current strategy adoption level, if known	Interim 10-year Milestone	Suggested Goal	Units	BWSR	SWCD	NRCS	MPCA	Cities	County	DNR	Landowners	Non-Profit/ Lk. Assoc.	
Low	Moose River (0701010308-03)	**Moose River (07010103-749)**	**Cass, Aitkin**	**Dissolved Oxygen (D.O.)**	Chronically low concentrations of D.O	Maintain or improve existing water quality	WQ Monitoring	Conduct additional WQ	Impaired due to natural causes	Develop site specific standard	Share data for decision making on future stream management	N/A				•						2025

Table 34: Key for strategies column

Parameter (include non-pollutant stressors)	Strategy key	
	Description	**Example BMPs/actions**
Total Suspended Solids (TSS)	**Improve upland/field surface runoff controls:** Soil and water conservation practices that reduce soil erosion and field runoff, or otherwise minimize sediment from leaving farmland.	Cover crops
		Water and sediment basins, terraces
		Rotations including perennials
		Conservation cover easements
		Grassed waterways
		Strategies to reduce flow – some of flow reduction strategies should be targeted to ravine subwatersheds
		Residue management – conservation tillage
		Forage and biomass planting
		Open tile inlet controls – riser pipes, french drains
		Contour farming
		Field edge buffers, borders, windbreaks and/or filter strips
		Stripcropping
	Protect/stabilize banks/bluffs: Reduce collapse of bluffs and erosion of streambank by reducing peak river flows and using vegetation to stabilize these areas.	Strategies for altered hydrology (reducing peak flow)
		Streambank stabilization
		Riparian forest buffer
		Livestock exclusion – controlled stream crossings
	Stabilize ravines: Reducing erosion of ravines by dispersing and infiltrating field runoff and increasing vegetative cover near ravines. Also may include earthwork/regrading and revegetation of ravine.	Field edge buffers, borders, windbreaks and/or filter strips
		Contour farming and contour buffer strips
		Diversions
		Water and sediment control basin
		Terrace
		Conservation crop rotation
		Cover crop
		Residue management – conservation tillage
	Stream channel restoration	Addressing road crossings (direct erosion) and floodplain cut-offs
		Clear water discharge: urban areas, ag tiling etc. – direct energy dissipation

Parameter (include non-pollutant stressors)	Strategy key	
	Description	**Example BMPs/actions**
		Two-stage ditches
		Large-scale restoration – channel dimensions match current hydrology and sediment loads, connect the floodplain, stable pattern, (natural channel design principals)
		Stream channel restoration using vertical energy dissipation: step pool morphology
	Improve forestry management	Proper water crossings and road construction
		Forest roads - cross-drainage
		Maintaining and aligning active forest roads
		Closure of inactive roads and post-harvest
		Location and sizing of landings
		Riparian Management Zone Widths and/or filter strips
	Improve urban stormwater management [to reduce sediment and flow]	See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs
Nitrogen (TN) or Nitrate	**Increase fertilizer and manure efficiency:** Adding fertilizer and manure additions at rates and ways that maximize crop uptake while minimizing leaching losses to waters	Nitrogen rates at maximum return to nitrogen (U of MN rec's)
		Timing of application closer to crop use (spring or split applications)
		Nitrification inhibitors
		Manure application based on nutrient testing, calibrated equipment, recommended rates, etc.
	Store and treat tile drainage waters: Managing tile drainage waters so that nitrate can be denitrified or so that water volumes and loads from tile drains are reduced	Saturated buffers
		Restored or constructed wetlands
		Controlled drainage
		Woodchip bioreactors
		Two-stage ditch
	Increase vegetative cover/root duration: Planting crops and vegetation that maximize vegetative cover and capturing of soil nitrate by roots during the spring, summer and fall.	Conservation cover (easements/buffers of native grass and trees, pollinator habitat)
		Perennials grown on marginal lands and riparian lands
		Cover crops
		Rotations that include perennials
		Crop conversion to low nutrient-demanding crops (e.g., hay).

Parameter (include non-pollutant stressors)	Strategy key	
	Description	**Example BMPs/actions**
Phosphorus (TP)	**Improve upland/field surface runoff controls:** Soil and water conservation practices that reduce soil erosion and field runoff, or otherwise minimize sediment from leaving farmland	Strategies to reduce sediment from fields (see above - upland field surface runoff)
		Constructed wetlands
		Pasture management
	Reduce bank/bluff/ravine erosion	Strategies to reduce TSS from banks/bluffs/ravines (see above for sediment)
	Increase vegetative cover/root duration: Planting crops and vegetation that maximize vegetative cover and minimize erosion and soil losses to waters, especially during the spring and fall.	Conservation cover (easements/buffers of native grass and trees, pollinator habitat)
		Perennials grown on marginal lands and riparian lands
		Cover crops
		Rotations that include perennials
	Preventing feedlot runoff: Using manure storage, water diversions, reduced lot sizes and vegetative filter strips to reduce open lot phosphorus losses	Open lot runoff management to meet Minn. R. 7020 rules
		Manure storage in ways that prevent runoff
	Improve fertilizer and manure application management: Applying phosphorus fertilizer and manure onto soils where it is most needed using techniques that limit exposure of phosphorus to rainfall and runoff.	Soil P testing and applying nutrients on fields needing phosphorus
		Incorporating/injecting nutrients below the soil
		Manure application meeting all 7020 rule setback requirements
	Address failing septic systems: Fixing septic systems so that on-site sewage is not released to surface waters. Includes straight pipes.	Sewering around lakes
		Eliminating straight pipes, surface seepages
	Reduce in-water loading: Minimizing the internal release of phosphorus within lakes	Rough fish management
		Curly-leaf pondweed management
		Alum treatment
		Lake drawdown
		Hypolimnetic withdrawal

Parameter (include non-pollutant stressors)	Strategy key	
	Description	Example BMPs/actions
	Improve forestry management	See forest strategies for sediment control
	Reduce Industrial/Municipal wastewater TP	Municipal and industrial treatment of wastewater P
		Upgrades/expansion. Address inflow/infiltration.
	Treat tile drainage waters: Treating tile drainage waters to reduce phosphorus entering water by running water through a medium which captures phosphorus	Phosphorus-removing treatment systems, including bioreactors
	Improve urban stormwater management	See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs
E. coli	**Reducing livestock bacteria in surface runoff:** Preventing manure from entering streams by keeping it in storage or below the soil surface and by limiting access of animals to waters.	Strategies to reduce field TSS (applied to manured fields, see above)
		Improved field manure (nutrient) management
		Adhere/increase application setbacks
		Improve feedlot runoff control
		Animal mortality facility
		Manure spreading setbacks and incorporation near wells and sinkholes
		Rotational grazing and livestock exclusion (pasture management)
	Reduce urban bacteria: Limiting exposure of pet or waterfowl waste to rainfall	Pet waste management
		Filter strips and buffers
		See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs
	Address failing septic systems: Fixing septic systems so that on-site sewage is not released to surface waters. Includes straight pipes.	Replace failing septic (SSTS) systems
		Maintain septic (SSTS) systems
	Reduce industrial/municipal wastewater bacteria	Reduce straight pipe (untreated) residential discharges
		Reduce WWTP untreated (emergency) releases
Dissolved Oxygen	Reduce phosphorus	See strategies above for reducing phosphorus

Parameter (include non-pollutant stressors)	Strategy key	
	Description	**Example BMPs/actions**
	Increase river flow during low flow years	See strategies above for altered hydrology
	In-channel restoration: Actions to address altered portions of streams.	Goal of channel stability: transporting the water and sediment of a watershed without aggrading or degrading.
		Restore riffle substrate
Chloride	Road salt management	[Strategies currently under development within Twin Cities Metro Area Chloride Management Plan]
Altered hydrology; peak flow and/or low base flow (Fish/Macroinvertebrate IBI)	**Increase living cover:** Planting crops and vegetation that maximize vegetative cover and evapotranspiration especially during the high flow spring months.	Grassed waterways
		Cover crops
		Conservation cover (easements and buffers of native grass and trees, pollinator habitat)
		Rotations including perennials
	Improve drainage management: Managing drainage waters to store tile drainage waters in fields or at constructed collection points and releasing stored waters after peak flow periods.	Treatment wetlands
		Restored wetlands
	Reduce rural runoff by increasing infiltration: Decrease surface runoff contributions to peak flow through soil and water conservation practices.	Conservation tillage (no-till or strip till w/ high residue)
		Water and sediment basins, terraces
	Improve urban stormwater management	See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs
	Improve irrigation water management: Increase groundwater contributions to surface waters by withdrawing less water for irrigation or other purposes.	Groundwater pumping reductions and irrigation management
Poor habitat (Fish/Macroinvertebrate IBI)	**Improve riparian vegetation:** Planting and improving perennial vegetation in riparian areas to stabilize soil, filter pollutants and increase biodiversity	50' vegetated buffer on waterways
		One rod ditch buffers
		Lake shoreland buffers
		Increase conservation cover: in/near water bodies, to create corridors

Parameter (include non-pollutant stressors)	Strategy key	
	Description	**Example BMPs/actions**
		Improve/increase natural habitat in riparian, control invasive species
		Tree planting to increase shading
		Streambank and shoreline protection/stabilization
		Wetland restoration
		Accurately size bridges and culverts to improve stream stability
	Restore/enhance channel: Various restoration efforts largely aimed at providing substrate and natural stream morphology.	Retrofit dams with multi-level intakes
		Restore riffle substrate
		Two-stage ditch
		Dam operation to mimic natural conditions
		Restore natural meander and complexity
Water temperature	Urban stormwater management	See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php/Information_on_pollutant_removal_by_BMPs
	Improve riparian vegetation: Actions primarily to increase shading, but also some infiltration of surface runoff.	Riparian vegetative buffers
		Tree planting to increase shading
Connectivity (Fish IBI)	**Remove fish passage barriers:** Identify and address barriers.	Remove impoundments
		Properly size and place culverts for flow and fish passage
		Construct by-pass
All [protection-related]	**Implement volume control/limited-impact development:** This is aimed at development of undeveloped land to provide no net increase in volume and pollutants	See MPCA Stormwater Manual: http://stormwater.pca.state.mn.us/index.php

4. Monitoring plan

The collection of current land and water data is an important component to both assess progress, and inform management and decision-making. For improved watershed management to work in the MRGRW, there needs to be reliable data that can be used to generate information. The basic needs of a monitoring plan must also include an understanding of variability, scale, confidence, and associated risk levels. For example, the scale of the Mississippi River at the city of Palisade, and the requirement of reliable stream hydrology data is different than the need for data on land uses, bacteria and habitat for the Split Hand Creek Subwatershed. Monitoring of both land and water components is needed and data is then used to inform and calibrate watershed models, evaluate progress towards defined goals, and desired outcomes. Section 7 of the MRGRW TMDL report includes more information on monitoring.

It is the intent of the implementing organizations in this watershed to make steady progress in terms of pollutant reduction. The response of the lakes and streams will be monitored and subsequently evaluated as management practices are implemented. Evaluation will occur minimally during the 1st, 3rd, and 9th year following implementation, where additional data is collected. Data will be evaluated and decisions will be made as to how to proceed for the next five years. The management approach to achieving the goals should be adapted as new monitoring data is collected and evaluated (Figure 34). Continued monitoring and "course corrections" responding to monitoring results are the most appropriate strategy for attaining the water quality goals established in the MRGRW TMDL. Management activities will be changed or refined to efficiently meet the TMDL and lay the groundwork for de-listing the impaired water bodies.

Again, this is a general guideline. Factors that may mean slower progress include limits in funding or landowner acceptance, challenging fixes (e.g., restoring ditched peatlands, invasive species) and unfavorable climatic factors. Conversely, there may be faster progress for some impaired waters, especially where high-impact fixes are slated to occur.

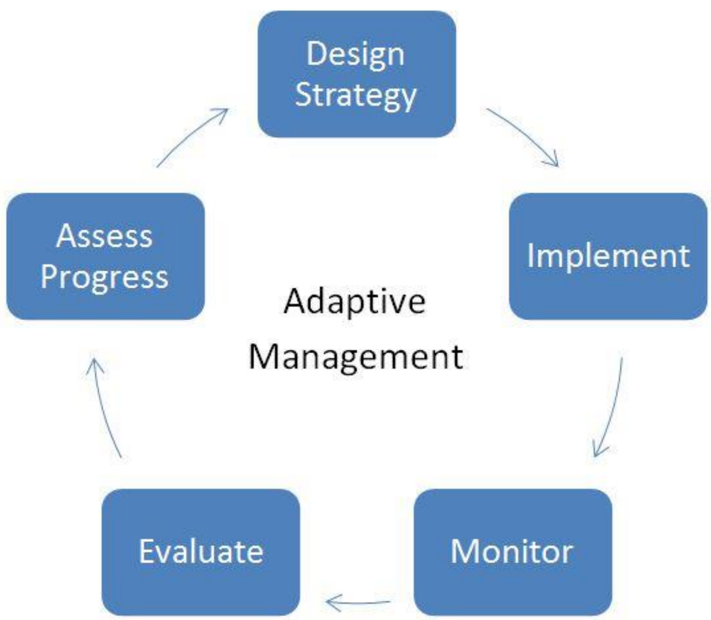


Figure 34. Adaptive Management

Data from numerous monitoring programs will continue to be collected and analyzed for the MRGRW. Monitoring is conducted by local, state and federal entities, and also special projects (for example BMP monitoring) as described in the following paragraphs.

DNR Aquatic Life Monitoring

The DNR conducts lake and stream surveys to collect information about game fish populations which are then used to evaluate abundance, relative abundance size (length and weight), condition, age and growth, natural reproduction/recruitment, and effects of management actions (stocking and regulations). Other information collected for lake population assessments includes basic water quality information (temperature, DO profile, Secchi, pH, and alkalinity), water level and for fish disease, and parasites. Additional information collected for lake surveys include lab water chemistry (TP, alkalinity, TDS, Chl-*a*, Conductivity, pH), watershed characteristics, shoreline characteristics, development, substrates, and aquatic vegetation. In the last few years, the DNR has begun near-shore sampling to develop fish IBIs at lakes in watersheds that have ongoing assessments. The frequency of sampling depends on importance, angler use, and specific data needs. The most important/heavily used lakes are sampled about every five years. Less important/heavily used lakes are sampled every 10 years or longer. If there is a management action (regulation or stocking) that needs to be evaluated more quickly, sampling could occur more frequently. Full surveys are only done if there is a perception that lake or stream conditions have undergone considerable change and a clear data need exists.

Stream Monitoring

As part of the MPCA IWM strategy, 83 stream sites were monitored for biology (fish and macroinvertebrates) and 15 sites were monitored for water chemistry from 2015 through 2017. A portion of these sites will be sampled in the next 10-year IWM cycle, beginning in 2025. Details about the MPCA IWM strategy can be found in the MRGRW Monitoring and Assessment Report: [https://www.pca.state.mn.us/sites/default/files/wq-ws3-07010103b.pdf].

The collection of continuous DO data is essential, at most sites, for the collection of DO measurements prior to 9:00 am. Moreover, the new MPCA river eutrophication assessment (DO flux) now requires a minimum of two DO logger deployments over separate years within the assessment window. The MPCA requires a record of pre-9 am DO readings in order to declare that the waterway contains enough DO to fully support aquatic life. DO logging equipment can collect regular DO measurements (e.g. every 30 minutes) while deployed in a waterway. Equipment is deployed for a maximum of two weeks at a time before it is retrieved for data retrieval, cleaning, and re-calibration. Prior to the next formal water quality assessment of the MRGRW, continuous DO monitoring should be conducted to fully assess the capacity of key reaches in the watershed to support aquatic life. Priority should be given to reaches and sites that are too remotely located from LGU offices for pre-9 am measurements.

Microbial Source Tracking should be conducted in all bacteria impaired streams to identify sources of fecal contamination prior to project implementation.

SWCDs will promote and encourage citizen participation in the MPCA Citizen Monitoring Program, with an emphasis on collecting data at the highest priority stream reaches as described in Section 2.5.

Lake Chemistry and Clarity Monitoring

As part of the MPCA IWM strategy the MPCA, citizen volunteers, and local partners (Itasca, Carlton and Aitkin SWCDs collected chemistry data from over 200 lakes in the MRGRW within the 10-year assessment window.

SWCDs will continue to promote and encourage citizen participation in the MPCA Citizen Monitoring Program. Highest priority lakes for citizen monitoring include impaired lakes, lakes with decreasing transparency trends and nearly impaired lakes. SWCDs will work with Lake Associations and conduct outreach efforts to promote the importance of citizen monitoring efforts.

Watershed Pollutant Load Monitoring

The WPLMN, which includes state and federal agencies, Metropolitan Council Environmental Services, state universities, and local partners, collects data on water quality and flow in Minnesota to calculate pollutant loads in rivers and streams. Pollutant loads are the amount of a pollutant that passes a monitoring station over a period of time. Data is collected at 199 sites around the state. There are four sites within the MRGRW.

Table 35. WPLMN stream monitoring sites for the Mississippi River-Grand Rapids Watershed.

Site Type	Stream Name	EQuIS ID
Basin	Mississippi River at Grand Rapids, MN	S003-656
Subwatershed	Prairie River near Taconite	S007-944
Subwatershed	Swan River near Jacobson, CR 431	S001-922
Subwatershed	Willow River near Pallisade, CSAH 5	S004-407

Pollutant loads are calculated for five substances:

- Total suspended solids
- Total phosphorus
- Nitrate plus nitrite nitrogen
- Total Kjeldahl nitrogen
- Dissolved orthophosphate

WPLMN data assist in watershed modeling, determining pollutant source contributions, developing reports, and measuring water quality restoration efforts.

Each year, approximately 25 to 35 water quality samples are collected at each monitoring site, either year-round or seasonally depending on the site. Water quality samples are collected near gaging stations, at or near the center of the channel. Samples are collected more frequently when water flow is moderate and high, when pollutant levels are typically elevated and most changeable. Pollutant concentrations are generally more stable when water flows are low, and fewer samples are taken in those conditions. This staggered approach generally results in samples collected over the entire range of flows.

BMP Monitoring

On-site monitoring of implementation practices should also take place in order to better assess BMP effectiveness. All BMPs installed utilizing financial assistance from the State of Minnesota will follow the

Operation, Maintenance, and Inspection Procedures adopted by BWSR. Qualified technical staff prepare an Operation and Maintenance Plan specific to the BMP and site. All practices are to be inspected by the landowner on a regular basis. Technical staff confirm that the project is functioning as designed through completion of site inspections during the effective life of the project. For BMPs installed through other sources, a variety of criteria such as land use, soil type, and other watershed characteristics, as well as monitoring feasibility, will be used to determine which BMPs to monitor. Monitoring of a specific type of implementation practice can be accomplished at one site but can be applied to similar practices under similar criteria and scenarios. Effectiveness of other BMPs can be extrapolated based on monitoring results.

5. References and further information

Mississippi River-Grand Rapids Reports

All Mississippi River-Grand Rapids reports referenced in this watershed report are available at the Mississippi River-Grand Rapids Watershed webpage: *https://www.pca.state.mn.us/water/watersheds/mississippi-river-grand-rapids*

Aadland, L. 2012. PowerPoint presentation - Natural Channel Design in a Legal Ditch System: Restoration of Lawndale Creek. Minnesota Department of Natural Resources, Fergus Falls, MN http://prrsum.umn.edu/sites/g/files/pua1546/f/restorationsymposium2012.pdf

Holden, J., P.J. Chapman, and J.C. Labadz. 2004. Artificial drainage of peatlands: hydrological and hydrochemical process and wetland restoration. Progress in Physical Geography 28(1): 95-123.

Minnesota Department of Natural Resources, Section of Fisheries. 2013. Fish Habitat Plan.

Minnesota Pollution Control Agency (MPCA). 2016. Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) Report and 303(d) List, 2016 Assessment Listing Cycle.

Myers, J. 2015. From failed cropland to filled wetland, Sax-Zim bog restoration underway. Duluth Tribune, September 17, 2015. https://www.duluthnewstribune.com/news/3840608-failed-cropland-filled-wetland-sax-zim-bog-restoration-underway

Price, J., A. Heathwaite, and A. Baird. 2003. Hydrological processes in abandoned and restored peatlands: An overview of management approaches. Wetlands Ecology and Management 11(1): 65-83.

Rosgen, D.L. (2011). Natural Channel Design: Fundamental Concepts, Assumptions, and Methods. *Stream Restoration in Dynamic Fluvial Systems: Scientific Approaches, Analyses, and Tools, Geophysical Monograph Series 194*, pp. 69–93. Washington, D.C.: American Geophysical Union.

Rosgen, D.L. (1997). A Geomorphological Approach to Restoration of Incised Rivers. *Proceedings of the Conference on Management of Landscapes Disturbed by Channel Incision*. Oxford, MS: University of Mississippi.

Rosgen, D.L. (1998). The Reference Reach – a Blueprint for Natural Channel Design. *Engineering Approaches to Ecosystem Restoration (Proceedings of the Wetlands Engineering and River Restoration Conference)*, pp. 1009–1016. Reston, VA: American Society of Civil Engineers.

Strack, M. J.M. Waddington, R.A. Bourbonniere, E.L. Buckton, K. Shaw, P. Whittington, J.S. Price. 2008. Effect of water table drawdown on peatland dissolved organic carbon export and dynamics. Hydrological Processes 22:3373-3385.

6. Appendix

Appendix A. MPCA Water Quality Trends

Lake ID	Lake name	Water Clarity Trend	Priority*
31030500	Ann	Decreasing Trend	C
31034900	Antler	No Evidence of Trend	A
31025900	Balsam	Decreasing Trend	C
11006900	Bass	Increasing Trend	B
31011500	Bass	No Evidence of Trend	C
31012400	Big Sucker	No Evidence of Trend	B
31021000	Blackberry	No Evidence of Trend	C
31039500	Bluewater	Increasing Trend	A
31006900	Buck	Increasing Trend	A
31042400	Burnt Shanty	Increasing Trend	B
31041300	Burrows	Decreasing Trend	B
31021400	Clearwater	Decreasing Trend	C
09006800	Cole	Decreasing Trend	B
31035600	Cowhorn	Increasing Trend	C
31019300	Crooked	No Evidence of Trend	C
09006200	Cross	Increasing Trend	B
01007101	Davis (Main Bay)	No Evidence of Trend	C
31037400	Forest	Increasing Trend	A
31037300	Hale	No Evidence of Trend	A
31036100	Hale	No Evidence of Trend	B
31002000	Hart	Decreasing Trend	B
31015400	Hartley	No Evidence of Trend	C
01014200	Hill	Decreasing Trend	C
31025400	Iaasac	Increasing Trend	C
31037200	Ice	Increasing Trend	B
01002200	Island	No Evidence of Trend	B
31025800	King	Increasing Trend	A
31009600	Lammon Aid	No Evidence of Trend	C
31023100	Lawrence	Decreasing Trend	A
31019800	Little Cowhorn	No Evidence of Trend	B
31061300	Little Long	Decreasing Trend	C
31009300	Little Sand	Increasing Trend	C
31034100	Little Split Hand	Increasing Trend	C
11000900	Little Thunder	Decreasing Trend	C
31039400	Little Trout	Increasing Trend	C
31039900	Little Wabana	Increasing Trend	A
31026601	Long (Main Bay)	No Evidence of Trend	C
31023800	Lower Lawrence	Decreasing Trend	C

Lake ID	Lake name	Water Clarity Trend	Priority*
31037000	McKinney	No Evidence of Trend	B
31019000	North Twin	Increasing Trend	A
31077500	No-ta-she-bun	No Evidence of Trend	A
31038400	Prairie	No Evidence of Trend	C
69084800	Prairie	No Evidence of Trend	C
01007700	Rat	No Evidence of Trend	B
01007200	Rock	No Evidence of Trend	B
01002300	Round	Decreasing Trend	A
31026800	Round	Decreasing Trend	A
31020900	Round	No Evidence of Trend	B
31043800	Sand	Increasing Trend	C
01006000	Sandy River	Increasing Trend	C
31008400	Shallow	No Evidence of Trend	A
31005700	Sherry	No Evidence of Trend	C
31014100	Shoal	No Evidence of Trend	A
31025500	Snaptail	Decreasing Trend	A
31019100	South Twin	No Evidence of Trend	A
31053800	Spider	Increasing Trend	B
31005100	Stingy	No Evidence of Trend	C
31006700	Swan	Increasing Trend	C
11006200	Thunder	Decreasing Trend	A
31021600	Trout	Increasing Trend	A
31041000	Trout	Increasing Trend	B
01005800	Vanduse	Increasing Trend	A
31039200	Wabana	Increasing Trend	B
31028100	Wasson	No Evidence of Trend	A
31026000	White Swan	Increasing Trend	C
09006300	Woodbury	Decreasing Trend	A

* Priority is based on Appendix 7 in Mississippi River Grand Rapids Monitoring and Assessment Report. High priority lakes are those that are particularly sensitive to an increase in phosphorus with a documented decline in water quality (measured by Secchi transparency), a comparatively high percentage of developed land use in the area, or monitored phosphorus concentrations close to the water quality standard.

Appendix B. Stream and Lake TMDL Summaries

Split Hand Creek (07010103-574) *E. coli* TMDL

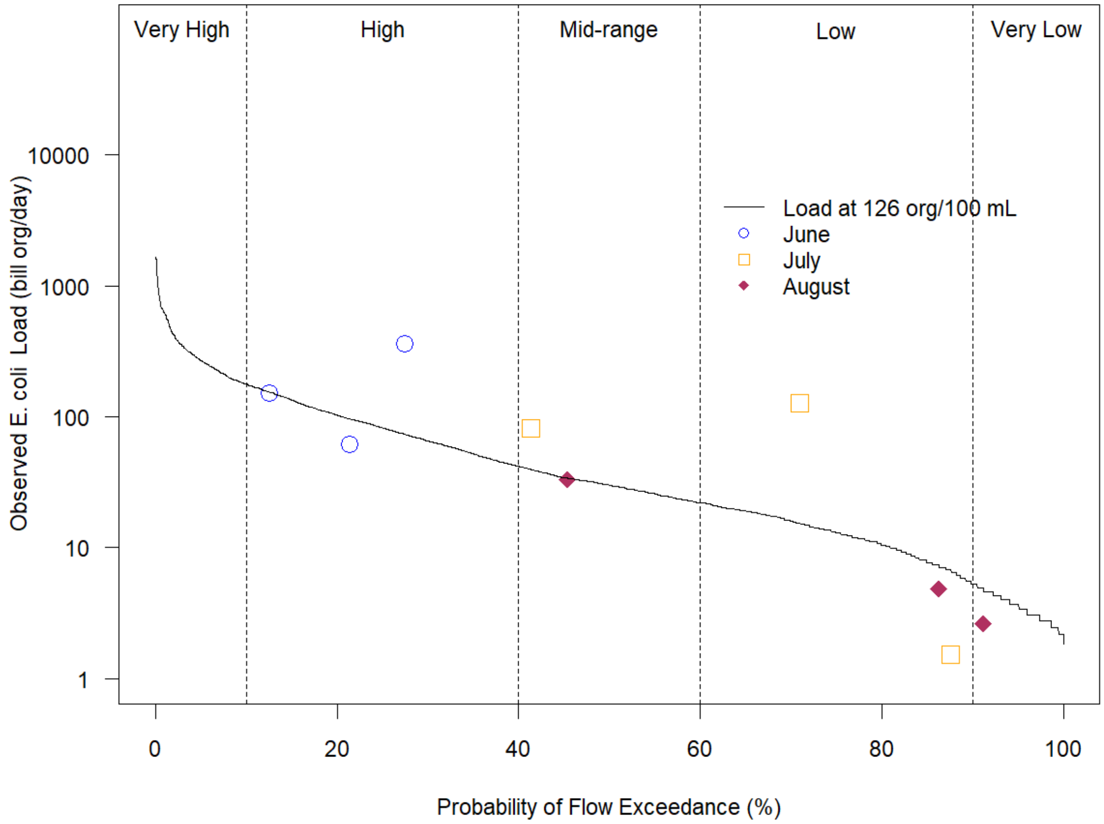


Figure 35. Split Hand Creek (07010103-574) *E. coli* Load Duration Curve
The load duration curve is the *E. coli* standard load at 126 org/100 ml. Plotted sample loads are based on monitored *E. coli* concentrations from station S008-477 collected 2006-2015.

Table 36. Split Hand Creek (07010103-574) *E. coli* TMDL and allocations

Split Hand Creek 07010103-574 Load Component		Flow Regime				
		Very High	High	Mid	Low	Very Low
		E. coli (billion organisms per day)				
Existing Load		***NA***	***151.5***	***57.1***	***4.8***	***2.6***
Wasteload Allocations	*NPDES Permitted Facilities*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
	Total WLA	**0**	**0**	**0**	**0**	**0**
Load Allocations	*Watershed Runoff*	*242.5*	*74.1*	*26.9*	*11.7*	*3.3*
	Total LA	**242.5**	**74.1**	**26.9**	**11.7**	**3.3**
10% MOS		**26.9**	**8.2**	**3.0**	**1.3**	**0.4**
Total Loading Capacity		**269.4**	**82.3**	**29.9**	**12.9**	**3.7**
Estimated Load Reduction		*NA*	*69*	*27*	*NA*	*NA*
		NA	*46%*	*48%*	*NA*	*NA*

Hasty Brook (07010103-603) *E. coli* TMDL

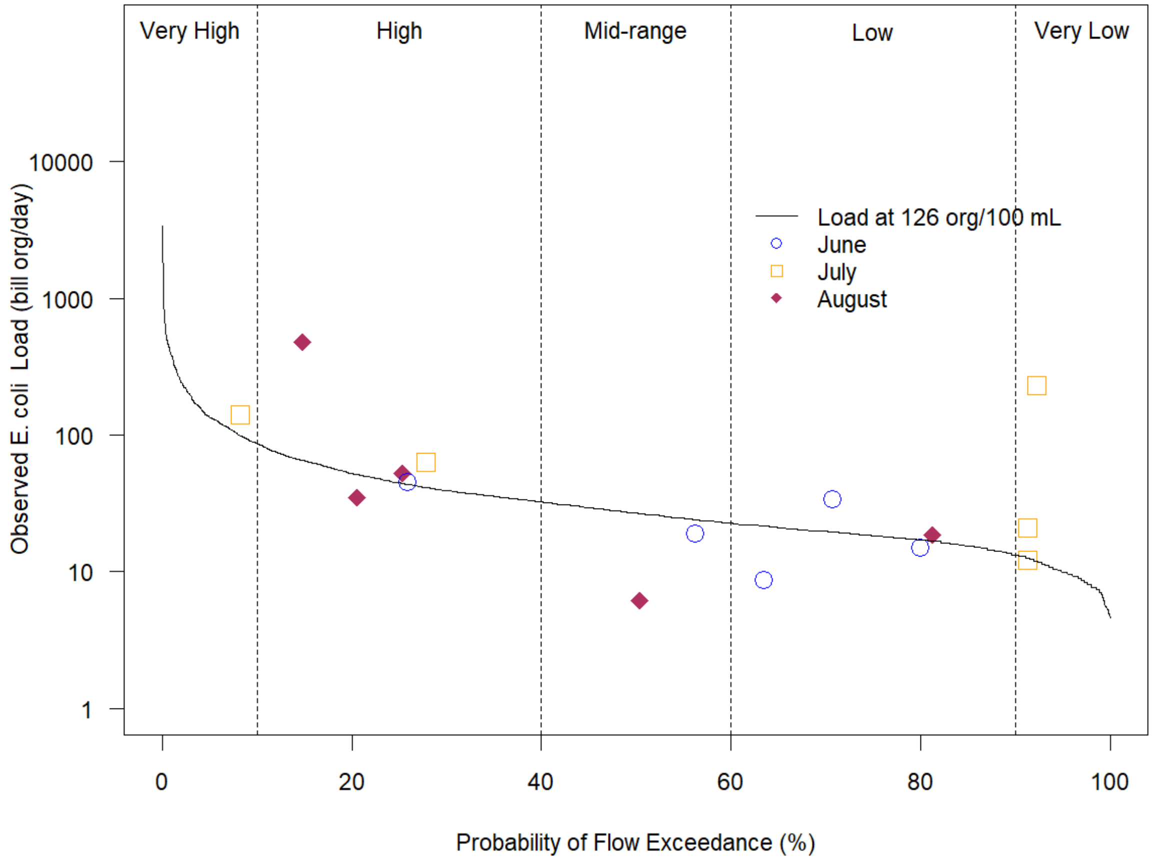


Figure 36. Hasty Brook (07010103-603) *E. coli* Load Duration Curve
The load duration curve is the *E. coli* standard load at 126 org/100 ml. Plotted sample loads are based on monitored *E. coli* concentrations from station S005-777 collected 2006-2015.

Table 37. Hasty Brook (07010103-603) *E. coli* TMDL and allocations

Hasty Brook 07010103-603 Load Component		Flow Regime				
		Very High	High	Mid	Low	Very Low
		E. coli (billion organisms per day)				
Existing Load		***140***	***52***	***12***	***17***	***21***
Wasteload Allocations	*NPDES Permitted Facilities*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
	Total WLA	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Load Allocations	*Watershed Runoff*	*121.2*	*40.2*	*24.1*	*16.4*	*8.9*
	Total LA	**121.2**	**40.2**	**24.1**	**16.4**	**8.9**
10% MOS		**13.5**	**4.5**	**2.7**	**1.8**	**1.0**
Total Loading Capacity		**134.7**	**44.7**	**26.8**	**18.2**	**9.9**
Estimated Load Reduction		*5.3*	*7.3*	*NA*	*NA*	*11.1*
		4%	*15%*	*NA*	*NA*	*53%*

Willow River (07010103-751) *E. coli* TMDL

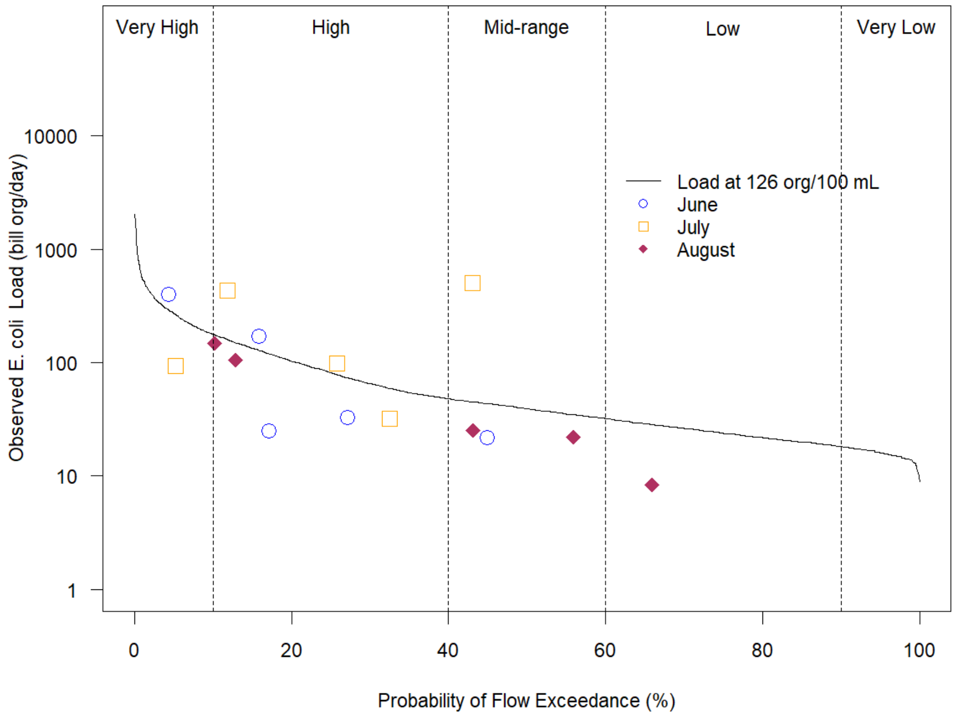


Figure 37. Willow river (07010103-751) *E. coli* Load Duration Curve
The load duration curve is the *E. coli* standard load at 126 org/100 ml. Plotted sample loads are based on monitored *E. coli* concentrations from station S006-260-collected between 2006-2015.

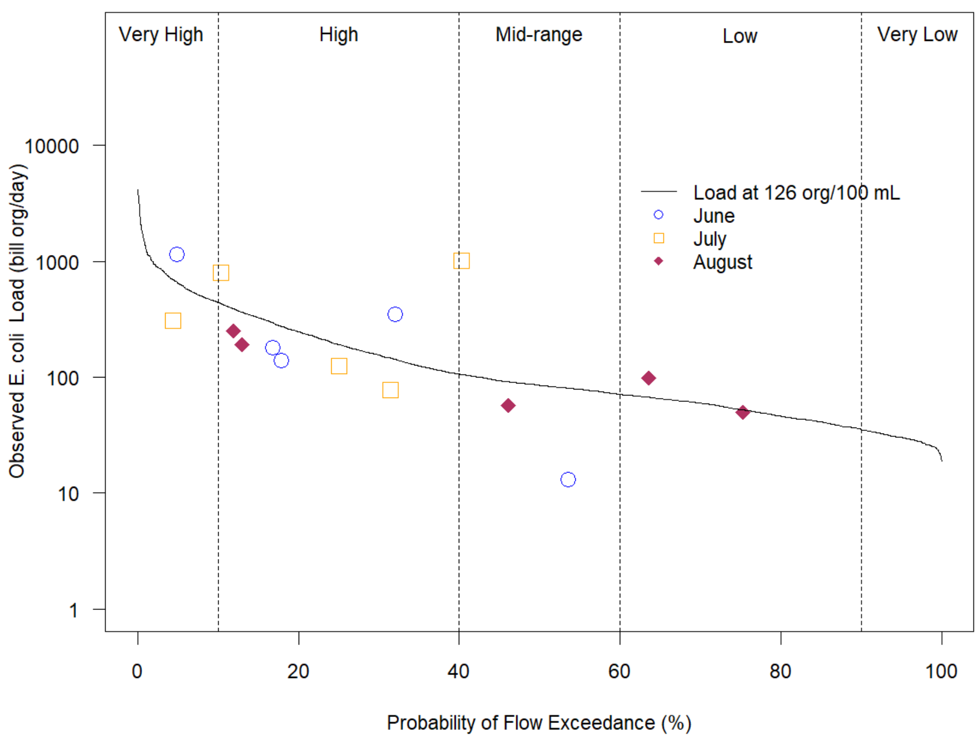


Figure 38. Willow river (07010103-751) *E. coli* Load Duration Curve
The load duration curve is the *E. coli* standard load at 126 org/100 ml. Plotted sample loads are based on monitored *E. coli* concentrations from station S006-257 collected 2006-2015.

Table 38. Willow River (07010103-751) *E. coli* TMDL and allocations

Willow River 007010103-751 Load Component		Flow Regime				
		Very High	High	Mid	Low	Very Low
		Billion organisms per day				
Existing Load		***245.0***	***101.5***	***23.7***	***8.4***	***NA***
Wasteload Allocations	*Remer WWTP (MNG580210)*	*1.7*	*1.7*	*1.7*	*1.7*	*1.7*
	Total WLA	**1.7**	**1.7**	**1.7**	**1.7**	**1.7**
Load Allocations	*Watershed Runoff*	*244.4*	*72.1*	*33.6*	*20.0*	*12.7*
	Total LA	**244.4**	**72.1**	**33.6**	**20.0**	**12.7**
10% MOS		**27.3**	**8.2**	**3.9**	**2.4**	**1.6**
Total Loading Capacity		**273.4**	**82.0**	**39.2**	**24.0**	**16.0**
Estimated Load Reduction		*NA*	*20*	*NA*	*NA*	*NA*
		NA	*19%*	*NA*	*NA*	*NA*

Swan River (07010103-753) *E. coli* TMDL

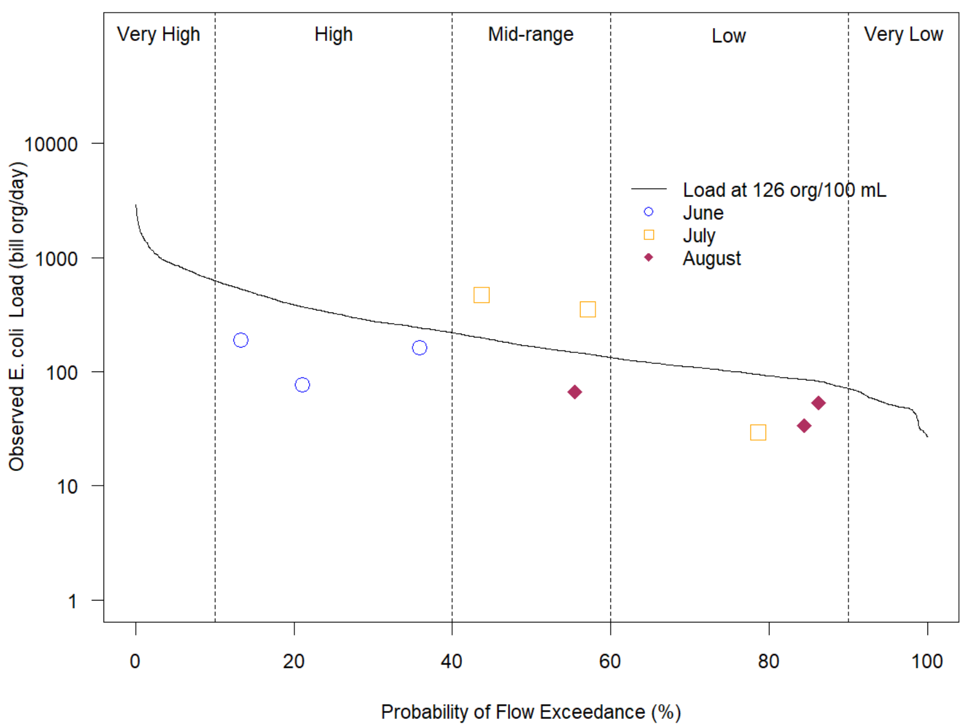


Figure 39. Swan River (07010103-753) *E. coli* Load Duration Curve
The load duration curve is the *E. coli* standard load at 126 org/100 ml. Plotted sample loads are based on monitored *E. coli* concentrations from station S000-936 collected 2006-2015.

Table 39. Swan River (07010103-753) *E. coli* TMDL and allocations

Swan River 07010103-753 Load Component		Flow Regime				
		Very High	High	Mid	Low	Very Low
		E. coli (billion organisms per day)				
Existing Load		*NA*	*160.8*	*349.9*	*33.7*	*NA*
Wasteload Allocations	*Coleraine-Bovey WWTP (MN0022012)*	2.4	2.4	2.4	2.4	2.4
	Keewatin WWTP (MN0022012)	1.5	1.5	1.5	1.5	1.5
	Marble WWTP (MN0020214)	0.5	0.5	0.5	0.5	0.5
	Nashwauk WWTP(MNG580184)	14.8	14.8	14.8	14.8	14.8
	Hibbing, MN MS4 (MN040000)	93.7	34.1	16.3	9.0	3.5
	Total WLA	**112.9**	**53.3**	**35.5**	**28.2**	**22.7**
Load Allocations	*Watershed Runoff*	658.4	239.9	114.3	62.8	24.1
	Total LA	**658.4**	**239.9**	**114.3**	**62.8**	**24.1**
10% MOS		**85.7**	**32.6**	**16.6**	**10.1**	**5.2**
Total Loading Capacity		**857.0**	**325.8**	**166.4**	**101.1**	**52**
Estimated Load Reduction		*NA*	*NA*	*183.5*	*NA*	*NA*
		NA	*NA*	*52%*	*NA*	*NA*

Tamarack River (07010103-758) *E. coli* TMDL

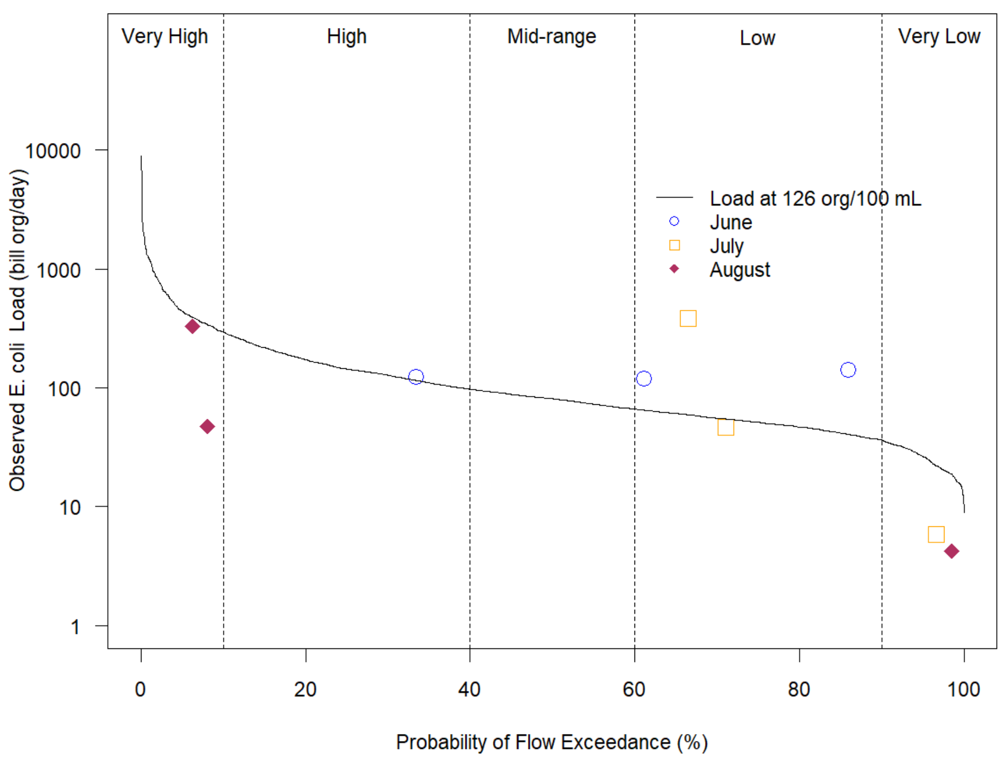


Figure 40. Tamarack River (07010103-758) *E. coli* Load Duration Curve
The load duration curve is the *E. coli* standard load at 126 org/100 ml. Plotted sample loads are based on monitored *E. coli* concentrations from station S008-441 collected 2006-2015.

Table 40. Tamarack River (07010103-758) *E. coli* TMDL and allocations

Tamarack River 07010103-758 Load Component		Flow Regime				
		Very High	High	Mid	Low	Very Low
		E. coli (billion organisms per day)				
Existing Load		***189.1***	***122.3***	***NA***	***129.2***	***5.0***
Wasteload Allocations	*Cromwell WWTP (MN0053341)*	*2.8*	*2.8*	*2.8*	*2.8*	*2.8*
	Total WLA	**2.8**	**2.8**	**2.8**	**2.8**	**2.8**
Load Allocations	*Watershed Runoff*	*395.6*	*127.1*	*70.2*	*43.3*	*20.8*
	Total LA	**395.6**	**127.1**	**70.2**	**43.3**	**20.8**
10% MOS		**44.3**	**14.4**	**8.1**	**5.1**	**2.6**
Total Loading Capacity		**442.7**	**144.3**	**81.1**	**51.2**	**26.2**
Estimated Load Reduction		*NA*	*NA*	*NA*	*78*	*NA*
		NA	*NA*	*NA*	*60%*	*NA*

Prairie River (07010103-760) *E. coli* TMDL

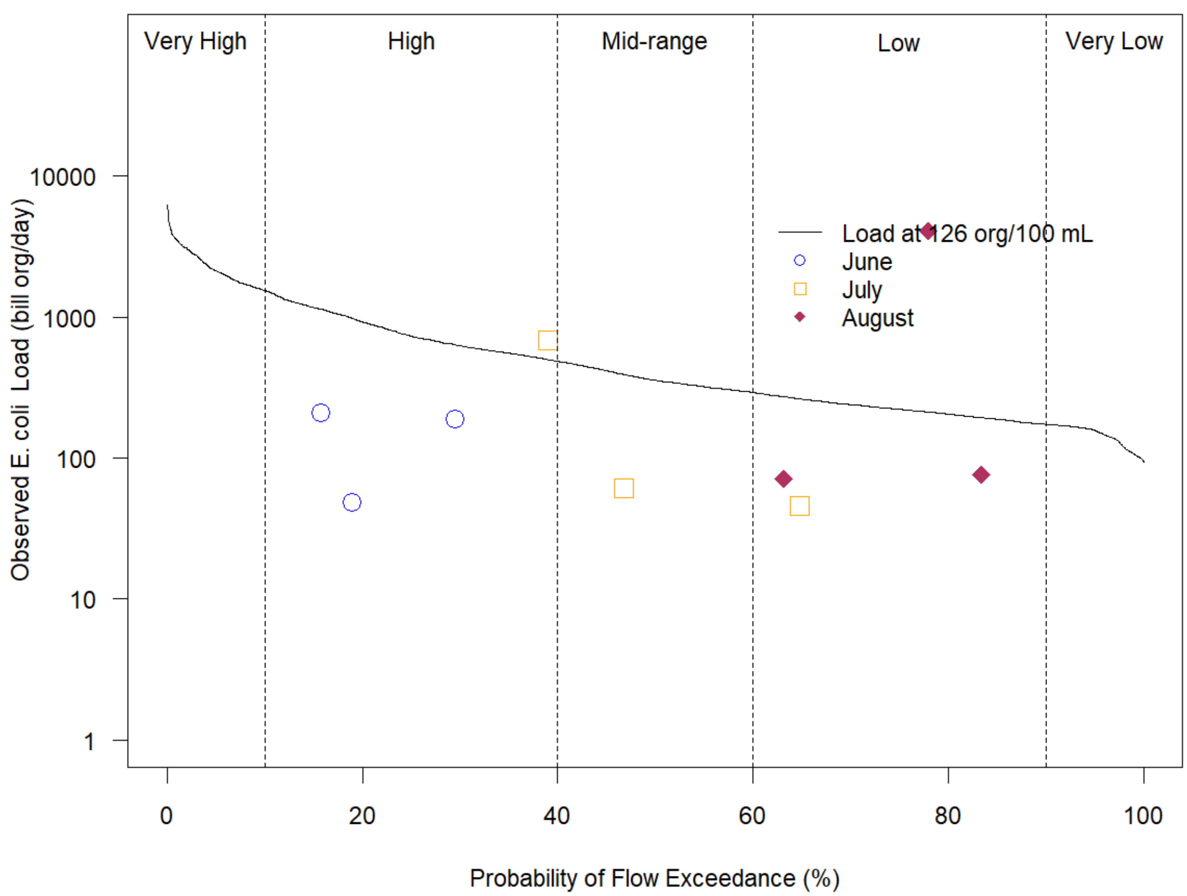


Figure 41. Prairie River (07010103-760) *E. coli* Load Duration Curve
The load duration curve is the *E. coli* standard load at 126 org/100 ml. Plotted sample loads are based on monitored *E. coli* concentrations from station S008-478, 2006-2015.

Table 41. Prairie River (07010103-760) *E. coli* TMDL and allocations

Prairie River 07010103-760 Load Component		Flow Regime				
		Very High	High	Mid	Low	Very Low
		E. coli (billion organisms per day)				
Existing Load		***NA***	***198.7***	***61.2***	***73.3***	***NA***
Wasteload Allocations	*Hibbing, MN MS4 (MN040000)*	*76.0*	*26.0*	*12.7*	*7.9*	*5.6*
	Total WLA	**76.0**	**26.0**	**12.7**	**7.9**	**5.6**
Load Allocations	*Watershed Runoff*	*1,850.0*	*631.0*	*308.9*	*191.9*	*136.4*
	Total LA	**1,850.0**	**631.0**	**308.9**	**191.9**	**136.4**
10% MOS		**214.0**	**73.0**	**35.7**	**22.2**	**15.8**
Total Loading Capacity		**2,140.0**	**730.0**	**357.3**	**222.0**	**157.8**
Estimated Load Reduction		*NA*	*NA*	*NA*	*NA*	*NA*
		NA	*NA*	*NA*	*NA*	*NA*

Eagle Lake (09-0057-00) TP TMDL

Table 42. Eagle Lake TP TMDL and Allocations

Eagle Lake Load Component		Existing	Goal		Reduction	
		(kg/yr)	(kg/yr)	(kg/day)	(kg/yr)	(%)
Wasteload Allocations	Construction stormwater (MNR100001)	0.010	0.010	0.000027	0.0	0%
	Industrial stormwater (MNR500000)	0.010	0.010	0.000027	0.0	0%
	Total WLA	**0.020**	**0.020**	**0.000054**	**0.0**	
Load Allocations*	*Watershed runoff*	*75.8*	*69.0*	*0.189*	*6.8*	*9%*
	Failing septics	*7.4*	*0.0*	*0.000*	*7.4*	*100%*
	Internal load	*99.5*	*68.5*	*0.188*	*31.0*	*31%*
	Total Watershed/In-lake	182.7	137.5	0.377	45.2	25%
	Atmospheric	26.8	26.8	0.073	0.0	0%
	Total LA	**209.5**	**164.3**	**0.45**	**45.2**	**22%**
MOS			**18.3**	**0.050**		
TOTAL		**209.5**	**182.6**	**0.50**		

*LA components are broken down for guidance in implementation planning; loading goals for these components may change through the adaptive implementation process, but the total LA for each lake will not be modified from the total listed in the table above

Phosphorus Reductions Needed to Meet Water Quality Goal

- 7 kg/yr from watershed sources
- 7.4 kg/yr from converting ~26 failing shoreline septic systems to conforming
- 31 kg/yr from internal/unknown sources

Phosphorus Source Summary

- Eagle Lake is 389 acres with a maximum depth of 35 feet and a shallow lake zone (<15 feet) that covers 30% of the lake surface area.
- Sediment phosphorus release rates based on sediment core sampling were greater than the release rates in the calibrated BATHTUB model, indicating that all of the added load to the BATHTUB model was likely due to internal loading from anoxic sediment phosphorus release.
- There is a diverse and healthy fish and aquatic plant community.
- Water levels have been collected since 1993. The recorded range is 3.91 feet, with a minimum recorded in August 2010 (1307.65 ft) and a maximum recorded in June 2012 (1311.56 ft). Except for the very high water levels in 2012, recent water levels have been at or below the OHW of 1309.2 ft.
- The lake watershed is 2,304 acres, or 6 times the lake surface area.
- The shoreline is well developed with seasonal conversion of cabins to year-round homes.
- Approximately 30% of the watershed is wetland.
- Assuming the watershed wetlands are contributing phosphorus at the flow-weighted mean concentration of 44-64 µg/L (average of 54.2 µg/L) measured from Musselshell Creek (tributary to Horseshoe Lake), compared to the HSPF predicted runoff phosphorus concentration of 19.6 µg/L, the additional load from the Eagle Lake wetlands beyond what was accounted for by HSPF is approximately 20 kg/yr of the 100 kg/yr of unknown/internal load.

Horseshoe Lake (01-0034-00) TP TMDL

Table 43. Horseshoe Lake TP TMDL and Allocations

Horseshoe Lake Load Component		Existing	Goal		Reduction	
		(kg/yr)	(kg/yr)	(kg/day)	(kg/yr)	(%)
Wasteload Allocations	Construction stormwater (MNR100001)	0.024	0.024	0.000066	0.0	0%
	Industrial stormwater (MNR500000)	0.024	0.024	0.000066	0.0	0%
	Total WLA	**0.048**	**0.048**	**0.000132**	**0.0**	
Load Allocations*	*Watershed runoff*	*242.4*	*143.8*	*0.394*	*98.6*	*41%*
	Failing septics	*0.4*	*0.0*	*0.000*	*0.4*	*100%*
	Internal/Unknown load	*83.4*	*38.0*	*0.104*	*45.4*	*54%*
	Total Watershed/In-lake	326.2	181.8	0.498	144.4	44%
	Atmospheric	16.5	16.5	0.045	0.0	0%
	Total LA	**342.7**	**198.3**	**0.543**	**144.4**	
MOS			**22.0**	**0.060**		
TOTAL		**342.7**	**220.4**	**0.603**	**144.4**	**42%**

*LA components are broken down for guidance in implementation planning; loading goals for these components may change through the adaptive implementation process, but the total LA for each lake will not be modified from the total listed in the table above.

Phosphorus Reductions Needed to Meet Water Quality Goal

- 99 kg/yr from watershed sources
- 0.4 kg/yr from converting ~3 failing shoreline septic systems to conforming
- 45 kg/yr from internal/unknown sources

Phosphorus Source Summary

- Horseshoe Lake is 210 acres with a maximum depth of 12 feet and a shallow lake zone (<15 feet) that covers 100% of the lake surface area.
- Natural springs have been observed near the shoreline and in the lake bottom.
- Sediment phosphorus release rates based on sediment core sampling were much less than the release rates in the calibrated BATHTUB model, indicating that the added load in the BATHTUB model was likely not due to internal loading from anoxic sediment phosphorus release
- There are occasional partial winterkills; the most recent observed was a partial kill in the winter of 2007-2008. Partial winterkills are likely due to the shallow, eutrophic nature of the lake.
- There was a healthy aquatic plant community in the most recent DNR fish survey in 2015.
- Water levels have been collected since 1970. The recorded range is 1.79 feet, with a minimum recorded in October 2006 (1223.7 ft) and a maximum recorded in April 2001 (1225.49 ft).
- Mid-summer mixing events, combined with sediment phosphorus release under anoxic conditions at the lake bottom, may be contributing to internal loading in the lake.
- The lake watershed is 21,622 acres, or 90 times the lake surface area.
- Approximately 32% of the watershed is wetland, with beaver issues on Musselshell Creek.
- Pollutant load monitoring on Musselshell Creek (Flow gage: H09077002, Water quality monitoring site: S009-505) in 2017 and 2018 by MPCA (Kevin Stroom) measured a flow-weighted mean concentration entering the lake of 44-64 µg/L (average 54.2 µg/L), compared to the HSPF predicted runoff phosphorus concentration of 51.4 µg/L. The estimated additional load from the wetland dominated drainage area of Musselshell Creek beyond what was accounted for by HSPF is approximately 4 kg/yr of the 83 kg/yr of the total added load. The remainder of the added load in the BATHUB model is likely coming from the near shore area, such as shoreline wetland and erosion sources. Near-shore sources are not accounted for in the HSPF model or other phosphorus source assessment tools utilized by this TMDL. Additional field surveys are needed to target the source of these near-shore sources.

North Island Lake (09-0060-01) TP TMDL

Table 44. North Island Lake TP TMDL and Allocations

Island Lake (North Basin) Load Component		Existing (kg/yr)	Goal (kg/yr)	Goal (kg/day)	Reduction (kg/yr)	Reduction (%)
Wasteload Allocations	Construction stormwater (MNR100001)	0.016	0.016	0.000044	0.0	0%
	Industrial stormwater (MNR500000)	0.016	0.016	0.000044	0.0	0%
	Total WLA	**0.032**	**0.032**	**0.000088**	**0.0**	
Load Allocations*	*Watershed runoff*	*133.7*	*110.1*	*0.301*	*23.6*	*18%*
	Failing septics	*2.2*	*0.0*	*0.000*	*2.2*	*100%*
	Internal/Unknown load	*13.4*	*0.0*	*0.000*	*13.4*	*100%*
	Total Watershed/In-lake	149.3	110.1	0.301	39.2	26%
	Island Lake (South Basin)	83.5	77.5	0.212	6.0	7%
	Atmospheric	7.8	7.8	0.021	0.0	0%
	Total LA	**240.6**	**195.4**	**0.544**	**45.2**	**19%**
MOS			**21.7**	**0.059**		
TOTAL		**240.6**	**217.1**	**0.593**		

*LA components are broken down for guidance in implementation planning; loading goals for these components may change through the adaptive implementation process, but the total LA for each lake will not be modified from the total listed in the table above.

Phosphorus Reductions Needed to Meet Water Quality Goal

- 24 kg/yr from watershed sources
- 2.2 kg/yr from converting ~10 failing shoreline septic systems to conforming
- 13 kg/yr from internal/unknown sources
- 6 kg/yr from Island Lake (South Basin) achieving its TMDL goals

Phosphorus Source Summary

- North Island Lake is 114 acres with a maximum depth of 25 feet and a shallow lake zone (<15 feet) that covers 86% of the lake surface area.
- Sediment phosphorus release rates based on sediment core sampling were greater than the release rates in the calibrated BATHTUB model, indicating that all of the added load to the BATHTUB model was likely due to internal loading from anoxic sediment phosphorus release.
- There is a healthy aquatic plant and fish community.
- Water levels have been collected since 1997. The recorded range was 4.11 feet, with a minimum recorded in September 2007 (1299.82 ft) and a maximum recorded in May 2005 (1303.93 ft).
- The lake watershed is 4,798 acres, or 42 times the lake surface area. Eagle Lake and South Island Lakes are upstream of North Island Lake.

- The shoreline is well developed and most residences are connected to the Cromwell sewer system.
- North Island Lake receives some stormwater runoff from the city of Cromwell.
- A ditch drains a wetland on the north side of the lake, and could release phosphorus to North Island Lake under fluctuating water level conditions in the wetland.
- There are livestock to the northeast of the lake.

South Island Lake (09-0060-02) TP TMDL

Table 45. South Island Lake TP TMDL and Allocations

Island Lake (South Basin) Load Component		Existing	Goal		Reduction	
		(kg/yr)	(kg/yr)	(kg/day)	(kg/yr)	(%)
Wasteload Allocations	Construction stormwater (MNR100001)	0.004	0.004	0.000011	0.0	0%
	Industrial stormwater (MNR500000)	0.004	0.004	0.000011	0.0	0%
	Total WLA	**0.008**	**0.008**	**0.000022**	**0.0**	
Load Allocations*	*Watershed runoff*	*34.9*	*31.6*	*0.086*	*3.3*	*10%*
	Failing septics	*2.8*	*0.0*	*0.000*	*2.8*	*100%*
	Internal load	*78.4*	*54.0*	*0.148*	*24.4*	*31%*
	Total Watershed/In-lake	116.1	85.6	0.234	30.5	26%
	Eagle Lake	46.3	42.4	0.116	3.9	9%
	Atmospheric	22.3	22.3	0.061	0.0	0%
	Total LA	**184.7**	**150.3**	**0.411**	**34.4**	**19%**
MOS			**16.6**	**0.046**		
TOTAL		**184.7**	**166.9**	**0.457**		

*LA components are broken down for guidance in implementation planning; loading goals for these components may change through the adaptive implementation process, but the total LA for each lake will not be modified from the total listed in the table above.

Phosphorus Reductions Needed to Meet Water Quality Goal

- 3 kg/yr from watershed runoff
- 2.8 kg/yr from converting ~11 failing shoreline septic systems to conforming
- 24 kg/yr from internal load

Phosphorus Source Summary

- South Island Lake is 324 acres with a maximum depth of 22 feet and a shallow lake zone (<15 feet) that covers 73% of the lake surface area.
- Sediment phosphorus release rates based on sediment core sampling were greater than the release rates in the calibrated BATHTUB model, indicating that all of the added load to the BATHTUB model was likely due to internal loading from anoxic sediment phosphorus release.

- There is a diverse aquatic plant community.
- The fish community is poor, with a fish-based index of biological integrity (FIBI) score of 26, or 12 points below the impairment threshold for similar lakes.
- Water levels were collected between 1997 and 2007. The recorded range was 2.75 feet, with a minimum recorded in July 2006 (1299.96 ft) and a maximum recorded in June 2005 (1302.71 ft).
- The lake watershed is 4,028 acres, or 12 times the lake surface area. Eagle Lake is upstream of South Island Lake.
- The shoreline is well developed with the northern half of residences connected to the Cromwell sewer system in 2007.
- South Island Lake receives some stormwater runoff from the city of Cromwell.

King Lake (31-0258-00) TP TMDL

Table 46. King Lake TP TMDL and Allocations

King Lake Load Component		Existing	Goal		Reduction	
		(kg/yr)	(kg/yr)	(kg/day)	(kg/yr)	(%)
Wasteload Allocations	Construction stormwater (MNR100001)	0.007	0.007	0.000019	0.0	0%
	Industrial stormwater (MNR500000)	0.007	0.007	0.000019	0.0	0%
	Total WLA	**0.014**	**0.014**	**0.000038**	**0.0**	
Load Allocations*	*Watershed runoff*	*16.1*	*14.1*	*0.039*	*2.0*	*12%*
	Failing septics	*2.3*	*0.0*	*0.000*	*2.3*	*100%*
	Internal load	*90.0*	*63.5*	*0.174*	*26.5*	*29%*
	Total Watershed/In-lake	108.4	77.6	0.213	30.8	28%
	Atmospheric	21.4	21.4	0.059	0.0	0%
	Total LA	**129.8**	**99.0**	**0.272**	**30.8**	**24%**
MOS			**11.0**	**0.030**		
TOTAL		**129.8**	**110.0**	**0.302**		

*LA components are broken down for guidance in implementation planning; loading goals for these components may change through the adaptive implementation process, but the total LA for each lake will not be modified from the total listed in the table above.

Phosphorus Reductions Needed to Meet Water Quality Goal

- 2 kg/yr from watershed runoff
- 2.3 kg/yr from converting ~9 failing shoreline septic systems to conforming
- 27 kg/yr from internal load

Phosphorus Source Summary

- King Lake is 311 acres with a maximum depth of just over 25 feet and a shallow lake zone (<15 feet) that covers 49% of the lake surface area.

- Sediment phosphorus release rates based on sediment core sampling were greater than the release rates in the calibrated BATHTUB model, indicating that all of the added load to the BATHTUB model was likely due to internal loading from anoxic sediment phosphorus release.
- The lake weakly stratifies and has low oxygen at the thermocline. Mid-summer mixing events, combined with sediment phosphorus release under anoxic conditions at the lake bottom, may be contributing to internal loading in the lake.
- Lake water levels have been noted as an issue on King Lake due to beaver dam issues at the lake outlet. However, no lake level data has been collected within the last 10 years. A hydrological and/or paleolimnological core study are needed to understand the impacts of water level on the in-lake nutrient dynamics of King Lake.
- The lake watershed is 890 acres, or 3 times the lake surface area.
- There is forestry activity to the north and east of the lake.
- Approximately 13% of the watershed is wetland and 48% woodland.
- The western and southwest shorelines are heavily developed, and shoreline erosion has been noted on the lake.
- There is an approximately 40 acre wetland complex on the northeast shore of King Lake.

Little Cowhorn Lake (31-0098-00) TP TMDL

Table 47. Little Cowhorn Lake TP TMDL and Allocations

Little Cowhorn Lake Load Component		Existing	Goal		Reduction	
		(kg/yr)	(kg/yr)	(kg/day)	(kg/yr)	(%)
Wasteload Allocations	Construction stormwater (MNR100001)	0.016	0.016	0.000044	0.0	0%
	Industrial stormwater (MNR500000)	0.016	0.016	0.000044	0.0	0%
	Total WLA	**0.032**	**0.032**	**0.000088**	**0.0**	
Load Allocations*	*Watershed runoff*	*41.1*	*30.7*	*0.084*	*10.4*	*25%*
	Failing septics	*0.0*	*0.0*	*0.000*	*0.0*	*0%*
	Internal load	*52.5*	*8.6*	*0.024*	*43.9*	*84%*
	Total Watershed/In-lake	93.6	39.3	0.108	54.3	58%
	Atmospheric	12.5	12.5	0.034	0.0	0%
	Total LA	**106.1**	**51.8**	**0.142**	**54.3**	**51%**
MOS			**5.8**	**0.016**		
TOTAL		**106.1**	**57.6**	**0.158**		

*LA components are broken down for guidance in implementation planning; loading goals for these components may change through the adaptive implementation process, but the total LA for each lake will not be modified from the total listed in the table above

Phosphorus Reductions Needed to Meet Water Quality Goal

- 10 kg/yr from watershed runoff
- 44 kg/yr from internal load

Phosphorus Source Summary

- Little Cowhorn Lake is 181 acres with a maximum depth of 12 feet and a shallow lake zone (<15 feet) that covers 100% of the lake surface area.
- Sediment phosphorus release rates based on sediment core sampling were greater than the release rates in the calibrated BATHTUB model, indicating that all of the added load to the BATHTUB model was likely due to internal loading from anoxic sediment phosphorus release.
- There is a long history of low winter oxygen levels with many severe winterkills documented in Little Cowhorn Lake due to the shallow, eutrophic nature of the lake.
- There was heavy submergent aquatic vegetation in the most recent DNR fish survey in 1992.
- No lake level data has been collected within the last 10 years.
- Mid-summer mixing events, combined with sediment phosphorus release under anoxic conditions at the lake bottom, may be contributing to internal loading in the lake.
- The lake watershed is 1,178 acres, or 6 times the lake surface area.
- There is only one residence on the lake.

- Approximately 23% of the watershed is wetland.

Split Hand Lake (31-0353-00) TP TMDL

Table 48. Split Hand Lake TP TMDL and Allocations

Split Hand Lake Load Component		Existing	Goal		Reduction	
		(kg/yr)	(kg/yr)	(kg/day)	(kg/yr)	(%)
Wasteload Allocations	Construction stormwater (MNR100001)	0.094	0.094	0.00026	0.0	0%
	Industrial stormwater (MNR500000)	0.094	0.094	0.00026	0.0	0%
	Total WLA	**0.188**	**0.188**	**0.00052**	**0.0**	
Load Allocations*	*Watershed runoff*	*196.1*	*177.5*	*0.486*	*18.6*	*9%*
	Failing septics	*3.4*	*0.0*	*0.000*	*3.4*	*100%*
	Wetland anoxic release	*78.7*	*78.7*	*0.216*	*0.0*	*0%*
	Internal load	*430.1*	*197.8*	*0.541*	*232.3*	*54%*
	Near-shore runoff	*825.2*	*379.4*	*1.039*	*445.8*	*54%*
	Total Watershed/In-lake	1,533.5	833.4	2.282	700.1	46%
	Atmospheric	94.5	94.5	0.259	0.0	0%
	Total LA	**1,628.2**	**928.1**	**2.541**	**700.1**	**43%**
MOS			**103.1**	**0.282**		
TOTAL		**1,628.2**	**1,031.2**	**2.824**		

*LA components are broken down for guidance in implementation planning; loading goals for these components may change through the adaptive implementation process, but the total LA for each lake will not be modified from the total listed in the table above.

Phosphorus Reductions Needed to Meet Water Quality Goal

- 19 kg/yr from watershed runoff
- 3.4 kg/yr from converting ~12 failing shoreline septic systems to conforming
- 232 kg/yr from internal load
- 446 kg/yr from near-shore runoff

Phosphorus Source Summary

- Split Hand Lake is 1,369 acres with a maximum depth of just over 30 feet and a shallow lake zone (<15 feet) that covers 42% of the lake surface area.
- Sediment phosphorus release rates based on sediment core sampling were less than the release rates in the calibrated BATHTUB model, indicating that only some of the added load in the BATHTUB model is likely due to internal loading from anoxic sediment phosphorus release.
- Lake water level fluctuations are an issue for Split Hand Lake. There is a history of high water levels, and even flooding of houses in recent years on the lake. In 2018, most docks were about one foot underwater.

- The lake watershed is 20,249 acres, or 15 times the lake surface area.
- Approximately 26% of the watershed is wetland.
- The Split Hand Creek drainage area is dominated by wetlands and enters Split Hand Lake on the western shore. Pollutant load monitoring on Split Hand Creek (Flow gage: H09053002, Water quality monitoring site: S009-506) in 2017 and 2018 measured a flow-weighted mean concentration entering the lake of 41-42 µg/L, compared to the HSPF predicted runoff phosphorus concentration of 16 µg/L. The estimated additional load from Split Hand Creek beyond what was accounted for by HSPF is approximately 80 kg/yr of the 1,334 kg/yr of the total added load. The remainder of the added load in the BATHUB model is likely coming from the near shore area, such as shoreline wetland and erosion sources. Near-shore sources are not accounted for in the HSPF model or other phosphorus source assessment tools utilized by this TMDL. Additional field surveys are needed to target the source of these near-shore sources.
- The eastern shoreline is well developed. Many of the residences have been converted from cabins to year-round homes.

Appendix C. Zonation Methods

By Paul J. Radomski and Kristin Carlson

Values-based models, such as Zonation, are an efficient method for prioritizing places on the landscape for protection or restoration of water resources. These models integrate individual landscape features with context and connections, and use an objective function to identify priority resource areas. The use of an additive benefits (i.e., multiple benefits) objective function in the value model allows for the inclusion of multiple landscape features. Value models also lend themselves to collaborative efforts, by providing an opportunity for participants to decide what features are valued and the ranking of those valued features. In addition, value models and the DNR five-component healthy watershed model used to structure the content in the value model are simple concepts that are easy to explain and apply at the local government scale. Value models do not provide guidance on what practices should be implemented where, so additional analysis and/or discussion on effective and appropriate BMPs will be necessary when project planning.

The first step of the four-step process involved determining which features should be included in the Zonation model. The WRAPS team decided on 30 features (i.e., data layers), grouped within six components (Table 1). Data for the *Culturally valuable lands* feature were not available, so this feature was excluded from analysis. Each data layer was on the same grid with a resolution of 30 by 30m. We used high-resolution data to maximize local planning realism and for greater practicality in local government water resource planning and implementation.

Weights were used to identify which features were valued more. Within the five-component healthy watershed framework, for example, water quality features could be weighted higher than biological features. The feature-specific weights used in Zonation were set using the analytic hierarchy process (AHP; Saaty and Peniwati 2007). A hierarchical survey (components → features) comprised of pairwise comparisons was used to identify the preferences of a diverse group of individuals within the watershed. Each individual taking the survey used his or her judgment about the relative importance of all survey elements. The relative importance values included “equal,” “prefer,” and “strongly prefer.” Individual responses were aggregated with a geometric mean, and the pairwise comparison matrix was constructed to compute the feature-specific weights consistent with the AHP.

The value models were developed using Zonation software (Moilanen et al. 2009). Zonation produces a nested hierarchy of spatial priorities. It begins with the full landscape and iteratively removes cells that contribute least to the objective; therefore, the removal order is the reverse order of the priority ranking. Zonation assumes that the full watershed is available for consideration. In these models, the lakes were masked out prior to analysis. This focused the prioritization on the terrestrial parcels, in accordance with the protection and restoration goals of the Mississippi River – Grand Rapids Watershed. Zonation’s algorithms seek maximal retention of weighted normalized landscape features.

To produce a map that identified areas on the landscape that provide multiple benefits, we used the additive benefit function within Zonation. This function aggregates values by summation across features:

$$V(P) = \Sigma w_j N_j(P)^{z}{}_{j}$$

where the value of a parcel *V(P)* is equal to the summation of weighted *w* normalized features of the parcel $N_j(P)$ to the power of *z* (set to 0.25 for all features).

Additionally, Zonation allows ranking to be influenced by neighboring parcels, so that highly valued areas can be aggregated, and fragmentation of areas can be minimized. We utilized the distribution-smoothing algorithm in Zonation, which assumes that fragmentation (low connectivity) generally should be avoided for all features. Initial analyses indicated that a connectivity distance of 200m may be appropriate for local government efforts targeted at the watershed scale. We found that very small connectivity distances made no difference in prioritization, since the connectivity effect did not extend very far, and very large connectivity distances aggregated cells across unrealistically large areas. We also found that across a modest range of connectivity distances the results were minor.

In addition, a survey was provided to citizens and civic leaders to identify their preferences about potential stewardship activities within the watershed.

References

Moilanen, A., H. Kujala, and J. Leathwick. 2009. The Zonation framework and software for conservation prioritization. Pages 196-210 in A. Moilanen, K. A. Wilson, and H. P. Possingham, editors. Spatial conservation prioritization: quantitative methods and computational tools. Oxford University Press, Oxford, UK.

Saaty, T.L., and K. Peniwati. 2007. Group decision-making: Drawing out and reconciling differences. Pittsburgh, PA: RWS Publications.

Table 49. Descriptions for features (i.e., data layers) used in land prioritization value models.

Objective	Description
Protect or Improve Waters of Concern	
Focus on Impaired waters	Catchments (i.e., drainage basins) upstream of aquatic life impaired lakes within the watershed. Identified as impaired by the MPCA.
Focus on Catchments with high pollution	Estimated TSS, TN, and TP by catchment as determined by hydrological models. Source: MPCA HSPF model.
Focus on Catchments of lakes with declining water quality	Lakes where long-term data suggest declining water quality.
Focus on Catchments of lakes vulnerable to nutrient addition	The relative susceptibility of a lake to phosphorus pollution (based on lake morphology and catchment hydrology). Source: Lakes of phosphorus sensitivity significance (MPCA and DNR).
Protect or Restore Shoreland	Land within 1000 feet of lake shoreline.
Focus on Catchments with altered hydrology	In small watersheds or catchments with greater than 60% open land or covered with young trees there is marked increase in runoff rates. Source: based on USDA Forest Service research of Sandy Verry; Mitch Brinks's analysis.
Reduce Erosion and Runoff	
Focus on Areas with high erosive potential	Stream Power index: This is an index of the channelized flow erosive potential. Calculated from LiDAR data.
Focus on Areas close to water	Lands close to a stream and lake are more valuable in the protection of water quality than those farther away. The data are the inverse distance from water.
Protect Existing priority wetlands	Existing wetlands as documented by the National Wetland Inventory (NWI) classified using methods from Aitkin County SWCD.
Protect or Restore Stream riparian areas	Stream riparian areas and potential flood zones (based on location, elevation and soil type).
Reduce Soil erosion risk	Susceptibility of soils to erosion. This variable is from the BWSR and UMN's Environmental Benefits Index; it was calculated from a subset of the universal soil loss equation.
Protect or Improve Fish and Wildlife Habitat	
Protect or Restore Trout streams	DNR designated trout stream riparian and floodplain areas.
Protect Sites of biodiversity significance	Areas with varying levels of native biodiversity that may contain high quality native plant communities, rare plants, rare animals, and/or animal aggregations. Identified by Minnesota Biological Survey.
Protect or Restore Sensitive lakeshore	Lakeshore areas that provide unique or critical ecological habitat. Protocols for identifying these areas were developed by the DNR.
Protect High value forests	DNR designated high conservation value forests due to plant and animals present and DNR designed old-growth forests.
Protect Unique Resources	
Protect or Restore Lakes of biological significance	Catchments of high quality lakes. List of high quality lakes based on dedicated biological sampling. Includes wild rice lakes, cisco lakes, high quality fish waters, and other unique lakes. Source: DNR.

Protect or Restore Ecological connections	Ecological corridors between generally large, intact, native or "semi-natural" terrestrial habitat patches. Source: DNR.
Protect or Restore Culturally valuable lands	Cultural lands valuable to citizens of the watershed.
Protect Rare features	Locations of species currently tracked by the DNR, including Endangered, Threatened, and Special Concern plant and animal species as well as animal aggregation sites.
Protect Groundwater	
Protect Groundwater of private wells in sensitive areas	Geologic sensitivity based on the Minnesota Well Index. Source: Minnesota Department of Health (MDH).
Focus on Drinking Water Supply Management Area (DWSMA) vulnerability	The risk associated with potential contaminant sources within a public water supply DWSMA to contaminate its drinking water supply. This risk is based on the aquifer's inherent geologic sensitivity, the assessed vulnerability of the public water supply well(s), and the composition of the groundwater. In highly vulnerable DWSMAs, there is a strong causal relationship between land use activities on the surface and groundwater quality. Includes Source Water Assessment Areas as designated by MDH.
Focus on Groundwater contamination susceptibility	The relative susceptibility of an area to groundwater contamination (based on geologic stratigraphy, aquifer transmissivity, and recharge potential).
Focus on Areas with high groundwater recharge	Estimated potential groundwater recharge. About 75% of drinking water and 90% of agricultural irrigation water in Minnesota are supplied from groundwater. The water that is withdrawn must be supplied by some combination of (1) increased recharge, (2) decreased discharge to streams, lakes, and other surface-water bodies, and (3) removal of water that was stored in the system. Source: U.S. Geological Survey, in cooperation with the MPCA.
Protect or Improve Forestry, Agricultural, and other Lands of Concern	
Implement BMPs on Pasture/hay	Land cover type is pasture or hay (areas used for livestock grazing or planted with perennial seed or hay crops).
Implement BMPs on Cultivated croplands	Land cover type is cultivated crops (areas used for the production of annual crops or actively tilled areas).
Implement BMPs on Valuable timber lands	Forest lands that have been identified as important.
Protect Lands close to protected lands	Lands close to protected lands may be more important for conservation, as larger, contiguous areas often have more value than smaller, fragmented lands. The data are the inverse distance to existing protected lands.
Protect or Improve Lands in Urban growth or Agricultural conversion areas	Lands identified more likely to be developed, and some of these lands that provide important ecosystem services may be of conservation value. Source: Mitch Brinks's analysis of land conversion risk and inverse distance to urban areas.

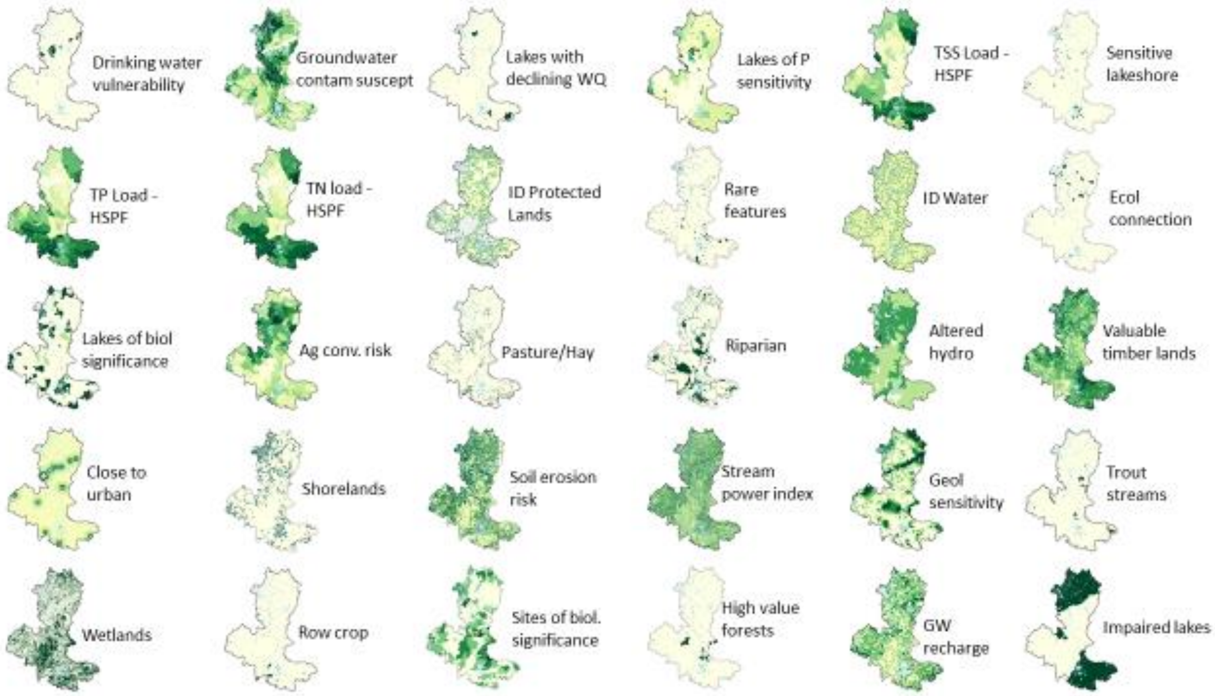


Figure 42. Layers associated with Zonation output