Mustinka River Watershed Restoration and Protection Strategy Report

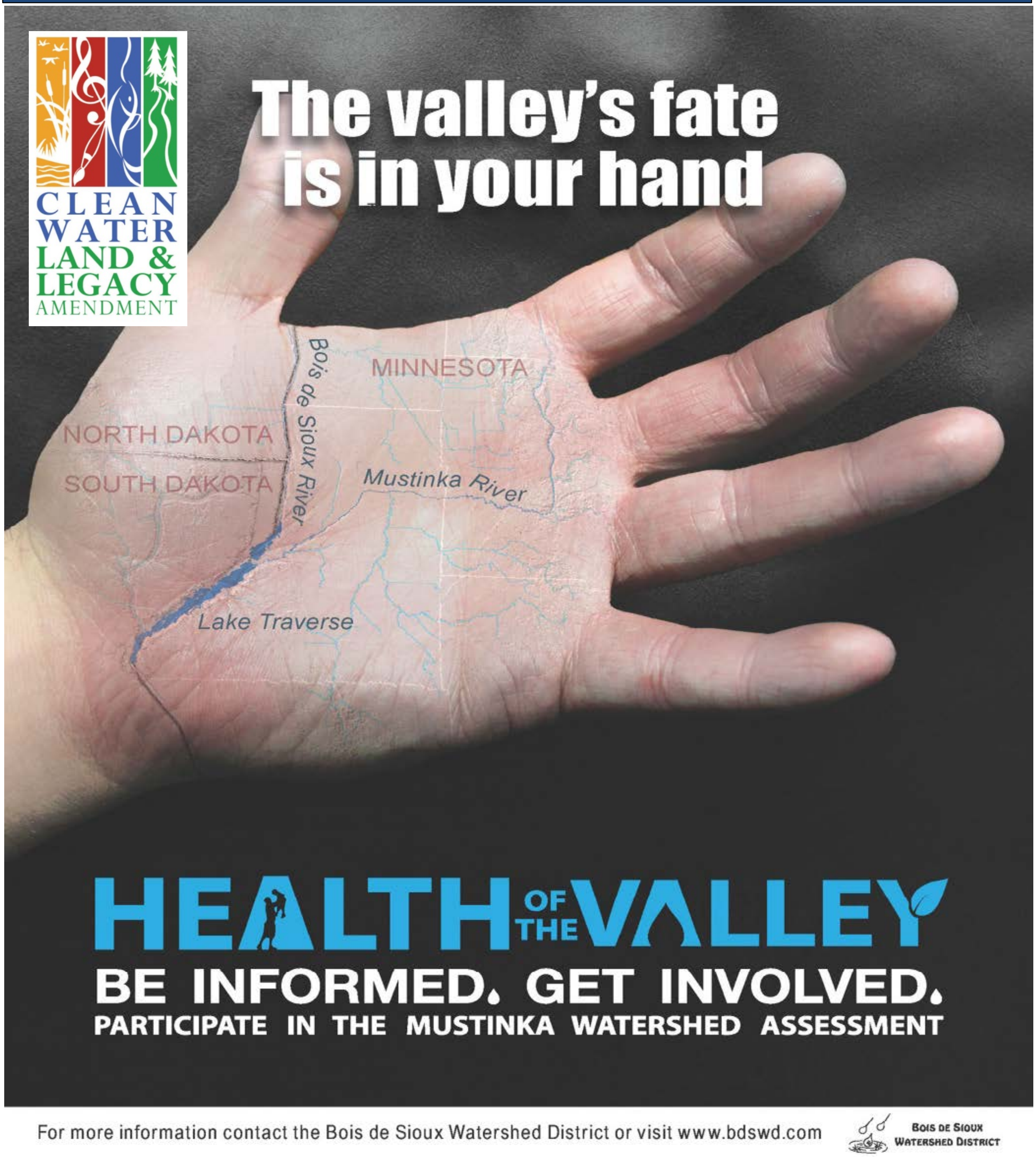

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Table of Contents

Key Terms

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

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

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

Hydrologic Unit Code (HUC): A Hydrologic Unit Code (HUC) is assigned by the USGS for each watershed. HUCs are organized in a nested hierarchy by size. For example, the Red River of the North Basin is assigned a HUC-4 of 0902 and the Mustinka River Watershed is assigned a HUC-8 of 09020102.

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

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

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

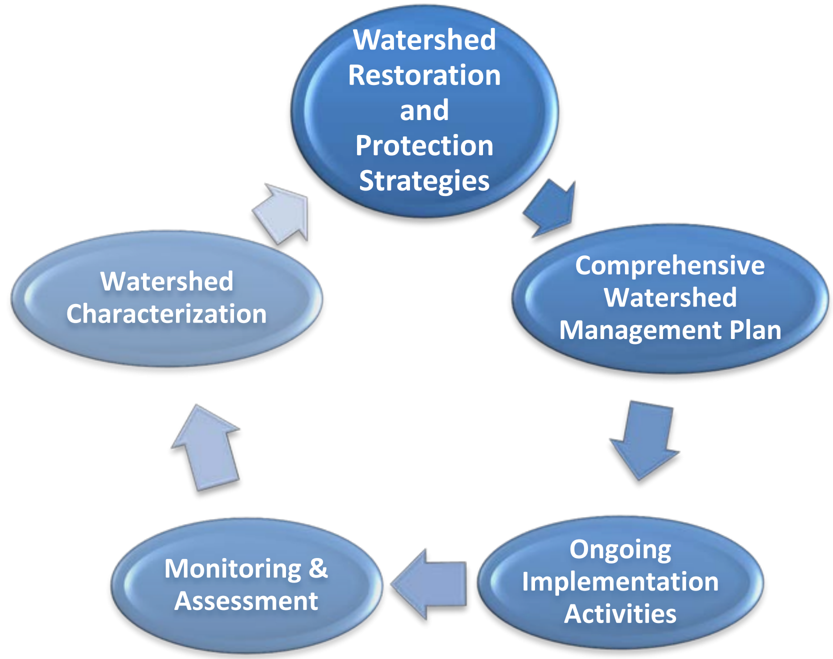
Restoration: This term is used to characterize actions taken in watersheds of impaired waters to improve conditions, eventually to meet water quality standards and achieve beneficial uses of the waterbodies.

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

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

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

What is the WRAPS Report?



The state of Minnesota has adopted a "watershed approach" to address the state's 80 "major" watersheds (denoted by 8-digit hydrologic unit code or HUC). This watershed approach incorporates **water quality assessment, watershed analysis, civic engagement, planning**, **implementation**, and **measurement of results** into a 10-year cycle that addresses both restoration and protection. It is also a one stop location for identification of water quality issues downstream of the watershed that needs to be considered in local water management.

As part of the watershed approach, waters not meeting state standards are still listed as impaired and Total Maximum Daily Load (TMDL) studies are performed, as they have been in the past, but in addition the watershed approach process facilitates a more cost-effective and comprehensive characterization of multiple water bodies and overall watershed health. A key aspect of this effort is to develop and utilize watershed-scale models and other tools to help state agencies, local governments and other watershed stakeholders determine how to best proceed with restoring and protecting lakes and streams. This report summarizes past assessment and diagnostic work and outlines ways to prioritize actions and strategies for continued implementation.

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: • *Mustinka River Watershed Monitoring and Assessment* • *Mustinka River Watershed Biotic Stressor Identification* • *Mustinka River 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 (local governments, Soil and Water Conservation Districts [SWCDs], watershed management groups, etc.) •State agencies (Minnesota Pollution Control Agency [MPCA], Department of Natural Resources [DNR], Board of Water and Soil Resources [BWSR], etc.)

Users' Guide

This Watershed Restoration and Protection Strategy (WRAPS) report summarizes past monitoring, water quality assessments, and other water quality studies that have been conducted in the Mustinka River Watershed. In addition, it outlines ways for local groups to prioritize projects that can be implemented in the watershed to improve water quality. The WRAPS report contains a large amount of information. The purpose of the following table is to provide a Quick Reference guide for users to quickly identify what information can be found in each section of the report.

Table 1. WRAPS Report Quick Reference Guide

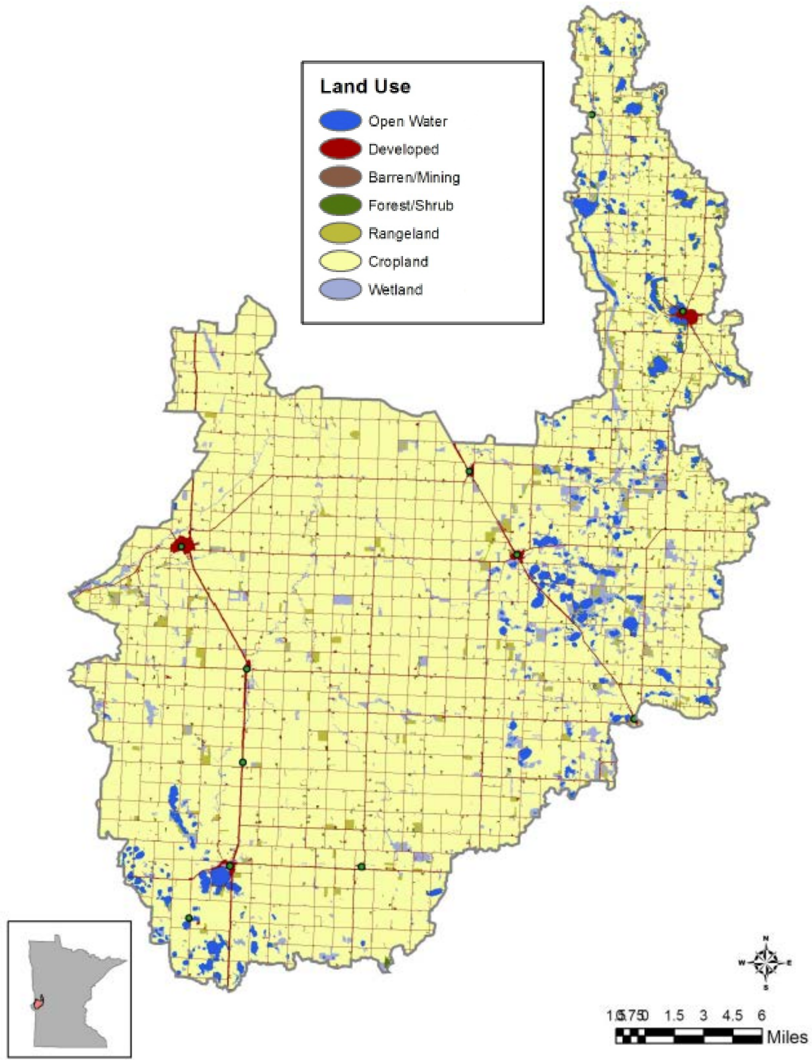
Section	Title	Description	Pages
Summaries of Past Monitoring and Water Quality Studies			
1	Watershed Background	A brief description of the Mustinka River Watershed.	10
2.1	Water Quality Assessment	A summary of how fishable, swimmable and usable the lakes and streams are in the watershed.	12
2.2	Water Quality Trends	A summary of lakes and streams with improving or declining water quality based on at least 10 years of monitoring data.	15
2.3.1	Stressors of Biological Impairments	A summary of factors that cause fish and invertebrate communities in streams to become unhealthy (also known as stressors).	15
2.3.2	Pollutant sources	A summary of sources of pollutants (such as phosphorus, bacteria or sediment) to lakes and streams, including point sources (such as sewage treatment plants) or non-point sources (such as runoff from the land).	16
2.4	TMDL Summary	A summary of TMDL studies in the watershed. A TMDL is a calculation of how much pollutant a lake or stream can receive before it becomes unfishable, unswimmable, or unusable.	21
2.5	Protection Considerations	A summary of lakes and streams in the watershed that are not impaired but are either close to becoming impaired or of exceptionally high quality and need to be protected.	22
Ways to Prioritize Projects that Protect or Restore Water Quality			
3.1	Civic Engagement	A summary of input meetings with local partners in the watershed on the development of the WRAPS report.	23

1. Watershed Background & Description

The Mustinka River Watershed covers 909 square miles (562,112 acres) in west central Minnesota, including areas of Otter Tail, Grant, Stevens, Big Stone, and Traverse Counties. The Mustinka River discharges into Traverse Lake, the headwater of the Bois de Sioux River.

Predominant land use is cultivated cropland (81%). Other minor land uses include emergent herbaceous wetlands (5%), developed open space (4%), open water (4%), and pasture/hay (3%). Cropland in the Mustinka River Watershed is dominated by soybeans and corn with some small areas of spring wheat.

Cities and towns within the Mustinka River Watershed include: Clinton, Donnelly, Elbow Lake, Graceville, Herman, Morris, Norcross, Wendell, and Wheaton.



The Mustinka River Watershed has two distinct regions, the headwater region in the northeast characterized by steeper topography and many small lakes and wetlands, and the downstream agricultural region characterized by flat topography and cultivated cropland.

Additional Mustinka & Red River Watershed Resources

USDA Natural Resources Conservation Service (NRCS) Rapid Watershed Assessment for the Mustinka River Watershed: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/mn/technical/dma/rwa/09020102.html

Minnesota Department of Natural Resources (DNR) Watershed Assessment Mapbook for the Mustinka River Watershed:
http://files.dnr.state.mn.us/natural_resources/water/watersheds/tool/watersheds/wsmb55.pdf

Minnesota Nutrient Reduction Strategy:

http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/nutrient-reduction/nutrient-reduction-strategy.html

Minnesota Nutrient Planning Portal:

http://mrbdc.mnsu.edu/mnnutrients/minnesota-major-watersheds

Red River Basin Commission Reports:

http://www.redriverbasincommission.org/Reports/reports.html

Manitoba State of Lake Winnipeg Report:

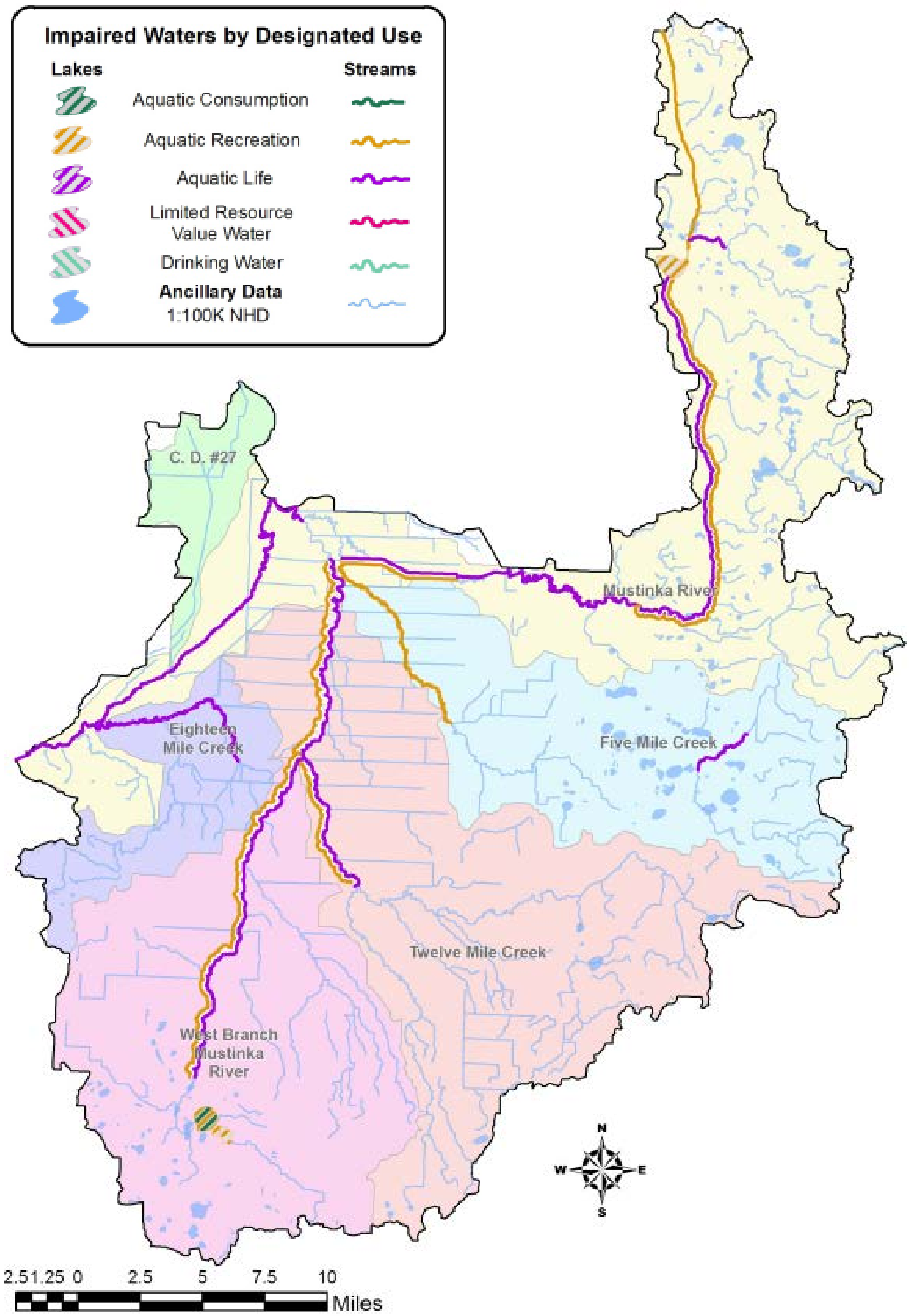
http://www.gov.mb.ca/conservation/waterstewardship/water_quality/state_lk_winnipeg_report/index.html

2. Watershed Conditions

Existing studies and planning already completed in the Mustinka River Watershed:

- Bois de Sioux Watershed District Overall Plan. May 2003. Prepared by HDR Engineering.
- Development of the Soil and Water Assessment Tool (SWAT) to Assess Water Quality in the Bois de Sioux and Mustinka River Watersheds. April 2008. Prepared by Bethany Kurz, Energy & Environmental Research Center, University of North Dakota.
- Red River Biotic Impairment Assessment. June 2009. Prepared by Emmons and Olivier Resources.
- Application of the Flow Reduction Strategy in the Bois de Sioux Watershed. April 2010. Prepared by JOR Engineering.
- Mustinka River Turbidity TMDL Report. June 2010. Prepared by the Minnesota Pollution Control Agency (MPCA).
- Mustinka River Turbidity TMDL Implementation Plan. November 2010. Prepared by Emmons and Olivier Resources.

Additionally, geomorphic evaluation of 22 separate reaches was conducted by Emmons & Olivier Resources, Incorporated (EOR), Department of Natural Resources (DNR), and the MPCA in October of 2011, across the Mustinka River Watershed as part of the 2015 Mustinka River Watershed TMDL study. The investigation found that channel dimensions have likely responded to increased streamflow in the region by becoming enlarged. Summaries of the geomorphic investigation by individual survey location are available in **Appendix A**.



2.1 Water Quality Assessment

This report addresses waters for protection or restoration of aquatic life uses based on the fishery, macroinvertebrate community, dissolved oxygen (DO) concentration, and turbidity levels and for aquatic recreation uses based on bacteria levels or nutrient levels and water clarity. Waters that are listed as impaired will be addressed through restoration strategies and a defined TMDL study. Waters that are not impaired will be addressed through protection strategies to help maintain water quality and recreation opportunities (see Section 2.5 and Section 3).

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

Streams

Streams are assessed for aquatic life and aquatic recreation designated uses.

Aquatic life use impairments include:

- Low fish index of biotic integrity (Fish IBI); which means an unhealthy fish community is present,
- Low macroinvertebrate (i.e., aquatic bugs) index of biotic integrity (Invertebrate IBI); which means an unhealthy macroinvertebrate community is present,
- DO levels too low to support fish or macroinvertebrate life,
- Turbidity/total suspended solids (TSS) levels too high to support fish or macroinvertebrate life,
- pH levels too low or too high to support fish or macroinvertebrate life, and
- Chlorides levels too high to support fish or macroinvertebrate life.

Aquatic recreation use impairments include: *Escherichia coli* (*E. coli*); bacteria, found in the intestinal tracts of warm-blooded animals, which is an indicator of fecal pollution levels that are too high for safe human contact (wading or swimming).

Table 2 below summarizes the ability of the stream reaches to support aquatic life uses and aquatic recreation uses in the Mustinka River Watershed. **Appendix B** includes a complete summary of the stream impairment assessment by designated use and pollutants for all assessed AUIDs.

Table 2. Stream Aquatic Life Use and Aquatic Recreation Use Assessment and Impairment Summary

Subwatershed	Total Stream Reaches	Aquatic Life Use				Aquatic Recreation Use			
		FS	NS	IF	NA	FS	NS	IF	NA
Mustinka River	**11**		6		5	1	3	2	5
Fivemile Creek	**4**		1	2	1		1		3
West Branch Mustinka River	**5**		2		3		1		4
Twelvemile Creek	**4**		2		2		2		2
Eighteenmile Creek	**1**		1					1	
Total	**25**		**12**	**2**	**11**	**1**	**7**	**3**	**14**

FS = fully supporting; NS = not supporting; IF = insufficient data to assess; NA = no monitoring data

Lakes

Lakes are assessed for aquatic recreation uses based on ecoregion specific water quality standards for total phosphorus (TP), chlorophyll-a (chl-*a*) (i.e., the green pigment found in algae), and secchi transparency depth. To be listed as impaired, a lake must not meet water quality standards for TP and either chl-*a* or secchi depth.

There are 188 lakes with surface areas greater than 10 acres; of these, 23 have had some water quality data collected. These lakes were chosen to be geographically representative of a wide-range of lakes in the watershed, or because they are a recreational and locally important resource. MPCA's monitoring approach is described in more detail in the Monitoring and Assessment Report. Table 3 below summarizes the ability of the assessed lakes to support aquatic recreation uses in the Mustinka River Watershed. **Appendix C** includes a complete summary of the lake assessment and aquatic recreation use impairments.

Table 3. Lake Aquatic Recreation Use Assessment and Impairment Summary

Subwatershed	Total Number of Assessed Lakes	Aquatic Recreation Use			Impaired Lakes
		FS	NS	IF	
Mustinka River	6		1	5	Lightning
Fivemile Creek	13			13	
West Branch Mustinka River	2		2		
Twelvemile Creek	2			2	East Toqua, Lannon
Eighteenmile Creek	0				
TOTAL	**23**	**0**	**3**	**20**	

FS = fully supporting; NS = not supporting; IF = insufficient data to assess; NA = no monitoring data

2.2 Water Quality Trends

A seasonal Kendall test for trend using R Statistical Software was used to identify statistically significant trends in the water quality of lakes and streams in the Mustinka River Watershed. Trends were only reported that had statistical confidence of at least 90% (meaning that there is at least a 90% chance that the data are showing a true trend and at most a 10% chance that the trend is a random result of the data), contained at least 10 years of data, and were missing no more than 75% of the samples from the entire period.

Long-term water quality and flow records are available from the Mustinka River at Highway 75 near Wheaton, Minnesota (station S000-062, AUID 09020102-502), and from Lightning (lake ID 26-0282) and Traverse (lake ID 78-0025) Lakes. There was a statistically significant decrease in average annual total suspended solid concentrations of 46% in the Mustinka River at Highway 75 near Wheaton from 2001 to 2011. However, there was not a corresponding statistically significant decrease in seasonal (winter = December through February, spring: March through May; summer: June through August; autumn: September through November) total suspended solid concentrations due to insufficient data available in any one season over time to calculate a long-term trend. Therefore, the average annual decrease may be a random result of data collected from different seasons over time. No statistically significant changes in average growing season Secchi depth transparency were observed in Lightning Lake based on 14 years of data collected between 1988 and 2011.

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 macroinvertebrate communities in streams to become unhealthy. Biological stressor identification is done for streams with either fish or macroinvertebrate biota impairments and encompasses both evaluation of pollutants and non-pollutant-related factors as potential stressors (e.g., altered hydrology, fish passage, habitat). Pollutant source assessments are completed where a biological stressor ID process identifies a pollutant as a stressor as well as for the typical pollutant impairment listings. **Pollutants** (such as phosphorus, bacteria or sediment) to lakes and streams include point sources (such as sewage treatment plants) or non-point sources (such as runoff from the land).

Stressors of Biologically-Impaired Stream Reaches

A stressor identification study was conducted to identify the factors (i.e., stressors) that are causing the fish and macroinvertebrate community impairments in the Mustinka River Watershed, including pollutants and non-pollutant-related factors, such as altered hydrology, fish passage, or habitat. Table 4 summarizes the primary stressors identified in streams with aquatic life impairments in the Mustinka River Watershed. Common stressors were interrupted, low for prolonged periods, or extremely low flows (**intermittent flow**), increased surface water runoff and seasonal variability in stream flow (**altered hydrology/flashiness**), lack of overwintering habitat and fish refugia due to wetland dominated headwaters with little to no oxygen (**lack of fish source area**), dams and improperly sized culverts that block fish passage (**fish barrier**), very low or highly fluctuating DO levels due to excess nutrients fertilizing stream algae growth (**DO/TP**), and increased suspended and deposited sediment that inhibits fish spawning and feeding behaviors (**turbidity/TSS**).

Table 4: Mustinka River Watershed Stressor Identification Study Summary

Subshed	AUID	Stream	Biological Impairment	Stressors					
				Intermittent Flow	Altered Hydrology/ Flashiness	Lack of fish source area	Fish Barrier	DO (TP)	Turbidity (TSS)
Mustinka River	**-580**	Mustinka River, Lightning Lake to Mustinka R Flowage	Fish				○	*	
	-538	Unnamed Creek	Fish, Inverts	○		○			
Fivemile Creek	**-578**	Fivemile Creek	Fish	○		○	○		
Twelvemile Creek	**-514**	Twelvemile Creek, upstream of West Branch Twelvemile	Fish, Inverts		○			●	●
	-557	Twelvemile Creek, West Branch to Mustinka R	Fish, Inverts		○			◉	●
Eighteenmile Creek	**-508**	Eighteenmile Creek	Fish, Inverts					●	

○ = No TMDL needed, ● = TMDL needed, ◉ = TMDL deferred, * = TMDL needed to address conventional DO impairment but not identified as primary stressor through SID process

Pollutant Sources

This section summarizes the sources of pollutants (such as phosphorus, bacteria or sediment) to lakes and streams in the Mustinka River Watershed, including point sources (such as sewage treatment plants) or non-point sources (such as runoff from the land).

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 or State Disposal System (NPDES/SDS) Permit. There are eight municipal wastewater facilities, two municipal water treatment facilities, nine industrial stormwater facilities, and eight large animal feeding operations that require NPDES permitting located in the Mustinka River Watershed (Table 5).

Table 5: Point Sources in the Mustinka River Watershed

Subshed	Point Source Name	Permit #	Type	Pollutant reduction needed beyond current permit conditions/ limits?	Receiving (impaired) water body
Mustinka River	Wheaton WWTP	MN0047287	Municipal Wastewater	No	Mustinka River (-502)
	Elbow Lake WWTP	MNG580082	Municipal Wastewater	Yes	Mustinka River (-580)
	Wendell WWTP	MNG580082	Municipal Wastewater	No	Mustinka River (-580)
	City of Herman Municipal Airport	A00001565	Industrial Stormwater	No	Mustinka River (-518)
	Grant County Highway Department	A00016180	Industrial Stormwater	No	Mustinka River (-580)
	Grant County Highway Garage Norcross	A00016185	Industrial Stormwater	No	Mustinka River (-518)
	Aggregate Industries – Elbow Lake	A00000427	Industrial Stormwater	No	Mustinka River (-580)
	City of Elbow Lake Municipal Airport	A00000371	Industrial Stormwater	No	Mustinka River (-580)
	Elbow Lake Gravel Inc	A00001795	Industrial Stormwater	No	Mustinka River (-580)
Fivemile Creek	Herman WWTP	MN0023647	Municipal Wastewater	No	Fivemile Creek (-510)
	City of Herman Public Works	A00010980	Industrial Stormwater	No	Fivemile Creek (-510)
	Grant County Highway Garage	A00016181	Industrial Stormwater	No	Fivemile Creek (-510)
West Branch	Big Stone Co Hutterite Colony Graceville	MN0064483	Municipal Wastewater	No	West Branch Twelve Mile Creek (-511)
	Graceville WWTP	MN0023540	Municipal Wastewater	Yes	West Branch Twelve Mile Creek (-511)
	Dumont WWTP	MN0064831	Municipal Wastewater	No	West Branch Twelve Mile Creek (-511)

Subshed	Point Source Name	Permit #	Type	Pollutant reduction needed beyond current permit conditions/ limits?	Receiving (impaired) water body
	City of Dumont	A00010548	Industrial Stormwater	No	West Branch Twelve Mile Creek (-511)
	Scott Andrews Farm - Sec 10	MNG440755	Feedlot	No	West Branch Twelve Mile Creek (-511)
	Renee Schwebach Farm	MNG441108	Feedlot	No	West Branch Twelve Mile Creek (-511)
	Arens Land & Livestock	MNG440495	Feedlot	No	West Branch Twelve Mile Creek (-511)
	Big Stone Co Hutterite Colony	MNG440392	Feedlot	No	West Branch Twelve Mile Creek (-511)
Twelve Mile Creek	Donnelly WTP	MNG640028	Municipal Water Treatment	No	Twelve Mile Creek (-514)
	Donnelly WWTP	MN0041319	Municipal Wastewater	No	Twelve Mile Creek (-514)
	Craig Lichtsinn Feedlot	MNG440304	Feedlot	No	Twelve Mile Creek (-514)
	Dollymount Dairy LLP	MNG440668	Feedlot	No	Twelve Mile Creek (-514)
	Pederson Family Farm Inc	MNG440876	Feedlot	No	Twelve Mile Creek (-514)
Eighteen-mile Creek	Wheaton WTP	MNG640115	Municipal Water Treatment	No	Eighteenmile Creek (-508)
CD #27	Valley Pork, LLP	MNG440400	Feedlot	No	Mustinka River (-503)

Nonpoint Sources

Nonpoint sources of pollution, unlike pollution from industrial and sewage treatment plants come from many diffuse sources. Nonpoint source pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes and streams. Common non-point pollutant sources in the Mustinka River Watershed are:

- **Fertilizer and/or manure runoff**: Fertilizer and manure contains high concentrations of phosphorus, nitrogen, and bacteria that can runoff into lakes and streams when not properly managed.
- **Field and stream erosion**: Field erosion can deliver sediment containing total suspended solids and phosphorus when soil is disturbed or exposed to wind and rain; stream erosion can deliver sediment from destabilized banks or transport of deposited sediment in the stream during very high flows.
- **Failing septic systems**: Septic systems that are not maintained or failing near a lake or stream can contribute excess phosphorus, nitrogen, and bacteria.
- **Internal loading**: Lake sediments contain large amounts of phosphorus that can be released into the lake water through physical mixing or under certain chemical conditions.
- **Upstream lakes and streams**: Some lakes and streams receive most of their pollutants from upstream waterbodies. For these lakes, restoration and protection efforts should focus on improving the water quality of the upstream contributing lake or stream.
- **Wildlife fecal runoff**: Dense or localized populations of wildlife, such as beavers or geese, can contribute phosphorus and bacteria pollutants to streams or ponds.

Fertilizer and/or manure runoff, field and stream erosion, and upstream loading were identified as common non-point pollutant sources to impaired streams, while fertilizer runoff, in-lake sediment phosphorus release (internal loading), and upstream lake loading were identified as common non-point pollutant sources to impaired lakes.

Table 6. Relative Magnitude of Contributing Nonpoint Pollutant Sources in the Mustinka River Watershed

Subwatershed	Pollutant	Watershed of Impaired Stream/Reach (AUID) and/or Lake (ID)	Fertilizer and/or manure run-off	Field and stream erosion	Failing septic systems	Internal loading	Upstream lakes and streams	Wildlife fecal runoff
Mustinka River	TP	Lightning Lake (26-0282-00)	●		○	○		
		Mustinka River (-580)	○	●				
	TSS	Mustinka River (-502)		⭘			●	
		Mustinka River (-503)		⭘			●	
		Mustinka River (-518)		⭘			●	
		Mustinka River (-580)		●				
		Mustinka River (-582)		●			●	
	E. coli	Mustinka River (-506)	●		○			⭘
		Mustinka River (-518)						
		Mustinka River (-580)	⭘		○			⭘
Fivemile Creek	*E. coli*	Fivemile Creek (-510)	●		○			○
West Branch	TP	East Toqua Lake (06-0138-00)	○		○	●	⭘	
		Lannon Lake (06-0139-00)	⭘		○	●		
		West Branch Twelvemile Creek (-511)	○	●				
	E. coli	West Branch Twelvemile Creek (-511)	●					○
Twelve Mile Creek	TP	Twelvemile Creek (-514)	○	●				
	TSS	Twelvemile Creek (-514)		●				
		Twelvemile Creek (-557)		●			⭘	
	E. coli	Twelvemile Creek (-514)	●					○
		Twelvemile Creek (-557)	●		○			○
Eighteenmile Creek	TP	Eighteenmile Creek (-508)	○	●				

Key: ● = High ⭘ = Moderate ○ = Low. **Note:** All sources listed in the table were identified in completed TMDL studies. The symbols in the table differentiate the relative ranking of implementation targeting for the more significant sources.

2.4 TMDL Summary

A TMDL is a calculation of how much pollutant a lake or stream can receive before it becomes unfishable, unswimmable, or unusable. These studies are required by the Clean Water Act for all impaired lakes and streams. There are 3 impaired lakes and 11 impaired streams in the Mustinka River Watershed with completed TMDL studies (Table 7). Table 8 and Table 21 (See Appendix D) summarize the individual TMDL wasteload and load allocations and percent reductions needed to meet water quality standards and goals for each impaired stream or lake.

Table 7. Completed Total Maximum Daily Load studies in the Mustinka River Watershed

Impaired Lake (ID) or Stream (AUID)	Impairment	TMDL Study	TMDL Pollutant		
			E. coli	TP	TSS
East Toqua Lake (06-0138-00)	Nutrient/ Eutrophication Biological Indicators	**		●	
Lannon Lake (06-0139-00)	Nutrient/ Eutrophication Biological Indicators	**		●	
Lightning Lake (26-0282-00)	Nutrient/ Eutrophication Biological Indicators	**		●	
Mustinka River (-502)	Turbidity	**			●
Mustinka River (-503)	Turbidity	*			●
Mustinka River (-506)	Bacteria	**	●		
Eighteenmile Creek (-508)	Dissolved oxygen, Fish & macroinvertebrate bioassessments	**		●	
Fivemile Creek (-510)	Bacteria	**	●		
West Branch Twelvemile Creek (-511)	Bacteria, Dissolved oxygen	**	●	●	
Twelvemile Creek (-514)	Bacteria, Dissolved oxygen, Turbidity, Fish & macroinvertebrate bioassessments	**	●	●	●
Mustinka River (-518)	Bacteria	**	●		
	Turbidity	*			●
Twelvemile Creek (-557)	Bacteria, Turbidity, Fish & macroinvertebrate bioassessments	**	●		●
Mustinka River (-580)	Bacteria, Dissolved oxygen, Turbidity, Fish bioassessments	**	●	●	●
Mustinka River (-582)	Turbidity	**			●

* June 2010 Mustinka River Turbidity TMDL: http://www.pca.state.mn.us/index.php/view-document.html?gid=14019
** 2015 Mustinka River Watershed TMDL (in progress): http://www.pca.state.mn.us/index.php/water/water-types-and-programs/minnesotas-impaired-waters-and-tmdls/tmdl-projects/red-river-basin-tmdl/mustinka-river-major-watershed.html

Table 8. Allocation summary for completed lake TMDLs in the Mustinka River Watershed

Lake (ID)	Pollutant	Allocations (kg/year)										Percent Reduction
		Wasteload Allocation			Load Allocation					MOS	RC	
		WWTFs	Construction & Industrial Stormwater	MS4 Communities	Watershed Runoff*	Internal P Release	Upstream Lake Outflow	Failing Septic Systems	Atmospheric Deposition	Margin of Safety	Reserve Capacity	
East Toqua Lake (06-0138-00)	TP	--	0.1	--	57.7	465.3	342.0	0.0	45.3	101.2	--	95%
Lannon Lake (06-0139-00)	TP	--	0.1	--	412.0	109.5	--	0.0	11.9	59.3	--	94%
Lightning Lake (26-0282-00)	TP	--	0.4	--	1,370.8	132.6	--	0.0	55.6	173.4	--	58%

***** Includes Wasteload Allocation transfers for future Regulated MS4 Communities

2.5 Protection Considerations

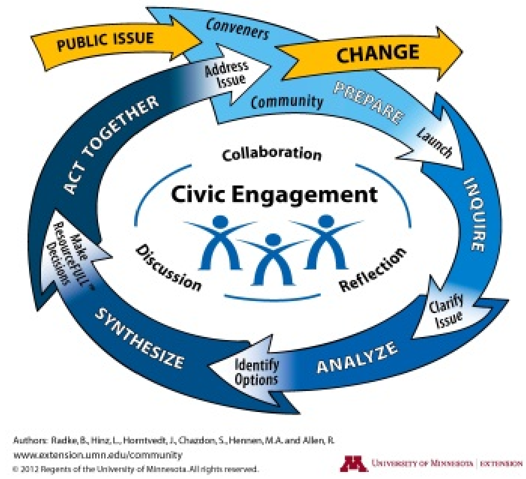
While the vast majority of lakes and rivers, in the Mustinka Watershed, are impaired for one or more designated uses, watershed stakeholders should seek opportunities to identify and implement protection strategies on the remaining, unimpaired waterbodies. Additionally, the recent and continued proliferation of tile drainage in the watershed should be considered as it will likely increase stress to waterbodies due to the increased nitrate and reactive phosphorus export.

3. Prioritizing and Implementing Restoration and Protection

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

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

3.1 Civic Engagement



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

Technical Committee Meetings

The Mustinka River Watershed is made up of numerous local partners who have been involved at various levels throughout the project. The technical committee is made up of members representing the Bois de Sioux Watershed District, MPCA, DNR, counties, and SWCDs within the watershed. Table 9 outlines the meetings that occurred regarding the Mustinka River Watershed monitoring, TMDL development, and WRAPS report planning. Additional information about technical committee members and meeting agendas can be found on the Mustinka River Watershed TMDL and WRAPS website: http://www.healthofthevalley.com/.

Table 9. Mustinka River Watershed TMDL Technical Committee Meetings

Date	Location	Meeting Focus
June 24, 2011	Bois de Sioux Watershed District Office, Wheaton, MN	Watershed Assessment and Monitoring
January 23, 2014		Source Assessment Summary, and TMDL and Allocations Approach
February 25, 2015		TMDL Results and WRAPS Kick-off
April 16, 2015		WRAPS Results

Civic Engagement

The MPCA along with the local partners and agencies in the Mustinka River Watershed recognize the importance of public involvement in the watershed process. Table 10 outlines the opportunities used to engage the public and targeted stakeholders in the watershed. More information can be found on the Mustinka River Watershed TMDL and WRAPS website: http://www.healthofthevalley.com/.

The Mustinka River Watershed WRAPS Report went through its 30-day public noticed review and comment period from March 28, 2016, through April 27, 2016. The MPCA received two comments regarding the WRAPS report, all of which were submitted by the Minnesota Department of Agriculture. All comments have been addressed in this final WRAPS report.

Table 10. Mustinka River Watershed TMDL Civic Engagement Meetings

Date	Location	Focus
October 2011	Press Release and Radio Spot on KFGO AM Radio's "Ripple Effects"	Project Kick-off and Stream Stability Assessment Field Work
April 2012	Poster Mailing (see report cover)	Health of the Valley Campaign
October 2012	Press Release and Radio Spot on KFGO AM Radio's "Ripple Effects"	Stream Health and Channel Stability
February 2013		Watershed Restoration and Soil Health
January 23, 2014	American Legion, Wheaton, MN	TMDL and WRAPS Open House
Ongoing	Project Website: www.healthofthevalley.com	TMDL and WRAPS Process, Events and Documentation

3.2 Targeting of Geographic Areas

The following section describes the specific tools and methodology that were used in the Mustinka River Watershed to identify, locate and prioritize potential watershed restoration actions within five focus HUC-12 watersheds, comprising about 30% of the total watershed area. These five watersheds were selected based on recommendations from stakeholders and are areas where current restoration efforts are currently being planned. While restoration actions need to be undertaken watershed-wide, focusing on these five watersheds allowed use of advanced BMP prioritization and targeting tools. These BMP analyses could not have been conducted watershed-wide because of the time and effort required; therefore, BMP results for the five HUC-12s, while representing locally relevant, actionable plans, are meant as an illustrative example of the types of analyses that should be conducted watershed-wide as BMP strategies are being developed in the future.

Three BMP tools were used in the five HUC-12 watersheds: (1) the HSPF model developed by EOR, (2) the Water Quality Decision Support Application (WQDSA) developed by the International Water Institute, and (3) the ACPF developed by Mark Tomer and others at the USDA-ARS (Ames, Iowa). The WQDSA and ACPF are recently developed GIS tools that utilize high resolution LiDAR (Light Detection and Ranging) digital elevation data to assist in prioritizing areas and finding suitable, field-scale BMP sites. The overall prioritization and targeting methodology was based upon the results of these three tools as well as economic analyses and is intended to serve as a roadmap to stimulate BMP planning and implementation discussions amongst stakeholders. It also provides rough estimates of the extent of BMP implementation and associated costs needed to achieve practical reduction goals at the HUC-8 (watershed-wide) scale. While proposed WRAPS actions outlined in Section 3.3 at HUC-8 and HUC-11 scale are aimed at reducing TSS/turbidity, *E. coli* and phosphorus and improving conditions stemming from altered hydrology (e.g., intermittency of flow, flashiness), for this HUC-12 scale analysis, reducing phosphorus loads was the sole focus. A 10% watershed-wide phosphorus reduction goal was targeted which conforms to the goal set forth in the MPCA's Nutrient Reduction Strategy (NRS) for the Red River Basin.

BMP Prioritization and Targeting Tools

HSPF Model

The HSPF is a large-basin, watershed model that simulates runoff and water quality in urban and rural landscapes. An HSPF watershed model was created for the Mustinka River Watershed for use with TMDL analyses. The model was constructed and calibrated using data from 2001-2006, focusing on simulation of flow, phosphorus, and sediment. Although model simulations and results are based on a more generalized, larger scale perspective of watershed processes (and thus, less useful with regards to finer scale prioritization compared to the LiDAR based analyses discussed below) their value lies in estimation of river flows and water quality in areas where limited or no observed data has been collected, as well as, estimations of the locations and proportions of watershed sources -- specific combinations of landuse, slopes and soils -- comprising pollutant loading at downstream locations (e.g., Wheaton) where more substantial observed data are available. HSPF modeled watershed sources were used in concert with results from the WQDSA to help select HUC-12 watersheds for the more focused BMP siting analyses using the ACPF discussed below.

Water Quality Decision Support Application

The WQDSA is a LiDAR-based analysis framework for small-watershed to field scale prioritization of potential pollutant source areas or "hotspots". Hotspots are distinct areas on the landscape judged to be contributing relatively high amounts of pollutants to nearby waterbodies. The WQDSA looks at the agricultural landscape at a very small scale -- in this case, individual 3 square meter source areas. In each source area, the WQDSA estimates (1) the amount of pollutants leaving the source area and (2) the proportion of these pollutants reaching the nearest stream. These resulting source area pollution estimates were summed and ranked at the HUC-12 watershed scale with those ranked the highest (e.g., upper 25%) being designated as hotspots. The WQDSA was created for the Red River basin and was run for the Mustinka River Watershed by the International Water Institute (IWI). The WQDSA output was used to target and prioritize phosphorus and sediment hotspots on the landscape in order to facilitate cost-effective BMP planning on the areas with the highest potential to contribute to downstream water quality pollution. These results were used to select HUC-12 watersheds for the more focused BMP siting analyses using the ACPF discussed below.

Agricultural Conservation Planning Framework

The ACPF is a LiDAR-based GIS analysis framework that, similar to the WQDSA, determines pollutant hotspots (principally based on estimated runoff risk) on the landscape but more importantly targets potential field-scale sites for a set of specific agricultural BMPs such as sediment control basins (WASCOBs), restored wetlands, riparian buffers and grassed waterways. Siting is based on LiDAR terrain analyses taking into account criteria identified by NRCS to meet Environmental Quality Incentives Programs (EQIP) specifications (e.g., contributing drainage area to BMP, location of dominant runoff flowpaths, basin depths and volumes, etc.).

BMP Prioritization and Targeting Approach and Results

The overall prioritization and targeting approach to meet the 10% phosphorus reduction goal utilized all three tools discussed above to varying degrees. The overarching BMP strategy was to reduce phosphorus fertilizer applications watershed wide by more efficiently applying phosphorus according to soil P tests (i.e., Bray-1). Research in Iowa watersheds suggests this practice of keeping soil P levels at an optimal range reduces phosphorus loads by an average of 17% and increases farmer profits due to reduced fertilizer application. In addition to the watershed-wide phosphorus practice, five HUC-12 watersheds were selected for more focused BMP analysis. In these watersheds, land retirement BMPs (e.g., CRP) and a BMP combining cover crops with no-till (which was also intended to improve soil health) were explored as well as "structural" type BMPs such as WASCOBs, riparian buffers, and grassed waterways.

The ACPF tool was run by EOR for five HUC-12 watersheds in the Mustinka River Watershed (see map in Appendix E) for targeting of specific field-scale structural BMP sites. These watersheds of interest were selected based on input received from stakeholders during planning meetings as well as results from HSPF modeling and the WQDSA (discussed above). Results of the ACPF analyses were intended to provide a basis for discussion on BMP planning and implementation within these watersheds, and also serve as an example of the potential value in doing ACPF analyses on additional HUC-12s within the Mustinka watershed in the future. Phosphorus was the pollutant of focus for this exploratory analysis although most of the results will apply to sediment as well.

Structural/Terrain Dependent BMP Siting using ACPF

Terrain dependent BMPs refer to those structural practices whose cost-effectiveness is dependent on characteristics of landscape (topography, soils, landuse). For example, the optimal locations for enhancing riparian buffers are at the intersections between perennial streams (vs. intermittent) and areas of relatively high overland runoff (i.e., where significant runoff flow from agricultural fields enters the stream via the riparian zone). Impoundments such as WASCOBs need to be sited where high runoff and erosion potential exist and where topography is conducive to impounding significant runoff after construction of a berm/embankment.

The ACPF tools were designed principally with depressional/prairie pothole topography in mind, particularly where WASCOBs, restored depressional wetlands and constructed nutrient removal wetlands are concerned (the latter refers to wetlands constructed within headwater channels for, principally, removal of nitrate). As such, the lake plain areas of the Mustinka provide little opportunity for harnessing existing on-field, riparian and in-channel depressional storage. In these areas, riparian buffers were the sole terrain dependent BMP sited. In the beach ridge/moraine areas, potential WASCOB locations were sited in addition to buffers. In all areas, significant overland flow paths were delineated where they entered perennial streams. These features represent areas of interest for possible implementation of grassed waterways and/or wider riparian buffers (or other form of grade stabilization, side inlet installation, etc.).

As implied above, BMP siting analysis was constrained to areas around perennial streams; this is due to the assumption that practices are more cost-effective when placed in areas with consistent flow. Intermittent streams can be important during certain seasons and precipitation events but the focus of the ACPF analysis was on channels most likely to export pollutants downstream.

ACPF results for WASCOBs, riparian buffers and grassed waterways were integrated into the overall BMP plan and are summarized below and in Table 11. ACPF methodology, results and implementation are discussed in greater detail within **Appendix E.**

BMP Cost-Benefit Analysis and Results

A cost-benefit analysis was conducted for the watershed-wide phosphorus application BMP in combination with ACPF-sited structural BMPs in the five targeted HUC-12s in the Mustinka River Watershed. The overall results suggest that adoption of the phosphorus application BMP on 30% of the total cropped area in the watershed (approximately 166,000 acres including 45,000 acres in targeted HUC-12s; 121,000 outside the targeted HUC-12s) combined with the ACPF targeted BMPs in the five HUC-12s of focus would meet the 10% phosphorus reduction goal set forth by the MPCA. If the total drainage area targeted for structural BMPs in the five subwatersheds is spread over the entire watershed, assuming a similar proportion of suitable site opportunities, roughly 10% of the Mustinka Watershed's cropped land would have to drain to one or more structural BMPs (WASCOBs, riparian buffers and/or grassed waterways) to achieve the 10% phosphorus reduction goal.

Further details about each ACPF practice can be found in Appendix E. Cost-benefit ratios (cost per pound of phosphorus removed) were based on the assumptions listed in Table 22 regarding the estimation of treated watershed area and phosphorus load for each practice. Cost-effectiveness of each ACPF practice is reported across all five HUC-12s in Table 11 below, and by individual HUC-12 in Appendix E.

Land retirement and cover crops have the highest (most expensive) cost-effectiveness ratio, reducing phosphorus application rates have the lowest (free) cost-effectiveness ratio, and edge-of-field, terrain dependent, structural Ag BMPs have moderate cost-effectiveness ratio.

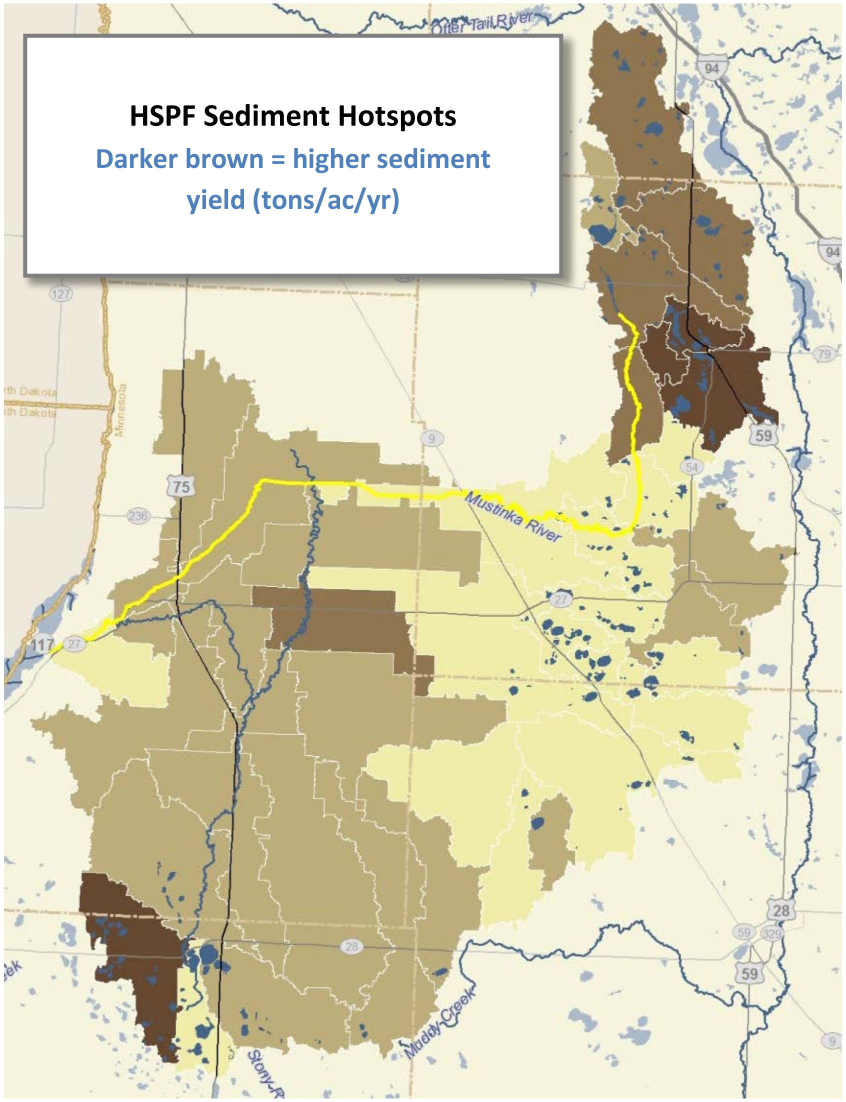
Table 11. Estimated phosphorus reductions and cost-effectiveness for proposed BMPs applied watershed-wide and in five targeted HUC-12 subwatersheds in the Mustinka River Watershed

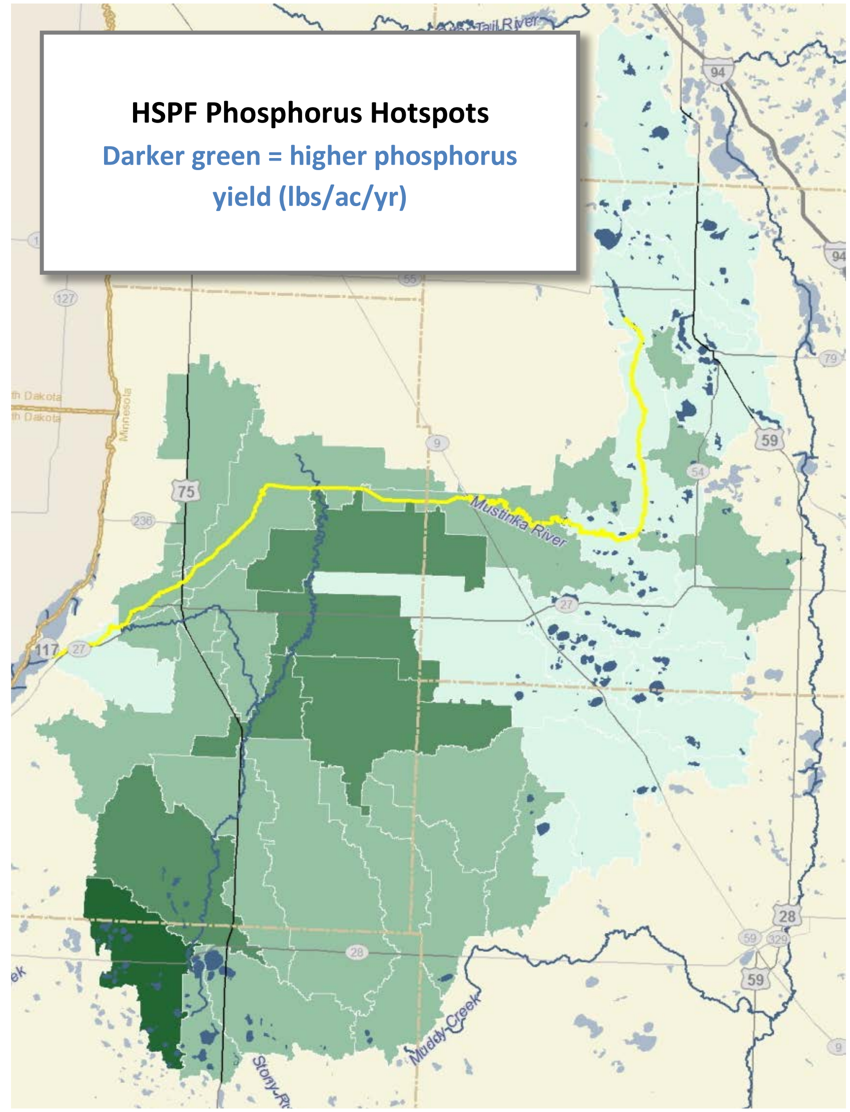
Category	Practice	% P Reduction	Cost ($/ac-yr)	Treated Watershed Area (ac)	Phosphorus Reduction (lb)	Cost-Benefit ($/lb P reduction)
Land Use Change	Corn/Soybean to Pasture and/or Land Retirement	75	585	46[1]	12	1,014
In-Field	Reduce phosphorus application rates	17	(-12)	166,000[2]	9,456	(-207)
	Cover crops, no-till, increase soil organic matter	29	78	28,225[1]	2,849	793
Edge-of-Field	Sediment basins	85	6	704[1]	208	22
	Riparian buffers	58	7	55,687[1]	11,241	34
	Grassed waterways	58	31	4,039[1]	815	155

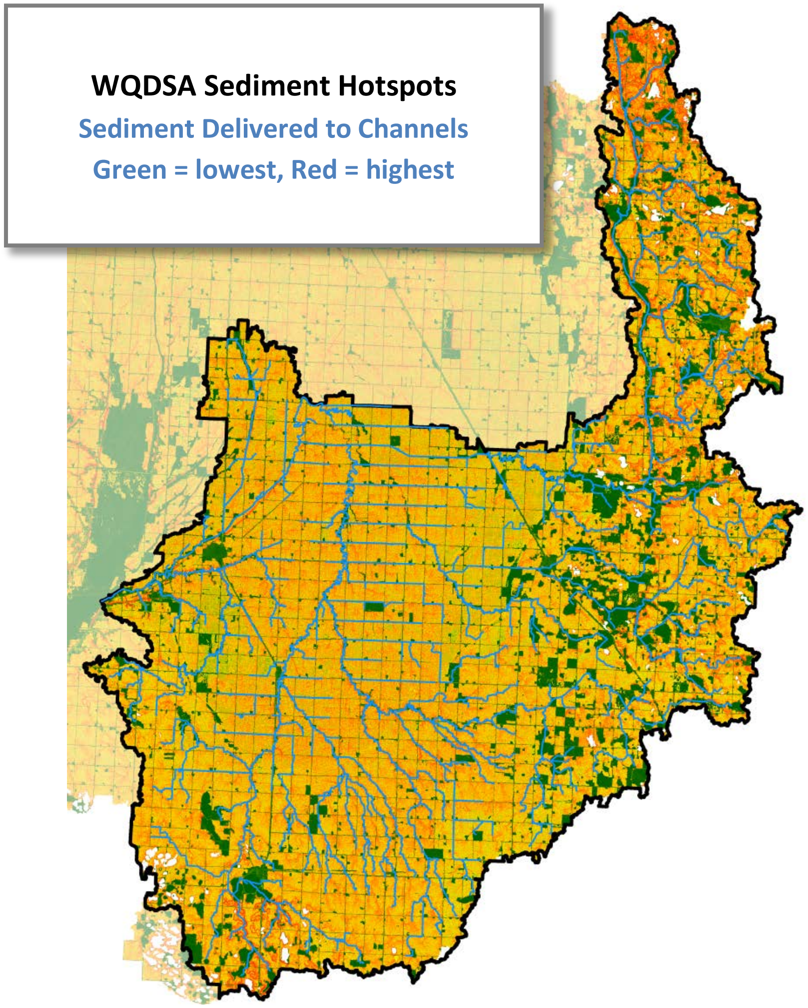
[1] BMP was applied in five targeted HUC-12 subwatersheds

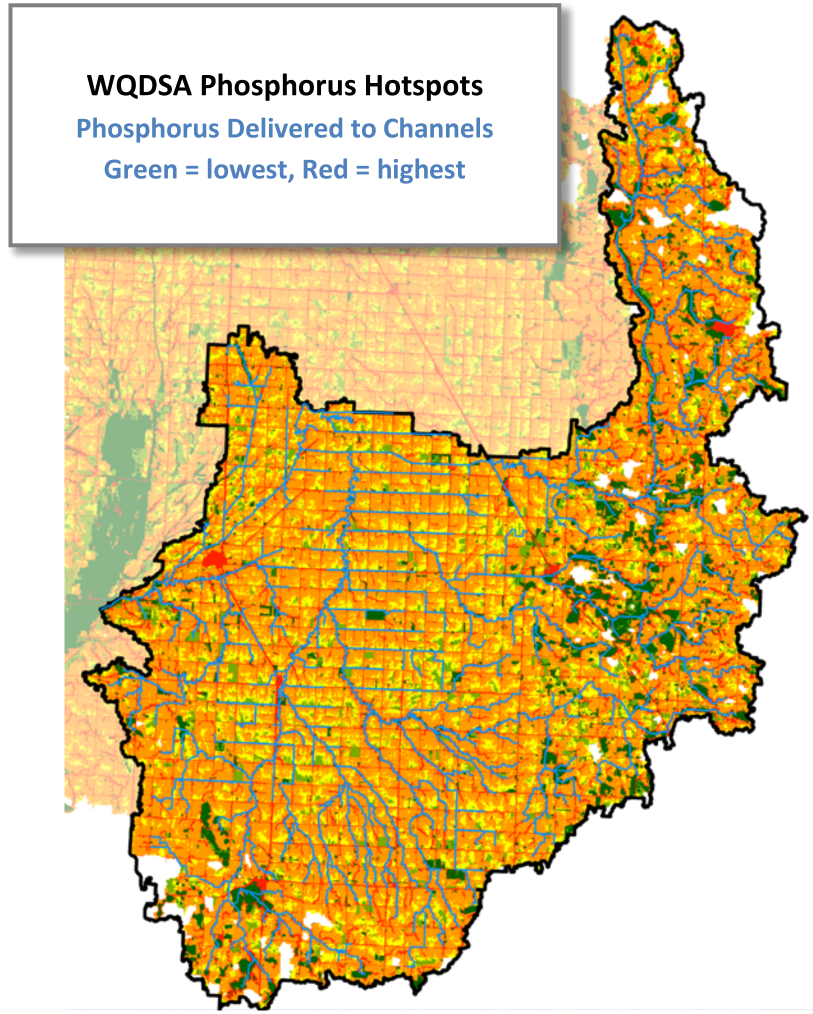
[2] BMP was applied watershed-wide

Tool	Description	How can the tool be used?	Notes	Link to Information and data
Light Detection and Ranging (LiDAR)	Elevation data in a digital elevation model (DEM) GIS layer. Created from remote sensing technology that uses laser light to detect and measure surface features on the earth.	General mapping and analysis of elevation/terrain. These data have been used for: erosion analysis, water storage and flow analysis, siting and design of BMPs, wetland mapping, and flood control mapping. A specific application of the data set is to delineate small catchments.	The layers are available on the MN Geospatial Information website for most counties.	*MnGEO*
Water Quality Decision Support Application / PTMapp	LiDAR based GIS terrain analyses for determining hydrologic and water quality pathways in rural landscapes.	Mapping of priority runoff and pollutant (nitrogen, phosphorus, sediment) source areas ("hotspots") for use in BMP targeting and planning strategies.	Developed and administered by International Water Institute; serves as foundation for the BWSR's PTMapp; public release of toolset was Fall 2015.	*RRBDIN*
Agricultural Conservation Planning Framework	LiDAR based GIS terrain analyses for determining potential locations for specific agricultural BMPs at the field scale.	Field scale mapping of potential locations of BMPs and creation of cost-effective BMP scenarios.	Developed and administered by USDA-ARS (Ames, IA); public release of toolset was Fall 2015.	*ACPF*
Hydrological Simulation Program – FORTRAN (HSPF) Model	Simulation of watershed hydrology and water quality for both conventional and toxic organic pollutants from pervious and impervious land. Typically used in large watersheds (greater than 100 square miles).	Incorporates watershed-scale and non-point source models into a basin-scale analysis framework. Addresses runoff and constituent loading from pervious land surfaces, runoff and constituent loading from impervious land surfaces, and flow of water and transport/ transformation of chemical constituents in stream reaches.	Local or other partners can work with MPCA HSPF modelers to evaluate at the watershed scale: 1) the efficacy of different kinds or adoption rates of BMPs, and 2) effects of proposed or hypothetical land use changes.	*AquaTerra*


HSPF Sediment Hotspots
Darker brown = higher sediment yield (tons/ac/yr)
Otter Tail River
Mustinka River
Muddy Creek


HSPF Phosphorus Hotspots
Darker green = higher phosphorus yield (lbs/ac/yr)
Mustinka River
Muddy Creek

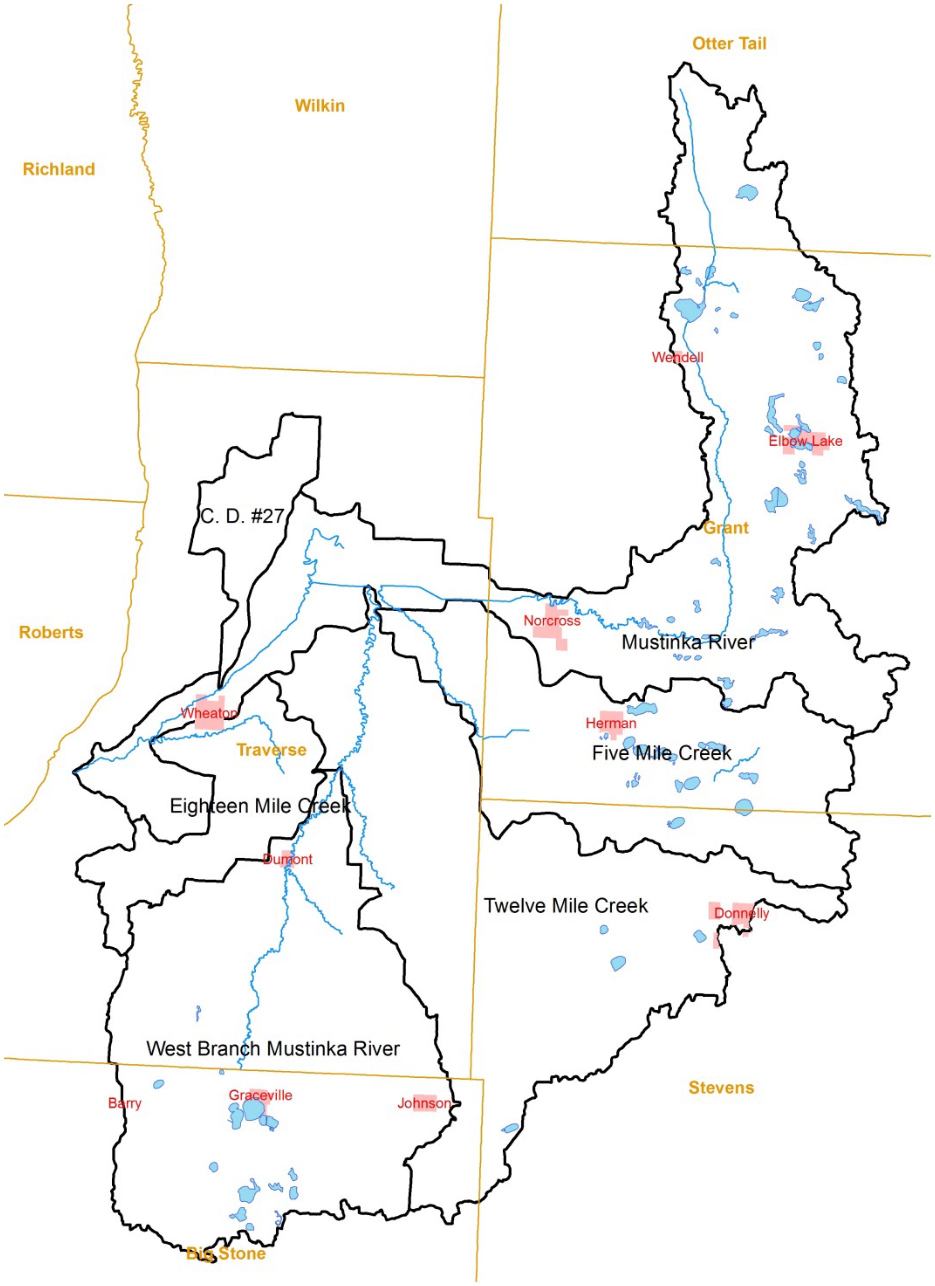

WQDSA Sediment Hotspots
Sediment Delivered to Channels
Green = lowest, Red = highest


WQDSA Phosphorus Hotspots
Phosphorus Delivered to Channels
Green = lowest, Red = highest

3.3 Restoration & Protection Strategies

This section provides detailed tables identifying restoration and protection strategies for individual lakes and streams in each HUC-11 subwatershed that restore or protect water quality. These projects are divided into sections by HUC-11 subwatershed, and include the following information:

- County location
- Water quality conditions and goals
- 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



This section provides a short description of the major water quality concerns in the Mustinka River Watershed that were developed based in part on input from local partners during the February 25, 2015, WRAPS Technical Advisory Committee meeting in Wheaton, Minnesota. These water quality concerns were used to guide the identification and prioritization of restoration and protection strategies in this section.

- **Carp**: are pervasive throughout the lakes and streams in the watershed; the vigorous bottom feeding behavior of carp re-suspends sediment, increases turbidity, and destroys habitat.
- **Impoundments**: have accumulated extensive sediment and need dredging.
- **Agricultural drainage**: past ditching and substantial recent and ongoing increases in tile drainage have altered watershed runoff patterns and stream flow; in particular, increases in tile drainage are likely to increase nitrate and reactive phosphorus concentrations in downstream streams and lakes. Misconceptions exist among farmers about the impact of tiling on nutrients in agricultural runoff.
- **Dissolved nutrients**: misconceptions exist among farmers about the difference between sediment, TP and reactive phosphorus, and the impacts agricultural practices have on the export of these different types of nutrients.
- **Soil health**: intensive agricultural practices deplete the organic matter content of the soil which increases nutrient leaching and decreases infiltration of runoff into the soil; soil health is marginal watershed-wide; challenges remain with cover crops to improve soil health due to herbicide residue and short growing season.
- **Degraded riparian condition**: there is an overall lack of stream buffers that stabilize stream banks and filter pollutants from watershed runoff; individual counties are in the process of conducting stream surveys to identify priority areas.
- **Altered hydrology**: stream channelization, loss of wetland storage, laser-guided grading of farmed-through head water streams, and tiling of the shallow groundwater – all components of altered hydrology – have exacerbated the effect of typical late-summer dry down conditions throughout the watershed. This results in extended periods of stagnant, low flow conditions in streams and ditches which adversely impacts local fish, macroinvertebrates, and nutrient release.
- **Ditch dredging**: dredging activities in low gradient systems potentially remove and re-deposit sediment and phosphorus on farm fields and/or riparian areas; more research is needed to understand how these activities affect sediment export downstream.
- **Wind erosion**: unprotected soils in winter result in extensive wind erosion of soil from fields.
- **Lack of stream connectivity**: perched culverts and disconnection from the natural floodplain have limited hydrologic and biologic connectivity in watershed streams.
- **Straight pipe septic systems**: some individual septic systems are failing and discharging nutrients and bacteria directly to lakes and streams.
- **Degraded water quality**: excess nutrients and sediment have resulted in degraded water quality of lakes and streams watershed-wide.

Watershed-wide

Table 12. Strategies and actions proposed for the entire Mustinka River Watershed

HUC-11 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see key below)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones (year ending 2021)	Governmental Units with Primary Responsibility								Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions	Goals / Targets and Estimated % Reduction				BdSWD	SWCD	MPCA	City	County	DNR	BWSR	MDA	
All	All Lakes	All	All	n/a	n/a	Septic system improvements	Address failed SSTS; use grant funds when possible	Replace all systems deemed Imminent Threat to Public Health because of surface water discharges, secure funding for cost-share program		X			X				n/a
						Wetland restoration	Restore all degraded or ditched wetlands identified through PTMApp/ACPF or by DNR program priorities.	Identify projects using PTMapp/ACPF or DNR wildlife management area program priorities, contact landowners, secure funding	X	X				X	X	X	n/a
						Shoreline restoration	Manage high water issues	Develop water management plan		X				X			n/a
						Improve soil health	Increase vegetative cover with cover crops; combine practice with no-till	Establish at least one 5-year pilot site in each HUC-11 and monitor soil organic matter content; Share with other landowners	X								n/a
						Sediment management	Wind erosion barriers; buffer strips	Identify priority areas using PTMapp or ACPF, contact landowners, and secure funding	X	X					X	X	n/a
						Nutrient management	Increase Ag P fertilizer application efficiency on 30% of cropland; shoreline buffers, side water inlets, sedimentation basins, ag BMPs on 10% of cropped land	Increase P fertilizer application efficiency on 15% of cropland; Identify priority areas using PTMapp or ACPF; contact landowners and secure funding; implement Ag BMPs on 5% of cropland	X	X					X	X	n/a
All	All Streams	All	All	n/a	n/a	Channel restoration	Restore proper channel geometry and appropriate buffered meandor corridors	Identify priority areas and secure funding						X			n/a
						Improve soil health	Increase vegetative cover with cover crops; combine practice with no-till	Establish at least one 5-year pilot site in each HUC-11 and monitor soil organic matter content; Share with other landowners	X								n/a
						Wetland restoration	Restore all degraded or ditched wetlands identified through PTMApp/ACPF or by DNR program priorities.	Identify projects using PTMapp/ACPF or DNR wildlife management area program priorities, contact landowners, secure funding	X	X				X	X	X	2031
						Sediment and nutrient management	Increase Ag P fertilizer application efficiency on 30% of cropland; strategically designed, located, and managed impoundments and collection channels to address TSS and TP issues watershed wide; ag BMPs on 10% of cropped land	Increase P fertilizer application efficiency on 15% of cropland; Conduct modeling to determine design, location and management of impoundments to maximize TSS and TP retention; implement Ag BMPs on 5% of cropland	X	X					X	X	n/a
							Wind breaks, shelterbelts, or vegetative plantings to reduce wind erosion	Identify priority areas using PTMapp or ACPF, contact landowners, and secure funding	X	X					X	X	n/a
Mustinka River (09020102010)	All streams	Grant, Otter Tail, Traverse	All	n/a	n/a	Sediment management	Red Path Impoundment	Identify priority areas using PTMapp or ACPF, contact landowners, and secure funding	X	X					X	X	n/a
						Ditch retrofits	Side water inlets and buffer strips on Ditch system #s 11 East	Complete retrofits on priority ditch systems	X	X							n/a
						Channel restoration	JD 14 - restore oxbow	Complete design and secure funding						X			n/a
						Impoundments	TCD 27 - multi-purpose storage project	Feasibility completed and funding secured	X	X			X				n/a
						Ditch retrofits	Ditch system #s: 9, 10, 36, 29, 30, 20, 46, 39, 48, and 27	Complete retrofits on priority ditch systems	X	X							n/a
Fivemile Creek (09020102020)	All streams	Grant, Stevens, Traverse	All	n/a	n/a	Detention storage	Big Lake Project		X	X			X				n/a
						Ditch retrofits	Ditch system #s: 8, 15, 32, 33, 21, 3, and 6	Complete retrofits on priority ditch systems	X	X							n/a
						Ditch systems with open inlets	Ditch system #s 9 and 29	Completed	X	X							n/a
						Flow management	Restore flow. Eliminate cropping protected waters channel.	Conduct modeling to determine flow restoration strategy			X			X			n/a

HUC-11 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see key below)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones (year ending 2021)	Governmental Units with Primary Responsibility								Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions	Goals / Targets and Estimated % Reduction				BdSWD	SWCD	MPCA	City	County	DNR	BWSR	MDA	
West Branch Mustinka River (09020102030)	All streams	Big Stone, Traverse	All	n/a	n/a	Detention storage	Moonshine Lake; Leonardsville 12; Leonardsville 31E; Leonardsville 31W; Tara 12		X	X			X				n/a
Twelvemile Creek (09020102040)	All streams	Stevens, Traverse, Big Stone	All	n/a	n/a	Detention storage	Moonshine 4; Moonshine 13; Moose Head; Eldorado 7; Dollymount 30		X	X			X				n/a
						Ditch system side-water inlets and buffer strips	Ditch system #s 1 East and West; and 42.	Completed	X	X							n/a
						Ditch system wetland restoration	Ditch system #1	Feasibility completed and funding secured		X					X		n/a
						Ditch retrofits	Ditch system #s 37*; 8; 2; 7*; 51; 16*; 17*; 40; 19; 4* (+ Fivemile); 23; 30; 35; 44; 28; 31*; 38; and 37. *Priority systems. Ditch system #s 1 and 15	Complete retrofits on priority ditch systems	X	X							n/a
Eighteenmile Creek (09020102050)	All streams	Traverse	All	n/a	n/a	Ditch retrofits	Ditch System #s 22; 41*; and 55. *Priority system	Complete retrofits on priority ditch systems	X	X							n/a

Key: Red rows = impaired waters requiring restoration; White rows = unimpaired waters requiring protection.

Mustinka River Subwatershed

Table 13. Strategies and actions proposed for the Mustinka River Subwatershed

HUC-11 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see key below)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones (year ending 2021)	Governmental Units with Primary Responsibility								Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions	Goals / Targets and Estimated % Reduction				BdSWD	SWCD	MPCA	City	County	DNR	BWSR	MDA	
Mustinka River (09020102010)	Mustinka River, Fivemile Cr to Unnamed Cr (09020102-502)	Traverse	Total suspended solids [Turbidity]	49% samples greater than 65 mg/L	92% reduction at very high flows; 37% reduction at high flows	Nutrient management	Ag BMPs, buffer strips; See strategies for All Streams	Identify priority areas using PTMapp or ACPF, contact landowners, and secure funding; See milestones for All Streams	X	X					X	X	2031
						Conservation	Keep existing CRP land in CRP program (make permanent)	Identify priority areas using site visits and/or GIS tools (PTMapp, ACPF) and secure funding		X			X				2031
						Wetland restoration	Wetland restoration projects; See strategies for All Streams	Identify projects using PTMapp/ACPF or DNR wildlife management area program priorities, contact landowners, secure funding	X	X				X	X	X	2031
						Stream restoration	Bank stabilization	Identify priority areas and secure funding		X				X			2031
						Drainage water management	Side water inlet; 25% of tiled cropland draining to constructed or restored wetlands	Identify suitable wetland sites (using GIS tools such as PTMapp or ACPF) and contact landowners	X	X							2031
						Improve soil health	Increase vegetative cover with cover crops; combine practice with no-till	Establish at least one 5-year pilot site in each HUC-11 and monitor soil organic matter content; Share with other landowners	X								2031
Mustinka River (09020102010)	Mustinka River, Unnamed Cr to Lk Traverse (09020102-503)	Traverse	Sediment oxygen demand [Dissolved oxygen]	5% samples less than 5 mg/L	<10% samples less than 5 mg/L	Sediment management	Buffer strips; maintain retention areas; See strategies for All Streams	Identify priority areas using PTMapp or ACPF, contact landowners, and secure funding; See milestones for All Streams	X	X					X	X	2031
						Wetland restoration	Wetland restoration projects; See strategies for All Streams	Identify projects using PTMapp/ACPF or DNR wildlife management area program priorities, contact landowners, secure funding	X	X				X	X	X	2031
						Improve soil health	Increase vegetative cover with cover crops; combine practice with no-till	Establish at least one 5-year pilot site in each HUC-11 and monitor soil organic matter content; Share with other landowners	X								2031
Mustinka River (09020102010)	Mustinka River, Unnamed Cr to Lk Traverse (09020102-503)	Traverse	Total suspended solids [Turbidity]	61% samples greater than 25 NTU	<10% samples greater than 25 NTU (or 47 mg/L TSS); 33-91% TSS reduction across all flow regimes	Sediment management	Gully erosion; Grade stabilization	Identify priority areas using PTMapp or ACPF, contact landowners, and secure funding	X	X					X	X	2031
Mustinka River (09020102010)	Mustinka River, Headwaters to Lightning Lk (09020102-506)	Otter Tail, Grant	*E. coli*	Seasonal geomean = 146-752 cfu/100mL	Seasonal geomean < 126 cfu/100mL; Unknown reduction across flow regimes	Septic system improvements	Address failed SSTS; use grant funds when possible	Replace all systems deemed Imminent Threat to Public Health because of surface water discharges, secure funding for cost-share program		X			X				2031
						Manure management	Buffer strips; manure pit closures	Conduct windshield survey to identify manure problems; Contact landowners of problem areas		X							2031
						Conservation	Keep existing CRP land in CRP program (make permanent)	Identify priority areas using site visits and/or GIS tools (PTMapp, ACPF) and secure funding		X			X				2031
Mustinka River (09020102010)	Mustinka River, Grant/Traverse County Line to Fivemile Cr (09020102-518)	Traverse	Total suspended solids [Turbidity]	42% samples greater than 25 NTU	<10% samples greater than 25 NTU (or 47 mg/L TSS); 78-89% TSS reduction across all flow regimes	Conservation	Buffer strips with permanent easements	Identify priority areas using site visits and/or GIS tools (PTMapp, ACPF) and secure funding		X			X				2031
						Improve soil health	Increase vegetative cover with cover crops; combine practice with no-till	Establish at least one 5-year pilot site in each HUC-11 and monitor soil organic matter content; Share with other landowners	X								2031
						Sediment management	Riparian buffers	Identify priority areas using PTMapp or ACPF, contact landowners, and secure funding	X	X					X	X	2031

HUC-11 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see key below)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones (year ending 2021)	Governmental Units with Primary Responsibility								Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions	Goals / Targets and Estimated % Reduction				BdSWD	SWCD	MPCA	City	County	DNR	BWSR	MDA	
						Flood damage reduction, Downstream flow augmentation, Sediment management, and Wetland restoration	The BdSWD Redpath Project will provide about 16,000 acre feet of flood control storage of which 13,000 acre feet will be gate controlled. This is expected to reduce damages to agricultural lands, roads, and bridges downstream along the Mustinka River, Twelvemile Creek and numerous legal ditch systems. This project will also help to minimize cross-over flows from the Mustinka Watershed to the Rabbit River Watershed and provide benefits on the Bois de Sioux River and Red River. Release of water following periods of high flow will help to sustain flows on the river. The project will reduce erosion and will allow suspended solids to settle out thereby reducing turbidity. Wetland areas totaling about 620 acres will be managed to provide spawning habitat for Northern Pike, feeding and resting areas for migrating shorebirds and waterfowl, and 300 acres of stream corridor restoration.	Secure funding package and complete phased construction	X								2031
						Drainage water management	25% of tiled cropland draining to constructed or restored wetlands	Identify suitable wetland sites (using GIS tools such as PTMapp or ACPF) and contact landowners	X	X							2031
Mustinka River (09020102010)	Unnamed Creek, Unnamed Cr to Mustinka R (09020102-538)	Grant	Intermittency of flow [Invert/Fish IBI]	Fish IBI = 9 Invert IBI = 25	Fish and Invert IBI above thresholds	Wetland restoration	Wetland restoration projects; See strategies for All Streams	Identify projects using PTMapp/ACPF or DNR wildlife management area program priorities, contact landowners, secure funding	X	X				X	X	X	2031
						Improve soil health	Increase vegetative cover with cover crops; combine practice with no-till	Establish at least one 5-year pilot site in each HUC-11 and monitor soil organic matter content; Share with other landowners	X								2031
						Drainage water management	25% of tiled cropland draining to constructed or restored wetlands	Identify suitable wetland sites (using GIS tools such as PTMapp or ACPF) and contact landowners	X	X							2031
Mustinka River (09020102010)	Unnamed Creek, Unnamed Cr to Mustinka R (09020102-538)	Grant	Lack of fish source area [Invert/Fish IBI]	Fish IBI = 9 Invert IBI = 25	Fish and Invert IBI above thresholds	Increase connectivity	Increase connectivity where appropriate	Feasibility completed and funding secured						X			2031
						Stream restoration	Improve riparian zones	Identify priority areas and secure funding		X				X			2031
Mustinka River (09020102010)	Mustinka River, Lightning Lk to Mustinka River Flowage (09020102-580)	Grant	*E. coli*	Seasonal geomean = 241-849 cfu/100mL	Seasonal geomean < 126 cfu/100mL; Unknown reduction across flow regimes	Septic system improvements	Address failed SSTS; use grant funds when possible	Replace all systems deemed Imminent Threat to Public Health because of surface water discharges, secure funding for cost-share program		X			X				2031
						Manure management	Buffer strips; manure pit closures	Conduct windshield survey to identify manure problems; Contact landowners of problem areas		X							2031
Mustinka River (09020102010)	Mustinka River, Lightning Lk to Mustinka River Flowage (09020102-580)	Grant	Stream eutrophication [Dissolved oxygen]	15% samples less than 5 mg/L DO; TP = 0.192 - 0.337 mg/L	<10% samples less than 5 mg/L; TP < 0.150 mg/L; 20-58% reduction in TP at very high to low flows	Nutrient management	Buffer strips; upland BMPs; winter wind erosion barriers; See strategies for All Streams	Identify priority areas using PTMapp or ACPF, contact landowners, and secure funding; See milestones for All Streams	X	X					X	X	2031
						Improve soil health	Increase vegetative cover with cover crops; combine practice with no-till	Establish at least one 5-year pilot site in each HUC-11 and monitor soil organic matter content; Share with other landowners	X								2031

HUC-11 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see key below)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones (year ending 2021)	Governmental Units with Primary Responsibility								Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions	Goals / Targets and Estimated % Reduction				BdSWD	SWCD	MPCA	City	County	DNR	BWSR	MDA	
Mustinka River (09020102010)	Mustinka River, Lightning Lk to Mustinka River Flowage (09020102-580)	Grant	Barrier to fish migration (Pine Ridge Dam) [Fish IBI]	Fish IBI = 25	Fish IBI above threshold	Increase connectivity	Dam removal, modification with rock-arch rapids, or bypass with nature-like fish passage channel	Feasibility completed and funding secured						X			2025
Mustinka River (09020102010)	Mustinka River, Lightning Lk to Mustinka River Flowage (09020102-580)	Grant	Total suspended solids [Turbidity]	5% samples greater than 65 mg/L	77% reduction at very high flows; 14% reduction at high flows	Sediment management	Improve outlet of Lightning Lake; buffer strips; upland BMPs; winter wind erosion barriers	Identify priority areas using PTMapp or ACPF, contact landowners, and secure funding	X	X					X	X	2031
						Improve soil health	Increase vegetative cover with cover crops; combine practice with no-till	Establish at least one 5-year pilot site in each HUC-11 and monitor soil organic matter content; Share with other landowners	X								2031
Mustinka River (09020102010)	Mustinka River, Mustinka River Flowage to Grant/Traverse County Line (09020102-582)	Grant	Total suspended solids [Turbidity]	63% samples greater than 65 mg/L	87% reduction at very high flows; 36% reduction at high flows	Sediment management	Wind erosion barriers; tributary BMPs	Identify priority areas using PTMapp or ACPF, contact landowners, and secure funding	X	X					X	X	2031
						Drainage water management	25% of tiled cropland draining to constructed or restored wetlands	Identify suitable wetland sites (using GIS tools such as PTMapp or ACPF) and contact landowners	X	X							2031
						Wetland restoration	Wetland restoration projects; See strategies for All Streams	Identify projects using PTMapp/ACPF or DNR wildlife management area program priorities, contact landowners, secure funding	X	X				X	X	X	2031
						Channel restoration	Channel restoration Hwy 9 west	Complete the channel restoration at Hwy 9 west						X			2021
Mustinka River (09020102010)	Mustinka River Ditch, Twelvemile Cr to Mustinka R (09020102-553)	Traverse	Fish IBI, Invert IBI, DO, Turbidity, *E. coli*	Insufficient data or not assessed	Maintain or improve water quality	Channel restoration	Restore proper channel geometry and appropriate buffered meandor corridors	Restore 8-9 miles of historical Mustinka River channel						X			2031
						Conservation	Keep existing CRP land in CRP program (make permanent)	Identify priority areas using site visits and/or GIS tools (PTMapp, ACPF) and secure funding		X			X				2031
						Stream restoration	Bank stabilization	Identify priority areas and secure funding		X				X			2031
						Wetland restoration	Wetland restoration projects; See strategies for All Streams	Identify projects using PTMapp/ACPF or DNR wildlife management area program priorities, contact landowners, secure funding	X	X				X	X	X	2031
						Nutrient management	Ag BMPs, buffer strips; See strategies for All Streams	Identify priority areas using PTMapp or ACPF, contact landowners, and secure funding; See milestones for All Streams	X	X					X	X	2031
						Manure management	Possible old manure pit; Feed lot projects	Conduct windshield survey to identify manure problems; Contact landowners of problem areas		X							2031
						Improve soil health	Increase vegetative cover with cover crops	Establish at least one 5-year pilot site in each HUC-11 and monitor soil organic matter content; Share with other landowners	X								2031
						Drainage water management	Side water inlet; 25% of tiled cropland draining to constructed or restored wetlands	Identify suitable wetland sites (using GIS tools such as PTMapp or ACPF) and contact landowners	X	X							2031
						Septic system improvements	Use MPCA grant funds to address SSTS; Address SSTS through land sales	Replace all systems deemed Imminent Threat to Public Health because of surface water discharges, secure funding for cost-share program		X			X				2031
Mustinka River (09020102010)	Trisko (26-0141-00)	Grant	Phosphorus	Insufficient data	Maintain or improve water quality	Shoreline restoration	Restore bank erosion	Completed		X				X			2021

HUC-11 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see key below)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones (year ending 2021)	Governmental Units with Primary Responsibility								Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions	Goals / Targets and Estimated % Reduction				BdSWD	SWCD	MPCA	City	County	DNR	BWSR	MDA	
Mustinka River (09020102010)	Flekkefjord (26-0142-00)	Grant	Phosphorus	Not assessed	Maintain or improve water quality	Storm water runoff management	Rain gardens Separate storm water and sanitary systems	Install 5 rain gardens; complete storm sewer separation	X	X		X			X		2031
Mustinka River (09020102010)	Lightning (26-0282-00)	Grant	Phosphorus	Growing season TP = 153 µg/L	Growing season TP < 90 µg/L 61% reduction in watershed runoff TP load 10% reduction in internal TP load	Shoreline restoration	Repair bluff erosion	Completed		X				X			2021
						Nutrient management	See strategies for All Lakes										2031
Mustinka River (09020102010)	Mud (56-0804-00)	Otter Tail	Phosphorus	Not assessed	Maintain or improve water quality	Nutrient management	Buffer strip on NW side of lake Address bank erosion issues BMPs on tributaries to lake	Completed	X	X					X	X	2021
						Water level management	DNR management of water level (WPA)	Develop water management plan						X			2031

Key: Red rows = impaired waters requiring restoration; White rows = unimpaired waters requiring protection.

Fivemile Creek Subwatershed

Table 14. Strategies and actions proposed for the Fivemile Creek Subwatershed

HUC-11 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see key below)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones (year ending 2021)	Governmental Units with Primary Responsibility								Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions	Goals / Targets and Estimated % Reduction				BdSWD	SWCD	MPCA	City	County	DNR	BWSR	MDA	
Fivemile Creek (09020102020)	Fivemile Creek, T127 R45W S24, East Line to Mustinka River Ditch (09020102-510)	Grant, Stevens, Traverse	*E. coli*	Seasonal geomean = 217-569 cfu/100mL	Seasonal geomean < 126 cfu/100mL; Unknown reduction across flow regimes	Septic system improvements	Address failed SSTS; use grant funds when possible	Replace all systems deemed Imminent Threat to Public Health because of surface water discharges, secure funding for cost-share program		X			X				2031
						Point source improvements	City of Herman leaking sanitary and storm system	Identify and fix sanitary and storm system leaks				X					2031
						Manure management	Manure application practices; ag BMPs; pasture management (12 operations); exclusion fencing; manure pit closures	Conduct windshield survey to identify manure problems; Contact landowners of problem areas		X							2031
Fivemile Creek (09020102020)	Unnamed Creek, Unnamed Cr to Unnamed Cr (09020102-578)	Grant, Stevens	Intermittency of flow [Fish IBI]	Fish IBI = 0	Fish IBI above threshold	Wetland restoration	Wetland restoration projects; See strategies for All Streams	Identify projects using PTMapp/ACPF or DNR wildlife management area program priorities, contact landowners, secure funding	X	X				X	X	X	2031
						Drainage water management	Side water inlets; 25% of tiled cropland draining to constructed or restored wetlands	Identify suitable wetland sites (using GIS tools such as PTMapp or ACPF) and contact landowners	X	X							2031
Fivemile Creek (09020102020)	Unnamed Creek, Unnamed Cr to Unnamed Cr (09020102-578)	Grant, Stevens	Barriers to fish migration [Fish IBI]	Fish IBI = 0	Fish IBI above threshold	Increase connectivity	Increase connectivity where appropriate	Feasibility completed and funding secured						X			2025
Fivemile Creek (09020102020)	Unnamed Creek, Unnamed Cr to Unnamed Cr (09020102-578)	Grant, Stevens	Lack of fish source area [Fish IBI]	Fish IBI = 0	Fish IBI above threshold	Increase connectivity	Increase connectivity where appropriate	Feasibility completed and funding secured						X			2025
Fivemile Creek (09020102020)	Unnamed Ditch, Unnamed ditch to Fivemile Cr (09020102-525)	Grant, Stevens	Fish IBI, Invert IBI, DO, Turbidity, *E. coli*	Not assessed	Maintain or improve water quality	Manure management	Pasture management	Conduct windshield survey to identify manure problems; Contact landowners of problem areas		X							2031
						Nutrient management	Buffer strips; side-water inlets; See strategies for All Streams	Identify priority areas using PTMapp or ACPF, contact landowners, and secure funding	X	X					X	X	2031
						Carp management	High velocity culvert to prevent fish passage	Install high velocity culvert and conduct follow-up monitoring					X	X			2031
						Improve soil health	Increase vegetative cover with cover crops; combine practice with no-till	Establish at least one 5-year pilot site in each HUC-11 and monitor soil organic matter content; Share with other landowners	X								2031
						Point source improvements	City of Herman leaking sanitary and storm system	Identify and fix sanitary and storm system leaks				X					2031
						Septic system improvements	Address failed SSTS; use grant funds when possible	Replace all systems deemed Imminent Threat to Public Health because of surface water discharges, secure funding for cost-share program		X			X				2031
Fivemile Creek (09020102020)	Pullman (26-0298-00)	Grant	Phosphorus	Not assessed	Maintain or improve water quality	Storm water runoff management	Rain gardens Separate storm water and sanitary systems	Install 5 rain gardens; complete storm sewer separation	X	X		X			X		2031

Key: Red rows = impaired waters requiring restoration; White rows = unimpaired waters requiring protection.

West Branch Subwatershed

Table 15. Strategies and actions proposed for the West Branch Subwatershed

HUC-11 Subwatershed	Waterbody and Location: Waterbody (ID)	Waterbody and Location: Location and Upstream Influence Counties	Parameter (incl. non-pollutant stressors)	Water Quality: Current Conditions	Water Quality: Goals / Targets and Estimated % Reduction	Strategies (see key below)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones (year ending 2021)	Governmental Units with Primary Responsibility: BdSWD	SWCD	MPCA	City	County	DNR	BWSR	MDA	Estimated Year to Achieve Water Quality Target
West Branch Mustinka River (09020102030)	Twelvemile Creek, West Branch T125 R46W S33, south line to Twelvemile Cr (09020102-511)	Big Stone, Traverse	*E. coli*	Seasonal geomean = 152-440 cfu/100mL	Seasonal geomean < 126 cfu/100mL; Unknown reduction across flow regimes	Septic system improvements	Address failed SSTS; use loans and grant funds when possible	Replace all systems deemed Imminent Threat to Public Health because of surface water discharges, secure funding for cost-share program		X			X				2031
						Manure management	Feedlot operations in Big Stone County; manure pit closures	Conduct windshield survey to identify manure problems; Contact landowners of problem areas		X							2031
West Branch Mustinka River (09020102030)	Twelvemile Creek, West Branch T125 R46W S33, south line to Twelvemile Cr (09020102-511)	Big Stone, Traverse	Stream eutrophication [Dissolved oxygen]	21% samples less than 5 mg/L DO; TP = 0.588 - 0.955 mg/L	<10% samples less than 5 mg/L; TP < 0.150 mg/L; 24-53% reduction in TP at low to very high flows	Nutrient management	Buffer strips; sedimentation basins; See strategies for All Streams	Identify priority areas using PTMapp or ACPF, contact landowners, and secure funding; See milestones for All Streams	X	X					X	X	2031
						Conservation	Keep existing CRP land in CRP program (make permanent)	Identify priority areas using site visits and/or GIS tools (PTMapp, ACPF) and secure funding		X			X				2031
						Improve soil health	Increase vegetative cover with cover crops; combined practice with no-till	Establish at least one 5-year pilot site in each HUC-11 and monitor soil organic matter content; Share with other landowners	X								2031
						Wetland restoration	Wetland restoration projects; See strategies for All Streams	Identify projects using PTMapp/ACPF or DNR wildlife management area program priorities, contact landowners, secure funding	X	X				X	X	X	2031
						Drainage water management	25% of tiled cropland draining to constructed or restored wetlands	Identify suitable wetland sites (using GIS tools such as PTMapp or ACPF) and contact landowners	X	X							2031
						Sediment management	Side water inlet	Identify priority areas using PTMapp or ACPF, contact landowners, and secure funding	X	X					X	X	2031
West Branch Mustinka River (09020102030)	Unnamed Creek, CD 33 to W Br Twelvemile Cr (09020102-524)	Traverse, Big Stone	Fish IBI, Invert IBI, DO, Turbidity, *E. coli*	Insufficient data or not assessed	Maintain or improve water quality	Septic system improvements	Address failed SSTS; use loans and grant funds when possible	Replace all systems deemed Imminent Threat to Public Health because of surface water discharges, secure funding for cost-share program		X			X				2031
						Nutrient management	Ag BMPs, buffer strips, sedimentation basins; See strategies for All Streams	Identify priority areas using PTMapp or ACPF, contact landowners, and secure funding	X	X					X	X	2031
						Manure management	Feedlot operations in Big Stone County	Conduct windshield survey to identify manure problems; Contact landowners of problem areas		X							2031
						Wetland restoration	Wetland restoration projects; See strategies for All Streams	Identify projects using PTMapp/ACPF or DNR wildlife management area program priorities, contact landowners, secure funding	X	X				X	X	X	2031
						Improve soil health	Increase vegetative cover with cover crops; combine practice with no-till	Establish at least one 5-year pilot site in each HUC-11 and monitor soil organic matter content; Share with other landowners	X								2031
						Ditch retrofits	2-stage ditches		X	X							2031
						Sediment management	Side water inlet	Identify priority areas using PTMapp or ACPF, contact landowners, and secure funding	X	X					X	X	2031
West Branch Mustinka River (09020102030)	East Toqua (06-0138-00)	Big Stone	Phosphorus	Growing season TP = 583 µg/L	Growing season TP < 90 µg/L 70% reduction in watershed runoff TP load	Nutrient management	Reduce urban runoff	Identify priority areas and secure funding		X		X					2031
							See strategies for all lakes										2031

HUC-11 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see key below)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones (year ending 2021)	Governmental Units with Primary Responsibility								Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions	Goals / Targets and Estimated % Reduction				BdSWD	SWCD	MPCA	City	County	DNR	BWSR	MDA	
					90% reduction in internal TP load												
West Branch Mustinka River (09020102030)	Lannon (06-0139-00)	Big Stone	Phosphorus	Growing season TP = 764 µg/L	Growing season TP < 90 µg/L 77% reduction in watershed runoff TP load 99% reduction in internal TP load	Nutrient management	See strategies for All Lakes										2031
West Branch Mustinka River (09020102030)	North Rothwell Slough (06-0147-00)	Big Stone	Phosphorus	Not assessed	Maintain or improve water quality	Nutrient management	Restore bluff erosion	Completed	X	X					X	X	2021

Key: Red rows = impaired waters requiring restoration; White rows = unimpaired waters requiring protection.

Twelvemile Creek Subwatershed

Table 16. Strategies and actions proposed for the Twelvemile Creek Subwatershed

HUC-11 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see key below)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones (year ending 2021)	Governmental Units with Primary Responsibility								Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions	Goals / Targets and Estimated % Reduction				BdSWD	SWCD	MPCA	City	County	DNR	BWSR	MDA	
Twelvemile Creek (09020102040)	Twelvemile Creek, T126 R45W S21, south line to W Br Twelvemile Cr (09020102-514)	Stevens, Traverse, Big Stone	*E. coli*	Seasonal geomean = 186-284 cfu/100mL	Seasonal geomean < 126 cfu/100mL; Unknown reduction across flow regimes	Septic system improvements	Address failed SSTS; use loans and grant funds when possible	Replace all systems deemed Imminent Threat to Public Health because of surface water discharges, secure funding for cost-share program		X			X				2031
						Manure management	Buffer strips; pasture management; manure pit closures	Conduct windshield survey to identify manure problems; Contact landowners of problem areas		X							2031
Twelvemile Creek (09020102040)	Twelvemile Creek, T126 R45W S21, south line to W Br Twelvemile Cr (09020102-514)	Stevens, Traverse, Big Stone	Stream eutrophication [Dissolved oxygen]	23% samples less than 5 mg/L DO; TP = 0.614 - 0.946 mg/L	<10% samples less than 5 mg/L; TP < 0.150 mg/L; 44-58% reduction in TP at low to very high flows	Nutrient management	Buffer strips with permanent easements; sedimentation basins; ag BMPs; See strategies for All Streams	Identify priority areas using PTMapp or ACPF, contact landowners, and secure funding; See milestones for All Streams	X	X					X	X	2031
						Drainage water management	Side water inlets; pattern tile outlet controls; 25% of tiled cropland draining to constructed or restored wetlands	Identify suitable wetland sites (using GIS tools such as PTMapp or ACPF) and contact landowners	X	X							2031
						Wetland restoration	Wetland restoration projects; See strategies for All Streams	Identify projects using PTMapp/ACPF or DNR wildlife management area program priorities, contact landowners, secure funding	X	X				X	X	X	2031
						Improve soil health	Grid soil sampling; Increase vegetative cover with cover crops; combine practice with no-till	Establish at least one 5-year pilot site in each HUC-11 and monitor soil organic matter content; Share with other landowners	X								2031
Twelvemile Creek (09020102040)	Twelvemile Creek, T126 R45W S21, south line to W Br Twelvemile Cr (09020102-514)	Stevens, Traverse, Big Stone	Altered hydrology/Flashiness [Invert/Fish IBI]	Fish IBI = 19 (0 2nd visit) Invert IBI = 13	Fish and Invert IBI above thresholds	Wetland restoration	Wetland restoration projects; See strategies for All Streams	Identify projects using PTMapp/ACPF or DNR wildlife management area program priorities, contact landowners, secure funding	X	X				X	X	X	2031
						Ditch retrofits		Complete retrofits on priority ditch systems	X	X							2031
						Drainage water management	Side water inlet; alternate tile intakes; 25% of tiled cropland draining to constructed or restored wetlands	Identify suitable wetland sites (using GIS tools such as PTMapp or ACPF) and contact landowners	X	X							2031
Twelvemile Creek (09020102040)	Twelvemile Creek, T126 R45W S21, south line to W Br Twelvemile Cr (09020102-514)	Stevens, Traverse, Big Stone	Total suspended solids [Turbidity]	8% samples greater than 65 mg/L	91% reduction at very high flows	Sediment management	Buffer strips with permanent easements; sedimentation basins; ag BMPs; side water inlets	Identify priority areas using PTMapp or ACPF, contact landowners, and secure funding	X	X					X	X	2031
						Wetland restoration	Wetland restoration projects; See strategies for All Streams	Identify projects using PTMapp/ACPF or DNR wildlife management area program priorities, contact landowners, secure funding	X	X				X	X	X	2031
						Improve soil health	Increase vegetative cover with cover crops; combine practice with no-till	Establish at least one 5-year pilot site in each HUC-11 and monitor soil organic matter content; Share with other landowners	X								2031
Twelvemile Creek (09020102040)	Twelvemile Creek, W Br Twelvemile Cr to Mustinka	Grant, Stevens, Traverse	*E. coli*	Seasonal geomean = 135-248 cfu/100mL	Seasonal geomean < 126 cfu/100mL; Unknown reduction across flow regimes	Septic system improvements	Address failed SSTS; use grant funds when possible	Replace all systems deemed Imminent Threat to Public Health because of surface water discharges, secure funding for cost-share program		X			X				2031

HUC-11 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see key below)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones (year ending 2021)	Governmental Units with Primary Responsibility								Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions	Goals / Targets and Estimated % Reduction				BdSWD	SWCD	MPCA	City	County	DNR	BWSR	MDA	
	River Ditch (09020102-557)					Manure management	Buffer strips; pasture management; manure pit closures	Conduct windshield survey to identify manure problems; Contact landowners of problem areas		X							2031
Twelvemile Creek (09020102040)	Twelvemile Creek, W Br Twelvemile Cr to Mustinka River Ditch (09020102-557)	Grant, Stevens, Traverse	Altered hydrology/ Flashiness [Invert/Fish IBI]	Fish IBI = 46 (26 2nd visit) Invert IBI = 17	Fish and Invert IBI above thresholds	Wetland restoration	Wetland restoration projects; See strategies for All Streams	Identify projects using PTMapp/ACPF or DNR wildlife management area program priorities, contact landowners, secure funding	X	X				X	X	X	2031
						Ditch retrofits		Complete retrofits on priority ditch systems	X	X							2031
						Drainage water management	Side water inlet; alternate tile intakes; 25% of tiled cropland draining to constructed or restored wetlands	Identify suitable wetland sites (using GIS tools such as PTMapp or ACPF) and contact landowners	X	X							2031
Twelvemile Creek (09020102040)	Twelvemile Creek, W Br Twelvemile Cr to Mustinka River Ditch (09020102-557)	Grant, Stevens, Traverse	Stream eutrophication/ Dissolved oxygen [Invert/Fish IBI]	TP = 0.351 mg/L	TP < 0.150 mg/L	Nutrient management	Decrease TP load from upstream -514 and -511; See strategies for All Streams Buffer strips with permanent easements Upland BMPs Winter wind erosion barriers	Identify priority areas using PTMapp or ACPF, contact landowners, and secure funding	X	X					X	X	2031
						Wetland restoration	Wetland restoration projects; See strategies for All Streams	Identify projects using PTMapp/ACPF or DNR wildlife management area program priorities, contact landowners, secure funding	X	X				X	X	X	2031
						Drainage water management	Side water inlet; pattern tile outlet controls; 25% of tiled cropland draining to constructed or restored wetlands	Identify suitable wetland sites (using GIS tools such as PTMapp or ACPF) and contact landowners	X	X							2031
						Improve soil health	Grid soil sampling; Increase vegetative cover with cover crops; combine practice with no-till	Establish at least one 5-year pilot site in each HUC-11 and monitor soil organic matter content; Share with other landowners	X								2031
Twelvemile Creek (09020102040)	Twelvemile Creek, W Br Twelvemile Cr to Mustinka River Ditch (09020102-557)	Grant, Stevens, Traverse	Total suspended solids [Turbidity]	8% samples greater than 65 mg/L	No reductions across flow regimes	Sediment management	Buffer strips with permanent easements; upland BMPs; winter wind erosion barriers	Identify priority areas using PTMapp or ACPF, contact landowners, and secure funding	X	X					X	X	2031
						Improve soil health	Increase vegetative cover with cover crops; combined practice with no-till	Establish at least one 5-year pilot site in each HUC-11 and monitor soil organic matter content; Share with other landowners	X								2031
						Drainage water management	25% of tiled cropland draining to constructed or restored wetlands	Identify suitable wetland sites (using GIS tools such as PTMapp or ACPF) and contact landowners	X	X							2031
						Ditch retrofits		Complete retrofits on priority ditch systems	X	X							2031

Key: Red rows = impaired waters requiring restoration; White rows = unimpaired waters requiring protection.

Eighteenmile Creek Subwatershed

Table 17. Strategies and actions proposed for the Eighteenmile Creek Subwatershed

HUC-11 Subwatershed	Waterbody and Location		Parameter (incl. non-pollutant stressors)	Water Quality		Strategies (see key below)	Strategy types and estimated scale of adoption needed to meet final water quality target	Interim 10-yr Milestones (year ending 2021)	Governmental Units with Primary Responsibility								Estimated Year to Achieve Water Quality Target
	Waterbody (ID)	Location and Upstream Influence Counties		Current Conditions	Goals / Targets and Estimated % Reduction				BdSWD	SWCD	MPCA	City	County	DNR	BWSR	MDA	
Eighteenmile Creek (09020102050)	Eighteenmile Creek, Unnamed Cr to Mustinka R (09020102-508)	Traverse	Stream eutrophication [Dissolved oxygen, Fish/Invert IBI]	TP = 0.546 mg/L	TP < 0.150 mg/L; 48-52% reductions at very high to low flows	Nutrient management	Buffer strips; side-water inlets; See strategies for All Streams	Identify priority areas using PTMapp or ACPF, contact landowners, and secure funding; See milestones for All Streams	X	X					X	X	2031
						Conservation	Keep existing CRP land in CRP program (make permanent)	Identify priority areas using site visits and/or GIS tools (PTMapp, ACPF) and secure funding		X			X				2031
						Improve soil health	Increase vegetative cover with cover crops; combined practice with no-till	Establish at least one 5-year pilot site in each HUC-11 and monitor soil organic matter content; Share with other landowners	X								2031
						Drainage water management	25% of tiled cropland draining to constructed or restored wetlands	Identify suitable wetland sites (using GIS tools such as PTMapp or ACPF) and contact landowners	X	X							2031

Key: Red rows = impaired waters requiring restoration; White rows = unimpaired waters requiring protection.

Table 18. Key for Strategies Column

Parameter (incl. non-pollutant stressors)	Strategy Key	
	Description	Example BMPs/actions
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
		Wetland restoration
		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
		Establish or re-establish 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
	Improve forestry management	Proper Water Crossings and road construction
		Forest Roads - Cross-Drainage
		Maintaining and aligning active Forest Roads
		Closure of Inactive Roads & Post-Harvest
		Location & Sizing of Landings
		Establish or re-establish 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
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 or restored wetlands
		Pasture management
		Restored wetlands
	Reduce bank/bluff/ravine erosion	Strategies to reduce TSS from banks/bluffs/ravines (see above for sediment)

Parameter (incl. non-pollutant stressors)	Strategy Key	
	Description	Example BMPs/actions
	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 & 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 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 which 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
	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	Bioreactor
	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

Parameter (incl. non-pollutant stressors)	Strategy Key	
	Description	Example BMPs/actions
	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
	Increase river flow during low flow years	See strategies above for altered hydrology
	In-channel restoration: Actions to address altered portions of streams.	
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 & buffers of native grass & 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 protected of waterways
		One rod ditch buffers
		Lake shoreland buffers
		Increase conservation cover: in/near water bodies, to create corridors
		Improve/increase natural habitat in riparian, control invasive species
		Tree planting to increase shading
		Streambank and shorline protection/stabilization
		Wetland restoration
		Accurately size bridges and culverts to improve stream stability
		Retrofit dams with multi-level intakes
		Restore riffle substrate

Parameter (incl. non-pollutant stressors)	Strategy Key	
	Description	Example BMPs/actions
	Restore/enhance channel: Various restoration efforts largely aimed at providing substrate and natural stream morphology.	Two-stage ditch
		Dam operation to mimic natural conditions
		Restore natural meander and complexity
Connectivity (Fish IBI)	Removal fish passage barriers: Identify and address barriers.	Dam removal
		Properly size and place culverts for flow and fish passage
		Construct nature-like fish passage

4. Monitoring Plan

Data from three monitoring programs will continue to be collected and analyzed for the Mustinka River Watershed:

Intensive Watershed Monitoring collects water quality and biological data throughout each major watershed, once every 10 years. This work is scheduled for its second iteration in the Mustinka River Watershed in 2020. This data provides a periodic but intensive “snapshot” of water quality throughout the watershed.

http://www.pca.state.mn.us/index.php/water/water-monitoring-and-reporting/water-quality-and-pollutants/water-quality-condition-monitoring/watershed-sampling-design-intensive-watershed-monitoring.html

The ***Watershed Pollutant Load Monitoring Network*** intensively collects pollutant samples and flow data to calculate daily sediment and nutrient loads on either an annual or seasonal (no-ice) basis. In the Mustinka River Watershed, there are three proposed seasonal subwatershed pollutant load monitoring sites.

http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/streams-and-rivers/watershed-pollutant-load-monitoring-network.html

The ***Citizen Surface Water Monitoring Program*** is a network of volunteers who make monthly lake and river transparency readings. Several dozen data collection locations exist in the Mustinka River Watershed. This data provides a continuous record of one water quality parameter throughout much of the watershed.

http://www.pca.state.mn.us/index.php/water/water-monitoring-and-reporting/volunteer-water-monitoring/volunteer-surface-water-monitoring.html

In addition to the monitoring conducted in association with the WRAPS process, each local unit of government associated with water management may have their own monitoring plan. Furthermore, there are many citizen monitors throughout the watershed collecting both stream and lake data. All data collected locally should be submitted regularly to the MPCA for entry into the EQuIS database system. http://www.pca.state.mn.us/index.php/data/surface-water.html

5. References and Further Information

Minnesota Pollution Control Agency (MPCA). 2010. Mustinka River Turbidity Total Maximum Daily Load Report. http://www.pca.state.mn.us/index.php/view-document.html?gid=14019.

Minnesota Pollution Control Agency (MPCA). 2013. Mustinka River Watershed Monitoring and Assessment Report. http://www.pca.state.mn.us/index.php/view-document.html?gid=20325.

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National Resources Conservation Service. 2012. Environmental Quality Incentives Program. http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/

Tomer, M.D., S.A. Porter, D.E. James, K.M.B. Boomer, J.A. Kostel, and E. McLellan. 2013. Combining precision conservation technologies into a flexible framework to facilitate agricultural watershed planning. Journal of Soil and Water Conservation 68(5): 113A-120A.

Tomer, M. D., Porter, S. A., Boomer, K. M. B., James, D. E., Kostel, J. A., Helmers, M. J., Isenhart, T. M., McLellan, E. (2015). Agricultural conservation planning framework: 1. Developing multi-practice watershed planning scenarios and assessing nutrient reduction potential. Journal of Environmental Quality. In press. https://data.nal.usda.gov/dataset/agricultural-conservation-planning-framework-acpf-toolbox.

Mustinka River Watershed Reports

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

Appendix A: Stream Geomorphic Surveys

Appendix A: Stream Geomorphic Surveys

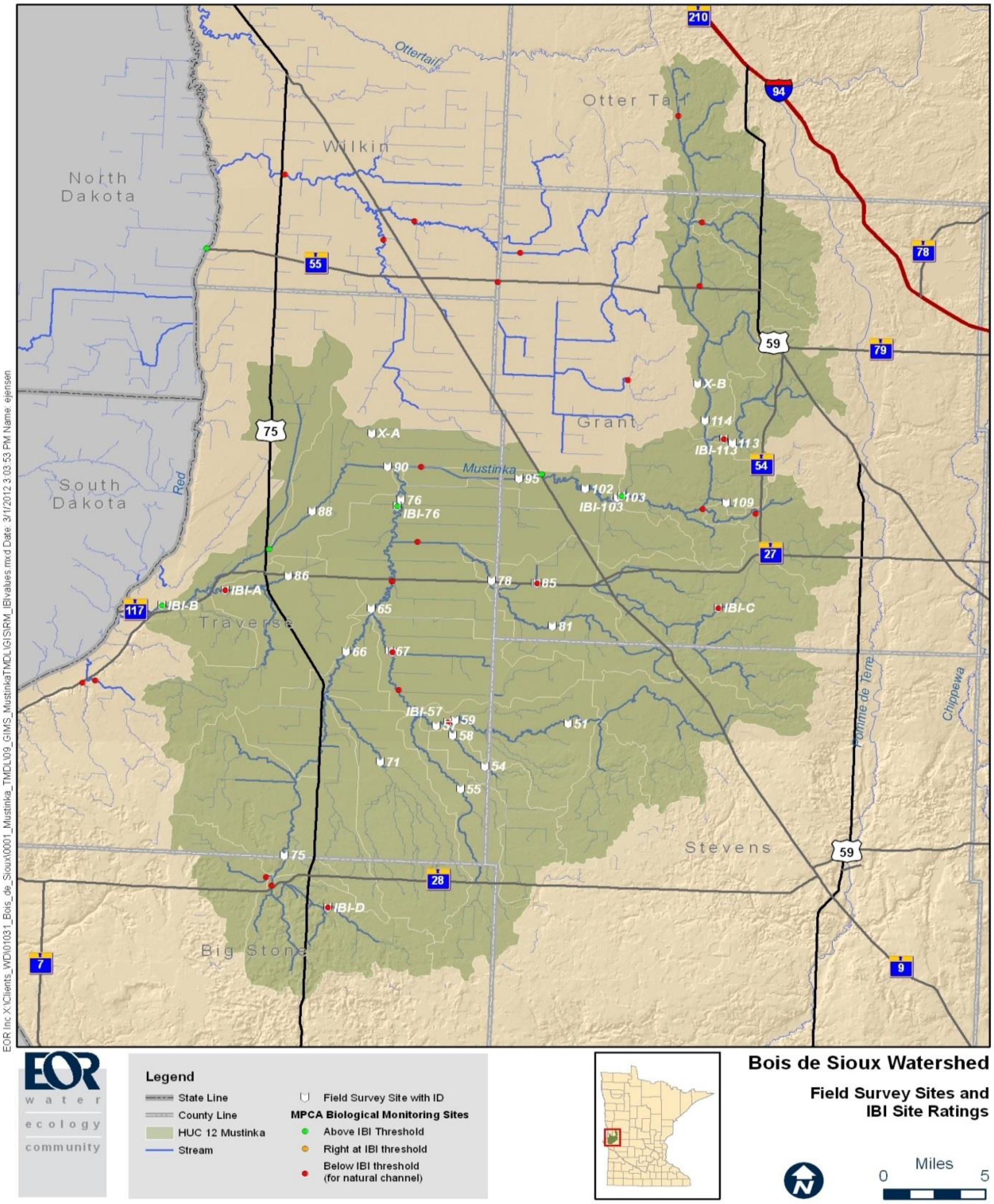


Figure 1. Survey Reaches and IBI Scores within the Mustinka Watershed

REACH INFORMATION	
Stream/River	Twelvemile
County	Stevens
Drainage Area	58.5 sq. miles
Date	10/26/2011
Field/Site ID	51
Bio Monitoring	No

GEOMORPHIC SUMMARY	
Est. Bankfull El.	1036.2’
Channel Slope	0.15%
Sinuosity	1.0
Bankfull Width	62.5’
W/D Ratio	70.7
Material (D50)	0.06 mm
BEHI Rating	High
NBS Rating	Very High

NOTES & OBSERVATIONS

- Bankfull width is extraordinary wide due to ditch geomorphology, reach position within a wetland complex and Red River Valley flooding characteristics; thus the W/D ratio is also very high; this phenomenon is common throughout this study area

REACH INFORMATION	
Stream/River	East Fork Twelvemile
County	Traverse
Drainage Area	17 sq. miles
Date	-
Field/Site ID	54
Bio Monitoring	No

GEOMORPHIC SUMMARY	
Est. Bankfull El.	-
Channel Slope	-
Sinuosity	-
Bankfull Width	-
W/D Ratio	-
Material (D50)	-
BEHI Rating	-
NBS Rating	-

NOTES & OBSERVATIONS

- Did not survey – no perennial flow and frequently no discernible channel; large cattail wetland flowage;

REACH INFORMATION	
Stream/River	West Fork Twelvemile
County	Traverse
Drainage Area	23 sq. miles
Date	-
Field/Site ID	55
Bio Monitoring	No

GEOMORPHIC SUMMARY	
Est. Bankfull El.	-
Channel Slope	-
Sinuosity	-
Bankfull Width	-
W/D Ratio	-
Material (D50)	-
BEHI Rating	-
NBS Rating	-

NOTES & OBSERVATIONS

- Did not survey – no perennial flow

REACH INFORMATION	
Stream/River	Twelvemile
County	Traverse
Drainage Area	107 sq. miles
Date	10/26/2011
Field/Site ID	57
Bio Monitoring	Yes

GEOMORPHIC SUMMARY	
Est. Bankfull El.	1040.79
Channel Slope	0.08%
Sinuosity	1.1
Bankfull Width	71.1
W/D Ratio	65.9
Material (D50)	0.062 mm
BEHI Rating	High
NBS Rating	High

NOTES & OBSERVATIONS

- Good buffer (width and quality)
- Some floodplain vegetation killed off by recent sustained high water

REACH INFORMATION	
Stream/River	Twelvemile
County	Traverse
Drainage Area	110 sq. miles
Date	-
Field/Site ID	59
Bio Monitoring	No

GEOMORPHIC SUMMARY	
Est. Bankfull El.	-
Channel Slope	-
Sinuosity	-
Bankfull Width	-
W/D Ratio	-
Material (D50)	-
BEHI Rating	-
NBS Rating	-

NOTES & OBSERVATIONS

- Did not complete survey, reach influenced by active beaver dam

REACH INFORMATION	
Stream/River	West Branch Twelvemile
County	Traverse
Drainage Area	493 sq. miles
Date	10/26/2011
Field/Site ID	65
Bio Monitoring	No

GEOMORPHIC SUMMARY	
Est. Bankfull El.	1014.1’
Channel Slope	0.03%
Sinuosity	1.5
Bankfull Width	33.3’
W/D Ratio	9.1
Material (D50)	0.27mm
BEHI Rating	High
NBS Rating	High

NOTES & OBSERVATIONS

- More entrenched than other study reaches;
- Channel evolution (lateral) is resulting in a number of severely eroding banks within reach

REACH INFORMATION	
Stream/River	West Brank Twelvemile
County	Traverse
Drainage Area	181 sq. miles
Date	-
Field/Site ID	66
Bio Monitoring	No

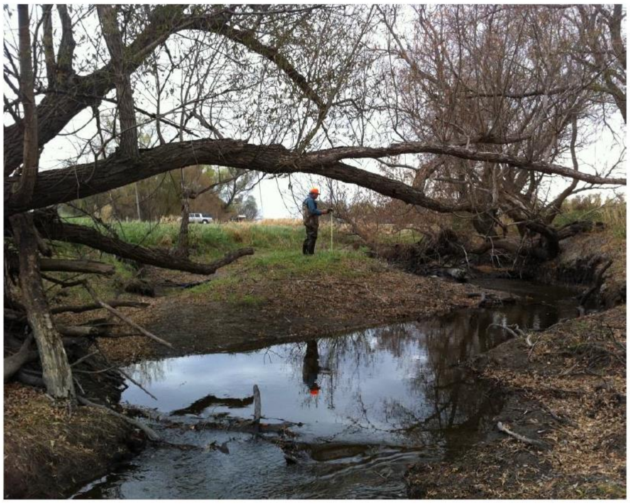
GEOMORPHIC SUMMARY	
Est. Bankfull El.	-
Channel Slope	-
Sinuosity	-
Bankfull Width	-
W/D Ratio	-
Material (D50)	-
BEHI Rating	-
NBS Rating	-

NOTES & OBSERVATIONS

- Did not complete survey – water levels were too high and soils were unconsolidated; possible downstream beaver dam?

REACH INFORMATION	
Stream/River	Twelvemile
County	Traverse
Drainage Area	169 sq. miles
Date	10/24/2011
Field/Site ID	67
Bio Monitoring	Yes

GEOMORPHIC SUMMARY	
Est. Bankfull El.	1023.1
Channel Slope	0.09%
Sinuosity	1.1
Bankfull Width	28.2
W/D Ratio	20.9
Material (D50)	0.36 mm
BEHI Rating	Very High
NBS Rating	Very High



NOTES & OBSERVATIONS

- Heavier shade in certain segments likely is resulting in less herbaceous vegetation and a slightly wider bankfull width.

REACH INFORMATION	
Stream/River	W. Branch Twelvemile
County	Traverse
Drainage Area	73 sq. miles
Date	10/24/2011
Field/Site ID	75
Bio Monitoring	No

GEOMORPHIC SUMMARY	
Est. Bankfull El.	1081.4’
Channel Slope	0.06%
Sinuosity	1.0
Bankfull Width	21.8’
W/D Ratio	10.2
Material (D50)	0.06 mm
BEHI Rating	Moderate
NBS Rating	Very Low

NOTES & OBSERVATIONS

- Stream channel confined to steep banks, no bankfull benches exists.
- Poor instream habitat (lack of pools and riffles, coarse substrate).

REACH INFORMATION	
Stream/River	Twelve Mile
County	Traverse
Drainage Area	514 sq. miles
Date	10/25/2011
Field/Site ID	76
Bio Monitoring	Yes

GEOMORPHIC SUMMARY	
Est. Bankfull El.	997.1
Channel Slope	0.002%
Sinuosity	1.3
Bankfull Width	53.6’
W/D Ratio	10.2
Material (D50)	0.68 mm
BEHI Rating	High
NBS Rating	Moderate

NOTES & OBSERVATIONS

- Significant erosion in first 650’ downstream of Cty Hwy 14 crossing; excluded from BEHI
- Very low gradient

REACH INFORMATION	
Stream/River	Fivemile
County	Traverse
Drainage Area	98.2 sq. miles
Date	10/26/2011
Field/Site ID	78
Bio Monitoring	No

GEOMORPHIC SUMMARY	
Est. Bankfull El.	1033.2'
Channel Slope	0.02%
Sinuosity	1.1
Bankfull Width	31.6'
W/D Ratio	26.1
Material (D50)	0.06 mm
BEHI Rating	Low
NBS Rating	Low

NOTES & OBSERVATIONS

- Some signs of aggradation, gravel was overlaying silt, longitudinal profile was silt dominated;
- Good buffer; ≥ 150' from stream centerline

REACH INFORMATION	
Stream/River	Five Mile
County	Grant
Drainage Area	19 sq. miles
Date	-
Field/Site ID	81
Bio Monitoring	No

GEOMORPHIC SUMMARY	
Est. Bankfull El.	-
Channel Slope	-
Sinuosity	-
Bankfull Width	-
W/D Ratio	-
Material (D50)	-
BEHI Rating	-
NBS Rating	-

NOTES & OBSERVATIONS

- Did not survey – no perennial flow and frequently no discernible channel; large cattail wetland flowage;

REACH INFORMATION	
Stream/River	CD#8
County	Grant
Drainage Area	69 sq. miles
Date	10/26/2011
Field/Site ID	85
Bio Monitoring	Yes

GEOMORPHIC SUMMARY	
Est. Bankfull El.	1040.8’
Channel Slope	0.17%
Sinuosity	1.0
Bankfull Width	15.6’
W/D Ratio	7.5
Material (D50)	0.06 mm
BEHI Rating	High
NBS Rating	Low

NOTES & OBSERVATIONS

- Similar to site 95, higher gradient of this reach appears to be connected to relative greater habitat quality witnessed (less embeddedness, aquatic vegetation, greater pool depth and frequency)

REACH INFORMATION	
Stream/River	Eighteenmile
County	Traverse
Drainage Area	12.9 sq. miles
Date	10/24/2011
Field/Site ID	86
Bio Monitoring	No

GEOMORPHIC SUMMARY	
Est. Bankfull El.	1004.5’
Channel Slope	0.06%
Sinuosity	1.6
Bankfull Width	28.3’
W/D Ratio	98.1
Material (D50)	0.06 mm
BEHI Rating	Very Low
NBS Rating	Very Low

NOTES & OBSERVATIONS

- This stream was dry during the assessment. A large beaver dam exists on the upstream end of the reach and is affecting the hydrology downstream.
- The very high width/depth ratio is indicative of a wide, shallow channel and low floodplain.

REACH INFORMATION	
Stream/River	Mustinka
County	Traverse
Drainage Area	757 sq. miles
Date	10/25/2011
Field/Site ID	88
Bio Monitoring	No

GEOMORPHIC SUMMARY	
Est. Bankfull El.	980.68
Channel Slope	0.003%
Sinuosity	1.0
Bankfull Width	54.9’
W/D Ratio	14.9
Material (D50)	0.062 mm
BEHI Rating	Moderate
NBS Rating	Low

NOTES & OBSERVATIONS

- Multiple side-inlet control failures in area
- Significant amount of floodplain vegetation killed off by recent sustained inundation

REACH INFORMATION	
Stream/River	Mustinka
County	Traverse
Drainage Area	739 sq. miles
Date	10/26/2011
Field/Site ID	90
Bio Monitoring	No

GEOMORPHIC SUMMARY	
Est. Bankfull El.	990.4’
Channel Slope	0.11%
Sinuosity	1.0
Bankfull Width	61.9’
W/D Ratio	17.9
Material (D50)	16 mm
BEHI Rating	High
NBS Rating	Moderate

NOTES & OBSERVATIONS

- Active channel evolution (lateral), which is resulting in a number of significant ditch bank failures; a separate BEHI and NBS was completed for bank failure within survey reach and scored Very High and High, respectively

REACH INFORMATION	
Stream/River	Mustinka
County	Grant
Drainage Area	191 sq. miles
Date	10/25/2011
Field/Site ID	95
Bio Monitoring	No

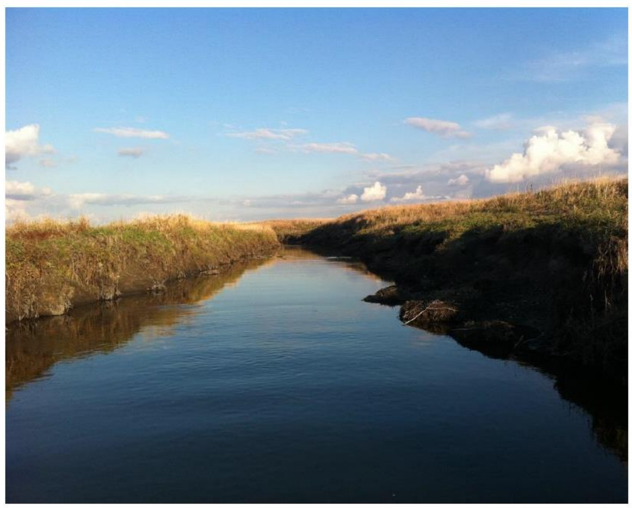
GEOMORPHIC SUMMARY	
Est. Bankfull El.	1036.2’
Channel Slope	0.05%
Sinuosity	1.0
Bankfull Width	57.1’
W/D Ratio	18.2
Material (D50)	1.5 mm
BEHI Rating	High
NBS Rating	High

NOTES & OBSERVATIONS

- Similar to site 85, higher gradient of this reach appears to be connected to relative greater habitat quality witnessed (less embeddedness, aquatic vegetation, greater pool depth and frequency)

REACH INFORMATION	
Stream/River	Mustinka
County	Grant
Drainage Area	185 sq. miles
Date	10/26/2011
Field/Site ID	102
Bio Monitoring	No

GEOMORPHIC SUMMARY	
Est. Bankfull El.	1036.2’
Channel Slope	0.02%
Sinuosity	2.3
Bankfull Width	29.7’
W/D Ratio	13.0
Material (D50)	1.1 mm
BEHI Rating	High
NBS Rating	High



NOTES & OBSERVATIONS

- A large beaver dam exists at the upper end of the reach and sediment is accumulating above the dam.
- A defined riffle/pool sequence exists below the dam with small cobble and boulders present.

REACH INFORMATION	
Stream/River	Mustinka
County	Grant
Drainage Area	171 sq. miles
Date	10/25/2011
Field/Site ID	103
Bio Monitoring	Yes

GEOMORPHIC SUMMARY	
Est. Bankfull El.	1045.0’
Channel Slope	0.02%
Sinuosity	1.9
Bankfull Width	33.2’
W/D Ratio	11.3
Material (D50)	3.2 mm
BEHI Rating	High
NBS Rating	Low

NOTES & OBSERVATIONS

- Eroded stream banks on outside bends of meanders typical in this reach.
- Defined riffle/pool sequence, pool depth greater than 3 feet.

REACH INFORMATION	
Stream/River	Mustinka
County	Grant
Drainage Area	12 sq. miles
Date	10/25/2011
Field/Site ID	109
Bio Monitoring	Yes

GEOMORPHIC SUMMARY	
Est. Bankfull El.	1105.5’
Channel Slope	0.46%
Sinuosity	1.0
Bankfull Width	24.4’
W/D Ratio	69.0
Material (D50)	0.06 mm
BEHI Rating	Very Low
NBS Rating	Very Low

NOTES & OBSERVATIONS

- This reach contains a very narrow and shallow stream that flows through a steep gradient grassy swale. Very little instream habitat exists in this reach.

REACH INFORMATION	
Stream/River	Mustinka
County	Grant
Drainage Area	24.5 sq. miles
Date	10/25/2011
Field/Site ID	113
Bio Monitoring	Yes

GEOMORPHIC SUMMARY	
Est. Bankfull El.	1100.5’
Channel Slope	0.04%
Sinuosity	1.2
Bankfull Width	17.1’
W/D Ratio	25.5
Material (D50)	0.06 mm
BEHI Rating	Moderate
NBS Rating	Very Low

NOTES & OBSERVATIONS

- Poor instream habitat, substrate consists of fine silt/clay.
- Floodplain is accessible during most storm events.

REACH INFORMATION	
Stream/River	Mustinka
County	Grant
Drainage Area	92 sq. miles
Date	10/25/2011
Field/Site ID	114
Bio Monitoring	No

GEOMORPHIC SUMMARY	
Est. Bankfull El.	1088.0’
Channel Slope	0.20%
Sinuosity	1.1
Bankfull Width	142.7’
W/D Ratio	214.6
Material (D50)	13.0 mm
BEHI Rating	Moderate
NBS Rating	Very Low

NOTES & OBSERVATIONS

- Relatively steep gradient between prominent riffles containing coarse substrate (gravel and small cobble).
- Floodplain accessible during high flow events.

REACH INFORMATION	
Stream/River	Eighteenmile
County	Traverse
Drainage Area	50 sq. miles
Date	10/26/2011
Field/Site ID	IBI A
Bio Monitoring	Yes

GEOMORPHIC SUMMARY	
Est. Bankfull El.	986.6'
Channel Slope	0.01%
Sinuosity	1.1
Bankfull Width	18.4'
W/D Ratio	12.9
Material (D50)	1.3 mm
BEHI Rating	Moderate
NBS Rating	Very Low

NOTES & OBSERVATIONS

- Stream banks well vegetated and stable.
- Coarse substrate and over-hanging riparian vegetation are key habitat features.

REACH INFORMATION	
Stream/River	Mustinka
County	Traverse
Drainage Area	858.3 sq. miles
Date	10/26/2011
Field/Site ID	IBI B
Bio Monitoring	Yes

GEOMORPHIC SUMMARY	
Est. Bankfull El.	979.0
Channel Slope	0.006%
Sinuosity	1.2
Bankfull Width	253.4'
W/D Ratio	41.0
Material (D50)	N/A
BEHI Rating	N/A
NBS Rating	Low

NOTES & OBSERVATIONS

- River system is relatively wide with a low floodplain resulting in a high width/depth ratio.
- Stream banks stable and well vegetated, deep pools present in this reach.

REACH INFORMATION	
Stream/River	Unknown
County	Grant
Drainage Area	10 sq. miles
Date	10/26/2011
Field/Site ID	IBI C
Bio Monitoring	Yes

GEOMORPHIC SUMMARY	
Est. Bankfull El.	1102.1’
Channel Slope	0.08%
Sinuosity	1.3
Bankfull Width	13.5’
W/D Ratio	11.2
Material (D50)	2.2 mm
BEHI Rating	Moderate
NBS Rating	Moderate

NOTES & OBSERVATIONS

- Headwater, higher gradient stream
- Intensively grazed

REACH INFORMATION	
Stream/River	CD-#8
County	Big Stone
Drainage Area	16.6 sq. miles
Date	10/24/2011
Field/Site ID	IBI D
Bio Monitoring	Yes

GEOMORPHIC SUMMARY	
Est. Bankfull El.	1099.0’
Channel Slope	0.37%
Sinuosity	1.3
Bankfull Width	9.8’
W/D Ratio	7.8
Material (D50)	4.0 mm
BEHI Rating	Moderate
NBS Rating	Low

NOTES & OBSERVATIONS

- A wide buffer zone exists upstream of 720th Avenue. The “E” channel in this reach is very stable with undercut banks and pools providing instream habitat. The stream is ditched downstream of 720th Avenue and no buffer exists.

REACH INFORMATION	
Stream/River	Former Mustinka
County	Traverse
Drainage Area	
Date	
Field/Site ID	X-A
Bio Monitoring	No

GEOMORPHIC SUMMARY	
Est. Bankfull El.	
Channel Slope	
Sinuosity	
Bankfull Width	
W/D Ratio	
Material (D50)	
BEHI Rating	
NBS Rating	

NOTES & OBSERVATIONS

- Did not survey; bottom unconsolidated and no longer an active flowage
- Former Mustinka River Channel, cut off by Army Corps bypass

Appendix B: Stream Assessment Status

Table 19: Assessment status of stream reaches in the Mustinka River Watershed

Subshed	AUID (Last 3 digits)	Stream	Reach Description	Aquatic Life							Aq Rec
				Fish Index of Biotic Integrity	Macroinvertebrate Index of Biotic Integrity	Dissolved Oxygen	Turbidity/TSS	Chloride	pH	Ammonia	Bacteria
Eighteenmile Creek	508	Eighteenmile Creek	Unnamed Cr to Mustinka R	NS	NS	NS	FS	FS	FS	FS	IF
Fivemile Creek	510	Fivemile Creek	T127 R45W S24, east line to Mustinka River Ditch	--	--	IF	FS	FS	FS	FS	NS
	525	Unnamed ditch	Unnamed ditch to Fivemile Cr	--	--	IF	FS	--	FS	--	NA
	564	Unnamed ditch	Unnamed Cr to Unnamed ditch	NA*	NA*						
	578	Unnamed creek	Unnamed Cr to Unnamed Cr	NS	--	--	--	--	--	--	NA
Mustinka River	502	Mustinka River (Old Channel)	Fivemile Cr to Unnamed Cr	NA*	NA*	FS	NS	FS	FS	FS	FS
	503	Mustinka River	Unnamed Cr to Lk Traverse	NA*	NA*	IF	NS	FS	FS	FS	IF
	506	Mustinka River	Headwaters to Lightning Lk	NA*	NA*	NS	FS	FS	FS	FS	NS
	518	Mustinka River	Grant/Traverse County line to Fivemile Cr	NA*	NA*	--	NS*	--	--	--	NS
	538	Unnamed creek	Unnamed Cr to Mustinka R	NS	NS	--	FS	--	--	--	NA
	553	Mustinka River Ditch	Twelvemile Cr to Mustinka R	--	--	--	NS*	--	--	--	NA
Mustinka River	559	Unnamed creek	Unnamed Cr to Unnamed Cr	NA*	NA*						

Subshed	AUID (Last 3 digits)	Stream	Reach Description	Aquatic Life							Aq Rec
				Fish Index of Biotic Integrity	Macroinvertebrate Index of Biotic Integrity	Dissolved Oxygen	Turbidity/TSS	Chloride	pH	Ammonia	Bacteria
	561	Unnamed creek	Unnamed Cr to Mustinka R	NA*	NA*						
	562	Unnamed creek	Unnamed Cr to Unnamed Cr	NA*	NA*						
	580	Mustinka River	Lightning Lk to Mustinka River Flowage	NS	FS	NS	NS	FS	FS	FS	NS
	582	Mustinka River	Mustinka River Flowage to Grant/Traverse County Line	FS	FS	IF	NS	--	FS	FS	IF
Twelvemile Creek	513	Twelvemile Creek (County Ditch 1)	Lundberg Lk to T126 R45W S28, north line	NA*	NA*						
	514	Twelvemile Creek	T126 R45W S21, south line to W Br Twelvemile Cr	NS	NS	NS	NS	--	FS	FS	NS
	557	Twelvemile Creek	W Br Twelvemile Cr to Mustinka River Ditch	NS	NS	IF	NS	FS	FS	FS	NS
	579	County Ditch 42	Between Twelvemile Cr and Fivemile Cr	NA*	NA*						
West Branch Mustinka River	511	Twelvemile Creek, West Branch	T125 R46W S33, south line to Twelvemile Cr	--	--	NS	FS	--	FS	FS	NS
	512	Judicial Ditch 4	Headwaters to Twelvemile Cr	NA*	NA*						
West Branch Mustinka River	524	Unnamed creek	CD 33 to W Br Twelvemile Cr	--	--	NS	FS	--	FS	--	NA
	527	County Ditch 8	Headwaters to Lannon Lk	NA*	NA*						

Subshed	AUID (Last 3 digits)	Stream	Reach Description	Aquatic Life							Aq Rec
				Fish Index of Biotic Integrity	Macroinvertebrate Index of Biotic Integrity	Dissolved Oxygen	Turbidity/TSS	Chloride	pH	Ammonia	Bacteria
	532	Unnamed creek	Unnamed Cr to Unnamed Cr	NA*	NA*						

FS = Fully Supporting: found to meet the water quality standard,
NS = Not Supporting: does not meet the water quality standard and therefore, is impaired,
IF = the data collected was insufficient to make a finding,
NA = not assessed
NA* = aquatic life assessment and/or impairments have been deferred until the adoption of Tiered Aquatic Life Uses due to the AUID being predominantly (>50%) channelized or having biological data limited to a station occurring on a channelized portion of the stream.
-- = no data collected for this parameter

Appendix C: Lake Assessment Status

Table 20: Assessment status of lakes in the Mustinka River Watershed

Subshed	Lake ID	Lake	Aquatic Recreation
Mustinka River	26-0140	Elbow	IF
	26-0141	Trisko	IF
	26-0185	Cottonwood	IF
	26-0235	Mustinka River Flowage	IF
	26-0282	Lightning	NS
	56-0804	Mud	IF
Fivemile Creek	26-0188	Unnamed	IF
	26-0194	Big	IF
	26-0199	Unnamed	IF
	26-0203	Nelson	IF
	26-0206	Keitzman Slough	IF
	26-0208	Ohlsrud	IF
	26-0213	East Niemaki	IF
	26-0214	West Niemaki	IF
	26-0215	Unnamed	IF
	26-0217	Unnamed	IF
	26-0218	Unnamed	IF
	26-0343	Unnamed	IF
	75-0241	Unnamed	IF
West Branch Mustinka River	06-0138	East Toqua	NS
	06-0139	Lannon	NS
Twelvemile Creek	75-0258	Unnamed	IF
	75-0348	Unnamed	IF

NS = Not Supporting: does not meet the water quality standard and therefore, is impaired
IF = the data collected was insufficient to make a finding

Appendix D: Completed Stream TMDL Allocation Summaries

Table 21. Allocation summary for completed stream TMDLs in the Mustinka River Watershed

Stream/ Reach (AUID)	Pollutant	Flow Zone	Allocations (TP/TSS in kg/day, *E. coli* in billions organisms/day)					Percent Reduction
			Wasteload Allocation		Load Allocation		Margin of Safety	
			WWTFs	Regulated Stormwater	Upstream Outflow	Watershed Runoff		
09020102-502	TSS	Very High	--	0.2	75,150.9	1,819.8	8,552.3	92%
		High	--	0.1	13,835.8	1,565.8	1,711.3	37%
		Mid	--	0.08	7,499.9	921.9	935.8	0%
		Dry	--	0.04	4,575.6	430.7	556.3	0%
		Very Dry	--	0.008	2,037.5	93.0	236.7	0%
09020102-503	TSS	Very High	894	24	52,381		5,924	91%
		High	894	3	6,604		835	88%
		Mid	894	<10	744		181	46%
		Dry	*	<10	*		*	77%
		Very Dry	*	<10	*		*	33%
09020102-506	*E. coli*	Very High	--	--	--	65.3	7.3	n/a
		High	--	--	--	10.6	1.2	n/a
		Mid	--	--	--	3.9	0.4	n/a
		Low	--	--	--	1.6	0.2	n/a
		Very Low	--	--	--	0.5	0.1	n/a
09020102-508	TP	Very High	--	0.00096	--	11.6	1.3	52%
		High	--	0.00018	--	2.2	0.2	48%
		Mid	--	0.0001	--	1.2	0.1	51%
		Low	--	0.00004	--	0.6	0.1	51%
		Very Low	--	0.00002	--	0.2	0.0	n/a
09020102-510	*E. coli*	Very High	3.4	--	--	138.4	15.7	n/a
		High	3.3	--	--	39.0	4.7	0%
		Mid	3.3	--	--	18.4	2.4	0%
		Low	3.3	--	--	7.8	1.2	77%
		Very Low	3.3	--	--	1.6	0.6	88%
09020102-511	*E. coli*	Very High	4.6	--	--	372.2	41.9	n/a
		High	4.6	--	--	63.7	7.6	n/a
09020102-511	*E. coli*	Mid	4.6	--	--	35.3	4.4	n/a
		Low	4.6	--	--	20.6	2.8	n/a
		Very Low	4.6	--	--	7.4	1.3	n/a

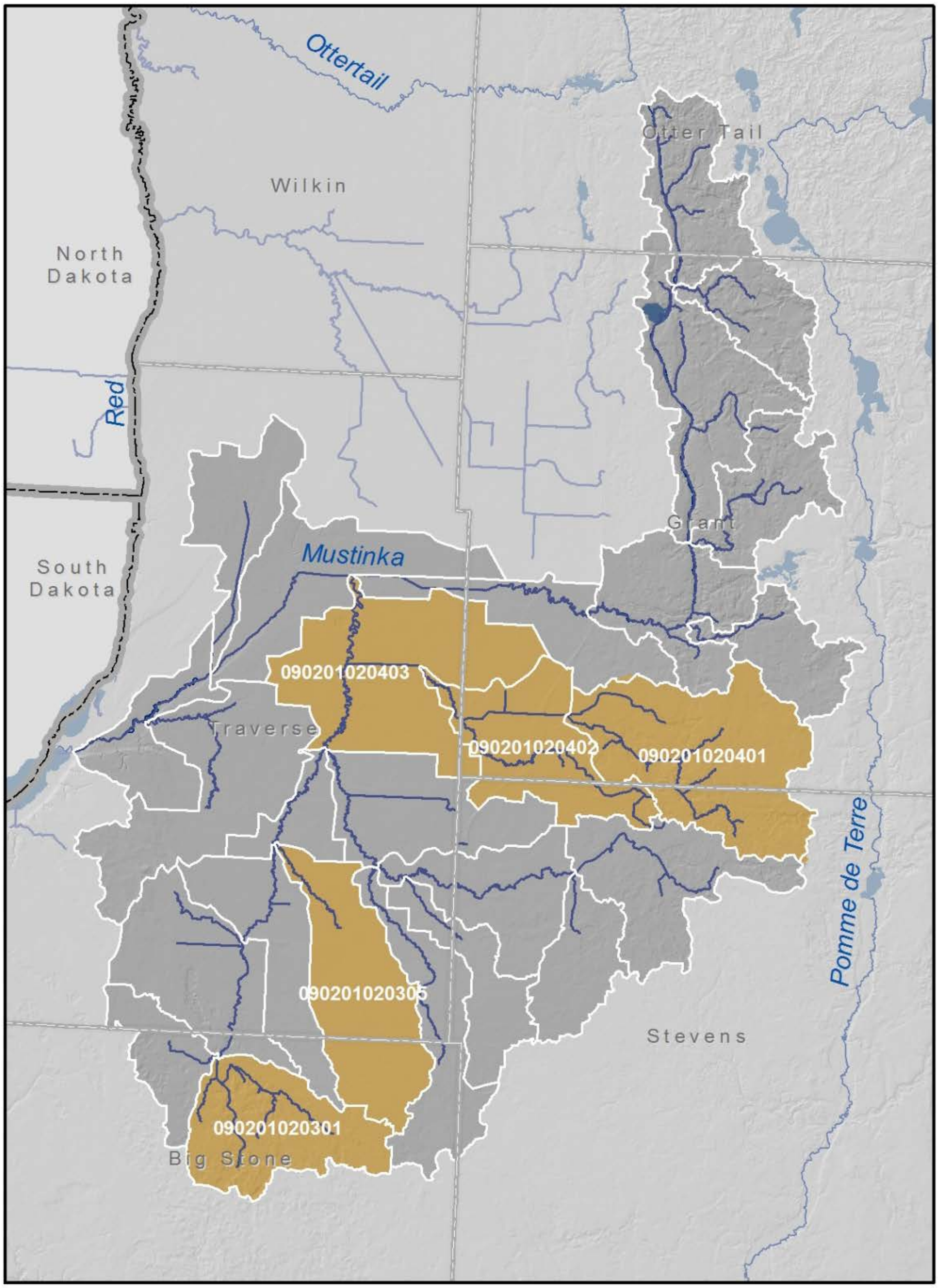
Stream/ Reach (AUID)	Pollutant	Flow Zone	Allocations (TP/TSS in kg/day, *E. coli* in billions organisms/day)					Percent Reduction
			Wasteload Allocation		Load Allocation		Margin of Safety	
			WWTFs	Regulated Stormwater	Upstream Outflow	Watershed Runoff		
09020102-511	TP	Very High	5.6	0.004	--	39.3	5.0	53%
		High	5.6	0.0002	--	2.6	0.9	34%
		Mid	*	0.0004	--	4.7	0.5	27%
		Dry	*	0.0002	--	3.0	0.3	24%
		Very Dry	*	0.0002	--	1.4	0.2	0%
09020102-514	*E. coli*	Very High	--	--	--	301.0	33.4	n/a
		High	--	--	--	64.2	7.1	n/a
		Mid	--	--	--	37.9	4.2	n/a
		Low	--	--	--	24.2	2.7	n/a
		Very Low	--	--	--	11.4	1.3	n/a
09020102-514	TP	Very High	--	0.003	--	35.8	4.0	58%
		High	--	0.0006	--	7.6	0.8	44%
		Mid	--	0.0004	--	4.5	0.5	44%
		Low	--	0.0002	--	2.9	0.3	46%
		Very Low	--	0.0002	--	1.4	0.2	0%
09020102-514	TSS	Very High	--	1.3	--	15,523.6	1,725.0	91%
		High	--	0.3	--	3,313.4	368.2	0%
		Mid	--	0.2	--	1,954.6	217.2	0%
		Low	--	0.1	--	1,246.0	138.5	0%
		Very Low	--	<0.1	--	589.0	65.4	0%
09020102-518	*E. coli*	Very High	--	--	361.9	157.0	72.6	n/a
		High	--	--	44.4	29.9	10.4	n/a
		Mid	--	--	17.2	14.8	4.5	49%
		Low	--	--	1.6	14.9	2.3	88%
		Very Low	--	--	0.5	5.2	0.8	78%
09020102-518	TSS	Very High	295	4	8,972		1,034	89%
		High	295	<1	1,003		145	85%
		Mid	*	<1	*		*	80%
09020102-518	TSS	Low	*	<1	*		*	78%
		Very Low	*	<1	*		*	80%
09020102-557	*E. coli*	Very High	--	--	888.2	49.8	104.2	n/a
		High	--	--	181.5	12.4	21.5	n/a
		Mid	--	--	107.9	5.5	12.6	n/a

Stream/ Reach (AUID)	Pollutant	Flow Zone	Allocations (TP/TSS in kg/day, *E. coli* in billions organisms/day)					Percent Reduction
			Wasteload Allocation		Load Allocation		Margin of Safety	
			WWTFs	Regulated Stormwater	Upstream Outflow	Watershed Runoff		
		Low	--	--	67.2	4.9	8.0	n/a
		Very Low	--	--	30.4	3.5	3.8	n/a
09020102-557	TSS	Very High	283.9	2.6	17,249.8	30,848.2	5,376.0	0%
		High	283.9	0.5	3,681.8	6,036.8	1,111.4	0%
		Mid	283.9	0.3	2,172.0	3,392.6	649.9	0%
		Low	283.9	0.2	1,384.6	2,054.9	413.7	0%
		Very Low	283.9	0.066	654.5	808.0	194.1	0%
09020102-580	*E. coli*	Very High	8.4	--	65.3	288.2	40.1	n/a
		High	8.3	--	10.6	25.5	4.8	n/a
		Mid	8.3	--	3.9	5.0	1.8	n/a
		Low	*	--	1.6	*	0.8	n/a
		Very Low	*	--	0.5	*	0.2	n/a
09020102-580	TP	Very High	12.56	0.004	--	30.2	4.8	20%
		High	0.62*	0.0006	--	4.4	0.6	30%
		Mid	0.62*	0.002	--	1.2	0.2	55%
		Dry	0.62*	0.0002	--	0.1	0.1	58%
		Very Dry	0.62*	0.0002	--	0.0	0.1	0%
09020102-580	TSS	Very High	296.5	2.8	--	18,325.9	2,069.5	77%
		High	296.5	0.2	--	1,952.9	250.0	14%
		Mid	296.5	0.08	--	551.5	94.2	0%
		Low	296.5	0.02	--	87.4	42.6	0%
		Very Low	*	<0.01	--	*	11.8	0%
09020102-582	TSS	Very High	--	0.5	18,625.1	3,211.5	2,426.3	87%
		High	--	0.2	2,249.6	877.2	347.4	36%
		Mid	--	0.08	847.9	499.1	149.7	0%
		Low	--	0.04	383.8	311.2	77.2	0%
09020102-582	TSS	Very Low	--	0.02	105.8	131.6	26.4	0%

* See TMDL WLA methodology for allocation determination at lower flow zones

n/a – insufficient monitoring to determine existing load and therefore percent reduction needed to meet TMDL

Appendix E: Agricultural Conservation Planning Framework



The ACPF is a LiDAR-based analysis framework that, similar to the WQDSA, determines pollutant hotspots (principally based on estimated runoff risk) on the landscape but also targets potential field-scale sites for a set of specific agricultural BMPs such as sediment control basins (WASCOBs), restored wetlands, riparian buffers and grassed waterways. Siting is based on LiDAR terrain analyses taking into account criteria identified by NRCS to meet EQIP specifications (e.g., contributing drainage area to BMP, location of dominant runoff flowpaths, basin depths and volumes, etc.).

The ACPF was run by EOR for five HUC-12 watersheds in the Mustinka River Watershed (see map in Appendix E). These watersheds of interest were selected based on input received from stakeholders during planning meetings as well as results from HSPF modeling and the Watershed Water Quality Decision Support Framework (discussed above). Results of the ACPF analyses were intended to provide a basis for discussion on BMP planning and implementation within these watersheds, and also serve as an example of the potential value in doing ACPF analyses on additional HUC-12s within the Mustinka watershed in the future. Phosphorus was the pollutant of focus for this exploratory analysis although most of the results will apply to sediment as well.

Structural/Terrain Dependent BMP Siting using ACPF

Terrain dependent BMPs refer to those structural practices whose cost-effectiveness is dependent on characteristics of landscape (topography, soils, landuse). For example, the optimal locations for enhancing riparian buffers are at the intersections between perennial streams (vs. intermittent) and areas of relatively high overland runoff (i.e., where significant runoff flow from agricultural fields enters the stream via the riparian zone). Impoundments such as WASCOBs need to be sited where high runoff and erosion potential exist and where topography is conducive to impounding significant runoff after construction of a berm/embankment.

The ACPF tools were designed principally with depressional/prairie pothole topography in mind, particularly where WASCOBs, restored depressional wetlands and constructed nutrient removal wetlands are concerned (the latter refers to wetlands constructed within headwater channels for, principally, removal of nitrate). As such, the lake plain areas of the Mustinka provide little opportunity for harnessing existing on-field, riparian and in-channel depressional storage. In these areas, riparian buffers were the sole terrain dependent BMP sited. In the beach ridge/moraine areas, potential WASCOB locations were sited in addition to buffers. In all areas, significant overland flow paths were delineated where they entered perennial streams. These features represent areas of interest for possible implementation of grassed waterways and/or wider riparian buffers (or other form of grade stabilization, side inlet installation, etc.).

As implied above, BMP siting analysis was constrained to areas around perennial streams; this is due to the assumption that practices are more cost-effective when placed in areas with consistent flow. Intermittent streams can be important during certain seasons and precipitation events but the focus of the ACPF analysis was on channels most likely to export pollutants downstream.

ACPF results for water and sediment control basins (WASCOBs), riparian buffers and grassed waterways were integrated into the overall BMP plan and are summarized below.

Approach

Best Management Practice (BMP) strategies were analyzed for five HUC-12s in the Mustinka River Watershed using the ACPF (see map on preceding page). BMP strategies were analyzed by taking into account the following factors:

- **Watershed Hot Spots**: areas within the watershed where modeling predicts higher than average nutrient production rates (See Section 3.2 for sediment and phosphorus hotspot maps)
- **BMP Performance**: research-based nutrient removal rates for a suite of BMPs
- **BMP Cost**: the cost associated with BMPs from an installation AND lost income standpoint
- **Terrain Suitability**: the watersheds were evaluated for areas where the terrain is most suited to implement specific structural BMPs

Watershed Hot Spots

Targeted land cover and management areas are general areas where nutrient yields are highest (e.g., P pounds/acre/year entering stream channels from adjacent lands) and where prioritization planning should begin. These areas present more practical BMP opportunities as costs for implementation would generally be a function of the size of the area treated and independent of the amount of nutrient treated. Potential target areas were selected using results of the WQDSA analysis which takes into account phosphorus erosion/export from fields and flow distance from the nearest stream; this procedure produces fairly fine scale determinations of probable hotspots. An additional methodology for determining hotspots was also implemented as part of the ACPF analysis discussed below and is based primarily on analysis of field scale runoff risk.

BMP Performance

Phosphorus reductions associated with BMPs were compiled from existing research and prior experience. Reduction estimates representing averages across research studies came from the MPCA's 2014 Minnesota Nutrient Reduction Strategy (MNRS). The average removal rate for each practice is found in Table 22.

Phosphorus removal rates are highest for no-till and practices aimed at trapping sediment since phosphorus is generally tied to sediment particles. Moderate to high rates of phosphorus removal are also seen in land retirement practices.

BMP Costs

Costs per acre per year were estimated based on information in the MNRS and EQIP BMP database. The TP percent reductions were divided by unit costs to generate a cost-effectiveness index. This index is designed to show relative differences between BMPs. Negative costs and cost-effectiveness indicate BMPs that have been demonstrated to result in a net profit.

Agricultural BMP costs were based on analysis from the MNRS and data from the EQIP database which accounts for the installation costs and lost revenues associated with each practice. The costs and cost-effectiveness values presented in Table 22 and Table 24 - Table 28 are based on costs per year per acre. These calculated costs are straight-forward for nutrient management BMPs, but costs for edge-of-field and land use change BMPs are primarily related to initial installation costs which can be substantial compared to the nutrient management costs. Therefore, sediment basin BMPs were assumed to have a 20-year life span whereby installation costs are spread evenly across 20 years. Similarly, riparian buffers, grassed waterways and land use change BMPs were assumed to have a 5-year life span – this reduced life span takes into account that these BMPs may be more easily re-introduced to agriculture if so desired than the aforementioned BMPs.

Moreover, edge-of-field BMP costs are associated with the BMP itself – the area of the BMP doing the treatment – not the upslope area treated. Therefore, to calculate cost per year per acre, the cost was divided by the upslope treatment area. Treatment areas for sediment basins were assumed to be 100 times the impoundment pool area (using Tomer 2013 guidelines) and 25 times the grassed waterway and riparian buffer areas (based on the ACPF analysis described later). This cost division across multiple years and treated acres makes these BMPs much more cost-effective and viable alternatives or supplements to the nutrient management BMPs.

It is important to note that the cost estimates for these BMPs do not take into account any potential cost savings or economic benefit that may be provided by the practice. For instance, increasing soil organic matter may eventually reduce fertilizer need and increase yield.

Table 22. BMP estimated reductions per unit area and costs

Category	Practice	% reduction per acre	Est. Cost ($/ac/yr)
In-Field Practices	Reduce phosphorus application rates	17	(12)
	Cover crops	29	78
	Convert intensive tillage to conservation tillage	33	26
	Convert conservation tillage to no-till	90	18
	Increase soil organic matter	0	NA
Edge-of-Field Practices	Sediment basins [1,a]	85	6
	Riparian buffers [2,b]	58	7
	Grassed waterways [2,b]	58	31
Land Use Changes	Perennials/energy crops [b]	34	698
	Pasture and/or land retirement [b]	75	585
	Extended alfalfa rotations [b]	59	71

[1] Assumed 1:100 ratio between pool area and upslope drainage area for /acre/yr costs

[2] Assumed 1:25 ratio between vegetated treatment area and upslope drainage area for /acre/yr costs

[a] Assumed lifespan of 20 years for /acre/yr costs

[b] Assumed 5-year commitment for /acre/yr costs

Terrain Suitability

Beyond the conceptual and modeled estimates of removal potential from applying various BMPs to the watershed, the task of determining where the BMPs should actually be placed is an important step. To place BMPs on inappropriate locations will reduce their effectiveness (increase costs) and likewise, targeting BMPs to locations where they will provide the most benefit will increase their effectiveness (decrease costs). In a large agricultural watershed like this, a prioritization and targeting framework is warranted to ensure efficient use of resources and avoid an inefficient "shotgun effect."

The ACPF features an ArcGIS toolbox that helps optimize the placement of structural BMPs on the landscape by evaluating terrain suitability using high-resolution digital elevation data (LiDAR). These BMPs are referred to here as "terrain-dependent" as the terrain in which they are placed affects both cost and effectiveness.

The GIS toolbox was implemented for five HUC-12 subwatersheds in the Mustinka River Watershed. Three terrain-dependent, structural Ag BMPs were analyzed: grassed waterways (GWWs), water and sediment control basins (WASCOBs or sediment basins), and riparian buffers. LiDAR with a 3-meter resolution was used as the topographic input data for the GIS tools used to assess potential sites.

The primary numerical output from the GIS analyses necessary for BMP scenario reduction analyses was the upslope drainage area calculated for each sited BMP aggregated at the HUC-12 subwatershed level.

These cumulative drainage areas represented the source areas to be treated for which the BMP percent reductions were applied.

Terrain Suitability is based on the notion that certain Ag BMPs are much more practical to implement if the topography in the targeted area maximizes the effectiveness of the practice and minimizes the installation and operating costs. An example of this concept is a nutrient removal wetland for which research has shown that denitrification is maximized when the wetland pool is shallow enough to support emergent wetlands plants but is continually filled. These attributes have been shown to be tied to existing depressional pool volume and the ratio between pool area and contributing upslope drainage area. Moreover, installation costs will be minimized if an existing (presumably drained) depression already exists and requires minimal design and excavation. A set of automated GIS tools was used to analyze terrain suitability for several types of structural BMPs and is discussed in detail later in this section. The assumptions and methodology used for the ACPF results analysis are presented below in Table 23.

Table 23. Assumptions and Methodology for ACPF BMP analysis

Agricultural Conservation Practice	Treated Watershed Area Estimate	Treated Phosphorus Load Estimate
Corn/Soybean to Pasture and/or Land Retirement	Total area of buffer boxes[1] with Runoff Rank of 'Critical' and 'High'	Zonal mean[2] of WQDSA TP yield (lb/ac/yr) of the buffer box multiplied by the buffer box area
Reduce phosphorus application rates	30% of total cropped area within the HUC-12	Zonal mean of WQDSA TP yield (lb/ac/yr) of the cropped area multiplied by the cropped area
Cover crops, no-till, increase soil organic matter	Total area of cropped fields with Runoff Risk of 'Critical' or 'Very High'	Zonal mean of WQDSA TP yield (lb/ac/yr) of cropped field area multiplied by the cropped field area
Water and Sediment Control Basins (WASCOB)	LiDAR based contributing area to WASCOB	Zonal mean of WQDSA TP yield (lb/ac/yr) of cropped field in which the WASCOB is located multiplied by the contributing area to the WASCOB
Riparian buffers	LiDAR based contributing area to buffer boxes via grassed waterway flow paths, assuming 90% and 95% of total contributing area in beach ridge-dominated and lake plain-dominated HUC-12s, respectively, intercepted by a buffer without a grassed waterway upstream	Zonal mean of WQDSA TP yield (lb/ac/yr) of contributing area multiplied by the contributing area
Grassed waterways	LiDAR based contributing area to buffer boxes via grassed waterway flow paths, assuming 5% of total	Zonal mean of WQDSA TP yield (lb/ac/yr) of contributing area multiplied by the contributing area

Agricultural Conservation Practice	Treated Watershed Area Estimate	Treated Phosphorus Load Estimate
	contributing area routed through a grassed waterway	

[1] Refers to uniformly sized polygons drawn along each side of perennial streams which serve as the analysis window for determining optimal buffer function

[2] Refers to ArcGIS: Spatial Analyst: Zonal Statistics function

Best Management Practice Selection

BMPs to be evaluated for applicability in the Mustinka River Watershed are split into the following three major categories:

In-field Practices

The first grouping of practices includes nutrient management practices as well as conservation practices associated with changes in in-field management practices such as use of conservation crops, no-tillage, or increasing organic matter. Because these practices are not mutually exclusive of one another, they were grouped together for the cost-benefit analysis using the cost and effectiveness estimates for cover crops.

Cover crops:

Although there are many options available for cover crop species the analysis uses fall-planted rye. Cover crops reduce soil erosion and limit the amount of nitrate-N leaching from the soil during the late fall-winter-early spring.

Convert intensive tillage to conservation tillage:

The practice consists of switching from moldboard to chisel plowing which leaves at least 30% crop residue on the fields before and after planting to reduce soil erosion.

Convert conservation tillage to no-till:

The practice consists of switching existing chisel plowing to no-till where the ground is not tilled as to not disturb the soil. This increases water infiltration, organic matter retention, nutrient cycling, and reduction of soil erosion.

Increasing organic matter:

For analysis purpose it is assumed that the organic matter is increased by 100%, which would take the soils in the watershed from an estimated 3% to 6%. Increased organic matter provides both greater water and nutrient retention preventing leaching and increasing soil fertility. Soil organic matter and is a major factor in the productivity and sustainability of agronomic systems. Currently, the primary practices for building soil organic matter are planting cover crops, reducing tillage and applying manure rather than commercial fertilizer. However, just cover crops in conjunction with no-till were incorporated into the BMP scenario analysis.

Edge-of-Field Practices

These practices are typically larger, sometimes structural practices that are terrain dependent. In contrast to the in-field practices, these BMPs can only be installed in areas that support them. This siting was done through use of the ACPF tools as described below.

Water and Sediment Control Basins (WASCOBS):

These are small earthen ridge-and-channel or embankments built across a small watercourse or area of concentrated flow within a field. They are designed to trap agricultural runoff water, sediment and sediment-borne phosphorus as it flows down the watercourse; this keeps the watercourse from becoming a field gully and reduces the amount of runoff and sediment and phosphorus leaving the filed. WASCOB's are usually straight slivers that are just long enough to bridge an area of concentrated flow and are generally grassed. The runoff water detained in a WASCOB is released slowly, usually via infiltration or a pipe outlet and tile line (Minnesota Department of Agriculture).

Riparian Buffers:

These are vegetated zones immediately adjacent to a stream and are generally designed to trap sediment and phosphorus laden surface runoff, which is important but not uniformly opportune along streams. However, different designs and vegetation can improve water quality in different ways. Where vegetation roots can interact with the water table, carbon cycling and denitrification may be enhanced. In areas where the water table depth and overland runoff is high, stiff-stemmed grasses may be beneficial to intercept and reduce runoff and sediment from reaching the stream. Where appreciable amounts of neither runoff nor groundwater can be intercepted, benefits such as stream bank stabilization may be possible (Tomer et al. 2013).

Grassed Waterways:

Grassed waterways are constructed channels that are seeded to grass and drain water from areas of concentrated flow. The vegetation slows down the water and the channel conveys the water to a stable outlet at a non-erosive velocity. Grassed waterways should be used where gully erosion is a problem. These areas are commonly located between hills and other low-lying areas on hills where water concentrates as it runs off the field (NRCS 2012). The size and shape of a grassed waterway is based on the amount of runoff that the waterway must carry, the slope, and the underlying soil type. It is important to note that grassed waterways also trap sediment entering them via field surface runoff and in this manner perform similarly to riparian buffer strips.

Land Use Changes

The following practices involve taking agricultural land out of production. As is noted in the cost section these are fairly high-cost practices primarily as a result of the loss of income that results. The analysis that is provided assumes that these practices, if implemented, would be targeted to the hot-spots identified by the watershed modeling. The practices would be further targeted by looking into the yield history of the specific fields so that the practices would only be placed in low-yield areas. This would help to minimize the cost per acre of the practices. Note that, for simplicity, only pasture/land retirement was examined for this report but the other practices have similar feasibility and cost-effectiveness.

Pasture/Land Retirement:

This practice removes land from agricultural production and converts it perennial vegetation to limit soil erosion. This is a long-term CRP program (10-15 year). The established vegetation is a near natural system that has animal habitat and soil improvement benefits.

Perennials/Energy Crops:

The practice consists of converting corn/soybean lands to perennial or energy crops. Perennial Crops are CRP long-term (10-15 years) program intended to reduce soil erosion by converting land to perennial crops. Energy Crops are perennial crops, such as switchgrass, that produce biomass that can be used as bio-energy feedstock. These crops improve soil cover, reduce soil erosion, and reduce nitrogen and phosphorus loss.

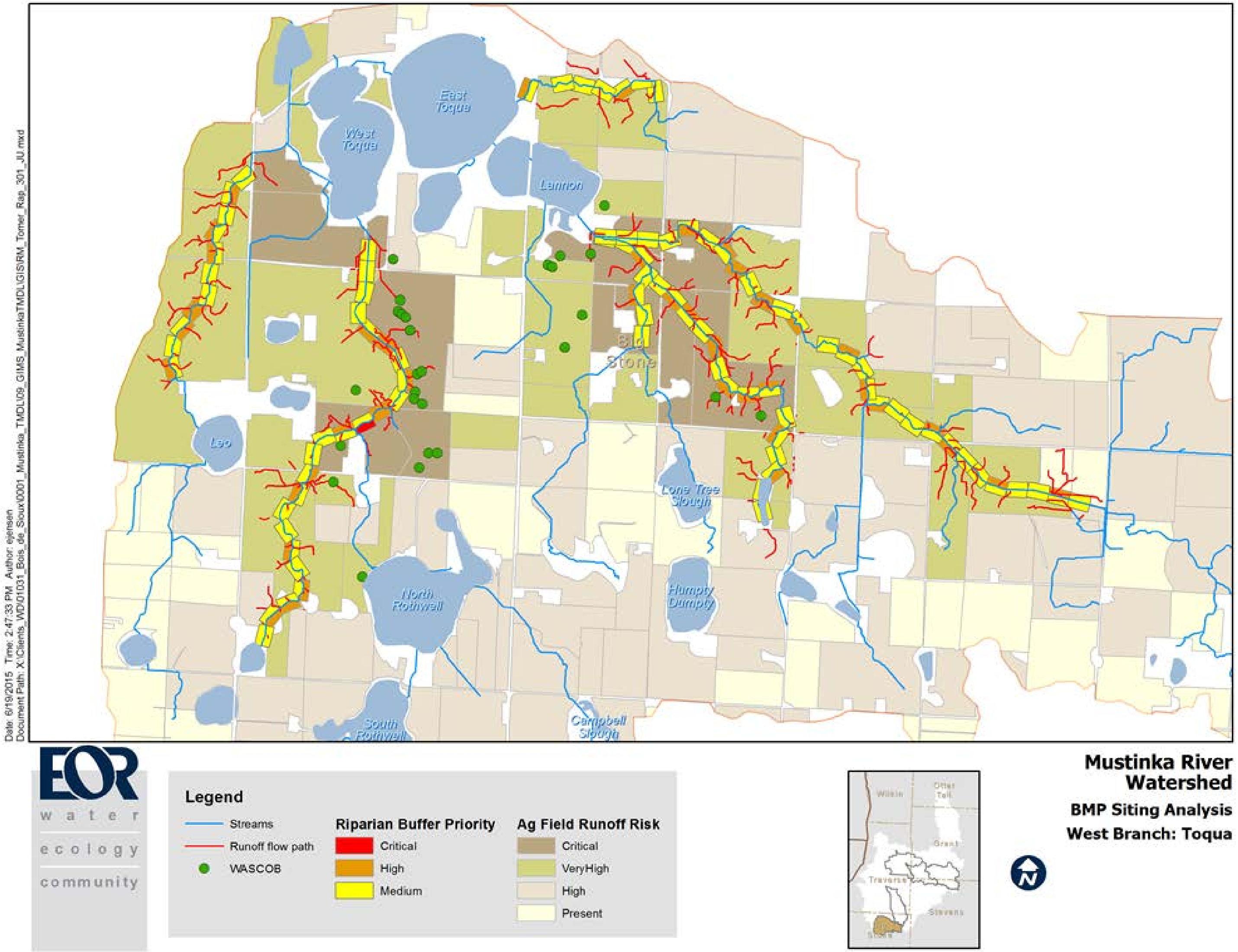
Extended Rotation:

An extend rotation is a rotation of corn, soybean, and at least three years of alfalfa or legume-grass mixtures managed for hay harvest. These crops provide soil cover, reduce soil erosion, and reduce phosphorus loss.

HUC 090201020301 Results: West Branch (Toqua)

Table 24. Agricultural Conservation Practice Framework reductions and cost-benefit for West Branch Toqua (090201020301)

Category	Practice	% P Reduction	Cost ($/ac-yr)	Treated Watershed Area (ac)	Phosphorus Reduction (lb)	Cost-Benefit ($/lb)
Land Use Change	Corn/Soybean to Pasture and/or Land Retirement	75	585	5	1	2,336
In-Field	Reduce phosphorus application rates	17	(-12)	7,144	423	(-199)
	Cover crops, no-till, increase soil organic matter	29	78	6,769	683	773
Edge-of-Field	Sediment basins	85	5.90	315	93	21
	Riparian buffers	58	6.78	7,004	1,414	34
	Grassed waterways	58	30.58	778	157	151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West Toqua
Lannon
Leo
Big Stone
Lone Tree Slough
Humpty Dumpty
North Rothwell
South Rothwell
Campbell Slough
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ecology
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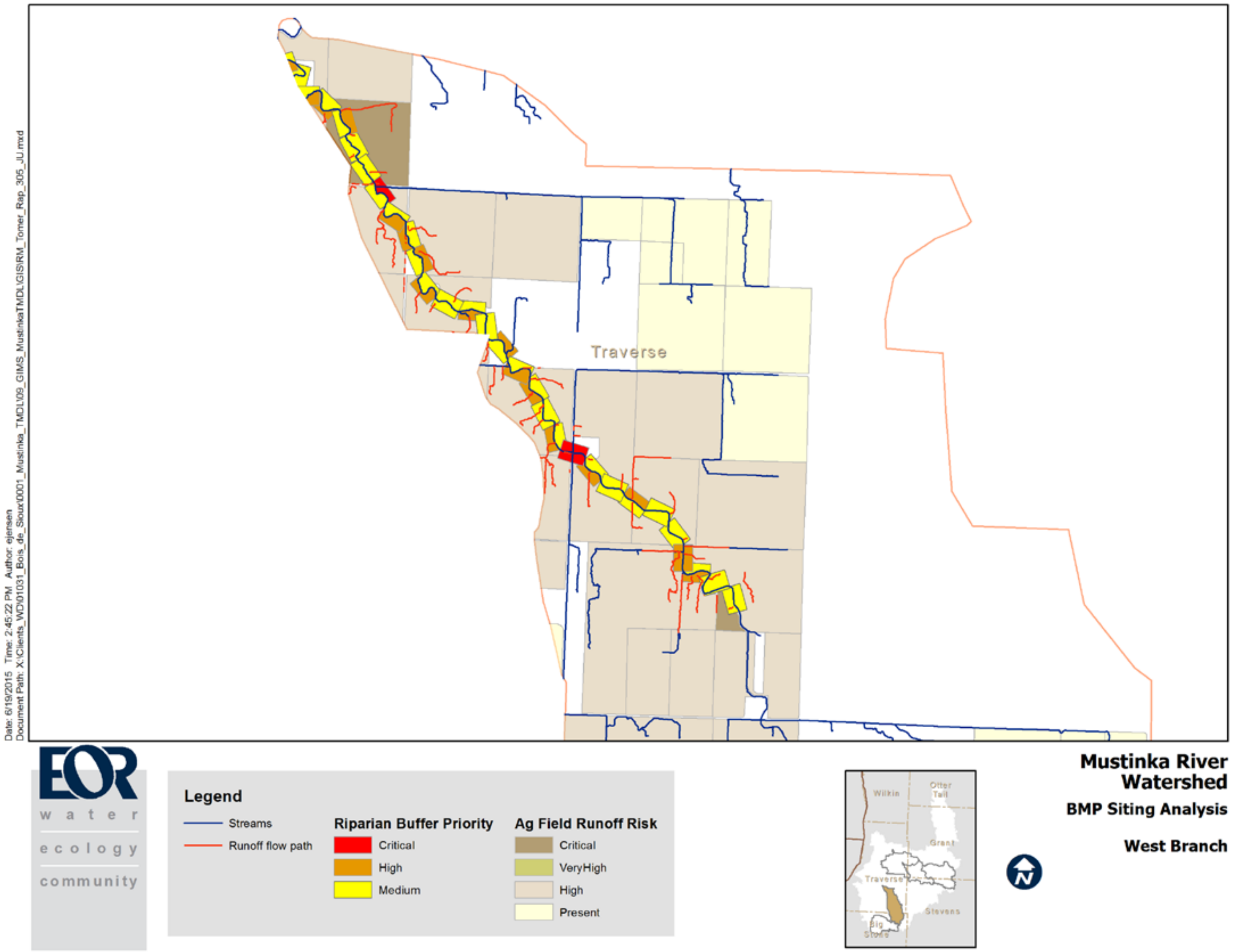
Legend
Streams
Runoff flow path
WASCOB
Riparian Buffer Priority
Critical
High
Medium
Ag Field Runoff Risk
Critical
VeryHigh
High
Present
Mustinka River Watershed
BMP Siting Analysis
West Branch: Toqua

HUC 090201020305 Results: West Branch

Table 25. Agricultural Conservation Practice Framework reductions and cost-benefit for West Branch (090201020305)

Category	Practice	% P Reduction	Cost ($/ac-yr)	Treated Watershed Area (ac)	Phosphorus Reduction (lb)	Cost-Benefit ($/lb)
Land Use Change	Corn/Soybean to Pasture and/or Land Retirement	75	585	16	4	1,524
In-Field	Reduce phosphorus application rates	17	(-12)	8,628	510	(-204)
	Cover crops, no-till, increase soil organic matter	29	78	164	17	817
Edge-of-Field	Sediment basins	85	5.90	--	--	--
	Riparian buffers	58	6.78	2,293	463	34
	Grassed waterways	58	30.58	121	24	155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water
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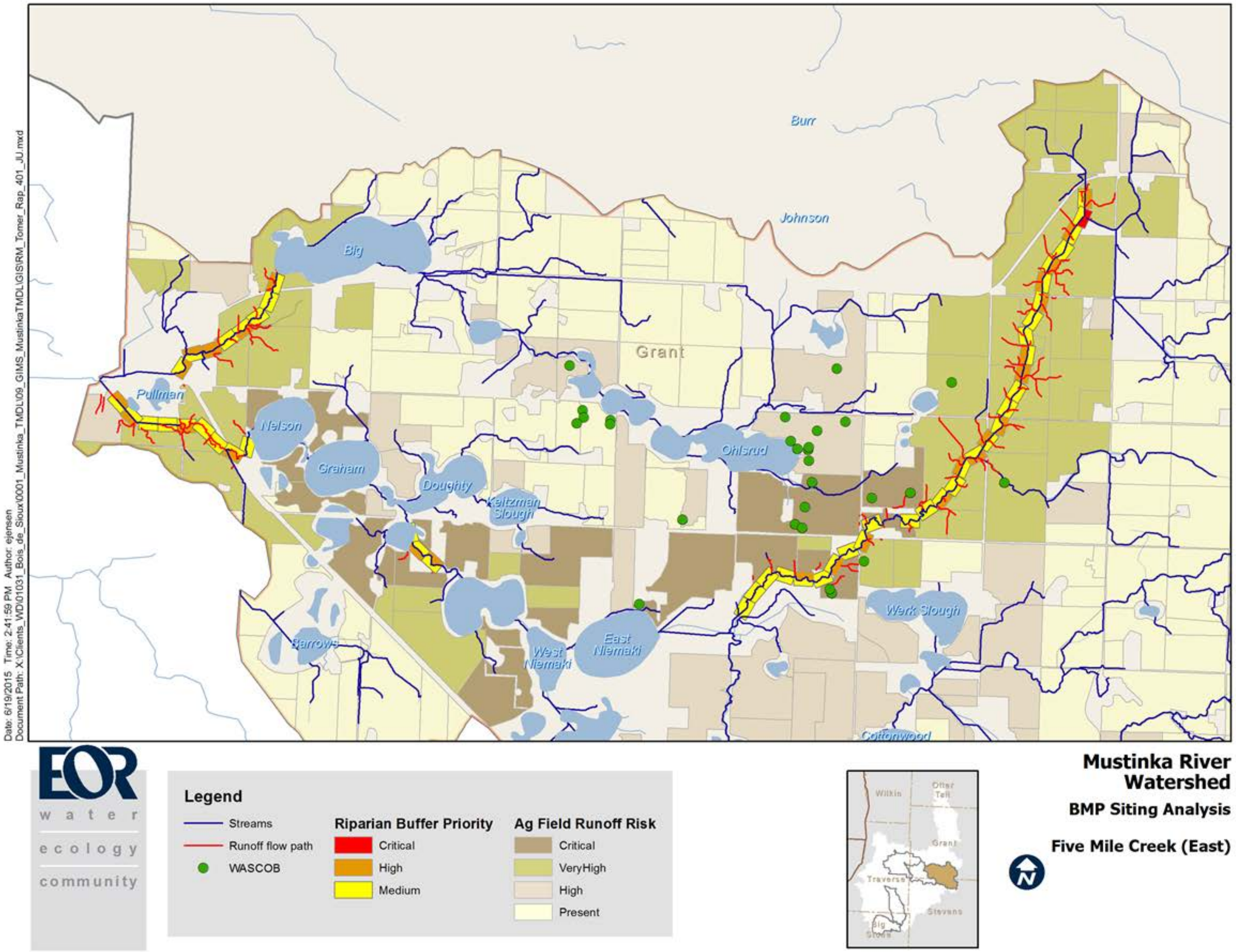
community
Legend
Streams
Runoff flow path
Riparian Buffer Priority
Critical
High
Medium
Ag Field Runoff Risk
Critical
VeryHigh
High
Present
Mustinka River Watershed
BMP Siting Analysis
West Branch

HUC 090201020401 Results: Five Mile Creek East

Table 26. Agricultural Conservation Practice Framework reductions and cost-benefit for Five Mile Creek East (090201020401)

Category	Practice	% P Reduction	Cost ($/ac-yr)	Treated Watershed Area (ac)	Phosphorus Reduction (lb)	Cost-Benefit ($/lb)
Land Use Change	Corn/Soybean to Pasture and/or Land Retirement	75	585	6	2	540
In-Field	Reduce phosphorus application rates	17	(-12)	12,016	711	(-215)
	Cover crops, no-till, increase soil organic matter	29	78	6,433	649	810
Edge-of-Field	Sediment basins	85	5.90	389	115	23
	Riparian buffers	58	6.78	11,950	2,412	35
	Grassed waterways	58	30.58	1,328	268	160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Burr
Johnson
Big
Grant
Pullman
Nelson
Graham
Doughty
Keitzman Slough
Ohlsrud
Werk Slough
Barrows
West Niemaki
East Niemaki
Cottonwood
EOR
water
ecology
community
Legend
Streams
Runoff flow path
WASCOB
Riparian Buffer Priority
Critical
High
Medium
Ag Field Runoff Risk
Critical
VeryHigh
High
Present
Wilkin
Otter Tail
Grant
Traverse
Stevens
Big Stone
Mustinka River Watershed
BMP Siting Analysis
Five Mile Creek (East)

HUC 090201020402 Results: Five Mile Creek West

Table 27. Agricultural Conservation Practice Framework reductions and cost-benefit for Five Mile Creek West (090201020402)

Category	Practice	% P Reduction	Cost ($/ac-yr)	Treated Watershed Area (ac)	Phosphorus Reduction (lb)	Cost-Benefit ($/lb)
Land Use Change	Corn/Soybean to Pasture and/or Land Retirement	75	585	6	1	520
In-Field	Reduce phosphorus application rates	17	(-12)	7,305	432	(-213)
	Cover crops, no-till, increase soil organic matter	29	78	7,514	758	807
Edge-of-Field	Sediment basins	85	5.90	--	--	--
	Riparian buffers	58	6.78	4,198	847	35
	Grassed waterways	58	30.58	221	45	159

HUC 090201020403 Results: Lower Twelve Mile Creek

Table 28. Agricultural Conservation Practice Framework reductions and cost-benefit for Lower Twelve Mile Creek (090201020403)

Category	Practice	Practice %P Reduction	Practice Cost ($/ac-yr)	Treated Watershed Area (ac)	Phosphorus Reduction (lb)	Cost-Benefit ($/lb)
Land Use Change	Corn/Soybean to Pasture and/or Land Retirement	75	585	13	3	1,186
In-Field	Reduce phosphorus application rates	17	(-12)	11,680	691	(-204)
	Cover crops, no-till, increase soil organic matter	29	78	7,346	741	784
Edge-of-Field	Sediment basins	85	5.90	--	--	--
	Riparian buffers	58	6.78	30,242	6,105	34
	Grassed waterways	58	30.58	1,592	321	152