Minnesota River and Greater Blue Earth River Basin Total Suspended Solids Total Maximum Daily Load Study

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Abbreviations

AGREETT	Agriculture Research, Education and Extension Technology Transfer Program
AUID	assessment unit ID
AWWDF	average wet weather design flow
BC	boundary condition
BMP	best management practice
BWSR	Board of Water and Soil Resources
cm	centimeter
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
CWA	Clean Water Act
DNR	Minnesota Department of Natural Resources
EIMS	Environmental Information Management Systems
EPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
EQuIS	Environmental Quality Information System
FDC	flow duration curve
FSA	Farm Service Agency
GBERBA	Greater Blue Earth River Basin Alliance
HSPF	Hydrologic Simulation Program–Fortran
HUC-8	8 digit hydrologic unit code
LA	load allocation
LC	loading capacity
LDC	load duration curve
MDA	Minnesota Department of Agriculture
mgd	million gallons per day
mg/L	milligrams per liter
mi^2	square mile
MnDOT	Minnesota Department of Transportation
MN R GBE	Minnesota River Greater Blue Earth

MOS	margin of safety
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer System
NCED	National Center for Earth-Surface Dynamics
NLCD	National Land Cover Database
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NTU	nephelometric turbidity unit
POTW	publicly owned treatment work
RC	reserve capacity
RIM	Reinvest in Minnesota
SDS	State Disposal System
SMM	South Metro Mississippi River
SWPPP	Stormwater Pollution Prevention Program
TMDL	total maximum daily load
ton/d	tons per day
TSS	total suspended solids
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WLA	wasteload allocation
WPLMN	Watershed Pollutant Load Monitoring Network
WRAPS	watershed restoration and protection strategy
WWTP	wastewater treatment plant
1W1P	One Watershed, One Plan

Executive Summary

The Clean Water Act (CWA), section 303(d) requires that total maximum daily loads (TMDLs) be established for surface waters that do not meet applicable water quality standards necessary to support their designated uses. A TMDL determines the maximum amount of pollutant a receiving water body can assimilate while still achieving water quality standards and allocates pollutant load reductions to pollution sources. This TMDL study covers 61 total suspended solids (TSS) impairments along the Minnesota River and its tributaries, including all of the TSS-impaired streams in the Greater Blue Earth River Basin (Blue Earth River, Le Sueur River, and Watonwan River watersheds). The project area covers the nine major watersheds from the outlet of Lac qui Parle Lake to the mouth of the Minnesota River at the confluence with the Mississippi River at Fort Snelling.

In 2012, the Minnesota Pollution Control Agency (MPCA) prepared draft TMDL reports for turbidity in the Minnesota River and Greater Blue Earth River basins. During their public notice periods, both reports generated significant comments and requests for contested case hearings. In 2014, the state adopted new water quality standards for TSS that replaced the turbidity standard. As a result, the allocations for the turbidity impairments needed to be recalculated, and the 2012 draft TMDL reports were withdrawn from U.S. Environmental Protection Agency (EPA) consideration under Section 303(d) of the CWA. In the current report, TMDLs are developed using the TSS standard; these TMDLs replace the 2012 draft turbidity TMDLs. Impairments from both the Minnesota River and Greater Blue Earth River basins were combined into one report for efficiency.

Land use in the watershed is dominated by agriculture, consisting of primarily corn and soybean rotations. There are also small amounts of urban area, wetland, and forest. Urban development is only significant in the Twin Cities Metropolitan Area. The primary sources of sediment in the project area include near-channel processes (e.g., bluff, ravine, and streambank erosion) and watershed runoff. Within each major watershed, near-channel sources account for between 63% and 83% of the TSS load. Much of the annual sediment load in the basin occurs in the spring as a result of snowmelt and spring storms in March through June. Drain tiling likely exacerbates sediment erosion in near-channel areas as a result of snowmelt and large storm events by increasing the rate and volume of water discharging to the river systems. The highest sediment concentrations occur during high and very high flow conditions.

A load duration curve (LDC) approach was used to determine the TMDL, or allowable pollutant load, for each impaired stream. Allocations for load, wasteload, and margin of safety (MOS) are provided, as well as needed reductions. The load allocation (LA) for each TMDL represents the allowable amount of loading from nonpermitted sources, including near-channel sources, watershed runoff, and natural background. Wasteload allocations (WLAs) for permitted sources are based on TSS concentration limits less than or equal to the TSS standard of 65 milligrams per liter (mg/L). The existing load of permitted municipal separate storm sewer systems (MS4s) represents their allowable load, or WLA. To meet the WLAs for permitted MS4s, TSS loading does not need to be reduced, but is not allowed to increase. A 10% explicit MOS is provided to account for uncertainty. Reductions needed to meet the TMDLs range from zero to 89%, with the highest reductions needed in the Le Sueur River Watershed.

Water quality standards will be achieved through a combination of practices focused on nonpoint sources, implemented through local water planning efforts throughout the basin over the next 10 years and beyond. The MPCA developed the *Sediment Reduction Strategy for the Minnesota River Basin and*

South Metro Mississippi River (SMM; Strategy) for the purpose of establishing a foundation for local water planning to reach sediment reduction goals (MPCA 2015b), and additional investigation is underway to further support selection of implementation measures. The Strategy focuses on reducing peak streamflow magnitude and duration to reduce near-channel erosion and reducing upland erosion through soil health enhancement as a priority. Milestone goals for both sediment reduction and reductions in flow are set for use as part of an adaptive management process. Management practices that reduce sediment loading in the Minnesota River Basin will also represent progress towards achieving the *South Metro Mississippi River TSS TMDL* (MPCA 2015a) and the Minnesota River and Lake Pepin excess nutrients TMDLs, which are underway.

Detailed implementation planning for the Minnesota River Basin will occur at the individual major watershed level as part of Minnesota's watershed approach. This watershed-level planning occurs on a 10-year cycle beginning with intensive watershed monitoring and culminates in local watershed implementation. A report on watershed restoration and protection strategies (WRAPS) is produced as part of this approach and addresses restoration of impaired watersheds and protection of unimpaired waters in each HUC-8 watershed. Targets and goals of HUC-8 scale WRAPS are informed by reach scale TMDLs and the *Sediment Reduction Strategy* (MPCA 2015b). The high-level strategies in the WRAPS report are then used to inform watershed management plans (e.g., One Watershed, One Plan (1W1P)), which focus on local priorities and knowledge to identify prioritized, targeted, and measurable actions and locally based strategies. These plans further define specific actions, measures, roles, and financing for accomplishing water resource goals.

Sediment reduction efforts at the magnitude needed to meet water quality standards will require participation from multiple organizations and all users of the land in the Minnesota River Basin. Making the progress needed to reach sediment reduction goals will require significant time and effort. It will include building on existing research and sediment reduction efforts, as well as identifying and implementing new and innovative programs and practices. The farming community has been and continues to be a vital partner to conservation efforts in the Minnesota River Basin. Reducing sediment and nutrient impacts on water resources is important to Minnesota farmers who innovate new practices to improve the sustainability of their farms. Continued support from the State, local governments, and farm organizations will be critical to finding and implementing solutions that work for individual farmers and help achieve the goal of clean water.

1. Project Overview

1.1 Purpose

The CWA and EPA regulations require that TMDLs be developed for waters that do not support their designated uses. In simple terms, a TMDL study determines what is needed to attain and maintain water quality standards in waters that are not currently meeting them. A TMDL study identifies pollutant sources as specifically as possible and allocates pollutant loads among those sources. The total of all allocations, including WLAs for point sources, LAs for nonpoint sources (including natural background), and the MOS, which is implicitly or explicitly defined, cannot exceed the maximum allowable pollutant load.

This TMDL study covers 61 turbidity and TSS impairments along the Minnesota River and its tributaries, including all of the turbidity and TSS-impaired streams in the Greater Blue Earth River Basin (Blue Earth River, Le Sueur River, and Watonwan River watersheds). The project area covers the nine eight-digit hydrologic unit code (HUC-8) watersheds from the outlet of Lac qui Parle Lake to the mouth of the Minnesota River at the confluence with the Mississippi River at Fort Snelling (Figure 1). This TMDL study does not replace existing turbidity or TSS TMDLs already completed in the Minnesota River Basin; rather, this report includes new TSS TMDLs developed to address impairments that did not previously have approved TMDLs.

Several recent and in-progress regional TMDL efforts are relevant to the TSS TMDLs addressed in this report. The *South Metro Mississippi River TSS TMDL* (MPCA 2015a) addresses the turbidity impairment on the Mississippi River from Fort Snelling in St. Paul to upper Lake Pepin downstream of Red Wing, in addition to the accelerated in-filling of Lake Pepin with sediment (Figure 2). Additionally, TMDL development is underway to address excess nutrients in Lake Pepin. Because the Minnesota River enters the Mississippi River at Fort Snelling and because phosphorus often moves through a watershed attached to sediment particles, progress made towards achieving the Minnesota River TSS TMDLs in this report will represent progress towards achieving the *South Metro Mississippi River TSS TMDL* (MPCA 2015a) and the Lake Pepin excess nutrients TMDL.

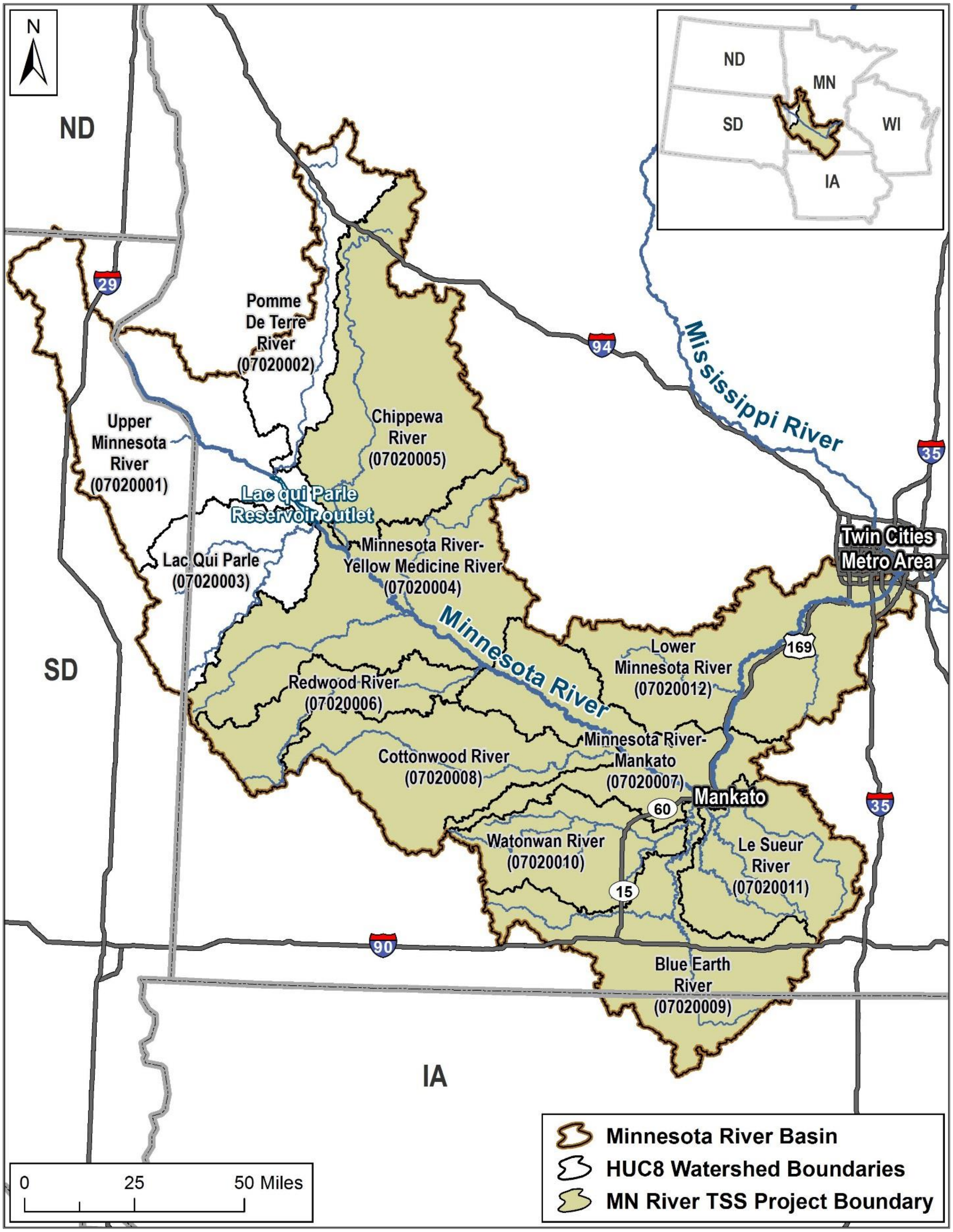

Figure 1. Minnesota River project area.

1.2 Identification of Water Bodies

A large portion of the Minnesota River Basin is included in the project area (Figure 2). This TMDL report applies to 61 reaches, or *assessment units* (AUIDs), for 26 rivers and streams that are impaired by TSS or turbidity across nine HUC-8 watersheds in the Minnesota River Basin (Table 1). TSS standards for the State of Minnesota (Minn. R. 7050.0222) were approved by EPA in 2015, replacing the turbidity standard, and future listings will be based on TSS instead of turbidity. However, existing turbidity impairments will remain listed as turbidity impairments. Impairments listed prior to 2016 are turbidity impairments, and impairments listed in 2016 or later are TSS impairments (Table 1). The TMDLs developed in this report to address the turbidity and TSS impairments are based on the new TSS standards.

The focus of this TMDL is on Minnesota River mainstem turbidity/TSS impairments downstream of Lac qui Parle Dam as well as turbidity/TSS impairments in the Watonwan, Le Sueur, and Blue Earth (Minnesota portion) HUC-8 watersheds. Appendix G lists all turbidity/TSS impairments in the Minnesota River Basin and their TMDL status.

Many of the AUIDs (referred to by assessment unit identification, or AUID) listed in Table 1 are consolidated reaches of older, shorter AUIDs with turbidity or TSS impairments. Appendix A lists the 38 Minnesota River reaches that were consolidated into 10 larger reaches. The impairments on the older, shorter AUIDs were transferred to the 10 larger reaches; these reaches are listed for TSS in the 2018 303(d) list of impaired waters.

In 2017, the MPCA adopted into Minn. R. ch. 7050, which was subsequently approved by U.S. EPA in 2018, a tiered aquatic life use (TALU) framework for the assessment of rivers and streams. The transition to this framework requires the redesignation of numerous stream AUIDs and in many cases changes to the extent of those AUIDs (i.e., splits) to account for varying aquatic life designated uses (modified, general, or exceptional) along a length of stream as determined through a use attainability analysis. When splits occur, the original AUID is retired and replaced by new identifiers that are associated with the resulting “child” AUIDs. As such, the AUIDs presented in this TMDL are subject to change as the process for redesignating streams is ongoing and adheres to the MPCA’s rotating watershed schedule. When such changes do occur either during TMDL development or after the approval process, it is standard practice to maintain the impairment on the downstream child AUID so that existing WLAs remain unaffected by this change. However, when child AUIDs further upstream are also deemed to retain the impairment, it is not standard practice to calculate new WLAs for each downstream node when the TMDL has already been drafted or approved. Otherwise, at least in the case of regional TMDLs, this could result in a process of continual revisions. Several reaches in the subwatersheds of the Minnesota Basin have been split into multiple AUIDs following assessment of the parent AUIDs and the drafting of this TMDL. These reaches are identified in Table 1 with footnote d. The TSS impairment listings assigned to the parent AUIDs have been carried through to the child AUIDs in each of these instances. Allocations were developed for the original parent AUIDs at the most downstream location of the original reach. Land use and pollutant sources are consistent between the new child AUIDs. Therefore, MPCA believes it is appropriate to address the child AUIDs with the allocations calculated for the original parent stream reach.

The MPCA includes waters throughout the state on the state's impaired waters list (MPCA 2016a), including waters that border Indian reservations. Two impaired Minnesota River reaches border Indian reservations: the Minnesota River from Granite Falls Dam to the Yellow Medicine River (AUID 07020004-748) borders the Upper Sioux Community, and the Minnesota River from Beaver Creek to Little Rock Creek (AUID 07020007-720) borders the Lower Sioux Community (Figure 3). These two impaired reaches are noted as having "partial tribal designation" in the state's 2018 impaired waters list. The impaired waters list provides the following information regarding partial tribal designation status: "This body of water is partially within a federally recognized Indian reservation. The state and tribe have worked cooperatively on this water quality assessment and agree that the water should be included on the State's impaired waters list. For the purposes of the 303(d) list, the assessment of the portion of the waterbody within the reservation is advisory to EPA only because EPA has stated that it does not approve the State's impaired waters listings for waters within the boundaries of an Indian reservation." Similarly, for this TMDL, the EPA reviews only the portion of the border reaches described in this paragraph that are not within the boundaries of an Indian reservation. The TMDL does not allocate pollutant load to any federally recognized Indian tribe in this watershed – the Upper Sioux and Lower Sioux.

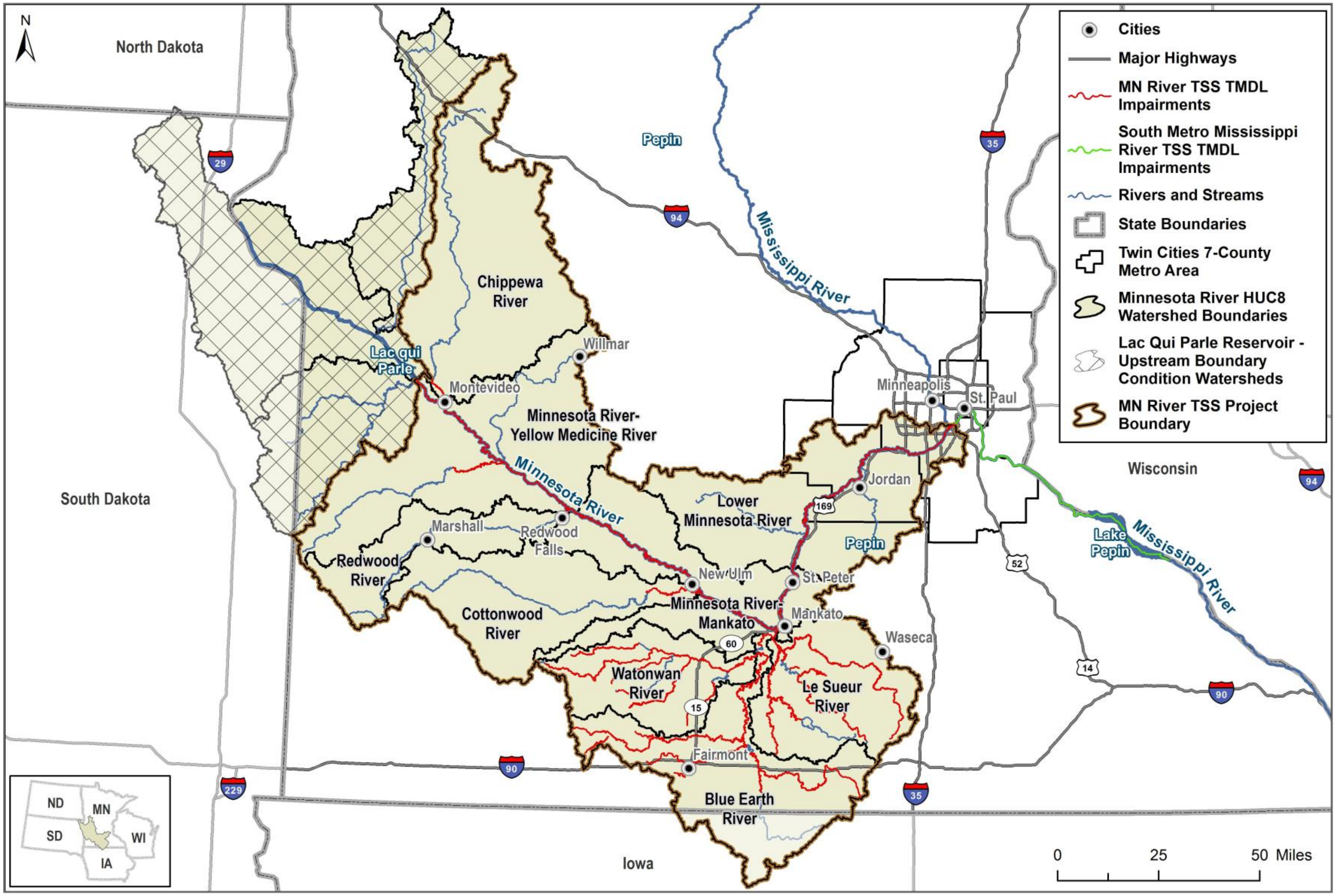

Figure 2. TSS impairments in the Minnesota River Basin project area.

Table 1. TSS and turbidity impairments in the Minnesota River Basin.

HUC-8	Stream Name	AUID (HUC-8)	Use Class	Description	Affected Designated Use	Year Listed	Target Start/ Completion
Minnesota River–Yellow Medicine River (07020004)	Yellow Medicine River	502	2B, 3C	Spring Creek to Minnesota River	Aquatic Life	2002	2008/2016
	Minnesota River	747	1C, 2Bd, 3C	Lac qui Parle Dam to Granite Falls Dam	Aquatic Life	a	
	Minnesota River [b]	748	2B, 3C	Granite Falls Dam to Yellow Medicine River	Aquatic Life	a	
	Minnesota River	749	2B, 3C	Yellow Medicine River to Echo Creek	Aquatic Life	a	
	Minnesota River	750	2B, 3C	Echo Creek to Beaver Creek	Aquatic Life	a	
Chippewa River (07020005)	Chippewa River	501	2B, 3C	Watson Sag to Minnesota River	Aquatic Life	2002	2004/2016
Redwood River (07020006)	Redwood River	501	2B, 3C	Ramsey Creek to Minnesota River	Aquatic Life	2004	2008/2016
Minnesota River–Mankato (07020007)	Minnesota River [c]	720	2B, 3C	Beaver Creek to Little Rock Creek	Aquatic Life	a	
	Minnesota River	721	2B, 3C	Little Rock Creek to Cottonwood River	Aquatic Life	a	
	Minnesota River	722	2B, 3C	Cottonwood River to Blue Earth River	Aquatic Life	a	
	Minnesota River	723	2B, 3C	Blue Earth River to Cherry Creek	Aquatic Life	a	
Cottonwood River (07020008)	Cottonwood River	501	2B, 3C	Judicial Ditch 30 to Minnesota River	Aquatic Life	2002	2016/2016
Blue Earth River (07020009)	Blue Earth River	501	2B, 3C	Le Sueur River to Minnesota River	Aquatic Life	2002	2008/2016
	Elm Creek	502	2B, 3C	Cedar Creek to Blue Earth River	Aquatic Life	1996	2004/2016
	Center Creek	503	2B, 3C	Lily Creek to Blue Earth River	Aquatic Life	2002	2004/2016

HUC-8	Stream Name	AUID (HUC-8)	Use Class	Description	Affected Designated Use	Year Listed	Target Start/ Completion
	Blue Earth River	504	2B, 3C	West Branch Blue Earth River to Coon Creek	Aquatic Life	2002	2004/2016
	Blue Earth River	507	2B, 3C	Willow Creek to Watonwan River	Aquatic Life	2008	2004/2016
	Blue Earth River	508	2B, 3C	East Branch Blue Earth River to South Creek	Aquatic Life	2002	2004/2016
	Blue Earth River	509	2B, 3C	Rapidan Dam to Le Sueur River	Aquatic Life	2004	2017/2016
	Blue Earth River	514	2B, 3C	Center Creek to Elm Creek	Aquatic Life	2010	2010/2016
	Blue Earth River	515	2B, 3C	Elm Creek to Willow Creek	Aquatic Life	2002	2004/2016
	Blue Earth River	518	2B, 3C	Coon Creek to Badger Creek	Aquatic Life	2008	2007/2016
	Cedar (Run) Creek	521	2C	Cedar Lake to Elm Creek	Aquatic Life	2006	2004/2016
	Elm Creek	522	2B, 3C	South Fork Elm Creek to Cedar Creek	Aquatic Life	2006	2004/2016
	Elm Creek[d]	523	2B, 3C	Headwaters to South Fork Elm Creek	Aquatic Life	2010	2004/2016
		630	*2B, 3C*	*Headwaters to 570th Ave*	*Aquatic Life*	*2020*[e]	*2020*[e]
		631	*2B, 3C*	*570th Ave to South Fork Elm Creek*	*Aquatic Life*	*2020*[e]	*2020*[e]
	Elm Creek, South Fork	524	2C	T103 R34W S30, W line to T103 R34W S1, N line	Aquatic Life	2010	2004/2017
	Lily Creek[d]	525	2B, 3C	Headwaters (Fox Lake 46-0109-00) to Center Crk	Aquatic Life	2006	2004/2016
		632	*2B, 3C*	*Headwaters (Fox Lake 46-0109-00) to N Bixby Rd*	*Aquatic Life*	*2020*[e]	*2020*[e]
		633	*2B, 3C*	*N Bixby Rd to Center Creek*	*Aquatic Life*	*2020*[e]	*2020*[e]
	Dutch Creek[d]	527	2B, 3C	Headwaters to Hall Lake	Aquatic Life	2006	2004/2016
		634	*2B, 3C*	*Headwaters to -94.507, 43.626*	*Aquatic Life*	*2020*[e]	*2020*[e]

HUC-8	Stream Name	AUID (HUC-8)	Use Class	Description	Affected Designated Use	Year Listed	Target Start/ Completion
		635	*2B, 3C*	*-94.507, 43.626 to T102 R31W S13, south line*	*Aquatic Life*	*2020*[e]	*2020*[e]
		636	*2B, 3C*	*T102 R31W S13, S line to T102 R31W S18, S line*	*Aquatic Life*	*2020*[e]	*2020*[e]
		637	*2B, 3C*	*T102 R30W S19, north line to Hall Lk*	*Aquatic Life*	*2020*[e]	*2020*[e]
	Blue Earth River, E Br.	553	2C, 3C	Brush Creek to Blue Earth River	Aquatic Life	2008	2004/2016
	Blue Earth River, E Br.[d]	554	2B, 3C	Headwaters to Brush Creek	Aquatic Life	2008	2004/2016
		649	*2B, 3C*	*East Branch; Headwaters to -93.663 43.624*	*Aquatic Life*	*2020*[e]	*2020*[e]
		650	*2B, 3C*	*-93.663 43.624 to -93.73 43.654*	*Aquatic Life*	*2020*[e]	*2020*[e]
	Blue Earth River	565	2B, 3C	Badger Creek to East Branch Blue Earth River	Aquatic Life	2008	2004/2016
Le Sueur River (07020011)	Le Sueur River	501	2B, 3C	Maple River to Blue Earth River	Aquatic Life	2002	2008/2016
	Unnamed Creek (Little Beauford Ditch)[d]	503	2B, 3C	Headwaters to Cobb River	Aquatic Life	2002	2004/2016
		642	*2B, 3C*	*Headwaters to Victory Dr (MN22)*	*Aquatic Life*	*2020*[e]	*2020*[e]
		643	*2B, 3C*	*Victory Dr (MN22) to Cobb R*	*Aquatic Life*	*2020*[e]	*2020*[e]
	Little Cobb River	504	2C	Bull Run Creek to Cobb River	Aquatic Life	2002	2004/2016
	Le Sueur River	506	2B, 3C	Cobb River to Maple River	Aquatic Life	2010	2008/2016
	Le Sueur River	507	2B, 3C	County Ditch 6 to Cobb River	Aquatic Life	2008	2004/2016
	Rice Creek	531	2B, 3C	Headwaters to Maple River	Aquatic Life	2010	2008/2016
	Maple River	534	2B, 3C	Rice Creek to Le Sueur River	Aquatic Life	2008	2004/2016

HUC-8	Stream Name	AUID (HUC-8)	Use Class	Description	Affected Designated Use	Year Listed	Target Start/ Completion
	Maple River	535	2B, 3C	Minnesota Lake Outlet to Rice Creek	Aquatic Life	2010	2010/2016
	County Ditch 3 (Judicial Ditch 9)[d]	552	2B, 3C	Judicial Ditch 9 to Maple River	Aquatic Life	2010	2008/2016
		652	*2B, 3C*	*JD 9 to -93.958, 43.852*	*Aquatic Life*	*2020*[e]	*2020*[e]
		653	*2B, 3C*	*-93.958, 43.852 to Maple R*	*Aquatic Life*	*2020*[e]	*2020*[e]
	Cobb River	556	2C	T107 R26W S30, west line to Le Sueur River	Aquatic Life	2008	2004/2016
	Cobb River	568	2C	T104 R23W S34, south line to Little Cobb River	Aquatic Life	2010	2008/2016
	Le Sueur River[d]	619	2B, 3C	Headwaters to Boot Creek	Aquatic Life	2010	2010/2016
		664	*2B, 3C*	*Headwaters to Freeborn/Steele County border*	*Aquatic Life*	*2020*[e]	*2020*[e]
		665	*2B, 3C*	*Freeborn/Steele County border to Boot Creek*	*Aquatic Life*	*2020*[e]	*2020*[e]
	Le Sueur River	620	2B, 3C	Boot Creek to CD6	Aquatic Life	2010	2010/2016
Lower Minnesota River (07020012)	Minnesota River	505	2C, 3C	RM 22 to Mississippi	Aquatic Life	1996	2014/2019
	Minnesota River	506	2C, 3C	Carver Creek to RM 22	Aquatic Life	1996	2014/2019
	Minnesota River	799	2B, 3C	Cherry Creek to High Island Creek	Aquatic Life	a	
	Minnesota River	800	2B, 3C	High Island to Carver Creek	Aquatic Life	a	
Watonwan River (07020010)	Watonwan River	501	2B, 3C	Perch Creek to Blue Earth River	Aquatic Life	2002	2008/2016
	Watonwan River	510	2B, 3C	South Fork Watonwan River to Perch Creek	Aquatic Life	2008	2004/2016
	Watonwan River	511	2B, 3C	Butterfield Creek to South Fork Watonwan River	Aquatic Life	2006	2004/2016
	Butterfield Creek	516	2C	Headwaters to St. James Creek	Aquatic Life	2008	2004/2016

HUC-8	Stream Name	AUID (HUC-8)	Use Class	Description	Affected Designated Use	Year Listed	Target Start/ Completion
	Watonwan River, South Fork	517	2B, 3C	Willow Creek to Watonwan River	Aquatic Life	2006	2004/2016
	Perch Creek	524	2C	Headwaters (Perch Lk 46-0046-00) to Spring Cr	Aquatic Life	2006	2004/2016
	St. James Creek (Kansas Lake Inlet)	528	2C	Headwaters to Kansas Lake	Aquatic Life	2002	2004/2016
	Watonwan River, South Fork	547	2B, 3C	Irish Lake to Willow Creek	Aquatic Life	2006	2008/2016
	Watonwan River	562	2B, 3C	North Fork Watonwan River to T107 R32W S13, east line	Aquatic Life	2006	2004/2016
	Watonwan River	563	2B, 3C	T107 R31W S18, west line to Butterfield Creek	Aquatic Life	2006	2004/2016
	Watonwan River, North Fork	564	2B, 3C	Headwaters to T107 R32W S6, east line	Aquatic Life	2006	2004/2016
	Watonwan River	566	2B, 3C	Headwaters to T107 R33W S33, east line	Aquatic Life	2006	2004/2016
	Watonwan River	567	2B, 3C	T107 R33W S34, west line to North Fork Watonwan River	Aquatic Life	2006	2004/2016

a. Listed for TSS in the 2018 303(d) list of impaired waters.
b. Adjacent to tribal lands of the Upper Sioux Community; noted as “partial tribal designation” in the state’s 2018 impaired waters list.
c. Adjacent to tribal lands of the Lower Sioux Community; noted as “partial tribal designation” in the state’s 2018 impaired waters list.
d. Reach split into multiple AUIDs following listing on 303(d) impaired waters list.
e. Split reach proposed to be added to the 2020 303(d) impaired waters list.

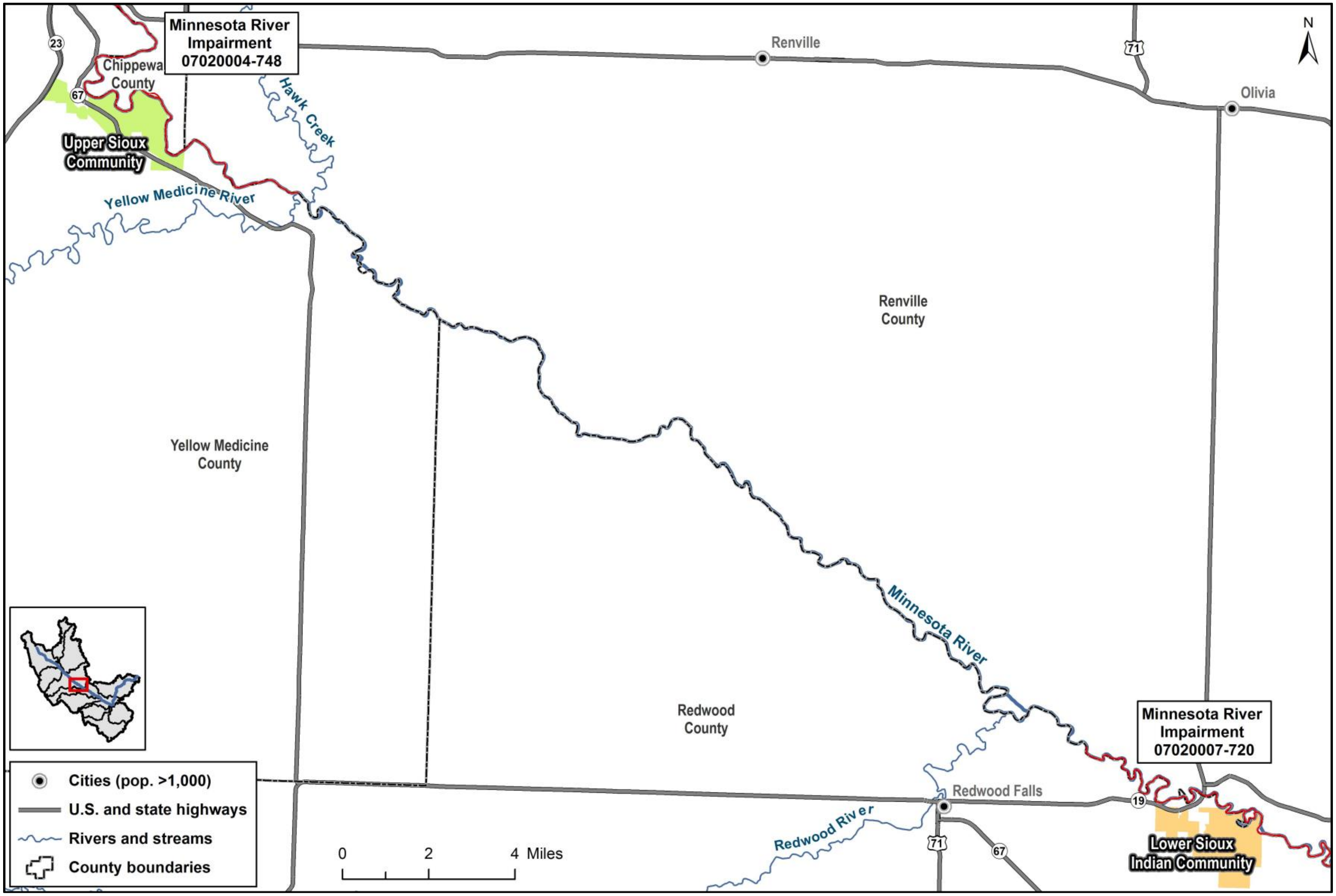

Figure 3. Location of tribal lands with respect to impaired waters.

1.3 Priority Ranking

The MPCA's schedule for TMDL completions, as indicated on the 303(d) impaired waters list, reflects Minnesota's priority ranking of this TMDL. The MPCA has aligned TMDL priorities with the watershed approach and WRAPS cycle. The schedule for TMDL completion corresponds to the WRAPS report completion on the 10-year cycle. Mainstem river TMDLs, which are not contained in major watersheds and thus not addressed in WRAPS, must also be completed. The MPCA developed a state plan, Minnesota's TMDL Priority Framework Report, to meet the needs of EPA's national measure (WQ-27) under EPA's Long-Term Vision for Assessment, Restoration and Protection under the CWA section 303(d) program. As part of these efforts, the MPCA identified water quality-impaired segments that will be addressed by TMDLs by 2022. The waters of the Minnesota River and Greater Blue Earth River basins addressed by this TMDL are part of the MPCA prioritization plan to meet EPA's national measure.

2. Applicable Water Quality Standards and Numeric Water Quality Targets

Minnesota adopted its first statewide water quality standards in 1967. The state has updated those standards by adding new standards and regulations periodically. The comprehensive federal CWA amendments of 1972 require states to adopt water quality standards that meet the minimum requirements of the federal CWA.

Under the CWA, every state must adopt water quality standards to protect, maintain, and improve the quality of the nation's surface waters. These standards represent a level of water quality that will support the CWA's goal of "fishable and swimmable" waters. Water quality standards consist of three components: beneficial uses, numeric or narrative standards, and a nondegradation policy. Minnesota's water quality standards are summarized in Table 2 and explained in greater detail following the table.

Table 2. Minnesota water quality standards.

Component	Description
Beneficial uses	Beneficial uses are the uses that states decide to make of their water resources. The process of determining beneficial uses is spelled out in the federal rules implementing the CWA.
Numeric standards	Numeric water quality standards represent safe concentrations in water that protect a specific beneficial use. If the standard is not exceeded, the use should be protected.
Narrative standards	Narrative water quality standards are statements that prohibit unacceptable conditions in or on the water, such as floating solids, scums, visible oil film, or nuisance algae blooms. Narrative standards are sometimes called "free froms" because they help keep surface waters free from basic types of water pollution.
Nondegradation	Nondegradation is equivalent to the federal term "antidegradation." The fundamental concept of nondegradation is that lakes, rivers, and streams whose water quality is better than the applicable standards should be maintained at that high level of quality and not allowed to degrade to the level of applicable standards.

Water quality standards can be found in several Minnesota rules, but the primary rule for statewide water quality standards is Minn. R. ch. 7050. Included in this rule are the following:

- A classification system of beneficial uses for both surface and groundwater
- Numeric and narrative water quality standards
- Nondegradation provisions
- Provisions for the protection of wetlands
- Treatment requirements and effluent limits for wastewater discharges
- Other provisions related to protecting Minnesota's water resources from pollution

All waters of Minnesota are assigned classes based on their suitability for the following beneficial uses:

Class 1. Domestic consumption

Class 2. Aquatic life and recreation

Class 3. Industrial consumption

Class 4. Agriculture and wildlife

Class 5. Aesthetic enjoyment and navigation

Class 6. Other uses

Class 7. Limited resource value

Beneficial uses of the TSS-impaired reaches of the Minnesota River Basin project are as follows:

- Minnesota River (Lac qui Parle Dam to Mississippi River): 1C, 2B, 2Bd, 2C, and 3C
- All other water bodies (Table 1) are classified as follows: 2B, 2C, and 3C

Subclasses are defined as follows:

- **Class 1C waters:** "The quality of class 1C waters of the state shall be such that with treatment consisting of coagulation, sedimentation, filtration, storage, and chlorination, or other equivalent treatment processes, the treated water will meet both the primary (maximum contaminant levels) and secondary drinking water standards issued by the United States Environmental Protection Agency." (Minn. R. ch. 7050.2221, subp. 4)
- **Class 2Bd waters:** "The quality of class 2Bd surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable. This class of surface waters is also protected as a source of drinking water." (Minn. R. ch. 7050.2222, subp. 3)
- **Class 2B waters:** "The quality of class 2B surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable. This class of surface water is not protected as a source of drinking water." (Minn. R. ch. 7050.2222, subp. 4)
- **Class 2C waters:** "The quality of class 2C surface waters shall be such as to permit the propagation and maintenance of a healthy community of indigenous fish and associated aquatic life, and their habitats. These waters shall be suitable for boating and other forms of aquatic recreation for which the waters may be usable." (Minn. R. ch. 7050.2222, subp. 5)
- **Class 3C waters:** "The quality of class 3C waters of the state shall be such as to permit their use for industrial cooling and materials transport without a high degree of treatment being necessary to avoid severe fouling, corrosion, scaling, or other unsatisfactory conditions." (Minn. R. ch. 7050.2223, subp. 4)

TSS Standard

The MPCA (2016a) defines TSS as:

> … soil particles, algae, and other materials that are suspended in water and cause a lack of clarity. Excessive TSS can harm aquatic life, degrade aesthetic and recreational qualities, and make water more expensive to treat for drinking.

The MPCA established TSS numeric criteria for class 2 waters. In the South River Nutrient Region, where the Minnesota River Basin is located, TSS may not exceed 65 mg/L in more than 10% of samples collected in the months of April through September. The MPCA (2016a) considers a stream to exceed the TSS standard (i.e., to be impaired by TSS):

> … if (1) the standard is exceeded more than 10% of the days of the assessment season (April through September) as determined from a data set that gives an unbiased representation of conditions over the assessment season, and (2) there are at least three such measurements exceeding the standard.

The class 2B turbidity standard (Minn. R. ch. 7050.0222) that was in place at the time of the impairment assessment for many reaches in the project area was 25 NTUs. Impairment listings occurred when greater than 10% of data points collected within the previous 10-year period exceeded the 25 NTU standard (or equivalent values for TSS or the transparency tube). If sufficient turbidity data did not exist, transparency tube data were used to evaluate waters for turbidity impairments for the 2006 through 2014 303(d) lists of impaired waters. A transparency tube measurement less than 20 centimeters (cm) indicated a violation of the 25 NTU turbidity standard. A stream was considered impaired if more than 10% of the transparency tube measurements were less than 20 cm.

Due to weaknesses in the turbidity standards, MPCA developed numeric TSS criteria to replace them. These TSS criteria are regional in scope and based on a combination of biotic sensitivity to the TSS concentrations and reference streams/least impacts streams as data allow. The results of the TSS criteria development were published by the MPCA in 2011. The new TSS standards were approved by EPA in January 2015. For the purpose of this TMDL report, the newly adopted 65 mg/L standard for class 2B waters is used to address the turbidity impairment listings in the Minnesota River Basin project area.

3. Previous TMDL Development

TMDLs that address sediment in the Minnesota River Basin and downstream have been in development for many years. Several TMDLs have been drafted but not completed for the Minnesota River Basin. Downstream of the Minnesota River, the EPA-approved *South Metro Mississippi River TSS TMDL* (MPCA 2015a) specifically addresses the need for sediment reduction from the Minnesota River Basin.

Draft Turbidity TMDLs for the Minnesota River and Greater Blue Earth River Basins.

Draft TSS TMDLs for turbidity-impaired waters were developed for Minnesota River mainstem reaches in the draft *Minnesota River Turbidity Total Maximum Daily Load* (MPCA 2012a) and for stream reaches in the Watonwan River, Le Sueur River, and Blue Earth River watersheds in the draft *Turbidity Total Maximum Daily Load Study, Greater Blue Earth River Basin* (MPCA n.d.). An extensive stakeholder involvement effort was undertaken for both studies, including a series of meetings with a stakeholder advisory committee, formation of a sediment research colloquium, and activities designed to build capability and capacity among stakeholders. See Section 11 for more information on the public participation aspects of developing the draft TMDL. Advisory committee materials and other documentation are available upon request.

During the public notice periods, both TMDL reports generated significant comments as well as requests for contested case hearings. After prolonged negotiations and responses to the comments and requests for hearings, in 2014 the state adopted new water quality standards for TSS that replaced the turbidity standard. As a result, the allocations for the turbidity impairments needed to be recalculated. The MPCA decided that the best course was to withdraw the 2012 drafts from EPA consideration under Section 303(d) of the CWA and redevelop the two TMDL reports as one combined study using the TSS standard. The following are highlights of significant differences between the 2012 Minnesota River and Greater Blue Earth River Watershed Turbidity TMDLs (MPCA 2012a, MPCA n.d.) and the TMDLs developed in this report.

- **Change to TSS water quality standard.** The water quality standard in effect during the development of the 2012 drafts of the Minnesota River and Greater Blue Earth River turbidity TMDLs for class 2Bd and 2B waters was a turbidity standard of 25 nephelometric turbidity units (NTU), which measures the amount of light penetration of water. A reach was identified as impaired due to turbidity when greater than 10% of data points collected within the previous 10-year period exceeded the 25 NTU standard (MPCA 2012b). Because turbidity is not a mass-based measurement, a surrogate was required to calculate the TMDLs. TSS, which measures suspended sediment and organic material, was used to set TMDLs for the impaired reaches addressed in the 2012 draft TMDL reports. Simple linear regressions were used to determine the TSS numerical equivalent to 25 NTU; the TSS equivalents served as the surrogate TSS targets. These surrogate targets ranged from 50 mg/L TSS for some of the upper watersheds to 100 mg/L TSS for the lower mainstem reaches of the Minnesota River.

  In June 2014, the MPCA adopted TSS water quality standards to replace the turbidity standard; the TSS standards were approved by EPA in January 2015. The TSS standards are region-specific and are based on a combination of biotic sensitivity to TSS concentrations and reference or least impacted streams. The Minnesota River Basin (including the Greater Blue Earth River Basin) is located in the South River Nutrient Region, which has a 65 mg/L TSS standard. The standard may be exceeded for no more than 10% of the time and applies from April 1 through September 30. The TSS concentration of 65 mg/L was used to develop the TMDLs for the impaired reaches addressed in this report. Turbidity impairments that were listed prior to the 2016 303(d) impaired waters list will continue to be displayed as turbidity impairments; subsequent impairments are listed as TSS. See Section 2: *Applicable Water Quality Standards and Numeric Water Quality Targets* for further information on the water quality standard.

- **Consolidating Minnesota River reaches**. The draft *Minnesota River Turbidity Total Maximum Daily Load* (MPCA 2012a) addressed nine mainstem impaired reaches. The impaired reaches were not all contiguous due to data limitations. Because of the nature of suspended sediment and its ability to be easily transported downstream, this patchwork of reach impairments is unlikely. Rather, the reaches not listed as impaired were likely an artifact of incomplete data. The MPCA recently consolidated some of the shorter reaches of the Minnesota River, resulting in fewer but longer mainstem reaches. Using additional data and professional judgment, the Minnesota River reaches were reassessed, and all of the Minnesota River mainstem reaches downstream of the Lac qui Parle Dam will be listed as impaired for turbidity or TSS and are addressed in this TMDL report. This includes the mainstem reaches between High Island Creek and the confluence with the Mississippi River that were not included in the 2012 draft Minnesota River Turbidity TMDL (MPCA 2012). See Table 1 and Appendix A for more information on the impairment listings and reach consolidations.
- **Hydrologic Simulation Program–FORTRAN (HSPF) model update**. Models for six of the Minnesota River's 12 HUC-8 watersheds were originally developed by MPCA and subsequently expanded and calibrated by Tetra Tech in 2002 to include the entire basin from Lac qui Parle to Jordan. In 2008, Tetra Tech refined the models for sediment simulation, and these models were used in the MPCA's 2012 draft Minnesota River and Greater Blue Earth turbidity TMDLs. Since then, the basin model was refined by RESPEC in 2014 and most recently by Tetra Tech in 2016 to incorporate new data and increase resolution. The primary differences between the 2008 HSPF model application used in the previous draft TMDLs and the 2016 model used in the current project are:
    - The 2008 model scale was at approximately the HUC10 scale; the 2016 model is at the HUC12 scale.
    - The 2016 model was extended through 2012.
    - The model was recalibrated based on newer observations and additional data on field-derived sediment sources. The simulations were recalibrated to agree with external information on water balance components and sediment sources:
        - Sediment was apportioned among upland, ravine, bluff, and channel erosion based on sediment budget studies of the Le Sueur and Greater Blue Earth River basins.
        - Model parameter adjustments were made to ensure that per-acre upland sediment loading rates are consistent with expected rates based on local and regional monitoring data and modeling studies.

See Section 4.4.1 for further information on the HSPF model.

- **Setting WLAs for MS4s**. In the 2012 draft, WLAs for MS4s were calculated by multiplying a sediment-export coefficient times the regulated MS4 area. The regulated MS4 area was based on the total developed area within the regulated MS4 boundaries, based on the 2001 National Land Cover Database (NLCD). In the TMDLs in this report, MS4 WLAs were calculated using the same TSS export rate (154 pounds/acre-year) as used by the downstream *South Metro Mississippi River TSS TMDL* (MPCA 2015a). The area of each permitted MS4 is based on the developed land within the MS4 jurisdictional boundaries, based on the 2011 NLCD. Source assessment indicated that developed areas within permitted MS4s contribute no more than 1% of existing TSS loads (with the exception of the Lower Minnesota River Watershed). It was determined that reductions to current TSS loading from permitted MS4s are not necessary. However, increases to TSS loading are not allowed. MS4s must follow the best management practices (BMPs) and reporting requirements as defined in their permits and Stormwater Pollution Prevention Program (SWPPP). For more information on source assessment and setting MS4 WLAs see Table 7 and Section 5.4.3.
- **Reasonable assurance**. The reasonable assurance section has been expanded beyond the 2012 draft incorporating the framework for implementation developed for the Chesapeake Bay TMDL project (EPA 2009). The revised reasonable assurance identifies multiple-scale efforts, from local BMP implementation to watershed and basin scale plans and strategies. Numerous programs, laws, and funding options also are identified as ways to provide reasonable assurance. Finally, the revised reasonable assurance section outlines how progress will be tracked through monitoring and reporting as well as contingency requirements if sediment reduction milestones are not met on schedule. For more information, see Section 8: *Reasonable Assurance*.

South Metro Mississippi River TSS TMDL. The *South Metro Mississippi River TSS TMDL* (MPCA 2015a) includes TSS allocations for the Upper Mississippi River, Minnesota River, Cannon River, and St. Croix River basins, as well as small rivers and streams in southeast Minnesota that flow directly into the Mississippi River. The SMM, from Fort Snelling in St. Paul to upper Lake Pepin downstream of Red Wing, is impaired due to high turbidity, which prevents sufficient sunlight from reaching the river bottom and allowing the growth and maintenance of submersed aquatic vegetation. The TSS TMDL addresses the turbidity impairment in addition to the accelerated in-filling of Lake Pepin with sediment. The TMDL is based on a site-specific standard of 32 mg/L TSS for the impaired reach.

The MPCA worked with a stakeholder advisory committee made up of representatives from agriculture, urban areas, wastewater treatment, and other interests to study the problem and make recommendations on reducing the amount of sediment in the river. A science advisory panel made up of representatives from universities and research groups also advised the agency on the project.

The TMDL report includes a description of recent research on sources of sediment to Lake Pepin (MPCA 2015a, Pages 38–39):

> Lake Pepin serves as a depositional basin where sediments from the South Metro Mississippi River Watershed have accumulated over many centuries. Scientists have analyzed sediment cores from Lake Pepin to estimate historical rates of sediment deposition, as well as recent changes in sources of sediment. Sediment dating techniques show that sediment accumulation

rates have increased by about a factor of 10 since European settlement. An estimated 80% of the sediment load is from the Minnesota River and several small Mississippi River tributaries. Recent estimates of sediment loads based on Lake Pepin core analysis correspond closely to monitored Mississippi River data at Lock and Dam 3 north of Red Wing, Minnesota (Engstrom et al. 2009). That is, recent monitored sediment loads measured at Lock and Dam 3, just upstream of Lake Pepin, corresponded very closely to sediment load estimates based on interpretation of Lake Pepin sediment cores taken in 1996 and 2008.

The St. Croix Watershed Research Station of the Science Museum of Minnesota has conducted several studies to determine what percentage of Lake Pepin sediment derives from erosion of agricultural fields, how much is from non-field sources, and how these proportions have changed over time. The studies used two radioisotopes to fingerprint and apportion sources of sediment in Lake Pepin and its tributary watersheds. These studies have found that, at present, an estimated 35% of the total sediment load to Lake Pepin, as measured by sediment core samples, originates from farm field erosion (Schottler et al. 2010). This proportion has shifted from an estimated 65% field/35% non-field in 1940 in response to increased erosion from non-field sources accompanied by stabilized erosion from fields…. The proportions vary greatly among watersheds depending on topography, stream gradient, land use and precipitation. Non-field sources include ravines, stream bluffs and streambanks.

Drastic land use changes to a river basin that is geologically predisposed to high erosion rates appear to be largely responsible for the dramatic increase in sediment loads from the Minnesota River over time. The sudden and extremely rapid southward drainage of Glacial Lake Agassiz through the River Warren channel some 11,500 [radiocarbon estimate] years ago carved out a wide, deep valley through which the Minnesota River runs today. Since that event, the tributary streams have been steadily down-cutting in their lower reaches to adjust to the new lower base level. The creation of steep valley walls around the Minnesota River mainstem and the lower reaches of its tributaries “primed” the landscape to erode sediment (Wilcock 2009). As is discussed [in] Section 6.2 [of the South Metro Mississippi River TSS TMDL], these geologically created land forms are natural, but the current rate of erosion and sediment loss are not. Land clearing, the tripling of acreage in row crop production, and increased flows in the Minnesota River and its tributaries since 1940 have exacerbated the landscape’s inherent potential for sediment loss and driven greater sediment loads.

Within the Minnesota River Basin, the proportions of sediment originating from streambanks, bluffs and ravines vary widely by major watershed, as well as by year. Bluff erosion appears to be significant in the Blue Earth River and Le Sueur River Watersheds, the highest contributors of sediment in the Minnesota River Basin (Sekely et al. 2002; Thoma et al. 2005). The main driver of bluff erosion in the long run is erosion at the toe of the bluff (Wilcock 2009). Net streambank erosion also appears to be a significant source of sediment in the Le Sueur Watershed, as indicated by historical widening of the stream channel in response to elevated river flows (Stephanie Day, National Center for Earth Surface Dynamics, University of Minnesota, Minneapolis, personal communication; [Lauer et al. 2017]). Bluff and bank erosion respond exponentially to increased stream flow, and the erosive force it generates (Charles Regan, MPCA, personal communication; Restrepo and Kjerfve 2000).

Erosion of ravines is driven by the volume and rate of water discharged to the ravine which is often increased by discharge from the upland drainage system (Wilcock 2009). Ravine erosion is most prominent in the catchments of deeply incised tributaries, often found moving down the Minnesota River escarpment. It is especially prominent in wetter years with high levels of surface runoff and tile line discharge (Patrick Baskfield, MPCA, Mankato, personal communication).

The Minnesota River Basin accounts for approximately 34% of the drainage area to the SMM, but contributes an average of 74% of the sediment load to the impairment. A hydrodynamic water quality model (Limno-Tech 2009) was used to evaluate the effects of load and flow reductions on turbidity, phosphorus, chlorophyll, and transparency in the Mississippi River and Lake Pepin. The TMDL includes the following reductions in the amounts of sediment flowing into the Mississippi River:

- 60% from the Minnesota River during high and very high flows and 50% during average and low flows
- 50% from the Cannon River
- 20% from the Upper Mississippi River
- 20% from smaller rivers and streams in Minnesota and Wisconsin that flow directly into the river

The *South Metro Mississippi River TSS TMDL* (MPCA 2015a) states that the TSS load reductions simulated in Minnesota River Scenario 4 in *Minnesota River Basin Turbidity TMDL Scenario Report* (Tetra Tech 2009) are approximately the types and magnitudes of land use changes and practices needed to meet the Minnesota River load reductions required by the South Metro TSS TMDL. Restoring the Mississippi will require the efforts of residents, businesses, landowners, and land renters from throughout Minnesota. Implementation strategies for the South Metro Mississippi River TMDL are provided in the *Sediment Reduction Strategy for the Minnesota River Basin and South Metro Mississippi River* (MPCA 2015b).

Minnesota River Basin TMDLs. Several TSS TMDLs in the Minnesota River Basin were completed and approved before the numeric TSS standards were promulgated (see Section 2) and are based on TSS surrogates of the former turbidity standard. These previously approved TMDLs are not revised in the current report and remain in effect. The approved TMDLs in Carver County (for Bevens, Silver, Carver, and Bluff Creeks) are based on TSS concentrations greater than the current 65 mg/L TSS standard (Table 3). If these reaches are shown to prevent achievement of the 65 mg/L standard in the current TMDL, these TMDLs will be revisited. Previously completed turbidity TMDLs in the Chippewa River Watershed are based on a 54 mg/L TSS target, which is more stringent than the current TSS standard. Other TSS TMDLs in the Minnesota River Basin are more recent and are based on the 65 mg/L numeric TSS standard (Table 3). This TMDL does not replace any existing turbidity or TSS TMDLs completed in the Minnesota River Basin (see Appendix G for a list of completed TMDLs). All future TSS TMDLs completed in the Minnesota River Basin will be developed based on the 65 mg/L water quality standard. As such, all future TMDLs will be consistent with downstream allocations. Strategies and planning to achieve TSS reductions are determined for each HUC-8 watershed through the WRAPS and 1W1P process as described in Sections 8.3 and Section 10.

Table 3. Approved TSS TMDLs in the Minnesota River Basin.

Water Body / Watershed	TMDL Report Reference	TSS Target (mg/L)	Impairment Watershed of Current Project in which the TMDLs are Located
TSS TMDLs based on TSS surrogates of former turbidity standard			
Bevens and Silver Creek	Carver County Land and Water Services and MPCA 2012a	110	07020012-800
Carver Creek	Carver County Land and Water Services and MPCA 2012b	100	07020012-505
Bluff Creek	Barr Engineering 2013	120	07020012-505
Lac qui Parle River Watershed	Wenck Associates, Inc. 2013	45	Not applicable—upstream of boundary condition at Lac qui Parle Lake outlet
Chippewa River Watershed	Wenck Associates, Inc. 2014	54	07020005-501
TSS TMDLs based on numeric TSS standard			
Chippewa River Watershed	MPCA 2017a	65	07020005-501
Hawk Creek Watershed	MPCA 2017b	65	07020004-749, 750
Yellow Medicine River Watershed	MPCA 2016b	65	07020004-747, 748, 749, 750, 502

4. Watershed and Water Body Characterization

The Minnesota River drains a 17,003-square mile (mi^2) basin, including all or parts of 37 counties. Its 13 major watersheds (i.e., HUC-8s) range in size from 699 mi^2 (the Redwood River Watershed) to 2,078 mi^2 (the Chippewa River Watershed). The MPCA (2015a, Page 30–31) previously described the Minnesota River Basin as follows.

> The Minnesota River flows southeast from its source at Big Stone Lake on the South Dakota border to Mankato, then northeast to join the Mississippi River at Fort Snelling, traversing a total of 335 miles…
>
> Land use, runoff and water quality change together as the river flows from west to east... Throughout all but the easternmost part of the basin, cultivated cropland dominates the landscape, accounting for an average of 80% of land use basin-wide.
>
> In the lower precipitation area of the western basin, land use includes corn production, soybean production, wheat production and grazing of beef cattle. Runoff rates are relatively low, along with average TSS concentrations. Tributaries such as the Pomme de Terre and Lac Qui Parle continue to support fairly healthy beds of mussels, a sign of relatively good water quality.
>
> As the river enters south-central Minnesota, higher average precipitation and rich, fine-textured soils favor the corn-soybean rotation, with an area of sugar beet production [formerly glacial Lake Benson] in the Hawk Creek Watershed. Land drainage through surface ditches and pattern tiling is more intense here, and suspended sediment concentrations of the mainstem grow progressively higher as the river approaches the confluence with the Blue Earth River Watershed. Here, TSS concentrations jump considerably in response to the extremely high sediment loads dumped into the river from the Le Sueur and Blue Earth Rivers, which discharge through a common outlet at Mankato.
>
> From Mankato to St. Peter, TSS concentrations tend to remain high, fed by sediment-rich water discharged from small tributaries that comprise the Middle Minnesota Watershed. From St. Peter or Henderson to Jordan, TSS concentrations and loads often dip – likely a result of floodplain deposition [in a wider pre-existing valley](settling out of the water column), increased base flow from groundwater, or both (MPCA 1997). As the Minnesota River passes through the progressively more urbanized region between Jordan and Fort Snelling, a 39-mile reach, TSS concentrations and loads again tend to dip by about 20% on average, from 141 mg/L at Jordan to 112 mg/L at Fort Snelling. This is based on Metropolitan Council Environmental Services monitoring data from 1993 to 2006. This trend has been attributed to a combination of floodplain deposition and dilution by urban stormwater runoff (Gupta et al. 2011, page 37). While this lowered TSS concentration ultimately benefits Lake Pepin the depositing sediment load in this lower portion of the Minnesota River is a significant concern.

Additional watershed characterization and water quality information has been summarized in multiple reports and research papers; see Section 12, Literature Cited, for a list of relevant references. The following sections provide summaries of the impaired subwatersheds, land cover, water quality, and sources of sediment.

4.1 Subwatersheds

Subwatersheds that drain to impaired waters range in area from 9 mi^2 to 17,010 mi^2 (Table 4). The subwatershed area includes all drainage area to the impairment, including from upstream AUIDs. The impairments are shown on maps in Figure 4 through Figure 7.

Table 4. Subwatershed areas.

Impaired Reach Name	Assessment Unit	Subwatershed Area (mi^2)
Yellow Medicine River	07020004-502	678
Minnesota River	07020004-747	6,375 [a]
Minnesota River	07020004-748	6,506 [a]
Minnesota River	07020004-749	7,883 [a]
Minnesota River	07020004-750	8,960 [a]
Chippewa River	07020005-501	2,078
Redwood River	07020006-501	699
Minnesota River	07020007-720	9,374 [a]
Minnesota River	07020007-721	9,601 [a]
Minnesota River	07020007-722	11,394 [a]
Minnesota River	07020007-723	15,174 [a]
Cottonwood River	07020008-501	1,315
Blue Earth River	07020009-501	3,552
Elm Creek	07020009-502	281
Center Creek	07020009-503	137
Blue Earth River	07020009-504	335
Blue Earth River	07020009-507	1,546
Blue Earth River	07020009-508	842
Blue Earth River	07020009-509	2,437
Blue Earth River	07020009-514	1,103
Blue Earth River	07020009-515	1,416
Blue Earth River	07020009-518	438
Cedar Creek	07020009-521	53
Elm Creek	07020009-522	134
Elm Creek	07020009-523	46
Elm Creek, South Fork	07020009-524	29
Lily Creek	07020009-525	39
Dutch Creek	07020009-527	17
Blue Earth River, East Branch	07020009-553	295
Blue Earth River, East Branch	07020009-554	130
Blue Earth River	07020009-565	518
Watonwan River	07020010-501	874
Watonwan River	07020010-510	679
Watonwan River	07020010-511	392
Butterfield Creek	07020010-516	62
Watonwan River, South Fork	07020010-517	215
Perch Creek	07020010-524	99
St. James Creek	07020010-528	11

Impaired Reach Name	Assessment Unit	Subwatershed Area (mi^2)
Watonwan River, South Fork	07020010-547	116
Watonwan River	07020010-562	202
Watonwan River	07020010-563	209
Watonwan River, North Fork	07020010-564	64
Watonwan River	07020010-566	89
Watonwan River	07020010-567	126
Le Sueur River	07020011-501	1,112
Unnamed creek (Little Beauford Ditch)	07020011-503	9
Little Cobb River	07020011-504	131
Le Sueur River	07020011-506	760
Le Sueur River	07020011-507	449
Rice Creek	07020011-531	82
Maple River	07020011-534	342
Maple River	07020011-535	196
County Ditch 3	07020011-552	68
Cobb River	07020011-556	310
Cobb River	07020011-568	145
Le Sueur River	07020011-619	86
Le Sueur River	07020011-620	254
Minnesota River	07020012-505	17,010 [a]
Minnesota River	07020012-506	16,723 [a]
Minnesota River	07020012-799	15,823 [a]
Minnesota River	07020012-800	16,559 [a]

a. The impairment subwatersheds of the Minnesota River mainstem include the area upstream of the Lac qui Parle Dam (4,102 mi^2). The area of upstream of the Lac qui Parle Dam was defined as a boundary condition during TMDL development.

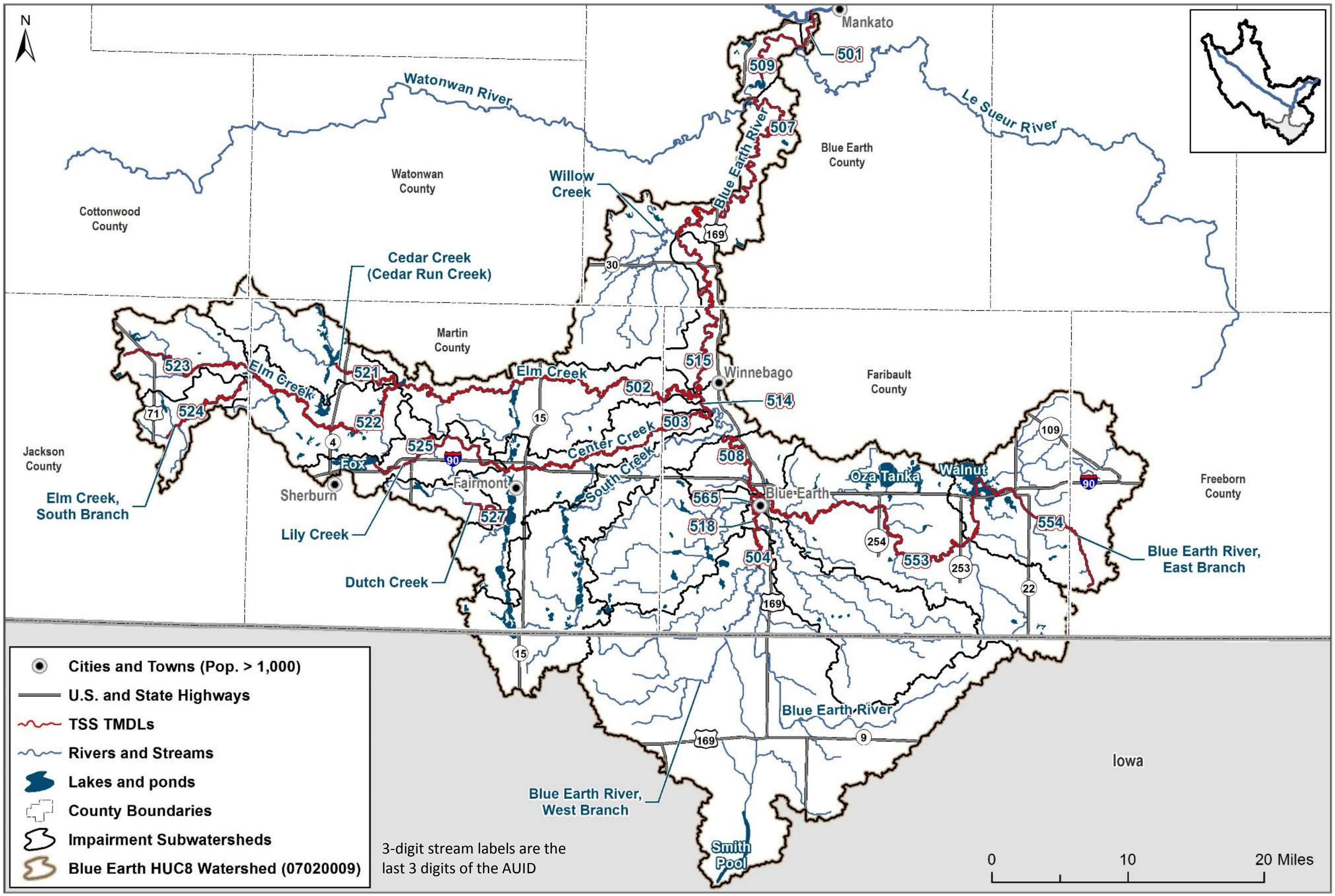

Figure 4. TSS impairments in the Blue Earth River Watershed (HUC 07020009). This TMDL study does not address any reaches located in Iowa.

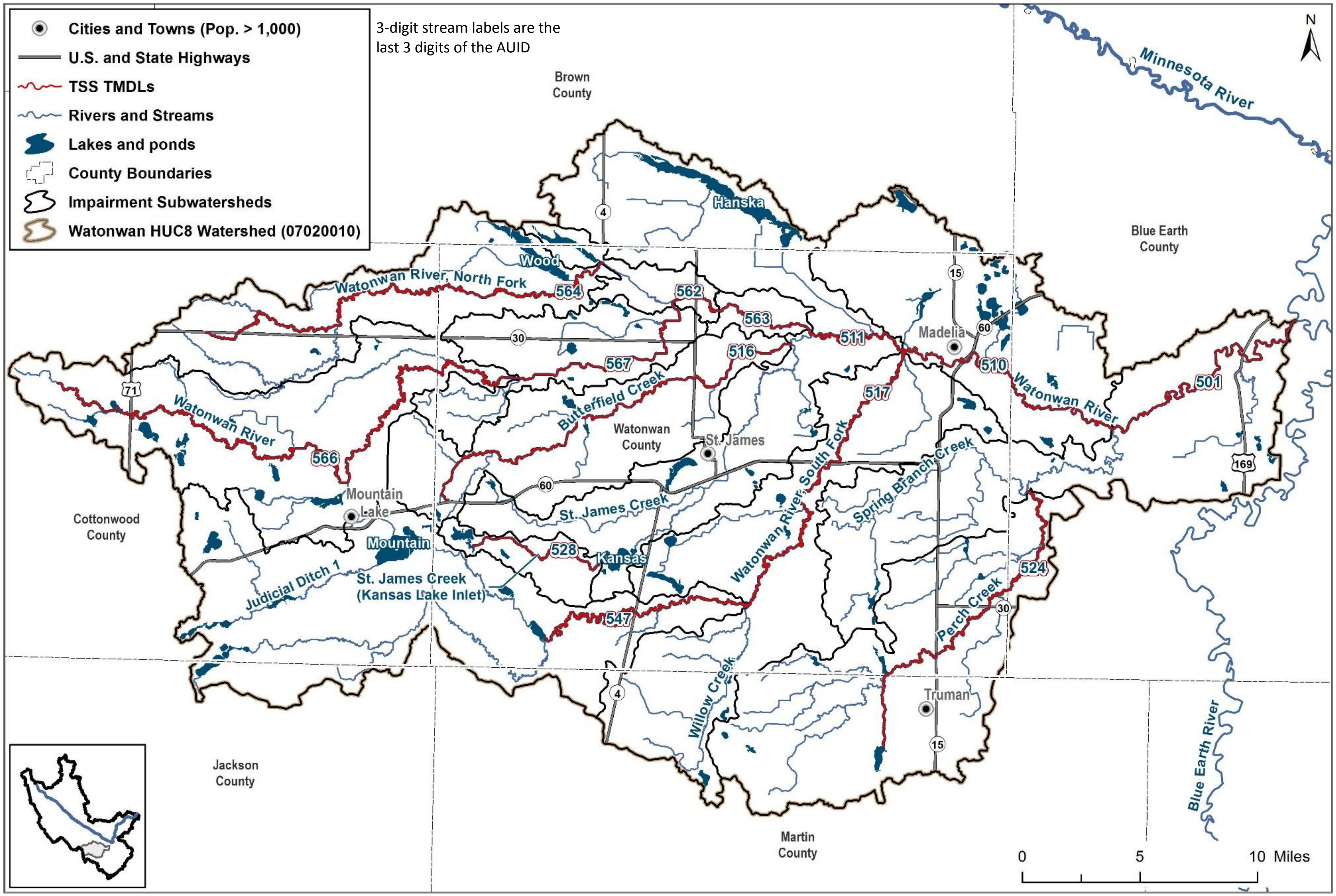

Figure 5. TSS impairments in the Watonwan River Watershed (HUC 07020010).

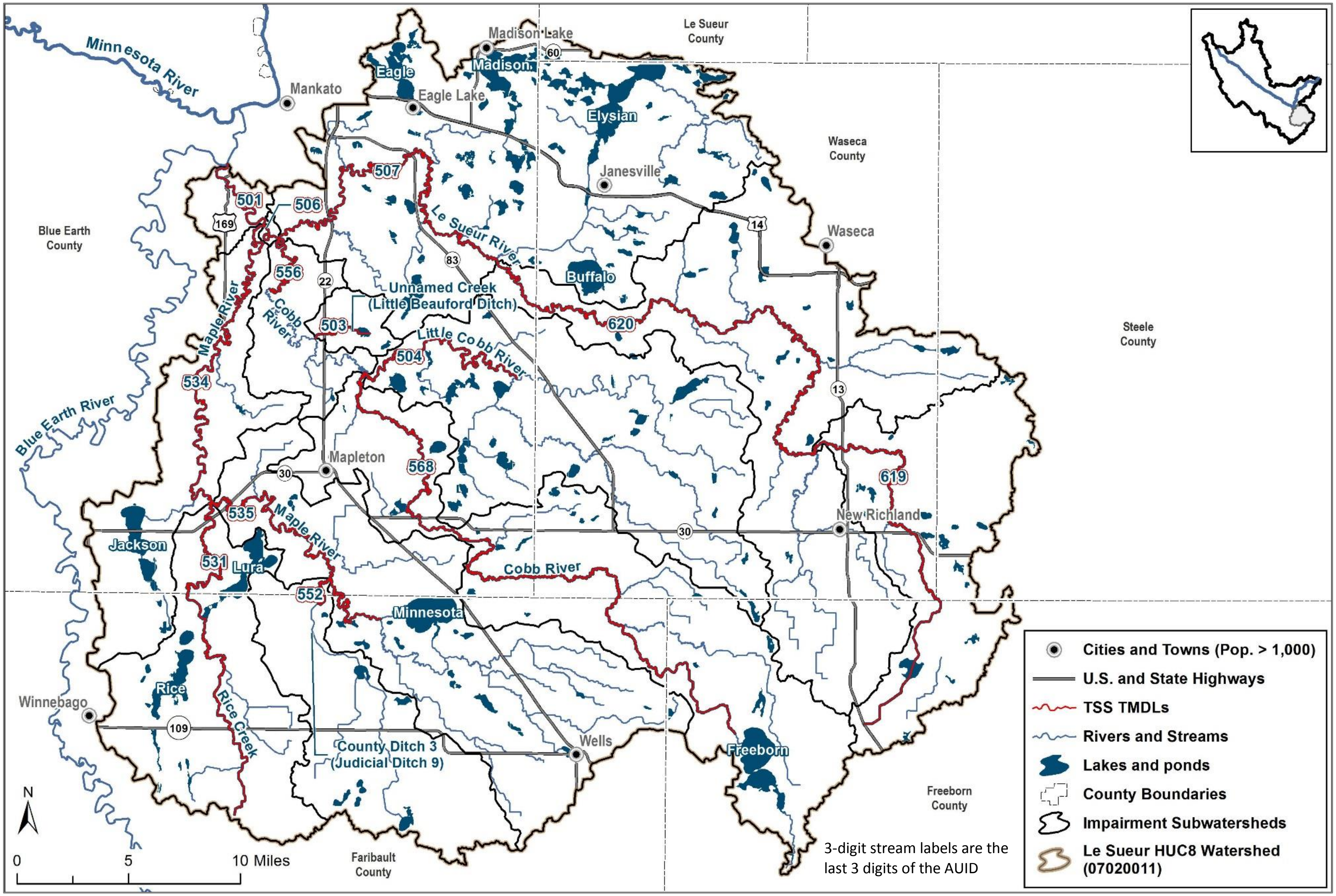

Figure 6. TSS impairments in the Le Sueur River Watershed (HUC 07020011).

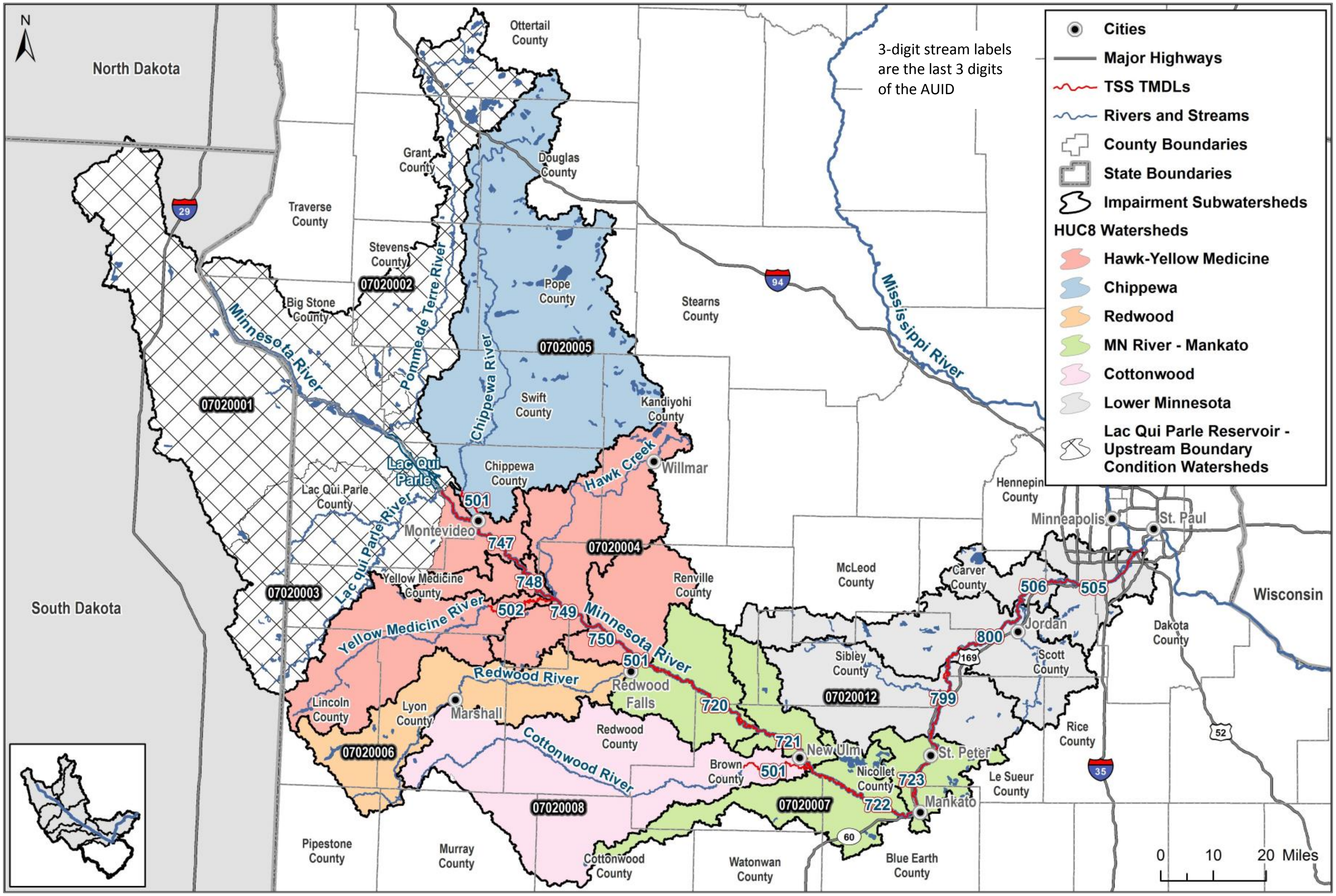

Figure 7. TSS impairments in the Minnesota River Basin, not including the Greater Blue Earth River Basin.

4.2 Land Cover

Land use in the 17,003-mi^2 Minnesota River Basin area is dominated by agriculture consisting of primarily corn and soybean rotations (Table 5 and Figure 8). There are also small sections of urban area, wetland, and forest. Only in the portion furthest downstream, in the Twin Cities Metropolitan Area, is the amount of urban development significant relative to the primarily agricultural land use of the rest of the basin.

Table 5. Land cover by HUC-8 watershed (USDA National Agricultural Statistics Service's Cropland Data Layer 2015). Percentages rounded to the nearest whole number.

HUC-8 Name	HUC-8 ID	Percent of Watershed									Area (mi^2)
		Open Water	Developed	Barren	Forest	Corn	Soy	Other Crops	Grassland/Pasture	Wetlands	
Minnesota River Headwaters	07020001	5	5	<1	2	22	26	5	24	11	2,129
Pomme de Terre	07020002	9	5	<1	7	27	26	5	10	11	875
Lac qui Parle	07020003	2	5	<1	1	30	32	3	18	9	1,096
Hawk–Yellow Medicine	07020004	2	6	<1	2	39	32	6	6	7	2,083
Chippewa	07020005	6	5	<1	6	32	24	5	12	10	2,078
Redwood	07020006	2	6	<1	1	39	35	2	10	5	699
Minnesota River–Mankato	07020007	4	7	<1	5	40	31	2	3	8	1,347
Cottonwood	07020008	1	5	<1	2	41	38	1	5	7	1,314
Blue Earth	07020009	1	6	<1	1	50	34	<1	3	5	1,563
Watonwan	07020010	1	6	<1	1	46	37	1	2	6	873
Le Sueur	07020011	2	6	<1	2	46	34	<1	4	6	1,111
Lower Minnesota	07020012	5	16	<1	9	30	23	1	10	6	1,835

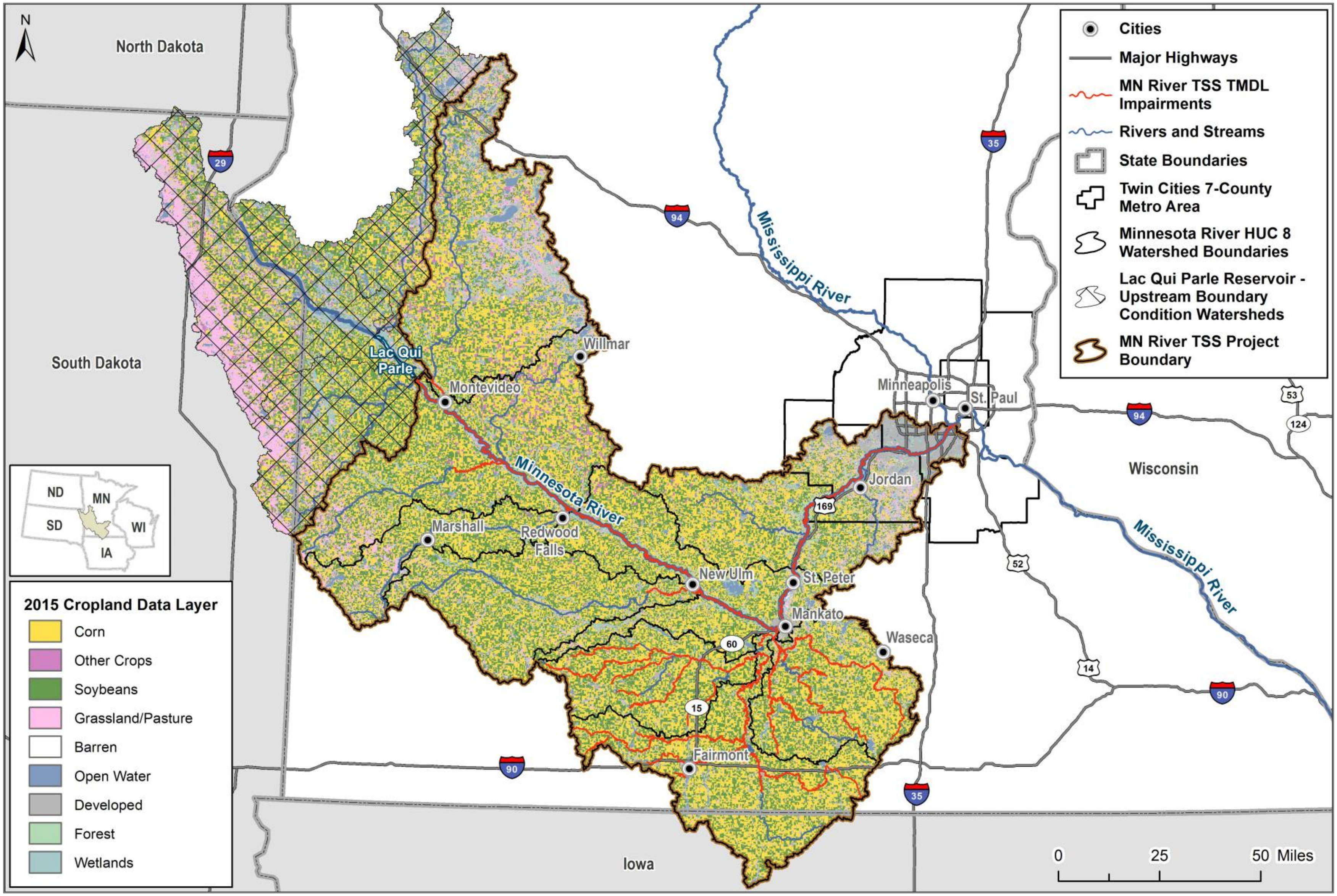

Figure 8. Land cover in the Minnesota River Basin.

4.3 Current/Historic Water Quality

Average flows in the Minnesota River at Jordan have increased since 1935 (MPCA 2015b), and these increased flows can have an effect on water quality over time. The cause of changing river flows has been debated in recent years, as described in the *Sediment Reduction Strategy for the Minnesota River and South Metro Mississippi River* (MPCA 2015b):

> Several studies have been conducted to determine the cause of higher recent decade river flows compared to historical flows in the Minnesota River Basin. Novotny and Stefan (2007) found increases in summer peak flows and increased winter and summer baseflows in several major river basins in Minnesota, including the Minnesota River Basin. They evaluated data from United States Geological Survey (USGS) gage stations in the Minnesota River Basin from 1932 through 2002 and linked the observed changes in stream flows to precipitation patterns in Minnesota as a function of climate change. Specifically, they found increases in mean annual precipitation, earlier spring snowmelt, and increased frequency and intensity of precipitation events to be the likely drivers of the changes in historical flow patterns. Sekely et al. (2002) and Schottler et al. (2013) reported that the mean annual precipitation has increased in the region by approximately 15% since 1940, although Schottler et al. (2013) indicates this is predominantly due to increased post-June rainfall. Early season precipitation (when soil is most vulnerable to sheet/rill erosion) has been constant or decreased since 1940 in many watersheds of the Minnesota River Basin.
>
> Other studies indicate that the observed increases in stream flows in southern Minnesota can also be attributed to post-European settlement changes in land use, particularly in association with agricultural practices. Some of these influential changes include wetland drainage, expansion of artificial drainage networks (resulting in loss of surface and subsurface water storage), and increased row crops. These land use changes have altered natural hydrological processes. Surface water storage in wetlands and ponds has decreased and estimated total annual evapotranspiration has also decreased from the cropping and drainage changes (Schilling and Helmers 2008; Schilling 2008; Lenhart et al. 2011a [2011]; Wang and Hejazi 2011; Schottler et al. 2013; Schilling et al. 2008).
>
> During the spring and fall, evapotranspiration from prairie vegetation exceeds that of row crops. During peak crop productivity, evapotranspiration rates from current cropping may exceed that of natural prairie vegetation... But, since precipitation and overland runoff volumes are higher in spring than during mid- to late summer, evapotranspiration changes during the spring months have the greatest potential effect on river flow.
>
> The reduced capacity for evapotranspiration from upland sources in early spring and fall results in a greater amount of precipitation entering receiving waters through artificial drainage networks (i.e., reduced water storage). Many conventional artificial drainage systems are designed to quickly remove standing water and excess soil water from the landscape to enhance crop productivity. This process reduces the residence time of water on the landscape, which further reduces the potential for evaporative loss and instead routes the water directly to rivers and streams (Schilling and Helmers 2008; Schottler et al. 2013).
>
> As discussed above, increased stream flows in the Minnesota River Basin have increased streambank erosion. Some researchers contend that near-channel sediment sources are influenced more by natural causes (i.e., glacial history and increased precipitation) rather than drainage practices (Gupta

et al. 2011). Kessler et al. (2013) determined that rates of streambank erosion have remained consistent between pre-settlement and post-settlement periods, but that the number of actively eroding sites may have increased. In contrast, several studies have found that streams in the Minnesota River Basin are exhibiting erosion rates far in excess of pre-settlement rates of erosion (Blann et al. 2009; Belmont et al. 2011).

In a recent study, Lenhart et al. (2011a [2011]) concluded that the moderate increase in annual precipitation alone cannot explain the large increase in average annual streamflow in the Minnesota River Basin. Further, the researchers found a significant streamflow increase in agricultural watersheds in 1980 through 2009 as compared to the period of 1940 through 1979 (Lenhart et al. 2011a [2011]). These results are consistent with Schottler et al. (2013) findings where river flows in many south central Minnesota watersheds were significantly higher during the period 1975 through 2009 compared to the period of 1940 through 1974. However, they also found no significant difference in stream flows between the two time periods in several watersheds, suggesting that precipitation alone does not explain the difference (Schottler et al 2013). Tome [*sic*] and Schilling (2009) found that both agricultural land use and climate change have led to increased streamflows, but that since the 1970's, climate change has been more influential in altering hydrology.

Recent TSS data (2006 through 2015) were evaluated for each impaired segment, and the results are presented in tabular summaries in Appendix B. Data from multiple monitoring sites along stream AUIDs were combined. If impaired segments had little TSS data, turbidity or transparency tube data were evaluated when available. Turbidity and transparency tube data were not used for TMDL development (see Section 5), but rather are presented to evaluate water quality conditions with the available data. Data collected in 1996 through 2005 were also evaluated when recent data (2006 through 2015) were unavailable.

The MPCA used TSS data from the Environmental Quality Information System (EQuIS) database (1995 through 2015). Additional data were downloaded from the Metropolitan Council's Environmental Information Management Systems (EIMS) online database.

The number of April through September TSS measurements per impaired reach ranges from zero (for nine reaches) to 577 (Table 6). The impairments that do not have TSS data were listed based on turbidity or transparency tube data. In one case (AUID 07020010-562), the impairment listing is a split from a former assessment unit, and there are no data on the portion of the reach that constitutes the new assessment unit. There are several impaired reaches with no exceedances of the standard during the 10-year TMDL time period (2006 through 2015); these reaches were either listed as impaired based on turbidity or transparency tube data, or based on data collected prior to 2006. The maximum recorded TSS concentration per reach ranges from 20 to 3,130 mg/L, and the frequency of TSS measurements that exceed the standard ranges from zero to 100%.

Table 6. Summary of TSS data for impaired reaches (April–September, 2006–2015).

HUC-8	Assessment Unit (last 3 digits)	Stream Name (Description)	Date Range	Sample count	Mean (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
07020004	502	Yellow Medicine River (Spring Creek to Minnesota River)	2006–2015	200	84	590	73	37%
	747	Minnesota River (Lac qui Parle Dam to Granite Falls Dam)	2006–2015	192	43	770	28	15%
	748	Minnesota River (Granite Falls Dam to Yellow Medicine River)	2006–2015	78	56	460	12	15%
	749	Minnesota River (Yellow Medicine River to Echo Creek)	2006–2015	10	77	140	8	80%
	750	Minnesota River (Echo Creek to Beaver Creek)	2006–2015	42	65	160	25	60%
07020005	501	Chippewa River (Watson Sag to Minnesota River)	2006–2015	10	38	56	0	0% [a]
07020006	501	Redwood River (Ramsey Creek to Minnesota River)	2006–2015	12	42	81	1	8%
07020007	720	Minnesota River (Beaver Creek to Little Rock Creek)	2006–2015	212	82	413	127	60%
	721	Minnesota River (Little Rock Creek to Cottonwood River)	2006–2015	20	93	200	15	75%
	722	Minnesota River (Cottonwood River to Blue Earth River)	2006–2015	237	112	1170	155	65%
	723	Minnesota River (Blue Earth River to Cherry Creek)	2006–2015	339	139	1970	260	77%
07020008	501	Cottonwood River (Judicial Ditch 30 to Minnesota River)	2006–2015	244	156	1550	136	56%
07020009	501	Blue Earth River (Le Sueur River to Minnesota River)	2006–2015	30	139	760	19	63%
	502	Elm Creek (Cedar Creek to Blue Earth River)	2006–2015	149	62	218	63	42%
	503	Center Creek (Lily Creek to Blue Earth River)	2006–2015	123	51	650	50	41%
	504	Blue Earth River (West Branch Blue Earth River to Coon Creek)	1996–2005	13	34	90	3	23%
	507	Blue Earth River (Willow Creek to Watonwan River)	1996–2005	16	216	420	10	63%
	508	Blue Earth River (East Branch Blue Earth River to South Creek)	1996–2005	16	88	440	9	56%
	509	Blue Earth River (Rapidan Dam to Le Sueur River)	2006–2015	231	149	1630	116	50%
	514	Blue Earth River (Center Creek to Elm Creek)	1996–2005	2	161	300	1	50%
	515	Blue Earth River (Elm Creek to Willow Creek)	2006–2015	77	140	2730	49	64%
	518	Blue Earth River (Coon Creek to Badger Creek)	2006–2015	79	56	524	13	16%
	521	Cedar Creek (Cedar Run Creek) (Cedar Lake to Elm Creek)	1996–2005	4	46	89	1	25%
	522	Elm Creek (South Fork Elm Creek to Cedar Creek)	2006–2015	26	54	164	9	35%
	523	Elm Creek (Headwaters to South Fork Elm Creek)	no TSS data					
07020009	524	Elm Creek, South Fork (T103 R34W S30, west line to T103 R34W S1, north line)	no TSS data					

HUC-8	Assessment Unit (last 3 digits)	Stream Name (Description)	Date Range	Sample count	Mean (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
	525	Lily Creek (Headwaters (Fox Lake 46-0109-00) to Center Creek)	1996–2005	6	132	632	1	17%
	527	Dutch Creek (Headwaters to Hall Lake)	2006–2015	104	34	460	10	10%
	553	Blue Earth River, East Branch (Brush Creek to Blue Earth River)	2006–2015	81	87	560	45	56%
	554	Blue Earth River, East Branch (Headwaters to Brush Creek)	no TSS data					
	565	Blue Earth River (Badger Creek to East Branch Blue Earth River)	2006–2015	2	36	38	0	0% [a]
07020010	501	Watonwan River (Perch Creek to Blue Earth River)	2006–2015	315	71	654	121	38%
	510	Watonwan River (South Fork Watonwan River to Perch Creek)	2006–2015	21	38	196	3	14%
	511	Watonwan River (Butterfield Creek to South Fork Watonwan River)	2006–2015	85	75	296	38	45%
	516	Butterfield Creek (Headwaters to St. James Creek)	2006–2015	17	31	100	3	18%
	517	Watonwan River, South Fork (Willow Creek to Watonwan River)	2006–2015	72	71	538	24	33%
	524	Perch Creek (Headwaters (Perch Lk 46-0046-00) to Spring Cr)	2006–2015	3	14	20	0	0% [a]
	528	St. James Creek (Kansas Lake Inlet) (Headwaters to Kansas Lake)	1992	6	229	746	4	67%
	547	Watonwan River, South Fork (Irish Lake to Willow Creek)	no TSS data					
	562	Watonwan River (North Fork Watonwan River to T107 R32W S13, east line)	no TSS data					
	563	Watonwan River (T107 R31W S18, west line to Butterfield Creek)	2006–2015	10	37	85	3	30%
	564	Watonwan River, North Fork (Headwaters to T107 R32W S6, east line)	2006–2015	15	17	74	1	7%
	566	Watonwan River (Headwaters to T107 R33W S33, east line)	no TSS data					
	567	Watonwan River (T107 R33W S34, west line to North Fork Watonwan River)	2006–2015	12	27	158	2	17%
07020011	501	Le Sueur River (Maple River to Blue Earth River)	2006–2015	284	236	2280	193	68%
	503	Unnamed Creek (Little Beauford Ditch) (Headwaters to Cobb River)	2006–2015	187	44	936	24	13%
	504	Little Cobb River (Bull Run Creek to Cobb River)	2006–2015	185	68	551	63	34%
	506	Le Sueur River (Cobb River to Maple River)	no TSS data					
	507	Le Sueur River (County Ditch 6 to Cobb River)	2006–2015	422	222	3130	257	61%
	531	Rice Creek (Headwaters to Maple River)	2006–2015	14	40	110	2	14%
	534	Maple River (Rice Creek to Le Sueur River)	2006–2015	577	126	2040	249	43%
07020011	535	Maple River (Minnesota Lake Outlet to Rice Creek)	2006–2015	4	86	95	4	100%

HUC-8	Assessment Unit (last 3 digits)	Stream Name (Description)	Date Range	Sample count	Mean (mg/L)	Maximum (mg/L)	Number of exceedances	Frequency of exceedances
	552	County Ditch 3 (Judicial Ditch 9) (Judicial Ditch 9 to Maple River)	2006–2015	11	23	73	1	9%
	556	Cobb River (T107 R26W S30, west line to Le Sueur River)	2006–2015	254	115	1230	143	56%
	568	Cobb River (T104 R23W S34, south line to Little Cobb River)	no TSS data					
	619	Le Sueur River (Headwaters to Boot Creek)	no TSS data					
	620	Le Sueur River (Boot Creek to CD6)	2006–2015	3	63	72	2	67%
07020012	505	Minnesota River (RM 22 to Mississippi)	2006–2015	410	88	614	186	45%
	506	Minnesota River (Carver Creek to RM 22)	2006–2015	64	128	714	49	77%
	799	Minnesota River (Cherry Creek to High Island Creek)	2006–2015	40	112	480	32	80%
	800	Minnesota River (High Island to Carver Creek)	2006–2015	296	130	1100	207	70%

a. These reaches with no exceedances of the standard during the 10-year TMDL time period were either listed as impaired based on turbidity or transparency tube data, or based on data collected prior to 2006.

Figure 9 presents a summary of TSS results from samples collected at sites with the most TSS samples in the lower reaches of each HUC-8 watershed; in some cases, this was the reach that was farthest downstream (e.g., 07020008-501 for the Cottonwood River).[1] The lowest TSS concentrations on average were observed in the Hawk–Yellow Medicine River Watershed, and the highest concentrations on average were observed in the Le Sueur River Watershed. These data were also evaluated with flow data, and the results are presented in the subsections that follow.

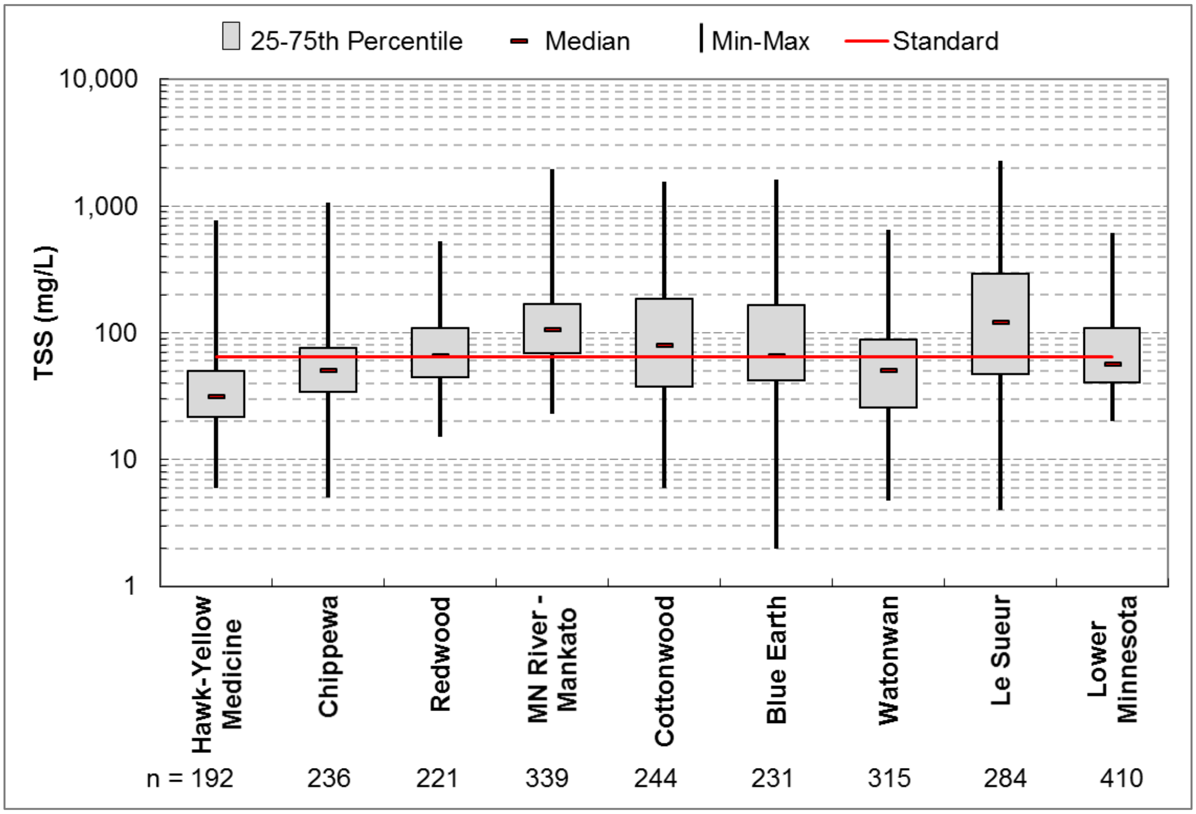

Figure 9. TSS concentrations summarized by HUC-8.

An evaluation of TSS concentrations shows that the 90th percentile of concentrations is never less than the TSS standard of 65 mg/L (Figure 10). The 90th percentile of concentrations was considerably larger than the standard in the Minnesota River–Mankato, Cottonwood River, Blue Earth River, and Le Sueur River watersheds.

[1] TSS data are from April through September during the years 2006 through 2015, except for the Chippewa and Redwood River watersheds with data from 2006 through 2012. Data are from either the segment farthest downstream in each HUC-8 or a nearby segment with considerable data.

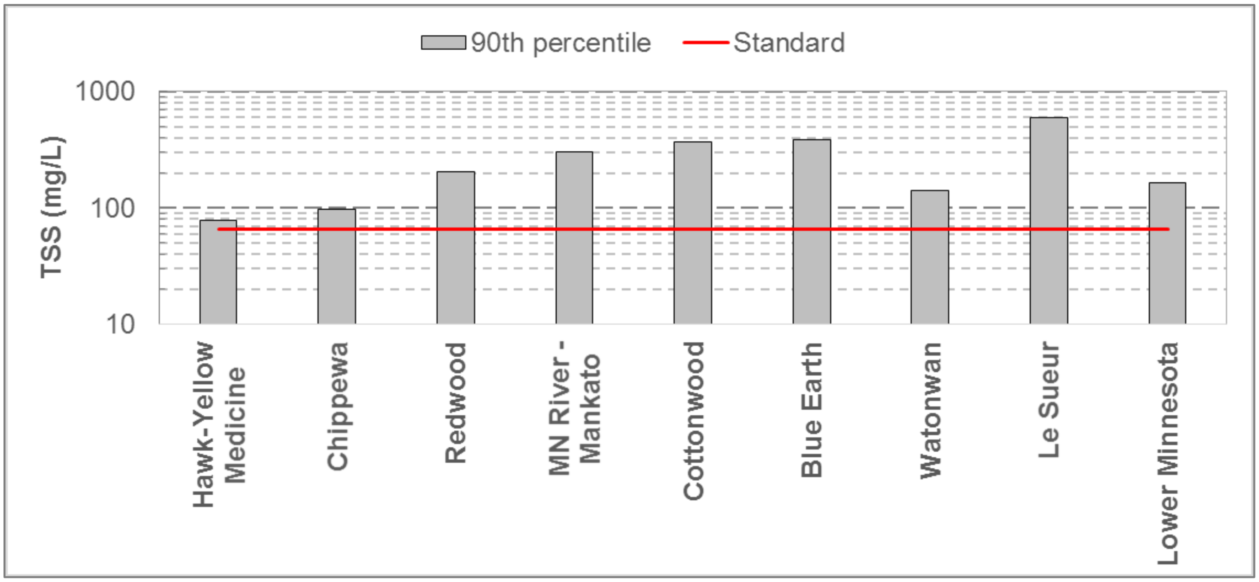

Figure 10. 90th percentile of TSS concentrations summarized by HUC-8.

The majority of the TSS in the streams is inorganic matter. During the months in which the TSS standard applies, TSS is composed of approximately 82% inorganic matter. This average is based on all paired inorganic suspended solids and TSS samples in the project area. The percent of TSS that is inorganic typically peaks in June and decreases through the later summer and fall months, as illustrated by data from the Cottonwood River (Figure 11) and Minnesota River (Figure 12).

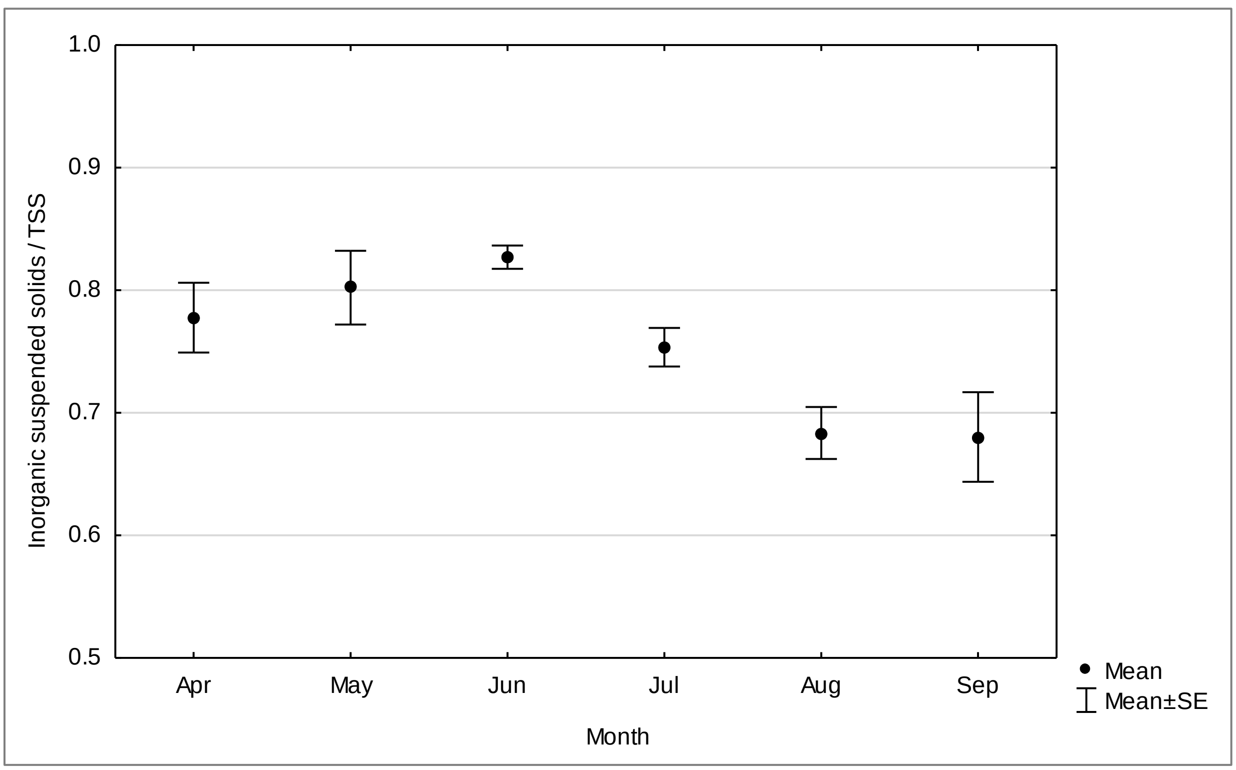

Figure 11. Proportion inorganic matter relative to TSS in the Cottonwood River, JD30 to Minnesota River (07020008-501).

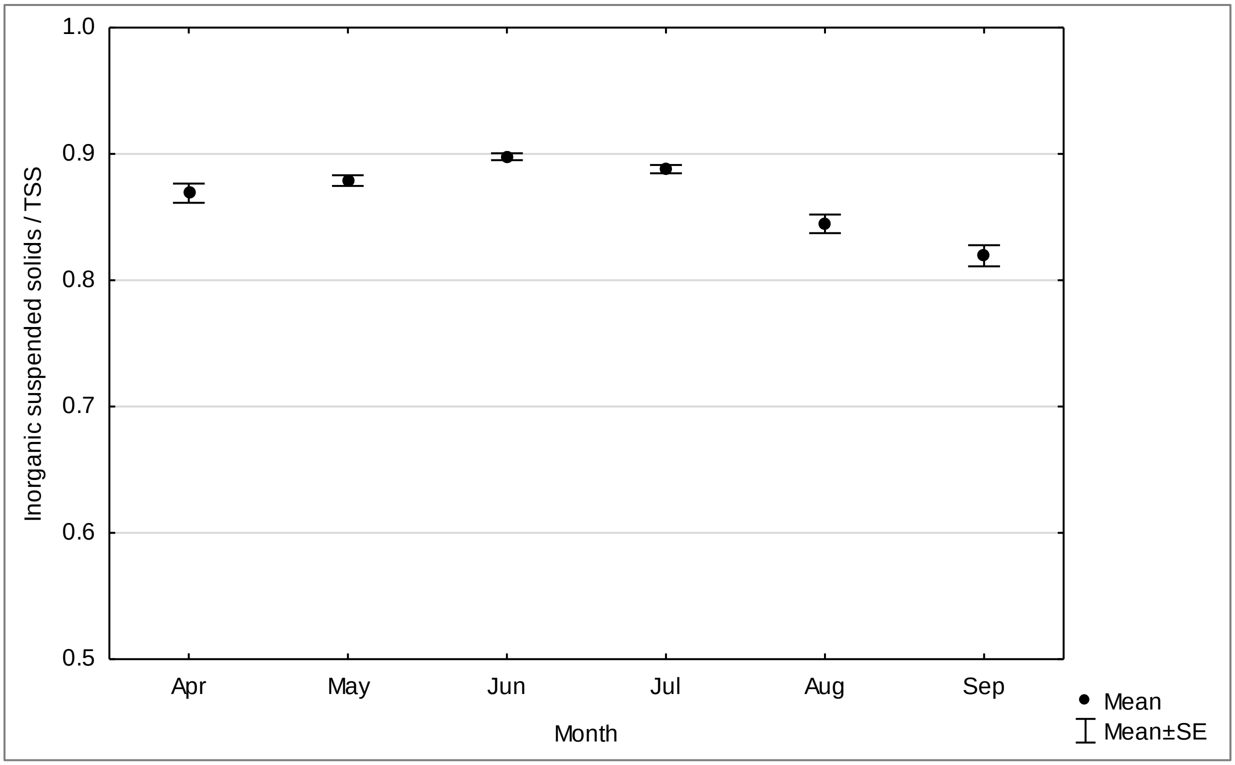

Figure 12. Proportion inorganic matter relative to TSS in the Minnesota River, High Island Creek to Carver Creek (07020012-800).

4.3.1 HUC-8 07020004: Hawk–Yellow Medicine Watershed

TSS concentrations in the Minnesota River (from Lac qui Parle Dam to Granite Falls Dam; AUID 07020004-747) exceeded the TSS standard more often during wetter conditions, mostly in the very high- to high-flow duration zones (Figure 13).

Available TSS data collected from 2006 through 2015 for each impaired segment are summarized in Appendix B. If little or no TSS data are available from 2006 through 2015, then data from 1996 through 2005 are summarized. Turbidity or transparency tube data are also summarized if little TSS data were available. Monitoring data are plotted in Appendix D.

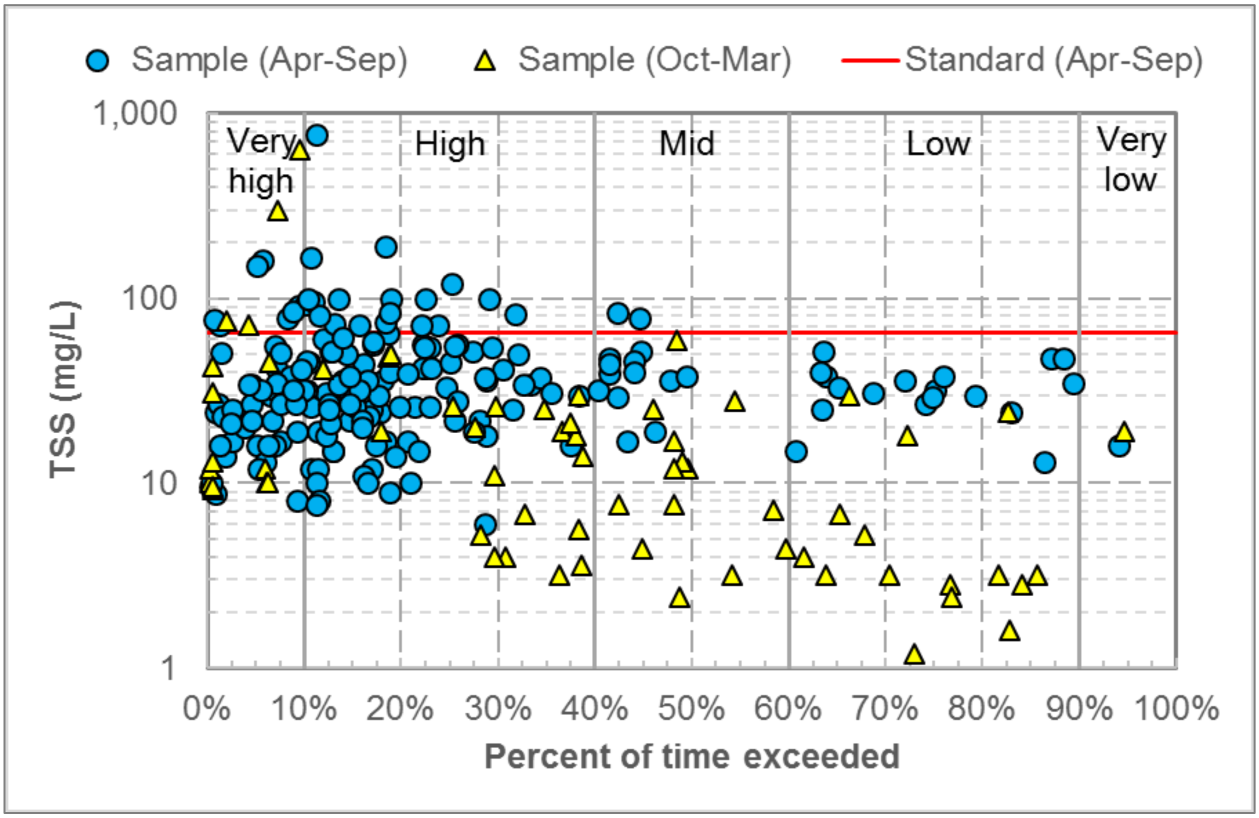

Figure 13. TSS concentrations in the Minnesota River (AUID 07020004-747).

4.3.2 HUC-8 07020005: Chippewa River Watershed

TSS concentrations in the Chippewa River (from Dry Weather Creek to Watson Sag; AUID 07020005-508) exceeded the TSS standard more often during wetter conditions, mostly in the very high- to mid-flow duration zones (Figure 14).

Available TSS data collected from 2006 through 2015 for each impaired segment are summarized in Appendix B. If little or no TSS data are available from 2006 through 2015, then data from 1996 through 2005 are summarized. Turbidity or transparency tube data are also summarized if little TSS data were available. Monitoring data are plotted in Appendix D.

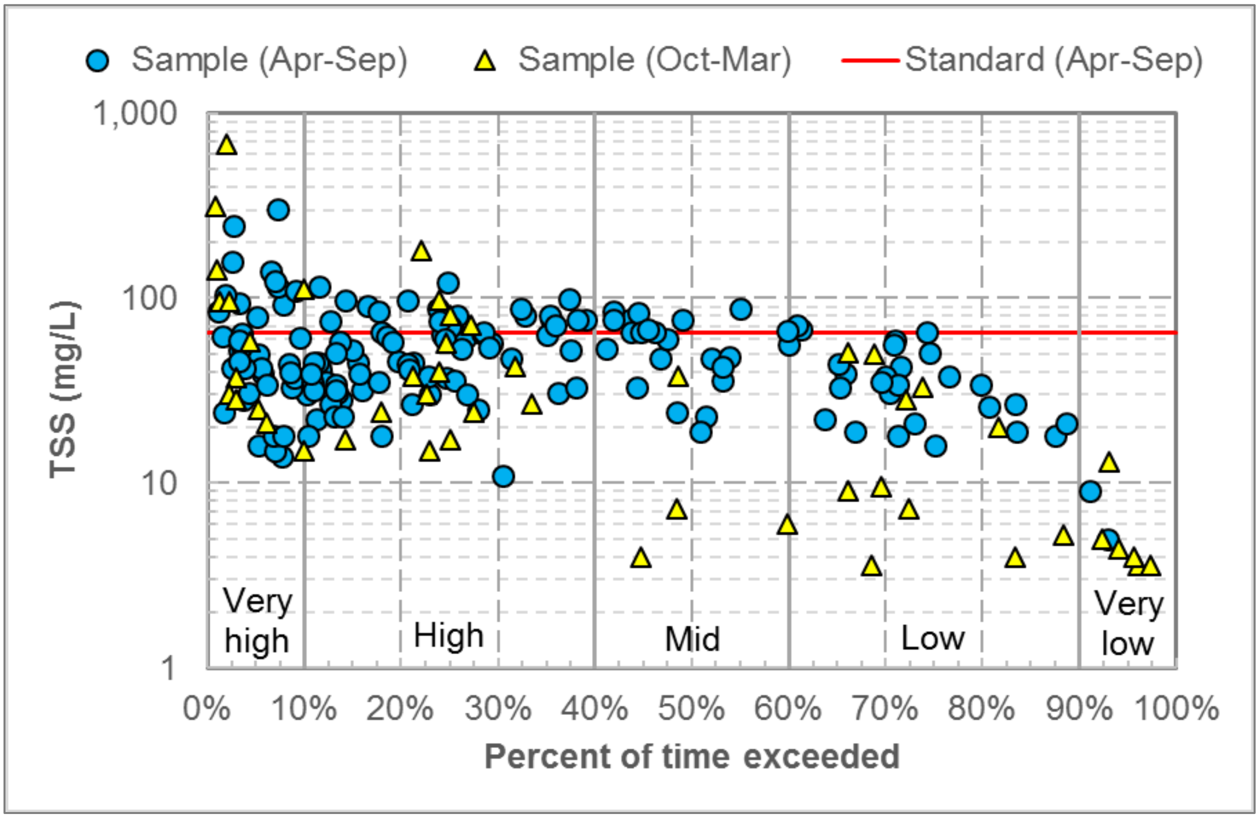

Figure 14. TSS concentrations in the Chippewa River (AUID 07020005-508).

4.3.3 HUC-8 07020006: Redwood River Watershed

TSS concentrations in the Redwood River (from Clear Creek to Redwood Lake; AUID 07020006-509) exceeded the TSS standard more often during wetter conditions, mostly in the very high- to high-flow duration zones (Figure 15). However, exceedances were observed in all flow zones.

Available TSS data collected from 2006 through 2015 for each impaired segment are summarized in Appendix B. If little or no TSS data are available from 2006 through 2015, then data from 1996 through 2005 are summarized. Turbidity or transparency tube data are also summarized if little TSS data were available. Monitoring data are plotted in Appendix D.

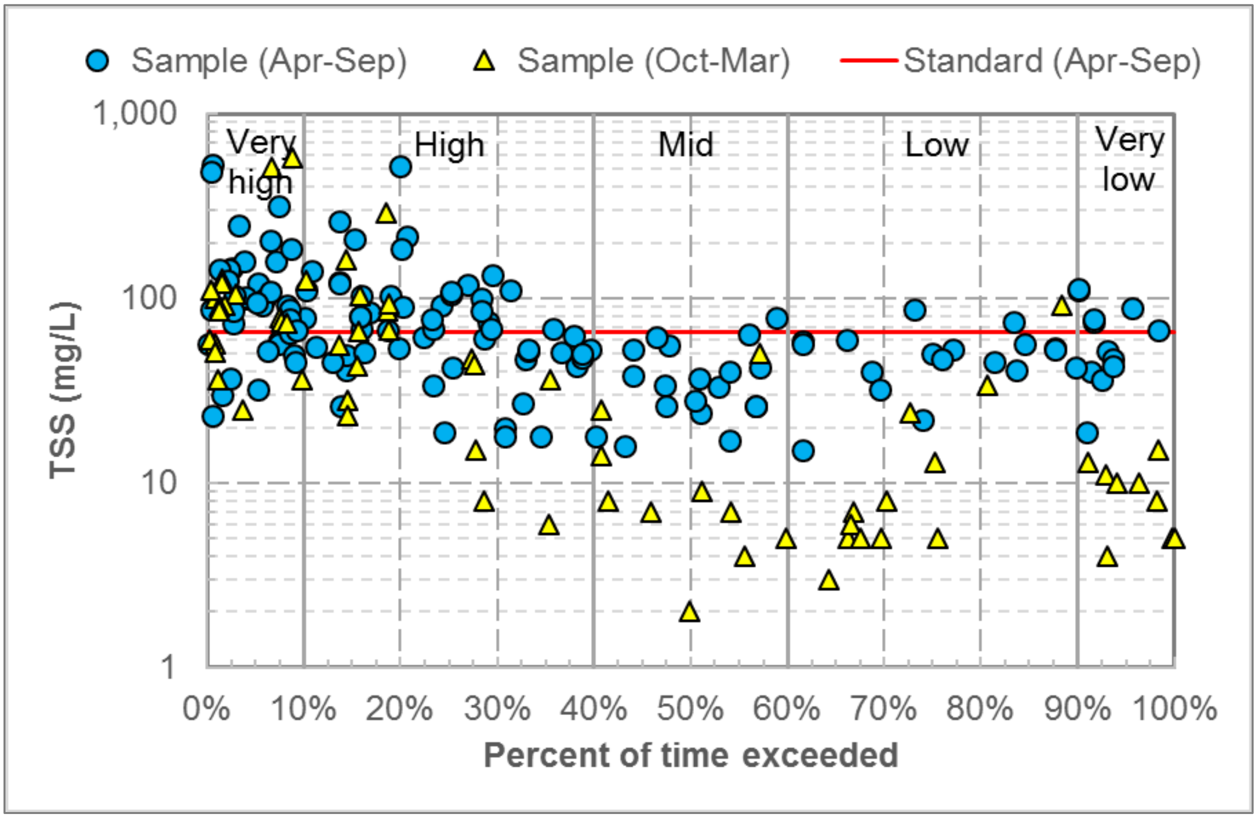

Figure 15. TSS concentrations in the Redwood River (AUID 07020006-509).

4.3.4 HUC-8 07020007: Minnesota River–Mankato Watershed

TSS concentrations in the Minnesota River (from Blue Earth River to Cherry Creek; AUID 07020007-723) exceeded the TSS standard during wetter conditions, mostly in the very high-, high-, and mid-flow duration zones (Figure 16). Generally, samples collected during April through September in the mid- to very low-flow duration zones had higher TSS concentrations than samples collected under similar flow conditions in October through March.

Available TSS data collected from 2006 through 2015 for each impaired segment are summarized in Appendix B. If little or no TSS data are available from 2006 through 2015, then data from 1996 through 2005 are summarized. Turbidity or transparency tube data are also summarized if little TSS data were available. Monitoring data are plotted in Appendix D.

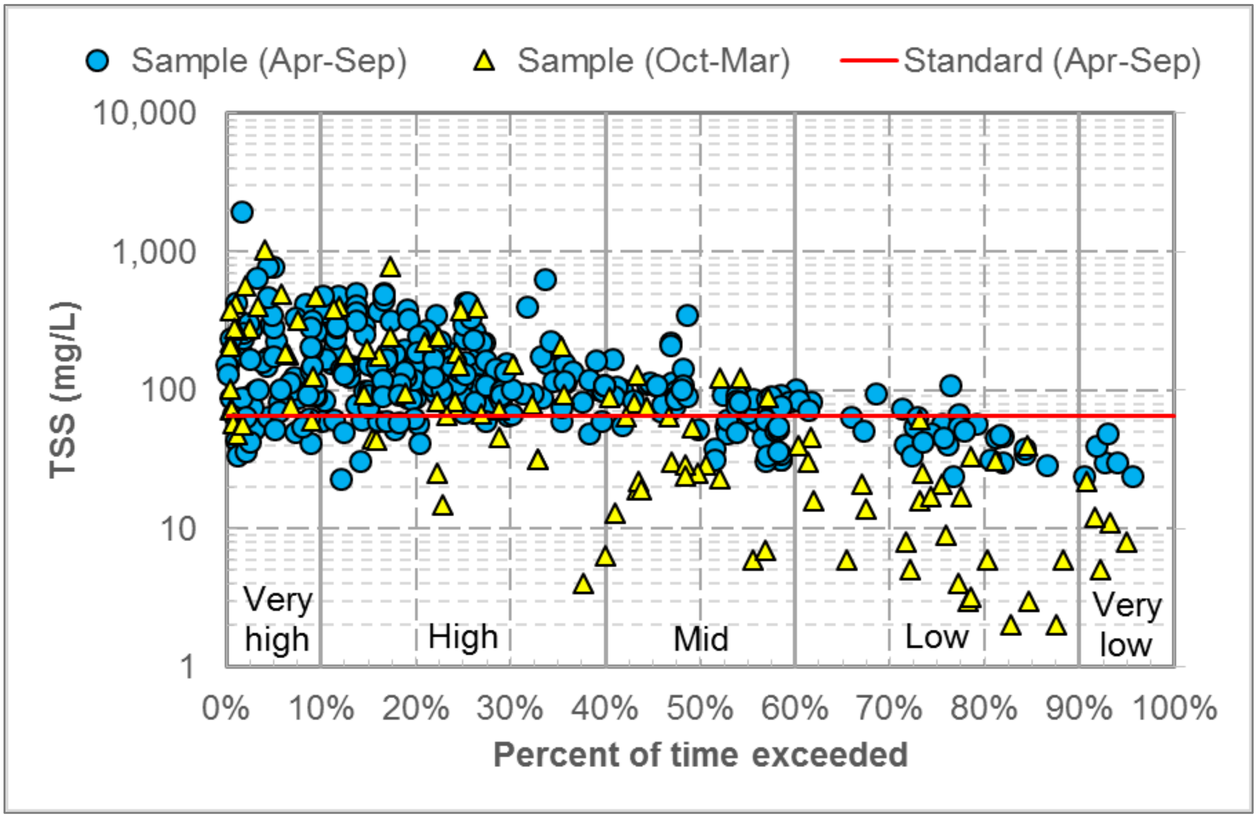

Figure 16. TSS concentrations in the Minnesota River (AUID 07020007-723), the lowest segment in HUC 07020007.

4.3.5 HUC-8 07020008: Cottonwood River Watershed

TSS concentrations in the Cottonwood River (from Judicial Ditch 30 to Minnesota River; AUID 07020008-501) exceeded the TSS standard during wetter conditions, mostly in the very high-, high-, and mid-range flow duration zones (Figure 17). Generally, larger flows contained higher TSS concentrations. All samples collected across the entire year in the very high-flow duration zone exceeded the TSS standard. During drier conditions, in the low- and very low-flow zones, samples collected during April through September had higher TSS concentrations than samples collected in October through March. This is the only impaired segment in HUC-8 07020008.

Available TSS data collected from 2006 through 2015 for each impaired segment are summarized in Appendix B. If little or no TSS data are available from 2006 through 2015, then data from 1996 through 2005 are summarized. Turbidity or transparency tube data are also summarized if little TSS data were available. Monitoring data are plotted in Appendix D.

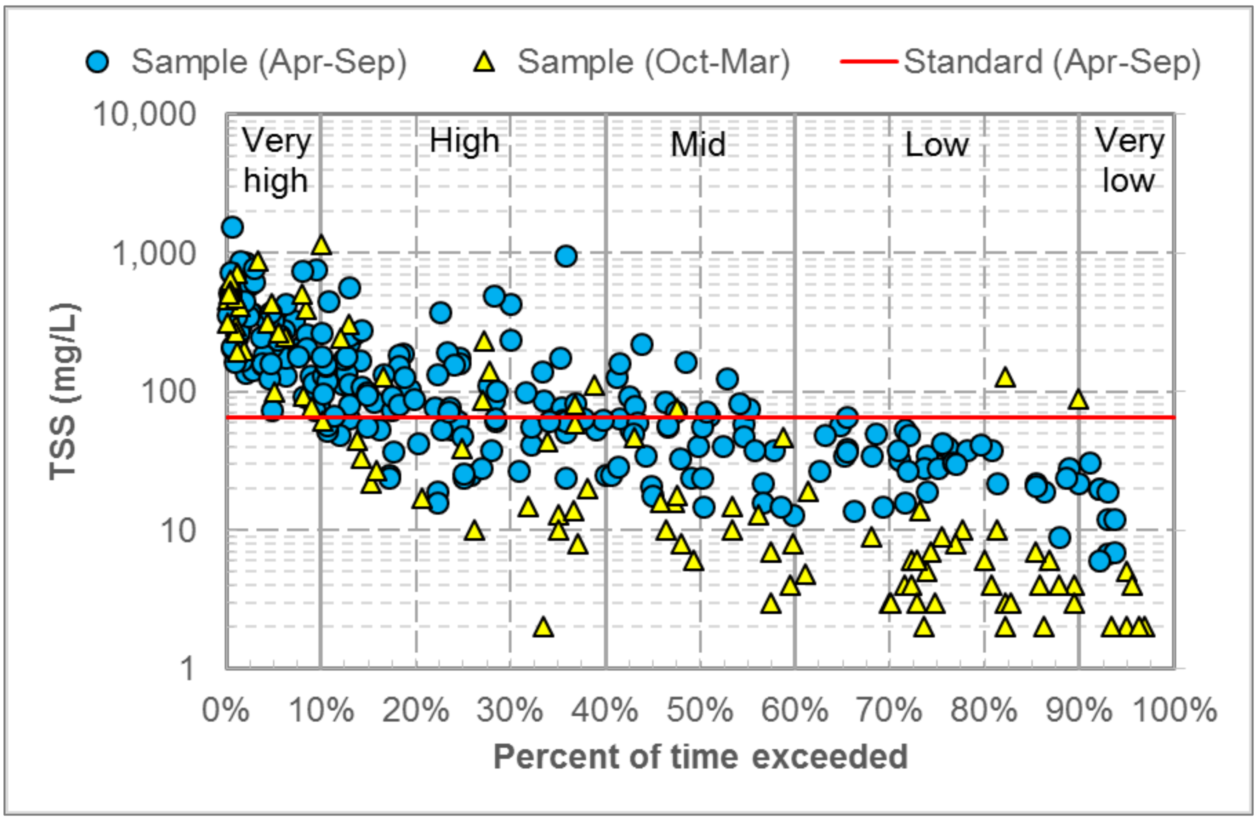

Figure 17. TSS concentrations in the Cottonwood River (AUID 07020008-501), the lowest segment in HUC-8 07020008.

4.3.6 HUC-8 07020009: Blue Earth River Watershed

TSS concentrations in the Blue Earth River (from Rapidan Dam to Le Sueur River; AUID 07020009-509) exceeded the TSS standard during wetter conditions, mostly in the very high-, high-, and mid-flow duration zones (Figure 18). Generally, larger flows contained higher TSS concentrations. Almost all samples collected across the entire year in the very high-flow duration zone exceeded the TSS standard. In the mid- through very low-flow duration zones, samples collected during April through September had higher TSS concentrations than samples collected in October through March.

Available TSS data collected from 2006 through 2015 for each impaired segment are summarized in Appendix B. If little or no TSS data are available from 2006 through 2015, then data from 1996 through 2005 are summarized. Turbidity or transparency tube data are also summarized if little TSS data were available. Monitoring data are plotted in Appendix D.

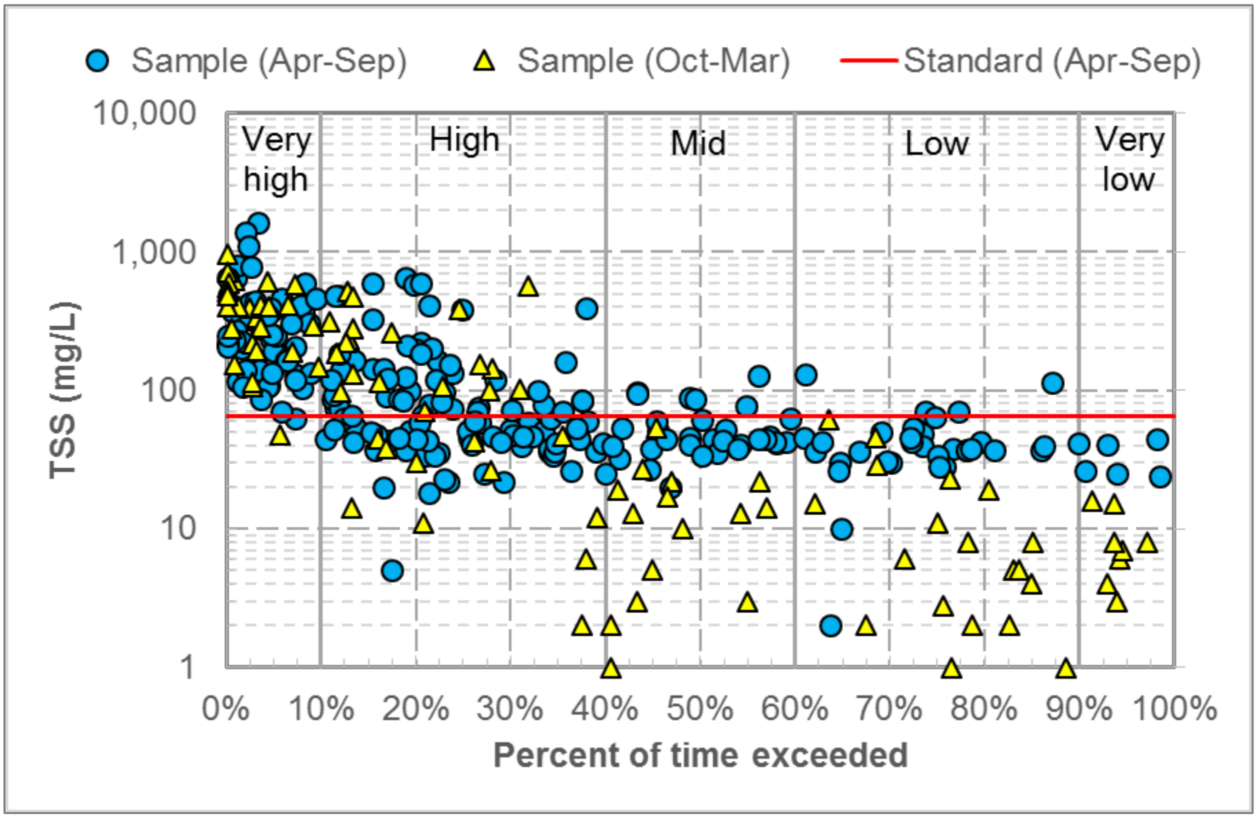

Figure 18. TSS concentrations in the Blue Earth River (AUID 07020009-509).

4.3.7 HUC-8 07020010: Watonwan River Watershed

TSS concentrations in the Watonwan River Watershed (from Perch Creek to Blue Earth River; AUID 07020010-501) exceeded the TSS standard during wetter conditions, mostly in the very high-, high-, and mid-flow duration zones (Figure 19). Generally, larger flows contained higher TSS concentrations. In the very low- through low-flow duration zones, samples collected during April through September had higher TSS concentrations than samples collected in October through March.

Available TSS data collected from 2006 through 2015 for each impaired segment are summarized in Appendix B. If little or no TSS data are available from 2006 through 2015, then data from 1996 through 2005 are summarized. Turbidity or transparency tube data are also summarized if little TSS data were available. Monitoring data are plotted in Appendix D.

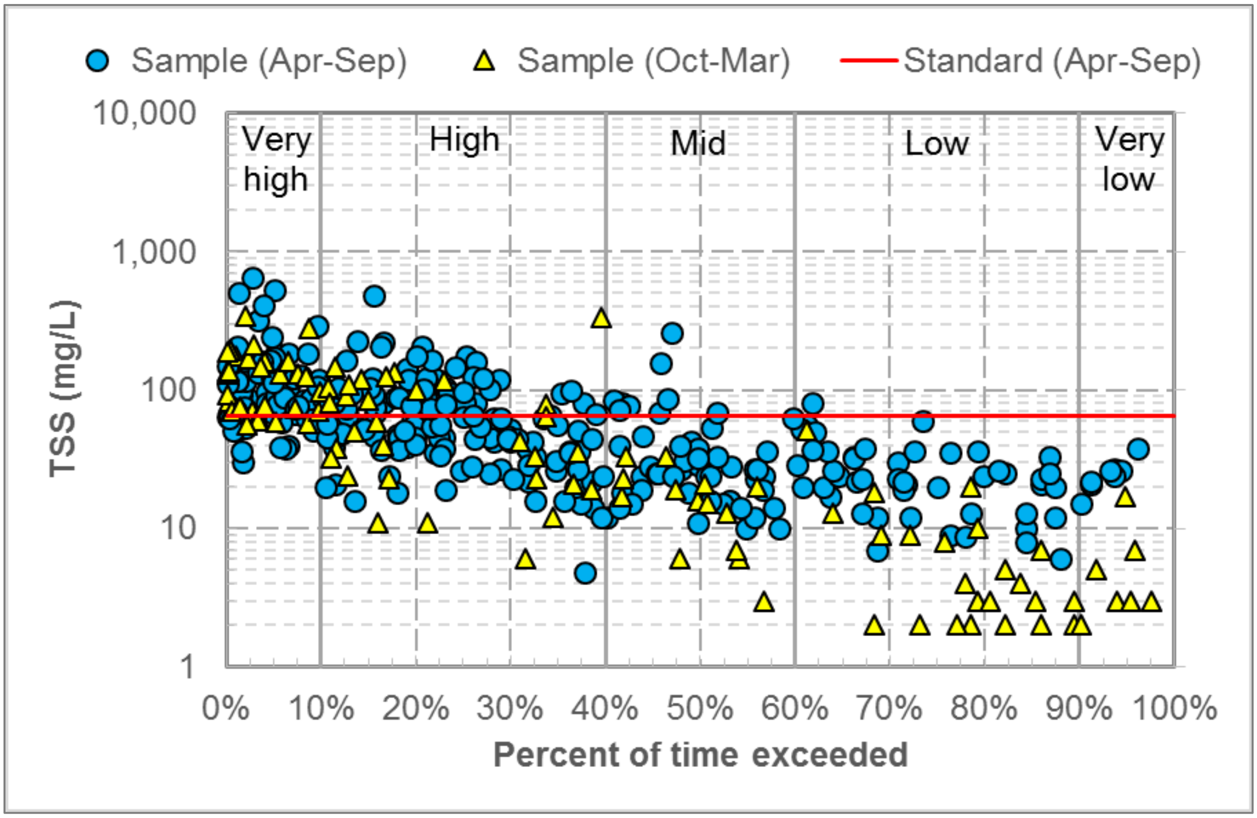

Figure 19. TSS concentrations in the Watonwan River (AUID 07020010-501), the lowest segment in HUC 07020010.

4.3.8 HUC-8 07020011: Le Sueur River Watershed

TSS concentrations in the Le Sueur River (from Maple River to Blue Earth River; AUID 07020011-501) exceeded the TSS standard during wetter conditions, mostly in the very high-, high, and mid-flow duration zones (Figure 20). Almost all samples collected across the entire year in the very high-flow duration zone exceeded the TSS standard. Generally, larger flows contained higher TSS concentrations.

Available TSS data collected from 2006 through 2015 for each impaired segment are summarized in Appendix B. If little or no TSS data are available from 2006 through 2015, then data from 1996 through 2005 are summarized. Turbidity or transparency tube data are also summarized if little TSS data were available. Monitoring data are plotted in Appendix D.

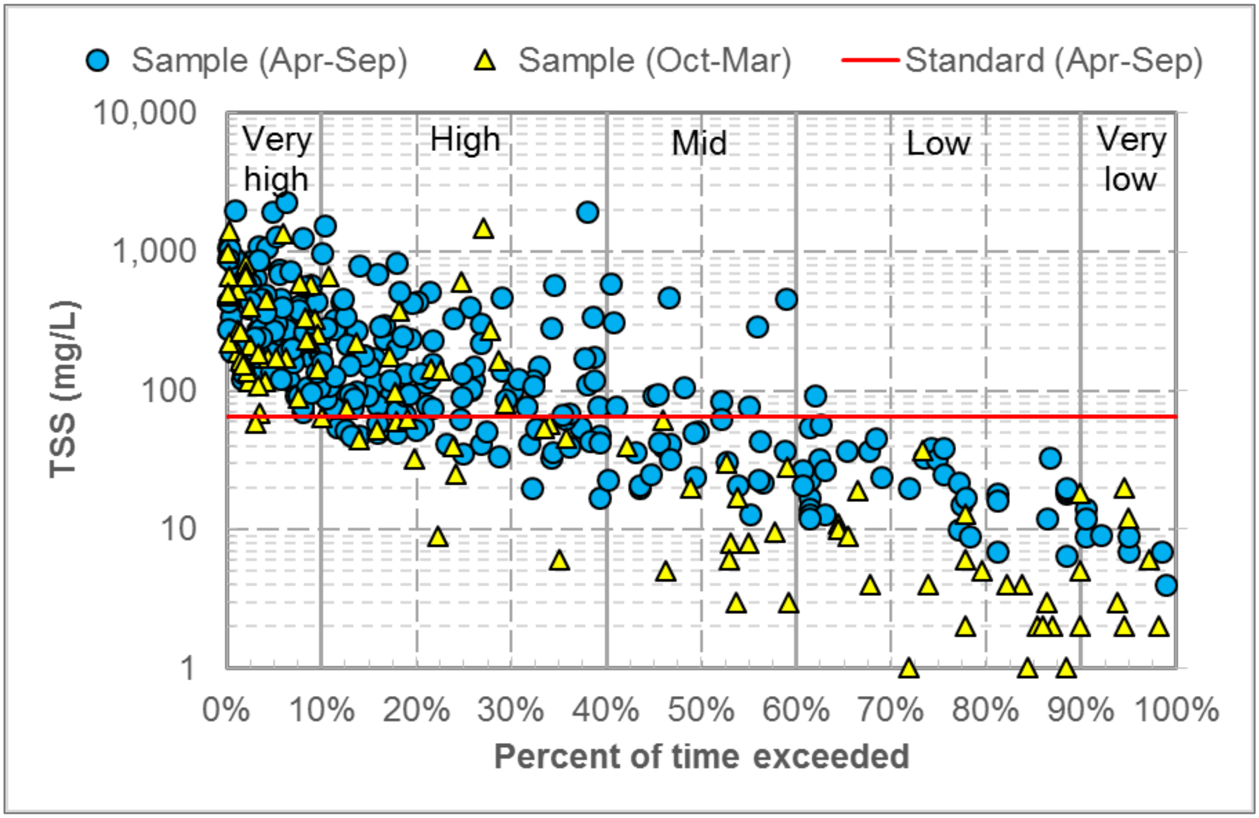

Figure 20. TSS concentrations in the Le Sueur River (AUID 07020011-501), the lowest segment in HUC 07020011.

4.3.9 HUC-8 07020012: Lower Minnesota River Watershed

TSS concentrations in the Minnesota River (from river mile 22 to Mississippi River; AUID 07020012-505) exceeded the TSS standard during wetter conditions, mostly in the very high- and high-flow duration zones (Figure 21). Concentrations decrease as flow increases in the very high-flow zone. This could be caused by backwater from the Mississippi River at very high flows, because TSS concentrations in the Mississippi River are typically lower than in the Minnesota River. In the mid- through very low-flow duration zones, samples collected during April through September had higher TSS concentrations than samples collected in October through March.

Available TSS data collected from 2006 through 2015 for each impaired segment are summarized in Appendix B. If little or no TSS data are available from 2006 through 2015, then data from 1996 through 2005 are summarized. Turbidity or transparency tube data are also summarized if little TSS data were available. Monitoring data are plotted in Appendix D.

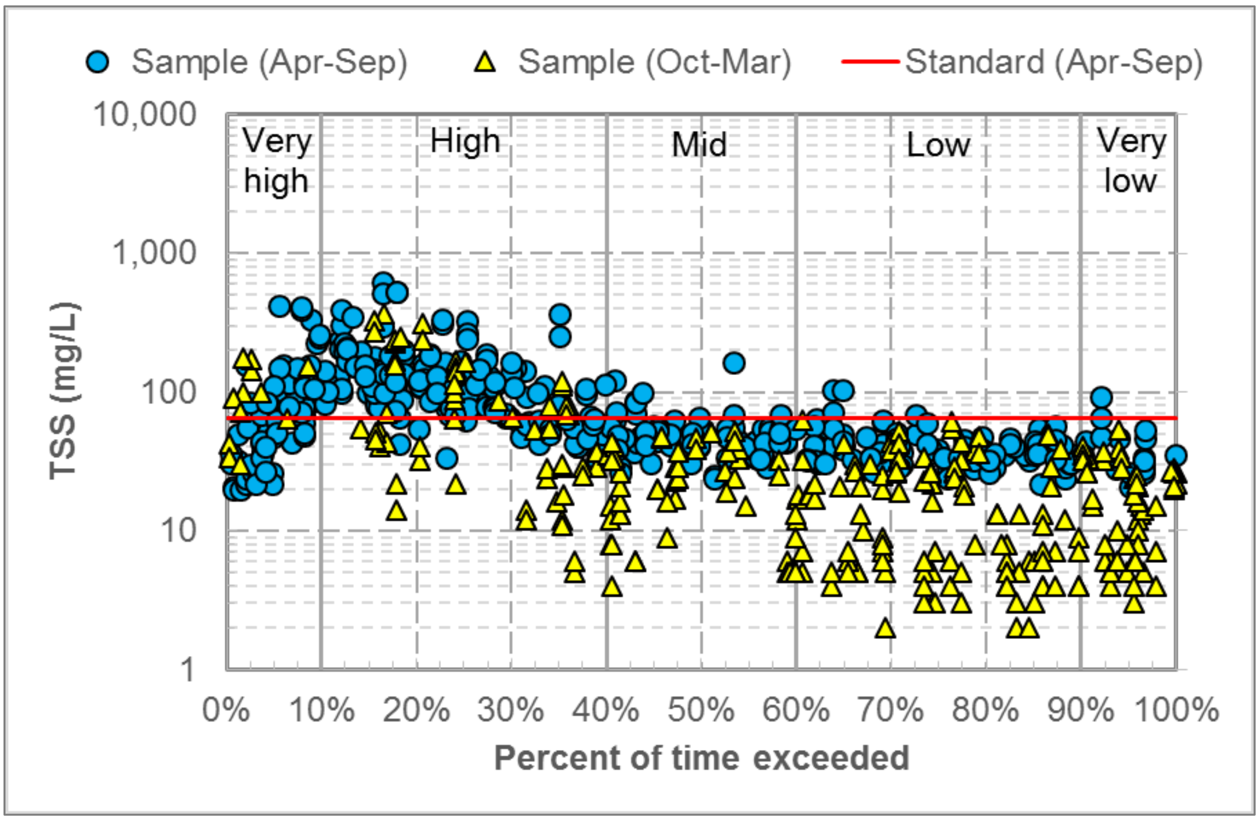

Figure 21. TSS concentrations in the Minnesota River (AUID 07020012-505), the lowest segment in HUC 07020012.

4.4 Sediment Sources

Source assessments are an important component of water quality studies and TMDL development. These analyses are generally used to evaluate the type, magnitude, timing, and location of pollutant loading to a water body (EPA 1999). The purpose of this section is to identify possible sources of sediment in the TMDL project area.

In the Minnesota River Basin, primary sources of sediment are near-channel processes and watershed runoff (also known as *upland loading*). Near-channel processes include bluff, ravine, and streambank erosion. Watershed runoff transports sediment from upland areas (e.g., row crop fields) to streams.

Sediment can be derived from both natural processes (also known as *natural background*) and human activities. Sediment source information is also discussed in *Identifying Sediment Sources in the Minnesota River Basin* (MPCA 2010) and *Sediment Reduction Strategy for the Minnesota River and South Metro Mississippi River* (MPCA 2015b).

4.4.1 Source Assessment Modeling Approach

The Minnesota River Basin HSPF model was used to characterize sediment loading from upland and near-channel sources to the impaired reaches. Point source loads to the impaired reaches are derived from the MPCA's summary of point source loading by major watershed compiled for annual trend reporting.

The MPCA developed initial HSPF models for the Minnesota River Basin in the 1990s and later expanded and refined the models (Tetra Tech 2016; Tetra Tech 2015; RESPEC 2014). The model outputs generated from the 2016 HSPF models were used to estimate sediment contributions from different sources.

The HSPF model is a comprehensive package for simulation of watershed hydrology and water quality for both conventional and toxic organic pollutants. HSPF is a comprehensive model of watershed hydrology and water quality that allows the integrated simulation of point sources, land and soil contaminant runoff processes, and in-stream hydraulic and sediment-chemical interactions. The results provide hourly runoff flow rates, sediment concentrations, and nutrient concentrations, along with other water quality constituents, at the outlet of any modeled subwatershed. Model documentation contains additional details about the model development and calibration (Tetra Tech 2016; Tetra Tech 2015; RESPEC 2014).

Within each subwatershed, the upland areas are separated into multiple land use categories. Simulated loads from upland areas represent the sediment loads that reach the modeled stream or lake; the loading rates do not represent field-scale soil loss estimates. Note that modeled streams do not typically include ephemeral streams or small perennial streams and ditches.

Near-channel sources include sediment loading from ravines, bluffs, and streambanks. The HSPF watershed model (Tetra Tech 2016) apportioned sediment loading between watershed runoff and near-channel sources based on sediment apportionment targets for the Minnesota River Basin. The sediment apportionment target for the basin as a whole is 23% of loading from watershed runoff, with a range of 14% to 31%; this target is for the mainstem Minnesota River and integrates the entire watershed area. The sediment apportionment targets were developed by the MPCA, taking into account multiple research efforts. The sediment budget for the Le Sueur River Watershed includes estimates of sediment loads from upland sheet and rill erosion, ravines, channel degradation, and bluff collapse. Sediment apportionment targets in the Le Sueur River Watershed are based on flow and sediment measurements above and below the knick zones of active headcuts in the Le Sueur River mainstem, Big Cobb River, and Maple River. Radiometric information aided in the partitioning of the field- and channel-derived sediment contributions based primarily on analysis of cores from depositional *integrator sites* (Schottler et al. 2010, plus additional ongoing work to further refine the interpretation by Schottler et al. (2010), as presented to Charles Regan of the MPCA, with additional information from sediment mass balance studies for the Le Sueur River Watershed and Greater Blue Earth River Basin provided in Gran et al. (2011) and Bevis (2015). Information from the Le Sueur River Watershed sediment budget and other on-going work in the Greater Blue Earth River Basin (e.g., Greater Blue Earth sediment budget) and throughout the Minnesota River Basin was used to partition sediment contributions among fields, ravines, bluffs, and streambank sources. Because there is more model-constraining information available about apportionment between upland and near-channel loading in the Greater Blue Earth River Basin than in the rest of the Minnesota River Basin, the sediment load estimates for the Greater Blue Earth River Basin are more refined than elsewhere in the Minnesota River Basin.

The HSPF model was used to quantify TSS loads from upland and near-channel sources. The model was also used to evaluate the conditions under which high sediment loading in the Minnesota River Basin is observed. A summary of modeled loads is presented in Table 7 (Section 4.4.4).

4.4.2 Nonpermitted Sources

Sedimentation in a stream is controlled by numerous, interrelated factors including hydrology, channel condition, and watershed land use. The primary nonpoint sources of sediment are delivery from upland areas and near-channel processes. Impairment occurs when external inputs to the stream become excessive, when stream characteristics are altered so that the stream can no longer assimilate these stresses, or a combination of the two. In the Minnesota River Basin, nonpoint sources are the largest sources of sediment (MPCA 2015b).

Upland Sources

Upland sources of sediment are largely the result of sheet, rill, and gully erosion occurring as precipitation falls and then runs off from exposed and unprotected land surfaces. As prairie grasslands were converted to plowed agricultural fields, minimal, near channel sources were augmented with relatively large surface runoff sediment sources, making uplands the largest sediment contributor around the time of European settlement. The conversion of small grains to soybeans in the 1940s further increased the amount of field erosion due to field surfaces being exposed and unprotected for longer periods of time (Schottler et al. 2013). Over the following decades, however, field contributions stabilized while near channel sources have risen substantially. The large increase in near channel sources is primarily due to changes in hydrology (as discussed below).

Agricultural activities such as livestock over-grazing and tilling crop fields can result in devegetated, exposed soil that is susceptible to erosion (EPA 2012). First-order and ephemeral streams flow intermittently, which makes them likely to receive disturbance. These sensitive areas have a high erosion potential, which can be exacerbated by farming practices but mitigated by BMPs such as grassed waterways. Runoff transported by tiles via open tile intakes can carry high concentrations of suspended sediment.

Cropland in the individual HUC-8 watersheds ranges from 55% to 83% of each HUC-8, and current farming practices typically leave fields unprotected for several months every year. Thus, the majority of unprotected soil in the watershed is likely on agricultural fields. In certain locations in each HUC-8; however, and especially in the Lower Minnesota HUC-8, other land uses such as permitted construction and mining sites as well as other non-ag land uses can be the locally dominant source of TSS.

TSS loading from upland sources estimated with the HSPF model is summarized by HUC-8 watershed in Section 4.4.4.

Near-Channel Sources

Near-channel sources of sediment are those in close proximity to the stream channel, including bluffs, banks, ravines, and the stream channel itself. Hydrologic changes in the landscape and altered precipitation patterns driven by climate change, such as more intense storms, can lead to increased TSS in surface waters. Subsurface drainage tiling, channelization of waterways, land cover alteration, and increases in impervious surfaces all decrease detention time in the watershed and increase flow from fields and in streams. Draining and tiling wetland areas can decrease water storage on the landscape, which can lead to lower evapotranspiration and increased river flow (Schottler et al. 2014). Over 90% of the original wetlands in Minnesota's native prairies and savannas were drained (USACE 2004).

The straightening and ditching of natural rivers increases the slope of the original watercourse and moves water off the land at a higher velocity in a shorter amount of time. These changes to the way water moves through a watershed and how it makes its way into a river can lead to increases in water velocity, scouring of the river channel, and increased erosion of the river banks (Schottler et al. 2014; Lenhart et al. 2013). Drain tiles may also increase channel erosion because runoff that travels through tiles can cause increased peak flows and velocities, both of which increase erosion.

TSS loading from near-channel sources estimated with the HSPF model is summarized by HUC-8 watershed in Section 4.4.4.

4.4.3 Permitted Sources

Point source pollution is defined by CWA section 502(14) as "any discernible, confined and discrete conveyance, including any ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agriculture stormwater discharges and return flow from irrigated agriculture."

Point sources that discharge sediment include facilities such as municipal wastewater treatment plants (WWTPs), industrial facilities, mining operations, concentrated animal feeding operations, and regulated stormwater (e.g., MS4s). Under the CWA, all point sources are regulated under the National Pollutant Discharge Elimination System (NPDES) program.

Concentrated Animal Feeding Operations (CAFOs)

NPDES permitted, State Disposal System (SDS) permitted and CAFOs not requiring permits, are not allowed to discharge to surface waters for precipitation events of less than a 25 year - 24 hour storm event and receive WLAs of zero. In cases of excessive precipitation (greater than the 25 year – 24 hour storm) only NPDES facilities may discharge as authorized by their applicable permit. Discharges from such overflows are allowable only if they do not cause or contribute to a violation of water quality standards. For the Minnesota River Basin, this 25-year storm event would range from 4 -5 inches of rain in a 24-hour period. Therefore, CAFO sites are not considered a significant source of sediment in the Minnesota River Basin. A list of CAFOs in the HUC-12 watersheds of each impaired reach addressed in this report is included in Appendix I.

Municipal and Industrial Wastewater

Municipal wastewater effluent can be a source of suspended solids. Effluent from mechanical treatment plants typically is approximately 81% organic matter and 19% inorganic particles (MPCA 2015c). The organic matter decomposes relatively rapidly and likely does not contribute to TSS impairments. Industrial wastewater comes from industries, mining operations, businesses, and other privately owned facilities that discharge wastewater to surface waters and must obtain NPDES permits to legally discharge.

In the Minnesota River project area, approximately 200 municipal and industrial wastewater facilities either are permitted to discharge sediment or can be reasonably expected to discharge sediment. NPDES permits limit the load or concentration of sediment, as TSS, that a municipal WWTP may discharge; the concentration limit is typically either 30 or 45 mg/L (as a calendar monthly average), which are both less than the stream standard of 65 mg/L TSS. Industrial wastewater often does not have a TSS concentration limit but is also expected to discharge at concentrations less than 65 mg/L TSS. Because the TSS concentration of wastewater effluent is typically below the stream standard, wastewater effluent is not considered a significant source of sediment to the impaired segments, representing less than 1% of the TSS load to the impaired segments. See Section 10.2.4 for information on the two facilities that are currently permitted to discharge at concentrations greater than 65 mg/L TSS; neither facility has violated the TSS stream standard.

TSS loading from wastewater was estimated from MPCA's summary of point source loading by major watershed compiled for annual trend reporting; summaries of loading by HUC-8 watershed are presented in Section 4.4.4.

Municipal Separate Storm Sewer Systems

MS4s are defined by the MPCA as conveyance systems owned or operated by an entity such as a state, city, township, county, district, or other public body having jurisdiction over disposal of stormwater or other wastes. The municipal stormwater permit holds permittees responsible for stormwater discharging from the conveyance system they own and/or operate. The conveyance system includes ditches, roads, storm sewers, and stormwater ponds. Stormwater runoff that falls under these permits is regulated as a point source and, therefore, must be included in the WLA portion of a TMDL. The EPA recommends that WLAs be broken down as much as possible in the TMDL, as information allows, to facilitate implementation planning and load reduction goals for MS4 entities.

TSS loading from regulated MS4 stormwater estimated with the HSPF model represents approximately 4% of the total TSS load in the Lower Minnesota River HUC-8 watershed and represents no more than 1% of the total TSS load in the remaining HUC-8 watersheds. Loads are summarized by HUC-8 watershed in Section 4.4.4. See Appendix F for a list of regulated MS4s in the project area.

Industrial Stormwater

Industrial stormwater is regulated through an NPDES permit when stormwater discharges have the potential to come into contact with materials and activities associated with the industrial activity. It is estimated that a small percent of the project area is permitted through the industrial stormwater permit, and industrial stormwater is not considered a significant source. On average, there is one permitted industrial stormwater site for every 10 square miles.

Construction Stormwater

Untreated stormwater that runs off a construction site often carries sediment and other pollutants to surface water bodies. An NPDES permit is required for construction activity that disturbs one or more acres of soil or for smaller sites if the activity is part of a larger development. A permit also might be required if the MPCA determines that the activity poses a risk to water resources. Coverage under the construction stormwater general permit requires sediment and erosion control measures that reduce stormwater pollution during and after construction activities. It is estimated that less than 0.05% of the project area is permitted through the construction stormwater permit, and construction stormwater is not considered a significant source.

4.4.4 Summary of Modeling Results

Sources by HUC-8 Watershed

The loads presented in this section represent the sum of the simulated loads that are delivered to the stream reaches in each modeled catchment, as opposed to field runoff or cumulative loading at each HUC-8 outlet. Uncertainties in the simulated loads are due in part to the following:

- TSS loads in the Minnesota River are not calibrated downstream of St. Peter (the outlet of the Minnesota River–Mankato HUC-8 watershed), and the river is increasingly unsuitable for one-dimensional modeling downstream of the USGS gage at Jordan[2].
- Because estimates to separate loading of ravines, bluffs, and streambanks were available only for the Greater Blue Earth River Basin, there is less confidence in simulated loads from near-channel sources in the other HUC-8 watersheds.
  - Bluff loading rates (Stephanie Day, National Center for Earth Surface Dynamics, University of Minnesota, Minneapolis, personal communication) from the Le Sueur River Watershed were applied to bluff areas represented in the Minnesota River–Mankato and Lower Minnesota River Watersheds. Applying the Le Sueur River Watershed loading rates to the Minnesota River mainstem is likely an overestimate because the Minnesota River impinges on its bluffs much less frequently than occurs in the Le Sueur River Watershed.
  - In the remaining watersheds, bluff loading rates were estimated as a calibration parameter, constrained by the source apportionment estimates.

The Blue Earth River HUC-8 watershed contributes the highest annual average TSS load in the Minnesota River Basin (Figure 22), with annual loads from the Le Sueur River and Lower Minnesota River watersheds also high compared to the remaining HUC-8 watersheds. Because pollutant loading takes into account both concentration and flow, the patterns of TSS loading among the HUC-8 watersheds (Figure 22) differ from the patterns of TSS concentration (Figure 9 and Figure 10). For example, the median TSS concentration in the Redwood River Watershed is 67 mg/L (Figure 9), which is higher than

[2] The Metropolitan Council, in cooperation with federal, state, and local agencies, developed a CE-QUAL-W2 model to simulate water quality in the lower 40 miles of the Minnesota River. This two-dimensional (longitudinal/vertical) model represents the river itself and does not simulate watershed loads.

the median concentration in the Yellow Medicine River Watershed (32 mg/L TSS). However, the Redwood River Watershed is smaller and therefore has lower total flows and loads (Figure 22).

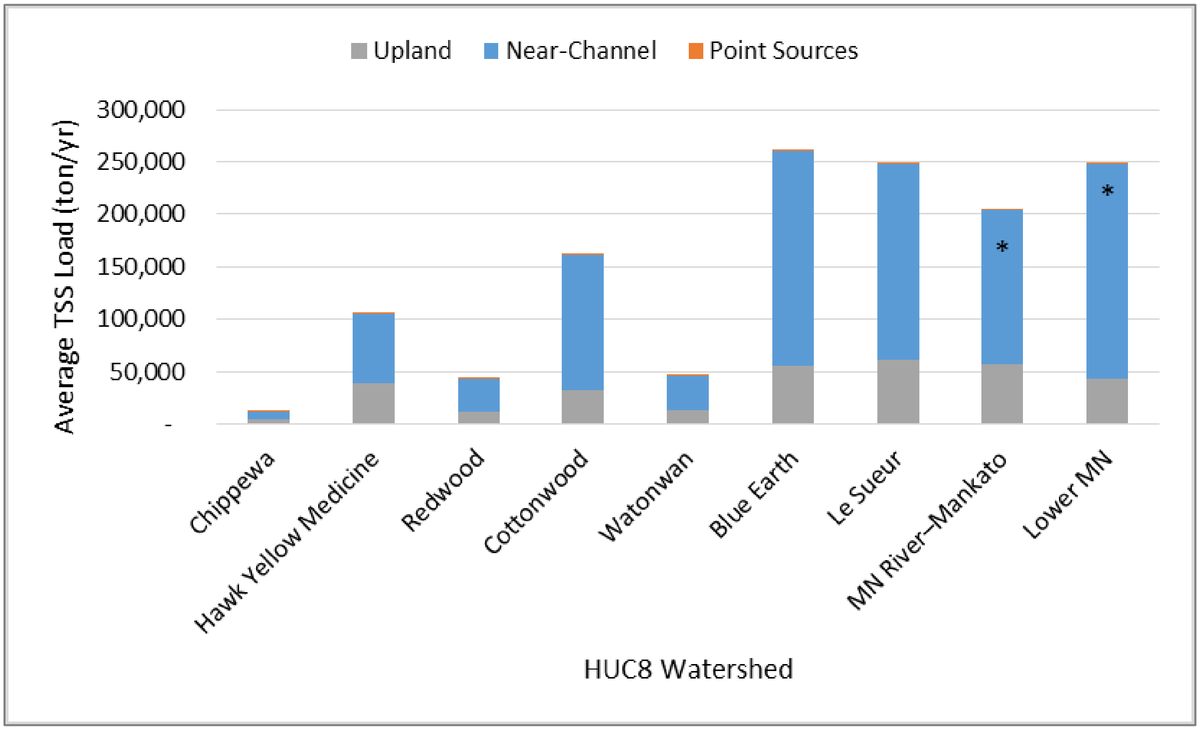

Figure 22. TSS loads by HUC-8 watershed.

*Loads from near-channel sources in the Minnesota River–Mankato and Lower Minnesota HUC-8 watersheds are likely over-estimated; see text above figure.

Within each HUC-8 watershed, near-channel sources accounted for between 63% and 83% of the TSS load, while upland sources accounted for most of the remainder (Table 7). Wastewater point sources always contributed negligible loads (0.3% or less). Runoff from cropland areas was the dominant upland source (12% to 31%), with non-MS4 urban land as the second largest upland source (1% to 5%), except in the Lower Minnesota River Watershed, where MS4 urban land was the second largest source (4%).

Table 7. TSS loads by source type by HUC-8 watershed.

Source	Chippewa	Hawk–Yellow Medicine	Redwood	Cottonwood	Watonwan	Blue Earth	Le Sueur	Minnesota River–Mankato	Lower Minnesota
Upland	**36%**	**37%**	**28%**	**20%**	**28%**	**22%**	**24%**	**28%**	**17%**
Cropland	31%	31%	24%	19%	23%	19%	22%	27%	12%
Feedlot	–	–	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Pasture	<1%	–	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Natural [a]	<1%	1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Urban (MS4)	–	–	1%	<1%	–	<1%	<1%	<1%	4%
Urban (Non-MS4)	4%	5%	2%	1%	4%	2%	2%	1%	1%
Near-channel	**64%**	**63%**	**72%**	**80%**	**72%**	**78%**	**76%**	**72%**	**83%**
Wastewater point sources	**0.3%**	**0.1%**	**0.1%**	**<0.1%**	**0.1%**	**<0.1%**	**<0.1%**	**0.1%**	**0.3%**

Notes: Percentages are rounded to the nearest integer (except for wastewater point sources that were rounded to one-tenth of a percent). Percentages do not sum exactly due to rounding.

"–" indicates that a source is not present in the specified watershed.

a. Forest, grassland, open water, and wetlands.

Conditions of High Sediment Loading

The HSPF model was used to investigate conditions of high sediment loading in the Minnesota River Basin (Tetra Tech 2016, 2017). Seasonality, months of high sediment loads and loading from intense storms were analyzed.

Seasonality. Across the 18-year simulation period, a majority (55% to 85%) of the sediment delivered to the mouth of each HUC-8 watershed and the Minnesota River at Jordan was delivered in March, April, May, and June. Between 80% and 89% of the in-stream TSS load occurred from April through September, the time of year in which the TSS standard applies. Large spring loads occurred in April and May, months that include spring snowmelt. Loads typically decreased in the later summer and early fall (Figure 23); such loads were rainfall-driven. Loads from November through February were negligible.

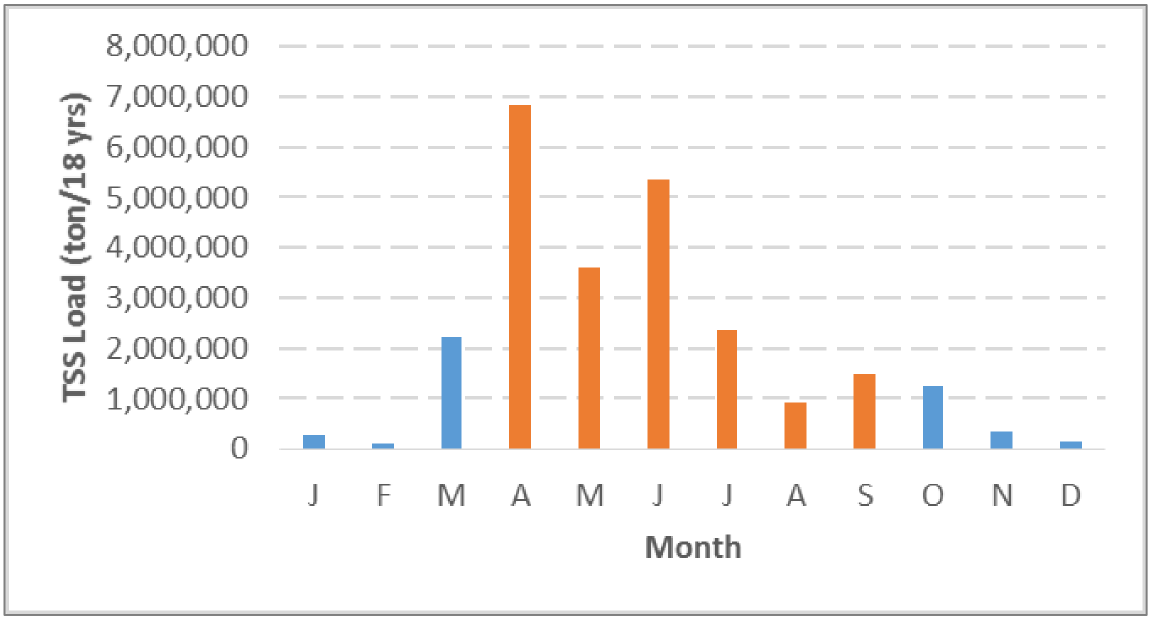

Figure 23. In-stream TSS loads at the Minnesota River at Jordan.
Columns in orange represent months the TSS standard applies (April through September); columns in blue represent months the TSS standard does not apply.

Months of high sediment loading. Months of high sediment loading were defined as any individual month that contributed more than 3% of the 18-year sediment load. If sediment loads were consistent throughout all 18 years of simulation, each individual month would contribute approximately 0.5% of the total 18-year load. A threshold of 3% was selected to represent months identified as "high sediment loading months." In each HUC-8 watershed, the load over the 18-year simulation that is delivered during high sediment loading months represents 21% to 52% of the total simulated load. For example, in the Le Sueur River Watershed, 6 out of 216 months were classified as high sediment loading months, and the sediment load from these 6 months represents 27% of the sediment loading over the 18-year simulation.

Almost all high sediment loading months were between March and June (51 of 66 high sediment loading months). Sediment sources in March and April were primarily from in-stream sources (bluff and stream); upland sources were slightly higher in May and June but in-stream sources still dominated. Occasionally, there were high sediment loading months when upland sources dominated; those events usually occurred in midsummer or early fall. The months with high sediment loads outside the March-to-June time period resulting from upland erosion were typically caused by long duration or very intense precipitation events that produced large amounts of overland flow.

Intense storms. At individual stations, high daily and/or hourly precipitation events at times caused very little sediment delivery in the following seven-day window, and sometimes high daily sediment had very little precipitation in the preceding seven-day window. Generally, however, a high daily sediment load was matched to either a large daily precipitation total or intense hourly precipitation event at some point during the preceding week. The evaluation of intense storms indicated that snowmelt coupled with spring convective storms, little vegetative cover, recent mechanical disturbance of the soil, and the effects of tile drains are likely the major contributing factors for sediment movement in the spring:

- Monthly sediment source attribution coupled with snowmelt water yield shows that snowmelt is generally associated with in-stream sources of sediment. In March, snowmelt is correlated with bluff and streambank sources, whereas there is a lower correlation between snowmelt and upland sources. Rivers typically rebound in March from winter low-flow conditions, mobilizing sediment from banks and bluffs that has been stored in the channel. In April, the correlation between snowmelt and bluff and streambank sources is lower than in March, but is still greater than the correlation with upland sources. One possible explanation for the differences between March and April is that April's high sediment loads are driven by a combination of snowmelt, rain-on-snow events, and strong spring convective storms, whereas March's high sediment loads are driven primarily by snowmelt. Snowmelt causes higher flows that scour in-stream sediment (bed, bank, and bluff) and, subsequently, the scoured sediment is transported downstream.

- Monthly sediment source attribution coupled with monthly precipitation shows that convective storms detaching sediment from uplands and scouring in-stream sources of sediment contribute to the late spring and early summer transport of sediment. High correlations between rainfall and upland sources are seen in May through September, and high correlations between rainfall and bluff and streambank sources are seen in April, May, and June. Late spring convective storms produce sediment from both upland and in-stream sources, whereas late summer and early fall events produce sediment primarily from land-based sources. Land with recent mechanical disturbance and/or bare soil, versus land with vegetative cover, is more susceptible to raindrop impact and particle detachment and, therefore, is more likely to contribute to the sediment load exported from each HUC-8 watershed.
- Tile drains with surface inlets can be direct sources of sediment load. Tile drains likely exacerbate sediment erosion from streambanks during both snowmelt and convective storms. Tile drains provide a pathway for water to be removed efficiently from the landscape. Without tile drains, snowmelt and/or convective stormwater would be held in the root zone for a longer period of time (weeks to months) than when tile drains are present. Sediment transport through tile drains is represented in the models, but is not well-constrained by observations or explicit information on the density of surface inlets.

5. TSS TMDL Development Approach

A TMDL for a water body that is impaired as a result of excessive loading of a particular pollutant can be described by the following equation:

TMDL = LC = ∑WLA + ∑LA + MOS + RC

where:

LC = *loading capacity*, or the greatest pollutant load a water body can receive without violating water quality standards.

WLA = *wasteload allocation*, or the portion of the TMDL allocated to existing or future permitted point sources of the relevant pollutant.

LA = *load allocation*, or the portion of the TMDL allocated to existing or future nonpoint sources of the relevant pollutant.

MOS = *margin of safety*, or an accounting of uncertainty about the relationship between pollutant loads and receiving water quality. The MOS can be provided implicitly through analytical assumptions or explicitly by reserving a portion of LC (EPA 1999).

RC = *reserve capacity*, an allocation of future growth. This is an MPCA-required element, if applicable. Not applicable in this TMDL.

As specified in 40 CFR 130.2(1), TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures. For the impairments addressed in this TMDL report, the TMDLs, allocations, and margins of safety are expressed in short tons of TSS per day. One short ton equals 2,000 pounds, and is referred to as “ton/d” in this report.

These TSS TMDLs were developed to address 61 impaired segments in the Minnesota River Basin. This section discusses the TMDL components.

5.1 Loading Capacity

Assimilative loading capacities for the streams were developed using LDCs (Cleland 2002). LDCs integrate flow and TSS data across streamflow regimes and provide assimilative loading capacities; LDCs also show load reductions necessary to meet water quality standards.

5.1.1 Development of Flow Duration Curves

Flow duration curves (FDCs) relate mean daily flow to the percent of time those values have been met or exceeded. For example, an average daily flow at the 50% exceedance value is the midpoint or median flow value; average daily flow in the reach equals the 50% exceedance value 50% of the time. The curve is divided into flow zones including very high flows (0% to 10%), high flows (10% to 40%), mid-range flows (40% to 60%), low flows (60% to 90%), and very low flows (90% to 100%). Figure 24 shows an example FDC for the Minnesota River (AUID 07020004-747).

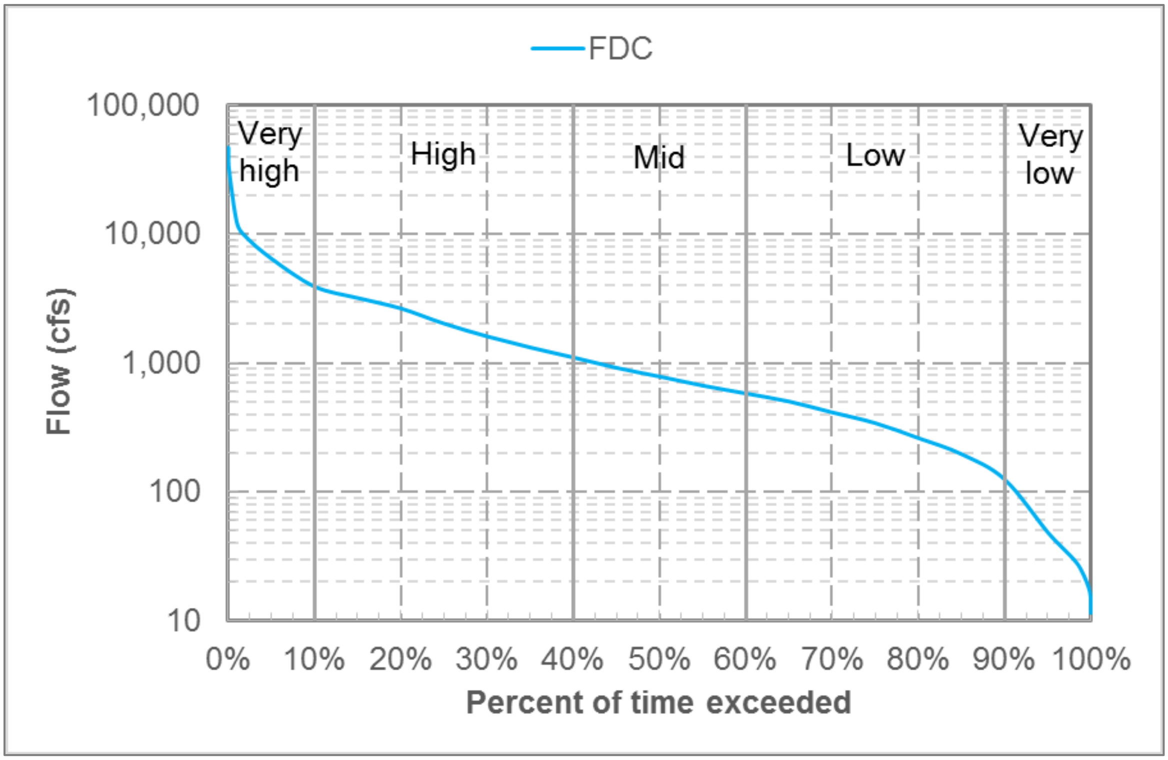

Figure 24. Example flow duration curve.

FDCs were developed using either daily average flow reported from continuously recording gages maintained by USGS or daily average flow from HSPF modeling (Tetra Tech 2016). Available Minnesota Department of Natural Resources (DNR) and the MPCA flow data were reviewed but not used for FDC development because of a lack of year-round data and shorter periods of record than for USGS flow gage data. However, flow data from DNR and MPCA stream flow gages with longer term records were used in calibration of the HSPF model (Tetra Tech 2015).

Using USGS gage data, FDCs were developed for 25 of the 61 impaired segments, including all Minnesota River impairments. The drainage area-ratio method was used to extrapolate USGS gage flows to the locations of the segment outlets. For example, flows from USGS gage 05320000 (Blue Earth River near Rapidan, Minnesota) collected from January 1, 1986, through December 31, 2015, were reduced by 41% to develop the FDC for AUID 07020009-502 because the impaired segment drains 1,416 mi^2 and the USGS gage drains 2,410 mi^2 (i.e., the impaired subwatershed is 59% of the gaged subwatershed). The FDC for segment 07020011-501 was developed directly using USGS gage flows because the impaired segment outlet is collocated with USGS gage 05320500 (Le Sueur River near Rapidan, Minnesota). Appendix C presents the USGS gage and period of record used to develop the FDC for each impaired segment.

For the remaining 36 impaired segments, FDCs were developed using daily average flow simulated in HSPF for the modeling period (January 1, 1995, through December 31, 2012). The outlets of 34 of the impaired segments were collocated with model output locations, and thus HSPF-simulated flows were used to develop FDCs. For the remaining two impairments (07020010-562 and 07020010-564), HSPF-simulated flows from nearby modeled reaches were drainage area-weighted to the impaired reach. Appendix C presents the HSPF model segment and period of record used to develop the FDC for each impaired segment. For additional information regarding HSPF modeling, see the brief summary in Section 4.4.1 or modeling documentation (Tetra Tech 2016; RESPEC 2014).

5.1.2 Development of Load Duration Curves

To develop LDCs, all average daily flow values were multiplied by the TMDL target for TSS (65 mg/L) and converted to a daily load to create “continuous” LDCs. For any given flow, the loading capacity (LC) is determined by selecting the point on the LDC that corresponds to the flow exceedance (along the x-axis).

LDCs were developed for each impaired reach (Appendix D), and an example is shown in Figure 25. The figures in Appendix D plot both the LDCs and loads calculated from water quality grab samples. Loads for the grab samples were calculated using the same flows used to calculate the LDCs. A nearby USGS gage was used to estimate the flow exceedance to plot water quality samples from 2013, 2014, or 2015 from reaches for which the 1995 through 2012 HSPF simulated flow was used to develop the LDC. The flow exceedance was then used to determine the corresponding HSPF flow (at that flow exceedance) for which to calculate a load for the grab water quality sample.

Each load calculated from a grab sample that plots above the LDC represents an exceedance of the TMDL target, whereas those that plot below the LDC are less than the TMDL target. In the example shown in Figure 25, several loads (blue circles and yellow triangles) plot above the LDC (red line) and thus exceed the TMDL in the very high-, high-, and mid-flow zones. In large river systems, local precipitation patterns do not necessarily correspond with watershed-wide precipitation. Therefore, a high TSS concentration observed during high flows might be the result of locally dry weather, and a high TSS concentration observed during low flows might be the result of locally wet weather.

The LDC method is based on an analysis that encompasses the cumulative frequency of historic flow data over a specified period. Because this method uses a long-term record of daily flow volumes, virtually the full spectrum of allowable loading capacities is represented by the resulting curve. In the TMDL equation tables in this report (Appendix D) only five points on the entire LC curve are depicted (the midpoints of the designated flow zones). The entire curve, however, represents the TMDL and is what is ultimately approved by the EPA.

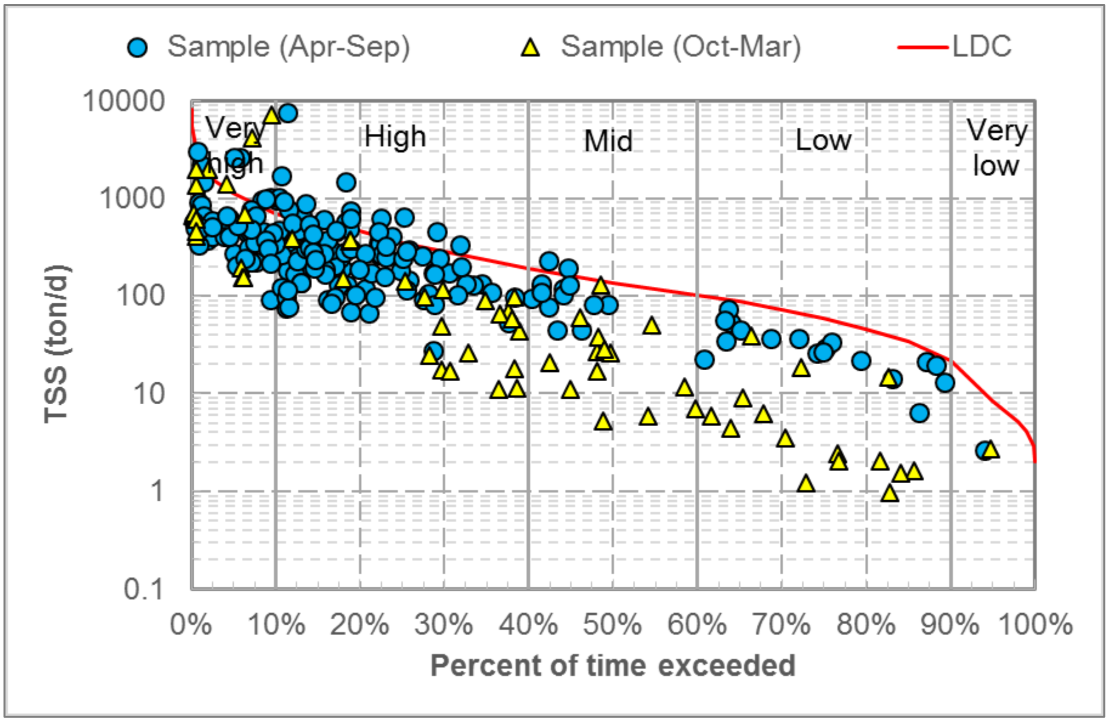

Figure 25. Example load duration curve.

5.1.3 MNR GBE TSS load capacities vs SMM load capacities

The approved *South Metro Mississippi River TSS TMDL* established loading capacities for contributing watersheds including the Upper Mississippi River, Minnesota River and St. Croix River. These loading capacities are based on a site-specific water quality standard of 32 mg/L TSS for Mississippi River Mile 844 to River Mile 780. The standard specifies it should be met five out of ten summers. The Minnesota River Greater Blue Earth (MN R GBE) TSS TMDL establishes loading capacities for stream reaches in the Minnesota River Basin to achieve the water quality standard of 65 mg/L. This approach is more prescriptive than the base loading approach applied to the Minnesota River Basin in the SMM TSS TMDL.

The two TMDLs apply different approaches to determine LC for the Minnesota River. The MN R GBE TSS TMDL approach described in Section 5.8.2, represents the entire flow record for a stream reach ranging from the very highest flows to the very lowest flows the reach has experienced over multiple years. Each point on the curve represents a discrete LC based on a specific average daily flow. As flow conditions are in constant flux, the load capacity for a particular flow represents a point in time and should not be thought of as an annual load capacity. The “Very high” flows in the Figure 25 have very high LC, but the stream is only under those “Very high” flow conditions for a relatively short time and should not be thought of as a “Very high” flow year.

The SMM TSS TMDL defined flow conditions based on a subset of annual loadings placed into bins of very high flow, high flow, medium flow, low flow and very low flow years. Annual loading capacities were calculated for each category of flow year and divided by 365 to determine a daily LC for each category of flow year. Therefore, the daily loading capacities for each of the five flow regimes present in both TMDLs for the lowest reach in the Minnesota River are not representative of the same volume of flow. The “Very high” flow zone load capacity for the MN R GBE TSS is much higher than the “Very high” flow load capacity for the SMM TSS TMDL because the average daily flows for the top 10% of flows are much higher than what is essentially an average flow condition for a year.

To provide a meaningful comparison of the two TMDLs' loading capacities a twofold analysis was conducted. The first was an analysis of the annual Minnesota River flows at Jordan (USGS 05330000) from 1985 through 2006 that compares the total cumulative flow by year to the annual loading assigned by the SMM TMDL to establish annual concentrations for comparison to the 65 mg/L standard. The mean concentration values are higher for the SMM TMDL than the standard applied by the MN R GBE TSS TMDL for all but the lowest flow regime, which has not been shown to be at risk of impairment. Second, to verify the loading from the MN R GBE TSS TMDL does not lead to a downstream impairment, annual flow volumes were calculated from each of the years (2004 through 2015) used to develop the LC at the lowest reach in the MN R GBE TSS TMDL (07020012-505). The total load of TSS in metric tons that would be delivered from the lowest reach of the Minnesota River based on the TMDL allocations was calculated based on the water quality standard applied in the TMDL (65 mg/L). The loads are presented below (Table 8). Over the 12 year flow record, the MN R GBE TSS TMDL would achieve the average flow condition total LC (355,656 metric tons/year; 1,001,617 kg/day) presented in Table 7 of the SMM TSS TMDL 6 of the 12 years. In addition, the Minnesota River loads achieve the very high flow condition total LC (530,454 metric tons/year; 1,480,521 kg/day) presented in Table 8 of the SMM TSS TMDL in 10 of the 12 years. This is a conservative analysis, as the SMM TSS TMDL separates the Minneapolis-St. Paul metropolitan area out as a separate "Metroshed" and assigns it its own allocations. In reality, approximately 40% of the "Metroshed" is located in the Minnesota River Basin with load capacity that could be assigned to the Minnesota River Basin increasing the overall load capacity of the Minnesota River in the SMM TSS TMDL.

Table 8. Flow and load estimates of the Minnesota River for the years 2004 – 2015. Loads are based on assumption of meeting the 65 mg/L standard.

Year	Total Annual Flow (cubic feet)	Total Annual TSS Load (metric tons)	Daily TSS Load (kilograms)
2004	1.7157E+11	315,791[ab]	865,180[ab]
2005	2.152E+11	396,095[b]	1,085,191[b]
2006	2.18404E+11	401,993[b]	1,101,350[b]
2007	2.14618E+11	395,024[b]	1,082,257[b]
2008	1.67877E+11	308,994[ab]	846,558[ab]
2009	1.43279E+11	263,717[ab]	722,512[ab]
2010	4.57186E+11	841,492	2,305,457
2011	4.77436E+11	878,492	2,406,827
2012	1.13973E+11	209,778[ab]	574,734[ab]
2013	1.8013E+11	331,546[ab]	908,345[ab]
2014	2.39781E+11	441,338[b]	1,209,145[b]
2015	1.51912E+11	279,608[ab]	766,049[ab]

[a]TSS load is less than the average flow condition loading capacity prescribed by the SMM TSS TMDL – 355,656 metric tons/year and 1,001,617 kg/day.

[b]TSS load is less than the very high flow condition loading capacity prescribed by the SMM TSS TMDL – 530,454 metric tons/year and 1,480,521 kg/day.

5.2 Percent Reductions

The existing concentration for each impairment was calculated as the 90th percentile of observed TSS concentrations from the months that the standard applies (April through September). The 90th percentile was used because the TSS standard states that the numeric criterion (65 mg/L) may be exceeded for no more than 10% of the time. The estimated percent reduction needed to meet each TMDL was calculated as the existing concentration minus the TSS standard (65 mg/L) divided by the existing concentration. This calculation approximates the reduction in concentration needed to meet the standard. If there are fewer than 10 TSS monitoring sample points for an impairment, the existing concentration and reduction are not reported. The percent reductions reported in the TMDL tables in Appendix D represent the overall reductions needed to meet the TMDLs but do not necessarily apply to each of the sources/allocations individually.

The TSS monitoring data used to calculate the percent reductions are from 2006 through 2015. The baseline year for implementation is 2010, the midpoint of the time period. BMPs present on the landscape during the model simulation time period are implicitly accounted for in the model.

5.3 Lac Qui Parle Boundary Condition

The domain of this TMDL is from the Lac qui Parle Dam downstream to the mouth of the Minnesota River. The following three HUC-8 watersheds are upstream of the TMDL project area, and thus are excluded from the TMDL:

- 07020001: Minnesota River–Headwaters
- 07020002: Pomme de Terre River
- 07020003: Lac qui Parle River

A boundary condition (BC) was developed at the Lac qui Parle Lake Dam using the TMDL target of 65 mg/L TSS and flow monitored at the USGS on the Minnesota River near Lac qui Parle (05301000). This BC is presented as a line item in the allocation tables presented in Appendix D.

5.4 Wasteload Allocation

The WLAs were divided into three primary categories:

- **Wastewater:** Treated effluent from regulated wastewater point sources. These wastewater treatment facilities are either publicly owned treatment works (POTWs) or industrial facilities. Individual WLAs are based on limits defined in NPDES permits.
- **Construction and industrial stormwater:** Stormwater runoff from construction sites or industrial facilities. Categorical WLAs are based on a percentage of the LC.
- **MS4 stormwater:** Stormwater runoff from permitted traditional and nontraditional MS4s. Individual and categorical WLAs are based on the relative area of an MS4 jurisdiction within a TMDL subwatershed.

Each of these categories is further discussed in the following subsections.

5.4.1 Municipal and Industrial Wastewater

In the Minnesota River project area, approximately 200 wastewater facilities are authorized through NPDES permits to discharge TSS; these facilities received WLAs. These permitted facilities include POTWs (e.g., Arlington WWTP) that discharge treated sanitary wastewater (and may also discharge treated industrial process water) and industrial facilities (e.g., Duininck Incorporated) that discharge treated wastewater from industrial processes, noncontact cooling water, and other types of industrial wastewater.

Individual WLAs were developed for each wastewater facility. All the WLAs are based on TSS concentration limits less than or equal to the TSS standard of 65 mg/L. Therefore, facilities that discharge consistent with their WLAs are not a cause for in-stream exceedances of the TSS standard within their receiving water bodies.

WLAs were calculated using information in the facilities' NPDES permits.

- **Load Limit:** When a permit defined a calendar monthly average TSS load limit, that limit was used as the WLA.

  For example, the Blue Earth WWTP (MN0020532) has a monthly average load limit of 111 kilograms per day (kg/d), which yields a WLA of 0.122 ton per day (ton/d).

- **Design Flow and Concentration Limits:** When a permit did not define a TSS load limit but did define one or more design flows and TSS concentration limits, the WLA was calculated using a design flow and a concentration limit. If an average wet weather design flow (AWWDF) was defined, it was used to calculate the WLA; if the AWWDF was not defined, then the maximum design flow was used to calculate the WLA. If a monthly average TSS concentration limit was defined, then that limit was used to calculate the WLA; if only a daily maximum concentration limit was defined, then that limit was used to calculate the WLA.

  For example, Fabcon Inc. (MN0068284) has a maximum design flow of 0.72 million gallons per day (mgd) and a TSS concentration limit of 30 mg/L, which yields a WLA of 0.0901 ton/d.

  0.72 mgd * 1,000,000 * 1g/0.26417 L * 30 mg/L *0.0000000011023 = 0.0901 ton/day

- **Design Flow and No Concentration Limits:** If a permit did not define a TSS load limit or TSS concentration limit but did define one or more design flows, then the WLA was calculated using a design flow and a TSS concentration target of 30 mg/L, consistent with Minn. R. 7053.0225, subp. 1 and 7053.0215, subp. 1. If an AWWDF was defined, it was used to calculate the WLA; if an AWWDF was not defined, then the maximum design flow was used to calculate the WLA.

  For example, Seneca Food Corp–Blue Earth (MN0001287) has an AWWDF of 0.145 mgd and no TSS concentration limit. Using 30 mg/L, the WLA is 0.0182 ton/d.

- **No Design Flow and No Concentration Limits:** If a permit did not define a design flow or TSS limit, then the WLA was calculated using an estimated design flow and a TSS concentration target of 30 mg/L (Minn. R. 7053.0225, subp. 1 and 7053.0215, subp. 1); this was the case for several dewatering permits. The design flow was estimated as the average reported flows for similar sites in the vicinity of the project area.

For example, Groebner Farms (MNG490270) has no design flows, no reported flows, and no TSS concentration limit. Using 3.6 mgd and 30 mg/L, the WLA is 0.452 ton/d.

If a WWTP is permitted to discharge through multiple outfalls, the WLAs for each outfall were summed to calculate a single WLA for the facility. WLAs were calculated for any “surface discharge” outfall that discharged wastewater from a waste-stream that could contain TSS; such waste-streams include sanitary wastewater treatment, process water, and noncontact cooling water. When a facility is permitted, the lowest WLA in an approved TMDL will be applied.

The total daily LC in the low or very-low flow zone for some reaches is less than the permitted wastewater treatment facility design flows. This is an artifact of using design flows for allocation setting and results in these point sources appearing to use all (or more than) the available LC. In reality, actual treatment facility flow can never exceed stream flow, as it is a component of stream flow. To account for these unique situations, the WLAs in these flow zones where needed are expressed as an equation rather than an absolute number:

Allocation = flow contribution from a given source x 65 mg/L (or NPDES permit concentration)

This amounts to assigning a concentration-based limit to these sources for the lower flow zones.

In the allocation tables presented in Appendix D, the individual WLAs are combined into one line item and referred to as “WLA for Wastewater.” Individual WLAs are reported in Appendix E.

5.4.2 Construction and Industrial Stormwater

The Construction Stormwater General Permit (MNR100001) regulates construction stormwater, and industrial stormwater is regulated through multiple permits: the multi-sector general permit for industrial stormwater (MNR050000), the general permit for non-metallic mining and associated activities (MNG490000), and individual permits that have industrial stormwater runoff components.

For each TMDL, 0.1% of the LC less the MOS and wastewater WLAs was allocated to construction site stormwater, and an additional 0.1% was allocated to industrial stormwater in a combined categorical WLA. 0.2% is considered a conservative approach, because less than 0.2% of the project area is regulated through the construction and industrial stormwater permits at any point in time.

$$\mathbf{WLA_{construction/industrial} = 0.2\% * (LC - MOS - BC - \sum WLA_{wastewater})}$$

where:

LC = loading capacity

$WLA_{construction/industrial}$ = wasteload allocation for construction site and industrial facilities stormwater

BC = load delivered at BC at Lac qui Parle Lake outlet

$WLA_{wastewater}$ = wasteload allocation for municipal and industrial wastewater

MOS = margin of safety

The total daily LC in the low or very-low flow zone for some reaches is less than the permitted wastewater treatment facility design flows. This is an artifact of using design flows for allocation setting and results in these point sources appearing to use all (or more than) the available LC. In reality, actual treatment facility flow can never exceed stream flow, as it is a component of stream flow. To account for these unique situations, the WLAs for Construction and Industrial Stormwater in these flow zones where needed are expressed as an equation rather than an absolute number:

Allocation = flow contribution from a given source x 65 mg/L (or NPDES permit concentration)

This amounts to assigning a concentration-based limit to these sources for the lower flow zones.

In the allocation tables presented in Appendix D, these two categorical WLAs are combined into one line item and referred to as "WLA for Construction/Industrial Stormwater." It is assumed that loads from permitted construction and industrial stormwater sites that operate in compliance with the permits are meeting the WLA.

5.4.3 Municipal Separate Storm Sewer Systems

MS4s are defined by the MPCA as conveyance systems owned or operated by an entity such as a state, city, township, county, district, or other public body having jurisdiction over disposal of stormwater or other wastes. Stormwater runoff that falls under the MS4 general permit is regulated as a point source and, therefore, must be included in the WLA portion of a TMDL. The EPA recommends that WLAs be broken down as much as possible in the TMDL, as information allows. This facilitates implementation planning and load reduction goals for the MS4 entities. The MS4 general permit applies solely to conveyance systems and does not cover in-stream or near stream sources (bluffs, ravines, streambanks) located within the boundaries of the MS4. These sources are considered nonpoint and are eligible for nonpoint source grant funding.

Under phase II of the NPDES stormwater program, MS4 communities outside of urbanized areas with populations greater than 10,000 (or greater than 5,000 if they discharge to or have the potential to discharge to an outstanding value resource, trout lake, trout stream, or impaired water) and MS4 communities within urbanized areas are regulated MS4s.

Under the NPDES stormwater program, MS4 entities are required to obtain a permit, then develop and implement an MS4 SWPPP, which outlines a plan to reduce pollutant discharges, protect water quality, and satisfy water quality requirements in the CWA. An annual report is submitted to the MPCA each year by the permittee documenting progress on implementation of the SWPPP. The municipal stormwater permit holds permittees responsible for stormwater discharging from the conveyance system they own and/or operate. The conveyance system includes ditches, roads, storm sewers, and stormwater ponds.

The phase II general NPDES/SDS Municipal Stormwater Permit for MS4 communities has been issued to cities, townships, and counties in the watershed as well as the Minnesota Department of Transportation (MnDOT). Stormwater conveyed from these systems is a regulated point source and, therefore, must be included in the WLA portion of the TMDL. Four MS4s are expected to come under permit coverage in the next permit cycle; these MS4s were also provided WLAs.

The regulated MS4 areas within each impairment watershed were determined using the following approaches:

- **City, Township, and Nontraditional MS4s:** Approximated using developed land within their jurisdictional boundaries. Developed land is one of the four developed land cover classes in the

2011 National Land Cover Database: open space, low intensity, medium intensity, and high intensity.

- **County MS4s:** The MS4 permits for the regulated road authorities apply to roads within the U.S. Census Bureau 2010 urban area. The regulated roads and rights-of-way were approximated by the county road lengths (county and county state aid highways in MnDOT's STREETS_LOAD shapefile[3]) in the 2010 urban area multiplied by an average right-of-way width of 90 feet on either side of the centerline.
- **Prior Lake–Spring Lake Watershed District MS4:** The surface area of the channel was approximated as an 18-foot width along the Prior Lake outlet channel centerline.
- **MnDOT Metro District MS4:** The MnDOT Metro District delineated their regulated area.
- **MnDOT Outstate District MS4:** The MnDOT Outstate District provided a list of regulated roads and rights-of-way. Buffers set to the rights-of-way on the regulated roads (MnDOT's STREETS_LOAD shapefile[3]) were delineated within the Mankato 2010 urban area.

Next, the MPCA selected an allowable average sediment export rate. To be consistent with the *South Metro Mississippi River TSS TMDL*, a TSS export rate of 154 pounds/acre-year was used to calculate MS4 WLAs. The South Metro Mississippi River TMDL's primary source of information for estimating sediment export from urban areas was "Review of Published Export Coefficient and Event Mean Concentration (EMC) Data," by the Environmental Laboratory of the U.S. Army Corps of Engineers. This summary report provides an extensive list of references. The MPCA went to each of the references and extracted the data (https://erdc-library.erdc.dren.mil/xmlui/handle/11681/3547). Based on these data, the MPCA estimated an annual median export of 154 pounds per acre for developed land uses.

Using the 154 pounds/acre-year export rate and the total MS4 area between Lac qui Parle Dam and the lowest reach of the Minnesota River (07020012-505), a total MS4 TSS load was calculated. Average flow conditions for the period 2004 through 2015 were used to calculate a TSS concentration attributable to MS4 load. This concentration was then used to calculate reach specific MS4 WLAs for the different flow zones.

For permitted MS4s, TSS loading does not need to be reduced to meet the WLAs but is not allowed to increase relative to the baseline year of 2010 (Section 5.2).

5.5 Margin of Safety

The purpose of the MOS is to account for uncertainty that the allocations will result in attainment of water quality standards. Section 303(d) of the CWA and EPA's regulations in 40 CFR 130.7 require that:

> TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numeric water quality standards with seasonal variations and a MOS,

[3] "Roads, Minnesota, 2012" downloaded from https://gisdata.mn.gov/dataset/trans-roads-mndot-tis,

> which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality.

The MOS can either be implicitly incorporated into conservative assumptions used to develop the TMDL or be added as a separate explicit component of the TMDL (EPA 1991).

The Minnesota River HSPF models were calibrated and validated using 57 stream flow gaging stations, with at least three gaging stations for each HUC-8 watershed (Tetra Tech 2016; RESPEC 2014). Fourteen gaging stations have long-term, continuous flow records; 22 have long-term, seasonal flow records; and 21 have short-term, seasonal flow records. Sixty-three in-stream water quality stations were used for the sediment calibration and corroboration; all stations have at least 100 TSS samples from the simulation period. Calibration results indicate that the HSPF model is a valid representation of hydrologic and sediment conditions in the watershed. The LDCs were developed using HSPF-simulated daily flow data. An explicit MOS of 10% was included in all 61 TSS TMDLs to account for uncertainty that the pollutant allocations would attain the water quality targets. The use of an explicit MOS accounts for environmental variability in pollutant loading, variability in water quality monitoring data, calibration and validation processes of modeling efforts, uncertainty in modeling outputs, conservative assumptions made during the modeling efforts, and limitations associated with the drainage area-ratio method used to extrapolate USGS flow data. The MOS was allocated after the Lac qui Parle BC was allocated (i.e., 10% of the quantity of the LC less Lac qui Parle BC).

5.6 Load Allocation Methodology

After allocations to the BC, wastewater, permitted MS4s, and MOS were determined for each reach and flow zone, the remaining LC was allocated to the LA. The LA includes nonpoint pollution sources that are not subject to permit requirements, including near-channel sources and watershed runoff. The LA also includes natural background sources of sediment.

Natural background is defined in both Minnesota rule and statute:

Minn. R. 7050.0150, subp. 4:

> “Natural causes” means the multiplicity of factors that determine the physical, chemical or biological conditions that would exist in the absence of measurable impacts from human activity or influence.

The Clean Water Legacy Act (Minn. Stat. § 114D.10, subd. 10) defines *natural background* as:

> … characteristics of the water body resulting from the multiplicity of factors in nature, including climate and ecosystem dynamics that affect the physical, chemical or biological conditions in a water body, but does not include measurable and distinguishable pollution that is attributable to human activity or influence.

Natural background sources are inputs that would be expected under natural, undisturbed conditions. Natural background sources can include inputs from natural geologic processes such as soil loss from stream development and upland erosion of areas not disturbed by human activity; atmospheric deposition; wildlife; and loading from grassland, forests, and other natural land covers. In 2016, when considering a challenge to the MPCA’s approach to natural background in the Little Rock Creek TMDL, the Minnesota Court of Appeals held that the MPCA is not required to develop a LA for natural background independent from other nonpoint sources. In that case, the MPCA gathered and considered natural background sources but did not assign a separate LA to those sources due to their marginal impact on Little Rock Creek's overall water quality. The MPCA followed a similar approach for this TMDL. The court also held that, as allowed by Minn. R. 7050.0170, background levels can be predicted based on data from watersheds with similar characteristics.

In a study of the Lake Pepin Watershed, Engstrom et al. (2009) found that loads have increased about one order of magnitude beyond natural background levels since presettlement times. The MPCA uses the year 1830 as a reference point for measuring the beginning of human effects on the TSS loads, based on estimates from Lake Pepin sediment cores. This period is prior to European settlement, which introduced dramatic changes to the landscape. These changes consisted primarily of converting more than 90% of native prairie and wetlands to agriculture through tillage and artificial drainage, along with the introduction of annual row crops. Schottler et al. (2010 Page 32) further explain that the land form that creates the potential for high erosion rates is natural, but today's high rates of erosion and sediment concentration are not natural:

> *Because of geologic history, non-field sources such as bluffs and large ravines are natural and prevalent features in some watersheds. Consequently these watersheds are predisposed to high erosion rates. However, it would be highly inaccurate to label this phenomenon as natural. Post-settlement increases in sediment accumulation rates in Lake Pepin, the Redwood Reservoir…and numerous lakes in agricultural watersheds … clearly show that rates of sediment erosion have increased substantially over the past 150 years. Coupling these observations with the non-field sediment yields determined in this study, demonstrates that the rate of non-field erosion must also have increased. The features and potential for non-field erosion may be natural, but the rate is not.*

Based on the MPCA's water body assessment process and the TMDL source assessment exercises, there is no evidence at this time to suggest that natural background sources are a major driver of the water body impairments and/or affect their ability to meet state water quality standards. For all impairments addressed in this study, natural background sources are implicitly included in the LA portion of the TMDL allocation tables, and TMDL reductions should focus on the major anthropogenic sources identified in the source assessment. Whereas the *South Metro Mississippi River TSS TMDL* (MPCA 2015a) provides explicit allocations for natural background conditions based on the order of magnitude increase in sedimentation since pre-European settlement times reported in Engstrom et al. (2009), the observed increase applies to the Minnesota River Basin as a whole. The method used to develop the natural background load for the Minnesota River Basin does not allow it to be extrapolated into the smaller watersheds of the individual impairments located throughout the basin.

Additionally, the TSS standard inherently addresses natural background conditions. Minnesota's regional TSS standards are based on reference or least-impacted streams and take into account differing levels of sediment present in streams and rivers in the many ecoregions across the state, depending on factors such as topography, soils, and climate (MPCA 2011).

The total daily LC in the low or very-low flow zone for some reaches is less than the permitted wastewater treatment facility design flows. This is an artifact of using design flows for allocation setting and results in these point sources appearing to use all (or more than) the available LC. In reality, actual treatment facility flow can never exceed stream flow, as it is a component of stream flow. To account for these unique situations, the LAs in these flow zones where needed are expressed as an equation rather than an absolute number:

Allocation = flow contribution from a given source x 65 mg/L

This amounts to assigning a concentration-based limit to these sources for the lower flow zones. By definition rainfall and thus runoff is very limited if not absent during low flow. Thus, runoff sources would need little-to-no allocation for these flow zones.

5.7 Seasonal Variation

Both seasonal variation and critical conditions are accounted for in this TMDL through the application of LDCs. LDCs evaluate water quality conditions across all flow regimes including high flow, which is the runoff condition in which sediment transport tends to be greatest. Seasonality is accounted for by addressing all flow conditions in a given reach. Seasonal variation is also addressed by the TSS water quality standard's application during the period when the highest TSS concentrations are expected via snowmelt and storm event runoff.

6. TSS TMDL Summaries

The estimated percent reductions needed to meet the TMDLs range from zero to 89% (Table 9). The impairments that do not require TSS reductions to meet their TMDL were originally listed in 2002 or 2004 based on turbidity data. The MPCA will reevaluate these reaches in the next impairment assessment for this watershed. Appendix D includes the TMDL tables and LDCs for all the impairments addressed in this report, organized by HUC-8 major watershed.

Many reaches have little-to-no TSS data, and therefore existing instream loads cannot be estimated with the monitoring data. Whereas TMDLs and allocations are developed for these reaches (Appendix D), reductions to meet the TMDLs are not provided. These reaches were listed as impaired based on turbidity or transparency tube data. Summary tables of turbidity and transparency tube data for these reaches are provided in the water quality summary tables in Appendix B.

The LDCs (Appendix D), when taken as whole, indicate that most of the exceedances of the TSS standard occur during higher flows. High TSS concentrations under high flows are typically due to upland runoff and near-channel sources and are associated with precipitation and/or snowmelt events (see Section 4.4: *Sediment Sources*). The *Sediment Reduction Strategy for the Minnesota River Basin and South Metro Mississippi River* (MPCA 2015b) includes strategies for reducing the impacts of these nonpoint source loads (see Section 10: *Implementation Strategy Summary*).

Table 9. Summary of percent reductions needed per impaired reach.

HUC-8	Stream Name	AUID (HUC-8-)	TSS Reduction (%)
Minnesota River–Yellow Medicine River (07020004)	Yellow Medicine River	502	69
	Minnesota River	747	17
	Minnesota River	748	14
	Minnesota River	749	47
	Minnesota River	750	46
Chippewa River (07020005)	Chippewa River	501	– [a]
Redwood River (07020006)	Redwood River	501	– [b]
Minnesota River–Mankato (07020007)	Minnesota River	720	57
	Minnesota River	721	55
	Minnesota River	722	70
	Minnesota River	723	78
Cottonwood River (07020008)	Cottonwood River	501	82
Blue Earth River (07020009)	Blue Earth River	501	85
	Elm Creek	502	46
	Center Creek	503	53
	Blue Earth River	504	– [c]
	Blue Earth River	507	– [c]
	Blue Earth River	508	– [c]
	Blue Earth River	509	83
	Blue Earth River	514	– [c]
	Blue Earth River	515	66
	Blue Earth River	518	30
	Cedar Creek (Cedar Run Creek)	521	– [c]
	Elm Creek	522	31
	Elm Creek	523	– [c]
	Elm Creek, South Fork	524	– [c]
	Lily Creek	525	– [c]

HUC-8	Stream Name	AUID (HUC-8-)	TSS Reduction (%)
Blue Earth River (07020009), continued	Dutch Creek	527	– [b]
	Blue Earth River, East Branch	553	54
	Blue Earth River, East Branch	554	– [c]
	Blue Earth River	565	– [c]
Watonwan River (07020010)	Watonwan River	501	54
	Watonwan River	510	32
	Watonwan River	511	59
	Butterfield Creek	516	16
	Watonwan River, South Fork	517	51
	Perch Creek	524	– [c]
	St. James Creek (Kansas Lake Inlet)	528	– [c]
	Watonwan River, South Fork	547	– [c]
	Watonwan River	562	– [c]
	Watonwan River	563	17
	Watonwan River, North Fork	564	– [b]
	Watonwan River	566	– [c]
	Watonwan River	567	20
Le Sueur River (07020011)	Le Sueur River	501	89
	Unnamed Creek (Little Beauford Ditch)	503	28
	Little Cobb River	504	49
	Le Sueur River	506	– [c]
	Le Sueur River	507	86
	Rice Creek	531	17
	Maple River	534	78
	Maple River	535	– [c]
	County Ditch 3 (Judicial Ditch 9)	552	– [b]
	Cobb River	556	74
	Cobb River	568	– [c]
	Le Sueur River	619	– [c]
	Le Sueur River	620	– [c]
Lower Minnesota River (07020012)	Minnesota River	505	60
	Minnesota River	506	74
	Minnesota River	799	68
	Minnesota River	800	73

a. This impairment was originally listed in 2002 based on turbidity data; however, the TSS data presented in this report do not show impairment. Older (1989–1994) TSS data evaluated by MPCA for the impairment assessment include observations that exceed the current TSS standard. The MPCA will reevaluate the reach in the next impairment assessment for this watershed.
b. This impairment was originally listed in 2004 based on turbidity data; however, the TSS data presented in this report do not show impairment. The MPCA will reevaluate the reach in the next impairment assessment for this watershed.
c. Sample size in TMDL period (2006–2015) less than 10% reduction not calculated.

7. Future Growth Considerations

7.1 New or Expanding Permitted MS4 WLA Transfer Process

Future transfer of watershed runoff loads in this TMDL might be necessary if any of the following scenarios occur within the project watershed boundaries:

- New development occurs within a regulated MS4 community. Newly developed areas that are not already included in the WLA must be transferred from the LA to the WLA to account for the growth.
- One regulated MS4 acquires land from another regulated MS4. Examples include annexation or highway expansions. In these cases, the transfer is WLA to WLA.
- One or more nonregulated MS4s become regulated. If this has not been accounted for in the WLA, then a transfer must occur from the LA.
- Expansion of a U.S. Census Bureau urban area encompasses new regulated areas for existing permittees. An example is existing state highways that were outside an urban area at the time the TMDL was completed, but are now inside a newly expanded urban area. This situation will require either a WLA-to-WLA transfer or an LA-to-WLA transfer.
- A new MS4 or other stormwater-related point source is identified and is covered under an NPDES permit. In this situation, a transfer must occur from the LA.

Load transfers will be based on methods consistent with those used in setting the allocations in this TMDL. In cases in which a WLA is transferred from or to a regulated MS4, the permittees will be notified of the transfer and will have an opportunity to comment on it.

7.2 New or Expanding Wastewater

The MPCA, in coordination with EPA Region 5, has developed a streamlined process for setting or revising WLAs for new or expanding wastewater discharges to water bodies with an EPA-approved TMDL (described in Section 3.7.1 *New and Expanding Discharges* in MPCA 2012c). This procedure will be used to update WLAs in approved TMDLs for new and expanding wastewater dischargers whose permitted effluent limits are at or below the in-stream target and will ensure that the effluent concentrations will not exceed applicable water quality standards or surrogate measures. The process for modifying any and all WLAs will be handled by the MPCA, with EPA input and involvement, once a permit request or reissuance is submitted. The overall process will use the permitting public notice process to allow for the public and EPA to comment on the permit changes based on the proposed WLA modification(s). Once any comments or concerns are addressed, and the MPCA determines that the new or expanded wastewater discharge is consistent with the applicable water quality standards, the permit will be issued and any appropriate updates will be made to the TMDL WLA(s).

For more information on the overall process, visit the MPCA's TMDL Policy and Guidance web page.

8. Reasonable Assurance

8.1 Framework

A TMDL report needs to provide reasonable assurance that water quality targets will be achieved through the specified combination of point and nonpoint source reductions reflected in the LAs and WLAs. According to EPA guidance (EPA 2002):

> When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint-source load reductions will occur ... the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. This information is necessary for the EPA to determine that the TMDL, including the LA and WLAs, has been established at a level necessary to implement water quality standards.

For the Minnesota River, required point source controls will be effective in improving water quality if accompanied by considerable reductions in nonpoint source loading. Reasonable assurance for permitted sources such as stormwater and wastewater is provided primarily via compliance with their respective NPDES permit programs, as described in Section 10.2.

The EPA has defined components of reasonable assurance and a framework for implementation as part of the Chesapeake Bay TMDL project (EPA 2009):

- Revise tributary strategies to identify controls needed to meet the TMDL allocations.
- Evaluate existing programmatic, funding, and technical capacity to fully implement tributary strategies.
- Identify gaps in current programs and local capacity to achieve the needed controls.
- Commit to systematically fill gaps and build program capacity.
- Agree to meet specific, iterative, short-term (one to two year) milestones.
- Demonstrate increased implementation and/or pollutant reductions.
- Commit to measure and evaluate progress at set times.
- Accept contingency requirements if milestones are not met.

For the Minnesota River TMDLs, downstream Lake Pepin TMDL, and South Metro Mississippi TSS TMDL, the MPCA has loosely adopted the Chesapeake Bay reasonable assurance framework, with some modifications as follows:

- Use the sediment reduction strategies for the Minnesota River Basin (included in the *Sediment Reduction Strategy* [MPCA 2015b]) and the local watershed plans (and WRAPS) to meet TMDL allocations according to a phased schedule of implementation. Together these strategies provide specific activities to be implemented at appropriate scales—broad basin wide initiatives and more specific actions for major watersheds. The *Sediment Reduction Strategy* was completed in 2015 and additional investigation is underway to further support selection of implementation measures; the MPCA staff are leading development of WRAPS; and the

Minnesota Board of Water and Soil Resources (BWSR) is providing guidance and resources for local water planning including 1W1P efforts.

- Evaluate existing programmatic, funding, and technical capacity to fully implement basin and watershed strategies.
- Pursue specific, iterative, short-term milestones as described in the *Sediment Reduction Strategy* (i.e., sediment reduction target of 25% by 2020 in the Minnesota River) and WRAPS documents. Continuously monitor progress and consider adaptive management. Minnesota is a leader in tracking BMP implementation and pollutant loading, and uses the following tools:
  - The Clean Water Legacy Act requires biennial reporting on the implementation of approved WRAPS and TMDL projects, including progress on BMP adoption and spending. Data for MPCA's BMP reporting is provided through BWSR's web-based conservation tracking system eLink, which tracks state-funded nonpoint source BMPs, including estimated load reductions. In addition, conservation easements associated with the Reinvest in Minnesota (RIM) Reserve program are tracked by BWSR. Implementation practices supported by the Natural Resources Conservation Service (NRCS) Environmental Quality Incentives Program (EQIP) are also made available at a HUC12 watershed scale. Regularly scheduled reporting allows state agencies to identify gaps in current programs, funding, and technical capacity to fully implement basin and watershed strategies.
  - The Watershed Pollutant Load Monitoring Network (WPLMN) measures and compares data on pollutant loads from Minnesota's rivers and streams and tracks water quality trends.
- Accept contingency requirements if certain milestones are not on schedule. Regular evaluation of permitted discharges will continue, but as the *Sediment Reduction Strategy* and this TMDL study determined that point sources make up a small portion of the sediment in the major rivers, reductions are focused on nonpoint sources. Contingency requirements to be implemented if nonpoint source targets are not met will focus on nonpoint sources themselves and could take the form of a review of statewide nonpoint source control programs and policies by state agencies and of their implementation by local agencies.

The targeting of BMPs and ongoing measurement of the effectiveness of nonpoint source remediation measures also will provide some assurance of achieving the LA of this TMDL. Minnesota has devoted significant time and resources to developing tools that support local government units' efforts to prioritize and target nonpoint source work. In addition, interagency work groups formed to direct the state's Clean Water Fund will help to ensure that nonpoint source load reductions will be achieved. These groups will develop aids and guidance related to monitoring, implementation, research, and identification of measures and outcomes. Within this framework of implementation, reasonable assurance will be provided with regard to nonpoint source controls through commitments of funding, watershed planning, and use of existing regulatory authorities.

The Clean Water Legacy Act (2006, subsequently amended with accountability language) provided the MPCA authority and direction for carrying out section 303(d) of the CWA and has served to shape tool development and WRAPS content, both of which support subsequent water planning and focusing of conservation monies. In November 2008, Minnesotans voted in support of the Clean Water, Land and Legacy Amendment to the state constitution. Through this historic vote, about $5.5 billion will be dedicated to the protection of water and land over 25 years. One-third of the annual proceeds from sales tax revenue, an estimated $90 million, will be devoted to a Clean Water Fund to protect, enhance, and restore water quality of lakes, rivers, streams, and groundwater. The amendment specifies that this funding must supplement and not replace traditional funding. Approximately two-thirds of the annual proceeds will be earmarked for water quality protection and restoration.

8.2 Basin, Regional, and Local Entities

In addition to local governments, counties, soil and water conservation districts, state and federal agencies, and volunteer/nongovernmental organizations, there are numerous watershed groups in the Minnesota River Basin (Table 10). These watershed groups have different levels of organization and structure, but share a common goal to protect and improve water quality. They typically conduct watershed outreach and education activities, monitoring, research, and project planning and implementation. They are often the link between landowners and planning initiatives set on a watershed, region, or basin wide scale. The level of activity being conducted by these organizations and available funding mechanisms such as the Clean Water Fund and CWA Section 319 grant programs to continue funding their work provide additional reasonable assurance that implementation will continue to occur to address nonpoint sources of sediment. For example, the Greater Blue Earth River Alliance has secured over $6 million in grant funds over the past 11 years to conduct research and implementation activities focused on water quality.

Table 10. Watershed organizations.
Organizations upstream of the boundary condition at Lac qui Parle Dam are not included.

Watershed Organization	Website
Chippewa River Watershed Project	http://www.chippewariver.org/
Yellow Medicine River Watershed District	http://www.ymrwd.org/
Hawk Creek Watershed Project	https://www.hawkcreekwatershed.org/
Redwood–Cottonwood Rivers Control Area	http://www.rcrca.com/
Greater Blue Earth River Alliance	http://www.gberba.org/
Le Sueur River Watershed Network	http://lesueurriver.org
High Island Watershed District High Island Creek Watershed Project	https://www.sibleyswcd.org/watersheds-program
Lower MN River Watershed District	http://watersheddistrict.org/

Other organizations in the Minnesota River Basin that are supporting implementation include:

- Minnesota River Basin Data Center, Minnesota State University Mankato Water Resource Center (http://mrbdc.mnsu.edu/)—Providing basin wide data management and coordination.
- Minnesota River Watershed Alliance and Minnesota River Congress (http://watershedalliance.blogspot.com/)—Coordinating basin wide governance and opportunities for stakeholders.
- Coalition for a Clean Minnesota River (http://www.ccmnriver.org/)—A grass-roots organization coordinating citizen and business interests in basin wide efforts.

The Minnesota River Basin Data Center includes a list of other organizations that are active in the Minnesota River Basin.

8.3 Summary of Local Plans

Minnesota has a long history of water management by local governments. 1W1P is rooted in this history and in work initiated by the Minnesota Local Government Roundtable (an affiliation of the Association of Minnesota Counties, Minnesota Association of Watershed Districts, and Minnesota Association of Soil and Water Conservation Districts). Roundtable members recommended that the local governments charged with water management responsibility should organize and develop focused implementation plans on a watershed scale.

The recommendation was followed by legislation that authorizes BWSR to adopt methods to allow comprehensive plans, local water management plans, or watershed management plans to serve as substitutes for one another or to be replaced with one comprehensive watershed management plan. This legislation is referred to as "1W1P" (Minn. Stat. §103B.101, subd. 14). Further legislation defining purposes and outlining additional structure for 1W1P, officially known as the Comprehensive Watershed Management Planning Program (Minn. Stat. §103B.801), was passed in May 2015.

BWSR's vision for 1W1P is to align local water planning on major watershed boundaries with state strategies towards prioritized, targeted, and measurable implementation plans—the next logical step in the evolution of water planning in Minnesota and an important component of the reasonable assurance framework. Figure 26 summarizes the current (May 2017) status of 1W1P in the state. Within the Minnesota River Basin, one watershed-based plan has been completed (Yellow Medicine River) and three are underway (Pomme de Terre, Watonwan, Hawk Creek).

As indicated in Figure 26, the transition to 1W1P will take time. Prior to full adoption of 1W1P, water planning continues to be done outside of the Twin Cities Metropolitan Area on a county basis, per the Comprehensive Local Water Management Act (Minn. Stat. §103B.301) (see link for status of local water management plans). Within the metropolitan area, water planning is subject to Minn. R. ch. 8410, and is done on a watershed district or watershed management organization basis. All local water plans incorporate implementation strategies aligned with or called for in TMDLs and WRAPS.

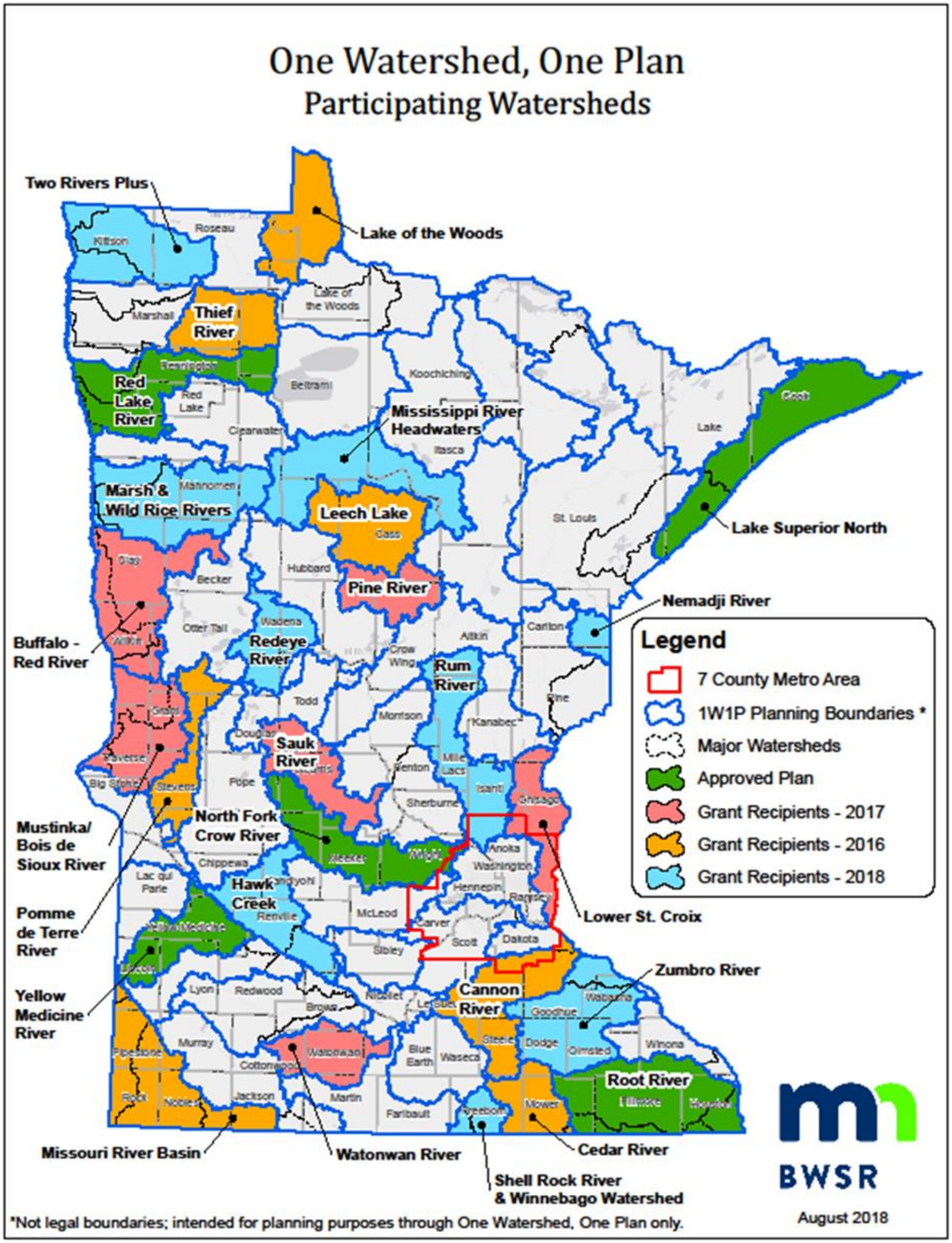

Figure 26. One Watershed, One Plan status map (August 2018).

8.4 Basin Wide Nonpoint Source Reduction Activities

Various state and regional nonpoint source reduction activities (programs) contribute to the reasonable assurance of the TMDL. The *Sediment Reduction Strategy for the Minnesota River Basin and South Metro Mississippi River* (MPCA 2015b) and *Nutrient Reduction Strategy* (MPCA 2014) provide a basin and state framework, respectively, of the activities, partners, and funding needs and opportunities to achieve the pollutant reductions needed to achieve water quality goals. WRAPS and comprehensive local water planning build on the basin and statewide strategies to prioritize and focus implementation activities in the major watersheds. The reasonable assurance provided by these efforts for this TMDL is supported by the opinion of the State of Minnesota Court of Appeals (2016) in A15-1622 MCEA vs MPCA & MCES stating that "*…substantial evidence exists to conclude that voluntary reductions from nonpoint sources have occurred in the past and can be reasonably expected to occur in the future*." The court decision was made in a lawsuit challenging the MPCA's issuance of a NPDES permit for five of the Metropolitan Council Environmental Services' municipal wastewater treatment facilities.

The following examples describe programs that have proven to be effective over time and/or that will reduce sediment loads going forward.

Buffer Program

The Buffer Law signed by Governor Dayton in June 2015 was amended on April 25, 2016, and further amended by legislation signed by Governor Dayton on May 30, 2017. The Buffer Law requires the following:

- For all public waters, the more restrictive of:
  - a 50-foot average width, 30-foot minimum width, continuous buffer of perennially rooted vegetation, or
  - the state shoreland standards and criteria.
- For public drainage systems established under Minn. Stat. ch. 103E, a 16.5-foot minimum width continuous buffer.

Alternative practices are allowed in place of a perennial buffer in some cases. The amendments enacted in 2017 clarify the application of the buffer requirement to public waters, provide additional statutory authority for alternative practices, address concerns over the potential spread of invasive species through buffer establishment, establish a riparian protection aid program to fund local government buffer law enforcement and implementation, and allowed landowners to be granted a compliance waiver until July 1, 2018, if they filed a compliance plan with the soil and water conservation district.

BWSR provides state oversight of the buffer program, which is primarily administered at the local level; compliance with the Buffer Law in the state is displayed at https://mn.gov/portal/natural-resources/buffer-law/map/compliance-map.jsp .

Groundwater Protection Rule

In June of 2019, the final Groundwater Protection Rule was finalized and published in the Minnesota State Register. This new rule will regulate nitrogen application in vulnerable groundwater areas. The rule will become effective January 1, 2020. The rule contains two parts and farmers may be subject to one part of the rule, both, or none at all depending on geographic location.

Part one restricts fall application of nitrogen fertilizer if a farm is located in a vulnerable groundwater area where at least 50% or more of a quarter section is designated as vulnerable or a public water drinking supply management area (DWSMA) with nitrate-nitrogen testing at least 5.4 mg/L in the previous ten years. Once the rule is effective, fall application restrictions will being in the fall of 2020.

Part two will apply to farming operations in a DWSMA with elevated nitrate levels and farms will be subject to a sliding scale of voluntary and regulatory actions based on the concentration of nitrate in the well and the use of BMPs. In part two, no regulatory action will occur until after at least three growing seasons once a DWSMA is determined to meet the criteria for level two.

Section 319 Small Watershed Focus Program

The federal CWA Section 319 (Section 319) grant program provides funding to states to address nonpoint source water pollution in watersheds. The MPCA has adopted a 319 Small Watersheds Focus Program to focus on geographically smaller and longer-term watershed projects (Section 319 Small Watersheds Focus). The intent of the program is to make measureable progress for targeted waterbodies in the 319 Focus Watersheds, ultimately restoring impaired waters and preventing degradation of unimpaired waters. Successful restorations in the Minnesota River Basin through this program will support the overall TSS reductions required for the Minnesota River.

Agricultural Water Quality Certification Program

The Minnesota Agricultural Water Quality Certification Program is a voluntary opportunity for farmers and agricultural landowners to take the lead in implementing conservation practices that protect waters. Those who implement and maintain approved farm management practices are certified and in turn obtain regulatory certainty for a period of 10 years.

Through this program, certified producers receive:

- **Regulatory certainty**: Certified producers are deemed to be in compliance with any new water quality rules or laws during the period of certification.
- **Recognition**: Certified producers may use their status to promote their business as protective of water quality.
- **Priority for assistance**: Producers seeking certification can obtain specially designated technical and financial assistance to implement practices that promote water quality.

Through this program, the public receives assurance that certified producers are using conservation practices to protect Minnesota's lakes, rivers, and streams.

Minnesota's Soil Erosion Law

Minnesota's soil erosion law is found in Minn. Stat. §§ 103F.401, through 103F.455. The law, which dates back to 1984, sets forth a strong public policy stating that a person may not cause excessive soil loss. The law was entirely permissive; however, in that it only encouraged local governments to adopt soil erosion ordinances and could not be implemented without a local government ordinance. The soil erosion law was changed in 2015 when a number of revisions were made by the Legislature and approved by the Governor to broaden its applicability.

Minnesota Laws 2015, regular and first special sessions changed the law by (1) repealing Minn. Stat. 103F.451, "Applicability," which eliminates the requirement that the law is only applicable with a local government ordinance; (2) creating specific Administrative Penalty Order authority in Minn. Stat. 103B.101, subd. 12a. for BWSR and counties to enforce the law; and 3) amending Minn. Stat. 103F.421, "Enforcement," to remove local enforcement only through civil penalty, and to revise requirements for state cost-share of conservation practices required to correct excessive soil loss. By definition, *excessive soil loss* means soil loss that is greater than established soil loss limits or evidenced by sedimentation on adjoining land or in a body of water. The result of the combined changes now sets forth statewide regulation of excessive soil loss regardless of whether a local government has a soil loss ordinance (BWSR 2016).

Agriculture Research, Education and Extension Technology Transfer Program (AGREETT)

The purpose of AGREETT is to support agricultural productivity growth through research, education and extension services. Since 2015, when the AGREETT program was established by the state legislature, significant progress has been made toward restoring and expanding capacity and research capabilities at the University of Minnesota in the College of Food, Agriculture and Natural Sciences, Extension and the College of Veterinary Medicine. As of February 2019, 21 faculty and extension educators have been hired along with needed infrastructure upgrades in the areas of crop and livestock productivity, soil fertility, water quality and pest resistance. Researchers who have been hired are pursuing work in the areas of manure management including strip till of liquid manure and precision application of manure based on nutrient content rather than volume, precision agriculture, agricultural practices to ensure good water quality under irrigation and promotion of BMPs for nitrogen and phosphorus management in row crop production. This addition of capacity at the University of Minnesota for public research covering several areas related to restoration and protection strategies will benefit water quality in the Minnesota River Basin long-term.

Drainage System Repair Cost Apportionment Option

Minnesota drainage law, Chapter 103E, was updated in 2019 to add a voluntary, alternative method for cost apportionment that better utilizes technology to more equitably apportion drainage system repair costs, based on relative runoff and sediment contributions to the system, thus providing an incentive to reduce runoff and sediment contributions to the drainage system. This voluntary option is available for drainage authorities to use and is limited to repair costs only. The option also includes applicable due process hearings, findings, orders and appeal provisions consistent with other aspects of drainage law.

Conservation Reserve Enhancement Program

Minnesota was awarded a $500 million Conservation Reserve Enhancement Program (CREP) funding that when fully implemented will convert approximately 60,000 acres of land to perennial cover (perpetual easements) within 54 counties in western and southern Minnesota, including the Minnesota River Basin (Figure 27).

CREP is an offshoot of the Conservation Reserve Program (CRP), the country's largest private-land conservation program. Administered by the U.S. Department of Agriculture (USDA) Farm

Service Agency (FSA), CREP targets state-identified, high-priority conservation issues. Five Minnesota state agencies have come together to support Minnesota CREP, including BWSR, Minnesota Department of Agriculture (MDA), Department of Health, DNR, and MPCA. This project is a federal, state, and local partnership and will voluntarily retire environmentally sensitive land using the nationally recognized RIM Reserve program. This is accomplished through permanent protection by establishing conservation practices via payments to farmers and agricultural landowners. Enrollment began in 2017.

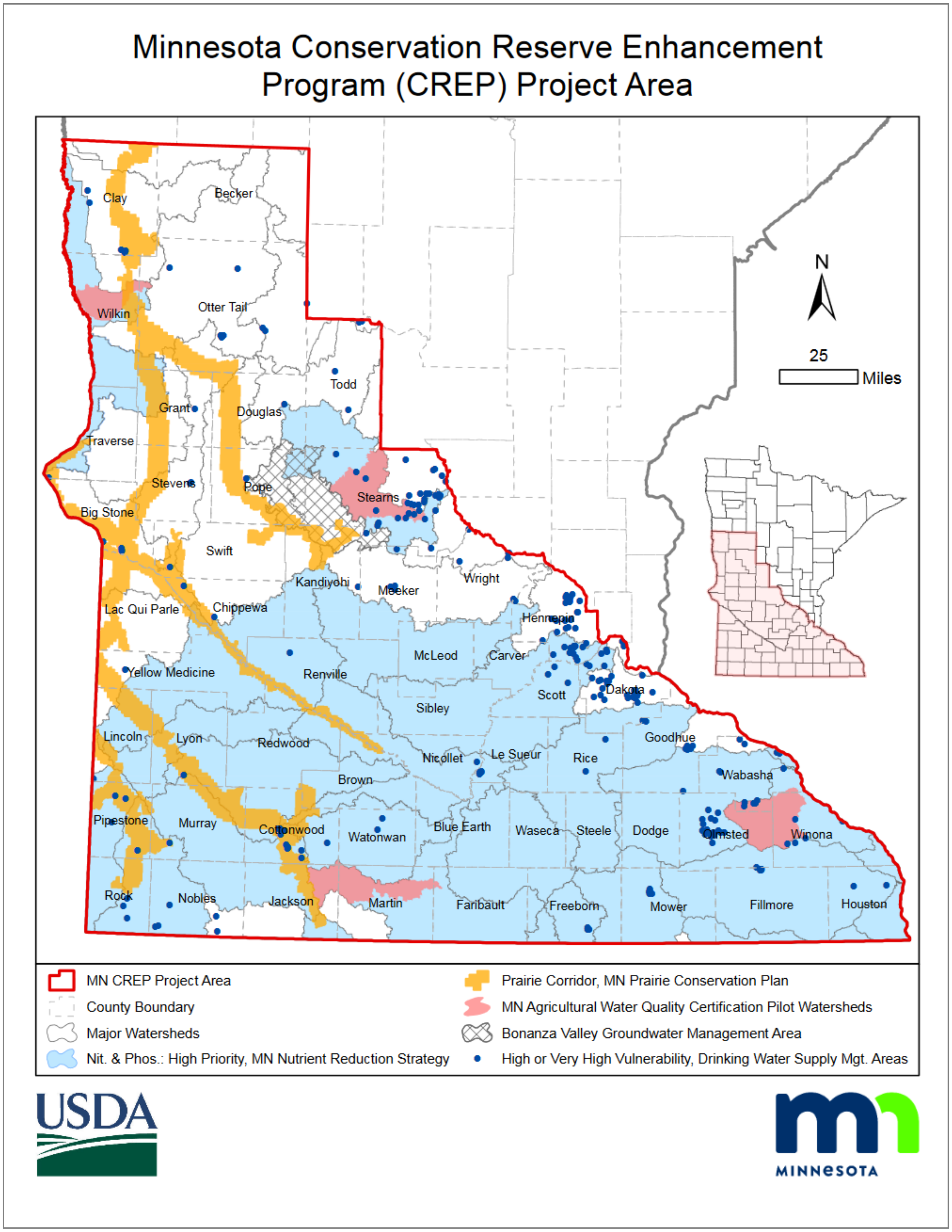

Figure 27. Minnesota CREP map.
Map from http://www.bwsr.state.mn.us/crep/

9. Monitoring Plan

This monitoring plan provides an overview of what is expected to occur at many scales in multiple watersheds within the Minnesota River Basin. Aquatic life will be the ultimate measure of water quality. Improving aquatic life depends on many factors, and improvements will likely not be detected over the next 5 to 10 years. Consequently, a monitoring plan is needed to track shorter term changes in water quality and land management. Monitoring is important for several reasons, including:

- Evaluating water bodies to determine if they are meeting water quality standards and tracking trends
- Assessing potential sources of pollutants
- Determining the effectiveness of implementation activities in the watershed
- Delisting of waters that are no longer impaired

Monitoring is also a critical component of an adaptive management approach and can be used to help determine when a change in management is needed. Several types of monitoring will be important to measuring success. The six basic types of monitoring listed below are based on the EPA's *Protocol for Developing Sediment TMDLs* (EPA 1999).

Baseline monitoring—identifies the environmental condition of the water body to determine if water quality standards are being met and identify temporal trends in water quality.

Implementation monitoring—tracks implementation of sediment reduction practices using BWSR's eLink or other tracking mechanisms.

Flow monitoring—is combined with water quality monitoring at the site to allow for the calculation of pollutant loads.

Effectiveness monitoring—determines whether a practice or combination of practices are effective in improving water quality.

Trend monitoring—allows the statistical determination of whether water quality conditions are improving.

Validation monitoring—validates the source analysis and linkage methods in sediment source tracking to provide additional certainty regarding study findings. For instance monitoring above and below knickpoints rather than just at the watershed outlet to help constrain and identify sediment sources.

There are many monitoring efforts in place to address each of the six basic types of monitoring. Key monitoring programs that will provide the necessary information to track trends in water quality and evaluate compliance with TMDLs include the following:

- Intensive watershed monitoring and assessment at the HUC-8 scale associated with Minnesota's watershed approach. This monitoring effort is conducted every 10 years for each HUC-8. An outcome of this monitoring effort is the identification of waters that are impaired (i.e., do not meet standards and need restoration) and waters in need of protection to prevent impairment. Over time condition monitoring can also identify trends in water quality. This helps determine whether water quality conditions are improving or declining, and it identifies how management actions are improving the state's waters overall.

- The MPCA's WPLMN measures and compares data on pollutant loads from Minnesota's rivers and streams and tracks water quality trends. WPLMN data will be used to assist with assessing impaired waters, watershed modeling, determining pollutant source contributions, developing watershed and water quality reports, and measuring the effectiveness of water quality restoration efforts. Data are collected along major river mainstems, at major watershed (i.e., HUC-8) outlets to major rivers, and in several subwatersheds. This long-term monitoring program began in 2007.
- Discovery Farms Minnesota is a farmer-led program that collects farm- and field-scale monitoring data under real-world conditions at a limited number of sites. The program is coordinated by the Minnesota Agricultural Water Resource Center in partnership with the MDA and the University of Minnesota Extension.
- BMP implementation monitoring is conducted by both BWSR (i.e., eLink) and USDA. Both agencies track the locations of BMP installations. Tillage transects and crop residue data are collected periodically and reported through the Tillage Transect Survey Data Center.
- Discharges from permitted municipal and industrial wastewater sources are reported through discharge monitoring records (see Section 4.4.3); these records are used to evaluate compliance with NPDES permits. Summaries of discharge monitoring records are available through the MPCA's Wastewater Data Browser.

10. Implementation Strategy Summary

The goals, timelines, and strategies for sediment load reductions in the impaired waters addressed in this TMDL report are set in a greater context of basin wide work to reduce sediment from both point and nonpoint sources in the overall Minnesota River Basin. The MPCA has developed the *Sediment Reduction Strategy for the Minnesota River Basin and South Metro Mississippi River* (MPCA 2015b) to establish a foundation for local water planning to reach sediment reduction goals developed as part of TMDLs. Additional investigation is underway to further support selection of implementation measures. The *Sediment Reduction Strategy* states:

> This high-level, large-scale Sediment Reduction Strategy was developed to initiate action and inform watershed planning efforts prior to the completion of the TMDLs. This document does not provide a detailed sequence of instructions that will lead to the sediment reduction goals for each watershed. Rather, it is a starting point that outlines general strategies and actions for local watershed managers to consider while developing individual action plans to meet local and downstream sediment reduction goals.

The *Sediment Reduction Strategy* outlines a milestone goal of reducing sediment in the Minnesota River by 25% by 2020 and by 50% by 2030, with a goal of meeting TMDL sediment reduction requirements by 2040 (MPCA 2015b). In addition to the sediment reduction goals, the *Sediment Reduction Strategy* also provides peak flow reduction goals to further address sediment reduction:

- Reduce two-year annual peak flow rates by 25% by 2030.
- Decrease the number of days the two-year peak flow is exceeded by 25% by 2030.

The MPCA expects that a combination of reduction strategies, simultaneously addressing reduction from upland and near-channel sources, will be most successful.

Management practices that reduce sediment loading in the Minnesota River Basin will also represent progress towards achieving the completed *South Metro Mississippi River TSS TMDL* (MPCA 2015a) and the Minnesota River and Lake Pepin excess nutrients TMDLs, which are underway. The *South Metro Mississippi River TSS TMDL* (MPCA 2015a) requires a 60% reduction in TSS loading from the Minnesota River under very high and high flows, and a 50% reduction in the remaining flow zones. The load reductions needed to meet the goals for the most downstream Minnesota River reach in this project (AUID 07020012-505) are greater under very high and high flows than they are under the remaining flows. Under very high flows, a load reduction of approximately 60% is needed to meet the TMDL, and an 80% reduction is needed under high flows (Figure 28). These reductions achieve the 60% load reduction needed for the Minnesota River in the downstream Mississippi River TSS TMDL. Lower load reductions are needed for the Minnesota River TMDL in the remaining flow zones, ranging from 0% under very low flows to 17% under mid-range flows (Figure 28).

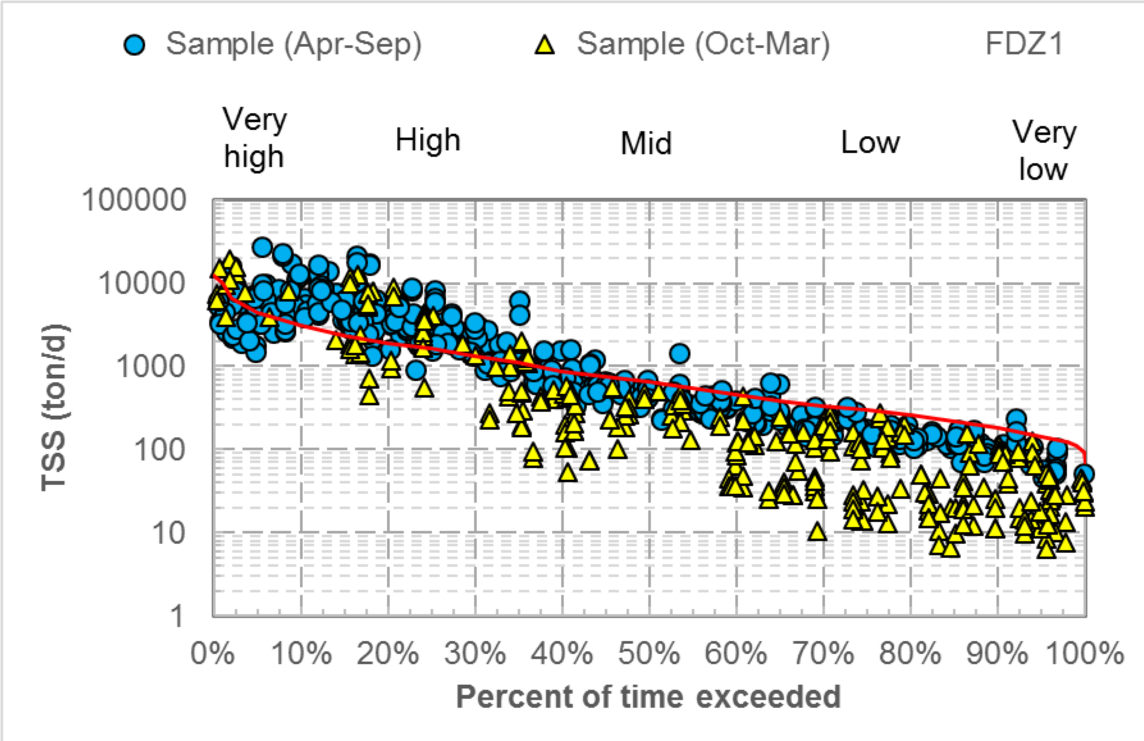

Figure 28. TSS load duration curve, Minnesota River (07020012-505).

Detailed implementation planning for the Minnesota River will occur at the individual major watershed (i.e., HUC-8) level as part of Minnesota's watershed approach. Minnesota's watershed approach to restoring and protecting water quality is based on a major watershed, or HUC-8, scale. This watershed-level planning occurs on a 10-year cycle beginning with intensive watershed monitoring and culminates in local implementation (Figure 29). A WRAPS report is produced as part of this approach and addresses restoration of impaired watersheds and protection of unimpaired waters in each HUC-8 watershed. The WRAPS for each HUC-8 watershed includes elements such as implementation strategies, timelines, and interim milestones. These high-level strategies are then used to inform watershed management plans (e.g., 1W1P as described in Section 8.2) that focus on local priorities and knowledge to identify prioritized, targeted, and measurable actions and locally based strategies. These plans further define specific actions, measures, roles, and financing for accomplishing water resource goals.

Table 11 lists the start date for watershed monitoring and assessment (i.e., intensive watershed monitoring) and the status of restoration and protection strategy development (i.e., WRAPS). All of the watersheds in the Minnesota River Basin are within the first 10-year cycle or beginning the second 10-year cycle (

Table 11).

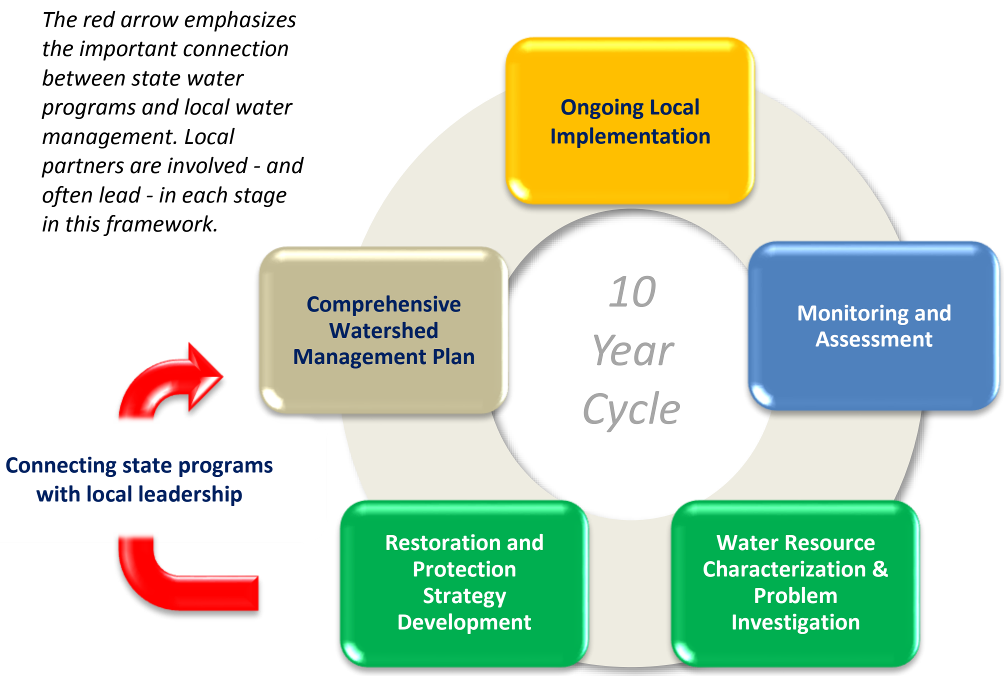

Figure 29. Minnesota's watershed approach.

Table 11. Priority watershed planning schedule.

Watershed	WRAPS Status	Intensive Watershed Monitoring Begins [a]	
		First Cycle	Second Cycle
Chippewa River	Approved (2017)	2009	2019
Hawk Creek	Approved (2017)	2010	2020
Yellow Medicine	Approved (2016)	2010	2020
Redwood River	Underway	2017	2026
Cottonwood River	Underway	2017	2026
Watonwan River	Underway	2013	2023
Blue Earth River	Underway	2017	2027
Le Sueur River	Approved (2015)	2008	2018
Minnesota River–Mankato	Underway	2013	2023
Lower Minnesota River	Underway	2014	2024

a. Anticipated schedule, subject to change.

10.1 Nonpermitted Sources

The *Sediment Reduction Strategy* focuses on reducing peak streamflow magnitude and duration to reduce near-channel erosion and on reducing upland erosion through soil health enhancement as a priority (MPCA 2015b). The *Sediment Reduction Strategy* also presents the following strategies to achieve sediment reduction goals:

- Establish a sediment reduction task force and stakeholder workgroups.

- Coordinate implementation with the state nutrient reduction strategy.
- Direct effective action toward implementation at the local level.
- Use existing soil conservation policy.
- Learn from successes and failures of other large-scale implementation efforts.
- Use prioritization tools.
- Address additional research and monitoring needs.

Additional investigation is underway to further support selection of implementation measures in the *Sediment Reduction Strategy*; additional technical analysis includes evaluating the hydrologic conditions under which impairments occur and simulating a variety of potential BMPs on the field scale as well as larger watershed and basin wide scales.

Specific to the Greater Blue Earth River Basin, a five-year research study titled the Collaborative for Sediment Source Reduction–Greater Blue Earth River Basin concluded in 2017 and provided an evaluation of sediment reduction strategies. Primary implementation findings included the following:

- Ravines that are large local sources of sediment can be targeted. Investment in stabilizing these ravines is worthwhile, but not sufficient to reduce sediment loading to meet water quality standards.
- Eroding bluffs that threaten infrastructure and produce exceptionally large amounts of sediment can be targeted. Investment in stabilizing these bluffs is worthwhile, but bluff stabilization is not the most effective solution for long-term reduction in sediment loading across the watershed.
- Achieving water quality standards will require priority investment in more temporary water storage to reduce high river flows and bluff erosion. This is a critical component of a strategy to reduce sediment in the Minnesota River.

Sediment reduction efforts at the magnitude needed to meet water quality standards will require participation from multiple organizations and all users of the land in the watershed. Making the progress needed to reach sediment reduction goals will require significant time and effort. It will include building on existing research and sediment reduction efforts, as well as identifying and implementing new and innovative programs and practices.

A combination of practices that keep the soil and sediment in place, temporarily store water, reduce surface and subsurface runoff volume and peak flows, and/or address near-channel sources will be needed to effectively reduce erosion from nonpoint sources. The magnitude, frequency, and timing of erosional processes, as well as the cost-effectiveness of related solutions, will ultimately determine the balance of the selected practices in any one particular area of the basin.

A wide range of BMPs has been developed to reduce sediment erosion and transport from upland areas, including the following:

- Grassed waterways
- Water and sediment basins
- Conservation cover easements

- Residue management through conservation or reduced tillage
- Forage and biomass planting
- Cover crops
- Contour cropping
- Strip cropping
- Open tile inlet controls—riser pipes or French drains
- Vegetated buffers on field edges and riparian areas

In addition to BMPs focused on upland sediment erosion and transport, BMPs that address runoff and drain tile flows are also needed (e.g., controlled drainage). Finally, improving the soil's water-holding capacity through soil health enhancement is critical.

Practices and actions for reducing near-channel sources of sediment include direct and indirect controls. *Direct controls* include practices such as limiting ravine erosion with a drop structure or energy dissipater, or controlling streambank or bluff erosion through stream channel restoration. *Indirect controls* typically involve land management practices and structural practices designed to temporarily store water or shift runoff patterns by increasing evapotranspiration at critical times of the year. The temporary storage of water and a shift in runoff patterns are needed to reduce peak flows and extend the length of storm hydrographs, which in turn will reduce the erosive power of streamflow on streambanks and bluffs. While direct controls are an important option, they are designed for fixing discrete erosion sites on the landscape and will not make significant water quality impacts at the watershed scale. Indirect controls can be applied watershed wide with the cumulative potential to reduce flows and sediment delivery to the Minnesota River.

10.2 Permitted Sources

10.2.1 Construction Stormwater

The WLA for stormwater discharges from sites where there is construction activity reflects the number of construction sites larger than one acre expected to be active in the watershed at any one time, and the BMPs and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. The BMPs and other stormwater control measures that should be implemented at construction sites are defined in the state's NPDES/SDS general stormwater permit for construction activity (MNR100001). If a construction site owner/operator obtains coverage under the NPDES/SDS general stormwater permit and properly selects, installs, and maintains all BMPs required under the permit, including those related to impaired waters discharges and any applicable additional requirements found in Appendix A of the construction general permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL. All local construction stormwater requirements must also be met.

10.2.2 Industrial Stormwater

The WLA for stormwater discharges from sites where there is industrial activity reflects the number of sites in the watershed for which NPDES industrial stormwater permit coverage is required and the BMPs and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. The BMPs and other stormwater control measures that should be implemented at the industrial sites are defined in the state's NPDES/SDS industrial stormwater multi-sector general permit (MNR050000) or NPDES/SDS general permit for construction sand and gravel, rock quarrying and hot mix asphalt production facilities (MNG490000). If a facility owner or operator obtains stormwater coverage under the appropriate NPDES/SDS permit and properly selects, installs, and maintains all BMPs required under the permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL. All local stormwater management requirements must also be met.

10.2.3 MS4s

There are 60 regulated MS4s in the Minnesota River Basin and 4 MS4s that are expected to come under permit coverage in the next permit cycle (see Appendix F). To meet the WLAs for permitted MS4s, TSS loading does not need to be reduced but is not allowed to increase. MS4 permittees are required to document compliance with WLA(s) over time as part of their MS4 SWPPP. MS4s must determine if they are currently meeting their WLA(s) and, if not, provide a narrative strategy and compliance schedule to meet the WLA(s).

For new development projects, the MPCA’s current phase II MS4 general permit requires no net increase from pre-project conditions (on an annual average basis) of stormwater discharge volume, stormwater discharges of TSS, or stormwater discharges of total phosphorus. For redevelopment projects, the MPCA’s current phase II MS4 general permit requires a net reduction from pre-project conditions (on an annual average basis) of stormwater discharge volume, stormwater discharges of TSS, and stormwater discharges of total phosphorus. These provisions in the MS4 permit will prevent increases in annual loading.

10.2.4 Wastewater

Municipal and industrial wastewater treatment facilities are regulated through NPDES permits. These permits include sediment effluent limits designed to meet water quality standards, along with monitoring and reporting requirements to ensure effluent limits are met. For all but two wastewater facilities with WLAs, compliance with TSS permit effluent limits provides for the attainment of facilities’ WLA(s).

The current permit limit for Dairy Farmers of America Inc–Winthrop (MN0003671) is based on 66 mg/L TSS, and the current permit limit for Superior Minerals Company (MN0063584) is based on 188 mg/L TSS. Because both WLAs are based on 65 mg/L TSS, a water quality based effluent limit (WQBEL) will need to be considered upon permit reissuance.

10.3 Cost

TMDLs are required to include an overall approximation of implementation costs (Minn. Stat. § 114D.25). Nonpoint source cost information in the *South Metro Mississippi River TMDL* (MPCA 2015a) is used to provide the anticipated range of costs to achieve sediment reduction in the Minnesota River Basin. The costs to implement the activities outlined in the implementation strategy are approximately $10 to $40 million dollars per HUC-8 major watershed (MPCA 2015a) over the next 25 years.

10.4 Adaptive Management

The implementation strategy and the future detailed WRAPS reports focus on adaptive management (Figure 30) to ensure management decisions are based on the most recent knowledge. An adaptive management approach allows for changes in the management strategy if environmental indicators suggest that the strategy is inadequate or ineffective. Continued monitoring and course corrections responding to monitoring results are the most appropriate strategy for attaining the water quality goals established in this TMDL.

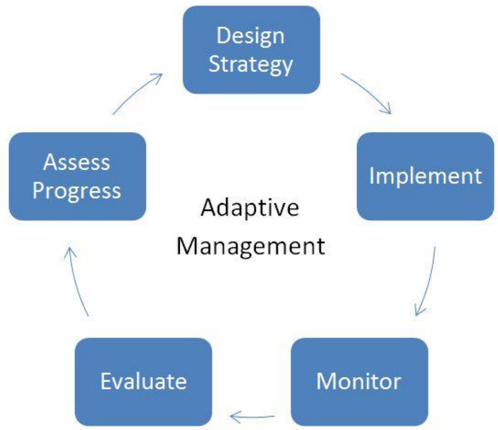

Figure 30. Adaptive management process.

Natural resource management involves a temporal sequence of decisions (or implementation actions), in which the best action at each decision point depends on the state of the managed system (Williams et al. 2009). As a structured iterative implementation process, adaptive management offers the flexibility for responsible parties to monitor implementation actions, determine the success of such actions, and ultimately, base management decisions upon the measured results of completed implementation actions and the current state of the system. This process enhances the understanding and estimation of predicted outcomes and ensures refinement of necessary activities to better guarantee desirable results. In this way, understanding of the resource can be enhanced over time and management can be improved (Williams et al. 2009).

The sediment reduction needs in the TMDL represent aggressive goals. Implementation will be conducted using an adaptive management approach. Changes in technology, research, weather, and other variables may alter the course of action. Continued monitoring and adjustments responding to monitoring results are the most appropriate strategy for attaining the water quality targets established in this TMDL.

Three types of activities are needed: (1) groundwork, including research and developing more specific strategies prior to implementation based on planning and logistical work, prioritization, and the identification of funding mechanisms; (2) implementation activities based on the groundwork already described; and (3) continued implementation in cases in which practices are not adopted. Interim milestones are provided in the *Sediment Reduction Strategy* (MPCA 2015b) that are in part based on the timeline needed to implement these activities: 25% reduction by 2020, 50% reduction by 2030, and a goal of meeting TMDL sediment reduction requirements by 2040. Adjustments to this timeline will occur as organizations undertake various facets of the research and implementation agendas. Additionally, local watershed projects may elect to prioritize the list differently given local needs. This timeline is not intended to delay work. Rather the approach is to allow time for research, demonstrations, and development of targeting mechanisms prior to focused implementation activities.

Additional information on using an adaptive management approach for the Minnesota River Basin is provided in the *Sediment Reduction Strategy* (MPCA 2015b).

11. Public Participation

This section describes the large stakeholder involvement processes conducted as part of development of the draft turbidity TMDLs for the Minnesota River and the Greater Blue Earth River Basin. In addition, the draft turbidity TMDLs each went through a public review comment period (Minnesota River—February 27, 2012, through May 29, 2012; Greater Blue Earth—April 23, 2012, through May 29, 2012). Those comments were taken into account in developing this TMDL document.

11.1 Draft Minnesota River Turbidity TMDL Stakeholder Meetings

Several stakeholder-focused activities were conducted between 2006 and 2010 designed to foster communication and commitment. Early in the process, a stakeholder advisory committee was formed, made up of representatives from major interest sectors, principally agriculture, cities, watersheds, local governments, and state agencies, but also including environmental organizations such as Coalition for a Clean Minnesota River. The advisory committee met once a quarter on average, with additional smaller gatherings by sector as needed.

The meetings were attended by approximately 40 people each and were designed with at least three purposes in mind:

- To keep stakeholders informed about progress on the TMDL
- To present timely technical information in lay language, and to seek feedback
- To facilitate dialogue to build shared understanding of the TMDL process and the choices facing the community

Presenters and panelists included MPCA staff and managers, hydrologic modeling experts, watershed professionals, researchers, and stakeholders.

Meetings included:

- March 2006 Stakeholder Committee Meeting

    Presentations:

    - March Meeting Agenda—Larry Gunderson, MPCA
    - Middle Minnesota River Watershed Report—Kevin Kuehner, Brown-Nicollet-Cottonwood Water Board
    - Natural and Background Turbidity Sources—Jim Klang, MPCA

- June 6, 2006, Stakeholder Committee Meeting (9:30 a.m.), Redwood Area Community Center, Redwood Falls.

    Draft Agenda

    Presentations:

    - Agricultural Practices in South Central Minnesota
    - Agricultural Practices in South Central Minnesota - Maps

- Chippewa River Watershed Project Since 1998

- July 20, 2006, Stakeholder Committee Meeting (9:30 a.m.), University of Minnesota Southern Research and Outreach Center, Waseca.

  Draft Agenda

- September 11, 2006, Stakeholder Committee Meeting (9:30 a.m.–3 p.m.), New Ulm Community Center.

  Draft Agenda

  Presentations:

  - Streambank/Bluff Erosion Estimate for High Island Creek and Watonwan River Watersheds

- November 2006 Stakeholder Committee Meeting

  Agenda

  Presentations:

  - Sediment Delivery Concepts—Pete Cooper, USDA
  - TMDL Update—Larry Gunderson, MPCA
  - Minnesota River Turbidity and Sediment Values—Pat Baskfield, MPCA
  - Practices For High Sensitivity Lands—Linda Meschke, Rural Advantage
  - Erosion Sensitivity in the Minnesota River Basin—Jason Ewert, MPCA

- March 29, 2007, Stakeholder Committee Meeting (10 a.m.–3 p.m.), Redwood Area Community Center, Redwood Falls.

- July 11, 2007, Stakeholder Committee Meeting (10 a.m.–3 p.m.), Holiday Inn, New Ulm.

  Agenda

  Presentations:

  - Ag Sector Issues
  - Urban Sector Issues
  - Watershed Sector Issues
  - Combined Sector Issues

- September 12, 2007, Stakeholder Committee Meeting (10 a.m.–3 p.m.), Holiday Inn, New Ulm.

  Presentations:

  - Hydraulic Change, Hydraulic Continuity, and Channel Response
  - How Does Sediment Affect Fish and Macroinvertebrates?

- November 27, 2007, Stakeholder Committee Meeting (10 a.m.–3 p.m.), Country Inn and Suites, Mankato.

Agenda: Developing scenarios for the water quality model

- March 10, 2008, Stakeholder Committee Meeting, New Ulm.

  Presentations:

  - Sediment Levels in the Minnesota River—Scott Matteson, MSU–Mankato Water Resources Center
  - Geochemical Fingerprinting—Dr. Dan Engstrom, St. Croix Watershed Research Station
  - Sediment Source Estimates Using Regression Techniques—Pat Baskfield, MPCA

- July 24, 2008, Stakeholder Committee Meeting (10 a.m.–3 p.m.), New Ulm Holiday Inn.

  Agenda: Preliminary modeling results

- December 16, 2008, Stakeholder Committee Meeting (10 a.m.–3 p.m.), New Ulm Holiday Inn.

  Agenda: Project status and latest modeling results.

- February 3, 2009, Advisory Committee Meeting (12:30–3:30 p.m.), New Ulm Public Library.

  Agenda: Model results, Lake Pepin allocations, communication strategy

  Presentations:

  - Elements of modeling scenario—Larry Gunderson, MPCA
  - Model results—Chuck Regan, Barr Engineering (currently with MPCA)
  - Allocation process for TMDL—Larry Gunderson, MPCA
  - Lake Pepin allocations for the Minnesota River—Norman Senjem, MPCA
  - Next steps—Hafiz Munir, MPCA

- August 27, 2009, Advisory Committee Meeting (10 a.m.–3 p.m.), New Ulm Public Library.

  Agenda: Summary of turbidity research synthesis, HSPF model results

  Presentations:

  - Identifying sediment sources in Minnesota River Basin
  - HSPF model scenarios 1–4
  - Turbidity TMDL allocations

- July 1, 2010, Stakeholder Meeting (9:30 a.m.–12 p.m.), Holiday Inn, New Ulm.

  Agenda: Catch-up conversations, What's up with the turbidity TMDL?

  - Progress and plans
  - Research status
  - Hydrology simulation
  - The new TMDL approach

- MPCA policies
- Urban partners
- A healthy, prosperous basin

The Minnesota River Summit was held in New Ulm in January 2007 and was attended by 200 stakeholders who had played leadership roles in water quality improvement over several decades. With its emphasis on identifying how progress could be accelerated, perhaps the most commonly held goal among the group, the two-day meeting surfaced two general conclusions:

- Communication throughout the watershed, from Western Minnesota to the Twin Cities, needs strengthening. With many groups addressing multiple agendas, the need for raising the profile of water quality work was underscored.
- Owing to the size of the watershed, and the complexity of both pollutants and societal issues, the group felt the need for a way to see the problem as a whole: How do these TMDL studies and others fit together, and with that, what are the high-leverage points for exponential change?

In June 2007, a second summit was held in New Ulm and was attended by about 50 selected stakeholders. The focus was on discussing strategies for moving forward.

11.2 Greater Blue Earth River Basin Stakeholder Meetings

The draft Greater Blue Earth River Basin Turbidity TMDL project worked closely with a broad array of county, state, and citizen groups and organizations. To address the broad interests that would be involved in the project, multiple stakeholder groups were developed. These groups were divided into technical/professional, related organizations, and volunteers/citizens.

The technical group included state, federal, and local government employees, research groups and projects, and joint powers boards. Agencies on the mailing and contact lists include USDA, NRCS, FSA, MPCA, BWSR, University of Minnesota Twin Cities, Mankato State University, USGS, National Center for Earth-Surface Dynamics (NCED), and Greater Blue Earth River Basin Alliance (GBERBA), Citizen Stream Monitoring Program volunteers, and concerned citizens.

Activities and meetings:

- November 2007—Presentation to GBERBA (Policy and Technical) regarding project; asked for assistance thorough the development of a subcommittee.
- January 2008—Updated GBERBA technical board on project progress.
- February 2008—Attended technical meeting, begin subcommittee selection process.
- February 2008—Sent out letters to Citizen Stream Monitoring Program volunteers and agricultural groups and organizations asking for participation in the project.
- March 2008—Afternoon meeting with GBERBA. Involved area project updates and thesis presentation.
- May 25, 2008 (4:30–8 p.m.)—Open public meeting in St. James.

- May 26, 2008 (4:30–8 p.m.)—Open public meeting in Waldorf.
- May 27, 2008 (4:30–8 p.m.)—Open public meeting in Blue Earth.
- July 12, 2008—Presentation at Gustavus Adolphus College for the Mayday conference.
- August 25, 2008 (6:30–7:30 p.m.)—Open public meeting held at the Mankato Public Library.
- September 17, 2008—Open technical advisory team meeting held at the USDA Service Center in Mankato.
- October 29, 2008 (7–8 p.m.)—Open public meeting held at Winnebago Community Center.
- February 17, 2009—Meeting at MPCA to discuss various aspects of the GBERB TMDL and the Minnesota River TMDL.
- September 23, 2009—Open technical advisory team meeting held at the MPCA office in Mankato.
- November 23, 2009—Open technical advisory team meeting to discuss loading and natural background held at the MPCA office in Mankato.
- February 15, 2010—Draft of the TMDL is sent to all technical advisory team members to allow for input and comments.
- March 24, 2010—Open technical advisory team meeting to discuss the draft of the TMDL.

11.3 Public Notice for Comments

A draft of this TMDL report was made available pre-public notice in April 2018. The MPCA staff met with stakeholder groups prior to the public notice period.

An opportunity for public comment on this draft TMDL report was provided via a public notice in the *State Register* from July 22, 2019 through September 20, 2019. There were 20 comments that were responded to as a result of the public notice.

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Appendices (See Separate Document)

Appendix A. Minnesota River AUID consolidation summary

Appendix B. Water quality summary tables

Appendix C. Flow data sources

Appendix D. Load duration curves and TMDLs

Appendix E. Individual wastewater WLAs

Appendix F. List of regulated MS4s that are part of categorical WLAs

Appendix G. List of Turbidity/TSS Impairments in the Minnesota River Basin below Lac qui Parle Dam and TMDL Status

Appendix H. HSPF Hydrology and Sediment Calibration and Validation Reports

Appendix I. CAFOs by HUC12