Watershed

July 2021

Marsh River Watershed
Total Maximum Daily Load Report

A watershed-wide report with a TSS and an *E. coli* TMDL to address impairments in the Marsh River.

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Cover Photo Credit: Taken by MPCA biological monitoring crew at the Marsh River biological monitoring station 05RD113 on July 7, 2014.

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Abbreviations

1W1P	One Watershed, One Plan
8-HUC	8-digit hydrologic unit code
10-HUC	10-digit hydrologic unit code
ARM	Agricultural Runoff Model
AQL	aquatic life
AQR	aquatic recreation
AU	animal unit
AUID	assessment unit identifier
BMP	best management practice
BWSR	Board of Water and Soil Resources
CAFO	concentrated animal feeding operation
CREP	Conservation Reserve Enhancement Program
CRP	Conservation Reserve Program
CWA	Clean Water Act
CWLA	Clean Water Legacy Act
cfs	cubic foot per second
DNR	Minnesota Department of Natural Resources
DO	dissolved oxygen
E. coli	*Escherichia coli*
EDA	Environmental Data Access
EPA	U.S. Environmental Protection Agency
EQuIS	Environmental Quality Information System
GIS	geographic information system
HSPF	Hydrological Simulation Program-Fortran
IBI	Index of Biological Integrity
in/yr	inches per year
ITPHS	imminent threat(s) to public health and safety
IWM	intensive watershed monitoring
LA	load allocation
LDC	load duration curve

LGU	local government unit
LIDAR	Light Detection and Ranging
MAWQCP	Minnesota Agricultural Water Quality Certification Program
mgd	million gallons per day
mg/L	milligrams per liter
mL	milliliter
MOS	margin of safety
MPCA	Minnesota Pollution Control Agency
MS4	municipal separate storm sewer system
NLCD	national land cover dataset
NPDES	National Pollutant Discharge Elimination System
NPS	nonpoint source
NRCS	Natural Resource Conservation Service
NRS	Nutrient Reduction Strategy
org/day	organisms per day
PWP	Permanent Wetland Preserve
RIM	Reinvest in Minnesota
SDS	state disposal system
SSTS	subsurface sewage treatment systems
SWCD	soil and water conservation district
TALU	tiered aquatic life uses
TMDL	total maximum daily load
TP	total phosphorus
TSS	total suspended solids
WLA	wasteload allocation
WQBELs	water quality-based effluent limits
WRAPS	Watershed Restoration and Protection Strategy
WWTP	wastewater treatment plant

Executive summary

Section 303(d) of the Clean Water Act (CWA) provides authority for completing Total Maximum Daily Loads (TMDLs) to achieve state water quality standards and/or designated uses. A TMDL is required to be completed for all impairments on Minnesota's 303(d) list and establishes the maximum amount of a pollutant a waterbody can receive on a daily basis and still meet water quality standards. The TMDL is divided into wasteload allocations (WLAs) for point or permitted sources, load allocations (LAs) for nonpoint sources (NPS) and natural background, plus a margin of safety (MOS).

The Marsh River Watershed (MRW) is in northwest Minnesota and is located in the Lake Agassiz Plain ecoregion within the Red River of the North (Red River) Basin. The MRW covers an area of approximately 362 square miles in Minnesota. The MRW boundaries presented in this TMDL cover portions of three counties in Minnesota including Norman (91% of the watershed), Clay (8%), and Polk (1%). The 8-digit Hydrologic Unit Code (8-HUC) 09020107, which the MRW is part of, encompasses areas in both North Dakota and Minnesota. Only waterbodies within the boundaries of Minnesota are included in this TMDL report.

Addressing multiple impairments in one TMDL report is consistent with Minnesota's Water Quality Framework that seeks to develop watershed-wide protection and restoration strategies, rather than focus on individual impairments. There are 13 impairments in four stream reaches listed on Minnesota's 2020 303(d) list (MPCA, 2019) within the MRW. This TMDL report addresses four impairments with two TMDLs: one aquatic recreation (AQR) use impairment caused by excessively high *Escherichia coli* (*E. coli*) with an *E. coli* TMDL and three aquatic life (AQL) use impairments caused by excessively high turbidity, and indicated by poor fish bioassessments and poor benthic macroinvertebrates bioassessments, with a total suspended solids (TSS) TMDL. All four of these addressed impairments are in the main stem of the Marsh River (assessment unit identifier [AUID] 09020107-503; hereafter, AUIDs are shortened to their unique 3-digit suffix [e.g., -503]). The impairment caused by high turbidity is addressed with a TSS TMDL, because Minnesota shifted from turbidity standards to TSS standards in 2015. The AQL use impairments identified by poor benthic macroinvertebrate and fish communities in -503 are also addressed with the TSS TMDL, because high suspended sediment was identified as a stressor. There are also nonpollutant stressors to the biological communities in -503, such as flow regime instability and insufficient physical habitat. Implementation of best management practices (BMPs) that lessen the severity to which both the nonpollutant and pollutant (TSS) stressors negatively affect biological communities will improve the index of biological integrity (IBI) scores with the goal of the scores meeting state standards.

Nine impairments in the MRW on Minnesota's 2020 303(d) list (MPCA, 2019) of impaired waterbodies that require a TMDL are not addressed in this TMDL report. The seven impairments on the mainstem of the Red River will be addressed later in other TMDL reports. An AQL use impairment caused by low dissolved oxygen (DO) in the Marsh River (-503) is not addressed due to insufficient information (MPCA, 2017). There is an AQL use impairment in County Ditch 11 (AUID -517) identified by poor fish communities, and while high suspended sediment is a stressor, TSS meets standards. DO is also a stressor, but low flow is the main cause, and more data is needed to determine whether a pollutant for which a TMDL can be developed also causes the low DO (MPCA, 2018).

This TMDL report used a variety of methods to evaluate current loading contributions by the various pollutant sources, as well as the allowable pollutant loading capacity (LC) of the impaired waterbody.

These methods include the use of available data, the Hydrological Simulation Program – FORTRAN (HSPF) model, and the load duration curve (LDC) approach. In the Marsh River (-503), available data showed that the majority of *E. coli* loading is attributed to livestock (53%) and the HSPF model showed that the vast majority of sediment loading originated from the stream bed and bank (52%) and cropland (40%). Overall estimated reductions of 0.5% and 29% are needed to meet standards for *E. coli* and TSS, respectively, in the Marsh River (-503). There are two National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) permitted wastewater treatment plants (WWTPs) that discharge within the drainage area of the impaired waterbody. Permit limits are already assigned to these WWTPs for TSS and fecal coliform that are consistent with the WLAs assigned in this report's TMDLs.

A general strategy and cost estimate for implementation to address the impairments are included. Implementation efforts will focus on NPS. Contributions by NPS are not regulated and will need to be addressed on a voluntary basis. Permitted point sources are addressed through the Minnesota Pollution Control Agency's (MPCA) NPDES/SDS permit programs. More information on the implementation strategies can be found in the *Marsh River Watershed Restoration and Protection Strategies (WRAPS) Report* (MPCA, 2021).

1. Project overview

1.1 Purpose

Section 303(d) of the federal CWA requires that TMDLs be developed for waters that do not support their designated uses. These waters are referred to as "impaired" and are listed in Minnesota's list of impaired waterbodies. The term "TMDL" refers to the maximum amount of a given pollutant a waterbody can receive on a daily basis and still achieve water quality standards. 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 and allocates pollutant loads among those sources. The total of all allocations, including WLAs for permitted sources, LAs for nonpermitted sources (including natural background), and the MOS, which is implicitly or explicitly defined, cannot exceed the maximum allowable pollutant load.

The passage of Minnesota's Clean Water Legacy Act (CWLA) in 2006 provided a policy framework and resources to state and local governments to accelerate efforts to monitor, assess, and restore impaired waters and to protect unimpaired waters. The result has been a comprehensive "watershed approach" that integrates water resource management efforts, local governments, and stakeholders to develop watershed-scale TMDL reports, restoration and protection strategies, and plans for Minnesota's 80 major watersheds. The information gained and strategies developed in the watershed approach are presented in major watershed-scale WRAPS reports, which guide restoration and protection of streams, lakes, and wetlands across the watershed, including those for which TMDL calculations are not made.

This document addresses impairments in the MRW, Minnesota's portion of the 8-digit hydrologic code unit (8-HUC) 09020107, that are listed on Minnesota's 2020 impaired waters list (MPCA, 2019) of waterbodies that are impaired and require a TMDL (hereafter referred to as Minnesota's 2020 303[d] list). This TMDL report addresses four impairments with two TMDLs: one AQR use impairment (caused by excessively high *E. coli*) with an *E. coli* TMDL and three AQL use impairments (caused by excessively high turbidity and indicated by poor fish bioassessments and poor benthic macroinvertebrates bioassessments) with a TSS TMDL. All four of these addressed impairments are in the main stem of the Marsh River (AUID -503).

The MRW drains approximately 361.7 square miles of cropland, wetlands, and rich soils with 91%, 8%, and 1% of the watershed being located in portions of Norman, Clay, and Polk Counties, respectively. The Marsh River originates at the dike connection with the Wild Rice River, located two miles southeast of Ada, Minnesota, and flows northwest for 51.45 miles until it reaches its confluence with the Red River of the North (Red River), 2.1 miles northwest of Shelly, Minnesota. No part of the MRW is located within the boundary of a Native American Reservation.

The goal of this TMDL report is to quantify the pollutant reductions needed to meet state water quality standards for TSS and *E. coli* for the Marsh River (-503) (see **Table 1** and **Figure 1**). Also discussed are how BMPs can be implemented to decrease *E. coli* and TSS loading and alleviate stressors to the biological communities in -503. This TMDL report is developed and established in accordance with Section 303(d) of the CWA and provides WLAs and LAs for the watershed as appropriate.

1.2 Identification of waterbodies

There are currently 13 impairments in 4 stream reaches on Minnesota's 2020 303(d) list (MPCA, 2019) in the MRW as shown in **Table 1**. **Table 1** also indicates the four impairments that are addressed in this report and which impairments are not. The AUID (-503) for which there are TMDLs developed in this report is shown in **Figure 1**.

Table 1. Marsh River Watershed impairments on Minnesota's 2020 303(d) list (MPCA, 2019).

AUID (09020107-###)	Waterbody	Designated Use Classes	Pollutant	Affected Use [c]	Listing Year	TMDL Target Completion Year	Addressed?
-503	Marsh River, Headwaters to Red R	2Bg [a], 3C	*E. coli*	AQR	2018	2028	Yes: *E. coli* TMDL
			Benthic macroinvertebrates bioassessments	AQL	2018	2028	Yes: TSS TMDL
			Fish bioassessments	AQL	2018	2028	
			Turbidity [b]	AQL	2008	2028	
			Dissolved oxygen	AQL	2010	2028	No [d]
-517	County Ditch (CD) 11, CD 66 to Marsh R	2Bm [a], 3C	Fish bioassessments	AQL	2018	2028	No [e]
-501	Red River of the North, Buffalo R to Elm R (ND)	1C, 2Bdg [a], 3C	Mercury in fish tissue	AQC	1998	2033	No: Red River mainstem impairments will be addressed in other TMDL reports.
			Mercury in water column	AQC	2008	2021	
			Fecal coliform [b]	AQR	1994	2029	
			Turbidity [b]	AQL	1996	2029	
			Dissolved oxygen	AQL	2010	2029	
-522	Red River of the North, Elm R (ND) to Marsh R	1C, 2Bdg [a], 3C	Mercury in fish tissue	AQC	1998	2033	
			Turbidity [b]	AQL	1996	2029	

[a] Tiered aquatic life use (TALU) designations: m = modified, g = general, and e = exceptional.
[b] Total suspended solids standards replaced the turbidity standards in 2015 and *E. coli* standards replaced fecal coliform standards in 2008.
[c] AQC = aquatic consumption, AQR = aquatic recreation, AQL = aquatic life
[d] More data and research is needed to determine if the low DO is due to a pollutant for which a TMDL can be developed.
[e] Data "strongly supports" high suspended sediment as a stressor (MPCA, 2018), but TSS meets standards. Data "neither supports nor weakens" low DO as a stressor, but DO data were insufficient to determine if standards are met and the limited data on total phosphorus and response variables suggest eutrophication is not an issue.

The two biological impairments (those identified by poor fish bioassessments and benthic macroinvertebrates bioassessments) being addressed in this report are based on IBI scores. The IBI scores assess the health of fish (F-IBI) and macroinvertebrate (M-IBI) communities. The IBI scores for stations located in AUID -503 are shown in **Table 2** and indicate that fish communities are in better condition than macroinvertebrates.

Table 2. Fish and macroinvertebrate index of biological integrity (IBI) scores for Marsh River (09020107-503) biological stations.

Date	Station	F-IBI impairment threshold (confidence interval)	F-IBI score (mean) [a]	M-IBI impairment threshold (confidence interval)	M-IBI score (mean) [a]
8-23-2005	05RD113	50 (±9)	**47.65** [b]		
9-2-2005	05RD113			41 (±13.6)	**20.9** [b]
7-24-2006	05RD173	42 (±16)	**0**		
8-15-2006	05RD173			41 (±13.6)	**17** [c]
7-7-2014	05RD113	50 (±9)	**53.20**		
7-7-2014	14RD072	50 (±9)	**39.39**		
7-30-2014	14RD061	50 (±9)	**55.34**	41 (±13.6)	**34.9**
7-30-2014	14RD072	50 (±9)	**54**	41 (±13.6)	**13.0**
8-6-2014	05RD113			41 (±13.6)	**34**

[a] Score is above confidence interval (CI), above threshold but below CI, below threshold but above CI, or below CI.

[b] Data was not used for assessments in 2016 (MPCA, 2017), because it was outside the 10 year range (2006-2015).

[c] Data was not used for assessments in 2016 (MPCA, 2017), because flow was too low.

Unlike conventional pollutants causing impairments such as *E. coli* and TSS, biological impairments are not those for which a TMDL can be directly calculated. Because a TMDL cannot be developed to directly address biological impairments, they are further investigated through a process called stressor identification to identify what factors are causing stress to biological communities, and if any of those stressors are ones that can be addressed with a TMDL. The stressors investigated for biological impairments in the MRW include loss of longitudinal connectivity, insufficient base flow, insufficient physical habitat, high suspended sediment, and low DO (MPCA 2018). A list of the stressors for the three biological impairments are provide in **Table 3**. The stressors listed in **Table 3** are scaled on the level of support identifying the stressor as a cause of the biological impairment, ranging from no evidence (NE) to convincingly supports (+++).

Table 3. Summary of probable stressors for biological impairments in the Marsh River Watershed (MPCA, 2018).

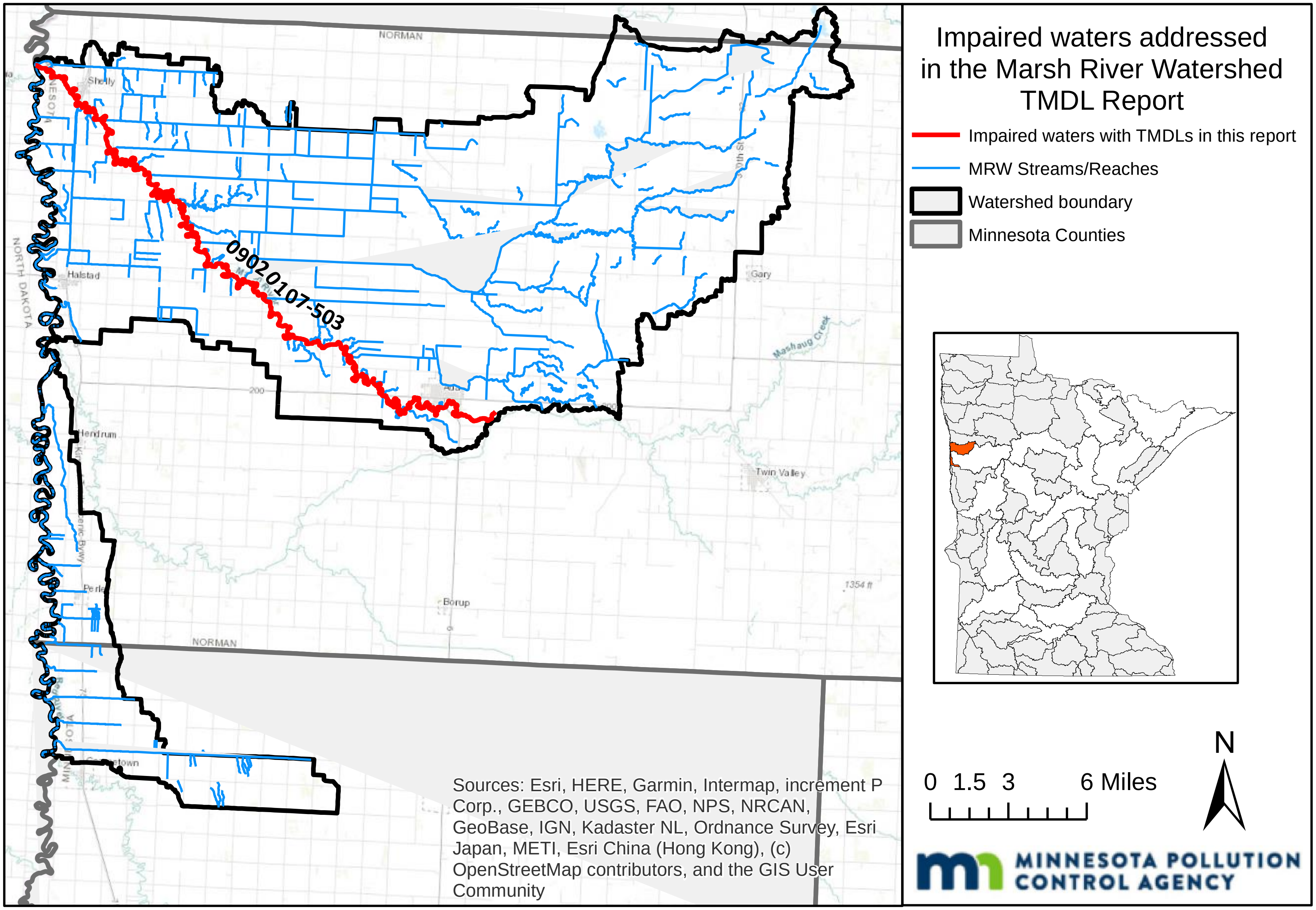
AUID (09020107-###)	Waterbody	Biological impairment	Stressors				
			Loss of longitudinal connectivity	Flow Regime instability	Insufficient physical habitat	High suspended sediment	Low dissolved oxygen
-503	Marsh River, Headwaters to Red R	Fish bioassessments	0	+++	+	++	0
		Benthic macroinvertebrates bioassessments	NE	+++	++	++	+
-517	County Ditch 11, CD 66 to Marsh R	Fish bioassessments	+++	++	+++	++	++

Key: **+++** the available evidence *convincingly supports* the case for the candidate cause as a stressor, **++** the available evidence *strongly supports* the case for the candidate cause as a stressor, **+** the available evidence *somewhat supports* the case for the candidate cause as a stressor, **0** *neither supports nor weakens* the case for the candidate cause as a stressor, **NE** *no evidence* is available to support the case for the candidate cause as a stressor, and **NA** *not applicable.*

If a stressor is a pollutant or if a nonpollutant stressor is linked to a pollutant (e.g., habitat issues driven by high TSS or low DO caused by excess phosphorus), it is subject to load quantification, and a TMDL is required. The high suspended sediment stressor to the biological communities in AUID -503 is a pollutant, so it will be addressed with the TSS TMDL. **Table 3** shows that there are also nonpollutant stressors to the biological communities in -503 such as flow regime instability and insufficient physical habitat. Implementation of BMPs that lessen the severity to which both the nonpollutant and pollutant (TSS) stressors negatively affect biological communities will improve the IBI scores, with the goal of the scores being at or above the thresholds shown in **Table 2** (preferably high enough to be above the upper confidence intervals). Strategies to address all of the stressors to the biological communities have been developed in the WRAPS report (MPCA, 2021) and will be further discussed in **Section 8.2**.

Several impairments in the MRW are being deferred. The AQL use impairment identified by poor fish bioassessments in County Ditch 11 (-517) will be deferred for several reasons. Although high suspended sediment was found as a stressor, it is not addressed with a TSS TMDL in this report because (1) according to the LDC, there were too few observed data points resulting in no data on existing conditions or reduction estimates for two flow regimes, (2) no reduction was required in the three flow regimes where reduction estimates were able to be calculated, and (3) water quality assessments determined that this AUID meets TSS standards (MPCA, 2017). Low DO is also a stressor in -517, but is primarily due to low flow, and the MPCA (2018) recommends more data to determine whether a conventional pollutant is the cause of the low DO. An additional deferment is the AQL use impairment caused by low DO in the Marsh River (AUID -503), because more data and research is needed to determine if the low DO is due to a pollutant for which a TMDL can be developed. All seven impairments in the two reaches of the Red River's mainstem will be addressed later in other TMDL reports (**Table 1**).

Figure 1. Impaired waters in the Marsh River Watershed addressed in this TMDL report.



1.3 Priority ranking

The Minnesota Pollution Control Agency's (MPCA) schedule for TMDL completions, as indicated on Minnesota's Section 303(d) impaired waters list, reflects Minnesota's priority ranking of the TMDLs in this report. The MPCA has aligned TMDL priorities with the watershed approach. The schedule for TMDL completion corresponds to the WRAPS report completion on the 10-year cycle. The MPCA developed a state plan, Minnesota's TMDL Priority Framework Report, to meet the needs of the 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 impaired waters addressed in this TMDL report are part of the MPCA's prioritization plan to meet the EPA's national measure.

2. Applicable water quality standards and numeric water quality targets

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

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

Together, the beneficial uses, numeric and narrative criteria, and antidegradation protections provide the framework for achieving CWA goals. Minnesota's water quality standards are in Minn. R. chs. 7050 and 7052.

2.1 Beneficial uses

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

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

The Class 2 AQL beneficial use includes a tiered aquatic life uses (TALU) framework for rivers and streams. The framework contains three tiers—exceptional, general, and modified uses.

All surface waters are protected for multiple beneficial uses, and numeric and narrative water quality criteria are adopted into rule to protect each beneficial use. TMDLs are developed to protect the most sensitive use of a waterbody.

2.2 Criteria (Narrative and Numeric) and state standards

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

- Cold water AQL and habitat, also protected for drinking water: Classes 1B; 2A, 2Ae, or 2Ag; 3A or 3B; 4A and 4B; and 5;

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

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

The MPCA assesses individual waterbodies for impairment for Class 2 uses— AQL and AQR. Class 2A waters are protected for the propagation and maintenance of a healthy community of cold water AQL and their habitats. Class 2B waters are protected for the propagation and maintenance of a healthy community of cool or warm water AQL and their habitats. Protection of AQL entails the maintenance of a healthy aquatic community as measured by F-IBI and M-IBIs. F-IBI and M-IBI scores are evaluated against criteria established for individual monitoring sites by waterbody type and use subclass (exceptional, general, and modified).

Both Class 2A and 2B waters are also protected for AQR activities including bathing and swimming, and the consumption of fish and other aquatic organisms. In streams, AQR is assessed by measuring the concentration of *E. coli* in the water, which is used as an indicator species of potential waterborne pathogens. To determine if a lake supports AQR activities, its trophic status is evaluated using total phosphorus (TP), Secchi depth, and chlorophyll-*a* as indicators. The ecoregion standards for AQR protect lake users from nuisance algal bloom conditions fueled by elevated phosphorus concentrations that degrade recreational use potential.

2.3 Antidegradation policies and procedures

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

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

2.4 Marsh River Watershed water quality standards

The impaired waterbody with TMDLs in this report is classified as Class 2B and 3C. Relative to AQL and AQR, the designated beneficial uses for the more stringent classification, 2B waters, are described in Minn. R. 7050.0222, subp. 4:

> **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 aquatic biota, 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.*

Minnesota's narrative water quality standard for all Class 2 waters (Minn. R. 7050.0150, subp. 3 [2018]) states that:

> *The aquatic habitat, which includes the waters of the state and stream bed, shall not be degraded in any material manner, there shall be no material increase in undesirable slime growths or aquatic plants, including algae, nor shall there be any significant increase in harmful pesticide or other residues in the waters, sediments, and aquatic flora and fauna; the normal aquatic biota and the use thereof shall not be seriously impaired or endangered, the species composition shall not be altered materially, and the propagation or migration of the aquatic biota normally present shall not be prevented or hindered by the discharge of any sewage, industrial waste, or other wastes to the waters.*

Further criteria on how the standards were used to determine stream impairments are outlined in *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment: 305(b) Report and 303(d) List* (MPCA, 2016). Details from both aforementioned resources and others found on MPCA's TMDL policy and guidance website (MPCA, 2019) were used to develop **Section 2.4.1**.

2.4.1 Streams

Applicable water quality standards for the impaired stream addressed in this TMDL report (Marsh River: AUID -503) are shown in **Table 4**.

Table 4. Surface water quality standards for Marsh River (09020107-503), which is addressed in this report.

Pollutant	Water Quality Standard	Units	Criteria	Period of Time Standard Applies
E. coli	Not to exceed 126	org/100 mL	Monthly geometric mean	April 1 - October 31
	Not to exceed 1,260	org/100 mL	Upper 10th percentile	
Total suspended solids (TSS)-South River Nutrient Region	Not to exceed 65	mg/L	Upper 10th percentile	April 1 - September 30

Escherichia (*E.*) *coli*

Minnesota uses two standards for impairments caused by high *E. coli*. According to Minn. R. 7050.0222 (2018), the water quality standards for *E. coli*, states:

> ***Escherichia (E.) coli*** *- Not to exceed 126 organisms per 100 milliliters as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than ten*

percent of all samples taken during any calendar month individually exceed 1,260 organisms per 100 milliliters. The standard applies only between April 1 and October 31.

The *E. coli* standard is based on the geometric mean of water quality observations. Geometric mean is used in place of arithmetic mean in order to describe the central tendency of the data, dampening the effect that very high or very low values have on arithmetic means. The MPCA's *Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) Report and 303(d) List* (MPCA, 2016) provides details regarding how waters are assessed for conformance to the *E. coli* standard.

Total Suspended Solids

In January of 2015, the EPA issued an approval of the adopted amendments to the State Water Quality Standards, replacing the historically used turbidity standard with TSS standards. Since the AQL use impairment caused by high turbidity in the Marsh River (-503) was listed in 2008, it is still listed as turbidity. This TMDL report will address the impairment caused by turbidity by developing a TSS TMDL to be consistent with current water quality standards. The TSS TMDL also addresses the two biological impairments in the Marsh River (-503), as discussed previously in **Section 1.2**.

TSS is a measurement of the weight of suspended mineral (e.g., soil particles) or organic (e.g., algae) sediment per volume of water. Minnesota's TSS standards are based on nutrient regions, which are loosely based on ecoregions. The MRW is located in the South River Nutrient Region (SRNR). The state TSS standard for the SRNR is 65 milligrams per liter (mg/L).

3. Watershed and waterbody characterization

The MRW is located in the Red River Basin in the northwestern portion of Minnesota and is comprised of cropland, wetlands mainly along the Marsh River and in the very upper watershed, and rich soils. The MRW has a total drainage of 361.7 square miles, spanning across Norman (91% of the watershed), Clay (8%), and Polk (1%) counties. The Marsh River originates at the dike connection with the Wild Rice River, located 2 miles southeast of Ada, Minnesota, and flows northwest for 51.45 miles until it reaches its confluence with the Red River, 2.1 miles northwest of Shelly, Minnesota. Most of the MRW experiences intermittent flow conditions. The main flow contribution into the Marsh River is through the dike system, but this flow is dependent upon the Wild Rice River reaching 95% total flow in order to flow over the dike.

This watershed lies within the Lake Agassiz Plains Ecoregion (Omernik & Gallant, 1988). This area is largely utilized for agriculture, as it features rich soils that formed from historical, glacial Lake Agassiz. Soils formed in the western part of the watershed include glacial lake deposits featuring fine textures with poor internal drainage. Moving east in the watershed, the beach ridge (a remnant of the now-absent Lake Agassiz shoreline) is made up of moderately coarse and medium textured soil mostly comprised of clay with sand and gravel from the lakeshore deposits. The soils in the watershed have low infiltration rates, thus making them susceptible to runoff with overland flow. The watershed has relatively low relief in the western lake plain with increasing slope moving east into the beach ridge.

Much of the Lake Agassiz Plain has been drained for agricultural use. The drainage network in place today in the Red River Basin "has thousands of miles of principal drains and probably tens of thousands of miles of small laterals and on-farm channels." (Carlyle, 1984). The Red River Valley is among the world's largest artificially drained landscapes. From the early 1900s, the MRW has been managed for optimal agricultural production (Offelen, Evarts, Johnson, Groshens, & Berg, 2002). During settlement in the area, flood management was a concern. Early flood management practices included modifying natural stream channels to develop vast drainage systems for agriculture. This watershed-wide alteration changed the natural hydrology of the entire watershed, causing an abrupt change within the whole ecosystem (Offelen, Evarts, Johnson, Groshens, & Berg, 2002). Historically, logging practices also occurred within the area. The connection of the Marsh River with the Wild Rice River provided an efficient way of floating logs to a sawmill just east of Ada, Minnesota. More recently, this connection is used for flood management purposes. During high flow events, when the Wild Rice River reaches 95% flow, water flows over the dike allowing the excess water to flow down the Marsh River before reaching its confluence with the Red River (MPCA, 2017).

The following provides relevant physical watershed and waterbody characteristics of impaired reaches in the MRW. More detailed information on the watershed and waterbody characteristics can be found in the *Marsh River Watershed Monitoring and Assessment Report* (MPCA, 2017) and the *Marsh River Watershed Stressor Identification Report* (MPCA, 2018).

3.1 Streams

The watershed for the Marsh River includes 51.45 miles of the Marsh River, in addition to multiple streams and small tributaries flowing into the Marsh River. The main tributary with the largest contributions to Marsh River is County Ditch 11. Approximately two-thirds of the watercourses in the watershed have been hydrologically altered (67%), while only 33% remain natural. All major tributaries within Marsh River's watershed have been channelized, with the exception of Spring Creek. The watershed experiences an undulating hydrograph with frequent periods of high flows and an overall decline of base flow. As a result, flood management remains an issue during high flows, and the river can experience periods with no flow. **Table 5** provides the drainage area and reach length for the impaired reach (Marsh River [-503]) addressed in this report.

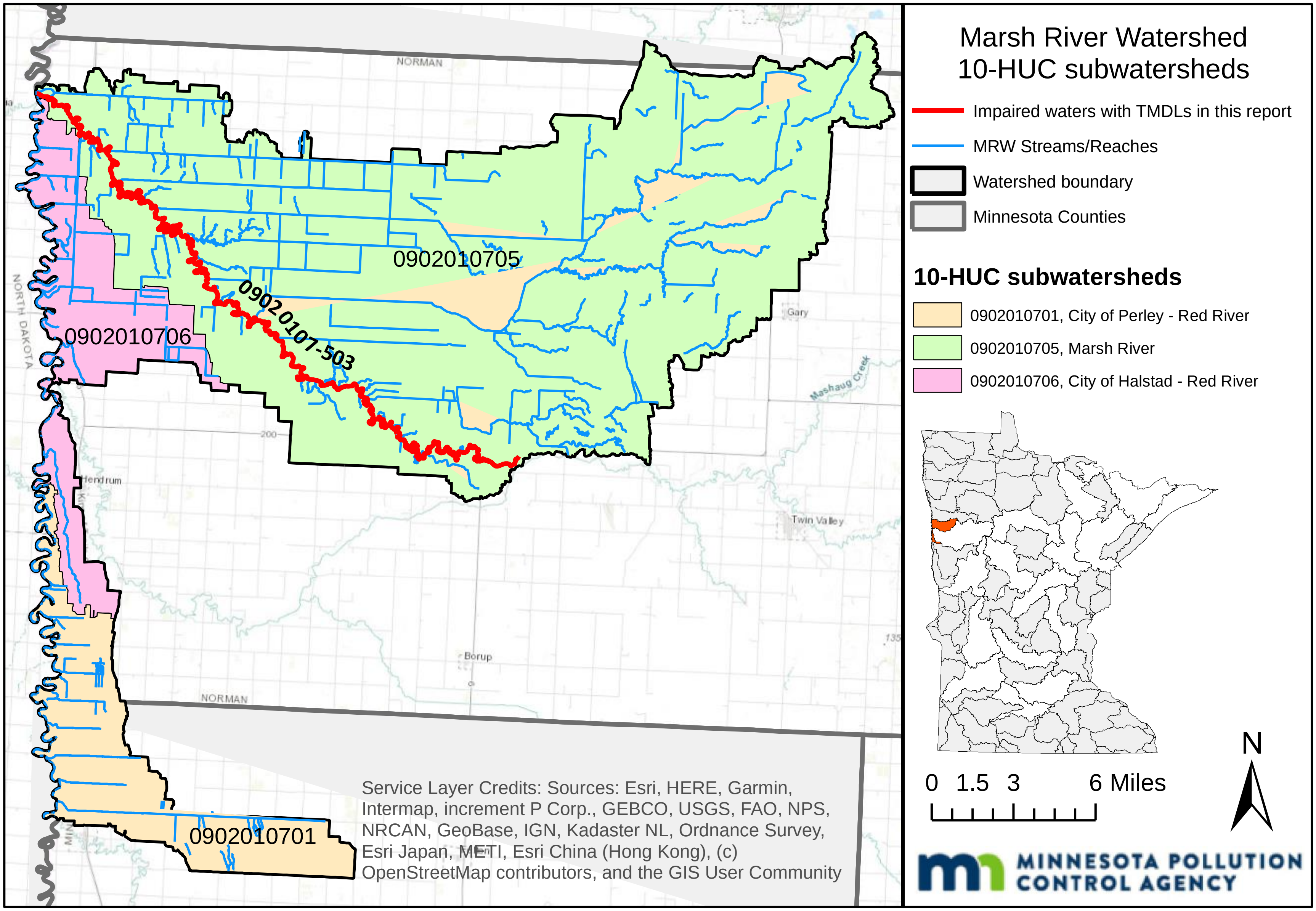
Table 5. Approximate drainage area of impaired stream reaches.

8-HUC Watershed	Stream/Reach Name	AUID (09020107-###)	Entire drainage area [sq mi]	Reach Length [miles]
Marsh River (09020107)	Marsh River, Headwaters to Red R	-503	284.9	51.45

3.2 Subwatersheds

The MRW is located in the Red River Basin in the northwestern portion of Minnesota. The MRW includes the drainage area of the Marsh River plus direct drainage to the Red River. The 10-digit HUCs are provide in **Figure 2**. The Marsh River (AUID -503) drainage area lies wholly within HUC 0902010705.

Figure 2. 10-digit HUCs in the Marsh River Watershed.



3.3 Land use

The land use for the entire watershed and 10-HUC subwatersheds is summarized in **Table 6** and shown in **Figure 3**. Row crop is the largest land use in each subwatershed, and the watershed as a whole. Wetlands and lakes comprise the distant, second most common land cover, but are primarily limited to the eastern, upland portion of the 0902010705 10-HUC subwatershed. The conversion of native vegetation to agricultural lands has resulted in the following conditions: increased overland flow; decreased groundwater recharge (lower groundwater infiltration); and increased NPS transport of sediment, nutrients, chemicals (agricultural and residential), and feedlot runoff.

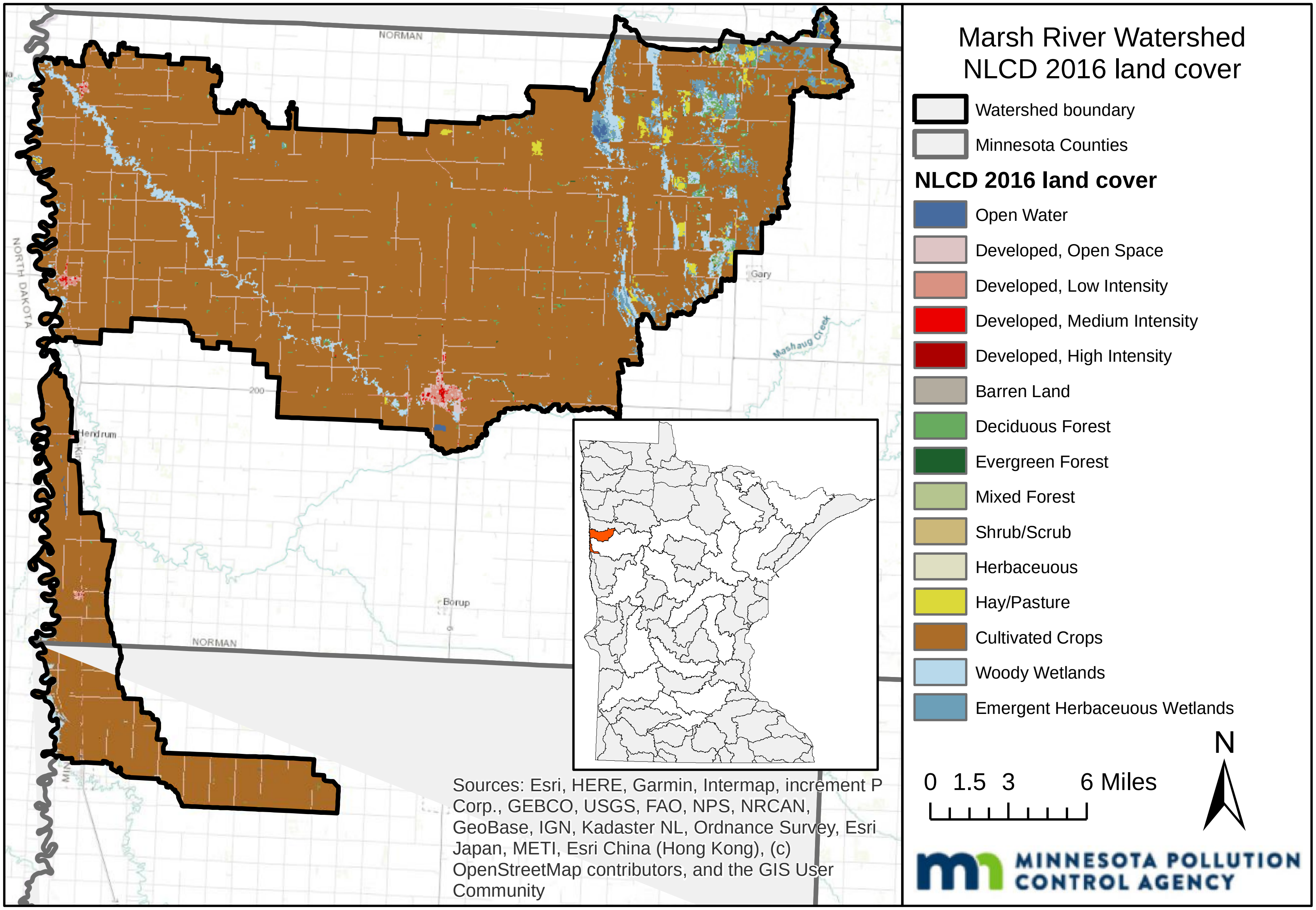
Groundwater recharge in the region is slow and varies from 1.5 to 8.5 inches per year (MPCA, 2017). High agricultural land use contributes to high nutrient, sediment, and fecal contaminant export as well, which can impact both surface waters and aquifers. Agricultural land use exceeds 85% in each 10-HUC subwatershed and receiving surface and groundwater reflect these uses, with elevated nutrient and *E*. *coli* loading being common throughout the MRW.

Table 6. Land cover percentages in the Marsh River Watershed and 10-HUC subwatersheds based on the NLCD 2016 (Yang, et al., 2018).

8-HUC/10-HUC subwatershed	Cropland	Rangeland	Developed	Wetland	Open Water	Forest/ Shrub	Barren/ Mining
09020107	**88.2%**	**0.7%**	**3.8%**	**5.7%**	**0.6%**	**1%**	**0.01%**
0902010701	90.1%	0.02%	4.1%	4.0%	1.7%	0.1%	0.01%
0902010705 [a]	88.0%	0.9%	3.6%	6.2%	0.2%	1.2%	0.01%
0902010706	88.4%	0.1%	5.0%	3.8%	2.5%	0.2%	0.03%

[a] This 10-HUC contains, and is the drainage basin for, the impaired waterbody addressed in this report (Marsh River, AUID -503).

Figure 3. Land use/land cover in the Marsh River Watershed based on the NLCD 2016 (Yang, et al., 2018).



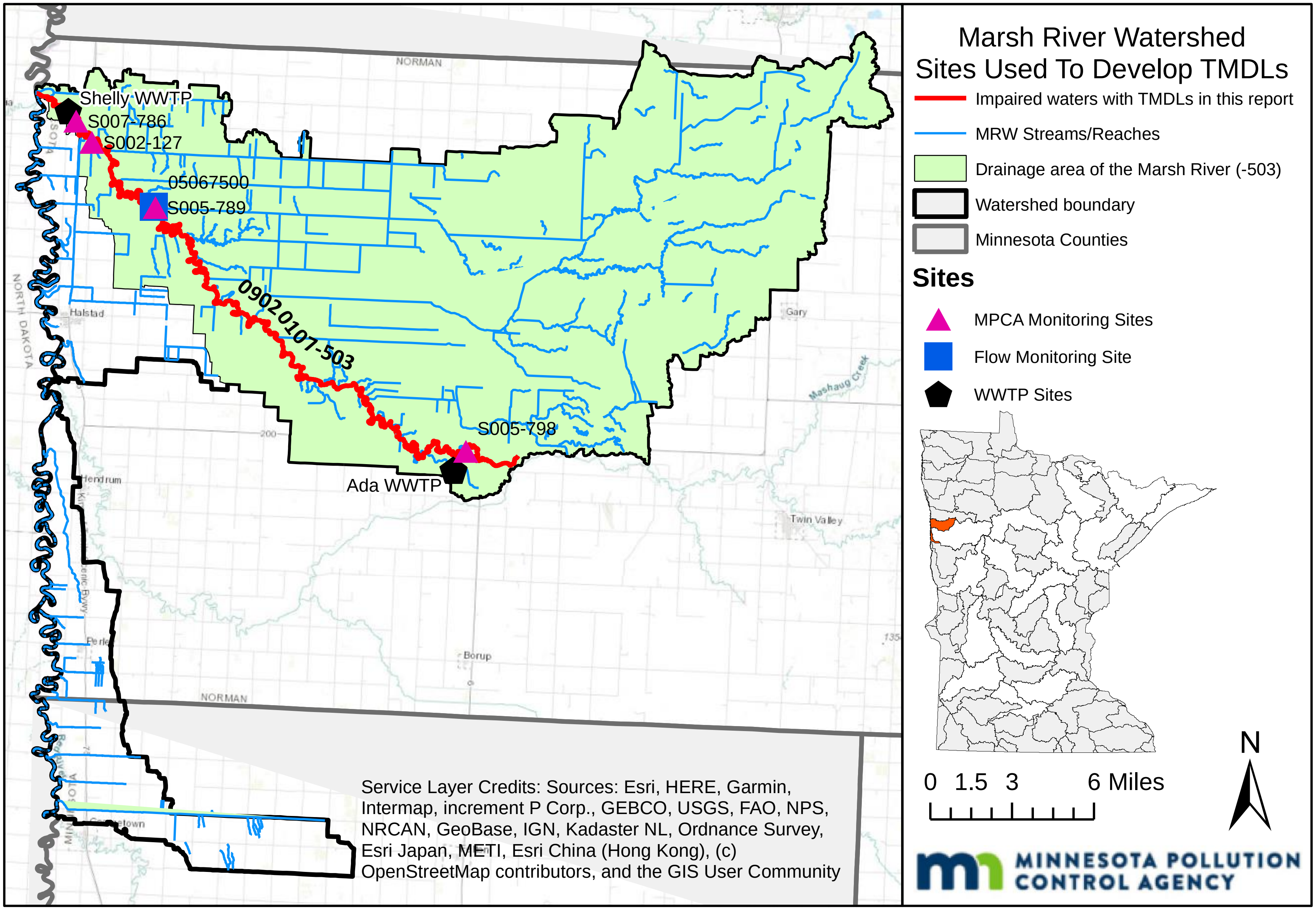
3.4 Current/historical water quality

Existing water quality conditions were described using data downloaded from the MPCA's Environmental Quality Information System (EQuIS) database (MPCA, 2019). EQuIS stores water quality data from more than 17,000 sampling locations across the state, containing information from Minnesota streams and lakes dating back to 1926. Data are collected by the MPCA, partner agencies (soil and water conservation districts [SWCDs], watershed districts, etc.), grantees, and citizen volunteers. Monitoring locations used for this TMDL report are shown in **Figure 4**. Collected data are summarized in **Table 7** and **Table 8**. All water quality sampling data utilized for assessments, modeling, and data analysis for this report and reference reports are stored in this database and are accessible through the MPCA's Environmental Data Access (EDA) website (MPCA, 2019).

The MPCA conducts 2 years of intensive watershed monitoring (IWM) in all 80 major watersheds in Minnesota on a 10-year cycle (i.e., every major watershed is sampled for 2 years, once every 10 years). The MRW IWM occurred in 2014 and 2015.

Ten years of data (2007 through 2016) were used for development of the TMDL studies in this report. For *E. coli*, only data collected during the months of April through October were used. For the TSS standard, data collected from April through September were used.

Figure 4. Monitoring locations in the Marsh River watershed used in this TMDL report.



3.4.1 *Escherichia (E.) coli*

E. coli loading is not to exceed a monthly geometric mean (at least five samples are needed) of 126 organisms per 100 mL in one or more months for a reach from April to October. A waterbody that exceeds the acute standard concentration of 1,260 organisms per 100 mL for more than 10% of individual samples during any calendar month is also identified as impaired. The geometric mean is used to describe *E. coli* data as the geometric mean better normalizes data collected from different flow zones, as may occur during periods of low flow or high flow storm events, and allows a percentage change to be made equally to the geometric mean across watersheds. The geometric mean can be calculated using the following function:

$$\text{Geometric mean} = \sqrt[n]{x_1 * x_2 * \dots x_n}$$

Where $x_1, x_2, \dots, x_n$ are *E. coli* concentrations for each sampling month.

Table 7 summarizes the *E. coli* data on the Marsh River (AUID -503). For each month at the two sampling stations (individually and combined), the table shows the number of samples collected (n), the geometric mean of those samples, and the number of the samples that exceeded the *E. coli* standard of 1,260 org/100mL.

Table 7. Current spatial and temporal (monthly) conditions of *E. coli* in the Marsh River (09020107-503).

AUID (09020107-###)		-503		
Month	Site ID	S002-127	S007-786	AUID (both sites)
	Sampling Years	2008-2010	2014-2015	2008-2015
April	# of samples	0	0	0
	Geometric mean (org/100mL)			
May	# of samples	0	0	0
	Geometric mean (org/100mL)			
June	# of samples	5	5	10
	Geometric mean (org/100mL)	96.1	144.9	118.0
July	# of samples	4	5	9
	Geometric mean (org/100mL)	207.7	112.1	**147.4**[a]
August	# of samples	5	5	10
	Geometric mean (org/100mL)	180.6	75.0	116.4
September	# of samples	2	0	2
	Geometric mean (org/100mL)	124.5	0	124.5
October	# of samples	0	0	0
	Geometric mean (org/100mL)			
All (Apr. – Oct.)	# of samples	16	15	31
	# (%) of samples >1260 org/100 mL	1 (0.625%)	0	1 (3%)

[a] This bolded number indicates an exceedance of the 126 org/100 mL monthly geomean standard and the reason for listing AUID 503 as impaired due to *E. coli* after assessments in 2016.

3.4.2 Total Suspended Solids

TSS data was summarized by AUID and station for the TSS impaired stream in the MRW in **Table 8**. The TSS TMDLs are based on the current TSS standard for the Southern Rivers Nutrient Region of 65 mg/L. Variations of TSS based on flow zones can be seen in the TSS LDC (i.e., **Figure 10**).

Table 8. Total suspended solids conditions and water quality sites for the impaired reach addressed in this report (Marsh River, AUID -503).

Name of waterbody (AUID)	Site ID	Total Suspended Solids (TSS)			
		Sampling Years	N	90th percentile [mg/L]	# of Exceedances
Marsh River, Headwaters to Red R (09020107-503)	S002-127	2007-2016	123	98.2	19
	S005-789	2010-2016	45	82	10
	S005-798	2009	4	43.6	0
	S007-786	2014	10	55.6	1
	AUID (all 4 sites)	2007-2016	181	92	30

3.5 Pollutant source summary

Sources of pollutants in the MRW include permitted and nonpermitted sources. The permitted sources discussed here are pollutant sources that require a NPDES permit. Nonpermitted sources are pollutant sources that do not require an NPDES permit. All Minnesota NPDES permits are also SDS permits, but some pollutant sources require SDS permit coverage alone without NPDES permit coverage (e.g., spray irrigation, large septic systems, land application of biosolids, and small feedlots).

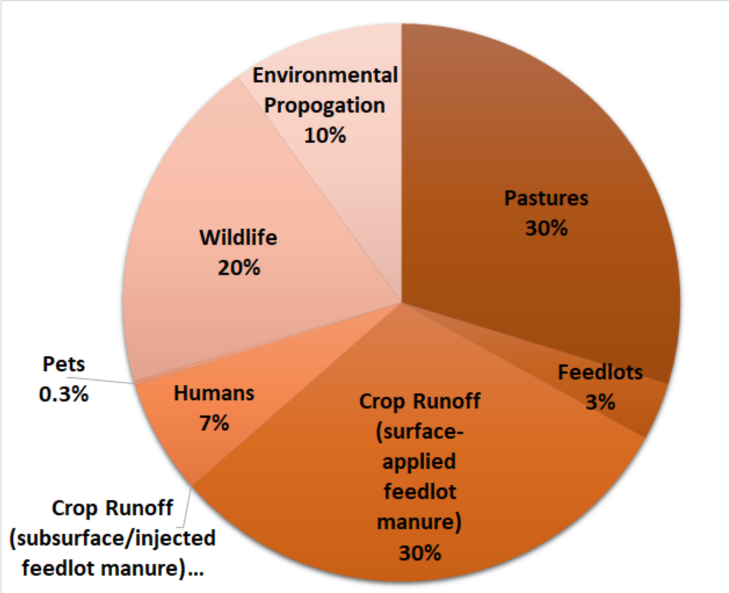
The term “nonpermitted” does not indicate that the pollutants are illegal, but rather that they do not require an NPDES/SDS permit. Some nonpermitted sources are unregulated, and some nonpermitted sources are regulated through non-NPDES programs such as state and local regulations.

3.5.1 *Escherichia coli*

E. *coli* produced in the MRW was estimated using available data on livestock and manure application, pasture, human populations (wastewater treatment plants [WWTPs] and subsurface sewage treatment systems [SSTS]), pets, and wildlife populations based on literature rates from previous studies on sources. Assessing the number of *E*. *coli* generated by major sources in the watershed can aid in implementing conservation activities to reduce fecal contamination to surface waters.

The greatest source of *E*. *coli* loading in the drainage area of the Marsh River (AUID -503) is manure from livestock (**Figure 5**). It accounts for 63% of *E*. *coli* loading and is inclusive of surface (30%) and subsurface (0%) applied manure, manure from pasture grazing livestock (30%), and manure from livestock in feedlots (3%). Humans account for 7% of *E*. *coli* loading and the remaining 30% is estimated to come directly from wildlife, pets, and environmental propagation of *E. coli* (default of 10% was used). A general summary of the permitted and nonpermitted sources of *E. coli* is given below.

Figure 5: Bacteria sources in the drainage area of the Marsh River as determined by the MPCA's *Bacteria Source Estimates Calculator* (Appendix A) (MPCA, 2007).



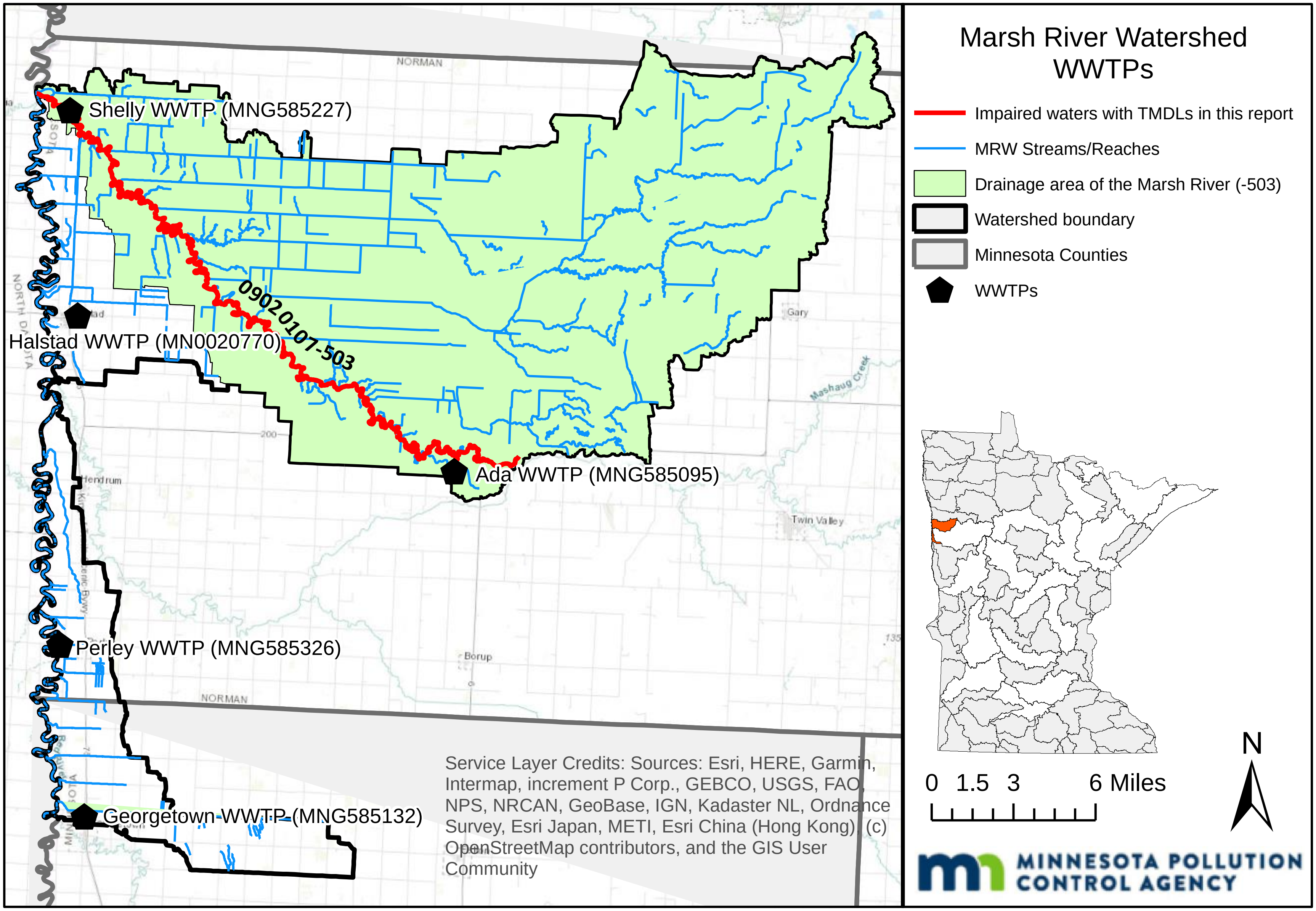
3.5.1.1 Permitted sources

The permitted sources of *E. coli* are animal feedlots and WWTPs. There are no permitted municipal separate storm sewer systems (MS4s) in the MRW.

Animal Feedlots–In Minnesota, all federally defined concentrated animal feeding operations (CAFOs) (U.S. EPA) that discharge wastewater or manure to waters of the U.S. are issued and must operate under a NPDES/SDS permit. All animal feedlots or manure storage areas that do not require an NPDES/SDS permit but are capable of holding 1,000 or more animal units (AUs) or the manure from 1,000 or more AUs must operate under a state issued SDS permit. Animal feedlots with either an NPDES/SDS or SDS permit must be designed to totally contain runoff, and manure management planning requirements are more stringent than for smaller animal feedlots. CAFOs are inspected by the MPCA in accordance with the MPCA NPDES Compliance Monitoring Strategy, approved by the EPA. There are currently no animal feedlots in the MRW that require or have an NPDES/SDS or SDS permit. However, there is a large CAFO currently being proposed near Ada with just under 4,000 AUs that will require an NPDES/SDS permit.

Wastewater Treatment Plants – There are five NPDES/SDS wastewater permits in the MRW (**Figure 6**), and all of them are domestic WWTPs. Of the five WWTPs, two discharge near or directly to impaired reach -503 (**Figure 4**) and are sources of fecal contamination (see **Section 4.3.3.1**). One WWTP is located in Ada, Minnesota, and the other is in Shelly, Minnesota. Both are controlled discharge (pond) systems with discharge windows from March 1 to June 30 and September 1 to December 31, with no discharge to ice covered waters. WWTPs can become a greater source of *E. coli* during low flow periods if low flow conditions occur during discharge. Rarely, during extreme high flow conditions, WWTPs may also be a source if they become overloaded and have an emergency discharge of partially or untreated sewage, known as a release.

Figure 6. WWTPs and their NPDES/SDS permit numbers in the Marsh River Watershed.



3.5.1.2 Nonpermitted sources

SSTS –Subsurface sewage treatment systems that do not provide adequate treatment of raw sewage (such as a straight pipe systems that transport sewage, raw or partially treated, directly to a waterbody, drainage system, or ground surface [Minn. Stat. 2019, 115.55, subd. 1]) are noncompliant and imminent threats to public health and safety (ITPHS). Systems that are ITPHS near waterways can be a source of fecal contamination to waterbodies especially during low flow. While not a source of fecal contamination to surface water, another category of noncompliant SSTS are those that have a functioning, intact tank and soil absorption system, but fail to have an adequate amount of unsaturated soil between sewage discharge and groundwater or bedrock (termed "failing" as they fail to protect groundwater). Educating the public as to what constitutes a noncompliant (ITPHS and/or failing) SSTS is crucial.

Counties are required to submit annual reports to the MPCA regarding SSTS compliance within their respective county. Data reported is aggregated by each county so the exact location of SSTS are not known to the State of Minnesota. Reports from 2018 for the two counties that have contributing areas to the impaired Marsh River (-503) indicate that the percentage of SSTS that present an IPHT is 2% in Clay and 5% in Norman County (**Table 9**). While the estimates are for the entire counties, the drainage area of the Marsh River (-503) covers 32% of Norman County and <1% of Polk County. These counties continue to invest in the education of rural homeowners on the maintenance and impact that noncompliant systems can have on humans and wildlife. Additionally, counties continue to develop county-wide geographic information system (GIS) databases for SSTS to facilitate outreach and inspection of noncompliant systems.

Table 9. 2018 estimates of compliant and noncompliant (failing and IPHT) SSTS in the counties partially encompassed by the watershed of the impaired Marsh River (09020107-503). Numbers are based on raw data used to develop the 2018 SSTS Annual Report (MPCA, 2019).

	Norman	Polk
# (%) potentially failing SSTS	187 (20%)	1,174 (23%)
# (%) potential IPHT SSTS	47 (5%)	102 (2%)
# (%) compliant SSTS	701 (75%)	3,829 (75%)
Total # of SSTS	**935**	**5,105**

Animal Feedlots – Animal Feedlots that do not require an NPDES/SDS or SDS permit can be a significant source of *E. coli*. In Minnesota, animal feedlot operators are required to register their animal feedlot with the county feedlot officer if the county is delegated, or with the MPCA if the county is nondelegated, if they are 1) an animal feedlot capable of holding 50 or more AUs, or a manure storage area capable of holding the manure produced by 50 or more AUs; and/or 2) an animal feedlot capable of holding 10 or more and fewer than 50 AUs, or a manure storage area capable of holding the manure produced by 10 or more and fewer than 50 AUs, that is located within shoreland. Shoreland, in most cases, refers to land that is 1,000 feet or less from a lake or 300 feet or less from a river or stream. Further explanation of registration requirements can be found in Minn. R. 7020.0350.

A summary of the 19 active, registered feedlots with more than 0 AUs in the MRW (16 of which are within the watershed of the Marsh River [AUID -503]) is provided in **Table 10**. **Figure 7** shows the locations and AUs for the animal feedlots in the MRW.

Table 10. Summary of the animal feedlots in the Marsh River Watershed (09020107) and the watershed of the Marsh River (09020107-503). [a]

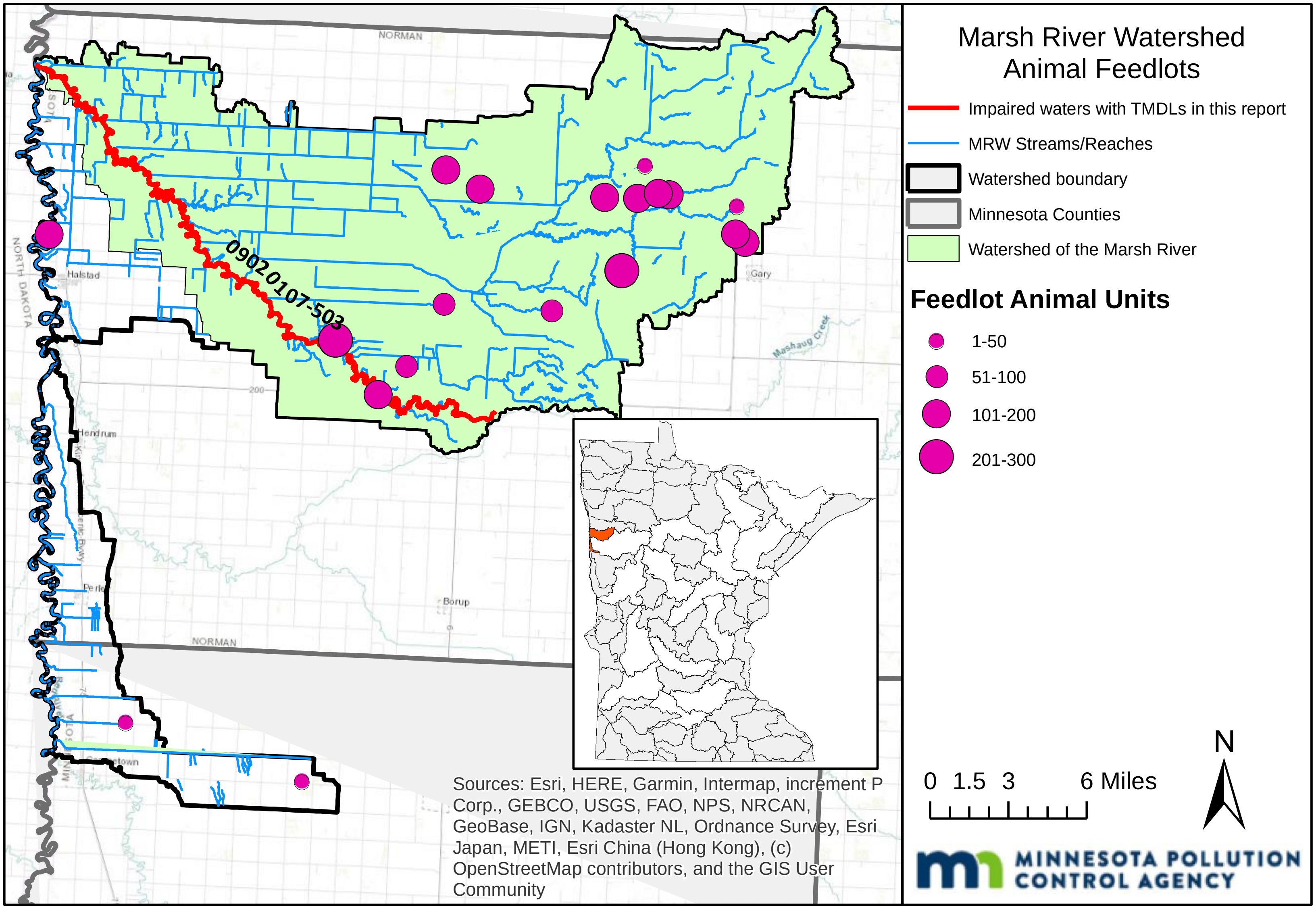
Description	Marsh River Watershed **(8-HUC: 09020107)**	Marsh River **(AUID 09020107-503)**
General		
Total Animal Feedlots	19	16
Total CAFOs	0	0
Total AUs	2055.4	1878.8
Primary Animal Type	Bovines 71%	Bovines 69%
	Swine 25%	Swine 26%
Sensitive Areas		
Open Lot Animal Feedlots	17	14
Animal Feedlots in Shoreland	6	5
Open Lot Animal Feedlots in Shoreland	6	5

[a] Only animal feedlots that are active, registered, and have more than 0 AUs as of July 2020 are included in this table. Animal feedlot data can be found at the MN Geospatial Commons website (MPCA, 2020). None of the animal feedlots have or require an NPDES/SDS or SDS permit.

Manure from animal feedlots can be a significant source of *E. coli* from fecal contamination. They accumulate a large amount of manure that is usually stockpiled on site until field conditions and crop rotation allow for spreading manure on crop fields as a fertilizer. The timing of manure spreading can decrease the likelihood of fecal contamination loading to nearby waterbodies, as indicated by the presence of *E. coli*. Specifically, the spreading of manure on frozen soil in late winter is likely to result in surface runoff during snowmelt and precipitation events. Deferring manure application until soils have thawed decreases overland runoff associated with snowmelt and large precipitation events. Incorporating manure is a preferred BMP to reduce the runoff of waste and associated fecal contaminants, as injected manure reduces the risk of surface runoff associated with large precipitation events.

Short term manure stockpile sites on fields prior to land application are included in the land applied manure calculations as manure is conventionally stockpiled on the same field, or very near, to which it is applied. Manure stockpiled for more than a year must be registered with the MPCA as a feedlot facility (see short-term stockpile site definition in Minn. R. 7020.0300, subp. 21a), but for the purposes of this TMDL report all manure was assumed to be applied within one year.

Figure 7. Animal feedlots and animal units in the Marsh River Watershed. [a]



[a] Only animal feedlots that are active, registered, and have more than 0 AUs as of July 2020 are included in this figure. Animal feedlot data can be found at the Minnesota Geospatial Commons website (MPCA, 2020).

Pasture – According to Minn. R. 7020.0300, subp. 3 (2019), pastures shall not be considered animal feedlots, thus they are considered to be a separate source. Livestock can contribute fecal contamination to waterbodies (as indicated by the presence of elevated *E. coli* levels) from poorly managed pasture lands that are overgrazed, or through the direct access of livestock to surface waters. Poorly maintained pasture can have significant overland surface flow during heavy precipitation events resulting in manure transport from the pasture. Livestock with direct access to streams and lakes can defecate directly into the waterbody resulting in direct contamination.

Natural background – "Natural background" is defined in both Minnesota statute and rule. The CWLA (Minn. Stat. § 114D.15, subd. 10) defines natural background as "characteristics of the waterbody resulting from the multiplicity of factors in nature, including climate and ecosystem dynamics, that affect the physical, chemical, or biological conditions in a waterbody, but does not include measurable and distinguishable pollution that is attributable to human activity or influence." Minn. R. 7050.0150, subp. 4 states, "'Natural causes' means the multiplicity of factors that determine the physical, chemical, or biological conditions that would exist in a waterbody in the absence of measurable impacts from 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 processes such as loading from wildlife. However, for each impairment, natural background levels are implicitly incorporated in the water quality standards used by the MPCA to determine/assess impairment, and therefore natural background is accounted for and addressed through the MPCA's waterbody assessment process. Natural background conditions were evaluated within this source assessment portion of this report. These source assessment exercises indicate that natural background inputs are generally low compared to livestock, WWTPs, noncompliant SSTS, and other anthropogenic sources.

Based on the MPCA's waterbody 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 impairment caused by high *E. coli* and/or affect the Marsh River's ability to meet state water quality standards.

Naturalized *E. coli* – The relationship between *E. coli* sources and *E. coli* concentrations found in streams is complex, involving precipitation and flow, temperature, sunlight and shading, livestock management practices, wildlife contributions, *E. coli* survival rates, land use practices, and other environmental factors. Research in the last 15 years has found the persistence of *E. coli* in soil, beach sand, and sediments throughout the year in the north central United States without the continuous presence of sewage or mammalian sources. This *E. coli* that persists in the environment outside of a warm-blooded host is referred to as naturalized *E. coli* (Jang, et al., 2017). Naturalized *E. coli* can originate from different types of *E. coli* sources, including natural background sources such as wildlife and human attributed sources such as pets, livestock, and human wastewater. Therefore, whereas naturalized *E. coli* can be related to natural background sources, naturalized *E. coli* is not always from a natural background source.

An Alaskan study (Adhikari, Barnes, Schiewer, & White, 2007) found that total coliform bacteria in soil were able to survive for six months in subfreezing conditions. Two studies near Duluth, Minnesota found that *E. coli* were able to grow in agricultural field soil (Ishii, et al., 2009) and temperate soils (Ishii, Ksoll, Hicks, & Sadowsky, 2006). A study of ditch sediment in the Seven Mile Creek Watershed in southern

Minnesota found that strains of *E. coli* had become naturalized to the water−sediment ecosystem (Chandrasekaran, et al., 2015). Survival and growth of fecal coliform has been documented in storm sewer sediment in Michigan (Marino & Gannon, 1991), and *E. coli* regrowth was documented on concrete and stone habitat within an urban Minnesota watershed (Burns & McDonnell Engineering Company, 2017). This ability of *E. coli* to survive and persist naturally in watercourse sediment can increase *E. coli* counts in the water column, especially after resuspension of sediment (e.g., (Jamieson, Joy, Lee, Kostaschuk, & Gordon, 2005)).

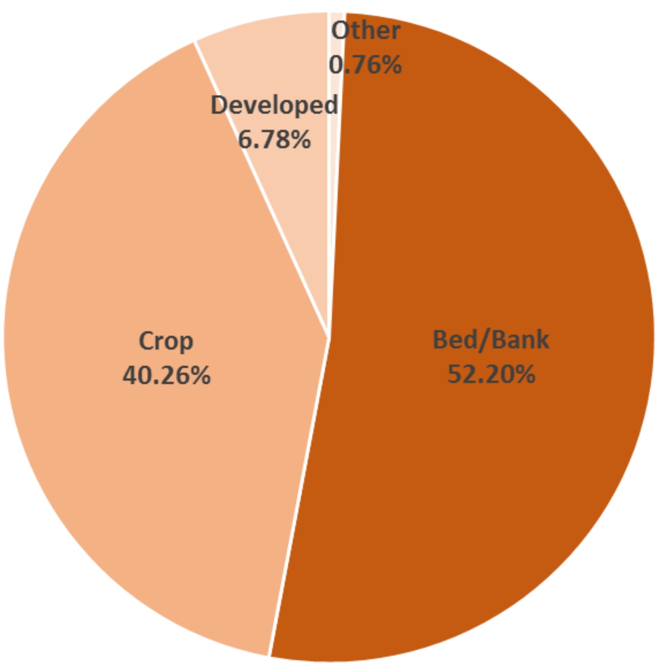
The MPCA does not currently employ any methods as standard practice to estimate (using an equation or model) or measure (using a laboratory analysis) what proportion of *E. coli* is naturalized. While a measurement would be preferable over an estimate, it is also more expensive, because it involves a laboratory component. The adaptation and evolution of naturalized *E. coli* that allows it to survive and reproduce in the environment makes it physically and genetically distinct from *E. coli* that cannot survive outside of a warm-blooded host. Laboratory methods target those physical and genetic differences and quantify their presence to provide a measurement. The MPCA is developing a protocol for the use of laboratory analyses to track *E. coli* to their source(s) (i.e., microbial source tracking); these approaches may shed light on naturalized *E. coli*.

Pets –Pets can be a contributor of *E. coli* in surface waters, but they are a small contributor with loading approximately continuous over the course of a year.

3.5.2 Total Suspended Solids

Figure 8 provides a summary of sediment sources based on the HSPF model. The figure indicates that stream bed/bank and cropland are the sources for the vast majority of sediment (52% and 40%, respectively).

Figure 8. TSS source assessment in the Marsh River Watershed, based on HSPF modeling.



A general summary of sources of TSS is given below.

3.5.2.1 Permitted sources

Wastewater Effluent - Wastewater from NPDES/SDS-permitted sites can be a source of TSS. Two NPDES/SDS-permitted sites drain to reaches within the drainage area of the Marsh River: Ada WWTP and Shelly WWTP. These permitted sites have strict TSS restrictions that contribute little to the daily load. The permit limits for TSS that are already assigned to these WWTPs are consistent with the WLAs assigned in this report's TSS TMDL. More discussion is provided in the WLAs section of the TMDL (see **Section 4.4.3.1**).

Construction Stormwater – The annual average area under construction in Norman County (which encompasses 91% of MRW) is 0.014% based on construction activity covered under the Construction Stormwater General Permit (MNR100001) from 2015 through 2019 (MPCA, 2020). TSS from permitted construction stormwater is not considered a significant source of TSS load to the impaired stream reach.

Industrial Stormwater – Stormwater from industrial activities can contribute to the TSS load of waterbodies, but there is very little industrial activity within the watershed of the impaired stream reach. The annual average area under industrial activities in Norman County from 2015 through 2019 is assumed to be the same as what has undergone construction activities (0.014%).

Municipal Stormwater Runoff – There are no municipalities with an MS4 NPDES/SDS permit within the watershed of the impaired stream addressed in this TMDL report.

3.5.2.2 Nonpermitted sources

Streambank Erosion – Streambank erosion was determined by HSPF to be the most significant contributor of sediment to streams in the MRW (**Figure 8**). Streambed and bank erosion is estimated to cause about 52% of the annual TSS load and is attributed to poor riparian vegetation management near stream channels, channelization, and altered hydrology throughout the region. Altered hydrology has led to increased stream flows due to extensive ditching, loss of wetlands, lower soil water storage from tiling, altered evapotranspiration cycles, and decreased water residence time in the stream channel due to stream straightening. Managing water on, and below fields, in addition to deep-rooted vegetation in the riparian zone, can stabilize soil and decrease sediment loading, lowering TSS in adjacent waterbodies.

Overland Erosion – Overland runoff of sediment was determined to be the second greatest contributor of TSS to waterbodies in the MRW, with approximately 40% determined to come from crop surfaces and about 7% from developed areas. High TSS can occur when heavy rains fall on unprotected soils, dislodging particles that are then transported with surface runoff to adjacent waterbodies. Losses are greatest during the spring, April through June, when vegetation is not yet actively growing, and rainfall is elevated. Ephemeral systems, streams, and gullies are highly susceptible to intermittent flows and have high erosion potential in agricultural systems. Farming practices can exacerbate erosion in sensitive areas if soil is unprotected from rain and there is insufficient buffering of stream channels. Other overland erosion sources include sheet and rill runoff from upland fields and livestock pastures in riparian zones.

Atmospheric Deposition – The atmosphere can contribute TSS loading to streams. Average wind speeds in the MRW are greater than five miles per hour and strong seasonal winds are capable of transporting sediment from fields. During bare soil periods, before crops have established in the spring and after fall tillage, significant amounts of soil can be transported by wind into adjacent streams and ditches. This has been exacerbated by the now common practice of “rolling” beans after planting. Rolling breaks down larger soil clods into fine particles and is done to create a smooth, flat soil surface to facilitate harvest in the fall. Windblown sediment is a likely source of TSS within the MRW but, depending on the time of year, is a highly variable percentage of total TSS in the impaired stream addressed in this report.

Natural background – “Natural background” is defined in both Minnesota statute and rule. The CWLA (Minn. Stat. § 114D.15, subd. 10) defines natural background as “characteristics of the waterbody resulting from the multiplicity of factors in nature, including climate and ecosystem dynamics, that affect the physical, chemical, or biological conditions in a waterbody, but does not include measurable and distinguishable pollution that is attributable to human activity or influence.” Minn. R. 7050.0150, subp. 4 states, “‘Natural causes’ means the multiplicity of factors that determine the physical, chemical, or biological conditions that would exist in a waterbody in the absence of measurable impacts from 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 upland erosion and stream development, atmospheric deposition, loading from the small amount of forested land in the watershed of the Marsh River, etc. However, for each impairment, natural background levels are implicitly incorporated in the water quality standards used by the MPCA to determine/assess impairment, and therefore natural background is accounted for and addressed through the MPCA’s waterbody assessment process. Natural background conditions were evaluated within this source assessment portion of this report. The extensive alteration of the landscape for crop production (which leads to higher high flows and more streambank erosion) and, to a lesser extent area-wise, development (e.g., cities, roads) leaves very little natural landscape left as a potential source. These source assessment exercises indicate that natural background inputs are generally low compared to animal feedlots (especially open lots with exposed sediment), cropland, streambank, WWTPs, and other anthropogenic sources.

Based on the MPCA’s waterbody 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 impairment caused by high TSS and/or affect the Marsh River’s ability to meet state water quality standards.

4. TMDL development

A TMDL represents the maximum mass of a pollutant that can be assimilated by a receiving waterbody without causing or contributing to an impairment in the receiving waterbody. TMDLs are developed based on the following equation:

$$TMDL = LC = \sum WLA + \sum LA + MOS + RC$$

Where:

LC = loading capacity, or the greatest amount of a pollutant a waterbody can receive and still meet water quality standards (see **Sections 4.3.1** and **4.4.1**);

WLA = wasteload allocation, or the portion of the LC allocated to existing or future permitted point sources (see **Sections 4.3.3** and **4.4.3**);

LA = load allocation, or the portion of the LC allocated for existing or future NPS (see **Sections 4.3.2** and **4.4.2**);

MOS = margin of safety, or accounting for any uncertainty associated with attaining the water quality standard. The MOS may be explicitly stated as an added, separate quantity in the TMDL calculation or maybe implicit, as in a conservative assumption (U.S. EPA, 2007) (see **Sections 4.3.4** and **4.4.4**);

RC = reserve capacity, if applicable, is the portion of the TMDL that accommodates for future loads (see **Sections 4.3.6** and **4.4.6**);

As stated in the 40 CFR 130.2(i), TMDLs can be expressed in terms of mass per time, toxicity, or other appropriate measures. For this TMDL report, the TMDLs, allocations, and margins of safety are expressed in mass/day. Discussion of each TMDL component as it applies to each pollutant is discussed in greater detail in **Section 4.3** and **Section 4.4**.

4.1 Data Sources

4.1.1 Hydrological Simulation Program-Fortran

The HSPF model is a comprehensive package for simulation of watershed hydrology, sediment transportation, and water quality for conventional and toxic organic pollutants. HSPF incorporates watershed-scale Agricultural Runoff Model (ARM) and NPS models into a basin-scale analysis framework that includes fate and transport in one dimensional stream channels. It 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 result of this simulation is a time history of the runoff flow rate, sediment load, and nutrient and pesticide concentrations, along with a time history of water quantity and quality at the outlet of any subwatershed.

4.1.2 Environmental Quality Information Systems

The MPCA uses a database called EQuIS to store water quality data from more than 17,000 sampling locations across the state. EQuIS contains information from Minnesota streams and lakes dating back to 1926. All discrete water quality sampling data utilized for assessments and data analysis for this TMDL report are stored in this accessible database: *EDA* (MPCA, 2019).

4.2 Data

Flow data and water quality data are two important components in the development of the TMDLs. Observed daily flow data was available in AUID -503 from a USGS station. Flow data from the years 2007 through 2016 were used to develop TMDLs. The water quality data were obtained from the MPCA through EQuIS and EDA. The years of water quality data used correspond to the flow conditions period (2007 through 2016). **Table 11** provides a list of the flow station and water quality stations used to develop the LDCs.

Table 11. Flow and water quality monitoring sites used for TMDL development in the MRW.

AUID	Pollutant/Stressor	Flow Station (USGS or HSPF ID)	Water quality station with relevant data (years of data)
09020107-503	*E. coli*	USGS #05067500	S002-127 (2008-2010), S007-786 (2014-2015)
	Turbidity (TSS)	USGS #05067500	S002-127 (2007-2016), S007-786 (2014), S005-789 (2010-2016), S005-798 (2009)

4.3 *Escherichia coli*

4.3.1 Loading capacity methodology

The LC is the greatest amount of a pollutant a waterbody can receive and still meet the water quality standard. The loading capacities for impaired stream reaches in the MRW were determined using the LDC approach. An LDC is developed by combining the (simulated or observed) river/stream flow at the downstream end of the AUID with the observed/measured *E. coli* data available within the segment. Methods detailed in the EPA document *An Approach for Using Load Duration Curves in the Development of TMDLs,* were used in creating the curves (U.S. EPA, 2007).

A system's water quality often varies based on flow regime, with elevated pollutant loadings sometimes occurring more frequently under one regime or another. Loading dynamics during certain flow zones can be indicative of the type of pollutant source causing an exceedance (i.e., point sources contributing more loading under the lowest flow zones). The LDC approach identifies these flow regimes and presents the observed and "allowable" loading within each flow zone, to compute necessary load reductions. To represent different types of flow events and pollutant loading during these events, five flow zones were identified based on percent exceedance: Very High Flow (0% to 10%), High Flow (10% to 40%), Mid Flow (40% to 60%), Low Flow (60% to 90%), and Very Low Flow (90% to 100%).

Benefits of LDC analysis include: (1) the loading capacities are calculated for multiple flow zones, not just a single point; (2) use of the method helps identify specific flow zones and hydrologic processes/patterns where loading may be a concern; and (3) ensuring that the applicable water quality standards are protective across all flow regimes. Some limitations with the LDC approach exist: (1) the approach is limited in the ability to track individual loadings or relative source contributions, and (2) the method is most appropriate when a correlation between flow and water quality exists and flow is the driving force behind pollutant delivery mechanics.

The LDC method is based on an analysis that encompasses the cumulative frequency of historical 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 summary table of this report (e.g., **Table 14**), only five points on the entire LC curve are depicted (the midpoints of the designated flow zones). However, it should be understood that the entire curve represents the TMDL, and it is what the EPA ultimately approves.

Table 12 provides the methodology to convert flows and concentrations to *E*. *coli* loads. The LC was calculated using the geometric mean (i.e., geomean) standard of 126 organisms/100 mL and was used in the development of the TMDL summary table. The water quality standard for *E. coli* applies during April to October. Loads are calculated as organisms per day (org/day) and reported as billions of organisms per day.

Table 12. Converting flow and concentration into *E*. *coli* load.

Load (org/day) = *E. coli* Standard (organisms/100mL) * Flow (cfs) * Factor			
Multiply by **28.316** to convert	ft^3 per second	→	L/sec
Multiply by **1000** to convert	liters per second	→	mL/sec
Divide by **100** to convert	milliliters per second	→	organisms/sec
Multiply by **86,400** to convert	organisms per second	→	organisms/day

4.3.2 Load allocation methodology

The LA represent the portion of the LC designated for NPS of *E. coli*. The LA is the remaining load once the WLA and MOS are determined and subtracted from the LC. The LA includes all sources of *E. coli* that do not require NPDES/SDS permit coverage, including unregulated watershed runoff of fecal contaminants from animal feedlots, pastures, agricultural fields, wildlife, and pets; direct fecal contamination by livestock, wildlife, and pets with access to waterbodies; noncompliant SSTS that are IPHTs; and a consideration for natural background conditions. NPS of *E. coli* were previously discussed in **Section 3.5.1.2**.

4.3.3 Wasteload allocation methodology

WLAs represent the regulated portion of the LC, requiring an NPDES/SDS permit. Regulated sources may include MS4 permitted areas, NPDES/SDS permitted feedlots, and domestic or industrial WWTPs. The only regulated sources of *E. coli* in the watershed of -503 are two WWTPs; there are no MS4s or NPDES/SDS permitted feedlots in the drainage basin.

4.3.3.1 Wastewater Treatment Plants

Domestic WWTPs are NPDES/SDS permitted facilities that process primarily wastewater from domestic sanitary sewer sources (sewage). Pond facilities include city or sanitary district treatment facilities, wayside rest areas, or national or state parks and are limited to controlled discharge typically from a single secondary treatment pond. All pond WWTPs are permitted to discharge only during specified discharge windows in the spring and fall. The discharge windows for pond WWTPs in the MRW are March 1 through June 30 and September 1 through December 31, with no discharge to ice covered waters.

There are two NPDES/SDS permitted WWTPs within the drainage area of -503: Ada WWTP and Shelley WWTP. Both of these are Class D pond facilities, each with one or two primary pond cell(s) and one secondary pond cell. *E. coli* WLAs for these two WWTPs are based on the maximum daily discharge of six inches per day from the secondary pond and the *E. coli* water quality standard. Although surface water quality is now based on *E. coli*, WWTPs are permitted based on fecal coliform concentrations. Like *E. coli*, fecal coliform are an indicator of fecal contamination. The primary function of a bacterial effluent limit is to ensure that the effluent is being adequately treated, either naturally (sunlight) or with a disinfectant, to ensure a complete of near-complete kill of fecal bacteria prior to discharge. The WWTPs, permit numbers, permitted flows, and *E. coli* WLAs within the watershed of the impaired reach, Marsh River (-503), are provided in **Table 13**. The permit limits for fecal coliform that are already assigned to these WWTPs are consistent with the WLAs assigned in this report's *E. coli* TMDL.

Table 13. Calculations of *E. coli* WLAs for NPDES/SDS-permitted, domestic wastewater treatment plants draining within the watershed of the impaired reach (Marsh River, 09020107-503).

			A	B	C	D	E	F	
Facility (permit number)	**Receiving water (09020107-###)**	**Average wet weather design flow (mgd)**	**Secondary pond size (acres)**	**Mean operating depth of A (feet)**	**Permitted maximum daily discharge (liters/day) (=A*0.5*1233480.22)[a]**	**# of days discharging per year at maximum rate ((B/0.5)*2)**	**Maximum allowed *E. coli* concentration (org/100 mL)**	**Daily *E. coli* WLA (10^9 org/day) (=C*(E*10)/10^8)[a]**	**Annual *E. coli* WLA (10^9 org/year) (=F*D)**
Ada WWTP (MNG585095)	Unnamed ditch (-506)	0.448	14	3	8,634,362	12	126	**10.8793**	130.5516
Shelly WWTP (MNG585227)	Marsh River (-503)	0.042	4.93	3	3,040,529	12	126	**3.8311**	45.9732

[a] Calculated based on the acreage of the secondary treatment pond and a maximum discharge of six inches per day.

4.3.3.2 Construction and Industrial Stormwater

WLAs for activities covered under the Construction Stormwater General Permit (MNR100001) were not developed for *E. coli*, since *E. coli* is not a typical pollutant associated with construction sites. Industrial stormwater receives a WLA only if fecal bacteria is part of benchmark monitoring for an industrial site in the drainage area of an impaired waterbody. There are no fecal bacteria benchmarks associated with any Industrial Stormwater General Permit (MNR050000) in the impaired watershed. Therefore, no industrial stormwater *E. coli* WLAs were assigned.

4.3.3.3 Municipal Separation Storm Sewer System (MS4)

There are no NPDES/SDS permitted MS4s in the drainage basin of the *E. coli*-impaired reach.

4.3.3.4 NPDES/SDS-Permitted Animal Feedlots

There are no NPDES/SDS permitted animal feedlots in the watershed of the Marsh River (-503).

4.3.3.5 WLA during low flows

The total daily LC of some stream reaches during low and very low flow regimes are very small due to the occurrence of very low flows in the stream/river. Consequently, for some of the impaired reaches the permitted wastewater design discharge is close to, or higher than, the streamflow during these flow regimes. This translates to these point sources appearing to use all of, or exceeding, the LC during these flow periods. In reality, this will never occur as the discharge is a part of the streamflow and can never exceed total streamflow. To account for these unique situations, the WLA (and LA) are expressed as an equation rather than an absolute number. The equation is:

Allocation = Point Source Discharge X Water Quality Standard Concentration

Consistent units are used to obtain the load. This assigns a concentration-based limit to the WLA for these lower flow rates.

4.3.4 Margin of safety

The purpose of the MOS is to account for any uncertainty with attaining water quality standards. Uncertainty can be associated with data collection, lab analysis, data analysis, modeling error, and implementation activities. The MOS is an explicit 10% of the LC and was applied to each flow regime for the *E. coli* TMDL. The explicit 10% MOS accounts for:

- Uncertainty in the observed daily flow record;
- Uncertainty in the observed water quality data; and
- Variability in flow. Allocations and loading capacities are based on flow, which varies from very high to very low. This variability is accounted for using the LDCs and summarizing with five flow regimes.

The majority of the MOS is apportioned to uncertainty related to the flow record rather than with the other causes for uncertainty, because they are accounted for using the LDC methodology. All the flow data used to generate the LDCs were classified as “approved for publication” and assumed the recorded flow is within 10% of actual flow. There is no reason to believe that this number is inappropriate.

4.3.5 Seasonal variation

Monthly geometric means for *E. coli* bacteria within the impaired reach is often very near or above the state chronic standard (126 org/100mL) from April through October (**Table 7**). During the 10-year assessment timeframe (2006 through 2015) exceedance of the acute *E. coli* standard (1,260 org/100mL) occurred once on July 29, 2008, in AUID -503 (MPCA, 2017). Fecal bacteria are most productive at temperatures similar to their origination environment in animal digestive tracts. Thus, these organisms are expected to be at their highest concentrations during warmer summer months when stream flow is low and water temperatures are high. High *E. coli* concentrations in many reaches continue into the fall, which may be attributed to constant sources of *E. coli* (such as IPHT SSTS and animal access to the stream) and less flow for dilution. However, some of the data may be skewed as more samples were collected in the summer months than in September and October (in fact, no samples were collected on AUID -503 in October). Seasonal and annual variations are accounted for by setting the TMDL across the entire flow record using the LDC method.

4.3.6 Reserve capacity

No reserve capacity was included for the point sources in the MRW, given the nature of assumptions used to create the WLAs. Similarly, no reserve capacity was included for NPS in the watershed (LAs), given that the land use in the MRW is dominated by agriculture and is unlikely to substantially change in the future.

4.3.7 TMDL summary

The TMDL results are provided below. For the *E*. *coli* TMDL, a figure of the LDC is provided (**Figure 9**), followed by the TMDL summary table with the LC, WLAs, LA, MOS, observed loads, and estimated percent reductions identified by flow regime (**Table 14**). In addition, the TMDL summary table also includes the highest observed monthly geometric mean from the months that the standard applies using *E. coli* data from 2007 through 2016. Five or more samples were needed in a month to be considered the highest observed monthly geometric mean. An estimated representative percent reduction (calculated by comparing the highest observed monthly geometric mean to the geometric mean standard) is also provided. This representative percent reduction is one number (versus five numbers from the LDC method) that can be used to set goals for planning purposes. It should be noted that differences between the load reductions from the LDCs and the representative percent reduction are due to differences in the methodologies and timeframes used to derive the reductions. For example, the LDC load reductions are derived by flow regime, whereas the representative percent reduction is derived by sampling months. **Table 15** shows much of the same data by flow zone as **Table 14** but with greater precision to understand how numbers were rounded in the TMDL summary table. If no observed data is available during any of the flow regimes, the observed load and estimated load reduction are left blank.

The following rounding conventions were used for the LCs, WLAs, and observed loads in the TMDL summary table (mass refers to billions of *E. coli* organisms):

- Values ≥10 reported in mass/day have been rounded to the nearest pound;
- Values <10 and ≥1 reported in mass/day have been rounded to the nearest tenth of a pound; and
- Values <1.0 reported in mass/day have been rounded to the nearest hundredth or to enough significant digits so that the value is greater than zero and a number is displayed in the table.

If the WLA requires a flow-concentration relationship for low flows (see **Section 4.3.3.5**), it is identified by "***".

Figure 9. *E. coli* LDC for Marsh River, Headwaters to Red River (AUID 09020107-503).

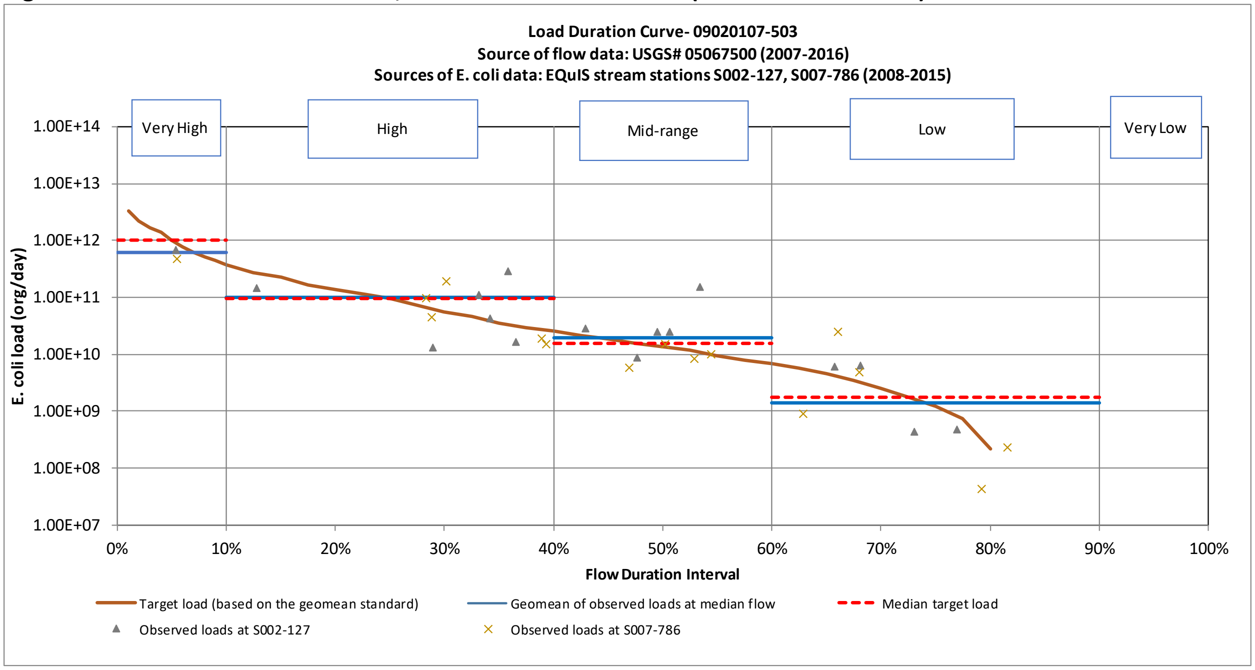


Table 14. *E. coli* TMDL summary for Marsh River, Headwaters to Red River (AUID 09020107-503).

- Listing year: 2018
- Baseline years: 2010-2011
- Numeric standard used to calculate TMDL: 126 org/100 mL *E. coli*

E. coli		**Flow zones**				
		Very High	**High**	**Mid-Range**	**Low**	**Very Low**
		(billion org/day)				
Wasteload Allocation	**Total WLA**	**14.8**	**14.8**	***	***	***
	Ada WWTP (MNG585095)	11	11	***	***	***
	Shelly WWTP (MNG585227)	3.8	3.8	***	***	***
Load Allocation	**Total LA**	**892.4**	**71.6**	**14.4**	**1.53**	**0.00**
Margin of Safety (MOS)		**100.8**	**9.6**	**1.6**	**0.17**	**0.00**
Loading Capacity		**1,008**	**96**	**16**	**1.7**	**0.00**
Observed Load		626	100	20	1.4	N/A
Estimated Percent Reduction		0%	4%	20%	0%	N/A
Highest Observed Monthly Geometric Mean		147.4 org/100 mL				
Estimated representative percent reduction		14.5%				

*** = The permitted wastewater design flows exceed the stream flow in the indicated flow zones. The WLAs are expressed as an equation rather than an absolute number: WLA = (flow contribution from a given source) x 126 org/100 mL (or NPDES permit concentration). See **Section 4.3.3.5** for more details.

Table 15. Extended *E. coli* values by flow zone for Marsh River, Headwaters to Red River (09020107-503) using the geometric mean standard.

Flow zone (%)	Median flow (cfs)	Observed concentration (org/100mL)	Observed load (billion)	Target load (billion)	Load minus MOS (billion)	Load reduction (billion) [a]	Load reduction (%) [a]
0-10	327.10	78.2511	626.2054	1008.3162	907.4846	-382.1107	-61.0%
10-40	31.025	132.3950	100.4915	95.6374	86.0737	4.8540	4.8%
40-60	5.06	160.2578	19.8388	15.5979	14.0381	4.2409	21.4%[b]
60-90	0.56	102.9467	1.4104	1.7263	1.5598	-0.3158	-22.4%
90-100	0.0			0.0000	0.0000		

[a] Positive values indicate flow zones that require a reduction in *E. coli* load.

[b] Critical conditions occur during the mid-range flow zone.

4.4 Total Suspended Solids

4.4.1 Loading capacity methodology

Like *E. coli*, LDCs were used to represent the LC for the TSS impaired reach (AUID -503). Description of the LDC methodology can be found in **Section 4.3.1**. The flow component of the LC curve is based on observed daily flows from USGS flow station #05067500 and the concentration component is the TSS concentration criteria of 65 mg/L for the SRNR. The TSS LDC for the impaired reach is shown in **Section 4.4.7**. The red curve of the LDC represents the allowable TSS LC of the reach for each daily flow. The median (or midpoint) load of each flow zone is used to represent the total LC in the TMDL summary table.

Table 16 provides the methodology and conversion factors to transform flows and concentrations to loads. The TSS standard-based LDCs were created using the SRNR TSS standard of 65 mg/L. The TSS standard only applies during the months of April through September. Loads for TSS are calculated as US tons/day.

Table 16. Converting flow and concentration to sediment load.

Load (US tons/day) = TSS standard (mg/L) * Flow (cfs) * Conversion Factor			
For each flow regime			
Multiply **flow** (cfs) by **28.31** (L/ft^3) and **86,400** (sec/day) to convert	cfs	→	L/day
Multiply **TSS Standard** (65 mg/L) by **L/day** to convert	L/day	→	mg/day
Divide **mg/day** by **907,184,740** (mg/US ton) to convert	mg/day	→	US tons/day

4.4.2 Load allocation methodology

LAs represent the portion of the LC designated for NPS of TSS. The LA is the remaining load once the WLAs and MOS are determined and subtracted from the LC. The LA includes all sources of TSS that do not require NPDES/SDS permit coverage, including unregulated watershed runoff, internal loading, groundwater, atmospheric deposition, and a consideration for natural background conditions. NPS of TSS were previously discussed in **Section 3.5.2.2**.

4.4.3 Wasteload allocation methodology

WLAs are developed for any point source/permitted discharge in the drainage area of the impaired reach. These are discharges requiring an NPDES/SDS permit and typically include domestic or industrial

WWTPs, permitted MS4s, construction stormwater, industrial stormwater, and animal feedlots. WLAs for AUID -503 are provided in the TMDL summary table in **Section 4.4.7**.

4.4.3.1 Wastewater Treatment Plants

WLAs for WWTPs are based on the reported design allowable discharge and the permitted concentration limits. The WWTPs, permit numbers, permitted flows, and WLAs within the drainage area of Marsh River (AUID -503) are provided in **Table 17**. The permit limits for TSS that are already assigned to these WWTPs are consistent with the WLAs assigned in this report's TSS TMDL.

Table 17. TSS WLAs for NPDES/SDS-permitted, domestic wastewater treatment plants draining within the watershed of the impaired reach (Marsh River, AUID 09020107-503).

			A	B	C	D	E	F	
Facility (Permit Number)	**Receiving water (09020107-###)**	**Average Wet Weather Design Flow (mgd)**	**Secondary Pond Size (acres)**	**Mean Operating Depth of A (feet)**	**Permitted maximum daily discharge (liters/day) (=A*0.5*1233480.22)[a]**	**# of days discharging per year at maximum rate ((B/0.5)*2)**	**Discharge limit: Calendar month avg (mg/L)**	**Daily TSS WLA (US tons/day) (=(C*E)/907,184,740)**	**Annual TSS WLA (US tons/year) (=F*D)**
Ada WWTP (MNG585095)	Unnamed ditch (-506)	0.448	14	3	8,634,362	12	45	**0.4283**	5.1396
Shelly WWTP (MNG585227)	Marsh River (-503)	0.042	4.93	3	3,040,529	12	45	**0.1508**	1.8096

[a] Calculated based on the acreage of the secondary treatment pond and a maximum discharge of six inches per day.

4.4.3.2 Construction and Industrial Permits

Stormwater runoff from construction sites that disturb: (a) one acre of soil or more, (b) less than one acre of soil and are part of a "larger common plan of development or sale" that is greater than one acre, or (c) less than one acre, but determined to pose a risk to water quality are regulated under the NPDES/SDS Construction Stormwater General Permit (MNR100001). This permit requires and identifies BMPs to be implemented to protect water resources from mobilized sediment and other pollutants of concern. If the owner/operators of impacted construction sites obtain and abide by the NPDES/SDS Construction Stormwater General Permit, the stormwater discharges associated with those sites are expected to meet the WLAs set in this TMDL study.

Similar to construction activities, industrial sites are regulated under general permits, in this case either the NPDES/SDS Industrial Stormwater Multi-Sector General Permit (MNR050000) or the NPDES/SDS General Permit for Nonmetallic Mining and Associated Activities (MNG490000). Like the NPDES/SDS Construction Stormwater General Permit, these permits identify BMPs to be implemented to protect water resources from pollutant discharges at the site. If the owner/operators of industrial sites abide by the necessary NPDES/SDS general stormwater permits, the discharges associated with those sites are expected to meet the WLAs set in this TMDL study.

The WLAs for construction and industrial stormwater discharges that are covered by the state's general construction and industrial stormwater permits (NPDES/SDS permit # MNR100001, MNR050000, and MNG490000) were combined and addressed through a categorical allocation, because they make up a very small fraction of the watershed area. The annual average area under construction in Norman County (which encompasses 91% of MRW) is 0.014% based on construction activity covered under the Construction Stormwater General Permit (MNR100001) from 2015 through 2019 (MPCA 2020). The annual average area under industrial activities in Norman County from 2015 through 2019 is assumed to be the same as what has undergone construction activities (0.014%). Therefore, to calculate the WLA for construction and industrial stormwater, this TMDL study assumes that 0.028% of the LC for the stream reach is assigned to construction/industrial stormwater WLA.

4.4.3.3 Municipal Separation Storm Sewer System

There are no NPDES/SDS permitted MS4 areas in the drainage basins of TSS impaired stream reaches.

4.4.3.4 NPDES/SDS-Permitted Animal Feedlots

There are no NPDES/SDS-permitted animal feedlots in the watershed of the Marsh River (-503).

4.4.3.5 WLA during low flows

The total daily LC of some stream reaches during low and very low flow regimes are very small due to the occurrence of very low flows in the stream/river. Consequently, the permitted wastewater design discharge is close to or higher than the streamflow during these flow regimes. This translates to these point sources appearing to use all of, or exceeding, the LC during these flow periods. In reality, this will never occur as the discharge is a part of the streamflow and can never exceed total streamflow. To account for these unique situations, the WLA (and LA) are expressed as an equation rather than an absolute number. The equation is:

Allocation = Point Source Discharge X Water Quality Standard Concentration

Consistent units are used to obtain the load. This assigns a concentration-based limit to the WLA for these lower flow rates.

4.4.4 Margin of safety

The purpose of the MOS is to account for any uncertainty with attaining water quality standards. Uncertainty can be associated with data collection, lab analysis, data analysis, modeling error, and implementation activities. The MOS is an explicit 10% of the LC and was applied to each flow regime for the TSS TMDL. The explicit 10% MOS accounts for:

- Uncertainty in the observed daily flow record;
- Uncertainty in the observed water quality data; and
- Variability in flow. Allocations and loading capacities are based on flow, which varies from very high to very low. This variability is accounted for using the LDCs and summarizing with five flow regimes.

The majority of the MOS is apportioned to uncertainty related to the flow record rather than with the other causes for uncertainty because they are accounted for using the LDC methodology. All the flow data used to generate the LDCs were classified as "approved for publication" and assumed the recorded flow is within 10% of actual flow.

4.4.5 Seasonal variation

Both seasonal variation and identification of the critical conditions are accounted for in this TMDL through the application of LDCs. LDCs evaluate water quality conditions across all flow zones including high flow, runoff conditions where sediment transport tends to be greatest. Seasonality is accounted for by addressing all flow zones in a given reach. The maximum load reduction for the TSS TMDL occurs during the very high flow zone.

4.4.6 Reserve capacity

No reserve capacity was included for the point sources in the MRW, given the nature of assumptions used to create the WLAs. Similarly, no reserve capacity was included for NPS in the watershed (LAs), given that the land use in the MRW is dominated by agriculture and is unlikely to substantially change in the future.

4.4.7 TMDL summary

The LDC and TMDL summary for the TSS-impaired reach in MRW are provided below (**Figure 10** and **Table 18**, respectively). The LC, WLAs, LA, MOS, observed loads, and estimated percent reductions are identified by flow regime in **Table 18**. A representative load reduction was also calculated to provide a more easily understood load reduction. This representative load reduction is one number (versus five numbers from the LDC method) that can be used to set goals for planning purposes. The representative reduction goal is derived from the observed data using the 90th percentile of the existing observed data and is shown in **Table 18**. **Table 19** shows much of the same data by flow zone as **Table 18** but with greater precision to understand how numbers were rounded in the TMDL summary table. If no observed data is available during any of the flow zones, the observed load and estimated load reduction are left blank.

The following rounding conventions were used for the LCs, WLAs, and observed loads in the TMDL summary table (mass refers to US tons of TSS):

- Values ≥10 reported in mass/day have been rounded to the nearest pound;
- Values <10 and ≥1 reported in mass/day have been rounded to the nearest tenth of a pound; and
- Values <1.0 reported in mass/day have been rounded to the nearest hundredth of a pound or to enough significant digits so that the value is greater than zero and a number is displayed in the table.

If the WLA requires a flow-concentration relationship for low flows (see **Section 4.4.3.5**), it is identified by "***".

Figure 10. TSS LDC for Marsh River, Headwaters to Red River (AUID 09020107-503).

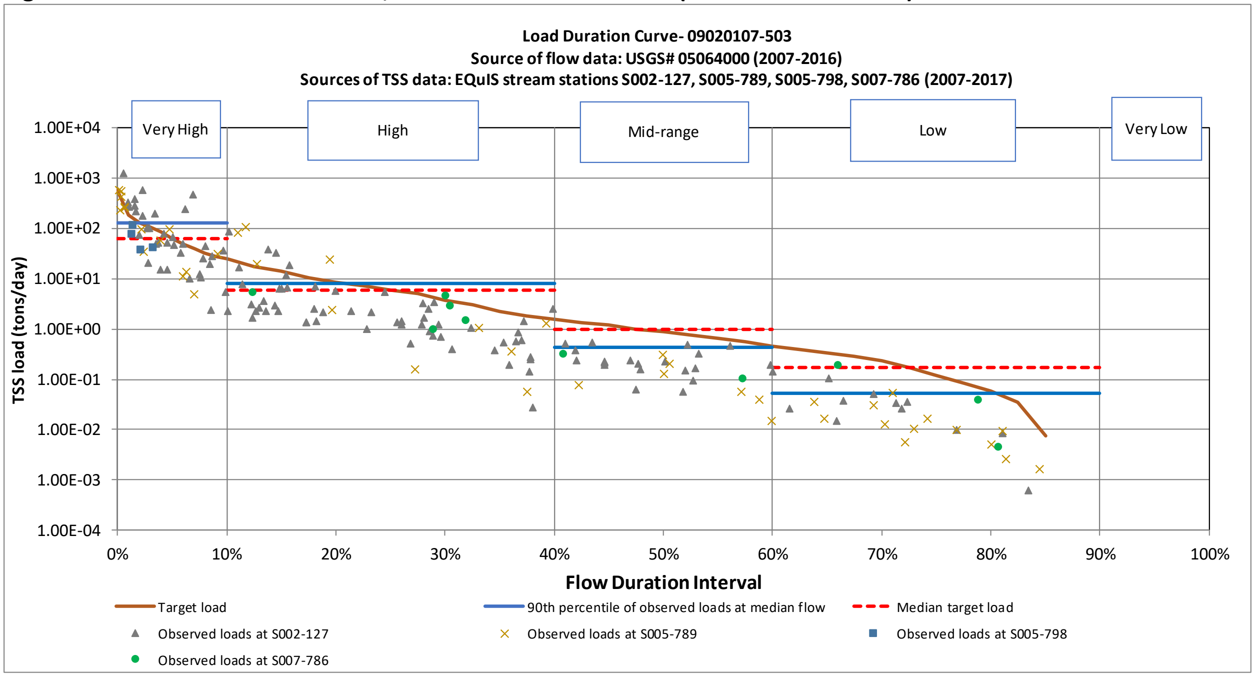


Table 18. TSS TMDL summary for Marsh River, Headwaters to Red River (AUID 09020107-503).

- Listing year: 2008
- Baseline years: 2010-2011
- Numeric standard used to calculate TMDL: 65 mg/L TSS

Total Suspended Solids		Flow zones				
		Very High	High	Mid-Range	Low	Very Low
		[US tons/day]				
Wasteload Allocation	**Total WLA**	**0.60**	**0.582**	**0.5803**	***	***
	Ada WWTP (MNG585095)	0.43	0.43	0.43	***	***
	Shelly WWTP (MNG585227)	0.15	0.15	0.15	***	***
	Construction/Industrial Stormwater	0.02	0.002	0.0003	***	***
Load Allocation	**Total LA**	**56.1**	**4.818**	**0.3197**	**0.153**	**0.00**
Margin of Safety (MOS)		**6.3**	**0.60**	**0.10**	**0.017**	**0.00**
Loading Capacity		**63**	**6.0**	**1.0**	**0.17**	**0.00**
Observed Load		125	8.1	0.42	0.05	N/A
Estimated Percent Reduction		49.6%	25.9%	0%	0%	N/A
Observed 90th percentile concentration (mg/L)		92				
Overall estimated percent reduction		29%				

*** = The permitted wastewater design flows exceed the stream flow in the indicated flow zone(s). The WLAs are expressed as an equation rather than an absolute number: WLA = (flow contribution from a given source) x 65 mg/L (or NPDES permit concentration). See **Section 4.4.3.5** for more details.

Table 19. Extended TSS values by flow zone for Marsh River, Headwaters to Red River (AUID 09020107-503).

Flow Zone (%)	Median Flow (cfs)	Observed Concentration (mg/L)	Observed Load (US tons)	Target Load (US tons)	Load minus MOS (US tons)	Load Reduction (US tons) [a]	Load Reduction (%) [a]
0-10	360.65	129.0	125.4660	63.2193	56.8974	62.2467	49.6% [b]
10-40	34.1	88.0	8.0926	5.9775	5.3797	2.1151	26.1%
40-60	5.7223	27.3	0.4213	1.0031	0.9028	-0.5818	-138.1%
60-90	0.9895	19.3	0.0515	0.1735	0.1561	-0.1220	-237.8%
90-100	0.00			0.00	0.00		

[a] Positive values indicate flow zones that require a reduction in TSS load.

[b] Critical conditions occur during the very high (0%-10%) flow zone.

5. Future growth considerations

According to the Minnesota State Demographic Center (MN Dept of Administration, 2015), over the next 20 years (2015 to 2035), the populations in the counties that overlap with the drainage area of the Marsh River (-503) are projected to decrease (Norman, -14.2%) or slightly increase (Polk, +1.1%). Like most of Minnesota's rural areas, this loss of population will likely occur in the rural areas and small towns and will result in a negligible amount of change in land use.

5.1 New or expanding permitted MS4 WLA transfer process

Though unlikely, future transfer of watershed runoff loads in this report's TMDLs may be necessary if any of the following scenarios occur within the project watershed boundaries.

- 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.
- A new MS4 or other stormwater-related point source is identified and is covered under a NPDES/SDS Permit. In this situation, a transfer must occur from the LA to a WLA.

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

5.2 New or expanding wastewater (TSS and *E. coli* TMDLs only)

The MPCA, in coordination with the EPA Region 5, has developed a streamlined process for setting or revising WLAs for new or expanding wastewater discharges to waterbodies with an EPA approved TMDL (MPCA 2014). This procedure will be used to update WLAs in approved TMDLs for new or expanding wastewater dischargers whose permitted effluent limits are at or below the instream 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 input and involvement by the EPA, 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 updates to the TMDL WLA(s) will be made.

For more information on the overall process, visit the MPCA's TMDL Policy and Guidance webpage (MPCA, 2019).

6. Reasonable Assurance

A TMDL needs to provide reasonable assurance that water quality targets will be achieved through the specified combination of point and NPS reductions reflected in the LAs and WLAs. According to EPA guidance (U.S. EPA, 2002), "When a TMDL is developed for waters impaired by both point and NPS, 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 achieve water quality standards". In the drainage area of the Marsh River (-503), considerable reductions in NPS are required.

The MPCA will:

- Evaluate existing programmatic, funding, and technical capacity to implement basin and watershed strategies;
- Identify gaps in current programs, funding, and local capacity to achieve the needed controls;
- Build program capacity for short-term and long-term goals;
- Demonstrate increased implementation and/or pollutant reductions; and
- Commit to track/monitor/assess and report progress at set regular times.

6.1 Reduction of permitted sources

6.1.1 Permitted construction and industrial stormwater

Regulated construction and industrial stormwater was given a categorical WLA in the TSS TMDL in this report. Construction activities disturbing one acre or more are required to obtain NPDES/SDS permit coverage through the MPCA. Compliance with TMDL requirements are assumed when a construction site owner/operator meets the conditions of the Construction General Permit and properly selects, installs, and maintains all BMPs required under the permit, including any applicable additional BMPs required in Section 23 of the Construction Stormwater General Permit for discharges to impaired waters, or compliance with local construction stormwater requirements if they are more restrictive than those in the State General Permit. Industrial activities require permit coverage under the State's NPDES/SDS Industrial Stormwater Multi-Sector General Permit (MNR050000) or NPDES/SDS Nonmetallic Mining/Associated Activities General Permit (MNG490000). If a facility owner/operator obtains stormwater coverage under the appropriate NPDES/SDS permit and properly selects, installs, and maintains BMPs sufficient to meet the benchmark values in the permit, the stormwater discharges would be expected to be consistent with the WLA in the TSS TMDL.

6.1.2 Permitted wastewater

All domestic (i.e., WWTPs) and industrial wastewater NPDES/SDS permits in the watershed will reflect limits consistent with WLAs described herein. Discharge monitoring is conducted by permittees and routinely submitted to the MPCA for review.

NPDES/SDS permits for discharges that may cause or have reasonable potential to cause or contribute to an exceedance of a water quality standard are required to contain water quality-based effluent limits (WQBELs) consistent with the assumptions and requirements of the WLAs in this TMDL report. Attaining the WLAs, as developed and presented in this TMDL report, is assumed to ensure meeting the water quality standards for the relevant impaired waters listings. During the permit issuance or reissuance process, wastewater discharges will be evaluated for the potential to cause or contribute to violations of water quality standards. WQBELs will be developed for WWTPs whose discharges are found to have a reasonable potential to cause or contribute to pollutants above the water quality standards. The WQBELs will be calculated based on low flow conditions, may vary slightly from the TMDL WLAs, and will include concentration based effluent limitations.

6.1.3 Permitted animal feedlots

See the discussion of the state's Feedlot Program in **Section 6.2.2**, which applies to both permitted and nonpermitted feedlots.

6.2 Reduction of nonpermitted sources

Reliable means of reducing NPS pollutant loads are addressed in the Marsh River WRAPS report (MPCA, 2021), a companion document to this TMDL report. The WRAPS report covers all waterbodies in the MRW, providing strategies to restore waters that are impaired and protect those that are unimpaired. In order for the impaired Marsh River (AUID -503) to meet water quality standards, the majority of pollutant reductions in the drainage area will need to come from NPS. Agricultural drainage and surface runoff are major contributors of nutrients, fecal contamination (as indicated by elevated *E*. *coli* levels), sediment, and increased flows throughout the watershed. As described in the Marsh River WRAPS report, the BMPs included therein have all been demonstrated to be effective in reducing transport of pollutants to surface water. The combinations of BMPs discussed throughout the WRAPS report were derived from Minnesota's Nutrient Reduction Strategy (NRS) (MPCA, 2014) and related tools. As such, they were vetted by a statewide engagement process prior to being applied in the watershed.

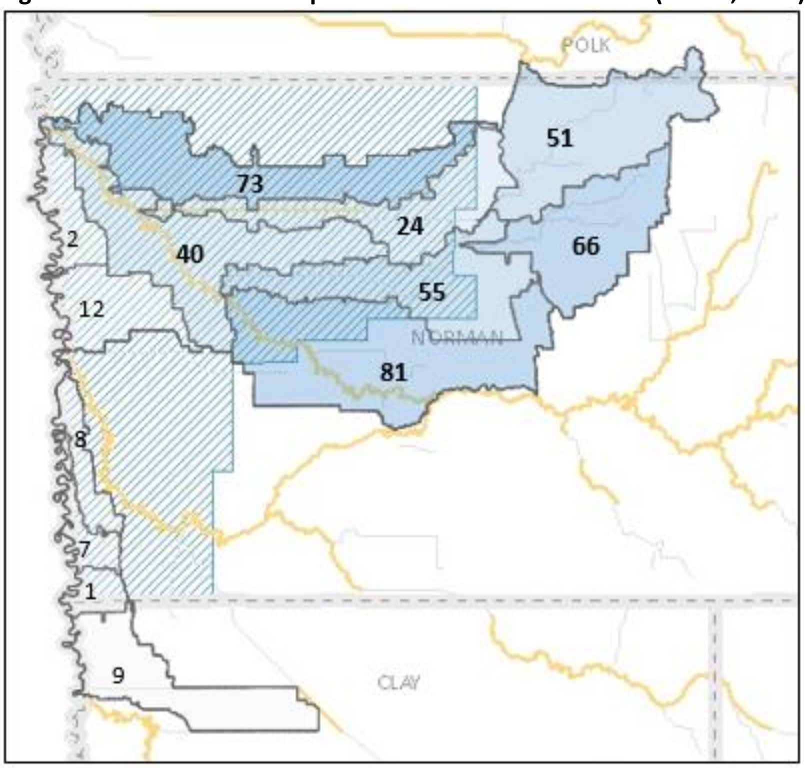
Selection of sites for BMPs will be led by LGUs, county SWCDs, watershed districts, and county planning and zoning, with support from state and federal agencies. These BMPs are supported by programs administered by the SWCDs and the Natural Resource Conservation Service (NRCS). Local resource managers are well-trained in promoting, placing, and installing these BMPs. The counties within the watershed have shown significant levels of adoption of these practices. State and local agencies will need to work with landowners to identify priority areas for BMPs and practices that will help reduce nutrient runoff, as well as streambank and overland erosion. Agencies, organizations, LGUs, and citizens alike need to recognize that resigning waters to an impaired condition is not acceptable. Throughout the course of the WRAPS and TMDL meetings, local stakeholders endorsed the BMPs selected in the WRAPS report. These BMPs reduce pollutant loads from runoff (i.e., phosphorus, sediment, and pathogens) and loads delivered through drainage tiles or groundwater flow.

To help achieve NPS reductions, a large emphasis has been placed on public participation, where the citizens and communities that hold the power to improve water quality conditions are involved in discussions and decision-making. The watershed's citizens and communities will need to voluntarily adopt the practices at the necessary scale and rates to achieve the 10-year targets presented in the

Marsh River WRAPS Report (MPCA, 2021). The WRAPS report also presents the allocations of the pollutant/stressor goals and targets to the primary sources and the estimated years to meet the goals developed by the WRAPS Local Work Group. The strategies identified and relative adoption rates developed by the WRAPS Local Work Group were used to calculate the adoption rates needed to meet the pollutant 10-year targets. In addition to public participation, several government programs are in place to support a political and social infrastructure that aims to increase the adoption of strategies that will improve watershed conditions and reduce loading from NPS.

Several nonpermitted pollutant reduction programs exist to support implementation of NPS reduction BMPs in the MRW. These programs identify BMPs, provide means of focusing BMPs, and support their implementation via state initiatives, ordinances, and/or dedicated funding. The number of BMPs per 12-HUC subwatershed (of which there are 13 in the MRW) is tracked on the MPCA's Healthier Watersheds website (MPCA, 2019). As of July 2020, the number of BMPs implemented per 12-HUC ranged from 1 to 81 (**Figure 11**). All of the BMPs that have been implemented within the drainage area of the Marsh River from 2004 through 2019 are listed below in **Table 20**.

Figure 11. Number of BMPs per subwatershed in the MRW (MPCA, 2019). [a]



[a] Larger, bolded numbers correspond to subwatersheds within the drainage area of the Marsh River (-503).

Table 20. BMPs that have been implemented within the drainage area of the Marsh River (09020107-503).

Strategy	Practice Description	Total BMPs	Installed Amount (by unit)	Units
Nutrient management (cropland)	Nutrient Management	63	14,254	acres
Living cover to crops in fall/spring	Cover Crop	58	7,621	acres
Tillage/residue management	Residue and Tillage Management, Reduced Till	52	19,128	acres

Strategy	Practice Description	Total BMPs	Installed Amount (by unit)	Units
	Residue and Tillage Management, No-Till	6	977	acres
	Residue Management, Mulch Till	4	247	acres
Converting land to perennials	Critical Area Planting	5	153	acres
	Conservation Cover	1	41	acres
Tile inlet improvements	Grade Stabilization Structure	4	5	count
	Subsurface Drain	1	500	feet
Stream banks, bluffs & ravines	Grade Stabilization Structure	4	5	count
	Stream Channel Stabilization	1	3,700	feet
Drainage ditch modifications	Grade Stabilization Structure	4	5	count
Pasture management	Access Control	5	14	acres
Tile drainage treatment/storage	Wetland Restoration	3	180	acres
Habitat & stream connectivity	Wetland Restoration	3	180	acres
Designed erosion control	Field Border	1	1,120	feet
	Water & Sediment Control Basins	1	1	count
Buffers and filters - field edge	Conservation Cover	1	41	acres
	Filter Strip	1	4	acres
	Riparian Forest Buffer	1	1	feet
Septic System Improvements	Septic System Improvement	1	1	count
Crop Rotation	Conservation Crop Rotation	1	96	acres
Other	Integrated Pest Management (IPM)	58	16,685	acres
	Windbreak/Shelterbelt Establishment	51	59,963	feet
	Well Decommissioning	15	17	count
	Windbreak/Shelterbelt Renovation	8	5,775	feet
	Cooperative Weed Management Area	7	7	count
	Forage and Biomass Planting	4	191	acres
	Watering Facility	4	4	count
	Underground Outlet	2	492	feet
	Agrichemical Handling Facility	1	1	count
	Dike	1	1,718	feet
	Mulching	1	2	acres
	Obstruction Removal	1	0	acres
	Restoration and Management of Rare and Declining Habitats	1	41	acres
	Water Well	1	1	count

The following examples describe large-scale programs that have proven to be effective and/or will reduce pollutant loads going forward.

6.2.1 Subsurface Sewage Treatment Systems Program

SSTS are regulated through Minn. Stat. §§ 115.55 and 115.56. SSTS specific rule requirements can be found in Minn. R. 7080 through 7083. Regulations include the following:

- Minimum technical standards for individual and mid-size SSTS;
- A framework for local units of government to administer SSTS programs;
- Statewide licensing and certification of SSTS professionals, SSTS product review and registration, and establishment of the SSTS Advisory Committee; and
- Various ordinances for SSTS installation, maintenance, and inspection.

Each county maintains an SSTS ordinance, in accordance with Minn. Stat. and Minn. R., establishing minimum requirements for regulation of SSTS, for the treatment and dispersal of sewage within the applicable jurisdiction of the county, to protect public health and safety, to protect groundwater quality, and to prevent or eliminate the development of public nuisances. Ordinances serve the best interests of the county's citizens by protecting health, safety, general welfare, and natural resources. In addition, each county zoning ordinance prescribes the technical standards that on-site septic systems are required to meet for compliance and outlines the requirements for the upgrade of systems found not to be in compliance. This includes systems subject to inspection at transfer of property, upon the addition of living space that includes a bedroom and/or a bathroom, and at discovery of the failure of an existing system.

All known ITPHS are recorded in a statewide database by the MPCA. From 2006 to 2019, 797 alleged straight pipes were tracked by the MPCA statewide, 765 of which were abandoned, fixed, or were found not to be a straight pipe system. The remaining known, unfixed, straight pipe systems have received a notice of noncompliance and are currently within the 10-month deadline to be fixed, have been issued Administrative Penalty Orders, or are docketed in court. More information on SSTS financial assistance can be found at MPCA's SSTS financial assistance webpage (MPCA, 2020).

6.2.2 Animal feedlot program

The MPCA's animal feedlot program addresses both permitted (of which there are currently none in the MRW) and nonpermitted animal feedlots. The animal feedlot program implements rules governing the collection, transportation, storage, processing, and disposal of animal manure and other livestock operation wastes. Minn. R. ch. 7020 regulates feedlots in the state of Minnesota. All animal feedlots capable of holding 50 or more AUs, or 10 in shoreland areas, are subject to this rule. The focus of the rule is on animal feedlots and manure storage areas that have the greatest potential for environmental impact. An animal feedlot holding 1,000 or more AUs is permitted in Minnesota.

The animal feedlot program is implemented through cooperation between MPCA and delegated county governments in 50 counties in the state. The MPCA works with county representatives to provide training, program oversight, policy and technical support, and formal enforcement support when needed. A county participating in the program has been delegated authority by the MPCA to administer the animal feedlot program. These delegated counties receive state grants to help fund their feedlot programs based on the number of feedlots in the county and the level of inspections they complete. In recent years, annual grants given to these counties statewide totaled about two million dollars (MPCA, 2017). In the drainage area of the Marsh River (AUID -503), the counties of Norman and Polk are delegated the feedlot regulatory authority. The counties will continue to implement the feedlot program and work with producers on manure management plans.

6.2.3 Minnesota buffer law

Minnesota's buffer law (Minn. Stat. § 103F.48) was signed into Minnesota law by Governor Dayton in June 2015 and requires the following:

- 50-foot buffers are required for the shore impact zone of streams classified as protected waters (Minn. Stat. 103F.201) within areas of agricultural land use. November 1, 2017, was the deadline for compliance; and
- 16.5-foot minimum width buffers are required on public drainage ditches (Minn. Stat. 103E.021). November 1, 2018, was the deadline for compliance.

These buffers help filter out phosphorus, nitrogen, and sediment. Alternative practices are allowed in place of a perennial buffer in some cases. Amendments enacted in 2017 clarify more clearly which waters require buffers, provide a timeline for implementing the buffers, describe tools for LGUs to use in tracking and reporting compliance, 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, when they filed a compliance plan with the appropriate SWCD.

The Board of Water and Soil Resources (BWSR) provides oversight of the buffer program, which is primarily administered at the local level. Compliance with the buffer law is 90% to 94% in Polk County and 95% to 100% in Norman and Clay Counties in the MRW as of January 2020 (BWSR, 2020).

6.2.4 Minnesota Agricultural Water Quality Certification Program

The Minnesota Agricultural Water Quality Certification Program (MAWQCP) is a voluntary opportunity for farmers and agricultural landowners to take the lead in implementing conservation practices that protect our water. Those who implement and maintain approved farm management practices will be 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; and
- Priority for technical 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. Since the start of the program in 2014, the program has achieved the following (estimates as of April 2021):

- Enrolled over 700,000 acres;
- Included 1,037 producers;
- Added more than 2,000 new conservation practices;

- Kept nearly 39,000 tons of sediment per year out of Minnesota rivers;
- Saved over 112,000 tons of soil and over 49,000 pounds of phosphorus per year on farms;
- Cut greenhouse gas emissions by more than 40,000 tons annually.

There are no acres in the MRW that are certified under the MAWQCP (as of December 31, 2019).

6.2.5 Section 319 Small Watershed Focus Program

The federal CWA Section 319 grant program provides funding to states to address NPS water pollution in watersheds. The MPCA has adopted a Section 319 Small Watersheds Focus Program to focus on geographically smaller and longer term watershed projects. The intent of the program is to make measureable progress for targeted waterbodies in the Section 319 focus watersheds, ultimately restoring impaired waters and preventing degradation of unimpaired waters. As of 2020, no Section 319 projects have been done in the MRW. If Section 319 funding is awarded within the MRW in the future, successful restorations in the watershed through this program will support the required pollutant reductions.

6.2.6 Minnesota Nutrient Reduction Strategy

The Minnesota NRS (MPCA, 2014) guides activities that support nitrogen and phosphorus reductions in Minnesota waterbodies and those waterbodies downstream of the state (e.g., Lake Winnipeg, Lake Superior, and the Gulf of Mexico). The NRS was developed by an interagency coordination team with help from public input. Fundamental elements of the NRS include:

- Defining progress with clear goals;
- Building on current strategies and success;
- Prioritizing problems and solutions;
- Supporting local planning and implementation; and
- Improving tracking and accountability.

Included within the strategy discussion are alternatives and tools for consideration by drainage authorities, information on available tools and approaches for identifying areas of phosphorus and nitrogen loading and tracking efforts within a watershed, and additional research priorities. The NRS is focused on incremental progress and provides meaningful and achievable nutrient load reduction milestones that allow for better understanding of incremental and adaptive progress toward final goals. The strategy has set a reduction of 10% for phosphorus and 13% for nitrogen in the Red River Basin (relative to average 2003 conditions). The Minnesota NRS documented a 4.3% reduction of the phosphorus load leaving the state via the Red River from the 2000 baseline to current. *Water Quality Trends for Minnesota Rivers and Streams at Milestone Sites* also notes that sites across Minnesota show reductions over the period of record for TSS, phosphorus, ammonia, and biochemical oxygen demand (MPCA, 2014). These reports generally agree that while further reductions are needed, domestic and industrial phosphorus loads, as well as loads of runoff-driven pollutants (i.e., TSS and TP) are decreasing; a conclusion that lends assurance that the Marsh River WRAPS and TMDL goals and strategies are reasonable and that long-term, enduring efforts to decrease erosion and nutrient loading to surface waters have the potential to reduce pollutant loads.

Successful implementation of the NRS will require broad support, coordination, and collaboration among agencies, academia, local government, and private industry. The MPCA is implementing a framework to integrate its water quality management programs on a major watershed scale, a process that includes:

- IWM;
- Assessment of watershed health;
- Development of WRAPS reports; and
- Management of NPDES/SDS and other regulatory and assistance programs.

This framework will result in nutrient reduction for the Red River Basin as a whole and the major watersheds within the basin.

6.2.7 Conservation easements

Conservation easements are a critical component of the state's efforts to improve water quality by reducing soil erosion, reducing phosphorus and nitrogen loading, and improving wildlife habitat and flood attenuation on private lands. Easements protect the state's water and soil resources by permanently restoring wetlands, adjacent native grassland wildlife habitat complexes, and permanent riparian buffers. In cooperation with county SWCDs, BWSR's programs compensate landowners for granting conservation easements and establishing native vegetation habitat on economically marginal, flood prone, environmentally sensitive, or highly erodible lands. These easements vary in length of time from 10 years to permanent/perpetual easements. Types of conservation easements in Minnesota include Conservation Reserve Program (CRP), Conservation Reserve Enhancement Program (CREP), Reinvest in Minnesota (RIM), and the Wetland Reserve Program (WRP) or Permanent Wetland Preserve (PWP). As of August 2019, in the counties that are located in the MRW, there were 98,383 acres of short-term conservation easements such as CRP and 42,520 acres of long term or permanent easements (CREP, RIM, WRP) (BWSR, 2019).

6.3 Summary of local plans

Minnesota has a long history of water management by local government, which included developing water management plans along county boundaries since the 1980s. The BWSR-led One Watershed, One Plan (1W1P) program is rooted in work initiated by the Local Government Water Roundtable (Association of Minnesota Counties, Minnesota Association of Watershed Districts, and Minnesota Association of SWCDs). The Roundtable recommended that local governments organize to develop focused implementation plans based on watershed boundaries. That recommendation was followed by the legislation (Minn. Stat. § 103B.801) that would establish the 1W1P program, which provides policy, guidance, and support for developing comprehensive watershed management plans that:

- Align local water planning purposes and procedures on watershed boundaries to create a systematic, watershed-wide, science-based approach to watershed management;
- Acknowledge and build off existing local government structure, water plan services, and local capacity;
- Incorporate and make use of data and information, including WRAPS;

- Solicit input and engage experts from agencies, citizens, and stakeholder groups; focus on implementation of prioritized and targeted actions capable of achieving measurable progress; and
- Serve as a substitute for a comprehensive plan, local water management plan, or watershed management plan developed or amended, approved, and adopted.

The Wild Rice – Marsh Comprehensive Management Plan (a result of the 1W1P program), which includes the area of the MRW, was developed in 2019 and 2020 and approved by BWSR on December 17, 2020 (WRWD, 2020). Its development was led by the Wild Rice Watershed District. The plan incorporates information that resulted from the Marsh River WRAPS project including, but not limited to, impairments, TMDL reduction goals, and implementation strategies. In this plan, seven issues were identified as top priorities and include sediment loading, altered hydrology, flooding, soil health, phosphorus loading, channel integrity, and wild rice protection, the first two of which directly relate to the TSS TMDL and the three impairments it addresses in this report. The plan has many goals that can decrease sediment loading, but the most relevant goal is sediment reduction, specifically decreasing sediment loading in the MRW to meet the 29% overall reduction needed to meet the TSS TMDL in this report. The plan lists ditch stabilization and reducing runoff volume by increasing water storage to address the altered hydrology priority issue. Increased *E. coli* is considered a mid-level priority in the plan. The short-term goal is to implement 20 projects to decrease *E. coli* loading, and the long-term goal is to implement projects at all potential loading sites. These *E. coli* goals are applicable to the entire plan area, but the Marsh River is one of the priority streams for implementation.

6.4 Funding

Funding sources to implement TMDLs can come from local, state, federal, and/or private sources. Examples include BWSR's Watershed-based Implementation Funding, Clean Water Fund Competitive Grants (e.g., Projects and Practices), and conservation funds from NRCS (e.g., Environmental Quality Incentives Program and Conservation Stewardship Program).

Watershed-based implementation funding is a noncompetitive process to fund water quality improvement and protection projects for lakes, rivers/streams, and groundwater. This funding allows collaborating local governments to pursue timely solutions based on a watershed's highest priority needs. The approach depends on the completion of a comprehensive watershed management plan developed under the 1W1P program to provide assurance that actions are prioritized, targeted, and measurable.

BWSR has begun the transition of moving toward watershed-based implementation funding to accelerate water management outcomes, enhance accountability, and improve consistency and efficiency across the state. This approach allows more clean water projects to be implemented and helps local governments spend limited resources where they are most needed.

Watershed-based implementation funding assurance measures are based on fiscal integrity and accountability for achieving measurable progress towards water quality elements of comprehensive watershed management plans. Assurance measures will be used as a means to help grantees meaningfully assess, track, and describe use of these grant funds to achieve clean water goals through prioritized, targeted, and measureable implementation. The following assurance measures are supplemental to existing reporting and on-going grant monitoring efforts:

- Understand contributions of prioritized, targeted, and measurable work in achieving clean water goals;
- Review progress of programs, projects, and practices implemented in identified priority areas;
- Complete Clean Water Fund grant work on schedule and on budget; and
- Leverage funds beyond the state grant.

Over $19,800,000 has been spent on watershed implementation projects in the MRW since 2004 (MPCA, 2019).

6.4.1 Prioritization

The Marsh River WRAPS details a number of tools that provide means for identifying priority pollutant sources and implementation work in the watershed. Further, LGUs in the watershed often employ their own local analysis for determining priorities for work.

Light Detection and Ranging (LIDAR) data is available for all of the MRW within Minnesota. It is being increasingly used by LGUs to examine landscapes, understand watershed hydrology, and prioritize BMP targeting.

6.5 Reasonable Assurance Summary

In summary, significant time and resources have been devoted to identifying the best BMPs, providing means of focusing them in the MRW, and supporting their implementation via state initiatives and dedicated funding. The MRW TMDL and WRAPS process engaged partners to arrive at reasonable examples of BMP combinations that attain pollutant reduction goals. Some of the data and information gathered during the MRW TMDL and WRAPS process went into the Wild Rice – Marsh Comprehensive Management Plan (a result of the 1W1P program), which includes the area of the MRW. With completion and approval of the Wild Rice – Marsh Comprehensive Management Plan, watershed partners now qualify for watershed-based implementation funding, which is a noncompetitive process to fund water quality improvement and protection projects for lakes, rivers/streams, and groundwater. This funding allows collaborating local governments to pursue timely solutions based on a watershed's highest priority needs. Minnesota is a leader in watershed planning as well as monitoring and tracking progress toward water quality goals and pollutant load reductions.

7. Monitoring plan

The MPCA has three water quality monitoring programs for collecting data, enabling water quality condition assessments to be completed, and creating a long-term data set to track progress towards water quality goals. These programs will continue to collect and analyze data in the MRW as part of *Minnesota's Water Quality Monitoring Strategy* (MPCA, 2011). Data needs are considered by each program and additional monitoring is implemented when deemed necessary and feasible. The monitoring programs are:

IWM (MPCA, 2017) data provide a periodic but intensive "snapshot" of water quality throughout the watershed. This program collects water quality and biological data at stream monitoring stations across the watershed for 2 years, every 10 years. The most recent IWM in the MRW occurred in 2014 and 2015. To measure pollutant trends and conditions across the watershed, the MPCA will re-visit and re-assess the watershed, as well as monitor new sites in areas of interest. This work is scheduled to start its second iteration in the MRW in 2024.

Watershed Pollutant Load Monitoring Network (MPCA, 2019) data provide a continuous and long-term record of water quality conditions at the major watershed and subwatershed scale. This program collects pollutant samples and flow data to calculate continuous daily flow, sediment loads, and nutrient loads. In the MRW, there is one load monitoring site (W59007001); it is located in the Marsh River near Shelly, MN.

Citizen Stream and Lake Monitoring Program (MPCA, 2020) data provide a continuous record of waterbody transparency throughout much of the watershed. This program relies on a network of private citizen volunteers who make monthly lake and river measurements annually.

8. Implementation strategy summary

The strategies described in this section are potential actions to reduce *E. coli* (by reducing fecal contamination) and TSS in the MRW in Minnesota. A more detailed discussion on implementation strategies can be found in the *Marsh River WRAPS Report* (MPCA, 2021).

8.1 Permitted sources

8.1.1 Construction stormwater

Exactly half of each categorical WLA for stormwater is attributed to construction stormwater. The construction stormwater portion of the WLAs that is discharged from sites where there is construction activity reflects the area of construction sites greater 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 Minnesota'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 Section 23 of the Construction General Permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL. Construction activity must also meet all local government construction stormwater requirements.

8.1.2 Industrial stormwater

Exactly half of each categorical WLA for stormwater is attributed to industrial stormwater. BMPs and other stormwater control measures should be implemented at industrial stormwater sites to limit the discharge of pollutants of concern. Minnesota's NPDES/SDS Industrial Stormwater Multi-Sector General Permit (MNR050000) and NPDES/SDS Nonmetallic Mining/Associated Activities General Permit (MNG490000) establish benchmark concentrations for pollutants in industrial stormwater discharges. If a facility owner/operator obtains stormwater coverage under the appropriate NPDES/SDS permit and properly selects, installs, and maintains BMPs sufficient to meet the benchmark values in the permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL report. Industrial activity must also meet all local government stormwater requirements.

8.1.3 Wastewater

The MPCA issues NPDES/SDS permits for WWTPs that discharge into waters of the state. The permits have site specific limits that are based on water quality standards. WWTPs discharging into impaired reaches did not require any changes to their discharge permit limits due to the WLAs calculated in this TMDL report. Permits regulate discharges with the goals of protecting public health and AQL and assuring that every facility treats wastewater. In addition, SDS permits set limits and establish controls for land application of sewage.

The requirements of the WWTPs NPDES/SDS permits, along with the WLAs, should be sufficient implementation strategies for the WWTPs in the MRW. If a WWTP follows all requirements under the NPDES/SDS wastewater permit, the wastewater discharge would be expected to be consistent with the WLA in this TMDL report.

8.2 Nonpermitted sources

A summary of potential BMPs to reduce NPS of targeted pollutants is provided in **Table 21**. A goal of implementing BMPs to reduce *E. coli* and sediment loading from NPS is to meet the TMDLs for -503 in this report (no reductions in these pollutants is required from point sources). Only agricultural BMPs are shown in the table because 88% of the MRW is cultivated crops, so these types of BMPs have the greatest amount of applicable land area for potential implementation. BMPs and implementation strategies to address these pollutants is explored more thoroughly in the *Marsh River WRAPS Report* (MPCA, 2021) and the *Wild Rice – Marsh River Watershed 1W1P* (WRWD, 2020).

Table 21. Summary of agricultural BMPs for agricultural sources and their primary targeted pollutants and nonpollutant stressor.

BMP (NRCS standard)	Targeted pollutant				Targeted nonpollutant stressor
	E. coli	Sediment	Nitrate	Phosphorus	Flow regime instability
Filter strips (636)	X	X		X	
Riparian buffers (390)	X	X		X	
Clean water diversion (362)	X			X	
Access control/fencing (472 and 382)	X	X		X	
Water storage facilities (313) and nutrient management (590)	X		X	X	X
Drainage water management (554)			X		X
Bioreactors (605)			X		
Grassed waterways (412)		X		X	X
Water and sediment control basins (638)		X		X	X
Conservation cover (327)		X	X	X	X
Conservation/reduced tillage (329 and 345)		X		X	X
Cover crops (340)		X	X	X	X

Implementing BMPs within the drainage area of -503 to meet the TMDL for TSS will also address the impairments that were identified by poor fish bioassessments and benthic macroinvertebrate bioassessments when BMPs are also implemented to address the targeted nonpollutant stressor (flow regime instability in **Table 21**). Loss of longitudinal connectivity, DO, and insufficient habitat, which are also nonpollutant stressors to the biological communities are not listed separately in **Table 21**, because 1) they are stressors to a lesser degree than flow regime instability (**Table 3**) and 2) they can be addressed by addressing other targets in the table, for example by implementing BMPs to decrease phosphorus (addresses DO), decrease sediment (addresses habitat), and stabilize the flow regime (addresses all three stressors).

There are many benefits of implementing the BMPs in the drainage area of -503 to stabilize the flow regime by increasing base flow during dry times of the year and decreasing high flows during wet times of the year. Increasing base flow will increase DO and connectivity (increasing connectivity will also increase the availability of sufficient habitat), which will alleviate the degree to which these stress biological communities. Decreasing high flows will decrease sediment loading that would otherwise lead to habitat loss and increased suspended sediment. While the goal in the *Marsh River WRAPS Report* (MPCA, 2021) is to ultimately maintain flow in all AUIDs in the MRW, the 10-year target for addressing flow regime instability is a measurable increase in flow during drier periods. The *Wild Rice – Marsh River Watershed 1W1P* (WRWD, 2020) also provides more information on the planned implementation projects and schedule for the drainage area of the Marsh River.

Implementing BMPs that have the maximum, positive impact to as many pollutants and nonpollutants as possible would be most beneficial. For example, implementing cover crops addresses four of the five targets in **Table 21** as opposed to implementing bioreactors which only addresses one of the five targets in the table.

Table 20 also showed that many of the BMPs in **Table 21** have already been implemented in at least one location within the drainage area of the Marsh River (-503).

8.3 Cost

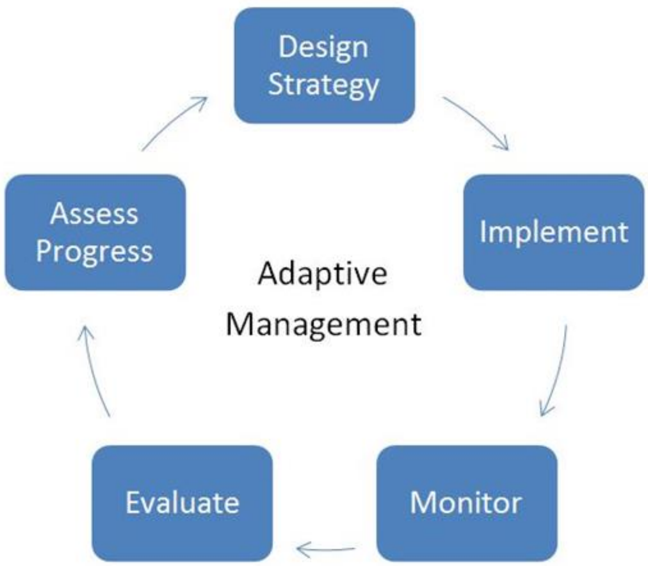
The CWLA requires that a TMDL include an overall approximation of the cost to implement a TMDL [Minn. Stat. 2019, 114D.25]. The costs to implement the activities outlined in the *Marsh River WRAPS Report* (MPCA, 2021) are approximately $10 to $20 million over the next 20 years. This range reflects the level of uncertainty in the source assessment and addresses the high priority sources identified in **Section 3.5**. The cost includes increasing local capacity to oversee implementation in the watershed and the voluntary actions needed to achieve reductions. Required buffer installation and replacement of ITPHS systems are not included.

8.4 Adaptive management

Adaptive management is an iterative implementation process that makes progress toward achieving water quality goals while using any new data and information to reduce uncertainty and adjust implementation activities. Adaptive management is an ongoing process of evaluating and adjusting the strategies and activities that will be developed to implement the TMDL studies. The implementation of practicable controls should take place even while additional data collection and analysis are conducted to guide future implementation actions. Adaptive management does not include changes to water quality standards or LC. Any changes to water quality standards or LC must be preceded by appropriate administrative processes, including public notice and an opportunity for public review and comment.

The *Marsh River WRAPS Report* (MPCA, 2021) provides details of the management strategies and activities listed in **Section 8.2**. The WRAPS report focuses on adaptive management (**Figure 12**) to evaluate project progress as well as to determine if the implementation plan should be amended. Implementation of TMDL-related activities can take many years, and water quality benefits associated with these activities can also take many years. As the pollutant source dynamics within the watershed are better understood, implementation strategies and activities will be adjusted and refined to efficiently meet the TMDLs and lay the groundwork for de-listing the impaired reaches. The follow up water monitoring program outlined in **Section 7** will be integral to the adaptive management approach, providing assurance that implementation measures are succeeding in attaining water quality standards.

Figure 12. Adaptive management



9. Public participation

An open house style meeting was held on May 30, 2018, to provide an opportunity for the public to attend, learn, and provide input on the Marsh River WRAPS project. It was held in Twin Valley, Minnesota, which is in the Wild Rice River Watershed, because it addressed both the Marsh River WRAPS project and the Wild Rice River WRAPS project.

9.1 Public notice

An opportunity for public comment on the draft TMDL report was provided via a public notice in the State Register from April 12, 2021 through May 12, 2021. Because of the COVID-19 pandemic, it was not possible to hold an in-person public meeting to present the draft TMDL and WRAPS reports. A two-page flyer was developed instead with information and web addresses to prerecorded, on-demand presentations available to the public with material that would normally be discussed at an in-person meeting. The MPCA e-mailed the flyer to local and state partners shortly after the beginning of public notice.

There were no comment letters received during the public comment period.

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Appendix A: Bacteria source estimates calculator spreadsheet for the drainage area of the Marsh River.

Bacteria Source Estimates Calculator

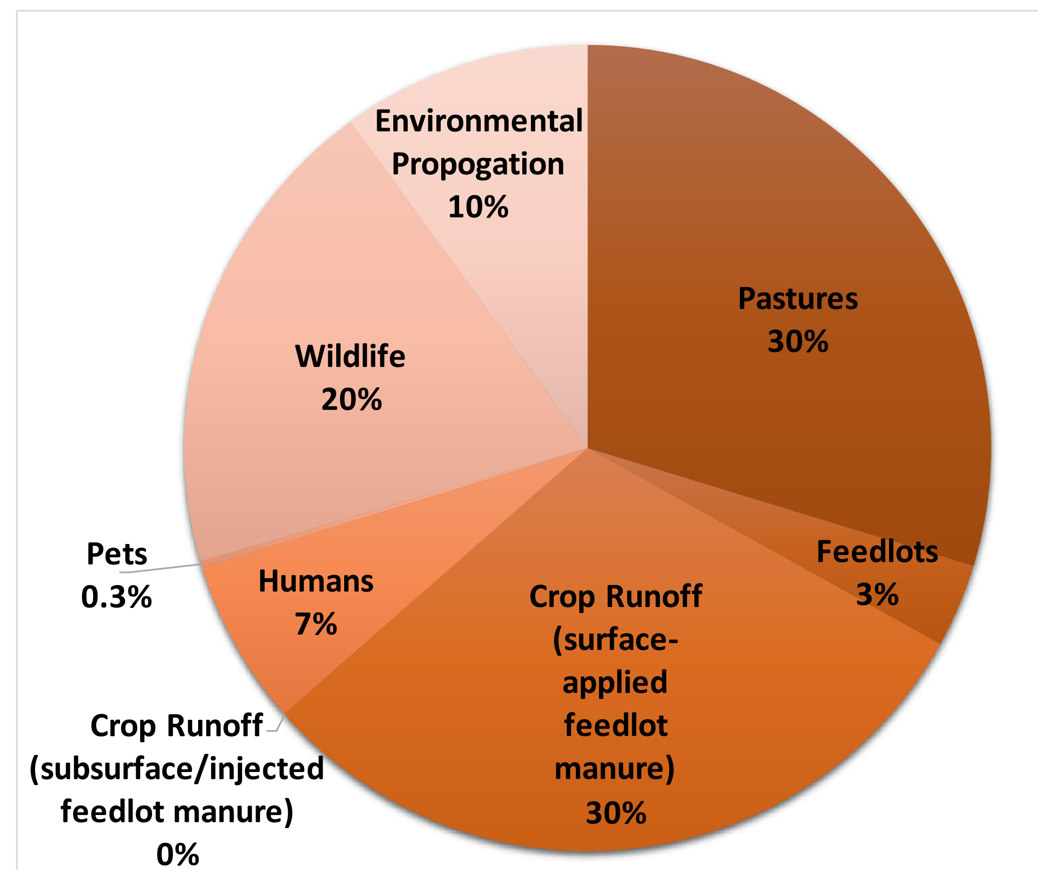
DIRECTIONS : [green cell] = enter value for watershed (known or assumption).

Watershed	**wat.**
Total area (ac)	182829
Total Pasture (ac)	1144
Pasture <1000ft of water body (ac)	319
Total AUs	1879
% feedlot AUs whose manure stockpiles w/o runoff controls	66%
number of pasture acres per 1 grazed AU	1.6
% Feedlot manure applied Surface	100%
% Feedlot manure applied Subsurface	0%
Pasture >1000 ft (ac)	825
pasture <1000ft AUS	199
pasture >1000ft AUs	516
Feedlot AUs	1164
Feedlot inadequate runoff AUs	768
Feedlot surface applied AUs	1164
Feedlot subsurface applied AUs	0
Human population	2596
number of failing septics per 1,000 acres	0.3
number of people per failing septic	2.5
# humans comparable to 1 AU	7
# acres per 1 wildlife AU of total watershed	400
humans per pet (one pet for every x humans)	3
# pets comparable to 1 AU	30
% of total load due to environmental propogation	10%
people using failing septics	137
% of human wastewater inadequatetly treated (on failing septics)	5%
of human wastewater is adequately treated	95%
Human - inadequate treatment AUs	20
Human - adequate treatment AUs	351
Pet AUs	29
Wildlife AUs	457
Wet conditons (time with active runoff)	5%
Dry conditions (no active runoff)	95%

Total Livestock AUs data includes pastured animals

each AU produces 1 unit of manure/bacteria

	condition	Pastures adjacent waterways	Other pastures	Pastures	Feedlots	Crop Runoff (surface-applied feedlot manure)	Crop Runoff (subsurface/injected feedlot manure)	Humans	Pets	Wildlife	Environmental Propogation	Human - adequately treated wastewater	Human - inadequately treated wastewater	SUM of Crop applied manure
Delivery ratio (assumed)	wet	5.0%	1.0%		0.5%	3.0%	0.2%		1.0%	3.0%		0.05%	2.0%	
Production x Delivery ratio x % of time	wet	0.5	0.3		0.2	1.7	0.0		0.0	0.7		0.0	0.0	
Delivery ratio (assumed)	dry	0.5%	0.0%		0.0%	0.0%	0.0%		0.0%	0.1%		0.05%	1.0%	
Production x Delivery ratio x % of time	dry	0.9	0.0		0.0	0.0	0.0		0.0	0.4		0.2	0.2	
Total Delivered Units		1.4	0.3	1.7	0.2	1.7	0.0	0.4	0.0	1.1	1	0.2	0.2	1.7
Total Delivered Percentage		25.2%	4.5%	29.7%	3.4%	30.5%	0.0%	6.7%	0.3%	19.5%	10.0%	3.1%	3.6%	30.5%



Calculator by J Boettcher

Calculation method based on GBE fecal TMDL, but with other/additional assumptions and calculation methods

Notes on the bacteria source estimates calculator spreadsheet for the drainage area of the Marsh River:

- The **Total Pasture (ac) with grazing animals** value was determined based on the following assumptions. Approximately 1,526 acres of land cover (Homer, et al., 2015) in the drainage area of the Marsh River are pasture/hay. Assuming 75% of the pasture/hay land cover is pasture with grazing animals on it, the total number of acres that have grazing animals is assumed to be 1,144.
- The **Total AUs** cell was filled in with 1,879 based on MPCA's animal feedlots data as of July 2020 (MPCA, 2020).
- The **% feedlot AUs whose manure stockpiles w/o runoff controls** was estimated based on animal feedlot data (MPCA, 2020). Most animal feedlots that are turkey, chicken, and pig operations keep animals in total confinement and have runoff controls and larger, permitted animal feedlots are more likely than the smaller, nonpermitted ones to have runoff control. These animal feedlots (those with turkeys, chickens, and pigs and large animal feedlots [however, there are no large animal feedlots in the drainage area of the Marsh River]) comprise approximately 44% of the AUs in the drainage area of the Marsh River. The remaining 66% of AUs reside on small bovine, horse, etc. feedlots and are assumed to not have runoff controls, so 66% was chosen as the value.
- The **number of pasture acres per 1 grazed AU** is based on the recommendation (NRCS, 2009) that a cow/calf pair (~1 AU) requires 1.5-2 acres of forage space for 12 months. The lower end of the range (1.6 acres) was used as the estimate in the spreadsheet.
    - Also, of the 16 animal feedlots in the drainage area of the Marsh River, 12 have pastures. Those 12 pastures have a total of 1,425, AUs which is similar to the number of estimated pasture acres (1,144). Since approximately half of the AUs are assumed to be in the pasture at any given time (the other half may be in the feedlot area for example), there are 712 AUs in pastures, which equates to a ratio of 1.6 acres to 1 AU.
- Of the 16 animal feedlots in the drainage area of the Marsh River, 12 have pastures. Of those 12, 4 are flagged for being near a river/stream or shoreland. Those 4 feedlots with pastures have a total of 398.7 AUs. Assuming that approximately half of these AUs will be in the pasture at any given time (the other half may be in the feedlot area for example), there are 199 AUs in pastures that are near a waterbody. Since the ratio of acres to AU is 1.6 to 1, the **Pasture <1000 ft of water body (ac)** was estimated to be 319.
- **Human population** and **number of people per failing septic** were estimated based on township demographic data (Minnesota Dept of Administration 2019).
- The **number of failing septic systems per 1,000 acres** was based on the raw data used to develop the 2018 SSTS Annual Report (MPCA, 2019). Estimates of ITPHS septic systems were used instead of those that are "failing" as ITPHS systems are sources of *E. coli*.
- The remaining values were best estimates or default values.