Watershed

July 2023

Blue Earth River Watershed Total Maximum Daily Load Report

E. coli and phosphorus TMDLs for impaired streams and lakes

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Contents

List of tables

List of figures

Abbreviations

1W1P	One Watershed, One Plan
AQC	aquatic consumption
AQL	aquatic life
AQR	aquatic recreation
AU	animal unit
AUID	assessment unit identifier
BC	boundary condition
BMP	best management practice
BWSR	Board of Water and Soil Resources
CAFO	concentrated animal feeding operation
Chl-*a*	chlorophyll-*a*
CRP	Conservation Reserve Program
CREP	Conservation Reserve Enhancement Program
CWA	Clean Water Act
DEM	digital elevation model
DMR	Discharge Monitoring Report
DNR	Minnesota Department of Natural Resources
DO	dissolved oxygen
DWSMA-SW	Drinking Water Supply Management Area – Surface Water
E. coli	*Escherichia coli*
EPA	U.S. Environmental Protection Agency
EQuIS	Environmental Quality Information System
ft	feet
HAB	harmful algal bloom
HSPF	Hydrologic Simulation Program–Fortran
HUC	Hydrologic Unit Code
IBI	index of biotic integrity
IDNR	Iowa Department of Natural Resources
ITPHS	imminent threats to public health and safety

I&I	inflow and infiltration
km^2	square kilometer
LA	load allocation
lb	pound
LDC	load duration curve
m	meter
MAWQCP	Minnesota Agricultural Water Quality Certification Program
MCL	maximum contaminant level
MDA	Minnesota Department of Agriculture
MDH	Minnesota Department of Health
mg	milligrams
mL	milliliter
MOS	margin of safety
MPCA	Minnesota Pollution Control Agency
MS4	municipal separate storm sewer system
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
org	organisms
PWP	Permanent Wetland Preserve
RIM	Reinvest in Minnesota
SAM	Scenario Application Manager
SDS	state disposal system
SONAR	Statement of Need and Reasonableness
SSO	sanitary sewer overflow
SSTS	subsurface sewage treatment systems
SWCD	soil and water conservation district
SWPPP	Stormwater Pollution Prevention Plan
TMDL	total maximum daily load
TP	total phosphorus
TSS	total suspended solids
USDA	United States Department of Agriculture

USGS	United States Geological Survey
WBIF	watershed-based implementation funding
WCBP	Western Corn Belt Plains
WLA	wasteload allocation
WPLMN	Watershed Pollutant Load Monitoring Network
WRAPS	Watershed Restoration and Protection Strategy
WRP	Wetland Reserve Program
WQBEL	water quality-based effluent limit
WTP	water treatment plant
WWTP	wastewater treatment plant
yr	year
µg	micrograms

Executive summary

The Federal Clean Water Act (CWA), Section 303(d) requires total maximum daily loads (TMDLs) to be produced for surface waters that do not meet applicable water quality standards necessary to support their designated uses (i.e., impaired waters). A TMDL determines the maximum amount of a pollutant a receiving water body can assimilate while still achieving water quality standards, and allocates allowable pollutant loads to various sources needed to meet water quality standards. This TMDL study addresses impairments in the Blue Earth River Watershed in south-central Minnesota. These impairments include high levels of *Escherichia coli* (*E. coli*), high levels of nutrients, and impaired fish assemblages, affecting aquatic recreation (AQR) and aquatic life (AQL) designated uses. Twelve *E. coli* TMDLs address 12 AQR *E. coli* impairments, and 7 phosphorus TMDLs address 11 AQR nutrient impairments and 6 AQL fish impairments. One of the phosphorus TMDLs addresses five impaired lakes that make up the Fairmont Chain of Lakes.

Land cover in the watershed is predominantly agricultural, with corn and soybeans the dominant crops. The primary sources of *E. coli* to the impaired water bodies are from nonpermitted sources, including livestock and inadequately treated wastewater. The pollutant load capacity of the *E. coli*-impaired streams was determined using load duration curves (LDCs). These curves represent the allowable pollutant load at any given flow condition. Water quality data were compared with the LDCs to determine load reduction needs. The *E. coli* data, when taken as a whole, indicate that exceedances of the *E. coli* standard occur under medium to very high flows, and *E. coli* load reductions are needed to address multiple source types. The estimated percent reductions needed to meet the *E. coli* TMDLs range from 60% to 85%.

The primary sources of phosphorus to the impaired lakes are watershed runoff from cropland and internal recycling. The nutrient loading capacity for each impaired lake was calculated using BATHTUB, an empirical model of reservoir eutrophication developed by the U.S. Army Corps of Engineers. The models were calibrated to existing water quality data. Reductions in phosphorus are presented on an average annual or seasonal basis and will need to come primarily from agricultural runoff. The estimated percent reductions needed to meet the phosphorus TMDLs range from 31% to 61%.

The TMDL implementation strategy highlights an adaptive management process to achieving water quality standards and restoring beneficial uses. Implementation strategies include agricultural runoff control and soil improvements (e.g., conservation tillage and cover crops); runoff control from feedlots; nutrient management; pasture management; septic system improvements; converting land to perennials; buffers and filter strips; urban stormwater runoff control; and in-lake management. Public participation included meetings and information communication with watershed stakeholders at various points during the project. The TMDL study is supported by previous work including the *Blue Earth River Watershed Monitoring and Assessment Report* (MPCA 2020a), *Blue Earth River Watershed Stressor Identification Report* (MPCA 2021a), *Blue Earth River Watershed Characterization Report* (DNR 2021), *Blue Earth River Watershed Stressor Identification Report – Lakes* (DNR 2022a), the Blue Earth River Watershed hydrology and water quality model (RESPEC 2014, Tetra Tech 2015, Tetra Tech 2016, with 2022 updated calibration by MPCA), the *Blue Earth River Watershed Lake Water Quality Improvement Study* (MPCA 2023a), and the *Blue Earth River Watershed WRAPS* (MPCA 2023b) and references therein.

1. Project overview

1.1 Introduction

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 included in Minnesota’s list of impaired water bodies. The term “TMDL” refers to the maximum amount of a given pollutant a water body 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 wasteload allocations (WLAs) for permitted sources, load allocations (LAs) for nonpermitted sources (including natural background), and the margin of safety (MOS), which is implicitly or explicitly defined, cannot exceed the maximum allowable pollutant load.

The Blue Earth River Watershed is identified as U.S. Geological Survey Hydrologic Unit Code (HUC)-8 07020009 and covers an area of more than 1,500 square miles in south central Minnesota and north central Iowa (Figure 1). Before its confluence with the Minnesota River in the city of Mankato, the Blue Earth River receives inflow from the Le Sueur River (HUC-8 07020011) and the Watonwan River (HUC-8 07020010), bringing the total drainage area of the Blue Earth River Basin to over 3,500 square miles. This collective area is referred to as the Greater Blue Earth River Basin. This TMDL report addresses impairments only in the HUC-8 Blue Earth River Watershed and does not address impairments in the Le Sueur River or Watonwan River Watersheds. The Blue Earth River Watershed extends to the south into the state of Iowa. The Minnesota portion of the Blue Earth River Watershed covers 1,215 square miles, or approximately 78% of the HUC-8 watershed. This TMDL report addresses only impairments within Minnesota’s portion of the Blue Earth River Watershed and does not assign allocations to Iowa.

This TMDL report is a component of a larger effort to develop watershed restoration and protection strategies (WRAPS) for the Blue Earth River Watershed. Other components of the larger effort include the *Blue Earth River Watershed Monitoring and Assessment Report* (MPCA 2020a), *Blue Earth River Watershed Stressor Identification Report* (MPCA 2021a), *Blue Earth River Watershed Characterization Report* (DNR 2021), *Blue Earth River Watershed Stressor Identification Report – Lakes* (DNR 2022a), the Blue Earth River Watershed hydrology and water quality model (RESPEC 2014, Tetra Tech 2015, Tetra Tech 2016, with 2022 updated calibration by MPCA), the *Blue Earth River Watershed Lake Water Quality Improvement Study* (MPCA 2023a), and the *Blue Earth River Watershed WRAPS* (MPCA 2023b) and references therein. The *Blue Earth River Watershed Lake Water Quality Improvement Study* (MPCA 2023a) contains background and technical information about the Fairmont Chain of Lakes TMDL.

Previously approved TMDL reports include many impairments and/or watershed areas in the Blue Earth River Watershed, and downstream of it:

- *Lower Minnesota River Dissolved Oxygen Total Maximum Daily Load Report* (MPCA 2004). This report establishes phosphorus TMDLs to address dissolved oxygen (DO) impairments on the lower 22 miles of the Minnesota River. The Blue Earth River Watershed is upstream of the Lower Minnesota River DO impairments.

- *Fecal Coliform TMDL Assessment for 21 Impaired Streams in the Blue Earth River Basin* (MSU Mankato 2007) and the related 2019 modifications to stormwater WLAs to account for new regulated MS4s (MPCA 2019a). This report establishes fecal coliform TMDLs for 12 impaired reaches in the Blue Earth River Watershed, in addition to fecal coliform TMDLs in other watersheds in the Greater Blue Earth River Basin, which includes the Le Sueur River and Watonwan River HUC-8 Watersheds. This report is referred to herein as the 2007 fecal coliform TMDL report.
- *Minnesota River E. coli Total Maximum Daily Load and Implementation Strategies* (MPCA 2019b). This report establishes *E. coli* TMDLs for five Minnesota River reaches and includes reaches downstream of the confluence of the Blue Earth River with the Minnesota River. Because fecal coliform TMDLs had already been approved for the Blue Earth River Watershed, the Blue Earth River Watershed is not in the TMDL focus area of the Minnesota River *E. coli* TMDLs, and the Minnesota River *E. coli* TMDL report does not include *E. coli* reduction strategies for the Blue Earth River Watershed.
- *South Metro Mississippi River Total Suspended Solids Total Maximum Daily Load* (MPCA 2015a). This report establishes total suspended solids (TSS) TMDLs for the Mississippi River from the confluence with the Minnesota River, through Lake Pepin, to the confluence with the Chippewa River of Wisconsin.
- *Minnesota River and Greater Blue Earth River Basin Total Suspended Solids Total Maximum Daily Load Study* (MPCA 2020b). This report establishes TSS TMDLs for 29 impaired reaches in the Blue Earth River Watershed, in addition to TSS TMDLs in other watersheds in the Minnesota River Basin.
- *Lake Pepin and Mississippi River Eutrophication Total Maximum Daily Load Report* (MPCA 2021b). This report establishes phosphorus TMDLs for Lake Pepin and the Mississippi River from the Crow River to the St. Croix River.
- *Minnesota Statewide Mercury TMDL* (MPCA 2007a). In the Blue Earth River Watershed, there are 13 water bodies with aquatic consumption (AQC) impairments based on mercury in fish tissue and 2 based on mercury in the water column. Of these mercury impairments, 13 TMDLs were approved as part of the *Minnesota Statewide Mercury TMDL* (MPCA 2007a), and 2 were included in revisions to Appendix A of the *Minnesota Statewide Mercury TMDL*, which are submitted to the U.S. Environmental Protection Agency (EPA) every 2 years with the impaired waters list.

Figure 1. Location of Blue Earth River Watershed in Minnesota.

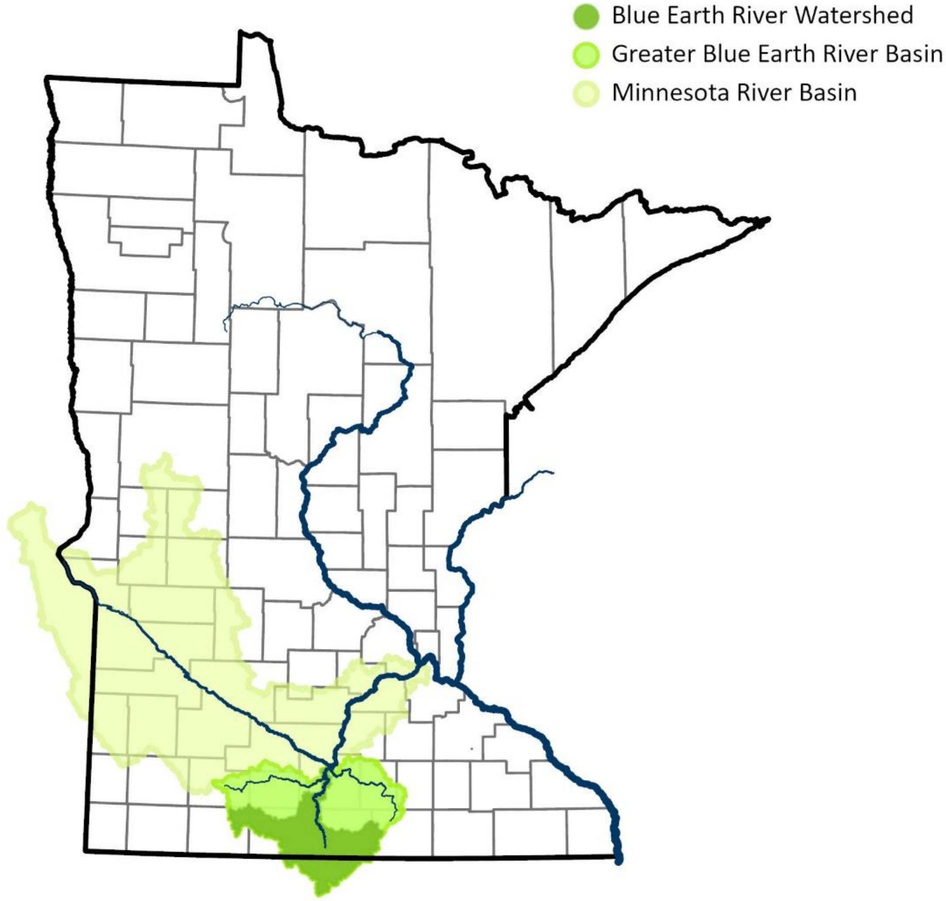
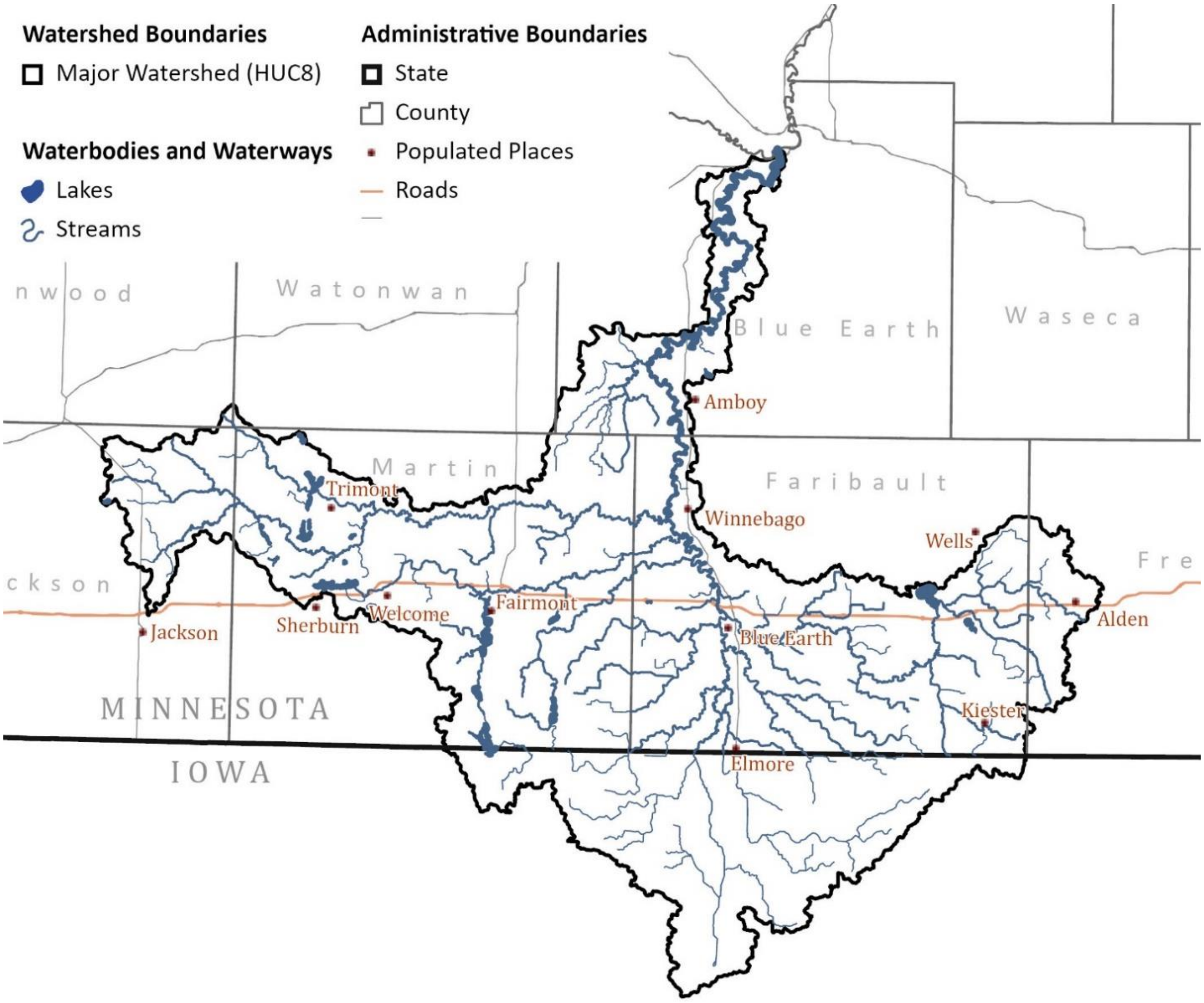


Figure 2. Blue Earth River Watershed overview.



1.2 Identification of water bodies

This report contains *E. coli* TMDLs for stream reaches with AQR *E. coli* impairments and phosphorus TMDLs for lakes with AQR nutrient and/or AQL fish impairments (Figure 3, Table 2). Phosphorus TMDLs are developed for nutrient impairments and for fish impairments for which nutrients are identified as a stressor. Total phosphorus (TP) is typically considered to be the limiting nutrient in Minnesota lakes, meaning that algal growth will increase with increases in phosphorus.

TMDLs developed in this report address some of the remaining impairments in the watershed that need a TMDL. The remaining TMDLs will be developed in future TMDL reports (see Table 25 in Appendix A for a list of all impairments in the watershed). The TMDLs that were not developed in this report are primarily biological impairments for which stressors need to be identified to determine the appropriate pollutant for TMDL development. Of the 11 impaired lakes addressed in this report, 5 lakes are part of the Fairmont Chain of Lakes (Figure 3)—Amber, Hall, Budd, Sisseton, and George Lakes. The phosphorus TMDL analysis for these lakes was completed on the Chain of Lakes Watershed as a whole, and one phosphorus TMDL addresses the nutrient impairments on all five lakes.

The lake phosphorus TMDLs for the Fairmont Chain of Lakes, Fish, and Cedar Lakes also address the AQL fish impairments on those lakes. *Blue Earth River Watershed Stressor Identification Report – Lakes* (DNR 2022a Section 4.1) identifies eutrophication (excess nutrients) as a stressor to the fish in all six of the lakes and physical habitat alteration as a stressor in Amber, Hall, Budd, Sisseton, and Fish. Water quality data and watershed disturbance information indicate that eutrophication occurs at a level that impairs the fish assemblages in these lakes (Table 1, DNR 2022a). Mean summer TP concentrations range from 75 to 145 µg/L in these lakes. Disturbed land uses in the impaired lakes range from 46% to 93%; these levels are well above 40%, which is the disturbance that Cross and Jacobson (2013) identified as the threshold for lakes having significantly elevated TP concentrations. Eutrophication in these lakes, caused at least in part by high phosphorus concentrations, likely contributes to the impaired fish communities.

Table 1. Stressor summary to lakes with fish impairments (adapted from Table 4-1 in DNR 2022a).

AUID	Lake name	Total phosphorus (µg/L) [a]	% watershed disturbance	% agriculture	% of agriculture land as cultivated crops	Active feedlots (CAFOs) [b]	% developed	Watershed to lake area ratio
46-0034-00	Amber	107	86	81	97	6 (2)	5	65
46-0031-00	Hall	79	89	83	98	18 (2)	6	46
46-0030-00	Budd	75	88	80	98	0 (0)	9	116
46-0025-00	Sisseton	85	88	79	98	0 (0)	9	202
46-0145-00	Fish	116	83	78	100	1 (0)	5	7
46-0121-00	Cedar	145	93	89	100	22 (12)	4	41

a. See Section 3.6 and Table 12 for data and methods used to calculate these growing season means, which differ slightly from the means presented in DNR 2022a.

b. Feedlots in direct drainage area to the lake. See Section 3.7.1.2 and Table 16 for data and methods used to identify feedlot numbers, which differ slightly from the data presented in DNR 2022a.

It is expected that reductions in phosphorus concentrations and in eutrophic conditions will lead to improved fish assemblages. Because TMDLs are developed only for pollutant stressors (i.e., stressors for which loads can be measured), TMDLs are not developed to address the physical habitat alteration stressor.

Although TMDLs are not developed in this report for nonpollutant stressors to biological impairments, all stressors—not just those with associated TMDLs—are addressed in the WRAPS report (MPCA 2023b). The WRAPS report provides an opportunity to call for environmental improvements in situations where TMDLs alone would not. Nonpollutant stressors include factors such as habitat alteration or flow, and TMDLs typically are not developed for nonpollutant stressors because they are not subject to load quantification. Table 25 in Appendix A lists all Blue Earth River Watershed impairments, including those addressed by TMDLs in this document. Because not all water bodies have been monitored and assessed, water bodies that are not identified as impaired do not necessarily meet water quality standards.

Finer-scale maps of the impaired lakes and their watershed boundaries are in the Appendix B maps.

Figure 3. Blue Earth River Watershed impairments addressed in this report and impairment watershed boundaries.

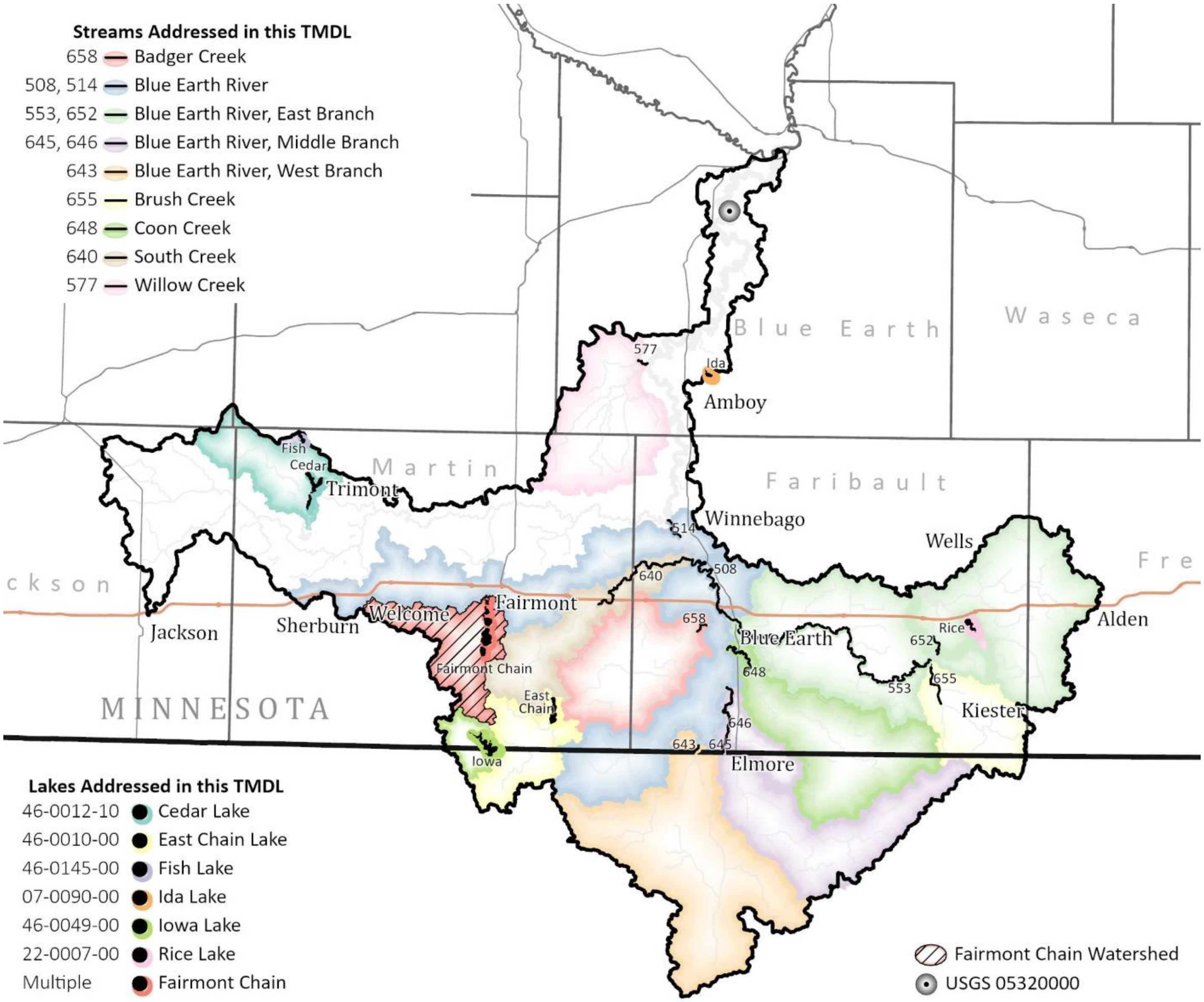


Table 2. Impaired water bodies in the Blue Earth River Watershed addressed in this report (2022 impaired waters list).

AUID [a]	Water body name	Water body description	Use class [b]	Listing year	Target completion year	Affected designated use [c]	Pollutant or stressor	TMDL parameter	Category 4A upon TMDL approval
07020009-652	Blue Earth River, East Branch	T102 R25W S23, north line to Unnamed ditch	2Bg	2020	2031	AQR	*E. coli*	*E. coli*	Y
07020009-655	Brush Creek	Unnamed cr to E Br Blue Earth R							
07020009-553	Blue Earth River, East Branch	Brush Cr to Blue Earth R							
07020009-648	Coon Creek	T102 R27W S33, south line to Blue Earth R							
07020009-645	Blue Earth River, Middle Branch	MN/IA border to -94.104 43.514							
07020009-646	Blue Earth River, Middle Branch	-94.104 43.514 to W Br Blue Earth R							
07020009-643	Blue Earth River, West Branch	MN/IA border to 15th St							
07020009-658	Badger Creek	Little Badger Cr to -94.136 43.64							
07020009-508	Blue Earth River	E Br Blue Earth R to South Cr							
07020009-640	South Creek	-94.300 43.661 to Blue Earth R							
07020009-514	Blue Earth River	Center Cr to Elm Cr							
07020009-577	Willow Creek	Unnamed cr to Blue Earth R							

AUID [a]	Water body name	Water body description	Use class [b]	Listing year	Target completion year	Affected designated use [c]	Pollutant or stressor	TMDL parameter	Category 4A upon TMDL approval
22-0007-00	Rice	Lake or Reservoir	2B	2020	2031	AQR	Nutrients	TP	Y
46-0049-00	Iowa [d]	Lake or Reservoir	2B	2020	2031	AQR	Nutrients	TP	Y
46-0010-00	East Chain	Lake or Reservoir	2B	2020	2031	AQR	Nutrients	TP	Y
46-0034-00	Amber	Lake or Reservoir	2Bd	2006	2031	AQR	Nutrients	TP [e]	Y
				2020	2031	AQL	Fish [f]		Y
46-0031-00	Hall	Lake or Reservoir	2Bd	2006	2031	AQR	Nutrients		Y
				2020	2031	AQL	Fish		Y
46-0030-00	Budd	Lake or Reservoir	2Bd	2006	2031	AQR	Nutrients		Y
				2020	2031	AQL	Fish		Y
46-0025-00	Sisseton	Lake or Reservoir	2Bd	2006	2031	AQR	Nutrients		Y
				2020	2031	AQL	Fish		Y
46-0024-00	George	Lake or Reservoir	2Bd	2006	2031	AQR	Nutrients		Y
46-0145-00	Fish	Lake or Reservoir	2B	2020	2031	AQR	Nutrients	TP	Y
				2020	2031	AQL	Fish		Y
46-0121-00	Cedar	Lake or Reservoir	2B	2020	2031	AQR	Nutrients	TP	Y
				2020	2031	AQL	Fish		Y
07-0090-00	Ida	Lake or Reservoir	2B	2020	2031	AQR	Nutrients	TP	Y

a. AUID = assessment unit identifier.
b. Use classes—2B: aquatic life and recreation–cool or warm water habitat; 2Bd: aquatic life and recreation, also protected as a source of drinking water; 2Bg: general cool and warm water aquatic life and habitat; 1C: drinking water, with treatment.
c. AQR: aquatic recreation; AQL: aquatic life.
d. Iowa Lake crosses the Minnesota–Iowa border. The Iowa portion of the lake is known as Iowa Lake S.G.M.A. (State Game Management Area), ID IA 04-BLU-969, and is classified as B(LW), HH, and C (see Section 2.4.2).
e. The Fairmont Chain of Lakes TP TMDL addresses the nutrient and fish impairments on the five impaired lakes in the Fairmont Chain—Amber, Hall, Budd, Sisseton, and George.
f. Fish bioassessments listings are noted as “fish” in this table.

1.3 Tribal lands

The Blue Earth River Watershed is located on the traditional homelands of the Dakota Oyate. However, no part of the Blue Earth River Watershed is located within the boundary of federally recognized Tribal land, and the TMDL does not allocate pollutant load to any federally recognized Tribal Nation in this watershed.

1.4 Priority ranking

The Minnesota Pollution Control Agency (MPCA's) schedule for TMDL completions, as indicated on Minnesota's Section 303(d) impaired waters list, reflects Minnesota's priority ranking of this TMDL. The MPCA has aligned TMDL priorities with the watershed approach. The schedule for TMDL completion corresponds to the WRAPS report completion following the 10-year watershed monitoring cycle. The MPCA developed a state plan, *Prioritization Plan for Minnesota 303(d) Listings to Total Maximum Daily Loads* (MPCA 2015b), to meet the needs of EPA's national measure (WQ-27) under *EPA's Long-Term Vision for Assessment, Restoration and Protection under the CWA Section 303(d) Program* (EPA 2013). As part of these efforts, the MPCA identified water quality impaired segments that were to be addressed by TMDLs by 2022.

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
- 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 – aquatic life and recreation
- Class 3 – industrial consumption
- Class 4 – agriculture and wildlife
- Class 5 – aesthetic enjoyment and navigation
- Class 6 – other uses and protection of border waters
- Class 7 – limited resource value waters

The Class 2 AQL beneficial use includes a tiered AQL uses 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 water body.

2.2 Narrative and numeric criteria 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; 3; 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; 3; 4A and 4B; and 5
- Cool and warm water AQL and habitat and wetlands: Classes 2B, 2Be, 2Bg, 2Bm, or 2D; 3; 4A and 4B; and 5
- Limited resource value waters: Classes 3; 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 water bodies for impairment for Class 2 uses— AQL and recreation. 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 fish and macroinvertebrate indices of biotic integrity (IBIs). Fish and invertebrate IBI scores are evaluated against criteria established for individual monitoring sites by water body 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 (org). 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 al activities, its trophic status is evaluated using TP, Secchi depth, and chlorophyll-*a* (chl-*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.
- 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 Blue Earth River Watershed water quality standards

2.4.1 *E. coli*

There are two *E. coli* criteria for class 2 waters—one is applied to monthly *E. coli* geometric mean concentrations, and the other is applied to individual samples (Table 3). Exceedances of either *E. coli* criterion in class 2 waters indicate that a water body does not meet the applicable designated use. The class 2 criterion for *E. coli* apply from April through October. The *E. coli* TMDLs in this report are based on the monthly geometric mean criterion of 126 org/100 mL. It is assumed that practices implemented to meet the geometric mean criterion will also address the individual sample criterion (1,260 org/100 mL), and that the individual sample criterion will also be met. Although the TMDLs are based on the monthly geometric mean criterion, both criteria apply.

Table 3. Water quality criteria for class 2 water bodies.

Parameter	Water Quality Standard	Numeric Criteria
E. coli	Not to exceed 126 org per 100 milliliters (org/100 mL) as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than 10% of all samples taken during any calendar month individually exceed 1,260 org/100 mL. The standard applies only between April 1 and October 31.	≤ 126 org/100 mL (monthly geometric mean) ≤ 1,260 org/100 mL (individual sample)

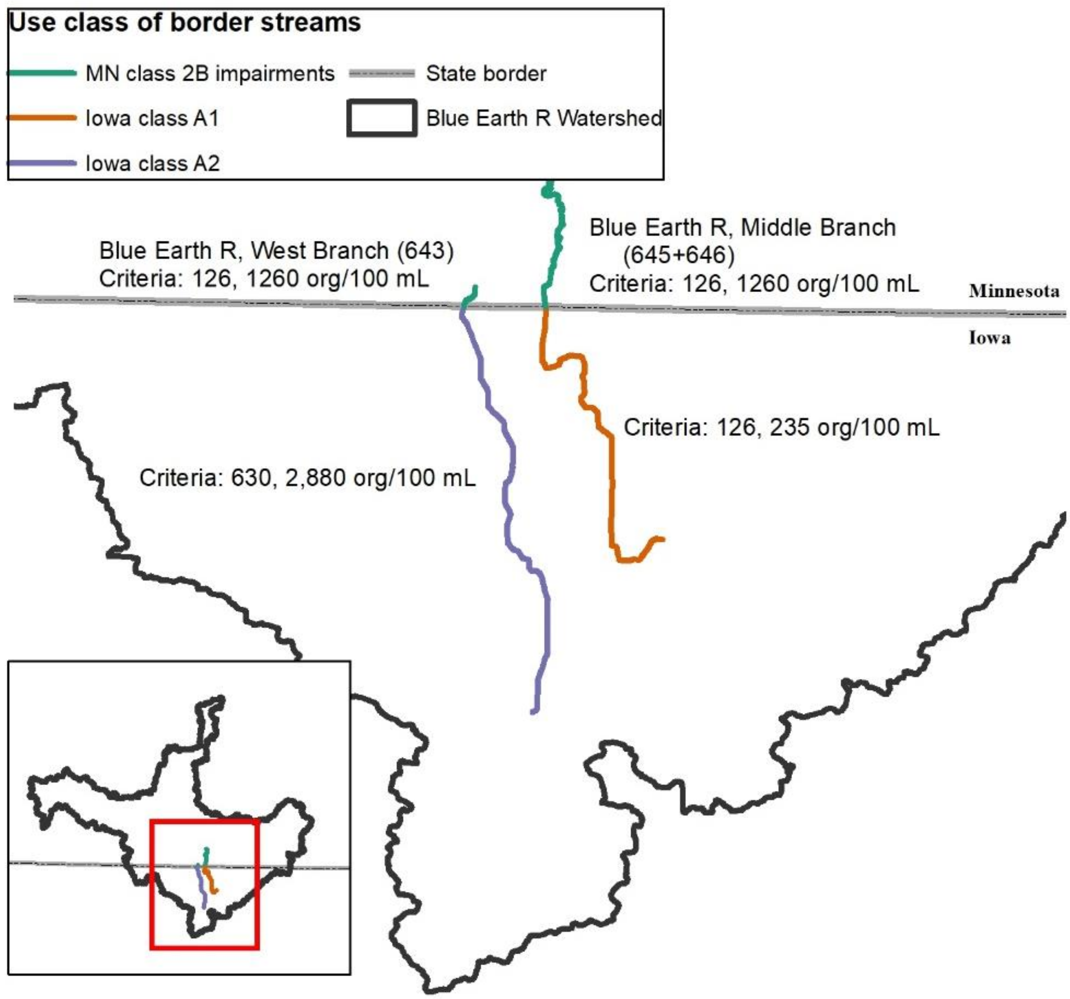
Two of the reaches with *E. coli* impairments begin at the Minnesota–Iowa state border: 07020009-645—Blue Earth River, Middle Branch (MN/IA border to -94.104 43.514) and 07020009-643—Blue Earth River, West Branch (MN/IA border to 15th St). The designated use of the Iowa stream reach that is immediately upstream of Minnesota's Middle Branch impairment (07020009-645) is primary contact recreation (A1), and the Iowa *E. coli* criteria are as restrictive as the Minnesota criteria (Table 4, Figure 4). The designated use of the Iowa stream reach that is immediately upstream of Minnesota's West Branch impairment (07020009-643) is secondary contact recreation (A2), and the Iowa *E. coli* criteria are less restrictive than the Minnesota criteria (Table 4, Figure 4). There are no known *E. coli* monitoring data from the Iowa stream reaches immediately upstream of the Minnesota impairments, and these reaches have not been assessed for *E. coli* impairment. MPCA contacted Iowa Department of Natural Resources (IDNR) to inform IDNR of this TMDL and to provide an opportunity to comment.

Table 4. Summary of Iowa water quality criteria for *E. coli* in surface waters designated for primary or secondary contact recreation (IDNR 2022).

Standard Type	Class A1: Primary Contact Recreational Use [a]	Class A2: Secondary Contact Recreational Use [a]
Geometric mean (org /100 mL)	126	630
Sample maximum (org /100 mL)	235	2,880

a. Criteria for these two reaches apply from March 15 to November 15

Figure 4. Comparison of *E. coli* criteria in Minnesota and Iowa for impaired border streams.



See Table 4 for more information about the criteria in Minnesota and Iowa.

2.4.2 Phosphorus

Lake eutrophication standards in Minnesota differ by ecoregion and by lake depth, and the standards contain numeric criteria for phosphorus, which is referred to as the causal variable, and chl-*a* concentration and Secchi disk transparency, which are referred to as the response variables. Chl-*a* concentration is a measure of the amount of suspended algae in a water body. Exceedance of the TP and either the chl-*a* or Secchi transparency standard indicates that a lake is impaired (Minn. R. ch. 7050, MPCA 2022a).

Shallow lakes typically have a maximum depth of less than 15 feet and a littoral area greater than 80% of the total surface area of the lake. All the impaired lakes addressed with TMDLs in this report are assessed as shallow lakes and are located in the Western Corn Belt Plains (WCBPs) Ecoregion. The numeric eutrophication criteria for shallow lakes in the WCBPs Ecoregion (Table 5) serve as targets for the lake TMDLs. The lake TMDLs were developed for TP; the numeric target used to develop the TMDLs is 90 micrograms (µg)/liter (L).

To be delisted from the impaired waters list, a lake must meet the TP standard and either the chl-*a* or Secchi transparency standards (MPCA 2022a). In developing the lake nutrient standards for Minnesota lakes (Minn. R. ch. 7050), the MPCA evaluated data from a large cross-section of lakes within each of the state's ecoregions (MPCA 2005). Clear relationships were established between the causal factor TP and the response variables chl-*a* and Secchi transparency. Based on these relationships there is a reasonable probability that by meeting the phosphorus target in each lake, the chl-*a* and/or Secchi standards will likewise be met.

Table 5. Eutrophication criteria for class 2B lakes and shallow lakes in the Western Corn Belt Plains Ecoregion.

Parameter	Shallow lakes
TP (µg/L)	≤ 90
Chl-*a* (µg/L)	≤ 30
Secchi transparency (meters [m])	≥ 0.7

Iowa Lake is located on the Minnesota–Iowa border, containing surface area in both states. The Iowa portion of the lake has the following classifications (IDNR 2019):

- B(LW)—Lakes and wetlands: Artificial and natural impoundments with hydraulic retention times and other physical and chemical characteristics suitable to maintain a balanced community normally associated with lake-like condition.
- HH—Human health: Waters in which fish are routinely harvested for human consumption or waters both designated as a drinking water supply and in which fish are routinely harvested for human consumption.
- C—Drinking water supply: Waters which are used as a raw water source of potable water supply.

Iowa water quality standards do not contain numeric nutrient criteria for these water body classifications. The following are components of the state's narrative criteria (Section 61.3(2)), which apply to Iowa Lake:

> c. Such waters shall be free from materials attributable to wastewater discharges or agricultural practices producing objectionable color, odor, or other aesthetically objectionable conditions.
>
> e. Such waters shall be free from substances, attributable to wastewater discharges or agricultural practices, in quantities which would produce undesirable or nuisance AQL.

Iowa Lake is not listed as impaired in Iowa. The MPCA assumes that by meeting Minnesota's numeric eutrophication criteria for shallow lakes in the WCBPs Ecoregion, Iowa's narrative criteria for lakes will also be met in Iowa Lake.

3. Watershed and water body characterization

The 1,565-square mile Blue Earth River Watershed is located in south central Minnesota and north central Iowa in the WCBPs ecoregion. The Minnesota portion of the watershed covers approximately 80% (1,215 square miles) of the watershed and is located primarily in Martin, Faribault, and Blue Earth counties, with smaller portions of the watershed in Jackson and Freeborn counties. The rest of the watershed is located in north central Iowa in Emmet, Kossuth, and Winnebago counties and consists of headwater portions of the West Branch Blue Earth River, Middle Branch Blue Earth River, and Coon Creek.

Five of the impaired lakes addressed in this report—Amber, Hall, Budd, Sisseton, and George Lake—are part of the city of Fairmont Chain of Lakes (Figure 3 and Figure 49). The *Blue Earth River Watershed Lake Water Quality Improvement Study* (MPCA 2023a) contains detailed evaluation of water quality in the Fairmont Chain of Lakes. Much of the background information for the Fairmont Chain of Lakes TMDL can be found in the water quality improvement study report (MPCA 2023a), which is referenced throughout this TMDL report.

Much of the data in this TMDL report is derived from the MPCA's Hydrologic Simulation Program–Fortran (HSPF) model application of the Blue Earth River Watershed, which was developed in conjunction with model applications for the Minnesota River Watershed (RESPEC 2014, Tetra Tech 2015, Tetra Tech 2016) and updated by MPCA in 2022 (3/31/2022 model version). HSPF is a comprehensive model of watershed hydrology and water quality that allows the integrated simulation of point sources, land and soil contaminant runoff processes, and in-stream hydraulic and sediment-chemical interactions. The results provide hourly runoff flow rates, sediment concentrations, and nutrient concentrations, along with other water quality constituents, at the outlet of any modeled subwatershed. Within each subwatershed, the upland areas are separated into multiple land cover categories, and loads generated from these land cover categories can be tabulated from the HSPF model. The model evaluates both permitted and nonpermitted sources including watershed runoff, the near channel, and wastewater point sources. The HSPF model is used to simulate flows in the impaired streams and to estimate phosphorus loads and runoff volumes to the impaired lakes in this report. Model documentation contains additional details about model development (RESPEC 2014, Tetra Tech 2015, Tetra Tech 2016). Additional models and data sources were used for the Fairmont Chain of Lakes TMDLs, as documented in the *Blue Earth River Watershed Lake Water Quality Improvement Study* (MPCA 2023a).

3.1 Climate trends

Climate is a foundational ecological condition that influences hydrology and water quality. *Climate summary for watersheds: Blue Earth River* (DNR 2019) provides an overview of climate conditions based on data from 1895 through 2018. The report focuses on trends in seasonal and annual temperature and precipitation. Long-term data show that annual average temperatures in the Blue Earth River Watershed have increased and that most years during the past two decades have been warmer than average (Figure 5). Monthly average temperatures peak in July, and winter temperatures on average have increased over time, with less change in the summer months (Figure 6). As air temperatures have risen over recent decades, lake surface water temperatures have also increased. Average July through August surface temperatures in Minnesota lakes are approximately 1.5 to 2.0 degrees Celsius warmer than 50 years ago. Warmer lake surface waters can: increase the potential for harmful algal blooms (HABs) and invasive species; lead to habitat loss for cold and cool water adapted fish, invertebrates, and other AQL; and lead to changes in thermal stratification, leading to higher internal phosphorus loading, loss of oxygen in bottom waters in deep lakes, and more unstable or temporary stratification in shallow lakes.

Annual precipitation in the Blue Earth River Watershed also shows an upward trend (Figure 7). Monthly precipitation is typically highest in May and June, and increases in precipitation in recent years were most pronounced in April through July (Figure 8). The frequency of 1-inch and 3-inch rain events has increased in general in Minnesota, along with the size of the heaviest rainfall of the year. Minnesota has also experienced an increase in devastating, large-area extreme rainstorms (DNR 2022b). Climate projections indicate these big rains will continue increasing into the future (DNR 2022b).

This increase in the frequency and size of rainfall events affects river and stream flows. Peak flows in the Minnesota River have increased over the last few decades (Figure 9). Higher flows result in greater stream channel erosion and sediment transport. These in turn impact local and downstream habitat for fish and other AQL, and may degrade recreational uses. Heavy rains and high flows in the city of Fairmont have resulted in wastewater releases in the city, in which the wastewater treatment plant (WWTP) is bypassed and sanitary system flows are pumped into surface waters (MDH 2022).

Figure 5. Annual average temperature, Blue Earth River Watershed.

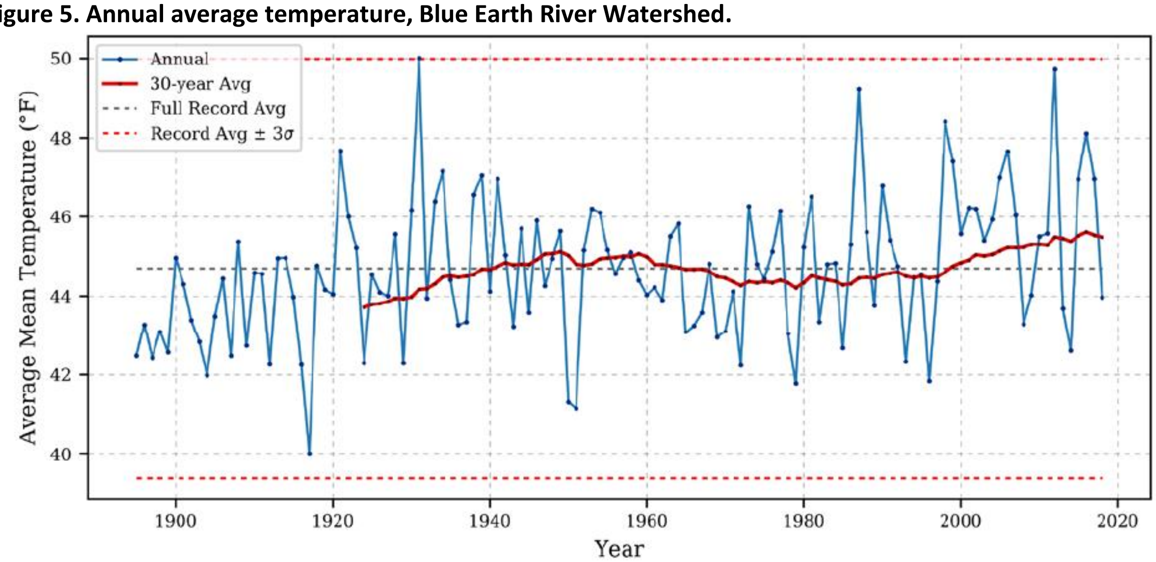


Figure from DNR (2019).

Figure 6. Monthly average temperature distribution and departure from record mean, Blue Earth River Watershed.

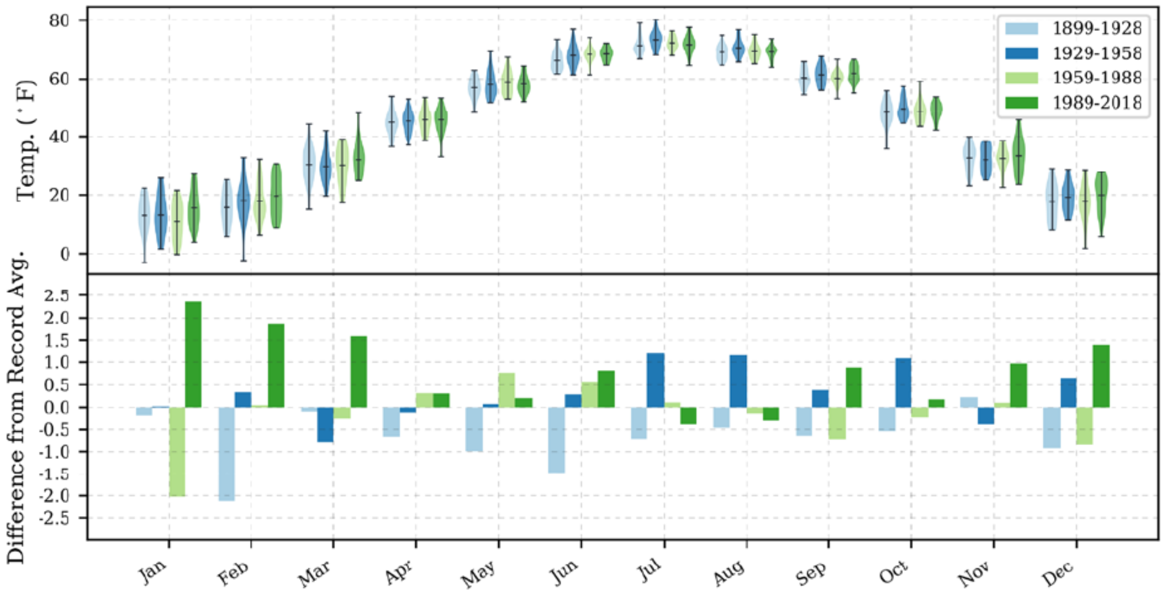


Figure from DNR (2019).

Figure 7. Annual precipitation, Blue Earth River Watershed.

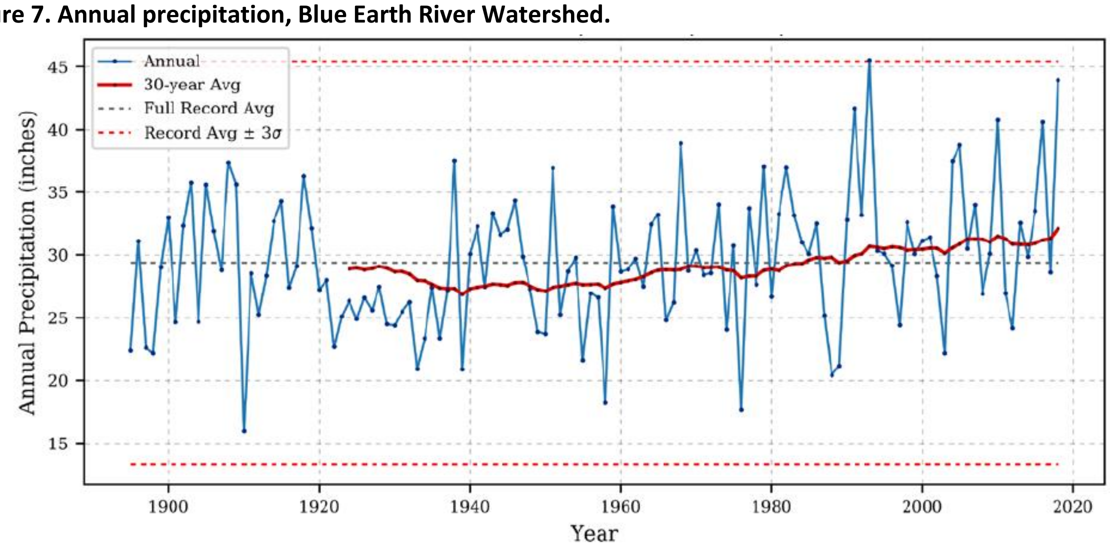


Figure from DNR (2019).

Figure 8. Monthly precipitation distribution and departure from record mean, Blue Earth River Watershed.

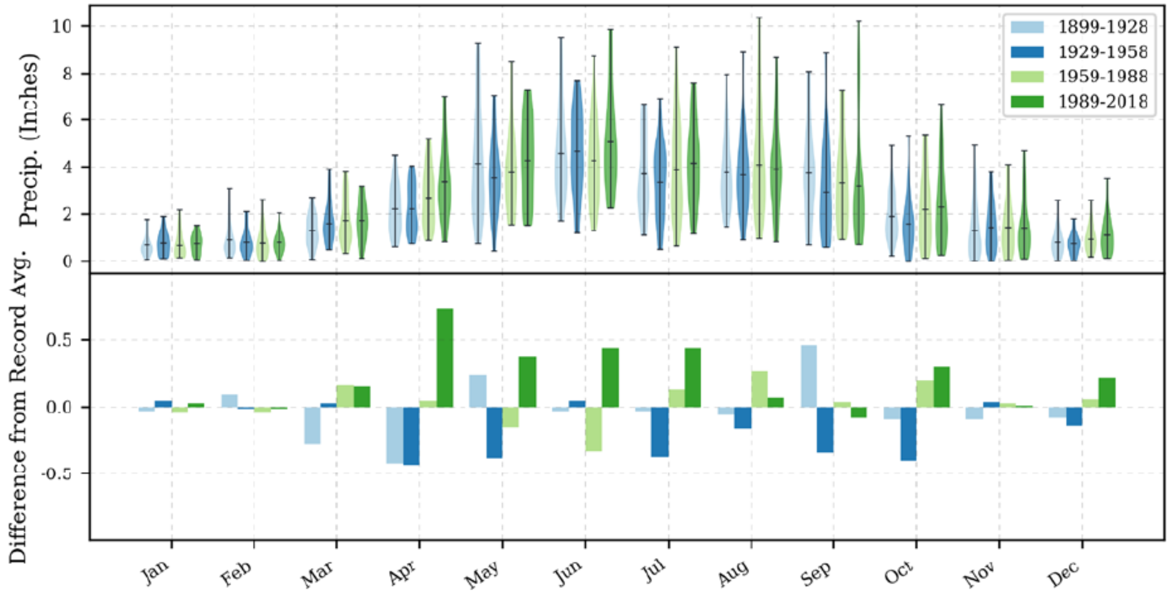


Figure from DNR (2019).

Figure 9. Trends in flood flows: percent difference from median annual peak.

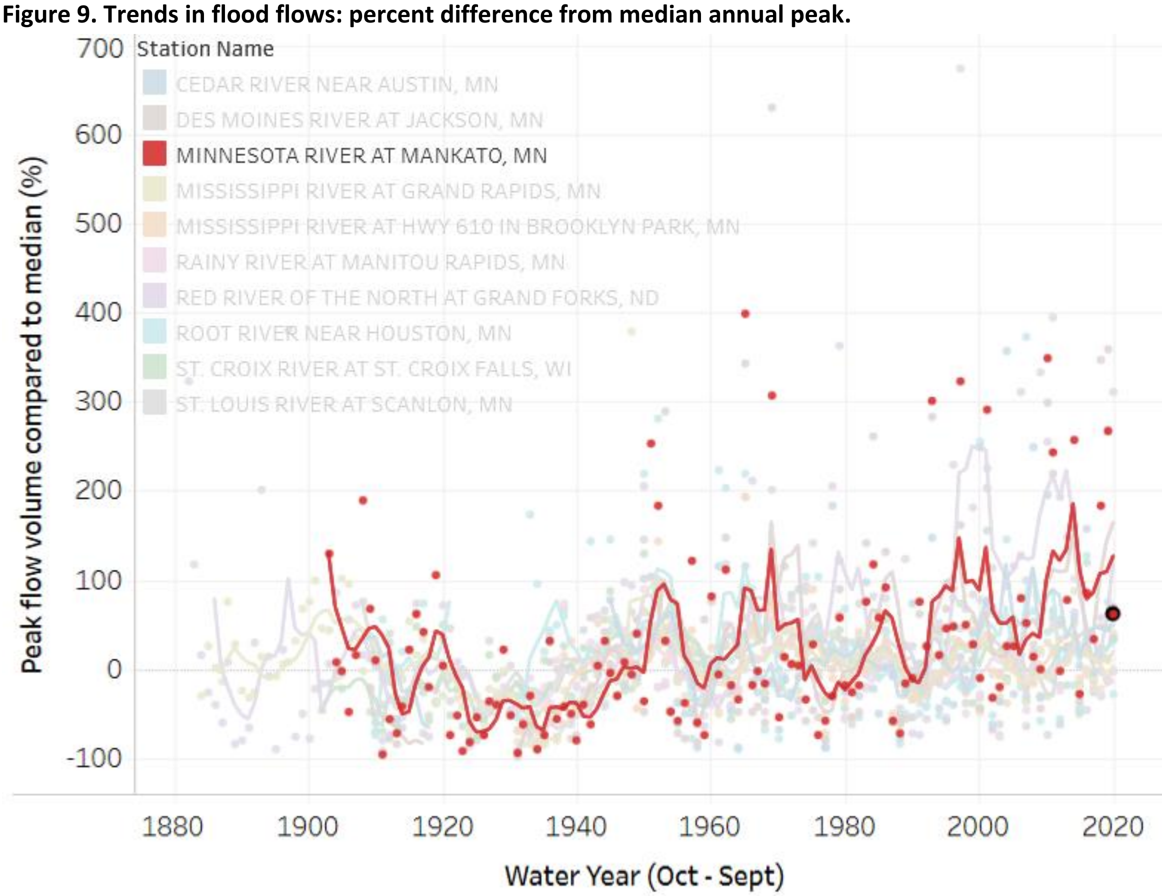


Figure from *Climate Change and Minnesota's Surface Waters* (MPCA 2021d). Points represent water year (Oct–Sep) flow; lines represent the trailing five-year moving average. Data from the USGS National Water Information System.

3.2 Lakes

The 11 impaired lakes addressed in this TMDL report are located in the WCBPs Ecoregion, and they are all assessed by MPCA as shallow lakes (Table 6). The impaired lakes and their drainage areas are shown in Figure 3; maps of individual impaired lake watersheds are in Appendix B. Part of the Iowa Lake and East Chain Lake watersheds are located in Iowa, and part of Iowa Lake is in Iowa (see Appendix B).

Table 6. Impaired water bodies in the Blue Earth River Watershed for which TMDLs are developed in this report.

AUID	Lake name	Surface area (ac)	Maximum depth (ft)	Mean depth (ft)	Watershed area (including lake surface area; ac)	Watershed area: lake surface area	Upstream impaired lake
22-0007-00	Rice	257	4	3.2	1,029	4.0	–
46-0049-00	Iowa	680	9	5.1	9,778	14.4	–
46-0010-00	East Chain	479	6	5.1	36,477	76.2	Iowa
46-0034-00	Amber	182	16.5	12.1	11,926	66	–
46-0031-00	Hall	548	27	7.8	25,787	47	Amber
46-0030-00	Budd	228	23	12.8	26,538	116	Hall
46-0025-00	Sisseton	138	18.5	9.5	28,510	207	Budd
46-0024-00	George	83	10	5.6	28,938	349	Sisseton
46-0145-00	Fish	149	5	4.5	1,013	6.8	–
46-0121-00	Cedar	713	6	3.5	29,278	41.1	Fish
07-0090-00	Ida	111	8	5.1	350	3.2	–

Data sources: Surface areas and maximum depths from MPCA's *Lake and streams water quality dashboard* and/or DNR's *LakeFinder* website; mean depths from DNR's *Lake Basin Morphology* spatial data layer or HSPF model. Watershed areas from HSPF model and City of Fairmont stormsewer drainage boundaries (Section 3.4).

3.3 Streams

The watershed areas of the impaired streams are shown in Table 7, and the impairments and their watersheds are shown in Figure 3.

Table 7. Watershed areas of impaired streams in the Blue Earth River Watershed.

AUID	Water body name	Watershed area (ac) [a]
07020009-652	Blue Earth River, East Branch	77,790
07020009-655	Brush Creek	30,399
07020009-553	Blue Earth River, East Branch	188,828
07020009-648	Coon Creek	63,710
07020009-645	Blue Earth River, Middle Branch	58,227
07020009-646	Blue Earth River, Middle Branch	70,716
07020009-643	Blue Earth River, West Branch	99,425
07020009-658	Badger Creek	49,488
07020009-508	Blue Earth River	539,026
07020009-640	South Creek	71,821
07020009-514	Blue Earth River	705,973
07020009-577	Willow Creek	54,045

a. Watershed area includes the entire drainage area to the impairment.

3.4 Subwatersheds

The watershed boundaries of the impaired streams and lakes (Figure 3) were developed using multiple data sources, starting with watershed delineations from the Blue Earth River Watershed HSPF model. The model watershed boundaries are based on Minnesota Department of Natural Resources (DNR) Level 7 watershed boundaries. Where additional watershed breaks were needed to define the impairment watersheds, DNR Level 8 and 9 watershed boundaries were used. For impairment watersheds that were on a finer scale than the DNR Level 9 boundaries, watershed breaks are based on a digital elevation model (DEM).

The Fairmont Chain of Lakes Watershed boundaries were further refined by stormsewer and sub-catchment information provided by the City of Fairmont (MPCA 2023a).

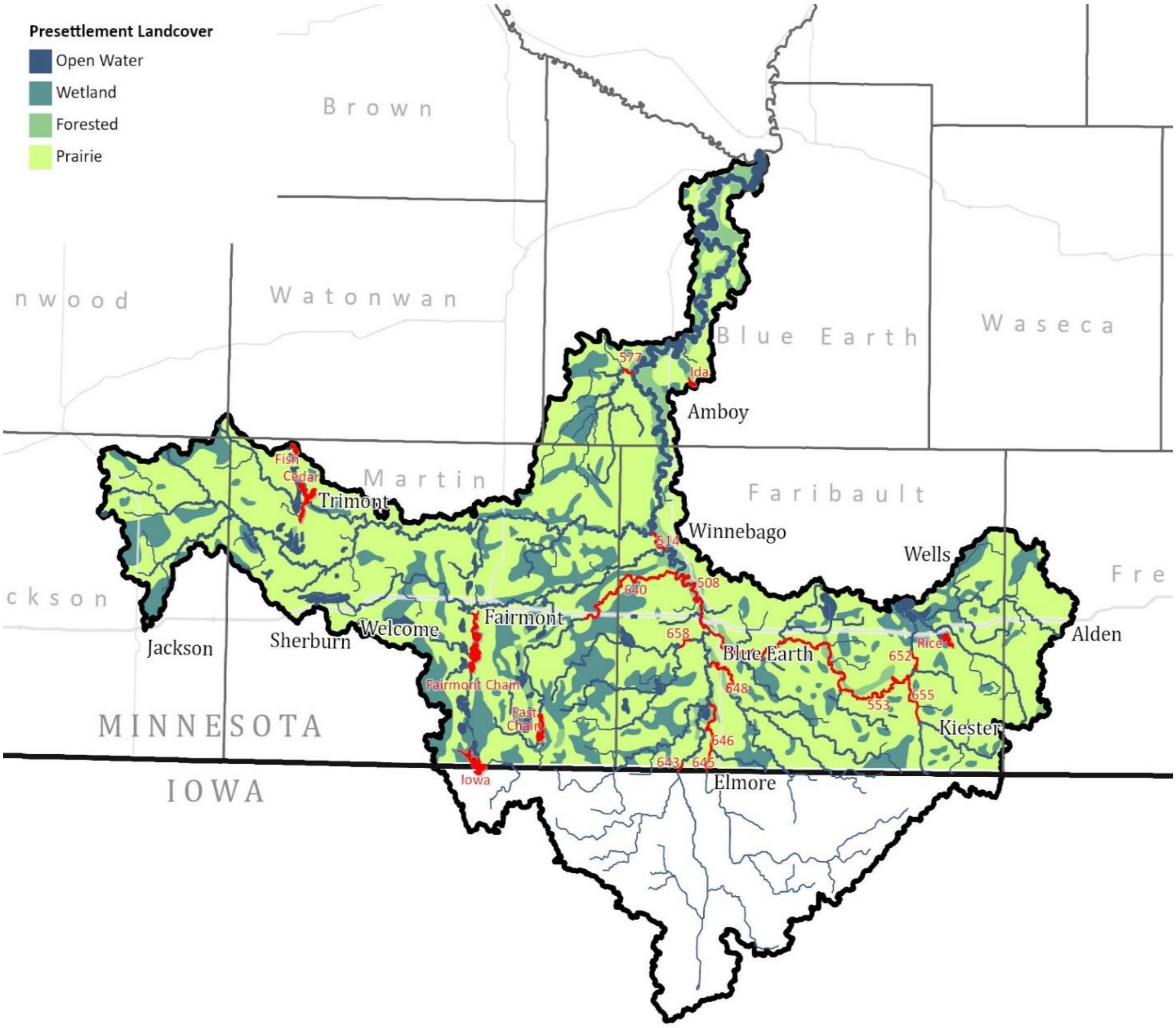
The watershed boundary of each impaired lake is shown at a finer scale in the Appendix B maps.

3.5 Land cover

Pre-European settlement land cover in the Minnesota portion of the impairment watersheds was primarily prairie and wet prairie (indicated as wetland in Figure 10). Lands within the watershed were opened to nonindigenous settlement in the middle 1800s. Over the following century and a half, the landscape was almost entirely converted to agricultural uses. To increase arable land surface, wetlands and free-flowing streams were converted to networks of agricultural drainage ditches.

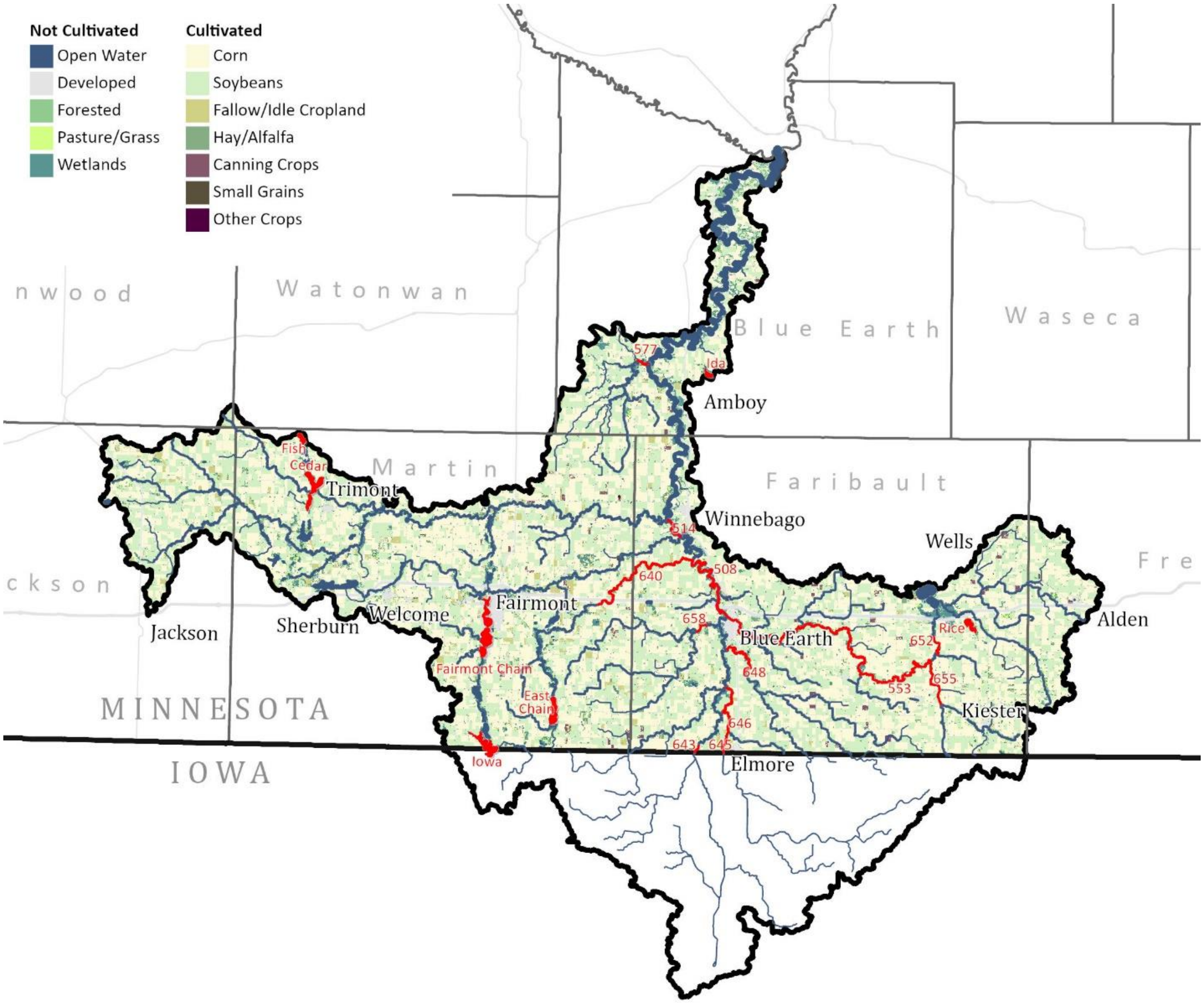
Today, land cover in the Blue Earth River Watershed is primarily agricultural, with corn and soybeans the dominant crops (Figure 11, Table 8). Other crops are present, such as alfalfa and other hay crops, but represent less than 3% of the land area of individual impairment watersheds. Drain tile is prevalent in the watershed and continues to expand (MDH 2022). Developed areas and wetlands also represent a portion of some of the impairment watersheds.

Figure 10. Presettlement land cover in the Blue Earth River Watershed.



Data source: Pre-European settlement vegetation, DNR (often referred to as Marschner presettlement vegetation).

Figure 11. Land cover in the Blue Earth River Watershed.



Data source: 2019 Cropland Data Layer, United States Department of Agriculture (USDA), National Agricultural Statistics Service (NASS).

Table 8. Watershed land cover percent area by impairment.

Percentages rounded to nearest whole number. Data source: 2019 Cropland Data Layer, United States Department of Agriculture (USDA), National Agricultural Statistics Service (NASS).

Impairment type	AUID	Water body name	Corn	Soy-beans	Other crops [a]	Fallow / idle cropland	Grassland / pasture	Developed	Forest and shrub	Wetland	Open water [b]
Streams, *E. coli*	652	Blue Earth River, East Branch	51%	32%	2%	<1%	2%	5%	1%	5%	2%
	655	Brush Creek	58%	31%	<1%	<1%	3%	4%	1%	3%	<1%
	553	Blue Earth River, East Branch	52%	33%	2%	<1%	2%	5%	1%	5%	<1%
	648	Coon Creek	52%	39%	1%	<1%	2%	4%	<1%	2%	<1%
	645	Blue Earth River, Middle Branch	54%	37%	<1%	<1%	3%	5%	<1%	1%	<1%
	646	Blue Earth River, Middle Branch	53%	37%	<1%	<1%	3%	5%	<1%	2%	<1%
	643	Blue Earth River, West Branch	54%	35%	<1%	1%	4%	4%	<1%	2%	<1%
	658	Badger Creek	51%	38%	1%	3%	<1%	4%	<1%	3%	<1%
	508	Blue Earth River	52%	35%	1%	1%	2%	5%	<1%	4%	<1%
	640	South Creek	51%	27%	1%	3%	3%	4%	<1%	7%	4%
	514	Blue Earth River	50%	34%	1%	2%	2%	5%	<1%	5%	1%
	577	Willow Creek	50%	40%	<1%	2%	<1%	4%	<1%	4%	<1%
Lakes, phosphorus	22-0007	Rice	37%	16%	<1%	<1%	3%	3%	4%	11%	26%
	46-0049	Iowa	42%	33%	<1%	<1%	2%	5%	<1%	6%	12%
	46-0010	East Chain	53%	26%	1%	1%	4%	4%	<1%	6%	5%
	46-0024	Fairmont Chain [c]	44%	27%	<1%	3%	2%	11%	1%	5%	6%
	46-0145	Fish	40%	37%	<1%	<1%	<1%	5%	<1%	3%	15%
	46-0121	Cedar	49%	35%	<1%	2%	<1%	4%	<1%	3%	4%
	07-0090	Ida	22%	2%	<1%	<1%	2%	2%	3%	28%	41%

a. Other crops include sweet corn, spring wheat, oats, alfalfa, other hay, and peas.
b. Open water includes the surface area of the impaired water bodies.
c. The Fairmont Chain of Lakes Watershed land cover summaries in the *Blue Earth River Watershed Lake Water Quality Improvement Study* (MPCA 2022) differ slightly from the figures in this table because land cover data provided by the City of Fairmont were used in the water quality improvement study for area within the city whereas CDL 2019 is summarized for the entire watershed in this table.

3.6 Water quality

Flow and water quality data are presented to evaluate impairments and trends in water quality. Data from the last 10 years (2012 through 2021) were used in the water quality summary tables. For all impairments except for the Fairmont Chain of Lakes, the only available data from within this 10-year period is from 2017 to 2018. Water quality data from the MPCA's Environmental Quality Information System (EQuIS) were used for the analyses; data from the University of Minnesota's Lake Browser (satellite derived water quality data) were used to supplement the water quality analysis for the Fairmont Chain of Lakes. Because this study uses a combination of different data sources (i.e., EQuIS and Minnesota's Lake Browser), the data summaries and numbers provided in the following sections may differ slightly from those provided on the MPCA's water quality dashboard and in other studies and reports.

3.6.1 *E. coli* impairments

Simulated flow data from the Blue Earth River Watershed HSPF model were evaluated in addition to *E. coli* monitoring data to evaluate the impairments. Flow data were used to approximate the stream flow conditions when each water quality sample was taken. These analyses are described in more detail in this section.

3.6.1.1 Flow data

Long-term, continuous flow data are available from the United States Geological Survey (USGS) flow gaging station on the Blue Earth River near Rapidan, Minnesota (USGS site 05320000; Figure 3). Additional, limited flow data are available from two tributaries to the Blue Earth River (Center Creek and Elm Creek). Due to limited flow gage records across the watershed, simulated daily average flows from the HSPF model (3/31/2022 version) were used in developing the *E. coli* stream TMDLs (Table 9). The HSPF model is calibrated to flow monitoring data and provides long term, continuous flow estimates. Simulated flows are available at the downstream end of each model reach. In some cases, HSPF-simulated flows were drainage area-weighted to impaired stream reaches. The drainage area-weighting approach assigns flow to a given reach based on the proportion of the subwatershed area within the HSPF catchment.

The model reports (RESPEC 2014, Tetra Tech 2015, Tetra Tech 2016) describe the framework and the data that were used to develop the model. See also the brief summary of HSPF modeling in the introduction to Section 3.

Table 9. Model reaches used to simulate stream flow in impaired reaches in the Blue Earth River Watershed. Reach numbers refer to the Blue Earth River Watershed HSPF model. The simulation is from 1996–2017.

Reach Name	AUID	Model Reach Number
Blue Earth River, East Branch	652	105
Brush Creek	655	111
Blue Earth River, East Branch	553	133
Coon Creek	648	59
Blue Earth River, Middle Branch	645	30 (area-weighted)

Reach Name	AUID	Model Reach Number
Blue Earth River, Middle Branch	646	30
Blue Earth River, West Branch	643	43 (area-weighted)
Badger Creek	658	73 (area-weighted)
Blue Earth River	508	190
South Creek	640	205
Blue Earth River	514	250
Willow Creek	577	353

Flow duration curves were developed for each impaired reach with the simulated flows. Flow duration curves relate mean daily flow to the percent of time those values have been met or exceeded. For example, an average daily flow at the 50% exceedance value is the midpoint or median flow value; average daily flow in the reach equals the 50% exceedance value 50% of the time. The curve is divided into flow zones, including very high flows (0% to 10%), high flows (10% to 40%), mid-range flows (40% to 60%), low flows (60% to 90%), and very low flows (90% to 100%).

Flow duration curves were developed using simulated daily average flows (1996 through 2017). Simulated flows from all months (even those outside of the time period that the standard is in effect) were used to develop the flow duration curves. The flow duration curves were used to develop the *E. coli* LDCs, described in the following section.

3.6.1.2 *E. coli* data

All of the *E. coli* data on the impaired reaches are from 2017 and 2018. In 2017, three samples per month from June through August were taken from all impaired reaches except for Willow Creek. Two or more samples per month were taken from all impaired reaches in 2018.

To develop LDCs, all daily average flows were multiplied by the monthly geometric mean water quality standard (i.e., 126 org/100 mL *E. coli*) and converted to a daily load to create "continuous" LDCs that represent the load in the stream when the stream meets its water quality standard under all flow conditions. Loads calculated from water quality monitoring data are also plotted on the LDC, based on the concentration of the sample multiplied by the simulated flow on the day that the sample was taken. The HSPF model does not extend beyond 2017 and monitored flows from the Blue Earth River gage near Rapidan, Minnesota (USGS 05320000) were used to plot water quality samples from 2018, based on the percent exceeds flow at the Blue Earth River gage on the day that the sample was taken. Because the percent exceeds flow in the Blue Earth River may not always represent the percent exceeds flow in the impaired reach, the *E. coli* monitored load estimates from 2018 may have more error than the 2017 data. 2017 and 2018 data are symbolized differently in the LDCs (Appendix B). Each load calculated from a water quality sample that plots above the LDC represents a sample with an *E. coli* concentration higher than that depicted in the LDC (126 org/100 mL), whereas those that plot below the LDC are less than 126 org/100 mL.

Monitoring sites for each impaired reach are listed in Table 10, and data are summarized in Table 11. The overall *E. coli* geometric mean concentration per reach ranges from 258 org/100 mL on the Middle

Branch Blue Earth River (AUID 646) to 653 org/100 mL on the West Branch Blue Earth River downstream of the Iowa border (AUID 643). All the monthly geometric mean concentrations on all impaired reaches exceed the 126 org/100 mL standard (Figure 12), and 7% to 27% of the individual samples at each site exceed the 1,260 org/100 mL standard. There is no clear spatial pattern in overall *E. coli* concentrations; geometric means by site vary across the watershed (Figure 12). The reach with the highest overall geometric mean is the Blue Earth River West Branch (642), which is located immediately downstream of the state border in Minnesota. However, other reaches have similarly high *E. coli* concentrations (e.g., Badger Creek [658] and South Creek [640]), indicating that excessive loading of *E. coli* to surface waters exists throughout the entire Blue Earth River Watershed.

Although maximum recorded *E. coli* concentrations are higher in the higher flow zones, the median concentration per flow zone does not vary substantially among the flow zones (Figure 13). Data are not available from the very low flow zone.

Water quality summary tables and LDCs are presented for each impairment in Appendix B.

Table 10. Monitoring sites used in *E. coli* analysis of impaired reaches in the Blue Earth River Watershed.

Reach Name	AUID	Monitoring site(s)
Blue Earth River, East Branch	652	S009-436
Brush Creek	655	S009-435
Blue Earth River, East Branch	553	S000-534
Coon Creek	648	S000-533
Blue Earth River, Middle Branch	645	S000-583
Blue Earth River, Middle Branch	646	S009-437
Blue Earth River, West Branch	643	S000-584
Badger Creek	658	S000-519
Blue Earth River	508	S000-036
South Creek	640	S000-540, S007-572
Blue Earth River	514	S000-523
Willow Creek	577	S007-573, S014-893

Table 11. Summary of water quality data (2017–2018) for impaired reaches in the Blue Earth River Watershed.
E. coli geometric mean and maximum units are org/100 mL. All data are from Jun–August. Additional water quality summary tables are presented for each impairment in Appendix B: *Water quality summaries and TMDLs by water body*.

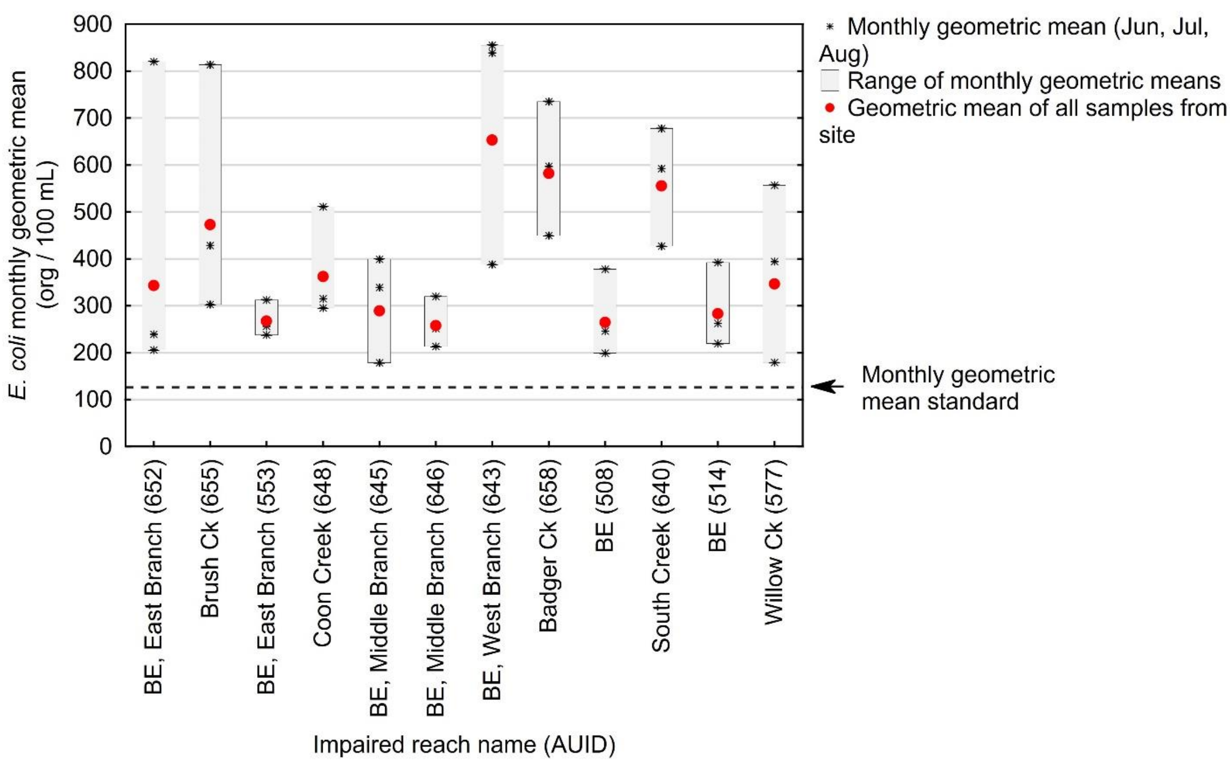
Reach name (description)	AUID	Sample count	*E. coli* geometric mean	*E. coli* maximum [a]	Frequency of exceedance [b]
Blue Earth River, East Branch, (T102 R25W S23, north line to Unnamed ditch)	652	15	343	9,208	100% / 13%
Brush Creek, (Unnamed cr to E Br Blue Earth R)	655	15	473	2,481	100% / 20%
Blue Earth River, East Branch, (Brush Cr to Blue Earth R)	553	15	267	2,909	100% / 13%
Coon Creek, (T102 R27W S33, south line to Blue Earth R)	648	15	362	2,420	100% / 13%
Blue Earth River, Middle Branch, (MN/IA border to -94.104 43.514)	645	15	289	2,481	100% / 13%

Reach name (description)	AUID	Sample count	*E. coli* geometric mean	*E. coli* maximum [a]	Frequency of exceedance [b]
Blue Earth River, Middle Branch, (-94.104 43.514 to W Br Blue Earth R)	646	15	258	1,439	100% / 7%
Blue Earth River, West Branch, (MN/IA border to 15th St)	643	15	653	8,164	100% / 27%
Badger Creek, (Little Badger Cr to -94.136 43.64)	658	15	582	3,255	100% / 20%
Blue Earth River, (E Br Blue Earth R to South Cr)	508	15	265	1,860	100% / 13%
South Creek, (-94.300 43.661 to Blue Earth R)	640	15	555	2,909	100% / 13%
Blue Earth River, (Center Cr to Elm Cr)	514	15	283	1,553	100% / 13%
Willow Creek, (Unnamed cr to Blue Earth R)	577	11	346	1,567	100% / 9%

a. The maximum recordable value for *E. coli* concentration depends on the extent of sample dilution and is often 2,420 org/100 mL. Concentrations that are noted as 2,420 org/100 mL are likely higher, and the magnitude of the exceedances is not known.

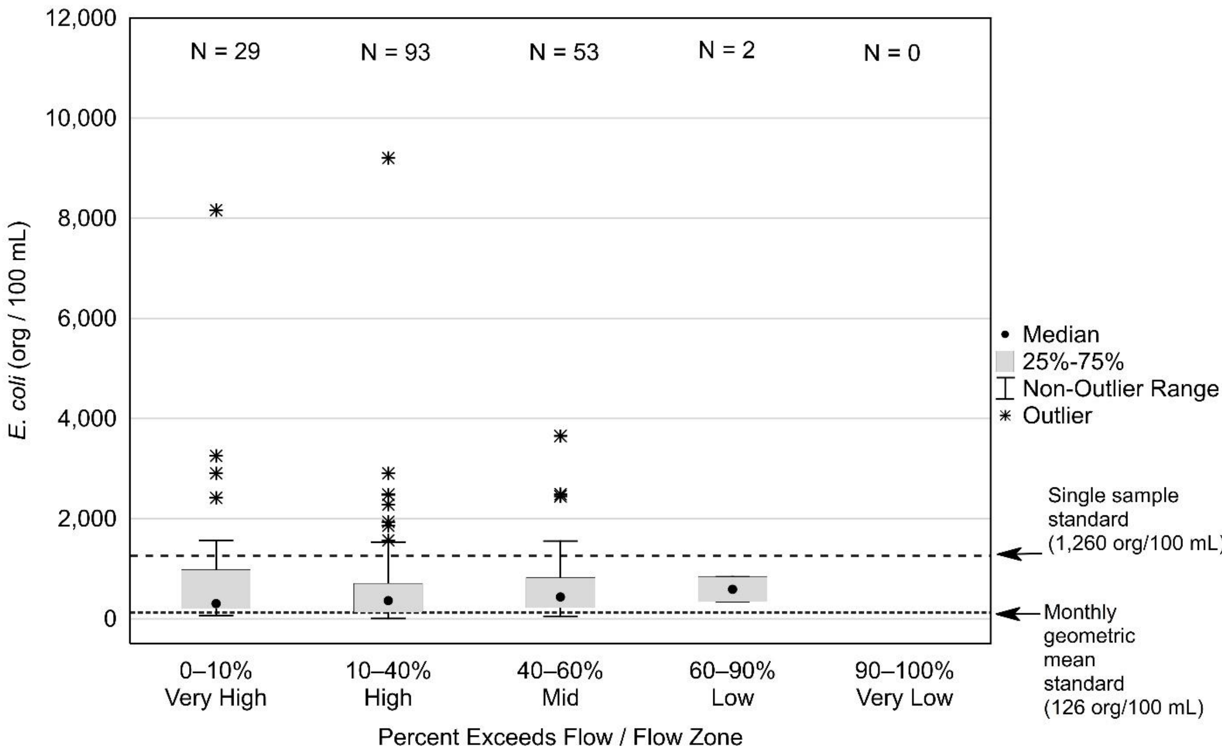
b. Frequencies of exceedance: monthly geometric mean standard / individual sample standard. The monthly frequencies are calculated as the number of months (aggregated across both years of data) when the monthly standard was exceeded divided by the number of months of data.

Figure 12. *E. coli* monthly geometric mean concentrations (2017–2018) for all reaches in the Blue Earth River Watershed with *E. coli* impairments addressed in this report.



BE = Blue Earth River. Data from 2017 and 2018 were aggregated by month. The three black markers per impaired reach represent a geometric mean for each of the three months (June, July, and August) for which there are monitoring data.

Figure 13. Box plot of *E. coli* concentration by flow zone for all reaches in the Blue Earth River Watershed with *E. coli* impairments addressed in this report.



3.6.2 Nutrient impairments

Lake water quality is often evaluated using three associated parameters: TP, chl-*a*, and Secchi depth. TP is typically considered to be the limiting nutrient in Minnesota lakes, meaning that algal growth will increase with increases in phosphorus. Chl-*a* is the primary pigment in aquatic algae and has been shown to have a direct correlation with algal biomass. Secchi depth is a physical measurement of water transparency. Increasing Secchi depths indicate less turbidity in the water column and increasing water quality. Conversely, rising TP and chl-*a* concentrations point to decreasing water quality and thus decreased water transparency. Measurements of these three parameters are interrelated.

TP, chl-*a*, and Secchi transparency data from 2012 to 2021 are summarized to evaluate compliance with water quality standards (Table 12). Previous years of data, where available, are included in graphs in Appendix B to evaluate trends in water quality. The tables and graphs summarize monitoring data from the growing season (June through September) because the water quality standards apply to growing season means. Results are presented in Appendix B and are summarized in Table 12.

On average, growing season mean phosphorus and chl-*a* concentrations exceeded the criteria in all lakes except for Hall, Budd, and Sisseton Lakes, which met the TP but not the chl-*a* criterion. Secchi transparency in all lakes except for the Fairmont Chain of Lakes did not meet the criterion. More discussion about water quality in the Fairmont Chain of Lakes can be found in the Blue Earth River Watershed Lake Water Quality Improvement Study (MPCA 2023a).

Table 12. Growing season means for impaired lakes, 2012–2021.

AUID	Lake name	Years of data	TP		Chl-*a*		Secchi	
			µg/L	N	µg/L	N	m	N
22-0007-00	Rice	2017–2018	165	8	137	8	0.30	8
46-0049-00	Iowa	2017–2018	149	9	167	9	0.27	9
46-0010-00	East Chain	2017–2018	175	8	95	8	0.33	8
46-0034-00	Amber	2017–2021	107	54	63	67	1.0	97
46-0031-00	Hall	2017–2021	79	56	44	67	1.1	68
46-0030-00	Budd	2017–2021	75	52	64	61	1.3	78
46-0025-00	Sisseton	2017–2021	85	51	73	60	1.2	85
46-0024-00	George	2017, 2018, 2020, 2021	145	39	81	58	1.0	70
46-0145-00	Fish	2017–2018	116	8	71	8	0.30	8
46-0121-00	Cedar	2017–2018	145	8	83	8	0.38	8
07-0090-00	Ida	2017–2018	261	8	143	8	0.30	8

3.7 Pollutant source summary

Sources of pollutants in the Blue Earth River Watershed include permitted and nonpermitted sources. The permitted sources discussed here are pollutant sources that require a National Pollutant Discharge Elimination System (NPDES) permit. Nonpermitted sources are pollutant sources that do not require an NPDES permit. Most Minnesota NPDES permits are also State Disposal System (SDS) permits; however, some pollutant sources require SDS permit coverage alone without NPDES permit coverage (e.g., spray irrigation, large septic systems, land application of biosolids, and some feedlots).

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

3.7.1 Pollutant source types

This section describes the *E. coli* and phosphorus sources to the impaired water bodies. A summary of pollutant sources can be found in Sections 3.7.2: *E. coli source summary* and 3.7.3: *Phosphorus source summary*.

3.7.1.1 Permitted sources

Municipal and industrial wastewater

Permitted municipal and industrial wastewater is a source of *E. coli* and phosphorus in the impaired watersheds. Wastewater is domestic sewage and other wastewater collected and treated by municipalities and industries before being discharged to water bodies as wastewater effluent. Wastewater enters surface water either as treated effluent or through releases of untreated wastewater.

A release is an unauthorized discharge of untreated or partially treated wastewater to the environment. Examples include sanitary sewer overflows (SSOs) from a plugged collection system or pumping untreated wastewater out of a manhole to a nearby ditch. Unauthorized releases such as SSOs are most common when wastewater systems are inundated with rain/snow melt or from pump or electrical failures. While NPDES permits do not authorize the discharge of untreated or partially treated wastewater, and operators avoid releasing untreated wastewater into the environment, releases are sometimes necessary for a number of reasons, including electrical or mechanical failures, flows that exceed the collection system's designed capacity, and treatment system problems. When releases occur, the WWTP operator is required to immediately contact the Minnesota Duty Officer, discontinue the release as soon as possible, recover all substances and materials, if possible, collect representative sample(s) of the release, and report sample results to the MPCA.

There is a meaningful distinction between wet weather and dry weather releases. Wet weather releases occur when flows overwhelm a WWTP or its collection system. The excess rain/snow melt or groundwater can enter the wastewater collection system through inflow and infiltration (I&I) from storms, floods, or groundwater due to leaky sewer systems and noncompliant private service lateral lines, as well as improper connections such as sump pumps, foundation drains, or downspouts that are connected to the sanitary sewer. When the excess water overwhelms the designed capacity of the collection system or the WWTP, the release of untreated or partially treated wastewater may be necessary in order to protect wastewater infrastructure and avoid imminent public health threats associated with sewage backflow into homes and businesses. Wet weather releases are often relatively dilute compared to full strength wastewater, although even dilute wastewater may contain disease causing microorganisms. Because receiving water bodies are typically at high flows during wet weather events, the water quality impact of wet weather releases can be relatively minor. Dry weather releases, which are often due to mechanical failures, can deliver full strength wastewater to water bodies during base flow or low flow, and the resulting water quality impacts can therefore be greater than those associated with wet weather releases.

The degree of environmental harm posed by a release depends on the volume, flow rate, and length of time of the release; the strength of the release; and the volume and flow rate of the receiving water body. For example, a high strength discharge to a small river that is at low summer flow may be harmful. A more diluted discharge to a large river under high flow conditions will have less of an effect. Releases during conditions of flooding may have little measurable impact on water quality.

The wastewater releases that occurred in the Minnesota portion of the Blue Earth River Watershed from 2010 through 2019 were due to wet weather and mechanical failures (Table 13). Wet weather releases occurred more frequently than mechanical failures (which may occur during either dry or wet weather) and ranged from 0 to 11 releases annually. Heavy rains and high flows in the city of Fairmont have resulted in wet weather wastewater releases in the city (MDH 2022; see Section 3.1: *Climate trends*).

Table 13. Wastewater releases from WWTPs in the Minnesota portion of the Blue Earth River Watershed, 2010–2019.

Release type	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total
Wet weather	9	6	0	5	5	0	10	0	11	7	53
Mechanical failures	1	0	0	0	2	0	1	0	1	1	6

E. coli

Wastewater dischargers that operate under NPDES permits are required to disinfect wastewater to reduce fecal coliform concentrations to 200 org/100 mL or less as a monthly geometric mean. This standard is protective to the 126 org/100 mL *E. coli* class 2 water standards. Like *E. coli*, fecal coliform is an indicator of fecal contamination. The primary function of a fecal bacteria effluent limit is to assure that the effluent is being adequately treated and disinfected to assure a complete or near complete kill of fecal bacteria prior to discharge (MPCA 2007b). Dischargers to class 2 waters are required to disinfect from April 1 through October 31, and dischargers to class 7 waters are required to disinfect from May 1 through October 31. There are no permitted combined sewer overflows in the impaired watersheds.

There are 11 wastewater dischargers with fecal coliform effluent limits in the Minnesota portion of the watersheds of the *E. coli* impairments, and there are three in Iowa (Figure 14). These wastewater dischargers are potential sources of *E. coli* to the impaired water bodies.

One WWTP in the project area discharges to a class 7 water—Alden WWTP. The Alden WWTP disinfection requirement (May 1 through October 31) is one month shorter than the time frame of the *E. coli* standard of the downstream impaired reach (AUID 652—Blue Earth River, East Branch). Alden WWTP is a potential source of *E. coli* to the East Branch Blue Earth River in April when disinfection is not required. To determine the likelihood that Alden WWTP contributes to *E. coli* impairment in April, discharge volumes, surface water monitoring data, and the location of the effluent discharge point were evaluated (Table 14). The facility design flow was compared to simulated low flows in the stream, because wastewater effluent is more likely to have an effect on stream water quality under low flow conditions. As the facility design flow relative to stream flow increases, there is a greater chance that the wastewater effluent could contribute to *E. coli* impairment.

The facility design flow represents only 3% of the simulated low flow in the impaired reach. Also, wastewater in ponds is typically disinfected in April even if not required by the permit because the long residence time and ultraviolet radiation kill pathogens. Due to these factors, in addition to the low probability of low flows in April and the distance from the discharge to the impaired reach (which allows for additional bacteria die-off in surface waters), Alden WWTP effluent wastewater is not likely to be a significant *E. coli* source in April.

Table 14. Alden WWTP design flow as a percent of class 2 impaired reach flow.

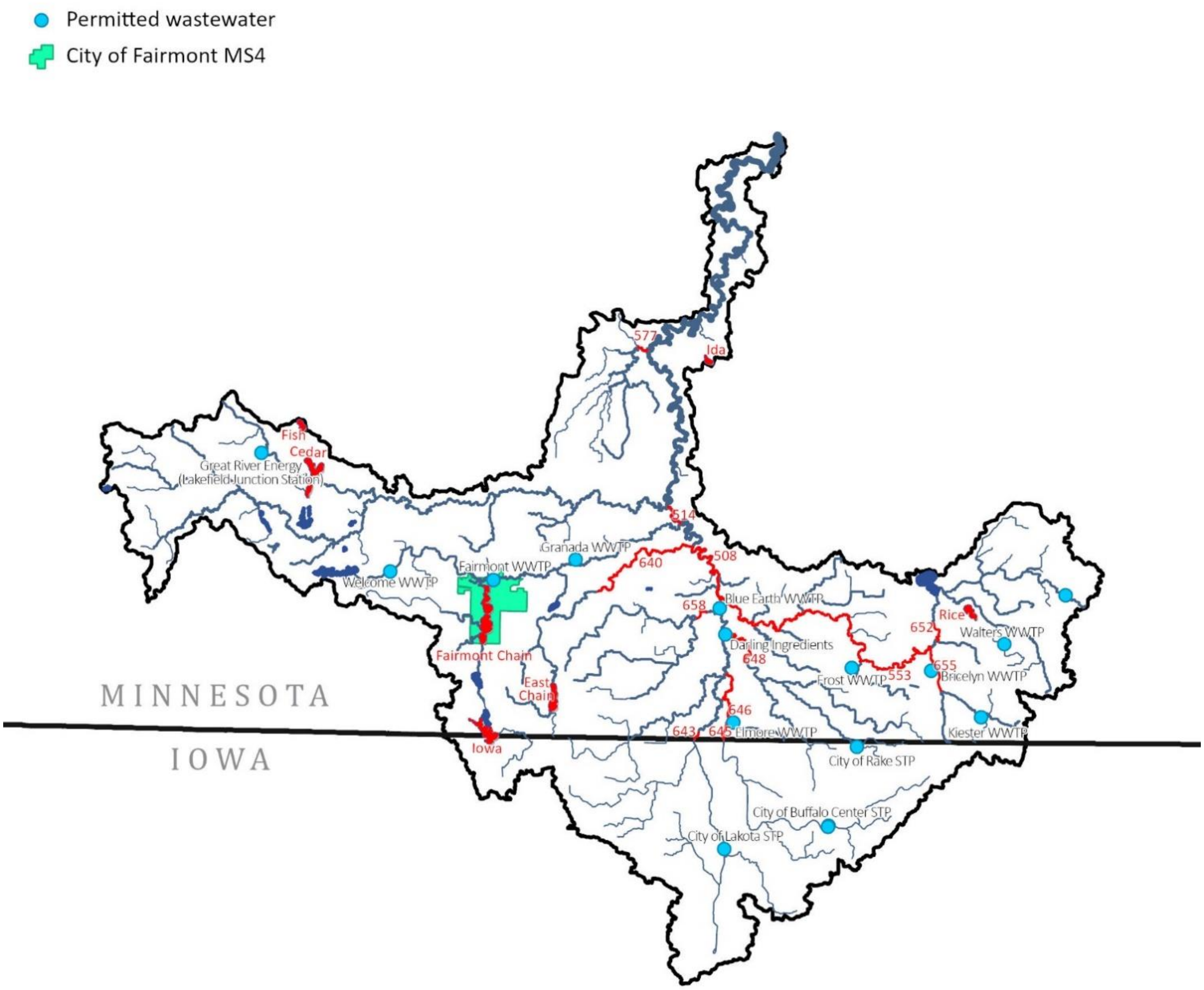
Wastewater facility (NPDES permit #)	Max daily flow (cfs)	Downstream class 2 impaired reach	Approximate distance to impaired class 2 reach (miles)	April exceedances observed in class 2 reach	Impaired reach low flow (cfs) [a]	Facility design flow as a percent of low flow in impaired reach
Alden WWTP (MNG585118)	0.246	652	16	no data	9.2	3%

a. 25th percentile of simulated daily flow (Jan–Dec). Because the 25th percentile of simulated April flows is higher (78 cfs), the year-round flow estimate provides a conservative analysis.

Monthly geometric means of effluent monitoring data are used to determine compliance with permits. Of the facilities in Minnesota, there are two fecal coliform permit exceedances documented in discharge monitoring reports (DMRs) between 2000 and 2019. The Blue Earth WWTP reported one minor exceedance (203 org/100 mL) in 2016 of the monthly geometric mean effluent limit (200 org/100 mL), and Darling International–Blue Earth reported one exceedance (1,956 org/100 mL) in 2010. Both of these discharges are located in the Blue Earth River Watershed (AUID 07020009-508). There were no observed exceedances of the fecal coliform permit limits in 2017 or 2018, which is when the instream *E. coli* data were collected from the impaired streams (Section 3.6.1.2). Exceedances of wastewater fecal coliform permit limits could lead to exceedances of the in-stream *E. coli* standard at times, but there is no evidence that these exceedances are primary contributors to *E. coli* impairment.

The effect of releases of untreated wastewater on *E. coli* concentrations in the impaired waters is not known; quantities, types, and treatment levels of the released wastewater, as well as weather and stream flow conditions, across the reported releases were variable and, in some cases, unknown. Additional information and monitoring in the watershed could be used to further evaluate this source and its potential effect on water quality.

Figure 14. Permitted MS4 and wastewater in the impairment watersheds.



See Section 4.4.4.2 for more information on the City of Fairmont MS4 delineation.

Phosphorus

There is one active permitted industrial wastewater facility that is a potential source of phosphorus to the impaired lakes. Great River Energy – Lakefield Junction Station (permit #MN0067709, SD001) is a combustion turbine electrical generation facility that discharges industrial stormwater and reverse osmosis reject water. This industrial wastewater is discharged to a tributary of Cedar Creek (07020009-656), approximately seven miles upstream of Cedar Lake in the Cedar Lake Watershed (Figure 57). The discharge permit does not have phosphorus limits or monitoring requirements. There are no monitoring data from the TMDL time period (2012 through 2021). The majority of monitoring data (8 of 11 samples from 2005 through 2010) before then were below the detection limit at the time (200 µg/L). The other three samples range from 100 to 390 µg/L. To estimate the existing phosphorus load from this facility, the maximum design flow (0.009 mgd) was multiplied by 190 µg/L. This estimated existing load, 5 pounds (lb)/year (yr), represents less than 0.03% of the TP load to Cedar Lake. This wastewater source is not expected to contribute to water quality impairment in Cedar Lake.

Another permitted wastewater discharger was the Fairmont Water Treatment Plant (WTP, permit #MN0045527), which was located approximately one mile west of Hall Lake along Dutch Creek, in the Fairmont Chain of Lakes Watershed (Figure 50). This was the site of the City of Fairmont's former water supply facility. The former facility consisted of three settling basins that were historically used as discharge ponds for lime sludge. In 2013, the City of Fairmont constructed a new water treatment system and therefore, beginning that year, no longer used the discharge ponds at the former site in their water treatment process. The current permit for the old Fairmont WTP ponds contains requirements for quarterly monitoring of any discharge (including TP) from the ponds along with annual reporting of facility closure progress. Decommissioning of the settling basins, completed in August of 2021, included periodic dewatering of the ponds leading up to this point in 2019, 2020, and 2021. DMRs for Fairmont WTP indicate TP discharge from the ponds to Dutch Creek from the 2019 through 2021 dewatering activities were small and ranged from less than 1 to 3.8 lb per year. The last reported discharge from the facility was in June 2021. The City of Fairmont is expected to apply for termination of the permit. Because this facility has already been decommissioned and is not expected to discharge to surface waters, it is not considered a potential phosphorus source to the Fairmont Chain of Lakes and is not further discussed in this report.

Releases of untreated wastewater in the Fairmont Chain of Lakes Watershed have been documented (MDH 2022). The effect of releases of untreated wastewater on water quality conditions in the impaired lakes is not known; quantities, types, and treatment levels of the released wastewater, as well as weather and stream flow conditions, across the reported releases were variable and, in some cases, unknown. Additional information and monitoring in the watershed could be used to further evaluate this source and its potential effect on water quality.

Municipal separate storm sewer systems

A municipal separate storm sewer system (MS4) is a conveyance or system of conveyances (roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, storm drains, etc.) that is also:

- Owned or operated by a public entity (which can include the state, cities, townships, counties, or other public body having jurisdiction over disposal of stormwater)
- Designed or used for collecting or conveying stormwater
- Not a combined sewer
- Not part of a publicly owned treatment works

MS4s in Minnesota must satisfy the requirements of the MS4 general permit if they are located in an urbanized area and used by a population of 1,000 or more or owned by a municipality with a population of 10,000 or more, or a population of at least 5,000 and the system discharges to specially classified bodies of water. Minnesota state rule (Minn. R. 7090) establishes criteria and a process for designating future MS4s. The MS4 general permit (MNR040000) is designed to reduce the amount of sediment and other pollutants entering state waters from stormwater systems. Entities regulated by the MS4 general permit must develop a stormwater pollution prevention program and adopt best practices.

The Phase II General NPDES/SDS Municipal Stormwater Permit for MS4 communities has been issued to the City of Fairmont (MS400239) in the Blue Earth River Watershed; this is the only permitted MS4 entity in the impairment watersheds (Figure 14). Although the MS4 permit regulates only stormwater conveyances, the MS4-regulated area was approximated using the jurisdictional boundary of the city of Fairmont. Using the entire city boundary acknowledges that future stormwater conveyance within the city boundary will be MS4-regulated area.

Permitted MS4s can be a source of *E. coli* and phosphorus to surface waters through the impact of urban systems on stormwater runoff. Stormwater runoff, which delivers and transports pollutants to surface waters, is generated in the watershed during precipitation events.

E. coli

Sources of *E. coli* in stormwater runoff from permitted MS4s include fecal matter from pets and wildlife. Impervious surfaces (e.g., roads, driveways, and rooftops) connect the locations where fecal matter is deposited to surface waters through stormwater that flows across the landscape into lakes, streams, and wetlands.

Urban sources of *E. coli* were identified in Minneapolis (Burns & McDonnell Engineering Company, Inc. 2017) and Duluth (Burns & McDonnell Engineering Company, Inc. 2020), Minnesota, including several sources that may be applicable in the Blue Earth River Watershed: leaf litter, organic debris, and soil accumulated in catch basin inlets; ponded water and stagnant debris; stream, streambank, and riparian sediment; areas where birds congregate (soccer fields, parks, open water); and construction activity. Although Minneapolis and Duluth have more dense urban development than the Blue Earth River Watershed, the results in these studies may be indicative of developed areas outside of the Minneapolis and Duluth study areas, including both regulated and unregulated stormwater runoff.

Phosphorus

Urbanized areas can be a source of phosphorus to lakes through decaying vegetation (leaves, grass clippings, lawns, etc.), domestic and wild animal waste, soil and deposited particulates from the air, road salt, and oil and grease from vehicles. Although land cover in the Amber Lake and George Lake

Watersheds is predominantly cultivated crops, these two lakes are located within the city of Fairmont municipal boundary. The city of Fairmont represents approximately 22% (6,270 acres) of the Fairmont Chain of Lakes Watershed, although only about 40% of this area is considered developed (i.e., residential, commercial, industrial park, parkland, etc.). As of 2021, there were still approximately 2,500 acres of undeveloped cropland within the city of Fairmont municipal boundary that drain to the Fairmont Chain of Lakes.

Runoff volumes and phosphorus loads from developed areas within the city of Fairmont were estimated using the City's model, which was incorporated into the greater Fairmont Chain of Lakes Watershed loading model as discussed in the water quality improvement study report (MPCA 2023a).

Construction stormwater

Construction stormwater is regulated through an NPDES/SDS permit. Untreated stormwater that runs off of a construction site often carries sediment to surface water bodies. Because phosphorus travels adsorbed to sediment, construction sites can also be a source of phosphorus to surface waters. Phase II of the stormwater rules adopted by the EPA requires an NPDES/SDS permit for a construction activity that disturbs one acre or more of soil; a permit is needed for smaller sites if the activity is either part of a larger development or if the MPCA determines that the activity poses a risk to water resources. Coverage under the construction stormwater general permit requires sediment and erosion control measures that reduce stormwater pollution during and after construction activities (see Section 8.1.1).

E. coli

E. coli is not a typical pollutant in construction stormwater.

Phosphorus

On average, 0.23% of the area in the Blue Earth River Watershed is under construction stormwater permit coverage (2017 through 2021). Phosphorus loading from construction stormwater is inherently incorporated in the watershed runoff estimates and is not considered a significant source. At the time of writing this report, there was no permitted construction stormwater in the watersheds of Rice, Iowa, Fish, and Ida lakes.

Industrial stormwater

Industrial stormwater is regulated through an NPDES/SDS permit when stormwater discharges have the potential to come into contact with materials and activities associated with the industrial activity.

E. coli

E. coli is not a typical pollutant in industrial stormwater.

Phosphorus

Industrial stormwater is limited in the watersheds of the impaired lakes. At the time of writing this report, there was permitted industrial stormwater from one three-acre site in the Sisseton Lake drainage area in the Fairmont Chain of Lakes Watershed. Phosphorus loading from industrial stormwater is inherently incorporated in the watershed runoff estimates and is not considered a significant source.

NPDES/SDS permitted animal feeding operations

Feedlots and manure storage areas can be a source of *E. coli* and phosphorus due to runoff from the animal holding areas or the manure storage areas. Although TMDL reports typically consider only NPDES permitted sources in discussions of permitted sources, this discussion of permitted feedlots includes NPDES and SDS permitted feedlots because of similar discharge requirements.

Concentrated animal feeding operation (CAFO) is a federal definition that implies not only a certain number of animals but also specific animal types. The MPCA and IDNR use the federal definition of a CAFO in permit requirements of animal feedlots along with the state definition of an animal unit (AU). In Minnesota, all CAFOs and feedlots that have 1,000 or more AUs must operate under an NPDES or SDS permit. CAFOs with fewer than 1,000 AUs and that are not required by federal law to maintain NPDES permit coverage may choose to operate without an NPDES permit.

A current manure management plan that complies with Minn. R. 7020.2225 and the respective permit is required for all permitted CAFOs and feedlots with 1,000 or more AUs.

In Minnesota, CAFOs and feedlots with 1,000 or more AUs must be designed to contain all manure, manure contaminated runoff, process wastewater, and the precipitation from a 25-year, 24-hour storm event. Having and complying with an NPDES or SDS permit authorizes discharges to waters of the United States and waters of the state (with NPDES permits) or waters of the state (with SDS permits) due to a 25-year, 24-hour precipitation event (approximately 5.8 inches in the Blue Earth River Watershed) when the discharge does not cause or contribute to nonattainment of applicable state water quality standards. Large CAFOs with fewer than 1,000 AUs that have chosen to forego NPDES permit coverage are not authorized to discharge and must contain all runoff, regardless of the precipitation event. Large CAFOs permitted with an SDS permit are authorized to discharge to waters of the state, although they are not authorized to discharge to waters of the U.S. Therefore, many large CAFOs in Minnesota have chosen to obtain an NPDES permit, even if discharges have not occurred at the facility.

CAFOs are inspected by the MPCA in accordance with the MPCA NPDES Compliance Monitoring Strategy approved by the EPA. All CAFOs (NPDES permitted, SDS permitted, and not required to be permitted) are inspected by the MPCA on a routine, risk-based basis with an appropriate mix of field inspections, offsite monitoring, and compliance assistance.

For feedlots with NPDES permits, surface applied solid manure is prohibited during the month of March. Winter application of manure (December through February) requires fields to be approved in their manure management plan, and the feedlot owner/operator must follow a standard list of setbacks and BMPs. Winter application of surface applied liquid manure is prohibited except for emergency manure application as defined by the NPDES permit. “Winter application” refers to application of manure to frozen or snow-covered soils, except when manure can be applied below the soil surface.

Of the approximately 420 animal feedlots in the Minnesota portion of the project area, there are 99 CAFOs with NPDES or SDS permits. All NPDES and SDS permitted feedlots are designed to contain all manure, manure-contaminated runoff, process wastewater, and the precipitation from a 25-year, 24-hour storm event, and as such they are not considered a significant source of *E. coli* or phosphorus. All other feedlots are accounted for as nonpermitted sources. The land application of all manure, regardless of whether the source of the manure originated from permitted (e.g., CAFOs) or nonpermitted feedlots, is also accounted for as a nonpermitted source.

In Iowa, open feedlots that have a capacity of more than 1,000 AU may need an NPDES permit. However, there are no NPDES-permitted feedlots in the Iowa portion of the watershed.

3.7.1.2 Nonpermitted sources

Nonpermitted sources of *E. coli* and phosphorus in the Blue Earth River Watershed include watershed runoff, nonpermitted feedlots and wastewater, internal loading, atmospheric deposition, upstream water bodies, natural background sources, and naturalized *E. coli.*

Watershed runoff

Precipitation that falls in a watershed drains across the land surface, and a portion of it eventually reaches lakes and streams. Pollutants such as fecal bacteria and phosphorus are carried with the runoff water and delivered to surface water bodies. The sources of pollutants in watershed runoff may include soils, fertilizer, vegetation, release from wetlands, and livestock, pet, and wildlife waste. A portion of the phosphorus in watershed runoff can be considered natural background sources, which are inputs that would be expected under natural, undisturbed conditions.

E. coli

The primary source of *E. coli* that is transported to surface water bodies through watershed runoff in the Blue Earth River Watershed is livestock manure from nonpermitted feedlots and from land application of manure. This source is discussed under *non-NPDES/SDS permitted animal feeding operations* below.

Watershed runoff from developed areas that are not permitted MS4s has the same source types and mechanisms of delivery as watershed runoff from permitted MS4s, discussed under *Municipal separate storm sewer systems* under Permitted sources (Section 3.7.1.1).

Phosphorus

Because there are more data available in the Fairmont Chain of Lakes Watershed than in the remaining watersheds, a more detailed approach was used to estimate phosphorus loads in watershed runoff to the Fairmont Chain of Lakes.

- Watershed runoff volumes and phosphorus loads for the rural portions (i.e., outside the city of Fairmont boundary) of the Fairmont Chain of Lakes Watershed were estimated using the Fairmont Chain of Lakes Watershed Loading Model described in the Blue Earth Watershed Lake Water Quality Study (MPCA 2023a).
- Rice, Iowa, East Chain, Fish, Cedar, and Ida lakes: Phosphorus loads in watershed runoff to these lakes were estimated with the Blue Earth River Watershed HSPF model (see Section 3). Average annual (2008 through 2017) runoff volume and unit area phosphorus loading rates from the HSPF model by land cover category were calculated for the Blue Earth River Watershed as a whole (Table 15). These loading rates indicate the amount of phosphorus that comes from the watershed per acre of land and were multiplied by the areas of each land cover category in each watershed to estimate the watershed runoff phosphorus load to each lake. Data from the 2006

National Land Cover Database (NLCD) were used to align with the HSPF model; land cover change between 2001 and 2019 in these watersheds was minimal.

For the following lakes that are located upstream of an impaired lake, the load from the upstream lake outlet was accounted for by multiplying the modeled flow in the outlet by the average TP concentration in the lake: South Silver Lake in the Iowa Lake Watershed, Iowa Lake in the East Chain Lake Watershed, Willmert Lake in the Fairmont Chain of Lakes Watershed, and Fish Lake in the Cedar Lake Watershed.

Watershed runoff load estimates to each lake are presented in Appendix B.

Table 15. Total phosphorus unit area loading rates and concentrations from the Blue Earth River Watershed HSPF model.

Land cover	TP yield (lb/ac-yr)	TP concentration (µg/L)
Cropland	0.60	288
Developed	0.30	151
Forest	0.06	51
Grassland	0.17	119
Pasture	0.28	199
Wetland	0.07	59

Non-NPDES/SDS permitted animal feeding operations

Livestock are potential sources of fecal bacteria and nutrients to streams in the Blue Earth River Watershed, particularly when direct access is not restricted and/or where feeding structures are located adjacent to riparian areas. In Minnesota, feedlots under 1,000 AUs and those that are not federally defined as CAFOs do not operate with permits. Feedlots with greater than 50 AUs, or greater than 10 AUs in shoreland areas, are required to register with the county feedlot officer if the county is delegated, or with the MPCA if the county is nondelegated. Facilities with fewer AUs are not required to register. Shoreland is defined by Minn. R. 7020.0300 as land within 1,000 feet from the normal high-water mark of a lake, pond, or flowage, and land within 300 feet of a river or stream.

Manure that is generated on feedlots is usually stockpiled on site or on crop fields, or stored in liquid manure storage areas on site until field conditions and the crop rotation allow for applying the manure as fertilizer. Manure can be delivered to surface waters from failure of manure containment, runoff from the feedlot itself, or runoff from nearby fields where the manure is applied. The timing of manure spreading, as well as the application rate and method, affects the likelihood of pollutant loading to nearby water bodies. The spreading of manure on frozen soil in the late winter is likely to result in surface runoff with precipitation and snowmelt runoff events. Deferring manure application until snow has melted and soils have thawed decreases overland runoff associated with large precipitation events. Injecting or incorporating manure is a preferred best management practice (BMP) to reduce the runoff of waste and associated pollutants. Incorporating manure into the soil reduces the risk of surface runoff associated with large precipitation events.

Facilities that obtain an interim or construction short form feedlot permit, in addition to feedlots with an operating permit (NPDES or SDS; see Section 3.7.1.1), are required to develop and maintain a manure management plan. Feedlots with more than 300 AUs that use a Commercial Animal Waste Technician to apply their manure and have never obtained a permit are not required to have a manure management plan.

While a full accounting of the fate and transport of manure was not conducted for this project, a large portion of it is ultimately applied to the land surface and, therefore, this source is of possible concern. Minn. R. 7020.2225 and Chapter 65 of the Iowa Administrative Code contain several requirements for land application of manure; however, there are no explicit requirements for *E. coli* treatment prior to land application.

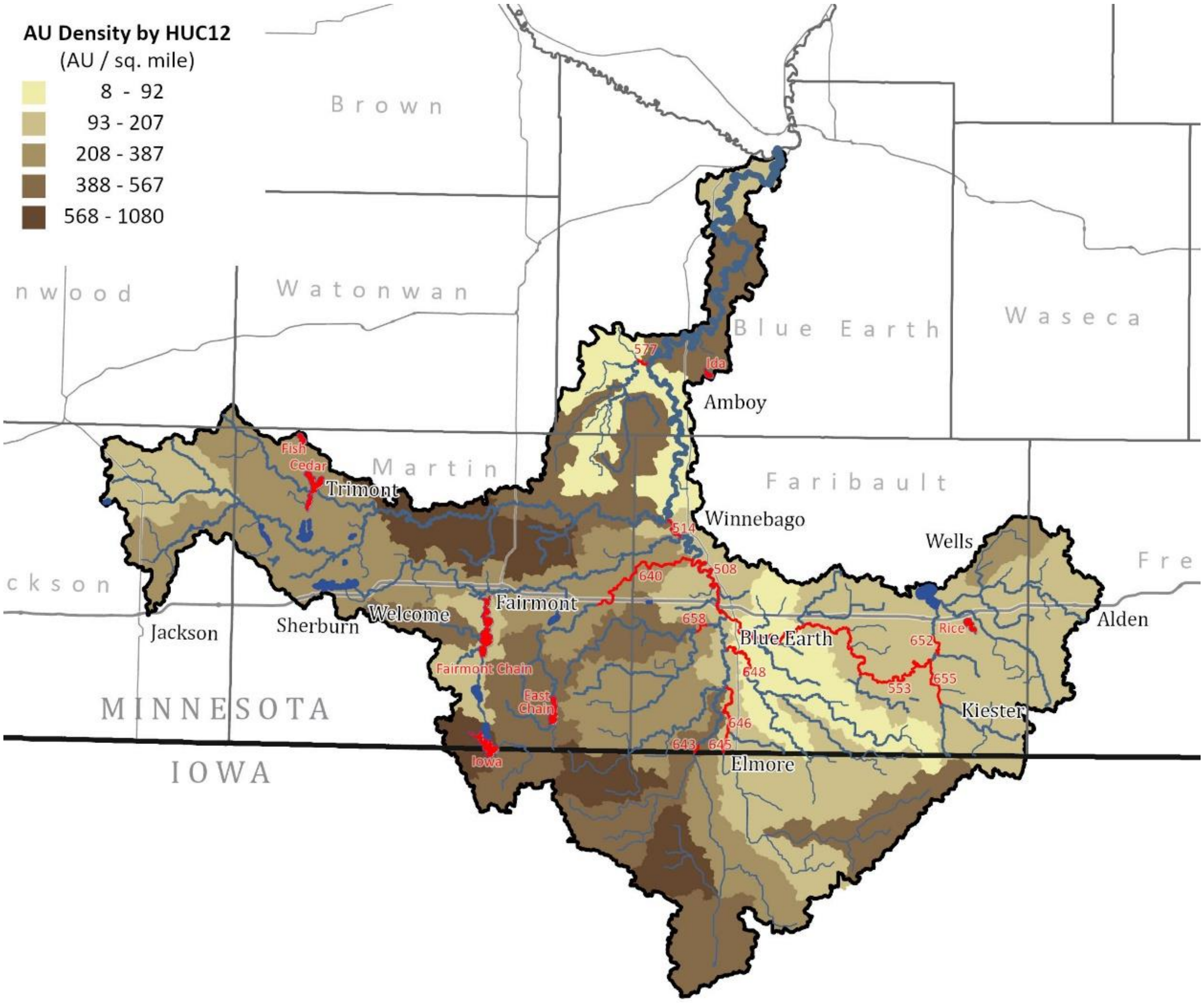
All non-CAFOs are inspected in delegated counties by the county feedlot officer on a routine basis in accordance with the delegated county's Delegation Agreement and Work Plan, which is prepared with and approved by the MPCA every other year. All of the counties in the Minnesota portion of the Blue Earth River Watershed are delegated counties.

In Iowa, confinements, which are totally roofed operations, do not require NPDES permits. These AFOs operate as zero discharge facilities. The majority of the AFOs in the Iowa portion of the Blue Earth River Watershed are confinements; the remaining Iowa AFOs are open feedlots that do not require an NPDES permit.

Information on feedlot locations and the numbers of registered animals and AUs were obtained from the MPCA's database of registered feedlots. This database includes the maximum number of animals that each registered feedlot can hold; therefore, the actual number of livestock in registered facilities is likely lower. Because feedlot registrations change over time, the estimates of the number of feedlots and animals in this report are approximate. AU densities in feedlots in the Blue Earth River Watershed are mapped in Figure 15, and more detail on livestock in the watersheds of the *E. coli* and phosphorus lake impairments are provided on the following pages.

The 2007 fecal coliform TMDL report (MSU–Mankato 2007) estimated that over 98% of the fecal material produced by livestock (in permitted and nonpermitted feedlots) is applied to cropland as fertilizer. Of this manure that is applied to cropland, approximately 71% is incorporated and 27% is surface applied. The report concludes that runoff from pastures, feedlots, and agricultural fields where manure is applied has the potential to be a significant source of fecal bacteria and other pollutants to surface waters in the Blue Earth River Watershed.

Figure 15. Animal unit densities in the Blue Earth River Watershed.

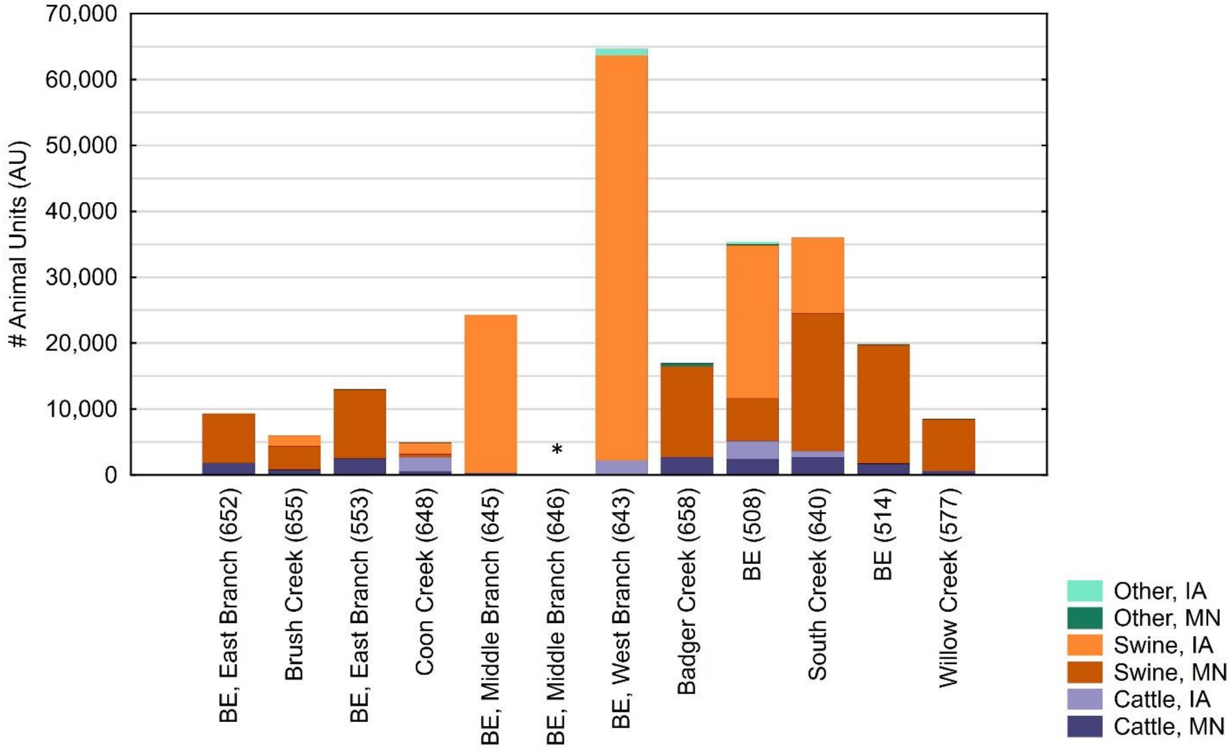


Animal units include nonpermitted, permitted, and confinement feedlots.

E. coli

In the watersheds of the *E. coli* impairments, the primary animal types are swine and cattle. The numbers of AUs in all registered feedlots were summed by impairment watershed, animal type, and state (Figure 16). The summary includes feedlots that have zero discharge requirements (CAFOs and NPDES/SDS-permitted feedlots in Minnesota and confinements in Iowa) and feedlots that do not have zero discharge requirements and therefore have the potential to contribute *E. coli* directly to surface water runoff. The “zero discharge” feedlots, if compliant with regulations, do not contribute *E. coli* directly to surface waters. However, because a large portion of manure from these facilities is ultimately applied to nearby land surfaces as fertilizer, some of this *E. coli* does reach surface waters and is thus a potential primary source. The “contributing” feedlots have the potential to contribute *E. coli* directly to surface waters through watershed runoff from the feedlots themselves.

Figure 16. Animal units by livestock animal type.



BE = Blue Earth River
Other = donkey/mule, elk, goat
*There are approximately 60 animal units in the watershed of AUID 646.

Phosphorus

In the watersheds of the phosphorus impairments, the primary animal type is swine, followed by cattle. The numbers of AUs in all registered feedlots were summed by impairment watershed and animal type (Table 16). Similar to the livestock summary for the *E. coli* impairments, the summary includes CAFOs and non-CAFOs because a large portion of manure from these facilities is ultimately applied to nearby land surfaces as fertilizer.

See Appendix B: *Water quality summaries and TMDLs by water body* for more information on feedlots in the individual lake watersheds.

Table 16. Numbers of feedlots and animal units in watersheds of impaired lakes.

Name	Primary livestock type	CAFOs		Non-CAFOs		Animal unit density (AU/square mile)
		Animal units	# feedlots	Animal units	# feedlots	
Rice	Swine	0	0	150	1	93
Iowa	Swine	0	0	10,416	11	682
East Chain [a]	Swine, beef cattle	10,840	8	11,171	21	386
Amber [b]	Swine	1,728	2	1,554	4	176
Hall [c]	Swine, cattle	2,424	2	7,289	16	215
Budd [c]	NA	0	0	0	0	0

Name	Primary livestock type	CAFOs		Non-CAFOs		Animal unit density (AU/square mile)
		Animal units	# feedlots	Animal units	# feedlots	
Sisseton [c]	NA	0	0	0	0	0
George [c]	NA	0	0	0	0	0
Fish	NA	0	0	0	1	0
Cedar	Swine	12,132	12	3,776	10	348
Ida	NA	0	0	0	0	0

a. Direct drainage area only (i.e., downstream of Iowa Lake).

b. Amber Lake direct drainage area as well as all upstream lake drainage areas (i.e., North Silver and Willmert Lakes).

c. Direct drainage area only.

Nonpermitted wastewater

Individual subsurface sewage treatment systems

Adequate wastewater treatment is vital to protecting the health, safety, and environment in Minnesota. Approximately 30% of Minnesotans rely on subsurface sewage treatment systems (SSTSs). SSTSs that fail to treat wastewater adequately threaten groundwater used for drinking water and surface water used for recreation. Inadequate treatment of wastewater/sewage, which contains bacteria, viruses, parasites, nutrients, and chemicals, can result in contamination of drinking water sources. Additionally, straight-pipe wastewater "systems," which route raw wastewater to the ground or nearby waters, can directly impact lakes, streams, and wetlands.

SSTSs can fail for a variety of reasons, including excessive water use, poor design, physical damage, and lack of maintenance. Common limitations that contribute to failure include seasonal high water table, fine-grained soils, bedrock, and fragipan (i.e., altered subsurface soil layer that restricts water flow and root penetration). Septic systems can fail hydraulically through surface breakouts or hydrogeologically from inadequate soil filtration. Failure potentially results in higher levels of pollutant loading to nearby surface waters.

Septic systems that are conforming and are appropriately sited still discharge small amounts of phosphorus, but they typically do not discharge *E. coli*. Failing septic systems do not protect groundwater from contamination; these systems are seepage pits, cesspools, drywells, leaching pits, or other pits, and any system with less than the required vertical separation distance from the seasonal high water table. Septic systems that discharge untreated sewage to the land surface or directly to streams are considered imminent threats to public health and safety (ITPHS) and can contribute *E. coli* and phosphorus directly to surface waters. ITPHS typically include straight pipes (i.e., no treatment), effluent ponding at ground surface, effluent backing up into homes, unsafe tank lids, electrical hazards, or any other unsafe condition deemed by a certified SSTS inspector. Therefore, not all of the ITPHSs discharge pollutants directly to surface waters.

Estimates of SSTS failure rates in the Blue Earth River Watershed range from 11% to 47%, and ITPHS rates range from 12% to 28% (Table 17). Rates of noncompliant SSTS overall have been decreasing in the watershed.

There are relatively few SSTSs along the shorelines of the impaired lakes, and loading from SSTSs is expected to be insignificant relative to loading from watershed runoff to these lakes. Loading from SSTSs was not explicitly quantified.

Table 17. Average county SSTS failure and ITPHS rates (2010–2019 average) for counties in the Blue Earth River Watershed.

Rates are provided by counties to MPCA and are estimates only; the data do not represent verified compliance status.

County name	Failing	ITPHS
Blue Earth County	28%	12%
Cottonwood County	35%	28%
Faribault County	– [a]	21%
Freeborn County	32%	16%
Jackson County	47%	15%
Martin County	11%	16%
Watonwan County	19%	17%

a. Data not available.

Other potential wastewater sources of *E. coli* in the watershed may include straight pipe discharges, earthen pit outhouses, and land application of septage. Straight pipe systems are unpermitted and illegal sewage disposal systems that transport raw or partially treated sewage directly to a lake, stream, drainage system, or the ground surface. Straight pipe systems are required to be addressed 10 months after discovery (Minn. Stat. § 15.55, subd. 11). Outhouses, or privies, are legal disposal systems and are regulated under Minn. R. 7080.2150, subp. 2F and Minn. R. 7080.2280. Septage disposal is regulated under Minn. R. 7041 and Minn. R. 7080 as well as in local and federal regulations.

Areas and communities with SSTS concerns

To ensure that effective sewage treatment occurs across the state, the MPCA regularly conducts surveys of local governmental units to identify areas in the state that may be areas of concern; these areas are defined as five or more homes within a half mile of each other that have inadequate sewage treatment. These areas are generally unincorporated communities, may not have an organized structure, may consist of families with limited financial resources, and many times do not qualify for the same financial assistance as large, incorporated communities. As of 2019, there were eight communities in the impairment watersheds identified as areas and communities with SSTS concerns. The communities may have been listed because they were known to be noncompliant (i.e., ITPHS that backs up into the house or surface discharges inadequately treated wastewater, or a treatment system that is failing to protect groundwater and has a leaky tank or not enough soil separation under the SSTS before reaching saturated soil conditions) or due to an unknown status of SSTS compliance and were listed because of poor soils in the area, small lot size, or are older systems that may be out of compliance.

Internal phosphorus recycling

Internal phosphorus recycling, often referred to as "internal loading," can be a substantial component of the phosphorus budget in lakes. The sediment phosphorus originates as an external phosphorus load that settles out of the water column to the lake bottom. There are multiple mechanisms by which phosphorus can be released back into the water column as recycled phosphorus:

- Low oxygen concentrations (also called anaerobic conditions or anoxia) in the water overlying the sediment can lead to phosphorus release. In shallow lakes that undergo intermittent mixing of the water column throughout the growing season, the released phosphorus can mix with surface waters throughout the summer and become available for algal growth.
- Bottom-feeding fish such as carp and black bullhead forage in lake sediments. This physical disturbance can release phosphorus into the water column.
- Wind energy in shallow depths can mix the water column and disturb bottom sediments, which leads to phosphorus release.
- Other sources of physical disturbance, such as motorized boating in shallow areas, can disturb bottom sediments and lead to phosphorus release.

Increasing surface water temperatures resulting from warmer air temperatures can lead to changes in thermal stratification, leading to higher internal phosphorus recycling, loss of oxygen in bottom waters in deep lakes, and more unstable or temporary stratification in shallow lakes (see Section 3.1: *Climate trends*).

Additionally, high densities of panfish such as black crappie, bluegill, and perch can affect the trophic interactions in a lake. For example, if panfish consumption of large-bodied zooplankton is high, zooplankton grazing on algae can be reduced and can lead to higher levels of algae.

The role of internal phosphorus recycling in the impaired lakes was evaluated by examining multiple data sources:

- Surface TP concentrations in many lakes increase from June through August each year despite generally decreasing flows, external TP concentrations, and external TP loads during this time period.
- 2021 mean summer TP concentrations in Amber Lake and George Lake were higher than previous summers (2017 through 2020) despite very low rainfall totals, runoff volumes, external TP concentrations, and external TP loads in 2021.
- DO concentrations: Although temperature and DO profile data are limited, surface TP concentration spikes have been observed in some of the lakes when thermal stratification weakens and/or breaks down in late summer.
- Fisheries surveys conducted by the DNR: High abundances of bottom-feeding fish such as carp and black bullhead indicate that internal loading from these fish can be substantial. Fisheries information was obtained from the DNR's LakeFinder website and was supplemented by conversations with DNR staff.
- Lake modeling: The lake response models inherently include a recycled phosphorus load that is typical of lakes in the model development data set (see Section 4.5.1 for the lake modeling approach). Because an average amount of recycled phosphorus is inherent in the lake models, the full recycled phosphorus load to a lake cannot be explicitly quantified. In some cases, recycled phosphorus loading to a lake is greater than the recycled phosphorus load that is inherent in the model. In these cases, an additional phosphorus load can be added to the lake

phosphorus budget to calibrate the lake response model. This approach was used to estimate recycled phosphorus loads in all of the impaired lakes except for the Fairmont Chain of Lakes (see Section 4.5.1). The additional phosphorus load was attributed to recycled phosphorus loading and/or other sources such as watershed loads, feedlots, or septic system loads that were not quantified with the available data. This additional phosphorus load is noted as "watershed runoff and internal recycling" in the phosphorus source summaries and TMDL tables in Appendix B.

In Amber, Hall, Budd, and Sisseton, an additional phosphorus load was not needed to calibrate the lake models, and minimal adjustments were made to the phosphorus sedimentation calibration factors (MPCA 2023a). There is evidence that internal phosphorus recycling likely occurs in these lakes during certain times of the year—surface TP concentration spikes have been observed in most of the lakes when thermal stratification weakens and/or breaks down in late summer. However, not enough data are available at this time to confidently estimate internal phosphorus recycling in the Fairmont Chain of Lakes. See the *Blue Earth River Watershed Lake Water Quality Improvement Study* (MPCA 2023a) for further discussion of internal phosphorus recycling in the Fairmont Chain of Lakes.

Atmospheric deposition

Phosphorus is bound to atmospheric particles that settle out of the atmosphere and are deposited directly onto surface water. Phosphorus loading from atmospheric deposition to the surface area of the impaired lakes was estimated using the average for the Minnesota River basin (0.37 lb/acre-year, Barr Engineering 2007).

Upstream water bodies

To account for phosphorus removal and release in lakes located upstream of phosphorus impairments, loading from selected lakes was estimated. Loading was calculated as the product of the average annual simulated flow at the lake outlet and the average monitored growing season phosphorus concentration for the following lakes: South Silver Lake (46-0020) in the Iowa Lake Watershed; Iowa Lake in the East Chain Lake Watershed; Willmert Lake in the Fairmont Chain of Lakes Watershed; and Fish Lake in the Cedar Lake Watershed.

Natural background sources

"Natural background" is defined in both Minnesota statute and rule. The Clean Water Legacy Act (Minn. Stat. § 114D.15, subd. 10) defines natural background as "characteristics of the water body resulting from the multiplicity of factors in nature, including climate and ecosystem dynamics, that affect the physical, chemical, or biological conditions in a water body, but does not include measurable and distinguishable pollution that is attributable to human activity or influence." 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 water body 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 of *E. coli* and phosphorus can include inputs from natural geologic processes such as soil loss from upland erosion and stream development, atmospheric deposition, and 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 water body assessment process. Natural background conditions were evaluated within the source assessment portion of this study. These source assessment exercises indicate that natural background inputs are generally low compared to livestock, cropland, failing SSTSs, and other anthropogenic sources.

Based on the MPCA's water body assessment process and the TMDL source assessment exercises, there is no evidence at this time to suggest that natural background sources are a major driver of any of the impairments and/or affect the water bodies' ability to meet state water quality standards.

Naturalized *E. coli*

The adaptation and evolution of naturalized *E*. *coli* that allow survival and reproduction in the environment make naturalized *E*. *coli* physically and genetically distinct from *E*. *coli* that cannot survive outside of a warm-blooded host. This naturalized *E. coli* may be a source of *E. coli* to the impairments.

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 1) natural background sources such as wildlife and 2) 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* are not always from a natural background source.

An Alaskan study (Adhikari et al. 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. 2010) and temperate soils (Ishii et al. 2006). A study by Chandrasekaran et al. (2015) 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. Survival and growth of fecal coliform has been documented in storm sewer sediment in Michigan (Marino and Gannon 1991), and *E. coli* regrowth was documented on concrete and stone habitat within an urban Minnesota watershed (Burns & McDonnell Engineering Company, Inc. 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 et al. 2005).

Although naturalized *E. coli* might exist in the watershed, there is no evidence to suggest that naturalized *E. coli* are a major driver of impairment and/or affect the water bodies' ability to meet state water quality standards.

3.7.2 *E. coli* source summary

The behavior of fecal bacteria in the environment is complex. Concentrations of fecal bacteria in a water body depend not only on their source but also factors such as weather, flow, and water temperature. As these factors fluctuate, the concentrations of fecal bacteria in the water may increase or decrease. Some fecal bacteria can survive and grow in the environment while others tend to die off with time (Ishii et al. 2006, Chandrasekaran et al. 2015, Sadowsky et al. n.d., and Burns & McDonnell 2017). See *Water Quality and Bacteria Frequently Asked Questions* (MPCA 2019c) for additional background information about sources of fecal bacteria. The MPCA uses the *E. coli* water quality standard to identify water bodies that may be contaminated with fecal waste. Higher levels of *E. coli* in the water may or may not be accompanied by higher levels of pathogens and an increased risk of harm. Varying survival rates of fecal bacteria make it impossible to definitively state when pathogens are present.

Monitoring data indicate that *E. coli* concentrations can be elevated under mid to very high flows (Figure 13), suggesting that a range of source types contribute to impairment including runoff driven sources and sources that enter a water body directly. The primary sources of *E. coli* to the impaired water bodies in the Blue Earth River Watershed are from nonpermitted sources:

- Livestock (see Figure 15 for AU densities)
    - Runoff from feedlots or manure stockpiles without runoff controls, pastures, and agricultural fields where manure is applied (especially surface applied manure).
    - Runoff from noncompliant permitted feedlots.
    - Direct access of livestock to riparian areas.
- Inadequately treated wastewater: Rates of ITPHS septic systems in the watershed range from 12% to 28% (Table 17), but information on the specific locations of ITPHS are not known. Because the rates of ITPHS are substantial throughout the watershed, ITPHS are considered a likely source of *E. coli*. Small community wastewater treatment areas of concern also have the potential to contribute to impairment.

Other sources of *E. coli* include the following:

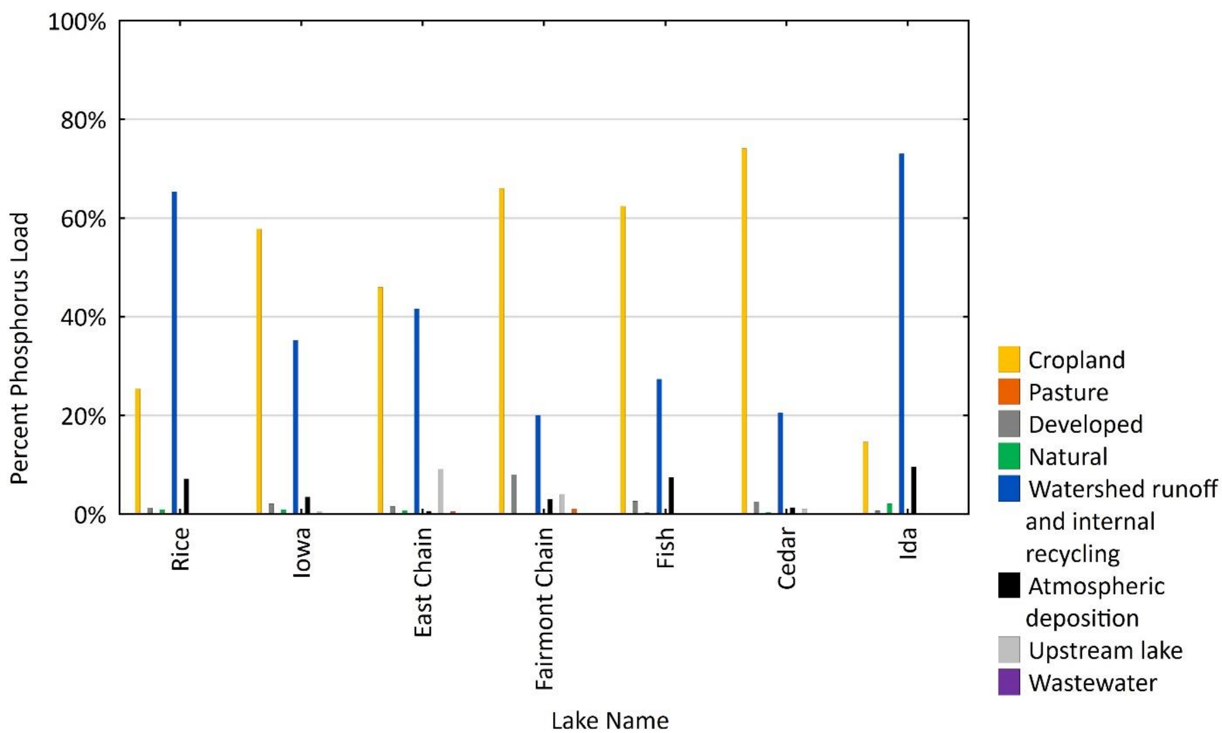
- Municipal and industrial wastewater (permit exceedances and unauthorized releases): Effluent from WWTPs is typically below the *E. coli* standard and is not considered a significant source. Occasionally, unauthorized releases of wastewater have been reported. In such instances, wastewater is a potential source of impairment, depending on the frequency of the releases, the flow in the receiving water body, and the location with respect to the impaired water body.
- Stormwater runoff: Stormwater runoff is a potential source of *E. coli* to impaired streams that flow through developed areas of cities, such as the Blue Earth River (AUIDs 553 and 508).
- Natural background: Waste from wildlife may be a source of *E. coli* to the impaired streams but is generally considered to be low compared to other sources. Wildlife could represent a more substantial part of overall *E. coli* loading in isolated areas of high wildlife density and under low flow conditions.

- Naturalized assemblages: Naturalized *E. coli* is considered to be a potential source for all of the impairments. However, they are likely not a major driver of impairment and/or affect water bodies' ability to meet state water quality standards

3.7.3 Phosphorus source summary

The primary phosphorus loads to the impaired lakes are watershed runoff from cropland and internal recycling (Figure 17). Phosphorus sources also include watershed runoff from developed areas and atmospheric deposition. Appendix B: *Water quality summaries and TMDLs by water body* includes more detailed information on phosphorus sources to each impaired lake.

Figure 17. Phosphorus sources to impaired lakes.



The only point source is Great River Energy–Lakefield Junction Station in the Cedar Lake Watershed, which represents less than 1% of the load to the lake.

4. TMDL development

A water body's TMDL represents the loading capacity, or the amount of pollutant that a water body can assimilate while still meeting water quality standards. The loading capacity is divided up and allocated to the water body's pollutant sources. The allocations include WLAs for NPDES-permitted sources, LAs for nonpermitted sources (including natural background), and an MOS, which is implicitly or explicitly defined. The sum of the allocations and MOS cannot exceed the loading capacity, or TMDL. This section describes the approach used to derive the TMDLs and allocations. The TMDL tables are included in Appendix B: *Water quality summaries and TMDL by water body*.

A reserve capacity was not assigned in these TMDLs. Reserve capacity in Minnesota *E. coli* TMDLs is not needed for new or expanding wastewater dischargers whose permitted effluent limits are at or below the instream target (Section 5.2). A reserve capacity also is not warranted for the phosphorus TMDLs in this report. In the watersheds of the impaired lakes, the existing population centers that are not currently served by permitted wastewater treatment facilities do not have sufficient population density to justify the use of reserve capacity.

4.1 Overall approach

The stream *E. coli* TMDLs were developed with LDCs, and the lake phosphorus TMDLs were developed using the lake response model BATHTUB. More details on these approaches are in Section 4.4 and 0, respectively.

4.2 Seasonal variation and critical conditions

The application of LDCs in the *E. coli* TMDLs addresses seasonal variation and critical conditions. LDCs evaluate pollutant loading across all flow regimes including high flow, which is when pollutant loading from watershed runoff is typically the greatest, and low flow, which is when loading from direct sources to the stream typically has the most impact. Because flow varies seasonally, LDCs address seasonality through their application across all flow conditions in the impaired water body.

Seasonal variations are addressed in lake TMDLs by assessing conditions during the summer growing season, which is when the water quality standards apply (June 1 through September 30). The frequency and severity of nuisance algal growth in Minnesota lakes is typically highest during the growing season. The nutrient standards set by the MPCA, which are a growing season concentration average rather than an individual sample (i.e., daily) concentration value—were set with this concept in mind. Additionally, by setting the TMDL to meet targets established for the most critical period (summer), the TMDL will inherently be protective of water quality during all other seasons.

Seasonal variation and critical conditions are also addressed by the water quality standards. The *E. coli* standards for AQR apply from April through October, and the eutrophication standards for lakes apply from June through September. These time periods are when AQR is more likely to occur in Minnesota waters and when high *E. coli* and phosphorus concentrations generally occur.

4.3 Baseline year

For the *E. coli* impairments and the non-Fairmont Chain of Lakes impairments, the monitoring data used to calculate the percent reductions are from 2017 and 2018. The baseline year for implementation is 2017 (end of year), the midpoint of the time period. BMPs present on the landscape during the model simulation time period are implicitly accounted for in the model.

For the Fairmont Chain of Lakes phosphorus TMDL, the monitoring data used to calculate the percent reductions are from 2017 through 2021. BMPs (e.g., constructed basins, filters, stormwater wetlands, and grit chambers) installed in the City of Fairmont through 2021 are incorporated into the existing conditions loads; therefore, the baseline year for implementation is 2021 (end of year).

4.4 *E. coli*

Because the *E. coli* standards for the impairments addressed in this report apply April through October, the *E. coli* TMDLs and allocations also apply April through October.

4.4.1 Loading capacity methodology

The loading capacities for the *E. coli* impairments were developed using LDCs. See Section 3.6.1 for a description of LDC development. The loading capacity was calculated as simulated flow at the downstream end of each impaired reach multiplied by the *E. coli* monthly geometric mean standard (126 org/100 mL). The LDCs provide loading capacities along all flows observed in the stream along with observed loads calculated from monitoring data and simulated flow. For any given flow in the LDC, the loading capacity is determined by selecting the point on the LDC that corresponds to the flow exceedance (along the x-axis).

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 equation tables of this report, only five points on the entire loading capacity curve are depicted (the midpoints of the designated flow zones). However, the entire curve represents the TMDL and is what the EPA ultimately approves.

4.4.2 Margin of safety

The MOS accounts for uncertainty concerning the relationship between water quality and allocated loads. The MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as a load set aside). An explicit MOS of 10% was included in the *E. coli* TMDLs to account for these uncertainties. The use of an explicit MOS accounts for uncertainty in water quality monitoring, environmental variability in flow and pollutant loading, calibration and validation of modeling efforts, and uncertainty in modeling outputs. This MOS is considered to be sufficient given the robust flow dataset and the calibration results of the HSPF model. Simulated flows from the HSPF model were used to develop the LDCs for the *E. coli* impairments (the HSPF model does not simulate *E. coli* loads).

The Blue Earth River HSPF model was calibrated as part of the Minnesota River Watershed HSPF models. These models were calibrated and validated using 57 stream flow gaging stations, with three long-term gaging stations in the Blue Earth River Watershed (Tetra Tech 2015). Calibration results indicate that the HSPF model is a valid representation of hydrologic conditions in the watershed.

4.4.3 Boundary conditions

Boundary conditions (BCs) are used to set aside load for a geographic area in a TMDL watershed without establishing LAs or WLAs for that area. If part of an impairment watershed is in another state, a BC allocates a lump sum load to the area that does not fall under Minnesota's jurisdiction. Minnesota cannot establish allocations for other jurisdictions, and any reductions noted in this TMDL that are needed in the neighboring jurisdiction are consistent with Minnesota's water quality standards and not more stringent (see Section 2.4 for Minnesota and Iowa water quality standards).

A BC load was assigned for impairments that contain a portion of their watershed in Iowa. The BC load assumes that water quality standards are being met at the state line and takes into account all point and nonpoint sources in Iowa. BCs were calculated using the proportion of the total watershed area in Iowa. Each BC load was calculated as follows:

Boundary condition load =
percent of the total watershed area in Iowa x
(loading capacity – MOS – wastewater WLAs [where applicable])

In the TMDL tables (Appendix B), the BC load is assigned to the portion of the watershed in Iowa, and the remaining allocations in the tables are assigned to the portion of the watershed in Minnesota.

4.4.4 Wasteload allocation methodology

The WLA is allocated to existing or future NPDES-permitted pollutant sources.

4.4.4.1 Municipal and industrial wastewater

E. coli WLAs were assigned to permitted municipal and industrial wastewater based on the *E. coli* geometric mean standard (126 org/100 mL) multiplied by the facility's design flow (average wet weather design flow or maximum daily flow; Table 18). For WWTPs with controlled discharge, the maximum daily discharge volume for each facility was used.

The fecal coliform permit limit for all facilities that are assigned *E. coli* WLAs in this report is 200 org per 100 mL as a calendar month geometric mean. Existing effluent limits are consistent with *E. coli* WLA assumptions (Table 18); it is assumed that if a facility meets the fecal coliform limit of 200 org per 100 mL it is also meeting the *E. coli* WLA. All wastewater WLAs for *E. coli* are listed in Table 18 and in the TMDL tables in Appendix B.

The purpose of fecal bacterial effluent limits in wastewater permits is to ensure that wastewater facilities provide effective disinfection during the applicable time periods, and fecal coliform effluent limits will continue in NPDES permits for Minnesota wastewater treatment facilities (MPCA 2007b).

Table 18. Wastewater wasteload allocations for *E. coli.*

Fecal coliform permit limit is 200 org per 100 mL as a calendar month geometric mean for all facilities in this table.

Facility name	Permit number (surface discharge station)	Design flow (mgd) [a]	Impaired water body AUID	Months during which disinfection is required	Flow Type	*E. coli* WLA (billion organisms per day)	Existing permit consistent with WLA assumptions
Alden WWTP	MNG585118 (SD001, 002)	2.46	652	May–Oct [b]	Controlled	11.73	Y
Blue Earth WWTP	MN0020532 (SD001)	0.98	508	Apr–Oct	Continuous	4.67	Y
Bricelyn WWTP	MNG585129 (SD001)	0.466	655	Apr–Oct	Controlled	2.22	Y
Darling International–Blue Earth [c]	MN0002313 (SD001, 002)	3.35	508	Apr–Oct	Controlled and continuous	3.35	Y
Elmore WWTP	MNG585110 (SD001)	2.493	646	Apr–Oct	Controlled	11.89	Y
Fairmont WWTP	MN0030112 (SD001)	3.9	514	Apr–Oct	Continuous	18.60	Y
Frost WWTP	MNG585120 (SD001)	0.393	553	Apr–Oct	Controlled	1.87	Y
Granada WWTP	MNG585023 (SD001)	0.362	514	Apr–Oct	Controlled	1.72	Y
Kiester WWTP	MNG585097 (SD001)	0.497	655	Apr–Oct	Controlled	2.37	Y
Walters WWTP	MNG585223 (SD001)	0.143	652	Apr–Oct	Controlled	0.68	Y
Welcome WWTP	MN0021296 (SD003)	0.26	514	Apr–Oct	Continuous	1.24	Y

a. Flow used to calculate the WLA: average wet weather design flow (continuous flow type) or maximum daily flow (controlled flow type). Darling International–Blue Earth is calculated from the sum of maximum daily flow for both continuous and controlled facilities.

b. Alden WWTP effluent is not likely to be a significant *E. coli* source in April (see Table 14 Section 3.7.1.1). Future permits will determine whether the permit limit will apply during April.

c. Doing business as Darling Ingredients Inc. (as of 2022)

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

Allocation = flow contribution from a given source x 126 org *E. coli*/100 mL

This amounts to assigning a concentration based WLA to these sources for the lower flow zones. Rainfall, and thus runoff, is very limited if not absent during low flow. Because of this, runoff sources would need little to no allocation for these flow zones.

4.4.4.2 Municipal separate storm sewer systems

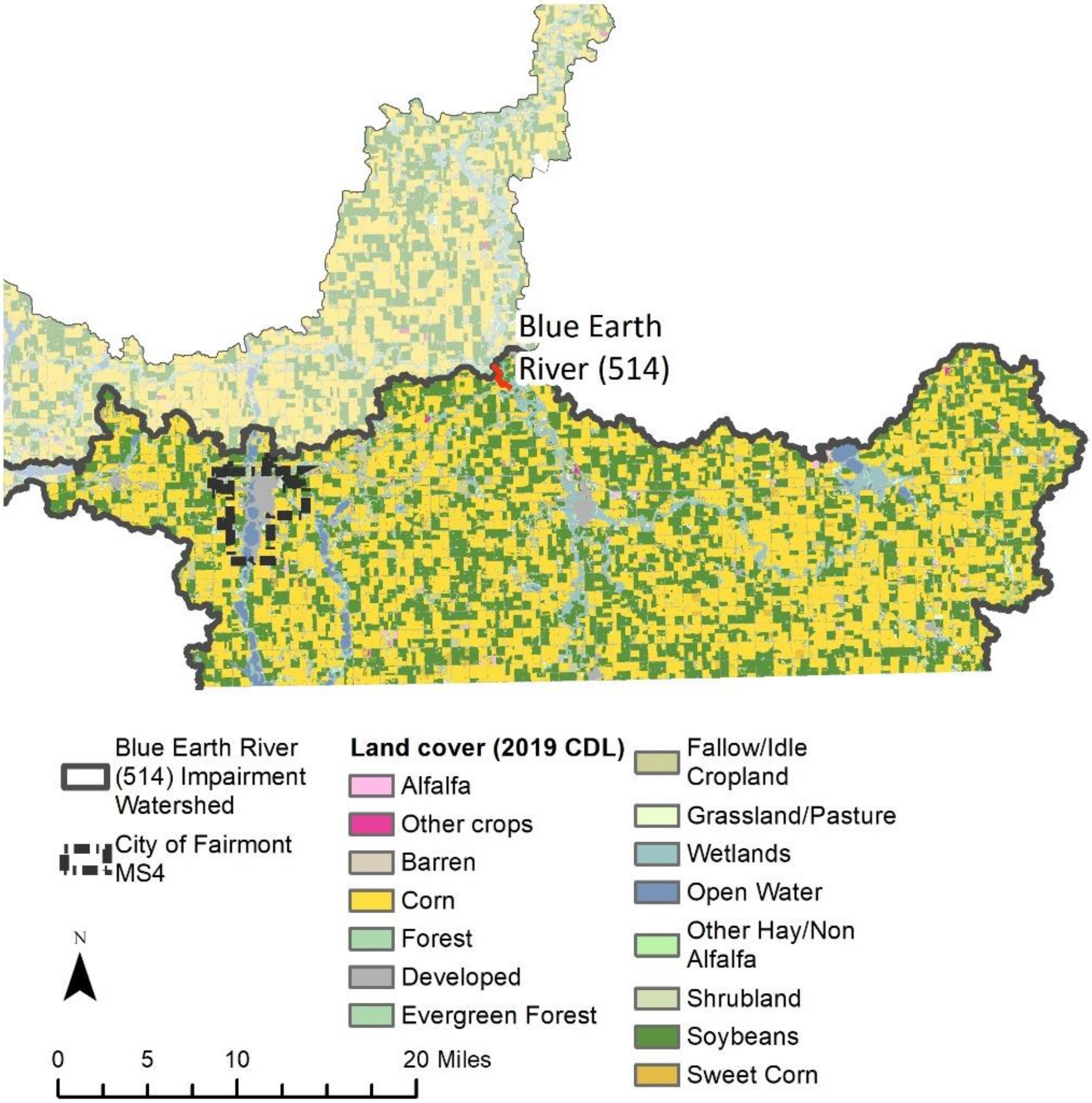
There is one permitted MS4 in the watersheds of the *E. coli* impairments—the City of Fairmont. The city is entirely within the watershed of the most downstream Blue Earth River impairment (Reach 514; Table 19, Figure 18). The entire area of the city is represented in the TMDL as the regulated MS4 area. Using the entire city boundary acknowledges that future stormwater conveyance within the city boundary will be MS4-regulated. The city's area was divided by the total area of the watershed to represent the percent coverage of the permitted MS4 within the impairment watershed (Table 19). The WLAs for the permitted MS4 were calculated as the percent coverage of the permitted MS4 multiplied by the loading capacity minus the BC, MOS, and wastewater WLAs.

The City of Fairmont received fecal coliform MS4 WLAs for the Blue Earth River (reaches 501 and 509) and Center Creek (503 and 526) in the 2007 fecal coliform TMDL report (MSU Mankato 2007). Because of these previously assigned fecal coliform WLAs, and because the MS4 General Permit requirements are for bacteria, which includes fecal coliform and *E. coli*, the city's *E. coli* MS4 WLA for reach 514 (Table 19, Table 58) will not result in additional MS4 permit requirements. See Section 8.1.3 in the *Implementation strategy summary* for more information.

Table 19. Permitted MS4 and estimated regulated area for *E. coli* impairments.

MS4 name and permit number	Estimated regulated area (ac)	Estimated regulated percent area of the watershed	Impaired water body	Impaired water body AUID	Pollutant
Fairmont City MS4 (MS400239)	10,797	1.5%	Blue Earth River (Center Cr to Elm Cr)	514	*E. coli*

Figure 18. Regulated MS4 (City of Fairmont) in Blue Earth River Watershed (Center Cr to Elm Cr; 514) for *E. coli* TMDL.



4.4.4.3 Construction and industrial stormwater

WLAs for regulated construction stormwater (MNR100001) are not developed in Minnesota because *E. coli* is not a typical pollutant from construction sites.

Industrial stormwater receives a WLA only if the pollutant is part of benchmark monitoring for an industrial site in the watershed of an impaired water body. There are no fecal bacteria or *E. coli* benchmarks associated with the industrial stormwater general permit (MNR050000), and therefore industrial stormwater *E. coli* WLAs were not assigned.

4.4.4.4 NPDES/SDS permitted animal feeding operations

WLAs are not assigned to CAFOs, including CAFOs with NPDES or SDS permits, and CAFOs not requiring permits; this is equivalent to a WLA of zero. Although the NPDES and SDS permits allow discharge of manure and manure contaminated runoff due to a precipitation event greater than or equal to a 25-year, 24-hour precipitation event, the permits prohibit discharges that cause or contribute to nonattainment of water quality standards.

All other non-CAFO feedlots and the land application of all manure are accounted for in the LA for nonpermitted sources.

4.4.5 Load allocation methodology

The LA is allocated to existing or future nonpermitted pollutant sources. The LA was calculated as the TMDL minus the MOS, the BC, and the WLAs.

Natural background conditions were also evaluated, where possible, within the modeling and source assessment portion of this study (Section 3.7.1.2). Natural background sources are implicitly included in the LA portion of the TMDL table, and reductions should focus on the major human attributed sources identified in the source assessment.

4.4.6 Percent reduction

The estimated percent reduction provides a rough approximation of the overall reduction needed for the water body to meet the TMDL. The percent reduction is a means to capture the level of effort needed to reduce *E. coli* concentrations in the watershed. The percent reductions should not be construed to mean that each of the separate sources listed in the TMDL table needs to be reduced by that amount.

The existing concentration was calculated as the maximum monthly observed geometric mean *E. coli* concentration for each impairment. The percent reduction needed to meet the standard was calculated as the maximum monthly observed geometric mean concentration minus the geometric mean standard (126 org/100 mL) divided by the maximum monthly observed geometric mean concentration. By using the highest observed monthly geometric mean, the percent reduction calculation approximates the reduction in *concentration* (as opposed to load) needed to meet the monthly geometric mean standard overall, aggregated across all flow conditions.

4.4.7 *E. coli* TMDL summary

The LDCs and TMDL tables are in Appendix B. The estimated percent reductions needed to meet the *E. coli* TMDLs range from 60% to 85% (Table 20). The LDCs (Appendix B) and other *E. coli* analyses (Figure 13), when taken as a whole, indicate that exceedances of the *E. coli* standard occur under mid to very high flows. Load reductions are needed to address multiple source types (see Section 3.7.2: *E. coli* source summary).

Table 20. Summary of percent reductions needed to meet the *E. coli* standard in impaired reaches of the Blue Earth River Watershed.

AUID	Water body name	Location/reach description	Maximum observed monthly geometric mean	Percent reduction in concentration needed to meet *E. coli* standard	TMDL table in Appendix B
07020009-652	Blue Earth River, East Branch	T102 R25W S23, north line to Unnamed ditch	820	85%	Table 28
07020009-655	Brush Creek	Unnamed cr to E Br Blue Earth R	814	85%	Table 31
07020009-553	Blue Earth River, East Branch	Brush Cr to Blue Earth R	312	60%	Table 34
07020009-648	Coon Creek	T102 R27W S33, south line to Blue Earth R	511	75%	Table 37
07020009-645	Blue Earth River, Middle Branch	MN/IA border to -94.104 43.514	399	68%	Table 40
07020009-646	Blue Earth River, Middle Branch	-94.104 43.514 to W Br Blue Earth R	320	61%	Table 43
07020009-643	Blue Earth River, West Branch	MN/IA border to 15th St	855	85%	Table 46
07020009-658	Badger Creek	Little Badger Cr to -94.136 43.64	735	83%	Table 49
07020009-508	Blue Earth River	E Br Blue Earth R to South Cr	378	67%	Table 52
07020009-640	South Creek	-94.300 43.661 to Blue Earth R	677	81%	Table 55
07020009-514	Blue Earth River	Center Cr to Elm Cr	392	68%	Table 58
07020009-577	Willow Creek	Unnamed cr to Blue Earth R	557	77%	Table 61

See Table 3 for *E. coli* standard.

4.5 Phosphorus

Although the lake eutrophication standards apply June–September, the lake TMDL analysis is based on either annual (January through December) or seasonal (April through October) loads. The Fairmont Chain of Lakes TMDL is based on seasonal loading due to the lakes' short hydraulic and nutrient residence times (MPCA 2023a); the TMDLs for the remaining lakes are based on annual loads. The TMDLs were calculated as the annual/seasonal phosphorus load to each lake that will allow the lake to meet water quality standards during June through September. Therefore, the TMDL and allocations apply from April through October for the Fairmont Chain of Lakes and January through December for the remaining lakes.

4.5.1 Loading capacity methodology

Allowable phosphorus loads to the impaired lakes were determined using the lake response model BATHTUB. BATHTUB is a steady state model that predicts eutrophication response in lakes based on empirical formulas developed for nutrient balance calculations and algal response (Walker 1987). The model was developed by the U.S. Army Corps of Engineers and has been used extensively in Minnesota and across the Midwest for lake nutrient TMDLs. A spreadsheet version of the BATHTUB model was used for the Blue Earth River Watershed Lake TMDLs. The BATHTUB model requires nutrient loading inputs from the upstream watershed and atmospheric deposition (Section 3.7.1), lake morphometric data (Table 6), and estimated mixed depth. Watershed runoff volumes and loads were derived from the HSPF model (see Section 3 for a brief description of the model) and the Fairmont Chain of Lakes Watershed loading model (MPCA 2023a).

The BATHTUB models were calibrated to the average lake phosphorus concentration, consisting of all data collected in the 10-year period of 2012 through 2021 (Table 12). Modeled watershed runoff, atmospheric deposition, and upstream lake loads (Figure 17 and Appendix B) were input to the BATHTUB models. For all the lakes except the Fairmont Chain of Lakes, the models were calibrated by adding an additional load (see *Internal phosphorus recycling* in Section 3.7.1.2). The additional phosphorus load was attributed to internal phosphorus recycling and/or other sources such as watershed loads, feedlots, or septic system loads that were not quantified with the available data. The Fairmont Chain of Lakes model was calibrated by adjusting the phosphorus sediment calibration factor to reflect the lower phosphorus retention observed when internal phosphorus recycling is high. This approach was used for the Fairmont Chain of Lakes because of the higher certainty in the external phosphorus loading model, which was calibrated to extensive monitoring data. An additional explicit phosphorus load was added to calibrate the George Lake model, the most downstream lake in the Fairmont Chain of Lakes.

After each model was calibrated, the TMDL scenario was developed according to the following:

- BCs for upstream lakes: BC allocations for impaired lakes are based on phosphorus standards, and allocations for lakes meeting the phosphorus standard are based on the lake's current phosphorus concentration (see Section 4.5.3).
- Willmert Lake (46-0014) in the Amber Lake Watershed: Although data suggest that Willmert Lake does not meet water quality standards, the lake is not listed as impaired because the assessment was inconclusive. In the Fairmont Chain of Lakes TMDL, loading from Willmert Lake is assigned a LA, which is based on the lake meeting phosphorus standards (90 µg/L). This is not considered a BC because the lake is not listed as impaired, and therefore all sources in the watershed must be accounted for in the allocations.
- Watershed load
    - Rice, Iowa, East Chain, Cedar, Ida: The target TP concentration in watershed runoff is 150 µg/L.
    - Fish: The watershed load reduction needed for Fish Lake is less stringent than the lakes in the above bullet and therefore the concentration target is higher. The target TP

concentration in watershed runoff to Fish Lake is 182 µg/L. This concentration is based on an equal percent reduction in Fish Lake from watershed and internal loading.

- Fairmont Chain of Lakes: The target TP concentration in watershed runoff is 183 µg/L (MPCA 2023a). This target applies to all watershed runoff in the Fairmont Chain of Lakes drainage area downstream of Willmert Lake. The target was derived such that, if achieved, all lakes in the chain would achieve lake water quality targets.

- No changes to loading from atmospheric deposition.
- The remaining load reductions needed to meet the water quality standard are from internal recycling and watershed loading (sources that were not quantified with the available data).

The total allowable load to the lake in each TMDL table represents the loading capacity, the total estimated load reduction is the sum of the load reductions needed from the individual allocations in the TMDL table, and the percent reduction needed to meet the TMDL is the total estimated load reduction divided by the existing load. The total estimated load reduction is greater than the difference between the total existing load and the total TMDL load (i.e., loading capacity) due to the MOS. The estimated percent reduction provides a rough approximation of the overall reduction needed for the impaired lakes to meet the TMDLs. Model inputs and outputs are presented in Appendix C.

4.5.2 Margin of safety

An explicit MOS of 10% was included in the phosphorus TMDLs for Rice, Iowa, East Chain, Fish, Cedar, and Ida Lakes (i.e., the non-Fairmont Chain lakes). This MOS is considered to be sufficient given the available dataset and the calibration results of the HSPF model. Simulated flows and phosphorus loading rates from the model were used to develop the BATHTUB lake models and TMDLs for the impaired lakes. In addition to the justification described for the *E. coli* TMDLs (Section 4.4.2), the following applies to the phosphorus TMDL MOS: 63 in-stream water quality stations were used for the sediment calibration and corroboration of the HSPF model, with four stations in the Blue Earth River Watershed. The sediment and nutrient calibration was revised in 2022 with data from three stations (3/31/2022 model version). Calibration results indicate that the HSPF model is a valid representation of hydrologic and nutrient loading conditions in the watershed.

Implicit and explicit MOSs were used in the Fairmont Chain of Lakes TMDL. Phosphorus loads simulated with HSPF and the Fairmont Chain of Lakes Watershed loading model were used to estimate phosphorus loads to the impaired lakes. A robust data set was used to develop the watershed and lake models, which includes the following items:

- Five years (2017 through 2021) of intensive flow, water quality, and pollutant load monitoring for Dutch Creek Station S003-000 conducted by the MPCA and MDA;
- Five years (2017 through 2021) of lake water quality monitoring for Amber, Hall, Budd, Sisseton, and George Lakes throughout the summer growing season; and
- Five years (2017 through 2021) of remote sensing-derived water quality data (chl-*a* and Secchi depth) for all lakes in the Fairmont Chain of Lakes available through the University of Minnesota Lake Browser.

The BATHTUB models generally show good agreement between observed lake water quality and the water quality predicted by the lake response model (Appendix C: *Lake modeling documentation*). The watershed loading model and lake response model reasonably reflect the watershed and lake conditions. The lake water quality improvement targets outlined in MPCA (2023a) for Hall, Budd, and Sisseton are lower than the 90 µg/L TP criterion. The Chain of Lakes TMDL scenario is based on these water quality improvement targets, and the TMDL load reduction goals are expected to result in the following lake TP concentrations: 88 µg/L in Amber Lake, 65 µg/L in Hall Lake, 62 µg/L in Budd Lake, 72 µg/L in Lake Sisseton, and 90 µg/L in George Lake, thus providing an implicit MOS for the first four lakes in the Fairmont Chain of Lakes. (See Figure 54 in Appendix B.) An implicit MOS is also incorporated for George Lake: the individual lake model for George Lake assumes that Sisseton Lake will meet 75 µg/L TP, but the upstream loading goals for Sisseton are expected to achieve an even lower mean concentration—72 µg/L TP. This provides an implicit MOS of approximately 4% for George Lake. The lake TP concentration targets and loading goals for the lakes throughout the Fairmont Chain of Lakes are incorporated into the TMDL and provide implicit MOS that all lakes will meet the shallow lake water quality standard (90 µg/L).

Modeling for George Lake suggests that the internal recycling/unidentified load requires a load reduction of approximately 77% (2,605 lb/season) for George Lake to meet the 90 µg/L water quality standard. Since the exact source of this load is unclear at this time, and to provide further assurance that George Lake will meet the shallow lake standard, the TMDL internal recycling/unidentified load was reduced to zero (i.e., 100% reduction rather than 77%; 3,381 lb/season). Setting this load to zero provides an explicit MOS of approximately 7% for George Lake within the Fairmont Chain of Lakes TMDL. The 7% explicit MOS, combined with the 4% implicit MOS described above, provides a total MOS of approximately 11% for George Lake.

The 100% reduction target for internal recycling/unidentified loads to George Lake do not imply that internal recycling needs to be eliminated in George Lake. The BATHTUB model implicitly assumes an average rate of internal loading. Additional internal load was added to the George Lake model during calibration; this internal load represents loading that is in addition to the average rate assumed in the model. The percent reduction for internal loading in the TMDL table refers to the additional internal load. That is, a 100% reduction in internal load indicates that the additional internal load needs to be reduced until the total internal load equals the average rate of internal loading that is implicit in BATHTUB.

Even more important than the MOS described above, effective adaptive management during implementation of the Fairmont Chain of Lakes TMDL will provide the ultimate assurance that these lakes will achieve water quality targets and standards. Sections 8.2 and 8.5 describe the adaptive management process and the types of implementation strategies that will help meet the lake TMDLs targets and goals in this report.

4.5.3 Boundary conditions

BCs are described in Section 4.4.3. Two types of BCs are used in the lake phosphorus TMDLs:

- State boundary. BCs were established for Iowa Lake and East Chain Lake, which contain a portion of their watershed in Iowa. Each BC load was calculated as the percent of the total watershed area in Iowa multiplied by the load allocated to watershed runoff (not including upstream impaired lake watersheds, which are accounted for as a separate BC). The BCs account for all point and nonpoint sources in Iowa; allocations are not assigned to any individual sources in Iowa. Load reductions needed from the watershed area in Iowa are consistent with Minnesota's standards and not more stringent. In the TMDL tables (Appendix B), the BC load is assigned to the portion of the watershed in Iowa, and the remaining allocations in the tables are assigned to the portion of the watershed in Minnesota.

- Upstream impairment. BCs were established for upstream impaired water bodies. The BC assumes that the upstream TMDL is met and was calculated as average annual simulated flow at the lake outlet multiplied by the TP lake water quality standard (90 µg/L) for the following water bodies:
  - Iowa Lake in the East Chain Lake Watershed (Figure 44 in Appendix B); and
  - Fish Lake in the Cedar Lake Watershed (Figure 55 in Appendix B).

  See *Upstream water bodies* in Section 3.7.1.2: *Nonpermitted sources* for information on the existing loads from these BCs.
- Upstream lake meeting water quality standards. South Silver Lake (46-0020) in the Iowa Lake Watershed meets the applicable phosphorus standard (65 µg/L) and is not listed as impaired. The MPCA assumes that sources in the South Silver Lake Watershed do not contribute to impairment of Iowa Lake. A BC was calculated equal to the existing load from South Silver Lake: average annual simulated flow at the lake outlet multiplied by the existing lake phosphorus concentration (48 µg/L).

4.5.4 Wasteload allocation methodology

WLAs are allocated to existing or future NPDES-permitted pollutant sources. If a permittee that is assigned a WLA in this report has previously been assigned one or more WLAs for the same pollutant for another TMDL, the applicable permit(s) and/or associated planning documents will need to address the most restrictive WLA.

4.5.4.1 Municipal and industrial wastewater

The WLA for Great River Energy—Lakefield Junction Station (Figure 57) is based on the WLA development approach in the Lake Pepin TMDL (MPCA 2021). WLAs for industrial wastewater sources with phosphorus concentrations less than 1.0 milligrams (mg)/L were calculated as the existing load x 1.15 (5.2 lb/yr x 1.15 = 6.0 lb/yr, or 2.7 kg/yr). This 2.7 kg/yr phosphorus limit was developed as part of the *Phosphorus Effluent Limit Review for the Blue Earth and Watonwan River Watershed* (MPCA 2017a). The discharge does not currently have a phosphorus permit limit; upon permit reissuance, a water quality based effluent limit (WQBEL) will be developed if the discharge is found to have a reasonable potential to cause or contribute to excursions above the water quality standards.

Table 21. Wastewater wasteload allocation for phosphorus.

Facility name	Permit number	Surface discharge station	Design flow (mgd)	Impaired water body (AUID)	Permit limit	Phosphorus wasteload allocation [a]	Existing permit consistent with WLA assumptions
Great River Energy—Lakefield Junction Station	MN0067709	SD001	0.009 (max design flow)	Cedar Lake (46-0121-00)	No P permit limit	5.5 lb/yr = 2.7 kg/yr	N [b]

a. Equal to the discharge's WLAs in the Lake Pepin TMDL (MPCA 2021).

b. Upon permit reissuance, a WQBEL will be developed if the discharge is found to have a reasonable potential to cause or contribute to excursions above the water quality standards. WQBELs must be consistent with assumptions and requirements of any EPA approved TMDL WLA.

4.5.4.2 Municipal separate storm sewer systems

The jurisdictional area of the city of Fairmont in the Fairmont Chain of Lakes Watershed is 5,095 acres (8 square miles) and was used as a proxy for the MS4 regulated area in the TMDL calculations (Table 22, Figure 19). Using the entire city boundary acknowledges that future stormwater conveyance within the city boundary will be MS4-regulated. The WLA for the city in the Fairmont Chain of Lakes TMDL (1,855 lb/season; Table 77) was calculated as modeled (2017 through 2021) watershed runoff volume from the regulated area multiplied by the target watershed runoff TP concentration of 183 µg/L. This target applies to all watershed runoff in the Fairmont Chain of Lakes drainage area and was derived such that, if achieved, all lakes in the chain would achieve lake water quality targets or better. See Appendix D for guidance on documentation of compliance with the City's MS4 TP WLA.

Assigned WLAs will result in additional MS4 permit requirements per the next MS4 General Permit; see Section 8.1.3 in the *Implementation strategy summary* for more information.

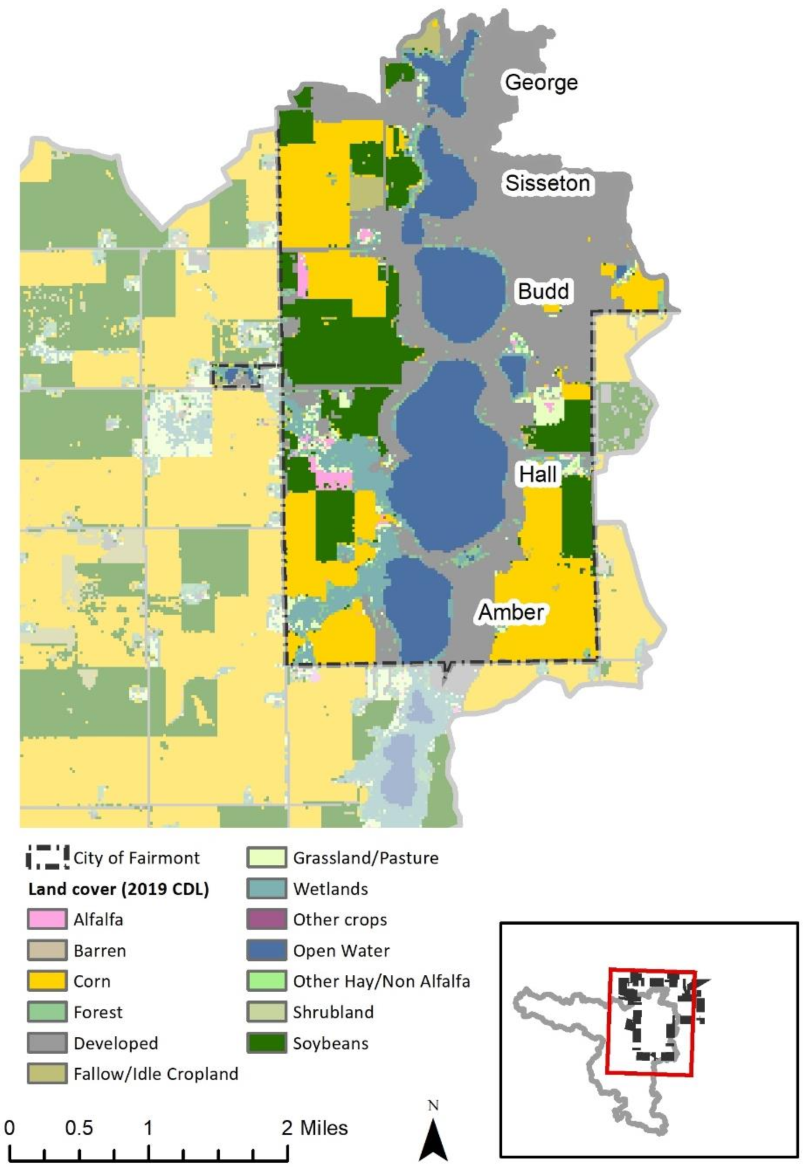
Table 22. Permitted MS4 WLA for phosphorus.

MS4 name and permit number	Estimated regulated area (ac) [a]	Estimated regulated percent area of the watershed	Impaired water body	Impaired water body AUIDs	Phosphorus wasteload allocation (lb/season)	Target watershed runoff phosphorus concentration (µg/L)
City of Fairmont (MS400239)	5,095	19%	Fairmont Chain of Lakes: Amber, Hall, Budd, Sisseton, George	46-0034-00 46-0031-00 46-0030-00 46-0025-00 46-0024-00	1,855 [b]	183

a. Does not include surface area of impaired lakes.

b. Assumes a TP watershed runoff concentration of 183 µg/L.

Figure 19. Regulated MS4 (City of Fairmont) in Fairmont Chain of Lakes Watershed for phosphorus TMDL.



4.5.4.3 Construction stormwater

WLAs are assigned to permitted construction stormwater (NPDES permit MNR100001) to account for existing and potential future sources. A categorical WLA for construction stormwater was calculated for each lake TMDL. On average, 0.23% of the area in the Blue Earth River Watershed is under construction stormwater permit coverage (2017 through 2021). Construction stormwater WLAs were calculated as 0.23% multiplied by the load allocated to watershed runoff minus upstream BCs and wastewater WLAs. In the Fairmont Chain of Lakes TMDL, the WLA for permitted construction stormwater within the City of Fairmont MS4 area is combined with the MS4 WLA, as any activity within city limits is presumed to discharge to the MS4.

4.5.4.4 Industrial stormwater

Industrial stormwater is regulated through NPDES permits (MNR050000 and MNG490000) when stormwater discharges have the potential to come into contact with materials and activities associated with the industrial activity. To allow for current and future permitted industrial stormwater activities, the WLA for industrial stormwater was calculated as equal to the construction stormwater WLA: 0.23% multiplied by the load allocated to watershed runoff minus upstream BCs and wastewater WLAs. In the Fairmont Chain of Lakes TMDL, the WLA for permitted industrial stormwater within the City of Fairmont MS4 area is combined with the MS4 WLA, as any activity within city limits is presumed to discharge to the MS4.

4.5.4.5 NPDES/SDS permitted animal feeding operations

WLAs are not assigned to CAFOs, including CAFOs with NPDES or SDS permits, and CAFOs not requiring permits; this is equivalent to a WLA of zero. Although the NPDES and SDS permits allow discharge of manure and manure contaminated runoff due to a precipitation event greater than or equal to a 25-year, 24-hour precipitation event, the permits prohibit discharges that cause or contribute to nonattainment of water quality standards.

All other non-CAFO feedlots and the land application of all manure are accounted for in the LA for nonpermitted sources.

4.5.5 Load allocation methodology

The LA is allocated to existing or future nonpermitted pollutant sources. Where sufficient data are available, sources within the LA are provided individually in the TMDL tables for guidance in implementation planning; the individual loading goals for the nonpermitted sources may change through the adaptive implementation process.

The LAs are based on each lake's TMDL scenario (Section 4.5.1). To allow for the MOS, where explicit, the allocations for watershed loading (all watershed sources) and internal recycling were reduced proportional to the relative existing watershed vs. internal recycling by a total amount equal to the MOS.

Natural background conditions were also evaluated, where possible, within the modeling and source assessment portion of this study (Section 3.7.1.2). Natural background sources are implicitly included in the LA portion of the TMDL tables, and reductions should focus on the major human attributed sources identified in the source assessment.

4.5.6 Percent reduction

The estimated percent reductions provide a rough approximation of the reductions needed for the water body to meet the TMDL. The percent reduction is a means to capture the level of effort needed to reduce phosphorus loads to the impaired lakes. The percent reductions needed to meet each allocated load in the TMDL tables were calculated as follows: (existing load – allocated load)/existing load. The total estimated load reduction is the sum of the load reductions needed from the individual allocations in the TMDL table, and the percent reduction needed to meet the TMDL is the total estimated load reduction divided by the existing load. Load reductions needed from the watershed area in Iowa are consistent with Minnesota's standards and not more stringent.

4.5.7 TMDL summary

The percent reductions needed to meet the loading capacity for each impaired lake range from 38% to 70% (Table 23). These estimated percent reductions provide a rough approximation of the reductions needed for each lake to meet the TMDL. Appendix B contains the TMDL tables for each lake.

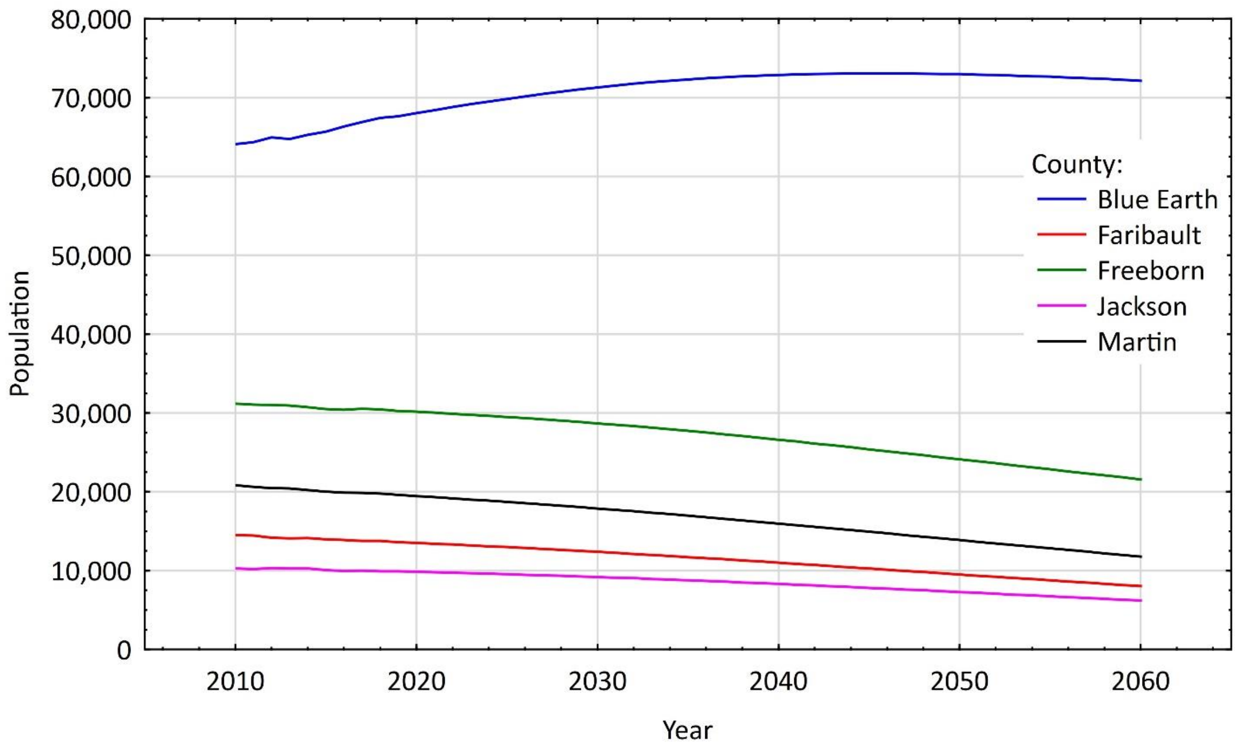
Table 23. Percent reductions to meet lake loading capacities.

AUID	Lake name	Loading capacity	Percent load reduction	TMDL table in Appendix B
22-0007-00	Rice	525 lb/yr	70	Table 65
46-0049-00	Iowa	3,684 lb/yr	60	Table 69
46-0010-00	East Chain	11,987 lb/yr	63	Table 73
46-0034-00 46-0031-00 46-0030-00 46-0025-00 46-0024-00	Fairmont Chain of Lakes (Amber, Hall, Budd, Sisseton, George)	11,330 lb/season	39	Table 77
46-0145-00	Fish	508 lb/yr	38	Table 81
46-0121-00	Cedar	9,833 lb/yr	56	Table 85
07-0090-00	Ida	249 lb/yr	53	Table 89

5. Future growth considerations

Potential changes in population and land cover over time in the Blue Earth River Watershed could result in changing pollutant sources and water quality condition. Between 2010 and 2019, population decreased by 3% to 7% in all counties in the Blue Earth River Watershed except for Blue Earth County, which experienced a 6% increase driven by growth of the city of Mankato area (Minnesota State Demographic Center 2021). These trends are expected to continue (Figure 20).

Figure 20. Population projections by county.



Data from Minnesota State Demographic Center (2021).

Annexation is an option for the city of Fairmont to bring more area into its boundaries and extend services to properties. The city of Fairmont's *Fairmont Forward: 2040 Comprehensive Plan* (City of Fairmont n.d.) indicates potential future annexation of areas that drain to the city's lakes. Because wastewater services would be extended to the annexed areas and because the wastewater effluent is not discharged in the Chain of Lakes Watershed, these annexations do not require a reserve capacity in the lake TMDLs.

5.1 New or expanding permitted MS4 WLA transfer process

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

1. New development occurs within a permitted MS4. Newly developed areas that are not already included in the WLA must be transferred from the LA to the WLA to account for the growth.

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

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

5.2 New or expanding wastewater

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 water bodies with an EPA approved TMDL for TSS or *E. coli* (described in MPCA 2012). 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.

6. Reasonable assurance

"Reasonable assurance" shows that elements are in place, for both permitted and nonpermitted sources, that are making (or will make) progress toward needed pollutant reductions.

6.1 Reduction of permitted sources

6.1.1 Permitted MS4s

The MPCA is responsible for applying federal and state regulations to protect and enhance water quality in Minnesota. The MPCA oversees stormwater management accounting activities for all MS4 entities listed in this TMDL report. The MS4 General Permit requires regulated municipalities to implement BMPs that reduce pollutants in stormwater to the maximum extent practicable. A critical component of permit compliance is the requirement for the owners or operators of a permitted MS4 conveyance to develop a Stormwater Pollution Prevention Plan (SWPPP). The SWPPP addresses all permit requirements, including the following six measures:

- Public education and outreach
- Public participation
- Illicit discharge detection and elimination program
- Construction site runoff controls
- Post-construction runoff controls
- Pollution prevention and municipal good housekeeping measures

A SWPPP is a management plan that describes the MS4 permittee's activities for managing stormwater within their regulated area. In the event of a completed TMDL study, MS4 permittees must document the WLA in their NPDES/SDS permit application and provide an outline of the BMPs to be implemented that address needed reductions. The MPCA requires MS4 owners or operators to submit their application and corresponding SWPPP document to the MPCA for review. Once the application and SWPPP are deemed adequate by the MPCA, all application materials are placed on 30-day public notice, allowing the public an opportunity to review and comment on the prospective program. Once NPDES/SDS permit coverage is granted, permittees must implement the activities described within their SWPPP and submit an annual report to the MPCA documenting the implementation activities completed within the previous year, along with an estimate of the cumulative pollutant reduction achieved by those activities.

This TMDL report assigns WLAs to the permitted MS4 in the study area. The MS4 General Permit requires permittees to develop compliance schedules for EPA approved TMDL WLAs not already being met at the time of permit application. A compliance schedule includes BMPs that will be implemented over the permit term, a timeline for their implementation, and a long-term strategy for continuing progress towards assigned WLAs. For WLAs being met at the time of permit application, the same level of treatment must be maintained in the future. Regardless of WLA attainment, all permitted MS4s are still required to reduce pollutant loadings to the maximum extent practicable.

The MPCA's stormwater program and its NPDES permit program are regulatory activities providing reasonable assurance that implementation activities are initiated, maintained, and consistent with WLAs assigned in this study.

6.1.2 Permitted construction stormwater

Regulated construction stormwater was given a categorical WLA is this study. Construction activities disturbing one acre or more are required to obtain NPDES permit coverage through the MPCA. Compliance with TMDL requirements is 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 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.

6.1.3 Permitted industrial stormwater

Industrial stormwater was given a categorical WLA in this study. 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 this TMDL report.

6.1.4 Permitted wastewater

Any NPDES permitted facility discharging wastewater that has a reasonable potential to cause or contribute to the water quality impairments addressed by these TMDLs include, or will include upon permit reissuance, water quality based effluent limits that are consistent with the assumptions and requirements of these TMDL WLAs. 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 facilities whose discharges are found to have a reasonable potential to cause or contribute to exceedances of applicable water quality standards. The WQBELs will be calculated based on low flow conditions, may vary slightly from the TMDL WLAs, and may include concentration based effluent limitations.

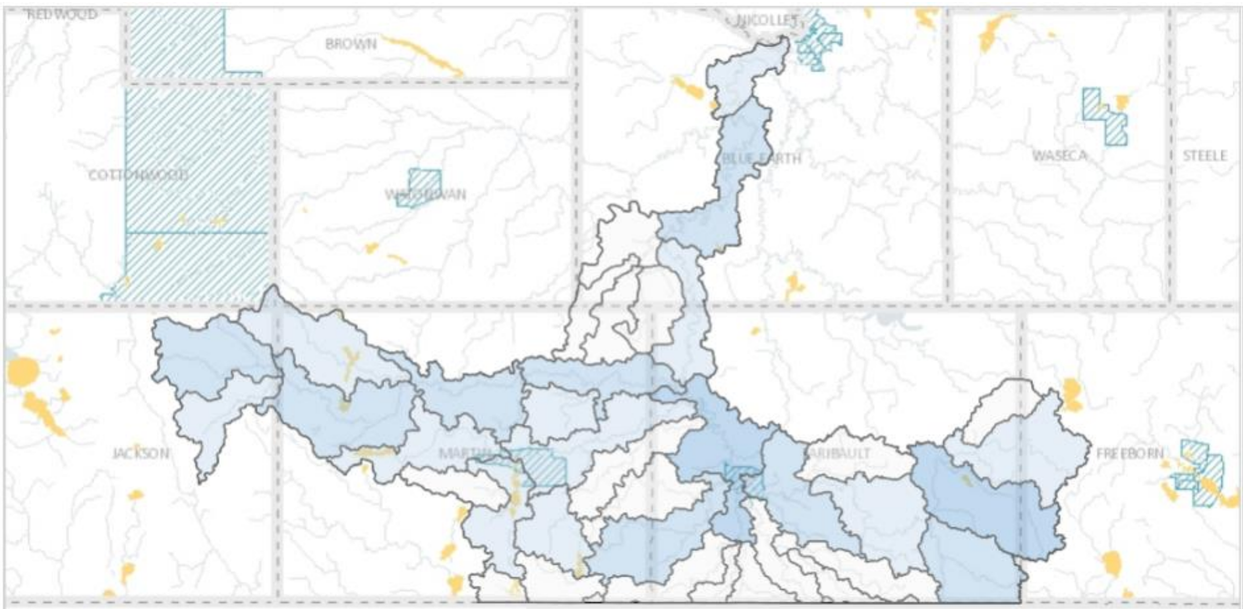
6.1.5 Permitted feedlots

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

Several nonpermitted reduction programs exist to support implementation of nonpoint source reduction BMPs in the Blue Earth River Watershed. These programs identify BMPs, provide means of focusing BMPs, and support their implementation via state initiatives, ordinances, and/or dedicated funding. Figure 21 shows the number of BMPs per subwatershed, as tracked on the MPCA's Healthier Watersheds website (https://www.pca.state.mn.us/water/healthier-watersheds).

Figure 21. Number of BMPs per subwatershed in the Minnesota portion of the Blue Earth River Watershed (2004–2021)



Data from the MPCA's Healthier Watersheds website.

Many soil and water conservation districts (SWCDs) are active in the project area. The SWCD staff are the main contact with landowners, building working relationships and providing technical and financial assistance to reduce impacts from agricultural and urban sources. Focus areas include nutrient management and tillage practices to reduce sediment and nutrient loading. Many practices recommended to landowners are designed to provide multiple water quality benefits including diversifying crops, expanding buffer opportunities, improving manure storage and application, and mitigating impacts of tile drainage.

A portion of some of the impairment watersheds are located in Iowa. *Iowa's Nonpoint Source Management Plan* (IDNR 2012, IDNR 2018) includes planning efforts to address nonpoint source runoff in Iowa. The rest of the focus of this section is on plans and programs that address Minnesota pollutant sources. The following examples describe large-scale programs that have proven to be effective and/or will reduce pollutant loads going forward.

6.2.1 SSTS regulation

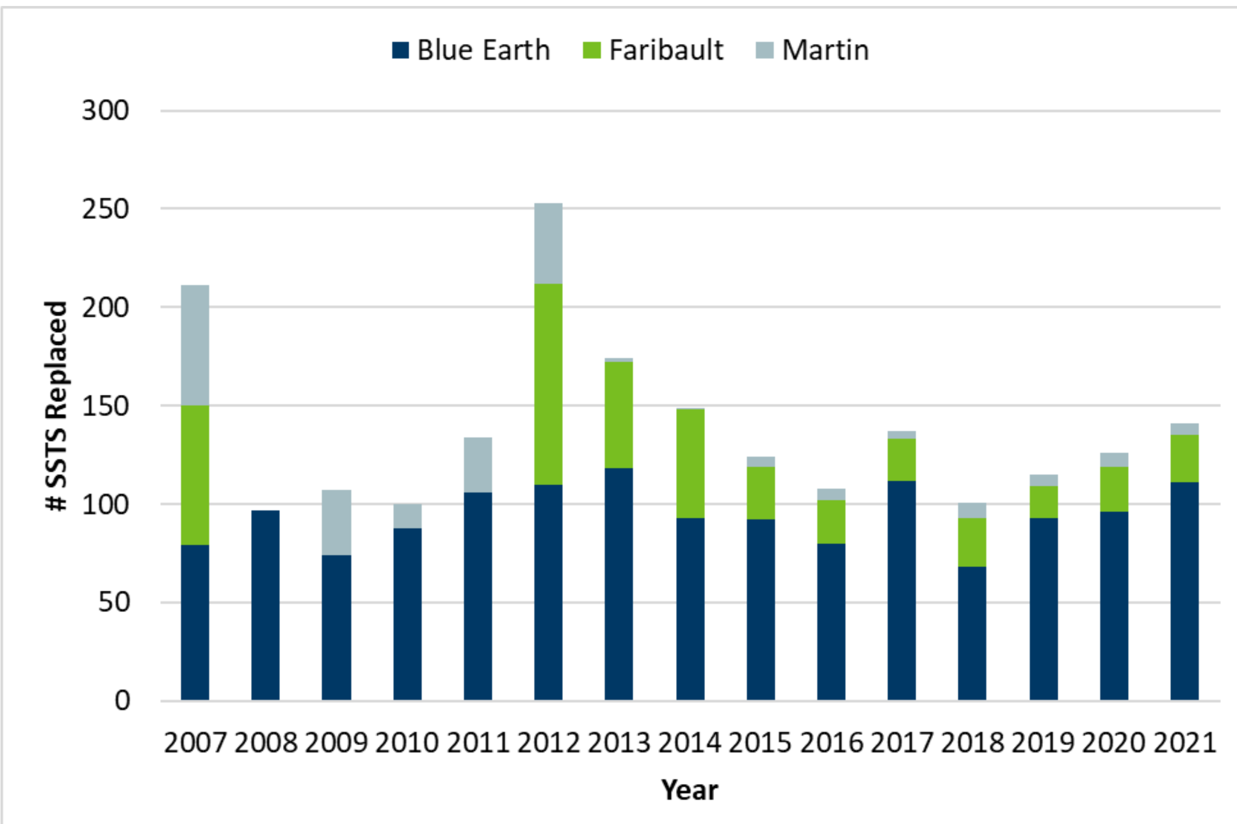
SSTSs are regulated through Minn. Stat. §§ 115.55 and 115.56. SSTS specific rule requirements can be found in Minn. R. 7080 through 7083. Regulations include the following:

- Minimum technical standards for design and installation of 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 residents 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. Since 2002, the primary counties within the Blue Earth River Watershed have, on average, replaced 160 systems per year (Figure 22).

Figure 22. SSTS replacements by county by year.



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. The MPCA, through the Clean Water Partnership Loan Program, has awarded over $1,638,000 to the primary counties within the Blue Earth River Watershed (Blue Earth, Faribault, and Martin counties) to provide low interest loans for SSTS upgrades since 2000. More information on SSTS financial assistance can be found at the following URL: https://www.pca.state.mn.us/water/ssts-financial-assistance.

6.2.2 Feedlot Program

The MPCA's Feedlot Program addresses both permitted and nonpermitted feedlots. The 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 feedlots 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. All feedlots capable of holding 50 or more AUs, or 10 in shoreland areas, are required to register. A feedlot holding 1,000 or more AUs is required to obtain a permit.

The Feedlot Program is implemented through cooperation between the 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 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 2017b). All the counties in the project area are delegated counties.

From 2012 through 2021, 525 feedlot facilities were inspected in the Blue Earth River Watershed, with 434 of those inspections occurring at non-CAFO facilities and 91 at CAFO facilities. There have been an additional 40 facilities with manure application reviews within the watershed; 38 of those inspections were conducted at CAFO facilities and two at non-CAFO facilities.

6.2.3 Minnesota buffer law

Minnesota's buffer law (Minn. Stat. § 103F.48) requires perennial vegetative buffers of up to 50 feet along lakes, rivers, and streams and buffers of 16.5 feet along ditches. 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 the application of the buffer requirement to public waters, provide additional statutory authority for alternative practices, address concerns over the potential spread of invasive species through buffer establishment, establish a riparian protection aid program to fund local government buffer law enforcement and implementation, and allowed landowners to be granted a compliance waiver until July 1, 2018, 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 ranges from 95% to 100% for all counties in the Blue Earth River Watershed as of January 2023.

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 2023):

- Enrolled over 963,000 acres
- Included 1,316 producers
- Added more than 2,500 new conservation practices
- Kept over 43,321 tons of sediment out of Minnesota rivers
- Saved 127,000 tons of soil and 54,600 lb of phosphorus on farms
- Cut greenhouse gas emissions by more than 46,000 tons annually

Approximately 31,018 acres and 46 producers in the Blue Earth River Watershed are certified under the MAWQCP (through October, 2022).

6.2.5 Section 319 Small Watershed Focus Program

The federal CWA Section 319 grant program provides funding to states to address nonpoint source 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 measurable progress for targeted water bodies in the Section 319 focus watersheds, ultimately restoring impaired waters and preventing degradation of unimpaired waters. Successful restorations in the Blue Earth River Watershed through this program will support the required pollutant reductions.

The Dutch Creek Watershed, which is part of the George Lake Watershed in Fairmont, is part of the MPCA's Section 319 Small Watersheds Focus Program. The Fairmont Chain of Lakes is a primary drinking water source of the city of Fairmont, with the intake to the WTP in Budd Lake. The nitrate concentration in Budd Lake exceeded the maximum contaminant level (MCL) for drinking water in May 2016. Nitrate concentrations in the lake have since not exceeded the MCL; however, nitrate concentrations are often 5 to 6 mg/L, causing concern for the city. In addition to the elevated nitrates, TP concentrations are also often elevated. Monitoring and modeling indicate that Dutch Creek is the major contributor of nutrients and sediment to the lakes.

The eutrophication in the lakes is of great interest to watershed residents. The effects of eutrophication go beyond the drinking water concerns from nitrate and HAB toxins, and also have potential recreational and economic impacts due to the degraded aesthetics of the lakes. Fairmont and Martin County have identified and are invested in addressing the nutrient and sediment loading in the watershed. State and federal agencies, including the MPCA, Minnesota Department of Health (MDH), Minnesota Department of Agriculture (MDA), DNR, and EPA, have invested in studies and monitoring in this area.

The *Dutch Creek and Fairmont Chain of Lakes Section 319 Small Watershed Focus Program Nine Key Elements (NKE)* (MPCA 2020c) *small watershed plan* is meant to approach the watershed system and holistically address all of the area concerns, with emphasis on the nonpoint sources of pollution. Much of the early implementation activities have started and will continue in the Dutch Creek Watershed. The plan will be continually evaluated and updated using the plan's milestones and goals.

The *Brush Creek & Blue Earth River Sediment* project is also a Section 319 project. Awarded in 2019 and lasting through August 2023, the project goal is to implement BMPs that focus on sediment reduction, nutrient transport, and increased infiltration in the Blue Earth River Watershed. Planned BMPs include cover crops and conservation tillage, in-channel practices, and community outreach. A 2-stage ditch with 13 rock riffles was incorporated in a ditch design to slow down flows and settle out sediment to reduce pollution to the downstream watershed.

6.2.6 Previously completed TMDLs

Implementation of other TMDLs with watershed area in the Blue Earth River Watershed will support the required pollutant reductions in this current TMDL report:

- *Greater Blue Earth River Basin Fecal Coliform TMDL Report Implementation Plan* (GBERBA 2007). This implementation plan for the 2007 fecal coliform TMDL report includes BMPs to address manure management, feedlots or manure stockpiles without runoff controls, managed rotational grazing, septic system management, urban stormwater runoff, and municipal sewage control.

- *South Metro Mississippi River Total Suspended Solids TMDL* (MPCA 2015a). This TMDL calls for a 50% to 60% reduction in TSS loading from the Minnesota River Basin. Practices designed to reduce TSS loading will also reduce phosphorus and *E. coli* loads. Loads from regulated MS4s are required to meet an average TSS loading rate of 154 lb/ac-yr.

- *Minnesota River and Greater Blue Earth River Basin Total Suspended Solids TMDL Study* (MPCA 2020b). Implementation of the TMDLs in this report are set in a greater context of basin-wide work to reduce sediment from point and nonpoint sources in the Minnesota River Basin. The *Sediment Reduction Strategy for the Minnesota River Basin and South Metro Mississippi River* (MPCA 2015c) establishes a foundation for local water planning to reach sediment reduction goals developed as part of TMDLs.

- *Lake Pepin and Mississippi River Eutrophication TMDL Report* (MPCA 2021b). These TMDLs call for a 50% reduction in phosphorus from nonpoint sources in the Minnesota River.

6.2.7 Minnesota Nutrient Reduction Strategy

The *Minnesota Nutrient Reduction Strategy* (MPCA 2014) guides activities that support nitrogen and phosphorus reductions in Minnesota water bodies and water bodies downstream of the state (e.g., Lake Winnipeg, Lake Superior, and the Gulf of Mexico). The Nutrient Reduction Strategy was developed by an interagency steering team with help from public input, and a progress report was completed in 2020. *5-year Progress Report on Minnesota's Nutrient Reduction Strategy* (MPCA 2020d) provides an update on progress made in the state towards achieving the nutrient reduction goals and associated BMP implementation outlined in the original 2014 strategy. *Watershed Nutrient Loads to Accomplish Minnesota's Nutrient Reduction Strategy Goals* (2022c) integrates the state's nutrient reduction strategy into local watershed work by developing load reduction planning goals on a HUC-8 watershed basis.

Fundamental elements of the *Minnesota Nutrient Reduction Strategy* 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 and local water resource managers, information on available approaches for reducing phosphorus and nitrogen loading and tracking efforts within a watershed, and additional research priorities. The *Minnesota Nutrient Reduction Strategy* 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 set a reduction goal of 45% for both phosphorus and nitrogen in the Mississippi River basin (relative to average 1980 through 1996 conditions), a similar level of nutrient reduction for the Red River/Lake Winnipeg basin (relative to the mid to late 1990s), and a no net increase goal from the 1970s for the Lake Superior basin. The strategy also emphasizes the need to achieve local nutrient reduction needs within HUC-8 watersheds.

Successful implementation of the *Minnesota Nutrient Reduction Strategy* will continue to require broad support, coordination, and collaboration among agencies, academia, local government, and private industry. Minnesota is implementing a watershed approach to integrate its water quality management programs on a major watershed scale, a process that includes:

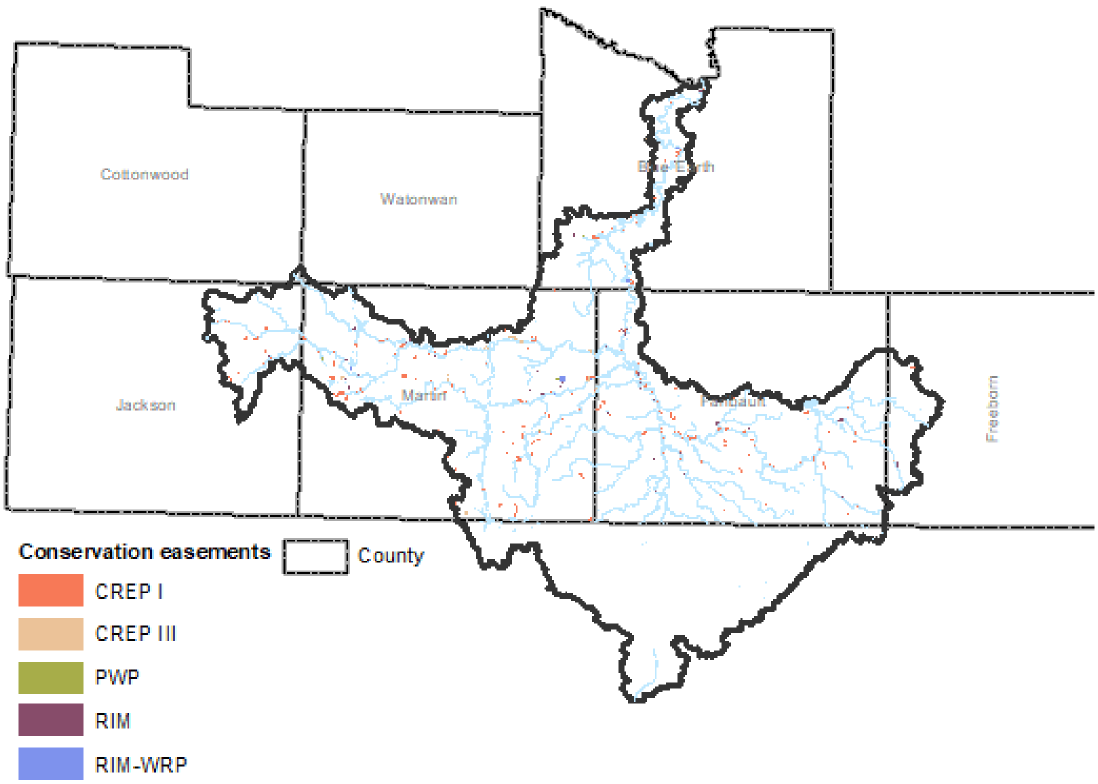
- Watershed monitoring;
- Assessment of watershed health;
- Development of WRAPS reports that include BMP scenarios to achieve nutrient load reductions; and
- Management of NPDES and other regulatory and assistance programs

This framework will result in nutrient reduction for the basin as a whole and the major watersheds within the basin. Figures 30 and 41 of the Blue Earth River WRAPS Report (MPCA 2023b) illustrate the Blue Earth River Watershed's nutrient flow weighted mean concentrations relative to the rest of the state of Minnesota.

6.2.8 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, state and federal 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. Conservation easement types 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 2022, in the primary counties (Blue Earth, Faribault, and Martin) that are located in the Blue Earth River Watershed, there were 17,649 acres of short-term conservation easements such as CRP and 21,745 acres of long term or permanent easements (CREP, RIM, WRP) (Figure 23).

Figure 23. State-funded conservation easements in the counties that are located in the Blue Earth River Watershed (data from BWSR).



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 established the 1W1P program, which provides policy, guidance, and support for developing comprehensive watershed management plans:

- 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, residents, and stakeholder groups; focus on implementation of prioritized and targeted actions capable of achieving measurable progress.

- Serve as a substitute for a comprehensive plan, local water management plan, or watershed management plan developed or amended, approved, and adopted.

A 1W1P has not yet been written for the Blue Earth River Watershed. Until the completion of a comprehensive watershed management plan (e.g., 1W1P), county water plans remain in effect per the Comprehensive Local Water Management Act (Minn. Stat. § 103B.301). Those plans may be updated with new information, or their expiration dates may be extended pending future participation in the 1W1P program. Local water plans incorporate implementation strategies aligned with or called for in TMDLs and WRAPS and are implemented by SWCDs, counties, state and federal agencies, and other partners.

The following is a list of local county water plans for counties in the Blue Earth River Watershed and a brief description of how each plan addresses the water quality issues identified in this report:

- *Blue Earth County Water Management Plan 2017–2026* (Blue Earth County 2017) includes the following priorities, which will reduce *E. coli* and phosphorus loading to surface waters:
  - Shoreland buffers: Riparian buffer law implementation.
  - Wastewater: Eliminate discharge of untreated and undertreated wastewater to surface water and groundwater. Ensure all SSTS are in compliance with Blue Earth County Code.
  - Cropland: Increase adoption of voluntary BMPs to protect and improve soil health and water quality.
  - Feedlots: Minimize potential transport of bacteria and nutrients to surface water and groundwater from feedlots and manure applied to cropland.
  - Stormwater management: Ensure community resilience with stormwater management that prevents flooding and protects water quality.
- *Faribault County Local Water Management Plan 2018–2027* (Faribault County 2018) includes the priority concern to protect and restore the quality and manage the quantity of surface water. For this priority concern, the goals and objectives are the following:
  - Goal 1: Address impacts of altered hydrology, decreased evapotranspiration and storage due to vegetation, land use, and drainage changes.
    - Implement multipurpose drainage management practices to mitigate existing impacts from altered hydrology in agricultural areas.
    - Implement increased vegetation and landscape diversification to mitigate storage loss due to landscape change.
    - Implement BMPs to reduce impacts from urban areas and impervious surfaces.
    - Prevent additional impacts of altered hydrology through regulatory controls and better planning of drainage activities.
    - Prevent additional impacts of urban areas and impervious surfaces through regulatory controls and better planning of stormwater activities.

    - Acquire data necessary to gain a better understanding of the resources, threats, trends, and status for planning and implementation.
    - Information sharing, education, and outreach on strategies to mitigate the effects of altered hydrology.
  - Goal 2: Address the quality of surface water through strategies to conserve and manage soil health; strategies to reduce, trap, or treat nutrients and sediment; and information sharing on sustainable farming options.
    - Implement management practices to conserve and manage soil health; and reduce, trap, and treat nutrients and sediment.
    - Implement structural practices to reduce, trap, and treat nutrients and sediment.
    - Prevent additional impacts to surface waters through better land use and regulatory controls.
    - Acquire data necessary to gain a better understanding of the resources, threats, trends, and status for planning and implementation.
    - Information sharing, education, and outreach on strategies to conserve and manage soil health; and reduce, trap, and treat nutrients and sediment.
- *Martin County Local Water Plan 2017–2026* (Martin County Water Planning 2016) includes a surface water priority concern to address water quality and water quantity/drinking water supply. For this priority concern, the goals and objectives are the following:
  - Goal 1: Surface water quality—To improve the quality of all surface waters throughout Martin County with an emphasis on impaired TMDL listed waters to a level that allows them to be delisted.
    - Continue and develop upon public outreach and education programming regarding impaired waters and their impact on public health and recreation.
    - Address the implementation goals as stated for TMDL listed waters. Reduce nitrate, phosphorus, and sediment concentrations in all county water bodies.
    - Reduce impacts to surface water from urban areas and impervious surfaces.
  - Goal 2: Surface Water Quantity—Reduce peak flow events to help prevent erosion and maintain the integrity of crop fields.
    - Decrease the amount of surface runoff entering water bodies.
    - Decrease the impact of peak flow events regarding erosion and flooding of nearby crop fields.
  - Goal 3: Surface water drinking water supply—Meet drinking water requirements on Budd Lake.
    - Continue to improve the water quality on Budd Lake to a level that is acceptable for use as Fairmont's drinking water supply.

- *Jackson County Local Water Management Plan, 2013 Amendment* (Jackson SWCD 2013) includes the following priority concerns and objectives:
    - Improve surface water quality: Objectives include preventing soil erosion; encouraging perennial cover, buffers, and conservation tillage; improving stream bank and lakeshore development; and addressing TMDL impaired waters.
    - Feedlots and SSTS: Objectives include improving nutrient management, maintaining feedlot inventory and registration, encouraging appropriate technology for SSTS and community sewer systems, and continuing to bring nonconforming septic systems into compliance with regulations.
    - Drainage management: Objectives include restoring the hydrograph, promoting the use of modern structures and technology, wetland restoration and management, and reducing impacts of flooding.
    - Protect groundwater: Objectives include supporting well head protection, preventing groundwater contamination, and protecting long-term supplies.
- Freeborn County's *Comprehensive Water Plan Amendment to Implementation 2016–2021* (Freeborn County 2016) includes the following priority concerns and goals that relate to water quality:
    - Surface waters
        - Address impaired and unimpaired surface waters
        - Manage watersheds to reduce bacteria, nutrients, chemicals, and sediments from entering surface waters.
        - Manage watersheds to control surface water runoff
        - Partner with other agencies to improve surface waters
    - Soils and erosion
        - Protect and preserve topsoil
        - Control soil erosion
    - SSTS
        - Protect surface water and ground water from SSTS contamination
    - Feedlots
        - Protect surface water and groundwater resources from feedlot/animal waste contamination
        - Manage animal manure for land applications
    - Drainage

    - Maintain drainage systems while improving agricultural productivity as well as improving drainage water quality, understanding the systems are part of a larger tributary system
- Municipal wastewater and stormwater implementation
    - Protect surface water and groundwater from municipal wastewater and stormwater contamination
- *2022 Surface Water Intake Protection Plan: City of Fairmont Public Water System* (MDH 2022): This plan will drive implementation of activities to protect the source water for the city of Fairmont for the next 10 years (2022 through 2032). The Drinking Water Supply Management Area – Surface Water (DWSMA-SW) is designed to protect water users from long-term health effects related to low levels of contamination that originate from nonpoint source pollution. The Fairmont DWSMA-SW comprises the Budd Lake Watershed. Practices such as agricultural BMPs that are included in the plan to protect drinking water are also expected to improve surface water quality in the Budd Lake Watershed, which includes Amber Lake, in addition to downstream George Lake.

6.4 Examples of pollution reduction efforts

Local SWCDs are active in the project area and impaired subwatersheds. The SWCDs provide technical and financial assistance on topics such as conservation farming, nutrient management, streambank stabilization, and many others. SWCD involvement in the watershed includes conservation farming tours, workshops, educational activities, nitrate tests, agricultural BMP installation and cost share, and tree and rain barrel sales for county residents to help improve water quality and reduce pollutant loading.

In addition to the state-wide programs listed above, several SWCD-led nonpermitted source reduction projects that are located in the watershed or influence the watershed were completed in recent years:

- Martin SWCD installed a grass waterway in the Fairmont Chain of Lakes Watershed in 2022. The BMP reduces pollutant loading by an estimated 13 lb of phosphorus, 279 lb of nitrogen, and 57 tons of sediment annually for the life expectancy of the project (10 years).
- Fairmont Lakes Foundation, Inc. is a nonprofit organization formed to promote stewardship of the five lakes in the city of Fairmont. The group's priority activities are education and outreach about water quality. They host lake clean-ups every year, coordinate stenciling of storm drains to keep intakes clean, and provide information on steps individuals can take on their own property to improve the lakes. Fairmont Lakes Foundation, Inc. has also partnered with the City of Fairmont on projects that improve habitat and protect the drinking water supply.
- The Faribault County Soil Health Team is a landowner driven/SWCD coordinated group. The goal of the group is to increase awareness of soil health and benefits of reduced tillage, cover crops, and diverse crop rotations making agriculture sustainable for future generations. The Soil Health Team members implement soil health practices on their own land and provide outreach to the

community through hosting field days, demonstration sites, and a variety of speaking opportunities.

- Blue Earth County is reducing pollution from septic systems through focused efforts on the proper location, design, installation, use, and maintenance of individual SSTS. From 2011 to 2021, there were 191 septic systems replaced in the Blue Earth River Watershed in Blue Earth County. Of those systems, 101 were straight pipes or imminent threats to public health.
- In an ongoing effort, Minnesota Pheasants, Inc. is using the Blue Earth County restorable wetland/depression inventory from LiDAR to help identify future acquisitions. Minnesota Pheasants, Inc. volunteers and board members have acquired several hundred acres of land in the Blue Earth River Watershed that have been restored to upland habitat and prairie wetlands. These practices not only provide pheasant habitat and public hunting opportunities but also help to reduce erosion and store water in the watershed.

6.5 Funding

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

WBIF 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 been moving more of its available funding away from competitive grants and toward WBIF to accelerate water management outcomes, enhance accountability, and improve consistency and efficiency across the state. This approach allows more clean water projects identified through planning to be implemented without having to compete for funds, and helps local governments spend limited resources where they are most needed.

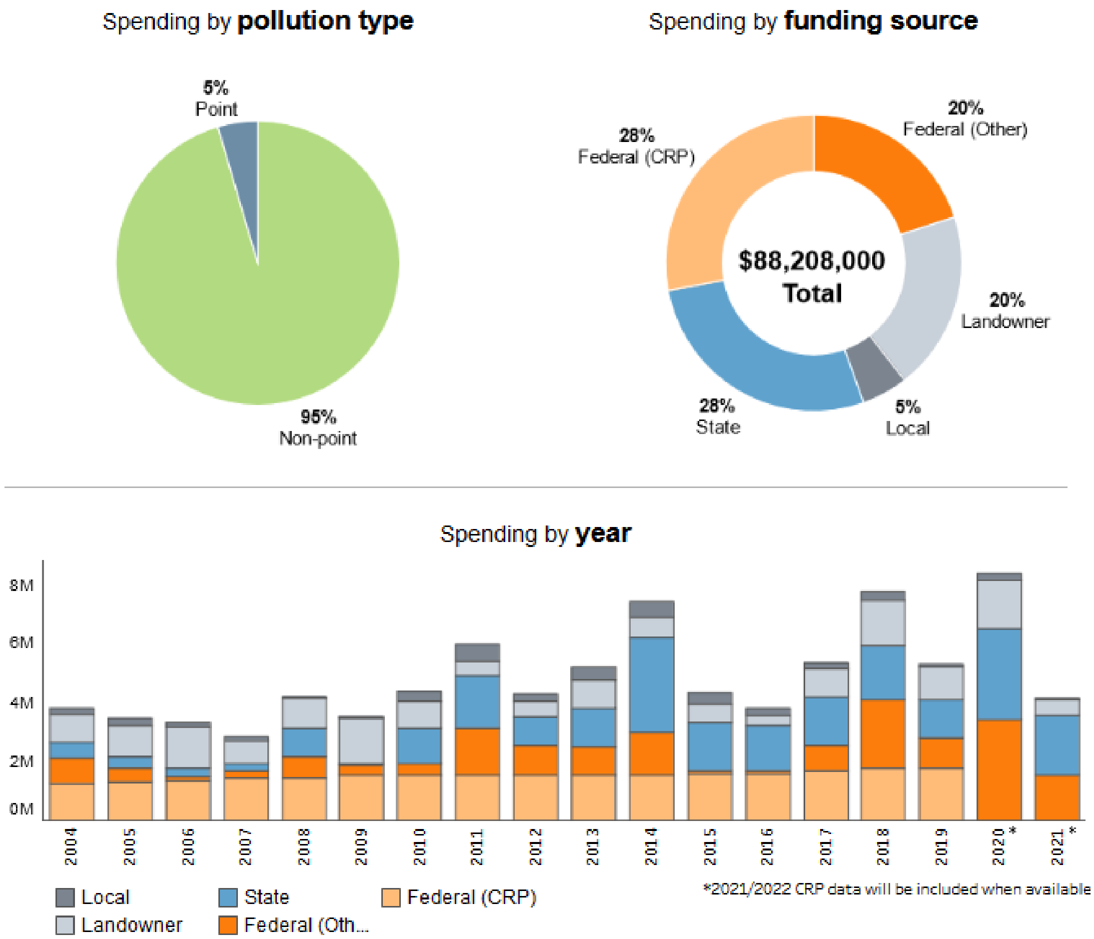
WBIF assurance measures summarize and systematically evaluate how WBIF dollars are being used to achieve clean water goals identified in comprehensive watershed plans. The measures will be used by BWSR to provide additional context about watershed plan implementation challenges and opportunities. The 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.
- Leverage funds beyond the state grant.

The Blue Earth River Watershed will become eligible for WBIF upon completion of the 1W1P process.

Over $88,000,000 has been spent from a variety of sources on watershed implementation projects in the Blue Earth River Watershed from 2004 through 2021 (Figure 24).

Figure 24. Spending for watershed implementation projects; data from the MPCA's Healthier Watersheds website.



6.6 Reasonable assurance conclusion

In summary, significant time and resources have been devoted to identifying the best BMPs, providing means of focusing them in the Blue Earth River Watershed, and supporting their implementation via state, local, and federal initiatives and dedicated funding. The Blue Earth River WRAPS and TMDL process engaged partners to arrive at reasonable scenarios of BMP combinations that attain pollutant reduction goals. Minnesota is a leader in watershed planning as well as monitoring and tracking progress toward water quality goals and pollutant load reductions.

7. Monitoring

7.1 Monitoring

These monitoring activities provide an overview of what is expected to occur at many scales in the Blue Earth River Watershed, subject to availability of monitoring resources. The AQR and AQL designated uses will be the ultimate measures of water quality. Improving the state of these designated uses depends on many factors, and improvements may not be detected over the next 5 to 10 years or much longer. Consequently, a monitoring plan is needed to track shorter and longer term changes in water quality and land management. Monitoring is important for several reasons:

- Evaluating water bodies to determine if they are meeting water quality standards and tracking trends;
- Assessing potential sources of pollutants;
- Determining the effectiveness of implementation activities in the watershed;
- Delisting of waters that are no longer impaired; and
- Implementing an adaptive management approach to help determine when a change in management is needed.

There are many monitoring efforts in place to address the different types of monitoring. Several key monitoring programs will provide the information to track trends in water quality and evaluate compliance with TMDLs:

- Monitoring and assessment at the HUC-8 scale associated with Minnesota's watershed approach. This monitoring effort is conducted by the MPCA approximately every 10 years for each HUC-8. An outcome of this monitoring effort is the identification of waters that are impaired (i.e., do not meet standards and need restoration) and waters in need of protection to prevent impairment. Over time, condition monitoring can also identify trends in water quality. This helps determine whether water quality conditions are improving or declining, and it identifies how management actions are improving the state's waters overall. See *Blue Earth River Watershed Monitoring and Assessment Report* (MPCA 2020a) for more information.
- The MPCA's Watershed Pollutant Load Monitoring Network (WPLMN) measures and compares data on pollutant loads from Minnesota's rivers and streams and tracks water quality trends. WPLMN data will be used to assist with assessing impaired waters, watershed modeling, determining pollutant source contributions, developing watershed and water quality reports, and measuring the effectiveness of water quality restoration efforts. Data are collected along major river main stems, at major watershed (i.e., HUC-8) outlets to major rivers, and in several subwatersheds. In the Blue Earth River Watershed, main stem WPLMN sites are located at Blue Earth (30021001 and 30021003) and Winnebago (30025001), the outlet site is located at Rapidan (site 30092001), and a subwatershed site is located at East Branch Blue Earth River at Blue Earth (30046002). This long-term monitoring program began in 2007.

- DNR and MPCA support monitoring by MDA and Martin SWCD at two stations: Dutch Creek near Fairmont (30072001) and Elm Creek near Huntley (30051001). Data collection includes pesticides in addition to more conventional water quality parameters. MDA monitoring reports are available on their website: https://www.mda.state.mn.us/pesticide-monitoring-reports.
- The MPCA's Volunteer Water Monitoring Program provides records of water body transparency. This program relies on a network of volunteers who measure transparency approximately monthly. Volunteers monitor 9 lake and 13 stream locations within the Blue Earth River Watershed. See *Blue Earth River Watershed Monitoring and Assessment Report* (MPCA 2020a) for more information.
- Implementation monitoring is conducted by both BWSR (i.e., eLINK) and the United States Department of Agriculture (USDA). Both agencies track the locations of BMP installations. Tillage transects and crop residue data are collected periodically and reported through the Minnesota Tillage Transect Survey Data Center. BMP tracking information is readily available through the MPCA's "Healthier Watersheds" webpage.
- Discharges from permitted municipal and industrial wastewater sources are reported through discharge monitoring records; these records are used to evaluate compliance with NPDES/SDS permits. Summaries of discharge monitoring records are available through the MPCA's Wastewater Data Browser.

7.2 Optional monitoring

As opportunities arise, additional monitoring could be completed to further refine the source assessment, evaluate BMPs, and track water quality trends. Please see the water quality improvement report (MPCA 2023a) for optional monitoring recommendations for Amber Lake and George Lake.

8. Implementation strategy summary

This section summarizes implementation strategies that could be used to help achieve the TMDLs in this report.

For many of the implementation strategies discussed in this section, BMPs will need to be selected, designed, operated, and maintained to account for climate trends, including warmer surface waters and the expected continued increase in the size and frequency of rain events (Section 3.1: *Climate trends*). Climate change will affect the function of many BMPs, and implementation planning should account for the resilience of BMPs to the impacts of climate change (Johnson et al. 2022).

8.1 Permitted sources

8.1.1 Construction stormwater

The WLA for stormwater discharges from sites where there is construction activity reflects the number 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 Stormwater 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

The WLA for stormwater discharges from sites where there is industrial activity reflects the number of sites in the watershed for which NPDES industrial stormwater permit coverage is required, and the BMPs and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. 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 Municipal separate storm sewer systems

The City of Fairmont (MS4 MS400239) is assigned *E. coli* WLAs for the Blue Earth River TMDL (Table 19, Table 58) and phosphorus WLAs (Table 22) for the Fairmont Chain of Lakes TMDL (Table 77). The general NPDES/SDS permit requirements must be consistent with the assumptions and requirements of an approved TMDL and associated WLAs. The BMP stormwater control measure requirements are defined in the State's General Municipal Separate Storm Sewer NPDES/SDS Permit (MNR040000).

The following provides additional information on implementation of the *E. coli* and phosphorus MS4 WLAs:

- *E. coli*: Because the city has already been assigned fecal coliform WLAs in previous TMDLs, and because the MS4 General Permit requirements are for bacteria, which includes fecal coliform and *E. coli*, the city's *E. coli* MS4 WLA for reach 514 (Table 19, Table 58) will not result in additional MS4 permit requirements. The MS4 General Permit has instituted performance-based requirements for MS4s with fecal coliform or *E. coli* WLAs requiring reductions. If future permit requirements remain the same, MS4s are expected to inventory potential bacteria sources and prioritize bacteria reduction activities that address the identified sources. Further information and up to date guidance can be found in the *Minnesota Stormwater Manual* (MPCA 2022b).
- Phosphorus: The MS4 WLA for the Fairmont Chain of Lakes TMDL equates to a watershed runoff target of 183 µg/L TP. In the city's NPDES/SDS MS4 permit application submitted to the MPCA after approval of this Chain of Lakes TMDL, the city will provide an outline of BMPs to be implemented that address the reductions needed to meet the MS4 runoff target loading concentration of 183 µg/L TP. See Table 77 and Section 6.1 of the *Blue Earth River Watershed Lake Water Quality Improvement Study* (Section 6 in MPCA 2023a) for general implementation strategies. Appendix D contains guidance for documentation of compliance with MS4 TP WLA for the City of Fairmont.

Projects undertaken recently may take a few years to influence water quality. Any wasteload-reducing BMP implemented after the baseline year will be creditable toward the MS4's load reductions. If a BMP was implemented during or just prior to the baseline year, the MPCA is open to presentation of evidence by the MS4 permit holder to demonstrate that it should be considered as a credit.

Prior to implementation, permitted MS4s are encouraged to compare their sewersheds (e.g., catchments, pipesheds, etc.) with the drainage areas for each impaired water body to ensure appropriate BMP crediting. If a permitted MS4 sewershed is different from what is defined as the drainage area in this report, the sewershed should be considered part of the MS4 contribution to the impaired water if sufficient evidence of the appropriate sewershed area is provided to the MPCA. With Agency approval, any wasteload-reducing BMP implemented since the TMDL baseline year within the sewershed of an impaired water will be creditable towards an MS4's load reduction for purposes of annual reporting and demonstrating progress towards meeting the WLA(s).

8.1.4 Wastewater

All of the *E. coli* WLAs for wastewater (Table 18) have permits that are consistent with the WLA assumptions and are implemented through the NPDES program. There is one phosphorus WLA for wastewater, Great River Energy—Lakefield Junction Station (Permit # MN0067709); this discharge does not include phosphorus limits or monitoring requirements (Table 21). At permit reissuance, the need for WQBELs and/or additional monitoring requirements will be considered by permitting staff.

To address wastewater releases (see *Municipal and industrial wastewater* in Section 3.7.1.1: Permitted sources), implementation strategies are recommended to decrease the I&I of stormwater and groundwater into wastewater collection systems and reduce the frequency of excess flows that lead to releases of untreated wastewater. Adoption of clean water intrusion ordinances also help reduce the frequency and magnitude of wastewater releases through the development of policies and funding programs to assess and, where necessary, replace leaky private lateral connections to the sanitary system. Funding options, such as the MPCA's Clean Water Partnership Loan or MDA's AgBMP Loan programs, can be used to help local governments and residents update lateral pipes.

8.1.5 Feedlots

The NPDES and SDS feedlot permits include design, construction, operation, and maintenance standards that all CAFOs must follow. WLAs are not assigned to CAFOs in this TMDL report, including CAFOs with NPDES or SDS permits, and CAFOs not requiring permits; this is equivalent to a WLA of zero. If the CAFOs are properly permitted and operate under the applicable NPDES or SDS permit, then the CAFOs are expected to be consistent with this TMDL. MPCA inspections of large CAFOs focus on high-risk facilities located within or near environmental justice areas, waters impaired by *E. coli* or excess nutrients, drinking water supply and vulnerable groundwater areas, and other sensitive water features, and on facilities that haven't been inspected in the most recent five years. CAFOs that are found to be noncompliant are required to return to compliance in accordance with applicable NPDES or SDS conditions and Minn. R. ch. 7020.

8.2 Nonpermitted sources

Implementation of the Blue Earth River Watershed TMDL will require numerous BMPs that address non-NPDES-permitted sources of *E. coli* and phosphorus. This section provides an overview of example BMPs that may be used for implementation. The BMPs included in this section are not exhaustive, and the list may be amended. Likely sources of *E. coli* to target for implementation are livestock and ITPHS, and phosphorus sources to target for implementation are cropland runoff and lake internal phosphorus loading. SSTSs that are failing to protect groundwater are required by state law to be addressed and are therefore also considered a priority source of phosphorus.

Although there is evidence that internal phosphorus recycling occurs within the impaired lakes, it is assumed that the rate of recycling will decrease as the lake and sediments equilibrate to lower external phosphorus loads. Implementation strategies to decrease internal phosphorus recycling could be considered if in-lake TP and eutrophication response variables do not improve, or are slow to improve, after significant watershed reductions are achieved. These strategies could include, but are not limited to water level drawdown, sediment dredging, sediment phosphorus immobilization or chemical treatment (e.g., alum), and biomanipulation (e.g., carp management). The MPCA recommends feasibility studies for any lake in which major in-lake management strategies are proposed. The *Minnesota State and Regional Government Review of Internal Phosphorus Load Control* paper (MPCA 2020c) provides more information on internal load BMPs and considerations. The *Dutch Creek and Fairmont Chain of Lakes Section 319 Small Watershed Focus Program NKE* plan (MPCA 2020c) recommends targeted monitoring and data collection to assess internal phosphorus recycling throughout the Fairmont Chain of Lakes in or around year five of the plan. These data will be analyzed in year six of the plan and a report will be produced to determine the extent of internal phosphorus recycling and the feasibility of addressing the results.

Table 24 summarizes example BMPs that can be implemented to achieve goals of the TMDLs. The table is not an exhaustive list of all applicable BMPs, and actual implementation may vary. The Blue Earth River Watershed WRAPS (MPCA 2023b) developed concurrently with this report contains a more comprehensive list of implementation strategies.

Table 24. Example BMPs for nonpermitted sources.

Strategy	BMP examples [a]	Targeted pollutant	
		E. coli	**Phosphorus**
Agricultural runoff control and manure management	Conservation tillage		X
	Cover crops		X
	Filter strips and field borders	X	X
Feedlot runoff control	Feedlot runoff reduction and treatment	X	X
	Feedlot manure/storage addition	X	X
Nutrient management	Nutrient management	X	X
	Manure incorporation within 24 hours	X	X
Pasture management	Conventional pasture to prescribed rotational grazing		X
	Livestock access control	X	X
Septic system improvements	Septic system improvement (maintenance and replacement)	X	X
Converting land to perennials	Conservation cover perennials		X
Buffers and filters	Riparian buffers and field borders	X	X
Urban stormwater runoff control	Green infrastructure practices	X	X
	Improved lawn/turf vegetation and soil practices	X	X
In-lake management [b]	Water level drawdown, sediment dredging, sediment phosphorus immobilization or chemical treatment (e.g., alum), and biomanipulation (e.g., carp management).		X

a. Descriptions of BMP examples can be found in the *Agricultural BMP Handbook for Minnesota* (Lenhart et al. 2017), the Minnesota Stormwater Manual (MPCA 2021c), the *MPCA's Lake Protection and Management* website, and the University of Minnesota Extension's *Onsite Sewage Treatment Program* website.

b. The *Minnesota State and Regional Government Review of Internal Phosphorus Load Control* paper (MPCA et al. 2020d) provides more information on internal load BMPs and considerations.

8.3 Water quality trading

Water quality trading can help achieve compliance with WLAs or water quality based effluent limits. Water quality trading can also offset increased pollutant loads in accordance with antidegradation regulations. Water quality trading reduces pollutants (e.g., TP or TSS) in rivers and lakes by allowing a point source discharger to enter into agreements under which the point source "offsets" its pollutant load by obtaining reductions in a pollutant load discharged by another point source operation or a nonpoint source or sources in the same watershed. The MPCA must establish specific conditions governing trading in the point source discharger's NPDES permit or in a general permit that covers the point source discharger. The MPCA implements water quality trading through permits. See MPCA's *Water Quality Trading Guidance* (MPCA 2021) for more information.

8.4 Cost

The costs to achieve the TMDLs are approximately $12 to $15 million dollars. This range reflects the level of uncertainty in the source assessment and addresses the likely sources identified in Section 3.7. The cost includes increasing local capacity over the next 20 years to oversee implementation in the watershed and the voluntary actions needed to achieve necessary TMDL reductions. Costs for implementing the TMDL and achieving the required pollutant load reductions were estimated by developing an implementation scenario; actual implementation will likely differ.

The cost of required actions, including compliance with the Minnesota Buffer Law, replacement of ITPHS systems, and SSTS maintenance, were not considered in the overall cost calculation because their costs are already accounted for in existing programs.

8.4.1 *E. coli* cost methods

Costs to achieve the *E. coli* TMDLs were calculated based on feedlot BMPs and nutrient management. This cost assessment accounts for the uncertainty of a qualitative *E. coli* source assessment.

For feedlots, the unit cost for bringing feedlots into compliance with feedlot regulations is based on the MPCA's 1999 *Statement of Need and Reasonableness* (SONAR) *In the Matter of Proposed Amendments to Minnesota Rules Relating to Animal Feedlots, Storage, Transportation, and Utilization of Animal Manure* (MPCA 1999). In the SONAR, the estimated cost to bring a facility into compliance with the feedlot rules is provided by livestock sector: $19,000 for the beef sector, $36,000 for the dairy sector, and $43,000 for the swine sector. For the TMDL implementation cost estimate, these costs were adjusted for average United States inflation rates through 2021, and it was assumed that 20% of beef and dairy feedlots are not in compliance and 12% of swine facilities are not in compliance.

Costs for nutrient management on cropland within a 1,000-meter buffer of connected streams to the *E. coli* impairments were estimated using the BMP database of HSPF–Scenario Application Manager (SAM; version 2.12).

8.4.2 Phosphorus cost methods

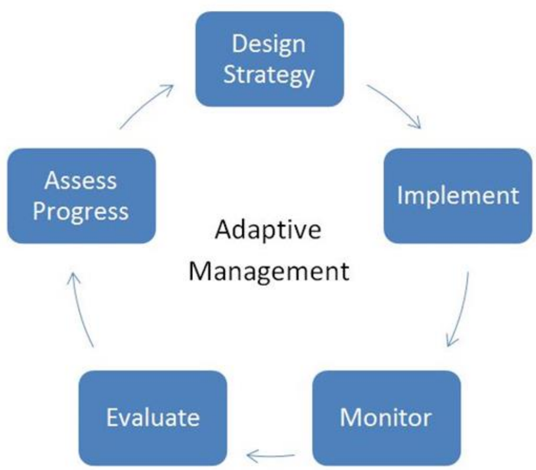
The *Dutch Creek and Fairmont Chain of Lakes Section 319 Small Watershed Focus Program NKE* plan (MPCA 2020c) estimates that implementation of all practices in the plan will achieve a phosphorus reduction in the Fairmont Chain of Lakes Watershed of 13,800 lb per year, for a total cost of $3.7 million. This phosphorus reduction is sufficient to meet the TMDL phosphorus reduction target of approximately 7,000 lb per year.

To estimate costs to achieve water quality standards in the remaining impaired lakes, BMP efficiencies and costs in the BMP database of HSPF–SAM were used to develop an implementation scenario that achieves the TP percent reductions called for in the TMDL tables. A 52% reduction of TP loading is needed over a combined 55,521 acres of cropland. BMPs used in this scenario are cover crops, filter strips, reduced tillage, nutrient management, manure management, water and sediment control basins, restoration of tiled wetlands, and alternative tile intakes. The example implementation scenario is an estimate of cost-share dollars needed to incentivize adoption of the practice. The costs do not take into account design and construction oversight or operation and maintenance costs. The costs do not include BMPs to reduce internal recycling of phosphorus. Although there is evidence that internal phosphorus recycling occurs within the impaired lakes, it is assumed that the rate of recycling will decrease as the lake and sediments equilibrate to lower external phosphorus loads (Section 8.2).

8.5 Adaptive management

The implementation strategies and the more detailed WRAPS report, which was prepared concurrently with this TMDL report, are based on the principle of adaptive management (Figure 25). Continued monitoring and "course corrections" responding to monitoring results are the most appropriate strategy for attaining the water quality goals established in this TMDL report. Management activities will be changed or refined as appropriate over time to efficiently meet the TMDL and lay the groundwork for de-listing the impaired water bodies.

Figure 25. Adaptive management.



9. Public participation

Several projects were developed as part of the Blue Earth River WRAPS process to inform local officials and the public about the watershed approach and to facilitate early, active, and diverse participation. The main goal was to provide an open and forthright outlet for public comment and input through public events that allow constructive input and a format that is perceived to be fair and legitimate.

Two key audiences were local elected officials and farmers. Local officials are key decision-makers, provide leadership, and provide connections to the farming community. Farmers are key because most of the land in the watershed and pollutants/stressors come from nonpoint sources. Efforts were made to provide the information collected and processes associated with the watershed approach to identify mutually beneficial goals, build relationships, provide information, and learn from those impacted.

A Blue Earth Watershed website was created to be a hub for all information pertaining to the Blue Earth River: https://www.bewatershed.org/. The site was developed to include but not limited to the TMDL, WRAPS, and 1W1P process; recreational activities; local contacts; events; and project information. The site continues to help guide information to the public and share long-term results.

An opportunity for public comment on the draft TMDL report was provided via a public notice in the State Register from May 8, 2023 through June 7, 2023. There were no comment letters received as a result of the public comment period. For further information on public participation for this TMDL report, please see the WRAPS report.

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Appendix A. Impaired waters and TMDL status

This appendix lists all the impairments in the Blue Earth River Watershed along with the TMDL status of each impairment (Table 25). This table represents a snapshot in time because the EPA category will change when additional TMDLs are developed.

Table 25. Impaired water bodies of the Blue Earth River Watershed (as of the 2022 impaired waters list) and TMDL development status.

See the WRAPS report (MPCA 2023b) for a summary table of stressors to the AQL impairments. Impairment order: HUC-10 watershed from upstream to downstream, east to west; alphabetical by water body name; AUID.

HUC-10	Water body name	Water body description	AUID (HUC-8-)	Use class [a]	Year added to list	Affected designated use	Listing parameter	EPA category in next impaired waters list [c]	TMDL developed in this report	TMDL pollutant	TMDL approval year
East Branch Blue Earth River (0702000905)	Blue Earth River, East Branch	Brush Cr to Blue Earth R	553	2Bg	2004	AQL	Fish bio	5	N		
					2008	AQL	Turbidity	4A	N	TSS	2020 [c]
					2020	AQR	*E. coli*	4A	Y	*E. coli*	
	Blue Earth River, East Branch	Headwaters to -93.663 43.624	649	2Bg	2008	AQL	Turbidity	4A	N: Approved TMDL for 07020009-554 (parent AUID)	TSS	2020 [c]
	Blue Earth River, East Branch	-93.663 43.624 to -93.73 43.654	650	2Bg	2008	AQL	Turbidity	4A	N: Approved TMDL for 07020009-554 (parent AUID)	TSS	2020 [c]
	Blue Earth River, East Branch	-93.73 43.654 to T102 R25W S14, south line	651	2Bg	2008	AQL	Turbidity	4A	N: Approved TMDL for 07020009-554 (parent AUID)	TSS	2020 [c]
	Blue Earth River, East Branch	T102 R25W S23, north line to Unnamed ditch	652	2Bg	2020	AQL	Invert bio	5	N		
					2008	AQL	Turbidity	4A	N: Approved TMDL for 07020009-554 (parent AUID)	TSS	2020 [c]
					2020	AQR	*E. coli*	4A	Y	*E. coli*	
	Blue Earth River, East Branch	Unnamed ditch to Brush Cr	653	2Bg	2008	AQL	Turbidity	4A	N: Approved TMDL for 07020009-554 (parent AUID)	TSS	2020 [c]
	Brush Creek	Headwaters to Unnamed cr	654	2Bg	2004	AQL	Fish bio	5	N		
	Brush Creek	Unnamed cr to E Br Blue Earth R	655	2Bg	2020	AQR	*E. coli*	4A	Y	*E. coli*	
	County Ditch 25	Headwaters to CD 5	603	2Bg	2020	AQL	Fish bio	5	N		
					2020	AQL	Invert bio	5	N		
	County Ditch 26	Headwaters to CSAH 13	628	2Bg	2020	AQL	Invert bio	5	N		

HUC-10	Water body name	Water body description	AUID (HUC-8-)	Use class [a]	Year added to list	Affected designated use	Listing parameter	EPA category in next impaired waters list [c]	TMDL developed in this report	TMDL pollutant	TMDL approval year
East Branch Blue Earth River (0702000905), continued	County Ditch 8	Headwaters to -94.054 43.618	669	2Bg	2020	AQL	Invert bio	5	N		
	Foster Creek	T103 R24W S35, east line to T102 R24W S6, west line	556	2Bg	2020	AQL	Invert bio	5	N		
	Judicial Ditch 14	Unnamed cr to Foster Cr	623	2Bg	2020	AQL	Invert bio	5	N		
	Rice	Lake or Reservoir	22-0007	2B	2020	AQR	Nutrients	4A	Y	Phosphorus	
	Thisius Branch	CD 1 to Foster Cr	622	2Bg	2020	AQL	Fish bio	5	N		
					2020	AQL	Invert bio	5	N		
Coon Creek (0702000904)	Coon Creek	T102 R27W S33, south line to Blue Earth R	648	2Bg	2020	AQL	Fish bio	5	N		
					2020	AQL	Invert bio	5	N		
					2020	AQR	*E. coli*	4A	Y	*E. coli*	
	County Ditch 31	MN/IA border to Coon Cr	612	2Bg	2020	AQL	Fish bio	5	N		
					2020	AQL	Invert bio	5	N		
	Judicial Ditch 13	20th St to 480th Ave	665	2Bg	2020	AQL	Invert bio	5	N		
Middle Branch Blue Earth River (0702000903	Blue Earth River, Middle Branch	MN/IA border to -94.104 43.514	645	2Bg	2020	AQR	*E. coli*	4A	Y	*E. coli*	
	Blue Earth River, Middle Branch	-94.104 43.514 to W Br Blue Earth R	646	2Bg	2020	AQL	Fish bio	5	N		
					2020	AQR	*E. coli*	4A	Y	*E. coli*	
West Branch Blue Earth River (0702000902)	Blue Earth River, West Branch	MN/IA border to 15th St	643	2Bg	2020	AQL	Fish bio	5	N		
					2020	AQR	*E. coli*	4A	Y	*E. coli*	
	Blue Earth River, West Branch	15th St to Blue Earth R	644	2Bg	2020	AQL	Fish bio	5	N		
	Judicial Ditch 7	MN/IA border to W Br Blue Earth R	611	2Bg	2020	AQL	Fish bio	5	N		

HUC-10	Water body name	Water body description	AUID (HUC-8-)	Use class [a]	Year added to list	Affected designated use	Listing parameter	EPA category in next impaired waters list [c]	TMDL developed in this report	TMDL pollutant	TMDL approval year
Badger Creek-Blue Earth River (0702000908)	Badger Creek	Little Badger Cr to -94.136 43.64	658	2Bg	2020	AQR	*E. coli*	4A	Y	*E. coli*	
	Blue Earth River	W Br Blue Earth R to Coon Cr	504	2Bg	2004	AQL	Fish bio	5	N		
					1994	AQR	Fecal coliform	4A	N	Fecal coliform	2007 [d]
					1998	AQC	Mercury in fish tissue	4A	N	Mercury	2007 [e]
					2002	AQL	Turbidity	4A	N	TSS	2020 [c]
	Blue Earth River	E Br Blue Earth R to South Cr	508	2Bg	2002	AQL	Fish bio	5	N		
					1998	AQC	Mercury in fish tissue	4A	N	Mercury	2007 [e]
					2002	AQL	Turbidity	4A	N	TSS	2020 [c]
					2020	AQR	*E. coli*	4A	Y	*E. coli*	
	Blue Earth River	Center Cr to Elm Cr	514	2Bg	2020	AQL	Fish bio	5	N		
					1998	AQC	Mercury in fish tissue	4A	N	Mercury	2007 [e]
					2010	AQL	Turbidity	4A	N	TSS	2020 [c]
					2020	AQR	*E. coli*	4A	Y	*E. coli*	
	Blue Earth River	South Cr to Center Cr	516	2Bg	2004	AQL	Fish bio	5	N		
					1998	AQC	Mercury in fish tissue	4A	N	Mercury	2007 [e]
	Blue Earth River	Coon Cr to Badger Cr	518	2Bg	2020	AQL	Fish bio	5	N		
					2004	AQC	Mercury in fish tissue	4A	N	Mercury	2007 [e]
					2008	AQL	Turbidity	4A	N	TSS	2020 [c]
	Blue Earth River	Badger Cr to E Br Blue Earth R	565	2Bg	2020	AQL	Fish bio	5	N		
					1998	AQC	Mercury in fish tissue	4A	N	Mercury	2007 [e]
					2008	AQL	Turbidity	4A	N	TSS	2020 [c]

HUC-10	Water body name	Water body description	AUID (HUC-8-)	Use class [a]	Year added to list	Affected designated use	Listing parameter	EPA category in next impaired waters list [c]	TMDL developed in this report	TMDL pollutant	TMDL approval year
	Judicial Ditch 14 (Badger Creek)	T101 R28W S18, west line to Little Badge Cr	568	2Bg	2020	AQL	Invert bio	5	N		
	Little Badger Creek	345th Ave to Badger Cr	642	2Bg	2020	AQL	Fish bio	5	N		
					2020	AQL	Invert bio	5	N		
South Creek (0702000906)	East Chain	Lake or Reservoir	46-0010	2B	2020	AQR	Nutrients	4A	Y	Phosphorus	
	Iowa	Lake or Reservoir	46-0049	2B	2020	AQR	Nutrients	4A	Y	Phosphorus	
	Judicial Ditch 38	Headwaters to 245th Ave	660	2Bg	2020	AQL	Fish bio	5	N		
	Judicial Ditch 98	Headwaters to Sager Lk	610	2Bg	2020	AQL	Invert bio	5	N		
	South Creek	-94.337 43.642 to -94.300 43.661	639	2Bg	2020	AQL	Invert bio	5	N		
	South Creek	-94.300 43.661 to Blue Earth R	640	2Bg	2020	AQR	*E. coli*	4A	Y	*E. coli*	
	South Silver	Lake or Reservoir	46-0020	2B	2020	AQL	Fish bio	5	N		
Center Creek (0702000907)	Amber	Lake or Reservoir	46-0034	1C, 2Bd	2020	AQL	Fish bio	4A	Y	Phosphorus	
					2006	AQR	Nutrients	4A	Y	Phosphorus	
	Budd	Lake or Reservoir	46-0030	1C, 2Bd	2006	AQR	Nutrients	4A	Y	Phosphorus	
					2020	AQL	Fish bio	4A	Y	Phosphorus	
					1998	AQC	PCBs in fish	5	N		
	Center Creek	Lily Cr to Blue Earth R	503	2Bg	1996	AQL	Ammonia	5	N		
					2002	AQL	Fish bio	5	N		
					2020	AQL	Invert bio	5	N		
					1996	AQR	Fecal coliform	4A	N	Fecal coliform	2007 [d]
					2002	AQL	Turbidity	4A	N	TSS	2020 [c]

HUC-10	Water body name	Water body description	AUID (HUC-8-)	Use class [a]	Year added to list	Affected designated use	Listing parameter	EPA category in next impaired waters list [c]	TMDL developed in this report	TMDL pollutant	TMDL approval year
Center Creek (0702000907), continued	Center Creek	George Lk to Lily Cr	526	2Bg	2006	AQR	Fecal coliform	4A	N	Fecal coliform	2007 [d]
	Dutch Creek	Headwaters to -94.507 43.626	634	2Bg	2006	AQR	Fecal coliform	4A	N: Approved TMDL for 07020009-527 (parent AUID)	Fecal coliform	2007 [d]
					2006	AQL	Turbidity	4A	N: Approved TMDL for 07020009-527 (parent AUID)	TSS	2020 [c]
	Dutch Creek	94.507 43.626 to T102 R31W S24, north line	635	2Bg	2020	AQL	Chlorpyrifos	5	N		
					2006	AQL	Turbidity	4A	N: Approved TMDL for 07020009-527 (parent AUID)	TSS	2020 [c]
					2006	AQR	Fecal coliform	4A	N: Approved TMDL for 07020009-527 (parent AUID)	Fecal coliform	2007 [d]
	Dutch Creek	T102 R31W S13, south line to T102 R31W S18, south line	636	2Bg	2020	AQL	Fish bio	5	N		
					2006	AQL	Turbidity	4A	N: Approved TMDL for 07020009-527 (parent AUID)	TSS	2020 [c]
					2006	AQR	Fecal coliform	4A	N: Approved TMDL for 07020009-527 (parent AUID)	Fecal coliform	2007 [d]
	Dutch Creek	T102 R30W S19, north line to Hall Lk	637	2Bg	2006	AQL	Turbidity	4A	N: Approved TMDL for 07020009-527 (parent AUID)	TSS	2020 [c]
					2006	AQR	Fecal coliform	4A	N: Approved TMDL for 07020009-527 (parent AUID)	Fecal coliform	2007 [d]
	Fox	Lake or Reservoir	46-0109	2B	2010	AQR	Nutrients	5	N		
					2020	AQL	Fish bio	5	N		
	George	Lake or Reservoir	46-0024	1C, 2Bd	2006	AQR	Nutrients	4A	Y	Phosphorus	

HUC-10	Water body name	Water body description	AUID (HUC-8-)	Use class [a]	Year added to list	Affected designated use	Listing parameter	EPA category in next impaired waters list [c]	TMDL developed in this report	TMDL pollutant	TMDL approval year
Center Creek (0702000907), continued	Hall	Lake or Reservoir	46-0031	1C, 2Bd	2006	AQR	Nutrients	4A	Y	Phosphorus	
					2020	AQL	Fish bio	4A	Y	Phosphorus	
	Lily Creek	Headwaters (Fox Lk 46-0109-00) to N Bixby Rd	632	2Bg	2006	AQR	Fecal coliform	4A	N: Approved TMDL for 07020009-525 (parent AUID)	Fecal coliform	2007 [d]
					2006	AQL	Turbidity	4A	N: Approved TMDL for 07020009-525 (parent AUID)	TSS	2020 [c]
	Lily Creek	N Bixby Rd to Center Cr	633	2Bg	2020	AQL	Fish bio	5	N		
					2020	AQL	Invert bio	5	N		
					2006	AQR	Fecal coliform	4A	N: Approved TMDL for 07020009-525 (parent AUID)	Fecal coliform	2007 [d]
					2006	AQL	Turbidity	4A	N: Approved TMDL for 07020009-525 (parent AUID)	TSS	2020 [c]
	Sisseton	Lake or Reservoir	46-0025	1C, 2Bd	2006	AQR	Nutrients	4A	Y	Phosphorus	
					2020	AQL	Fish bio	4A	Y	Phosphorus	
Elm Creek (0702000909)	Big Twin	Lake or Reservoir	46-0133	2B	2010	AQR	Nutrients	5	N		
					2020	AQL	Fish bio	5	N		
					2002	AQC	Mercury in fish tissue	4A	N	Mercury	2008 [e]
	Cedar	Lake or Reservoir	46-0121	2B	2020	AQL	Fish bio	4A	Y	Phosphorus	
					2020	AQR	Nutrients	4A	Y	Phosphorus	
	Cedar Creek (Cedar Run Creek)	Cedar Lk to Elm Cr	521	2Bg	2020	AQL	Invert bio	5	N		
					2006	AQR	Fecal coliform	4A	N	Fecal coliform	2007 [d]
					2006	AQL	Turbidity	4A	N	TSS	2020 [c]

HUC-10	Water body name	Water body description	AUID (HUC-8-)	Use class [a]	Year added to list	Affected designated use	Listing parameter	EPA category in next impaired waters list [c]	TMDL developed in this report	TMDL pollutant	TMDL approval year
Elm Creek (0702000909), continued	Cedar Creek (Cedar Run Creek)	T104 R33W S6, west line to 60th Ave	656	2Bg	1994	AQL	Dissolved oxygen	5	N		
					2006	AQR	Fecal coliform	4A	N: Approved TMDL for 07020009-560 (parent AUID)	Fecal coliform	2007 [d]
	Cedar Creek (Cedar Run Creek)	60th Ave to Cedar Lk	657	2Bg	1994	AQL	Dissolved oxygen	5	N		
					2006	AQR	Fecal coliform	4A	N: Approved TMDL for 07020009-560 (parent AUID)	Fecal coliform	2007 [d]
	Elm Creek	Cedar Cr to Blue Earth R	502	2Bg	2006	AQL	Fish bio	5	N		
					1994	AQR	Fecal coliform	4A	N	Fecal coliform	2007 [d]
					1996	AQL	Turbidity	4A	N	TSS	2020 [c]
	Elm Creek	S Fk Elm Cr to Cedar Cr	522	2Bg	2020	AQL	Fish bio	5	N		
					2020	AQL	Invert bio	5	N		
					2006	AQR	Fecal coliform	4A	N	Fecal coliform	2007 [d]
					2006	AQL	Turbidity	4A	N	TSS	2020 [c]
	Elm Creek	Headwaters to 570th Ave	630	2Bg	2010	AQL	Turbidity	4A	N	TSS	2020 [c]
	Elm Creek	570th Ave to S Fk Elm Cr	631	2Bg	2020	AQL	Fish bio	5	N		
					2010	AQL	Turbidity	4A	N	TSS	2020 [c]
	Elm Creek, South Fork	T103 R34W S30, west line to T103 R34W S1, north line	524	2Bg	2010	AQL	Turbidity	4A	N	TSS	2020 [c]
	Elm Creek, South Fork	T104 R34W S36, south line to Elm Cr	561	2Bg	2020	AQL	Fish bio	5	N		
					2020	AQL	Invert bio	5	N		
	Fish	Lake or Reservoir	46-0145	2B	2020	AQL	Fish bio	4A	Y	Phosphorus	
					2020	AQR	Nutrients	4A	Y	Phosphorus	

HUC-10	Water body name	Water body description	AUID (HUC-8-)	Use class [a]	Year added to list	Affected designated use	Listing parameter	EPA category in next impaired waters list [c]	TMDL developed in this report	TMDL pollutant	TMDL approval year
Elm Creek (0702000909), continued	Independence	Lake or Reservoir	32-0017	2B	2018	AQC	Mercury in fish tissue	4A	N	Mercury	2018 [e]
	Judicial Ditch 3	-94.351 43.739 to Elm Cr	627	2Bg	1996	AQL	Dissolved oxygen	5	N		
					2020	AQL	Fish bio	5	N		
					2006	AQR	Fecal coliform	4A	N: Approved TMDL for 07020009-505 (parent AUID)	Fecal coliform	2007 [d]
Willow Creek (0702000910)	County Ditch 89/Judicial Ditch 24	Headwaters to Willow Cr	620	2Bg	2020	AQL	Fish bio	5	N		
	Unnamed creek	Unnamed cr to Willow Cr	566	2Bg	2020	AQL	Invert bio	5	N		
	Unnamed creek	Unnamed cr to Willow Cr	625	2Bg	2020	AQL	Fish bio	5	N		
	Willow Creek	Unnamed cr to Blue Earth R	577	2Bg	2020	AQL	Fish bio	5	N		
					2020	AQR	*E. coli*	4A	Y	*E. coli*	
Blue Earth River (0702000911)	Blue Earth River	Le Sueur R to Minnesota R	501	2Bg	2020	AQL	Fish bio	5	N		
					1994	AQR	Fecal coliform	4A	N	Fecal coliform	2007 [d]
					2002	AQC	Mercury in fish tissue	4A	N	Mercury	2007 [e]
					2002	AQC	Mercury in water column	4A	N	Mercury	2007 [e]
					2002	AQL	Turbidity	4A	N	TSS	2020 [c]
	Blue Earth River	Willow Cr to Watonwan R	507	2Bg	2020	AQL	Fish bio	5	N		
					1998	AQC	Mercury in fish tissue	4A	N	Mercury	2007 [e]
					2008	AQL	Turbidity	4A	N	TSS	2020 [c]

HUC-10	Water body name	Water body description	AUID (HUC-8-)	Use class [a]	Year added to list	Affected designated use	Listing parameter	EPA category in next impaired waters list [c]	TMDL developed in this report	TMDL pollutant	TMDL approval year
Blue Earth River (0702000911), continued					2020	AQL	Fish bio	5	N		
					2016	AQL	Nutrients	5	N: P TMDL to be developed in conjunction with Minnesota River P TMDLs		
					2008	AQR	Fecal coliform	4A	N	Fecal coliform	2007 [d]
					2002	AQC	Mercury in fish tissue	4A	N	Mercury	2007 [e]
					2002	AQC	Mercury in water column	4A	N	Mercury	2007 [e]
	Blue Earth River	Rapidan Dam to Le Sueur R	509	2Bg	2004	AQL	Turbidity	4A	N	TSS	2020 [c]
	Blue Earth River	Watonwan R to Rapidan Dam	510	2Bg	1998	AQC	Mercury in fish tissue	4A	N	Mercury	2007 [e]
					2002	AQL	Fish bio	5	N		
					1998	AQC	Mercury in fish tissue	4A	N	Mercury	2007 [e]
	Blue Earth River	Elm Cr to Willow Cr	515	2Bg	2002	AQL	Turbidity	4A	N	TSS	2020 [c]
	Ida	Lake or Reservoir	07-0090	2B	2020	AQR	Nutrients	4A	Y	Phosphorus	

a. Use classes—1C: domestic consumption (requires heavy treatment); 2B: aquatic life and recreation—cool or warm water habitat; 2Bd: aquatic life and recreation—cool or warm water habitat, also protected as a source of drinking water; 2Bg: general cool and warm water aquatic life and habitat.
b. 4A: Impaired or threatened but a TMDL study has been approved by USEPA. 4A categories for impairments addressed in this report are proposed upon approval.
5: Use assessment indicates an impaired status and a TMDL report has not been completed.
c. Approved TMDL in MPCA (2020).
d. Approved TMDL in MSU Mankato (2007).
e. Approved TMDL in MPCA (2007) or revisions to Appendix A of MPCA (2007).

Appendix B. Water quality summaries and TMDLs by water body

E. coli

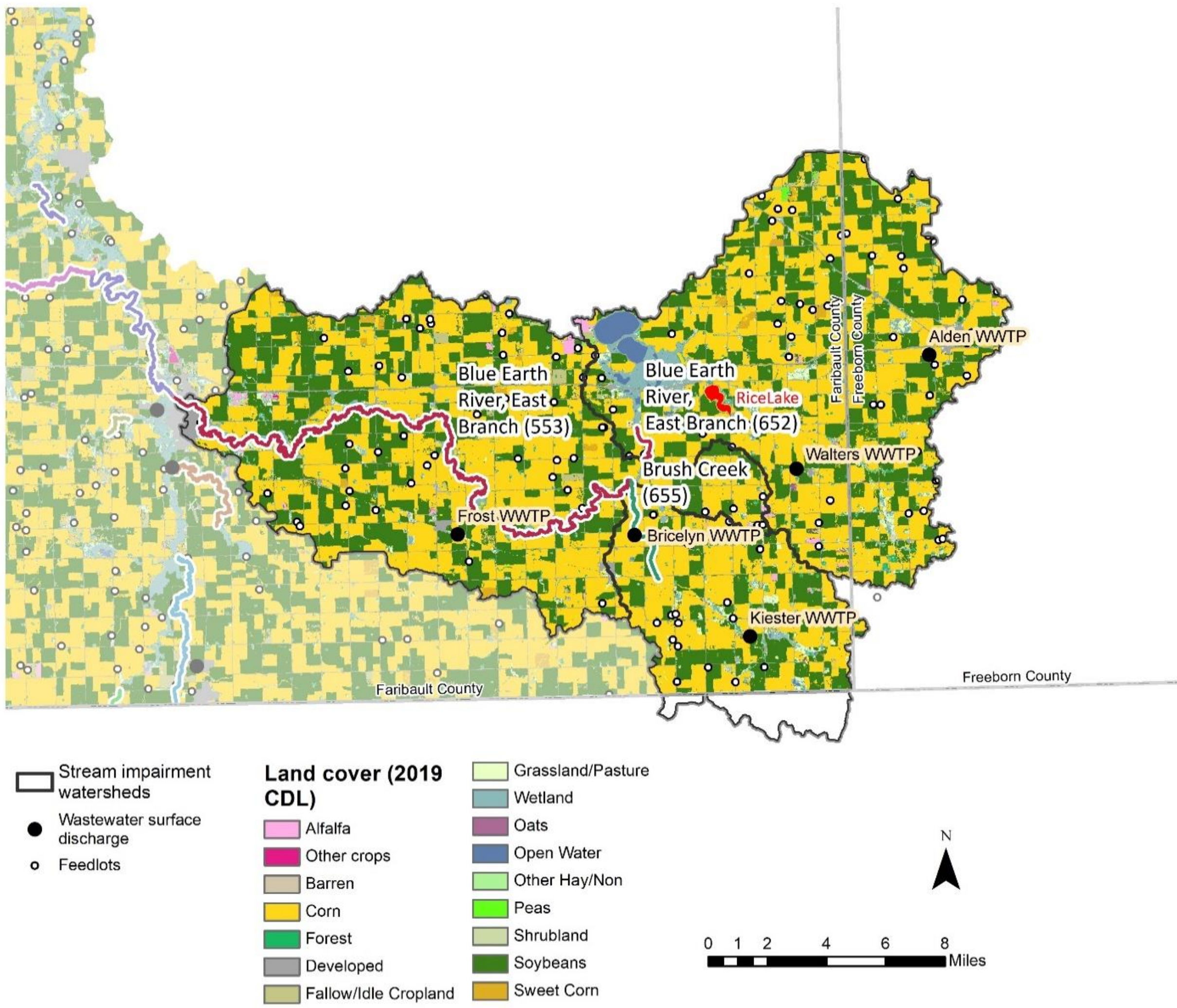
All *E. coli* data are from June, July, and August in 2017 and 2018. The following tables and figures are presented for each impairment:

- *E. coli* data summary by year
- *E. coli* data summary by month, with data from 2017 and 2018 aggregated
- LDC and monitoring data
    - Monitoring data from 2017 and 2018 are symbolized differently; see Section 3.6.1.2 for more information.
    - The LDC displays two curves: (1) The *E. coli* TMDL is based on the monthly geometric mean standard (126 org/100 mL); and (2) the *E. coli* load at the individual sample standard (1,260 org/100 mL) is displayed for reference. The monitoring data are individual sample points.
- TMDL table (Loads in the TMDL tables are rounded to two significant digits, except in the case of values greater than 100, which are rounded to the nearest whole number, and wastewater WLAs, which are rounded to two decimal places. Percent reductions are rounded to the nearest whole number.)

The maximum recordable value for *E. coli* concentration depends on the extent of sample dilution and is often 2,420 org/100 mL. Concentrations that are noted as 2,420 org/100 mL are likely higher, and the magnitude of the exceedances is not known.

Impairment group 1: East Branch Blue Earth River (652 and 553) and Brush Creek (655)

Figure 26. Watershed boundaries, land cover, feedlots, and wastewater surface discharges for *E. coli* impairments: East Branch Blue Earth River (652 and 553) and Brush Creek (655).



Blue Earth River, East Branch, T102 R25W S23, north line to Unnamed ditch (07020009-652)

Table 26. Annual summary of *E. coli* data at Blue Earth River, East Branch (07020009-652; April–October).

Year	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of exceedance
2017	9	582	75	9,208	2	22%
2018	6	155	63	921	0	0%

Table 27. Monthly summary of *E. coli* data at Blue Earth River, East Branch (07020009-652; 2017–2018).

Values with asterisks indicate months in which the monthly geometric mean standard of 126 org/100 mL was exceeded or the individual standard of 1,260 org/100 mL was exceeded in greater than 10% of the samples.

Month	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of exceedance
Jun	5	206 *	75	1,246	0	0%
Jul	5	239 *	75	701	0	0%
Aug	5	820 *	63	9208	2	40% *

Figure 27. Blue Earth River, East Branch (07020009-652) *E. coli* load duration curve.

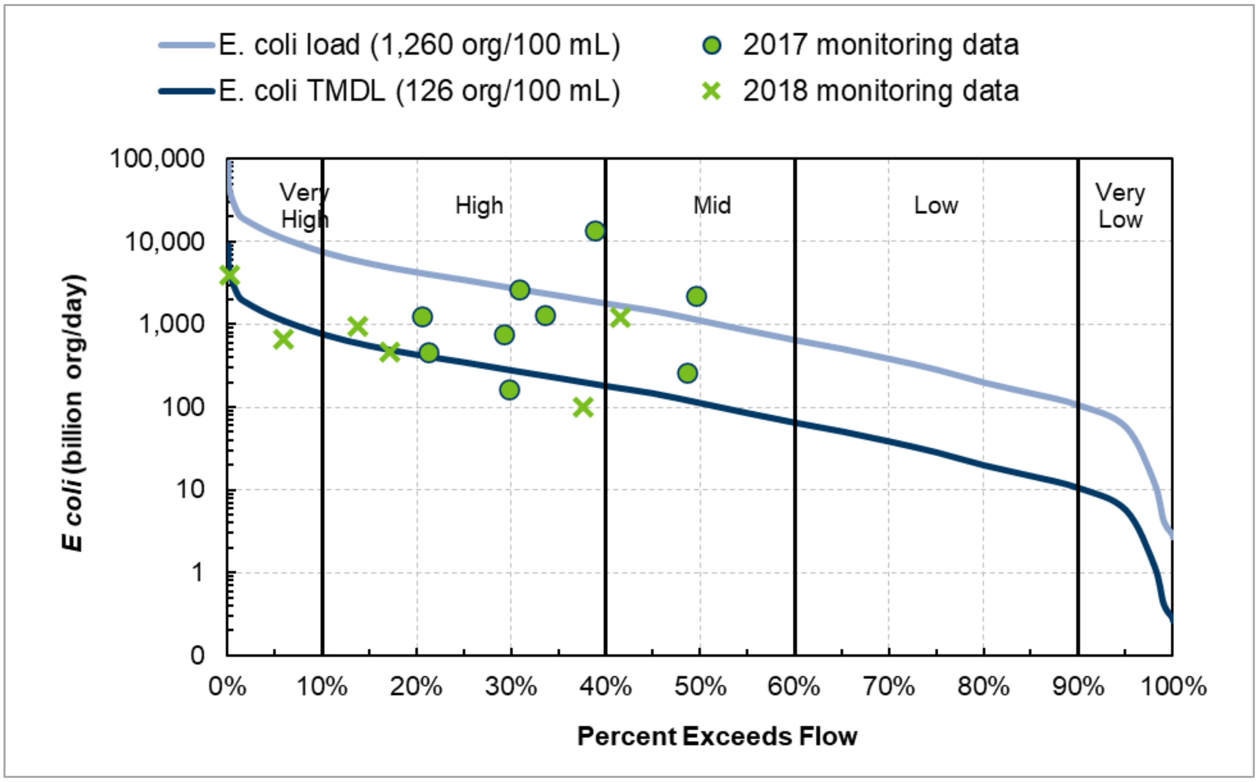


Table 28. Blue Earth River, East Branch (07020009-652) *E. coli* TMDL summary.

- Listing year: 2020
- Baseline year: 2017
- Numeric standard used to calculate TMDL: 126 org/100 mL *E. coli*
- TMDL and allocations apply Apr–Oct

TMDL parameter		*E. coli* load (b org/d)				
		Very high	High	Mid	Low	Very low
WLA	Alden WWTP (MNG585118, SD001+2) [a]	11.73	11.73	11.73	11.73	– [b]
	Walters WWTP (MNG585223, SD001)	0.68	0.68	0.68	0.68	–
	Total WLA	*12.41*	*12.41*	*12.41*	*12.41*	–
LA		1,069	298	88	13	–
MOS		120	35	11	2.8	0.57
TMDL		1,201	345	111	28	5.7
Maximum observed monthly geometric mean (org/100 mL)		820				
Estimated percent reduction		85%				

a. Alden WWTP effluent is not likely to be a significant *E. coli* source in April, when the facility is not required to disinfect (see Table 14 in Section 3.7.1.1). Future permits will determine whether the permit limit will apply during April.

b. "–"indicates that the permitted wastewater design flows exceed the stream flow in the indicated flow zone. The allocations are expressed as an equation rather than an absolute number: allocation = (flow contribution from a given source) x (126 org per 100 mL) x conversion factors. See Section 4.4.4.1 for more detail.

Brush Creek, Unnamed cr to E Br Blue Earth R (07020009-655)

Table 29. Annual summary of *E. coli* data at Brush Creek (07020009-655; April–October).

Year	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of exceedance
2017	9	617	84	2,481	3	33%
2018	6	317	120	613	0	0%

Table 30. Monthly summary of *E. coli* data at Brush Creek (07020009-655; April–October).

Values with asterisks indicate months in which the monthly geometric mean standard of 126 org/100 mL was exceeded or the individual standard of 1,260 org/100 mL was exceeded in greater than 10% of the samples.

Month	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of exceedance
Jun	5	303 *	84	776	0	0%
Jul	5	814 *	292	2,481	2	40% *
Aug	5	429 *	120	1,314	1	20% *

Figure 28. Brush Creek (07020009-655) *E. coli* load duration curve.

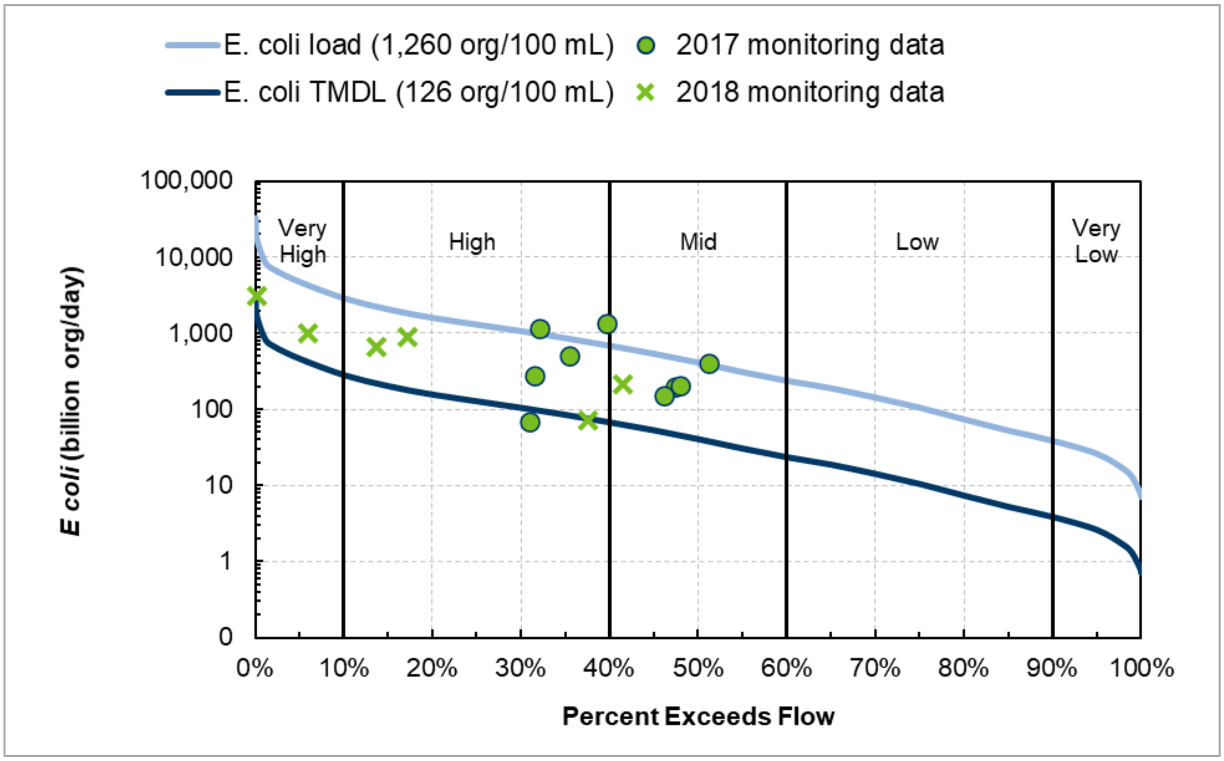


Table 31. Brush Creek (07020009-655) *E. coli* TMDL summary.

- Listing year: 2020
- Baseline year: 2017
- Numeric standard used to calculate TMDL: 126 org/100 mL *E. coli*
- TMDL and allocations apply Apr–Oct

		E. coli **load (b org/d)**				
TMDL parameter		**Very high**	**High**	**Mid**	**Low**	**Very low**
Boundary condition at Iowa state line [a]		54	14	4.2	0.57	– [b]
WLA	Kiester WWTP (MNG585097, SD001)	2.37	2.37	2.37	2.37	–
	Bricelyn WWTP (MNG585129, SD001)	2.22	2.22	2.22	2.22	–
	Total WLA	*4.59*	*4.59*	*4.59*	*4.59*	–
LA		360	96	28	3.8	–
MOS		47	13	4.1	1.0	0.26
TMDL		466	128	41	10	2.6
Maximum observed monthly geometric mean (org/100 mL)		814				
Estimated percent reduction		85%				

a. This boundary condition load is assigned to the portion of the watershed in Iowa and is not a TMDL allocation (Section 4.4.3). Minnesota cannot establish allocations for other jurisdictions, and any reductions noted in this TMDL that are needed from the watershed area in Iowa are consistent with Minnesota's water quality standards and not more stringent. The remaining load in this table after the boundary condition is removed represents the Minnesota allocations.

b. "–" indicates that the permitted wastewater design flows exceed the stream flow in the indicated flow zone. The allocations are expressed as an equation rather than an absolute number: allocation = (flow contribution from a given source) x (126 org per 100 mL) x conversion factors. See Section 4.4.4.1 for more detail.

Blue Earth River, East Branch, Brush Cr to Blue Earth R (07020009-553)

Table 32. Annual summary of *E. coli* data at Blue Earth River, East Branch (07020009-553; April–October).

Year	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of exceedance
2017	9	280	10	2,909	1	11%
2018	6	249	74	1,565	1	17%

Table 33. Monthly summary of *E. coli* data at Blue Earth River, East Branch (07020009-553; April–October).

Values with asterisks indicate months in which the monthly geometric mean standard of 126 org/100 mL was exceeded or the individual standard of 1,260 org/100 mL was exceeded in greater than 10% of the samples.

Month	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of exceedance
Jun	5	238 *	10	2,909	2	40% *
Jul	5	312 *	122	602	0	0%
Aug	5	256 *	74	529	0	0%

Figure 29. Blue Earth River, East Branch (07020009-553) *E. coli* load duration curve.

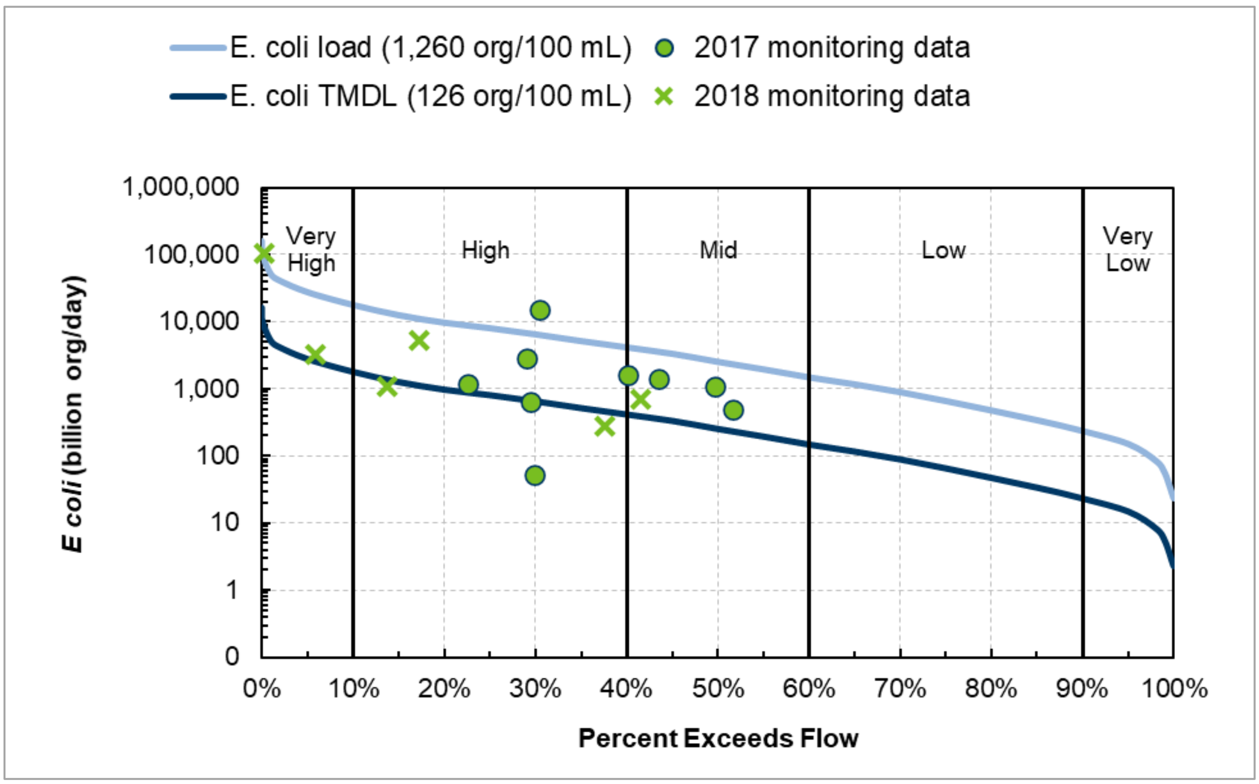


Table 34. Blue Earth River, East Branch (07020009-553) *E. coli* TMDL summary.

- Listing year: 2020
- Baseline year: 2017
- Numeric standard used to calculate TMDL: 126 org/100 mL *E. coli*
- TMDL and allocations apply Apr–Oct

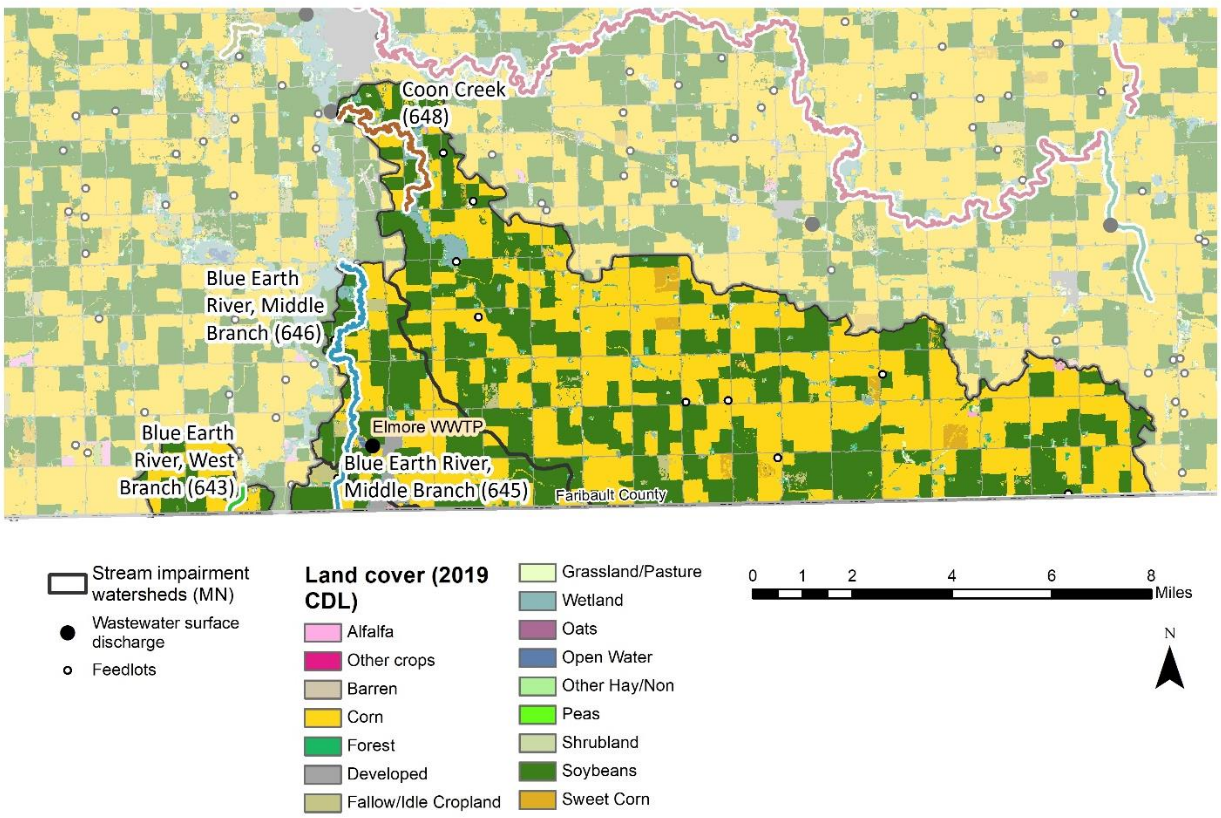
TMDL parameter		*E. coli* load (b org/d)				
		Very high	**High**	**Mid**	**Low**	**Very low**
Boundary condition at Iowa state line [a]		52	15	4.4	0.85	– [b]
WLA	Alden WWTP (MNG585118, SD001+2)	11.73	11.73	11.73	11.73	–
	Walters WWTP (MNG585223, SD001)	0.68	0.68	0.68	0.68	–
	Kiester WWTP (MNG585097, SD001)	2.37	2.37	2.37	2.37	–
	Bricelyn WWTP (MNG585129, SD001)	2.22	2.22	2.22	2.22	–
	Frost WWTP (MNG585120, SD001)	1.87	1.87	1.87	1.87	–
	Total WLA	*18.87*	*18.87*	*18.87*	*18.87*	–
LA		2,442	694	206	40	–
MOS		279	81	25	6.6	1.5
TMDL		2,792	809	254	66	15
Maximum observed monthly geometric mean (org/100 mL)		312				
Estimated percent reduction		60%				

a. This boundary condition load is assigned to the portion of the watershed in Iowa and is not a TMDL allocation (Section 4.4.3). Minnesota cannot establish allocations for other jurisdictions, and any reductions noted in this TMDL that are needed from the watershed area in Iowa are consistent with Minnesota's water quality standards and not more stringent. The remaining load in this table after the boundary condition is removed represents the Minnesota allocations.

b. "–"indicates that the permitted wastewater design flows exceed the stream flow in the indicated flow zone. The allocations are expressed as an equation rather than an absolute number: allocation = (flow contribution from a given source) x (126 org per 100 mL) x conversion factors. See Section 4.4.4.1 for more detail.

Impairment group 2: Coon Creek (648), Middle Branch Blue Earth River (645 and 646), and West Branch Blue River (643)

Figure 30. Watershed boundaries, land cover, feedlots, and wastewater surface discharges for *E. coli* impairments: Coon Creek (648), Middle Branch Blue Earth River (645 and 646), and West Branch Blue River (643).



Coon Creek, T102 R27W S33, south line to Blue Earth R (07020009-648)

Table 35. Annual summary of *E. coli* data at Coon Creek (07020009-648; April–October).

Year	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of exceedance
2017	9	296	63	1,935	1	11%
2018	6	491	109	2,420	1	17%

Table 36. Monthly summary of *E. coli* data at Coon Creek (07020009-648; April–October).

Values with asterisks indicate months in which the monthly geometric mean standard of 126 org/100 mL was exceeded or the individual standard of 1,260 org/100 mL was exceeded in greater than 10% of the samples.

Month	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of exceedance
Jun	5	511 *	185	2,420	2	40% *
Jul	5	315 *	63	794	0	0%
Aug	5	295 *	109	921	0	0%

Figure 31. Coon Creek (07020009-648) *E. coli* load duration curve.

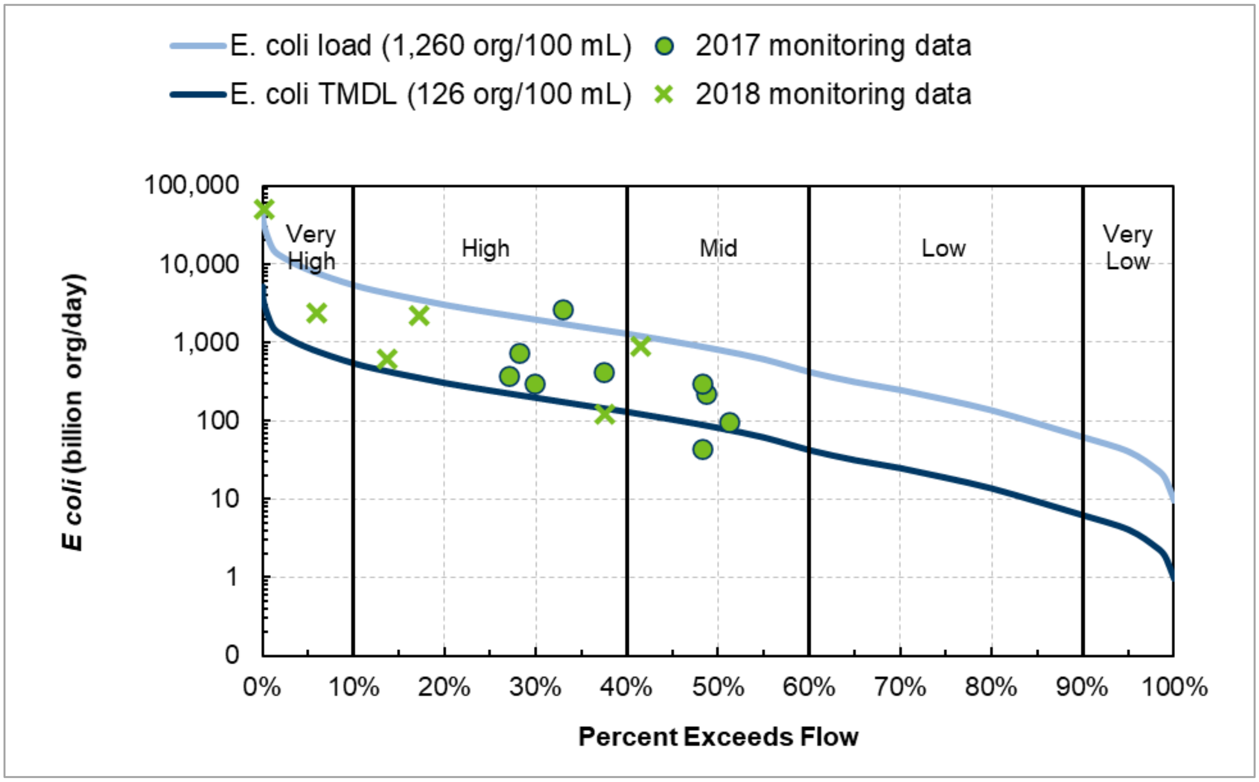


Table 37. Coon Creek (07020009-648) *E. coli* TMDL summary.

- Listing year: 2020
- Baseline year: 2017
- Numeric standard used to calculate TMDL: 126 org/100 mL *E. coli*
- TMDL and allocations apply Apr–Oct

	***E. coli* Load (b org/d)**				
TMDL Parameter	**Very High**	**High**	**Mid**	**Low**	**Very Low**
Boundary condition at Iowa state line [a]	296	85	28	6.7	1.4
LA	462	132	44	10	2.2
MOS	84	24	8.0	1.9	0.40
TMDL	842	241	80	19	4.0
Maximum observed monthly geometric mean (org/100 mL)	511				
Estimated percent reduction	75%				

a. This boundary condition load is assigned to the portion of the watershed in Iowa and is not a TMDL allocation (Section 4.4.3). Minnesota cannot establish allocations for other jurisdictions, and any reductions noted in this TMDL that are needed from the watershed area in Iowa are consistent with Minnesota's water quality standards and not more stringent. The remaining load in this table after the boundary condition is removed represents the Minnesota allocations.

Blue Earth River, Middle Branch, MN/IA border to -94.104 43.514 (07020009-645)

Table 38. Annual summary of *E. coli* data at Blue Earth River, Middle Branch (07020009-645; April–October).

Year	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of exceedance
2017	9	327	52	2,481	1	11%
2018	6	240	41	1,439	1	17%

Table 39. Monthly summary of *E. coli* data at Blue Earth River, Middle Branch (07020009-645; April–October).

Values with asterisks indicate months in which the monthly geometric mean standard of 126 org/100 mL was exceeded or the individual standard of 1,260 org/100 mL was exceeded in greater than 10% of the samples.

Month	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of exceedance
Jun	5	399 *	86	2,481	2	40% *
Jul	5	339 *	149	776	0	0%
Aug	5	178 *	41	504	0	0%

Figure 32. Blue Earth River, Middle Branch (07020009-645) *E. coli* load duration curve.

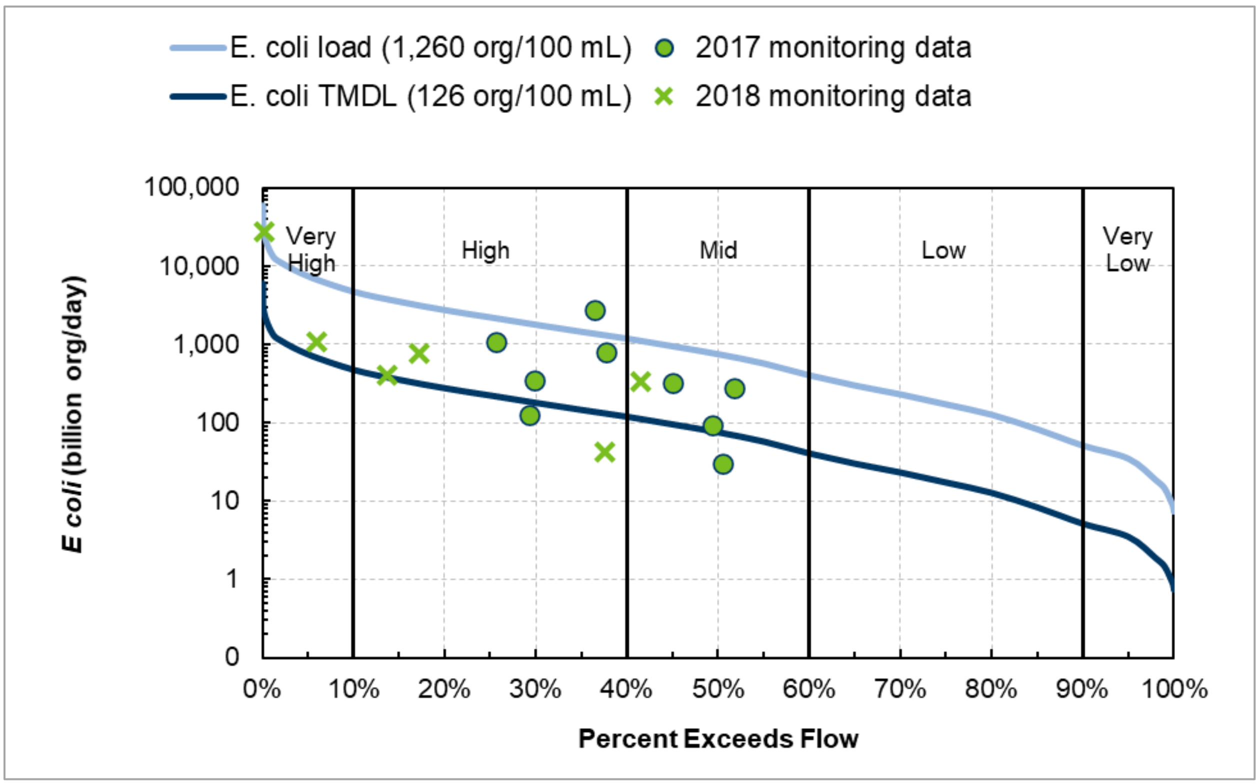


Table 40. Blue Earth River, Middle Branch (07020009-645) *E. coli* TMDL summary.

- Listing year: 2020
- Baseline year: 2017
- Numeric standard used to calculate TMDL: 126 org/100 mL *E. coli*
- TMDL and allocations apply Apr–Oct

TMDL Parameter	*E. coli* Load (b org/d) Very High	High	Mid	Low	Very Low
Boundary condition at Iowa state line [a]	654	196	67	15	3.1
LA	7.0	2.0	0.50	0.30	0.050
MOS	74	22	7.5	1.7	0.35
TMDL	735	220	75	17	3.5
Maximum observed monthly geometric mean (org/100 mL)	399				
Estimated percent reduction	68%				

a. This boundary condition load is assigned to the portion of the watershed in Iowa and is not a TMDL allocation (Section 4.4.3). Minnesota cannot establish allocations for other jurisdictions, and any reductions noted in this TMDL that are needed from the watershed area in Iowa are consistent with Minnesota's water quality standards and not more stringent. The remaining load in this table after the boundary condition is removed represents the Minnesota allocations.

Blue Earth River, Middle Branch, -94.104 43.514 to W Br Blue Earth R (07020009-646)

Table 41. Annual summary of *E. coli* data at Blue Earth River, Middle Branch (07020009-646; April–October).

Year	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of exceedance
2017	9	287	75	1,439	1	11%
2018	6	220	51	763	0	0%

Table 42. Monthly summary of *E. coli* data at Blue Earth River, Middle Branch (07020009-646; April–October).

Values with asterisks indicate months in which the monthly geometric mean standard of 126 org/100 mL was exceeded or the individual standard of 1,260 org/100 mL was exceeded in greater than 10% of the samples.

Month	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of exceedance
Jun	5	251 *	63	1,439	1	20% *
Jul	5	320 *	98	763	0	0%
Aug	5	213 *	51	520	0	0%

Figure 33. Blue Earth River, Middle Branch (07020009-646) *E. coli* load duration curve.

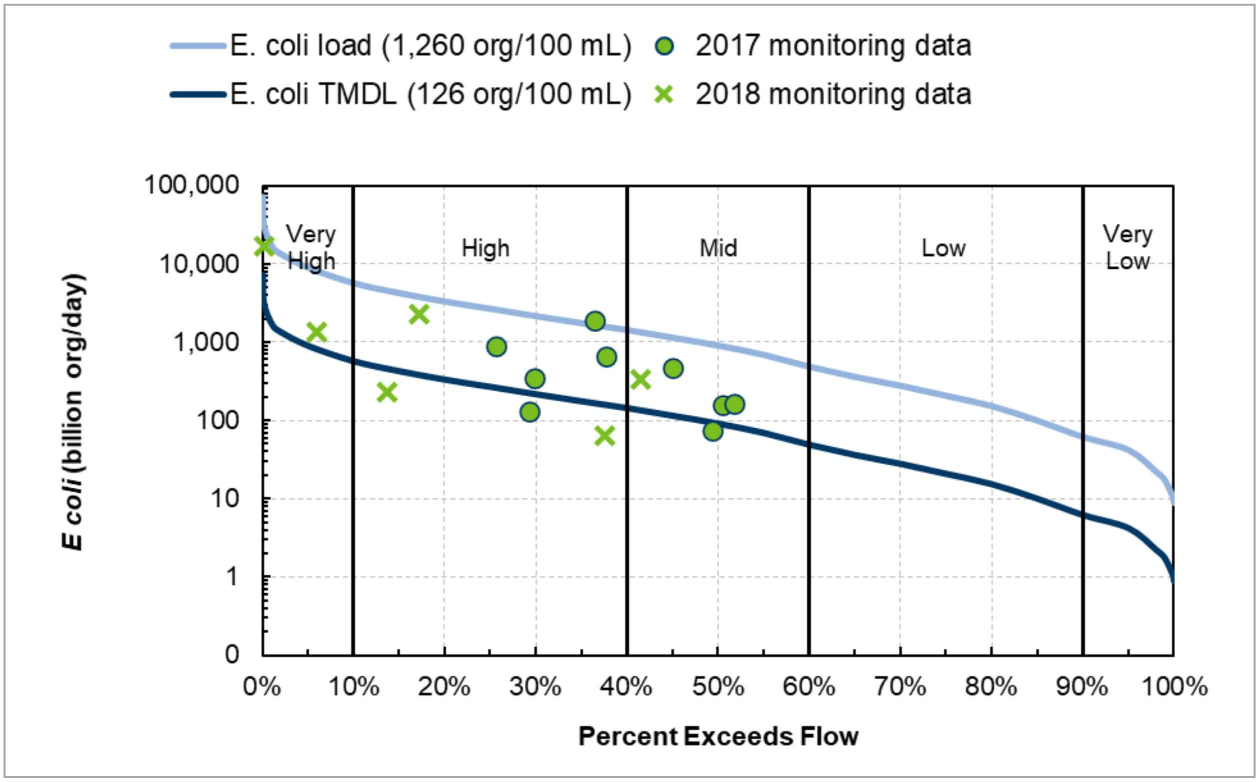


Table 43. Blue Earth River, Middle Branch (07020009-646) *E. coli* TMDL summary.

- Listing year: 2020
- Baseline year: 2017
- Numeric standard used to calculate TMDL: 126 org/100 mL *E. coli*
- TMDL and allocations apply Apr–Oct

		***E. coli* load (b org/d)**				
TMDL parameter		**Very high**	**High**	**Mid**	**Low**	**Very low**
Boundary condition at Iowa state line [a]		700	202	62	6.2	– [b]
WLA	Elmore WWTP (MNG585110, SD001)	11.89	11.89	11.89	11.89	–
LA		95	28	8	0.81	–
MOS		90	27	9.1	2.1	0.42
TMDL		897	269	91	21	4.2
Maximum observed monthly geometric mean (org/100 mL)		320				
Estimated percent reduction		61%				

a. This boundary condition load is assigned to the portion of the watershed in Iowa and is not a TMDL allocation (Section 4.4.3). Minnesota cannot establish allocations for other jurisdictions, and any reductions noted in this TMDL that are needed from the watershed area in Iowa are consistent with Minnesota's water quality standards and not more stringent. The remaining load in this table after the boundary condition is removed represents the Minnesota allocations.

b. "–"indicates that the permitted wastewater design flows exceed the stream flow in the indicated flow zone. The allocations are expressed as an equation rather than an absolute number: allocation = (flow contribution from a given source) x (126 org per 100 mL) x conversion factors. See Section 4.4.4.1 for more detail.

Blue Earth River, West Branch, MN/IA border to 15th St (07020009-643)

Table 44. Annual summary of *E. coli* data at Blue Earth River, West Branch (07020009-643; April–October).

Year	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of exceedance
2017	9	765	165	3,654	3	33%
2018	6	515	75	8,164	1	17%

Table 45. Monthly summary of *E. coli* data at Blue Earth River, West Branch (07020009-643; April–October).

Values with asterisks indicate months in which the monthly geometric mean standard of 126 org/100 mL was exceeded or the individual standard of 1,260 org/100 mL was exceeded in greater than 10% of the samples.

Month	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of exceedance
Jun	5	839 *	171	8,164	2	40% *
Jul	5	388 *	160	1,022	0	0%
Aug	5	855 *	75	3,654	2	40% *

Figure 34. Blue Earth River, West Branch (07020009-643) *E. coli* load duration curve.

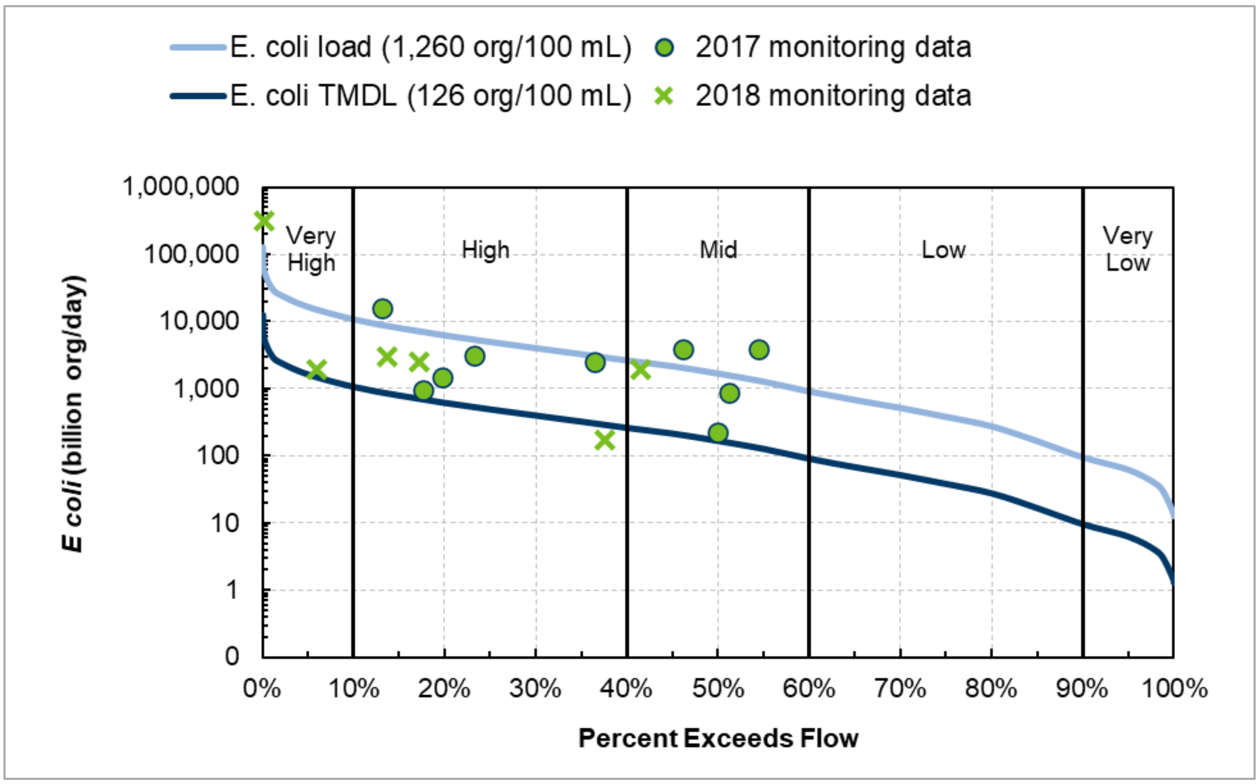


Table 46. Blue Earth River, West Branch (07020009-643) *E. coli* TMDL summary.

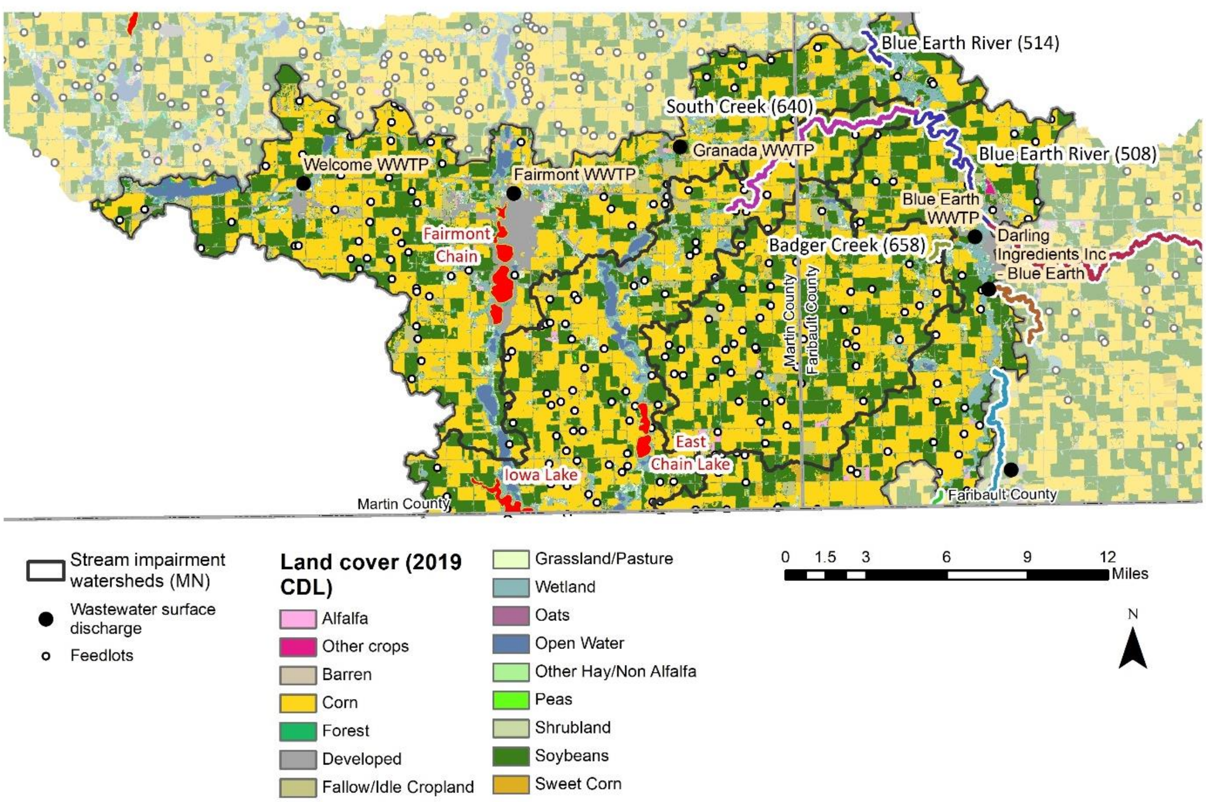
- Listing year: 2020
- Baseline year: 2017
- Numeric standard used to calculate TMDL: 126 org/100 mL *E. coli*
- TMDL and allocations apply Apr–Oct

	***E. coli* Load (b org/d)**				
TMDL Parameter	**Very High**	**High**	**Mid**	**Low**	**Very Low**
Boundary condition at Iowa state line [a]	1,441	435	147	34	5.5
LA	29.0	9.0	3.0	0.20	0.080
MOS	163	49	17	3.8	0.62
TMDL	1,633	493	167	38	6.2
Maximum observed monthly geometric mean (org/100 mL)	855				
Estimated percent reduction	85%				

a. This boundary condition load is assigned to the portion of the watershed in Iowa and is not a TMDL allocation (Section 4.4.3). Minnesota cannot establish allocations for other jurisdictions, and any reductions noted in this TMDL that are needed from the watershed area in Iowa are consistent with Minnesota's water quality standards and not more stringent. The remaining load in this table after the boundary condition is removed represents the Minnesota allocations.

Impairment group 3: Badger Creek (658), Blue Earth River (508 and 514), and South Creek (640)

Figure 35. Watershed boundaries, land cover, feedlots, and wastewater surface discharges for *E. coli* impairments: Badger Creek (658), Blue Earth River (508 and 514), and South Creek (640).



Badger Creek, Little Badger Cr to -94.136 43.64 (07020009-658)

Table 47. Annual summary of *E. coli* data at Badger Creek (07020009-658; April–October).

Year	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of exceedance
2017	9	640	187	3,255	1	11%
2018	6	505	73	1,553	2	33%

Table 48. Monthly summary of *E. coli* data at Badger Creek (07020009-658; April–October).

Values with asterisks indicate months in which the monthly geometric mean standard of 126 org/100 mL was exceeded or the individual standard of 1,260 org/100 mL was exceeded in greater than 10% of the samples.

Month	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of exceedance
Jun	5	597 *	187	3,255	1	20% *
Jul	5	735 *	301	1,281	1	20% *
Aug	5	450 *	73	1,553	1	20% *

Figure 36. Badger Creek (07020009-658) *E. coli* load duration curve.

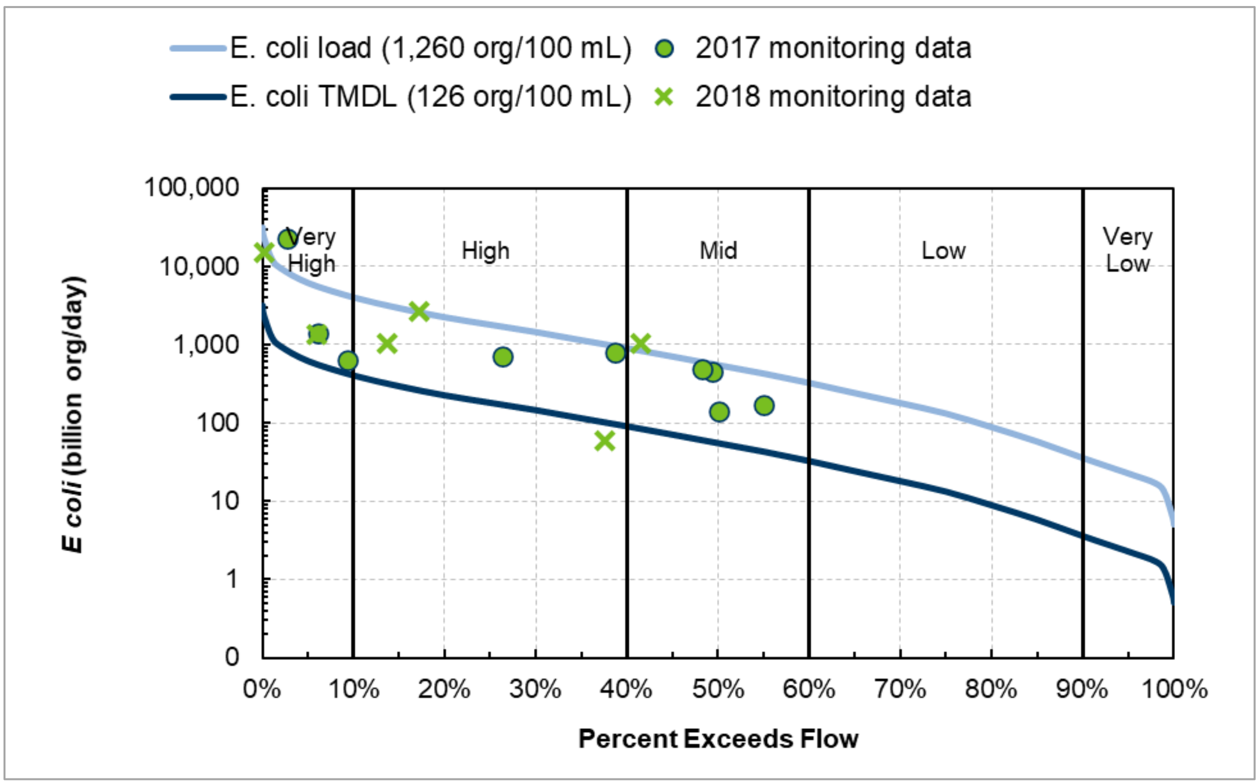


Table 49. Badger Creek (07020009-658) *E. coli* TMDL summary.

- Listing year: 2020
- Baseline year: 2017
- Numeric standard used to calculate TMDL: 126 org/100 mL *E. coli*
- TMDL and allocations apply Apr–Oct

TMDL Parameter	*E. coli* Load (b org/d)				
	Very High	High	Mid	Low	Very Low
LA	557	163	50	12	2.1
MOS	62	18	5.5	1.3	0.23
TMDL	619	181	55	13	2.3
Maximum observed monthly geometric mean (org/100 mL)	735				
Estimated percent reduction	83%				

Blue Earth River, E Br Blue Earth R to South Cr (07020009-508)

Table 50. Annual summary of *E. coli* data at Blue Earth River (07020009-508; April–October).

Year	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of exceedance
2017	9	242	135	1860	1	11%
2018	6	303	52	1414	1	17%

Table 51. Monthly summary of *E. coli* data at Blue Earth River (07020009-508; April–October).

Values with asterisks indicate months in which the monthly geometric mean standard of 126 org/100 mL was exceeded or the individual standard of 1,260 org/100 mL was exceeded in greater than 10% of the samples.

Month	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of exceedance
Jun	5	378 *	135	1,860	1	20% *
Jul	5	246 *	85	644	0	0%
Aug	5	199 *	52	1,414	1	20% *

Figure 37. Blue Earth River (07020009-508) *E. coli* load duration curve.

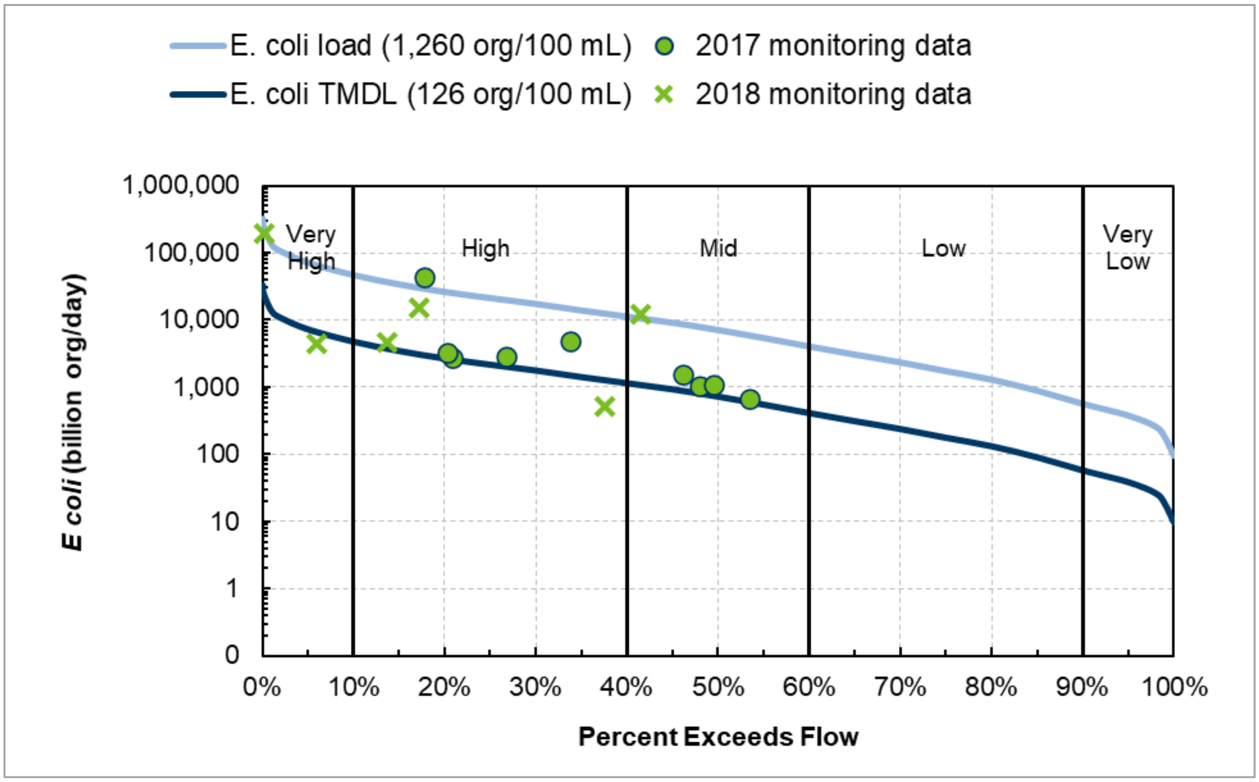


Table 52. Blue Earth River (07020009-508) *E. coli* TMDL summary.

- Listing year: 2020
- Baseline year: 2017
- Numeric standard used to calculate TMDL: 126 org/100 mL *E. coli*
- TMDL and allocations apply Apr–Oct

		***E. coli* load (b org/d)**				
TMDL Parameter		**Very high**	**High**	**Mid**	**Low**	**Very low**
Boundary condition at Iowa state line [a]		2,501	735	236	46	– [b]
	Alden WWTP (MNG585118, SD001+2)	11.73	11.73	11.73	11.73	–
	Walters WWTP (MNG585223, SD001)	0.68	0.68	0.68	0.68	–
	Kiester WWTP (MNG585097, SD001)	2.37	2.37	2.37	2.37	–
	Bricelyn WWTP (MNG585129, SD001)	2.22	2.22	2.22	2.22	–
	Frost WWTP (MNG585120, SD001)	1.87	1.87	1.87	1.87	–
	Elmore WWTP (MNG585110, SD001)	11.89	11.89	11.89	11.89	–
	Blue Earth WWTP (MN0020532, SD001)	4.67	4.67	4.67	4.67	–
	Darling International–Blue Earth (MN0002313, SD001+2)	3.35	3.35	3.35	3.35	–
WLA	*Total WLA*	*38.78*	*38.78*	*38.78*	*38.78*	–
LA		3,911	1,149	368	71	–
MOS		717	214	71	17	3.8
TMDL		7,168	2,137	714	173	38
Maximum observed monthly geometric mean (org/100 mL)		378				
Estimated percent reduction		67%				

a. This boundary condition load is assigned to the portion of the watershed in Iowa and is not a TMDL allocation (Section 4.4.3). Minnesota cannot establish allocations for other jurisdictions, and any reductions noted in this TMDL that are needed from the watershed area in Iowa are consistent with Minnesota's water quality standards and not more stringent. The remaining load in this table after the boundary condition is removed represents the Minnesota allocations.

b. "–" indicates that the permitted wastewater design flows exceed the stream flow in the indicated flow zone. The allocations are expressed as an equation rather than an absolute number: allocation = (flow contribution from a given source) x (126 org per 100 mL) x conversion factors. See Section 4.4.4.1 for more detail.

South Creek, -94.300 43.661 to Blue Earth R (07020009-640)

Table 53. Annual summary of *E. coli* data at South Creek (07020009-640; April–October).

Year	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of exceedance
2017	9	703	408	2,909	1	11%
2018	6	390	84	1,553	1	17%

Table 54. Monthly summary of *E. coli* data at South Creek (07020009-640; April–October).

Values with asterisks indicate months in which the monthly geometric mean standard of 126 org/100 mL was exceeded or the individual standard of 1,260 org/100 mL was exceeded in greater than 10% of the samples.

Month	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of exceedance
Jun	5	593 *	84	2,909	1	20% *
Jul	5	427 *	279	667	0	0%
Aug	5	677 *	226	1,553	1	20% *

Figure 38. South Creek (07020009-640) *E. coli* load duration curve.

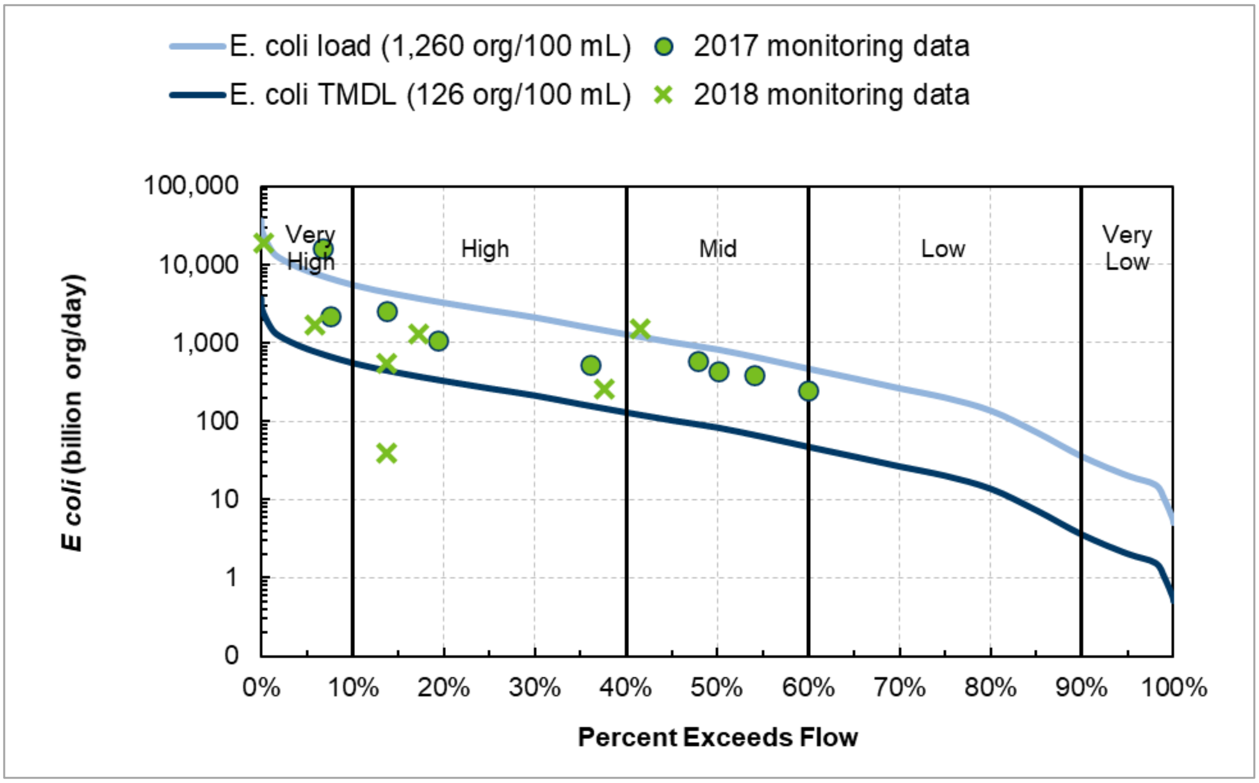


Table 55. South Creek (07020009-640) *E. coli* TMDL summary.

- Listing year: 2020
- Baseline year: 2017
- Numeric standard used to calculate TMDL: 126 org/100 mL *E. coli*
- TMDL and allocations apply Apr–Oct

TMDL parameter	*E. coli* load (b org/d)				
	Very high	High	Mid	Low	Very low
Boundary condition at Iowa state line [a]	173	54	17	4.1	0.41
LA	580	181	57	14	1.4
MOS	84	26	8.2	2.0	0.2
TMDL	837	261	82	20	2.0
Maximum observed monthly geometric mean (org/100 mL)	677				
Estimated percent reduction	81%				

a. This boundary condition load is assigned to the portion of the watershed in Iowa and is not a TMDL allocation (Section 4.4.3). Minnesota cannot establish allocations for other jurisdictions, and any reductions noted in this TMDL that are needed from the watershed area in Iowa are consistent with Minnesota's water quality standards and not more stringent. The remaining load in this table after the boundary condition is removed represents the Minnesota allocations.

Blue Earth River, Center Cr to Elm Cr (07020009-514)

Table 56. Annual summary of *E. coli* data at Blue Earth River (07020009-514; April–October).

Year	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of exceedance
2017	9	275	109	1,274	1	11%
2018	6	295	63	1,553	1	17%

Table 57. Monthly summary of *E. coli* data at Blue Earth River (07020009-514; April–October).

Values with asterisks indicate months in which the monthly geometric mean standard of 126 org/100 mL was exceeded or the individual standard of 1,260 org/100 mL was exceeded in greater than 10% of the samples.

Month	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of exceedance
Jun	5	392 *	97	1,274	1	20% *
Jul	5	219 *	63	733	0	0%
Aug	5	262 *	109	1,553	1	20% *

Figure 39. Blue Earth River (07020009-514) *E. coli* load duration curve.

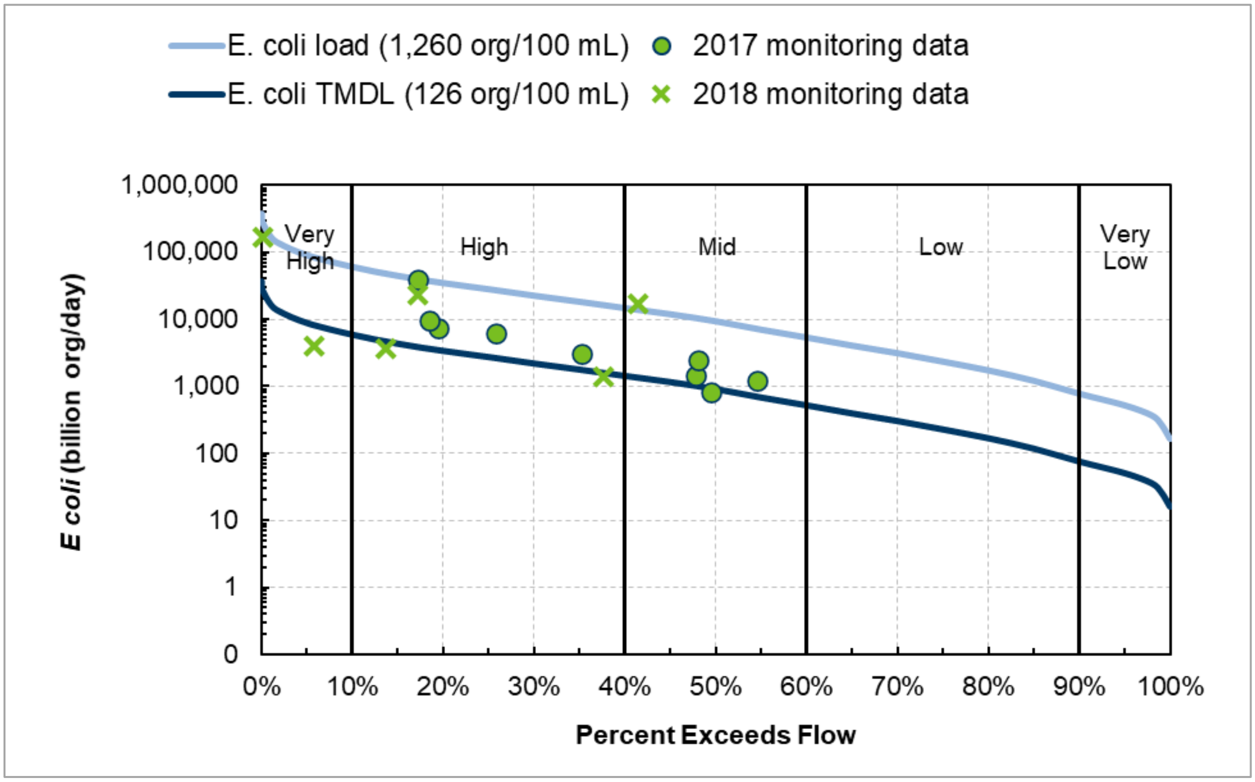


Table 58. Blue Earth River (07020009-514) *E. coli* TMDL summary.

- Listing year: 2020
- Baseline year: 2017
- Numeric standard used to calculate TMDL: 126 org/100 mL *E. coli*
- TMDL and allocations apply Apr–Oct

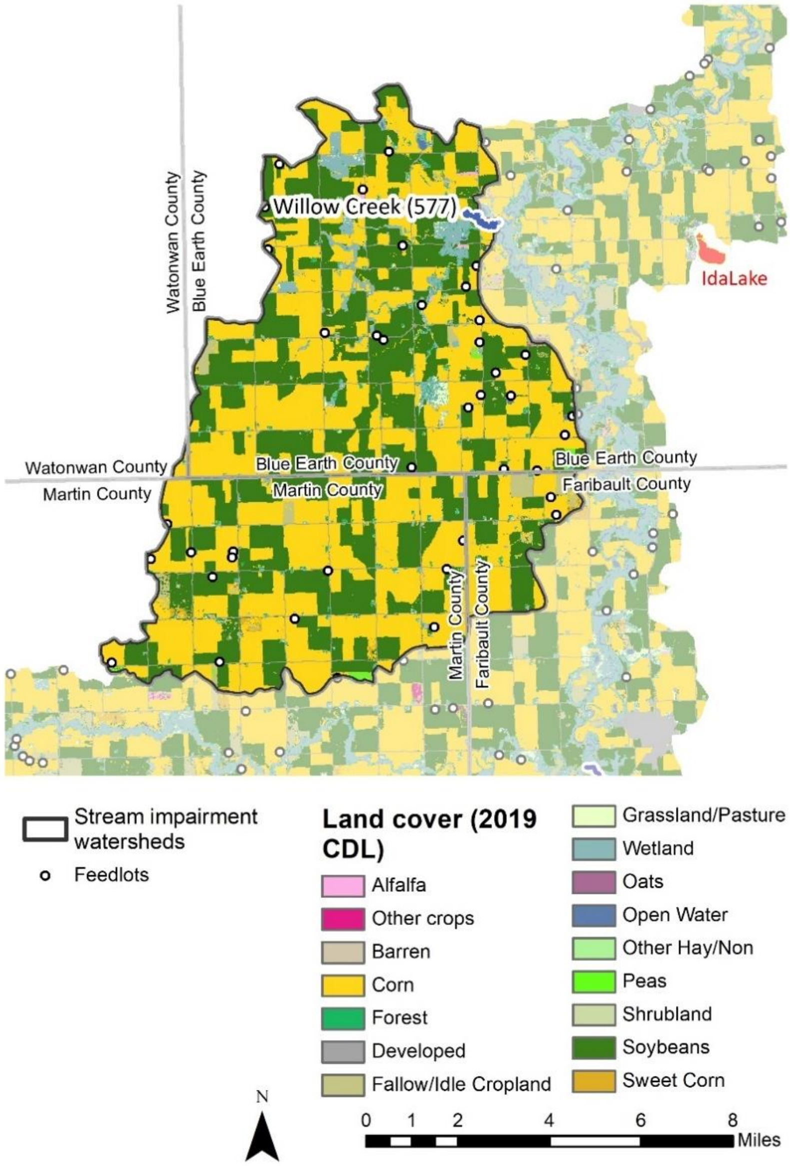
TMDL Parameter		*E. coli* load (b org/d)				
		Very high	**High**	**Mid**	**Low**	**Very low**
Boundary condition at Iowa state line [a]		2,546	778	246	47	– [b]
WLA	Alden WWTP (MNG585118, SD001+2)	11.73	11.73	11.73	11.73	–
	Walters WWTP (MNG585223, SD001)	0.68	0.68	0.68	0.68	–
	Kiester WWTP (MNG585097, SD001)	2.37	2.37	2.37	2.37	–
	Bricelyn WWTP (MNG585129, SD001)	2.22	2.22	2.22	2.22	–
	Frost WWTP (MNG585120, SD001)	1.87	1.87	1.87	1.87	–
	Elmore WWTP (MNG585110, SD001)	11.89	11.89	11.89	11.89	–
	Blue Earth WWTP (MN0020532, SD001)	4.67	4.67	4.67	4.67	–
	Darling International–Blue Earth (MN0002313, SD001+2)	3.35	3.35	3.35	3.35	–
	Welcome WWTP (MN0021296, SD003)	1.24	1.24	1.24	1.24	–
	Granada WWTP (MNG585023, SD001)	1.72	1.72	1.72	1.72	–
	Fairmont WWTP (MN0030112, SD001)	18.6	18.6	18.6	18.6	–
	Fairmont MS4 (MS400239)	39	12	3.8	0.72	–
	Total WLA	*99*	*72*	*64*	*61*	–
LA		5373	1641	519	99	–
MOS		891	277	92	23	5.1
TMDL		8909	2768	921	230	51
Maximum observed monthly geometric mean (org/100 mL)		392				
Estimated percent reduction		68%				

a. This boundary condition load is assigned to the portion of the watershed in Iowa and is not a TMDL allocation (Section 4.4.3). Minnesota cannot establish allocations for other jurisdictions, and any reductions noted in this TMDL that are needed from the watershed area in Iowa are consistent with Minnesota's water quality standards and not more stringent. The remaining load in this table after the boundary condition is removed represents the Minnesota allocations.

b. "–" indicates that the permitted wastewater design flows exceed the stream flow in the indicated flow zone. The allocations are expressed as an equation rather than an absolute number: allocation = (flow contribution from a given source) x (126 org per 100 mL) x conversion factors. See Section 4.4.4.1 for more detail.

Impairment group 4: Willow Creek (577)

Figure 40. Watershed boundary, land cover, and feedlots for *E. coli* impairment Willow Creek (577).



Willow Creek, Unnamed cr to Blue Earth R (07020009-577)

Table 59. Annual summary of *E. coli* data at Willow Creek (07020009-577; April–October).

Year	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of exceedance
2017	5	662	345	1,567	1	20%
2018	6	202	5	717	0	0%

Table 60. Monthly summary of *E. coli* data at Willow Creek (07020009-577; April–October).

Values with asterisks indicate months in which the monthly geometric mean standard of 126 org/100 mL was exceeded or the individual standard of 1,260 org/100 mL was exceeded in greater than 10% of the samples.

Month	Sample count	Geometric mean (org/100 mL)	Minimum (org/100 mL)	Maximum (org/100 mL)	Number of individual standard exceedances	Frequency of exceedance
Jun	5	557 *	216	1,567	1	20% *
Jul	2 [a]	395	228	683	0	0%
Aug	4 [a]	179	5	836	0	0%

a. Not enough samples to assess compliance with the monthly geometric mean standard.

Figure 41. Willow Creek (07020009-577) *E. coli* load duration curve.

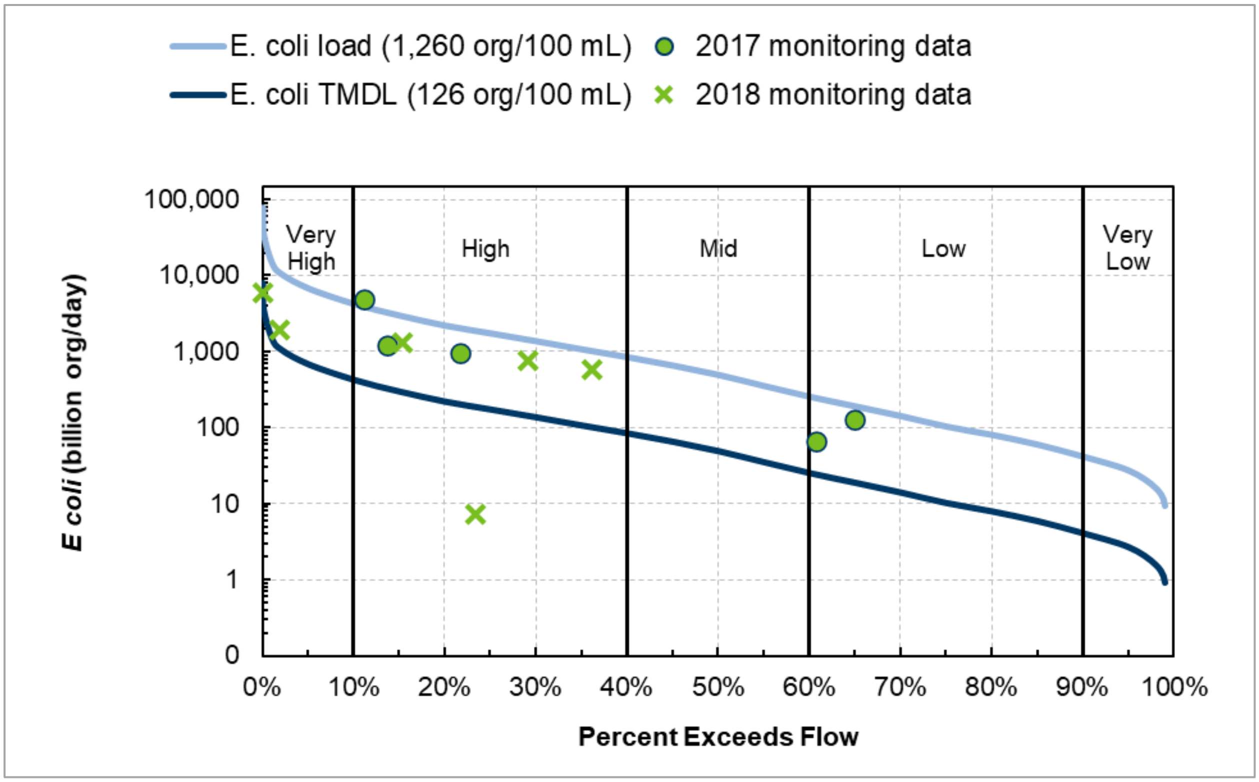


Table 61. Willow Creek (07020009-577) *E. coli* TMDL summary.

- Listing year: 2020
- Baseline year: 2017
- Numeric standard used to calculate TMDL: 126 org/100 mL *E. coli*
- TMDL and allocations apply Apr–Oct

TMDL Parameter	*E. coli* Load (b org/d)				
	Very High	High	Mid	Low	Very Low
LA	607	155	44	9	2.4
MOS	67	17	4.9	1.0	0.27
TMDL	674	172	49	10	2.7
Maximum observed monthly geometric mean (org/100 mL)	557				
Estimated percent reduction	77%				

Phosphorus

The following information is presented for each impaired lake:

- Watershed characterization: Brief description of the lake and watershed location, land cover, feedlot locations, and development
- Lake conditions: Summary of lake morphometry, water quality, and fisheries
- Phosphorus source summary: Results of the phosphorus source assessment described in Section 3.7
- TMDL summary: TMDL table

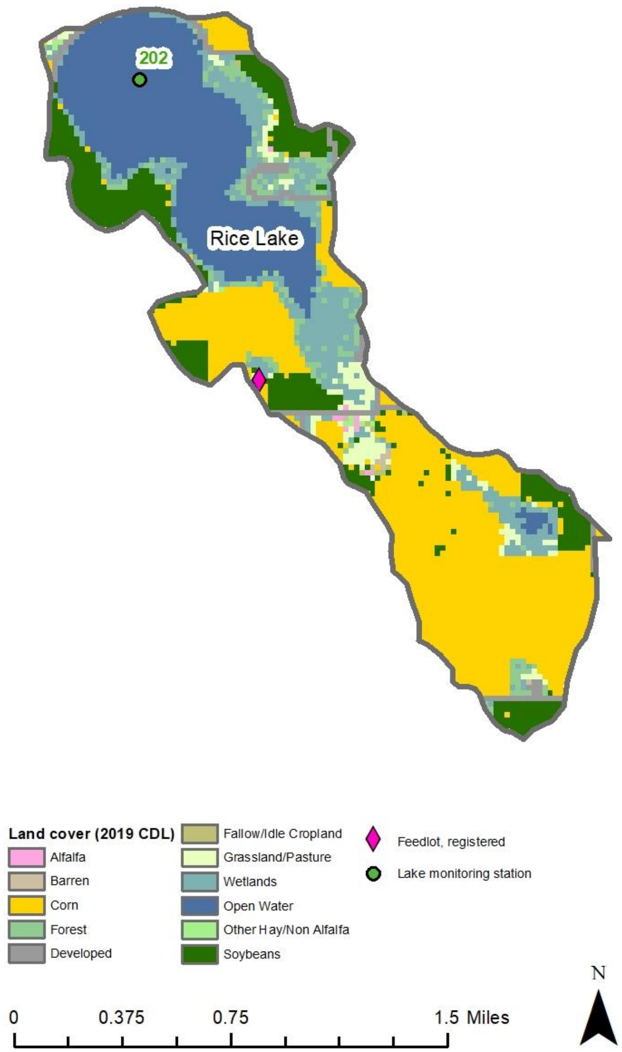
Rice Lake (22-0007-00)

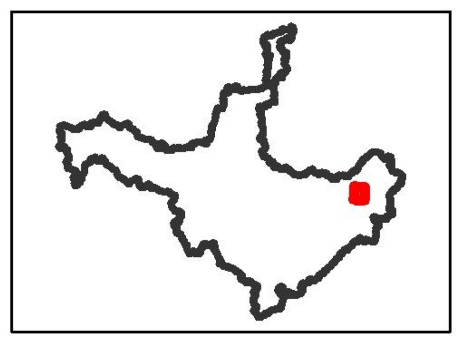
Watershed characterization

The Rice Lake Watershed is relatively small (1.6 square miles), with a watershed to lake ratio of 4:1. The entire watershed is in Faribault County, and there are no cities in the watershed (Figure 42). Land cover is approximately 53% corn and soybean rotation, with most of the rest of the watershed open water and wetland (Table 8, Figure 42). There is one registered feedlot in the Rice Lake Watershed, with swine as the primary livestock type. Land application of manure from nearby feedlots that are located outside of the Rice Lake Watershed may also contribute nutrients to Rice Lake.

Residential development around the lake is moderate, with a forested buffer surrounding most of the lake. A section of shoreline in the northwest corner lacks vegetative buffer between the lake and the adjacent land use.

Figure 42. Rice Lake Watershed land cover, feedlots, monitoring sites, and air photo.





Lake conditions

Water quality

Rice Lake is a shallow, highly productive lake with a maximum depth of four ft and a mean depth of approximately three ft (Table 62). Rice Lake does not meet any of the three components of the lake eutrophication standard (Table 87, Figure 61). There are limited temperature and DO depth profile data for Rice Lake. The water column may temporarily stratify, which can lead to intermittent low DO and phosphorus recycling from sediments. However, the extent of stratification and low DO is unknown due to limited data. Data from 2018 show slightly lowered DO concentrations at one-meter depth relative to surface waters (e.g., 7.8 mg/L at 1 m vs. 9.1 at the surface on 8/30/2018).

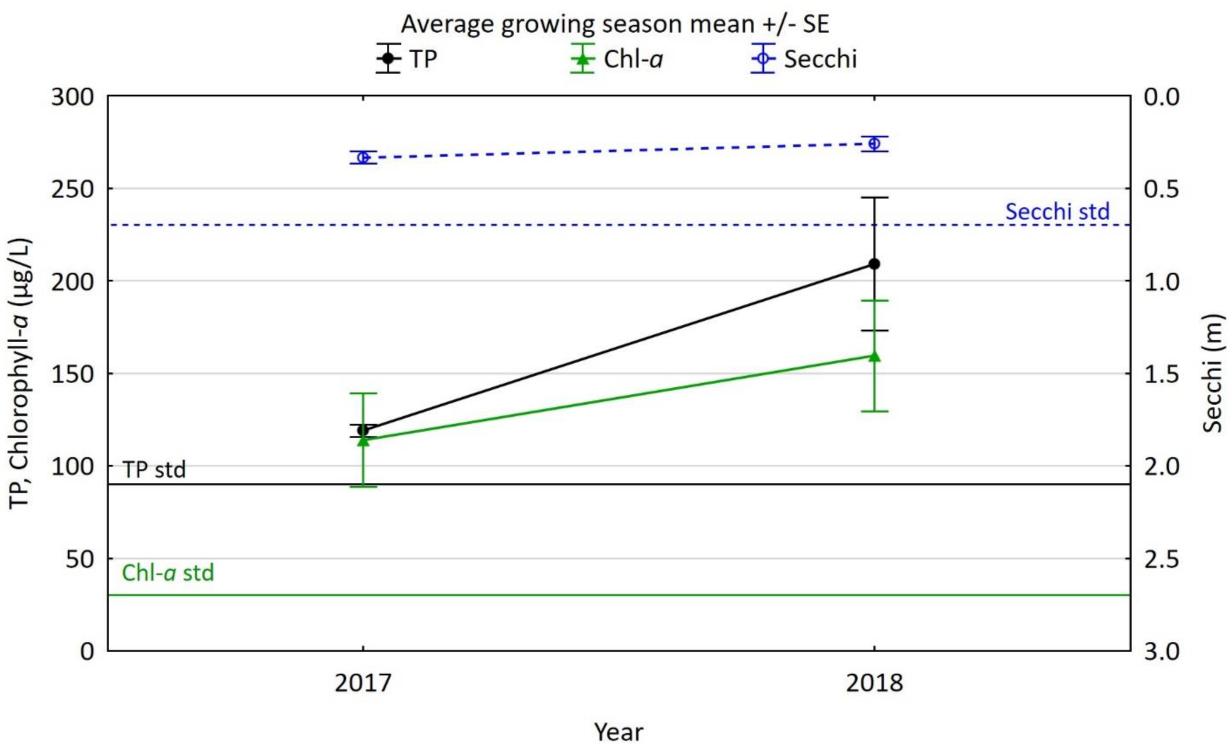
Table 62. Rice Lake morphometry and watershed size.

Surface area (ac)	Maximum depth (ft)	Mean depth (ft)	Watershed area (sq. mi.)	Percent littoral area
257	4	3.2	1.6	100

Table 63. Rice Lake water quality summary (site 22-0007-00-202) and standards.

Parameter	Observed (2017–2018)	Sample size	Water quality standard
TP (µg/L)	164	8	90
Chl-*a* (µg/L)	137	8	30
Secchi (m)	0.30	8	0.7

Figure 43. Rice Lake total phosphorus, chlorophyll-*a*, and Secchi depth means by year, site 202.



Fisheries

The sport fish community in Rice Lake consists of northern pike, black crappie, bluegill, and yellow perch. Walleye fry were stocked in 2003 and northern pike fry were stocked in 2003, 2005, 2007, 2008, 2010, and 2011. The current management plan calls for northern pike fry to be stocked in two out of three years.

Rice Lake has a history of high numbers of black bullhead, which led to DNR reclamations in 1998 and 1999. The lake also has a history of winterkills: even after an aeration system was installed in 2000, the lake experienced a winterkill in 2000–2001. In 2006, the lake was once again shifting toward being dominated by black bullhead, and black bullhead remained high in the last survey in 2011. Carp were not captured in the 2003 or 2006 surveys but were present at moderate to high levels in 2011.

Phosphorus source summary

The primary identified source of phosphorus to the lake is cropland runoff; other sources include watershed runoff from developed areas, internal recycling, and atmospheric deposition (Table 64). The watershed runoff component of "watershed runoff and internal recycling" is in addition to the modeled watershed load and is attributed to loads that were not quantified with the available data. Internal recycling of phosphorus is likely driven by bottom feeding fish such as black bullhead and carp in addition to phosphorus release from sediment.

Table 64. Rice Lake phosphorus sources.

Source		TP Load lb/yr	TP Load %
Watershed runoff	Cropland	341	26
	Developed	17	1
	Natural (grassland, forest, wetland)	12	<1
Watershed runoff and internal recycling		877	65
Atmospheric deposition		96	7
Total		*1,343*	*100*

Rice Lake TMDL summary

To reach the Rice Lake phosphorus standard (90 µg/L), the total load to the lake needs to be reduced by approximately 70%. Loads are allocated to permitted and nonpermitted sources, and load reductions from watershed runoff and internal recycling are needed (Table 65). The Rice Lake TMDL allocations are based on an average annual watershed runoff TP concentration target of 150 µg/L, with the remaining reductions from internal recycling.

Table 65. Rice Lake (22-0007) phosphorus TMDL summary.

- Listing year: 2020
- Baseline year: 2017
- Numeric standard used to calculate TMDL: 90 µg/L TP
- TMDL and allocations apply Jan–Dec

<table>
<tr><th colspan="2" rowspan="2">TMDL parameter</th><th>Existing TP load</th><th colspan="2">TMDL TP load</th><th colspan="2">Estimated load reduction</th></tr>
<tr><th>lb/yr</th><th>lb/yr</th><th>lb/d</th><th>lb/yr</th><th>%</th></tr>
<tr><td rowspan="3">LA</td><td>Watershed runoff</td><td rowspan="2">1,247</td><td>202 [a]</td><td>0.55</td><td rowspan="2">872</td><td rowspan="2">70%</td></tr>
<tr><td>Internal recycling</td><td>173</td><td>0.47</td></tr>
<tr><td>Atmospheric deposition</td><td>96</td><td>96</td><td>0.26</td><td>0</td><td>0%</td></tr>
<tr><td rowspan="2">WLA</td><td>Construction stormwater</td><td>0</td><td>0.47</td><td>0.0013</td><td>0</td><td>0%</td></tr>
<tr><td>Industrial stormwater</td><td>0</td><td>0.47</td><td>0.0013</td><td>0</td><td>0%</td></tr>
<tr><td colspan="2">MOS</td><td>–</td><td>53</td><td>0.15</td><td>–</td><td>–</td></tr>
<tr><td colspan="2">Total load</td><td>1,343</td><td>525</td><td>1.4</td><td>872 [b]</td><td>70%</td></tr>
</table>

a. The watershed runoff allocation equates to 0.26 lb/ac-yr.

b. The total estimated load reduction is greater than the difference between the total existing load and the total TMDL load (i.e., loading capacity) due to the MOS (see Section 4.5.1).

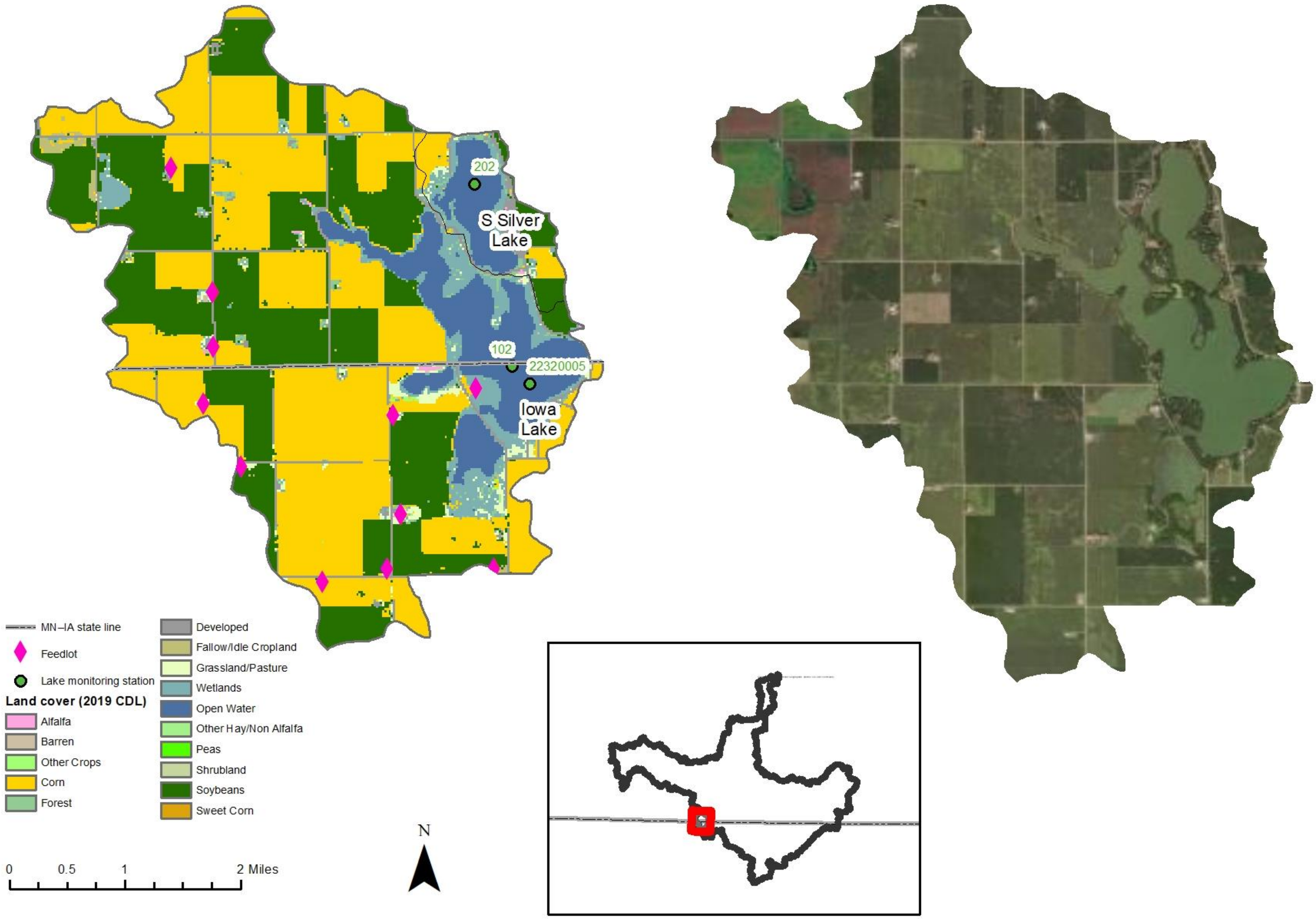
Iowa Lake (46-0049-00)

Watershed characterization

Iowa Lake and its watershed are located on the Minnesota–Iowa border in Martin County, Minnesota and Emmet County, Iowa. Sixty-six percent of the watershed area is in Minnesota and 34% is in Iowa. There are no cities in the watershed (Figure 44). Land cover is approximately 75% corn and soybean rotation, with most of the rest of the watershed open water and wetland (Table 8, Figure 44). Residential development lines the south-east shoreline.

There are approximately 11 feedlots in the Iowa Lake Watershed. None of the three feedlots in the Minnesota portion of the watershed are CAFOs, and the primary livestock type is swine. The Iowa feedlots are a mix of confinement and open feedlots. The maximum capacity of registered feedlots in both states is over 10,000 AUs. Land application of manure from nearby feedlots that are located outside of the Iowa Lake Watershed may also contribute nutrients to Iowa Lake.

Figure 44. Iowa Lake Watershed land cover, feedlots, monitoring sites, and air photo.



Lake conditions

Water quality

Iowa Lake is a shallow lake with a maximum depth of nine feet and a mean depth of approximately five ft (Table 66). Iowa Lake does not meet any of the three components of the lake eutrophication standard (Table 67, Figure 45). Data from 2019 and 2020 are available from the Iowa portion of the lake[1] and are comparable to the data from the Minnesota monitoring site (Figure 45). Temperature and DO depth profile data from 2018 show lower DO concentrations in bottom waters relative to surface water (Figure 46). The water column may temporarily stratify, which can lead to intermittent low DO and phosphorus recycling from sediments. However, the extent of stratification and low DO is unknown due to limited data.

Table 66. Iowa Lake morphometry and watershed size.

Surface area (ac)	Maximum depth (ft)	Mean depth (ft)	Watershed area (sq. mi.)	Percent littoral area
680	9	5.1	15	100

Table 67. Iowa Lake water quality summary (site 46-0049-00-102) and standards.

Parameter	Observed (2017–2018)	Sample size	Water quality standard
TP (µg/L)	149	9	90
Chl-*a* (µg/L)	167	9	30
Secchi (m)	0.27	9	0.7

[1] Data downloaded 6/2/2022 from AquIA https://programs.iowadnr.gov/aquia/Sites/22320005

Figure 45. Iowa Lake growing season means of TP, chl-*a*, and Secchi, sites 101 (2008–2009) and 102 (2017–2018) in Minnesota, site 22320005 (2019–2020) in Iowa.

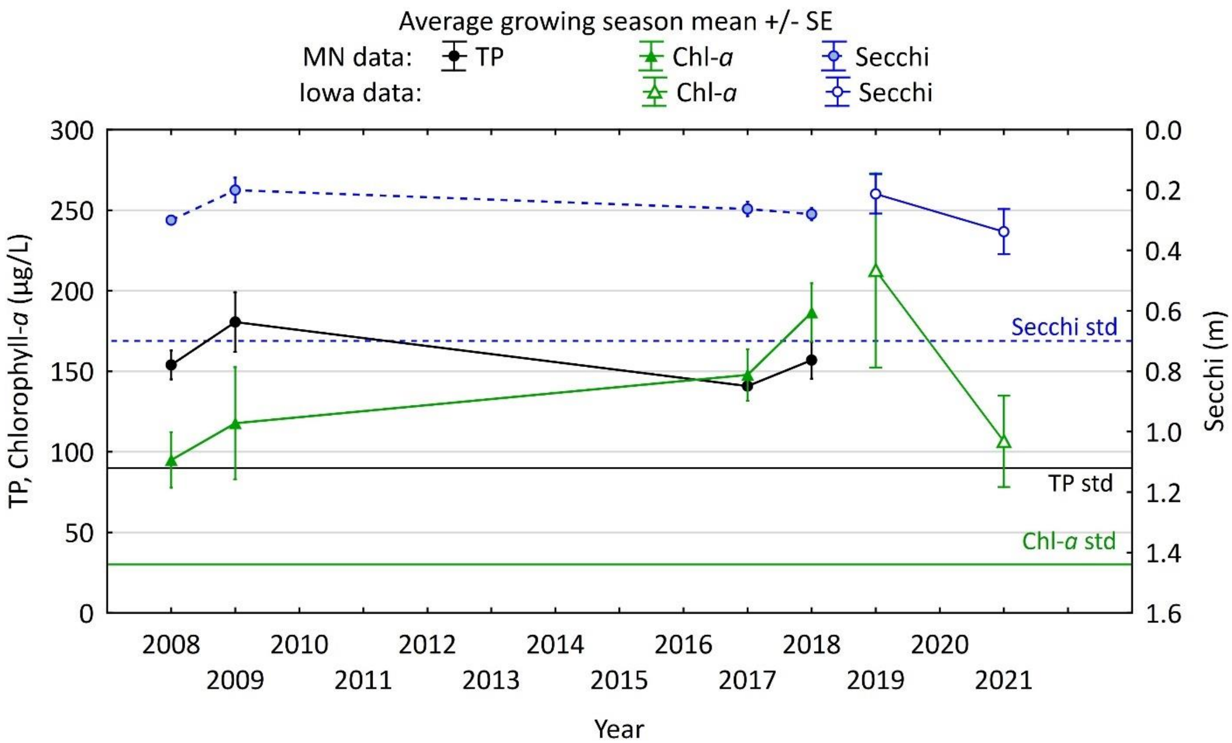
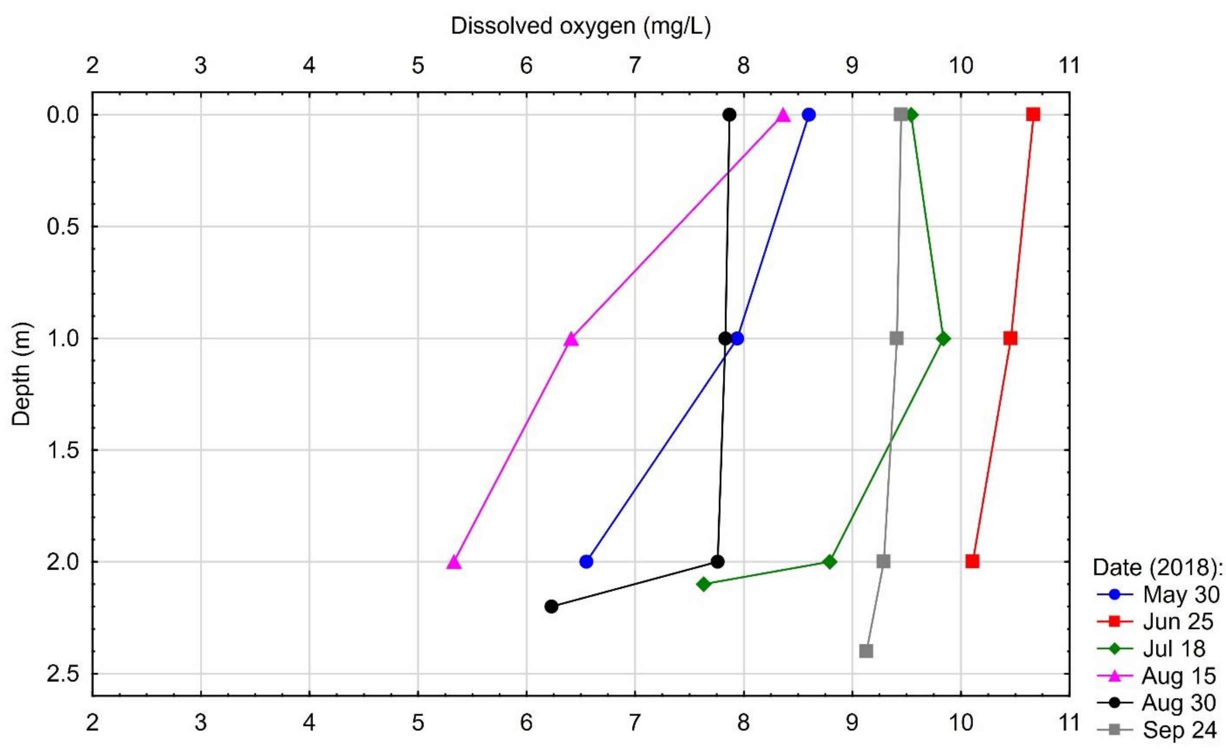


Figure 46. Iowa Lake 2018 dissolved oxygen depth profiles at site 102.



Fisheries

Iowa Lake is managed by the DNR for yellow perch, northern pike, walleye, and black and white crappie. The lake is susceptible to low DO concentrations in the winter, and there was likely a winterkill in 2013–2014. The most recent DNR fisheries survey was conducted in August 2017. Common carp were the most abundant species by weight, followed by bigmouth buffalo, freshwater drum, and black bullhead. Yellow perch numbers were down compared to prior surveys, and northern pike abundance has been low for many years. Black crappie abundance was also low, but the population is successfully reproducing. The Minnesota DNR and Iowa DNR cooperatively manage the lake fishery. Management approaches include using rock barriers to cut off carp spawning areas.

Phosphorus source summary

The primary identified source of phosphorus to the lake is cropland runoff; other sources include watershed runoff from developed areas, internal recycling, and atmospheric deposition (Table 68). The watershed runoff component of "watershed runoff and internal recycling" is in addition to the modeled watershed load and is attributed to loads that were not quantified with the available data. Internal recycling of phosphorus is likely driven by bottom feeding fish such as carp and black bullhead.

Table 68. Iowa Lake phosphorus sources.

Source		TP Load	
		lb/yr	**%**
Watershed runoff	Cropland	4,284	58
	Developed	153	2
	Natural (grassland, forest, wetland)	70	<1
Watershed runoff and internal recycling		2,615	35
Atmospheric deposition		253	3
South Silver Lake outlet		39	<1
Total		*7,414*	*100*

Iowa Lake TMDL summary

To reach the Iowa Lake phosphorus standard (90 µg/L), the total load to the lake needs to be reduced by approximately 60%. Loads are allocated to permitted and nonpermitted sources, and load reductions from watershed runoff and internal recycling are needed (Table 69). The Iowa Lake TMDL allocations are based on an average annual watershed runoff TP concentration target of 150 µg/L, South Silver Lake at existing conditions (48 µg/L), and the remaining reductions from internal recycling.

Table 69. Iowa Lake (46-0049) phosphorus TMDL summary.

- Listing year: 2020
- Baseline year: 2017
- Numeric standard used to calculate TMDL: 90 µg/L TP
- TMDL and allocations apply Jan–Dec

TMDL parameter		Existing TP load	TMDL TP load		Estimated load reduction	
		lb/yr	lb/yr	lb/d	lb/yr	%
Boundary condition at Iowa state line [a]		1,532	787	2.2	745	49%
Boundary condition at South Silver Lake (46-0020) in MN		39	39	0.11	0	0%
LA	Watershed runoff (MN)	5,590	1,523 [b]	4.2	3,360	60%
	Internal recycling		707	1.9		
	Atmospheric deposition	253	253	0.69	0	0%
WLA	Construction stormwater	0	3.4	0.0093	0	0%
	Industrial stormwater	0	3.4	0.0093	0	0%
MOS		–	368	1.0	–	–
Total load		7,414	3,684	10	4,105 [c]	60%

a. This boundary condition load is assigned to the portion of the watershed in Iowa and is not a TMDL allocation (Section 4.5.3). Minnesota cannot establish allocations for other jurisdictions, and any reductions noted in this TMDL that are needed from the watershed area in Iowa are consistent with Minnesota's water quality standards and not more stringent. The remaining load in this table after the Iowa boundary condition is removed represents the Minnesota allocations.

b. The watershed runoff allocation equates to 0.28 lb/ac-yr.

c. The total estimated load reduction is greater than the difference between the total existing load and the total TMDL load (i.e., loading capacity) due to the MOS (see Section 4.5.1).

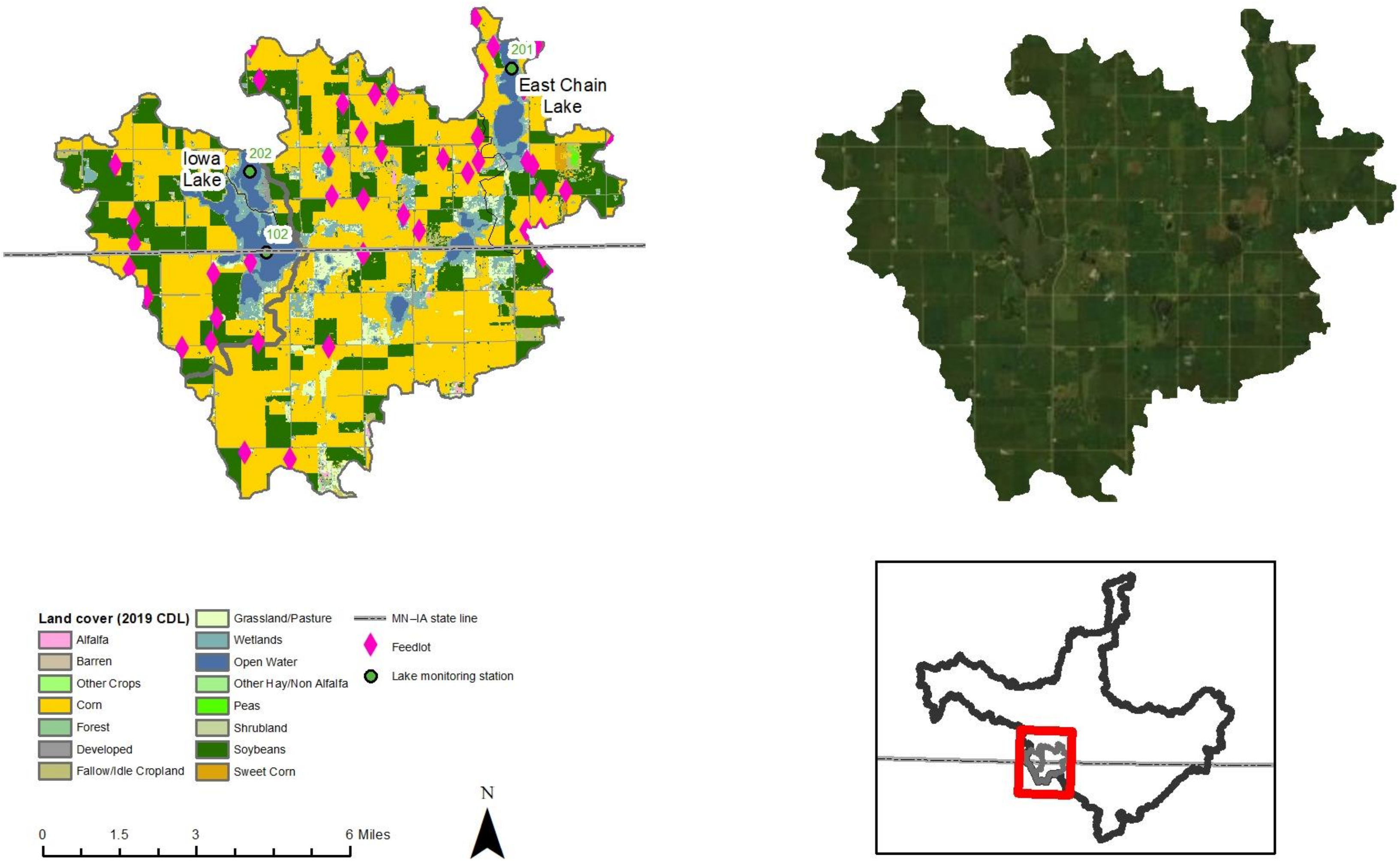
East Chain Lake (46-0010-00)

Watershed characterization

The East Chain Lake Watershed is located on the Minnesota–Iowa border in Martin County, Minnesota and Emmet and Kossuth counties, Iowa. Fifty-six percent of the watershed area is in Minnesota and 44% is in Iowa. The unincorporated community of East Chain is located on the northern shore of the lake. Land cover is approximately 80% corn and soybean rotation, with the majority of the rest of the watershed open water and wetland (Table 8, Figure 47).

There are approximately 29 registered feedlots in the East Chain Lake Watershed downstream of Iowa Lake. Sixteen of the 25 feedlots in the Minnesota portion of the watershed are CAFOs. The primary livestock type in the Minnesota feedlots (CAFOs and non-CAFOs) are swine (13,000 AUs) and beef cattle (4,700 AUs). The Iowa feedlots are a mix of confinement and open feedlots, with 12,600 AUs. Land application of manure from nearby feedlots that are located outside of the East Chain Lake Watershed may also contribute nutrients to East Chain Lake.

Figure 47. East Chain Lake Watershed land cover, feedlots, monitoring sites, and air photo.



Lake conditions

Water quality

East Chain Lake is a shallow lake with a maximum depth of six ft and a mean depth of approximately five ft (Table 70). East Chain Lake does not meet any of the three components of the lake eutrophication standard (Table 71, Figure 48). There is no temperature or DO depth profile data for East Chain Lake. The water column may temporarily stratify, which can lead to intermittent low DO and phosphorus recycling from sediments. However, the extent of stratification and low DO is unknown due to limited data.

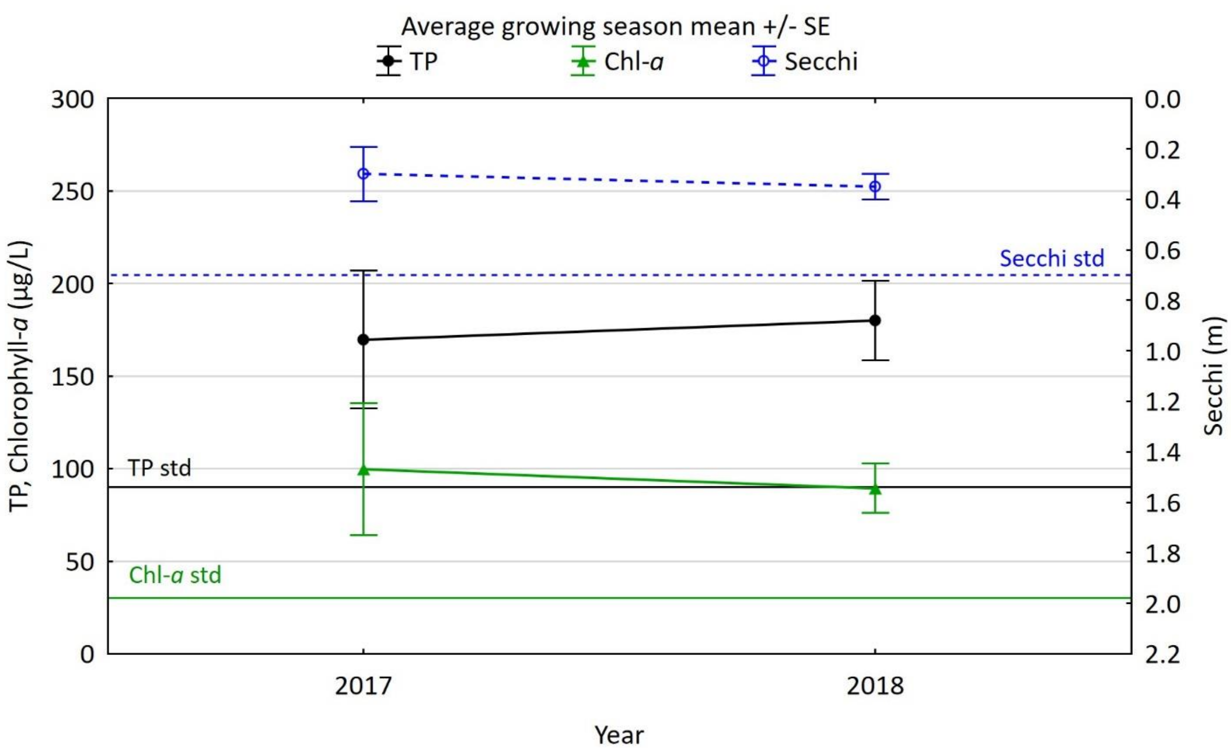
Table 70. East Chain Lake morphometry and watershed size.

Surface area (ac)	Maximum depth (ft)	Mean depth (ft)	Watershed area (sq. mi.)	Percent littoral area
479	6	5.1	57	100

Table 71. East Chain Lake water quality summary (site 46-0010-00-201) and standards.

Parameter	Observed (2017–2018)	Sample size	Water quality standard
TP (µg/L)	175	8	90
Chl-*a* (µg/L)	95	8	30
Secchi (m)	0.33	8	0.7

Figure 48. East Chain Lake growing season means of TP, chl-*a*, and Secchi, site 201.



Fisheries

East Chain Lake is managed by the DNR for northern pike, with yellow perch as the secondary management species. The lake is susceptible to low DO concentrations in the winter, and winterkills were documented during the winters of 2000–2001, 2008–2009, and 2013–2014. The most recent DNR fisheries survey was conducted in May 2019. Species sampled included northern pike, yellow perch, and black crappie. Black bullhead and carp densities were above normal. Modifications to the outlet control structure are being considered to improve fish passage.

Phosphorus source summary

The primary identified source of phosphorus to the lake is cropland runoff; other sources include watershed runoff from developed areas, internal recycling, and atmospheric deposition (Table 72). The watershed runoff component of "watershed runoff and internal recycling" is in addition to the modeled watershed load and is attributed to loads that were not quantified with the available data. Internal recycling of phosphorus is likely driven by bottom feeding fish such as black bullhead and carp.

Table 72. East Chain Lake phosphorus sources.

Source		TP Load	
		lb/yr	**%**
Watershed runoff	Cropland	13,231	46
	Pasture	127	<1
	Developed	449	2
	Natural (forest, grassland, wetland)	215	<1
Watershed runoff and internal recycling		11,998	42
Atmospheric deposition		178	<1
Iowa Lake Outlet		2,616	9
Total		*28,814*	*100*

East Chain Lake TMDL summary

To reach the East Chain Lake phosphorus standard (90 µg/L), the total load to the lake needs to be reduced by approximately 63%. Loads are allocated to permitted and nonpermitted sources, and load reductions from watershed runoff and internal recycling are needed (Table 73). The East Chain Lake TMDL allocations are based on an average annual watershed runoff TP concentration target of 150 µg/L, Iowa Lake meeting water quality standards (90 µg/L), and the remaining reductions from internal recycling.

Table 73. East Chain Lake (46-0010) phosphorus TMDL summary.

- Listing year: 2020
- Baseline year: 2017
- Numeric standard used to calculate TMDL: 90 µg/L TP
- TMDL and allocations apply Jan–Dec

<table>
<tr><th colspan="2" rowspan="2">TMDL parameter</th><th>Existing TP load</th><th colspan="2">TMDL TP load</th><th colspan="2">Estimated load reduction</th></tr>
<tr><th>lb/yr</th><th>lb/yr</th><th>lb/d</th><th>lb/yr</th><th>%</th></tr>
<tr><td colspan="2">Boundary condition at Iowa state line [a]</td><td>6,702</td><td>3,508</td><td>9.6</td><td>3,194</td><td>48%</td></tr>
<tr><td colspan="2">Boundary condition at Iowa Lake (46-0049)</td><td>2,616</td><td>1,580</td><td>4.3</td><td>1,036</td><td>40%</td></tr>
<tr><td rowspan="3">LA</td><td>Watershed runoff (MN)</td><td rowspan="2">19,318</td><td>3,822 [b]</td><td>10</td><td rowspan="2">13,806</td><td rowspan="2">71%</td></tr>
<tr><td>Internal recycling</td><td>1,690</td><td>4.6</td></tr>
<tr><td>Atmospheric deposition</td><td>178</td><td>178</td><td>0.49</td><td>0</td><td>0%</td></tr>
<tr><td rowspan="2">WLA</td><td>Construction stormwater</td><td>0</td><td>5</td><td>0.014</td><td>0</td><td>0%</td></tr>
<tr><td>Industrial stormwater</td><td>0</td><td>5</td><td>0.014</td><td>0</td><td>0%</td></tr>
<tr><td colspan="2">MOS</td><td>–</td><td>1,199</td><td>3.2</td><td>–</td><td>–</td></tr>
<tr><td colspan="2">Total load</td><td>28,814</td><td>11,987</td><td>32</td><td>18,036 [c]</td><td>63%</td></tr>
</table>

a. This boundary condition load is assigned to the portion of the watershed in Iowa and is not a TMDL allocation (Section 4.5.3). Minnesota cannot establish allocations for other jurisdictions, and any reductions noted in this TMDL that are needed from the watershed area in Iowa are consistent with Minnesota's water quality standards and not more stringent. The remaining load in this table after the Iowa boundary condition is removed represents the Minnesota allocations.

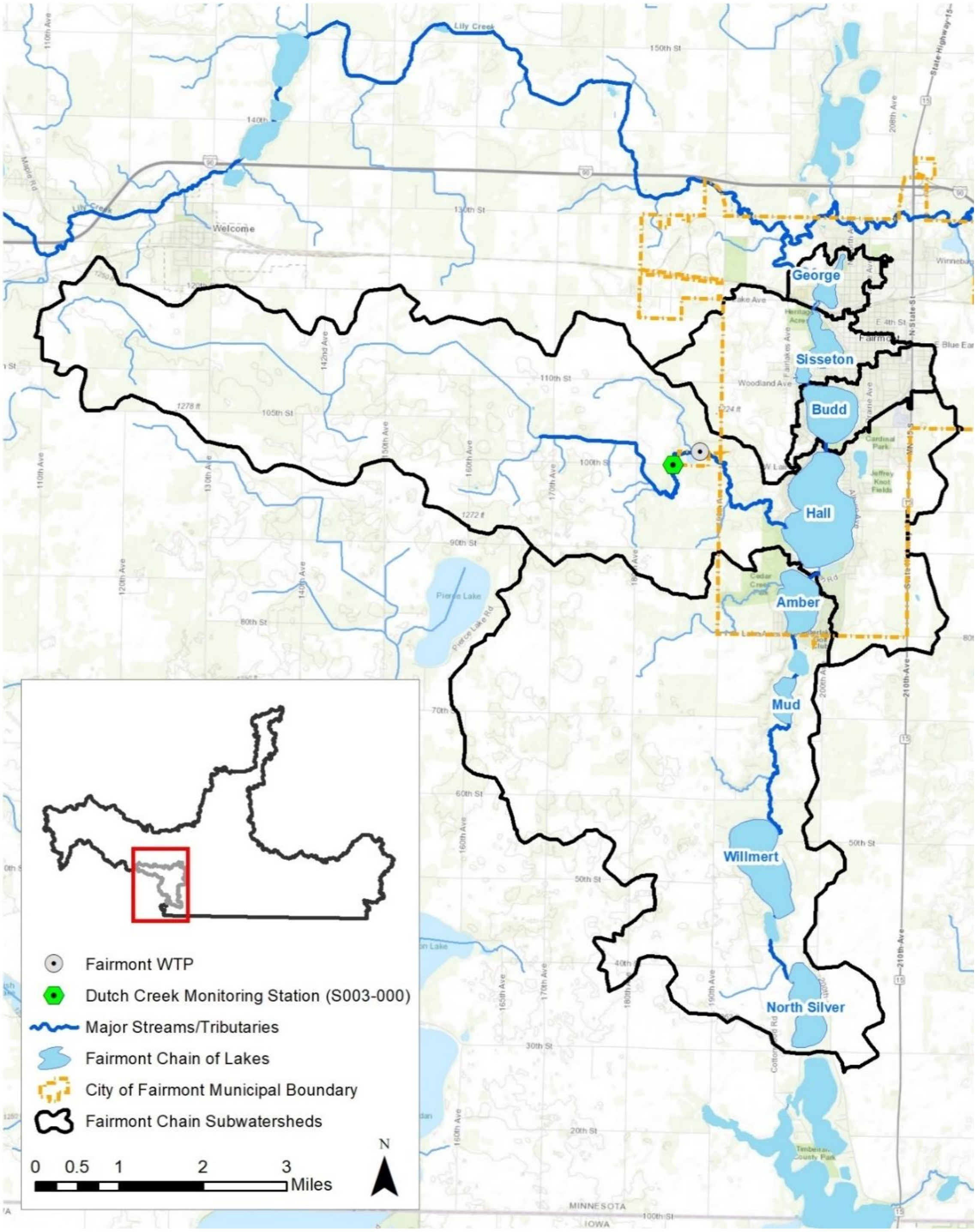
b. The watershed runoff allocation equates to 0.28 lb/ac-yr.

c. The total estimated load reduction is greater than the difference between the total existing load and the total TMDL load (i.e., loading capacity) due to the MOS (see Section 4.5.1).

Fairmont Chain of Lakes: Amber (46-0034-00), Hall (46-0031-00), Budd, (46-0030-00), Sisseton (46-0025-00), and George (46-0024-00)

The *Blue Earth River Watershed Lake Water Quality Improvement Study* (MPCA 2023a) includes supporting information to the Fairmont Chain of Lakes analysis presented in this report. Figure 49 shows an overview of the Fairmont Chain of Lakes Watershed.

Figure 49. Fairmont Chain of Lakes Watershed overview.



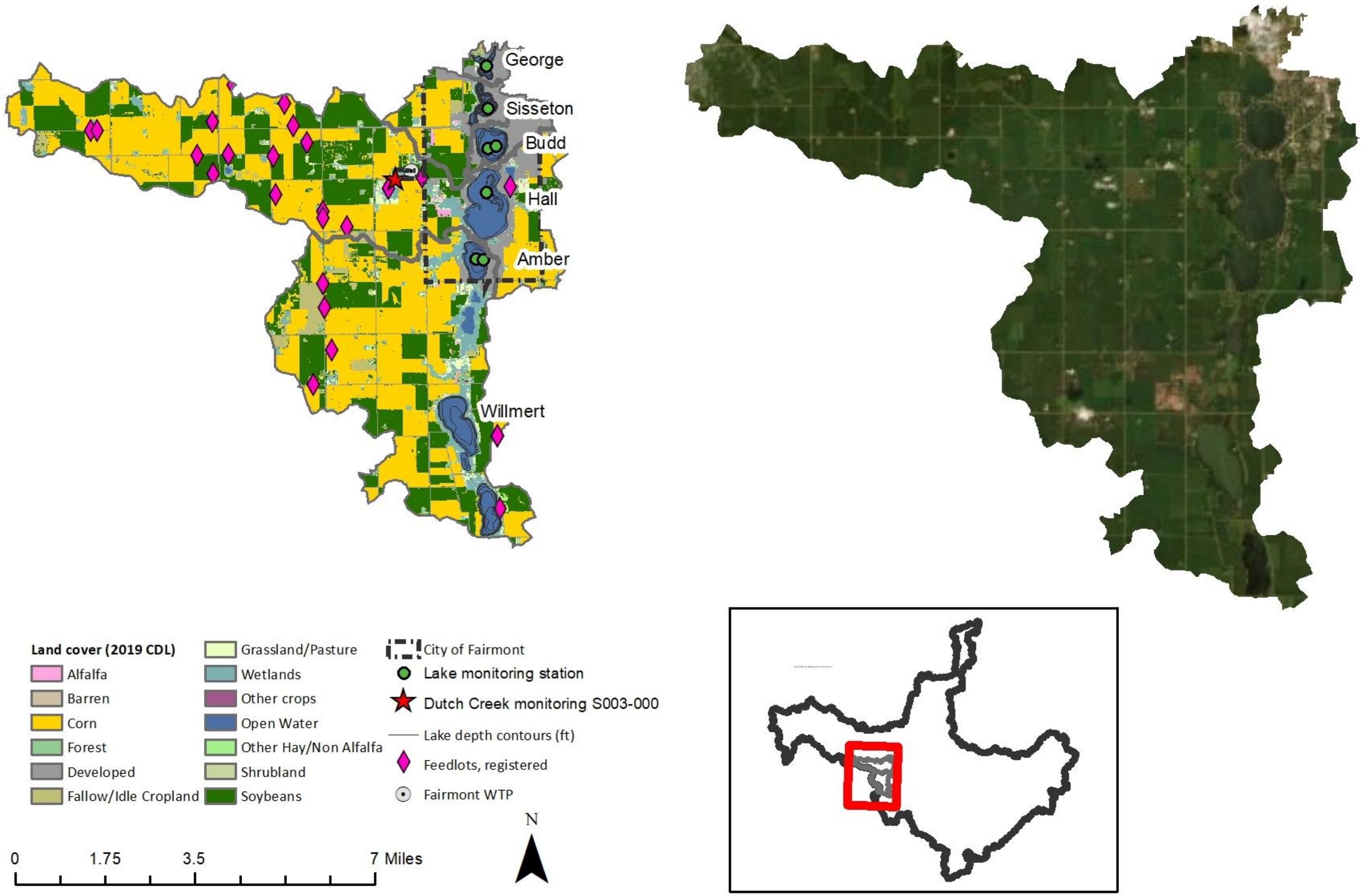
Watershed characterization

Land cover throughout the Fairmont Chain of Lakes Watershed is primarily agricultural, with corn and soybeans the dominant crops (Figure 50, Table 8). Other crops are present, such as alfalfa and other hay crops, but generally represent less than 3% of each lake's direct drainage area. There is little variation in elevation across the watershed. Agricultural lands are flat (slope less than 3%) and are typically tile-drained, which impacts watershed hydrologic pathways. All five lakes are situated within the city of

Fairmont and therefore developed land (e.g., residential, commercial / industrial, park land) represents a substantial portion of the direct drainage areas. Overall, developed land represents approximately 11% of the Fairmont Chain of Lakes' total drainage area.

There are 24 registered feedlots within the Fairmont Chain of Lakes drainage area, four of which are CAFOs with an NPDES permit (Table 16). All of the feedlots are located in the Amber and Hall Lake drainage areas (Figure 50). Swine account for nearly all (94%) of the registered livestock in the watershed, followed by cattle (6%). Land application of manure from nearby feedlots that are located outside of the Fairmont Chain of Lakes Watershed may also contribute nutrients to the Fairmont Chain of Lakes.

Figure 50. Fairmont Chain of Lakes Watershed land cover, feedlots, monitoring sites, and air photo.



Lake conditions

Water quality

Water quality samples were collected by Martin SWCD staff on each of the Fairmont Chain of Lakes priority lakes in 2017, 2018, 2020, and 2021. University of Minnesota Lake Browser chl-*a* and Secchi depth data are available for each impaired lake from 2017 through 2021 and were combined with the field samples.

TP data indicate mean summer growing season concentrations for Hall, Budd, and Sisseton Lakes, when averaged over the recent five-year monitoring period (2017 through 2021), were below the 90 µg/L shallow lake standard (Table 75, Figure 51). Amber and George lakes are the only priority lakes that exceeded the shallow lake TP standard. Mean summer TP concentrations fluctuate from year to year in each lake depending on various environmental factors such as temperature, rainfall, timing of storm events and drought conditions, antecedent water quality conditions (i.e., previous fall or summer), and water quality conditions in upstream lake(s).

None of the priority lakes in the Fairmont Chain of Lakes met the 30 µg/L WCBP shallow lake chl-*a* standard (Table 75, Figure 52). Mean summer chl-*a* concentrations ranged from 44 µg/L in Hall Lake to 81 µg/L in George Lake. The chl-*a* standard was exceeded over 65% of the summer growing season in all of the priority lakes indicating nuisance algae blooms are common throughout the Fairmont Chain of Lakes.

Despite high chl-*a* levels, mean summer Secchi depths for all five lakes met the 0.7-meter shallow lake standard from 2017 through 2021 (Table 75, Figure 53). Water clarity in the priority lakes generally followed a pattern of clear conditions early in the season (i.e., May, June, and early July) followed by sharp declines in clarity in late summer when chl-*a* levels increased.

Table 74. Fairmont Chain of Lakes morphometry and watershed size.

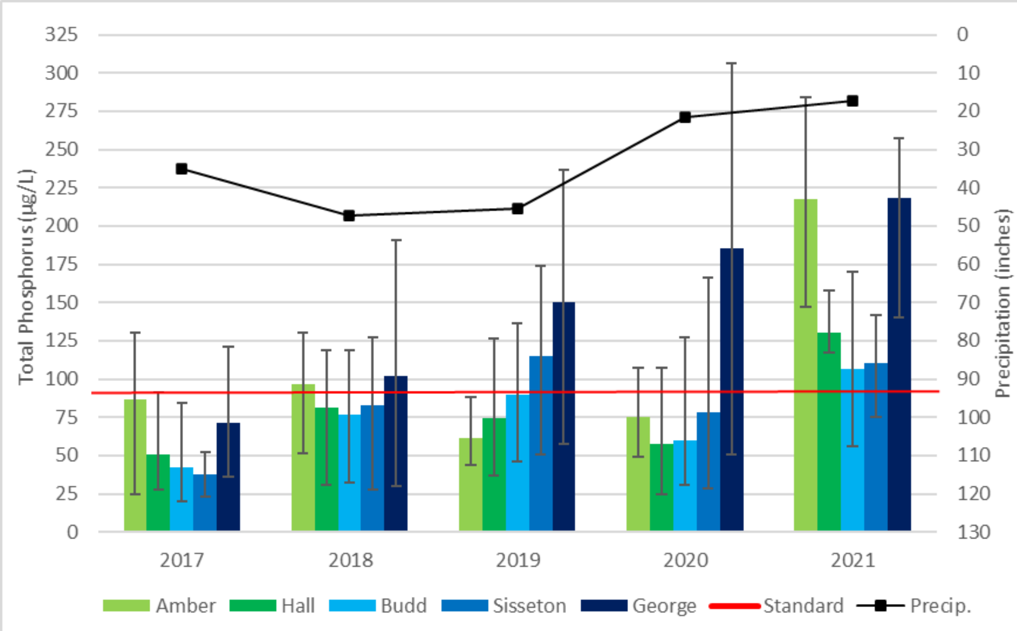
Lake	Surface area (ac)	Maximum depth (ft)	Mean depth (ft)	Watershed area (including lake surface area; ac)	Percent littoral area
Amber	182	16.5	12.1	11,926	64
Hall	548	27	7.8	25,787	91
Budd	228	23	12.8	26,538	49
Sisseton	138	18.5	9.5	28,510	79
George	83	10	5.6	28,938	100

Table 75. Fairmont Chain of Lakes 2017–2021 water quality summary and standards.

	TP (µg/L)		Chl-*a* (µg/L)		Secchi (m)	
Parameter	**µg/L**	**N**	**µg/L**	**N**	**M**	**N**
Amber	107	54	63	67	1.0	97
Hall	79	56	44	67	1.1	68
Budd	75	52	64	61	1.3	78
Sisseton	85	51	73	60	1.2	85
George	145	39	81	58	1.0	70

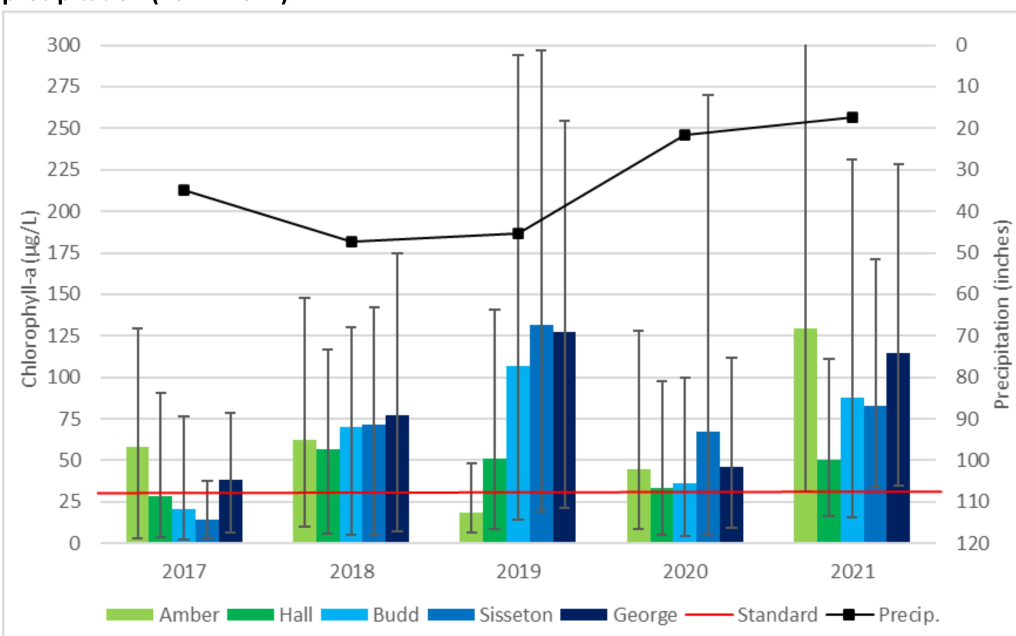
Water quality standard	90		30		0.7	

Figure 51. Fairmont Chain of Lakes summer growing season mean TP concentrations (solid bars) and annual precipitation (2017–2021).



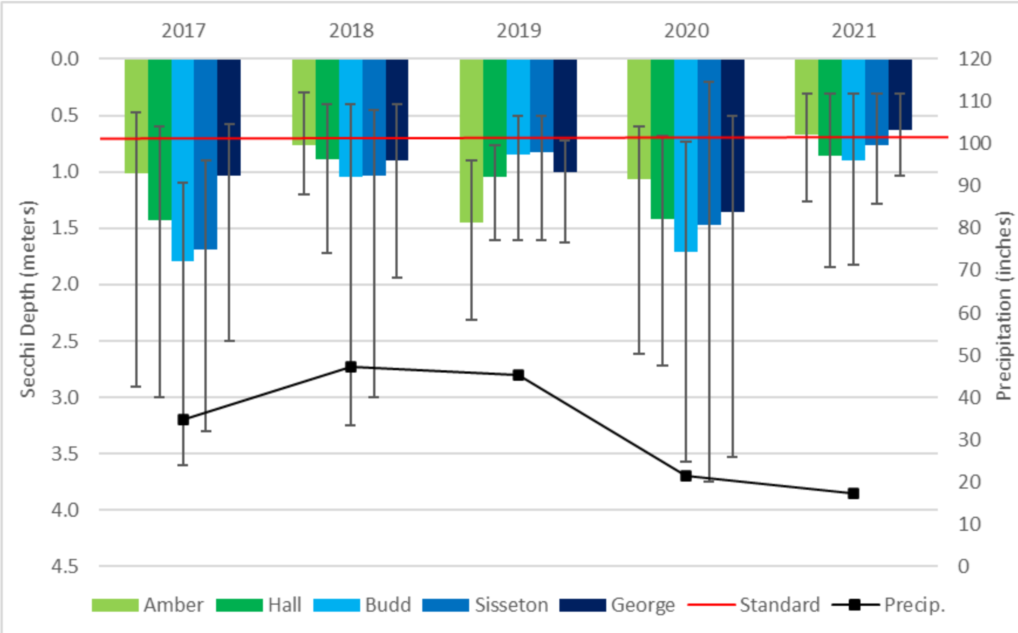
Error bars represent maximum and minimum summer growing season TP concentrations.

Figure 52. Fairmont Chain of Lakes summer growing season mean chl-*a* concentrations (solid bars) and annual precipitation (2017–2021).



Error bars represent maximum and minimum concentrations.

Figure 53. Fairmont Chain of Lakes summer growing season mean Secchi depth (solid bars) and annual precipitation (2017–2021).



Error bars represent maximum and minimum Secchi depth.

There are multiple lines of evidence that suggest that internal phosphorus recycling occurs within the Fairmont Chain of Lakes:

- Surface TP concentrations in all five lakes increase from June through August each year despite generally decreasing flows, external TP concentrations, and external TP loads during this time period
- 2021 mean summer TP concentrations for Amber, Hall, Budd, and George were higher than previous summers (2017 through 2020) despite extremely low rainfall totals, runoff volumes, external TP concentrations, and external TP loads in 2021
- Although temperature and DO profile data is rather limited, surface TP concentration spikes have been observed in most of the lakes when thermal stratification weakens and/or breaks down in late summer
- Phosphorus settling/retention rates in the BATHTUB models had to be reduced from default values to calibrate the Budd, Sisseton, and George models to observed values.

This study does not attempt to explicitly quantify the amount of phosphorus that is recycled within the lakes due to a general lack of data to confidently estimate this. Because internal phosphorus recycling reflects recycling of loads that originally entered the lake from the watershed, the amount of P recycling is expected to vary with external load. Internal phosphorus recycling is implicitly accounted for by the process used to develop and calibrate the lake BATHTUB models (Section 4.5.1 and MPCA 2023a).

The *Blue Earth River Watershed Lake Water Quality Improvement Study* (MPCA 2023a) contains supporting information and additional water quality analysis on the Fairmont Chain of Lakes.

Fisheries

The Fairmont Chain of Lakes is a popular fishing destination for anglers in southwest Minnesota. There are no major barriers among the lakes in the Fairmont Chain of Lakes, so fish are able to move relatively freely throughout the chain during high water levels. The lakes are primarily managed by the DNR for walleye and muskellunge, and secondarily for several species including black crappie, yellow perch, bluegill, and channel catfish. DNR assessment reports indicate that fish communities in the Fairmont Chain of Lakes have undergone several changes over the last 40 years. Below is a summary of some of the important changes and trends noted in the DNR reports:

- Beginning in the mid-1980s, survey numbers for several key gamefish species, including walleye, bluegill, white crappie, and yellow perch, began to decline.
- During the 1980s, catch rates increased for several less desirable fish species such as black bullhead, common carp, and freshwater drum. It is unclear whether the increase in the less desirable species caused the decrease in gamefish by destroying vegetation and by predation, or if the decrease in gamefish allowed the less desirable species to fill a void that was left when the gamefish numbers decreased.
- Historically, some of the shallower basins in the Fairmont Chain of Lakes have been susceptible to winterkills. It is suspected that mild winters over the past 20+ years have reduced the frequency and severity of winterkill in the Fairmont Chain of Lakes.
- In or around 2012, yellow bass were illegally introduced to the Fairmont Chain of Lakes and have since established a self-sustaining population. Although yellow bass are native to Minnesota, this species tends to become very abundant in a fish community and can outcompete other desirable fish, such as yellow perch. Recent surveys indicate that yellow bass are one of the most abundant panfish in several of the Fairmont lakes.
- In 2016, muskellunge were introduced by the DNR to the Fairmont Chain of Lakes to provide an additional predator species and biological control for undesired species. It will likely take at least 5 to 10 years for muskellunge to become a noticeable member of the fish community.

Despite some of these changes, a total of 18 fish species have been sampled throughout the Fairmont Chain of Lakes since 2000, making it one of the more diverse fish communities in the region.

Although common carp density has not been assessed in the Fairmont Chain of Lakes, DNR surveys provide a relative means to track carp trends and changes over time within a lake and compare catch rates to other lakes. Some of the key takeaways from the DNR survey data include:

- In Amber Lake, common carp catch rates were moderate (i.e., within the normal range of similar lakes) throughout the 1970s and 1980s and then increased to at or above the upper normal range throughout much of the 1990s. Common carp catch rates peaked in 2001 following a significant winter kill event, and have decreased in nearly every survey since 2001. During the most recent survey in 2018, common carp catch rates for both lakes were near the median of similar lakes in the region. Common carp average weights, on the other hand, have steadily increased in both lakes since the 2001 winterkill and were at or above the upper normal range during the 2018 survey. This suggests that while total carp numbers in Amber may be on the decline, several large carp remain in these lakes.

- Common carp catch rates for Hall, Budd, Sisseton, and George Lakes have been steadily decreasing from peak values in 1989 that were well above the upper normal range for similar lakes. During the most recent surveys, common carp catch rates were within the normal range for Hall, Budd, and Sisseton, while George was still slightly above the upper normal range. Similar to Amber, common carp average weights have steadily increased in Hall, Budd, Sisseton, and George. Average weights were above the upper normal range in all four lakes during the most recent survey.
- When comparing lakes across the chain, Amber has historically had the highest common carp catch rates but lowest average weight. Conversely, Budd and Sisseton tend to have the lowest catch rates and highest average weights.

Phosphorus source summary

The primary identified sources of phosphorus to the Fairmont Chain of Lakes are from cropland and feedlot agricultural runoff (Table 76). Other sources include internal recycling and watershed runoff from developed areas. The internal recycling/unidentified load in Table 76 is attributed to recycled phosphorus loading and/or other sources such as watershed loads that were not quantified with the available data. Given the moderate to high common carp catch rates and high average weights in the Fairmont Chain of Lakes, it is possible, if not likely, that common carp have some impact on water quality conditions throughout the chain. The primary process by which common carp affect water quality in lakes is through resuspension of bottom sediments which, in turn, can increase internal phosphorus recycling and reduce phosphorus sedimentation and retention.

The *Blue Earth River Watershed Lake Water Quality Improvement Study* (MPCA 2023a) includes tables with the phosphorus sources to each impaired lake individually.

Table 76. Fairmont Chain of Lakes phosphorus sources.

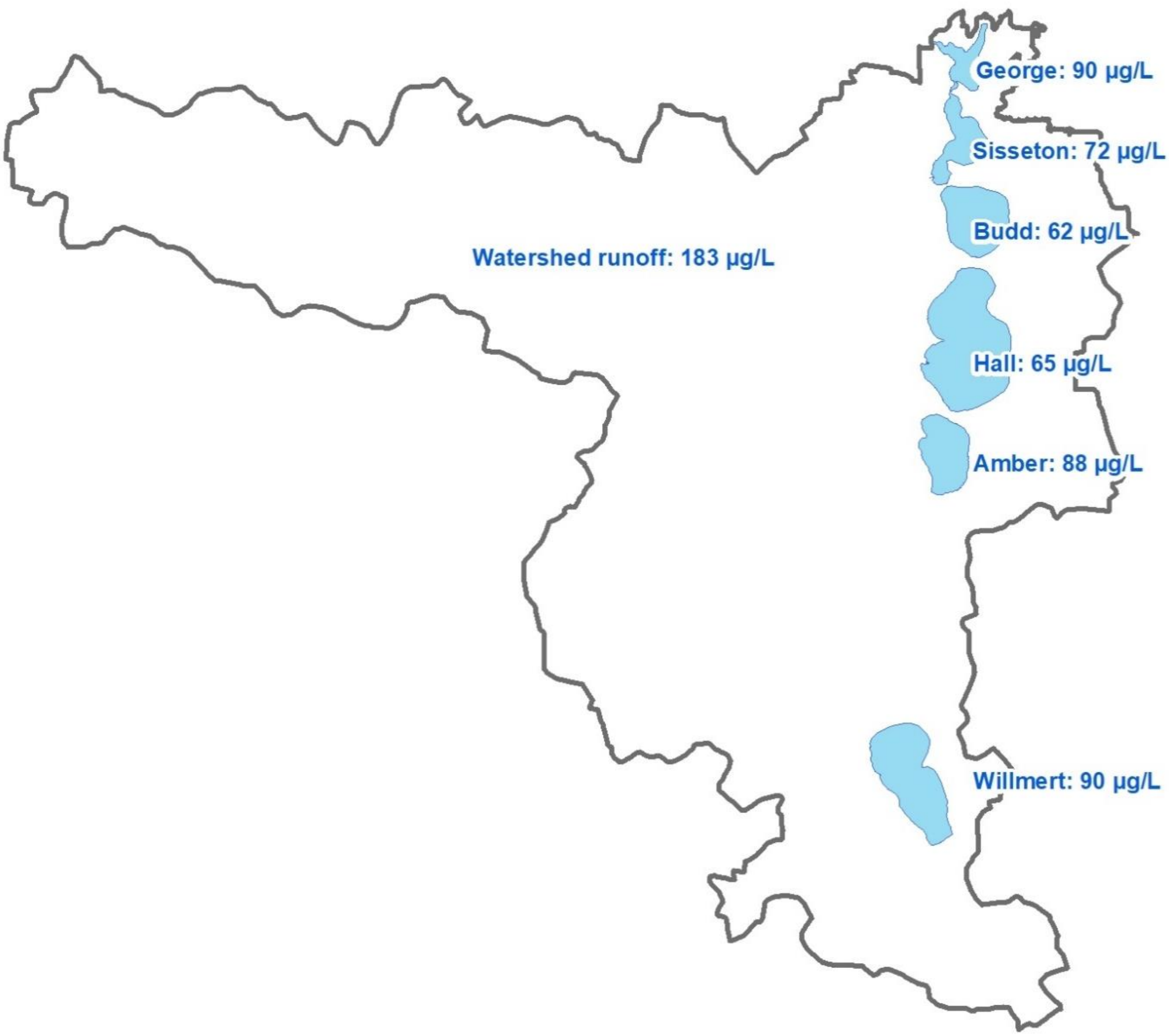
Source		Area (acres)	TP Load (lb/season)	% Load
Willmert Lake outlet		3,603	610	4%
Watershed runoff, noncity area	Cropland and feedlot	16,631	10,073	58%
	Grassland and pasture	488	121	<1%
	Developed	768	207	1%
	Forest and shrub	252	14	<1%
	Wetland and open water	922	58	<1%
Watershed runoff, city area	Developed	2,444	1,123	6%
	Cropland and feedlot	2,509	1,267	7%
	Wetlands and ponds [a]	142	0	0%
Atmospheric deposition		1,179	439	3%
Internal recycling / unidentified		0	3,381	20%
Total		*28,938*	*17,293*	*100*

a. Simple Estimator default rates assume zero net flow and TP loading from wetlands, ponds, and open water areas.

Fairmont Chain of Lakes TMDL summary

The Fairmont Chain of Lakes TMDL scenario achieves lake water quality standards in all five impaired lakes (Figure 54). In the TMDL scenario, all watershed runoff inputs have a TP concentration of 183 µg/L, Willmert Lake meets its TP criterion (90 µg/L), and internal recycling and/or unidentified loads to George Lake are reduced by 77% (Table 77). TP concentrations are expected to be below the TP criterion in Hall, Budd, and Sisseton; these water quality conditions are needed for George Lake (the most downstream lake in the chain) to meet the TP criterion. The Fairmont Chain of Lakes TMDL establishes loading targets for the lake system as a whole. Loading goals for the individual impaired lakes are provided in the *Blue Earth River Watershed Lake Water Quality Improvement Study* (MPCA 2023a).

Figure 54. Fairmont Chain of Lakes TMDL scenario: lake and watershed runoff TP concentrations.



To reach the phosphorus standard (90 µg/L) in all five impaired lakes in the Fairmont Chain of Lakes, the total load needs to be reduced by approximately 39%. Loads are allocated to permitted and nonpermitted sources, and load reductions from watershed runoff, upstream lakes, and internal recycling are needed (Table 77). The Fairmont Chain of Lakes TMDL allocations are based on an average annual watershed runoff TP concentration target of 183 µg/L, Willmert Lake at its water quality target of 90 µg/L, and the remaining reductions from internal recycling or unidentified sources.

Table 77. Fairmont Chain of Lakes phosphorus TMDL summary: Amber (46-0034-00), Hall (46-0031-00), Budd, (46-0030-00), Sisseton (46-0025-00), and George (46-0024-00).

Loading goals for the individual impaired lakes are provided in the *Blue Earth River Watershed Lake Water Quality Improvement Study* (MPCA 2023a).

- Listing year: 2006
- Baseline year: 2021
- Numeric standard used to calculate TMDL: 90 µg/L TP
- TMDL and allocations apply Apr–Oct

TMDL parameter		Existing TP load	TMDL TP load		Estimated load reduction	
		lb/season [a]	lb/season	lb/d	lb/season	%
Willmert Lake [b]		602	579	2.4	23	4%
LA	Watershed runoff (unregulated)	10,432	7,631 [c]	32	2,801	27%
	Internal recycling / unidentified (to George Lake)	3,381	0	0.0	3,381	100% [c]
	Atmospheric deposition	439	439	1.8	0	0%
WLA	Watershed runoff, city of Fairmont MS4 (MS400239) [d]	2,390	1,855 [e]	7.7	535	22%
	Construction stormwater (non-MS4 area)	25	25	0.10	0	0%
	Industrial stormwater (non-MS4 area)	25	25	0.10	0	0%
MOS			776	3.2		
Total load		17,294	11,330	47	6,740 [f]	39%

a. "Season" in this TMDL represents April through October.

b. Willmert Lake existing loading assumes TP of 93 µg/L and TMDL load assumes TP of 90 µg/L.

c. 100% reduction in internal recycling assumes that the additional internal recycling is removed, and the remaining internal recycling to the lake equals the average rate of internal recycling that is implicit in BATHTUB (see Section 4.5.2).

d. Includes developed and agricultural areas in the city boundary in addition to permitted construction and industrial stormwater.

e. Assumes a TP watershed runoff concentration of 183 µg/L. See Section 4.5.4.2 and Appendix D for more information about the MS4 WLA.

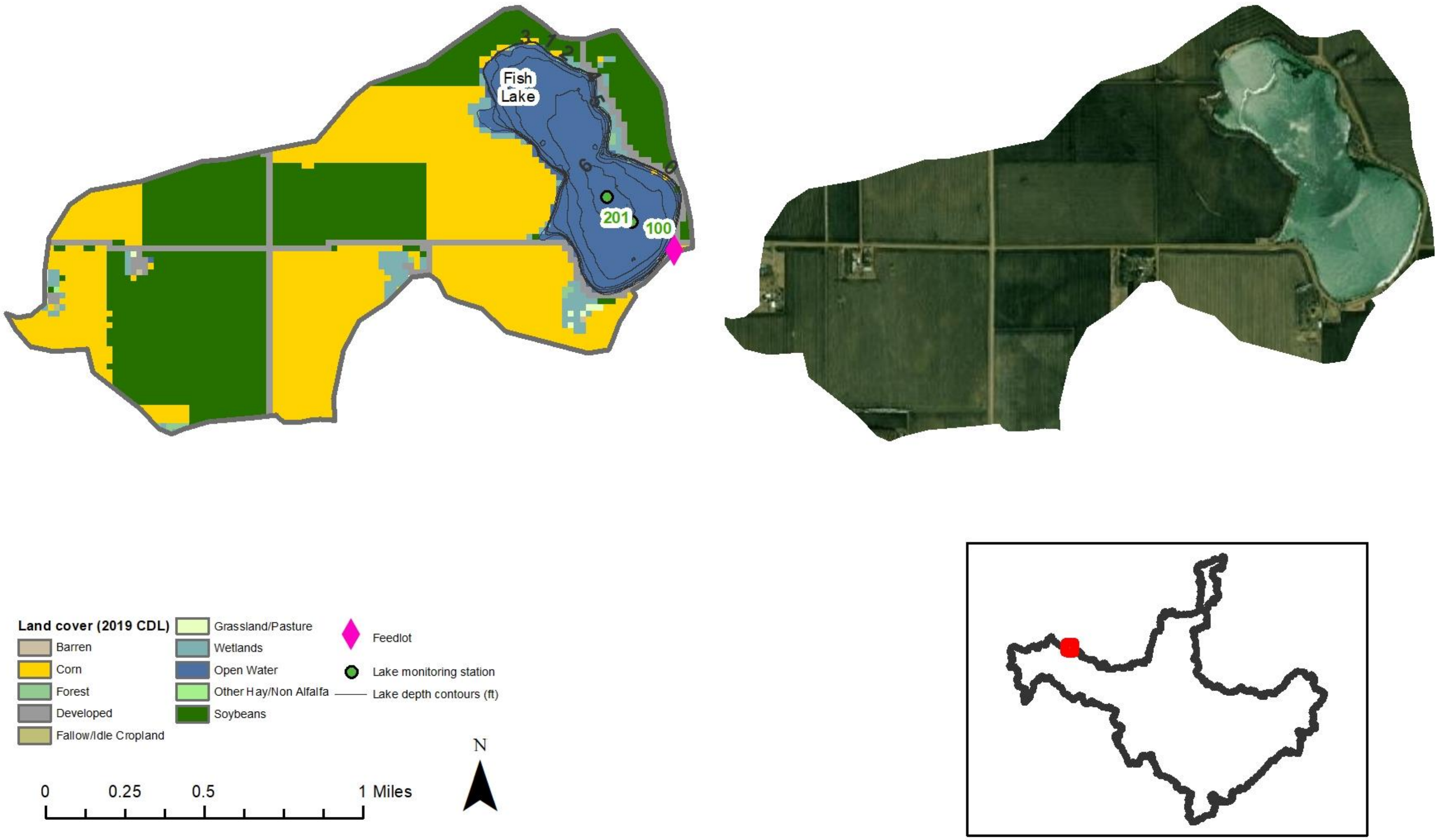
f. The total estimated load reduction is greater than the difference between the total existing load and the total TMDL load (i.e., loading capacity) due to the MOS (see Section 4.5.1).

Fish Lake (46-0145-00)

Watershed characterization

The Fish Lake Watershed is relatively small (less than two square miles), with a watershed to lake ratio of 7:1. The entire watershed is in Martin County, and there are no cities in the watershed (Figure 55). Land cover is approximately 77% corn and soybean rotation, with the majority of the rest of the watershed open water, wetlands, and roads (Table 8, Figure 55). There is one feedlot in the watershed, on the southeastern shore, but this feedlot does not currently have livestock. Land application of manure from nearby feedlots that are located outside of the Fish Lake Watershed may contribute nutrients to the lake.

Figure 55. Fish Lake Watershed land cover, feedlots, monitoring sites, and air photo.



Lake conditions

Water quality

Fish Lake is a shallow lake with a maximum depth of five feet and a mean depth of 4.5 feet (Table 78). Fish Lake does not meet any of the three components of the lake eutrophication standard (Table 79, Figure 56). There is no temperature or DO depth profile data for Fish Lake. The water column may temporarily stratify, which can lead to intermittent low DO and phosphorus recycling from sediments. However, the extent of stratification and low DO is unknown due to limited data.

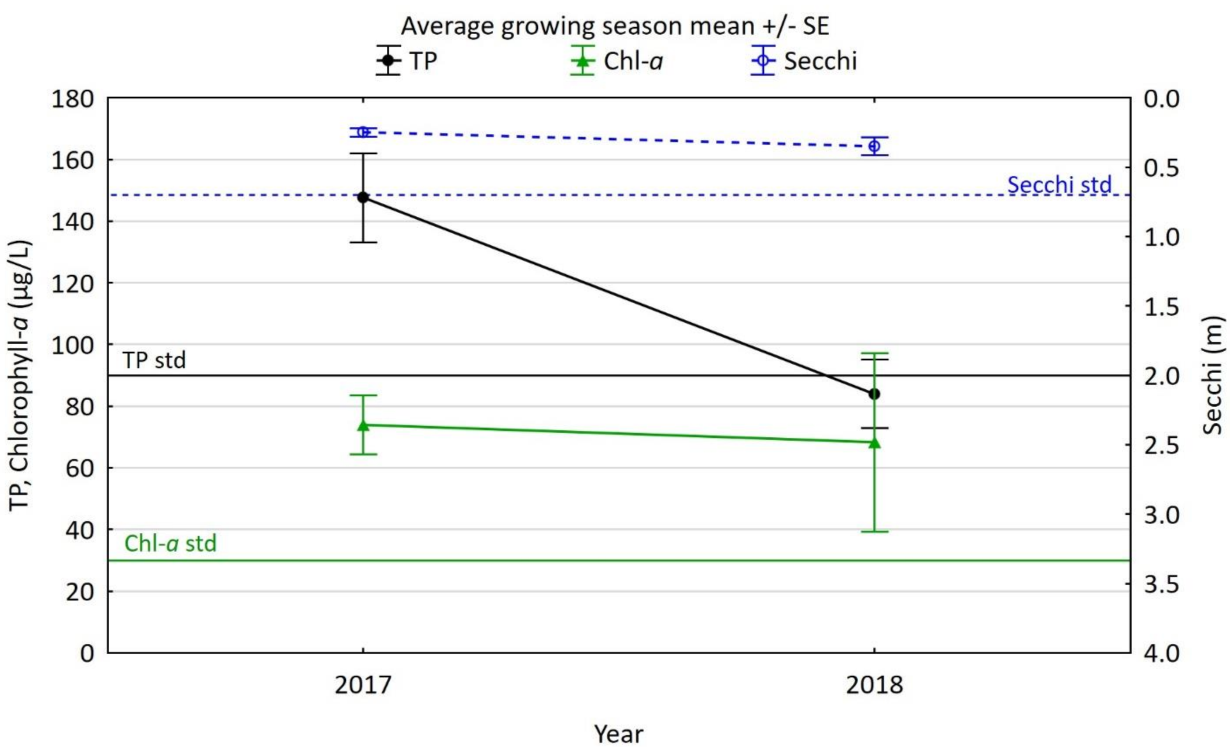
Table 78. Fish Lake morphometry and watershed size.

Surface area (ac)	Maximum depth (ft)	Mean depth (ft)	Watershed area (sq. mi.)	Percent littoral area
149	5	4.5	1.6	100

Table 79. Fish Lake water quality summary (site 46-0145-00-201) and standards.

Parameter	Observed (2017–2018)	Sample size	Water quality standard
TP (µg/L)	116	8	90
Chl-*a* (µg/L)	71	8	30
Secchi (m)	0.30	8	0.7

Figure 56. Fish Lake growing season means of TP, chl-*a*, and Secchi, site 201.



Fisheries

Fish Lake is managed by the DNR primarily for northern pike and secondarily for walleye, yellow perch, and black crappie. The lake is susceptible to low DO concentrations in the winter. The Watonwan Game and Fish Club used to operate an aeration system, but it has not been used recently. In a July 2015 DNR fisheries survey, species sampled included northern pike, walleye, yellow perch, black crappie, channel catfish, and black bullhead. Carp abundance decreased in the surveys between 2000 and 2015. A 2021 survey found high abundances of channel catfish.

Phosphorus source summary

The primary identified source of phosphorus to the lake is cropland runoff; other sources include watershed runoff from developed areas, internal recycling, and atmospheric deposition (Table 80). The watershed runoff component of “watershed runoff and internal recycling” is in addition to the modeled watershed load and is attributed to loads that were not quantified with the available data. Internal recycling of phosphorus is likely driven by bottom feeding fish such as black bullhead and carp.

DNR assessed lakeshore habitat of Fish Lake in July 2017. Overall lakeshore habitat quality was low, indicating either development and/or a lower than expected amount of natural habitat. Poor quality lakeshore habitat can contribute phosphorus loads to a lake and may exacerbate watershed loads to Fish Lake.

Table 80. Fish Lake phosphorus sources.

Source		TP Load lb/yr	TP Load %
Watershed runoff	Cropland	461	62
Watershed runoff	Developed	19	3
Watershed runoff	Natural (grassland, forest, wetland)	2	<1
Watershed runoff and internal recycling		202	27
Atmospheric deposition		55	7
Total		*739*	*100*

Fish Lake TMDL summary

To reach the Fish Lake phosphorus standard (90 µg/L), the total load to the lake needs to be reduced by approximately 38%. Loads are allocated to permitted and nonpermitted sources, and load reductions from watershed runoff and internal recycling are needed (Table 81). The Fish Lake TMDL allocations are based on equal percent reductions for watershed and internal recycling, which translates to an average annual watershed runoff TP concentration target of 182 µg/L.

Table 81. Fish Lake (46-0145) phosphorus TMDL summary.

- Listing year: 2020
- Baseline year: 2017
- Numeric standard used to calculate TMDL: 90 µg/L TP
- TMDL and allocations apply Jan–Dec

<table>
<tr><th colspan="2" rowspan="2">TMDL parameter</th><th>Existing TP load</th><th colspan="2">TMDL TP load</th><th colspan="2">Estimated load reduction</th></tr>
<tr><th>lb/yr</th><th>lb/yr</th><th>lb/d</th><th>lb/yr</th><th>%</th></tr>
<tr><td rowspan="3">LA</td><td>Watershed runoff</td><td rowspan="2">684</td><td>282 [a]</td><td>0.77</td><td rowspan="2">283</td><td rowspan="2">41%</td></tr>
<tr><td>Internal recycling</td><td>119</td><td>0.33</td></tr>
<tr><td>Atmospheric deposition</td><td>55</td><td>55</td><td>0.15</td><td>0</td><td>0%</td></tr>
<tr><td rowspan="2">WLA</td><td>Construction stormwater</td><td>0</td><td>0.65</td><td>0.0018</td><td>0</td><td>0%</td></tr>
<tr><td>Industrial stormwater</td><td>0</td><td>0.65</td><td>0.0018</td><td>0</td><td>0%</td></tr>
<tr><td colspan="2">MOS</td><td>–</td><td>51</td><td>0.14</td><td>–</td><td>–</td></tr>
<tr><td colspan="2">Total load</td><td>739</td><td>508</td><td>1.4</td><td>283 [b]</td><td>38%</td></tr>
</table>

a. The watershed runoff allocation equates to 0.33 lb/ac-yr.

b. The total estimated load reduction is greater than the difference between the total existing load and the total TMDL load (i.e., loading capacity) due to the MOS (see Section 4.5.1).

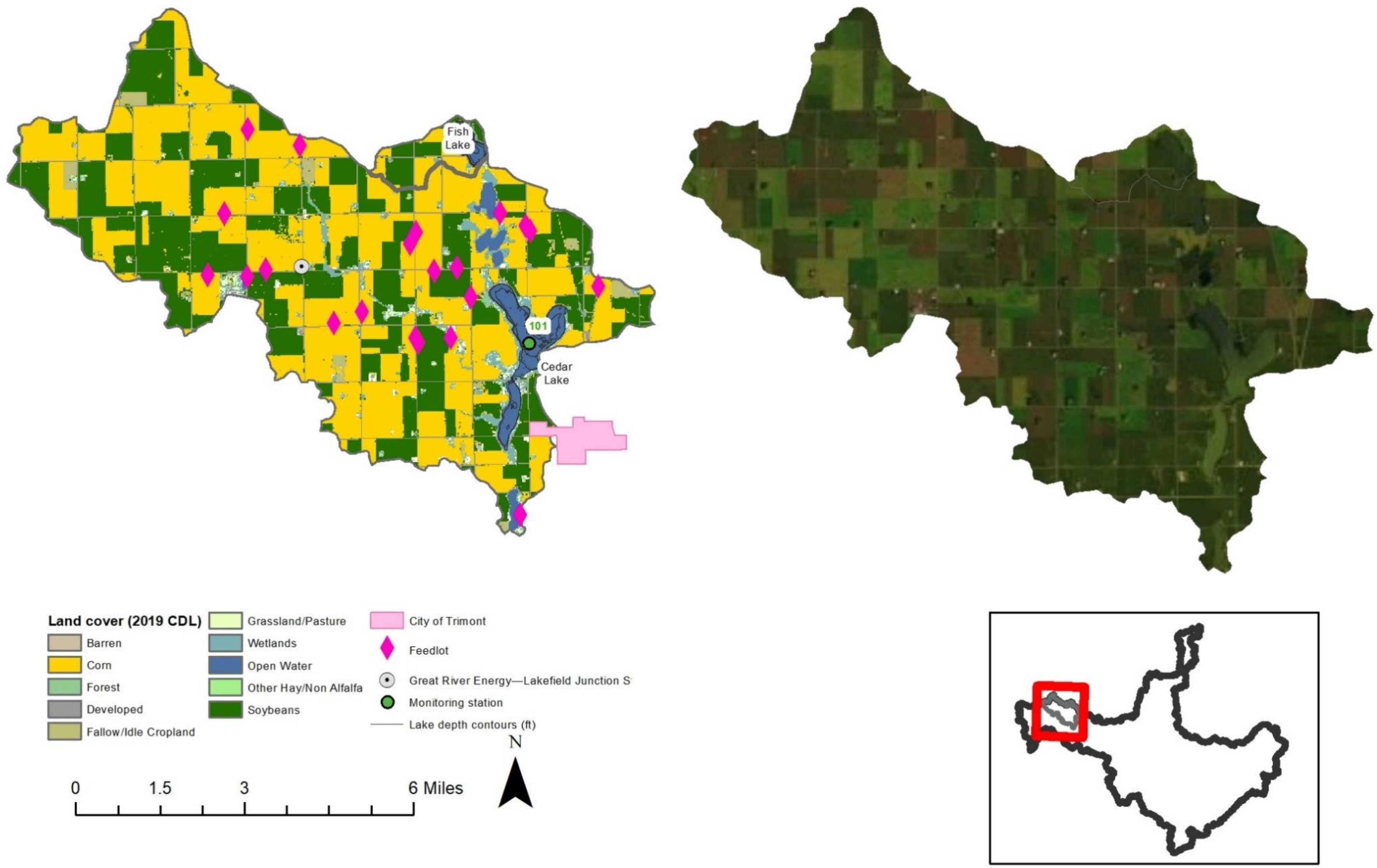
Cedar Lake (46-0121-00)

Watershed characterization

The Cedar Lake Watershed is 46 square miles and includes the Fish Lake Watershed. The lake and the majority of the watershed are in Martin County, with portions of the upper watershed in Jackson, Cottonwood, and Watonwan counties (Figure 3). Except for a small portion of the city of Trimont, there are no cities in the watershed (Figure 57). Land cover is approximately 84% corn and soybean rotation, with the majority of the rest of the watershed open water, wetlands, and roads (Table 8, Figure 57).

There are approximately 21 registered feedlots in the Cedar Lake Watershed; over half of them are CAFOs. The primary livestock type (95% of AUs) in both the CAFOs and non-CAFO feedlots is swine, and the primary livestock at the remaining feedlots is beef cattle. The maximum capacity of these registered feedlots is over 15,000 AUs. Land application of manure from nearby feedlots that are located outside of the Cedar Lake Watershed may also contribute nutrients to the lake.

Figure 57. Cedar Lake Watershed land cover, feedlots, monitoring sites, and air photo.



Lake conditions

Water quality

Cedar Lake is a shallow lake with a maximum depth of 6 ft and a mean depth of approximately 3.5 ft (Table 82). Cedar Lake does not meet any of the three components of the lake eutrophication standard (Table 83, Figure 58). Temperature and DO depth profile data from 2018 show slightly lower DO concentrations in bottom waters relative to surface water at times (Figure 59). The water column may temporarily stratify, which can lead to intermittent low DO and phosphorus recycling from sediments. However, the extent of stratification and low DO is unknown due to limited data.

Table 82. Cedar Lake morphometry and watershed size.

Surface area (ac)	Maximum depth (ft)	Mean depth (ft)	Watershed area (sq. mi.)	Percent littoral area
713	6	3.5	46	100

Table 83. Cedar Lake water quality summary (site 46-0121-00-101) and standards.

Parameter	Observed (2017–2018)	Sample size	Water quality standard
TP (µg/L)	145	8	90
Chl-*a* (µg/L)	83	8	30
Secchi (m)	0.38	8	0.7

Figure 58. Cedar Lake growing season means of TP, chl-a, and Secchi, site 101.

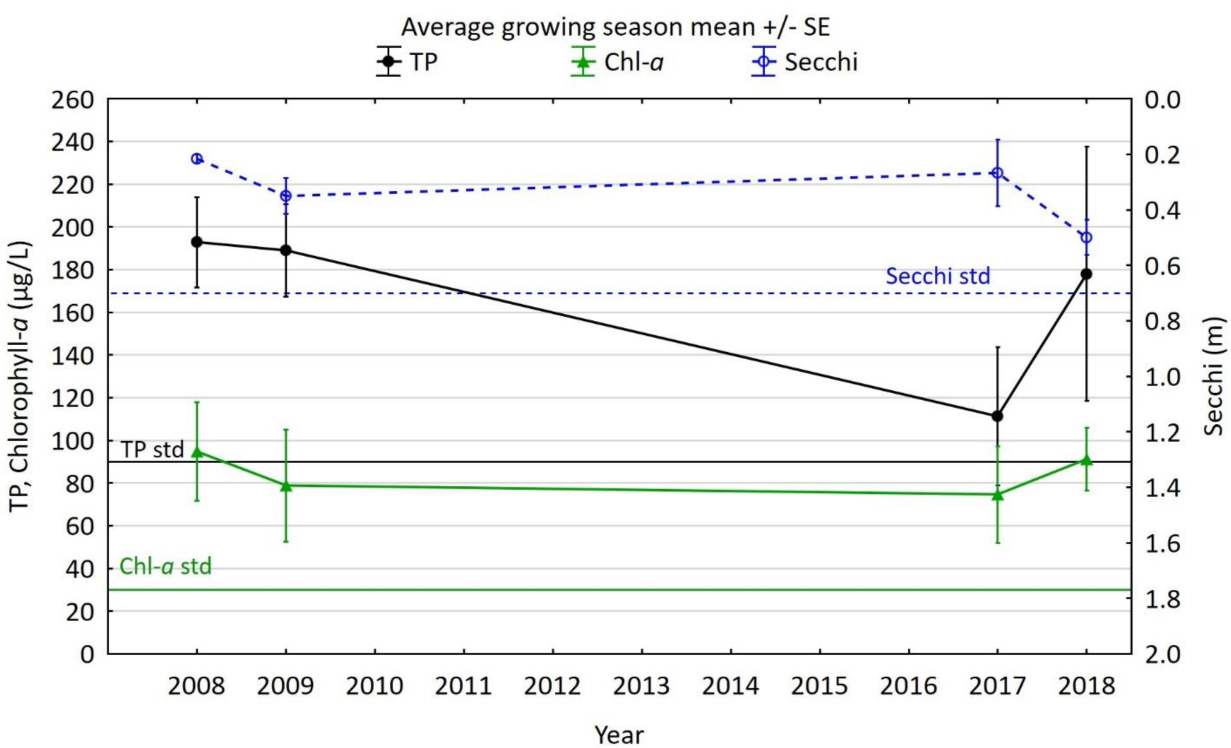
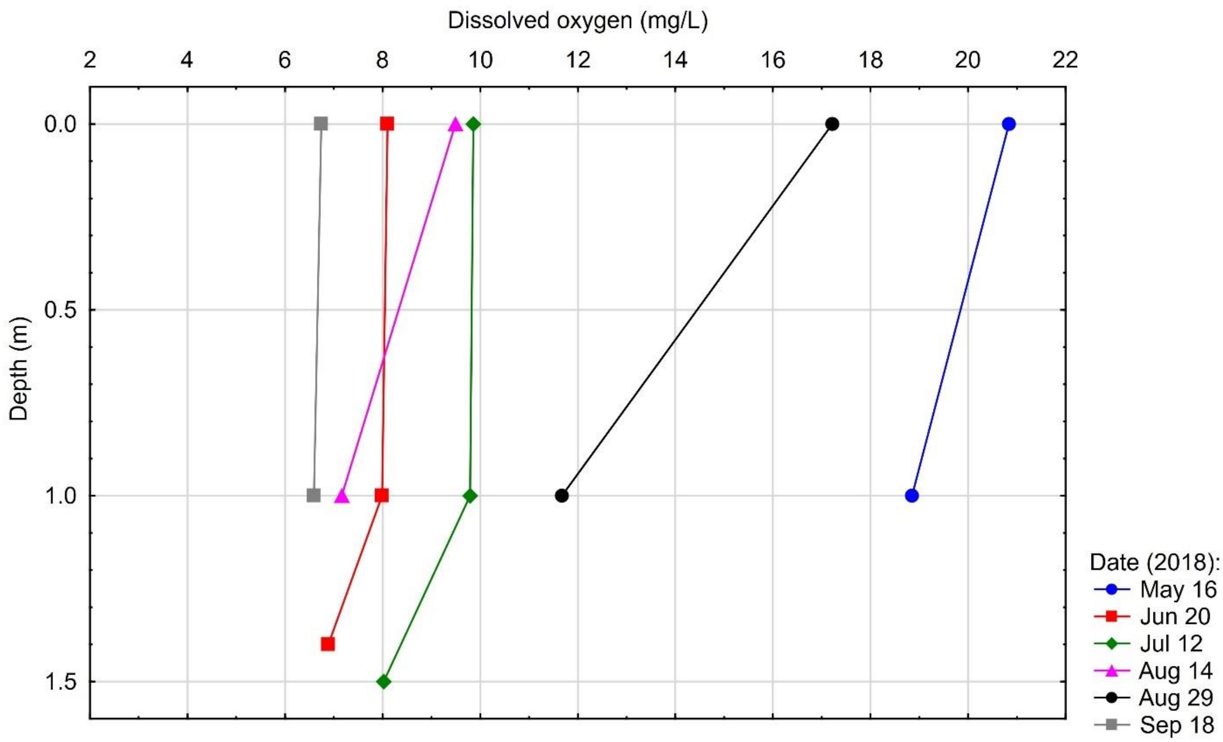


Figure 59. Cedar Lake 2018 dissolved oxygen depth profiles at site 101.



Fisheries

Cedar Lake is managed by the DNR primarily for northern pike and secondarily for crappie, walleye, and yellow perch. The lake is susceptible to low DO concentrations in the winter, with the most recent winterkill occurring in 2013–2014. Water quality improvements were observed by fisheries staff after the winterkill. At times the aeration system was turned off to enhance winterkill; the resulting strong winterkill provided enhanced fishing for several years after the event. The most recent DNR fisheries survey was conducted in June 2018. The target management species were sampled, as were above average abundances of black bullhead and common carp.

Phosphorus source summary

The primary identified source of phosphorus to the lake is cropland runoff; other sources include watershed runoff from developed areas, internal recycling, atmospheric deposition, and wastewater (Table 84). The watershed runoff component of “watershed runoff and internal recycling” is in addition to the modeled watershed load and is attributed to loads that were not quantified with the available data. Internal recycling of phosphorus is likely driven by bottom feeding fish such as black bullhead and carp.

Table 84. Cedar Lake phosphorus sources.

Source		TP Load lb/yr	TP Load %
Watershed runoff	Cropland	14,815	74
	Developed	502	3
	Natural (grassland, forest, wetland)	85	<1
Point source: Great River Energy – Lakefield Junction Station		5	<0.03
Watershed runoff and internal recycling		4,116	21
Atmospheric deposition		263	1
Fish Lake outlet		204	1
Total		19,990	100

Cedar Lake TMDL summary

To reach the Cedar Lake phosphorus standard (90 µg/L), the total load to the lake needs to be reduced by approximately 56%. Loads are allocated to permitted and nonpermitted sources, and load reductions from watershed runoff and internal recycling are needed (Table 85). The Cedar Lake TMDL allocations are based on an average annual watershed runoff TP concentration target of 150 µg/L, Fish Lake meeting water quality standards (90 µg/L), and the remaining reductions from internal recycling.

Table 85. Cedar Lake (46-0121) phosphorus TMDL summary.

- Listing year: 2020
- Baseline year: 2017
- Numeric standard used to calculate TMDL: 90 µg/L TP
- TMDL and allocations apply Jan–Dec

TMDL parameter		Existing TP load lb/yr	TMDL TP load lb/yr	TMDL TP load lb/d	Estimated load reduction lb/yr	Estimated load reduction %
Boundary condition at Fish Lake (46-0145)		204	158	0.43	46	23%
LA	Watershed runoff	19,502	7,586 [a]	21	11,113	57%
	Internal recycling		803	2.2		
	Atmospheric deposition	263	263	0.72	0	0%
WLA	Great River Energy – Lakefield Junction Station (permit MN0067709, SD001)	5	6	0.016	0	0%
	Construction stormwater	17 [b]	17	0.047	0	0%
	Industrial stormwater	0	17	0.047	0	0%
MOS		–	983	2.7	–	–
Total load		19,991	9,833	27	11,158 [c]	56%

a. The watershed runoff allocation equates to 0.28 lb/ac-yr.

b. Loading from construction stormwater is assumed to be in compliance with the NPDES permit and therefore equal to the WLA.

c. The total estimated load reduction is greater than the difference between the total existing load and the total TMDL load (i.e., loading capacity) due to the MOS (see Section 4.5.1).

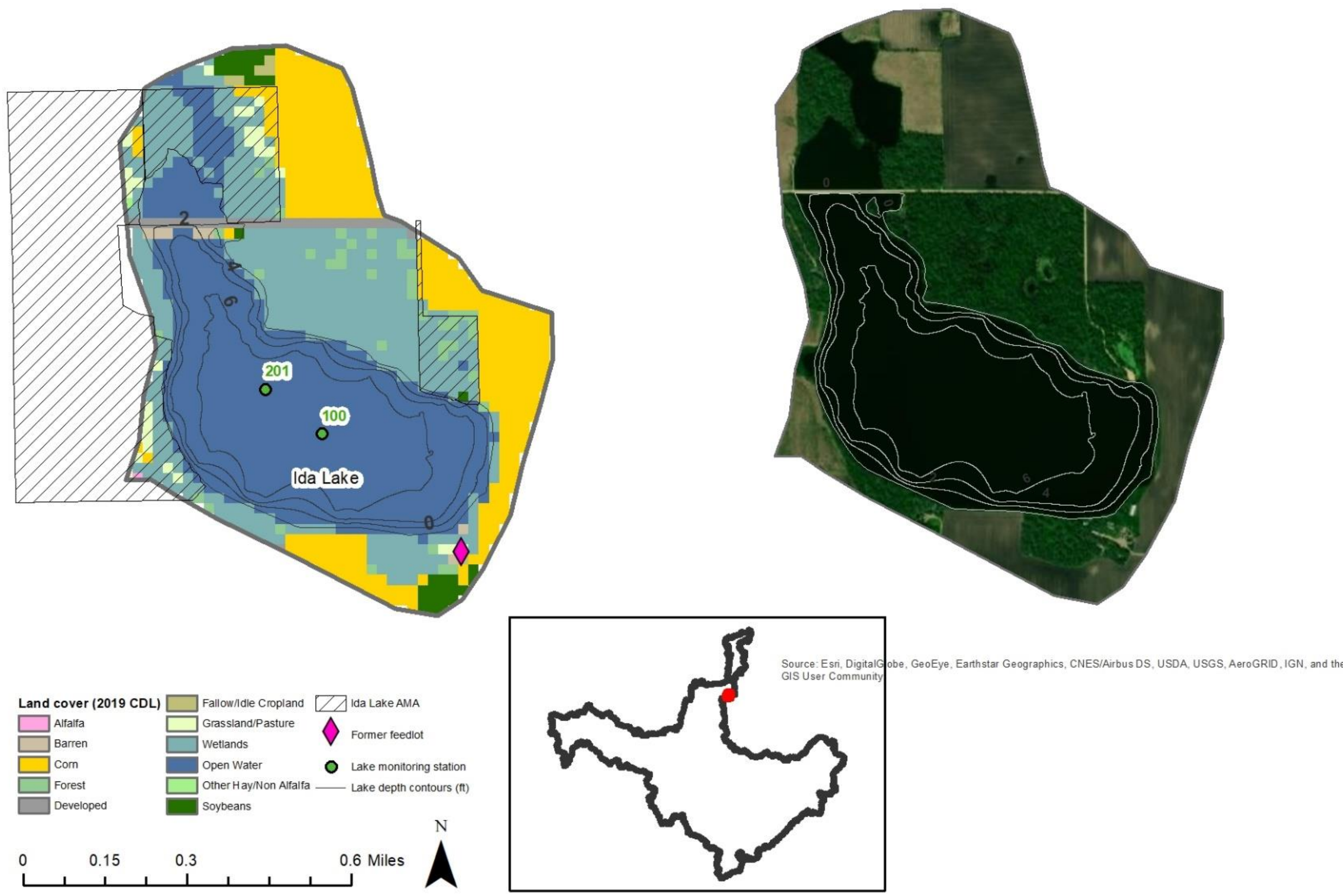
Ida Lake (07-0090-00)

Watershed characterization

The known Ida Lake Watershed is relatively small (0.5 square miles), with a watershed to lake ratio of 3:1. However, there may be additional subsurface drainage across the watershed boundary that has increased the watershed size. The TMDL modeling uses the DNR Level 8 watershed boundary. The entire watershed is in Blue Earth County, and there are no cities in the watershed (Figure 60). Land cover is approximately 24% corn and soybean rotation, with the majority of the rest of the watershed open water and wetland (Table 8, Figure 60). Agricultural drain tile, which drains to the lake, was installed to the north of the lake in the early 2000s. There are no registered feedlots in the Ida Lake Watershed, although there is one former feedlot site close to the south-east shoreline.

The Ida Lake Watershed is a closed basin with no outflow from the lake. As a result, the water level in the lake is artificially high, which has led to high rates of erosion along the shoreline. The natural outlet was on the northwest side of the lake where a road (T-40) crosses. This road, which bisects the north portion of the lake, has been flooded and closed down.

Figure 60. Ida Lake Watershed land cover, feedlots, monitoring sites, and air photo.



Lake conditions

Water quality

Ida Lake is a shallow lake with a maximum depth of eight ft and a mean depth of five ft (Table 86). Ida Lake does not meet any of the three components of the lake eutrophication standard (Table 87, Figure 61). There is no temperature or DO depth profile data for Ida Lake. The water column may temporarily stratify, which can lead to intermittent low DO and phosphorus recycling from sediments. However, the extent of stratification and low DO is unknown due to limited data.

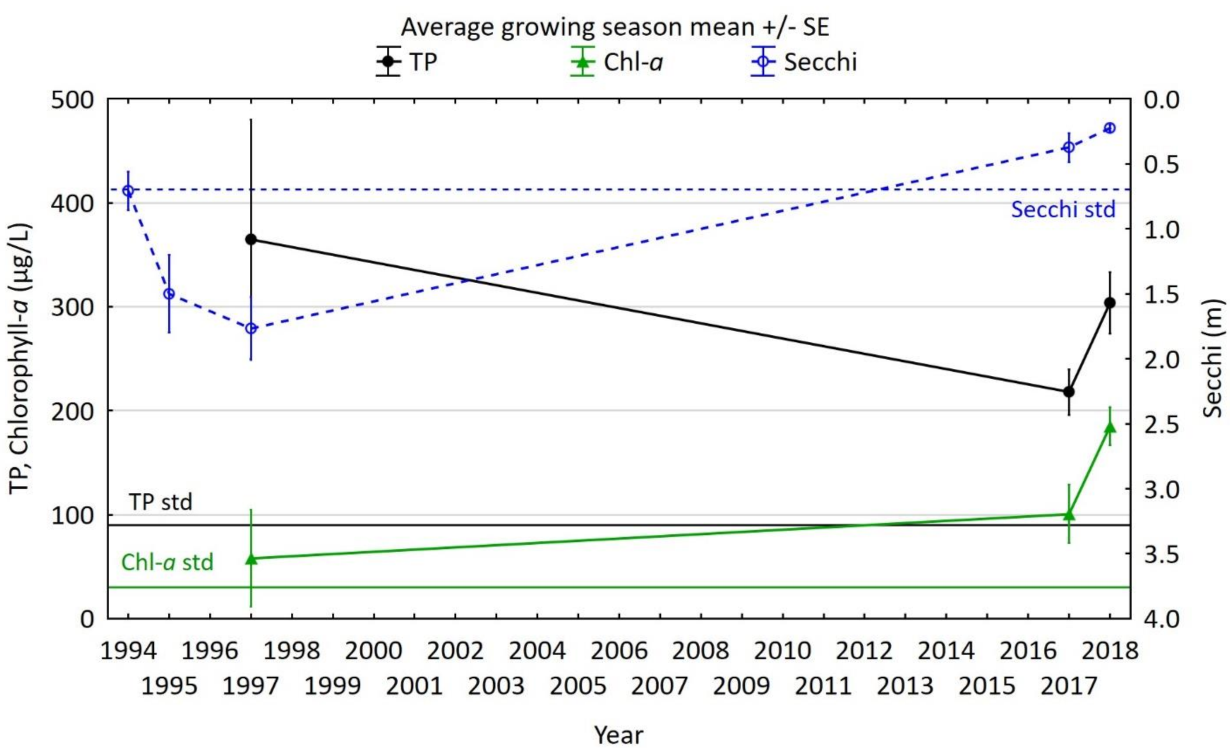
Table 86. Ida Lake morphometry and watershed size.

Surface area (ac)	Maximum depth (ft)	Mean depth (ft)	Watershed area (sq. mi.)	Percent littoral area
111	8	5.1	0.5	100

Table 87. Ida Lake water quality summary (site 07-0090-00-201) and standards.

Parameter	Observed (2017–2018)	Sample size	Water quality standard
TP (µg/L)	261	8	90
Chl-*a* (µg/L)	143	8	30
Secchi (m)	0.30	8	0.7

Figure 61. Ida Lake growing season means of TP, chl-a, and Secchi, site 100 (1997) and site 201 (remaining years).



Fisheries

Ida Lake is primarily managed as a walleye fishery. Ida Lake's small size and shallow water column make it prone to winterkill despite past use of an aeration system.

Aquatic macrophytes

DNR Fisheries staff have observed high densities of curly-leaf pondweed.

Phosphorus source summary

The primary identified source of phosphorus to the lake is cropland runoff; other sources include watershed runoff from developed areas, internal recycling, and atmospheric deposition (Table 88). The watershed runoff component of "watershed runoff and internal recycling" is in addition to the modeled watershed load and is attributed to loads that were not quantified with the available data.

Because the lake does not have an outlet, phosphorus inputs to the lake never leave and continue to recycle between the sediments and the water column; this leads to high internal recycling rates. The historical farming and feedlot in the watershed likely contributed phosphorus loading to the lake; some of this phosphorus may be in the lake sediments and contributing to high internal recycling rates.

During a 2013 fisheries survey, severe shoreline erosion (e.g., 8 to 10-ft high eroded banks) was observed where deep-rooted shoreline vegetation was absent. Shoreline erosion can contribute phosphorus loads to a lake and is likely a component of the high internal recycling identified in Ida Lake.

Internal recycling of phosphorus is likely driven by shoreline erosion and bottom feeding fish such as black bullhead.

Table 88. Ida Lake phosphorus sources.

Source		TP Load lb/yr	TP Load %
Watershed runoff	Cropland	63	15
	Developed	3	<1
	Natural (grassland, forest, wetland)	9	2
Watershed runoff and internal recycling		314	73
Atmospheric deposition		41	10
Total		*430*	*100*

Ida Lake TMDL summary

To reach the Ida Lake phosphorus standard (90 µg/L), the total load to the lake needs to be reduced by approximately 53%. Loads are allocated to permitted and nonpermitted sources, and load reductions from watershed runoff and internal recycling are needed (Table 89). The Ida Lake TMDL allocations are based on an average annual watershed runoff TP concentration target of 150 µg/L, with the remaining reductions from internal recycling.

Table 89. Ida Lake (07-0090) phosphorus TMDL summary.

- Listing year: 2020
- Baseline year: 2017
- Numeric standard used to calculate TMDL: 90 µg/L TP
- TMDL and allocations apply Jan–Dec

TMDL parameter		Existing TP load	TMDL TP load		Estimated load reduction	
		lb/yr	lb/yr	lb/d	lb/yr	%
LA	Watershed runoff	389	52 [a]	0.14	206	53%
	Internal recycling		131	0.36		
	Atmospheric deposition	41	41	0.11	0	0%
WLA	Construction stormwater	0	0.12	0.00033	0	0%
	Industrial stormwater	0	0.12	0.00033	0	0%
MOS		–	25	0.068	–	–
Total load		430	249	0.68	206 [b]	53%

a. The watershed runoff allocation equates to 0.22 lb/ac-yr.

b. The total estimated load reduction is greater than the difference between the total existing load and the total TMDL load (i.e., loading capacity) due to the MOS (see Section 4.5.1).

Appendix C. Lake modeling documentation

A spreadsheet version of the lake model BATHTUB (Walker 1987) was used to model lake phosphorus concentration in each impaired lake. See Section 0 for more information on the lake modeling. The tables in this appendix show model inputs and select outputs.

Rice Lake

Global variables		
Averaging period (yrs)	1	
Precipitation (in/yr)	34.3	
Evaporation (in/yr)	34.3	
Atmospheric TP Load (kg/km^2-yr)	41.7	
Model options		
P balance	CB-Lakes	
P calibration	decay rates	
Model coefficients		
TP	1	
TP availability factor	1	
Segment	**Baseline**	**TMDL**
Area (ac)	257	
Mean depth (ft)	3.1	
Mean depth of mixed layer (ft)	3.1	
Observed TP (µg/L)	164	
Target TP (µg/L)	90	
TP internal load release rate (mg/m2-d)	3.1	0.8
TP internal load time of release (d)	122	122
Hydraulic residence time (yr)	1.5	
Overflow rate (m/yr)	0.6	
Watershed		
Watershed area (km2)	3.1	
Watershed to lake area ratio	2.986	

Segment mass balance: Baseline	**Flow (hm3/yr)**	**Flow (cfs)**	**% Flow**	**TP load (lb/yr)**	**% TP load**	**TP concentration (µg/L)**
Precipitation	0.90	1.01	58%	95.61	7%	48
Watershed Runoff	0.66	0.74	42%	369.47	28%	253
Watershed runoff and internal recycling				877.43	65%	
Total	1.57	1.76	100%	1342.51	100%	389
Evaporation	0.90	1.01	58%	0.00	0%	0
Sedimentation/retention				1103.20	82%	
Outflow	0.66	0.74	42%	239.31	18%	164
Segment mass balance: TMDL	**Flow (hm3/yr)**	**Flow (cfs)**	**% Flow**	**TP load (lb/yr)**	**% TP load**	**TP concentration (µg/L)**

Precipitation	0.90	1.01	58%	95.61	18%	48
Watershed Runoff	0.66	0.74	42%	218.88	42%	150
Watershed runoff and internal recycling				210.74	40%	
Total	1.57	1.76	100%	525.23	100%	152
Evaporation	0.90	1.01	58%	0.00	0%	0
Sedimentation/retention				393.90	75%	
Outflow	0.66	0.74	42%	131.33	25%	90
Load reductions				**TP load reduction (lb/yr)**	**% TP reduction**	
Precipitation				0.00	0%	
Watershed Runoff				150.59	41%	
Watershed runoff and internal recycling				666.69	76%	
Total				817.28	61%	

Iowa Lake

Global variables		
Averaging period (yrs)	1	
Precipitation (in/yr)	32.3	
Evaporation (in/yr)	32.3	
Atmospheric TP Load (kg/km^2-yr)	41.7	
Model options		
P balance	CB-Lakes	
P calibration	decay rates	
Model coefficients		
TP	1	
TP availability factor	1	
Segment	**Baseline**	**TMDL**
Area (ac)	680	
Mean depth (ft)	5.1	
Mean depth of mixed layer (ft)	5.1	
Observed TP (µg/L)	149	
Target TP (µg/L)	90	
TP internal load release rate (mg/m2-d)	3.5	1.2
TP internal load time of release (d)	122	122
Hydraulic residence time (yr)	0.5	
Overflow rate (m/yr)	2.9	
Watershed		
Watershed area (km2)	36.8	
Watershed to lake area ratio	13.376	

Segment mass balance: Baseline	Flow (hm3/yr)	Flow (cfs)	% Flow	TP load (lb/yr)	% TP load	TP concentration (µg/L)
Precipitation	2.26	2.53	22%	252.81	3%	51
South Silver Lk outlet	*0.37*	*0.41*	*4%*	*38.90*	*1%*	*48*
Direct drainage	*7.60*	*8.51*	*74%*	*4506.67*	*61%*	*269*
Watershed runoff total	7.96	8.92	78%	4545.57	61%	259
Watershed runoff and internal recycling				2615.31	35%	
Total	10.22	11.45	100%	7413.70	100%	329
Evaporation	2.26	2.53	22%	0.00	0%	0
Sedimentation/retention				4797.54	65%	
Outflow	7.96	8.92	78%	2616.15	35%	149
Segment mass balance: TMDL	**Flow (hm3/yr)**	**Flow (cfs)**	**% Flow**	**TP load (lb/yr)**	**% TP load**	**TP concentration (µg/L)**
Precipitation	2.26	2.53	22%	252.81	7%	51
South Silver Lk outlet	*0.37*	*0.41*	*4%*	*38.90*	*1%*	*48*
Direct drainage	*7.60*	*8.51*	*74%*	*2512.16*	*68%*	*150*
Watershed runoff total	7.96	8.92	78%	2551.06	69%	145
Watershed runoff and internal recycling				879.96	24%	
Total	10.22	11.45	100%	3683.83	100%	164
Evaporation	2.26	2.53	22%	0.00	0%	0
Sedimentation/retention				2103.60	57%	
Outflow	7.96	8.92	78%	1580.22	43%	90
Load reductions				**TP load reduction (lb/yr)**	**% TP reduction**	
Precipitation				0.00	0%	
South Silver Lk outlet				0.00	0%	
Direct drainage				1994.52	44%	
Watershed runoff total				1994.52	44%	
Point				0.00		
Watershed runoff and internal recycling				1735.35	66%	
Total				3729.87	50%	

East Chain Lake

Global variables		
Averaging period (yrs)	1	
Precipitation (in/yr)	32.7	
Evaporation (in/yr)	32.7	
Atmospheric TP Load (kg/km^2-yr)	41.7	
Model options		
P balance	CB-Lakes	

P calibration	decay rates	
Model coefficients		
TP	1	
TP availability factor	1	
Segment	**Baseline**	**TMDL**
Area (ac)	479	
Mean depth (ft)	16.8	
Mean depth of mixed layer (ft)	16.8	
Observed TP (µg/L)	175	
Target TP (µg/L)	90	
TP internal load release rate (mg/m2-d)	23.0	4.7
TP internal load time of release (d)	122	122
Hydraulic residence time (yr)	0.3	
Overflow rate (m/yr)	16.3	
Watershed		
Watershed area (km2)	145.1	
Watershed to lake area ratio	74.848	

Segment mass balance: Baseline	**Flow (hm3/yr)**	**Flow (cfs)**	**% Flow**	**TP load (lb/yr)**	**% TP load**	**TP concentration (µg/L)**
Precipitation	1.61	1.80	5%	178.21	1%	50
Iowa Lake outlet	*7.96*	*8.92*	*24%*	*2616.15*	*9%*	*149*
Watershed runoff	*23.57*	*26.41*	*71%*	*14022.82*	*49%*	*270*
Watershed runoff total	31.53	35.33	95%	16638.97	58%	239
Watershed runoff and internal recycling				11997.85	42%	
Total	33.14	37.14	100%	28815.03	100%	394
Evaporation	1.61	1.80	5%	0.00	0%	0
Sedimentation/retention				16648.61	58%	
Outflow	31.53	35.33	95%	12166.43	42%	175
Segment mass balance: TMDL	**Flow (hm3/yr)**	**Flow (cfs)**	**% Flow**	**TP load (lb/yr)**	**% TP load**	**TP concentration (µg/L)**
Precipitation	1.61	1.80	5%	178.21	1%	50
Iowa Lake outlet	*7.96*	*8.92*	*24%*	*1580.22*	*13%*	*90*
Watershed runoff	*23.57*	*26.41*	*71%*	*7794.66*	*65%*	*150*
Watershed runoff total	31.53	35.33	95%	9374.88	78%	135
Watershed runoff and internal recycling				2433.45	20%	
Total	33.14	37.14	100%	11986.54	100%	164
Evaporation	1.61	1.80	5%	0.00	0%	0
Sedimentation/retention				5729.53	48%	
Outflow	31.53	35.33	95%	6257.02	52%	90

Load reductions				TP load reduction (lb/yr)	% TP reduction	
Precipitation				0.00	0%	
Iowa Lake outlet				1035.92	40%	
Watershed runoff				6228.16	44%	
Watershed runoff total				7264.09	44%	
Watershed runoff and internal recycling				9564.40	80%	
Total				16828.49	58%	

Fairmont Chain of Lakes

See the *Blue Earth River Watershed Lake Water Quality Improvement Study* (MPCA 2023a).

Fish Lake

Global variables		
Averaging period (yrs)	1	
Precipitation (in/yr)	32.3	
Evaporation (in/yr)	32.3	
Atmospheric TP Load (kg/km^2-yr)	41.7	
Model options		
P balance	CB-Lakes	
P calibration	decay rates	
Model coefficients		
TP	1	
TP availability factor	1	
Segment	**Baseline**	**TMDL**
Area (ac)	149	
Mean depth (ft)	4.5	
Mean depth of mixed layer (ft)	4.5	
Observed TP (µg/L)	116	
Target TP (µg/L)	90	
TP internal load release rate (mg/m2-d)	1.2	0.8
TP internal load time of release (d)	122	122
Hydraulic residence time (yr)	1.0	
Overflow rate (m/yr)	1.3	
Watershed		
Watershed area (km2)	3.5	
Watershed to lake area ratio	5.789	

Segment mass balance: Baseline	Flow (hm3/yr)	Flow (cfs)	% Flow	TP load (lb/yr)	% TP load	TP concentration (µg/L)
Precipitation	0.49	0.55	38%	55.44	7%	51
Watershed Runoff	0.80	0.89	62%	482.62	65%	275

Watershed runoff and internal recycling				201.90	27%	
Total	1.29	1.45	100%	739.95	100%	260
Evaporation	0.49	0.55	38%	0.00	0%	0
Sedimentation/retention				536.03	72%	
Outflow	0.80	0.89	62%	203.92	28%	116
Segment mass balance: Scenario	**Flow (hm3/yr)**	**Flow (cfs)**	**% Flow**	**TP load (lb/yr)**	**% TP load**	**TP concentration (µg/L)**
Precipitation	0.49	0.55	38%	55.44	11%	51
Watershed Runoff	0.80	0.89	62%	319.39	63%	182
Watershed runoff and internal recycling				133.60	26%	
Total	1.29	1.45	100%	508.43	100%	179
Evaporation	0.49	0.55	38%	0.00	0%	0
Sedimentation/retention				350.21	69%	
Outflow	0.80	0.89	62%	158.21	31%	90
Load reductions				**TP load reduction (lb/yr)**	**% TP reduction**	
Precipitation				0.00	0%	
Watershed Runoff				163.24	34%	
Watershed runoff and internal recycling				68.29	34%	
Total				231.53	31%	

Cedar Lake

	Segment 1 (S Basin)		**Segment 2 (N Basin)**	
Global variables				
Averaging period (yrs)	1		1	
Precipitation (in/yr)	32.3		32.3	
Evaporation (in/yr)	32.3		32.3	
Atmospheric TP Load (kg/km^2-yr)	41.7		41.7	
Model options				
P balance	2nd order, Available P		2nd order, Available P	
P calibration	decay rates		decay rates	
Model coefficients				
TP	1		1	
TP availability factor	1		1	
Segment	**Baseline**	**TMDL**	**Baseline**	**TMDL**
Area (ac)	169		538	
Mean depth (ft)	3.9		4.6	
Mean depth of mixed layer (ft)	3.9		4.6	

Observed TP (µg/L)	119		145	
Target TP (µg/L)	90		90	
TP internal load release rate (mg/m2-d)	0.0	0.0	7.0	1.7
TP internal load time of release (d)	0	0	122	122
Hydraulic residence time (yr)	0.17		0.14	
Overflow rate (m/yr)	7.2		9.8	
Watershed				
Watershed area (km2)	21.8		93.8	
Watershed to lake area ratio	31.806		43.092	

Segment 1 (S Basin) mass balance: <u>Baseline</u>	**Flow (hm3/yr)**	**Flow (cfs)**	**% Flow**	**TP load (lb/yr)**	**% TP load**	**TP concentration (µg/L)**
Precipitation	0.56	0.63	10%	62.91	2%	51
South basin watershed	*4.94*	*5.53*	*90%*	*2965.99*	*98%*	*273*
Watershed runoff total	4.94	5.53	90%	2965.99	98%	273
Point	0.012	0.014	0.23%	5.29	0.17%	193
Watershed runoff and internal recycling				0.00	0%	
Total	5.51	6.17	100%	3034.19	100%	250
Evaporation	0.56	0.63	10%	0.00	0%	0
Sedimentation/retention				1677.30	55%	
Outflow	4.95	5.54	90%	1356.90	45%	124
Segment 2 (N Basin) mass balance: <u>Baseline</u>	**Flow (hm3/yr)**	**Flow (cfs)**	**% Flow**	**TP load (lb/yr)**	**% TP load**	**TP concentration (µg/L)**
Precipitation	1.79	2.00	8%	200.14	1%	51
Fish outlet (part of HSPF subshed 298)	*0.80*	*0.89*	*3%*	*203.92*	*1%*	*116*
North (part of HSPF subshed 298)	*6.19*	*6.94*	*27%*	*3664.90*	*22%*	*269*
West trib (HSPF R295)	*14.26*	*15.98*	*62%*	*8772.33*	*52%*	*279*
Watershed runoff total	21.25	23.81	92%	12641.15	75%	270
Point	0.00	0.00	0%	0.00	0%	
Watershed runoff and internal recycling				4115.96	24%	81
Total	23.03	25.81	100%	16957.25	100%	
Evaporation	1.79	2.00	8%	0.00	0%	0
Sedimentation/retention				10164.88	60%	
Outflow	21.25	23.81	92%	6792.37	40%	145
Total mass balance: <u>Baseline</u>	**Flow (hm3/yr)**	**Flow (cfs)**	**% Flow**	**TP load (lb/yr)**	**% TP load**	**TP concentration (µg/L)**
Precipitation	2.3	2.63	8%	263.05	1%	51
South basin watershed	*4.94*	*5.53*	*17%*	*2965.99*	*15%*	*273*
Fish outlet (part of HSPF subshed 298)	*0.80*	*0.89*	*3%*	*203.92*	*1%*	*116*
North (part of HSPF subshed 298)	*6.19*	*6.94*	*22%*	*3664.90*	*18%*	*269*
West trib (HSPF R295)	*14.26*	*15.98*	*50%*	*8772.33*	*44%*	*279*

Watershed runoff total	26.2	29.34	92%	15607.14	78%	270
Point	0.012	0.014	0.044%	5.29	0.026%	193
Watershed runoff and internal recycling	0.0			4115.96	21%	65
Total	28.5	31.98	100%	19991.44	100%	
Evaporation	2.3	2.63	8%	0.00	0%	0
Sedimentation/retention	0.0			11842.18	59%	
Outflow	26.2	29.35	92%	8149.27	41%	141
Segment 1 (S Basin) mass balance: TMDL	**Flow (hm3/yr)**	**Flow (cfs)**	**% Flow**	**TP load (lb/yr)**	**% TP load**	**TP concentration (µg/L)**
Precipitation	0.56	0.63	10%	62.91	4%	51
South basin watershed	*4.94*	*5.53*	*90%*	*1632.01*	*96%*	*150*
Watershed runoff total	4.94	5.53	90%	1632.01	96%	150
Point	0.0124	0.014	0.23%	5.95	0.35%	217
Watershed runoff and internal recycling				0.00	0%	
Total	5.51	6.17	100%	1700.87	100%	140
Evaporation	0.56	0.63	10%	0.00	0%	0
Sedimentation/retention				777.21	46%	
Outflow	4.95	5.54	90%	923.66	54%	85
Segment 2 (N Basin) mass balance: TMDL	**Flow (hm3/yr)**	**Flow (cfs)**	**% Flow**	**TP load (lb/yr)**	**% TP load**	**TP concentration (µg/L)**
Precipitation	1.79	2.00	8%	200.14	2%	51
Fish outlet (part of HSPF subshed 298)	*0.80*	*0.89*	*3%*	*158.21*	*2%*	*90*
North (part of HSPF subshed 298)	*6.19*	*6.94*	*27%*	*2047.09*	*25%*	*150*
West trib (HSPF R295)	*14.26*	*15.98*	*62%*	*4715.81*	*58%*	*150*
Watershed runoff total	21.25	23.81	92%	6921.11	85%	148
Point	0.00	0.00	0%	0.00	0%	
Watershed runoff and internal recycling				1010.78	12%	
Total	23.03	25.81	100%	8132.03	100%	160
Evaporation	1.79	2.00	8%	0.00	0%	0
Sedimentation/retention				3916.08	48%	
Outflow	21.25	23.81	92%	4215.95	52%	90
Total mass balance: TMDL	**Flow (hm3/yr)**	**Flow (cfs)**	**% Flow**	**TP load (lb/yr)**	**% TP load**	**TP concentration (µg/L)**
Precipitation	2.3	2.63	8%	263.05	3%	51
South basin watershed	*4.94*	*5.53*	*17%*	*1632.01*	*17%*	*150*
Fish outlet (part of HSPF subshed 298)	*0.80*	*0.89*	*3%*	*158.21*	*2%*	*90*
North (part of HSPF subshed 298)	*6.19*	*6.94*	*22%*	*2047.09*	*21%*	*150*
West trib (HSPF R295)	*14.26*	*15.98*	*50%*	*4715.81*	*48%*	*150*
Watershed runoff total	26.2	29.34	92%	8553.12	87%	148
Point	0.012	0.014	0.044%	5.95	0.061%	217
Watershed runoff and internal recycling				1010.78	10%	

Total	28.5	31.98	100%	9832.90	100%	156
Evaporation	2.3	2.63	8%	0.00	0%	0
Sedimentation/retention				4693.29	48%	
Outflow	26.2	29.35	92%	5139.61	52%	89
Load reductions Segment 1 (S Basin)				**TP load reduction (lb/yr)**	**% TP reduction**	
Precipitation				0.00	0%	
South basin watershed				*1333.99*	45%	
Fish outlet (part of HSPF subshed 298)				*0.00*		
North (part of HSPF subshed 298)				*0.00*		
West trib (HSPF R295)				*0.00*		
Watershed Runoff				1333.99	45%	
Point				-0.66	-13%	
Watershed runoff and internal recycling				0.00		
Total				1333.32	44%	
Load reductions Segment 2 (N Basin)				**TP load reduction (lb/yr)**	**% TP reduction**	
Precipitation				0.00	0%	
South basin watershed				0.00		
Fish outlet (part of HSPF subshed 298)				45.71	22%	
North (part of HSPF subshed 298)				1617.81	44%	
West trib (HSPF R295)				4056.52	46%	
Watershed Runoff				5720.04	45%	
Point				0.00		
Watershed runoff and internal recycling				3105.18	75%	
Total				8825.22	52%	
Load reductions TOTAL						
Precipitation				0.00	0%	
South basin watershed				1333.99	45%	
Fish outlet (part of HSPF subshed 298)				45.71	22%	
North (part of HSPF subshed 298)				1617.81	44%	
West trib (HSPF R295)				4056.52	46%	
Watershed Runoff				7054.02	45%	
Point				-0.66	-13%	
Watershed runoff and internal recycling				3105.18	75%	
Total				10158.55	51%	

Ida Lake

Global variables		
Averaging period (yrs)	1	
Precipitation (in/yr)	32.7	

Evaporation (in/yr)	47.6	
Atmospheric TP Load (kg/km^2-yr)	41.7	
Model options		
P balance	CB-Lakes	
P calibration	decay rates	
Model coefficients		
TP	0.5	
TP availability factor	1	
Segment	**Baseline**	**TMDL**
Area (ac)	111	
Mean depth (ft)	5.1	
Mean depth of mixed layer (ft)	5.1	
Observed TP (µg/L)	261	
Target TP (µg/L)	90	
TP internal load release rate (mg/m2-d)	2.6	1.3
TP internal load time of release (d)	122	122
Hydraulic residence time (yr)	270.2	
Overflow rate (m/yr)	0.0	
Watershed		
Watershed area (km2)	1.0	
Watershed to lake area ratio	2.153	

Segment mass balance: Baseline	**Flow (hm3/yr)**	**Flow (cfs)**	**% Flow**	**TP load (lb/yr)**	**% TP load**	**TP concentration (µg/L)**
Precipitation	0.37	0.42	68%	41.28	10%	50
Watershed Runoff	0.17	0.19	32%	75.14	17%	197
Watershed runoff and internal recycling				313.67	73%	
Total	0.55	0.61	100%	430.09	100%	357
Evaporation	0.54	0.61	100%	0.00	0%	0
Sedimentation/retention				428.61	100%	
Outflow	0.00	0.00	0%	1.48	0%	261
Segment mass balance: Scenario	**Flow (hm3/yr)**	**Flow (cfs)**	**% Flow**	**TP load (lb/yr)**	**% TP load**	**TP concentration (µg/L)**
Precipitation	0.37	0.42	68%	41.28	17%	50
Watershed Runoff	0.17	0.19	32%	57.27	23%	150
Watershed runoff and internal recycling				151.06	61%	
Total	0.55	0.61	100%	249.61	100%	207
Evaporation	0.54	0.61	100%	0.00	0%	0
Sedimentation/retention				248.51	100%	
Outflow	0.00	0.00	0%	1.10	0%	194

Load reductions				**TP load reduction (lb/yr)**	**% TP reduction**	
Precipitation				0.00	0%	
Watershed Runoff				17.87	24%	
Watershed runoff and internal recycling				162.61	52%	
Total				180.48	42%	

Appendix D. Guidance for documentation of compliance with MS4 TP WLA for the City of Fairmont

Permit overview

This supplement to the *Blue Earth River Watershed TMDL Report* is to assist the City of Fairmont with future MS4 General Permit reapplications. Assuming the current 2020 MS4 General Permit requirements remain the same or similar for TP WLAs in the 2025 MS4 General Permit, during the 2025 General Permit reapplication, the city must determine if they are meeting their assigned TP WLA for the Fairmont Chain of Lakes.

- If the City is meeting the WLA, the city must:
    - Document all structural stormwater BMPs that have been implemented in order to achieve the WLA
    - Provide estimated reductions
- If the City is not meeting their TP WLA at the time of permit reissuance, the City must:
    - Submit a compliance schedule that includes proposed BMPs for the permit cycle and the planned implementation year for each BMP
    - Provide a cumulative estimate of load reductions
    - Provide a target year for meeting the WLA

Fairmont Chain of Lakes

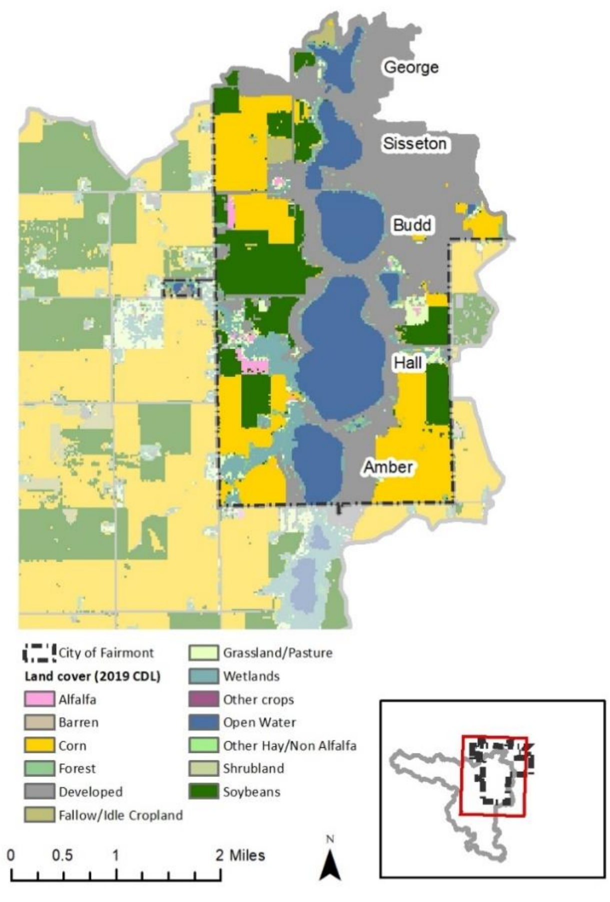
The jurisdictional area of the City of Fairmont within the Fairmont Chain of Lakes Watershed was used to develop the WLA mass load for the Fairmont Chain of Lakes (Table D-1, Figure D-1). Using the entire city boundary acknowledges that any future stormwater conveyance within the city boundary will be MS4-regulated. The Fairmont Chain of Lakes TMDL WLA for the City (1,855 lb/season) was calculated as modeled watershed runoff volume from the jurisdictional area multiplied by the target watershed runoff TP concentration of 183 µg/L. This target applies to all watershed runoff in the Fairmont Chain of Lakes drainage area, both in and outside of the city limits, and was derived such that, if achieved, all lakes in the chain would achieve lake water quality targets or better.

Table D-1. Permitted MS4 and estimated regulated area for lake phosphorus impairments

MS4 name and permit number	Estimated regulated area (ac) [a]	Estimated regulated percent area of the watershed	Impaired water body	Impaired water body AUID	Phosphorus wasteload allocation (lb/season)
City of Fairmont (MS400239)	5,095	19%	Fairmont Chain of Lakes: Amber, Hall, Budd, Sisseton, George	46-0034-00 46-0031-00 46-0030-00 46-0025-00 46-0024-00	1,855

a. Does not include lake surface area of impaired lakes.

Figure D-1. Regulated MS4 (City of Fairmont) in Fairmont Chain of Lakes Watershed for phosphorus TMDL.



The Fairmont Chain of Lakes MS4 WLA equates to a phosphorus loading rate of 0.36 lb/ac-season (1,855 lb/season divided by 5,095 ac), with the season being April through October. HSPF-simulated flows from 2008 through 2017 (the most recent 10 years in the HSPF simulation) indicate that approximately 75% of annual flows occur in April through October, which is the averaging period of the Fairmont Chain of Lakes TMDL. If we assume that the average TP concentration in watershed runoff is the same in April through October compared to January through December, the Chain of Lakes MS4 WLA equivalent of 0.36 lb/ac-season translates into an annual WLA equivalent of 0.48 lb/ac-yr (0.36/0.75).

However, because the target watershed runoff phosphorus contribution in the TMDL scenario is based on a concentration (183 µg/L), the annual loading target and unit area loading target will vary based on watershed runoff volume for the period of interest. Simulated seasonal runoff volumes from MS4 areas during the TMDL model period (2017 through 2021) vary by a factor of over four (Table D-2). Because the watershed runoff concentration target remains constant at 183 µg/L, the target load (i.e., volume multiplied by concentration) and the target unit area loading rate (i.e., load divided by area) are both directly proportional to volume and therefore also vary by over a factor of four (Table D-2). These calculations demonstrate the importance of using the same range of precipitation values in determining future WLA compliance.

Table D-2. Relationship between precipitation and loading targets.

			Modeled (2017–2021)			TMDL target	
Year	Annual precip (inches)	Seasonal precip (inches; Apr–Oct)	MS4 runoff (ac-ft/season)	MS4 P load (lb/season)	MS4 P loading rate (lb/ac-season)	MS4 P target load (lb/season) [a]	MS4 P target unit area loading rate (lb/ac-season)
2017	34.9	29.0	2,961	1,672	0.33	1,475	0.29
2018	47.3	40.4	6,974	4,629	0.91	3,471	0.68
2019	45.4	36.2	5,148	3,694	0.73	2,562	0.50
2020	21.5	16.8	1,919	1,067	0.21	955	0.19
2021	17.4	15.7	1,621	886	0.17	807	0.16
Avg	33.3	27.6	3,725	2,390	0.47	1,855 [b]	0.36

a. Modeled runoff volume x 183 µg/L.

b. 1,855 is the City's WLA (Table 77).

TMDL WLA compliance

The City of Fairmont provided their Simple Estimator worksheets containing their structural stormwater BMPs at the beginning of TMDL development. This information was used to model 2017 through 2021 TP loads from the city's jurisdictional boundary within the Fairmont Chain of Lakes Watershed, which includes nonregulated areas.

During the 2025 General MS4 permit reapplication, the City can use the following guidance to determine if they are meeting the Fairmont Chain of Lakes WLA, as a unit area load or concentration target. This analysis should only consider regulated stormwater conveyance areas at time of permit re-issuance. The City can utilize the Simple Estimator or other models/tools using the following approach.

- Depending on the model, use precipitation values in the appropriate time step from the TMDL period of 2017 through 2021.
- If using the Simple Estimator:
    - Start with Simple Estimator version provided to the MPCA in 2022.
    - Revise with any new or updated land use or subwatersheds within the regulated area.
    - Add in any additional area treated by new BMPs since the baseline condition of 2021.

- Set mean annual precipitation to 33.3 inches/year (Column E of the Simple Estimator). If calculating seasonal load, use 27.6 inches/season (Table D-2).

- If the resulting annual unit area load for areas draining to regulated stormwater conveyance in the city is less than either 0.48 lb/ac-yr or 0.36 lb/ac-season, the City would be meeting the WLA.
- Alternatively, if an updated version of the Simple Estimator is developed that contains a concentration field, and if the City's runoff concentration within their regulated stormwater conveyance is less than 183 µg/L, they would be meeting the WLA.
    - The City can also calculate concentrations from the current version of the Estimator by dividing TP loads by flow.

Other TP TMDLs

In addition to this phosphorus WLA assigned to the City in the Fairmont Chain of Lakes TMDL, the City of Fairmont was assigned a phosphorus MS4 WLA of 0.35 lb/ac-year in the Lake Pepin TMDL; this MS4 WLA is expressed as a unit area loading rate and applies to all regulated MS4s in the Lake Pepin Watershed (MPCA 2021b). In future MS4 permit applications, the City of Fairmont will be expected to document whether they are meeting their phosphorus WLAs in the Lake Pepin TMDL.

The Lake Pepin TMDL is based on data from 1985 through 2006. In order to determine WLA compliance for Pepin, the City can use a similar process as above, but should use mean average rainfall from the 1985 through 2006 period. A quick comparison based on the slightly lower annual precipitation values of the Lake Pepin TMDL period versus the Fairmont Chain of Lakes TMDL period and the unit area load differences, it would appear that the Pepin unit area load target is more stringent than the Fairmont Chain of Lakes unit area load target. However, a more thorough model analysis by the City would need to be completed in order to confirm this.

The City of Fairmont also has an assigned TP WLA for the *Lower Minnesota River Dissolved Oxygen TMDL* (MPCA 2004). That TMDL assigned a target reduction of 30% from the baseline low flow condition of 1988. Compliance can be documented by determining if BMPs put in place since 1988, using precipitation values for August and September of 1988, achieve a 30% reduction in impervious surface phosphorus loading.