Watonwan River Watershed Total Maximum Daily Load Study

MINNESOTA POLLUTION CONTROL AGENCY

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Abbreviations

1W1P	One Watershed, One Plan
AFO	animal feeding operation
AGREETT	Agriculture Research, Education and Extension Technology Transfer Program
AUID	assessment unit identification
BMP	best management practice
BWSR	Board of Water and Soil Resources
CAFO	concentrated animal feeding operation
chl-*a*	chlorophyll-*a*
CWA	Clean Water Act
DEM	digital elevation model
DMR	discharge monitoring report
DNR	Minnesota Department of Natural Resources
E. coli	*Escherichia coli*
EPA	United States Environmental Protection Agency
EQuIS	Environmental Quality Information System
GBERBA	Greater Blue Earth River Basin Alliance
HSPF	Hydrologic Simulation Program–Fortran
HUC	hydrologic unit code
IPHT	imminent public health threat
LA	load allocation
lb/day	pounds per day
m	meters
MDA	Minnesota Department of Agriculture
mgd	million gallons per day
mL	milliliter
MnDOT	Minnesota Department of Transportation
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/100 mL	organisms per 100 milliliters
org/d	organisms per day
SDS	State Disposal System
SIETF	Subsurface Sewage Treatment Systems Implementation and Enforcement Task Force
SSTS	Subsurface Sewage Treatment System
SWCD	soil and water conservation district
TMDL	total maximum daily load
TP	total phosphorus
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WASCOB	water and sediment control basin
WLA	wasteload allocation
WRAPS	Watershed Restoration and Protection Strategy
WWTP	wastewater treatment plant
µg/L	micrograms per liter

Executive Summary

The 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. 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 the stream and lake impairments in the Watonwan River Watershed in south central Minnesota. The causes of impairment in the watershed include high levels of *Escherichia coli* (*E. coli*) and total phosphorus (TP), affecting aquatic recreation designated uses. Ten *E. coli* TMDLs for streams and four phosphorus TMDLs for lakes are provided. Stream impairments related to sediment are being addressed in a separate concurrent report.

Land cover in the Watonwan River Watershed is predominantly agricultural with the dominant crops being corn and soybeans; artificial drainage is common. Very little of the watershed is developed. Potential sources of pollutants include watershed runoff (both regulated and unregulated), municipal wastewater, septic systems and untreated wastewater, livestock, atmospheric deposition, and lake internal loading. High priority pollutant sources include human sources such as: septic systems with imminent threats to public health and safety; agricultural sources such as livestock and runoff from cropland; and internal lake phosphorus loading.

The pollutant load capacity of the impaired streams was determined through the use of load duration curves. These curves represent the allowable pollutant load at any given flow condition. Water quality data were compared with the load duration curves to determine load reduction needs. 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. A 10% explicit margin of safety (MOS) was incorporated into all TMDLs to account for uncertainty. The estimated percent reductions needed to meet the TMDLs range from 7% to 89%.

The implementation strategy section highlights an adaptive management process to achieving water quality standards and restoring beneficial uses. Implementation strategies include: septic system upgrades, replacement, and maintenance; agricultural best management practices (BMPs; e.g., filter strips, riparian buffers, drainage water management, and conservation cover); stream restoration; lake internal load management; and education and outreach. Public participation included meetings with watershed stakeholders to present watershed data and gather input on implementation strategies to improve water quality. The TMDL study is supported by previous work, including the *Watonwan Watershed Monitoring and Assessment Report* (MPCA 2016), *Watonwan Watershed Characterization Report* (DNR 2016), and the Minnesota River Watershed hydrology and water quality model (Tetra Tech 2015, Tetra Tech 2016). The farming community has been and continues to be a vital partner to conservation efforts in the Minnesota River Basin. Reducing sediment and nutrient impacts on water resources is important to Minnesota farmers who innovate new practices to improve the sustainability of their farms. Continued support from the State, local governments, and farm organizations will be critical to finding and implementing solutions that work for individual farmers and help achieve the goal of clean water.

1. Project Overview

1.1 Purpose

The CWA and United States Environmental Protection Agency (EPA) regulations require that TMDLs be developed for waters that do not support their designated uses. In simple terms, a TMDL study determines what is needed in terms of pollution reductions 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 point sources, load allocations (LAs) for nonpoint sources (including natural background), and the MOS, which is implicitly or explicitly defined, cannot exceed the maximum allowable pollutant load.

This TMDL study covers four lake eutrophication (phosphorus) and 10 *E. coli* stream impairments within the Watonwan River Watershed (United States Geological Survey [USGS] Hydrologic Unit Code [HUC] 8 07020010). The project area covers the 878-square-mile watershed in south central Minnesota (Figure 1).

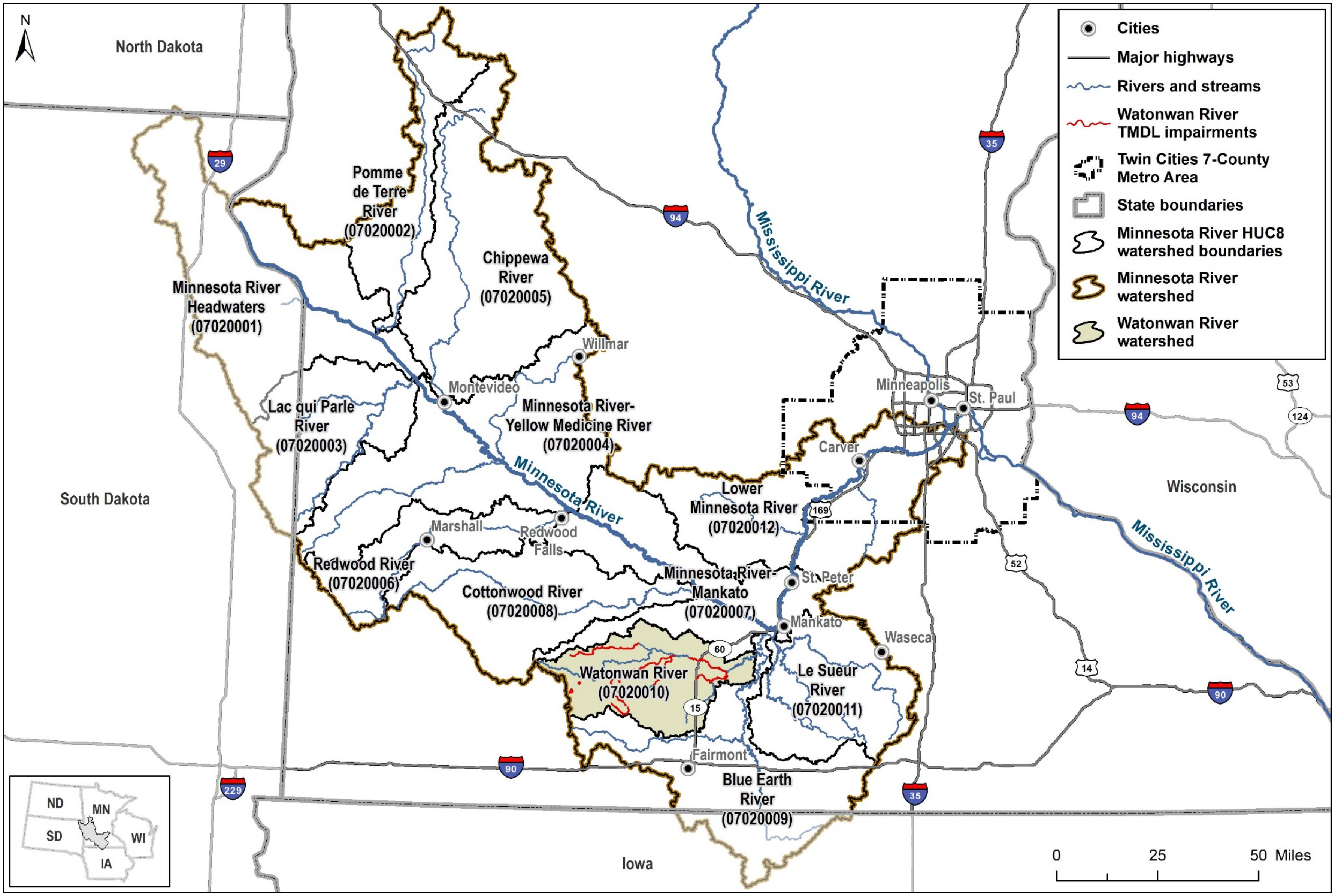


Figure 1. Watonwan River Watershed.

1.2 Identification of Waterbodies

The Watonwan River Watershed TMDL report addresses four impaired lakes (Table 1) and 10 impaired stream reaches, or assessment units (Table 2). The lakes have aquatic recreation impairments as identified by eutrophication indicators, and the stream impairments affect aquatic recreation or limited resource value designated uses based on high levels of pathogens (*E. coli*). Aquatic consumption (fish tissue) impairments are not addressed in this report and therefore are not presented in Table 1 or Table 2. Impaired waterbodies are shown in Figure 2. Sediment related stream impairments are also not addressed in this report but are addressed in the draft Minnesota River and Greater Blue Earth Basin Total Suspended Solids TMDL Study. No part of the Watonwan River Watershed is located within the boundary of a Native American Reservation. This TMDL does not allocate pollutant load to any federally recognized Native American tribe.

In this report, the impairments are listed in tables ordered from upstream to downstream. All stream assessment unit identifications (AUIDs) for streams begin with 07020010, which is the eight-digit HUC for this watershed. The reaches are identified in this report with the last three digits of the full AUID. For example, AUID 07020010-510 is referred to as reach 510.

Table 1. Phosphorus impairments in the Watonwan River Watershed.
All four lakes are in the Western Corn Belt Plains ecoregion.

Lake Name	Lake ID	Use Class	Lake Type	Affected Designated Use	Year Listed
Eagle Lake	17-0020-00	2B	Shallow lake	Aquatic Recreation	2010
Butterfield Lake	83-0056-00	2B	Shallow lake	Aquatic Recreation	2016
Kansas Lake	83-0036-00	2B	Shallow lake	Aquatic Recreation	2016
Bingham Lake	17-0007-00	2B	Shallow lake	Aquatic Recreation	2010

Table 2. Stream *E. coli* impairments in the Watonwan River Watershed (HUC8 07020010).
All of the impairments were listed in 2016.

Stream Name	Description	Assessment Unit ID (AUID) [a]	Use Class [b]	Affected Designated Use	Year listed
Watonwan River, North Fork	Headwaters to T107 R32W S6, east line	564	2Bg	Aquatic Recreation	2016
Butterfield Creek	Headwaters to St James Cr	516	2Bg	Aquatic Recreation	2016
St James Creek	T106 R32W S25, west line to T106 R31W S19, north line	576	2Bm	Aquatic Recreation	2016
St James Creek	T106 R31W S18, south line to Butterfield Cr	502	7	Limited Resource Value	2016
St James Creek	Butterfield Cr to Watonwan R	515	7	Limited Resource Value	2016
Judicial Ditch 1	T105 R33W S8, west line to Irish Lk	581	2Bg	Aquatic Recreation	2016
Watonwan River, South Fork	-94.8475 43.8813 to Irish Lk	568	2Bg	Aquatic Recreation	2016
Spring Branch Creek	T106 R30W S22, west line to Perch Cr	574	2Bm	Aquatic Recreation	2016
Perch Creek	Spring Cr to Watonwan R	523	2Bg	Aquatic Recreation	2016
Watonwan River	S Fk Watonwan R to Perch Cr	510	2Bg	Aquatic Recreation	2016

a. The AUIDs begin with 07020010; the values in this column are the last 3 digits of the AUID.

b. Use classes—2Bg: aquatic life and recreation—general warm water habitat (lakes and streams); 2Bm: aquatic life and recreation—modified warm water habitat (streams); 7: limited resource value water.

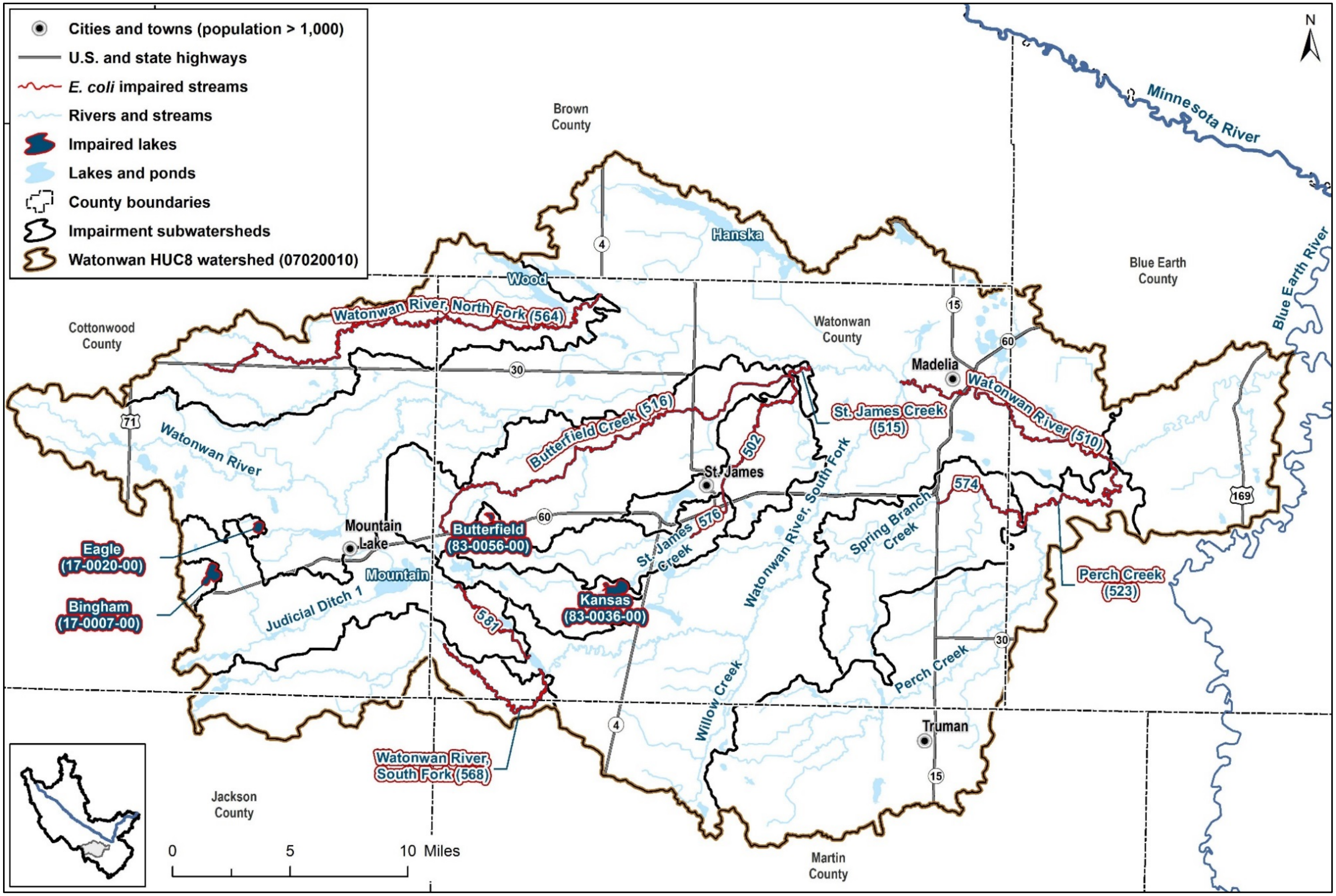


Figure 2. Impairments in the Watonwan River Watershed.

1.3 Priority Ranking

The Minnesota Pollution Control Agency's (MPCA's) schedule for TMDL completions, as indicated on the 303(d) impaired waters list, reflects Minnesota's priority ranking of this TMDL. The MPCA has aligned TMDL priorities with the watershed approach and the Watershed Restoration and Protection Strategies (WRAPS) cycle. The MPCA developed a state plan Minnesota's TMDL Priority Framework Report to meet the needs of EPA's national measure (WQ-27) under EPA's Long-Term Vision for Assessment, Restoration and Protection under the CWA Section 303(d) Program. As part of these efforts, the MPCA identified water quality impaired segments that will be addressed by TMDLs by 2022. The Watonwan River Watershed waters addressed by this TMDL are part of that MPCA prioritization plan to meet EPA's national measure.

2. Applicable Water Quality Standards and Numeric Water Quality Targets

Water quality standards are designed to protect designated uses. The standards consist of the designated uses, criteria to protect the uses, and other provisions such as antidegradation policies that protect the water body.

2.1 Designated Uses

Use classifications are defined in Minn. R. 7050.0140, and water use classifications for individual water bodies are provided in Minn. R. 7050.0470, 7050.0425, and 7050.0430. This TMDL report addresses the waterbodies that do not meet the standards for class 2 and 7 waters. The impaired streams in this report are classified as class 2Bg, 2Bm, and/or 7 waters (Table 1). Class 2B waters are protected for aquatic life and recreation, and the streams in this project fall into two categories—class 2Bg, which are general warm water habitat and class 2Bm, which are modified warm water habitat. Class 7 waters are limited resource value waters and are protected for aesthetic qualities, secondary body contact use, and groundwater for use as a potable water supply. The lakes addressed in this report are classified as class 2B waters (Table 2), which are protected for aquatic life and recreation.

2.2 Water Quality Standards

Water quality standards for class 2 waters are defined in Minn. R. 7050.0222, and water quality standards for class 7 waters are defined in Minn. R. 7050.0227. Water quality standards for *E. coli* and eutrophication (phosphorus) are presented in Table 3 and Table 4.

In Minnesota, *E. coli* is used as an indicator species of potential waterborne pathogens. There are two *E. coli* standards each for class 2 and class 7 waters—one is applied to monthly *E. coli* geometric mean concentrations, and the other is applied to individual samples. Exceedances of either *E. coli* standard in class 2 or 7 waters indicates that a water body does not meet the applicable designated use. The class 2 standard applies from April through October, whereas the class 7 standard applies from May through October. Exceedances of the eutrophication standard in lakes indicate that the lake does not meet the aquatic recreation designated use. The numeric water quality standards for these parameters (Table 3 and Table 4) serve as targets for the applicable Watonwan River Watershed TMDLs.

Chlorophyll-*a* (chl-*a*) and Secchi transparency standards must be met in lakes, in addition to meeting phosphorus limits. In developing the lake nutrient standards for Minnesota lakes (Minn. R. 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, it is expected that by meeting the phosphorus target in each lake, the chl-*a* and Secchi transparency standards Table 4) will likewise be met.

Table 3. Water quality standards for *E. coli* parameters in class 2 and class 7 streams

Water body Type	Water Quality Standard	Numeric Standard/Target
Class 2 streams	Not to exceed 126 organisms 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 organisms per 100 milliliters. The standard applies only between April 1 and October 31.	≤ 126 organisms/100 mL water (monthly geometric mean) ≤ 1,260 organisms/100 mL water (individual sample)
Class 7 streams	Not to exceed 630 organisms per 100 milliliters as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than 10% of all samples taken during any calendar month individually exceed 1,260 organisms per 100 milliliters. The standard applies only between May 1 and October 31.	≤ 630 organisms/100 mL water (monthly geometric mean) ≤ 1,260 organisms/100 mL water (individual sample)

Table 4. Eutrophication standards for class 2B shallow lakes in the Western Corn Belt Plains ecoregion

Parameter	Shallow Lakes Standard
Phosphorus, total (micrograms per liter [µg/L])	90
Chlorophyll-*a* (µg/L)	30
Secchi Transparency (meters [m])	≥ 0.7

3. Watershed and Water body Characterization

The Watonwan River Watershed spans approximately 878 square miles and is located in south central Minnesota in the Western Corn Belt Plains ecoregion. It is 1 of 12 major watersheds in the Minnesota River Basin and drains portions of Blue Earth, Brown, Cottonwood, Jackson, Martin, and Watonwan counties. The river flows 113 miles from within Cottonwood County to the east until its confluence with the Blue Earth River near Garden City, Minnesota. Little natural meander remains in the Watonwan River; it has been straightened or altered to provide drainage for surrounding farm land and to decrease flooding. Seventy percent of the Watonwan Watershed has altered watercourses. The river has three primary tributaries (North Fork Watonwan, South Fork Watonwan, and Watonwan rivers) and four minor tributaries (Butterfield, Saint James, Willow, and Perch creeks).

The *Watonwan River Watershed Hydrology, Connectivity, and Geomorphology Assessment Report* (DNR 2014) provides information on the hydrology, connectivity, and geomorphology in the watershed.

3.1 Lakes

Impaired lakes range in surface area from 49 to 403 acres, with watershed area to surface area ratios from 5 to 23 (Table 5). The impaired lakes are shown in Figure 2.

Table 5. Lake morphometry and watershed area

Lake Name	Lake ID	Surface Area (acres) [a]	Mean Depth (m) [b]	Max Depth (m) [b]	Littoral Area (% total area less than 15 feet deep, or 4.6 m) [b]	Watershed Area (incl. lake surface area; ac) [c]	Watershed Area : Surface Area
Eagle Lake	17-0020-00	105	1.6	2.6	100%	531	5.1
Butterfield Lake	83-0056-00	49	1.9	3.0	100%	538	11.0
Kansas Lake	83-0036-00	403	1.3	2.0	100%	9,184	22.8
Bingham Lake	17-0007-00	270	2.6	4.0	100%	1,658	6.1

a. Surface areas are from DNR's lake basin morphology shapefile except for Butterfield, which is from the MPCA's impaired waters shapefile.
b. Mean depth, maximum depth, and littoral areas are from the DNR's lake basin morphology shapefile. Mean depth for Butterfield is derived from the relationship between mean depth and maximum depth in the other impaired shallow lakes in this watershed and in the Watonwan River Watershed.
c. See Section 3.3 for information on subwatershed boundaries.

3.2 Streams

The watershed sizes of the impaired stream reaches range from 23,463 acres to 434,360 acres (Table 6). The subwatershed area includes all drainage area to the impairment, including from upstream assessment units. Loading capacity from each of the impaired reaches is cumulative and is carried downstream to the next impaired reach. The impairments are shown in Figure 2.

Table 6. Watershed areas of impaired streams

Stream Name	AUID	Watershed Area (acres) [a]
Watonwan River, North Fork	564	40,885
Butterfield Creek	516	39,953
St James Creek	576	23,463
St James Creek	502	38,496
St James Creek	515	79,397
Judicial Ditch 1	581	33,431
Watonwan River, South Fork	568	25,802
Spring Branch Creek	574	25,809
Perch Creek	523	95,852
Watonwan River	510	434,360

a. Watershed area includes all drainage area to the impairment

3.3 Subwatersheds

The watershed boundaries of the impaired waterbodies (Figure 2) were developed using multiple data sources, starting with watershed delineations from the MPCA's Hydrologic Simulation Program–Fortran (HSPF) model application of the Watonwan River Watershed (Tetra Tech 2015). The model watershed boundaries are based on Minnesota Department of Natural Resources (DNR) Level 8 watershed boundaries and modified with a 30-meter digital elevation model (DEM). Where additional watershed breaks were needed to define the impairment watersheds, DNR Level 8 and Level 9 watershed boundaries were used.

3.4 Land Cover

Land cover in the Watonwan River Watershed is predominantly agricultural, with the dominant crops being corn and soybeans (Table 7, Figure 3). Artificial drainage is common in the watershed and is used to remove ponded water from flat or depressional areas (NRCS n.d.). Very little of the watershed is developed. Loss of wetlands in several subwatersheds of the Watonwan River Watershed was noted in the *Watonwan Watershed Monitoring and Assessment Report* (MPCA 2016). The largest losses were seen in Perch Creek and Spring Branch Creek with at least a 51% loss of wetlands.

Table 7. Land cover in impaired watersheds (2016 Cropland Data Layer)
Percentages rounded to the nearest whole number.

Water body Name	Stream AUID / Lake ID	Percent of Watershed (%)							
		Developed	Corn	Soybeans	Other crops	Grassland/pasture	Forest	Wetlands	Open water
Eagle Lake	17-0020-00	4	43	22	<1	4	1	6	20
Watonwan River, North Fork	564	5	46	36	1	3	1	6	2
Butterfield Creek	516	7	49	36	1	1	<1	5	1
Butterfield Lake	83-0056-00	6	39	25	2	3	<1	13	12
Kansas Lake	83-0036-00	4	43	37	<1	1	1	7	7
St James Creek	576	6	44	40	<1	1	<1	6	3
	502	8	43	37	<1	1	<1	8	3
	515	7	47	36	1	1	<1	6	2
Bingham Lake	17-0007-00	6	40	20	1	9	<1	6	18
Judicial Ditch 1	581	6	43	35	<1	6	1	7	2
Watonwan River, South Fork	568	4	46	41	<1	3	<1	4	2
Spring Branch Creek	574	5	54	37	<1	<1	<1	4	<1
Perch Creek	523	6	48	38	<1	1	1	5	1
Watonwan River	510	6	47	34	1	2	1	7	2

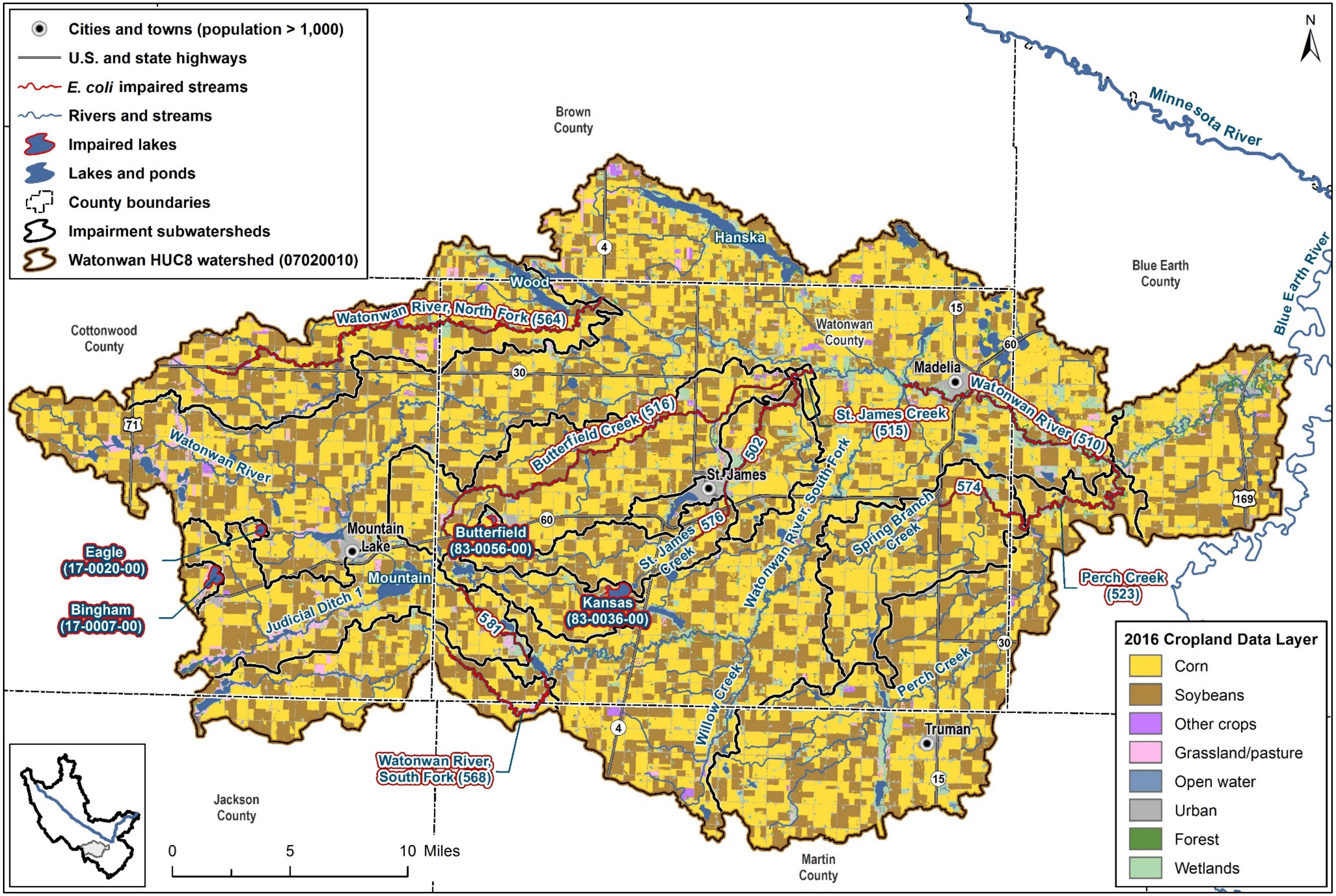


Figure 3. Land cover in the Watonwan River Watershed.

3.5 Current/Historic Water Quality

Flow and water quality data are presented in this section to evaluate the impairments and trends in water quality. Data from the years 2006 through 2015 were used in the water quality summary tables. If data from 2006 through 2015 were not available, data prior to the 10-year time period were evaluated, as available, to examine trends in water quality. Water quality data from the Environmental Quality Information System (EQuIS) database were used for the analysis. The following describes the analyses completed for impaired lakes and streams.

3.5.1 Lakes

Water quality data from 2006 to 2015 were summarized for TP, chl-*a*, and Secchi transparency. Data were summarized over the entire period to evaluate compliance with the water quality standards, and by year to evaluate trends in water quality. The summaries include monitoring data from the growing season (June through September); the water quality standards apply to growing season means. Results are presented in Appendix A and are summarized in Figure 4 through Figure 6. Phosphorus data are limited, with only one to two years of data within the TMDL timeperiod of 2006 to 2015 (Figure 4). On average, growing season mean phosphorus concentrations are lowest in Butterfield Lake (94 µg/L). The chl-*a* concentration patterns differ somewhat, with Bingham Lake and Kansas Lake having lower concentrations on average than Eagle Lake and Butterfield Lake (Figure 5). More Secchi depth data are available than phosphorus and chl-*a*. Clarity on average is lowest in Butterfield Lake (0.2 meters) and is variable in Bingham Lake, the lake with the longest data record (Figure 6).

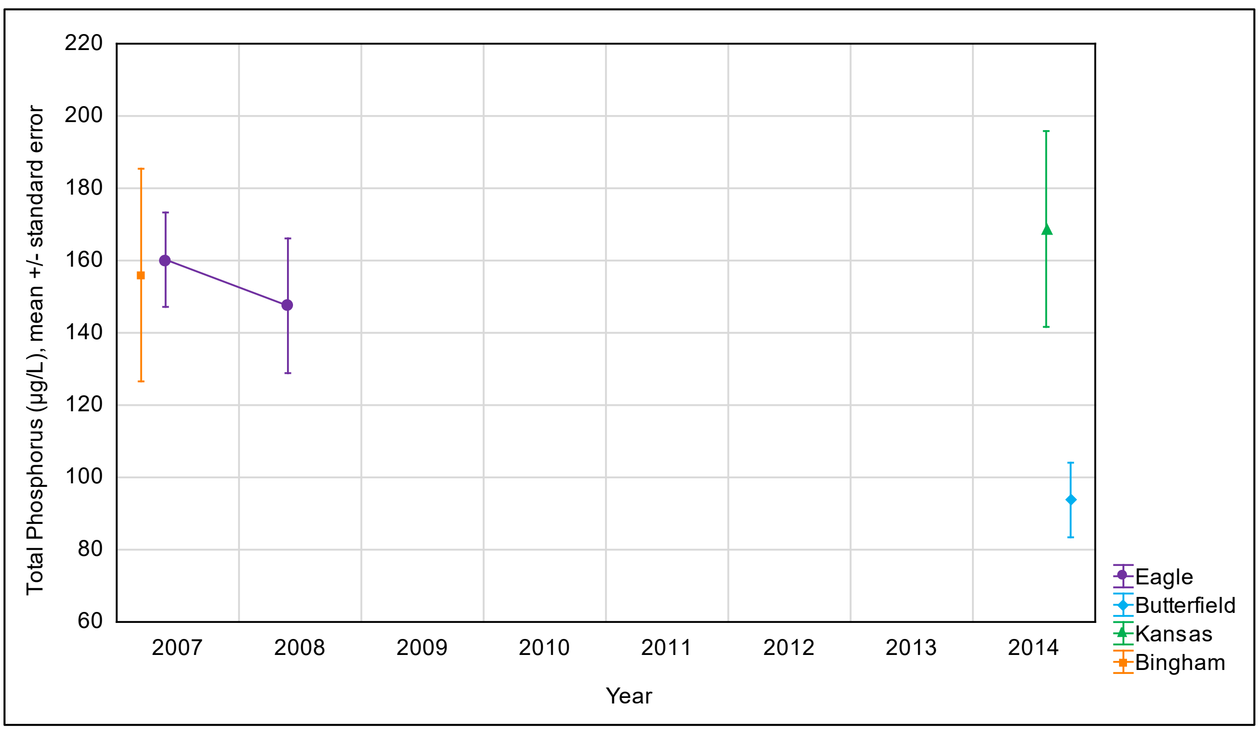


Figure 4. Growing season mean phosphorus concentrations by year for impaired lakes.

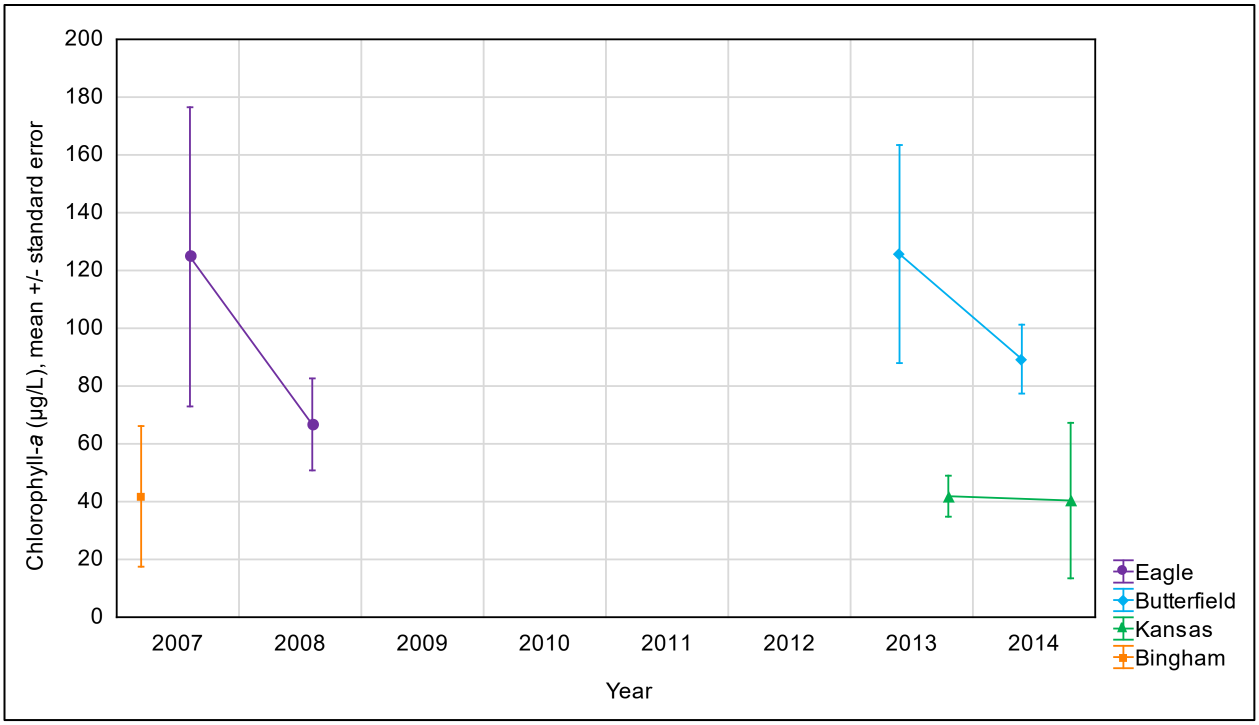


Figure 5. Growing season mean chlorophyll-*a* concentrations by year for impaired lakes.

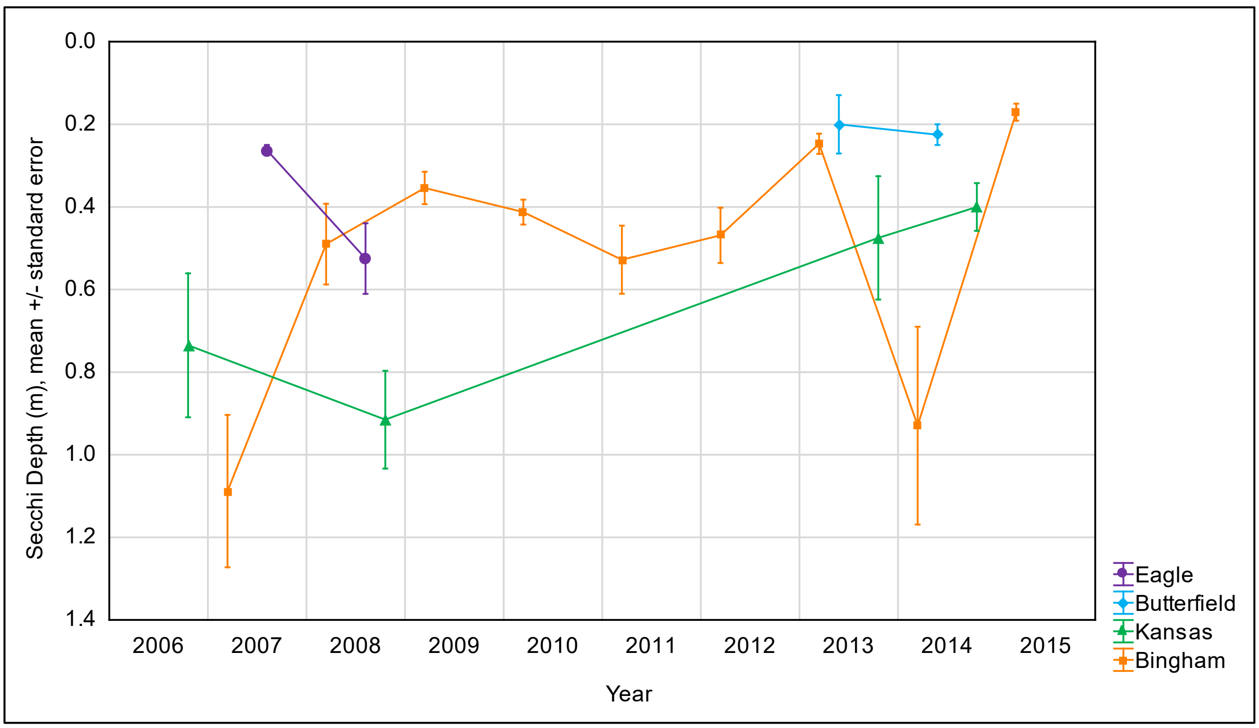


Figure 6. Growing season mean Secchi depths by year for impaired lakes.

3.5.2 Streams

Flow

The analyses used the following sources of flow data (Table 8):

- The MPCA provided flow data from Hydstra, a database that stores MPCA and DNR stream gauging data. Daily average flows from one gage were calculated and used in the analyses.

- Daily average flows were simulated with the MPCA's HSPF model application for the Watonwan River Watershed (2016-02-18 version). HSPF model validation was performed at the Watonwan River site near Garden City, Minnesota; Hydstra ID 31051001, for the time period of January 1, 1995, through January 1, 2002 (Tetra Tech 2015) Appendix E. Simulated flows are available at the downstream end of each model reach. The model reports (Tetra Tech 2015, Tetra Tech 2016) describe the framework and the data that were used to develop the model and include information on the calibration and validation.

Flow records from the one monitoring gage were prioritized over simulated flows and were used for the Watonwan River TMDL. The drainage area-ratio method was used to extrapolate gage flows to the locations of the segment outlet. Flows from MPCA/DNR gage 31051001 on the Watonwan River collected from January 1, 1986, through December 31, 2015, were reduced by 20% to develop the flow duration curve for AUID 07020010-510 because the impaired segment drains 679 square miles and the MPCA/DNR gage drains 848 square miles (i.e., the impaired subwatershed is 80% of the gaged subwatershed).

For the remaining nine impaired segments, daily average flow simulated in HSPF for the modeling period (January 1, 1995 through December 31, 2012) was used in the analyses. The outlets of five of the impaired segments were collocated with model output locations, and thus HSPF-simulated flows were used to develop flow duration curves. For the remaining four impairments, HSPF-simulated flows from nearby modeled reaches were drainage area-weighted to the impaired reach. For additional information regarding HSPF modeling, see the brief summary in Section 3.6.3 or modeling documentation (Tetra Tech 2015, Tetra Tech 2016).

Table 8. Stream flow data sources

Stream Name	AUID	Flow Source	Period of Record
Watonwan River, North Fork	564	HSPF Reach 99, area-weighted	1/1/1995–12/31/2012
Butterfield Creek	516	HSPF Reach 123	1/1/1995–12/31/2012
St James Creek	576	HSPF Reach 131, area-weighted	1/1/1995–12/31/2012
St James Creek	502	HSPF Reach 131, area-weighted	1/1/1995–12/31/2012
St James Creek	515	HSPF Reach 133	1/1/1995–12/31/2012
Judicial Ditch 1	581	HSPF Reach 181	1/1/1995–12/31/2012
Watonwan River, South Fork	568	HSPF Reach 184, area-weighted	1/1/1995–12/31/2012
Spring Branch Creek	574	HSPF Reach 251	1/1/1995–12/31/2012
Perch Creek	523	HSPF Reach 253	1/1/1995–12/31/2012
Watonwan River	510	MPCA/DNR station 31051001, area-weighted	1/1/1986–12/31/2015

Pollutants

Water quality data from 2006 to 2015 were summarized for the *E. coli* impairments. Data were summarized by year to evaluate trends in long term water quality, and by month to evaluate seasonal variation. The summaries of data by year only consider data taken during the time period that the standard is in effect (April/May through October for class 2 and class 7 waters, respectively). Where there are multiple sites along one assessment unit, data from the sites were combined and summarized together. The frequency of exceedances represents the percentage of samples that exceed the water quality standard.

Load duration curves are provided for each impaired stream. Water quality is often a function of stream flow, and load duration curves are used to evaluate the relationships between hydrology and water quality. For example, *E. coli* concentrations can increase with rising flows if manure applied to cropland is a substantial source. Other parameters may be more concentrated at low flows and diluted by increased water volumes at higher flows. The load duration curve approach provides a visual display of the relationship between stream flow and water quality. Load duration curves were developed as follows.

<u>Develop flow duration curves</u>: 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 either daily average flow reported from continuously recording gages or daily average flow from HSPF modeling (Tetra Tech 2015, Tetra Tech 2016). Table 8 presents the modeled stream segment number or monitoring gage and period of record used to develop the flow duration curve for each impaired segment. 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.

<u>Develop load duration curves</u>: To develop load duration curves, all average daily flows were multiplied by the water quality standard (i.e., 126 or 630 org/100 milliliter [mL] *E. coli*), and converted to a daily load to create “continuous” load duration curves 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 load duration curve, based on the concentration of the sample multiplied by the simulated or gaged flow (Table 8) on the day that the sample was taken. A nearby gage (MPCA/DNR gage 31051001) was used to estimate the flow exceedance to plot water quality samples from 2013 and 2014 from reaches for which the 1995 through 2012 HSPF simulated flow was used to develop the load duration curve. The flow exceedance was then used to determine the corresponding HSPF flow (at that flow exceedance) for which to calculate a load for the water quality sample. Each load calculated from a water quality sample that plots above the load duration curve represents an exceedance of the water quality target, whereas those that plot below the load duration curve are less than the water quality target.

To compare water quality data across all impaired reaches, a composite *E. coli* concentration duration curve was developed (Figure 7). Concentration duration curves are similar to load duration curves, except that concentration instead of load is plotted on the y-axis. This provides a comparison of water quality conditions across multiple reaches with varying flows.

Water quality summary tables and load duration curves are presented for each impairment in Appendix A, and Table 9 summarizes the water quality data.

The number of *E. coli* samples per impaired reach ranges from 12 to 30. The maximum recorded *E. coli* concentration per reach ranges from 1,935 to 8,164 org/100 mL. The frequencies of exceedance of the monthly geometric mean standard range from 50% to 100%, and the frequencies of exceedance of the individual sample standard range from 7% to 36% (Table 9). There is not a strong relationship between *E. coli* concentrations and flow across all of the reaches with *E. coli* impairments. Exceedances of the single sample standard occur across all flow conditions, with the majority of exceedances under high and low flow conditions and fewer under moderate flow conditions (Figure 7).

Table 9. Summary of *E. coli* data for impaired reaches.
Summaries include data from months during which the standard applies (see Section 2.2). *E. coli* units are org/100 mL.

Stream Name (description)	AUID	Date Range	Sample Count	Geo-metric Mean	Max-imum [a]	Number of Exceedances of Individual Standard
Watonwan River, North Fork (Headwaters to T107 R32W S6, east line)	564	2013–2014	15	545	2,723	2
Butterfield Creek (Headwaters to St James Cr)	516	2013–2014	15	522	≥ 2,420	2
St James Creek (T106 R32W S25, west line to T106 R31W S19, north line)	576	2013–2014	12	615	2,755	4
St James Creek (T106 R31W S18, south line to Butterfield Cr)	502	2013–2014	14	949	8,164	5
St James Creek (Butterfield Cr to Watonwan R)	515	2013–2014	15	594	4,884	3
Judicial Ditch 1 (T105 R33W S8, west line to Irish Lk)	581	2013–2014	15	557	≥ 2,420	2
Watonwan River, South Fork (-94.8475 43.8813 to Irish Lk)	568	2013–2014	15	680	2,755	2
Spring Branch Creek (T106 R30W S22, west line to Perch Cr)	574	2013–2014	15	405	≥ 2,420	1
Perch Creek (Spring Cr to Watonwan R)	523	2013–2014	15	545	≥ 2,420	2
Watonwan River (S Fk Watonwan R to Perch Cr)	510	2013–2014	30	290	1,935	5

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.

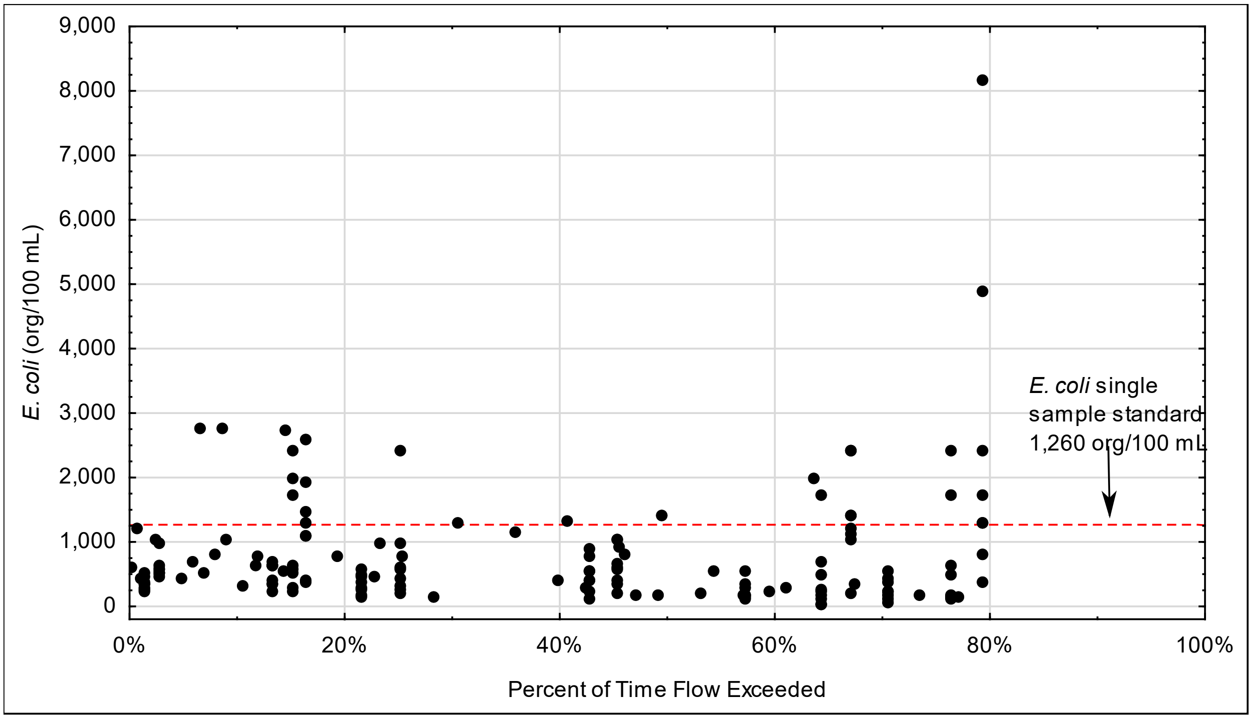


Figure 7. *E. coli* concentration duration curve for all reaches with *E. coli* impairments.

3.6 Pollutant Source Summary

Source assessments are used to evaluate the type, magnitude, timing, and location of pollutant loading to a water body. Source assessment methods vary widely with respect to their applicability, ease-of-use, and acceptability. The purpose of this section is to identify possible sources of *E. coli* and phosphorus in the watershed.

3.6.1 Pollutant Source Types

The pollutant sources evaluated in this report are permitted sources such as wastewater, stormwater, and permitted animal feeding operations (AFOs); and nonpermitted sources such as watershed runoff, septic systems, and internal loading. This section describes each of the pollutant source types in general. More details specific to pollutant type are provided in sections 3.6.2 and 3.6.3.

Permitted Sources of Pollution

Point source pollution is defined by CWA section 502(14) as "any discernible, confined and discrete conveyance, including any ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation (CAFO), or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agriculture stormwater discharges and return flow from irrigated agriculture." Under the CWA, all point sources are regulated under the National Pollutant Discharge Elimination System (NPDES) program. Permitted sources in the Watonwan River Watershed include regulated stormwater, municipal wastewater, and permitted AFOs.

Regulated Stormwater

Currently there are no regulated MS4s in the Watonwan River Watershed. Regulated stormwater delivers and transports pollutants to surface waters and is generated in the watershed during precipitation events. The sources of pollutants in stormwater are many, including decaying vegetation (leaves, grass clippings, etc.), domestic and wild animal waste, soil, deposited particulates from the air, road salt, and oil and grease from vehicles. There are two types of regulated stormwater in the watershed:

- *Construction stormwater* is runoff from a construction site. An NPDES permit is required for construction activity that disturbs one or more acres of soil or for smaller sites if the activity is part of a larger development. A permit also might be required if the MPCA determines that the activity poses a risk to water resources. Coverage under the construction stormwater general permit requires sediment and erosion control measures that reduce stormwater pollution during and after construction activities. Construction stormwater area percentages by county were obtained from the Minnesota Stormwater Construction Manual and area weighted to impaired subwatersheds. It is estimated that between 0.025% to 0.071% of the project area is regulated through the construction stormwater permit, so construction stormwater is not considered a significant source.
- *Industrial stormwater* is regulated through an NPDES permit when stormwater discharges have the potential to come into contact with materials and activities associated with the industrial activity.

Municipal Wastewater

Municipal wastewater (Figure 8) is the domestic sewage and wastewater collected and treated by municipalities before being discharged to waterbodies as municipal wastewater effluent. Ten wastewater treatment plants (WWTPs) discharge to impaired reaches in the Watonwan River Watershed.

NPDES/SDS Permitted Animal Feeding Operations

Of the approximately of 416 AFO in the Watonwan River Watershed (Figure 9), there are 100 CAFOs. CAFOs are defined by the EPA based on the number and type of animals. The MPCA currently uses the federal definition of a CAFO in its permit requirements of animal feedlots along with the definition of an animal unit (AU). In Minnesota, the following types of livestock facilities are required to operate under a NPDES Permit or a state issued State Disposal System (SDS) Permit: a) all federally defined CAFOs that have had a discharge, some of which are under 1000 AUs in size; and b) all CAFOs and non-CAFOs that have 1000 or more AUs.

CAFOs and AFOs with 1,000 or more AUs must be designed to contain all manure and manure contaminated runoff from precipitation events of less than a 25-year – 24-hour storm event. Having and complying with an NPDES permit allows some enforcement protection if a facility discharges due to a 25-year 24-hour precipitation event (approximately 5.3” in 24 hours) and the discharge does not contribute to a water quality impairment. Large CAFOs permitted with an SDS permit or those not covered by a permit must contain all runoff, regardless of the precipitation event. Therefore, many large CAFOs in Minnesota have chosen to have a NPDES permit, even if discharges have not occurred in the past at the facility. A current manure management plan which complies with Minn. R. 7020.2225 and the respective permit is required for all CAFOs and AFOs with 1,000 or more AUs. A list of facilities is included in Appendix D.

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 basis with an appropriate mix of field inspections, offsite monitoring and compliance assistance.

For the Watonwan River Watershed TMDL, all NPDES and SDS permitted feedlots are designed to have zero discharge, and as such they do not receive a WLA. All other non-CAFO feedlots and the land application of all manure are accounted for in the LA for nonpoint sources

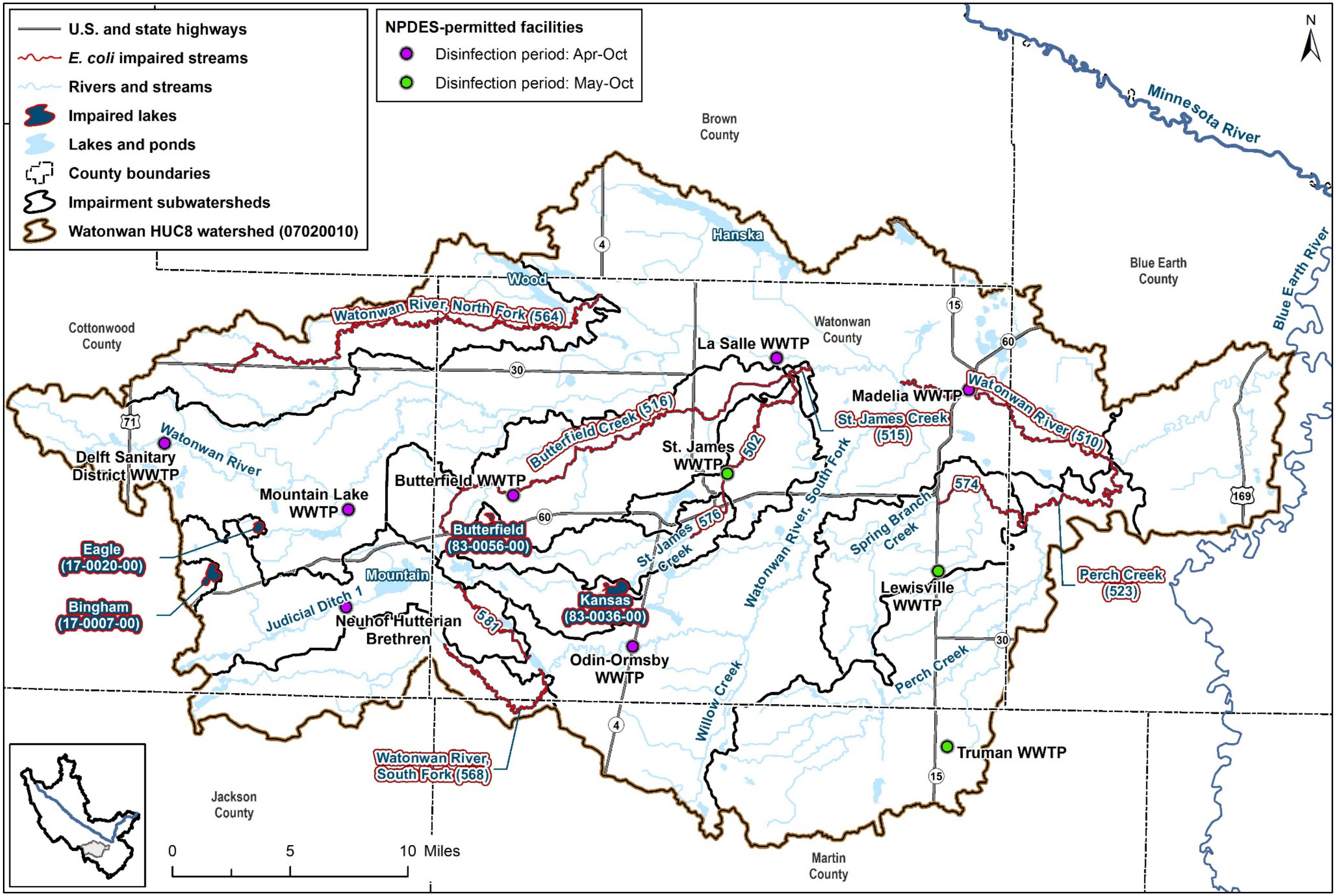


Figure 8. NPDES-permitted wastewater discharges in the Watonwan River Watershed.

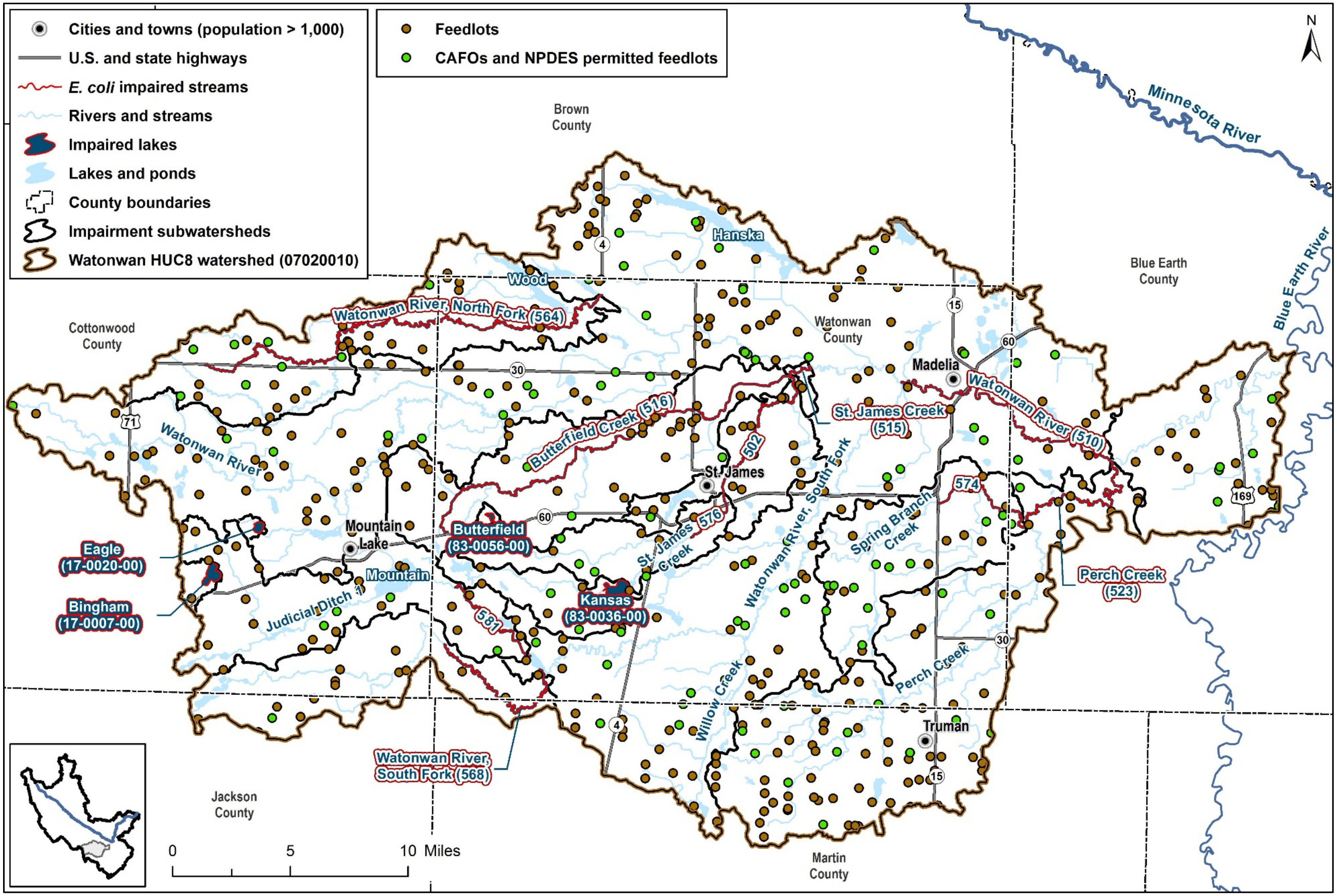


Figure 9. Feedlots in the Watonwan River Watershed.
Data from the MPCA's registered feedlot database.

Nonpermitted Sources of Pollution

There are many nonpermitted sources of pollution in the watershed. Nonpermitted sources of pollution include unregulated watershed runoff, Subsurface Sewage Treatment Systems (SSTS) and straight pipes, nonpermitted AFOs, and other pollutant-specific sources that are provided in the pollutant-specific discussions (sections 3.6.2 and 3.6.3), including internal phosphorus loading in lakes.

Unregulated Watershed Runoff

Watershed runoff, which transports and delivers pollutants to surface waters, is generated in the watershed during precipitation events. The sources of pollutants in watershed runoff are many, including soil particles, crop and lawn fertilizer, manure applied to cropland in accordance with Minn. R. 7020.2225, decaying vegetation (leaves, grass clippings, etc.), and domestic and wild animal waste.

Nonpermitted Wastewater

Human derived sources of pollution include SSTSs, straight pipe systems, and earthen pit outhouses. 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. Straight pipes (i.e., unpermitted and illegal sewage disposal systems that transport raw or partially settled sewage directly to a lake, stream, drainage system, or the ground surface) and SSTSs that discharge untreated sewage to the land surface are considered imminent public health threats (IPHTs). Straight pipes systems are required to be addressed 10 months after discovery (Minn. Stat. § 115.542, subd. 11).

Non-NPDES/SDS Permitted Animal Feeding Operations

In Minnesota, AFOs are required to register with their respective delegated county or the state if they are 1) an animal feedlot capable of holding 50 or more AUs, or a manure storage area capable of holding the manure produced by 50 or more AUs outside of shoreland; or 2) an animal feedlot capable of holding 10 or more AUs, or a manure storage area capable of holding the manure produced by 10 or more AUs, that is located within shoreland. Further explanation of registration requirements can be found in Minn. R. 7020.0350. AFOs under 1,000 AUs and those that are not federally defined as CAFOs do not operate with permits. However, the facilities must operate in compliance with applicable portions of Minn. R. 7020.

The animals raised in AFOs produce manure that is stored in pits, lagoons, tanks, and other storage devices. The manure is then applied or injected to area fields as fertilizer. When stored and applied properly, this beneficial re-use of manure provides a natural source for crop nutrition. It also lessens the need for fuel and other natural resources that are used in the production of fertilizer. AFOs; however, can pose environmental concerns; inadequately treated manure runoff from open lot feedlot facilities and improper application of manure can contaminate surface or groundwater.

Registered feedlots in the Watonwan River Watershed are mapped in Figure 9.

3.6.2 *E. coli* Source Summary

Impaired reaches were monitored as part of the Watonwan Watershed Approach and were assessed based on an average 15 samples to determine impairment status. More data could be collected at the individual reaches to better understand sources for implementation activities. Sources of fecal bacteria are typically widespread and often intermittent. In the Watonwan River Watershed, the *E. coli* standard is exceeded across all flow conditions, indicating a mix of source types (Figure 7). Weather conditions drive loading at the very high flow zone, with agricultural and urban runoff being the main source of runoff. Under low flow conditions, it is assumed that continuous sources including failing sewage treatment systems, unsewered communities and other potential point sources could be contributing to impairments. Further monitoring and utilizing adaptive management processes will help to identify sources and implementation strategies.

A qualitative approach was used to identify permitted and nonpermitted sources of *E. coli* in the watershed. *E. coli* from livestock and SSTSs are the highest priority sources in the Watonwan River Watershed. Detailed explanation and rationale for the priority ranking is provided in the following subsections.

Permitted Sources of *E. coli*

Potential permitted sources of *E. coli* in the Watonwan River Watershed include WWTP and permitted AFOs.

Wastewater

The 10 permitted wastewater dischargers with fecal coliform permit limits in the Watonwan River Watershed are considered potential *E. coli* sources that require TMDL WLAs. Wastewater dischargers that operate under NPDES permits are required to disinfect wastewater to reduce fecal coliform concentrations to 200 organisms/100 mL or less as a monthly geometric mean. Like *E. coli*, fecal coliform bacteria are an indicator of fecal contamination. The primary function of a fecal bacteria effluent limit is to assure that the effluent is being adequately treated with a disinfectant to assure a complete or near complete kill of fecal bacteria prior to discharge (MPCA 2007). 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, which is one month shorter than the time frame of the *E. coli* standard of the downstream impaired reaches. There are three dischargers to class 7 waters; these dischargers are a potential source of *E. coli* to downstream class 2 waters in April when disinfection is not required.

To determine the likelihood that dischargers to class 7 waters contribute to *E. coli* impairments in April, discharge volumes, surface water monitoring data, and the locations of the effluent discharge points were evaluated (Table 10). The facility design flows were 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.

Analysis of daily April flows for reaches affected by facilities not required to disinfect in April show a low percentage of WWTP flow compared to the average daily flow; Reach 510 ~ 2.3%, Reach 523 ~ 0.8% and Reach 574 ~ 1.0%. Due to the low probability of low flows in April, the distance to Class 2 waters and bacteria die-off in surface waters, effluent wastewater bacteria are not likely to be significant sources.

While there is the potential that discharges from these facilities could contribute to downstream *E. coli* impairments on class 2 waters in April, WLAs assigned to the three WWTPs shown in Table 10 are only applicable May through October.

Table 10. Design flows of WWTPs that are not required to disinfect in April as a percent of class 2 impaired reach flows

Wastewater Facility (NPDES Permit #)	Design Flow (cfs) [a]	Downstream Class 2 Impaired Reach	Approximate Distance to Impaired Class 2 Reach (miles)	April Exceedances Observed in Impaired Class 2 Reach	Impaired Reach Low Flow (cfs) [b]	Facility Design Flow as a Percent of Low Flows in Impaired Reach
Lewisville WWTP (MN0065722)	0.721	07020010-574	6	no data	2.67	27%
Saint James WWTP (MN0024759)	4.58	07020010-510	14	no data	29.23	16%
Truman WWTP (MN0021652)	1.21	07020010-523	14	no data	10.27	12%

a. Flow is either the average wet weather design flow (for Saint James WWTP and Truman WWTP, which are continuously discharging facilities) or the maximum daily pond flow (for Lewisville WWTP, which is a controlled discharge).

b. 75th percentile flow, simulated.

Monthly geometric means of effluent monitoring data are used to determine compliance with permits. Of the 10 WWTPs in the Watonwan River Watershed, 7 facilities have documented fecal coliform permit exceedances as provided in discharge monitoring reports (DMRs) for the time period between 2006 and 2015 (Table 11). Exceedances of wastewater fecal coliform permit limits could lead to exceedances of the instream *E. coli* standard at times. For the majority of the exceedances listed in Table 11, there are no surface water *E. coli* samples from the impaired reaches during the same month; therefore, it is difficult to determine if the permit exceedances led to exceedances of the surface water *E. coli* standard in the impaired reaches. There is one recorded exceedance in the Watonwan River (reach 510) in the same month (June 2014) as a reported exceedance of the Delft Sanitary District WWTP's fecal coliform calendar monthly geometric mean permit limit. However, because the WWTP is located over 40 miles upstream of the impaired reach and the permit limit exceedance was relatively minor (212 org fecal coliform/100 mL), the WWTP discharge likely did not lead to the instream exceedance of the *E. coli* standard.

Table 11. Wastewater treatment facilities with documented fecal coliform permit exceedances (2006–2015)

Wastewater Facility (NPDES Permit #)	*E. coli* Impairment AUID	Number of Permit Exceedances (2006–2015)	Reported Fecal Coliform Calendar Monthly Geometric Means that Exceed Permit Limit (org/100 mL)
Saint James WWTP (MN0024759)	07020010-502	1	217
Delft Sanitary District WWTP (MN0066541)	07020010-510	8	212–784
Odin-Ormsby WWTP (MN0069442)		2	400–2,480
Mountain Lake WWTP (MNG580035)		1	208
Butterfield WWTP (MN0022977)	07020010-516	2	350

Wastewater Facility (NPDES Permit #)	*E. coli* Impairment AUID	Number of Permit Exceedances (2006–2015)	Reported Fecal Coliform Calendar Monthly Geometric Means that Exceed Permit Limit (org/100 mL)
Truman WWTP (MN0021652)	07020010-523	1	347
Lewisville WWTP (MN0065722)	07020010-574	1	3,900

Permitted Animal Feeding Operations

There are 100 permitted AFOs and/or CAFOs in the impaired watersheds. Due to the requirement of these operations to completely contain runoff, facilities that are permit compliant are not expected to be a source of *E. coli* to surface waters.

Nonpermitted Sources of *E. coli*

Nonpermitted pollutant sources evaluated as potential sources of *E. coli* in the Watonwan River Watershed include waste from humans, livestock, and wildlife. Pet waste can be a source *of E. coli* and is considered to be part of watershed runoff from developed areas; there is a greater likelihood that uncollected pet waste in an urban area will reach surface waters through stormwater runoff than it would in a rural area with less impervious surfaces. Unregulated watershed runoff from developed areas, while not a direct source of *E. coli*, was evaluated for its role in the transport of *E. coli* across a watershed.

Human

SSTSs that function properly likely do not contribute *E. coli* to surface waters, but SSTSs that are considered IPHTs (Section 3.6.1) can contribute *E. coli* to surface waters. The MPCA compiles the estimated percentage of septic systems that are IPHTs as reported by counties. The approach to identifying IPHTs varies by county, and IPHTs typically include straight pipes, 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 IPHTs discharge pollutants directly to surface waters. In the Watonwan River Watershed, percentages of IPHTs range from 9% in Blue Earth County to 39% in Cottonwood County (Table 12).

Table 12. Average septic system percent imminent threats to public health and safety by county.
Data from MPCA. These percentages are reported as estimates by local units of government for planning purposes and general trend analysis. These values may be inflated due to relatively low total SSTS estimated per jurisdiction. Additionally, estimation methods for these figures can vary depending on local unit of government resources available.

County	2017 Estimated Percent IPHT
Blue Earth	9
Brown	24
Cottonwood	39
Jackson	15
Martin	15
Watonwan	13

Other human-derived possible sources of *E. coli* in the watershed include straight pipe discharges and earthen pit outhouses. Straight pipe systems and earthen pit outhouses likely exist in the watershed, but their numbers and locations are unknown and also illegal and they were not given a WLA.

Application of biosolids from WWTPs and land application of septage could also be a potential source of *E. coli*. Application of biosolids is regulated under Minn. R. 7401, and land application of septage by Minn. R. 7080, and includes pathogen reduction in biosolids prior to spreading on agricultural fields or other areas. Application should not result in violations of the *E. coli* water quality standard.

Livestock

Livestock are potential sources of fecal bacteria and nutrients to streams in the Watonwan River Watershed, particularly when direct access is not restricted and/or where feeding structures are located adjacent to riparian areas.

Animal waste from nonpermitted AFOs can be delivered to surface waters from failure of manure containment, runoff from the AFO itself, or runoff from nearby fields where the manure is applied. 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 concern. Minn R. 7020.2225 contains several requirements for land application of manure; however, there are no explicit requirements for *E. coli* or bacteria treatment prior to land application. Manure practices that inject or incorporate manure pose lower risk to surface waters than surface application with little or no incorporation. In addition, manure application on frozen/snow covered ground in late winter months presents a high risk for runoff (Frame et al. 2012). Registered feedlots are mapped in Figure 9.

Wildlife

In the rural portions of the project area, deer, waterfowl, and other animals can be *E. coli* sources, with greater numbers in remnant natural areas, wetlands and lakes, and river and stream corridors. Deer densities in the Minnesota River deer management zone range from 3 to 10 deer per square mile from the years 2010 through 2015 (Farmland and Wildlife Populations and Research Group 2015). Large geese populations near and within developed areas can also be of concern. Due to the relatively low density of deer compared to livestock in the watershed (over 200 AUs per square mile, based on data from the National Agricultural Statistics Service), wildlife is likely not a major contributor to *E. coli* in surface waters in the Watonwan River Watershed.

Unregulated Watershed Runoff

Unregulated watershed runoff from developed areas can be a source of *E. coli* to surface waters through the delivery of *E. coli* to surface waters. Impervious areas (such as roads, driveways, and rooftops) can directly connect the location where *E. coli* is deposited on the landscape to points where watershed runoff carries *E. coli* into surface waters. For example, there is a greater likelihood that uncollected pet waste in an urban area will reach surface waters through watershed runoff than it would in a rural area with less impervious surfaces. Wildlife, such as birds and raccoons, can be another source of *E. coli* in urban watershed runoff (Wu et al. 2011, Jiang et al. 2007). Recent studies in Minneapolis using microbial markers show that birds are a primary source of the *E. coli* entering stormwater conveyances (Sadowsky et al. 2017). Growth and persistence of *E. coli* in soil and organic debris were also noted in the Minneapolis study. The Watonwan River Watershed is predominantly rural; however, the small portion of developed areas may be a possible source of *E. coli*.

3.6.3 Phosphorus Source Summary

Phosphorus is an essential nutrient for aquatic and terrestrial life and is found naturally throughout a watershed. As such, there are several potential sources of phosphorus contributing excess amounts to impaired waterbodies. Where applicable, average annual phosphorus loads were estimated with the Minnesota River Basin HSPF model (2016-02-18 version; Tetra Tech 2015, Tetra Tech 2016). The MPCA developed initial HSPF models for the Minnesota River Basin in the 1990s and later expanded and refined the models (Tetra Tech 2015, Tetra Tech 2016). The HSPF models refined in 2016 were used to simulate phosphorus to support this TMDL effort. 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 and nutrient concentrations, along with other water quality constituents, at the outlet of any modeled subwatershed. Model documentation contains additional details about the model development and calibration (Tetra Tech 2015, Tetra Tech 2016).

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

Permitted Sources of Phosphorus

Permitted sources of phosphorus include regulated stormwater and AFOs that either operate under NPDES/ SDS permits and/or are federally defined CAFOs. There are no permitted wastewater facilities contributing to the impaired lakes.

Regulated Construction and Industrial Stormwater

Regulated construction and industrial stormwater is a potential source of phosphorus to impaired lakes. Untreated stormwater that runs off a construction or industrial site is carried through stormwater pipes and often discharged into surface waters. Along the way, it can pick up pollutants such as phosphorus and deliver them directly to a water body. Impervious areas (such as roads and rooftops) can directly connect the location where pollutants are deposited on the landscape to points where stormwater runoff carries them into surface waters. There is no regulated Municipal Separate Storm Sewer System (MS4) runoff contributing to the impaired lakes.

Permitted Animal Feeding Operations

There are two NPDES permitted AFOs in the impaired lakes watersheds. Due to the requirement of permitted AFOs to completely contain runoff, facilities that are permit compliant are not a source of phosphorus to surface waters. The phosphorus source assessment assumes that the permitted AFOs are in compliance.

Nonpermitted Sources of Phosphorus

Nonpermitted pollutant sources to the impaired waterbodies include watershed runoff, tile drainage, septic systems, internal loading, and atmospheric deposition.

Unregulated Watershed Runoff

Watershed runoff transports and delivers pollutants to surface waters. The developed areas in the impairment watersheds are not regulated through an MS4 permit and can be a source of phosphorus loads. In addition, animal waste is rich in nutrients such as phosphorus and nitrogen and may contribute to phosphorus loading to impaired lakes.

Phosphorus loads from watershed runoff were estimated with the Minnesota River Basin HSPF model. Modeled loading rates by land cover type were applied to the land covers based on area in each impaired lake watershed.

Non-NPDES/SDS Permitted Feedlots

The feedlot loading rate was applied to the total estimated feedlot area, based on the number of AUs in the MPCA's registered feedlot database. The following lake watersheds have identified non-NPDES/SDS Permitted feedlots: Bingham Lake, two feedlots both of which have open lots; Kansas Lake, seven total feedlots with three of them having open lots and four total confinement. In each of the lake watersheds no pastures were identified adjacent to the lakes.

Tile Drainage

Tile drains with surface inlets can be direct sources of phosphorus load. Tile drains provide a pathway for water to be removed efficiently from the landscape. Without tile drains, snowmelt and/or convective stormwater would be held in the root zone for a longer period of time (weeks to months) than when tile drains are present. The water efficiently removed with tile drains also contains nutrients that would otherwise potentially be trapped in vegetation. Loads from tile drainage were not explicitly quantified in the HSPF model, but are implicitly included in the overall load estimates.

Septic Systems

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.

Internal loading

Internal phosphorus loading from lake bottom sediments 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 internal loading.

- Low oxygen concentrations (also called anoxia) in the water overlying the sediment can lead to phosphorus release. In a shallow lake that undergoes intermittent mixing of the water column throughout the growing season (i.e., polymixis), the released phosphorus can mix with surface waters throughout the summer and become available for algal growth. In deeper lakes with a more stable summer stratification period, the released phosphorus remains in the bottom water layer until the time of fall mixing, when it mixes with surface waters.
- Curly-leaf pondweed (*Potamogeton crispus*), which can reach nuisance levels in shallow lakes, decays in the early summer and releases phosphorus to the water column. It is not known if curly-leaf pondweed is present in the impaired lakes.

- Bottom-feeding fish such as carp and black bullhead forage in lake sediments. This physical disturbance can release phosphorus into the water column. Fisheries data available on the DNR's LakeFinder website indicate that black bullhead are present in all of the impaired lakes addressed in this TMDL report, and carp are present in all of the impaired lakes except for Eagle Lake.
- 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.

To estimate internal loads, an additional phosphorus load was added to the phosphorus budgets to calibrate the lake response models (see Section 4.7.1); these loads were attributed to internal loading. Internal loading rates are likely high in these lakes due to several factors, including shallow depths, lack of vegetation, bottom-feeding fish, and stagnant water conditions. However, a portion of the load that was attributed to internal loading in these lakes could be from watershed or septic system loads that were not quantified with the available data.

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 impaired lakes was estimated using the average for the Minnesota River Basin (0.42 kilograms per hectare per year, Barr Engineering 2007).

Summary of Results

The phosphorus source assessment results for the impaired lakes are presented in Table 13.

Table 13. Phosphorus source assessment for impaired lakes

Lake Name (ID)	Watershed Loading by Land Cover Type						Internal Loading [a]	Atmospheric Deposition
	Forest	Crop	Grass/ Pasture	Wetland	Feedlots	Developed		
Total Phosphorus (TP) Load (pounds/year, or lb/yr)								
Bingham Lake (17-0007-00)	<1	294	7	2	1	25	2,475	101
Eagle Lake (17-0020-00)	<1	100	1	1	0	4	590	40
Kansas Lake (83-0036-00)	1	2,197	2	7	5	66	2,323	151
Butterfield Lake (83-0056-00)	<1	110	1	1	0	7	84	19
TP Load (percent)								
Bingham Lake (17-0007-00)	<1%	10%	<1%	<1%	<1%	1%	86%	3%
Eagle Lake (17-0020-00)	<1%	14%	<1%	<1%	0%	1%	80%	5%
Kansas Lake (83-0036-00)	<1%	46%	<1%	<1%	<1%	1%	50%	3%

Lake Name (ID)	Watershed Loading by Land Cover Type						Internal Loading [a]	Atmospheric Deposition
	Forest	Crop	Grass/ Pasture	Wetland	Feedlots	Developed		
Butterfield Lake (83-0056-00)	<1%	51%	<1%	<1%	0%	3%	38%	8%

a. A portion of the load that was attributed to internal loading could be from watershed or septic system loads that were not quantified with the available data.

4. TMDL Development Approach

A TMDL is the total amount of a pollutant that a receiving water body can assimilate while still achieving water quality standards. TMDLs can be expressed in terms of mass per time or by other appropriate measures. A TMDL for a water body that is impaired as a result of excessive loading of a particular pollutant can be described by the following equation:

TMDL = WLA + LA + MOS

where:

TMDL = *total maximum daily load,* also known as loading capacity, which is the greatest pollutant load a water body can receive without violating water quality standards.

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

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

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

A summary of the allowable pollutant loads is presented in this section. The allocations for each of the various sources and parameters are provided in Appendix A.

4.1 Overall Approach

Streams: Assimilative loading capacities for the streams were developed using load duration curves (Cleland 2002). See Section 3.5 for a description of load duration curve development. The load duration curves provide assimilative loading capacities and show load reductions necessary to meet water quality standards. For any given flow in the load duration curve, the loading capacity is determined by selecting the point on the load duration curve that corresponds to the flow exceedance (along the x-axis). Load duration curves were developed for each impaired reach (Appendix A).

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

Lakes: Allowable pollutant loads in 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. The BATHTUB model requires nutrient loading inputs from the upstream watershed and atmospheric deposition, morphometric data for the lake, and estimates of mixing depth and non-algal turbidity. Watershed loads were derived from the HSPF model (Tetra Tech 2016; see Section 3.6.3 for a brief description of the model).

Additional details on the approaches used to develop the TMDL components are provided in the following sections.

4.2 Margin of Safety

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

> TMDLs shall be established at levels necessary to attain and maintain the applicable narrative and numeric water quality standards with seasonal variations and a MOS, which takes into account any lack of knowledge concerning the relationship between effluent limitations and water quality.

The MOS can either be implicitly incorporated into conservative assumptions used to develop the TMDL or be added as a separate explicit component of the TMDL (EPA 1991). An explicit MOS of 10% was included in the TMDLs to account for uncertainty that the pollutant allocations would attain the water quality targets. The use of an explicit MOS accounts for environmental variability in pollutant loading, variability in water quality monitoring data, calibration and validation processes of modeling efforts, uncertainty in modeling outputs, conservative assumptions made during the modeling efforts, and limitations associated with the drainage area-ratio method used to extrapolate flow data. This MOS is considered to be sufficient given the robust datasets used and high quality of modeling, as described below.

The Minnesota River HSPF model was calibrated and validated using 57 stream flow gaging stations, with at least three gaging stations for each HUC8 watershed; five of the stream flow gaging stations are in the Watonwan River Watershed (Tetra Tech 2015). Of the stations in the Watonwan River Watershed, one gaging station has long-term, continuous flow records, and four have short-term, seasonal flow records. Sixty-three stream water quality stations were used for the Minnesota River Basin sediment calibration and corroboration; all stations have at least 100 water quality samples from the simulation period. Of the 63 stations in the Minnesota River Basin, one is in the Watonwan River Watershed (Tetra Tech 2016). The calibration site is located near the pour point of the watershed and therefore integrates conditions in the entire Watonwan River Watershed. Calibration results indicate that the HSPF model is a valid representation of hydrologic and water quality conditions in the watershed. Flow data used to develop the stream TMDLs are derived from either HSPF-simulated daily flow data or long term monitoring data. Where monitoring data were used, the flow data consist of over 25 years of daily flow records.

The HSPF model was also used to estimate watershed phosphorus loading to the impaired lakes. The BATHTUB models used to develop the lake TMDLs show generally good agreement between the observed lake water quality and the water quality predicted by the lake response models (see Appendix C for details). The watershed loading models and lake response models reasonably reflect the watershed and lake conditions.

4.3 Seasonal Variation and Critical Conditions

The CWA requires that TMDLs take into account critical conditions for flow, loading, and water quality parameters as part of the analysis of loading capacity.

Both seasonal variation and critical conditions are accounted for in the stream TMDLs through the application of load duration curves. Load duration curves evaluate water quality conditions across all flow regimes including high flow, which is the runoff condition where pollutant transport and loading from upland sources tend to be greatest, and low flow, when loading from wastewater and other direct sources to the waterbodies has the greatest impact. Seasonality is accounted for by addressing all flow conditions in a given reach. Seasonal variation is also addressed by the water quality standards' application during the period when high pollutant concentrations are expected via storm event runoff. Using this approach, it has been determined that load reductions are needed for specific flow conditions.

Seasonal variations are addressed in the lake phosphorus 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.

4.4 Baseline Year

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

4.5 Construction and Industrial Stormwater WLAs

Construction stormwater is regulated through the Construction Stormwater General Permit MNR100001, and a single categorical WLA for construction stormwater is provided for each of the impaired lakes. The average annual percent area of each county that is regulated through the construction stormwater permit (provided in the Minnesota Stormwater Manual [Minnesota Stormwater Manual contributors 2018]) was area-weighted for each impairment watershed. For each applicable TMDL, the construction stormwater WLA was calculated as the percent area multiplied by the loading capacity (i.e., TMDL) less the MOS and wastewater WLAs. It is assumed that loads from permitted construction stormwater sites that operate in compliance with their permits are meeting the WLA. *E. coli* WLAs do not apply to construction stormwater since *E. coli* is not a typical pollutant from construction sites.

Industrial stormwater is regulated through the General Permit MNR050000 for Industrial Stormwater Multi-Sector. A single categorical WLA for industrial stormwater is provided for each impaired lake. Permitted industrial stormwater sources are not expected to be sources of *E. coli* and are not provided WLAs. The MPCA's industrial stormwater permit does not regulate discharges of *E. coli*. The permit does not contain *E. coli* benchmarks; industrial stormwater permittees are required to sample their stormwater for parameters that more closely match the potential contribution of pollutants for their industry sector or subsector. For example, recycling facilities and auto salvage yards are required to sample for TSS, metals, and other pollutants likely present at these types of facilities.

Permitted industrial activities make up a small portion of the watershed areas, and the industrial stormwater WLA for each impaired water body was set equal to the construction stormwater WLA. It is assumed that loads from permitted industrial stormwater sites that operate in compliance with the permit are meeting the WLA. In the allocation tables presented in Appendix A, these two categorical WLAs are combined into one line item and referred to as "WLA for Construction and Industrial Stormwater."

4.6 *E. coli*

4.6.1 Loading Capacity and Percent Reductions

The loading capacity was calculated as flow multiplied by the *E. coli* geometric mean standard (126 org/100 mL for class 2 streams and 630 org/100 mL for class 7 streams). It is assumed that practices that are implemented to meet the geometric mean standard will also address the individual sample standard (1,260 org/100 mL), and that the individual sample standard will also be met.

The estimated percent reduction needed to meet each TMDL was calculated by comparing the highest observed (monitored) monthly geometric mean from the months that the standard applies to the geometric mean standard (monitored – standard/monitored). Monthly geometric means were used to estimate percent reduction only if they are based on five or more samples.

4.6.2 Wasteload Allocation Methodology for Wastewater

WLAs are provided for municipal WWTPs. Because permitted AFOs and CAFOs are required to completely contain runoff, they are not allowed to discharge *E. coli* to surface waters and WLAs are not provided; this is equivalent to a WLA of zero.

The *E. coli* WLAs for municipal wastewater are based on the *E. coli* geometric mean standard of 126 organisms per 100 mL and the facility's average wet weather design flow (Appendix B). For WWTPs with controlled discharge, the maximum daily discharge volume for each facility was used.

The facilities that discharge to class 2 waters are required to disinfect from April 1 through October 31, which is the same time period that the class 2 stream *E. coli* standard applies. Similarly, facilities that discharge to class 7 waters are required to disinfect from May 1 through October 31, which is the time period that the class 7 stream *E. coli* standard applies. It is assumed that if a facility meets the fecal coliform limit of 200 organisms per 100 mL it is also meeting the *E. coli* WLA.

With the revisions of Minnesota's water quality rules in 2008, the State changed from a fecal coliform based standard to an *E. coli* based standard because it is a superior potential illness indicator and costs for lab analysis are less (MPCA 2007b). The revised standards now state:

> "*E. coli* concentrations are not to exceed 126 organisms 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."

The *E. coli* concentration standard of 126 organisms per 100 mL was considered reasonably equivalent to the previous fecal coliform standard of 200 org/100 mL from a public health protection standpoint. The SONAR (Statement of Need and Reasonableness) section that supports this rationale uses a log plot that shows a good relationship between these two parameters. The following regression equation was deemed reasonable to convert any data reported in fecal coliform to *E. coli* equivalents:

$$E.\ coli \text{ concentration (equivalents)} = 1.80 \times (\text{Fecal Coliform Concentration})^{0.81}$$

It should also be noted that most analytical laboratories report *E. coli* in terms of colony forming units per 100 milliliters (cfu/100 mL), not org/100 mL. This TMDL report will present *E. coli* data in cfu/100 mL since all of the monitored data collected for this TMDL was reported in these units. Bacteria TMDLs were written to achieve the bacteria water quality standard of 126 orgs/100 mL.

The total daily loading capacity in the low or very low flow zones for some reaches is less than the calculated wastewater treatment allowable load. This is an artifact of using design flows for allocation setting and results in these point sources appearing to use all (or more than) the available 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 limit to these sources for the lower flow zones. By definition rainfall and thus runoff is very limited if not absent during low flow. Thus, runoff sources would need little to no allocation for these flow zones.

All wastewater WLAs are listed in the TMDL tables in Appendix A and in the overall WLA table in Appendix B.

4.6.3 Load Allocation Methodology

Once the WLA and MOS were determined for each watershed and subtracted from the LC, the remaining pollutant load was allocated to the LA. The LA includes nonpoint pollution sources that are not subject to NPDES permit requirements, as well as "natural background" sources. "Natural background" is defined in both Minnesota rule and statute: Minn. R. 7050.0150, subp. 4 "Natural causes' means the multiplicity of factors that determine the physical, chemical or biological conditions that would exist in the absence of measurable impacts from human activity or influence." The Clean Water Legacy Act (Minn. Stat. § 114D.10, subd. 10) defines natural background as "characteristics of the water body resulting from the multiplicity of factors in nature, including climate and ecosystem dynamics that affect the physical, chemical or biological conditions in a water body, but does not include measurable and distinguishable pollution that is attributable to human activity or influence."

Natural background sources of *E. coli* are inputs that would be expected under natural, undisturbed conditions. The relationship between bacterial sources and bacterial concentrations found in streams is complex, involving precipitation and flow, temperature, livestock management practices, wildlife activities, survival rates, land use practices, and other environmental factors. Two Minnesota studies described the potential for the presence of "naturalized or indigenous" *E. coli* in watershed soils (Ishii et al. 2006), ditch sediment, and water (Chandrasekaran et al. 2015). Chandrasekaran et al. (2015) conducted DNA fingerprinting of *E. coli* in sediment and water samples from Seven Mile Creek, located in south-central Minnesota. They concluded that roughly 63.5% were represented by a single isolate, suggesting new or transient sources of *E. coli*. The remaining 36.5% of strains were represented by multiple isolates, suggesting persistence of specific *E. coli*. The study indicates that between the four sites sampled during the study period, an average of 12% of all *E. coli* isolated were a "persistent strain". 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 also evaluated as part of the source assessment. The source assessment exercises indicate that natural background inputs are generally low compared to livestock, cropland, and failing SSTSs.

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 waterbodies' ability to meet state water quality standards. For all impairments addressed in this TMDL study, natural background sources are implicitly included in the LA portion of the TMDL allocation tables, and TMDL reductions should focus on the major anthropogenic sources identified in the source assessment.

4.7 Phosphorus

4.7.1 Loading Capacity and Load Reduction

The BATHTUB models were calibrated to the long term average phosphorus concentration, consisting of all data from 2006 through 2015 (see Appendix A for a summary of existing water quality data). Annual precipitation from HSPF was used as input to the BATHTUB models. The complete model inputs and outputs are presented in Appendix C.

The models within BATHTUB inherently include an internal load that is typical of lakes in the model development data set. The data suggest that internal loads are greater than the average rates inherent in BATHTUB, and additional internal loads were included during model calibration. After the model was calibrated, the TMDL scenario was developed by reducing phosphorus load inputs until the lake TP standard was met. The total load to the lake in the TMDL scenario represents the loading capacity, and the percent reduction needed to meet the TMDL was calculated as the existing load minus the loading capacity divided by the existing load.

4.7.2 Wasteload Allocation Methodology

Construction and Industrial Stormwater WLAs

A categorical WLA is provided for construction stormwater and other industrial stormwater. See Section 4.5 for more details.

4.7.3 Load Allocation Methodology

The LA represents the portion of the loading capacity that is allocated to pollutant loads that are not regulated through an NPDES permit (e.g., unregulated watershed runoff, failing septic systems and IPHTs, and internal loading). The LA for each phosphorus TMDL was calculated as the loading capacity minus the MOS minus the WLAs.

Natural background was given consideration in the development of LA in this TMDL. Natural background is the landscape condition that occurs outside of human influence. Minn. R. 7050.0150, subp. 4, defines the term “Natural causes” as 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 conditions refer to inputs that would be expected under natural, undisturbed conditions. Natural background sources can include inputs from natural geologic processes such as soil loss from upland erosion and stream development, atmospheric deposition, and loading from forested land, wildlife, etc. For each impairment, natural background levels are implicitly incorporated in the lake phosphorus 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 also evaluated, where possible, within the modeling and source assessment portion of this study. The 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 waterbodies’ ability to meet state water quality standards. For all impairments addressed in this TMDL study, natural background sources are implicitly included in the LA portion of the TMDL allocation tables and TMDL reductions should focus on the major anthropogenic sources identified in the source assessment. Federal law instructs an agency to distinguish between natural and nonpoint source loads “wherever possible.” 40 CFR § 130.2(g). However, Minnesota law does not compel the MPCA to develop a separate LA for natural background sources, distinct from nonpoint sources (MPCA 2016b).

5. TMDL Summaries

A summary of allocations for all impaired lakes and streams are included in Table 14 and Table 15 below. Load duration curves and the complete water quality summaries for each impairment are included in Appendix A.

Table 14. Summary of allocations by stream reach.

Facility	Permit Number	Design Flow (mgd) [a]	*E. coli* Wasteload Allocation (billion organisms per day), Apr–Oct [b]	Impairment AUID
Truman WWTP	MN0021652	0.780	3.721 [c]	07020010-523
Butterfield WWTP	MN0022977	2.770	13.213	07020010-516, 515, 510
Madelia WWTP	MN0024040	1.314	6.268	07020010-510
Saint James WWTP	MN0024759	2.960	14.119 [c]	07020010-502, 515, 510
Lewisville WWTP	MN0065722	0.466	2.223 [c]	07020010-574, 523
Delft Sanitary District WWTP	MN0066541	0.006	0.029	07020010-510
La Salle WWTP	MN0067458	0.015	0.072	07020010-510
Odin-Ormsby WWTP	MN0069442	0.300	1.431	07020010-510
Mountain Lake WWTP	MNG580035	4.122	19.662	07020010-510
Neuhof Hutterian Brethren	MNG580113	0.116	0.553	07020010-581, 510

a. Average wet weather design flow or maximum daily pond flow, in million gallons per day (mgd).
b. See Section 4.6.2 in the report for the approach used to develop *E. coli* WLAs.
c. WLAs noted with footnote apply May–Oct; all others apply Apr–Oct.

Table 15. Summary of allocation by lake.

Lake Name	Allocation	TP Load (lb/yr)	TP Load (lb/day)
Eagle Lake (17-0020-00)	WLA for Construction and Industrial Stormwater	0.365	0.00100
	Load Allocation	272	0.746
	Margin of Safety	30.3	0.0830
	Loading Capacity	**303**	**0.830**
Butterfield Lake (83-0056-00)	WLA for Construction and Industrial Stormwater	0.0927	0.000254
	Load Allocation	185	0.507
	Margin of Safety	20.6	0.0564
	Loading Capacity	**206**	**0.564**
Kansas Lake (83-0036-00)	WLA for Construction and Industrial Stormwater	0.890	0.00244
	Load Allocation	1,778	4.88
	Margin of Safety	198	0.542
	Loading Capacity	**1,977**	**5.42**
Bingham Lake (17-0007-00)	WLA for Construction and Industrial Stormwater	1.39	0.00381
	Load Allocation	1,034	2.83
	Margin of Safety	115	0.315
	Loading Capacity	**1,150**	**3.15**

The estimated percent reductions needed to meet the TMDLs range from 7% to 89% (Table 16). The load duration curves (Appendix A and Figure 7), when taken as a whole, indicate that exceedances of the *E. coli* standard occur across all flow regimes. Load reductions are needed to address multiple source types (see Section 3.6.2: *E. coli* Source Summary). No reductions from current WWTP discharges are required to achieve the bacteria TMDLs. Reductions in phosphorus are presented on an average annual basis and will need to come primarily from cropland runoff and internal loading (see Section 3.6.3: Phosphorus Source Summary).

Table 16. Summary of load reductions per impaired water body.

Water body Name	AUID / Lake ID	Reduction (%)	
		E. coli	**Phosphorus**
Eagle Lake	17-0020-00	–	59%
Watonwan River, North Fork	564	85%	–
Butterfield Creek	516	82%	–
Butterfield Lake	83-0056-00	–	7%
Kansas Lake	83-0036-00	–	58%
St James Creek	576	81%	–
St James Creek	502	58%	–
St James Creek	515	18%	–
Bingham Lake	17-0007-00	–	60%
Judicial Ditch 1	581	86%	–
Watonwan River, South Fork	568	85%	–
Spring Branch Creek	574	83%	–
Perch Creek	523	89%	–
Watonwan River	510	75%	–

– Waterbodies indicated with "–" are not impaired by the indicated pollutant.

6. Future Growth Considerations

6.1 New or Expanding Permitted MS4 WLA Transfer Process

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

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

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

6.2 New or Expanding Wastewater

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

Additional reserve capacity was not added for phosphorus in municipal wastewater. There are no existing municipalities within the phosphorus impaired watersheds that are not already covered by a WLA for municipal wastewater. For more information on the overall process, visit the MPCA's TMDL Policy and Guidance web page.

7. Reasonable Assurance

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

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

In order to address pollutant loading in the Watonwan River Watershed, required point source controls will be effective in improving water quality if accompanied by considerable reductions in nonpoint source loading. Reasonable assurance for permitted sources such as stormwater, CAFOs, and wastewater is provided primarily via compliance with their respective NPDES permit programs, as described in Section 3.6.

Reasonable assurance for nonpermitted sources discussed in Section 3.6 is provided by the numerous nonpoint source reduction programs, local planning efforts, and the project implementation efforts of partners and participating organizations that continue to work towards improving water quality in the Watonwan River Watershed as described in the following sections.

7.1 Example Nonpermitted Source Reduction Programs

Several nonpermitted reduction programs exist to support implementation of nonpoint *E. coli* reduction BMPs in the Minnesota River Basin. These programs identify BMPs, provide means of focusing BMPs, and support their implementation via state initiatives, ordinances, and/or provide dedicated funding. The following examples describe large-scale programs that have proven to be effective and/or will reduce *E. coli* loads going forward.

MPCA Feedlot Program

The MPCA Feedlot Program implements rules governing the collection, transportation, storage, processing, and disposal of animal manure and other livestock operation wastes. Minn. R. 7020 regulates feedlots in the state of Minnesota. All feedlots capable of holding 50 or more AUs, or 10 in shoreland areas, are subject to this rule. A feedlot holding 1,000 or more AUs is permitted in the state of Minnesota. The focus of the rule is on animal feedlots and manure storage areas that have the greatest potential for environmental impact. Smaller feedlot operations are registered by counties and do not have permits.

The Feedlot Program is implemented through a cooperation between MPCA and 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, or a delegated county, has been given authority by the MPCA to delegate administration of 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, since 2012, annual grants given to these counties totaled about two million dollars (MPCA 2017). All of the major counties within the Watonwan River Watershed are delegated counties. Since 2012, there has been 232 feedlot facility inspections in the Watonwan River Watershed, with 186 of those inspection occurring at non-CAFO facilities and 46 at CAFO facilities. There has been an additional 75 manure application reviews within the watershed. Forty-four of those inspections were conducted at CAFO facilities and 31 at non-CAFO facilities.

SSTS Implementation and Enforcement

SSTSs are regulated through Minn. Stat. §§ 115.55 and 115.56. Regulations include:

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

In 2008, the MPCA amended and adopted rules concerning the governing of SSTS. In 2010, the MPCA was mandated to appoint a Subsurface Sewage Treatment Systems Implementation and Enforcement Task Force (SIETF). Members of the SIETF include representatives from the Association of Minnesota Counties, Minnesota Association of Realtors, Minnesota Association of County Planning and Zoning Administrators, and the Minnesota Onsite Wastewater Association. The group was tasked with:

- Developing effective and timely implementation and enforcement methods to reduce the number of SSTS that are an IPHT and enforce all violation of the SSTS rules (See report to the legislature; MPCA 2011)
- Assisting MPCA in providing counties with enforcement protocols and inspection checklists

Each County within the Watonwan River Watershed has ordinances 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, groundwater quality, and prevent or eliminate the development of public nuisances. Ordinances serve the best interests of the County's citizens by protecting its 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 counties within Watonwan River Watershed have, on average, upgraded/replaced 254 systems per year (Figure 10).

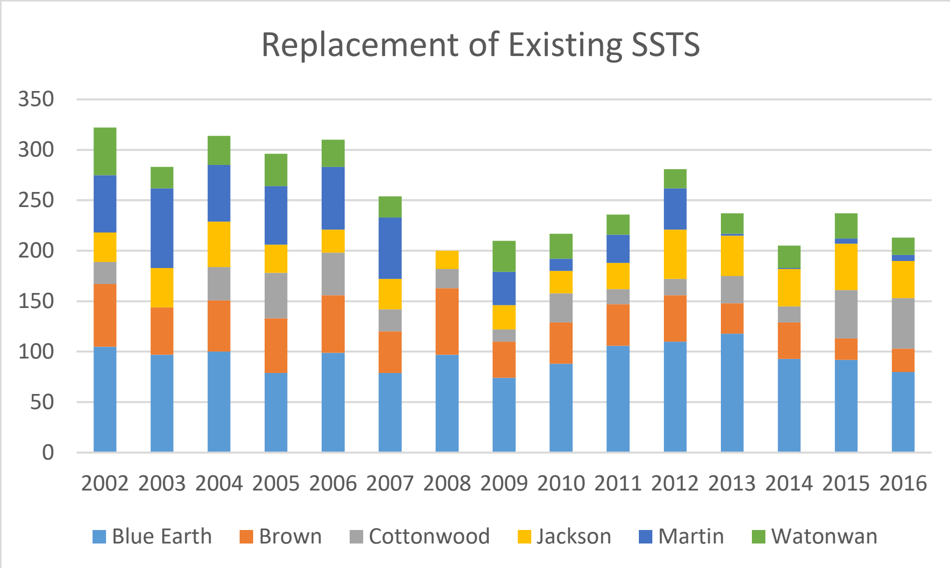


Figure 10. SSTS replacements by County for the 2002-2016 time period.

All known IPHTs are recorded in a statewide database by the MPCA. From 2006 to 2017, 742 straight pipes were tracked by the MPCA statewide. Seven hundred-one of those were abandoned, fixed, or were found not to be a straight pipe system. There have been 17 Administrative Penalty Orders issued and docketed in court. The remaining straight pipe systems received a notification of non-compliance and are currently within the 10-month deadline. The MPCA, through the Clean Water Partnership Loan Program, has awarded over $720,000 dollars to counties within the Watonwan River Watershed to provide low interest loans for SSTS upgrades since 2010. More information on SSTS financial assistance can be found at the following address: https://www.pca.state.mn.us/water/ssts-financial-assistance.

Buffer Program

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

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

Alternative practices are allowed in place of a perennial buffer in some cases. The amendments enacted in 2017 clarify the application of the buffer requirement to public waters, provide additional statutory authority for alternative practices, address concerns over the potential spread of invasive species through buffer establishment, establish a riparian protection aid program to fund local government buffer law enforcement and implementation, and allowed landowners to be granted a compliance waiver until July 1, 2018, when they filed a compliance plan with the soil and water conservation district (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 in the state is displayed at the Buffer Program Update. Table 17 summarizes the level of compliance estimates for counties located within the Watonwan River Watershed as of January 2019.

Table 17. Compliance with Minnesota Buffer Law as of January 2019 (BWSR).

County	Compliance with MN Buffer Law (%)
Blue Earth	95% - 100%
Brown	95% - 100%
Cottonwood	90% - 94%
Jackson	95% - 100%
Martin	95–100%
Watonwan	95% - 100%

Agricultural Water Quality Certification Program

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

Through this program, certified producers receive:

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

Through this program, the public receives assurance that certified producers are using conservation practices to protect Minnesota's lakes, rivers, and streams. Since the start of the program in 2014, the Ag Water Quality Certification Program has:

- Enrolled over 500,000 acres;
- Included 755 producers;
- Added more than 1,500 new conservation practices;
- Kept over 66 million pounds of sediment out of Minnesota rivers;
- Saved 163 million pounds of soil and 39,766 pounds of phosphorus on farms; and
- Reduced nitrogen losses by up to 49%.

Groundwater Protection Rule

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

Part one restricts fall application of nitrogen fertilizer if a farm is located in a vulnerable groundwater area where at least 50% or more of a quarter section is designated as vulnerable or a public water drinking supply management area (DWSMA) with nitrate-nitrogen testing at least 5.4 mg/L in the previous 10 years. Once the rule is effective, fall application restrictions will begin in the fall of 2020.

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

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

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

Drainage System Repair Cost Apportionment Option

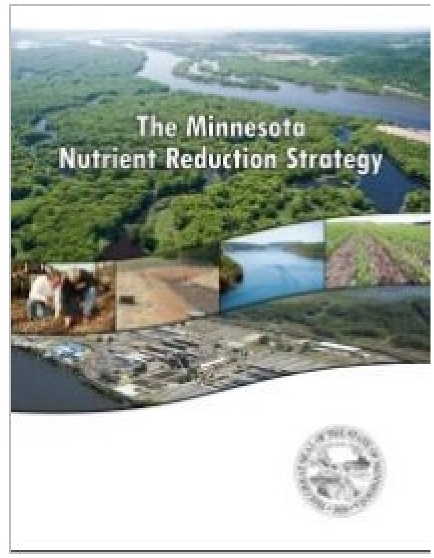
Minnesota drainage law, Chapter 103E, was updated in 2019 to add a voluntary, alternative method for cost apportionment that better utilizes technology to more equitably apportion drainage system repair costs, based on relative runoff and sediment contributions to the system, thus providing an incentive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

Minnesota Nutrient Reduction Strategy

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

- Defining progress with clear goals
- Building on current strategies and success
- Prioritizing problems and solutions
- Supporting local planning and implementation

- Improving tracking and accountability



Included within the strategy discussion are alternatives and tools for consideration by drainage authorities, information on available tools and approaches for identifying areas of phosphorus and nitrogen loading and tracking efforts within a watershed, and additional research priorities. The 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. It has set a reduction of 45% for both phosphorus and nitrogen in the Mississippi River, downstream of the Watonwan Watershed.

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

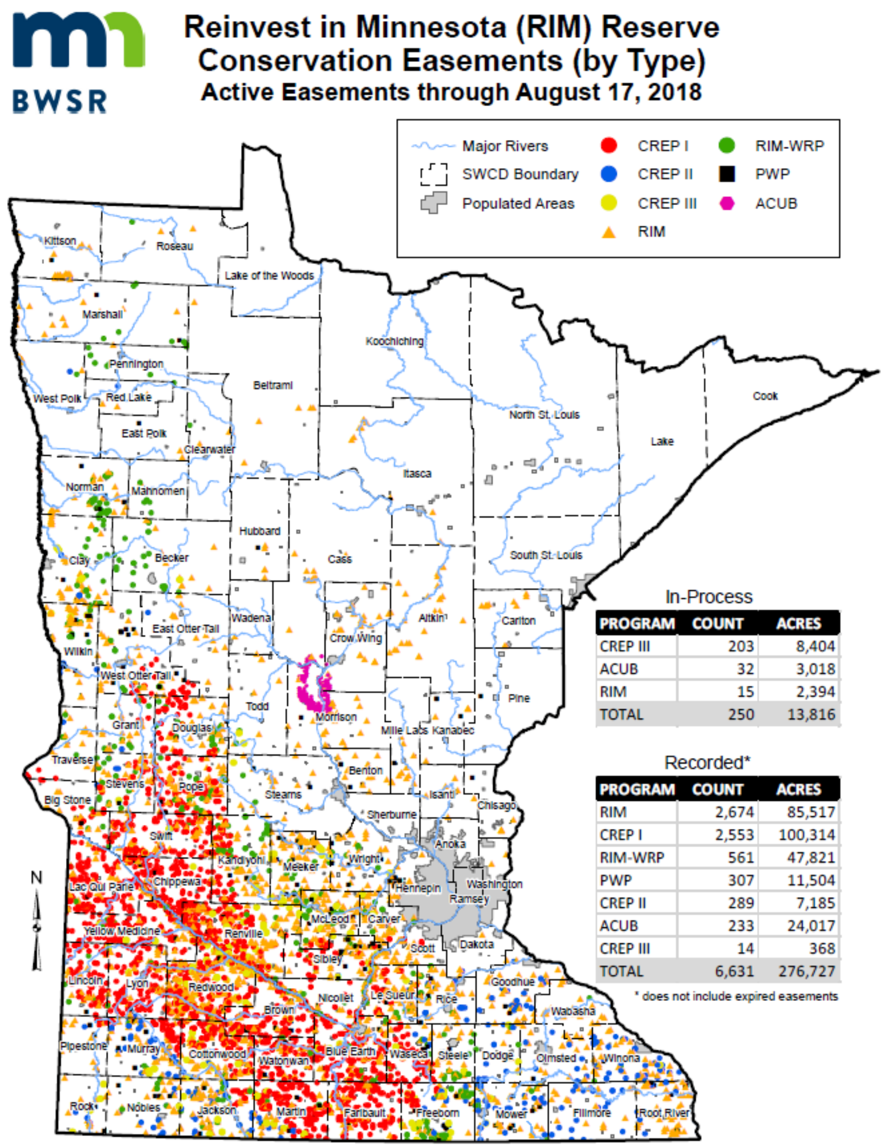
- Intensive watershed monitoring
- Assessment of watershed health
- Development of WRAPS reports
- Management of NPDES and other regulatory and assistance programs

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

Conservation Easements.

Conservation easements are a critical component of the state's efforts to improve water quality by reducing soil erosion, 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 and the USDA Natural Resources Conservation Service (NRCS), BWSR's programs compensate landowners for granting conservation easements and establishing native vegetation habitat on economically marginal, flood-prone, environmentally sensitive or highly erodible lands. These easements vary in length of time from 10 years to permanent/perpetual easements. Types of conservation easements in Minnesota include: Conservation Reserve Program (CRP); Conservation Reserve Enhancement Program (CREP); Reinvest in Minnesota (RIM); and the Wetland Reserve Program (WRP) or Permanent Wetland Preserve (PWP). As of August 2018, in the six counties that are located within the Watonwan Watershed, there was 55,341 acres of short-term conservation easements such as CRP and 37,360 acres of long term or permanent easements (CREP, RIM, WRP).

7.2 Summary of Local Plans



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

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

BWSR's vision for 1W1P is to align local water planning on major watershed boundaries with state strategies towards prioritized, targeted, and measurable implementation plans—the next logical step in the evolution of water planning in Minnesota and an important component of the reasonable assurance framework. A 1W1P for the Watonwan River Watershed is currently under development. BWSR is committed to completing all 1W1Ps by 2025. The eventual Watonwan River Watershed 1W1P will follow the completion of the WRAPS and is expected to have positive impacts on water quality in the TMDL project focus areas.

Until the completion of the 1W1P in the Watonwan River Watershed, water planning continues to be done on a county basis, per the Comprehensive Local Water Management Act (Minn. Stat. § 103B.301) (see the local water plan map for status of local water management plans and the list below for current plans). 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 major counties in the Watonwan River Watershed; URL links are provided as well:

- Blue Earth County Water Management Plan (2017–2026)
- Brown County Comprehensive Local Water Management Plan (2008-–2018), Amended 2013
- Cottonwood County Comprehensive Local Water Management Plan (2017–2027)
- Jackson County Local Water Management Plan (2008-2017)
- Martin County Local Water Plan (2017-2026)
- Watonwan County Local Water Management Plan 2014 Amendment (2008-2018)

7.3 Partners, Organizations, and Events

Local SWCDs are active in the project area and impaired watersheds. 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 *E. coli*, sediment, nitrate, and phosphorus loading. From 2004 to 2017, 1,314 BMPs were installed in the Watonwan Watershed by local partners. Figure 11 depicts the number of BMPs per subwatershed in the Watonwan Watershed. Additional information about the BMPs may be found on the MPCA's Healthier Watershed website https://www.pca.state.mn.us/water/healthier-watersheds.

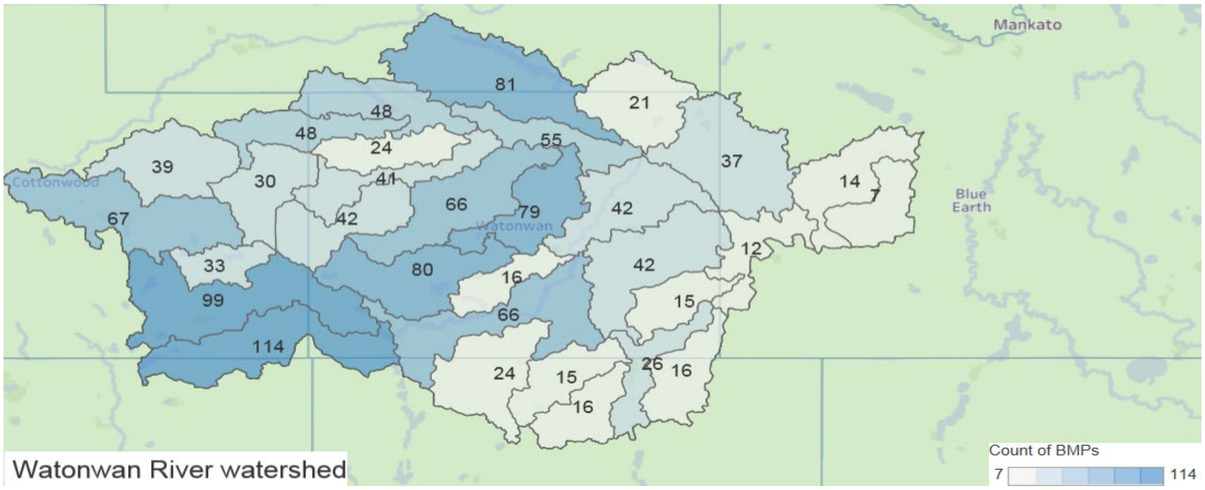


Figure 12. Number of BMP's per subwatershed

Several projects have been completed in recent years that are located within the watershed or influence the watershed; the following are examples:

- Blue Earth SWCD partnered with Nicollet and Le Sueur SWCDs to receive a Minnesota Department of Transportation (MnDOT) grant for various erosion projects in the three counties
- Blue Earth SWCD completed a county wide tillage and erosion research project with the University of Minnesota (U of M)
- Cottonwood SWCD served as coordinators for the Great Blue Earth River Partnership in 2016. Beginning in 2006, when the Cottonwood SWCD staff assumed the duties of the Greater Blue Earth River Basin Alliance (GBERBA) coordinators, over $6,143,837 dollars in grants funds have been awarded and used for the conservation of our natural resources
- Jackson County offers a rock inlet program to provide cost share for alternative tile intake options: http://www.co.jackson.mn.us/index.asp?SEC=6AF32B4D-8C28-49CC-A4E3-880FF4B5CACD&Type=B_BASIC
- Martin SWCD recently acquired a Clean Water Fund Accelerated Implementation grant to work with local lake associations around the county
- In Brown County there are 118 perpetual CREP easements comprising 5,050 acres
- Watonwan SWCD replaced 414 noncompliant SSTSs from 1998 to 2008 and upgraded over 130 failing SSTSs between 2008 and 2013

In addition to the SWCDs, several other groups are active in the Watonwan River Watershed and surrounding areas. These groups have different levels of organization and structure, but share a common goal to protect and improve water quality in the watershed. They typically conduct watershed outreach and education activities, monitoring, research, and project planning and implementation. They are often the link between landowners and planning initiatives set on a watershed, region, or basin-wide scale. The level of activity being conducted by these organizations, and available funding mechanisms such as the Clean Water Fund and CWA Section 319 grant programs, provide additional reasonable assurance that implementation will continue to occur to address nonpoint sources of sediment.

Organizations in and surrounding the Watonwan River Watershed that are supporting implementation include:

- **Watonwan River Watershed Network** (http://watonwanriver.org/) is a network of local citizens, staff, and students from Minnesota State University, Mankato (MSUM) Water Resources Center, GBERBA, and MPCA, who have been meeting to better understand their water quality and quantity concerns. The goal of the organization is to network and learn together, improve the information flow about the latest watershed science, and to find and support citizens that are interested in solving water quality and quantity problems and cleaning up area waters.
- **Greater Blue Earth River Basin Alliance (GBERBA)** (http://www.gberba.org/) is a local group in the Watonwan, Le Sueur, and Blue Earth River watersheds whose mission is to lead in the implementation and promotion of economically viable watershed activities through the combined efforts of local partners and the GBERBA. The accomplishments of GBERBA are many:
    - has brought over six million dollars to southern Minnesota in grants and cost share to implement water quality and quantity BMPs since 2007
    - includes partners from all counties located in the Watonwan River Watershed
    - completed a watershed plan in 2005 that identified water quality goals to reduce nutrient runoff to waterbodies and de-list impaired waterbodies through the TMDL process, among others
- **Coalition for a Clean Minnesota River** (http://www.ccmnriver.org/) is a grass-roots organization coordinating citizen and business interests in basinwide efforts including:
    - Storm sewer runoff education and awareness programs
    - River bank and curb side organic debris clean up
    - River and water quality related legislative initiatives, and
    - Various restoration projects
- **Minnesota River Basin Data Center**, Minnesota State University Mankato Water Resource Center (http://mrbdc.mnsu.edu/) provides basinwide data management and coordination
- **Minnesota River Watershed Alliance and Minnesota River Congress** (http://watershedalliance.blogspot.com/) coordinates basinwide governance and opportunities for stakeholders

In addition to the organizations and partners listed, events are hosted that work to promote water quality in and around the Watonwan River Watershed:

- Since 1998, Cottonwood County, along with nearby Brown and Nicollet Counties (outside of TMDL watershed), sponsor and help coordinate the annual Children's Water Festival for 4th grade students of the three counties
- The Annual Nutrient Management Conference hosted in Mankato by the Minnesota Department of Agriculture (MDA) Water Resource Center and U of M Extension. The 2018 conference covered trends in phosphorus and sulfur management, in-season nitrogen applications, and cures for phosphorus runoff losses from farmland

Participation of farmers and landowners is essential to implementing nonpoint source BMPs and improving water quality in the watershed. Educational efforts and cost-share programs will likely increase participation to levels needed to protect water quality. Additional assurance can be achieved during implementation of the TMDLs through contracts, memorandums of understanding, and other similar agreements, especially for BMPs that receive outside funds and cost share.

8. Monitoring

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

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

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

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

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

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

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

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

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

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

- Intensive monitoring and assessment at the HUC8 scale associated with Minnesota's watershed approach. This monitoring effort is conducted every 10 years for each HUC-8, and will recommence in 2023 in the Watonwan River Watershed. 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. Ultimately, this monitoring can determine when waters have been restored and can be delisted from the impaired waters list.

- Discovery Farms Minnesota is a farmer-led program that collects farm- and field-scale monitoring data under real-world conditions. The program is coordinated by the Minnesota Agricultural Water Resource Center in partnership with the MDA and the U of M Extension. There is one Discovery Farms core farm in Blue Earth County.
- Implementation monitoring is conducted by both BWSR (i.e., eLink) and 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 Tillage Transect Survey Data Center.
- Discharges from permitted municipal and industrial wastewater sources are reported through discharge monitoring records (see Section 3.6.2); these records are used to evaluate compliance with NPDES permits. Summaries of discharge monitoring records are available through the MPCA's Wastewater Data Browser.
- 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 mainstems, at major watershed (i.e., HUC-8) outlets to major rivers, and in several subwatersheds. This long-term monitoring program began in 2007. The Watonwan River Watershed has three WPLMN sites - one at the major watershed scale and two at the subwatershed scale.

9. Implementation Strategy Summary

Minnesota's [watershed approach] to restoring and protecting water quality is based on a major watershed, or HUC-8, scale. This watershed-level planning occurs on a 10-year cycle beginning with intensive watershed monitoring and culminates in local implementation (Figure 10). A WRAPS report is produced as part of this approach and addresses the development of strategies for restoration of impaired watersheds and protection of unimpaired waters in each HUC-8 watershed. The WRAPS for each HUC8 watershed includes elements such as implementation strategies, timelines, and interim milestones. These high-level reports are then used to inform watershed management plans that focus on local priorities and knowledge to identify locally-based prioritized, targeted, and measurable actions to implement the strategies. These plans further define specific actions, measures, roles, and financing for accomplishing water resource goals. Development of the WRAPS report for the Watonwan River Watershed was done concurrently with this report, and implementation strategies in that report will heavily influence and support implementation of this TMDL. The following sections provide an overview of potential implementation strategies to address the high priority pollutant sources including human wastewater sources such as SSTSs and IPHTs, agricultural sources such as livestock and runoff from cropland, and internal lake phosphorus loading. These implementation strategies align and build upon the restoration and protection strategies recommended in the previously developed *Watonwan River Watershed Hydrology, Connectivity, and Geomorphology Assessment Report* (DNR 2014).

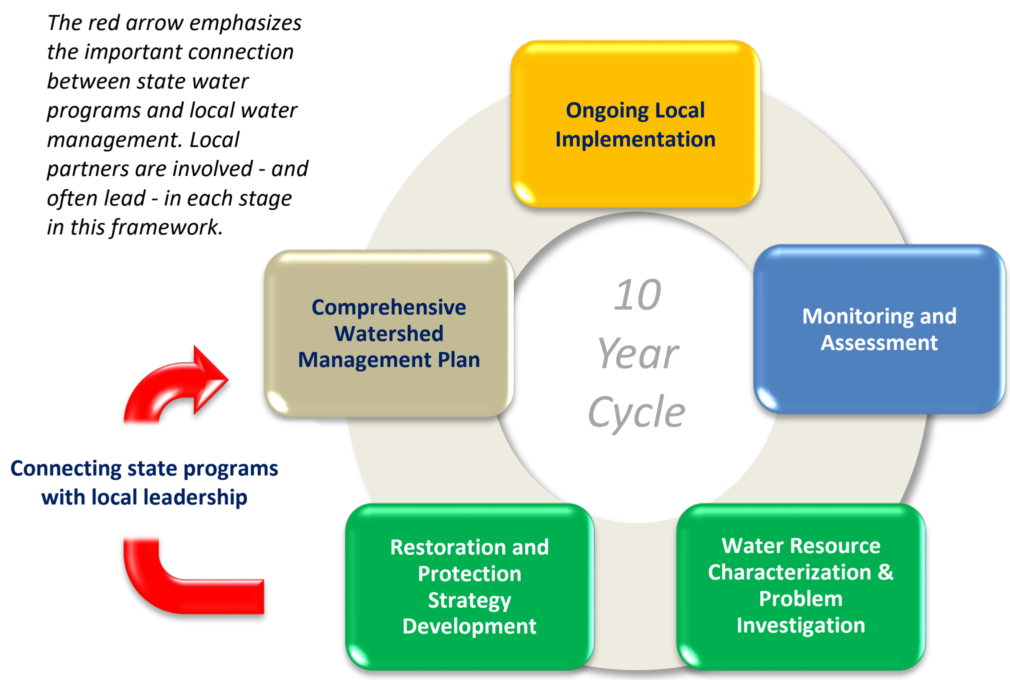


Figure 13. Minnesota's watershed approach.

9.1 Implementation Strategies for Permitted Sources

Permitted sources were not identified as priority sources in the pollutant source summary. Implementation of the Watonwan River Watershed TMDL for permitted sources will consist of permit compliance as explained below.

9.1.1 Construction Stormwater

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

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

9.1.3 Wastewater

Municipal wastewater treatment facilities are regulated through NPDES permits. These permits include effluent limits designed to meet water quality standards along with monitoring and reporting requirements to ensure effluent limits are met.

9.2 Implementation Strategies for Nonpermitted Sources

Implementation of the Watonwan River Watershed TMDL will require BMPs that address the sources of *E. coli* and phosphorus pollutants in the watershed. 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 after the development of the WRAPS report for the watershed.

Human wastewater sources such as SSTSs and IPHTs, agricultural sources such as livestock and runoff from cropland, and internal lake phosphorus loading were identified as high priority pollutant sources.

9.2.1 Human Sources

Septic System upgrades/replacement

A watershed-wide inventory of current systems and continuation of inspection programs in the area are necessary to help locate IPHTs. Once found, all known IPHTs must be brought into compliance within a 10-month period (see Section 3.6.1). The reductions in loading resulting from upgrading or replacing failing systems in the watershed depend on the level of failure present in the watershed. Upgrading or replacing IPHTs systems will result in 100% reduction in fecal bacteria loading from that system. The State of Minnesota offers the Clean Water Partnership 0% interest loan program for SSTS upgrades and compliance. See Section 7.1 for more information on the program.

Septic System maintenance

The most cost-effective BMP for managing loads from septic systems is regular maintenance. EPA recommends that septic tanks be pumped every three to five years, depending on the tank size and number of residents in the household (EPA 2002b). When not maintained properly, septic systems can cause the release of pathogens and excess nutrients into surface water. Annual inspections, in addition to regular maintenance, ensure that systems function properly. Compliance with state and county code is essential to reducing *E. coli* and phosphorus loading from septic systems. Septic systems are regulated under Minn. Stat. §§ 115.55 and 115.56. Counties must enforce ordinances in Minn. R. 7080 to 7083.

Public Education

Education is another crucial component of reducing phosphorus and *E. coli* loading from septic systems. Education can occur through public meetings, mass mailings, and radio and television advertisements. An inspection program can also help with public education because inspectors can educate owners about proper operation and maintenance during inspections.

9.2.2 Agricultural Sources

Several different agricultural BMPs can be used to target priority sources and their associated pollutants. Table 18 provides a summary of agricultural BMPs, their NRCS code, and their targeted pollutants. Descriptions of each BMP are provided below. More information on agricultural BMPs in the state of Minnesota can be found in the *Agricultural BMP Handbook for Minnesota* (Lenhart et al. 2017).

Table 18. Summary of agricultural BMPS for agricultural sources and their primary targeted pollutants.

BMP (NRCS standard)	Targeted Pollutant	
	E. coli	**Phosphorus**
Filter strips (636)	X	X
Riparian buffers (390)	X	X
Clean water diversion (362)	X	X
Access control/fencing (472 and 382)	X	X
Waste storage facilities (313) and nutrient management (590)	X	X
Grassed waterways (412)		X
Water and sediment control basins (638)		X
Conservation cover (327)		X

BMP (NRCS standard)	Targeted Pollutant	
	E. coli	**Phosphorus**
Conservation/reduced tillage (329 and 345)		X
Cover crops (340)		X

Filter strips (636) and riparian buffers (390)

Feedlot/wastewater filter strips are defined as “a strip or area of vegetation that receive and reduce sediment, nutrients, and pathogens in discharge from a setting basin or the feedlot itself. In Minnesota, there are five levels of runoff control, with Level 1 being the strictest and for the largest operations” (Lenhart et al. 2017). Riparian buffers are composed of a mix of grasses, forbs, sedges, and other vegetation that serves as an intermediate zone between upland and aquatic environments (Lenhart et al. 2017). The vegetation is tolerant of intermittent flooding and/or saturated soils that are prone to occur in intermediate zones.

Riparian buffers and filter strips that include perennial vegetation and trees can filter runoff from adjacent cropland, provide shade and habitat for wildlife, and reinforce streambanks to minimize erosion. The root structure of the vegetation uses enhanced infiltration of runoff and subsequent trapping of pollutants. Both, however, are only effective in this manner when the runoff enters the BMP as a slow moving, shallow “sheet”; concentrated flow in a ditch or gully will quickly pass through the vegetation offering minimal opportunity for retention and uptake of pollutants. Similarly, tile lines can often allow water to bypass a buffer or filter strip, thus reducing its effectiveness.

Clean water diversions (362)

Clean runoff water diversion “involves a channel constructed across the slope to prevent rainwater from entering the feedlot area or the farmstead to reduce water pollution” (Lenhart et al. 2017). Clean water diversions can take many forms including roof runoff management, grading, earthen berms, and other barriers that direct uncontaminated runoff from areas that may contain high levels of *E. coli* and nutrients.

Access control/fencing (472 and 382)

Fencing can be used with controlled stream crossings to allow livestock to cross a stream while minimizing disturbance to the stream channel and streambanks. Providing alternative water supplies for livestock allows animals to access drinking water away from the stream, thereby minimizing the impacts to the stream and riparian corridor. Some researchers have studied the impacts of providing alternative watering sites without structural exclusions and found that cattle spend 90% less time in the stream when alternative drinking water is furnished (EPA 2003).

Waste storage facilities (313) and nutrient management (590)

Manure management strategies depend on a variety of factors. A pasture or open lot system with a relatively low density of animals (one to two head of cattle per acre [EPA 2003]) may not produce manure in quantities that require management for the protection of water quality. For mid-size and large facilities, additional waste storage is needed. A waste storage facility is “an impoundment created by excavating earth or a structure constructed to hold and provide treatment to agricultural waste” (Lenhart et al. 2017). Waste storage facilities hold and treat waste directly from animal operations, process wastewater, or contaminated runoff.

Confined swine operations typically use liquid manure storage areas that are located under the confinement barn. Wash water used to clean the floors and remove manure buildup combines with the solid manure to form a liquid or slurry in the pit. The mixture is usually land applied in the spring and fall by injection/incorporation into the soil or transported offsite. Some facilities may have “open-air” liquid manure storage areas, which can pose a runoff risk if improperly managed.

Dairies in the Watonwan River Watershed store and handle manure in both liquid and solid form to be land applied at a later date. Other potential sources of wastewater include process wastewater such as parlor wash down water, milk-house wastewater, silage leachate, and runoff from outdoor silage feed storage areas. There are potential runoff problems associated with these wastewater sources if not properly managed. In addition, many small dairy operations have limited to no manure storage. Most poultry manure is handled as a dry solid in the state; liquid poultry manure handling and storage is rare. Improperly stockpiled poultry manure or improper land application can pose runoff issues.

Final disposal of waste usually involves land application on the farm or transportation to another site. Minn. R. 7020.2225 contains several requirements for land application of manure. These requirements vary depending on feedlot size and include provisions on manure nutrient testing, nutrient application rates (based on determination of crop needs and phosphorus soil testing), manure management plans, recordkeeping, and various limitations in certain areas or near environmentally-sensitive areas. Manure is typically applied to the land once or twice per year. To maximize the amount of nutrients and organic material retained in the soil, application should not occur on frozen ground or when precipitation is forecast during the next several days.

The MDA has recently developed an interactive model to assist livestock producers to evaluate the potential runoff risk for manure applications, based on weather forecasts for temperature and precipitation along with soil moisture content. The model can be customized to specific locations. It is advised that all producers applying manure utilize the model to determine the runoff risk, and use caution when the risk is “medium” and avoid manure application during “high” risk times. For more information and to sign up for runoff risk alerts from the MDA Runoff Risk Advisory Forecast, please see the MDA website.

Grassed waterways (412) and water and sediment control basins (638)

Grassed waterways and *water and sediment control basins* (WASCOBs) are both agricultural BMPs that aim to slow water flow off agricultural fields. Grassed waterways are areas of vegetative cover that are placed in line with high flow areas on a field. WASCOBs are vegetative embankments that are placed perpendicular to water’s flow path to pool and slowly release water. Both practices reduce erosion and sediment and phosphorus loss from agricultural fields.

Conservation Cover (327), conversation/reduced tillage (329 and 345), and cover crops (340)

Conservation cover, conversation/reduced tillage, and cover crops are all on-field agricultural BMPs that aim to reduce erosion and nutrient loss by increasing and/or maintaining vegetative cover and root structure. Conservation cover is the process of converting previously row crop agricultural fields to permanent perennial vegetation. Conservation or reduced tillage can mean any tillage practice that leaves additional residue on the soil surface; 30% or more cover is typically considered conservation tillage. In addition to reducing erosion, conservation tillage preserves soil moisture. Cover crops refer to "the use of grasses, legumes, and forbs planted with annual cash crops to provide seasonal soil cover on cropland when the soil would otherwise be bare" (Lenhart et al. 2017).

9.2.3 Internal Loading Lake Phosphorus Sources

Implementation strategies for internal loading reduction include water level drawdown, sediment phosphorus immobilization or chemical treatment (e.g., alum), and biomanipulation (e.g., carp).

Sequencing of in-lake management strategies both relative to each other as well as relative to external load reduction is important to evaluate and consider. In general, external loading, if moderate to high, should be the initial priority for reduction efforts. Biomanipulation may also be an early priority. However, it is generally believed that further in-lake management efforts involving chemical treatment (e.g., alum) can be considered after substantial external load reduction has occurred. The success of alum treatments depends on several factors including lake morphometry, water residence time, alum dose used, and presence of benthic-feeding fish (Huser et al. 2016).

The MPCA recommends feasibility studies for any lakes in which water level drawdown or chemical treatment is considered.

9.2.4 Education and Outreach

Education is a crucial component of reducing pollutant sources in the Watonwan River Watershed and important to increasing public buy-in of residents, business, and organizations. Education can occur through public events, mass mailings, and radio and television advertisements. An inspection program can also help with public education because inspectors can educate owners about proper operation and maintenance during inspections.

9.3 Cost

TMDLs are required to include an overall approximation of implementation costs (Minn. Stat. 2007, § 114D.25). The costs to implement the activities outlined in the strategy are approximately $10 to $25 million dollars over the next 20 years. This range reflects the level of uncertainty in the source assessment and addresses the high priority sources identified in Section 3.6. The cost includes increasing local capacity to oversee implementation in the watershed and the voluntary actions needed to achieve reductions. Required buffer installation and replacement of IPHTs systems are not included.

9.4 Adaptive Management

The implementation strategy and the future detailed WRAPS reports focus on adaptive management (Figure 11) to ensure management decisions are based on the most recent knowledge. An adaptive management approach allows for changes in the management strategy if environmental indicators suggest that the strategy is inadequate or ineffective. Continued monitoring and course corrections responding to monitoring results are the most appropriate strategy for attaining the water quality goals established in this TMDL.

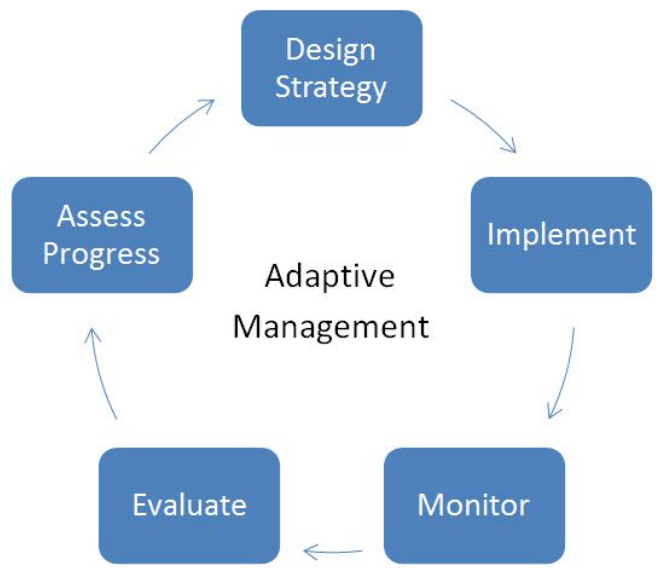


Figure 14. Adaptive management process.

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

10. Public Participation and Public Notice

PROJECT DEVELOPMENT

A broad goal of the Watershed Approach work and completion of the TMDL in the Watonwan River Watershed was to provide and improve Civic Engagement (CE) opportunites with local partners and citizens, to better understand connections and concerns around water, and the drivers and constraints to conservation adoption to inform the WRAPS development.

The Water Resources Center, MSUM worked with GBERBA and local conservation partners to gather input from citizens across the watershed through a series of interviews and focus groups. The project resulted in a network of citizens and conservation partners providing shared solution strategies to improve conservation delivery and watershed health. The insights and strategies from this group informed the WRAPS and will more broadly help shape conservation planning and delivery across the watershed. Several products developed include interviews, focus groups and public meetings across the watershed, summary reports, website, interactive story map, videos, animations and infographics. For more detail on the activities and information collected, see the website at http://watonwanriver.org/.

Local Conservation Partner Interviews

The process began by meeting with local conservation staff at the County, SWCD, and State level to understand how this project could support and build upon existing local efforts and gauge interest in participation with CE activities. Nine meetings were organized by MSUM and MPCA staff to discuss the watershed approach, current public participation efforts, ideas for engaging citizens and to learn about community leaders, connections and networks (people and organizations). The main goals behind these efforts were to understand existing organizational capacity and needs, community perspectives about water and BMPs and existing outreach efforts.

Engagement Team Meetings

The Team met 10 times throughout the project to focus on using social science assessments to inform the CE process and met frequently at the outset framing up an approach. Subsequent meetings were utilized to refine methods and approach. The broad goals of the group were to provide professional development and process design expertise for more strategic, efficient and effective watershed management. This team eventually morphed into the Civic Governance group exploring potential new organizing techniques.

Social Science Methods - Training Sessions

In trying to increase local capacity for civic engagement, local partners received training in social science methods by U of M Forestry Resources professors and staff. The engagment and local partner group was interested in learning more about using interviews and focus groups. Two training opportunities were provided to local partners by U of M staff to build local skills in conducting interviews and focus groups. Two additional training sessions were provided for the core engagement group to work with the data and help the team analyze the interview and focus data.

Interview Training - Qualitative Interviewing and Data Analysis Training Workshop - June 4, 2015

Interview Coding Training - December 9, 2015; May 24, 2016.

Focus Group Training - May 7, 2018

Conservation Partner Update Meetings

Many local conservation partners were integrated into the engagment team, civic governance group, and community conversation group. We held additional update meetings for interested local county, SWCD, state agency staff, and non-profit groups. Meetings provided updates and encouraged brainstorming ideas to improve on interview work, story building and prioritizing areas of interest.

Civic Governance Meetings

To increase the understanding of social capacity, the group sought training in the promising framework and philosophy to engage citizens called Civic Governance. Monthly trainings provided an opportunity for engagement team members to keep updated about project progress and brainstorm together about next steps for civic engagement and the Priority Management Zone (PMZ) projects. Training team members included representatives from Brown County, Martin County SWCD, Cottonwood County SWCD/GBERBA, MPCA, and MSU-WRC (WRC).

A series of 28 meetings were attended by the members. Information was used to plan for public participation activities related to the watershed work and for county staff planning related to their other position duties.

ACTIVITIES COMPLETED

This civic engagement project included the collection of social science information to guide the overall watershed investigation and implementation. The goal was to develop interest in the watershed process and provide an outlet for community-based watershed management. Staff from Minnesota State University-Mankato, U of M and the MPCA met frequently to develop an approach to involve the public and document information collected during the project (see above).

Several approaches were used to create opportunities to connect with citizens and local partners throughout the project including informal small group discussions, one-on-one interviews and formal large scale events and community dialogs. These activities were developed to understand local civic conditions and over the long term provide local support for and active participation in the watershed management process. Existing partnerships and community initiatives were leveraged to optimize resources. A summary of these events includes:

Citizen (PMZ) Interviews

Interview information was collected anonymously so individuals felt comfortable in stating their opinions. The information was compiled, analyzed and summarized to gather key points to lead other conversation and implementation planning**.** The Engagement Team coordinated efforts with the PMZ project to develop an interview template with assistance from U of M's Dr. Mae Davenport and Dr. Amit Pradhananga.

Dustin Anderson, Watonwan Watershed Technician, used the template and performed one-and-one interviews with 29 citizens from across the watershed. Empahsis was on farmers and landowners to learn more about cultural outlook and values. This information was used to better understand community assets, informal and formal networks, and individual and collective interests in order to build community readiness relative to the Watonwan River Watershed management goals.

Interview transcripts were analyzed and coded to distil key themes to help frame and focus our citizen outreach efforts as part of our broader effort to use social science information grounded in citizen perspectives to guide our efforts. The intention of this approach is to better understand, frame and communicate resource issues from a landowner's perspective.

Local Leader and Researcher Interviews – Stories

Through the PMZ interviewing process, citizens were identified and emerged that expressed an interest in learning more about the project and sharing their stories. Project staff interviewed and profiled watershed landowners who have successfully completed BMP projects or are managing their land with water resource protection and sustainability in mind. The goal was to clarify BMPs that improve water quality and provide local examples of watershed neighbors to strengthen peer-to-peer learning.

Many agreed to be a part of video interviews. Videos provide the dual benefit of being able to tell watershed restoration stories and also in building relationships and trust with key landowners. MSUM created a series of videos and print materials that summarized the benefits and challenges of implementing key BMPs.

MSUM interviewed 16 citizens who were identified by numerous sources as local leaders and/or who had already been involved in successful conservation efforts in the watershed. These interviewees included farmers, business owners, SWCD supervisor, crop advisor, local, and state staff.

MSUM also interviewed 11 scientists who are Watonwan River Watershed resource experts -- biologists, hydrologists, water quality specialists, geomorphologists -- to capture their stories as well.

City Staff Meetings

Two meetings were held with staff and interested elected officials from large and small cities across the watershed. Meetings were held in St. James, and focused on identifying shared concerns related to water management and infrastructure in their communities, in order to clarify watershed-wide shared problems and to learn from effective regional case studies. Participants were able to talk in small groups about their community water/stormwater concerns. They requested a follow up meeting to learn more about infrastructure funding.

The second meeting focused on: funding opportunities for rural infrastructure and water improvements with an emphasis on Capital Improvement Planning; programs and agency contacts for potential funding opportunities; and bringing interested city staff and elected officials from across the watershed together to share concerns related to water management and infrastructure in their communities. Interviews indicated that beyond water quality concerns, many smaller communities share concerns about funding infrastructure improvements, providing safe and affordable drinking water for their residents, as well as managing stormwater after heavy rains. In addition to the meetings, project staff also developed an interview template related to city water issues and conducted phone interviews of city managers and city clerks to better understand challenges communities are facing related to water and infrastructure.

Focus Group/Community Meetings

The Madelia Sportsmen Group was identified as a very active and effective conservation/recreation group in the watershed. A meeting was organized to gather input from members of the group on their perception of the river and challenges faced with working in the waterhsed. The goal of the meeting was to meet local leaders and to collect stories about how they have seen the river change over time.

Citizens told us stories about erosion and widening along the mainstem Watonwan River, described the water getting muddier, noting more flashy flows, and less fish diversity and dramatic changes in the past 7 to 10 years.

A follow up meeting was arranged to answer questions raised at the initial meeting and show a video about river flow and fisheries, provided aerial photo analysis that confirmed their observations about river widening, and brainstormed about way to help restore river flow with storage. The group provided advice about next steps in the watershed to gain citizen interest and momentum.

A third meeting of the Madelia Sportsmen Group provided a project update and sought feedback about the local work groups' ideas to improve conservation delivery and solution strategies for conservation challenges. The group provided feedback, raised good questions, and provided insights about next steps. They also told more stories about flashy river flows, more downed woody debris, river widening and changes in fisheries and hunting in the lower reaches of the Watonwan

Through the interview process, groundwater was identified as an issue in the watershed. MSUM met with interested parties to provide information, better understand their collective concerns, and to brainstorm about potential solutions. Partnering with Watonwan County and Minnesota Department of Health, they provided an overview of groundwater issues. The group identified questions that needed answering, information gaps, and suggested some next steps citizens could take to protect groundwater in the region.

NRCS organized a "Cover Crop & Soil Health Field Day" near Bingham Lake. The agenda included economics of soil health, producer perspectives in the Watonwan River Watershed, a rainfall simulator, and producer panel discussion. An overview of the Watershed Approach and water quality issues in the watershed was provided. The event attracted a large crowd, indicating widespread interest in soil health and provided discussion about the benefits of cover crops and reduced tillage practices. Producers from the region shared candid stories about the opportunities and challenges associated with these practices and personal testimonies about their benefits for soil. A Soil Health Information Day event was arranged at the St. James American Legion. The half-day session included an overview of the program "Profit Zone Manager" and a local farmer panel discussing cover crops, reduced tillage, and soil health practices. Event partners included local SWCDs, NRCS, Pheasants Forever and the Water Resources Center.

Watonwan Watershed Community Conversations

A series of seven meetings convened 25 to 35 citizens and conservation partners from across the watershed to talk about water quality concerns, and potential solutions that could lead to increased conservation adoption and improved water quality. The group agreed to meet in a series of three-hour meetings to share a meal and brainstorm potential leverage points for change in the watershed. The broad goal of the series of "think tank" meetings has been to discuss what researchers have learned from landowner interviews and watershed scientific investigations, and to brainstorm solution strategies to address those challenges together. The meetings provided ample time for small group discussions. The group identified numerous innovative ideas that could help to "move the needle" towards more conservation adoption. All of the meetings were held in St. James. At the November 2017 meeting, the group decided to continue to meet quarterly to continue to move solution strategies forward. For a summary of issues discussed with the group, see the following documents:

- *Leverage Points for Conservation Adoption*: http://watonwanriver.org/wp-content/uploads/2015/02/ww-leverage-points_2-18.pdf
- *Conservation Challenges and Solution Strategies: https://drive.google.com/file/d/17lviV59Fr-cnEoWCTOuGGPCF3sqj77Lj/view*

Open House Meetings & Discussions

Open house style meeting were held in the cities of Madelia, St. James, Mountain Lake, Lewisville, and Darfur. The goal for these series of meetings was to share the ideas that the group came up with other interested community members from across the watershed. The meetings provided feedback from a broader network of community members. At each meeting, citizens had the opportunity to learn more about the health of area rivers and lakes, learn about the results of interviews and focus groups and to hear about and reflect on the strategies to improve watershed health that the group of citizens and conservation partners came up with. While attendance was small at some meetings, the discussions were generally very productive and provided helpful input about the solution strategies and suggestions about the group's next steps.

SUMMARY

The project used social science methods, primarily interview and focus group data, to gather information and learn about community perspectives to inform and shape this project (see above for more detail).

A group of citizens and conservation partners were convened to evaluate the social science and bioassessment data gathered and the group developed strategies to address the challenges to conservation adoption.

A summary of documents was created to share more broadly with community members and local decision makers for use in future watershed planning.

The project provided a deeper understanding of how citizens across the Watonwan River Watershed connect with water, perceive water problems, and prioritize water issues.

Engagement Team, Civic Governance, and Local Work Group Members have increased capacity for working with citizens and using social science data to inform watershed planning.

Recommendations and consensus for action were created. See the following summary documents for more information (links provided above:

- Leverage Points for More Conservation Adoption
- Conservation Challenges and Solution Strategies

Local partners have a stronger foundation for future action and watershed planning and locally-derived strategies based on citizen input, perceptions, and priorities.

An opportunity for public comment on the draft TMDL report was provided via a public notice in the *State Register* from July 22, 2019 through September 20, 2019. There were 11 comment letters received and responded to as a result of the public comment period.

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Appendices

Appendix A. Water Quality Summary Tables and Figures, Load Duration Curves, and TMDL Tables

Appendix B. Wastewater Wasteload Allocations

Appendix C. Lake Modeling Documentation

Appendix D. Permitted CAFO Facilities

Appendix E. HSPF Hydrology Calibration and Validation Report

Appendix A. Water Quality Summary Tables and Figures, Load Duration Curves, and TMDL Tables

This section provides the water quality summary tables, load duration curves for streams, water quality summary figures and source assessment tables for lakes, and TMDL tables. See sections 3.5 and 4 in the report for an explanation of the data analyses.

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Figure 11. Number of BMP's per subwatershed...49

Eagle Lake (17-0020-00): Phosphorus

Table A-1. Eagle Lake (17-0020-00) water quality data summary, 2005–2016.
Values in red indicate violations of the standard.

Ecoregion	Shallow Lake	Parameter	Average of Annual Growing Season Means (Jun–Sep)	Water Quality Standard
Western Corn Belt Plains	Y	TP (µg/L)	154	≤ 90
		Chl-*a* (µg/L)	96	≤ 30
		Secchi (m)	0.4	≥ 0.7

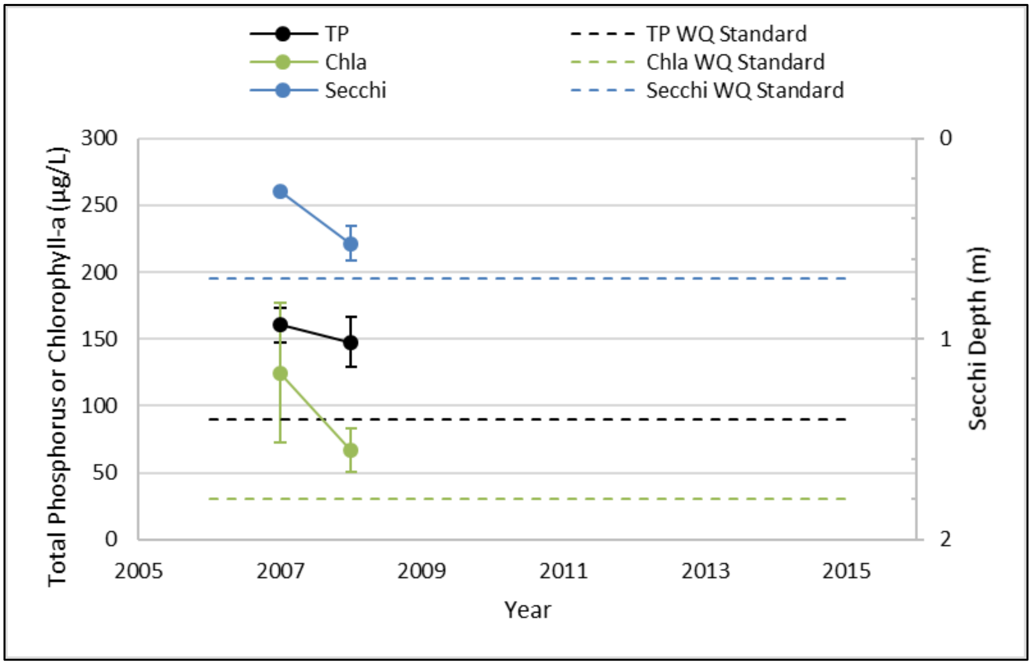

Figure A-1. Eagle Lake water quality data.
Growing season means + / - standard error.

Table A-2. Phosphorus source assessment, Eagle Lake (17-0020-00).

Source		TP Load (lb/yr)	TP Load (%)
Watershed	Forest	<1	<1%
	Crop	100	14%
	Grass/Pasture	1	<1%
	Wetland	1	<1%
	Feedlots	0	0%
	Developed	4	1%
Internal Loading		590	80%
Atmospheric Deposition		40	5%
Total		*736*	*100%*

Table A-3. Phosphorus TMDL summary, Eagle Lake (17-0020-00).

TMDL Parameter	TP Load (lb/yr)	TP Load (lb/day)
WLA for Construction and Industrial Stormwater	0.365	0.00100
Load Allocation	272	0.746
Margin of Safety	30.3	0.0830
Loading Capacity	**303**	**0.830**
Existing Load	736	2.02
Percent Load Reduction	59%	59%

Watonwan River, North Fork, Headwaters to T107 R32W S6, east line (07020010-564): *E. coli*

Table A-4. Annual summary of *E. coli* data at Watonwan River, North Fork (AUID 07020010-564; April–October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances
2013	9	487	147	1,986	1
2014	6	647	355	2,723	1

Table A-5. Monthly summary of *E. coli* data at Watonwan River, North Fork (AUID 07020010-564; April–October). Values in red 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. Standard applies only to months April–October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
Apr	0	--	--	--	--	--
May	0	--	--	--	--	--
Jun	5	817	428	2,723	1	20
Jul	5	535	285	776	0	--
Aug	5	371	147	1,986	1	20
Sep	0	--	--	--	--	--
Oct	0	--	--	--	--	--

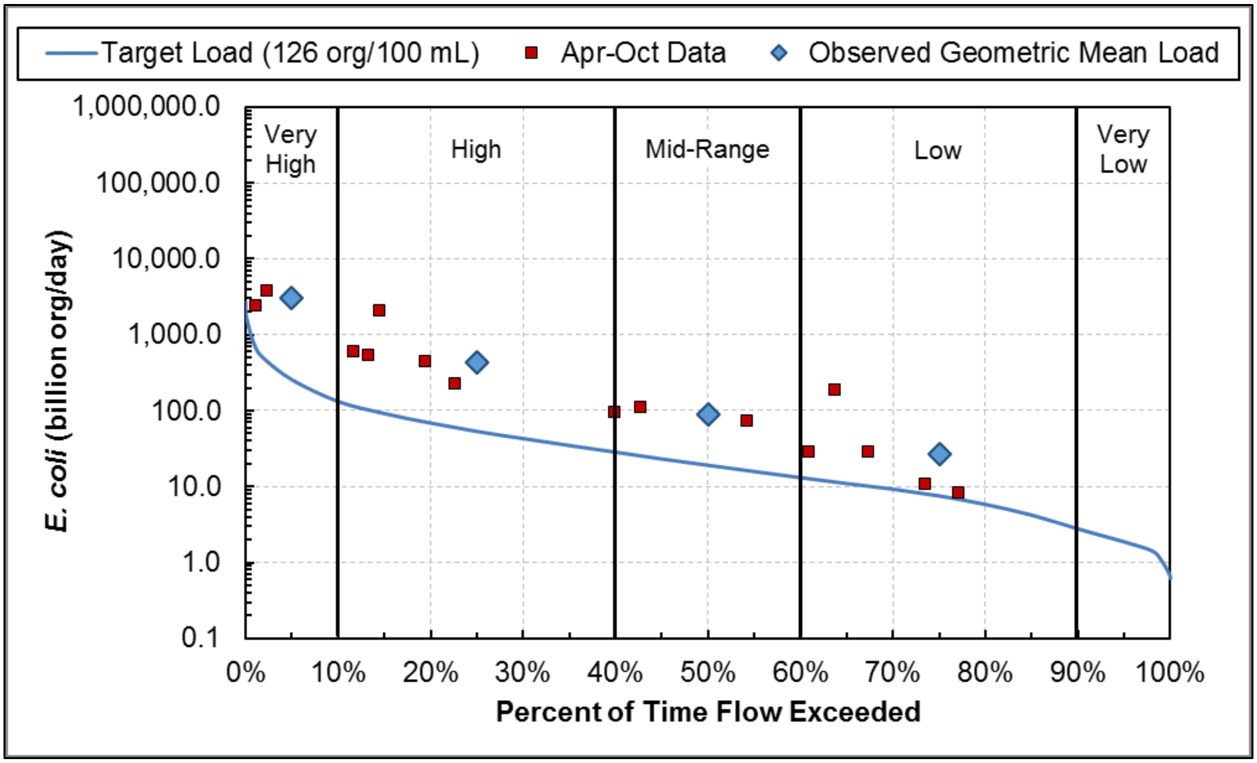

Figure A-2. *E. coli* load duration curve, Watonwan River–North Fork (AUID 07020010-564).

Table A-6. *E. coli* TMDL summary, Watonwan River–North Fork (AUID 07020010-564).

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
Load Allocation	233	49	17	6.8	1.7
Margin of Safety	26	5.4	1.9	0.75	0.19
Loading Capacity	259	54	19	7.6	1.9
Maximum Monthly Geometric Mean (org/100 mL)	817				
Estimated Percent Reduction	85%				

Butterfield Creek, Headwaters to St James Cr (07020010-516): *E. coli*

Table A-7. Annual summary of *E. coli* data at Butterfield Creek (AUID 07020010-516; April–October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances
2013	9	672	107	≥ 2,420 [a]	2
2014	6	358	148	1,106	0

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-8. Monthly summary of *E. coli* data at Butterfield Creek (AUID 07020010-516; 2006–2015).
Values in red 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. Standard applies only to months April–October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances	Percent of Individual Standard Exceedances
Apr	0	--	--	--	--	--
May	0	--	--	--	--	--
Jun	5	613	236	≥ 2,420 [a]	1	20
Jul	5	336	107	1,046	0	--
Aug	5	692	228	1,733	1	20
Sep	0	--	--	--	--	--
Oct	0	--	--	--	--	--

a. 2,420 org/100mL is the method's maximum recordable value.

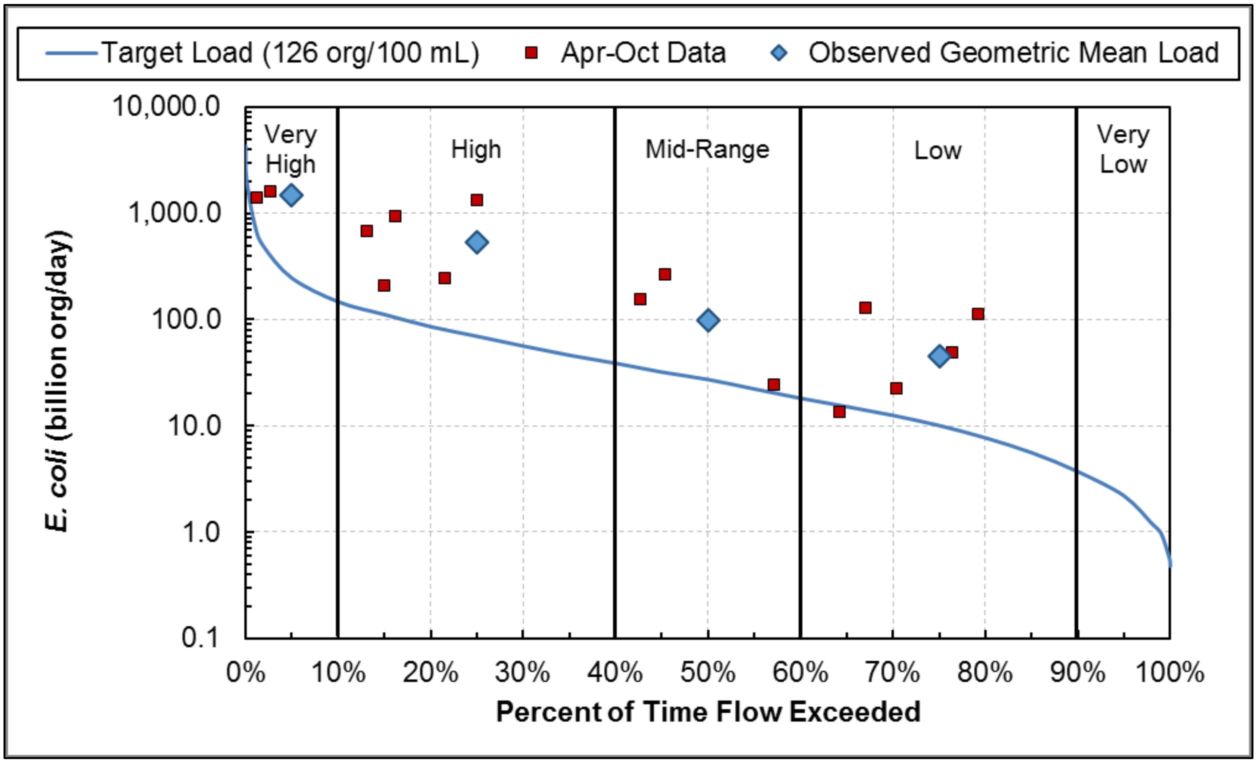

Figure A-3. *E. coli* load duration curve, Butterfield Creek (AUID 07020010-516).

Table A-9. *E. coli* TMDL summary, Butterfield Creek (AUID 07020010-516).

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
WLA: Butterfield WWTP (MN0022977)	13	13	13	– [a]	– [a]
Load Allocation	208	50	11	– [a]	– [a]
Margin of Safety	25	7.0	2.7	1.0	0.22
Loading Capacity	246	70	27	10	2.2
Maximum Monthly Geometric Mean (org/100 mL)	692				
Estimated Percent Reduction	82%				

a. The permitted wastewater design flows exceed the stream flow in the indicated flow zone(s). 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 4.6.2 for more detail.

Butterfield Lake (83-0056-00): Phosphorus

Table A-10. Butterfield Lake (83-0056-00) water quality data summary, 2005–2016.
Values in red indicate violations of the standard.

Ecoregion	Shallow Lake	Parameter	Average of Annual Growing Season Means (Jun–Sep)	Water Quality Standard
Western Corn Belt Plains	Y	TP (µg/L)	94	≤ 90
		Chl-*a* (µg/L)	108	≤ 30
		Secchi (m)	0.2	≥ 0.7

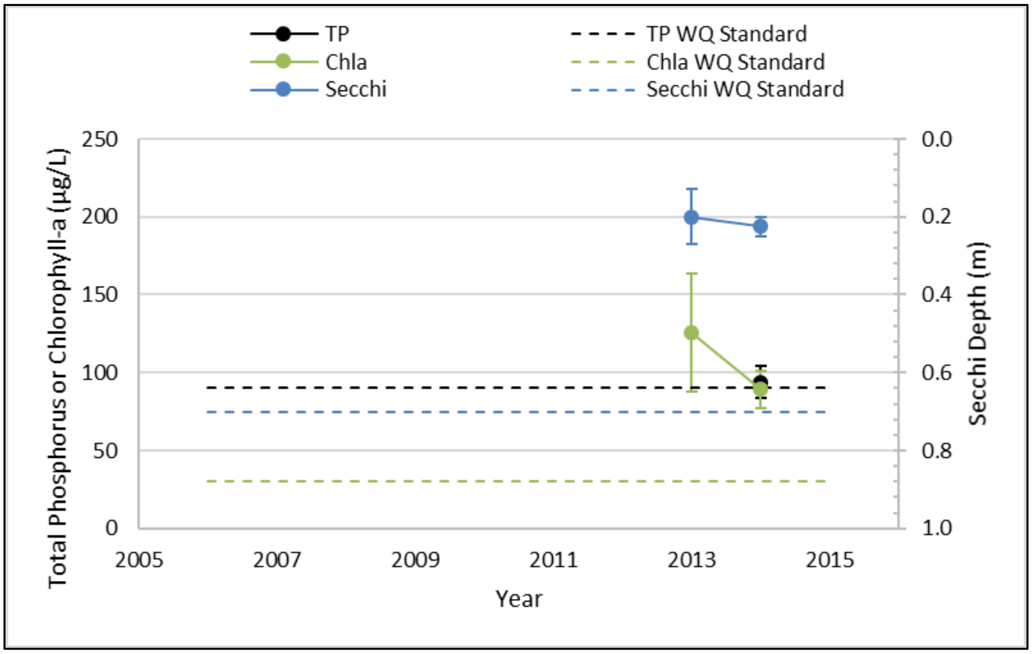

Figure A-4. Butterfield Lake water quality data.
Growing season means + / - standard error.

Table A-11. Phosphorus source assessment, Butterfield Lake (83-0056-00).

Source		TP Load (lb/yr)	TP Load (%)
Watershed	Forest	<1	<1%
	Crop	110	51%
	Grass/Pasture	1	<1%
	Wetland	1	<1%
	Feedlots	0	0%
	Urban	7	3%
Internal Loading		84	38%
Atmospheric Deposition		19	8%
Total		*222*	*100%*

Table A-12. Phosphorus TMDL summary, Butterfield Lake (83-0056-00).

TMDL Parameter	TP Load (lb/yr)	TP Load (lb/day)
WLA for Construction and Industrial Stormwater	0.0927	0.000254
Load Allocation	185	0.507
Margin of Safety	20.6	0.0564
Loading Capacity	**206**	**0.564**
Existing Load	222	0.608
Percent Load Reduction	7%	7%

Kansas Lake (83-0036-00): Phosphorus

Table A-13. Kansas Lake (83-0036-00) water quality data summary, 2005–2016.
Values in red indicate violations of the standard.

Ecoregion	Shallow Lake	Parameter	Average of Annual Growing Season Means (Jun–Sep)	Water Quality Standard
Western Corn Belt Plains	Y	TP (µg/L)	169	≤ 90
		Chl-*a* (µg/L)	41	≤ 30
		Secchi (m)	0.6	≥ 0.7

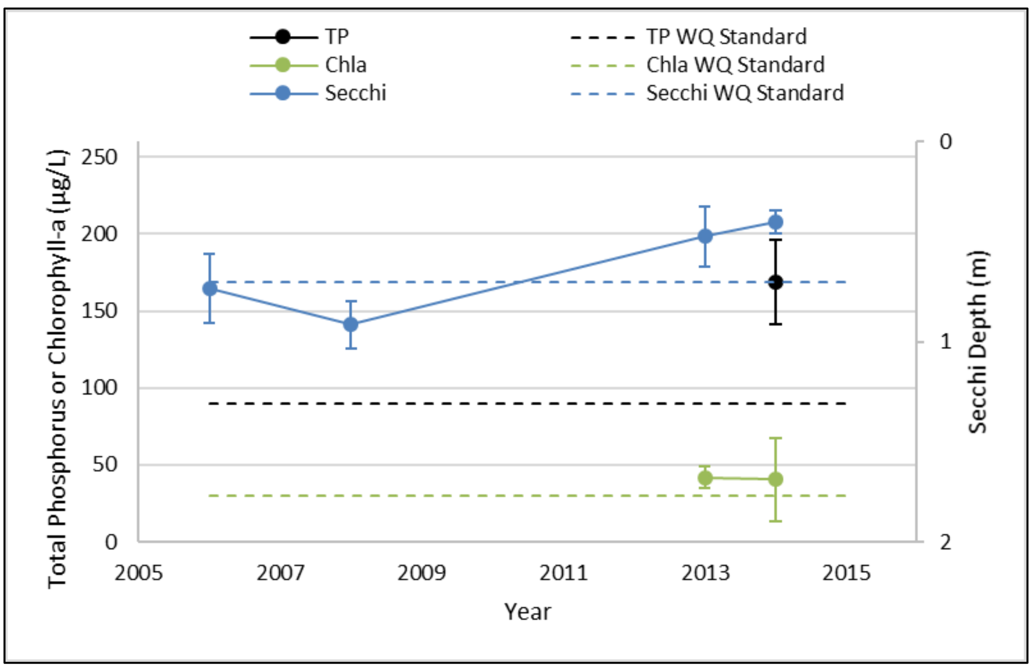

Figure A-4. Kansas Lake water quality data
Growing season means + / - standard error.

Table A-14. Phosphorus source assessment, Kansas Lake (83-0036-00).

Source		TP Load (lb/yr)	TP Load (%)
Watershed	Forest	1	<1%
	Crop	2,198	46%
	Grass/Pasture	2	<1%
	Wetland	7	<1%
	Feedlots	5	<1%
	Urban	66	1%
Internal Loading		2,324	50%
Atmospheric Deposition		151	3%
Total		*4,754*	*100%*

Table A-15. Phosphorus TMDL summary, Kansas Lake (83-0036-00).

TMDL Parameter	TP Load (lb/yr)	TP Load (lb/day)
WLA for Construction and Industrial Stormwater	0.890	0.00244
Load Allocation	1,778	4.88
Margin of Safety	198	0.542
Loading Capacity	**1,977**	**5.42**
Existing Load	4,754	13.0
Percent Load Reduction	58%	58%

St James Creek, T106 R32W S25, west line to T106 R31W S19, north line (07020010-576): *E. coli*

Table A-16. Annual summary of *E. coli* data at St James Creek (AUID 07020010-576; April–October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances
2013	7	624	167	1,414	2
2014	5	603	141	2,755	2

Table A-17. Monthly summary of *E. coli* data at St James Creek (AUID 07020010-576; 2006–2015).
Values in red 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. Standard applies only to months April–October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances
Apr	0	--	--	--	--
May	0	--	--	--	--
Jun	4 [a]	893	517	2,755	1
Jul	5	649	167	1,334	2
Aug	3 [a]	342	141	1,414	1
Sep	0	--	--	--	--
Oct	0	--	--	--	--

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

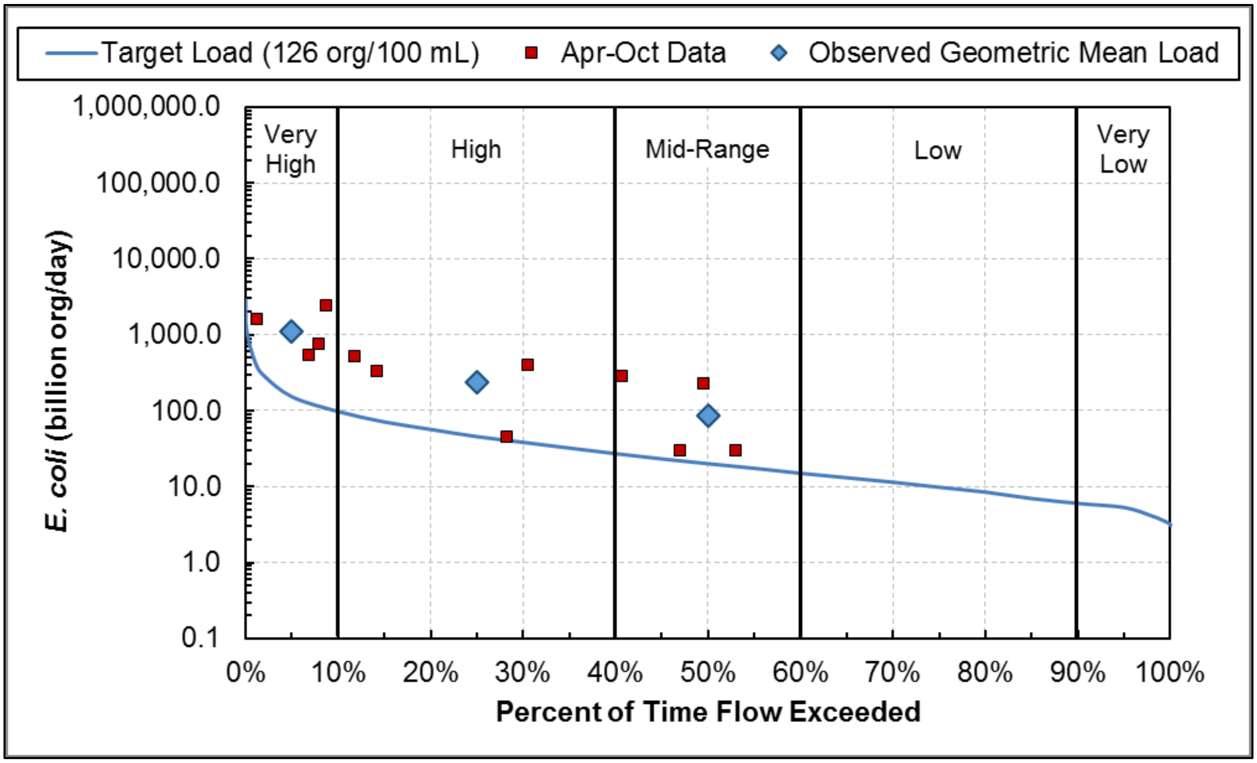

Figure A-5. ***E. coli*** **load duration curve, St James Creek (AUID 07020010-576).**

Table A-18. ***E. coli*** **TMDL summary, St James Creek (AUID 07020010-576).**

TMDL Parameter	Flow Zone				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	E. coli **Load (billion org/d)**				
Load Allocation	137	41	18	8.8	4.8
Margin of Safety	15	4.5	2.0	1.0	0.53
Loading Capacity	152	46	20	9.8	5.3
Maximum Monthly Geometric Mean (org/100 mL)	649				
Estimated Percent Reduction	81%				

St James Creek, T106 R31W S18, south line to Butterfield Cr (07020010-502): *E. coli*

Table A-19. Annual summary of *E. coli* data at St James Creek (AUID 07020010-502; April–October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances
2013	9	1,258	488	8,164	4
2014	5	572	341	2,603	1

Table A-20. Monthly summary of *E. coli* data at St James Creek (AUID 07020010-502; 2006–2015).
Values in red indicate months in which the monthly geometric mean standard of 630 org/100 mL was exceeded or the individual standard of 1,260 org/100 mL was exceeded in greater than 10% of the samples. Standard applies only to months April–October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances
Apr	0	--	--	--	--
May	4 [a]	1,198	613	2,603	2
Jun	5	502	341	659	0
Jul	5	1,489	383	8,164	3
Aug	0	--	--	--	--
Sep	0	--	--	--	--
Oct	0	–	–	–	–

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

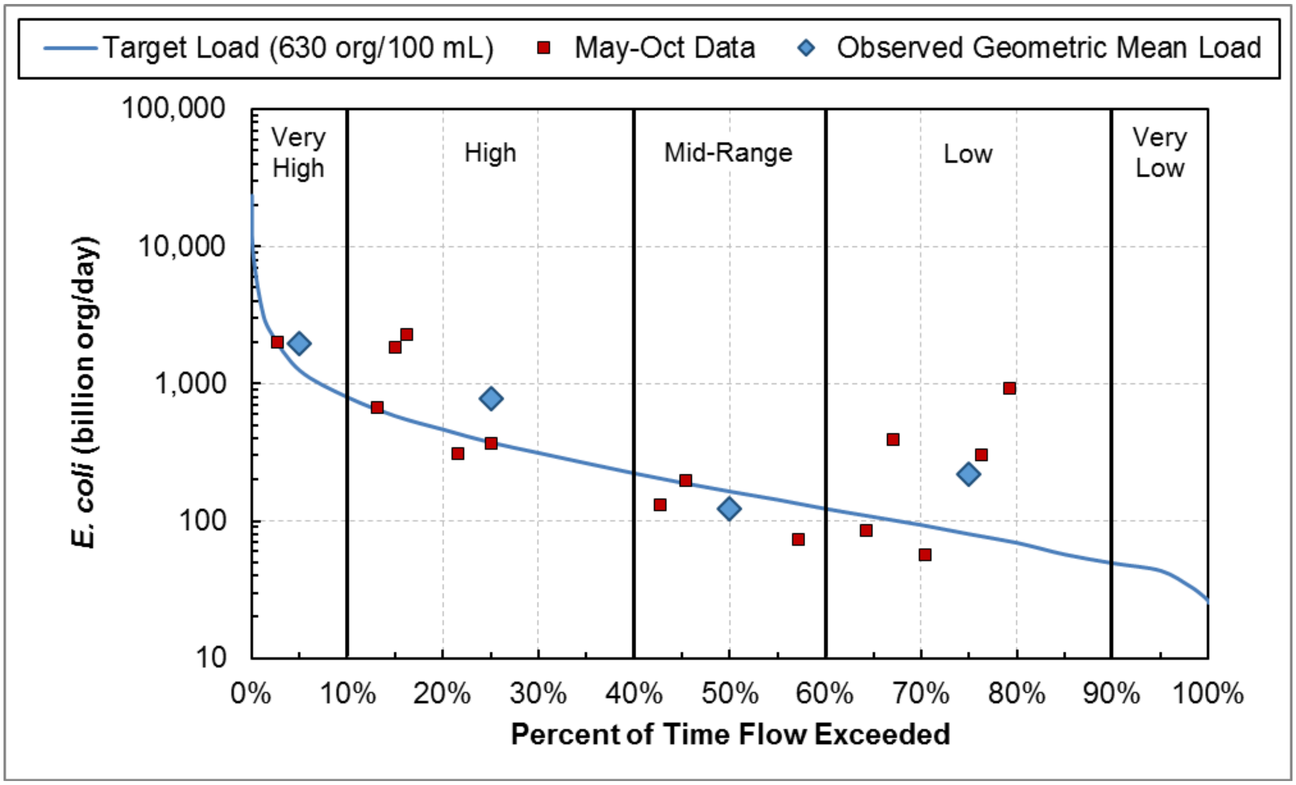

Figure A-6. ***E. coli*** **load duration curve, St James Creek (AUID 07020010-502).**

Table A-21. ***E. coli*** **TMDL summary, St James Creek (AUID 07020010-502).**

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
WLA: Saint James WWTP (MN0024759)	14	14	14	14	14
Load Allocation	1,112	322	134	58	25
Margin of Safety	125	37	16	8.0	4.3
Loading Capacity	1,251	373	164	80	43
Maximum Monthly Geometric Mean (org/100 mL)	1,489				
Estimated Percent Reduction	58%				

St James Creek, Butterfield Cr to Watonwan R (07020010-515): *E. coli*

Table A-22. Annual summary of *E. coli* data at St James Creek (AUID 07020010-515; April–October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances
2013	9	678	154	4,884	2
2014	6	486	220	1,309	1

Table A-23. Monthly summary of *E. coli* data at St James Creek (AUID 07020010-515; 2006–2015).
Values in red indicate months in which the monthly geometric mean standard of 630 org/100 mL was exceeded or the individual standard of 1,260 org/100 mL was exceeded in greater than 10% of the samples. Standard applies only to months April–October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances
Apr	0	--	--	--	--
May	5	768	350	1,733	2
Jun	5	403	167	649	0
Jul	5	676	154	4,884	1
Aug	0	--	--	--	--
Sep	0	--	--	--	--
Oct	0	–	–	–	–

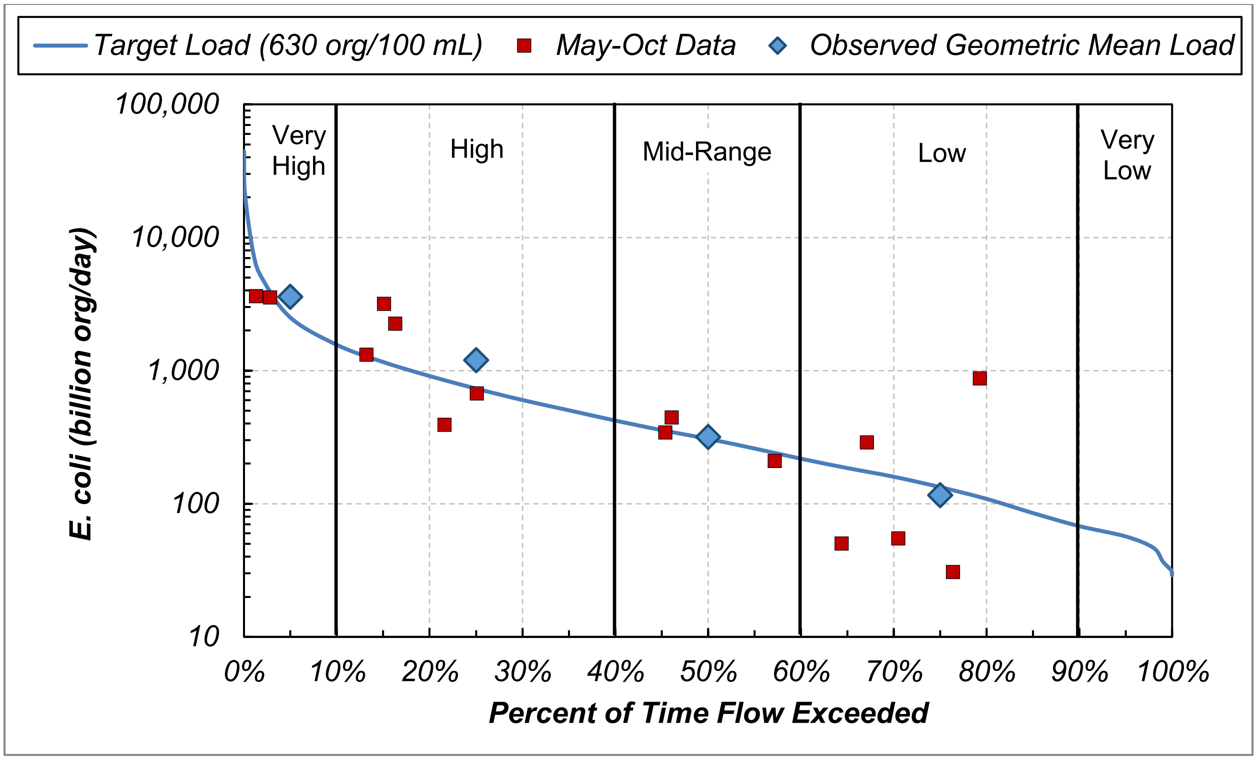

Figure A-7. *E. coli* load duration curve, St James Creek (AUID 07020010-515).

Table A-24. *E. coli* TMDL summary, St James Creek (AUID 07020010-515).

TMDL Parameter	**Flow Zone**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	***E. coli* Load (billion org/d)**				
WLA: Butterfield WWTP (MN0022977)	13	13	13	13	13
WLA: Saint James WWTP (MN0024759)	14	14	14	14	14
Load Allocation	2,224	633	249	93	24
Margin of Safety	250	73	31	13	5.7
Loading Capacity	2,501	733	307	133	57
Maximum Monthly Geometric Mean (org/100 mL)	768				
Estimated Percent Reduction	18%				

Bingham Lake (17-0007-00): Phosphorus

Table A-25. Bingham Lake (17-0007-00) water quality data summary, 2005–2016.
Values in red indicate violations of the standard.

Ecoregion	Shallow Lake	Parameter	Average of Annual Growing Season Means (Jun–Sep)	Water Quality Standard
Western Corn Belt Plains	Y	TP (µg/L)	156	≤ 90
		Chl-*a* (µg/L)	42	≤ 30
		Secchi (m)	0.5	≥ 0.7

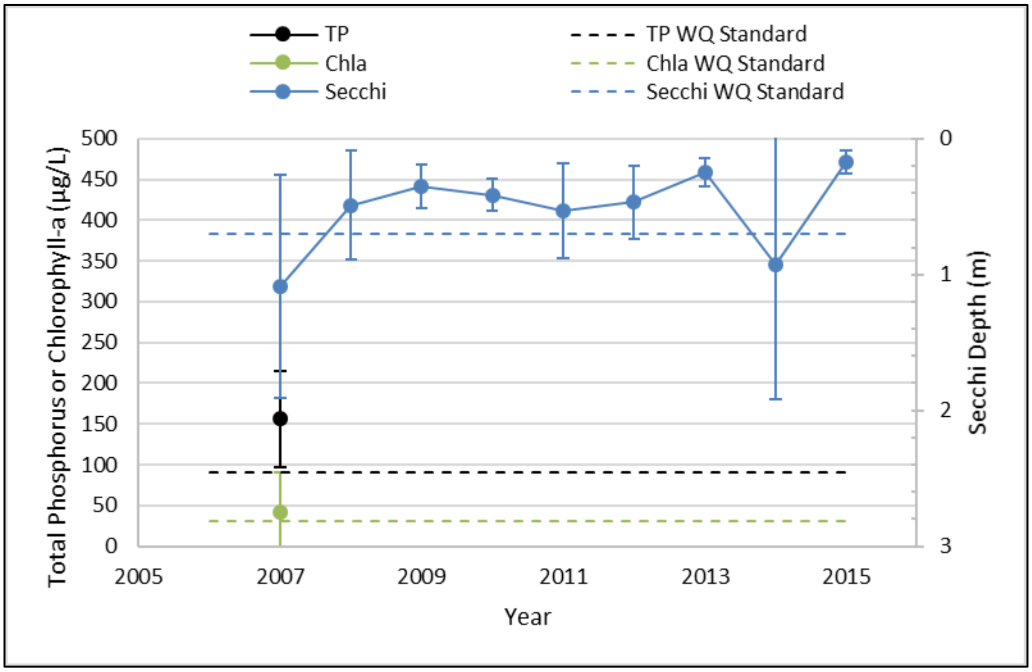

Figure A-8. Bingham Lake water quality data.
Growing season means + / - standard error.

Table A-26. Phosphorus source assessment, Bingham Lake (17-0007-00).

Source		TP Load (lb/yr)	TP Load (%)
Watershed	Forest	<1	<1%
	Crop	294	10%
	Grass/Pasture	7	<1%
	Wetland	2	<1%
	Feedlots	1	<1%
	Urban	25	1%
Internal Loading		2,475	86%
Atmospheric Deposition		101	3%
Total		*2,905*	*100%*

Table A-27. Phosphorus TMDL summary, Bingham Lake (17-0007-00).

TMDL Parameter	TP Load (lb/yr)	TP Load (lb/day)
WLA for Construction and Industrial Stormwater	1.39	0.00381
Load Allocation	1,034	2.83
Margin of Safety	115	0.315
Loading Capacity	**1,150**	**3.15**
Existing Load	2,905	7.96
Percent Load Reduction	60%	60%

Judicial Ditch 1, T105 R33W S8, west line to Irish Lk (07020010-581): *E. coli*

Table A-28. Annual summary of *E. coli* data at Judicial Ditch 1 (AUID 07020010-581; April–October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances
2013	9	577	192	≥ 2,420 [a]	2
2014	6	528	295	1,081	0

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-29. Monthly summary of *E. coli* data at Judicial Ditch 1 (AUID 07020010-581; 2006–2015).
Values in red 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. Standard applies only to months April–October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances
Apr	0	--	--	--	--
May	0	--	--	--	--
Jun	5	490	192	1,081	0
Jul	5	397	249	579	0
Aug	5	889	420	≥ 2,420 [a]	2
Sep	0	--	--	--	--
Oct	0	--	--	--	--

a. 2,420 org/100mL is the method's maximum recordable value.

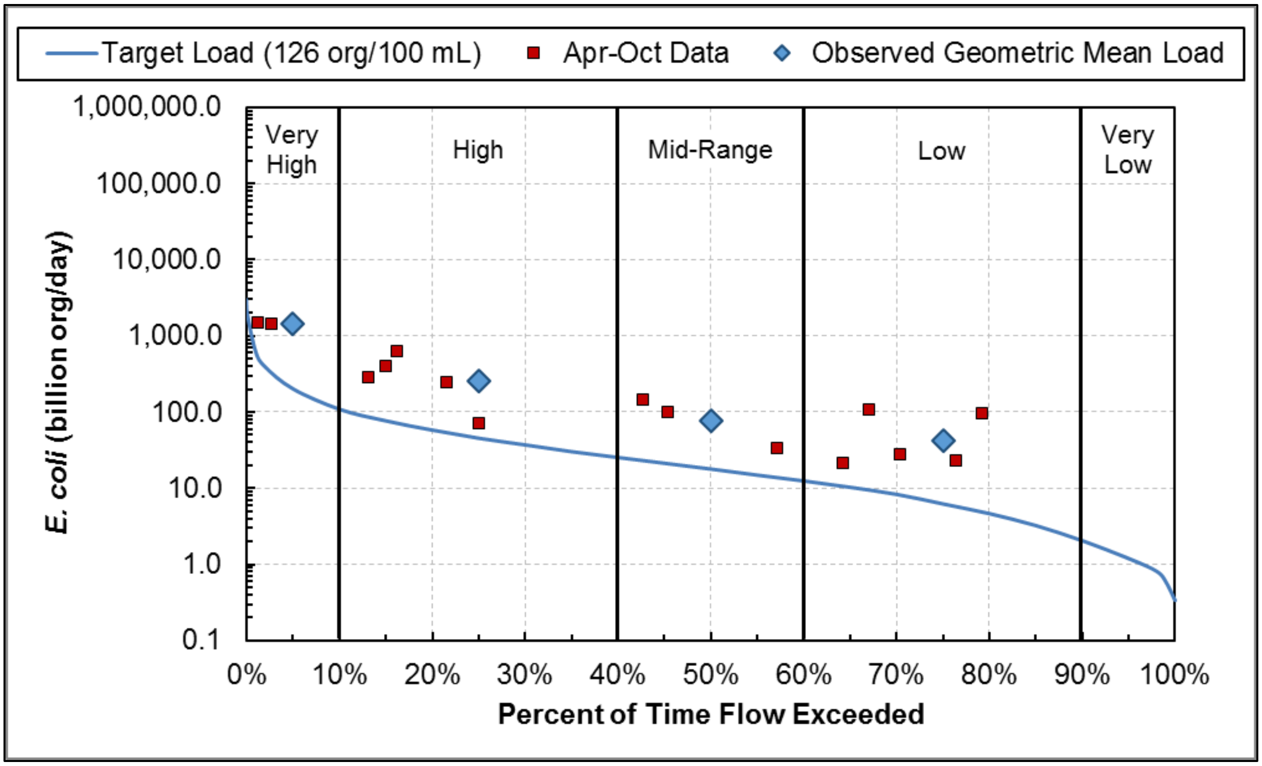

Figure A-9. *E. coli* load duration curve, Judicial Ditch 1 (AUID 07020010-581).

Table A-30. *E. coli* TMDL summary, Judicial Ditch 1 (AUID 07020010-581).

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
WLA: Neuhof Hutterian Brethren (MNG580113)	0.55	0.55	0.55	0.55	0.55
Load Allocation	183	41	16	5.1	0.53
Margin of Safety	20	4.6	1.8	0.6	0.12
Loading Capacity	204	46	18	6.3	1.2
Maximum Monthly Geometric Mean (org/100 mL)	889				
Estimated Percent Reduction	86%				

Watonwan River, South Fork, -94.8475 43.8813 to Irish Lk (07020010-568): *E. coli*

Table A-31. Annual summary of *E. coli* data at Watonwan River, South Fork (AUID 07020010-568; April–October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances
2013	9	599	236	1,733	1
2014	6	823	161	2,755	1

Table A-32. Monthly summary of *E. coli* data at Watonwan River, South Fork (AUID 07020010-568; 2006–2015). Values in red 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. Standard applies only to months April–October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances
Apr	0	--	--	--	--
May	0	--	--	--	--
Jun	5	850	328	2,755	1
Jul	5	651	291	1,145	0
Aug	5	569	161	1,733	1
Sep	0	--	--	--	--
Oct	0	--	--	--	--

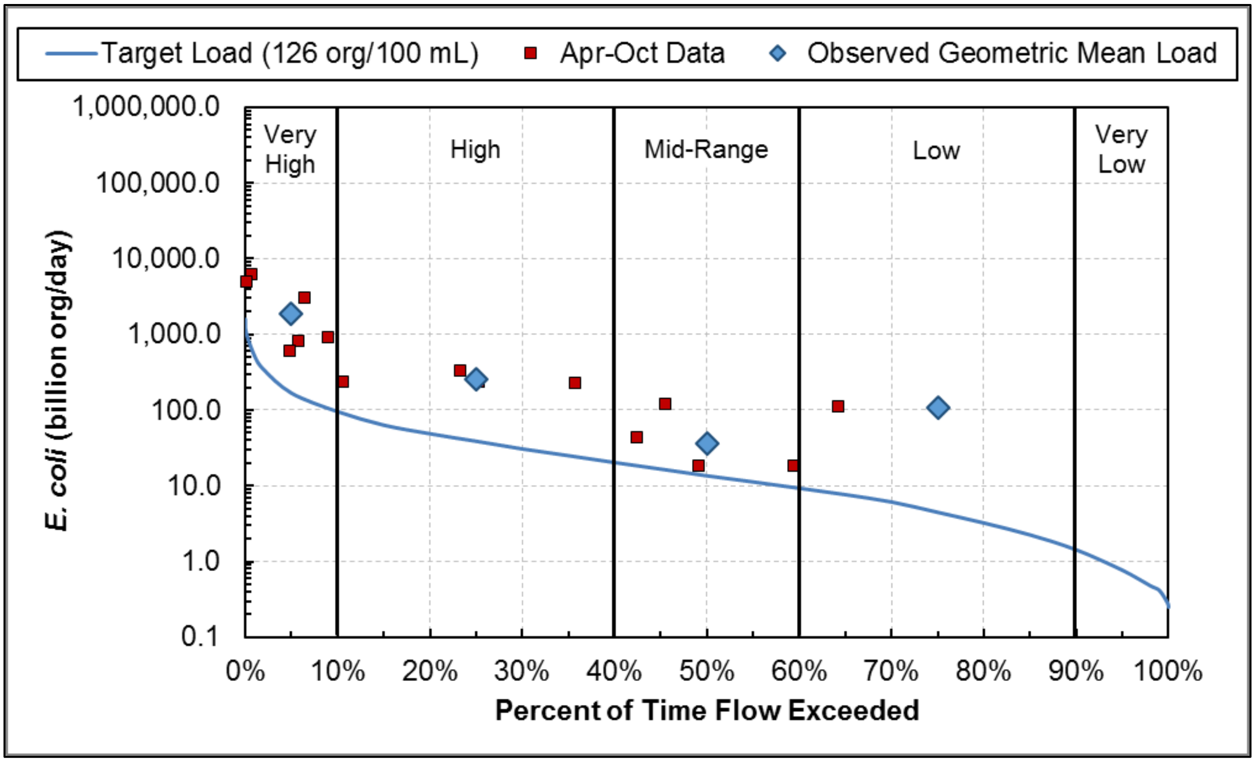

Figure A-10. *E. coli* load duration curve, Watonwan River-South Fork (AUID 07020010-568).

Table A-33. *E. coli* TMDL summary, Watonwan River-South Fork (AUID 07020010-568).

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
Load Allocation	151	35	13	4.1	0.69
Margin of Safety	17	3.9	1.4	0.45	0.077
Loading Capacity	168	39	14	4.6	0.77
Maximum Monthly Geometric Mean (org/100 mL)	850				
Estimated Percent Reduction	85%				

Spring Branch Creek, T106 R30W S22, west line to Perch Cr (07020010-574): *E. coli*

Table A-34. Annual summary of *E. coli* data at Spring Branch Creek (AUID 07020010-574; April–October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances
2013	9	503	145	≥ 2,420 [a]	1
2014	6	294	173	480	0

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-35. Monthly summary of *E. coli* data at Spring Branch Creek (AUID 07020010-574; 2006–2015). Values in red 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. Standard applies only to months April–October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances
Apr	0	--	--	--	--
May	0	--	--	--	--
Jun	5	744	414	≥ 2,420 [a]	1
Jul	5	423	183	1,046	0
Aug	5	212	145	387	0
Sep	0	--	--	--	--
Oct	0	--	--	--	--

a. 2,420 org/100mL is the method's maximum recordable value.

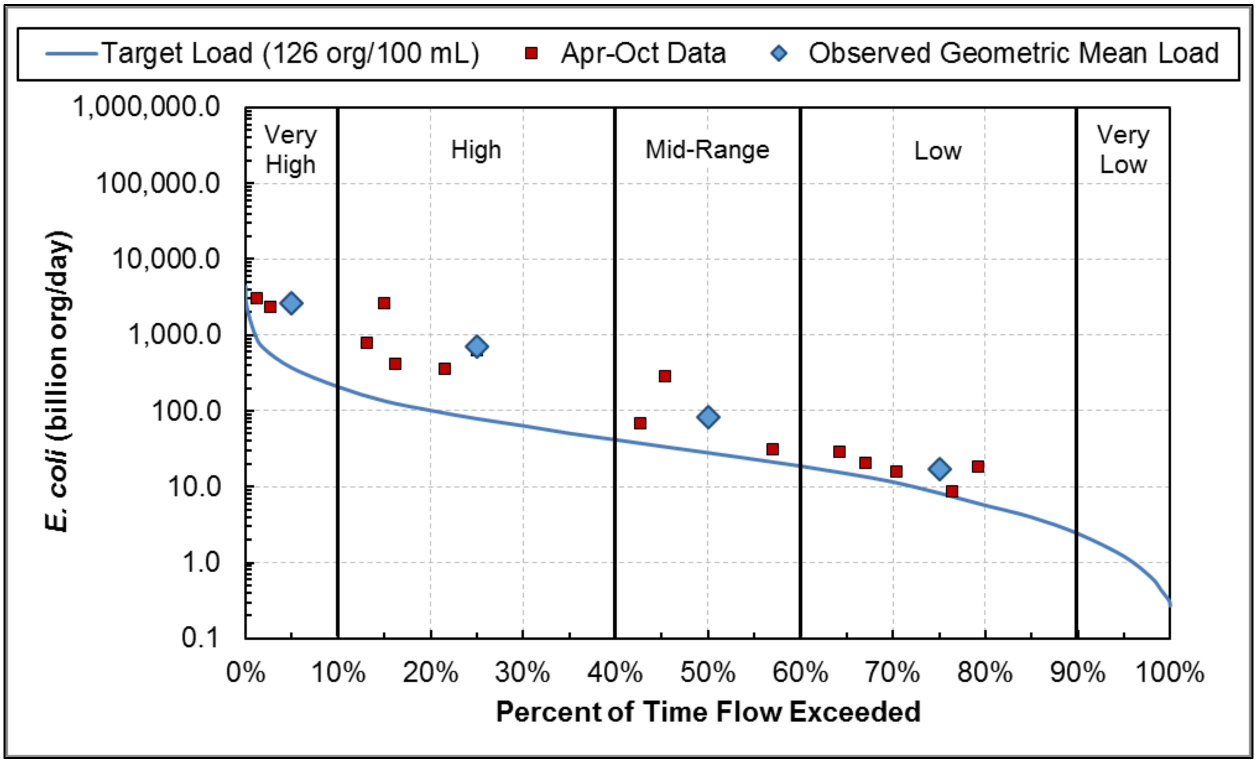

Figure A-11. *E. coli* load duration curve, Spring Branch Creek (AUID 07020010-574).

Table A-36. *E. coli* TMDL summary, Spring Branch Creek (AUID 07020010-574).

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
WLA: Lewisville WWTP (MN0065722)	2.2	2.2	2.2	2.2	– [a]
Load Allocation	332	69	23	5.2	– [a]
Margin of Safety	37	7.9	2.8	0.82	0.12
Loading Capacity	371	79	28	8.2	1.2
Maximum Monthly Geometric Mean (org/100 mL)	744				
Estimated Percent Reduction	83%				

a. The permitted wastewater design flows exceed the stream flow in the indicated flow zone(s). 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 4.6.2 for more detail.

Perch Creek, Spring Cr to Watonwan R (07020010-523): *E. coli*

Table A-37. Annual summary of *E. coli* data at Perch Creek (AUID 07020010-523; April–October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances
2013	9	697	345	≥ 2,420 [a]	2
2014	6	377	173	884	0

a. 2,420 org/100mL is the method's maximum recordable value.

Table A-38. Monthly summary of *E. coli* data at Perch Creek (AUID 07020010-523; 2006–2015).
Values in red 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. Standard applies only to months April–October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances
Apr	0	--	--	--	--
May	0	--	--	--	--
Jun	5	436	350	517	0
Jul	5	337	173	687	0
Aug	5	1,102	537	≥ 2,420 [a]	2
Sep	0	--	--	--	--
Oct	0	--	--	--	--

a. 2,420 org/100mL is the method's maximum recordable value.

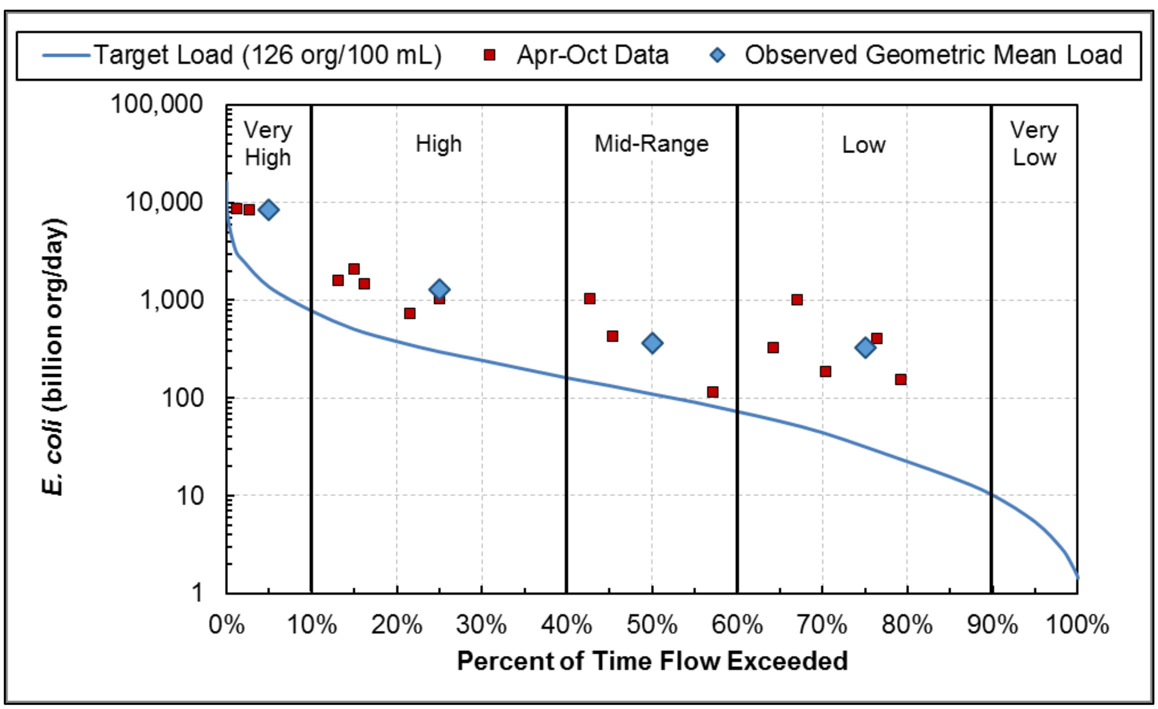

Figure A-12. *E. coli* load duration curve, Perch Creek (AUID 07020010-523).

Table A-39. *E. coli* TMDL summary, Perch Creek (AUID 07020010-523).

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
WLA: Truman WWTP (MN0021652)	3.7	3.7	3.7	3.7	– [a]
WLA: Lewisville WWTP (MN0065722)	2.2	2.2	2.2	2.2	– [a]
Load Allocation	1,230	262	93	23	– [a]
Margin of Safety	137	30	11	3.2	0.54
Loading Capacity	1,373	298	110	32	5.4
Maximum Monthly Geometric Mean (org/100 mL)	1,102				
Estimated Percent Reduction	89%				

a. The permitted wastewater design flows exceed the stream flow in the indicated flow zone(s). 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 4.6.2 for more detail.

Watonwan River, S Fork Watonwan R to Perch Cr (07020010-510): *E. coli*

Table A-40. Annual summary of *E. coli* data at Watonwan River (AUID 07020010-510; April–October).

Year	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances
2013	18	327	29	1,414	3
2014	12	242	74	1,935	2

Table A-41. Monthly summary of *E. coli* data at Watonwan River (AUID 07020010-510; 2006–2015).
Values in red 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. Standard applies only to months April–October.

Month	Sample Count	Geometric Mean (org/100 mL)	Minimum (org/100mL)	Maximum (org/100mL)	Number of Individual Standard Exceedances
Apr	0	--	--	--	--
May	0	--	--	--	--
Jun	10	509	223	1,935	2
Jul	10	138	29	345	0
Aug	10	348	74	1,414	3
Sep	0	--	--	--	--
Oct	0	--	--	--	--

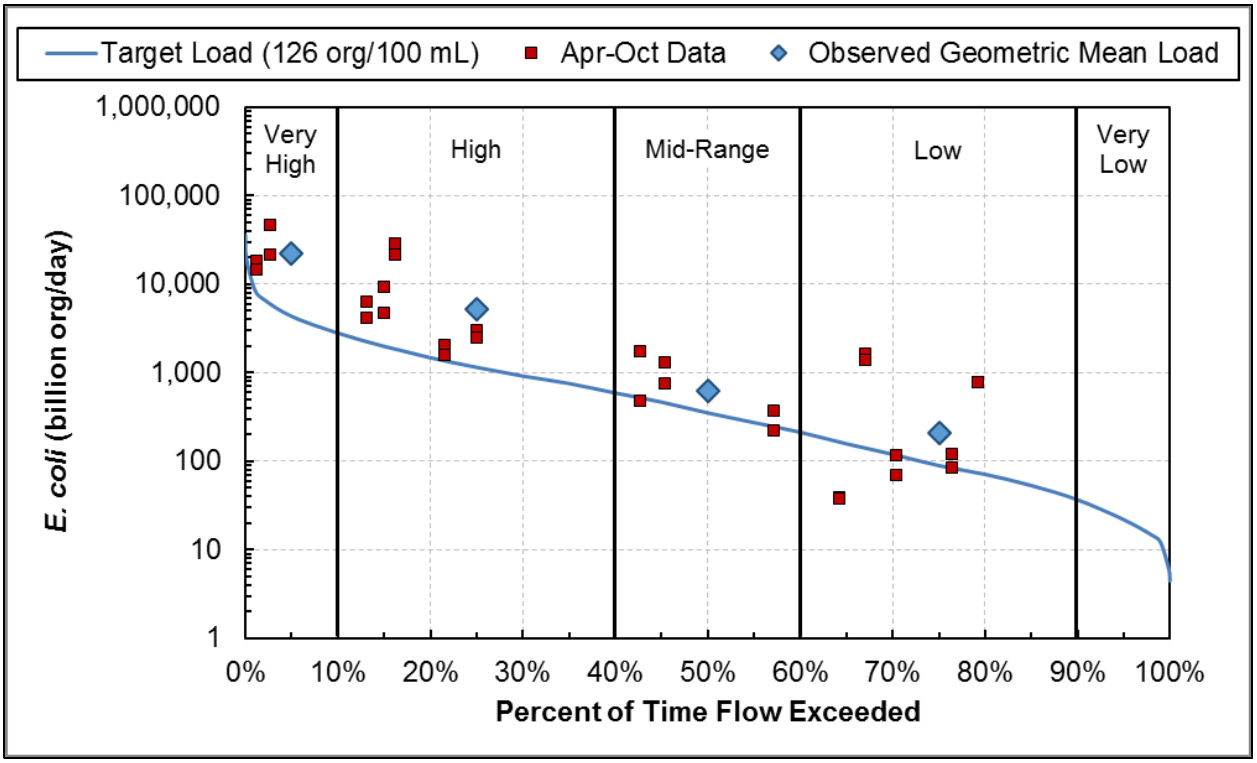

Figure A-13. ***E. coli*** **load duration curve, Watonwan River (AUID 07020010-510).**

Table A-42. ***E. coli*** **TMDL summary, Watonwan River (AUID 07020010-510).**

TMDL Parameter	Flow Zone				
	Very High	High	Mid	Low	Very Low
	E. coli Load (billion org/d)				
WLA: Butterfield WWTP (MN0022977)	13	13	13	13	– [a]
WLA: Delft Sanitary District WWTP (MN0066541)	0.029	0.029	0.029	0.029	– [a]
WLA: La Salle WWTP (MN0067458)	0.072	0.072	0.072	0.072	– [a]
WLA: Madelia WWTP (MN0024040)	6.3	6.3	6.3	6.3	– [a]
WLA: Mountain Lake WWTP (MNG580035)	20	20	20	20	– [a]
WLA: Neuhof Hutterian Brethren (MNG580113)	0.55	0.55	0.55	0.55	– [a]
WLA: Odin-Ormsby WWTP (MN0069442)	1.4	1.4	1.4	1.4	– [a]
WLA: Saint James WWTP (MN0024759)	14	14	14	14	– [a]
Load Allocation	3,900	993	264	26	– [a]
Margin of Safety	439	117	36	9.0	2.2
Loading Capacity	4,394	1,165	355	90	22
Maximum Monthly Geometric Mean (org/100 mL)	509				
Estimated Percent Reduction	75%				

a. The permitted wastewater design flows exceed the stream flow in the indicated flow zone(s). 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 4.6.2 for more detail.

Appendix B. Wastewater Wasteload Allocations

All wastewater WLAs are listed in the individual TMDL tables in Appendix A and are compiled in the following table.

Table B-19. Individual wastewater wasteload allocations.

Facility	Permit Number	Design Flow (mgd) [a]	*E. coli* Wasteload Allocation (billion organisms per day), Apr–Oct [b]	Impairment AUID
Truman WWTP	MN0021652	0.780	3.721 [c]	07020010-523
Butterfield WWTP	MN0022977	2.770	13.213	07020010-516, 515, 510
Madelia WWTP	MN0024040	1.314	6.268	07020010-510
Saint James WWTP	MN0024759	2.960	14.119 [c]	07020010-502, 515, 510
Lewisville WWTP	MN0065722	0.466	2.223 [c]	07020010-574, 523
Delft Sanitary District WWTP	MN0066541	0.006	0.029	07020010-510
La Salle WWTP	MN0067458	0.015	0.072	07020010-510
Odin-Ormsby WWTP	MN0069442	0.300	1.431	07020010-510
Mountain Lake WWTP	MNG580035	4.122	19.662	07020010-510
Neuhof Hutterian Brethren	MNG580113	0.116	0.553	07020010-581, 510

a. Average wet weather design flow or maximum daily pond flow, in million gallons per day (mgd).
b. See Section 4.6.2 in the report for the approach used to develop *E. coli* WLAs.
WLAs noted with footnote apply May–Oct; all others apply Apr–Oct.

Appendix C. Lake Modeling Documentation

Contents

A1.1 Eagle Lake (17-0020-00)

Benchmark Model

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.7	0.2
Evaporation (m)	0.7	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	42	0.50
Total N	0	0.50
Ortho P	0	0.50
Inorganic N	0	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Eagle	0	1	0.43	1.65	0.76	1.65	0.12	0	0	0	0.08	0	0	1.7	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	153.88	0.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Watershed	1	1	2.15	0.24	0	0	0	201.1	0	0	0	0	0	0	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.015	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Segment Mass Balance Based Upon Predicted Concentrations

Component:	TOTAL P		Segment:	1	Eagle	
		Flow	Flow	Load	Load	Conc
Trib Type	Location	hm^3/yr	%Total	kg/yr	%Total	mg/m^3
1 1	Watershed	0.240	44.4%	48.3	14.5%	201
PRECIPITATION		0.301	55.6%	18.1	5.4%	60
INTERNAL LOAD		0.000	0.0%	267.0	80.1%	
TRIBUTARY INFLOW		0.240	44.4%	48.3	14.5%	201
***TOTAL INFLOW		0.541	100.0%	333.3	100.0%	616
ADVECTIVE OUTFLOW		0.240	44.4%	37.0	11.1%	154
***TOTAL OUTFLOW		0.240	44.4%	37.0	11.1%	154
***EVAPORATION		0.301	55.6%	0.0	0.0%	
***RETENTION		0.000	0.0%	296.4	88.9%	

Hyd. Residence Time =	2.9562	yrs
Overflow Rate =	0.6	m/yr
Mean Depth =	1.6	m

TMDL Scenario

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.7	0.2
Evaporation (m)	0.7	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	42	0.50
Total N	0	0.50
Ortho P	0	0.50
Inorganic N	0	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Eagle	0	1	0.43	1.65	0.76	1.65	0.12	0	0	0	0.08	0	0	0.53	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	153.88	0.07	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Watershed	1	1	2.15	0.24	0	0	0	150	0	0	0	0	0	0	0

Segment Mass Balance Based Upon Predicted Concentrations

Component:	TOTAL P		Segment:	1	Eagle	
		Flow	Flow	Load	Load	Conc
Trib Type	Location	hm^3/yr	%Total	kg/yr	%Total	mg/m^3
1 1	Watershed	0.240	44.4%	36.0	26.2%	150
PRECIPITATION		0.301	55.6%	18.1	13.2%	60
INTERNAL LOAD		0.000	0.0%	83.2	60.6%	
TRIBUTARY INFLOW		0.240	44.4%	36.0	26.2%	150
***TOTAL INFLOW		0.541	100.0%	137.3	100.0%	254
ADVECTIVE OUTFLOW		0.240	44.4%	21.7	15.8%	90
***TOTAL OUTFLOW		0.240	44.4%	21.7	15.8%	90
***EVAPORATION		0.301	55.6%	0.0	0.0%	
***RETENTION		0.000	0.0%	115.6	84.2%	

Hyd. Residence Time = 2.9562 yrs
Overflow Rate = 0.6 m/yr

A1.2 Butterfield Lake (83-0056-00)

Benchmark Model

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.24	0.2
Evaporation (m)	0.24	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	42	0.50
Total N	0	0.50
Ortho P	0	0.50
Inorganic N	0	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Butterfield	0	1	0.2	1.92	0.64	1.92	0.12	0	0	0	0.08	0	0	0.52	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	93.75	0.11	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Watershed	1	1	2.18	0.27	0	0	0	201.27	0	0	0	0	0	0	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.015	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Segment Mass Balance Based Upon Predicted Concentrations

Component: TOTAL P **Segment: 1 Butterfield**

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
1	1	Watershed	0.270	84.9%	54.3	53.9%	201
PRECIPITATION			0.048	15.1%	8.4	8.3%	175
INTERNAL LOAD			0.000	0.0%	38.0	37.7%	
TRIBUTARY INFLOW			0.270	84.9%	54.3	53.9%	201
***TOTAL INFLOW			0.318	100.0%	100.7	100.0%	317
ADVECTIVE OUTFLOW			0.270	84.9%	25.5	25.3%	94
***TOTAL OUTFLOW			0.270	84.9%	25.5	25.3%	94
***EVAPORATION			0.048	15.1%	0.0	0.0%	
***RETENTION			0.000	0.0%	75.2	74.7%	

Hyd. Residence Time =	1.4222	yrs
Overflow Rate =	1.4	m/yr
Mean Depth =	1.9	m

TMDL Scenario

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.24	0.2
Evaporation (m)	0.24	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	42	0.50
Total N	0	0.50
Ortho P	0	0.50
Inorganic N	0	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Butterfield	0	1	0.2	1.92	0.64	1.92	0.12	0	0	0	0.08	0	0	0.52	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	93.75	0.11	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Watershed	1	1	2.18	0.27	0	0	0	175	0	0	0	0	0	0	0

Segment Mass Balance Based Upon Predicted Concentrations

Component: TOTAL P **Segment: 1 Butterfield**

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
1	1	Watershed	0.270	84.9%	47.3	50.5%	175
PRECIPITATION			0.048	15.1%	8.4	9.0%	175
INTERNAL LOAD			0.000	0.0%	38.0	40.6%	
TRIBUTARY INFLOW			0.270	84.9%	47.3	50.5%	175
***TOTAL INFLOW			0.318	100.0%	93.6	100.0%	294
ADVECTIVE OUTFLOW			0.270	84.9%	24.3	25.9%	90
***TOTAL OUTFLOW			0.270	84.9%	24.3	25.9%	90
***EVAPORATION			0.048	15.1%	0.0	0.0%	
***RETENTION			0.000	0.0%	69.4	74.1%	

Hyd. Residence Time = 1.4222 yrs
Overflow Rate = 1.4 m/yr
Mean Depth = 1.9 m

A1.3 Kansas Lake (83-0036-00)

Benchmark Model

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.8	0.2
Evaporation (m)	0.8	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	42	0.50
Total N	0	0.50
Ortho P	0	0.50
Inorganic N	0	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Kansas	0	1	1.63	1.34	1.76	1.34	0.12	0	0	0	0.08	0	0	1.77	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	168.75	0.16	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Watershed	1	1	37.17	4.45	0	0	0	232.4	0	0	0	0	0	0	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.015	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Segment Mass Balance Based Upon Predicted Concentrations

Component: TOTAL P **Segment: 1 Kansas**

Trib	Type	Location	Flow hm³/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m³
1	1	Watershed	4.450	77.3%	1034.2	48.0%	232
PRECIPITATION			1.304	22.7%	68.5	3.2%	53
INTERNAL LOAD			0.000	0.0%	1053.8	48.9%	
TRIBUTARY INFLOW			4.450	77.3%	1034.2	48.0%	232
***TOTAL INFLOW			5.754	100.0%	2156.4	100.0%	375
ADVECTIVE OUTFLOW			4.450	77.3%	751.3	34.8%	169
***TOTAL OUTFLOW			4.450	77.3%	751.3	34.8%	169
***EVAPORATION			1.304	22.7%	0.0	0.0%	
***RETENTION			0.000	0.0%	1405.1	65.2%	

Hyd. Residence Time =	0.4908	yrs
Overflow Rate =	2.7	m/yr
Mean Depth =	1.3	m

TMDL Scenario

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.8	0.2
Evaporation (m)	0.8	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km²-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	42	0.50
Total N	0	0.50
Ortho P	0	0.50
Inorganic N	0	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km²	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Kansas	0	1	1.63	1.34	1.76	1.34	0.12	0	0	0	0.08	0	0	0.27	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	168.75	0.16	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm³/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km²	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Watershed	1	1	37.17	4.45	0	0	0	150	0	0	0	0	0	0	0

Segment Mass Balance Based Upon Predicted Concentrations

Component: TOTAL P **Segment: 1 Kansas**

Trib	Type	Location	Flow hm³/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m³
1	1	Watershed	4.450	77.3%	667.5	74.4%	150
PRECIPITATION			1.304	22.7%	68.5	7.6%	53
INTERNAL LOAD			0.000	0.0%	160.7	17.9%	
TRIBUTARY INFLOW			4.450	77.3%	667.5	74.4%	150
***TOTAL INFLOW			5.754	100.0%	896.7	100.0%	156
ADVECTIVE OUTFLOW			4.450	77.3%	398.3	44.4%	90
***TOTAL OUTFLOW			4.450	77.3%	398.3	44.4%	90
***EVAPORATION			1.304	22.7%	0.0	0.0%	
***RETENTION			0.000	0.0%	498.4	55.6%	

Hyd. Residence Time =	0.4908	yrs
Overflow Rate =	2.7	m/yr
Mean Depth =	1.3	m

A1.4 Bingham Lake (17-0007-00)

Benchmark Model

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.72	0.2
Evaporation (m)	0.72	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km²-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	42	0.50
Total N	0	0.50
Ortho P	0	0.50
Inorganic N	0	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km²	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Bingham	0	1	1.09	2.64	1.68	2.64	0.12	0	0	0	0.08	0	0	2.82	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	156	0.19	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm³/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km²	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Watershed	1	1	6.71	0.74	0	0	0	201.9	0	0	0	0	0	0	0

Model Coefficients	**Mean**	**CV**
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.015	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Segment Mass Balance Based Upon Predicted Concentrations

Component: TOTAL P **Segment: 1 Bingham**

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
1	1	Watershed	0.740	48.5%	149.4	11.3%	202
PRECIPITATION			0.785	51.5%	45.8	3.5%	58
INTERNAL LOAD			0.000	0.0%	1122.7	85.2%	
TRIBUTARY INFLOW			0.740	48.5%	149.4	11.3%	202
***TOTAL INFLOW			1.525	100.0%	1317.9	100.0%	864
ADVECTIVE OUTFLOW			0.740	48.5%	115.4	8.8%	156
***TOTAL OUTFLOW			0.740	48.5%	115.4	8.8%	156
***EVAPORATION			0.785	51.5%	0.0	0.0%	
***RETENTION			0.000	0.0%	1202.5	91.2%	

Hyd. Residence Time =	3.8886	yrs
Overflow Rate =	0.7	m/yr
Mean Depth =	2.6	m

TMDL Scenario

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.72	0.2
Evaporation (m)	0.72	0.3
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr	Mean	CV
Conserv. Substance	0	0.00
Total P	42	0.50
Total N	0	0.50
Ortho P	0	0.50
Inorganic N	0	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Bingham	0	1	1.09	2.64	1.68	2.64	0.12	0	0	0	0.08	0	0	0.82	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	156	0.19	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Watershed	1	1	6.71	0.74	0	0	0	201.9	0	0	0	0	0	0	0

Segment Mass Balance Based Upon Predicted Concentrations

Component: TOTAL P **Segment: 1 Bingham**

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
1	1	Watershed	0.740	48.5%	149.4	28.6%	202
PRECIPITATION			0.785	51.5%	45.8	8.8%	58
INTERNAL LOAD			0.000	0.0%	326.5	62.6%	
TRIBUTARY INFLOW			0.740	48.5%	149.4	28.6%	202
***TOTAL INFLOW			1.525	100.0%	521.6	100.0%	342
ADVECTIVE OUTFLOW			0.740	48.5%	66.7	12.8%	90
***TOTAL OUTFLOW			0.740	48.5%	66.7	12.8%	90
***EVAPORATION			0.785	51.5%	0.0	0.0%	
***RETENTION			0.000	0.0%	454.9	87.2%	

Hyd. Residence Time = 3.8886 yrs
Overflow Rate = 0.7 m/yr
Mean Depth = 2.6 m

Appendix D. Permitted CAFO Facilities

Master Ai Name	Au Count	Permit Num	Site County Name	Huc12 Code	Huc12 Name
NPDES Permitted Facilities					
Menken Farms	250	MN0071251	Watonwan	70200100301	Upper Butterfield Creek
Macho-Eckstein Co LLC	1224.9	MNG440019	Watonwan	70200100602	City of La Salle-Watonwan River
Dickens Pigs Inc	1152	MNG440020	Watonwan	70200100303	Upper Saint James Creek
Christensen Farms Site C009	1200	MNG440061	Cottonwood	70200100202	Middle North Fork Watonwan River
Dan Sturm Farm	1410	MNG440080	Watonwan	70200100304	Lower Saint James Creek
Farmland	1080	MNG440081	Watonwan	70200100505	City of Lewisville
Robert Cunningham Farm 3	990	MNG440082	Watonwan	70200100404	Middle South Fork Watonwan River
Tilney Pork LLP	2206.8	MNG440084	Watonwan	70200100503	Upper Perch Creek
Harbitz Finisher	1200	MNG440086	Watonwan	70200100406	Lower South Fork Watonwan River
Mike Brandts Farm 1	888	MNG440147	Watonwan	70200100302	Lower Butterfield Creek
Mike Brandts Farm 1	872	MNG440147	Watonwan	70200100602	City of La Salle-Watonwan River
Christensen Farms Site C015	1200	MNG440152	Watonwan	70200100401	Bingham Lake
Flitter Site	1200	MNG440171	Blue Earth	70200100507	Lower Perch Creek
Heartland Ag Management - Roelofs Site	1480	MNG440172	Blue Earth	70200100605	County Ditch No 78
Neil D Hansen Farm	1200	MNG440249	Martin	70200100502	Judicial Ditch No 72
Jerry Gronewold - Ormsby Site	1233.6	MNG440254	Martin	70200100403	Willow Creek
Extra Tender LLP	1116	MNG440255	Martin	70200100403	Willow Creek
Bentdale Farms Inc	1376	MNG440256	Martin	70200100504	Judicial Ditch No 47
Schwartz Farms Inc - PAP	2758.9	MNG440286	Cottonwood	70200100201	Upper North Fork Watonwan River
Multi-Site - Dennis Coleman Farm - Sites 1-3	2599.2	MNG440372	Watonwan	70200100404	Middle South Fork Watonwan River
Elwood Heldt Farm	1230	MNG440402	Watonwan	70200100301	Upper Butterfield Creek
Riverdale Inc	2563.4	MNG440406	Watonwan	70200100506	Spring Branch Creek
Todd Arduser Farm	990	MNG440540	Watonwan	70200100506	Spring Branch Creek
Geistfeld Brothers Farm - Sec 4	1350	MNG440558	Martin	70200100502	Judicial Ditch No 72
J Evers Farms	936	MNG440571	Watonwan	70200100104	Cottonwood Lake
Christensen Farms Site F048	936	MNG440582	Watonwan	70200100104	Cottonwood Lake
Geistfeld Farm Inc	900	MNG440585	Watonwan	70200100506	Spring Branch Creek
Brad Bowers Farm	900	MNG440593	Watonwan	70200100506	Spring Branch Creek
Michael Pearson Farm	900	MNG440623	Watonwan	70200100105	East Sveadahl Church-Watonwan River
Dennis Arduser Farm - NW	900	MNG440627	Blue Earth	70200100506	Spring Branch Creek
Multi-Site - Triple R Pork LLC	1080	MNG440628	Blue Earth	70200100605	County Ditch No 78
Multi-Site - Triple R Pork LLC	1080	MNG440628	Blue Earth	70200100605	County Ditch No 78
Flohrs Finishing	2289	MNG440632	Martin	70200100403	Willow Creek
Bottem Farms Inc	2750	MNG440634	Watonwan	70200100602	City of La Salle-Watonwan River
Garth Carlson Farm - Sec 1	990	MNG440649	Martin	70200100504	Judicial Ditch No 47
Christensen Farms Site N008	645	MNG440651	Watonwan	70200100203	Lower North Fork Watonwan River
Tower Hill Farm	936	MNG440681	Watonwan	70200100601	Lake Hanska
Schwartz Farms Inc - Fieldon 31 Site	900	MNG440686	Watonwan	70200100506	Spring Branch Creek
North Branch Pork	840	MNG440697	Watonwan	70200100105	East Sveadahl Church-Watonwan River
Tim Steuber Pork - Site 6	1674	MNG440707	Martin	70200100502	Judicial Ditch No 72
Sanders Farms	885	MNG440709	Martin	70200100504	Judicial Ditch No 47
Multi-Site - Kueker Sites 1-3	900	MNG440728	Watonwan	70200100403	Willow Creek
Multi-Site - Kueker Sites 1-3	900	MNG440728	Watonwan	70200100403	Willow Creek
Petes Pigs	900	MNG440751	Martin	70200100501	Mink Creek
David Englin Farm - Sec 1	1556	MNG440766	Cottonwood	70200100203	Lower North Fork Watonwan River
Dickens Pigs Inc Site 2	1170	MNG440790	Watonwan	70200100405	Long Lake
SFI - Carlson 12	900	MNG440802	Cottonwood	70200100101	Headwaters Watonwan River
Christensen Farms Site N012	860	MNG440825	Cottonwood	70200100201	Upper North Fork Watonwan River
Schwartz Farms Inc - Immer	900	MNG440903	Cottonwood	70200100101	Headwaters Watonwan River
Schwartz Farms Inc - Delton Site	900	MNG440977	Cottonwood	70200100201	Upper North Fork Watonwan River
Romsdahl Long Lake Finisher	900	MNG441004	Watonwan	70200100303	Upper Saint James Creek
Romsdahl Irish Lake Finisher	900	MNG441006	Watonwan	70200100402	Upper South Fork Watonwan River
Aaron Eberhart Site 1	900	MNG441010	Watonwan	70200100406	Lower South Fork Watonwan River
CK Pork LLC Finisher	900	MNG441021	Watonwan	70200100303	Upper Saint James Creek

Schwartz Farms Inc - North View	900	MNG441047	Watonwan	70200100405	Long Lake
Matt & Jeff Romsdahl Farm	1200	MNG441083	Watonwan	70200100404	Middle South Fork Watonwan River
Frederickson Pork	900	MNG441093	Brown	70200100601	Lake Hanska
Lakeview Pork - Brown County	900	MNG441153	Brown	70200100601	Lake Hanska
Schwartz Farms Inc - CLF-1	1960	MNG441173	Cottonwood	70200100105	East Sveadahl Church-Watonwan River
Schwartz Farms Inc - Sveadahl 20	990	MNG441204	Watonwan	70200100104	Cottonwood Lake
Lange Finisher	990	MNG441221	Watonwan	70200100105	East Sveadahl Church-Watonwan River
Schwartz Farms Inc - South View Site	990	MNG441239	Watonwan	70200100404	Middle South Fork Watonwan River
HK Pork, LLC	990	MNG441253	Watonwan	70200100302	Lower Butterfield Creek
Braaten Home Site	1440	MNG441255	Watonwan	70200100301	Upper Butterfield Creek
Schwartz Farms Inc - Hesse Site	990	MNG441267	Cottonwood	70200100201	Upper North Fork Watonwan River
Oeltjenbruns Finishing Site	990	MNG441277	Cottonwood	70200100201	Upper North Fork Watonwan River
Schwartz Farms Inc - Urevig Site	990	MNG441281	Watonwan	70200100406	Lower South Fork Watonwan River
All Four Pork	945	MNG441304	Watonwan	70200100303	Upper Saint James Creek
Aaron Eberhart Farm	990	MNG441313	Watonwan	70200100604	City of Madelia-Watonwan River
Grover Barn 1	990	MNG441318	Blue Earth	70200100604	City of Madelia-Watonwan River
Pete's 3600 Head Site	1080	MNG441339	Watonwan	70200100405	Long Lake
Fieldon Finishers LLP	1488	MNG441555	Watonwan	70200100506	Spring Branch Creek
Aaron Eberhart Farm	1440	MNG441794	Blue Earth	70200100604	City of Madelia-Watonwan River
G & A Wendinger Farms LLC	1710	MNG441940	Blue Earth	70200100604	City of Madelia-Watonwan River
Pietsch-Davis Pork	990	MNG441962	Watonwan	70200100506	Spring Branch Creek
Coleman Chops	995.2	MNG441994	Watonwan	70200100404	Middle South Fork Watonwan River
Shane Kuehl Farm - Sec 9	1620	MNG442011	Martin	70200100502	Judicial Ditch No 72
SDS Permitted Facilities					
Christensen Farms Site F141	1440	MNG450035	Martin	70200100501	Mink Creek
Robert Cunningham Farm 1	1152	MNG450041	Watonwan	70200100404	Middle South Fork Watonwan River
Robert Cunningham Farm 2	1200	MNG450042	Watonwan	70200100303	Upper Saint James Creek
Geistfeld LLP	1440	MNG450043	Watonwan	70200100506	Spring Branch Creek
Ryan Brandts Hog Site	1353.6	MNG450047	Brown	70200100601	Lake Hanska
Circle R Farms Inc	1495.2	MNG450051	Cottonwood	70200100103	County Ditch No 37-Watonwan River
Christensen Farms Site N007/N009	1290	MNG450063	Cottonwood	70200100202	Middle North Fork Watonwan River
Christensen Farms Site F017	1248	MNG450064	Jackson	70200100402	Upper South Fork Watonwan River
TW Enterprises - Sec 20	1200	MNG450129	Cottonwood	70200100401	Bingham Lake
Tall B Pork	1710	MNG450131	Cottonwood	70200100401	Bingham Lake
Broste Site	1200	MNG450164	Brown	70200100603	Elm Creek
Kevin Fischer Farm	1465	MNG450180	Watonwan	70200100301	Upper Butterfield Creek
Janzen Sow Site - Sec 9	1183	MNG450181	Cottonwood	70200100401	Bingham Lake

Appendix E. HSPF Hydrology Calibration and Validation Report