Le Sueur River Watershed Total Maximum Daily Load

Minnesota Pollution Control Agency

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Authors

Eileen Campbell
Scott MacLean
Joanne Boettcher

Contributors / acknowledgements

Breeanna Bateman
Paul Davis
Marco Graziani
Chuck Regan
Benjamin Roush
Steve Weiss

Editing and Graphic Design

Cover photo: Eileen Campbell

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Acronyms

ARM	Agricultural Runoff Model
AUID	Assessment Unit ID
AWQCP	Agricultural Water Quality Certification Program
BMP	Best Management Practice
BWSR	Board of Water and Soil Resources
cfs	Cubic Feet per Second
CWA	Clean Water Act
CWLA	Clean Water Legacy Act
DNR	Minnesota Department of Natural Resources
DO	Dissolved Oxygen
EPA	U. S. Environmental Protection Agency
EQuIS	Environmental Quality Information System
HSPF	Hydrologic Simulation Program – FORTRAN
HUC	Hydrologic Unit Code
kg/ha	Kilograms per Hectare
LA	Load Allocation
lbs/day	Pounds per Day
LC	Loading Capacity
m	Meters
MDA	Minnesota Department of Agriculture
mg	Milligrams
mgd	Million Gallons per Day
mg/L	Milligrams per Liter
mL	Milliliters
MNDOT	Minnesota Department of Transportation
MOS	Margin of Safety
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer System
MSU-WRC	Minnesota State University, Mankato – Water Resources Center
NCHF	North Central Hardwood Forests
NPDES	National Pollutant Discharge Elimination System
NPS	Non-Point Source
NRCS	Natural Resources Conservation Service
org	Organisms
SDS	State Disposal System
SSTS	Subsurface Sewage Treatment System
SOD	Sediment Oxygen Demand
SWPPP	Storm Water Pollution Prevention Plan
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
µg/L	Micrograms per Liter
USGS	United States Geological Survey
WCBP	Western Corn Belt Plains
WLA	Wasteload Allocation
WRAPS	Watershed Restoration and Protection Strategies
WWTF	Wastewater Treatment Facilities

TMDL Summary Table

EPA/MPCA Required Elements	Summary	TMDL Page #
Location	The Le Sueur River Watershed in south-central Minnesota; see Figure 1.1	1
303(d) Listing Information	Total of 10 listings for *E. coli* bacteria, low dissolved oxygen and excess nutrients; see Table 1.1.	1
Applicable Water Quality Standards/ Numeric Targets	*See Section 2.*	4
Loading Capacity (expressed as daily load)	The loading capacities for all impairments are provided in Section 4.8.	24
Wasteload Allocation	The wasteload allocations for all impairments are provided in Section 4.8.	24
Load Allocation	The load allocations for all impairments are provided in Section 4.8.	24
Margin of Safety	*E. coli*, Dissolved Oxygen and Lakes, Excess Nutrients: Explicit MOS of 10% used; *See Section 4.5*	22
Seasonal Variation	*E. coli:* Load duration curve methodology accounts for seasonal variation; *See Section 4.6.1* Dissolved Oxygen: Standard is developed for critical conditions; *See Section 4.6.1* Excess Nutrients: Standard is developed for critical conditions; *See Section 4.6.2*	22
Reasonable Assurance	Changes in the landscape and hydrology will need to occur if pollutant levels are going to decrease. The source reduction strategies detailed in the implementation section have been shown to be effective in improving water quality. Many of the goals outlined in this TMDL report run parallel to objectives outlined in the local Water Plans. Various programs and funding sources are currently being utilized in the watershed and will also be used in the future. Additionally, Minnesota voters have approved an amendment to increase the state sales tax to fund water quality improvements.	29
Monitoring	Intensive watershed monitoring will occur on a 10-year schedule. Long term load monitoring at the watershed outlet and at five subwatershed stations is currently occurring.	29
Implementation	A summary of potential management measures is included as well as a rough approximation of the overall implementation cost to achieve the TMDL.	30
Public Participation	Public participation in the Le Sueur has been ongoing for the past two years. With respect to this specific TMDL: A public comment period was open from March 30th to April 29th, 2015. There were seven comment letters received and responded to as a result of the public comment period.	33

Executive Summary

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

This TMDL addresses one low dissolved oxygen (DO) impairment, five *E. coli* and four lake eutrophication impairments in the Le Sueur River Watershed. Addressing multiple impairments in one TMDL study is consistent with Minnesota's Water Quality Framework that seeks to develop watershed wide protection and restoration strategies rather than focus on individual reach impairments.

The Le Sueur River Watershed covers 710,832 acres in the Western Corn Belt Plains (WCBP) and North Central Hardwood Forests (NCHF) ecoregions and drains portions of five counties (Blue Earth, Faribault, Freeborn, Steele and Waseca) in the south-east Minnesota River Basin.

This TMDL used a variety of methods to evaluate current loading, contributions by the various pollutant sources as well as the allowable pollutant loading capacity (LC) of the impaired water bodies. These methods included the Hydrologic Simulation Program – FORTRAN (HSPF) model, the load duration curve approach and the BATHTUB lake eutrophication model.

A general strategy and cost estimate for implementation to address the impairments is included. Non-Point Sources (NPS) will be the focus of implementation efforts. NPS contributions are not regulated and will need to proceed on a voluntary basis. Permitted point sources will be addressed through the Minnesota Pollution Control Agency's (MPCA) National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) Permit (Permit) programs.

1 Project Overview

1.1 Purpose

The CWA Section 303(d) requires that states publish a list of surface waters that do not meet water quality standards and therefore, do not support their designated use(s). These waters are then classified as impaired and placed on the impaired waters list, which dictates that a TMDL must be completed. The TMDL calculates the maximum amount of a pollutant that a waterbody can receive and still meet water quality standards.

The passage of Minnesota's Clean Water Legacy Act (CWLA) in 2006 provided a policy framework and resources to state and local governments to accelerate efforts to monitor, assess and restore impaired waters and to protect unimpaired waters. The result has been a comprehensive "watershed approach" that integrates water resource management efforts, local governments, and stakeholders to develop watershed-scale TMDLs, restoration and protection strategies, and plans for each of Minnesota's 81 major watersheds. The information gained and strategies developed in the watershed approach are presented in major watershed-scale Watershed Restoration and Protection Strategy (WRAPS) reports, which should help restore and protect streams, lakes, and wetlands across the watershed, including those for which TMDL calculations are not made.

The watershed approach started in the Le Sueur River major watershed (Figure 1.1) in 2008, with intensive watershed monitoring and subsequent assessment, which resulted in ten proposed stream and lake impairment listings (Table 1.1). Several of the identified impairments were due to biological impairments; the stressors responsible for the biological impairment were identified in a stressor identification process (link provided on next page). Not all of the identified stressors are included in this TMDL because insufficient information currently exists on appropriate nitrate and Phosphrus thresholds for protecting biological communities and because altered hydrology and degraded habitat are not pollutants.

This TMDL addresses Le Sueur River major watershed impairments identified in the 2008 monitoring and assessment cycle that had not been addressed in prior TMDLs. Refer to these TMDL webpages for more details: *Blue Earth River Basin – Fecal Coliform* (MPCA 2013a), *Blue Earth River Basin - Turbidity* (MPCA 2013b), *Lower Minnesota River – Low Dissolved Oxygen* (MPCA 2013c), *Lura Lake – Excess Nutrients* (MPCA 2013d), *Minnesota River - Turbidity* (MPCA 2013e). Additional impairments are addressed in separate documents as well: the *State-wide Mercury TMDL* (MPCA 2007a) and the Le Sueur River and Little Beauford Ditch Acetochlor Impairment Response Report (MDA 2013).

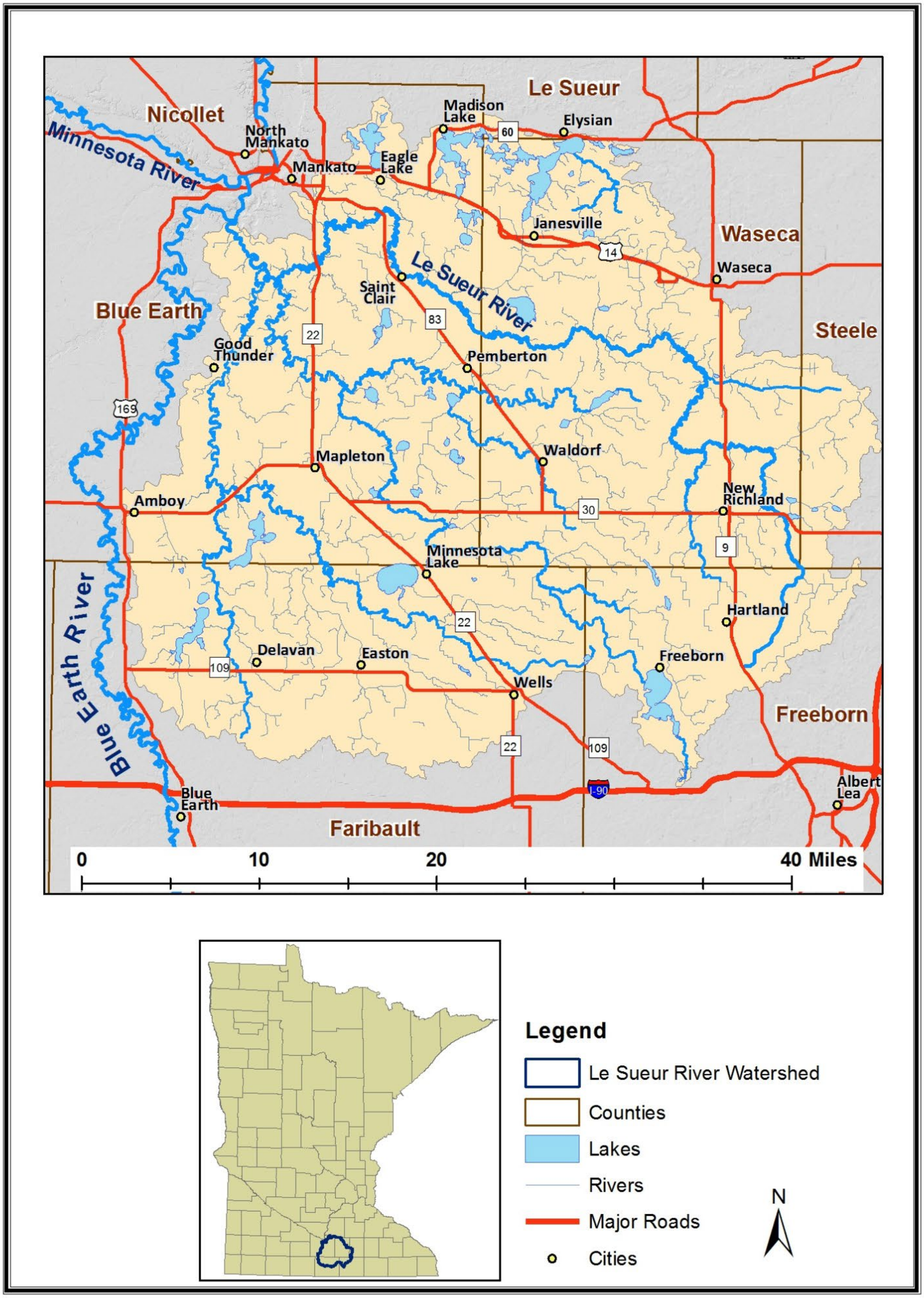

Figure 1.1: Le Sueur River Watershed - HUC 07020011 and location within Minnesota

1.2 Waterbodies and pollutants of concern

This TMDL report addresses ten impairment listings for six stream reaches and four lakes in the Le Sueur River Watershed (Table 1.1). Supporting documentation of the impairments can be found in:

- *Le Sueur River Watershed Monitoring and Assessment Report* (M&A report; MPCA 2012a)
- *Assessment Report of Selected Lakes within the Le Sueur River Watershed* (Lakes report; MPCA 2010a)
- *Le Sueur River Watershed Biotic Stressor Identification* (Stressor ID report; MPCA 2014a)

Table 1.1: Le Sueur River Watershed 303(d) impairments addressed in this TMDL

Waterbody	Reach Description or Lake	Year Listed	Stream Use Class/Lake Ecoregion and Type	Assessment Unit ID/Minnesota Department of Natural Resources (DNR) Lake #	Affected Designated Use	Pollutant or Stressor addressed
Little Cobb River	Bull Run Cr to Cobb R	2008	2C	07020011-504	Aquatic Life	Dissolved Oxygen
Le Sueur River	CD 6 to Cobb R	2010	2B	07020011-507	Aquatic Recreation	*Escherichia coli*
Boot Creek	Unnamed CR to T105 R22W S6, north line	2011	7	07020011-516	Aquatic Recreation	*Escherichia coli*
Rice Creek	Headwaters to Maple R	2011	2B	07020011-531	Aquatic Recreation	*Escherichia coli*
County Ditch 3 (Judicial Ditch 9)	JD 9 to Maple R	2011	2B	07020011-552	Aquatic Recreation	*Escherichia coli*
Cobb River	T104 R26W S30, west line to Le Sueur R	2010	2C	07020011-556	Aquatic Recreation	*Escherichia coli*
Madison	Lake	2008	NCHF Lakes	07-0044-00	Aquatic Recreation	Nutrient/Eutrophication Biological Indicators
Elysian (Upper – u/s dam)	Lake	2010	NCHF Shallow Lakes	81-0095-00	Aquatic Recreation	Nutrient/Eutrophication Biological Indicators
Eagle (North)	Lake	2010	NCHF Shallow Lakes	07-0060-01	Aquatic Recreation	Nutrient/Eutrophication Biological Indicators
Freeborn	Lake	2011	WCBP Shallow Lakes	24-0044-00	Aquatic Recreation	Nutrient/Eutrophication Biological Indicators

1.3 Priority Ranking

The MPCA's projected schedule for TMDL completions, as indicated on the 303(d) impaired waters list, implicitly reflects Minnesota's priority ranking of this TMDL. Ranking criteria for scheduling TMDL projects include, but are not limited to: impairment impacts on public health and aquatic life; public value of the impaired water resource; likelihood of completing the TMDL in an expedient manner, including a strong base of existing data and restorability of the waterbody; technical capability and willingness locally to assist with the TMDL; and appropriate sequencing of TMDLs within a watershed or basin. This coincides with the completion of the Le Sueur River WRAPS Report.

2 Applicable Water Quality Standards

The criteria used to determine stream and lake impairments are outlined in the MPCA's document Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment: 305(b) Report and 303(d) List (MPCA 2011a). Minn. R. ch. 7050.0470, lists waterbody classifications and Minn. R. ch. 7050.2222, lists applicable water quality standards. The impaired waters covered in this TMDL are classified as Class 2B or 2C, 3B, 3C, 4A, 5, 6 and 7. Relative to aquatic life and recreation, the designated beneficial uses for 2B, 2C and 7 waters are:

> Class 2B waters – The quality of Class 2B surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable.
>
> Class 2C waters – The quality of Class 2C surface waters shall be such as to permit the propagation and maintenance of a healthy community of indigenous fish and associated aquatic life, and their habitats. These waters shall be suitable for boating and other forms of aquatic recreation for which the waters may be usable.
>
> Class 7 waters - The quality of Class 7 waters of the state shall be such as to protect aesthetic qualities, secondary body contact use, and groundwater for use as a potable water supply.

The water quality standards that apply to the Le Sueur stream reaches in this TMDL are shown in Table 2.1. The water quality standards that apply to the lakes in this TMDL are shown in Table 2.2.

For more detailed information refer to the MPCA TMDL protocols (MPCA 2014b).

Table 2.1: Surface water quality standards for Le Sueur River Watershed stream reaches addressed in this TMDL

Parameter	Water Quality Standard	Units	Criteria	Period of Time Standard Applies
Escherichia coli; Class 2 waters	Not to exceed 126 Not to exceed 1,260	org/100 mL org/100 mL	Monthly geo mean Upper 10th percentile	April 1 – October 31
Escherichia coli; Class 7 waters	Not to exceed 630 Not to exceed 1,260	org/100 mL org/100 mL	Monthly geo mean Upper 10th percentile	May 1 – October 31
Dissolved Oxygen; Class 2 waters	Daily minimum of 5.0	mg/L	100 percent of days above 7Q10 flow; 50 percent of days at 7Q10 flow	Year round

Table 2.2: Lake water quality standards for Le Sueur River Watershed lakes addressed in this TMDL

Ecoregion/Type	Total Phosphorus Standard (µg/L)	Chlorophyll –a Standard (µg/L)	Secchi Depth (m)	Period of Time Standard Applies
NCHF Lakes	< 40	< 14	> 1.4	June 1 – September 30
NCHF Shallow Lakes	< 60	< 20	> 1.0	June 1 – September 30
WCBP Shallow Lakes	< 90	< 30	> 0.7	June 1 – September 30

In addition to meeting P limits, chlorophyll-a and Secchi transparency standards must also be met. 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 total Phosporus (TP) and the response variables chlorophyll-a and Secchi transparency. Based on these relationships it is expected that by meeting the P target in each lake, the chlorophyll-a and Secchi standards will likewise be met.

3 Watershed Characteristics

Located in south central Minnesota, the Le Sueur River Watershed covers 710,832 acres in the WCBP and NCHF ecoregions (Figure 3.1) and drains portions of five counties (Blue Earth, Faribault, Freeborn, Steele and Waseca). The eastern portion of the watershed is a gently rolling landscape, while the western half of the watershed is dominated by the relatively flat remnant of glacial Lake Minnesota. As the Le Sueur River approaches its confluence with the Blue Earth River, the gradient increases as it cuts through high bluffs. Eagle Lake, Wells and Janesville are the largest towns in the largely rural watershed. Land use statistics of the Le Sueur River Watershed and some of its subwatersheds are shown in Table 3.3. For more information on the Le Sueur River Watershed, refer to the *M&A report; MPCA, 2012a*.

3.1 Streams

Addressed stream subwatershed areas are listed in Table 3.1 and shown in Figure 3.1.

Table 3.1: Watershed area of streams addressed in this TMDL

Stream, Reach Description	**Assessment Unit ID (AUID)**	**Area (acres)**
Little Cobb River, Bull Run Cr to Cobb R	07020011-504	83,561
Le Sueur River, CD 6 to Cobb R	07020011-507	287,641
Boot Creek, Unnamed Cr to T105 R22W S6, north line	07020011-516	32,003
Rice Creek, Headwaters to Maple R	07020011-531	52,258
Cobb River, T104 R26W S30, west line to Le Sueur R	07020011-556	198,299
County Ditch 3 (Judicial Ditch 9), JD 9 to Maple R	07020011-552	43,369

3.2 Lakes

With the exception of Madison Lake, the impaired lakes in the Le Sueur River Watershed are shallow, polymictic lakes with a high percentage of littoral area (Table 3.2).

Table 3.2: Lake morphometry and watershed area of lakes addressed in this TMDL Best Management Practices

Lake	DNR Lake #	Surface Area (acres)	Average Depth (feet)	Max Depth (feet)	Lakeshed Area (acres)	Lakeshed/ Surface Area Ratio	Littoral Area (%)
Madison	07-0044-00	1,390	10	59	11,166	8:1	65
Elysian	81-0095-00	2,183	6	13	29,098	13:1	100
Eagle (North)	07-0060-01	479	3	9	3,091	6.5:1	100
Freeborn	24-0044-00	2,222	1.3	6.7	7,666	3.5:1	100

3.3 Subwatersheds

The impaired stream reach and lake subwatersheds addressed in this TMDL are shown in Figure 3.1. Ecoregions are also represented in the map.

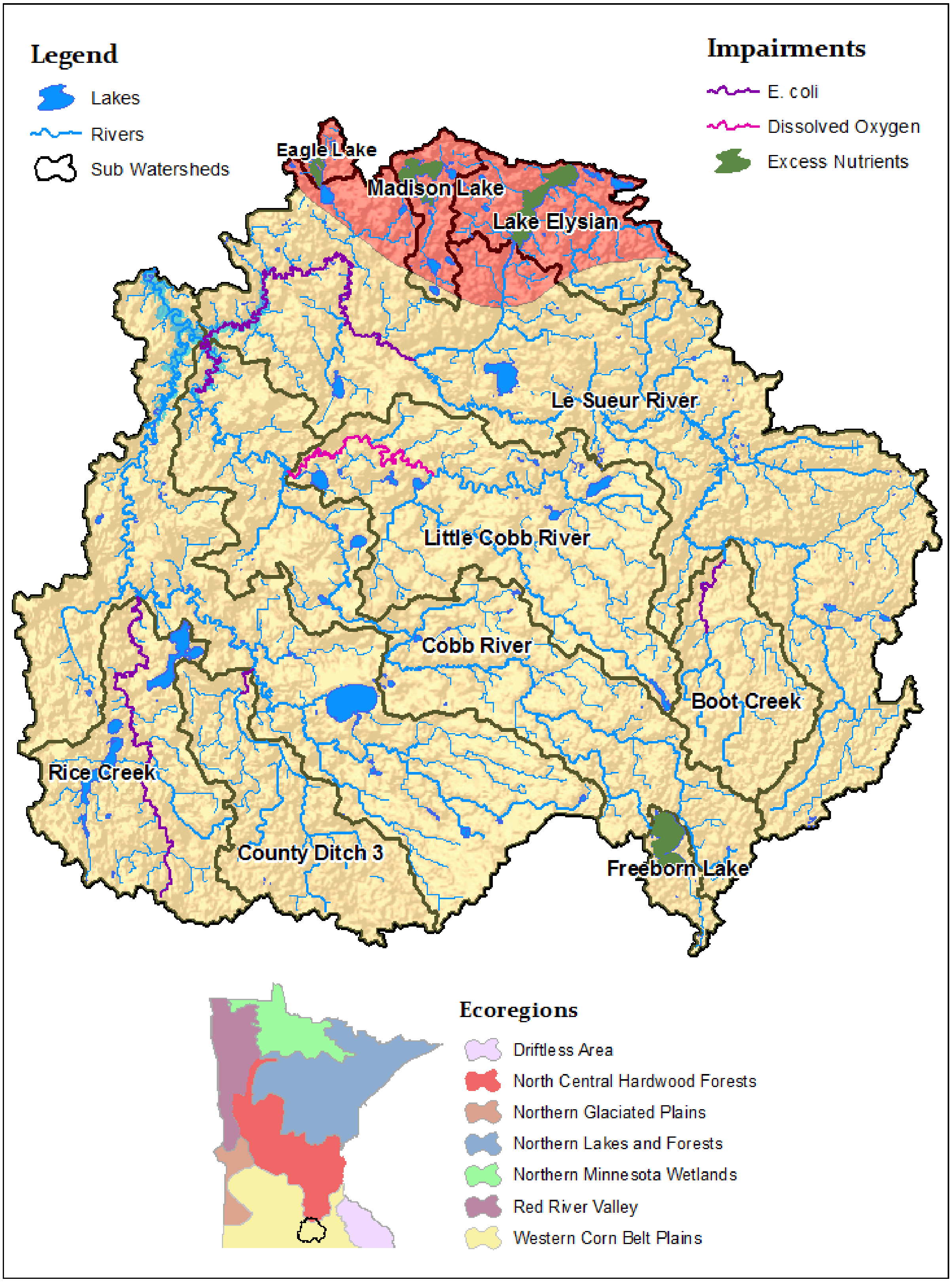

Figure 3.1: Stream reach and lake impairments addressed in the Le Sueur River Watershed TMDL and their respective subwatersheds along with the associated ecoregions.

3.4 Land Use

The land use in the Le Sueur River Watershed is summarized below (Table 3.3) with the majority of the land being used for agricultural purposes.

Table 3.3: Land use breakdowns of Le Sueur River Watershed subwatersheds (MRLC, 2006)

Watershed/ Catchment	Percent Open Water	Percent Developed	Percent Barren/ Mining	Percent Forest/Shrub	Percent Pasture/ Hay/Grassland	Percent Cropland	Percent Wetland
Le Sueur River (entire watershed)	2.2	6.6	<1	1.5	3.8	82.5	3.5
Le Sueur River (U/S of Cobb River)	2.3	7.3	<1	2.1	5.4	79.2	3.7
Boot Creek	<1	7.2	<1	<1	1.37	90.5	<1
Cobb River	1.9	6.0	<1	<1	2.9	84.4	3.7
Little Cobb River	1.3	5.7	<1	<1	2.7	86.5	3.1
Rice Creek	4.4	5.5	<1	<1	2.8	81.9	4.8
County Ditch 3 (Judicial Ditch 9)	<1	5.7	<1	<1	1.2	91.3	<1
Madison Lake	16.3	7.2	< 1	4	9.1	56.1	7.3
Lake Elysian	9.3	4.9	< 1	4.8	11.2	67	3.1
Eagle Lake North	16.7	3.2	< 1	3.7	8.8	53.7	13.7
Freeborn Lake	27.8	5.6	<1	<1	4.9	54.1	7.2

3.5 Current water quality

3.5.1 Streams

A summary of current water quality is provided in this section for the pollutants related to the DO and *E. coli* impairments addressed in this TMDL.

Low Dissolved Oxygen

In the Little Cobb River, two types of DO data have been collected. The United States Geological Survey (USGS) collected DO data for several short time periods in 2005 and 2006, and report minimum, maximum, and mean values for each day within the monitoring periods. Discreet DO data were collected by the MPCA and Minnesota State University, Mankato – Water Resources Center (MSU-WRC) from 2007-2012. Data from these two sources are summarized below in Table 3.4 and Table 3.5. Additional DO analysis for this reach can be found in the *Stressor ID report; MPCA, 2014a*.

Table 3.4: Summary of 2005 and 2006 USGS daily minimum, maximum and mean DO data

Dates	Dissolved Oxygen			Daily Flow		
	Min	Mean	Max	Min	Mean	Max
6/8/2005-8/21/2005	3.2	7.4	11.1	1.4	59	172
6/2/2006-6/18/2006	6.5	8.2	10.6	41	77	109
7/25/2006-8/9/2006	2.9	5.9	8.6	0.32	13	51
8/22/2006-8/26/2006	5.4	6.3	7.4	3.6	4.7	5.8

Table 3.5: Summary of 2007-2012 MPCA and MSU-WRC discrete DO data

Years	Number of samples	Number of samples before 9AM	Range of data (mg/L)	Number of Samples below 5 mg/L	Percent of samples below 5 mg/L
2007-2012	65	0	2.84 – 15.17	6	9%

E. coli

Bacteria data have been collected for multiple years in the Le Sueur River Watershed. The summarized data are presented in Table 3.6. The highest values for all of the impaired reaches are in June through September.

Table 3.6: Le Sueur River impaired reaches E. coli geometric means for all available 2008-2012 data

Site	Range of data (org/mL)	Geometric mean (org/mL) [number of samples]	Geometric Mean (org/mL) [number of samples]						
			Apr	May	Jun	Jul	Aug	Sep	Oct
Le Sueur -507 (u/s Cobb)	2 – 9932	155 [137]	81 [26]	105 [38]	294 [29]	142 [8]	123 [11]	488 [17]	112 [8]
Boot -516*	123 – > 2420	416 [17]	-	-	267 [6]	678 [5]	389 [6]	-	-
Rice -531*	70 – 2909	319 [17]	-	-	378 [6]	417 [5]	216 [6]	-	-
CD3 -552*	24 – 7701	300 [17]	-	-	248 [6]	313 [5]	349 [6]	-	-
Cobb -556	10 – 2738	94 [88]	106 [12]	66 [14]	100 [23]	77 [11]	48 [13]	387 [10]	66 [5]

*Only 2008-2009 June-August data available

3.5.2 Lakes

Current lake conditions are based on monitoring completed within the last 10 years (Table 3.7).

Table 3.7: Mean* in-lake conditions for impaired lakes in the Le Sueur River Watershed

Parameter	Madison Lake	Lake Elysian	Eagle Lake (north)	Freeborn Lake
Average Total Phosphorus (µg/L)	75 (17)	164.3 (15)	163 (10)	332 (8)
Average Chlorophyll-a (µg/L)	39.9 (17)	74.8 (15)	74.4 (10)	116.2 (8)
Average Secchi disk transparency (m)	1.05 (65)	0.51 (164)	0.28 (10)	0.23 (6)

* Number of samples shown in parentheses

3.6 Pollutant source summary

3.6.1 Streams

A summary of sources is provided in this section for the pollutants causing the low DO and *E. coli* impairments addressed in this TMDL. A more in depth discussion of biological stressors in the Le Sueur River Watershed, excluding *E. coli*, can be found in the *Stressor ID report; MPCA, 2014a*.

Low dissolved oxygen

Dissolved oxygen concentrations in the Le Sueur, like most streams, go through a diurnal cycle, generally reaching their maximum in late afternoon and minimum around sunrise. Aquatic plants and algae photosynthesize in the day, giving off oxygen. At night, respiration in bacteria, plants and animals depletes oxygen. High P loads to the streams causes excessive production of algae, exacerbating this cycle, causing very high diurnal DO swings. Also occurring at the same time is the death of algae from both upstream sources and those growing locally in the stream. When these algae die, they sink to the bottom of the stream and contribute to sediment oxygen demand (SOD), exacerbating the low DO levels, especially at very low flows.

E. coli

Likely sources of bacteria in the Le Sueur River Watershed include wastewater treatment facilities (WWTFs), unsewered communities, inadequate subsurface sewage treatment systems (SSTS), Municipal Separate Storm Sewer System (MS4) communities and livestock. These are described in more detail below. Additional bacteria source descriptions for the Le Sueur River Watershed can be found on the *Blue Earth River Basin – Fecal Coliform TMDL* webpage.

Livestock – Both feedlots and pasture are present in the Le Sueur River Watershed. Livestock can contribute bacteria to the watershed through runoff from poorly managed feedlots as well as direct loading if allowed access to streams or lakes. Additional runoff can occur through manure applications. Livestock numbers by watershed, based on the MPCA record of registered feedlots, are included in Table 3.8.

Table 3.8: Registered livestock numbers by stream subwatershed

Subwatershed	Number of Facilities	Livestock Type	Animal Units
Le Sueur River (U/S of Cobb River)	285	Birds, Bovines, Deer/Elk, Goats/Sheep, Horses, Llamas/Alpacas, Pigs, Other	79,311
Boot Creek	29	Birds, Bovines, Goats/Sheep, Horses, Pigs	6,958
Cobb River	255	Birds, Bovines, Goats/Sheep, Horses, Pigs, Other	90,151
Little Cobb River	100	Birds, Bovines, Goats/Sheep, Horses, Pigs	37,334
Rice Creek	46	Bovines, Deer/Elk, Horses, Pigs	16,116
County Ditch 3 (Judicial Ditch 9)	57	Birds, Bovines, Goats/Sheep, Horses, Pigs	13,487

WWTFs- Human waste can be a significant source of *E. coli* during low flow periods. Ten WWTFs discharge into the impaired stream reaches addressed in this report. Six of these facilities have controlled discharge (pond) systems with discharge windows during higher flows. These controlled discharge facilities are not likely to be a source during low flow periods. The other four facilities are continuous discharge systems and are likely a source during low flow periods. Rarely, during extreme high flow conditions, WWTFs may also be a source if they become overloaded and have an emergency discharge of partially or untreated sewage, known as a bypass.

Unsewered communities –10 unsewered, unincorporated communities are located in the addressed subwatersheds. The partially treated or untreated sewage from these communities is potentially a continuous source of bacteria. The proportion contributed by these sources tends to be more significant during lower stream flow conditions.

Inadequate SSTS –Without individual inspections it is difficult to know for certain the rate of compliance for septic systems in the watershed. Individual County estimates from the Le Sueur River Watershed range from 35%-75% compliance. These systems discharge partially treated or untreated sewage and are potentially a continuous source of bacteria. The proportion contributed by these sources tends to be more significant during lower stream flow conditions.

MS4 Communities – Parts of two MS4s, Mankato and Waseca, are located in the addressed subwatersheds. Stormwater runoff from these communities may contain bacteria.

Wildlife and pets may also be contributing some bacteria to the system.

E. coli bacteria may have the ability to reproduce naturally in water and sediment. Two Minnesota studies describe the presence and growth of “naturalized” or “indigenous” strains of *E. coli* in watershed soils (Ishii et al. 2006) and ditch sediment and water (Sadowsky et al. 2010). The latter study was conducted in the agriculturally-dominated Seven Mile Creek watershed located in south-central Minnesota. As much as 36% of *E. coli* strains found in the Seven Mile study was represented by multiple isolates, suggesting persistence of specific *E. coli*. While the primary author of the study suggests 36% might be used as a rough indicator of “background” levels of bacteria during this study, this percentage is not directly transferable to the concentration and count data of *E. coli* used in water quality standards and TMDLs. Additionally, because the study is not definitive as to the ultimate origins of this bacteria, it would not be appropriate to consider it as “natural” background (MPCA 2012c). Caution should be used before extrapolating the results of the Seven Mile Creek study to other watersheds.

3.6.2 Lakes

P source categories as well as runoff and P loads were extracted from the Le Sueur River Watershed HSPF model (Section 4.1). Land cover as NPSs of P in the Madison, Elysian, Eagle Lake North and Freeborn Watersheds are shown in Table 3.9.

Table 3.9: Land cover categories and ranges of relative coverage and P load contribution in the lake catchments

Land Use Source	Description	% area in lake catchments*	External P load (%)
Forest	Runoff from forested land can include decomposing vegetation and organic soils.	1-5	< 1
Cropland (Conventional and Conservation Tillage)	Runoff from agricultural lands can include applied manure, fertilizers, soil particles and organic material from agronomic crops.	63 - 76	77 - 89
Feedlots	Runoff from feedlots can deliver P from manure and soil loss.	<1	< 1
Pasture	Runoff can deliver P from manure deposited by livestock and wildlife. Runoff also includes P from vegetation and soil loss.	6 - 10	2 - 3
Grassland/Shrub	Surface runoff can deliver P from vegetation, wildlife waste and soil loss.	1 - 2	< 1
Developed (Pervious and Impervious)	Runoff from residences and impervious surfaces can include fertilizer, leaf and grass litter, pet waste and numerous other sources of P.	4 - 8	1 – 7
Wetlands/ Open Water	Wetlands and open water can export P through suspended solids as well as organic debris that flow through waterways.	5 – 18	< 1

* Catchment area does not include area of the lake itself.

Inadequate SSTS –The compliance rate of septic systems cannot be determined without individual inspections. However, county estimates range from 35%-75% compliance. P loads from septics were applied to the lake models using estimates from the HSPF model. The estimates of P load and percent external load are shown in Table 3.10.

Table 3.10: Estimate of phosphorus load from septic systems

Lake	**Estimate of Phosphorus Delivered (lbs/yr)**	**External P load (%)**
Madison	86.9	2.3
Elysian	167.1	1.1
Eagle North	116	8.7
Freeborn	65.5	1.1

Atmospheric Load – Direct atmospheric deposition to the surface of the lakes was based on regional values (Verry and Timmons 1977). Sources of particulate P in the atmosphere may include pollen, soil erosion, oil and coal combustion and fertilizers. The atmospheric export coefficient used in the model was 0.3 kg/ha. The percent atmospheric load to the lakes ranged from 3.6% to 8.7%.

Internal Load – Under anoxic conditions, weak iron-P bonds break, releasing P in a highly available form for algal uptake. Carp and other rough fish present in lakes can lead to increased nutrients in the water column as they uproot aquatic macrophytes during feeding and spawning and re-suspend bottom sediments. Over-abundance of aquatic plants can limit recreation activities and invasive aquatic species such as curly-leaf pondweed can change the dynamics of internal P loading. Historical impacts, such as WWTF effluent discharge, can also affect internal P loading. The nutrient retention models within the BATHTUB framework already account for nutrient recycling. However, additional internal load was added to the Madison Lake (0.48 $mg*m^{-2}*day^{-1}$) and Freeborn Lake (0.14 $mg*m^{-2}*day^{-1}$) models to bring predicted P concentrations more in line with the observed. Ideally, independent measurements of internal load would be available to verify the use of additional internal loading. Such data is not available for Madison or Freeborn Lake. However, these internal loading values do fall within the range reported in the literature (Nürnberg, 1984; Hoverson 2008). Despite the uncertainty as to the exact contribution internal loading has on P concentrations in Madison and Freeborn Lakes, internal processes are likely a significant source of P loading and should be addressed in a lake management plan.

Potential point source contributions include construction and industrial stormwater and industrial process wastewater. Construction and industrial stormwater are accounted for in the model through the "Developed" land use P delivery coefficient as described above. There are no industrial process wastewater discharges or WWTF discharges in the lake watersheds.

4 TMDL Development

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

$$\mathbf{TMDL = LC = \sum WLA + \sum LA + MOS + RC}$$

Where:

LC = loading capacity, or the greatest pollutant load a waterbody can receive without violating water quality standards;
WLA = wasteload allocation; the portion of the TMDL allocated to existing or future permitted point sources of the relevant pollutant;
LA = load allocation, or the portion of the TMDL allocated to existing or future nonpoint sources of the relevant pollutant;
MOS = margin of safety, or an accounting of uncertainty about the relationship between pollutant loads and receiving water quality. The MOS can be provided implicitly through analytical assumptions or explicitly by reserving a portion of LC (EPA, 1999).
RC = reserve capacity, an allocation of future growth. This is an MPCA-required element, if applicable. Not applicable in this TMDL.

Per Code of Federal Regulations (40CFR 130.2(1)), TMDLs can be expressed in terms of mass per time, toxicity or other appropriate measures. For the Le Sueur River Watershed impairments addressed in this report, the TMDLs, allocations and margins of safety are expressed in mass/day. Each of the TMDL components is discussed in greater detail below.

4.1 Data Sources

4.1.1 Hydrologic Simulation Program – FORTRAN (HSPF)

HSPF was used to simulate DO, P, and flow in the Le Sueur River Watershed; this output was used for analysis and TMDL calculations.

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

The HSPF watershed model contains components to address runoff and constituent loading from pervious land surfaces, runoff and constituent loading from impervious land surfaces, and flow of water and transport/transformation of chemical constituents in stream reaches. Primary external forcing is provided by the specification of meteorological time series. The model operates on a lumped basis within subwatersheds. Upland responses within a subwatershed are simulated on a per-acre basis and converted to net loads on linkage to stream reaches. Within each subwatershed, the upland areas are separated into multiple land use categories.

4.1.2 Environmental Quality Information System (EQuIS)

The MPCA uses a system called EQuIS to store water quality data from more than 17,000 sampling locations across the state. EQuIS contains information from Minnesota streams and lakes dating back to 1926.

All discreet water quality sampling data utilized for assessments and data analysis for this report are stored in this accessible database: Environmental Data Access (MPCA 2014c).

4.2 Loading capacity methodology

4.2.1 Streams, E. coli

The duration curve approach (EPA 2007) was utilized to address the *E. coli* impairments. A flow duration curve was developed using April-October, 1996-2009 daily average flow data provided by the Le Sueur River Watershed HSPF model. Modeled flows utilized in the duration curves were from the outlet of each impaired reach (Figure 3.1). Flow zones were determined for very high, high, mid, low and very low flow conditions. The mid-range flow value for each flow zone was then multiplied by the standard of 126 org/100ml to calculate the LC. For example, for the "very high flow" zone, the LC is based on the flow value at the 5th percentile. Conversions are shown in Table 4.1.

Table 4.1: Unit conversion factors used in *E. coli* calculations

Load (org/month) = Concentration (org/100mL) * Flow (cfs) * Factor			
multiply by **3785.2** to convert	mL per gallon	à	org/100 gallon
divide by **100** to convert	org/100 gallon	à	org/gallon
multiply by **7.48** to convert	gallon per ft^3	à	org/ft^3
multiply by **86,400** to convert	seconds per day	à	ft^3/day
multiply by **24,462,688** to convert	(org/100mL) * ft^3 / sec	à	org/day
Divide by **1 billion** to convert	org/day	à	Bil org/day

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 of this report (Table 4.8) only five points on the entire LC curve are depicted (the midpoints of the designated flow zones). However, it should be understood that the entire curve represents the TMDL and is what is ultimately approved by U. S. Environmental Protection Agency (EPA).

Estimated percent reductions for each of the bacteria impaired reaches were computed based on the April-October geometric mean of 2008-2012 data and are presented in Table 4.2. These are provided to indicate how much of a decrease from summer geometric means are needed to meet the water quality standard of 126 organisms/100mL.

Table 4.2: Percent reductions for *E. coli* impaired reaches based on 2008-2012 data

Site	Geometric mean (org/100mL) [# of samples]	Percent Reduction needed (to 126 org/100 mL)
Le Sueur -507 (u/s Cobb)	155 [137]	19%
Boot -516*	416 [17]	70%
Rice -531*	319 [17]	61%
CD3 -552*	300 [17]	58%
Cobb -556	94 [88]	N/A

*Only 2008-2009 June-August data available. Much lower confidence in the percent reduction needed in these reaches.

The resulting reduction percentage is only intended as a rough approximation, as it does not account for flow and since bacterial data is inherently highly variable. Reduction percentages are not a required element of a TMDL (and do not supersede the allocations provided), but are included here to provide a starting point to assess the magnitude of the effort needed in the watershed to achieve the standard.

4.2.2 Streams, Dissolved Oxygen

The calibrated Le Sueur HSPF model confirms that high P concentrations are likely causing low DO; model scenarios demonstrate that DO is sensitive to P. The need for a decrease in P and an increase in DO corroborates *Stressor ID report; MPCA, 2014a* findings, which states that both pollutants contribute to the biological impairments in the impaired stream reach in the Little Cobb River.

DO concentrations below the 7Q10 (seven-day consecutive low flow with a 10 year return frequency) are not subject to the DO standard. Daily model output for the Little Cobb River were used to estimate the 7Q10 using the statistical flow analysis tool DFLOW (EPA 2006). The 7Q10 was determined to be 0 cfs. Due to this fact, a non-zero compliance point was chosen and the model was evaluated for DO standard compliance at flows above 1 cfs, the 95th percentile flow of the 1996-2009 Little Cobb USGS gage data.

A compliance scenario was developed through several iterative runs of the calibrated model. For each model run, once the NPS TP was reduced by a given percentage, the percent reduction of phytoplankton settling as a result was viewed. The phytoplankton settling reduction percentage was then applied to the SOD constant to get a subsequent reduction in SOD. This is due to the fact that less P would grow less algae, therefore decreasing the algae dying and settling to the bottom and contributing to SOD. A 40% reduction of nonpoint TP resulted in a modeled attainment of the DO standard. Phosphorous allocations were subsequently developed with consideration of these model results to address the DO impairment.

4.2.3 Lakes, Excess Nutrients

The BATHTUB (version 6.14; Walker 1999) model framework was used to model P and water balance for lakes within the Le Sueur River Watershed. Data used to develop the model framework included: precipitation, evaporation, lake morphometry, lake water quality, animal units, watershed area, land use, flow and water quality, septic systems and NPDES dischargers. For more detail on the Le Sueur Lake model framework including sources of the model data, refer to the *Lakes Report; MPCA 2010a*.

BATHTUB's first order decay model provided relatively good agreement between predicted and observed TP for Eagle, Elysian and Freeborn Lakes while the Canfield-Bachmann Lakes model provided good agreement between the predicted and observed for Madison Lake (columns 2 and 3 in Table 4.3).

To calculate the P load capacity of each lake, external P inputs were reduced within the model until the predicted in-lake concentration matched the appropriate standard (columns 4-6 in Table 4.3). Using the modeled annual load and the annual load capacity, the load reduction was calculated (column 7 in Table 4.3).

Table 4.3: Observed and modeled mean phosphorus conditions in Le Sueur River Watershed lakes; phosphorus load reduction necessary to meet the water quality standard

Lake	Observed Total Phosphorus (µg/L)	Modeled Total Phosphorus (µg/L)	Total Phosphorus Standard (µg/L)	Modeled Annual Phosphorus Load (lbs)	Modeled Annual Phosphorus Load Capacity (lbs)	Load Reduction to Achieve TP Standard (%)
Madison	75	75	40	5,916	2,259	61.8
Elysian	164	175	60	14,976	5,102	65.9
Eagle North	163	167	60	1,336	475	64.5
Freeborn	332	332	90	7,067	1,869	73.5

4.3 Wasteload allocation methodology

WLAs are calculated in accordance with EPA guidance (2002) and presented as categorical WLAs. Categorical WLAs are pollutant loads that are equivalent for multiple permittees (several regulated MS4s) or a group of permittees (e.g. construction stormwater).

4.3.1 Wastewater Treatment Facilities

The WWTFs are NPDES/SDS permitted facilities that process primarily wastewater from domestic sanitary sewer sources (sewage). These include city or sanitary district treatment facilities, wayside rest areas, national or state parks, mobile home parks and resorts. There are no WWTFs in the impaired lake watersheds. Relevant WWTFs for the stream impairments are shown in Table 4.4.

Table 4.4: WWTF permits applicable to this TMDL study

Facility	Permit number	Reach(es)	City	System Type	Discharge Window
Delavan WWTF	MNG580109	Rice Creek -531	Delavan	Controlled discharge	3/1-6/15 and 9/15-12/31
Freeborn WWTF	MNG580018	Cobb -556	Freeborn	Controlled discharge	3/1-6/15 and 9/15-12/31
Hartland WWTF	MNG580102	Le Sueur River -507; Boot Creek -516	Hartland	Controlled discharge	3/1-6/15 and 9/15-12/31
Janesville WWTF	MNG580025	Le Sueur River -507	Janesville	Controlled discharge	3/1-6/15 and 9/15-12/31
Mapleton WWTF	MN0021172	Cobb -556	Mapleton	Controlled discharge	4/1-6/15 and 9/15-12/15
New Richland WWTF	MN0021032	Le Sueur River -507; Boot Creek -516	New Richland	Continuous discharge	NA
Pemberton WWTF	MNG580075	Little Cobb -504; Cobb-556	Pemberton	Controlled discharge	3/1-6/15 and 9/15-12/31
St. Clair WWTF	MN0024716	Le Sueur River -507	St. Clair	Continuous discharge	NA
Waldorf WWTF	MN0021849	Little Cobb -504; Cobb-556	Waldorf	Continuous discharge	NA
Waseca WWTF	MN0020796	Le Sueur River -507	Waseca	Continuous discharge	NA

For the *E. coli* impaired reaches, continuous discharge WWTF allocations were determined by multiplying the design flow by the permit limit of 126 org/100ml. Controlled discharge WWTF allocations were determined by multiplying the permit limit of 126 org/100ml by the maximum permitted discharge flow (based on a 6 inch per day discharge from the facility's secondary ponds) Individual *E. coli* WLA calculations and allocations are shown in Table 4.5. Refer to Table 4.8 for the combined load by reach.

Table 4.5: Individual WWTF *E. coli* WLA calculations

	A	B	C	A*B*C
Facility	Permit Limit (org/100 mL)	Design Flow (mgd)	Conversion factor	Load (billion org/day)
Delavan WWTF	126	0.407	0.03785	1.941
Freeborn WWTF		0.244		1.164
Hartland WWTF		0.396		1.889
Janesville WWTF		3.421		16.315
Mapleton WWTF		3.583		17.088
New Richland WWTF		0.6		2.861
Pemberton WWTF		0.652		3.109
Saint Clair WWTF		0.212		1.011
Waldorf WWTF		0.096		0.458
Waseca WWTF		3.5		16.692

The flow contribution from each of the WWTFs exceeds the designated "very low" flow for each of these streams. WWTF load can never exceed stream loads as it is a component of stream load. To account for this situation, the WLAs and LAs are expressed as an equation rather than an absolute number. This equation is:

Allocation = (flow contribution from a given source) x (126 org/100ml)

In essence, this amounts to assigning a concentration based limit to these sources. While this might be seen as overly stringent, these sources tend not to be significant contributors of bacteria under very low flow conditions.

In the DO impaired reach, one controlled discharge WWTF discharges directly to the impaired reach (Pemberton WWTF) and one continuous discharge WWTF discharges to an upstream reach (Waldorf WWTF). WWTF discharges to the impaired reach are a very small contributor to the phosphorous load. It was determined that the Pemberton WWTF discharge would be limited to not allow discharge in June through September, with an exception for certain high flow time periods when the P would not be contributing to the DO impairment. The current Waldorf WWTF permitted TP amount was found to be sufficient and was assigned as the WLA, however future eutrophication standards could result in a more stringent WLA for Waldorf.

4.3.2 Stormwater

Urban and suburban stormwater runoff, both from developing and built-out areas, carries pollutant loads that can match or exceed agricultural run-off on a per-acre basis. This runoff also contributes to channel instability and streambank erosion. Pollutants from stormwater runoff can include pesticides, fertilizer, oil, metals, pathogens, salt, sediment, litter and other debris. The MPCA has three categories for stormwater permits: municipal, construction and industrial.

Municipal

In 1987, the CWA was amended to include provisions for a two-phase program to address stormwater runoff. In March of 2003, the second phase of the program began. Phase II includes permitting and regulation of smaller construction sites, municipalities MS4 permits and industrial facilities. There are small portions of two MS4 communities in the Le Sueur River upstream of the confluence with the Cobb

River (AUID 07020011-507): the city of Mankato and the city of Waseca. Permit numbers can be found in Table 4.6. Due to the expansion of the 2010 census defined urban area, Eagle Lake and portions of Blue Earth County, Mankato Township and Lime Township are likely to become subject to MS4 permit requirements in the near future. These are included in Table 4.6. In addition to Assessment Unit ID (AUID) 07020011-507, the expanded area also affects Eagle Lake (North). To determine the WLA for each MS4 the applicable land area for each was divided by the watershed area of the affected reach or lake (Table 4.6). In the lake watershed, the area of the lake was subtracted from the potential future MS4 area as the lake itself can't be developed. This percent was then apportioned to the MS4 allocation after the MOS was subtracted from the total LC.

Table 4.6: Current and possible future applicable MS4 permits

Permit Number	MS4 Community	Applicable Reach/Lake	Acreage(Percent) of MS4 area in applicable watershed
MS400226	City of Mankato	**Le Sueur River**, CD 6 to Cobb R; 07020011-507	**1197 acres (0.4%)**
MS400258	City of Waseca	**Le Sueur River**, CD 6 to Cobb R; 07020011-507	**603 acres (0.2%)**
*	Eagle Lake	**Le Sueur River**, CD 6 to Cobb R; 07020011-507	**964 acres (0.3%)**
*	Blue Earth County	**Le Sueur River**, CD 6 to Cobb R; 07020011-507	**2346 acres (0.8%)**
*	Mankato Township	**Le Sueur River**, CD 6 to Cobb R; 07020011-507	**10758 acres (3.8%)**
*	Mankato Township	**Eagle Lake (North)**	**208 acres (6.7%)**
*	Lime Township	**Le Sueur River**, CD 6 to Cobb R; 07020011-507	**421 acres (.15%)**
*	Lime Township	**Eagle Lake (North)**	**602 acres (19.5%)**

*Future permitted MS4s have not yet been assigned MS4 identification numbers. These will be assigned upon receipt of MS4 permit coverage. Until this time, future permitted MS4s are not subject to requirements of the MS4 permit.

Minnesota Department of Transportation (MNDOT)

MNDOT highways and right of ways within MS4 areas are required to have a wasteload allocation. To determine the MNDOT WLA, the applicable land area for each was divided by the watershed area of the affected reach or lake (Table 4.6). This percent was then apportioned to the MNDOT WLA allocation after the MOS was subtracted from the total LC.

Construction

The MPCA issues construction permits for any construction activities disturbing:

- One acre or more of soil

- Less than one acre of soil if that activity is part of a “larger common plan of development or sale” that is greater than one acre
- Less than one acre of soil, but the MPCA determines that the activity poses a risk to water resources

Construction stormwater permit application records indicate approximately 0.61% of land use in the study area has been subject to construction over the last 10 years. The WLA for stormwater discharges from sites where there is construction activity reflects the number of construction sites less than 1 acre expected to be active in the watershed at any one time, and the Best Management Practices (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. It should be noted that all local construction stormwater requirements must also be met.

Industrial

Industrial sites might contribute to stormwater pollution when water comes in contact with pollutants such as toxic metals, oil, grease, de-icing salts and other chemicals from rooftops, roads, parking lots and from activities such as storage and material handling. Examples of exposed materials that would require a facility to apply for an industrial stormwater permit include: fuels, solvents, stockpiled sand, wood dust, gravel, metal and a variety of other materials. As part of the permit requirements, the facilities are required to develop and implement a Stormwater Pollution Prevention Plan (SWPPP). The SWPPP uses BMPs designed to eliminate or minimize stormwater contact with significant materials that might result in polluted stormwater discharges from the industrial site.

Industrial stormwater permit application records indicate approximately 0.07% of land use in the study area has been subject to permitted industrial activity over the last 10 years. 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 Nonmetallic Mining and Associated Activities facilities (MNG490000). If a facility owner/operator obtains coverage under the appropriate NPDES/SDS General Stormwater 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. It should be noted that all local stormwater management requirements must also be met.

Construction stormwater and industrial stormwater are lumped together into a categorical WLA based on an approximation of the land area covered by those activities. To account for these sources as well as allowing for the potential of higher rates of construction and additional industrial facilities, this TMDL assumes 1.0% of the land area for the construction and industrial stormwater category. Therefore, 1.0%

of the TMDL is apportioned to these activities through a categorical WLA. The allocation to this category is made after the MOS is subtracted from the total LC.

4.3.3 Livestock Facilities

NPDES livestock facilities are zero discharge facilities and therefore are given a WLA of zero and should not impact water quality in the watershed as a point source. The number of livestock facilities with NPDES permits located within each subwatershed is shown in Table 4.7. These are general feedlot permits and are covered as such under Minnesota's General Feedlot Permit, MNG440000. Discharge of P from fields where manure has been land-applied are covered under the LA portion of the TMDLs, provided the manure is applied in accordance with the permit.

Table 4.7: Number of NPDES livestock facilities by subwatershed.

Subwatershed	Number of NPDES Livestock Facilities
Le Sueur River (U/S of Cobb River)	25
Boot Creek	0
Cobb River	36
Little Cobb River	17
Rice Creek	7
County Ditch 3 (Judicial Ditch 9)	1
Madison Lake	1
Lake Elysian	3
Eagle Lake North	0
Freeborn Lake	0

4.3.4 Straight Pipe Septic Systems

Straight pipe septic systems are illegal and therefore receive a WLA of zero. According to Minn. Stat. 115.55, subd. 1, a straight pipe "means a sewage disposal system that includes toilet waste and transports raw or partially settled sewage directly to a lake, a stream, a drainage system, or ground surface".

4.4 Load allocation methodology

Once the WLA and MOS were determined for each watershed, the LA was assigned the remaining LC. The LA includes nonpoint pollution sources that are not subject to NPDES Permit requirements, as well as "natural background" sources. Natural background as defined in Minn. R. 7050.0150, subp. 4, refers to the multiplicity of factors that determine the physical, chemical or biological conditions that would exist in a waterbody in the absence of measurable impacts from human activity or influence. Anthropogenic sources of stress are not a component of natural background as it has been defined by Minnesota rule.

4.5 Margin of Safety

The purpose of the MOS is to account for uncertainty that the allocations will result in attainment of water quality standards.

For the stream TMDLs, an explicit 10% MOS is applied. This MOS has been used by the MPCA in several previous TMDLs and is expected to provide an adequate accounting of uncertainty. *E.coli* TMDLs have a MOS determined for each flow regime.

For the lake TMDLs an explicit 10% MOS is also applied. Therefore, the load capacity that is calibrated to attain the in-lake P concentration standard is reduced by 10% (LC – MOS). The result is the total annual P load the lake may receive and still meet water quality standards.

4.6 Seasonal variation

4.6.1 Streams

E. coli

Concentrations of *E. coli* vary throughout the summer in the Le Sueur River Watershed. While the standard is a geometric mean from April-October based on all available data in the impaired reach, June-September is the critical time period for exceedances of the *E. coli* standard in this watershed (Table 3.6). The only exception is the Cobb River where the only monthly geometric mean exceeding the standard is September. The duration curve approach using multiple years of flow data and the applicable time period of the standard will provide sufficient water quality protection during the critical summer period.

Low dissolved oxygen

Daily minimum DO concentrations are at their lowest in the summer low flow season.

4.6.2 Lakes

Water quality monitoring in Madison, Elysian, Eagle North and Freeborn Lakes suggests the in-lake TP concentrations vary over the course of the growing season (June – September), generally peaking in mid to late summer. The MPCA eutrophication water quality guideline for assessing TP is defined as the June through September mean concentration. The BATHTUB model was used to calculate the load capacities of each lake, incorporating mean growing season TP values. TP loadings were calculated to meet the water quality standards during the summer growing season, the most critical period of the year. Calibration to this critical period will provide adequate protection during times of the year with reduced loading.

4.7 Consideration of Growth on TMDL

Potential changes in population and land use over time in the Le Sueur River Watershed could result in changing sources of pollutants. Possible changes and how they may or may not impact TMDL allocations are discussed below.

4.7.1 Load Transfer

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

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

2. One regulated MS4 acquires land from another regulated MS4. Examples include annexation or highway expansions. In these cases, the transfer is WLA to WLA.

3. One or more non-regulated MS4s become regulated. If this has not been accounted for in the WLA, then a transfer must occur from the LA.

4. Expansion of a U.S. Census Bureau 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 will require either a WLA to WLA transfer or a LA to WLA transfer.

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

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

4.7.2 Wasteload Allocation

There are currently 10 unsewered communities in the Le Sueur River Watershed. These are mainly being addressed through SSTS upgrades upon property transfer and other local ordinances, though some additional programs will be utilized if deemed necessary. The MPCA has completed a report for small community wastewater needs with the goal of eliminating these sources of pollution (MPCA 2008). It is unlikely that these communities will grow significantly and that any new communities will develop in the future that will need a WLA assigned to them.

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

4.7.3 Load Allocations

Over 80% of land in the Le Sueur River Watershed is in agricultural use and is likely to remain in this general use class. However, conversion of some area from pasture/hay to row crops could occur. Despite this possible conversion, LCs would likely not substantially increase or decrease because calculations use long term, variable data sets.

4.8 TMDL summary

Table 4.8: Loading capacities and allocations for addressed stream AUIDs

Total Phosphorus	
Little Cobb River Bull Run Creek to Cobb River AUID# 07002011-504	**Pounds per day**
Loading Capacity	68
Margin of Safety	6.8
Wasteload Allocation*	
Permitted Wastewater Treatment Facilities** Waldorf WWTF Pemberton WWTF	2.8
Construction and Industrial Stormwater	0.6
Livestock facilities requiring NPDES permits	0
"Straight Pipe" Septic Systems	0
Load Allocation	57.8

*No Communities Subject to MS4 NPDES requirements are located in the watershed

**Waldorf is given its current TP permit limit. Pemberton will not be allowed to discharge in June-September unless receiving stream flows are above a certain threshold (to be defined in the permit).

Table 4.8 continued

E. coli					
Le Sueur River CD6 to Cobb River AUID# 07020011-507	**FLOW ZONE**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	Billion organisms per day				
Average Daily Loading Capacity	4741	1369	557	167	37
Margin of Safety	474	137	56	17	3.7
Wasteload Allocation					
Permitted Wastewater Treatment Facilities	39	39	39	39	***
Communities Subject to MS4 NPDES Requirements					
Mankato	17.1	4.9	2.0	0.6	***
Waseca	8.5	2.5	1.0	0.3	***
Eagle Lake*	12.8	3.7	1.5	0.5	***
Blue Earth County*	34.1	9.9	4.0	1.2	***
Mankato Township*	162.1	46.8	19.0	5.7	***
Lime Township*	6.4	1.8	.75	.23	***
Minnesota Department of Transportation	2.1	0.6	0.3	0.08	***
Livestock facilities requiring NPDES permits	0	0	0	0	0
"Straight Pipe" Septic Systems	0	0	0	0	0
Load Allocation	3984.9	1122.8	433.5	102.4	***

* Future permitted MS4s have not yet been assigned MS4 identification numbers. These will be assigned upon receipt of MS4 permit coverage. Until this time, future permitted MS4s are not subject to requirements of the MS4 permit.

***Computed allocation exceeded low flow allocation, therefore allocation = (flow contribution from a given source) x (126 org/100ml). See section 4.3 for details

Table 4.8 continued

E. coli					
Boot Creek Unnamed Creek to T105N R22W S6, north line AUID# 07020011-516	**FLOW ZONE**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	Billion organisms per day				
Average Daily Loading Capacity	564	137	51	17	4
Margin of Safety	56	14	5	2	NA
Wasteload Allocation*					
Permitted Wastewater Treatment Facilities	5	5	5	5	***
Livestock facilities requiring NPDES permits	NA	NA	NA	NA	NA
"Straight Pipe" Septic Systems	0	0	0	0	0
Load Allocation	502	117	41	10	***
Rice Creek Headwaters to Maple River AUID# 07020011-531	**FLOW ZONE**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	Billion organisms per day				
Average Daily Loading Capacity	938	209	76	17	2
Margin of Safety	94	21	8	2	NA
Wasteload Allocation*					
Wastewater treatment facilities	2	2	2	2	***
Livestock facilities requiring NPDES permits	0	0	0	0	0
"Straight Pipe" Septic Systems	0	0	0	0	0
Load Allocation	842	186	66	13	***

*No Communities Subject to MS4 NPDES requirements are located in the watershed
***WWTF design/discharge flow exceeded low flow, therefore allocation = (flow contribution from a given source) x (126 org/100ml). See section 4.3 for details

Table 4.8 continued

E. coli					
County Ditch 3 (Judicial Ditch 9) JD 9 to Maple River AUID# 07020011-552	**FLOW ZONE**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	Billion organisms per day				
Average Daily Loading Capacity	827	178	59	17	2
Margin of Safety	83	18	5.9	1.7	NA
Wasteload Allocation*					
Livestock facilities requiring NPDES permits	0	0	0	0	0
"Straight Pipe" Septic Systems	0	0	0	0	0
Load Allocation	744	160	53	15	2
Cobb River T104 R26W S30, west line to Le Sueur River AUID# 07020011-556	**FLOW ZONE**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
	Billion organisms per day				
Average Daily Loading Capacity	3380	1068	338	58	5
Margin of Safety	338	107	34	6	NA
Wasteload Allocation**					
Wastewater treatment facilities	22	22	22	22	***
Livestock facilities requiring NPDES permits	0	0	0	0	0
"Straight Pipe" Septic Systems	0	0	0	0	0
Load Allocation	3020	940	282	30	***

*No WWTFs or Communities Subject to MS4 NPDES requirements are located in the watershed.
**No Communities Subject to MS4 NPDES requirements are located in the watershed.
***WWTF design/discharge flow exceeded low flow, therefore allocation = (flow contribution from a given source) x (126 org/100ml).
See section 4.3 for details

Table 4.9: Total phosphorus loading capacities and allocations for Madison, Elysian, Eagle North and Freeborn Lakes

Madison Lake 07-0044-00	**TP lbs/day**
Loading Capacity	6.19
Margin of Safety	0.62
Wasteload Allocation*	
Construction and industrial stormwater	0.06
Livestock facilities requiring NPDES permits	0
"Straight pipe" septic systems	0
Load Allocation	5.51

Lake Elysian 81-0095-00	**TP lbs/day**
Loading Capacity	13.98
Margin of Safety	1.4
Wasteload Allocation*	
Construction and industrial stormwater	0.13
Livestock facilities requiring NPDES permits	0
"Straight pipe" septic systems	0
Load Allocation	12.45

Eagle Lake North 07-0060-01	**TP lbs/day**
Loading Capacity	1.3
Margin of Safety	0.13
Wasteload Allocation	
Communities Subject to MS4 NPDES Requirements	
Mankato Township**	0.08
Lime Township**	0.23
Construction and industrial stormwater	0.01
Livestock facilities requiring NPDES permits	0
"Straight pipe" septic systems	0
Load Allocation	0.85

Freeborn Lake 24-0044-00	**TP lbs/day**
Loading Capacity	5.12
Margin of Safety	0.51
Wasteload Allocation*	
Construction and industrial stormwater	0.05
Livestock facilities requiring NPDES permits	0
"Straight pipe" septic systems	0
Load Allocation	4.56

* No Communities Subject to MS4 NPDES requirements are located in the watershed

**Future permitted MS4s have not yet been assigned MS4 identification numbers. These will be assigned upon receipt of MS4 permit coverage. Until this time, future permitted MS4s are not subject to requirements of the MS4 permit.

5 Reasonable Assurance

A handful of point source reductions were identified for the Le Sueur River Watershed. To meet these reductions, point source permitting staff will work closely with the facilities to adjust permits as necessary for limits, adjustments in release times, and/or adjustments to when releases can occur based on current stream flow to ensure the reductions are feasible and can be obtained with minimal disruption to current facility operations. This hands-on model has proven successful for multiple point source reductions in Minnesota and provides reasonable assurance that the necessary point source reductions will be achieved.

The majority of pollutant reductions in the Le Sueur watershed will need to come from NPS contributors in order for the impaired waters to meet water quality standards. Of these sources, agricultural drainage and surface runoff are the dominant sources, while other NPSs contribute a small portion of the pollutant loads. Due to the lack of existing regulations and the current federal exemptions in creating regulations, reasonable assurance in the technical sense cannot be guaranteed. However, agencies, organizations, and citizens alike recognize that resigning waters to an impaired condition is not acceptable.

While field and model studies indicate that wide-scale adoption of agricultural BMPs will allow waters to meet water quality standards, there is no way to guarantee that citizens and communities will voluntarily adopt the necessary practices at the necessary rate. To best assure that NPS reductions are achieved, a large emphasis has been placed on citizen engagement, where the citizens and communities that hold the power to improve water quality conditions are involved in discussions and decision-making. Refer to Section 8: Public Participation for citizen engagement that has occurred in the Le Sueur River Watershed.

In addition to citizen engagement, several government programs have been created to support a political and social infrastructure that aims to increase the adoption of strategies that will improve watershed conditions. One example of a program is the Minnesota Agricultural Water Quality Certification Program (AWQCP), which provides regulatory security and incentives to landowners who adopt conservation practices. Additional financial programs include the 319 grant programs, and BWSR and NRCS incentive programs. Programs and activities are also occurring at the local government level, where county staff, commissioners, and residents are beginning to come together to address water quality issues.

6 Monitoring plan

Data from three water quality monitoring programs enables water quality condition assessment and creates a long-term data set to track progress towards water quality goals. These programs will continue to collect and analyze data in the Le Sueur River Watershed as part of *Minnesota's Water Quality Monitoring Strategy* (MPCA 2011b). Data needs are considered by each program and additional monitoring is implemented when deemed necessary and feasible. These monitoring programs are summarized below:

> Intensive Watershed Monitoring (MPCA 2012b) data provide a periodic but intensive "snapshot" of water quality throughout the watershed. This program collects water quality and biological data at roughly 100 stream and 50 lake monitoring stations across the watershed in one to 2 years, every 10 years. This work is scheduled to start its second iteration in the Le Sueur River Watershed in 2018.

Watershed Pollutant Load Monitoring Network (MPCA 3013f) data provide a continuous and long-term record of water quality conditions at the major watershed and subwatershed scale. This program collects pollutant samples and flow data to calculate continuous daily flow, sediment, and nutrient loads. In the Le Sueur River Watershed, there is an annual site near the outlet of the Le Sueur River and five seasonal (spring through fall) subwatershed sites.
Citizen Stream and Lake Monitoring Program (MPCA 2013g) data provide a continuous record of waterbody transparency throughout much of the watershed. This program relies on a network of volunteers who make monthly lake and river measurements. Roughly 100 citizen monitoring locations exist in the Le Sueur River Watershed.

7 Implementation Strategies

A group of professional water quality, planning, and conservation staff collaboratively developed the strategies presented in the Le Sueur River WRAPS report. These strategies, adopted at generally wide-scale rate and integrated in suites, are expected to bring waters in the Le Sueur River Watershed into a supporting status. Refer to the WRAPS report for details and adoption rates. Below is a summary of the recommended strategies, all of which cannot be credited toward WLA reductions for MS4 communities with permit requirements:

- No-till or strip till conservation tillage
- Cover crops and grassed waterways
- Nutrient, manure, and animal management
- Water retention and increased evapotranspiration from the landscape (basins, wetlands, extended retention)
- Field and riparian vegetated buffers
- Drainage volume reductions by system design
- Drainage water pollutant reductions through edge-of-field treatments (bioreactors, saturated buffers, treatment wetlands)
- Citizen education and discussions
- Urban stormwater BMPs
- Changes in policy and increased funding and other support
- Protect currently higher quality areas

The strategies and corresponding adoption rates presented in the Le Sueur River WRAPS Report are intended to meet interim water quality targets. To fully address the widespread water quality impairments in agriculturally-dominated watersheds such as the Le Sueur River Watershed, an integrated and multi-faceted approach using suites of BMPs is likely necessary. Several models/methods have been developed and are very similar including the model pictured here (Figure 7.1Figure 7.1; *Tomer et al. 2013*), the *Minnesota Nutrient Reduction Strategy* (MPCA 2013h), and the *"Treatment Train" approach as being demonstrated in the Elm Creek Watershed* (ENRTF 2013).

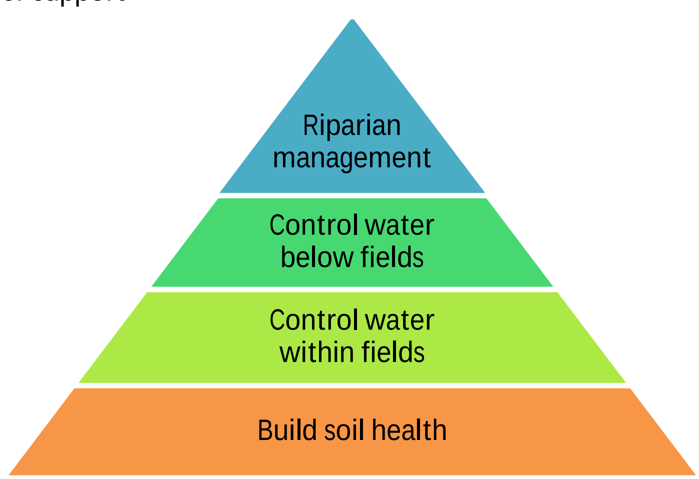

Figure 7.1: A conceptual model to address water quality impairments in agriculturally dominated watersheds

7.1 MS4, Construction and Industrial Stormwater Discharges

The WLA for stormwater discharges from sites where there are construction activities reflects the number of construction sites one or more acres 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. It should be noted that all local construction stormwater requirements must also be met.

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 & Gravel, Rock Quarrying and Hot Mix Asphalt Production facilities (MNG490000). If a facility owner/operator obtains coverage under the appropriate NPDES/SDS General Stormwater 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. It should be noted that all local stormwater management requirements must also be met.

In addition, NPDES Permit requirements must be consistent with the assumptions and requirements of an approved TMDL and associated WLA. For the purposes of this TMDL, the baseline year in the applicable reach (Le Sueur River upstream of the Cobb River) for implementation will be 2010, the mid-range year of the data years used for development of the percent pollutant reduction needed (Table 4.2). The rationale for this is that projects undertaken recently may take a few years to influence water quality. Any load-reducing BMP implemented since the baseline year will be eligible to "count" toward an MS4's load reductions. If a BMP was implemented during or just prior to the baseline year, the MPCA is open to presentation of evidence by the MS4 permit holder to demonstrate that it should be considered as a credit.

7.2 Cost of Implementation

Estimating the cost of bringing waters in the Le Sueur River Watershed into a supporting status is more an exercise of scale than a practical dollar estimate. Specifically, the costs are highly variable and include many assumptions. Furthermore, the costs will change as progressive practices are voluntarily adopted as the new farming standard. For these reasons, a rough estimate of cost was developed using NRCS cost-share rates, an estimated land value for crops taken out of production, and with assumptions regarding the specific items needed for a practice. This number is a representation of the scale of change that is needed more so than an actual tax-payer or individual burden. The cost also does not include ecosystem benefits, which if considered, could off-set much of the cost. The costs are based on the watershed-wide adoption rates as presented in the Le Sueur River WRAPS Report.

The estimated cost of agricultural BMPs to meet the Le Sueur River WRAPS 10-year water quality targets is roughly $150 million. The 10 year targets represent pollutant (or stressor) reductions that range from 5%-27%. So very roughly, this number can be extrapolated by (considering the ratio of the total goal to the 10-year target) a factor of five to roughly $750 million to estimate the total agricultural BMP expenditure necessary for waters to meet water quality standards. Additional costs to implement city storm water, resident, and lake-specific BMPs are roughly estimated to total $100 million based on the scale of reductions needed from these sources.

7.3 Adaptive Management

Adaptive management is an iterative implementation process that makes progress toward achieving water quality goals while using new data and information to reduce uncertainty and adjust implementation activities. The State of Minnesota has a unique opportunity to adaptively manage water resource plans and implementation activities every 10 years (Figure 7.2). This opportunity resulted from a voter-approved tax increase to improve state waters. The resulting interagency coordination effort is referred to as the Minnesota Water Quality Framework, which works to monitor and assess Minnesota's 81 major watersheds every 10 years. This Framework supports ongoing implementation and adaptive management of conservation activities and watershed-based local planning efforts.

Implementation of TMDL related activities can take many years, and water quality benefits associated with these activities can also take many years. As the pollutant source dynamics within the watershed are better understood, implementation strategies and activities will be adjusted and refined to efficiently meet the TMDL and lay the groundwork for de-listing the impaired reaches. The follow up water monitoring program outlined in Section 6 will be integral to the adaptive management approach, providing assurance that implementation measures are succeeding in attaining water quality standards.

Adaptive management does not include changes to water quality standards or LC. Any changes to water quality standards or LC must be preceded by appropriate administrative processes, including public notice and an opportunity for public review and comment.

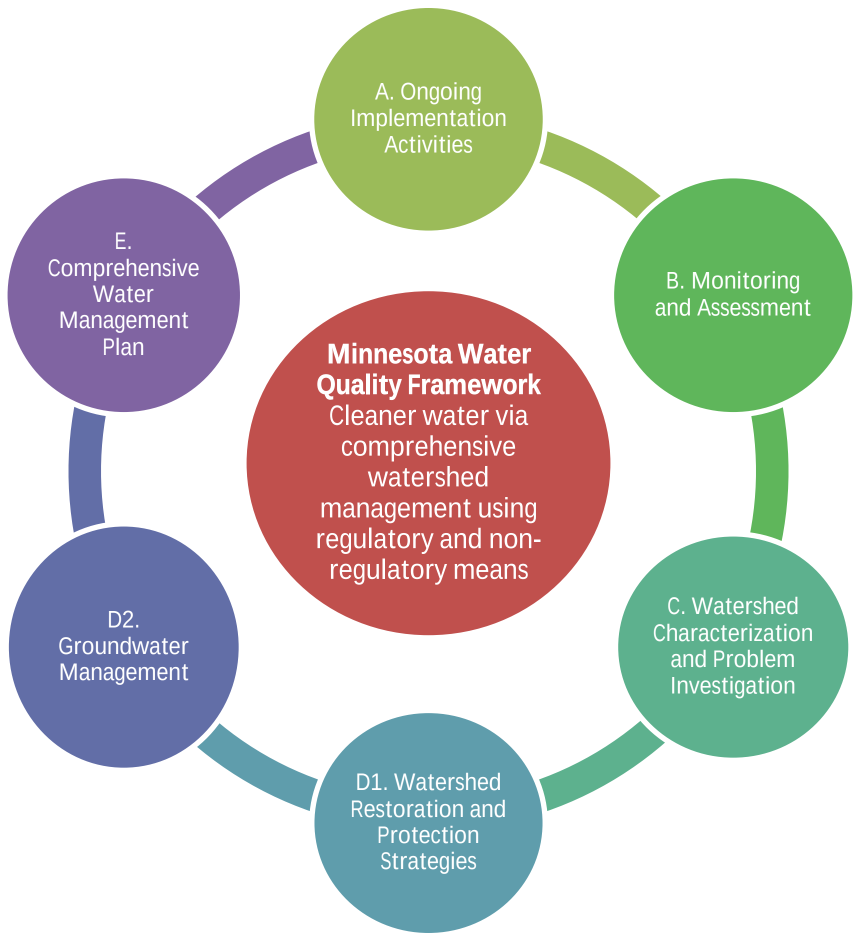

Figure 7.2: Minnesota's Water Quality Framework

8 Public Participation

This section summarizes four civic engagement/public participation efforts sponsored by the MPCA in collaboration with local partners: 1) Le Sueur River Watershed Network, 2) Lakes Focus Group, and 3) Citizen and farmer interviews conducted by SWCD staff.

8.1 Le Sueur River Watershed Network

Le Sueur River Watershed Network (2013) is composed of watershed residents, concerned citizens and groups, and resource agency staff. Resulting from a series of meetings that occurred between January and May of 2013, a Citizen Advisory Committee made seven recommendations to improve water quality. The summarized recommendations are in order of the committee's preference:

1. Storm water management and in-ditch storage
2. Experimentation and demonstration with temporary water storage
3. Strategically placed buffers, terraces, and grassed waterways
4. Communication and education for watershed residents
5. Less red tape
6. River channel maintenance of major snags
7. Streambank and ravine stabilization

8.2 Lakes Focus Group

A one-time meeting was held in February 2014, to solicit the preferred restoration and protection strategies of citizens who are interested in improving and protecting lakes within the Le Sueur River Watershed. The preferred strategies to implement in Lake Watersheds, in order of preference, were:

1. Lake buffers, setbacks, and native/healthy lakescaping
2. Public education/outreach
3. Nutrient management
4. Improved storm/drainage water management
5. Wetland restoration

8.3 Resident & Farmer Interviews

The SWCD staff designed and performed interviews of Le Sueur River Watershed residents and farmers. The objectives of these interviews were to: 1) connect residents and local staff, 2) learn resident opinions and concerns regarding water quality, and 3) provide maps and resources to spur conversations and identify conservation opportunities. Generalized themes from these interviews included:

- Farming has undergone significant changes over the last several decades. A wide spectrum of understanding and interest exists regarding water quality, conservation practices, and sustainable agriculture. Most farmers feel they are doing a good job with conservation, but economics are the largest factor in making agricultural land management choices.

- While many farmers have made some conservation improvements recently, there are many opportunities to improve conservation. For instance, some who practice no-till consider this a competitive edge, but most farmers have (real or perceived) obstacles to using no-till. Several potential projects and obstacles to adopting conservation practices were identified.

- The general public sees a need for increased conservation. In one county, the percent of interviewees that thought the following BMPs should be increased is: 72% increased vegetation, 43% riparian buffers, 29% ponds/wetlands, 21% conservation/sediment control structures, 18% progressive drainage design, 17% river/bank projects, 12% lake shore restoration, and 10% urban storm water BMPs.

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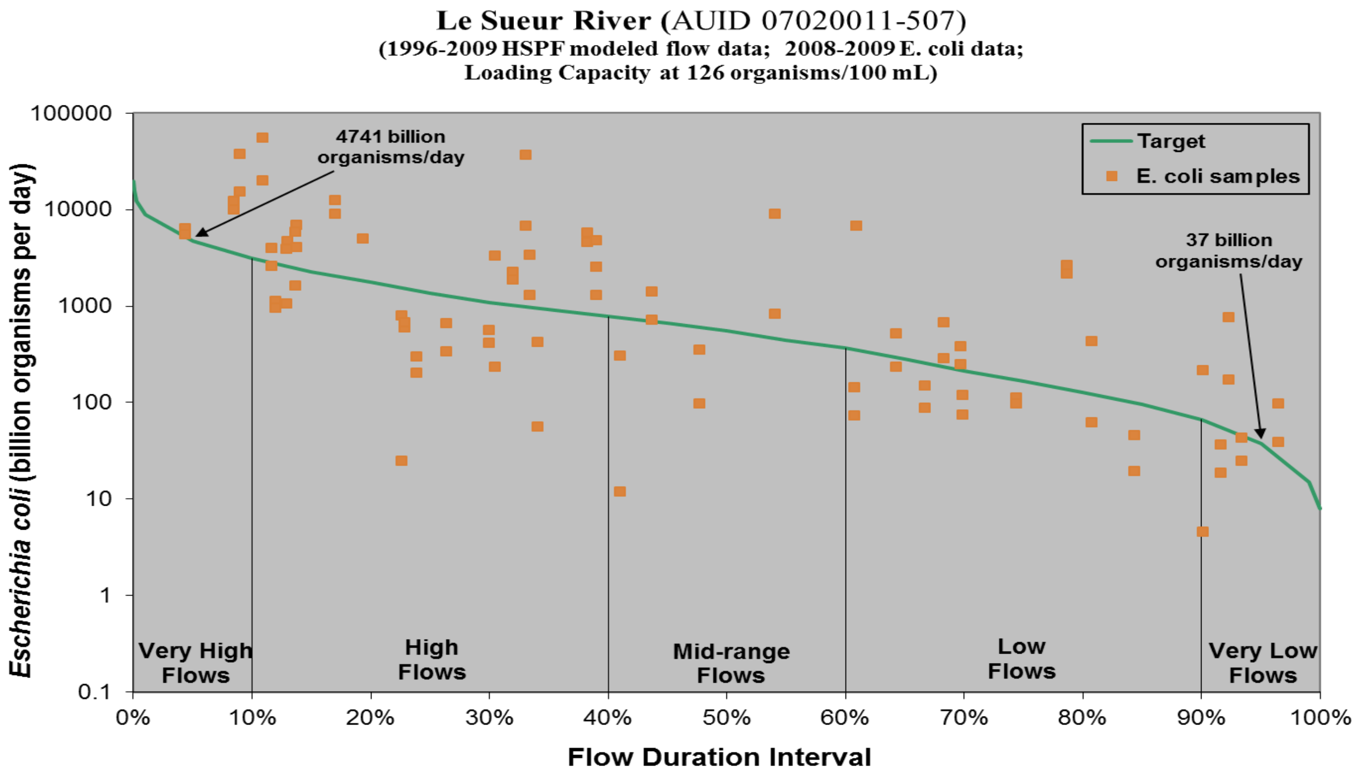
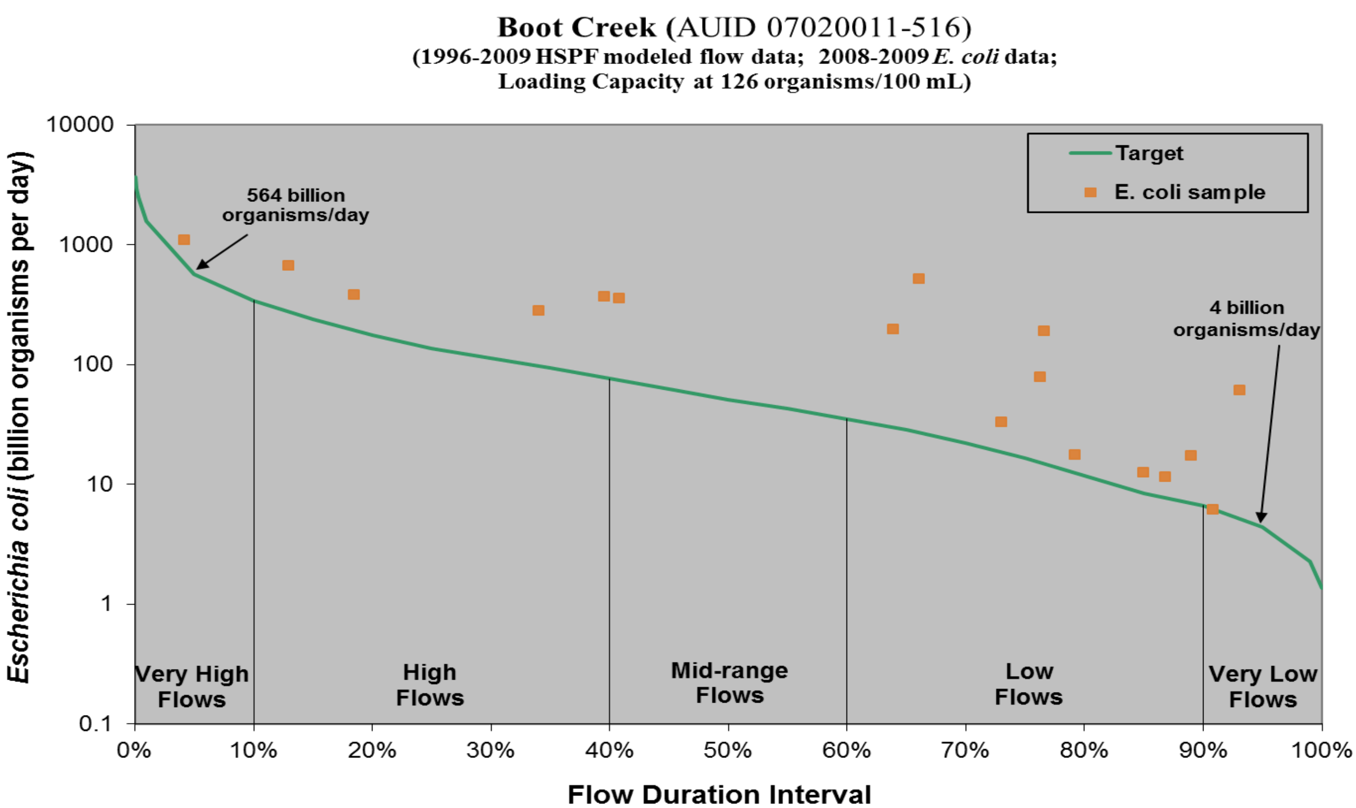
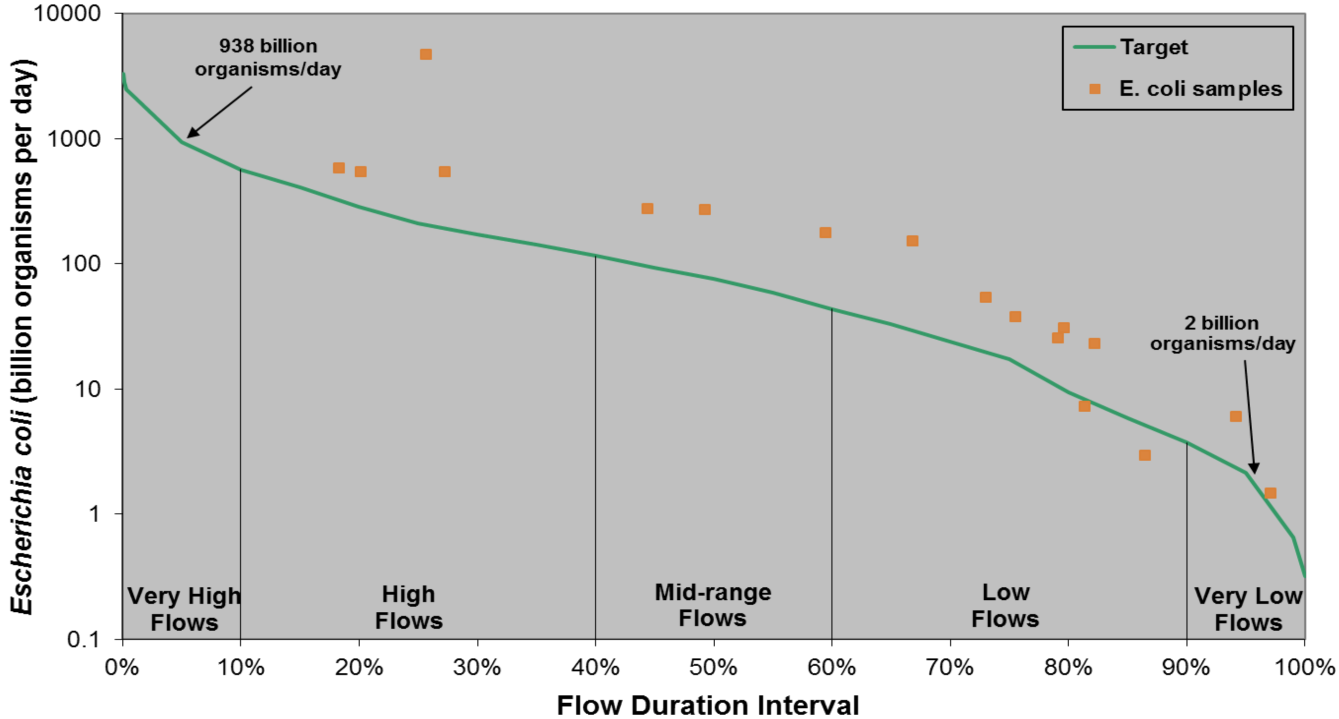
Appendix

Load duration curves for the *E. coli* impaired reaches are contained in this appendix.

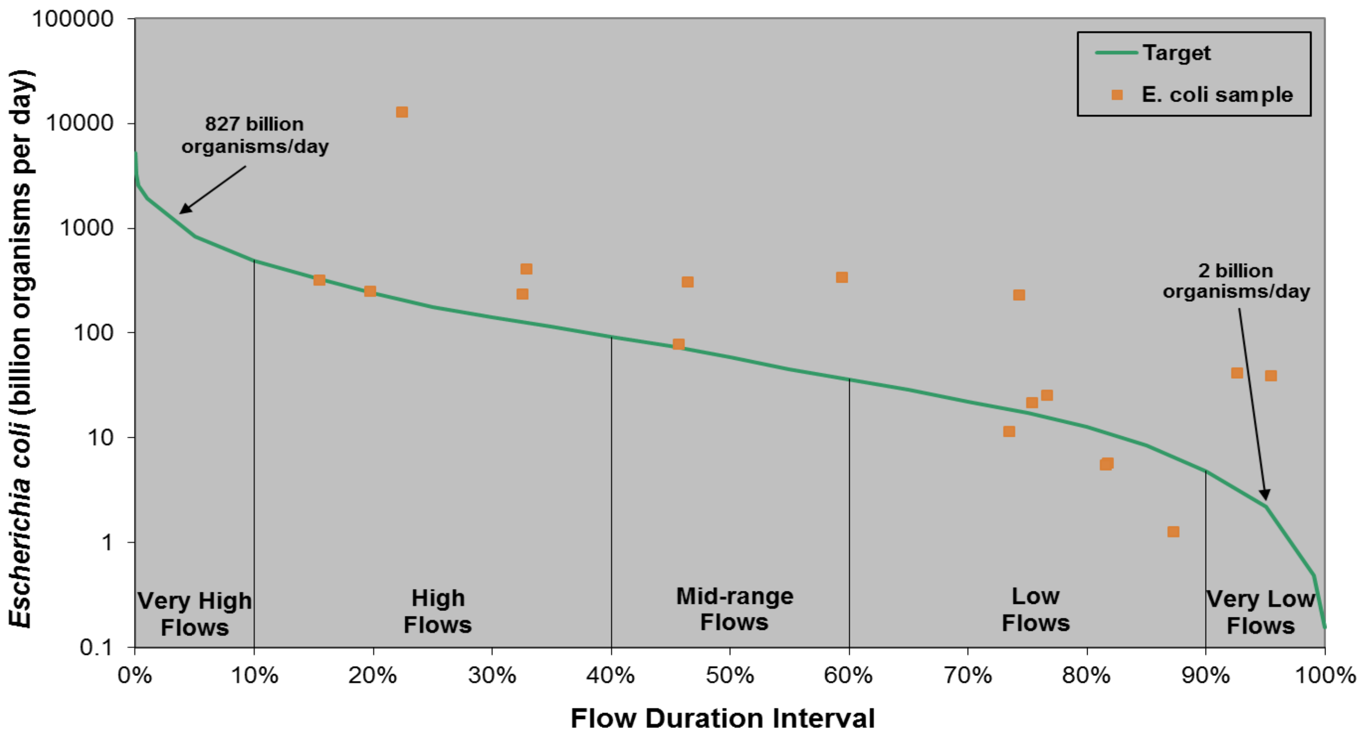


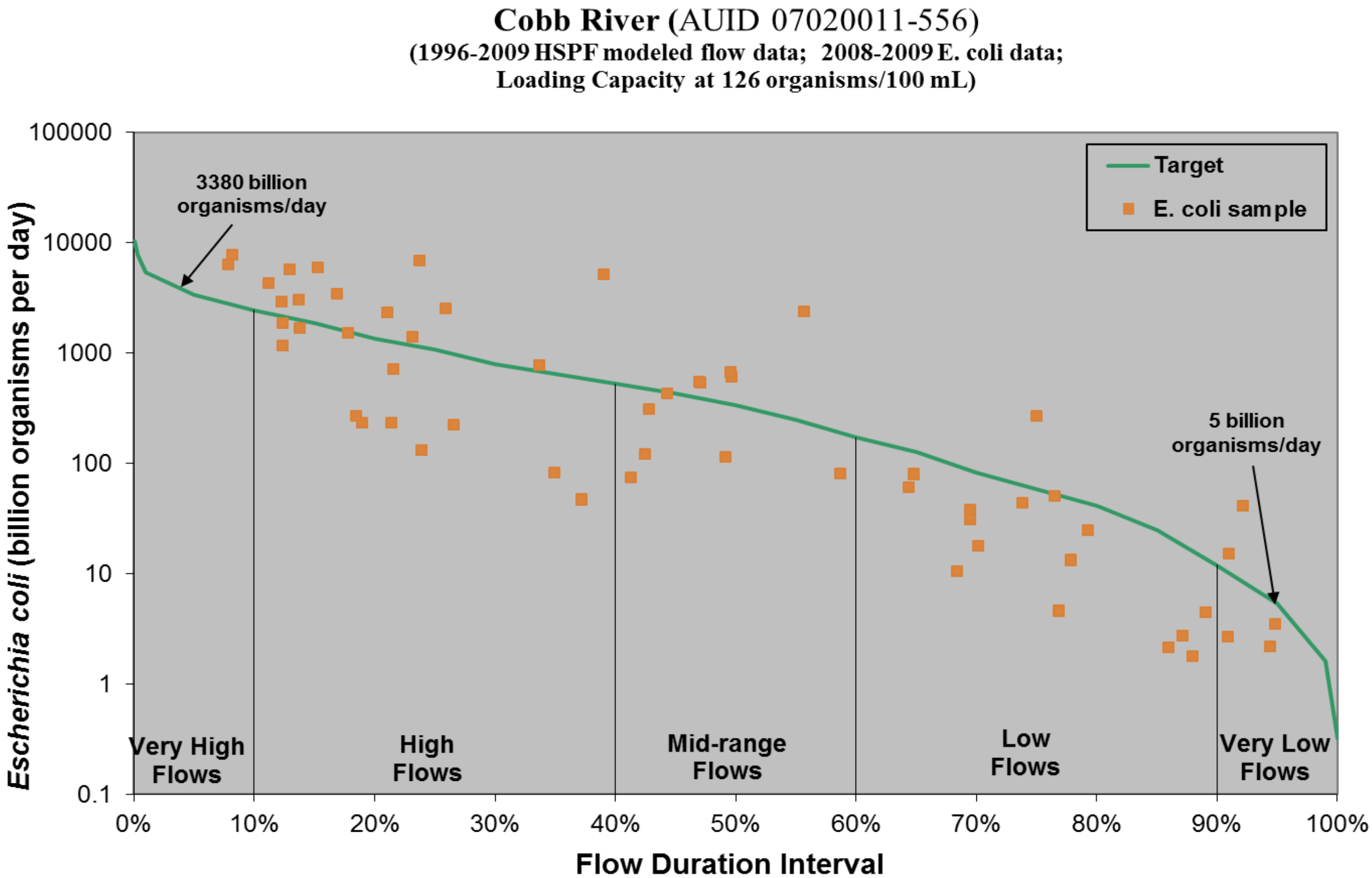


Rice Creek (AUID 07020011-531)
(1996-2009 HSPF modeled flow data; 2008-2009 E. coli data; Loading Capacity at 126 organisms/100 mL)



County Ditch 3/Judicial Ditch 9 (AUID 07020011-552)
(1996-2009 HSPF modeled flow data; 2008-2009 E. coli data; Loading Capacity at 126 organisms/100 mL)





Cobb River (AUID 07020011-556)
(1996-2009 HSPF modeled flow data; 2008-2009 E. coli data;
Loading Capacity at 126 organisms/100 mL)
100000
10000
1000
100
10
1
0.1
Escherichia coli (billion organisms per day)
3380 billion
organisms/day
5 billion
organisms/day
Target
E. coli sample
Very High
Flows
High
Flows
Mid-range
Flows
Low
Flows
Very Low
Flows
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Flow Duration Interval