Clearwater River Watershed

January 2021

Clearwater River Watershed Total Maximum Daily Load

This is a plan for restoring waters throughout the Clearwater River major watershed that are impaired by total suspended solids, *E. coli*, low dissolved oxygen, low index of biotic integrity scores, and eutrophication.

MINNESOTA POLLUTION CONTROL AGENCY

Red Lake Watershed District • Dedicated to Water Management

CLEAN WATER LAND & LEGACY AMENDMENT

Authors and contributors:

Corey Hanson, Red Lake Watershed District

Denise Oakes, Minnesota Pollution Control Agency

Stephanie Klamm, Minnesota Department of Natural Resources

Kara Fitzpatrick, Minnesota Pollution Control Agency

Chuck Johnson, Minnesota Pollution Control Agency

Ashley Hitt, Red Lake Watershed District

David Dollinger, Minnesota Pollution Control Agency

Moriya Rufer, RMB Environmental Laboratories, Inc.

Jason Vinje, Minnesota Department of Natural Resources

Lori Lynn Clark, Minnesota Department of Natural Resources

Andrea Plevan, Minnesota Pollution Control Agency

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Acronyms

1W1P	One Watershed One Plan
AF	Anoxic factor
AUID	Assessment Unit ID
BCG	Biological Condition Gradient
BEHI	Bank Erosion Hazard Index
BMP	best management practice
BOD	Biochemical oxygen demand
Cfs	Cubic feet per second
chl-*a*	Chlorophyll-*a*
CD	County ditch
CR	County road
CSAH	County State Aid Highway
CWLA	Clean Water Legacy Act
DNR	Minnesota Department of Natural Resources
DO	dissolved oxygen
E. coli	*Escherichia coli*
EPA	U.S. Environmental Protection Agency
EQuIS	Environmental Quality Information System
F-IBI	Fish index of biological integrity
HSPF	Hydrologic Simulation Program-Fortran
HSPF-SAM	Hydrologic Simulation Program-Fortran Scenario Application Manager
HUC	Hydrologic Unit Code
IBI	index of biological integrity
JD	Judicial ditch
km^2	square kilometer
LA	load allocation
Lb	pound
LC	Loading capacity
LDC	Load duration curve
LGU	Local Government Unit
m	meter
M-IBI	Macroinvertebrate index of biological integrity
mg/L	milligrams per liter
mL	milliliter
MOS	Margin of Safety
MPCA	Minnesota Pollution Control Agency
MPN	Most probable number (of organisms)
MS4	Municipal Separate Storm Sewer Systems
NPDES	National Pollutant Discharge Elimination System
OP	Orthophosphorus
ppb	Parts per billion (equal to µg/L)

PTMApp	Prioritize, Target, and Measure Application
RLWD	Red Lake Watershed District
RR	release rate
SID	Stressor Identification
SSTS	Subsurface Sewage Treatment Systems
SWAT	Soil and Water Assessment Tool
SWCD	Soil and Water Conservation District
SWI	Side water inlet
TALU	Tiered Aquatic Life Use
TMDL	Total Maximum Daily Load
TP	Total phosphorus
TSS	Total suspended solids
USGS	United States Geological Survey
WLA	Wasteload allocation
WRAPS	Watershed Restoration and Protection Strategy
WWTF	Wastewater treatment facility

Executive Summary

The Federal Clean Water Act (CWA; 1972) and federal regulations require each State to develop reports (or Total Maximum Daily Load (TMDL) Studies) for the identification and restoration of waterbodies that are deemed impaired by state regulations. In Minnesota, the Minnesota Pollution Control Agency (MPCA) is tasked with assessing and listing waterbodies that do not meet water quality standards (Minn. R. 7050.022) and for completing TMDL studies on waters that are not meeting standards. A TMDL is a calculation of the maximum amount of pollutant that can enter a waterbody without causing the concentration of the pollutant within the waterbody to exceed water quality standards. A TMDL report also identifies the pollutant sources causing the impairment, and allocates necessary pollutant load reductions to sources.

The Clearwater River (United States Geological Survey [USGS] - Hydrologic Unit Code [HUC] 09020305) is a tributary of the Red Lake River in northwest Minnesota, within the Red River of the North Basin. It is a diverse watershed that spans four ecoregions (Lake Agassiz Plain, Northern Minnesota Wetlands, North Central Hardwood Forests, and Northern Lakes and Forests). The Clearwater River Watershed contains small portions of two Tribal Nations. A very small portion of the southern edge of the watershed and one impaired water are partially contained within the boundaries of the White Earth Nation, however the TMDLs calculated do not require pollutant reductions from tribal lands. A slightly larger portion in the northeast part of the watershed is contained within the boundaries of the Red Lake Nation. Because of the very small areas within the watershed that are tribal lands, neither the White Earth Nation nor the Red Lake Nation had active roles in the development of this TMDL report. The prevalent land use transitions from forest and rangeland in the eastern portion of the watershed to cultivated cropland in the western portion of the watershed. The watershed has been divided into a total of seven HUC-10 subwatersheds that include the Upper Clearwater River, Middle Clearwater River, Lower Clearwater River, Lost River, Hill River, Poplar River, and Lower Badger Creek subwatersheds. Many lakes can be found in the southern and eastern portions of the watershed.

The Clearwater River Watershed TMDL addresses 44 impairments of aquatic life and recreation that have been found within 27 stream reaches and 3 lakes within the watershed. There are 14 aquatic consumption impairments for mercury in fish tissue found in 10 stream reaches and 4 lakes that are not addressed in this TMDL. Total suspended solids (TSS) impairments were found in five reaches of the Clearwater River and Nassett Creek. Aquatic life impairments due to low dissolved oxygen (DO) levels have been identified in 10 reaches of tributaries of the Clearwater River. Low index of biological integrity (IBI) scores have resulted in macroinvertebrate IBI (M-IBI) impairment designations for 3 reaches and fish IBI (F-IBI) impairments for 7 stream reaches within the Clearwater River Watershed. A river eutrophication impairment was identified in one reach of the Clearwater River. Impairments of recreational safety due to chronically high concentrations of *Escherichia coli* (*E. coli*) bacteria have been found along 15 reaches of the Clearwater River and its tributaries. Aquatic recreation is impaired by eutrophication (excess nutrients) in 3 lakes.

This report includes 24 total TMDLs. It recommends strategies for reducing nonpoint contributions of TSS using various erosion control strategies and best management practices (BMPs). Sources of *E. coli* pollution have been identified and described in this report along with strategies for addressing those sources. This report summarizes the causes of biological impairments that were identified by the

Clearwater River Watershed Stressor Identification (SID) Report. No pollutant-based stressors were found to be the cause of the biological or DO impairments, therefore no TMDL s were completed for these impairments. Recommendations are also given for the improvement of DO levels and the quality of aquatic life. The low DO levels that are caused by insufficient base flow or natural features of the landscape are a common stressor for aquatic biology and DO within biologically-impaired streams. Fish passage restrictions also limit F-IBI scores within some reaches.

TMDLs were calculated for reaches that were impaired by quantifiable pollutants. TSS and *E. coli* loading capacities and allocations were calculated using the load duration curve (LDC) method. TSS wasteload allocations (WLAs) were calculated for wastewater treatment facilities (WWTFs) that discharge to impaired waters. Recommended load reductions were calculated for sites with concurrent flow and sampling data.

As part of the concurrent Watershed Restoration and Protection Strategy (WRAPS) and TMDL project, efforts were made to inform and involve the public and local governmental units (LGUs) throughout the project. Past civic engagement efforts and plans for ongoing efforts are described in this document. There has been substantial cooperation among state and local agencies for project implementation and monitoring.

1. Project Overview

1.1 Purpose

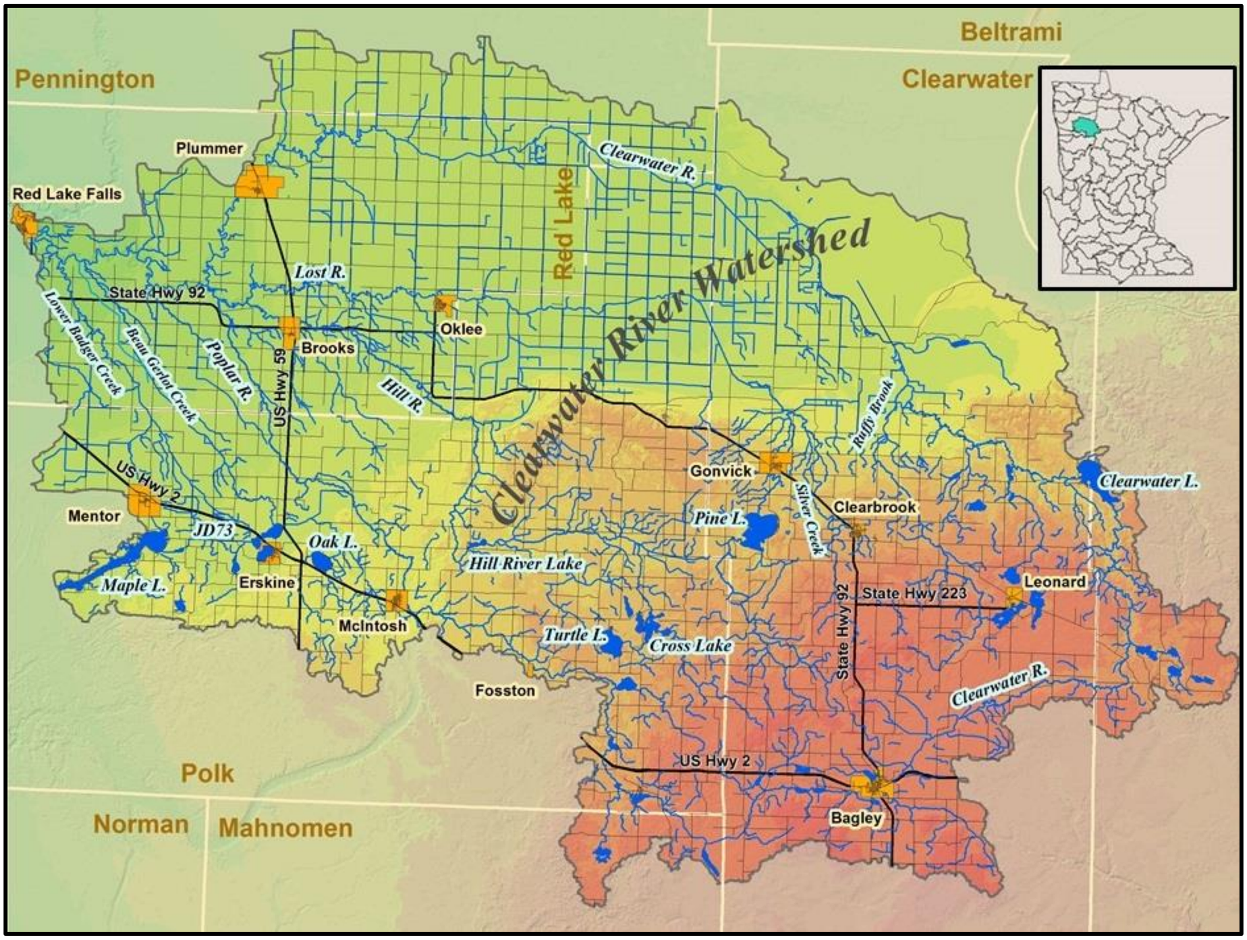


Figure 1-1. Clearwater River Watershed overview map.

This report establishes TMDLs for rivers, streams, lakes, and ditches in the Clearwater River Watershed (Figure 1-1) that are listed as impaired on the CWA 303(d) List of Impaired Waters. A TMDL is defined as the maximum quantity of a pollutant that a water body can receive while meeting the water quality standards for the protection of aquatic life and recreation. Impairments include high turbidity levels, high TSS concentrations, high *E. coli* levels, low DO levels, low IBI scores, and lake eutrophication. Portions of this watershed contain tribal land of the Red Lake and White Earth Nations; however, TMDLs in this report do not apply within the jurisdiction of those tribal nations, and meeting the goals of the TMDL is not dependent upon obtaining reductions from those portions of the water shed within those tribal nation jurisdictions. This report also characterizes features of the watershed, identifies sources of pollutants and stressors that are causing the impairments, and makes recommendations for future monitoring efforts. Intensive monitoring and stressor identification (SID) determined that DO and biological impairments in this watershed were linked to physical characteristics of waterways rather than pollutants. As a result, TMDLs were not completed on those impairments; however, the SID determinations are described in detail within this document.

In 2006, Minnesota passed the Clean Water Legacy Act (CWLA) to protect, restore, and preserve the quality of Minnesota's surface waters. As a result, the MPCA established a watershed approach for monitoring, assessment, and the development of TMDLs. One component of that work is the development of a watershed wide TMDL report for the impaired waterbodies within each watershed. This report is intended to fulfill the TMDL requirement. The watershed approach also includes the creation of a WRAPS report that summarizes watershed modeling outputs, identifies areas with high pollutant-loading rates, and suggests strategies for improving habitat (physical features of the streams) and protecting good quality waters. In addition, the CWLA requires including strategies that are capable of cumulatively achieving needed pollution load reductions for point and nonpoint pollutant sources. This information is to be used to inform local water planning and implementation.

This TMDL and the Clearwater River WRAPS provide technical information and strategies for achieving needed pollutant load reductions that will be incorporated into a future Clearwater River One Watershed One Plan (1W1P) document that will begin to be developed in 2021. The Clearwater River TMDL and WRAPS documents utilize data and information that was collected throughout a long history of water monitoring in the watershed. Past studies like the Clearwater River Nonpoint Study, the Clearwater River DO and Fecal Coliform TMDL, and recent intensive watershed monitoring add to the robust dataset that has been generated through multiple long-term monitoring programs that are active in the watershed.

1.2 Identification of Waterbodies

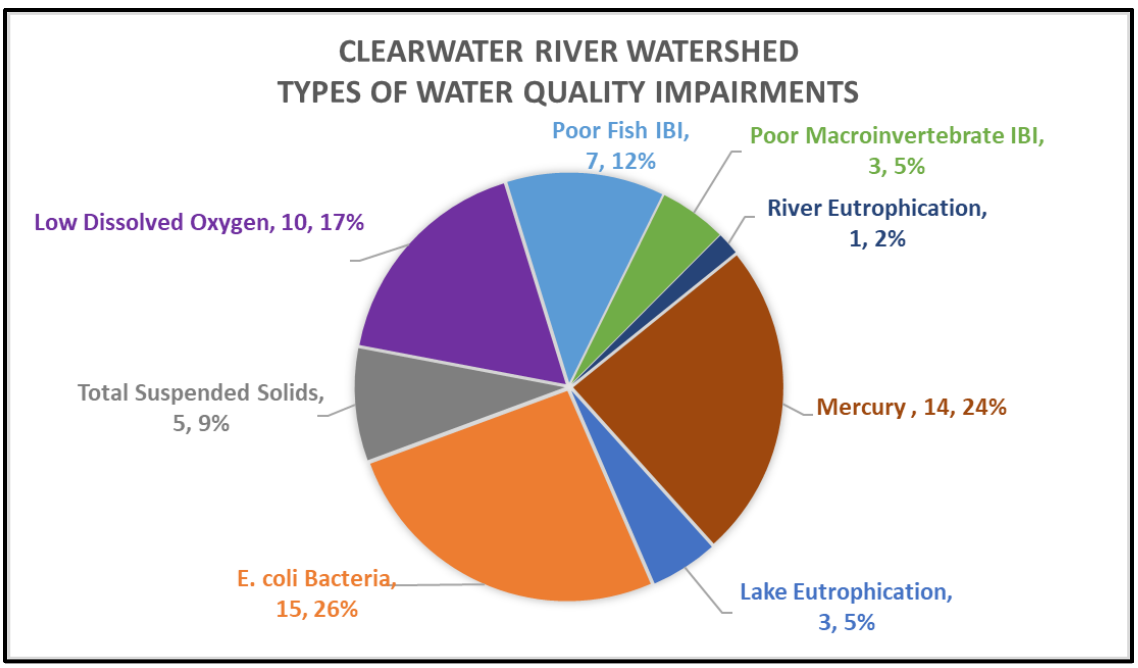


Figure 1-2. Chart of types of water quality impairments identified in the Clearwater River Watershed

A total of 36 rivers, streams, and ditches were assessed for at least one designated use during the 2016 assessment using data that was collected from 2006 through 2015. A total of 31 lakes were assessed for aquatic life, aquatic recreation, or both. The primary measurements and pollutants of concern within this watershed were *E. coli* bacteria, TSS, DO, lake eutrophication (TP, chlorophyll-a [chl-*a*], Secchi depth), river eutrophication (TP, BOD, DO flux, chl-*a*), F-IBI, M-IBI, un-ionized ammonia, and mercury. After the 2016 assessment was completed and the 2018 List of Impaired Waters was published, there were a total of 44 aquatic life and aquatic recreation impairments in the Clearwater River Watershed within 32 waterbodies. Those impairments are listed in Table 1-1 and shown in Figure 1-4. TMDLs were developed on a total of 24 pollutant-based impairments on 21 waterbodies. Three of those waterbodies are lakes and 18 are rivers, streams, or ditches. The most common impairment was *E. coli* bacteria (Figure 1-2). Much of the main channel of the Clearwater River (shown in the Figure 1-3 photo), between Ruffy Brook and the Red Lake River, was impaired by high TSS. The only Assessment Unit ID (AUID; 09020305-519) not determined to be impaired was along the lower reach of the Clearwater River, and was not assessed because it had no monitoring data due to a lack of access or crossings.

Each IBI and DO impairment was carefully investigated to identify the primary causes of the impairments during the SID process. The primary causes in the Clearwater River DO and IBI impairments were physical features of the channel and drainage area, and not excess pollutants. Because there were no cases in which excess pollutants were causing a DO or IBI impairment, no TMDLs were calculated to address those impairments. The IBI stressors are summarized and causes of low DO are described in this document. Most of the IBI impairments were significantly affected by low DO.

Six AUIDs along the main channel of the Clearwater River and one lake (Pine Lake) are impaired by mercury. Mercury impairment were not addressed by this TMDL because they have already been addressed by a statewide mercury TMDL that was approved by the EPA in 2007: https://www.pca.state.mn.us/sites/default/files/wq-iw4-01b.pdf.

Figure 1-3. Photo of Clearwater River in Red Lake Falls (AUID 501) (Station ID S002-118)

Table 1-1. Impaired waters in the Clearwater River Watershed

Clearwater River Watershed (09020305) Rivers, Streams, and Ditches on the Draft 2020 303(d) List of Impaired Waters								
Affected Use: Pollutant/Stressor	**Assessment Unit ID**	**Stream or Lake Name**	**Location/Reach Description**	**Designated Use Class**	**HUC-10 Subwatershed**	**Year Listed**	**Target Start/ Completion**	**Addressed in This TMDL?**
Aquatic Recreation: *Escherichia coli* Bacteria	09020305-502	Lower Badger Creek	CD 14 to Clearwater River	2B, 3C	0902030506	2018	2016/2019	Yes
	09020305-504	Poplar River	Highway 59 to Lost River	2B, 3C	0902030504	2018	2016/2019	Yes
	09020305-512	Lost River	Pine Lake to Anderson Lake	2B, 3C	0902030505	2018	2016/2019	Yes
	09020305-513	Ruffy Brook	Headwaters to Clearwater River	2B, 3C	0902030502	2008	2014/2019	Yes
	09020305-526	Unnamed Creek (Clear Brook)	Headwaters to Silver Creek	2B, 3C	0902030505	2018	2016/2019	Yes
	09020305-527	Silver Creek	Headwaters to Anderson Lake	2B, 3C	0902030505	2006	2014/2019	Yes
	09020305-529	Lost River	T148 R38W S17, south line to Pine Lake	2B, 3C	0902030505	2018	2016/2019	Yes
	09020305-530	Lost River	Unnamed Creek to T148 R38W S20, north line	1B, 2Ag, 3B	0902030505	2018	2016/2019	Yes
	09020305-539	Hill River	Hill River Lake to Lost River	2B, 3C	0902030503	2018	2016/2019	Yes
	09020305-545	Unnamed Creek (Nassett Creek)	T148 R38W S28, south line to Lost River	1B, 2Ag, 3B	0902030505	2018	2016/2019	Yes
	09020305-550	Judicial Ditch 73	Unnamed ditch (Near 187th Ave SE) to Tamarack Lake	2B, 3C	0902030506	2018	2016/2019	Yes
	09020305-574	Terrebonne Creek	CD 4 to CD 58	2B, 3C	0902030507	2010	2014/2019	Yes
	09020305-578	Brooks Creek	Unnamed creek to Hill River	2B, 3C	0902030503	2018	2016/2019	Yes
	09020305-647	Clearwater River	Ruffy Brook to JD 1	2B, 3C	0902030502	2018	2016/2019	Yes
	09020305-651	Beau Gerlot Creek	Upper Badger Creek to -96.1947 47.8413	2B, 3C	0902030507	2018	2016/2019	Yes
Aquatic Recreation: Nutrient/ Eutrophication Biological Indicators (Phosphorus)	04-0295-00	Long Lake	85-acre lake, 2 miles north of Pinewood	2B, 3C	0902030501	2018	2016/2019	Yes
	15-0156-00	Stony Lake	67-acre lake, 4 miles south of Gonvick	2B, 3C	0902030505	2018	2016/2019	Yes
	60-0189-00	Cameron Lake	226-acre lake, in Erskine	2B, 3C	0902030506	2018	2016/2019	Yes
Aquatic Life: Total Suspended Solids/Turbidity	09020305-501	Clearwater River	Lower Badger Creek to Red Lake River	2B, 3C	0902030507	2006	2014/2019	Yes
	09020305-511	Clearwater River	Lost River to Beau Gerlot Creek	2B, 3C	0902030507	2008	2014/2019	Yes
	09020305-545	Unnamed Creek (Nassett Creek)	T148 R38W S28, south line to Lost River	1B, 2Ag, 3B	0902030505	2018	2016/2019	Yes
	09020305-647	Clearwater River	Ruffy Brook to JD 1	2B, 3C	0902030502	2008	2014/2019	Yes
	09020305-648	Clearwater River	JD1 to Lost River	2B, 3C	0902030502	2008	2014/2019	Yes

Clearwater River Watershed (09020305) Rivers, Streams, and Ditches on the Draft 2020 303(d) List of Impaired Waters								
Affected Use: Pollutant/Stressor	**Assessment Unit ID**	**Stream or Lake Name**	**Location/Reach Description**	**Designated Use Class**	**HUC-10 Subwatershed**	**Year Listed**	**Target Start/ Completion**	**Addressed in This TMDL?**
Aquatic Life: **Low Dissolved Oxygen**	09020305-509	Walker Brook	Walker Brook L to Clearwater River	2B, 3C	0902030501	2002	2014/2019	No+
	09020305-517#	Clearwater River	Headwaters to T148 R36W S36, east line	2B, 3C	0902030501	2006	2014/2019	No***
	09020305-518	Poplar River	Spring Lake to Highway 59	2B, 3C	0902030504	2002	2014/2019	No***
	09020305-526	Unnamed Creek (Clear Brook)	Headwaters to Silver Creek	2B, 3C	0902030505	2018	2016/2019	No***
	09020305-529	Lost River	T148 R38W S17, south line to Pine Lake	2B, 3C	0902030505	2006	2014/2019	No***
	09020305-543	Poplar R Diversion	Unnamed ditch to Badger Lake	2B, 3C	0902030506	2006	2014/2019	No^
	09020305-545	Unnamed Creek (Nassett Creek)	T148 R38W S28, south line to Lost River	1B, 2Ag, 3B	0902030505	2018	2016/2019	No***
	09020305-550	Judicial Ditch 73	Unnamed ditch (Near 187th Ave SE) to Tamarack Lake	2B, 3C	0902030506	2018	2016/2019	No***
	09020305-645	Lost River	Anderson Lake to unnamed creek	2B, 3C	0902030505	2018	2016/2019	No***
	09020305-656	Hill River	Unnamed creek to Hill River Lake	2B, 3C	0902030503	2018	2016/2019	No***
Aquatic Life: **Poor Fish Index of Biological Integrity**	09020305-518	Poplar River	Spring Lake to Highway 59	2B, 3C	0902030504	2018	2016/2019	No***
	09020305-539	Hill River	Hill River Lake to Lost River	2B, 3C	0902030503	2018	2016/2019	No***
	09020305-561	Unnamed Creek (Trib to Poplar River Div.)	Gerdin Lake to Poplar River Diversion	2B, 3C	0902030506	2018	2016/2019	No***
	09020305-645	Lost River	Anderson Lake to unnamed creek	2B, 3C	0902030505	2018	2016/2019	No***
	09020305-652	Beau Gerlot Creek	-96.1947 47.8413 to Clearwater River	2B, 3C	0902030507	2018	2016/2019	No***
	09020305-656	Hill River	Unnamed creek to Hill River Lake	2B, 3C	0902030503	2018	2016/2019	No***
	09020305-658	(Red Lake) County Ditch 23	-96.1479 47.8855 to Clearwater River	2B, 3C	0902030507	2018	2016/2019	No***
Aquatic Life: **Poor Aquatic Macroinvertebrate Index of Biological Integrity**	09020305-518	Poplar River	Spring Lake to Highway 59	2B, 3C	0902030504	2018	2016/2019	No***
	09020305-527	Silver Creek	Headwaters to Anderson Lake	2B, 3C	0902030505	2018	2016/2019	No***
	09020305-652	Beau Gerlot Creek	-96.1947 47.8413 to Clearwater River	2B, 3C	0902030507	2018	2016/2019	No***

Clearwater River Watershed (09020305) Rivers, Streams, and Ditches on the Draft 2020 303(d) List of Impaired Waters								
Affected Use: Pollutant/Stressor	**Assessment Unit ID**	**Stream or Lake Name**	**Location/Reach Description**	**Designated Use Class**	**HUC-10 Subwatershed**	**Year Listed**	**Target Start/ Completion**	**Addressed in This TMDL?**
Aquatic Life: **Nutrient/Eutrophication Biological Indicators (Phosphorus)**	09020305-647	Clearwater River	Ruffy Brook to JD 1	2B, 3C	0902030502	2018	2016/2019	Yes
Aquatic Consumption: Mercury in Fish Tissue	04-0343-00	Clearwater Lake	997-acre lake, 2 miles west of Debs	2B, 3C	0902030501	1998	2007/2008	No*
	15-0081-00	Lake Lomond	93-acre lake at Bagley	2B, 3C	0902030501	1998	2007/2008	No*
	15-0149-00	Pine Lake	1240-acre lake, 2.5 miles south of Gonvick	2B, 3C	0902030505	2006	2008/2021	No*
	60-0305-00	Maple Lake	1582-acre lake, 1 mile south of Mentor	2B, 3C	0902030506	1998	2007/2008	No*
	09020305-501	Clearwater River	Lower Badger Creek to Red Lake River	2B, 3C	0902030507	1998	2007/2008	No*
	09020305-511	Clearwater River	Lost River to Beau Gerlot Creek	2B, 3C	0902030507	1998	2007/2008	No*
	09020305-517#	Clearwater River	Headwaters to T148 R36W S36 E line	2B, 3C	0902030501	1998	2007/2008	No*
	09020305-519	Clearwater River	Beau Gerlot Creek to Lower Badger Creek	2B, 3C	0902030507	2004	2007/2008	No*
	09020305-647	Clearwater River	Ruffy Brook to JD 1	2B, 3C	0902030502	1998	2007/2008	No*
	09020305-648	Clearwater River	JD 1 to Lost River	2B, 3C	0902030502	1998	2007/2008	No*
	09020305-649	Clearwater River	Clearwater Lake to Unnamed Creek	2B, 3C	0902030501	1998	2007/2008	No*
	09020305-650	Clearwater River	Unnamed creek to Ruffy Brook	2B, 3C	0902030502	1998	2007/2008	No*
	09020305-653	Clearwater River	T148 R35W S31, west line to unnamed creek	1B, 2Ag, 3B	0902030501	1998	2007/2008	No*
	09020305-654	Clearwater River	Unnamed creek to Clearwater Lake	1B, 2Ag, 3B	0902030501	1998	2007/2008	No*

*Mercury impairments have been addressed by a statewide mercury TMDL that was approved by the EPA in 2007: https://www.pca.state.mn.us/sites/default/files/wq-iw4-01b.pdf

***An examination of data and physical features of the watercourse's drainage area revealed that the impairment is either caused by non-pollutant factors and a change to category 4C will be requested, or additional monitoring data is recommended.

+EPA category changed from 5 to 4D. AUID was removed from the Draft 2020 List of Impaired Waters

^EPA category changed from 5 to 4C. AUID will remain on the Draft 2020 List of Impaired Waters, but a TMDL is not required.

Waters that are partially within Tribal lands.

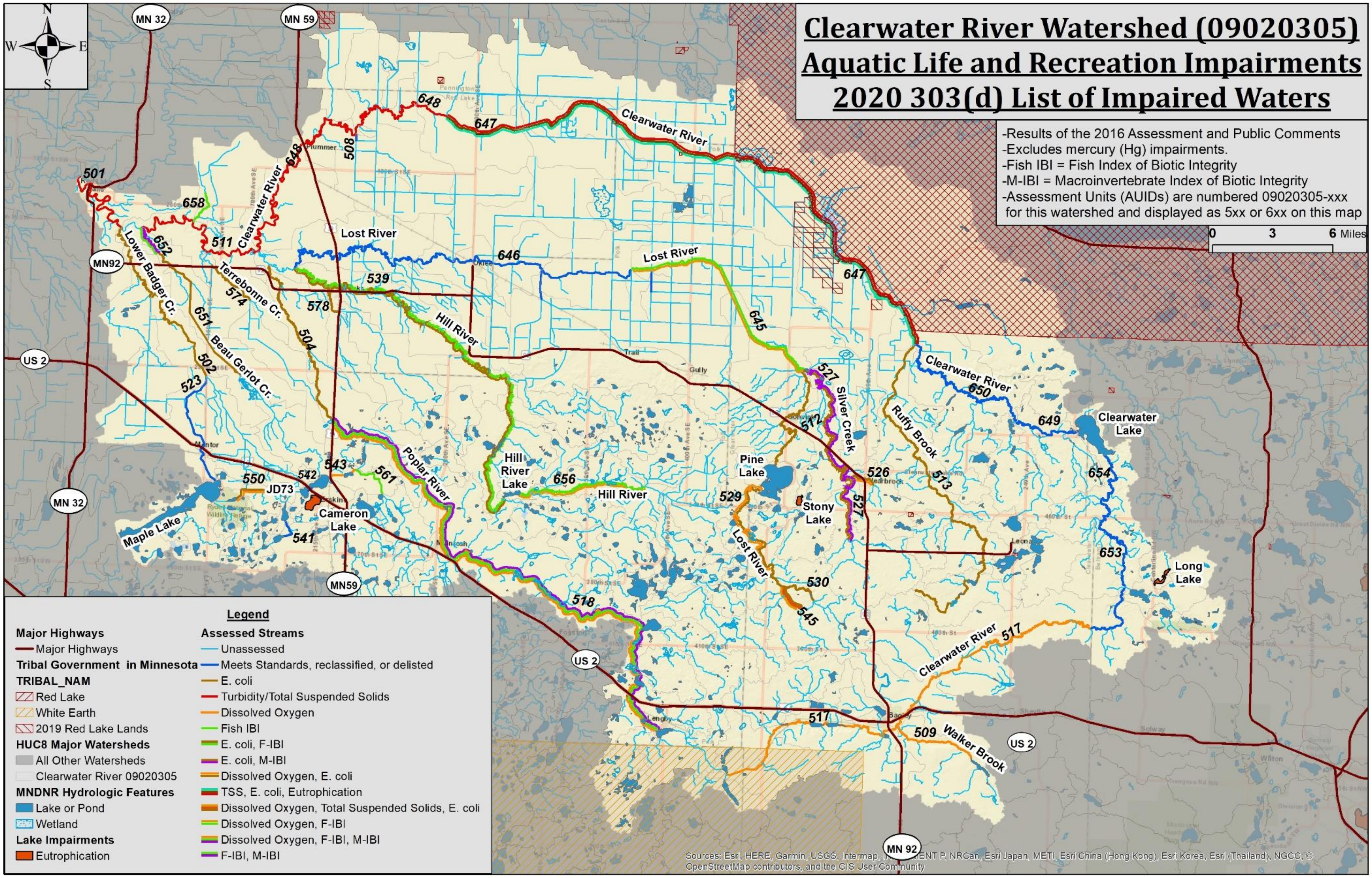


Figure 1-4. Impaired waters in the Clearwater River Watershed map

1.3 Priority Ranking

The MPCA's schedule for TMDL completions, as indicated on the CWA Section 303(d) impaired waters list, reflects Minnesota's priority ranking of this TMDL. The MPCA has aligned TMDL priorities with the watershed approach and WRAPS cycle. The schedule for TMDL completion corresponds to the WRAPS report completion following on the initial 10-year monitoring 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, which will be addressed by TMDLs by 2022. The Clearwater River Watershed waters addressed by this TMDL are part of that MPCA prioritization plan to meet the EPA's national measure.

2. Applicable Water Quality Standards and Numeric Water Quality Targets

This section describes the applicable water quality standards as they are described within the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) report and 303(d) List. Standards are summarized in Tables 2-1, 2-2 and 2-3. DO and *E. coli* standards are consistent throughout the watershed. The F-IBI and M-IBI impairment thresholds for individual reaches vary with TALU classifications. Water chemistry standards for the protection of aquatic life are different for each River Nutrient Region. Lake water quality expectations vary with ecoregion and maximum depth.

Table 2-1. Applicable water chemistry standards

Parameter	Use Class	Water Quality Standard	Criteria	Standard's Applicable Time Period
Total Suspended Solids – Trout Streams	2A	Not to exceed 10 mg/L	Maximum = 10% of Samples	April 1 – September 30
Total Suspended Solids – North River Nutrient Region	1C, 2B, 2Bd, 2Bg, 3C	Not to exceed 15 mg/l	Maximum = 10% of Samples	April 1 – September 30
Total Suspended Solids – Central River Nutrient Region	1C, 2B, 2Bd, 2Bg, 3C	Not to exceed 30 mg/l	Maximum = 10% of Samples	April 1 – September 30
Dissolved Oxygen	2B, 2Bd	Daily minimum of 5 mg/l	>90% of daily minimums need to exceed the standard	Open Water Months
Escherichia Coli	2A, 2B, 2Bd, 2C, 2D	126 Organisms per 100 ml*	Maximum Monthly Geometric Mean	April 1 – October 31
Escherichia Coli	2A, 2B, 2Bd, 2C, 2D	1,260 Organisms per 100 ml**	Maximum = 10% of Samples	April 1 – October 31

* Not to be exceeded as the geometric mean of not less than 5 samples in a calendar month.
** Not to be exceeded by 10% of all samples taken in a calendar month, individually.

Table 2-2. Applicable eutrophication standards for impaired rivers and lakes in the Clearwater River Watershed

Water Quality Characteristic	Region	Applicable Time Period	Criteria	TP Standard	Response Variables			
					chl-a	Secchi Disk	Diel DO Flux	BOD
River Eutrophication	Central River Nutrient Region	June 1 – September 30	Summer Average	100 µg/L	18 µg/L		3.5 mg/L	2.0 mg/L
Lake Eutrophication (Cameron and Stony Lakes)	North Central Hardwood Forest, Shallow Lakes (Class 2B)	June 1 – September 30	Summer average	60 µg/L	20 µg/L	1.0 m		
Lake Eutrophication (Long Lake)	Northern Lakes and Forests (Class 2B)	June 1 – September 30	Summer average	30 µg/L	9 µg/L	2.0 m		

2.1 Dissolved Oxygen

DO is required for essentially all aquatic organisms to live. When DO drops below acceptable levels, desirable aquatic organisms like fish and macroinvertebrates can be killed, harmed or displaced to higher DO reaches. Applied DO standards differ depending on the use class of the water. A 5 mg/L standard applies to all impaired waters in this watershed:

Class 2Bd, 2B, 2C. Not less than 5 mg/L as a daily minimum

The standard for DO is expressed as daily minimums and concentrations generally follow a diurnal cycle with lowest concentrations occurring in the absence of sunlight (i.e., overnight). Consequently, measurements in open-water months (April through November) should be made before 9:00 a.m.

A stream is considered impaired if:

1. More than 10% of the 'suitable' (taken before 9:00 a.m.) May through September measurements violate the standard and there are at least three such violations, or
2. More than 10% of the total May through September measurements violate the standard and there are at least three such violations, or
3. More than 10% of the total annual measurements violate the standard and there are at least three such violations.

Because the underlying criterion is that water quality standards can be exceeded no more than 10% of the relevant time, it is usually essential that measurements are a representative sample of overall water quality and are not biased towards certain types of conditions, such as storm events or certain times of the year. The relevant time generally refers not to the entire year, but rather to the usual water quality monitoring portion of the year. The requirement of at least three exceedances helps ensure that the measured data set is sufficiently large to provide an adequate picture of overall conditions.

In spite of the significant water quality improvements that have resulted from application of the DO standard, the current standard is not necessarily appropriate for all streams. Some low-gradient, heavily wetland-influenced streams may never meet the current DO standard of 5 mg/L, even though pollutant sources and anthropogenic influences are insignificant or even non-existent. In such cases, the current DO standard is not a useful indicator of the health of the water.

Until the DO standard is refined to fit such situations, the following will apply:

- AUIDs where all monitoring sites have wetland characteristics significant enough to preclude the use of the current DO standard as well as current biological criteria will be designated as 'not assessable' for aquatic life. The following statement will be used in the documentation: *Not assessed; the waterbody exhibits prevailing wetland characteristics. Assessment is deferred pending refinement of the assessment criteria or reclassification of the waterbody.* Where appropriate, some such waters will subsequently be moved into class 2D during the use-attainability review of the watershed.
- AUIDs where all monitoring sites have wetland influences significant enough to preclude the use of the current DO standard but which are assessable using biological criteria will be designated as 'not assessable' for DO. The following statement will be used in the documentation: *Not assessed for dissolved oxygen; the current standard of 5.0 mg/L is not a reliable indicator of the health of this type of heavily wetland influenced stream. Assessment for dissolved oxygen is deferred pending refinement of the assessment criteria.* (Individual monitoring sites within AUIDs can likewise be determined to be not assessable for DO because of wetland influences.)

A designation of 'full support' for DO generally requires at least 20 suitable measurements from a set of monitoring data that give a representative, unbiased picture of DO levels over at least two different years. However, if it is determined the data set adequately targets periods and conditions when DO exceedances are most likely to occur, a smaller number of measurements may suffice for a determination of 'full support'.

2.2 Total Suspended Solids

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

Applicable standards for TSS were used for the calculation of loading capacity (LC), allocations, and reductions to address TSS and turbidity impairments. Turbidity is an optical property of water useful for on-the-spot assessment of water quality conditions but needs to be converted to another parameter such as TSS in order to be used. With the adoption of the TSS standard, the state no longer applies the turbidity standard during official water quality assessments.

A stream is considered to exceed the standard for TSS if:

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

A stream is considered to meet the standard for TSS if the standard is met at least 90% of the days of the asssessment season. A designation of 'meeting the standard' for TSS generally requires at least 20 suitable measurements from a data set that gives an unbiased representation of conditions over at least two different years. However, if it is determined the data set adequately targets periods and conditions when exceedances are most likley to occur, a smaller number of measurements may suffice.

The applicable TSS standard varies by River Nutrient Region and stream classification, as noted in Table 2-1. The impaired portions of the Clearwater River are subject to the 30 mg/L standard for streams in the Central River Nutrient Region. Nassett Creek is a designated trout stream and is requried to meet the 10 mg/L standard for Class 2A waters.

2.3 *Escherichia coli*

The numeric standards in Minn. R. ch. 7050 (Waters of the State), that directly protect for primary (swimming and other recreation where immersion and inadvertently ingesting water is likely) and secondary (boating and wading where the likelihood of ingesting water is much smaller) body contact are the *E. coli* standards shown in Table 2-1. *E. coli* standards are applicable only during the warm months since there is very little swimming in Minnesota in the non-summer months. Exceedances of the *E. coli* standard mean that the recreational use is not being met.

The MPCA uses an *E. coli* standard based on a geometric mean EPA criterion of 126 *E. coli* colony forming units (cfu) per 100 ml. *E. coli* has been determined by EPA to be the preferred indicator of the potential presence of waterborne pathogens.

There is a considerable amount of *E. coli* data available in Minnesota, and older fecal coliform data. For assessment purposes, only *E. coli* measurements will be used. Exceptions to the exclusive use of *E. coli* data will be made only in special cases, using a ratio of 200 to 126 to convert fecal coliform to *E. coli.*

Data over the full 10-year period are aggregated by individual month (e.g. all April values for all 10 years, all May values, etc.). At least five values for each month is ideal, while a minimum of five values per month for at least three months, preferably between June and September, is necessary to make a determination. Assessment with less than these minimums may be made on a case-by-case basis.

Where multiple bacteria/pathogen samples have been taken on the same day on an assessment unit, the geometric mean of all the measurements will be used for the assessment analysis.

If the geometric mean of the aggregated monthly values for one or more months exceeds 126 organisms per 100 ml, that reach is considered impaired. In addition, a water body is considered impaired if more than 10% of individual values over the 10-year period (independent of month) exceed 1260 organisms per 100 ml. This assessment methodology more closely approximates the five-samples-per-month requirement of the standard while recognizing typical sampling frequencies, which rarely provide five samples in a single month and usually only one.

Expert review of the data provides a further evaluation. When fewer than five values are available for most or all months, the individual data are reviewed. In some circumstances where four values are available for some or all months, a mathematical analysis is done to determine the potential for a monthly geometric mean to exceed the 126 organisms/100ml standard. All assessments are reviewed by the Watershed Assessment Team (WAT) for each watershed.

Considerations in making the impairment determination include the following:

- Dates of sample collection (years and months)
- Variability of data within a month
- Magnitude of exceedances
- 'Remark' codes associated with individual values
- Previous assessments and 303(d) listings

2.4 Biological Indicators (Fish and Macroinvertebrate Indices of Biological Integrity)

Biological indicators (fish and macroinvertebrates in streams) are evaluated during the MPCA assessments. The presence of a healthy, diverse, and reproducing aquatic community is a good indication that the aquatic life beneficial use is being supported by a lake, stream, or wetland. The aquatic community integrates the cumulative impacts of pollutants, habitat alteration, and hydrologic modification on a water body over time. Monitoring the aquatic community, or biological monitoring, is a relatively direct way to assess aquatic life use support. Interpreting aquatic community data is accomplished using an IBI. The IBI incorporates multiple attributes of the aquatic community, called 'metrics', to evaluate a complex biological system. The MPCA developed fish and invertebrate IBIs to assess the aquatic life use of rivers and streams statewide in Minnesota. The impairment thresholds applied to specific AUIDs in the Clearwater River Watershed are shown in Table 2-3.

Table 2-3. Summary of F-IBI standards applied to impaired reaches of the Clearwater River Watershed

Impaired Reach Name (AUID)	Station #	F-IBI Class	F-IBI Score Threshold	M-IBI Class	M-IBI Threshold
Lower Badger Creek (09020305-502)	07RD026	NS(G)	47	Not sampled	Not sampled
	14RD239	NS(G)	47	SRR(G)	37
	14RD237	NS(G)	47	SRR(G)	37
Poplar River (09020305-518)	14RD218	NH(G)	42	SGP(G)	43
	05RD078	NS(G)	47	SGP(G)	43
	14RD216	NS(G)	47	PGP(G)	41
Silver Creek (09020305-527)	14RD235	NH(G)	42	SGP(G)	43
	15EM098	NH(G)	42	SRR(G)	37
	14RD231	NH(G)	42	SRR(G)	37
Hill River (09020305-539)	05RD026	NS(G)	47	SGP(G)	43
	14RD253	NS(G)	47	SGP(G)	43
	14RD221	NS(G)	47	SRR(G)	37
Trib. to the Poplar River Diversion (09020305-561)	14RD243	LG(M)	15	Not Sampled	Not Sampled
Beau Gerlot Creek (09020305-652)	14RD255	NH(G)	42	SRR(G)	37
Hill River (09020305-656)	14RD246	NS(G)	47	SGP(G)	43
County Ditch 23 (09020305-658)	14RD260	NH(G)	42	Not Sampled	Not Sampled

F-IBI Classes:
Low Gradient Streams (LG)
Northern Headwaters (NH)
Northern Streams (NS)

M-IBI Classes:
Prairie Streams-Glide/Pool Habitats (PGP)
Southern Streams-Riffle/Run Habitats (SRR)
Southern Streams-Glide/Pool Habitats (SGP)

TALU Framework Designation: General Use (G), Modified Use (M)

Further interpretation of aquatic community data is provided by an assessment threshold or biocriteria against which an IBI score can be compared. In general, an IBI score above this threshold is indicative of aquatic life use support, while a score below the threshold is indicative of non-support. Currently, Minnesota is using a combination of two similar concepts to set biocriteria: Biological Condition Gradient (BCG) and reference condition. To develop biocriteria protective of the structural and functional health of biological communities, Minnesota used the median of BCG level 4. Communities at the middle of this level can be best characterized as possessing *"overall balanced distribution of all expected major groups; ecosystem functions largely maintained through redundant attributes"* which is in line with the language of the CWA interim goal. This BCG-derived criterion was compared to criteria derived from reference sites to ensure the two approaches were closely aligned in each IBI class. This same BCG process was used to set the threshold for the lake F-IBI classes.

The state officially adopted the Tiered Aquatic Life Use (TALU) framework for assessing aquatic life in 2015. This framework refines Minnesota's single goal for aquatic life into three tiers based on the aquatic life potential for a water body. These tiered uses are Exceptional, General (GU), and Modified (MU). The process for determining the appropriate tier is called a Use Attainability Analysis and is carried out before the assessment process. The actual mechanisms for performing an assessment of TALUs are similar to the current process. The only major difference being the biocriteria threshold.

Each IBI assessment threshold is bracketed by a 90% confidence interval based on the variability of IBI scores obtained at sites sampled multiple times in the same year (i.e., replicates). Confidence intervals account for variability due to natural temporal changes in the community as well as method error. For assessment purposes, sites with IBI scores within the 90% confidence interval are considered 'potentially impaired'. Upon further review of available supporting information, an IBI parameter review may change to 'indicating support' or 'indicating severe impairment' depending on the extent and nature of this additional information.

2.5 Lake Eutrophication

Lakes where total phosphorus (TP) and at least one of the response variables (corrected chl-*a* or Secchi transparency) exceed the standards are considered impaired. The eutrophication standards applied to impaired lakes in this watershed are shown in Table 2-2. In developing the lake nutrient standards for Minnesota lakes (Minn. R. ch. 7050), the MPCA evaluated data from a large cross-section of lakes within each of the state's ecoregions (MPCA 2005). Clear relationships were established between the causal factor (TP) and the response variables (chl-*a* and Secchi transparency). Based on these relationships it is expected that by meeting the phosphorus target in each lake, the chl-*a* and Secchi standards will likewise be met.

Samples must be collected over a minimum of two years. Assessments only use data collected during the months of June through September. Typically, a minimum of 8 individual data points for TP, chl-*a* (corrected for pheophytin), and Secchi are required.

Data used for TP and chl-*a* calculations are limited to those collected from the uppermost three meters of the water column (surface). Data collected from the same lake during the same day are averaged. Daily average values from the most recent 10 years are used to calculate assessment statistics and summer averages. The summer average values are compared to the standards and the assessment is made.

Lakes where TP and at least one of the response variables exceed the standards are considered impaired. For lakes with excellent data quality (two+ years of data) and where all parameters are better than the standards, an assessment of full support is made. Lakes with good quality data (one year of data plus Secchi transparency trends) may be considered for full support assessment as well. In this case, the assessment thresholds have been adjusted by 20% (made more stringent) and lakes with good quality data that meet these thresholds will be considered fully supporting. This modification of the thresholds provides a margin of safety (MOS) to assure that lakes with less data are supporting the beneficial use.

For lakes that do not meet minimum data requirements and use-support cannot be determined, a determination of insufficient data will be made. In some instances, a lake may have good or excellent quality data but only one of the thresholds is exceeded (TP, chl-*a*, or Secchi transparency), while the other two are in compliance with the standards. In this instance, the lake will be considered to have insufficient data to determine impairment.

2.6 River Eutrophication

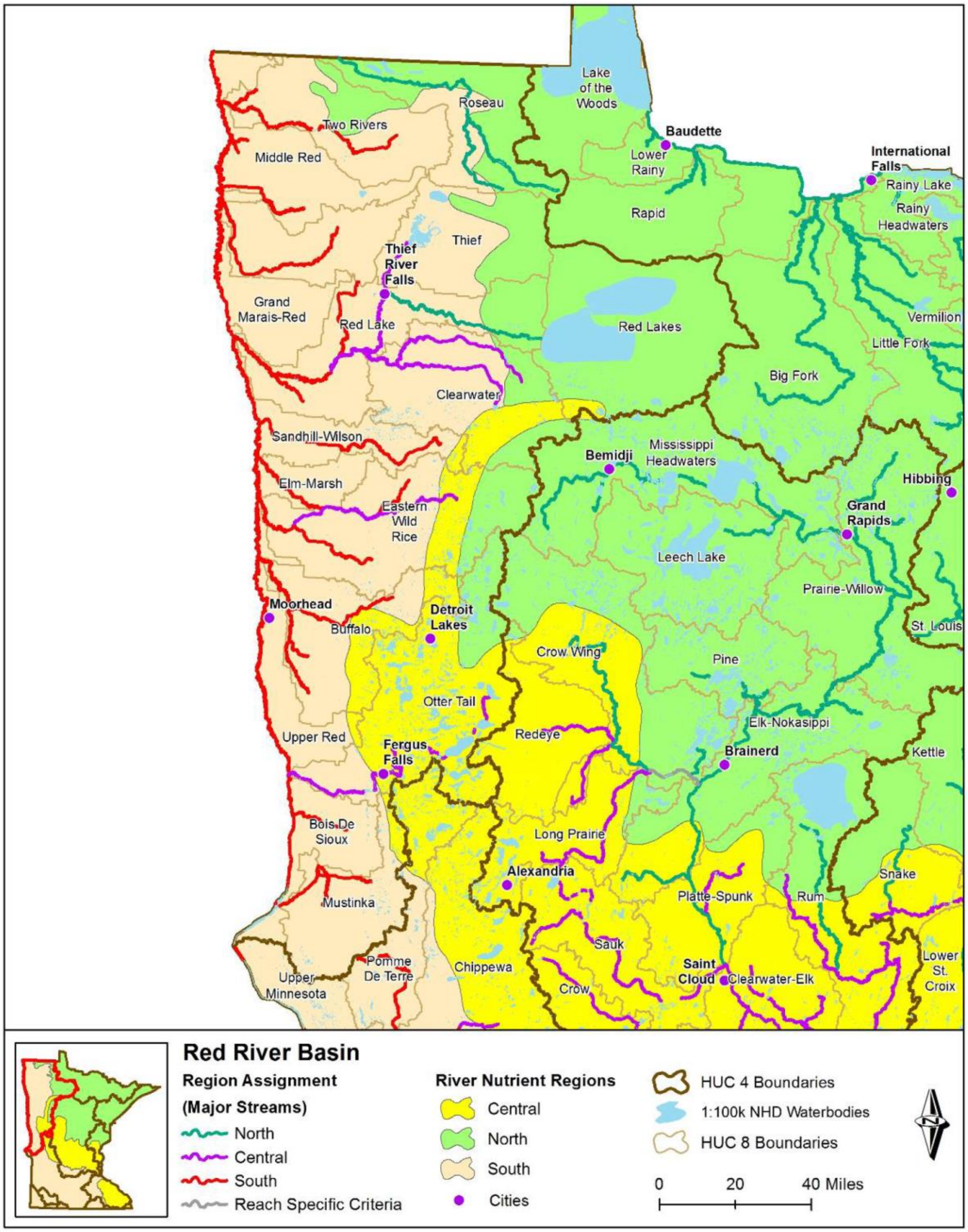


Figure 2-1. Red River Basin river nutrient regions and stream assignments for river eutrophication

The river eutrophication standard is a two-part standard, requiring an exceedance of the causative variable (TP) and a response variable that indicates the presence of eutrophication (i.e. undesirable levels of sestonic or suspended algae, benthic or attached algae, or excessive rooted vegetation). This response can be measured directly with sestonic chl-*a* or indirectly via DO flux (daily fluctuation of DO concentrations in mg/L), 5-day biochemical oxygen demand (BOD), or pH. These measures are highly correlated with each other in rivers and are indicators of stress for aquatic communities. River eutrophication standards vary by river nutrient region (Figure 2-1). The majority of the Clearwater River as well as the Hill, Poplar, and Lost Rivers are assigned the Central Region River Eutrophication standards because those rivers receive significant drainage from the Northern Minnesota Wetlands, Central Hardwood Forests, and Northern Lakes and Forests ecoregions.

For assessment purposes, the cause indicator (TP) and response indicators (chl-*a*, BOD, diel DO flux, or pH) are used in combination and not independently. The eutrophication rule clearly states the requirement that the cause and response indicators must both be exceeded to indicate an impaired condition.

The following data minimums and summarizations apply to the use of TP, chl-*a*, and BOD data:

- A minimum of 12 measurements per parameter within the 10-year assessment period (minimum 2 years required)
- Data compared to the standard is a seasonal average – June to September data only
- If multiple values exist for a parameter along a given reach for a single day, a daily average will be calculated prior to determining a seasonal average

The following data minimums and summarizations apply to the use of DO flux data:

- A minimum of a 4-day deployment is required – June to September
- A minimum of 2 deployments over separate years in the assessment window is required
- It is preferred that the deployments coincide with summers when chemistry is collected, and that the deployment is taken during mid-late summer
- Multiple deployments will be summarized separately

The following data minimums and summarizations apply to the use of DO flux data:

- Existing water quality standards for pH are used for the river eutrophication assessment
- Minimum of 20 samples necessary to indicate standard is met
- Review of data is limited to June to September

A stream is considered to exceed the river eutrophication standard if:

1. The TP concentration exceeds the standard; AND
2. chl-*a*, BOD5, DO Flux, OR pH exceeds the standard

A stream is considered to meet the river eutrophication standard if:

1. The TP concentration meets the standard; AND
2. all available response variables meet the standard (this includes the situation where no response variables are present). Not all response variables must be available to consider the reach to be meeting the river eutrophication standard. It is also possible to determine the reach is meeting the standard if 1) TP exceeds the standard AND all response variables are available in sufficient quantities (chl-*a*, BOD, DO Flux, pH) and they all meet the standard.

A stream is considered to have insufficient information if:

1. There are less than 12 samples of the causative variable OR no response variables meet the minimum data requirements, or
2. The causative and/or response variables are within the standard error of the mean and confidence does not exist in determining whether the reach meets or exceeds the standard.
3. The causative and/or response variables have low data confidence or are not representative of ambient conditions (poor QA/QC, flood or drought biased sampling, proximity to continuously discharging facilities, etc.).

3. Watershed and Waterbody Characterization

3.1 Subwatersheds

The Clearwater River HUC-8 major watershed encompasses seven HUC-10 subwatersheds. The Upper Clearwater River, Middle Clearwater River, Lower Clearwater River, Lost River, Hill River, Poplar River, and Lower Badger Creek HUC-10 subwatersheds are shown in Figure 3-1. The direct and total drainage areas of the impaired AUIDs within the Clearwater River Watershed are listed in Table 3-1.

The Upper Clearwater River Subwatershed encompasses the headwaters of the Clearwater River, the trout stream reach, Clearwater Lake, and the natural portion of the river upstream of the channelized reach. This subwatershed includes many lakes (Clearwater Lake, Buzzle Lake, Little Buzzle Lake, Walker Brook Lake, Long Lake, etc.). Walker Brook joins the Clearwater River in its headwaters near Bagley.

The Middle Clearwater River Subwatershed includes the entirety of the channelized portion (Figure 3-2) of the Clearwater River, Ruffy Brook, and a network of drainage ditches. Wild rice production is a unique feature of the Middle Clearwater River Subwatershed.

The Lower Badger Creek Subwatershed begins in the Erskine area in a series of ditches that bring water into Badger Lake, Mitchell Lake, Judicial Ditch 73 (JD 73), and Maple Lake. Polk County Ditch 14 flows from Maple Lake to Lower Badger Creek. This subwatershed includes many lakes, including the nutrient-impaired Cameron Lake that lies within the headwaters of this subwatershed.

The Poplar River begins at the outlet of Spring Lake near the town of Lengby. It flows northwest to its confluence with the Lost River. It flows near the towns of Fosston and McIntosh and receives treated domestic wastewater discharge from both of those communities. Water quality conditions in the Poplar River are affected, in part, by the varying gradient along the river. The concentration of DO decreases within areas of low gradient but recovers where there is sufficient gradient. The Poplar River Subwatershed includes some lakes, like Spring Lake, Whitefish Lake, and Poplar Lake.

The Hill River Subwatershed begins in the drainage area of Cross Lake and flows west, through Hill River Lake, and into the Lost River near the city of Brooks. Water quality conditions vary throughout the subwatershed. Channelized reaches and low gradient portions of the channel are limiting factors for DO levels and aquatic life. Livestock operations contribute to high *E. coli* concentrations. Water chemistry conditions (DO and TSS levels) improve for aquatic life within the downstream portion of the river.

The Lost River begins in the Pine Lake drainage area. The Pine Lake drainage area also includes Nassett Brook. The Lost River then flows from Pine Lake, through the town of Gonvick, and into Anderson Lake. Silver Creek begins southwest of the town of Clearbrook and also flows into Anderson Lake. The Lost

River then flows out of Anderson Lake and through a channelized reach (RLWD Project 4 drainage system). The river regains a natural channel approximately two miles west of the city of Oklee and continues flowing west to its confluences with the Hill River, Poplar River, and Clearwater River.

The Lower Clearwater River Subwatershed encompasses the Clearwater River, with a natural channel between the channelized reach and the river's confluence with the Red Lake River. The Clearwater River receives drainage from the Lost River (which includes the Hill River and Poplar River subwatersheds) and Lower Badger Creek Subwatersheds as it flows through the Lower Clearwater Subwatershed. This subwatershed also includes smaller tributary streams like Terrebonne Creek, Beau Gerlot Creek, and Red Lake County Ditch 23 (CD 23). The gradient of the Clearwater River increases as it flows between Plummer and Red Lake Falls. Although there is a long stretch without a public access, the river treats paddlers to great scenery, occasional rapids, and a good fishery.

Table 3-1. Drainage areas and related spatial characteristics of impaired streams in the Clearwater River Watershed

AUID 09020303 -XXX	Waterbody	Total Drainage Area (mi^2)	Direct Drainage Area (mi^2)	% of the 1,358.19 mi^2 Clearwater River Watershed	Upstream AUID 09020303-XXX	Monitored Tributary 09020303-XXX	Downstream AUID 09020303-XXX
501	Clearwater River	1358.19	10.28	0.76%	519	502	3-510
502	Lower Badger Creek	122.20	33.72	2.48%	524	523	5-501
504	Poplar River	116.82	16.93	1.25%	518	--	5-505
508	Red Lake County Ditch 57	13.59	0.04	0.00%	--	--	5-648
509	Walker Brook	16.14	10.75	0.79%	15-0060-00*	--	517
511	Clearwater River	1198.30	11.30	0.83%	648	575 (574), 658, 503 (507)	519
512	Lost River	60.13	16.20	1.19%	528	--	5-531
513	Ruffy Brook	54.05	54.05	3.98%	--	--	5-648
517	Clearwater River	116.28	100.14	7.37%	--	509	5-653
518	Poplar River	99.89	90.35	6.65%	60-001-00*	--	5-504
526	Clear Brook	6.24	6.24	0.46%	--	--	5-527
527	Silver Creek	34.37	28.13	2.07%	--	526	5-531
529	Lost River	30.62	10.12	0.75%	530	--	5-528
530	Lost River	20.50	10.18	0.75%	621	545, 624, 621	5-529
539	Hill River	177.23	54.50	4.01%	538	578	5-505
545	Nassett Creek	6.15	3.43	0.25%	--	--	5-530
550	JD73	49.99	1.18	0.09%	561	--	5-558
561	Trib to the Poplar R. Div.	25.56	2.10	0.15%	560	--	543
574	Terrebonne Creek	14.94	3.63	0.27%	576	--	575
578	Brooks Creek	23.56	2.18	0.16%	577	--	539
645	Lost River	151.42	50.10	3.69%	531	--	5-646
647	Clearwater River	488.81	211.18	15.55%	650	513	5-647
648	Clearwater River	569.42	67.02	4.93%	647	508	511
651	Beau Gerlot Creek	24.06	13.42	0.99%	521	--	652
652	Beau Gerlot Creek	26.09	2.03	0.15%	651	--	519
656	Hill River	98.07	56.65	4.17%	655	--	538
658	CD 23	13.49	5.84	0.43%	657	--	511

*Minnesota Department of Natural Resources Lake ID number (AUID for assessment purposes).

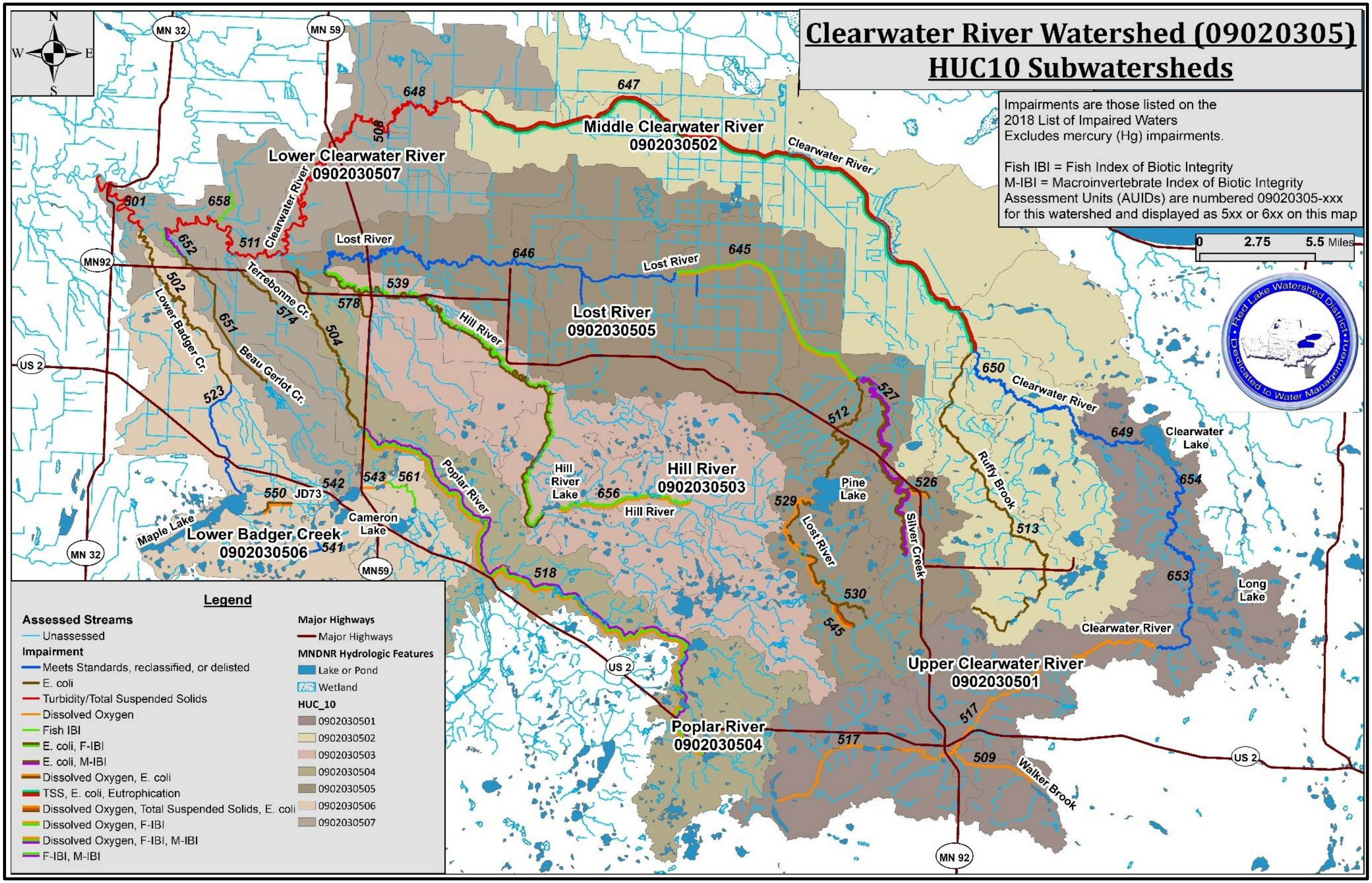


Figure 3-1. Clearwater River Watershed HUC-10 Subwatersheds map

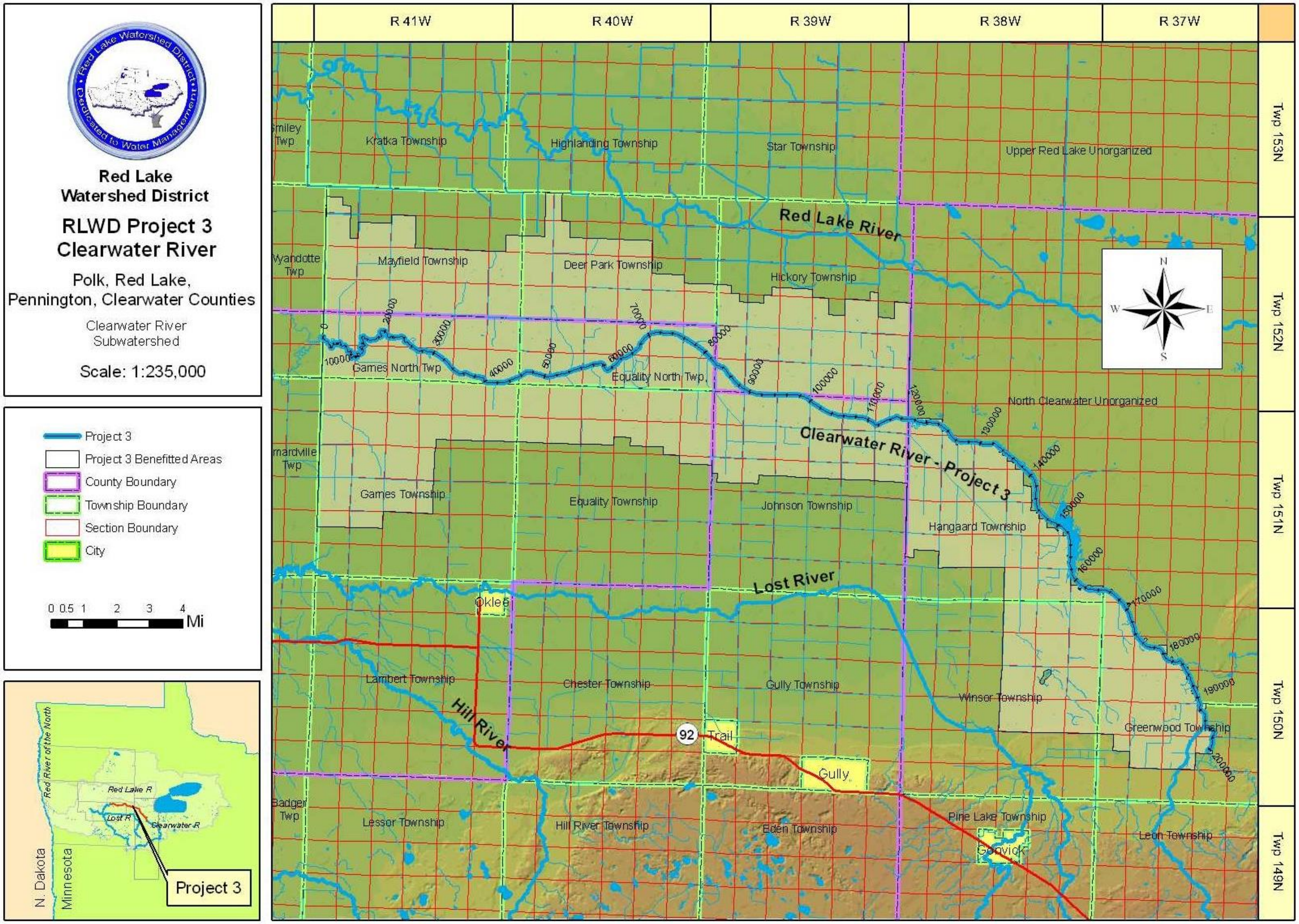


Figure 3-2. Map of the channelized, legal ditch system portion of the Clearwater River (portion of AUID 647)

Tribal Lands in the Clearwater River Watershed

A small portion of Clearwater River Watershed, along its northeastern boundary, lies within the Red Lake Nation (see Figure 1-4 for tribal lands). The Clearwater River is bordered by the Red Lake Nation on its right bank (looking downstream) from a short distance downstream of the Ruffy Brook confluence (roughly in alignment with 550th St) to the eastern border of Pennington County. Butcher Knife Creek is a tributary that flows through tribal land and into the Clearwater River from the east. The Red Lake Nation operates a wild rice farm along the south/west side of the river and owns scattered parcels of land throughout the watershed. There are no impaired waters that are partially or wholly located within the Red Lake Nation.

Another small portion of the watershed, on its southern boundary, is located in the White Earth Nation. The northeast corner of the White Earth Nation is located just south of the city of Lengby and just southwest of the city of Bagley (south of U.S. Highway 2 and west of Minnesota Highway 92). A small portion of the headwaters portion of the Clearwater River (09020303-517), which is impaired by DO lies within the White Earth Nation. A TMDL was not developed for this impairment.

Local stakeholders were invited to participate in the development of this TMDL document as part of a Technical Advisory Committee (TAC). Red Lake Nation and White Earth Nation staff were invited to be part of that TAC. Because there was such a small portion of the watershed that was within the White Earth Nation boundaries, no White Earth Nation staff participated in the development of this TMDL. Red Lake Nation staff were on the TAC, but because there the watershed contained such a small portion of the Red Lake Nation, Red Lake Nation staff had limited participation in the development of this document.

3.2 Lakes

Three lakes in the Clearwater River Watershed (Table 3-2) were identified as having impaired aquatic recreation due to high concentrations of nutrients, high concentrations of chl-*a*, and low Secchi disk transparency depths. All three lakes have relatively small drainage areas and shallow depths. Each lake lies within a headwaters portion of a subwatershed, so the total drainage areas are equal to the direct drainage areas of these lakes.

Table 3-2. Drainage areas and depths of impaired lakes

Lake ID	Waterbody	County	Lake Area (mi^2)	Drainage Area (mi^2)	% of the Clearwater River Watershed Area	Maximum Depth (Feet)	Upstream AUID	Downstream AUID
60-0189-00	Cameron Lake	Polk	0.35	2.02	0.15%	8.5	none	60-0212-00 Mitchell L.
04-0295-00	Long Lake	Beltrami	0.13	4.26	0.31%	17.8*	none	04-0297 Buzzle L.
15-0156-00	Stony Lake	Clearwater	0.10	0.30	0.02%	16**	none	No Outlet

Data source for drainage areas: USGS Stream Stats, https://streamstats.usgs.gov/ss/
*Maximum measured depth in Long Lake
**Estimated maximum depth provided by landowner

Cameron Lake 60-0189-00

Cameron Lake is a small, shallow lake located within the city of Erskine, in the Lower Badger Creek Subwatershed, (Figure 3-3 and Figure 3-4). Cameron Lake has a surface area of 224 aces, maximum depth of 8.5 feet, and littoral area that encompasses the entirety of the lake. The drainage area of the lake is approximately two square miles. There is a public access on the east end of the lake, within the city of Erskine, near the public beach. The eutrophication problem in Cameron Lake is evident in high TP and chl-*a* concentrations. Algal blooms can be severe in Cameron Lake. These blooms form dense mats during the growing season and cause odor, oxygen depletion, and (in extreme cases) potential human and animal health problems. Because of the eutrophication problems, the recreational value of the lake (fishing, swimming, and boating) is currently low. Water quality within Cameron Lake deteriorated to the point that the public beach was diked off from the rest of the lake and filled with city water. Blue-green algae and low levels of algal toxins were found in the lake during the summer of 2018. Fish in the lake are vulnerable to winterkill due to the shallow depth. In the most recent fishery survey (1989), a single bluegill was the only fish other than bullheads found in the lake.

Figure 3-3. Photo of Cameron Lake, looking northeast toward Erskine

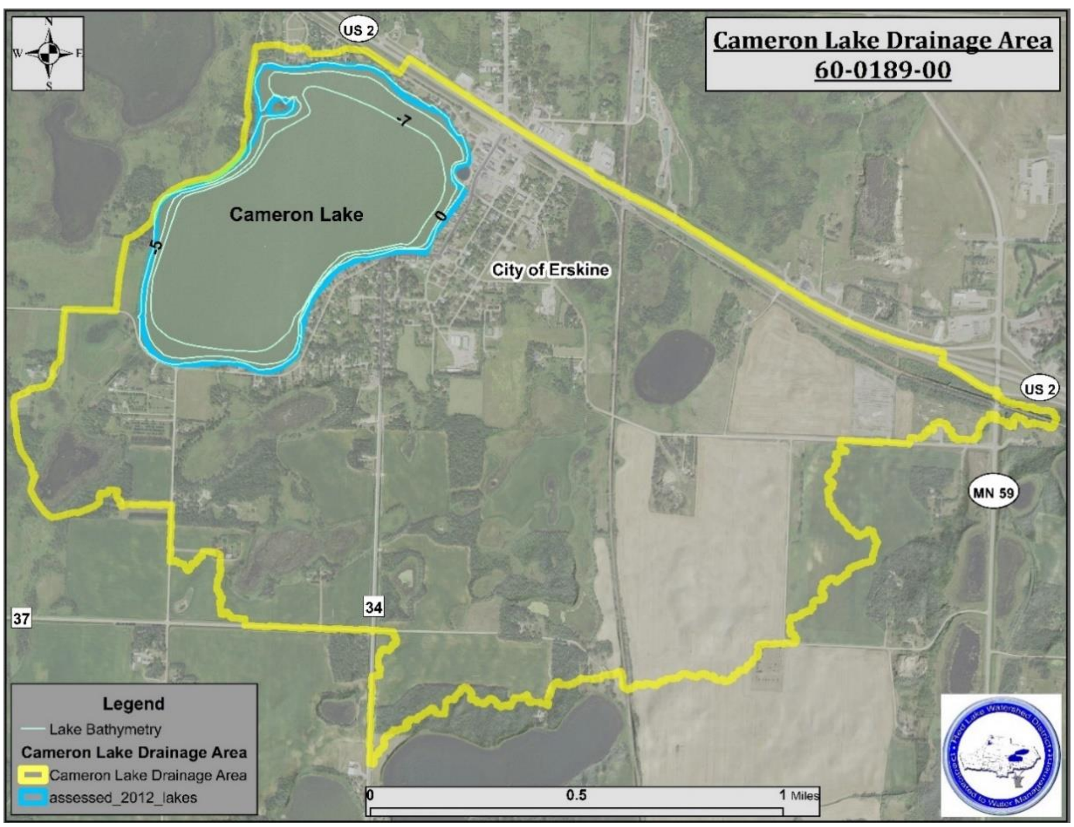


Figure 3-4. Map of the drainage area of Cameron Lake

Long Lake (04-0295-00)

Long Lake is a 96-acre lake with a drainage area of approximately 4.34 square miles (according to USGS StreamStats, Figure 3-6) located in the Upper Clearwater River Subwatershed, north of Pinewood, Minnesota in Buzzle Township and Beltrami County. Drainage from Long Lake flows through Buzzle Lake, and into the Clearwater River. There is relatively little development in the watershed of this lake. Bathymetry of the lake has not been mapped, so the maximum depth is not known for certain. According to a landowner, the lake gets about 25 feet in the southwest portion, but is shallower (less than 10 feet) in the northeast portion of the lake.

Figure 3-5. Photo of a former cattle farm on Long Lake, looking northeast from sampling station 04-0295-00-201

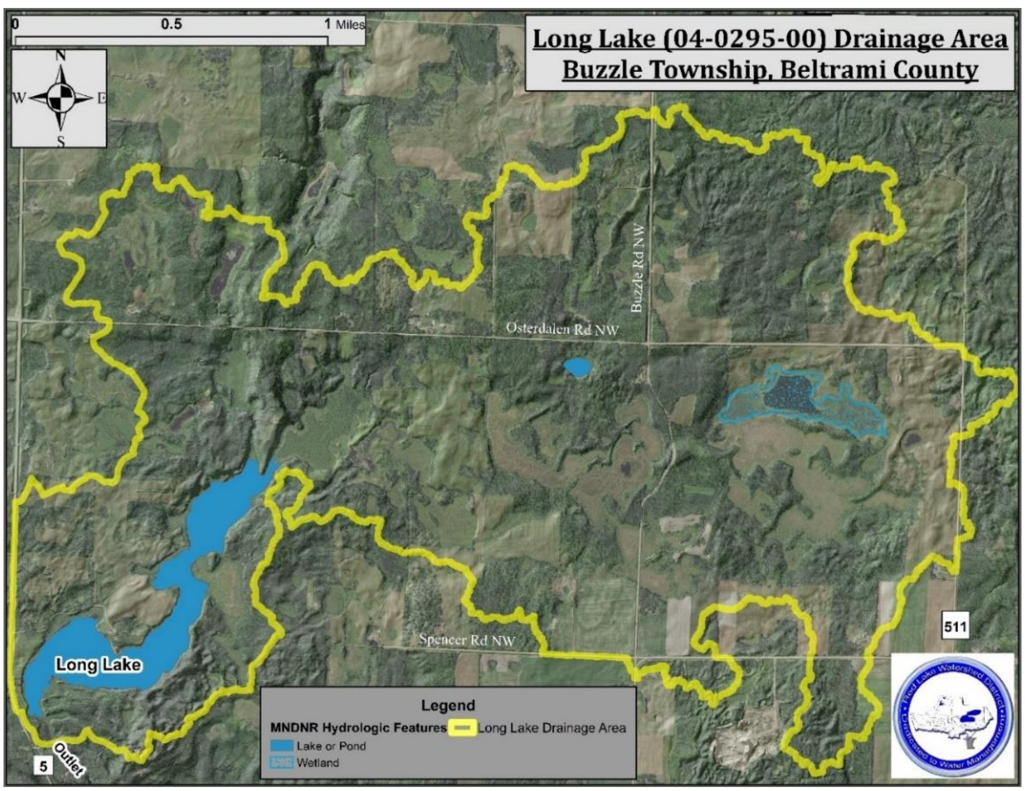


Figure 3-6. Map of the drainage area of Long Lake

The depth of Long Lake has been measured at 17.8 feet near the 04-0295-00-201 sampling site. Much of northeastern end of the lake, even in the open-water portion, is very shallow and the bottom of the lake has a layer of muck or very soft flocculated organic sediment (Figure 3-7). The eastern shore of the lake has a sand/gravel bottom (Figure 3-7). There is no public access to the lake. Much of the shoreline is forested and well buffered. Aquatic vegetation lines the shoreline. Much of the lake's shoreline is bordered by wetlands. There are two beaver lodges on the lake. There are no obvious, active sources of excess nutrients near the lake, although there had been a cattle operation along a portion of the lakeshore (a Red Barn can be seen in Figure 3-5). There is no record of fish sampling in this lake.

Figure 3-7. Photos of sandy (left) and soft (right) lake bottom along the shore of Long Lake

<u>Stony Lake (15-0156-00)</u>

Stony Lake is a 67-acre lake in the Lost River Subwatershed, in Clearwater County. It is a private lake with no public access located within the drainage area of Pine Lake. It does not have a flowing outlet. There is no outlet to the north. The downstream, north side of the lake is blocked by a high ridge (Stony Lake Drive). The drainage area of the lake is small, 0.3 square miles (Figure 3-8). The 2016 assessment determined this lake was impaired by high TP and chl-*a* concentrations. Lake sampling was completed in 2011 and 2012 in a cooperative effort between the Clearwater SWCD and a landowner. The landowner resumed volunteer sampling of the lake in 2018. The TP concentrations were very high in the 2011-2012 data and remained very high in the 2018 data. The maximum depth of the lake was unknown during the formal assessment, and the bathymetry had not been mapped. A landowner provided an estimated maximum depth of 16 feet to facilitate modeling and TMDL calculations. The landowner also described the shape of the lake bottom as saucer-shaped or bowl-shaped, which helped with estimations of lake volume for the modeling effort.

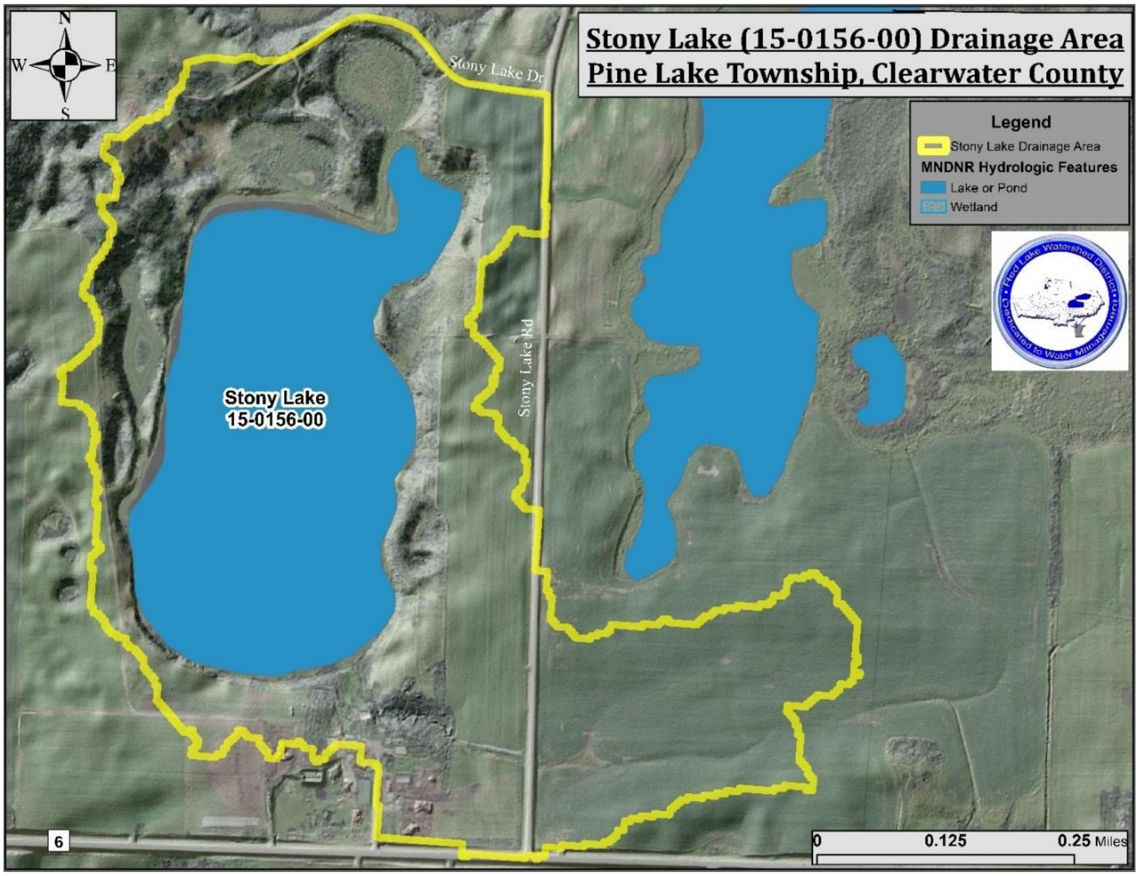


Figure 3-8. Map of the drainage area of Stony Lake

3.3 Streams

The Clearwater River Watershed is comprised of a diverse network of streams. The main channel of the Clearwater River forms the "backbone" of the watershed and it is joined by tributaries that vary in size and morphology along its path. There are designated trout streams in the watershed and one of them (Nassett Creek) is impaired by low DO and high TSS. Stream channel gradient varies throughout the watershed. Multiple streams are influenced by low gradient reaches that have wetland characteristics (including low DO). Approximately 47 miles of the Clearwater River were channelized by the United States Army Corps of Engineers (USACE) in the 1950s to reduce flooding and improve drainage for agriculture.

Much of the Clearwater River is impaired by high concentrations of TSS, beginning with the channelized reach of the Clearwater River and continuing downstream to the river's confluence with the Red Lake River. Water quality assessment statistics for the Clearwater River are similar to assessment statistics for the Red Lake River where they converge in Red Lake Falls. Both rivers have exceedance rates of the 30 mg/L TSS standard that are in the mid-20% range. Low DO was not been recorded near the confluence in either river during the 2006 through 2015 assessment period. The Clearwater River had a slightly higher average TP concentration, but the Red Lake River had a higher maximum monthly geometric mean *E. coli* concentration.

Lower Badger Creek is a relatively large tributary with its own HUC-10 subwatershed. It typically flows throughout the year but can become stagnant due to beaver dams. Overland erosion can contribute large amounts of sediment and other pollutants to this stream during runoff events. Although the results of biological sampling in the lower portion of Lower Badger Creek were good, a low score was recorded in an upstream, channelized portion of the stream. It was not listed as impaired because of that individual F-IBI score, but was addressed in the Clearwater River Watershed SID Report. The outlet of Red Lake County Ditch (CD 23) is an intermittent stream that flows into a natural channel before entering the Clearwater River from the north.

Several streams and multiple *E. coli*-impaired reaches converge near the town of Brooks and the Lost River's confluence with the Clearwater River. The lower reaches of the Hill River and Poplar River are both impaired by *E. coli* bacteria. Brooks Creek is a small tributary of the Hill River that is also impaired by high *E. coli*. The three assessed tributaries that flow directly into the south side of the Clearwater River between the Lost River confluence and Red Lake Falls are also impaired by *E. coli.* Terrebonne Creek is the smallest of those three and is affected by channelization. Beau Gerlot Creek is affected by channelization and has a biological impairment. Brooks Creek, Terrebonne Creek, and Beau Gerlot Creek are smaller streams that typically stop flowing in the late summer.

Biological and low DO impairments are found in the upstream and headwaters reaches of the Clearwater River, Hill River, Lost River, Poplar River, and Lower Badger Creek watersheds. Those impairments do not require TMDLs. Evidence examined during the 2016 assessment process and preparation of the Draft 2020 List of Impaired Waters indicated those impairments were the result of non-pollutant factors (Walker Brook, Red Lake County Ditch 57, and the Poplar River Diversion). Some previously listed impairments (Bee Lake Inlet, Badger-Mitchell Lake Channel) have been proposed for removal from the Draft 2020 List of Impaired Waters because the monitoring stations were representing lake/wetland water quality more than they are representing stream water quality. Further investigation of other biological and low DO impairments found that listed impairments are also caused by non-pollutant factors that include a lack of flow, lack of gradient (wetland characteristics), lack of habitat, and fish passage problems.

A cluster of impairments can be found in the Pine Lake and Gonvick area in the headwaters of the Lost River. Low DO impairments were found in the Pine Lake drainage area even though two reaches in that subwatershed were designated trout streams. Investigation of the Lost River designated trout stream found that it did not qualify for that designation due to high temperatures and low DO. Investigation of Nassett Creek found that there was sufficient DO in the lower portion of the stream, but not in upper reaches (partially due to beaver activity). Livestock operations upstream and downstream of Pine Lake have contributed to *E. coli* impairments in streams (Lost River upstream of Pine Lake, Lost River downstream of Pine Lake, and Nassett Creek), a lake impairment (Stony Lake), and a TSS impairment (Nassett Creek). Silver Creek flows north, roughly parallel and east of the Lost River's path, and joins with the Lost River at Anderson Lake. Silver Creek can experience intermittent flow and is impaired by high *E. coli* concentrations and a low M-IBI score.

Ruffy Brook is a tributary of the Clearwater River in Clearwater County. It begins in Dudley Township, near the city of Leonard, and flows north through Holst, Leon, and Greenwood Townships before entering the Clearwater River. A portion of Ruffy Brook within Leon Township was once a designated trout stream. After the state land through which the stream flowed was sold and much was cleared for pasture, the stream was no longer able to support trout. There has been some local interest in restoring the stream.

The headwaters portion of the Clearwater River, near the City of Bagley, features a very low gradient. The cause of the low DO levels in the Clearwater River and Walker Brook have been investigated in previous TMDL studies. Examination of the area's geology found low DO levels in that area are caused by natural conditions. In addition to the low gradient, the streams are fed by ancient groundwater with very little DO. Both streams are lined by fens in which DO is consumed by decaying organic matter.

3.4 Land Use

The Clearwater River Watershed (USGS HUC 09020305) is a diverse watershed that spans portions of four ecoregions (Lake Agassiz Plain, Northern Minnesota Wetlands, North Central Hardwood Forests, and Northern Lakes and Forests). The prevalent land use transitions from forest and rangeland in the eastern portion of the watershed to cultivated cropland in the western portion of the watershed (Figure 3-9). According to pre-European settlement data, the watershed has experienced a large amount of deforestation (Table 3-3). Current forest cover is approximately half the extent of pre-settlement forests that covered nearly 40% of the watershed. Approximately 2/3 of the pre-settlement prairie and wetlands have been converted to other land uses.

A unique feature of the Clearwater River Watershed is the wild rice paddies that are located in peatlands along a portion of the Clearwater River (Figure 3-10). Wild rice, as a domesticated agricultural grain crop, is grown in paddies flooded with water to an average depth of about one foot. Wild rice agriculture began along the Clearwater River in 1968, but did not expand to its current size until the mid-1970s. The paddies are mostly located along the reach of the Clearwater River from the Ruffy Brook confluence to the CSAH 10 crossing. In the 10 years between 1973 and 1983, development increased from 6,000 acres to 11,000 acres. There were 11,709 permitted acres in 1988. There currently are approximately 15,700 acres of wild rice paddies in the Clearwater River Watershed. On average, approximately 50% of these paddies are being used to grow rice in a given year. The remaining paddies are not flooded (rotation for disease prevention) and are used to grow other crops including soybeans, potatoes, and horseradish.

The paddies influence flow and water quality conditions within the river. Water is pumped from the River to fill the paddies prior to the start of the growing season. Approximately 30 inches of water is required annually to saturate the subsoil, initially fill the paddies, and make up for water lost through evaporation. Most of the water is appropriated during spring runoff and through the month of June. The paddies are drained during July and August to facilitate harvest.

Table 3-3. Table of pre-European settlement and current land use within the Clearwater River Watershed

Clearwater River Watershed Land Use Summary		
National Land Cover Database Category	**Pre-Settlement***	**Percent of Watershed - 2011****
Developed, Open Space		3.92%
Developed, Low Intensity		0.44%
Developed, Medium Intensity		0.06%
Developed, High Intensity		0.02%
Barren Land		0.09%
Shrub/Scrub	24.90%	0.87%
Grassland/Herbaceous	9.89%	2.87%
Deciduous Forest	24.55%	19.32%
Evergreen Forest	11.45%	2.65%
Mixed Forest	3.74%	0.01%
Pasture/Hay		18.06%
Cultivated Crops		33.56%
Woody Wetlands	7.53%	5.28%
Emergent Herbaceous Wetlands	17.24%	10.28%
Open Water	0.70%	2.57%

*Land use categories are named differently in the DNR presettlement data and the NLCD data. Presettlement values were placed into the categories that seemed most appropriate. The *Natural Vegetation of Minnesota* document from the DNR was used as guidance.
**2011 National Land Cover Database

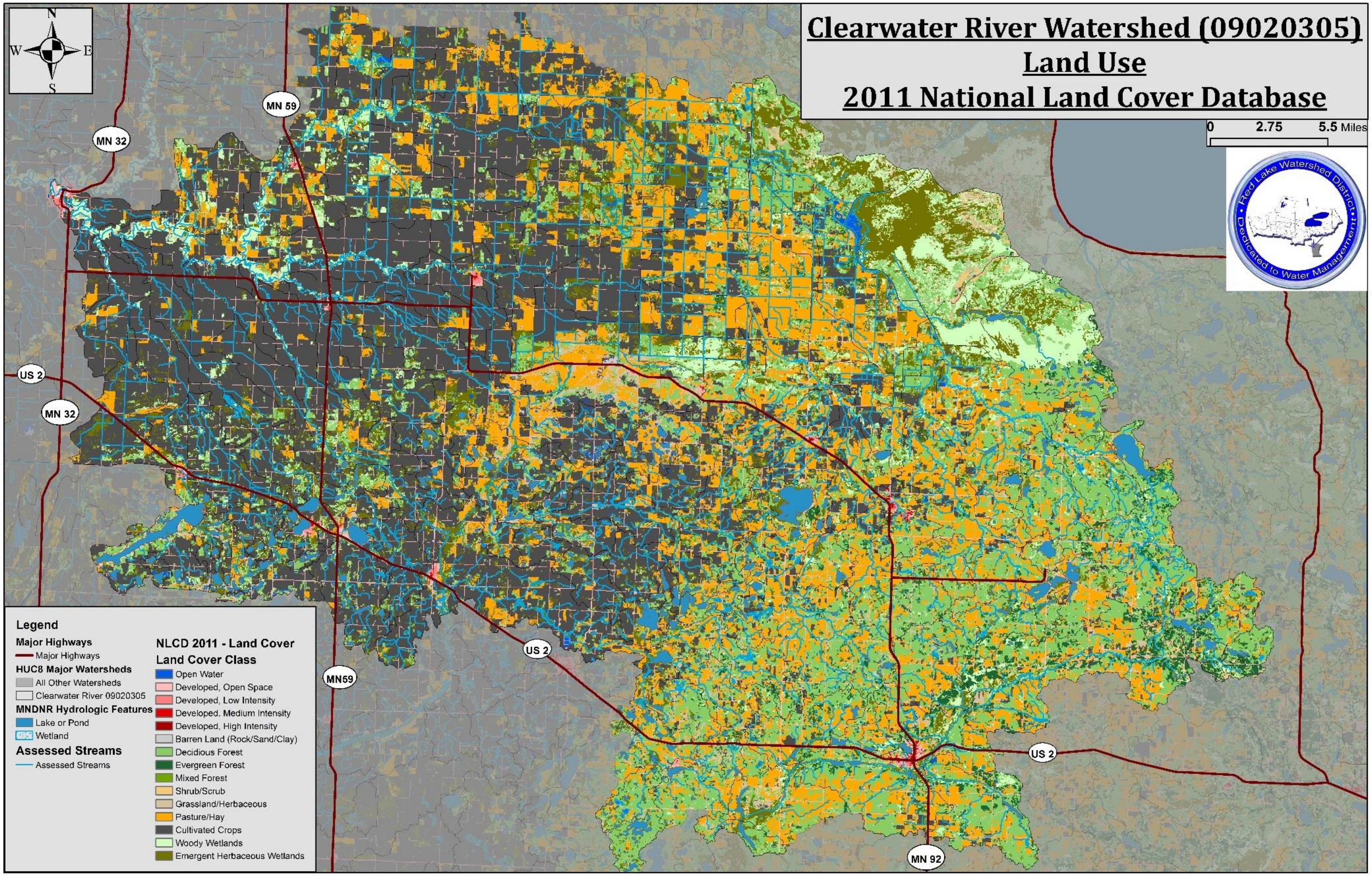


Figure 3-9. Land use map of the Clearwater River Watershed

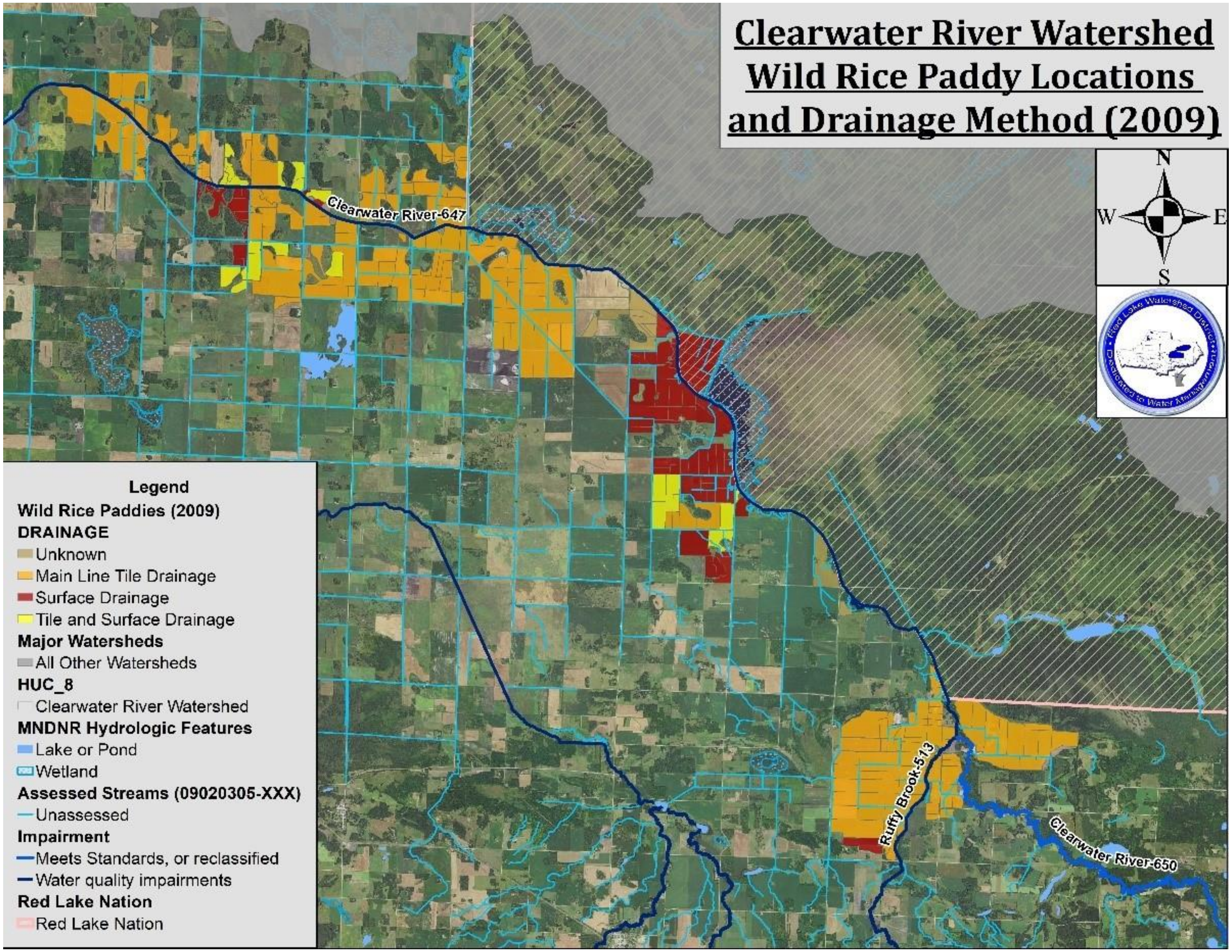


Figure 3-10. Wild rice paddies and types of drainage systems (2009) along the Clearwater River (AUID 647)

3.5 Current/Historic Water Quality

The oldest water quality data in the state's Environmental Quality Information System (EQuIS) water quality database from the Clearwater River were collected in 1977. Data collection efforts were minimal, however, until the late 1990s (Figure 3-11). The intensity of monitoring efforts has increased in the last two decades. Increased awareness of the importance of monitoring data collection, monitoring methods, water quality standards, and assessment results have motivated multiple, productive, local monitoring programs. State agencies have allocated funding for intensive studies, load monitoring, and supplemental condition monitoring. The scope of monitoring efforts has expanded to include continuous water quality monitoring with deployed loggers, increased local stage/flow monitoring, and biological monitoring. Additional information about current monitoring efforts can be found in the monitoring plan in Section 8 of this report.

Many of the original water quality impairments for turbidity, low DO, and fecal coliform were discovered by the intensive monitoring effort that was part of the Clearwater Nonpoint Study in 1992 to 1993. Spikes in the annual data collection efforts shown in Figure 3-11 typically coincide with an intensive study. The Clearwater Nonpoint Study spurred a series of implementation projects and smaller, intensive studies. The Cameron Lake Investigative Study identified the pollution sources that have contributed to the eutrophication in that lake. Water quality and flow within the watershed of Maple Lake and JD 73 was examined in a 1999 study. The Clearwater Lake Water Quality Study, completed in 2003, focused on the Clearwater River and its tributaries upstream of Clearwater Lake.

Concurrent with the Clearwater Lake study, the first Clearwater TMDL study focused on DO and fecal coliform impairments in the Clearwater Lake Watershed. The fecal coliform impairment of the trout stream reach of the Clearwater River (originally AUID 516 and was recently split into AUIDs 653 and 654) was delisted. The fecal coliform impairment of that reach had been discovered during the Clearwater Nonpoint Study. Overflowing, untreated domestic wastewater from the Bagley WWTF was identified as the source of high fecal coliform concentrations in the Clearwater River and eutrophication in Clearwater Lake. After the WWTF was upgraded, fecal coliform and *E. coli* concentrations have improved. The 2002 to 2003 studies found that the trout stream reach of the Clearwater River was no longer impaired by fecal coliform bacteria. The study also found that the Clearwater River and Walker Brook (especially Walker Brook) DO impairments were caused by natural features of the landscape (low gradient, ancient groundwater, and fens).

The next intensive study of the Clearwater River was the draft Clearwater River Fecal Coliform and DO TMDL Study (2009). That study examined fecal coliform impairments of the Clearwater River, Silver Creek, and Lost River. It examined the causes of low DO impairments of the Clearwater River, Walker Brook, Red Lake County Ditch 57 (CD 57), and the Poplar River. That study resulted in the delisting of fecal coliform impairments on the Clearwater River and the Lost River. Draft TMDL reports were produced as a product of this study, but they did not proceed to the public comment phase due to the timing of their completion. They were completed while the MPCA was beginning a shift to the watershed-based TMDL and WRAPS strategy. So, the finalization of those TMDL reports was postponed until the Clearwater River Watershed-based WRAPS process. The draft TMDL study identified data needs in the Clearwater River and the Poplar River. Additional continuous DO data was needed to confirm that the Clearwater River (AUID 09020305-510, at that time) was meeting the DO standard. An intensive study was needed along the Poplar River near the city of Fosston to determine the effect the WWTF's discharge had upon DO levels. That intensive monitoring as part of MPCA's watershed-based approach was accomplished during the beginning of the WRAPS process.

The Clearwater River intensive watershed monitoring and Surface Water Assessment Grant (SWAG) provided an opportunity to intensively collect samples, continuous DO data, and stage/flow data collection at strategic locations throughout the Clearwater River Watershed. New impairments were identified, and some impairments were delisted. Biological data was formally assessed for the first time, which led to multiple biological impairments. Investigative sampling provided important information about the sources of impairments.

Multiple impairments on multiple reaches have been delisted within the watershed due to implementation efforts and better data collection. The trout stream reach of the Clearwater River (09020305-516/653) was impaired by fecal coliform and un-ionized ammonia in past 303(d) impaired water lists. The fecal coliform impairment was delisted in 2006 and the ammonia impairment was delisted in 2018. A fecal coliform impairment on the Lost River (09020305-507) was delisted in 2012. The DO impairments of the Clearwater River AUIDs between Ruffy Brook and the Lost River (09020305-647/648) were delisted in 2018. That entire Ruffy Brook to Lost River reach (09020305-510, prior to split into 647/648) was delisted for fecal coliform in 2012, but the channelized portion (09020305-647) was added back to the 303(d) impaired waters list for an *E. coli* impairment in 2018.

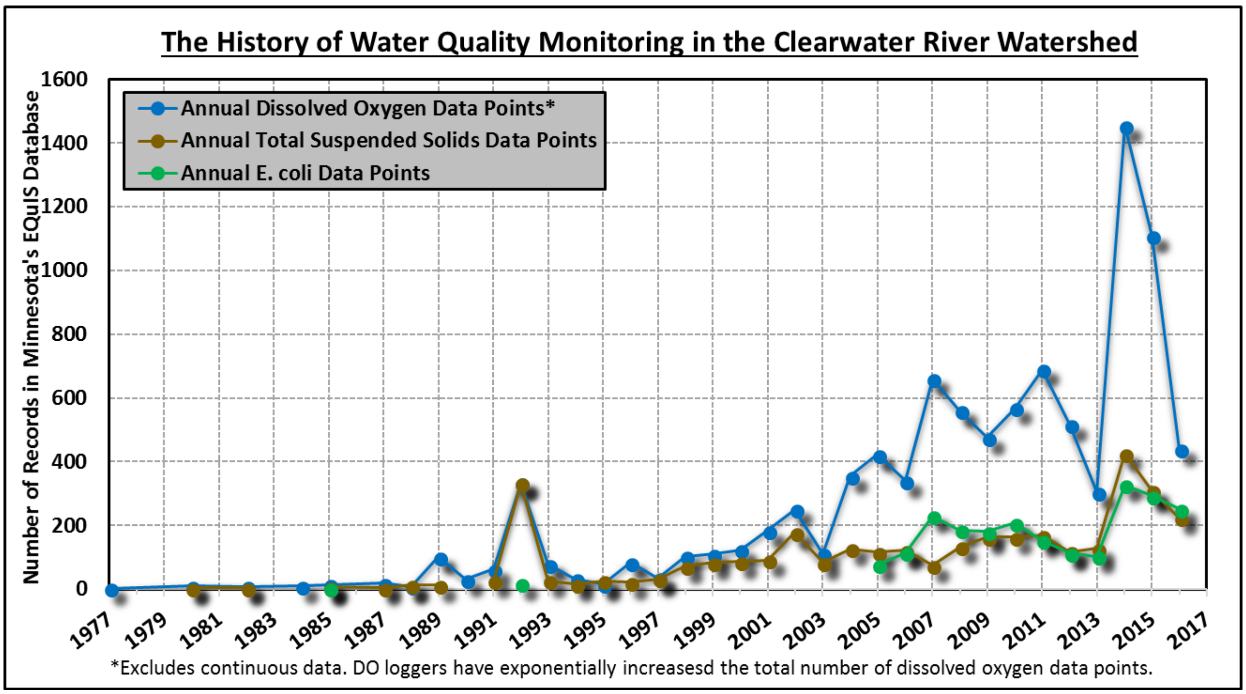


Figure 3-11. History of water quality monitoring in the Clearwater River Watershed

The number of impaired reaches and individual impairments identified increased during the 2016 assessment (Figure 3-12). An increase in data, rather than a decrease in water quality, was primarily responsible for the increase in known impairments.

- The 2016 assessment was the first time that the MPCA used index of biotic integrity data to assess conditions in the Clearwater River Watershed. Some waterways that were sampled for biology had not been previously sampled for water chemistry.

- The 2016 assessment was the first time that many streams had sufficient data for *E. coli* bacteria assessments.
- Six previously-assessed AUIDs were split during the 2016 assessment so that TALU standards could be applied properly. In most cases, a channelized portion of the reach was separated from a natural-channel portion so that different, appropriate biological standards could be applied to each new assessment unit. Local monitoring efforts have expanded to attain sufficient data from as many of those new assessment units as possible.

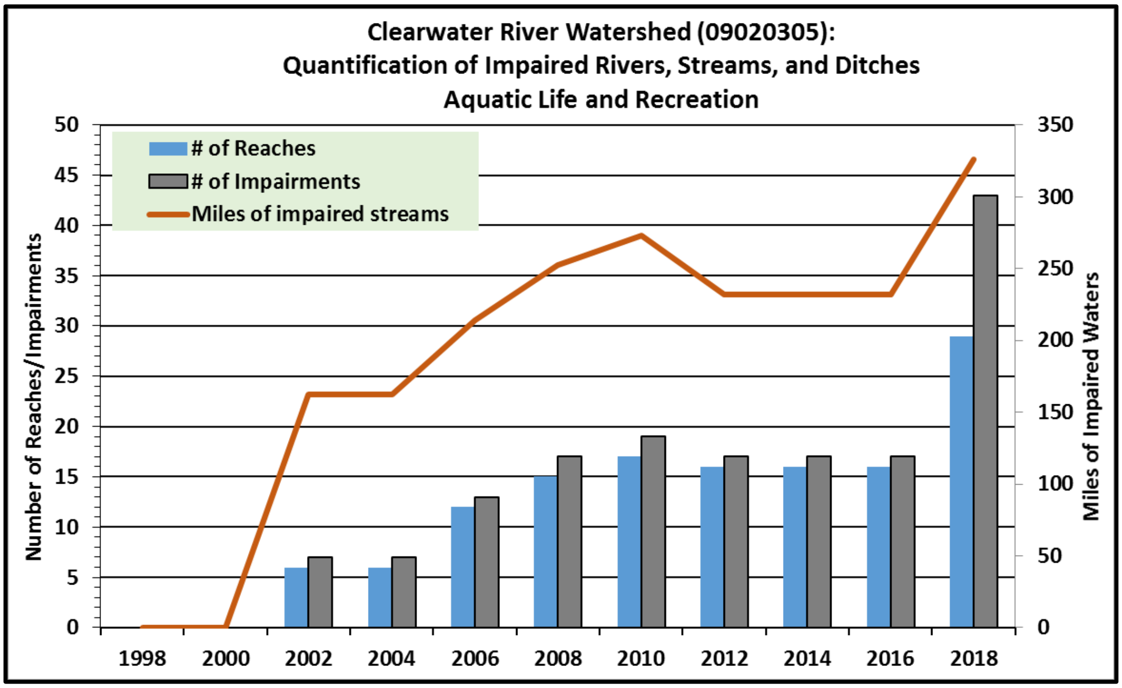


Figure 3-12. History of aquatic life and recreation impairments in the Clearwater River Watershed

Total Suspended Solids

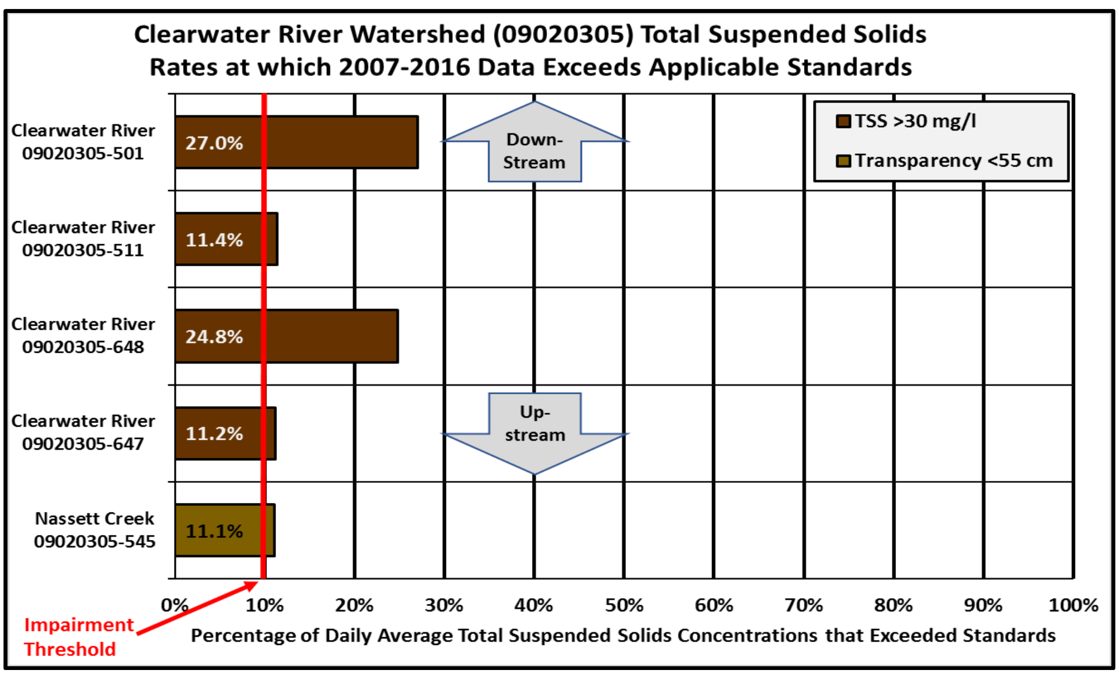


Figure 3-13. Comparison of TSS and transparency exceedance rates in impaired streams in the Clearwater River Watershed.

The turbidity impairments that existed prior to the 2016 303(d) List of Impaired Waters were based upon a 25 NTU standard. The Central River Nutrient Region TSS standard of 30 mg/L provides a level of protection that is similar to what the 25 NTU turbidity standard provided. More protective standards have been applied to streams in the North River Nutrient Region (15 mg/L) and trout streams (10 mg/L). The Clearwater River's TSS impairment extends from the beginning of the channelized reach (09020305-647) through the confluence with the Red Lake River (0920305-501), except for a gap between the confluences with Beau Gerlot Creek and Lower Badger Creek (09020305-519) due to a lack of data. That short reach has no road crossings and, therefore, no practical means of collecting regular water quality samples. The impairment of Nassett Creek was based on transparency data that was collected by the Bagley River Watch program. The Nassett Creek site S004-205 has been added to the RLWD long-term monitoring program so that TSS, *E. coli*, and other parameters can be regularly tested. Figure 3-13 shows how the exceedance rate of the TSS standard varies by reach along the Clearwater River. Monitoring of the next AUID upstream of the channelized reach (09020305-650) has not discovered any violations of the 30 mg/L TSS standard, 15 mg/L TSS standard, 40 cm s-tube standard, or 25 cm s-tube standard. Forty percent of the samples at CSAH 14 (S001-461) through 2018 have been equal to or less than the lab's 1 mg/L reporting limit for TSS.

Dissolved Oxygen

Professionals and volunteers (River Watch) collect many DO measurements throughout the watershed each year. Opportunities to collect pre-9 a.m. measurements are limited by the proximity of sites to an organization's office and by short holding times for other parameters. The RLWD and the MPCA have deployed equipment to record continuous DO data from many AUIDs throughout the watershed. After thorough documentation of natural or non-pollutant causes of DO impairments, some DO impairment listings have been removed from the list or re-categorized. The DO impairment of Walker Brook has been officially re-categorized to Class 4D (natural background). During the 2016 assessment process, three additional DO impairments were removed from the 303(d) List of Impaired Waters through re-categorization from EPA category 5 to category 3. Those waters included the Badger-Mitchell Lake channel portion of the Poplar River Diversion (09020305-542) and the Bee Lake Inlet (09020305-541). The Badger-Mitchell lake channel and Bee Lake inlet were reclassified because data from those sites represents conditions in upstream lakes or wetlands instead of representing water quality in a stream. Examination of the Poplar River Diversion upstream of Badger Lake (09020305-543) concluded that the DO impairment is caused by a combination of natural (low gradient and wetlands) and human-made (diversion structure and weir) causes. The 09020305-543 reach of the Poplar River Diversion will be re-categorized as a 4C impairment and will not require a TMDL. Red Lake CD 57 (09020305-508) was removed from the impaired waters list as a correction. No flow conditions are recorded in the data record for multiple years and months. A determination was made that this reach is not appropriate for aquatic life use assessment due to its intermittent nature.

Continuous DO data collected during the Clearwater River DO and Fecal Coliform TMDL Study, a study of Ruffy Brook, and the Clearwater River WRAPS aided the assessment and SID processes.

River Eutrophication

A TP impairment has been identified along AUID 09020305-647, a channelized portion of the Clearwater River that flows through Clearwater, Red Lake and Polk Counties. Figure 4-32 in Section 4.3 shows the extent of high TP concentrations along the Clearwater River. The Clearwater River has relatively low TP concentrations upstream of the channelized reach, but it becomes impaired within the channelized reach. The AUID 09020305-647 portion of the Clearwater River was found to be impaired because it exceeded the impairment thresholds for the BOD and DO flux response variables in addition to the TP standard. The Clearwater River exceeded the applicable TP standards in other locations but did not exceed response variable standards in 200 through 2015 data. Additional, targeted collection of response variable data is recommended to verify conditions in some nearly impaired reaches of the Clearwater River and its tributaries prior to future assessments.

E. coli

Some fecal coliform impairments were found in this watershed prior to adoption of the bacteria parameter *E. coli* for assessing the safety of aquatic recreation. Local monitoring efforts began regular sampling for *E. coli* bacteria in 2005 during the transition from fecal coliform to *E. coli* as the parameter used for aquatic recreation assessments. Due to the requirement of five samples per calendar month and only four years of regular monitoring, most reaches had insufficient data for an assessment when the watershed was assessed in 2009. Data needs were eventually met, and several new *E. coli* impairments were identified during the most recent assessment in 2016.

Index of Biotic Integrity

The first formal assessment of fish and macroinvertebrate communities in the Clearwater River Watershed by the MPCA was completed in 2016. Prior to the 2016 assessment, biological sampling results from the Clearwater River Watershed had been included in two reports that had been published by the DNR (Red River Basin Stream Survey Report, Red Lake River Watershed 2004) and the EPA (Development of Index of Biotic Integrity Expectations for the Lake Agassiz Plain Ecoregion 1998). Sampling was conducted in 2014 and 2015 by the MPCA in preparation for the assessment. The IBI assessment results from sites throughout the watershed are shown in Figures 3-15, 3-16, and 3-17. Figure 3-14 demonstrates how expectations vary for different streams and how far the biological scores for the impaired streams fall short of those expectations.

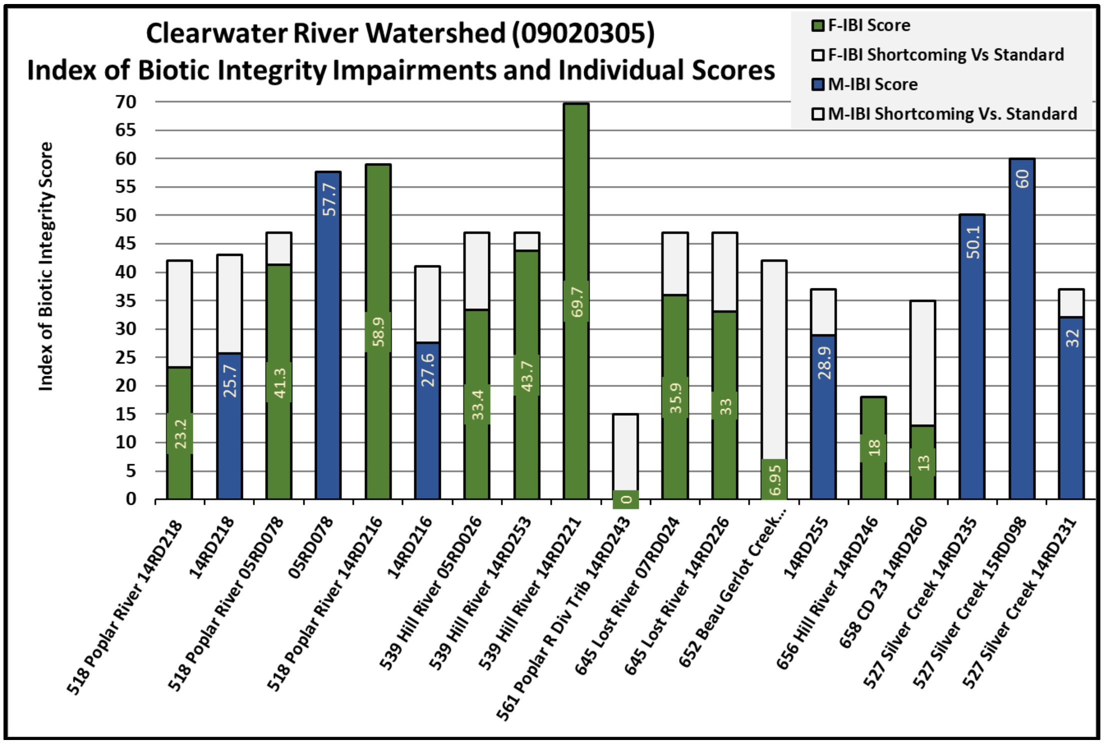


Figure 3-14. Graph of Clearwater River Watershed IBI scores relative to standards for impaired AUIDs

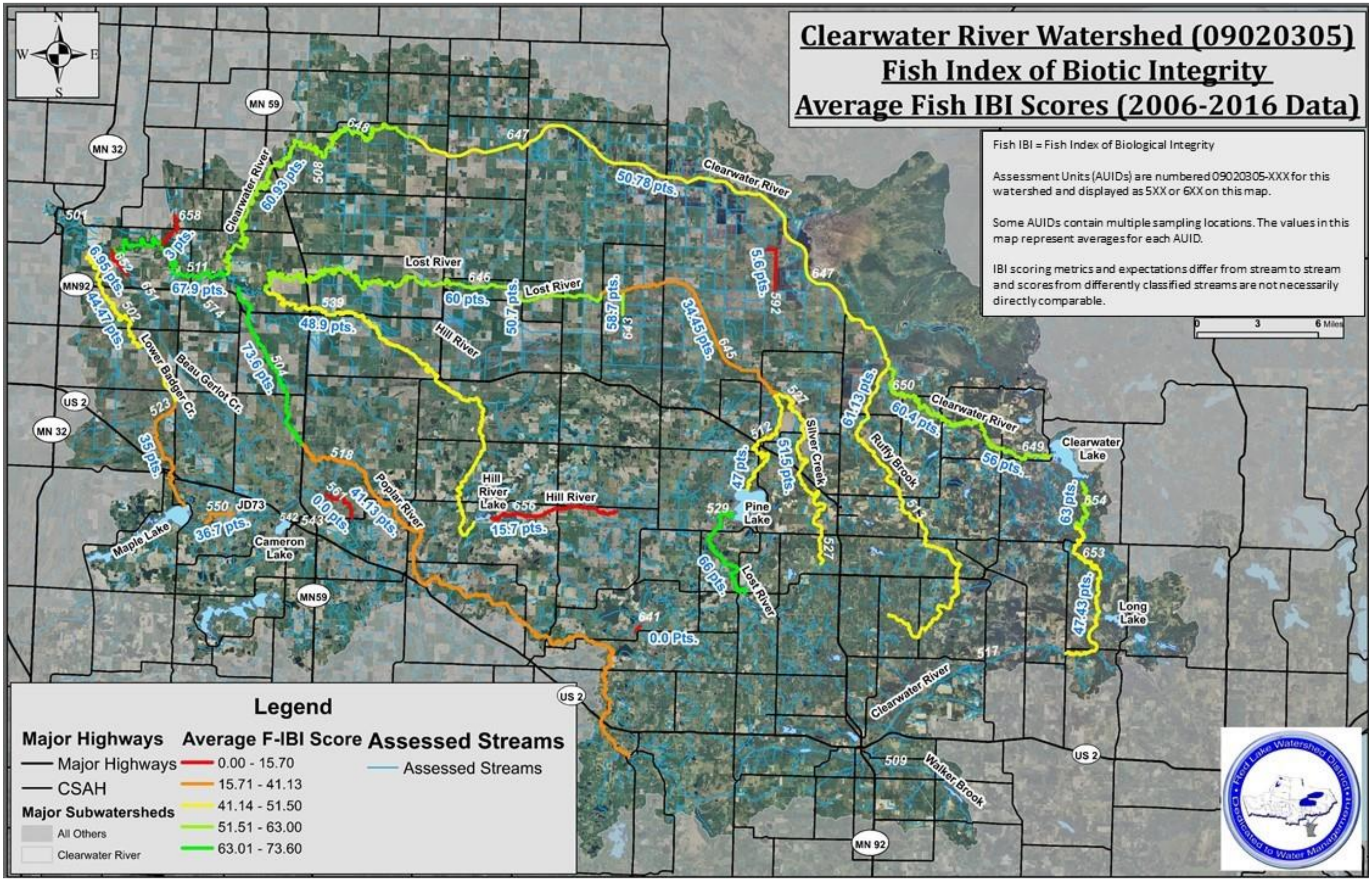


Figure 3-15. Clearwater River Watershed average F-IBI scores for each assessed AUID

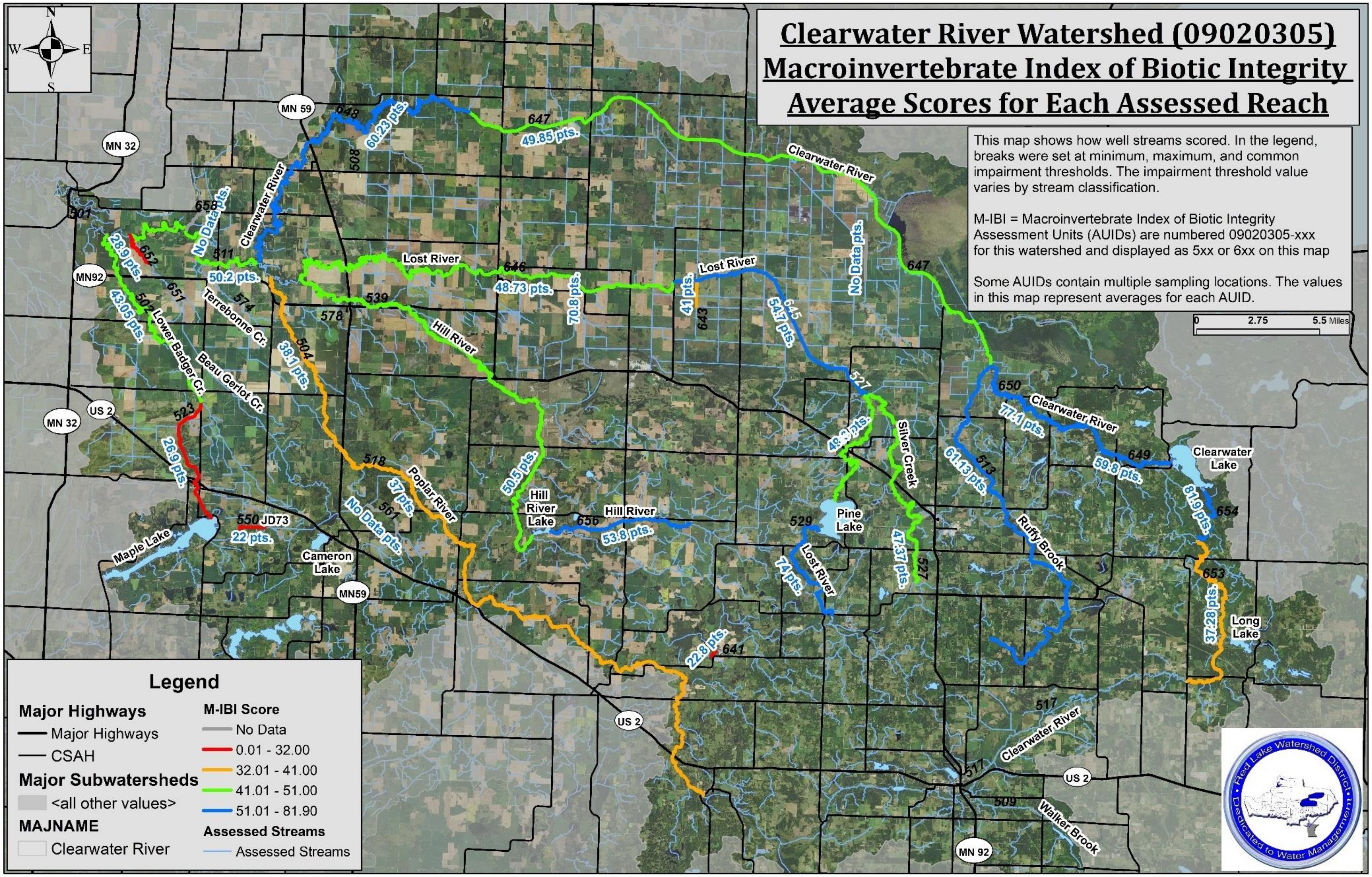


Figure 3-16. Clearwater River Watershed average M-IBI scores for each assessed AUID

Lake Water Quality

Thirty-two lakes in the watershed were assessed in 2016. Of these, three exceeded water quality standards. Those lakes were Cameron Lake (60-0189-00, near Erskine in Polk County), Long Lake (04-0295-00, near Pinewood in Beltrami County), and Stony Lake (15-0156-00, near Pine Lake in Clearwater County). Figure 3-17 displays how water quality conditions in each of the three impaired lakes compared to applicable water quality standards. Stony Lake and Cameron Lake are required to meet water quality standards for shallow lakes in the North Central Hardwood Forest ecoregion, which are also applied to shallow lakes in the Red River Valley ecoregion like. Long Lake is located within the Northern Lakes and Forest ecoregion where lakes are expected to have lower phosphorus concentrations and greater water clarity compared to other ecoregions.

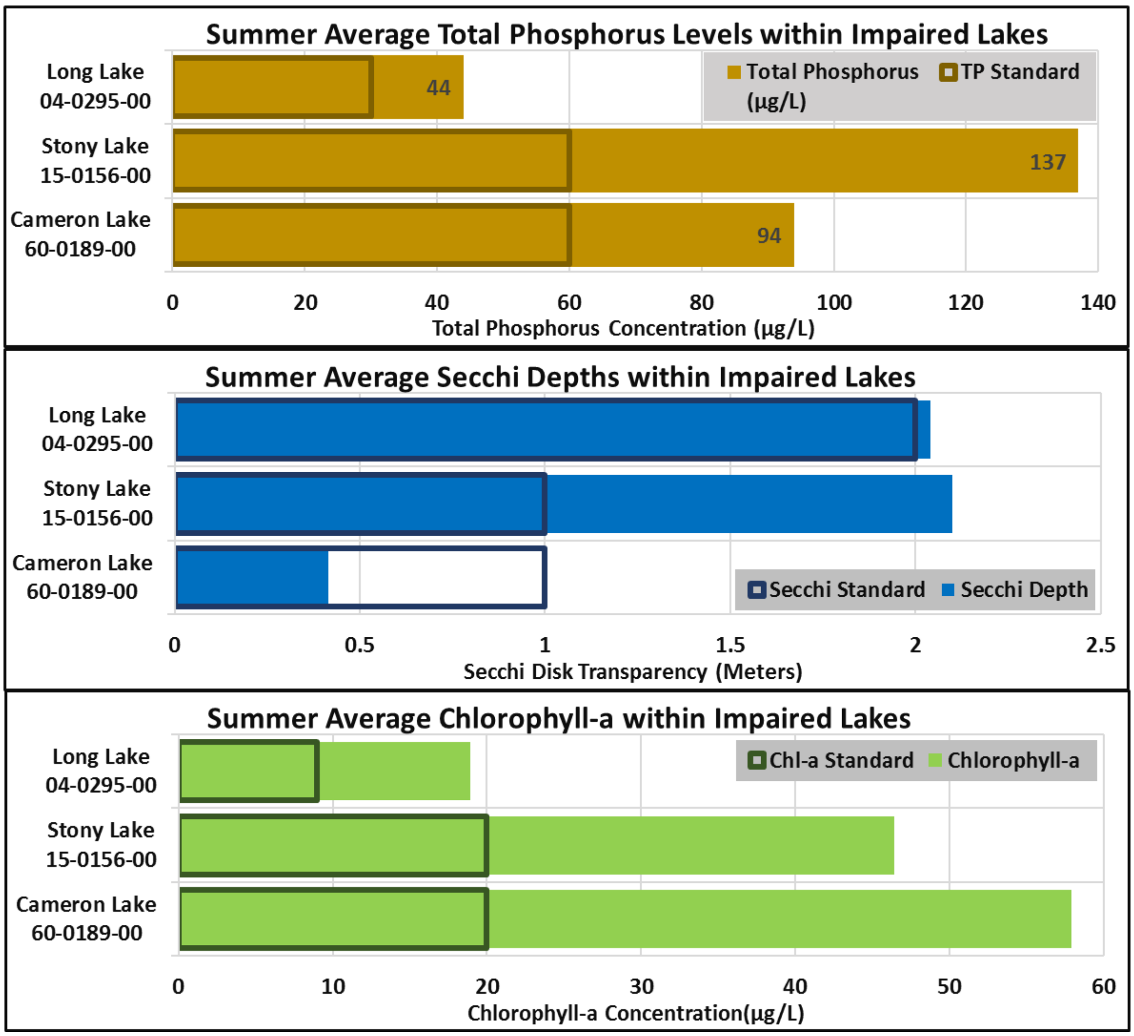


Figure 3-17. Summer lake water quality averages relative to standards for impaired lakes

Cameron Lake was known to have problems with algae blooms and was identified as hypereutrophic before any of its data was stored in STORET or EQuIS (1990s). Sampling in the years 2003 through 2006 at site 60-0189-00-145 confirmed that the lake was impaired and it was placed on the 2008 303(d) List of Impaired Waters. Other than the 2006 Cameron Lake data, most of the 2016 assessment's data from these three impaired lakes was collected in 2011 and 2012.

Results were consistent from 2011 to 2012, as shown in Figure 3-18. The majority of TP and chl-*a* samples from the three lakes exceeded standards. Cameron Lake and Stony Lake had very high TP and chl-*a* concentrations. Long Lake exceeded standards by the smallest margin and therefore is relatively close to meeting standards. Stony Lake retained adequate water clarity (only one measurement was less than one meter) despite having the highest TP and chl-*a* concentrations of any lake in the watershed. All Cameron Lake Secchi measurements have been less than the one-meter standard. Forty percent of Secchi measurements in Long Lake have failed to meet the two-meter standard. A recently renewed sampling effort in 2018 and 2019 has found that there is a possibility that Long Lake may be meeting standards prior to the next assessment. In addition to the typical lake assessment parameters (TP, Secchi, chl-*a*), the MPCA also collected TSS data. The TSS concentrations found within Cameron Lake ranged from 26 to 72 mg/L, which means that in-lake TSS often exceeded the 30 mg/L stream standard.

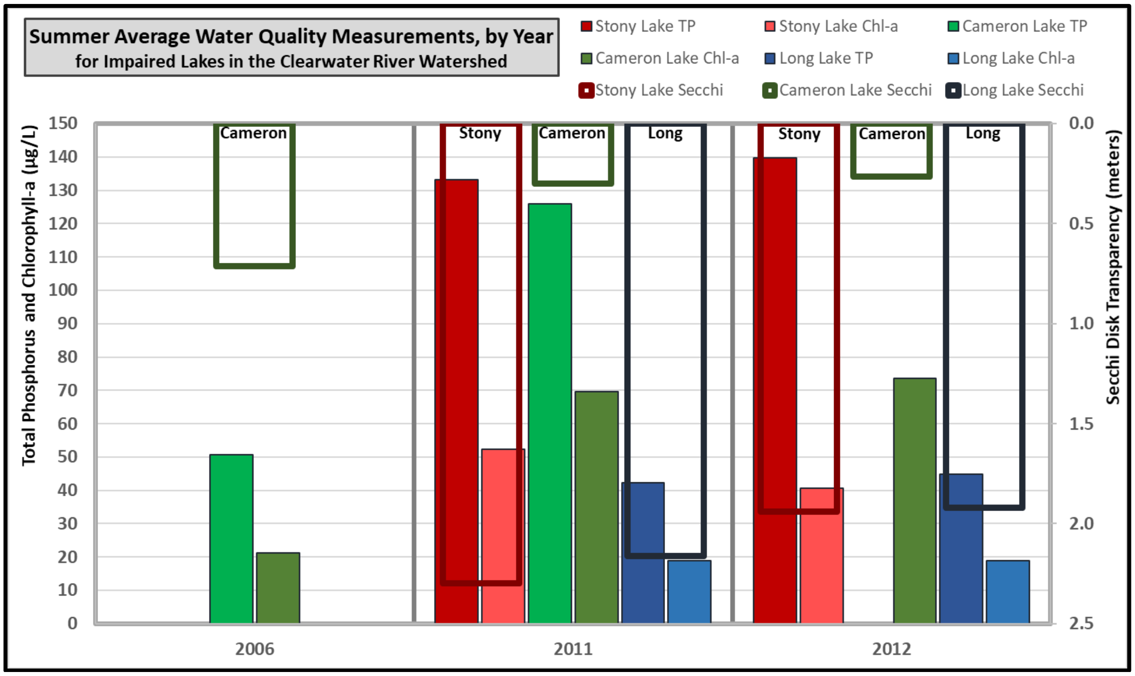


Figure 3-18. Summer lake water quality averages, sorted by site and year

Trend Analysis

The Mann-Kendall test was used to identify statistical trends in TSS, DO, TP, and *E. coli* at long-term monitoring sites along impaired reaches within the Clearwater River Watershed. Monitoring sites with at least 10 years of monitoring data were targeted for the analysis. The Mann-Kendall test is a non-parametric test for identifying trends in time series data. The data values were evaluated as an ordered time series. Each data value was compared to all subsequent data values. An Excel spreadsheet was created to calculate the Mann-Kendall statistic (S), the variance of S (VAR(S)), normalized test statistic (Z), and the probability associated with the normalized test statistic (f(z)) values for each period of time. In Table 3-4, the trend was shown to be decreasing if the Z value was negative and computed probability was greater than 90%. The trend was considered to be increasing if the Z value was positive and the computed probability was greater than 90%. A series of data points that produced a probability of significance that was greater than 99% was shown as a strong trend (either direction). Analysis of additional sites on unimpaired reaches can be found in the Clearwater River WRAPS.

Table 3-4. Summary of water quality trends within impaired reaches

AUID	Stream Name	SITE	Impaired Parameter	Years	Trend of Annual Averages	Trend of Summer Averages (May-Sept)
09020305-501	Clearwater River	S002-118	TSS	1990-2016	↑ (red)	↑ (red)
09020305-511	Clearwater River	S002-914	TSS	1992-2016	↓ (green)	↓ (green)
09020305-648	Clearwater River	S002-124	TSS	1992-2016	X	X
09020305-513	Ruffy Brook	S007-848 S008-057 S002-120	*E. coli*	2005-2016	X	X
09020305-527	Silver Creek	S002-082 S001-020	*E. coli*	2005-2016	↑ (red)	X
09020305-647	Clearwater River	S003-174	TSS	1998-2016	↓+ (green)	↓+ (green)
09020305-517	Clearwater River	S001-906	DO	1987-2015	↑ (green)	↑ (green)
09020305-517	Clearwater River	S001-458	DO	1992-2016	↑ (green)	X
09020305-543	Poplar R Diversion	S002-129	DO	1991-2016	↑ (green)	↑ (green)
09020305-504	Poplar River	S002-117 S007-608	*E. coli*	1992-2016	↑ (red)	↑ (red)
09020305-518	Poplar River	S002-091	DO	1991-2016	↑ (green)	↑ (green)
09020305-518	Poplar River	S003-127	DO	2001-2016	X	X
09020305-539	Hill River	S002-134	*E. coli*	2007-2016	X	X
09020305-512	Lost River	S001-007	*E. coli*	2005-2016	pts.	<10 data pts.
09020305-529	Lost River	S005-283	*E. coli*	2005-2016	X	<10 data pts.
09020305-529	Lost River	S005-283	DO	1992-2016	X	X
09020305-526	Clear Brook	S004-044	*E. coli*	2007-2016	pts.	<10 data pts.
09020305-526	Clear Brook	S004-044	DO	2004-2016	↑ (green)	↑+ (green)
09020305-509	Walker Brook	S002-122	DO	1992-2016	↓+ (red)	↓+ (red)

X = No Trend
↑ (red) = Upward Trend (Getting Worse)
↑+ (red) = Strong Upward Trend (Getting Significantly Worse)
↓ (green) = Downward Trend (Improvement)
↓+ (green) = Strong Downward Trend (Getting Significantly Better)
↑ (green) = Upward Trend (Getting Better)
↑+ (green) = Strong Upward Trend (Getting Significantly Better)
↓+ (red) = Strong Downward Trend (Getting Significantly Worse)

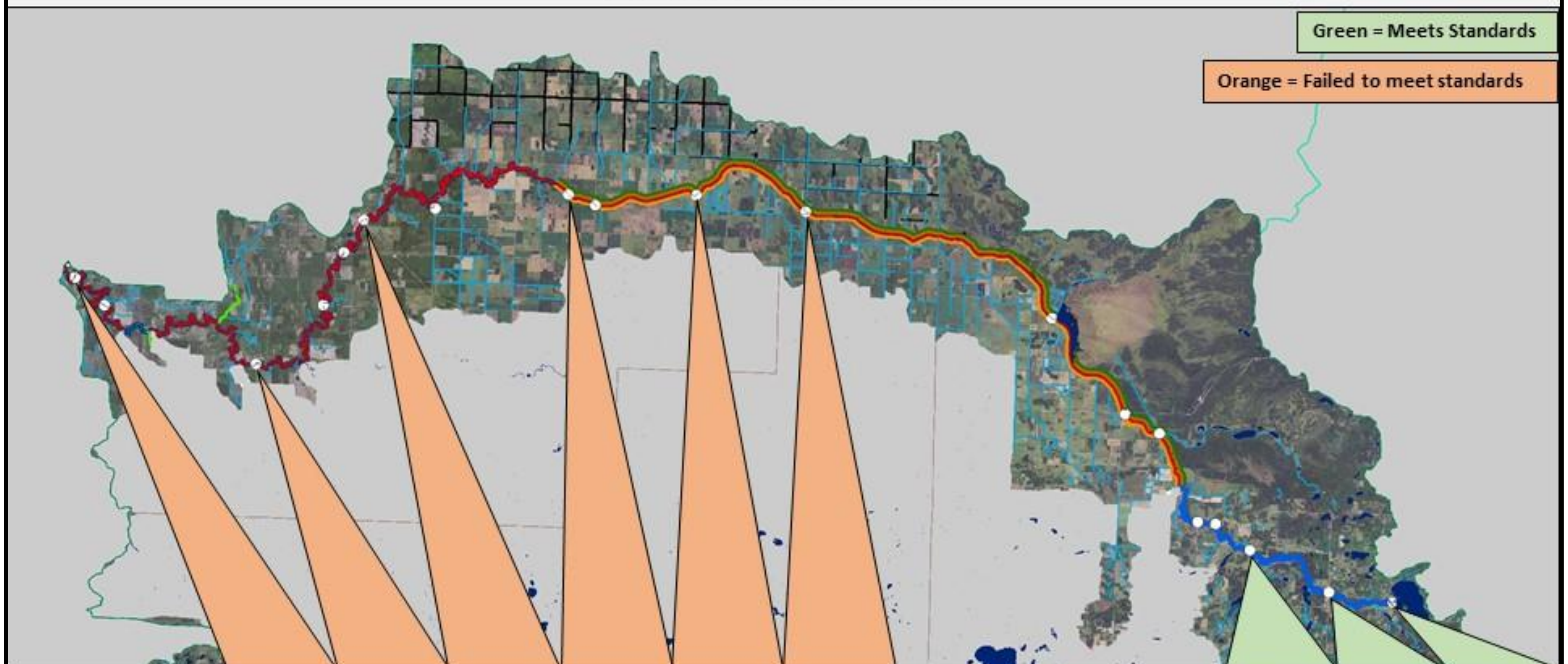
4. Pollutant Source Summary

4.1 Total Suspended Solids Sources

This section describes the point and nonpoint sources that contribute to excess TSS in impaired streams of the Clearwater River Watershed. The point and nonpoint sources for each impaired reach are described. Watershed-wide water quality modeling results, the results of investigative sampling, and a fluvial geomorphology study are also described.

Clearwater River

Site-By-Site Assessment Results for Total Suspended Solids
2007-2016 Data



Site ID:	S002-118	S002-914	S002-124	S002-916	S003-174	S002-121
AUID (09020305-XXX)	501	511	648	647	647	647
Street/Road:	Bottineau Ave	CSAH 12	Minnesota St. N	280th Ave SE	CSAH 10	370th Ave SE
Percentage of TSS Samples > 30 mg/L	27.0%	11.4%	25.0%	13.6%	16.1%	10.2%
Percentage of Secchi Tube Transparency <25 cm	20.4%	0.0%	14.1%	0.0%	No Data	6.6%
Number of April-Sept. Days with TSS Samples:	226	35	112	22	31	49

Site ID:	S002-752	S001-461	S002-119
AUID (09020305-XXX)	650	649	649
Street/Road:	CSAH 11	CSAH 14 (249th Ave)	Clearwater Lake Rd.
Percentage of TSS Samples > 15 mg/L	0.0%	0.0%	0.0%
Percentage of Secchi Tube Transparency <40 cm	0.0%	0.0%	0.0%
Number of April-Sept. Days with TSS Samples:	12	7	20

Figure 4-1. Longitudinal map of site-specific TSS assessment statistics

The boundary conditions of the TSS-impaired portions of the Clearwater River were examined in Table 4-1 to determine whether upstream portions of the Clearwater River or Clearwater River tributaries were contributing to the impairment in the Clearwater River. This table provides an indication of which tributaries may be contributing to TSS impairments in the Clearwater River, and which streams are not contributing to impairments. Clearwater Lake essentially "resets" TSS levels to natural background levels that are occasionally less than 1 mg/L (the laboratory's minimum reporting limit). None of the assessed tributaries of the Clearwater River were impaired by TSS, but the Lost River is one tributary that appears to exceed the standard at a specific station near its pour point. Aggregated data from the entire AUID 09020305-646 portion of the Lost River barely meets the TSS standard. The reach includes the long-term monitoring station at the city of Oklee (S001-131) that has had no exceedances of the 30 mg/L standard and offsets the high concentrations that have been discovered at S002-133 in assessments of aggregated data from the entire AUID. The Oklee WWTF lies between S001-131 (0% exceedance rate) and S002-133 (11.8% exceedance rate) and will be part of the WLAs for Clearwater AUIDs that are downstream of the Lost River confluence.

Table 4-1. TSS standard exceedance statistics for Clearwater River tributaries that flow into an impaired reach

Clearwater River Tributary Stream:	Lower Badger Creek	Beau Gerlot Creek	Terrebonne Creek	Poplar River	Hill River	Lost River	Ruffy Brook
Furthest Downstream AUID (09020305-XXX):	502	652	574	504	539	505	513
Furthest Downstream AUID with Sufficient 20006-2015 TSS Data (09020305-XXX):	502	651	574	504	539	646	513
Furthest Downstream Station Number(s) with Sufficient TSS Data:	S004-837	S004-816	S004-819	S007-608	S002-134	S002-133	S007-848 S008-057
Number of Daily Mean TSS Values at Furthest Downstream Station	59	27	36	25	54	85	23
Percentage that Exceed 30 mg/L	6.4%	0.0%	2.8%	0.0%	3.7%	11.8%	4.3%

4.1.1 Permitted Total Suspended Solids Sources

Municipal Separate Storm Sewer Systems

A municipal separate storm sewer system (MS4) is a conveyance or system of conveyances (roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, storm drains, etc.). It is owned or operated by a public entity (which can include cities, townships, counties, military bases, hospitals, prison complexes, highway departments, universities, etc.) that has jurisdiction over disposal of sewage, industrial wastes, stormwater, or other wastes. It is designed or used for collecting or conveying stormwater and discharges to waters of the United States. It is not a combined sewer. It also is not part of a publicly owned treatment works.

There are no MS4 or designated MS4 communities within the Clearwater River Watershed. The population of the largest cities (Red Lake Falls and Bagley) are each less than 1,500, so there are no municipalities along impaired reaches with populations greater than 5,000 that could be designated MS4s.

Wastewater Treatment Facilities

The TSS TMDLs for AUIDs 501, 511, and 648 account for discharge from the Plummer WWTF, which is the only WWTF that directly discharges to a reach of the Clearwater River that is impaired by high TSS. The WWTF is located west of the town and discharges to the 648 reach of the Clearwater River. The discharge is located downstream of the long-term monitoring site on that reach (S002-124) but upstream of two other long-term monitoring sites on impaired reaches 501 (S002-118) and 511 (S002-914).

The Gonvick WWTF discharges to the upper reach of the Lost River and the Clearbrook WWTF discharges to Ruffy Brook. The upper reach of the Lost River and Ruffy Brook were determined to not be contributing to the TSS impairment in the Clearwater River, therefore no WLAs will be established for the Gonvick or Clearbrook WWTFs. The Bagley WWTF discharges to the headwaters of the Clearwater River, upstream of Clearwater Lake. As discussed in Section 3.5, examination of water quality data has shown that the portion of the Clearwater River watershed upstream of Clearwater Lake is not contributing to the TSS impairment, so a WLA will not be established for the Bagley WWTF. The Oklee WWTF will be assigned a WLA for the TSS TMDLs for AUIDs 501 and 511 because along with erosion problems detailed later in the section, the water quality monitoring station downstream of the city of Oklee (S00-133) has a TSS exceedance rate of 11.8%, suggesting that the Oklee WWTF could be contributing to the downstream impairments.

Table 4-2 shows the AUIDS that are downstream of the Plummer and Oklee WWTFs. The annual wasteload from the Plummer WWTF is a very small portion of the annual load allocation (LA). Sediment discharged from a WWTF could, nonetheless, have potential to cause TSS exceedances during very low flow conditions when the total daily LC is also very low. The TSS concentration in discharge from the Plummer WWTF has rarely exceeded the 30 mg/L TSS standard. According to records stored in EQuIS, discharge from the Plummer WWTF only exceeded the 30 mg/L TSS standard during September of 2011. No changes to the Plummer WWTF limits are recommended.

Table 4-2. TSS-impaired waters and upstream WWTFs

Wastewater Treatment along the Clearwater River			WWTF	
HUC-10	Assessment Unit (TSS-Impaired)	AUID Descriptions	Plummer MN0024520-SD-2	Oklee MNG580038-SD-1
		HUC-10:	0902030507	0902030505
0902030507	Clearwater River 09020305-501	Lower Badger Creek to Red Lake River	X	X
0902030507	Clearwater River 09020305-511	Lost River to Beau Gerlot Creek	X	X
0902030507	Clearwater River 09020305-647	Ruffy Brook to JD1		
0902030507	Clearwater River 09020305-648	JD 1 to Lost River	X	
0902030505	Nassett Creek 09020305-545	T148 R38W S28, south line to Lost River		

Construction and Industrial Stormwater

Turbidity and TSS impairments along the Clearwater River have been identified at monitoring sites in Red Lake County and Polk County. Industrial and construction stormwater runoff from Pennington and Clearwater Counties can also contribute to the TSS impairments. According to publicly available

Construction Stormwater Permit information from the MPCA, the annual average percentage of land area under construction has ranged from 0.004% in Clearwater County to 0.021% in Polk County over the most recent 10 years. The percentage of the LA used for industrial stormwater was identical to the construction stormwater percentage. Industrial and construction stormwater was combined into one WLA because they make up a very small fraction of the watershed area. Both construction and industrial stormwater are regulated under a general permit program in Minnesota (MNR100001 and MNR500000).

4.1.2 Other (Nonpoint) Total Suspended Solids Sources

This section will describe the sources that have been identified for each individual reach and then describe watershed-wide findings from tools and studies like the Hydrologic Simulation Program-FORTRAN (HSPF) model, fluvial geomorphology assessment, and longitudinal sampling.

Clearwater River 09020305-501

The gradient and stream power increase as the river flows toward its confluence with the Red Lake River in Red Lake Falls. As the Clearwater River approaches Red Lake Falls and its gradient steepens, the river is lined with tall, eroding bluffs (Figure 4-2). The Clearwater River is impaired by excess TSS upstream of this reach, so it is already impaired at its furthest upstream extent by sources that contribute to AUIDs 511, 648, and 647. The frequency of high TSS readings was higher within this reach compared to the next assessed upstream AUID (AUID 511).

Figure 4-2. Photo of bluffs along the Clearwater River near Red Lake Falls (AUID 501)

Drainage system outlets, like the natural channel outlet of the CD 23 drainage system, need grade stabilization. The steep gradient between a tributary's last grade control point (usually a road culvert) and the Clearwater River causes the formation of large gullies and mass slumping of large sections of steep stream banks due to stream channel instability and degradation. The unstable outlets of tributary streams and ditches contribute to sediment loads in the Clearwater River.

The increase in turbidity and TSS along the Clearwater River is also likely influenced by an increase in the density of cultivated fields from east to west across the Clearwater River Watershed and those fields contributing sediment to the river during runoff events. Wind erosion, particularly during the winter and the planting season, carries topsoil into ditches where it is eventually transported into the river. Prior to the implementation of the Buffer Law, fields were farmed up to the edge of the riverbank in many locations. Stormwater runoff from the community of Red Lake Falls may also be contributing sediment loads in this segment of the river.

Clearwater River 09020305-511

The Clearwater River is impaired by excess TSS upstream of this reach, along AUID 648. The data from the AUID 511 portion of the Clearwater River between the Lost River and Beau Gerlot Creek confluences shows a lower exceedance rate (11.4%) in 2007 through 2016 data than the upstream reach (AUID 648, 24.8%). The results provide hope that conditions in this portion of the river are not as bad as other reaches. The relatively small dataset from AUID 511; however, is a caveat to be considered when comparing the two reaches.

There are some notable sources of sediment along this reach. Eroding streambanks were documented by fluvial geomorphology reconnaissance work. One very large eroding bank, where the Clearwater River flows near CR 120, is shown in Figure 4-3. There are many eroding streambanks downstream of CSAH 12. Like AUID 501, the outlets of drainage systems that flow into this reach are also very unstable. There are cultivated fields that encroach upon the river and buffers need to be improved. A cattle operation has reduced vegetative protection along a cut-bank.

Figure 4-3. Photo of high, steep, eroding streambank along Clearwater River (AUID 511)

The reconnaissance work completed for the fluvial geomorphology study found that the Lost River has been carrying a large load of sand within its lower reaches. The lower portion of the Lost River has problems with streambank stability and is transporting large amounts of sediment into the Clearwater

River. There is a very large sand bar in the Clearwater River near the Lost River confluence. Extensive sand bars can be seen in aerial photos of the lower portion of the Lost River and the Clearwater River downstream of where the two rivers meet. Those sandbars are visual evidence of sedimentation occurring within this reach.

The TSS concentrations throughout the whole AUID 646 portion of the Lost River have been slightly lower (9.7% exceedance rate) than the concentrations found in the AUID 511 portion of the Clearwater River, but there is significant erosion occurring along the downstream portion of AUID 646 along AUIDs 505 and 503. The furthest downstream long-term monitoring site on the Lost River exceeded the 30 mg/L standard in 11.8% of April through October, 2006 through 2015 samples.

Relatively clean water from some tributaries could be counteracting the influence of eroding streambanks and upstream impairments upon water quality in this reach. The Poplar River and Hill River both flow into the Lost River near its confluence with the Clearwater River (downstream of Lost River water quality station S002-133) and both meet TSS standards. Terrebonne Creek is another stream that meets TSS standards and flows into this portion of the Clearwater River (downstream of the S002-914 station; however).

Clearwater River 09020305-647

The TSS impairment of the Clearwater River begins within the channelized portion of the river (Figure 4-4). The site-specific assessment in Figure 4-1 shows a significant change in water quality from the furthest downstream site along the natural channel (S002-752, no TSS exceedances) and the furthest upstream assessable site within this channelized reach (S002-121, >10% TSS exceedance rate). Not only does the river meet the TSS standard at all sites upstream of the channelization, but every sample collected in the years 2007 through 2016 at upstream crossings between Clearwater Lake and Ruffy Brook has met the TSS standard. Ruffy Brook also meets the 30 mg/L TSS standard, even in a site-specific analysis of pour-point sampling stations (Table 4-1).

Figure 4-4. Photo of the Clearwater River, downstream of CSAH 10 (AUID 647)

The highest concentrations of TSS in the river occur during high flows, particularly in the spring and early summer. High TSS concentrations have occasionally occurred in Ruffy Brook, but in less than 10% of samples. The Clearwater River is in an impaired condition throughout most, if not all, of AUID 647. Data indicates that water quality quickly transitions from the excellent conditions found in the upstream reach (AUID 650) to an impaired condition near the upstream end of AUID 647. Longitudinal sampling during wild rice paddy discharge has recorded large increases in TSS from CSAH 11 in AUID 650 to the sites in AUID 647 (Figure 4-12). Along with increases in TSS, the channelized reach also exhibits elevated TP concentrations and decreased DO concentrations compared to upstream reaches. The first sufficiently sampled crossing (370th Avenue SE, S002-121) within the channelized reach has a TSS exceedance rate that is greater than the 10% impairment threshold. Downstream, the TSS standard is exceeded at increasingly higher frequencies. Streambank instability due to channelization and wild rice paddy discharge are two sources of sediment that are influencing water quality in this reach. There are cultivated fields that encroach upon the river and buffers need to be improved.

An assessment of fluvial geomorphology identified a very unstable section of the river at the upstream end of the channelized reach. Streambanks are eroding and channel degradation (head-cutting) is occurring. Upland sediment runoff can also contribute to TSS concentrations in the Clearwater River, especially during runoff events. May 31, 2016, longitudinal sampling (Figure 4-11) after a runoff event discovered a large increase in TSS from CSAH 5 to CR 127 near the lower end of AUID 647. The land is cultivated along both sides of the river between those two roads and the river is only minimally buffered. There are other stretches of stream bank near cultivated fields along which buffers could be improved.

Monitoring at the outlets of wild rice paddies during drawdown in late summer has shown that surface drainage within wild rice paddies has a very detrimental effect upon water quality in the Clearwater River (Figures 4-5 and 4-6). This sampling has also documented the benefits of adding controlled main-line tile drainage practices, along with elimination of surface drainage ditches within wild rice paddies, were that drainage water was clean, clear, and had low nitrate levels. Main-line tile drainage systems also provide benefits to the farmers like more even drainage, more even ripening, and less ditch maintenance. More information can be found in the *Red Lake River Farm to Stream Tile Drainage Water Quality Study Final Report*.

Figure 4-5. Photos of erosion within a wild rice paddy ditch (left) and sedimentation in the Clearwater River (AUID 647) from a wild rice paddy discharge (right)

Figure 4-6. Visual comparison wild rice paddy discharges: surface drained wild rice paddy (left) and a main line tile drained wild rice paddy (right)

Clearwater River 09020305-648

Streambank and overland erosion contribute to increases in TSS concentrations as the Clearwater River flows from the channelized reach to its confluence with the Lost River. Streambanks are sloughing where deep rooted and woody vegetation has been removed (Figure 4-7). Gullies have formed where runoff flows from cultivated fields. Feedlots and livestock grazing near the river have exposed soil and deposited animal waste that can be washed into the river during runoff events. There is a lack of accessible crossings in the upper portion of this reach, so there isn't detailed data that could improve the understanding of how TSS levels change between the downstream end of the channelized reach and the Plummer USGS Gauge monitoring station (S002-124). A kayak monitoring trip from CR 127 to Minnesota Street N with regular measurements of turbidity or transparency after a runoff event could help identify areas with the worst erosion problems. The development of detailed water quality models like PTMApp should also aid in identifying specific sites where implementation of BMPs could be most cost effective at reducing erosion and TSS loads. The outlets of drainage systems need to be stabilized where they enter the Clearwater River to prevent further head-cutting and gully formation.

Figure 4-7. Photo of undercut, eroding streambank along the Clearwater River (AUID 648)

Nassett Creek 09020305-545

Nassett Creek is a relatively small stream, which makes it susceptible to pollution (there is minimal dilution). It is held to a more protective TSS standard (10 mg/L) because it is a designated trout stream. The impairment designation was based upon transparency data and the prevalence of transparency readings that were less than 55 cm (21% of measurements). The TSS data from this stream was very limited, yet it included an exceedance of the 10 mg/L standard (13 mg/L on July 21, 2016). The most notable threat to stream banks and habitat along Nassett Creek comes from pastures where livestock have access to the stream. Livestock can have the effect of removing the woody and deep-rooted vegetation that is important for maintaining stream bank stability. Direct disturbance by the presence of livestock in the stream has been noted in the comments recorded during water quality monitoring site visits (Figure 4-8). Disturbance of the banks through trampling will negatively affect stream bank stability and surface protection. Feedlots are present within the drainage area. One is located near a channel in the headwaters of Nassett Creek. Runoff from that feedlot, however, appears to be mitigated by wetlands and ponds.

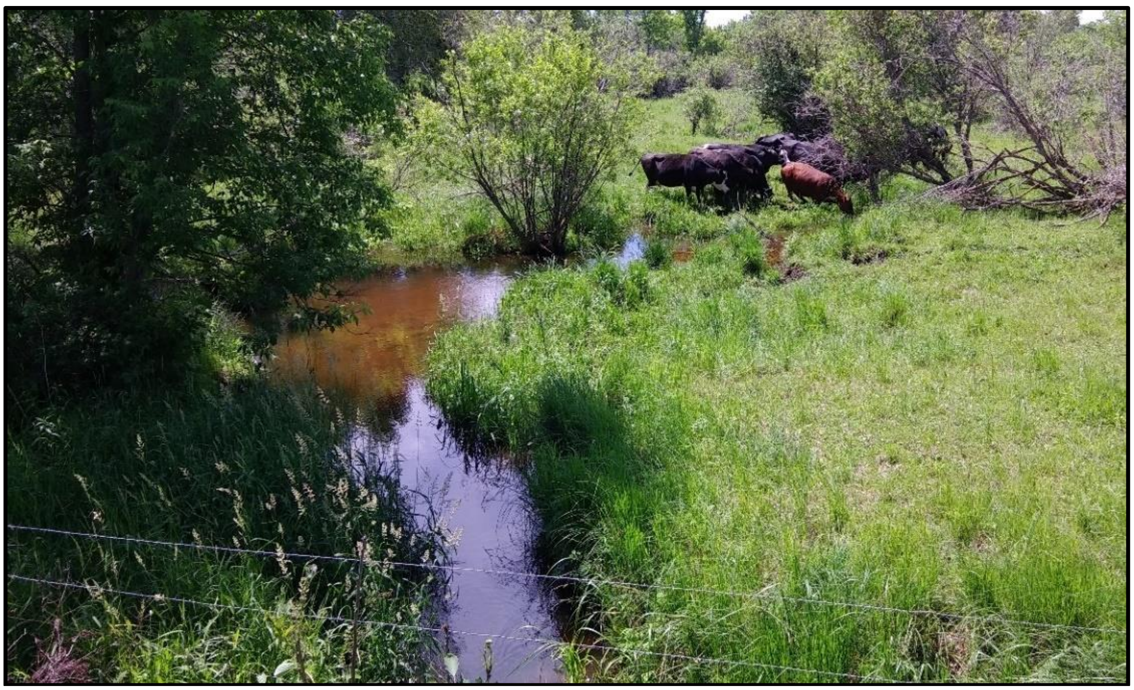


Figure 4-8. Photo of cattle upstream of a Nassett Creek water quality station S004-205 (AUID 545)

Nesset Creek Drive is a gravel road. Washouts and road maintenance have been occasionally noted as potential sources of sediment. The road at S004-205 washed out during the summer of 2007, prior to the April 19, 2007, sampling event that recorded a low transparency measurement. Beaver activity has also been noted. The Bagley Riverwatch program collected data from both Nesset Creek Drive crossings of Nassett Creek (S004-205 and S005-500). On most of the days in which transparency was low at the furthest downstream crossing (S004-205), transparency was good or at least met standards at the upstream crossing (S005-500). Sampler error was also identified, in some instances.

The unedited sampling record from 2006 through 2015 found that the creek violated the transparency standard in approximately 10.5% of measurements. The removal of the questionable data from September 19, 2012, dropped that rate down to approximately 8.9%. Exceedances of the TSS standard were recorded in 2016 and 2018, so the stream is still impaired. The 2016 TSS sampling included an exceedance of the 10 mg/L standard and brought the rate at which the stream violated water quality standards back up to 10.5%. The primary source of sediment seems to be a localized disturbance by cattle. A project to exclude cattle from this sensitive stream in Section 29 of Eddy Township would likely result in a future delisting of this reach's TSS impairment. Continued monitoring, with proper methods is imperative.

SWAT and HSPF Modeling Results

An HSPF model was created by RESPEC to simulate water quality parameters for the years 1996 through 2016. Flow monitoring and water quality sampling data were used to help calibrate the model. Calibration reports and memorandums for model development (RESPEC 2012), hydrology calibration (Burke 2013), and modeling contributing areas (RESPEC 2013) describe how the model was created. A more recent revision to the model extended the simulated period so that it goes through 2016 instead of 2009. A Scenario Application Manager for the HSPF model (HSPF-SAM) was also created for the watershed (https://www.respec.com/sam-file-sharing/). A useful application of the HSPF modeling data is the creation of maps that show sediment yield rates (Figure 4-10) in subbasins throughout the watershed. Sediment yield is the rate of sediment loss (tons per acre per year) in each subbasin and not the total sediment load from each basin. It is a way to compare erosion rates from subbasins of different sizes. Thus, Figure 4-10 shows the relative contributions of sediment from subbasins in the Clearwater River Watershed. Sediment yields generally appear to increase from east to west in the Clearwater River Watershed. This pattern is likely influenced by land use changes. The majority of overland erosion seems to have come from cultivated fields. Figure 4-9 shows that cultivated crops are the largest source of sediment, followed by instream erosion, according to the 1996 through 2016 HSPF model simulation. More cultivated crops will result in more sediment yields. Significant amounts of sediment are also contributed by runoff from developed land ("urban") and pasture. The subbasins with relatively high sediment yields can be targeted for BMP implementation. Roadside or aerial photo reconnaissance can be used to identify problem areas within those subbasins. When available, tools such as the Prioritize, Target, and Measure Application (PTMApp) will be used to target the precise locations (field scale) in a drainage area where BMPs will most cost-effectively reduce erosion. PTMApp will likely be created for the 1W1P process. A zonation model may also be completed for the watershed during the 1W1P process if local planning committees choose to utilize that tool.

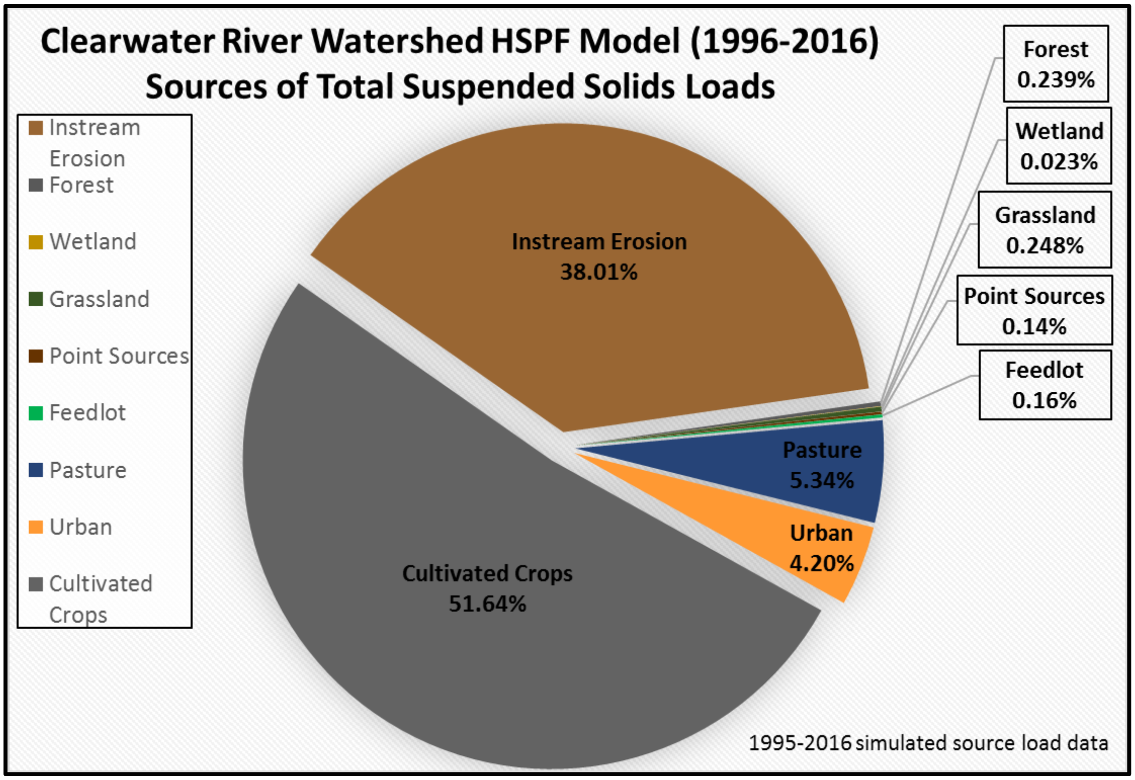


Figure 4-9. Chart of sediment sources estimated by the 1996-2016 HSPF model

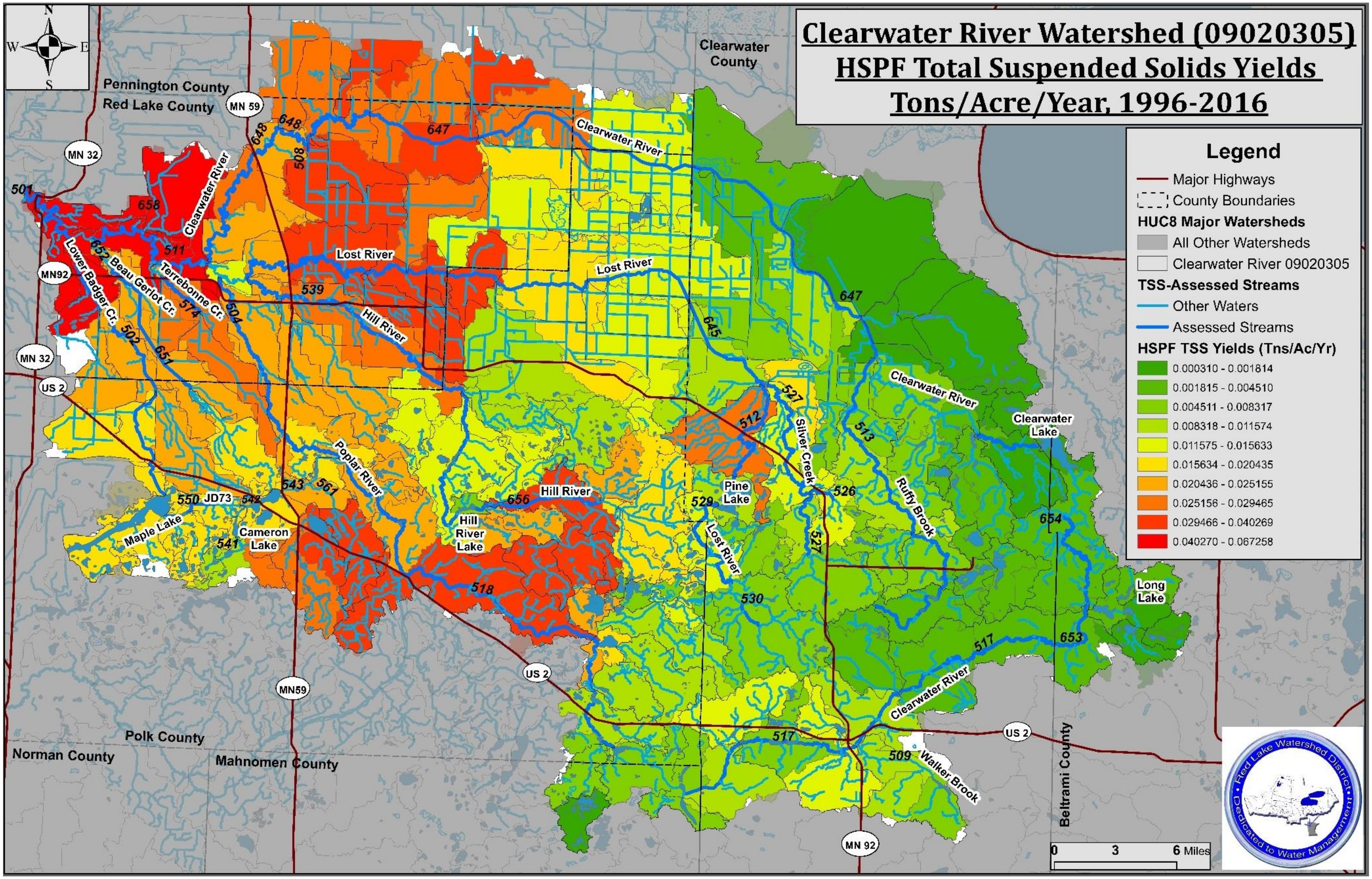


Figure 4-10. Clearwater River Watershed HSPF-modeled sediment yields and loads by subwatershed

Longitudinal Sampling Results

Longitudinal sampling can reveal how water quality conditions change along a waterway. It can be helpful in identifying sources of pollutants.

Longitudinal sampling of the main channel of the Clearwater River was conducted during a May 31, 2016 runoff event (Figure 4-11) and during an August 5, 2016 wild rice paddy discharge event (Figure 4-12). The August 5, 2016 samples also followed a runoff event. High TSS concentrations were recorded near the downstream end of Ruffy Brook on the previous day (August 4, 2016). The Ruffy Brook confluence is between the CSAH 11 and CSAH 5 crossings. Turbidity measurements on August 3, 2016 showed an increase from 0.3 FNU to 37 FNU from upstream of the wild rice paddies to downstream. A longitudinal, site-specific assessment of TSS along the Clearwater River (Figure 4-12) reveals where the impairment begins. The Clearwater River meets TSS standards upstream of the channelization and wild rice paddies.

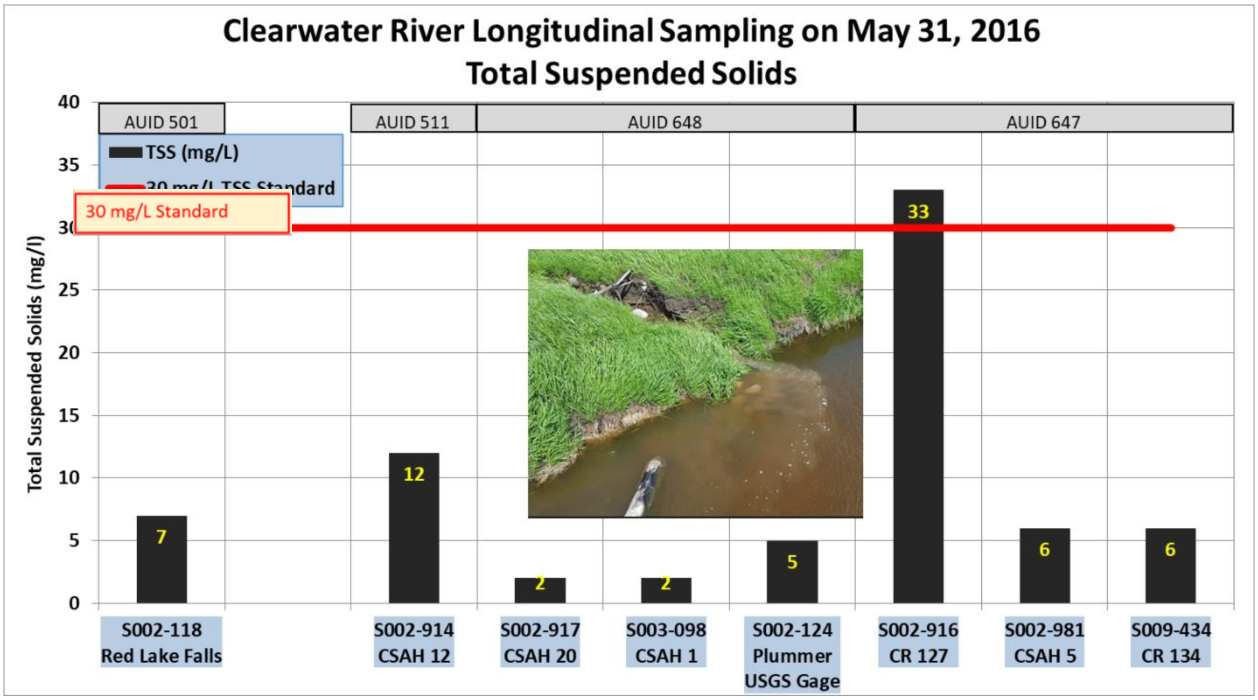


Figure 4-11. Longitudinal TSS sampling along Clearwater River after (AUIDs 501, 511, 648, and 647) after a runoff event, May 31, 2016

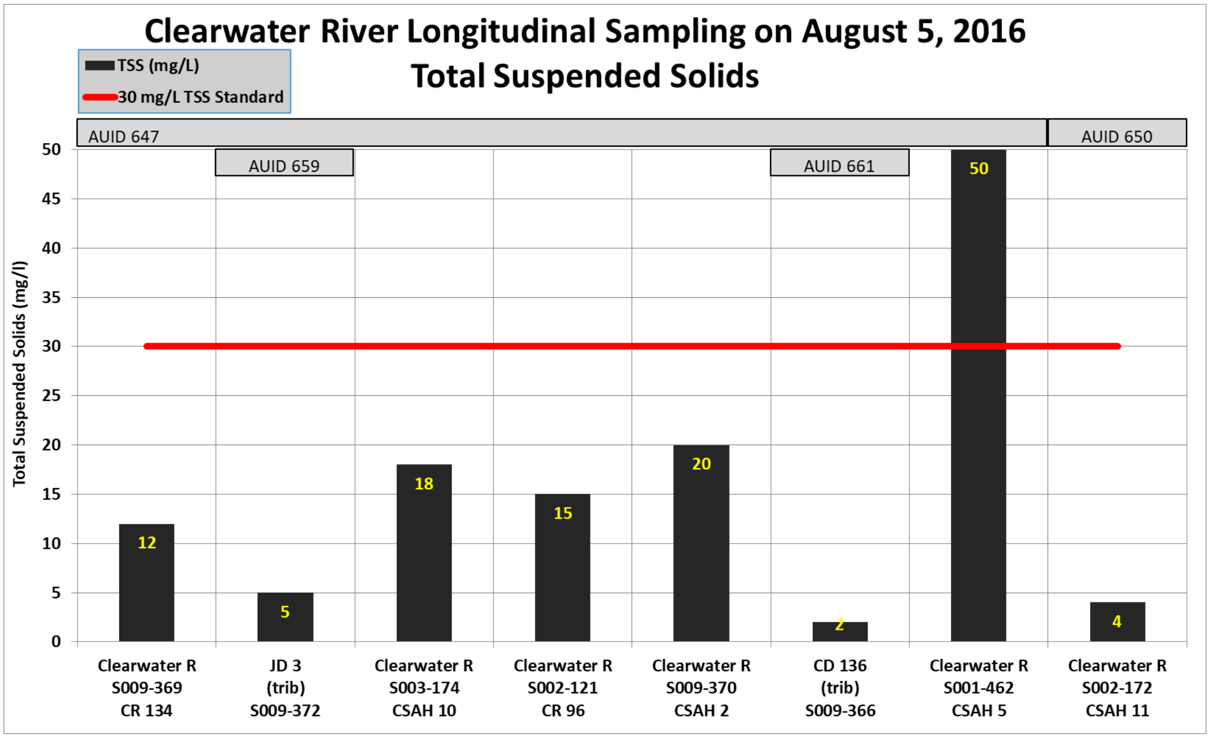


Figure 4-12. Longitudinal TSS sampling along Clearwater River (AUIDs 647, 659, 661, and 650) near pour points of tributary ditches during wild rice paddy discharge, August 5, 2016

Fluvial Geomorphology Assessment:

Staff from the DNR and the RLWD completed a fluvial geomorphology assessment throughout the Clearwater River Watershed. Notable erosion problems of riverbanks and were discovered during reconnaissance trips and full geomorphologic assessments. The DNR is currently finalizing the Clearwater River Watershed Fluvial Geomorphology Report. Some reaches of the Clearwater River were very stable, particularly in the headwaters of the watershed and the Poplar River. Channelized portions of the Clearwater River and the Lost River had stability problems. Near the mouth of the Clearwater River Watershed, the Clearwater River and its tributaries were at least moderately unstable. The gradient of the Clearwater River increases as it nears Red Lake Falls. Tall, unstable bluffs line the river. As tributary streams and ditches approach the Clearwater River in the western portion of the watershed, those channels also transition to steeper gradients.

The channelization of the Clearwater River began a short distance upstream of the Ruffy Brook confluence and continued downstream to a point slightly downstream of the JD 1 confluence. The increased slope caused deep head-cutting (as much as 13 feet, according to a landowner). Head-cutting threatened to cut off meanders, cut off water supplies to a rice farm, and cause more upstream erosion. Grade stabilization structures were constructed in Section 27 of Greenwood Township (Figure 9-1) and are still fulfilling their purpose. The structures are located a short distance upstream of the TSS-impaired AUID 647. The geomorphology study found that additional stabilization work is needed downstream of the existing structures. The Clearwater River is still head-cutting into the natural reach upstream of the channelized reach, particularly in the area upstream of the Ruffy Brook confluence. Evidence of the head-cutting (Figure 4-13) is seen in unstable streambanks, gouges in the riverbed, and a steep drop downstream of the last grade stabilization structure. An elevated layer of shell fragments and pebbles within an eroded streambank of the Clearwater River was found a short distance upstream of the channelized reach and provided an indication of where the elevation of the channel once was and the amount of head-cutting that has occurred along the reach. Additional grade stabilization structures are needed between the furthest downstream (existing) grade stabilization structure and the confluence with Ruffy Brook. Pfankuch ratings (Figure 4-15) show an abrupt change in stability from upstream of the grade stabilization project to downstream.

The geomorphology study documented some sediment sources that have already been mentioned in Section 4.1. Outlets of drainage systems and tributaries of the Clearwater River need stabilization along the lower portion of the river. Gradients between the last road crossing and the Clearwater River can be very steep. Steep gradients cause mass-wasting erosion problems and can impede fish passage. Width and quality of buffers need to be improved in many areas. Sharp contrasts in streambank stability are evident between banks that are protected by woody and deep-rooted vegetation and banks that have been stripped of vegetation for fields, pastures, development, or aesthetics.

Exploration of the Lost River between CR 118 and the confluence with the Clearwater River revealed that a large amount of sand is being transported along the lower portion of the river. Large sediment bars are visible in aerial photos. Reconnaissance via kayak discovered that, in addition to the sediment bars, trees and logs along the bank of the river appeared to have been sandblasted by powerful, sediment-laden streamflow (Figure 4-14).

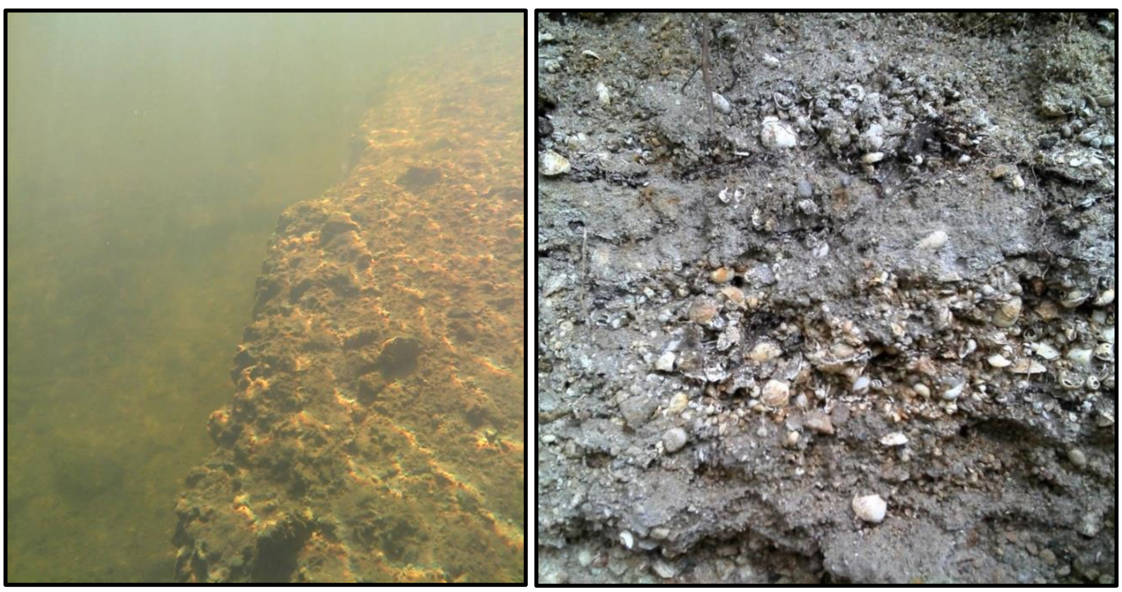


Figure 4-13. Photo evidence of head-cutting along the transition from natural channel to channelization along the Clearwater River (AUID 650).


Figure 4-14. Photo of a tree trunk over the Lost River (AUID 505) that has been abraded by swift, sediment-laden water

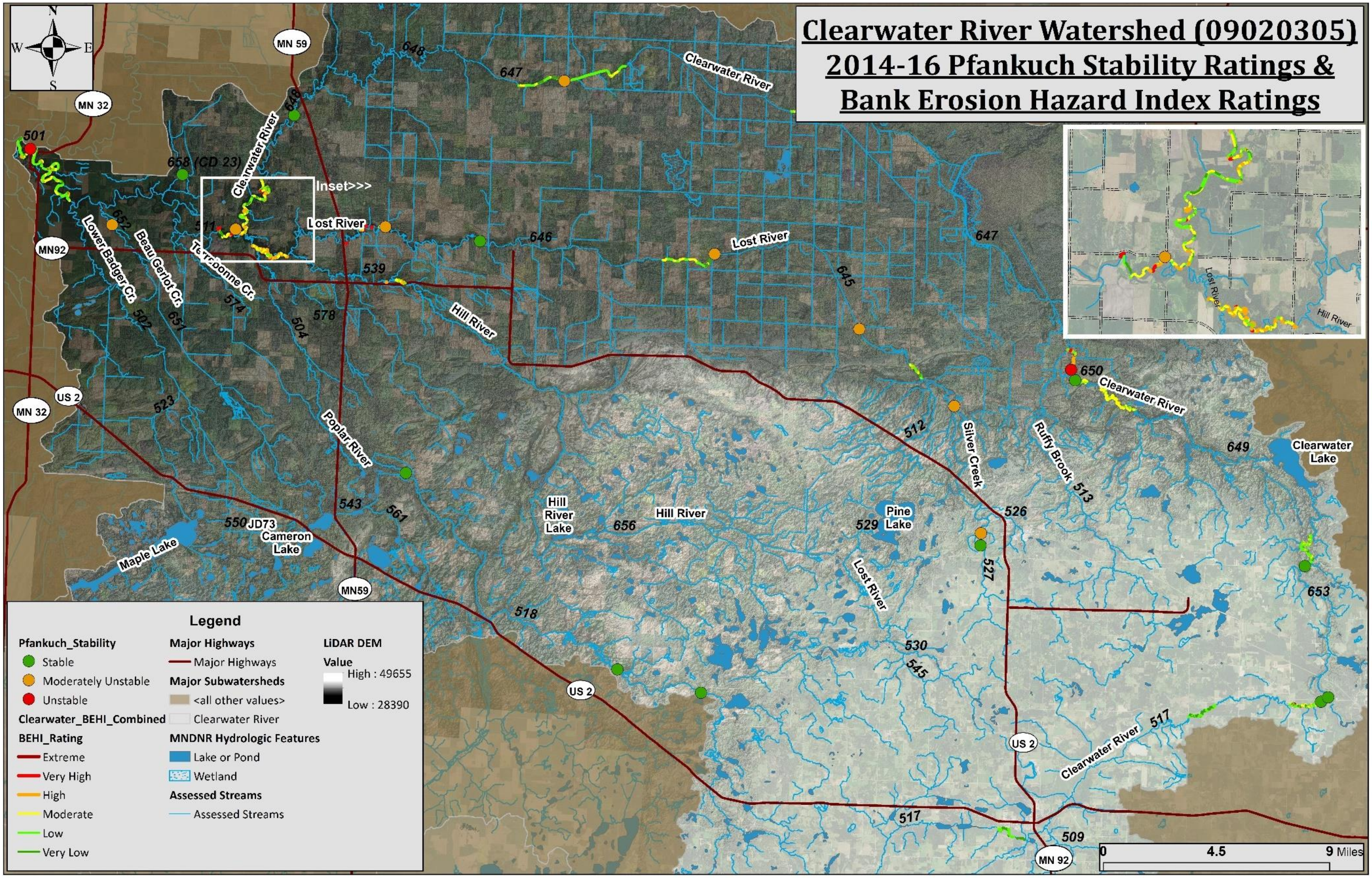


Figure 4-15. Pfankuch stability ratings and bank erosion hazard index ratings from the Clearwater River Fluvial Geomorphology Study

4.2 Sources of *E. coli* Bacteria

Even the most pristine streams in the Clearwater River Watershed contain some *E. coli* bacteria. Recent research has found that *E. coli* can persist in sediment throughout the year without the continuous presence of sewage or mammalian sources. An Alaskan study [Adhikari et al. 2007] found that total coliform bacteria in soil were able to survive for six months in subfreezing conditions. A study of cold water streams in southeastern Minnesota completed by the MPCA staff found that stream sediment disturbance causes resuspension of *E. coli* in the stream water. A study near Duluth, Minnesota [Ishii et al. 2010] found that *E. coli* were able to grow in agricultural field soil. A study by Chandrasekaran et al. [2015] of ditch sediment in the Seven Mile Creek Watershed in southern Minnesota found that strains of *E. coli* had become naturalized to the water−sediment ecosystem. Survival and growth of fecal coliform has been documented in storm sewer sediment in Michigan [Marino and Gannon 1991].

Impairments occur when there are sources that chronically contribute an excessive amount of *E. coli* and create potentially unsafe conditions for aquatic recreation. Sources of natural background *E. coli* bacteria may include wildlife, birds (naturally distributed), and bacteria that lives in soil or in-stream sediment. Often, *E. coli* impairments result from situations in which anthropogenic land use changes or stream modifications have led to discharge of pollutants, runoff of excess animal waste (feedlot locations are shown in Figure 5-24), unnatural concentration of birds or wildlife (under bridges/culverts or within wild rice paddies). The sources of *E. coli* from landscape disturbances are the ones that can most feasibly be targeted for implementation of restoration strategies. Sources of excess *E. coli* bacteria in impaired streams were identified through examination of the watershed and the analysis of microbial source tracking samples. The results are summarized in Table 4-3 and explained further in this section.

Table 4-3. Sources of *E. coli* bacteria for impaired reaches

E. coli Sources in Impaired Streams		Identifiable Sources				
Assessment Unit	Stream Name	Livestock	Birds	Stormwater	Waterfowl	Septic/ Wastewater
09020305-502	Lower Badger Creek		X		X	
09020305-504	Poplar River	X	X			X
09020305-512	Lost River	X		X		X
09020305-513	Ruffy Brook	X				
09020305-526	Clear Brook			X		X
09020305-527	Silver Creek	X	X	X		X
09020305-529	Lost River	X	X			
09020305-530	Lost River	X				
09020305-539	Hill River	X	X			X
09020305-545	Nassett Creek	X			X	
09020305-550	JD73		X			
09020305-574	Terrebonne Creek	X	X			
09020305-578	Brooks Creek		X			X
09020305-647	Clearwater River	X	X		X	X
09020305-651	Beau Gerlot Creek		X			X

<u>Microbial Source Tracking and Failing Septic Systems</u>

Microbial Source Tracking (MST) samples were collected from the Beau Gerlot Creek, Brooks Creek, Hill River, Lost River, JD 73, Terrebonne Creek, Silver Creek, Ruffy Brook, and Clearwater River in July and August 2016. The MST sample analysis helped identify sources of fecal coliform and *E. coli* pollution. Samples were analyzed by a lab in Florida (Source Molecular). *E. coli* samples were also collected and analyzed at RMB Environmental Laboratories in Detroit Lakes, Minnesota for total concentration of *E. coli* bacteria at the time of sampling. Past data were used as a guide for the timing of sample collection.

Table 4-4. Microbial source tracking analysis (fecal DNA testing) results of samples collected in the Clearwater River Watershed.

Date	Site Name (AUID)	Site ID Code	*E. coli* (MPN/ 100ml)	Analysis Requested	Quantification	DNA Analytical Results
7/14/2016	Beau Gerlot Creek at CR 114 (651, 652)	S008-058	125.9	Bird Fecal ID	<LOQ	Present
				Ruminant Fecal ID	Non-detect	Absent
				Humans 1	<LOQ	Present
				Human 2	<LOD	Absent
7/14/2016	Brooks Creek at CSAH 92 (578)	S006-506	248.1	Bird Fecal ID	<LOQ	Present
				Ruminant Fecal ID	Non-detect	Absent
				Humans 1	<LOQ	Present
				Humans 2	Non-detect	Absent
7/14/2016	Hill River at CR 119 (539)	S002-134	435.2	Bird Fecal ID	<LOQ	Present
				Ruminant Fecal ID	435 copies/100ml	Present
				Humans 1	<LOQ	Present
				Humans 2	Non-detect	Absent
7/28/2016	Lost River at 109th Ave (529)	S005-283	50.4	Bird Fecal ID	<LOQ	Present
				Ruminant Fecal ID	Non-detect	Absent
				Humans 1	Non-detect	Absent
7/28/2016	Judicial Ditch 73 at 343rd St. SE (550)	S003-318	143.9	Bird Fecal ID	<LOQ	Present
				Ruminant Fecal ID	Non-detect	Absent
				Humans 1	Non-detect	Absent
7/28/2016	Terrebonne Creek at CSAH 92 (574)	S004-819	73.3	Bird Fecal ID	Non-detect	Absent
				Ruminant Fecal ID	Non-detect	Absent
				Humans 1	Non-detect	Absent
8/4/2016	Silver Creek at 159th Ave near Clearbrook (527)	S000-712	>2,419.6	Bird Fecal ID	<LOQ	Present
				Canada Goose	Non-detect	Absent
				Ruminant Fecal ID	127,000 copies/100ml	Present (High)
				Dog Fecal ID	517 copies/100ml	Present (Low)
				Humans 1	<LOQ	Present)
				Humans 2	<LOQ	Present
8/4/2016	Ruffy Brook at CSAH 11 (513)	S008-057	>24,196	Bird Fecal ID	Non-detect	Absent
				Ruminant Fecal ID	80,500 copies/100ml	Present (Moderate)
				Humans 1	Non-detect	Absent
				Humans 2	Non-detect	Absent
8/4/2016	Clearwater River at CSAH 10 (647)	S003-174	1,413.60	Bird Fecal ID	Non-detect	Absent
				Canada Goose	Non-detect	Absent
				Ruminant Fecal ID	1,620 copies/100ml	Present (Low)
				Humans 1	Non-detect	Absent
				Humans 2	Non-detect	Absent
<LOD = Below the Limit of Detection (<10 copy numbers per reaction)						
<LOQ = Below the Limit of Quantification (present in a trace amount)						
Humans 1 = Human Bacteroidetes ID 1; Humans 2 = Human Bacteroidetes ID 2						

Tests revealed that human waste is entering Beau Gerlot Creek, Brooks Creek, Hill River, and Silver Creek. Test results (Table 4-4) have been shared with agencies with regulatory authority for septic systems. Significant contributions from ruminants (cattle, sheep, deer, chamois, or goats) were found in samples collected from the Clearwater River, Ruffy Brook, Silver Creek, and the Hill River. MST sample analysis revealed that birds are contributing to fecal pollution, albeit in trace amounts. Bird fecal DNA markers were discovered at six of the nine sites that were sampled for microbial source tracking. Cliff swallows concentrated under bridges and within culverts (living over the water) are a very likely contributor to the bird fecal matter found in the analysis.

4.2.1 Permitted *E. coli* sources

Municipal Separate Storm Sewer Systems

There are no MS4s within the Clearwater River Watershed, as previously stated in Section 4.1.1. There are no municipalities with populations that are large enough to become designated MS4s.

Wastewater Treatment Facilities

The Fosston and McIntosh WWTFs discharge to AUID 18 of the Poplar River. Two Fosston WWTF outlets discharge to the Poplar River between the CSAH 6 (S000-477) and CSAH 30 (S003-127) crossings. That reach of the Poplar River is not impaired by *E. coli*, but is located directly upstream of AUID 504, which is impaired by excess *E. coli*. Though AUID 518 is not impaired, portions of the reach could be considered 'nearly impaired' due to site-specific (S002-392) monthly geometric means that are greater than 100 MPN/100ml.

Historically, the Fosston WWTF has negatively impacted water quality in the Poplar River with extreme concentrations of nutrients and other pollutants documented in the river. There are records of citizen complaints to state and local agencies about discharge from the Fosston WWTF and the resulting poor water quality in the river over the years. Samples have been collected to document those conditions. The facility was upgraded in 2012 to improve the efficacy of the treatment process and additional improvements are tentatively planned for 2021 or 2022, pending funding. Two violations of the WWTF's *E. coli* limit have occurred since the 2012 improvements.

Figure 4-16. Photo of Poplar River water quality condition during Fosston WWTF discharge, July 7, 2016 at station S003-127 (AUID 518)

The most recent documented potential detrimental discharge from the Fosston WWTF was on July 7, 2016. As a result of a citizen compliant, RLWD staff collected samples upstream and downstream of the Fosston WWTF discharge. Significant increases in pollutants were identified in samples collected from downstream of the facility (1203.3 MNP/100ml *E. coli*, 143 mg/l BOD, 98 mg/l TSS, 6.47 mg/l TP, and 11.2 mg/l Ammonia at CSAH 30, S003-127) compared to upstream conditions (517.2 MNP/100ml *E. coli*, 2.96 mg/l BOD, 21 mg/l TSS, 0.13 mg/l TP, and <0.04 mg/l Ammonia at CSAH 6, S000-477). Even though the visual condition of the river (Figure 4-16) and the sample results indicate that the poor water quality that day did not appear to be caused by a natural event, the Fosston WWTF discharge was inaccessible for visual inspection to confirm or deny an active discharge. The RLWD staff contacted the MPCA the same day the complaint was received. This incident indicates that the WWTF can be a stressor to the Poplar River and its biology at times.

The McIntosh WWTF discharges to the Poplar River between the 283rd Avenue Southeast and 360th Street Southeast crossings. According to discharge records from 1999 through 2015 that are available in EQuIS, the McIntosh WWTF has not recorded an exceedance of its 200 MPN/100mL fecal coliform limit. The highest concentration in the available record was 18 MPN/100ml.

The Gonvick WWTF discharges directly to an impaired section of the Lost River (09020305-512), near Ash Street, on the northeast portion of the town. The discharge is located directly upstream of the S004-050 sampling station and is also upstream of the pour point water quality station at the 139th Avenue crossing (S000-924). The discharge record for this facility does show some exceedances of its 200 MPN/100ml limit for fecal coliform, as recent as May and July of 2014.

The Clearbrook WWTF is located east of the town of Clearbrook and discharges to a channel that flows to Ruffy Brook. The highest monthly geometric-mean concentration of fecal coliform that can be found in EQuIS for this facility is 97 MPN/100ml (the limit is 200 MPN/100ml). The discharge flows through 1.6 miles of a small ditch before entering Ruffy Brook. The direct cattle access to the lower portions of that ditch likely contribute much more *E. coli* bacteria than the WWTF. Because the Clearbrook WWTF discharges to an impaired stream that flows directly into AUID 647 of the Clearwater River, it will also be included in that TMDL.

The Plummer WWTF, Bagley WWTF, and Oklee WWTF do not discharge to waterways that are impaired by *E. coli* and have not been assigned a WLA. Assessment of those reaches have demonstrated their ability to assimilate the capacity of the *E. coli* from those discharges and maintain water quality standards. The Erskine WWTF does not discharge to surface waters, and the Red Lake Falls WWTF discharges to the Red Lake River. Neither of these WWTF have been assigned a WLA in the *E. coli* TMDLs. The Bagley WWTF discharges to a portion of the Clearwater River (AUID 517) that is not impaired by *E. coli*. Even though the Bagley WWTF could potentially affect downstream AUIDs 643 and 644, no exceedances of water quality standards were found along those reaches in the 2016 assessment. The Bagley WWTF has not been assigned a WLA for any of the *E. coli* TMDLs.

Table 4-5. Impaired AUIDs and upstream WWTFs that could contribute to *E. coli* impairments

Wastewater Treatment along the Clearwater River			City and Industrial WWTF Discharges and Permit Numbers			
HUC-10	*E. coli*-impaired Assessment Units	AUID Descriptions	Fosston MN0022128-SD-1 MN0022128-SD-2	McIntosh MNG580031 -SD-1	Clearbrook MNG580098 -SD-2	Gonvick MN0020541 -SD-1
		HUC-10:	0902030504	0902030504	0902030505	0902030505
0902030506	Lower Badger Ck 09020305-502	CD 14 to Clearwater R				
0902030504	Poplar River 09020305-504	Hwy 59 to Lost R	X	X		
0902030505	Lost River 09020305-512	Pine Lake to Anderson Lake				X
0902030502	Ruffy Brook 09020305-513	Headwaters to Clearwater R			X	
0902030505	Clear Brook 09020305-526	Headwaters to Silver Cr				
0902030505	Silver Creek 09020305-527	Headwaters to Anderson Lk				
0902030505	Lost River 09020305-529	T148 R38W S17, S line to Pine L				
0902030505	Lost River 09020305-530	Unnamed cr to T148 R38W S20, north line				
0902030503	Hill River 09020305-539	Hill River Lake to Lost River				
0902030503	Nassett Creek 09020305-545	T148 R38W S28, S line to Lost R				
0902030506	JD 73 09020305-550	Unnamed ditch to Tamarack L				
0902030507	Terrebonne Crk 09020305-574	CD 4 to CD 58				
0902030507	Brooks Creek 09020305-578	Unnamed cr to Hill River				
0902030502	Clearwater R 09020305-647	Ruffy Brook to JD1			X	
0902030507	Beau Gerlot Ck 09020305-651	Upper Badger Cr to -96.1947 47.8413				

4.2.2 Non-permitted E. coli sources

Each impaired reach was examined to identify the source(s) of excess *E. coli* bacteria. The WRAPS process included strategic collection and analysis MST samples that were analyzed for fecal DNA markers. Examination of aerial photos, longitudinal sampling, and plotting sampling events along LDCs also aided the identification of *E. coli* bacteria sources.

Lower Badger Creek 09020305-502

There were few obvious sources of *E. coli* bacteria in this watershed. Available data did not show any registered or permitted feedlots within the drainage area downstream of Maple Lake. The Lower Badger Creek LDC (Figure 5-10 in Section 5.2.1) shows that exceedances of the 126 MPN/100ml standard have occurred throughout the range of flows at S004-837 (CR 114). Sources of *E. coli* are contributing to exceedances during high-flow runoff events, mid-range flows, and during lower flows. During a runoff event in June 2016, longitudinal sampling (Figure 4-17) revealed that *E. coli* concentrations were okay in the upstream portions of the watershed but were near or greater than the 126 MPN/100ml chronic standard at the three downstream road crossings (County Road 117 through County Road 114).

The upstream AUID 523 is monitored with a long-term monitoring site near the outlet of Maple Lake (S002-130) and met the *E. coli* standards in the 2016 assessment. However, occasional high concentrations of *E. coli* have been recorded at S002-130. Investigative sampling at that location revealed that that *E. coli* is coming from natural sources (waterfowl) within a wetland area between the Maple Lake outlet structure and the CSAH 10 crossing (S002-130) and not from the lake. Although MST samples have not been collected from Lower Badger Creek, samples have been collected in nearby streams like Beau Gerlot Creek. Because Beau Gerlot Creek tested positive for bird fecal ID markers, birds (particularly cliff swallows under bridges and box culverts) are also very likely a source of *E. coli* bacteria in Lower Badger Creek. Human fecal DNA markers were also identified in samples from nearby streams. Due to the existence of an *E. coli* impairment and its proximity to other streams that are affected by septic effluent, the watershed should be targeted for inspections of septic systems.

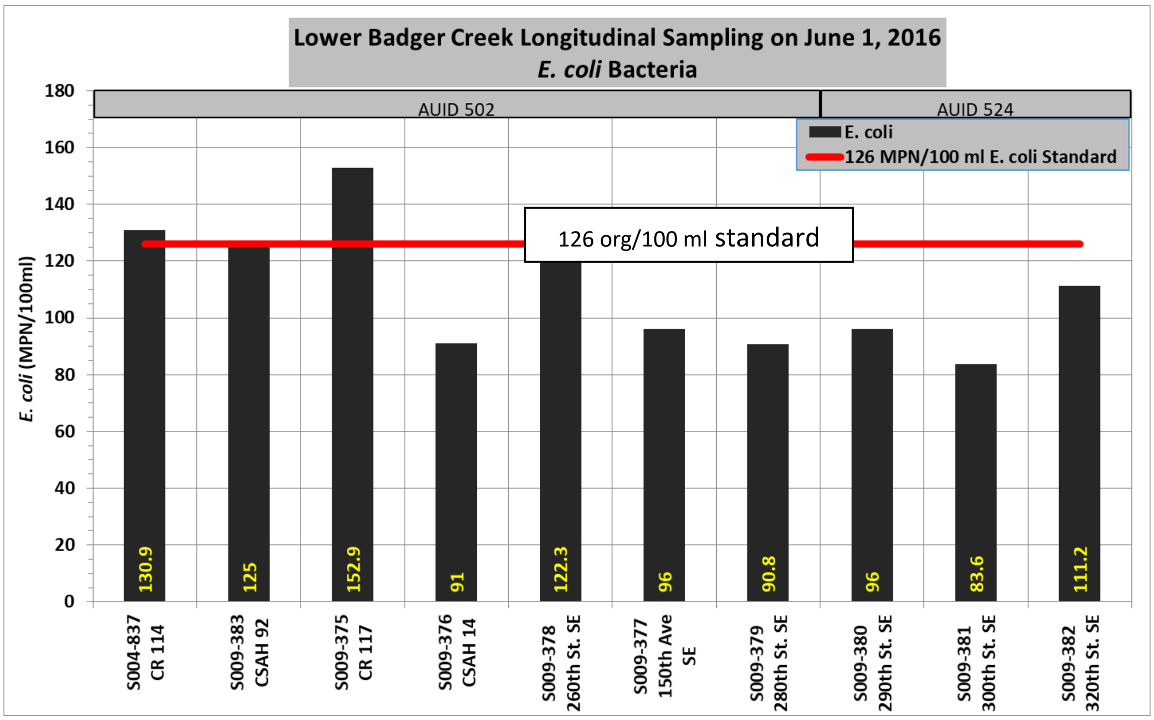


Figure 4-17. Longitudinal *E. coli* sampling along Lower Badger Creek (AUID 502 and 524), June 1, 2016

Poplar River 09020305-504

The LDC for the pour point of the 09020305-504 (Figure 5-11 in Section 5.2.1) reach of the Poplar River shows that exceedances of the 126 MPN/100ml chronic standard have occurred throughout the range of flows that have been observed at Station S007-608, but occur more frequently during higher flows. Longitudinal sampling in August 2016 identified portions of the watershed where *E. coli* concentrations increased. Bacteria concentrations were okay upstream of 290th Street Southeast. The sampling results revealed an increase in *E. coli* downstream of that crossing. There may have been a source of *E. coli* bacteria between the 290th Street Southeast crossing (58.3 MPN/100ml) and the CSAH 49 crossing (272.3 MPN/100ml). The sampling took place during flows that were on the lower end of the "high flow" category. Aerial photos show a livestock operation along the east side of Poplar River in Section 3 of Badger Township in Polk County.

Table 4-6. Site-specific *E. coli* assessment statistics for the Poplar River (AUID 504) (2006-2015 data)

Station ID	Road Crossing	AUID 09020305-XXX	May Geomean *E. coli*	June Geomean *E. coli*	July Geomean *E. coli*	August Geomean *E. coli*	September Geomean *E. coli*
S007-608	CR 118	504	15.1*	192.4	195.7	71.7	35.3*
S002-117	CSAH 92	504	23.8	110.4	268.2	138.8	174.7*
S002-091	315th St	518	15.9*	60.0	62.0*	110.8	93.6*
*<5 samples from this site in this calendar month. Shading indicates exceedances of the geometric-mean standard.							

A site-by-site assessment of *E. coli* concentrations (Table 4-6) revealed that both long-term sites along this AUID (at CSAH 92 and CR 118) exceed the 126 MPN/100ml standard in multiple months. There are no other long-term sampling sites along the impaired AUID. There are sites along the upstream AUID (AUID 518) that could represent water quality conditions near the upstream end of AUID 504. The furthest downstream long-term monitoring site (S002-091) on AUID 518 met the 126 MPN/100ml *E. coli* standard in all months. The riparian corridor between 315th Street and Highway 59 mostly consists of hunting land and state land. Travelling downstream from Highway 59, the first potential sources of *E. coli* bacteria within 09020305-504 become evident near the 220th Avenue Southeast crossing (S004-501) where there are some homes and there is a feedlot a short distance downstream of the crossing.

Microbial source tracking sample collection has not been completed for the Poplar River but has been conducted for nearby streams. The closest MST sampling locations were the Hill River at CR 119 and Terrebonne Creek at CSAH 92. Bird, human, and ruminant (cattle) fecal DNA markers were found in the Hill River, but none of those potential sources were detected in Terrebonne Creek. There are bridges along the Poplar River that have colonies of cliff swallows that could be contributing to *E. coli* concentrations. As a precaution, the watershed could be targeted for septic inspections.

Lost River 09020305-512

The LDC for the pour point of the 09020305-512 (Figure 5-12 in Section 5.2.1) reach of the Lost River shows that exceedances of the 126 MPN/100ml chronic standard have occurred throughout the range of flows. The Lost River (AUID 512) flows out of Pine Lake, past livestock operations, past residences, past the city of Gonvick, and into Anderson Lake. Significant data collection has occurred at three locations along the reach. Site-specific assessment of *E. coli* data in the Lost River shows that conditions worsen from upstream to downstream (Table 4-7). The monthly geometric mean concentrations of *E. coli* bacteria meet the 126 MPN/100ml standard near the outlet of Pine Lake, at 486th Street. Data collected upstream of the city of Gonvick at CSAH 8 (S007-607) fell short of meeting minimum data requirements but still indicates that the river was likely exceeding the standard at that location. July, August, and September geometric-means exceeded 126 MPN/100ml at CSAH 8, but more data was needed to meet the five samples/month minimum. At the furthest downstream site on the reach (139th Avenue, S000-924), the Lost River exceeded the 126 MPN/100ml standard in June, July, and August. The September geometric mean *E. coli* concentration at S000-924 was also higher than the standard, but that month fell short of minimum data requirements.

Table 4-7. Site specific *E. coli* assessment statistics for the Lost River (AUID 512) (2006-2015 data).

Station ID	Road Crossing	AUID 09020305-XXX	May Geomean *E. coli*	June Geomean *E. coli*	July Geomean *E. coli*	August Geomean *E. coli*	September Geomean *E. coli*
S001-007	486th St.	512	7.8	54.9*	18.0*	69.2*	8.4*
S007-607	CSAH 8	512	11.5*	47.1*	192.4*	179.4*	131.4*
S000-924	139th Ave	512	5.1	225.8	268.0	273.3	400.3
S004-500	CSAH 7	645	5.5	38.6	48.6	23.6	17.4
*<5 samples from this site in this calendar month. Shading indicates exceedances of the geometric-mean standard.							

Livestock operations along the river are a primary, suspected source of *E. coli* bacteria in the Lost River. There is one registered feedlot (according to publicly available 2016 GIS data) just downstream (northeast) of the city of Gonvick. That feedlot appears to be particularly impactful upon the Lost River. Cattle have access to the stream and have removed vegetation near the river (Figure 4-18). This area should be investigated under Minnesota's Buffer Law.

Figure 4-18. Livestock operation along the Lost River (AUID 512), northeast of Gonvick

In addition to the registered feedlot, there were other livestock operations along the Lost River. Cattle have access to the river a short distance upstream of the 139th Avenue sampling site. Livestock (cattle and horses) have destroyed vegetation along more than 670 meters of the Lost River corridor downstream (north) of 486th Street (Figure 4-19). Due to the livestock use of that corridor, streambanks have also become unstable.

Figure 4-19. Damaged stream banks along the Lost River (AUID 512) due to intensive grazing downstream (north) of the 486th Street crossing

Stormwater from the city of Gonvick was another potential nonpoint source of *E. coli* in the Lost River. Four stormwater outlets were known to exist in the city of Gonvick. The furthest upstream outlet drains the western side of the town and flows into the Lost River just upstream of the CSAH 7 crossing. Another section of the town drains to an outlet at the Maple Street crossing of the Lost River. Much of the area between Main Street and Oak Street drains to the Lost River through a culvert on the east side of the Samholt Lutheran Church cemetery. Stormwater drainage from the eastern part of the city of Gonvick flows to the Lost River through a channel along the east side of Ash Street. Samples collected upstream and downstream of the city of Gonvick during a 2004 stormwater study showed increases in fecal coliform concentrations from the upstream end of the town (S004-049 at CSAH 7 in Gonvick) to a site located downstream of town (S004-050). Longitudinal samples were more recently collected along the entire reach in 2017 (Figure 4-20). Those results showed high concentrations throughout the entire AUID.

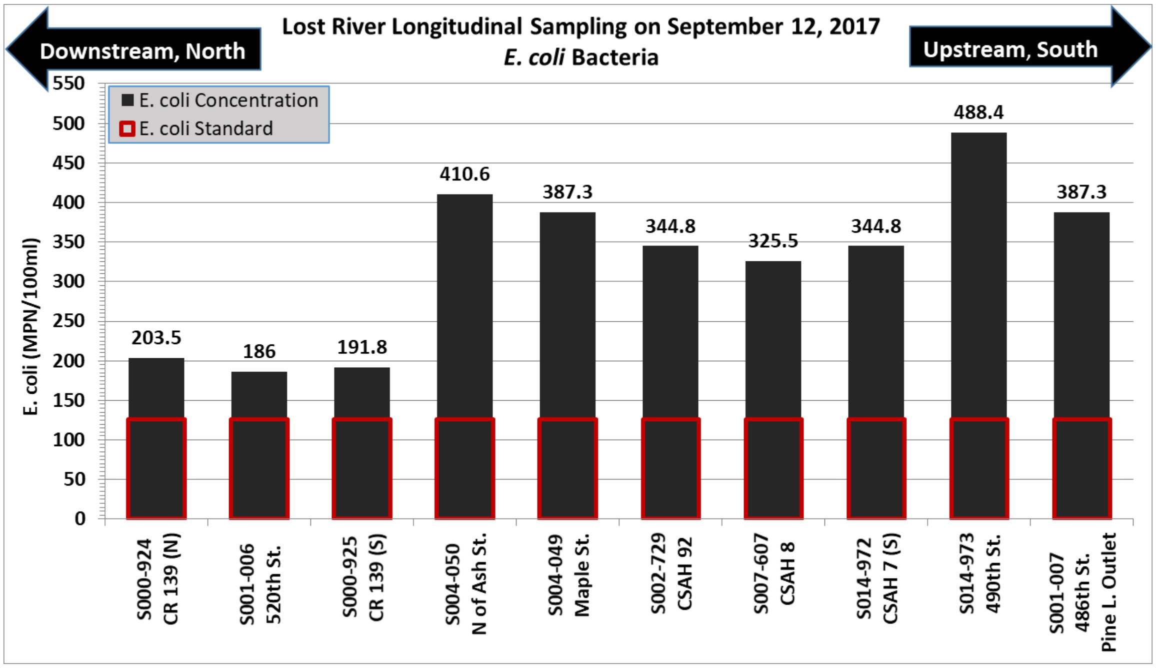


Figure 4-20 Longitudinal *E. coli* sampling along the Lost River (AUID 512), September 12, 2017

Ruffy Brook 09020305-513

The LDC for the 09020305-513 (Figure 5.13 in Section 5.2.1) reach of the Ruffy Brook shows that exceedances of the 126 MPN/100ml chronic standard have occurred throughout the range of flows. Historically, Ruffy Brook was a trout stream before land use changes rendered the stream incapable of supporting trout. State land along the Ruffy Brook corridor was sold to private landowners. Some of the new landowners cleared trees and began raising cattle along the stream. Those livestock operations have greatly contributed to an *E. coli* impairment, streambank instability, sedimentation, and the removal of woody vegetation (and shading) along the channel. Ruminant MST markers were found in a sample that was collected from Ruffy Brook. The tests did not find MST markers for birds or humans. The results of the MST sample analysis provide evidence that livestock are a primary source of the *E. coli* impairment in Ruffy Brook.

Longitudinal sampling along Ruffy Brook has shown large increases in *E. coli* concentrations downstream of livestock operations (Figure 4-21). Farms that appear to be negatively impacting *E. coli* concentrations and other characteristics of the stream (based on aerial photos and sampling data) are located:

- Downstream (north) of 510th Street
- Upstream (east) of 179th Avenue
- Upstream (south) of 490th Street
- Downstream (west) of County Road 16
- 0.25 miles south of CSAH 4, upstream (east) of County Road 76
- Upstream (east) of 221st Avenue
- Upstream (south) of CSAH 223.

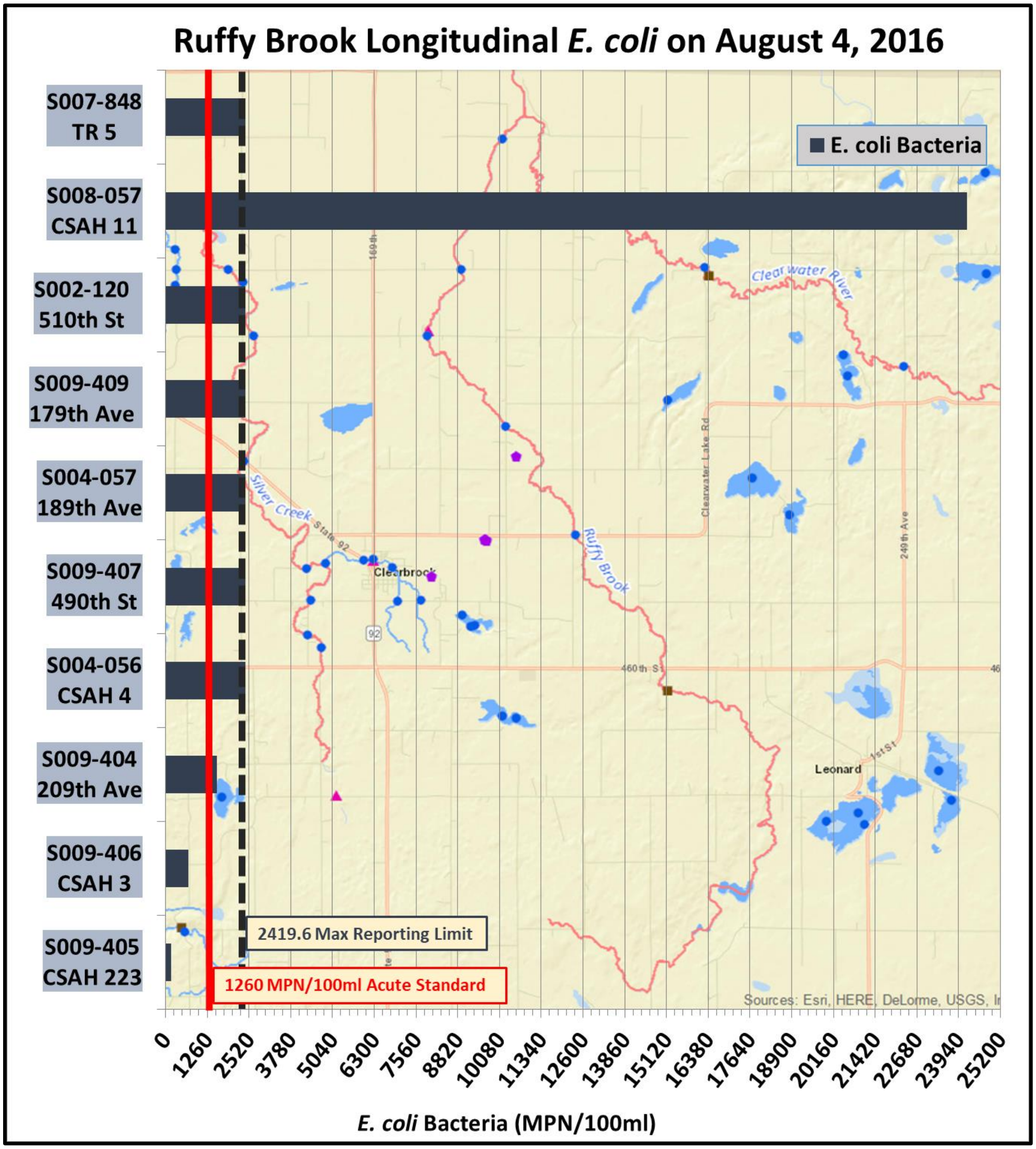


Figure 4-21. Longitudinal *E. coli* sampling along Ruffy Brook (AUID 513), August 4, 2016

There are three sites (Table 4-8) along Ruffy Brook with sufficient data for site-specific assessment (not for all months, though). They are all located at the downstream (north) end of the Ruffy Brook Subwatershed (final three crossings). Those sites exceeded the 126 MPN/100ml monthly geometric-mean standard. Site S008-057 at CSAH 11 also violates the 1,260 MPN/100ml standard in discrete measurements. Extreme concentrations have been recorded at that site. The laboratory performed a 1:10 dilution on the August 4, 2016 sample from S008-057 and the concentration was still too numerous to count (>24,196).

Table 4-8. Site-specific assessment statistics along Ruffy Brook (AUID 513), ordered upstream (top) to downstream (bottom)

Station ID	Road Crossing	May Geomean *E. coli*	June Geomean *E. coli*	July Geomean *E. coli*	August Geomean *E. coli*	September Geomean *E. coli*	Years Assessed
S002-120	510th St	233.8	357.5	267	209.9	166.3*	2006-15
S008-057	CSAH 11	83.5*	86.0*	408.3*	625.8*	317.3*	2006-15
S008-057	*CSAH 11*	*103.3*	*238.0*	*836.7**	*806.4*	*277.5*	*2009-18*
S007-848	TR 5	13*	142.8	127.7	199.8	307.7*	2006-15

*Fewer than 5 samples were collected from this site in this month.
Shading indicates exceedances of the geometric-mean standard.
Italics – This site was also assessed with more recent data due to a lack of data from the years 2006-2015

Clear Brook 09020305-526

Clear Brook is exposed to several nonpoint sources of *E. coli* bacteria as it flows from its headwaters, through the city of Clearbrook, and through a pasture to its confluence with Silver Creek. The LDC for this reach (Figure 5-14 in Section 5.2.1) shows that exceedances of the 126 MPN/100ml chronic standard have occurred during high and very high flows. An MST sample was collected from Silver Creek at S000-712, a short distance downstream of the Clear Brook and Silver Creek confluence. That sample revealed that birds, ruminants (cattle), dogs (likely in stormwater runoff within Clearbrook), and humans (septic systems) were contributing to *E. coli* concentrations in Clear Brook and Silver Creek (upstream of 159th Avenue). The sample was collected after a runoff event and had an overall concentration that was >2,419.6 MPN/100ml. Longitudinal sampling in 2017 (Figure 4-22) showed that there are large increases in *E. coli* concentrations as the stream flows through the town of Clearbrook.

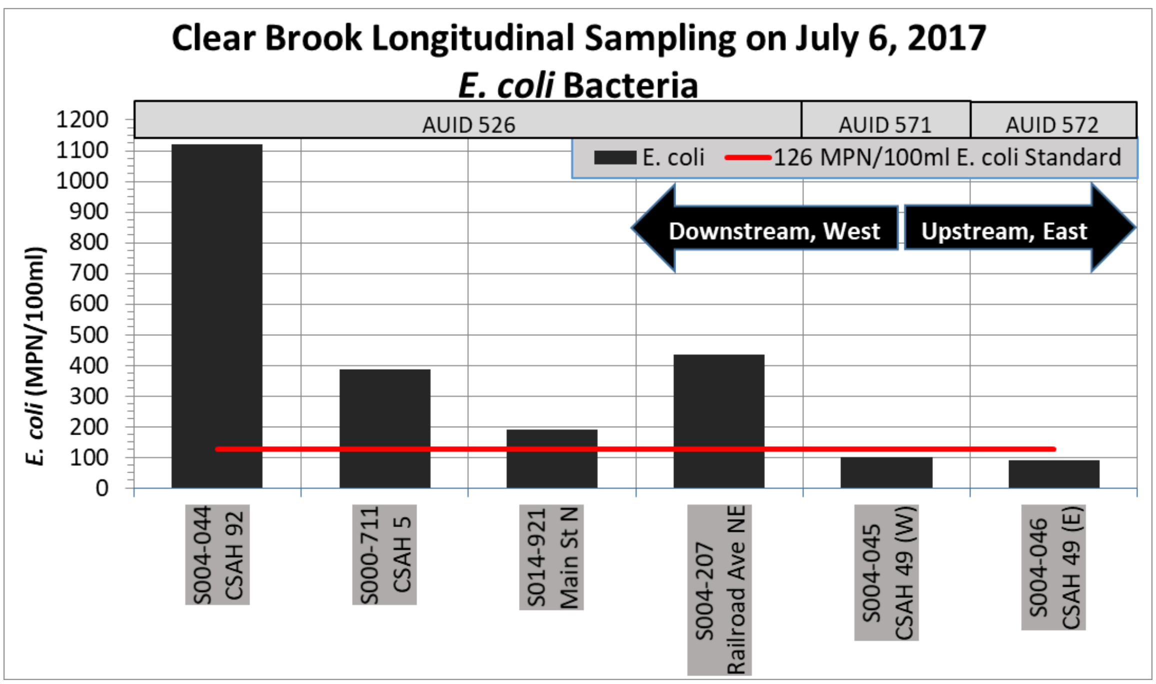


Figure 4-22. Longitudinal *E. coli* sampling along Clear Brook (AUIDs 526, 571, and 572), June 6, 2017

High fecal coliform and *E. coli* concentrations have also been recorded at the CSAH 49 crossing of an upstream portion of Clear Brook. Potential sources in that area are not obvious but may include pastured land along Clear Brook upstream (south) of CSAH 49. Plumes of sediment have been observed to be entering Clear Brook during runoff events. There could potentially be issues with an aging sewer system in Clearbrook, as the community has applied for funding to replace three miles of clay sewer tile. There are homes on the west side of Highway 92 that would have individual septic systems that could potentially be sources of the MST markers that were found in the stream. There is a cattle operation between CSAH 92 and 159th Avenue that surrounds the confluence of Clear Brook and Silver Creek and is one of the most obvious sources of *E. coli* bacteria in Silver Creek. It likely contributes *E. coli* to Clear Brook prior to the confluence and contributes to the impairment of Silver Creek, but it is not the cause of the impairment on Clear Brook because it is located downstream of any current Clear Brook monitoring site.

Silver Creek 09020305-527

As shown in Table 4-4, MST samples confirmed that cattle are the most significant source of *E. coli* bacteria in Silver Creek. Failing septic systems in the drainage areas of Silver Creek and Clear Brook are also contributing to *E. coli* in the stream. Possible locations of those systems could include areas that drain to Clear Brook downstream (west) of CSAH 92, or residences near Silver Creek upstream of its confluence with Clear Brook. Stormwater in the town of Clearbrook carries pollutants to Clear Brook, which then carries those pollutants to Silver Creek. The LDC for this reach (Figure 5-15 in Section 5.2.1) shows that exceedances of the 126 MPN/100ml chronic standard have occurred mostly during high and midrange flows. The influence of stormwater runoff upon *E. coli* concentrations is indicated by the presence of dog fecal DNA markers. Microbial source tracking sample analysis also indicated that birds are a source of fecal bacteria in Silver Creek. The bird waste could be coming from cliff swallows that are nesting under bridges and within culverts. It could also be coming from bird waste that is washed from impervious surfaces within the town of Clearbrook or just random (natural background) wildlife and waterfowl.

Table 4-9. Site-specific assessment statistics along Silver Creek (AUID 527), shown in an order from upstream (top) to downstream (bottom) (2006-2015 data)

Station ID	Road Crossing	May Geomean *E. coli*	June Geomean *E. coli*	July Geomean *E. coli*	August Geomean *E. coli*	September Geomean *E. coli*
S000-712	159th Ave	220.0	473.7	839.4	1139.2	472.6
S002-082	CR 111	9.7	88.6	222.4	155.1	107.5
S001-020	510th St	6.6*	200.1	295.5	227.5	129.7*

*Fewer than 5 samples were collected from this site in this month.
Shading indicates exceedances of the geometric-mean standard.

Three sites in the watershed had sufficient data to calculate site-specific assessment statistics (geometric means shown in Table 4-9). The 159th Avenue site (S000-712) consistently had the highest *E. coli* concentrations. It is located immediately downstream of an obvious source of *E. coli* bacteria where cattle (Figure 4-25) are often spotted within the stream channel. It was also downstream of Clearbrook stormwater runoff.

Longitudinal samples were collected along Silver Creek and Clear Brook on June 23, 2016 (Figure 4-23), during low flow conditions (<1 cubic feet per second [cfs]). Four of the nine sites exceeded the 126 MPN/100ml standard. The samples identified the Clear Brook drainage area and the livestock operation upstream of 159th Avenue as areas where *E. coli* concentrations increased in Silver Creek. The *E. coli* concentration was low at the CSAH 18 crossing in the headwaters of Silver Creek. At the next downstream crossing (161st Avenue), the concentration had greatly increased and exceeded the standard. Some livestock operations between CSAH 18 and 161st Avenue allow livestock to access the stream channel. Flow would have been even lower and more sensitive to disturbance or animal waste contributions in the upstream portions of the watershed. Another set of longitudinal samples were collected in 2017 (Figure 4-24) that also found high *E. coli* concentrations at 159th Avenue and in Clear Brook. A difference was that high concentrations were found at CSAH 18. Water was stagnant at CSAH 18 and 161st Avenue at the time of sampling and flow was minimal at the downstream end of the Silver Creek Subwatershed on July 24, 2017.

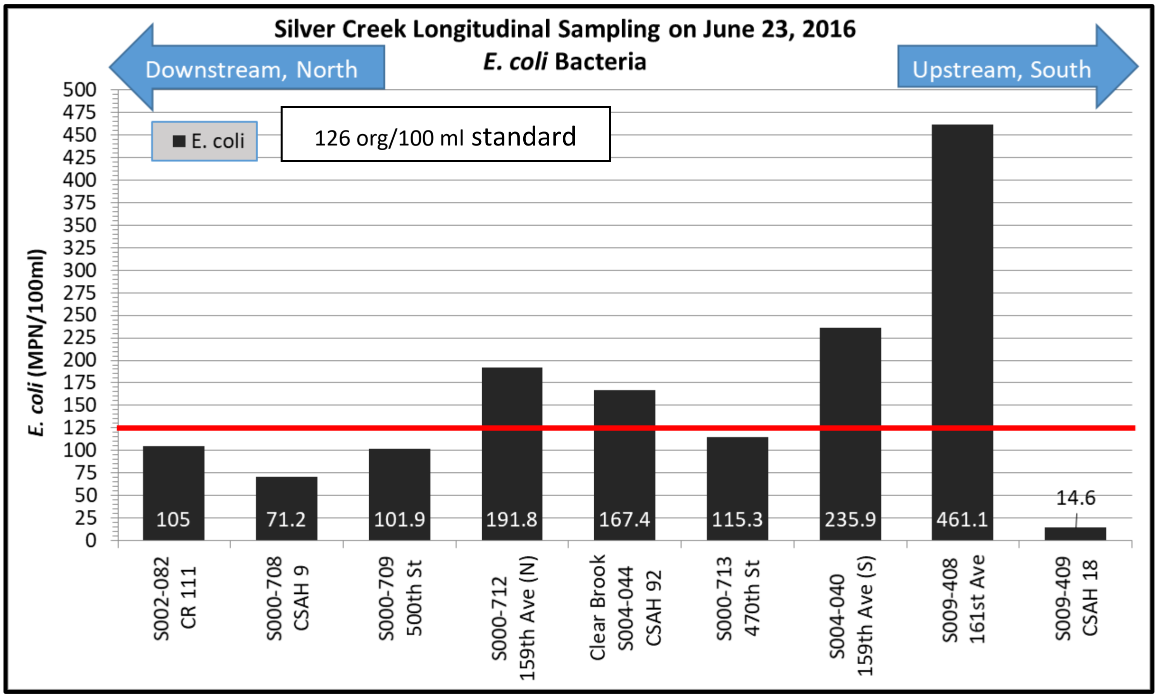


Figure 4-23. Longitudinal *E. coli* sampling throughout the Silver Creek Watershed (AUID 527), June 23, 2016

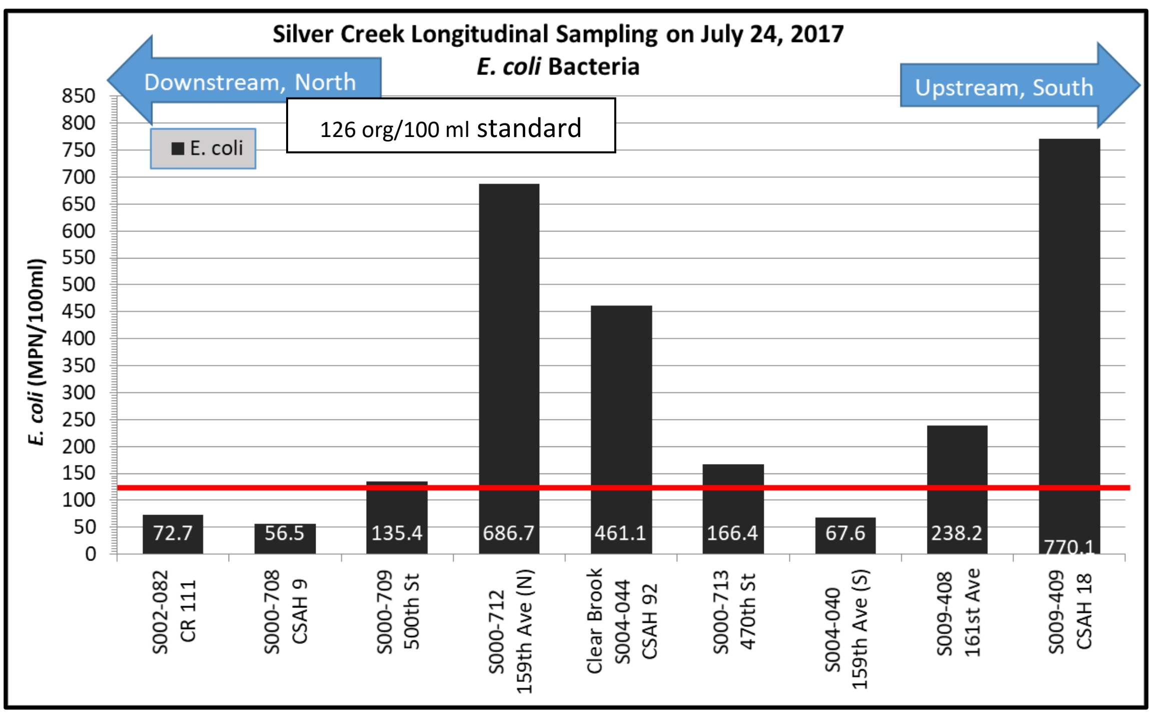


Figure 4-24. Longitudinal *E. coli* sampling throughout the Silver Creek Watershed (AUID 527), July 24, 2017

Figure 4-25. Pasture and cattle along Silver Creek, upstream of 159th Ave (station S000-712 on AUID 527)

Lost River 09020305-529

Livestock and natural background (birds and wildlife) sources of *E. coli* are contributing to this impairment. According to the LDC for the 109th Avenue crossing (S005-283) (Figure 5-16 in Section 5.2.1), exceedances of the *E. coli* standard have occurred throughout the range of flows that have been observed at the site, but have most frequently occurred during low flows. The MST sample that was collected near the pour point of this AUID only identified natural background, bird, fecal DNA markers. The overall concentration was low on that day, which indicates that only natural background sources were contributing and the actual causes of the *E. coli* impairment (sources of excess *E. coli*) might not have been contributing on that day. There are two feedlots within the immediate drainage area of 09020305-529, one of which is shown in Figure 4-26. However, there are no registered feedlots within the immediate drainage area of 09020305-530. Despite a lack of registered feedlots in the AUID 530 drainage area, there is at least one significant livestock operation along the stream in Section 35 of Eddy Township (Clearwater County).

The AUID 529 portion of the Lost River receives drainage from the Nassett Creek Subwatershed in which there are areas where cattle have direct access to the stream and have been spotted there during sampling events. There also is a livestock operation upstream of Township Road 17 in which the streambank is scarred by multiple cattle crossing sites. The influx of high concentrations of bacteria from the Nassett Creek Subwatershed could be a reason for the more severe impairment on AUID 529 compared to the less severe impairment of AUID 530.

Lost River 09020305-530

A portion of the designated trout stream reach of the Lost River (AUID 530) was impaired by high *E. coli* bacteria concentrations. Most of the exceedances of the *E. coli* standard in the Lost River, upstream of Pine Lake, were occurring during low and mid-range flows (Figure 5-17 in Section 5.2.1). The standard was exceeded during the month of June. A livestock operation on the north side of Nesset Creek Drive and pasture along Nassett Creek (also impaired by *E. coli* bacteria) were very likely contributors to the impairment in the Lost River.

There were multiple livestock operations along the reach between S004-206 and S005-501 and one residence along the reach. A feedlot along T-1 (Nesset Creek Drive) was the most likely human-made source of excess *E. coli* bacteria (Figure 4-26). Other sources of high *E. coli* concentrations within the Lost River included the sources (pasture) that were contributing to the *E. coli* impairment in Nassett Creek, which flows into the Lost River between S004-206 and S005-501. Natural background *E. coli* from birds, wildlife, and beaver also likely contribute to *E. coli* concentrations.

Figure 4-26. Livestock operation near the Lost River (AUID 530)

Table 4-10. Site-specific assessment statistics along the Lost River (AUID 530)and its tributaries upstream of Pine Lake, shown in an order from upstream (top) to downstream (bottom) (2006-2015 data)

Stream (AUID)	Station ID	Road Crossing	May *E. coli* Geomean	June *E. coli* Geomean	July *E. coli* Geomean	August *E. coli* Geomean	September *E. coli* Geomean
Lost River(530)	**S004-206**	141st Avenue	15.9*	60.0	62.0*	110.8	93.6*
Nassett Creek (545)	**S005-500**	Nesset Creek Drive	45.6	83.6	183.0	202.8	110.8
Nassett Creek (545)	**S004-205**	Nesset Creek Drive	22.5	922.6	494.4	412.1	116.5
Lost River (530)	**S005-501**	Lindberg Lake Road	38.6	105.0	118.8	306.7	74.5
Lost River (529)	**S005-283**	109th Avenue	66.4*	103.3	181.5	176.8*	155.9*

*Fewer than 5 samples were collected from this site in this month.
Shading indicates exceedances of the geometric-mean standard.

Longitudinal sampling in 2017 (Figure 4-27) found high (>126 MPN/100ml) *E. coli* concentrations downstream of pastured areas. Significant data collection has been completed at two sites along the reach (S005-501 at Lindberg Lake Road and S004-206 at 141st Avenue). Site-specific assessment statistic calculations (Table 4-10) revealed that the river was significantly impaired at the furthest downstream sampling station (S005-501) but was not impaired at the furthest upstream sampling station (S004-206).

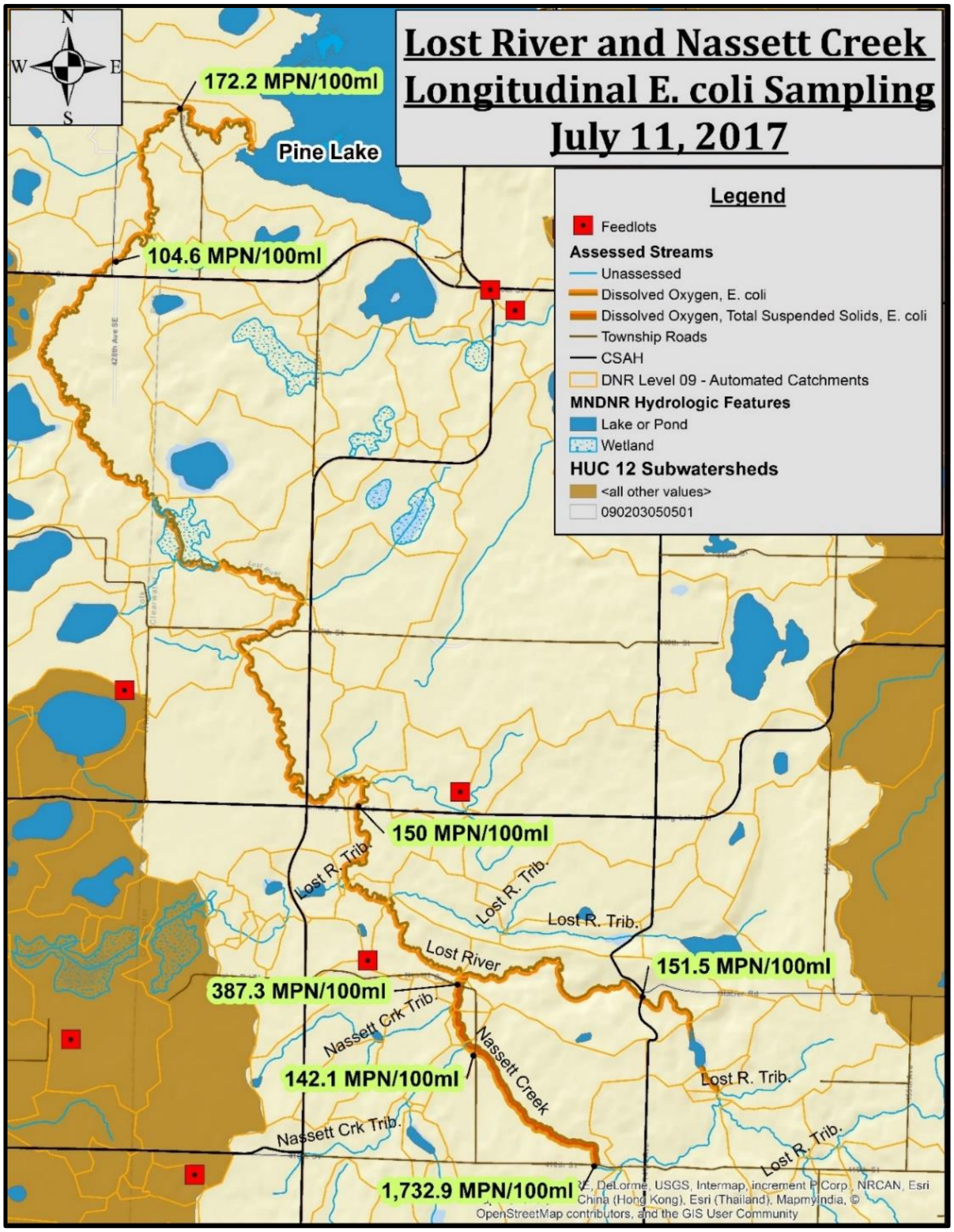


Figure 4-27. Longitudinal *E. coli* sampling and locations of feedlots in the drainage area of the Lost River (AUIDs 529 and 530) and Nassett Creek (AUID 545), July 11, 2017

Nassett Creek 09020305-545

Nassett Creek is impaired by high *E. coli* concentrations. A livestock operation with cattle access to the stream is located immediately upstream of the primary monitoring station (S004-205). Cattle have been seen walking in the stream, upstream of that sampling station (shown in Figure 4-8). Significant *E. coli* sampling has been conducted at the two crossings of Nassett Creek along Nesset Creek Drive. While the creek is more significantly impaired at the downstream site (S004-205), samples collected at the upstream crossing (S005-500) have also exceeded the 126 MPN/100ml chronic standard. There is some pasture upstream of both Nesset Creek Drive crossings. Natural sources (beaver and waterfowl) could also be contributing to excess *E. coli* concentrations in Nassett Creek. Longitudinal sampling was conducted along all three of the *E. coli* impaired AUIDs upstream of Pine Lake on July 11, 2017. High concentrations of *E. coli* bacteria were found at most of the monitoring sites (Figure 4-27). A large increase was observed between the upstream and downstream Nesset Creek Drive crossings of Nassett Creek. The *E. coli* concentration on that day more than doubled from S005-500 (142.1 MPN/100ml) to S004-205 (387.3 MPN/100ml). The highest concentration was found at the furthest upstream crossing of Nassett Creek (410th Avenue). Nassett Creek also flows through pasture near the 410th Street crossing. The LDC for this reach (Figure 5-19 in Section 5.2.1) shows that exceedances of the 126 MPN/100ml chronic standard have occurred throughout the range of flows.

Hill River 09020305-539

Livestock operations, failing septic systems, and birds have been identified as sources of excess *E. coli* bacteria in the Hill River. According to the LDC for this AUID (Figure 5-18 in Section 5.2.1), exceedances of the standard have occurred throughout the range of flows that have been observed at the site.

Though all sites exceeded standards, a longitudinal assessment of sites along AUID 539 where data was collected during the 2006-2015 assessment period (Table 4-11) revealed that the highest concentrations of *E. coli* bacteria had been found at the CR 129 crossing (S006-508). That site was located immediately downstream of a livestock operation where cattle have access to the stream. In a limited data set, the furthest upstream site was trending toward exceedance of the standard in three months.

Table 4-11. Site-specific assessment along the Hill River (AUID 539), shown in an order from upstream (top) to downstream (bottom) (2006-2015 data)

Station ID	Road Crossing	May Geomean *E. coli*	June Geomean *E. coli*	July Geomean *E. coli*	August Geomean *E. coli*	September Geomean *E. coli*
S003-498	CSAH 35		365.4*	166.4*	259.5*	285.1*
S006-508	CR 129	110.4*	642.1	398.4	631.5	302.4*
S002-134	CR 119	20.2	255.7	245.5	120.1	105.0

*Fewer than 5 samples were collected from this site in this month.
Shading indicates exceedances of the geometric-mean standard.

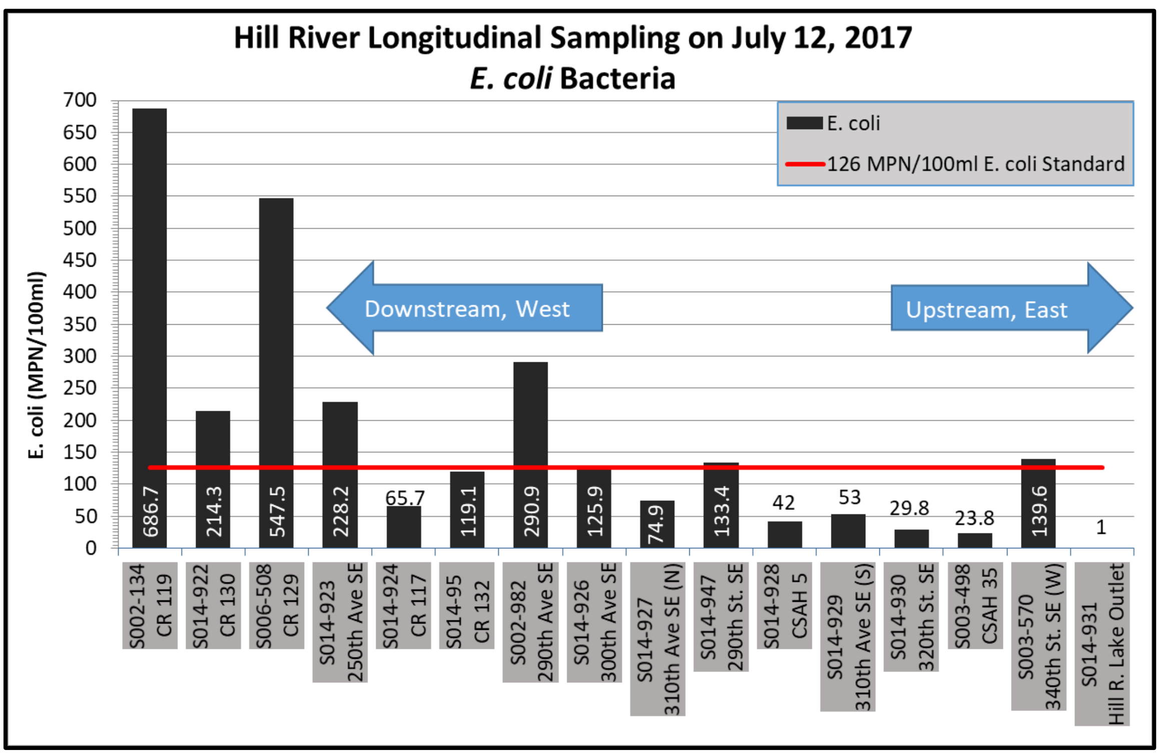


Figure 4-28. Longitudinal *E. coli* sampling along the Hill River (AUID 539), July 12, 2017

July 2017 longitudinal sampling (Figure 4-28) revealed peaks and valleys of *E. coli* concentrations along the Hill River along AUID 539 Essentially, no measurable *E. coli* was coming from Hill River Lake. In a short distance, the concentration increased to a level that exceeded the standard. There was a livestock operation on the east side of the river, upstream of the 340th Street Southeast crossing. The low-gradient, wetland-like, south-to-north-flowing portion of the Hill River between 340th Street Southeast and 290th Street Southeast may be depressing DO levels, but also may be filtering pollutants like *E. coli* from the stream. Downstream of a westward turn in the river (flowing toward Brooks), there was a large increase in *E. coli* between 250th Street Southeast and 250th Avenue SE. There did not appear to be any obvious livestock operations along this portion of the stream, but there were some homes. Downstream of the CSAH 92 crossing, a livestock operation was causing a significant increase in *E. coli* concentrations while also causing streambank instability problems. There was another pasture upstream of CR 130 where cattle had access to the stream. There was a large increase in *E. coli* concentration between CR 130 and CR 119. There did not appear to be any livestock operations along that portion of the channel.

Judicial Ditch 73 09020305-550

Exceedances of the *E. coli* standard in JD 73 occurred throughout the range of flows that were observed at the 343rd Street Southeast crossing (S003-318) (Figure 5-20 in Section 5.2.1). The exceedances appeared to be more severe during higher flows. The only source of *E. coli* bacteria that was confidently identified was the bird MST markers that were identified in a sample that was collected from the 343rd Street Southeast crossing. Culverts along this reach are generally not large enough to attract cliff swallows. The channel does flow through wetlands and small lakes, however, which are attractive to waterfowl. There are very few residences along the reach. Because JD 73 is a ditch that flows through wetlands, increased velocity during runoff events could flush organic sediment and other pollutants from the wetlands during high flows. Downstream of this reach of JD 73, the channel flows through Tamarack Lake within Rydell National Wildlife Refuge (NWR) and then through a large wetland. During large runoff events, the ditch has been known to flush a plume of organic sediment into Maple Lake. A similar flush of sediment could be occurring as JD 73 flows through some wetlands upstream of 343rd Street SE. That organic sediment could contain *E. coli* bacteria.

Terrebonne Creek 09020305-574

Compared to other impaired reaches, efforts to identify the source of *E. coli* pollution in Terrebonne Creek were less conclusive. Exceedances of the *E. coli* standard in Terrebonne Creek have occurred throughout the range of measurable flow within Terrebonne Creek (Figure 5-21 in Section 5.2.1). The creek was often stagnant at the CSAH 92 water quality monitoring station. Stage and flow levels were monitored during the open water months during the WRAPS process and stagnant conditions (zero cfs) were observed during more than 73% of the days that were monitored. Even when there was flow, the small size of this stream might have limited the amount of dilution that could offset minor sources of *E. coli* pollution. The highest recorded water level equated to 93.55 cfs. However, the tenth highest flow in the record is much lower, at 33.85 cfs, and 90% of the flows have been 3.84 cfs or lower. The highest concentrations have occurred during no flow. When assessed for each flow regime, all three regimes (very high, high, and no flow) exceeded the 126 MPN/100ml standard.

The 2007 through 2016 *E. coli* data from this reach was sorted by flow regime and assessment statistics were calculated for only the days with measurable flow (>0 cfs). The dataset was greatly reduced when the no-flow days were removed. The month of June was the only month that had sufficient data from days with measurable flow and the geometric mean concentration for that month (when there is measurable flow) exceeded the standard with a concentration of 146 MPN/100ml. The other months had insufficient data points for an assessment within the measurable flow subset of the data. That was likely due to the stream's tendency to stop flowing during July and August. The MST sample collected at S004-819 was unsuccessful at identifying a source of the fecal bacteria. No MST markers were detected for birds, ruminants, or humans. The overall concentration of *E. coli* bacteria was relatively low on the day that the MST sample was collected so the sources of excess *E. coli* were likely missed by the timing of that sample. Some crossings of Terrebonne Creek are box culverts that are inhabited by communities of cliff swallows. Bird droppings have been observed in the water at the CSAH 92 crossing (S004-819). Beaver activity has also been noticed at that site. There are residences that are located close enough to the stream to contribute to the impairment if their septic systems are failing, but human fecal DNA markers were not found in the MST sample. There did not appear to be any livestock operations within the riparian corridor of Terrebonne Creek in aerial photos, but there was one registered feedlot within the drainage area.

Brooks Creek 09020305-578

Brooks Creek was impaired due to a high geometric mean *E. coli* concentration for the month of August. The month of August had the second lowest average flow rate of the open-water months (Figure 4-29). There would be very little capacity for the dilution of possible *E. coli* sources that were consistently contributing (point sources, illicit discharge, and natural background) during the month of August. Bird and human fecal DNA markers were found in an MST sample from Brooks Creek.

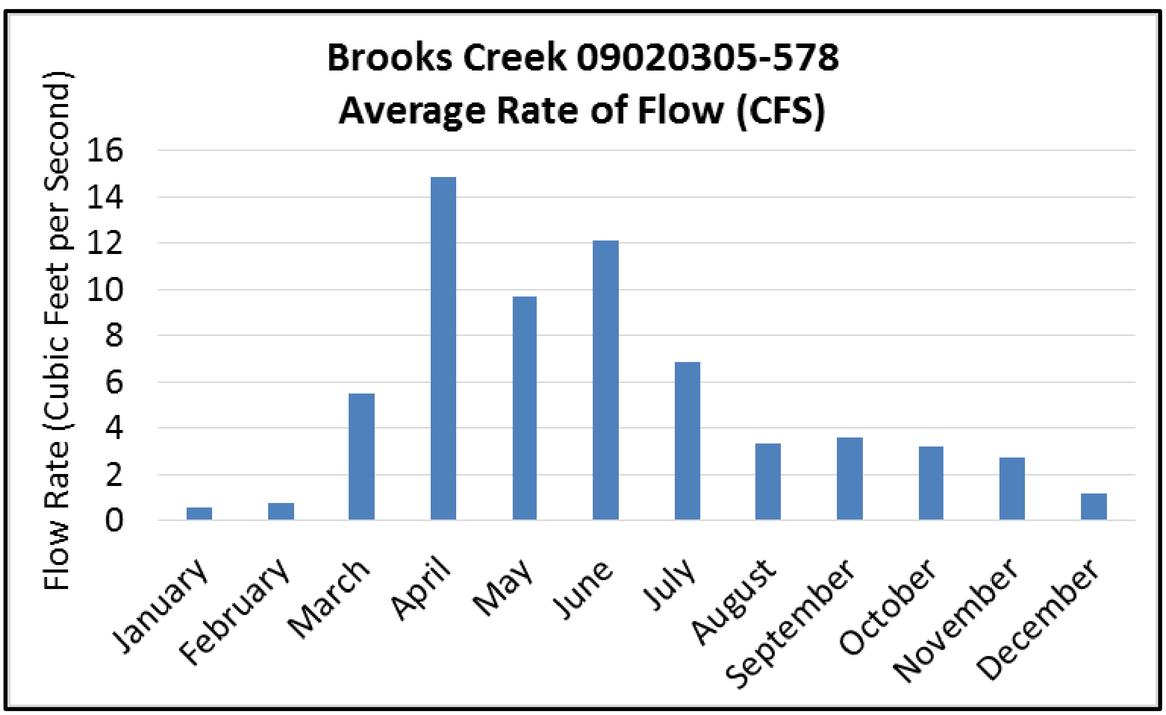


Figure 4-29. Monthly average flow rates (simulated by an HSPF model) in Brooks Creek (AUID 578)

The two furthest-downstream crossings along the impaired reach were box culverts. Large groups of cliff swallow nests can often be found within box culverts. If the contamination was occurring during the late summer, the source was likely not far upstream of the CSAH 92 crossing. The ditches in the headwaters of the stream were likely not flowing outside of runoff events. There were some homes near the stream and their septic systems could be inspected. The only feedlot that could possibly contribute to the problem was not located wholly within the drainage area but was located directly on the delineated drainage area boundary. There also appeared to be a smaller (but concentrated enough to be noticeable in aerial photographs) livestock operation near the 240th Avenue Southeast crossing of Brooks Creek (north of the creek, on the west side of the road).

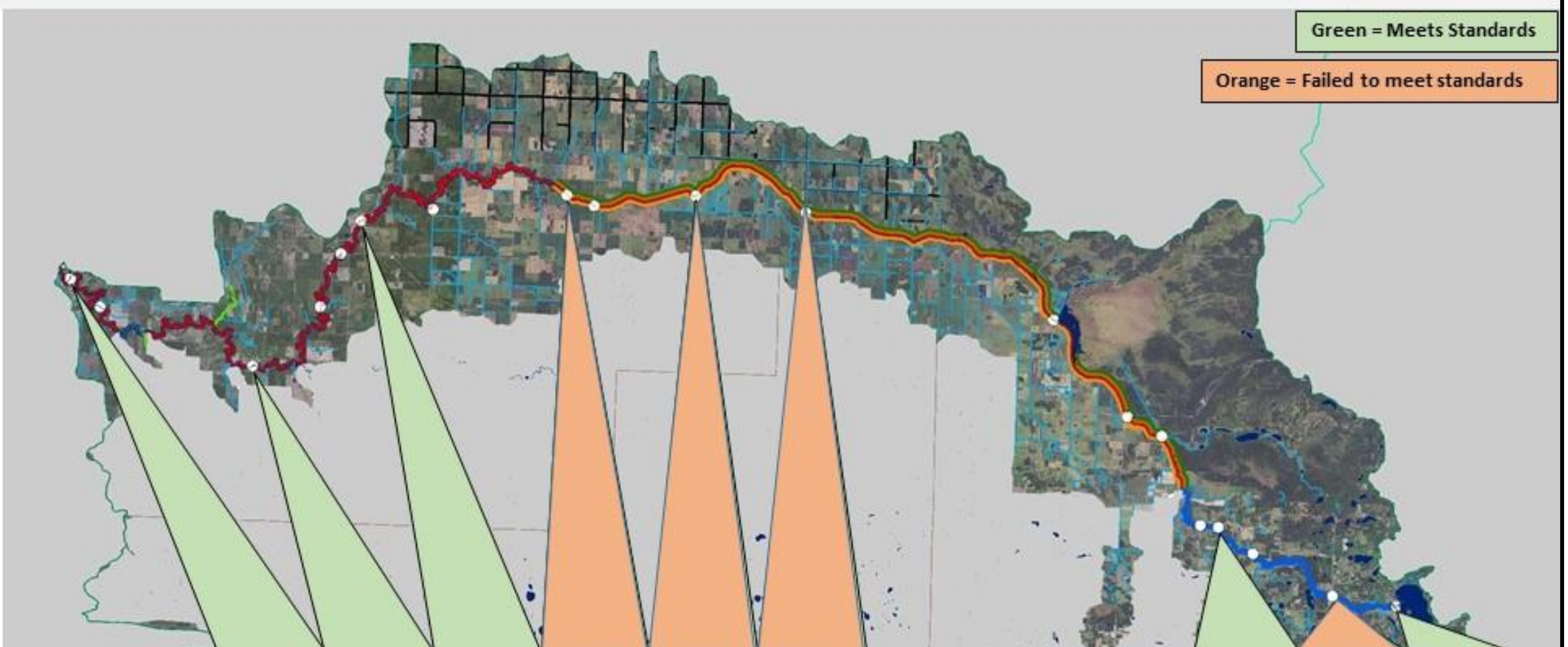
Clearwater River 09020305-647

The channelized portion of the Clearwater River (09020305-647) was impaired by excess *E. coli.* The river had been significantly sampled at three monitoring sites during the 2006 through 2015 assessment period: S002-916 (280th Avenue SE), S003-174 (CSAH 10), and S002-121 (370th Avenue SE). When assessed individually, in Figure 4-30, all three of those sites showed similar levels of impairment. August geometric mean concentrations exceeded the 126 MPN/100ml chronic standard at each of the three significant sampling stations along this segment of the river. All three of those sites are located downstream of wild rice paddies. The main channel of the Clearwater River was not impaired at S002-752, the CSAH 11 crossing within the next upstream reach (AUID 650). Ruffy Brook (AUID 513), however, is an *E. coli*-impaired stream that flows into the Clearwater River at the upstream end of this AUID.

The high concentrations of *E. coli* bacteria in Ruffy Brook could have significantly contributed to the impairment in the Clearwater River. Ruminant (livestock) fecal DNA markers were identified in a sample. There were livestock operations along Ruffy Brook, but not along the channelized portion of the Clearwater River. It was, therefore, reasonable to assume that much of the livestock-based *E. coli* pollution in this reach of the Clearwater River was coming from Ruffy Brook. The longitudinal sampling results in Figure 4-31 show how *E. coli* concentration increased at CSAH 5, which is the first road crossing downstream of the Ruffy Brook confluence. Though *E. coli* wasn't sampled during the August 5, 2016 longitudinal sampling along the Clearwater River, other pollutants (TSS in Figure 4-11 and TP in Figure 4-33) sharply increased downstream of the Ruffy Brook confluence. Figure 4-21 shows that a high concentration of *E. coli* was coming from Ruffy Brook on August 4, 2016. Discharge from some wild rice paddies, especially those with surface drainage instead of main line tile, could also discharge *E. coli* bacteria into the river. Wild rice paddies are often filled with waterfowl.

Clearwater River

Site-By-Site Assessment Results for *E. coli* Bacteria 2007-2016 Data



Site ID:	S002-118	S002-914	S002-124	S002-916	S003-174	S002-121				S002-752	S001-461	S002-119	
AUID (09020305-XXX)	501	511	648	647	647	647				650	649	649	
Street/Road:	Bottineau Ave	CSAH 12	Minnesota St. N	280th Ave SE	CSAH 10	370th Ave SE				CSAH 11	CSAH 14 (249th Ave)	Clearwater Lake Rd.	
May Geomean:	36.7	79.5	14.2	32.7	21.5	8.5				16.7	2	1.8	
June Geomean:	69.5	119.7	48.1	103	73.4	72.4				41.7	87.4	2.1	
July Geomean:	65.2	99.4	80.6	105.7	83.5	121.7				37.9	448	1	
August Geomean:	32.5	86.1	84.1	153	231.8	136.5				38.4	172.3	1.7	
September Geomean:	42.7	72.7	40.5	74.8	116.3	86.2				65.3	24.2	1	
Total # of May-September Days with Samples:	70	35	73	23	31	69				19	6	18	

Figure 4-30. Longitudinal assessment of *E. coli* along the Clearwater River (AUIDs 501, 511, 648, 647, 650, and 649)

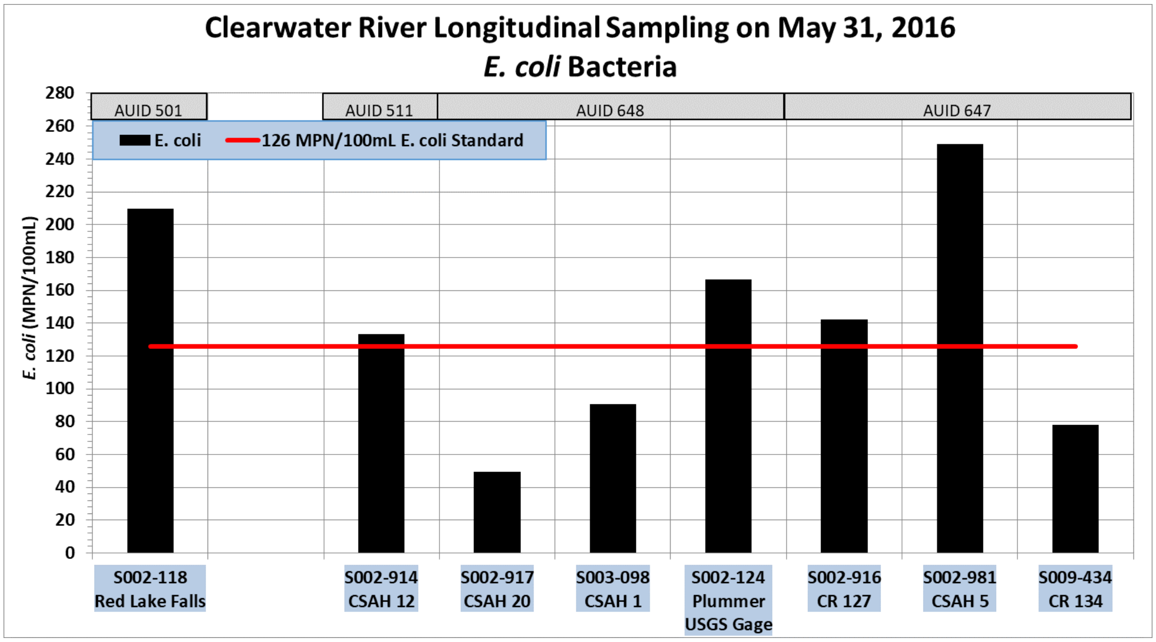


Figure 4-31. Longitudinal *E. coli* sampling along the Clearwater River (AUIDs 501, 511, 648, and 647), May 31, 2016

Beau Gerlot Creek 09020305-651

The Beau Gerlot Creek LDC in Section 5.2.1 indicated that exceedances of the 126 MPN/100ml standard have occurred throughout the range of flows that have occurred at S008-058 (CR 114) (Figure 5-24 in Section 5.2.1). Human and bird MST markers were found in a sample collected from Beau Gerlot Creek. Failing septic systems and natural background sources are, therefore, the primary concerns along this impaired reach. Upstream reaches of Beau Gerlot Creek have been severely impacted by agriculture (poor or nonexistent buffers), channelization and dredging.

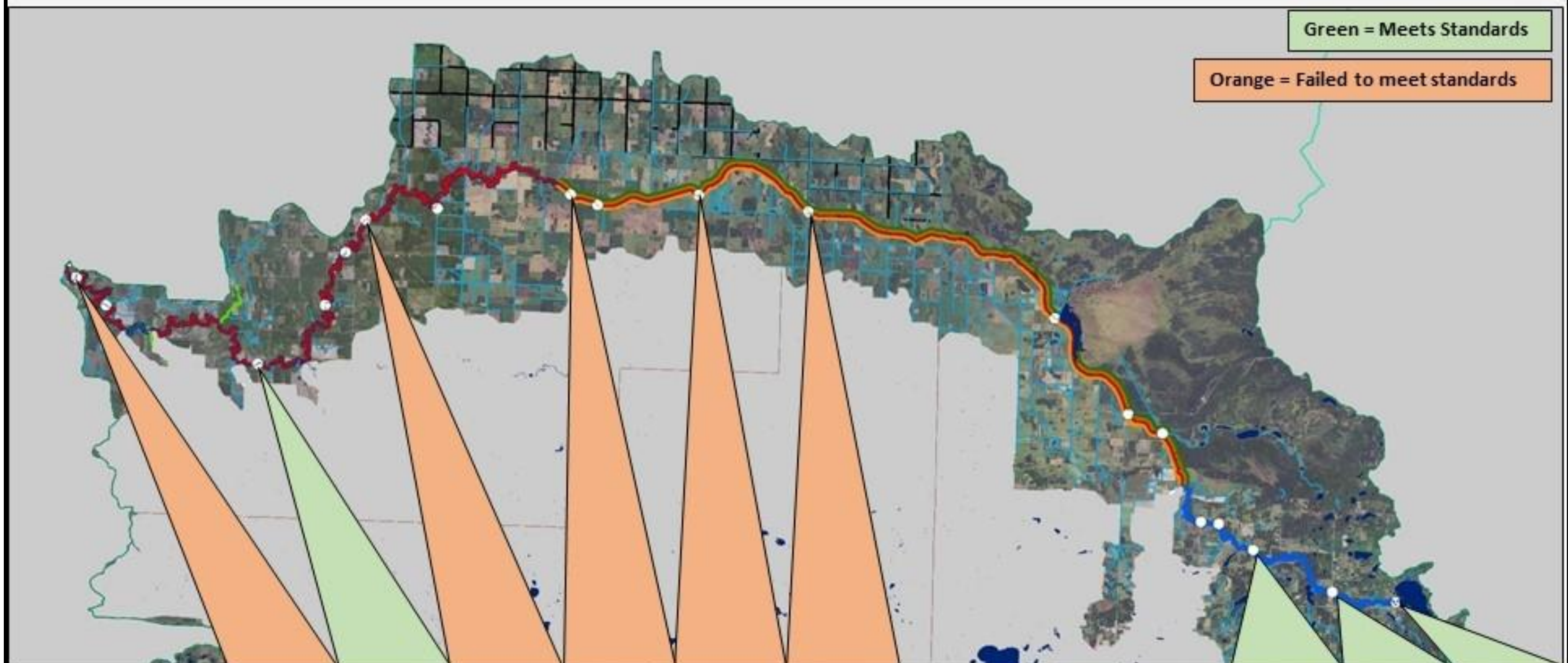
4.3 Sources of Total Phosphorus to Impaired Streams

One reach of the Clearwater River, AUID 647, was impaired by excess TP. The nonpoint sources of TP in the river were identical to the sources of sediment that were described in Section 4.1.2. There was a dramatic increase in TP concentrations from the natural reaches of the river downstream of Clearwater Lake (AUIDs 649 and 650) to the channelized reach (AUID 647). The abrupt change in water quality from the natural portion of the Clearwater River to the channelized portion was shown in short term, single-day, longitudinal sampling results shown in Figure 4-33, and in long-term summer averages shown in Figure 4-32. The most significant changes between AUID 650 (represented by station S002-752 in Figure 4-33) and AUID 647 (stations S002-121, S003-174, and S002-916 in Figure 4-33) that could lead to increased phosphorus loads include:

1. Confluence with Ruffy Brook
2. Channelization
3. Wild rice cultivation
4. More cultivated fields

Clearwater River

Site-By-Site Assessment Statistics for Total Phosphorus 2007-2016 Data



Site ID:	S002-118	S002-914	S002-124	S002-916	S003-174	S002-121	
AUID (09020305-XXX)	501	511	648	647	647	647	
Street/Road:	Bottineau Ave	CSAH 12	Minnesota St. N	280th Ave SE	CSAH 10	370th Ave SE	
Summer Average TP (mg/L, 2007-2016)	0.107	0.096	0.132	0.134	0.133	0.131	
Number of June-Sept. Days with TP Samples:	138	28	78	19	26	39	

Site ID:	S002-752	S001-461	S002-119
AUID (09020305-XXX)	650	649	649
Street/Road:	CSAH 11	CSAH 14 (249th Ave)	Clearwater Lake Rd.
Summer Average TP (mg/L, 2007-2016)	0.026	0.020	0.019
Number of June-Sept. Days with TP Samples:	10	5	15

Figure 4-32. Longitudinal assessment of summer average TP along the Clearwater River (AUIDs 501, 511, 648, 647, 650, and 649)

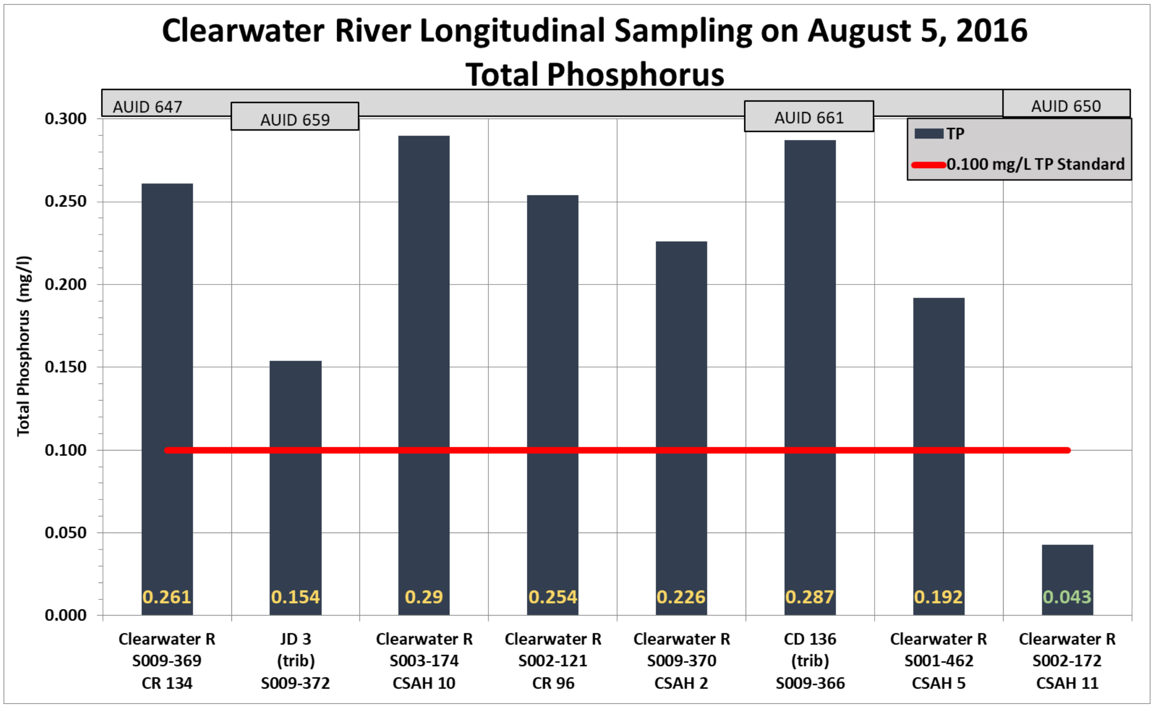


Figure 4-33. Longitudinal TP sampling along the Clearwater River (AUIDs 647 and 650) and tributary ditches (AUIDs 659 and 661), August 5, 2016

Table 4-12. Site specific average seasonal TP concentrations (June-September 2016-2015 data), upstream (top) to downstream (bottom).

Stream Name	AUID (09020305-XXX)	Station ID	Road Crossing	Upstream WWTF	Seasonal Average TP June – September 2006-2015 (mg/L)
Clearwater River	517	S001-458	CSAH 25	None	0.026
Clearwater River	517	S001-906	U.S Highway 2	Bagley	0.091
Clearwater River	517	S001-908	CSAH 2	Bagley	0.074
Clearwater River	653	S002-929*	CSAH 22	Bagley	0.078*
Clearwater River	653	S001-460	CSAH 24	Bagley	0.045
Clearwater Lake	04-0343-00	-204, and -205	N/A	Bagley	0.019
Clearwater River	649	S002-119	CSAH 4	Bagley	0.018
Clearwater River	650	S002-752*	CSAH 11	Bagley	0.026*
Ruffy Brook	513	S002-120	510th Street	Clearbrook	0.101
Ruffy Brook	513	S008-057	CSAH 11	Clearbrook	0.114*
Ruffy Brook	513	S007-848*	Township Road 5	Clearbrook	0.157*
Clearwater River	647	S002-121	370th Avenue Southeast	Bagley Clearbrook	0.130
Clearwater River	647	S003-174	CSAH 10	Bagley Clearbrook	0.125
Clearwater River	647	S002-916	County Road 127 (280th Avenue Southeast)	Bagley Clearbrook	0.134
*Total of at least 12 individual samples, but fewer than 12 daily average values. Shading indicates exceedances of the standard.					

4.3.1 Permitted Total Phosphorus Sources

Municipal Separate Storm Sewer Systems

There are no MS4s within the Clearwater River Watershed, as previously stated in Section 4.1.1. There are no municipalities with populations that are large enough to become designated MS4s.

Wastewater Treatment Facilities

Overall, the influence of upstream WWTFs upon TP concentrations in AUID 647 of the Clearwater River is minimal. An MPCA phosphorus effluent limit review determined that the existing limits for Bagley and Clearbrook WWTFs are sufficient to protect the Clearwater River from exceeding the river eutrophication TP standard. The potential influences of the two upstream WWTFs, Bagley and Clearbrook, were nonetheless examined to determine applicability to the impairment in AUID 647.

The Bagley and Clearbrook WWTFs are located upstream of the impaired AUID 647. The Bagley WWTF discharges to a headwaters reach of the Clearwater River (AUID 517). The Clearwater River flows through a trout stream reach (AUID 653) and AUID 654 before flowing into Clearwater Lake. From Clearwater Lake, it flows through two unimpaired reaches (AUIDs 649 and AUID 650) before the confluence with Ruffy Brook that is the upstream end of impaired AUID 647. The TP concentrations in AUIDs downstream of the city of Bagley and within Clearwater Lake clearly establish that the Bagley WWTF is not contributing to the impairment in AUID 647. The Bagley WWTF may be influencing water quality within AUIDs 517, AUID 653, and Clearwater Lake (AUID 654 lacks sampling data), but Clearwater Lake essentially resets concentrations to natural background levels. The average concentrations in Clearwater Lake and in the Clearwater River downstream of the lake equaled or were lower than the average concentration upstream of the Bagley WWTF. There was no evidence that the Bagley WWTF has any influence upon TP concentrations in AUID and it was not given a WLA for AUID 647.

The seasonal average TP concentrations (Table 4-12) at several stations near the pour point of Ruffy Brook exceeded the TP standard. Stream sampling in the vicinity of the Clearbrook WWTF was limited to one set of longitudinal samples in which the TP standard was exceeded upstream and downstream of the WWTF. Monthly average TP concentrations in discharge from the Clearbrook WWTF all exceed the 0.100 mg/L standard. The Clearbrook WWTF discharged a flow weighted summer mean concentration of 1.75 mg/L over the years 2006 through 2015. Though the majority of TP is coming from nonpoint sources, the existing evidence shows that the Clearbrook WWTF cannot be ruled-out as a contributor to the TP impairment in AUID 647. A WLA for the Clearbrook WWTF will be incorporated into the TP TMDL for AUID 647 on the Clearwater River.

Construction and Industrial Stormwater

According to publicly available information, the annual percentage of land area under construction has been 0.021% in Polk County, 0.005% in Red Lake County, and 0.004% in Clearwater County. The percentage of the LA used for industrial stormwater will be identical to the construction stormwater percentage. Industrial and construction stormwater will be combined into one WLA.

4.3.2 Non-Regulated Total Phosphorus Sources

Ruffy Brook flows into the Clearwater River at the upstream end of the reach that is impaired by river eutrophication. The summer average TP concentration along Ruffy Brook (AUID 513) was 0.119 mg/L in 2006 through 2015 data, which exceeds the 0.100 mg/L standard for TP. Channelization of the Clearwater River has created unstable channel conditions, head-cutting, and much erosion where the river transitions from a natural channel to a straightened channel. Cultivation of wild rice requires drainage of paddies prior to harvest. Some drainage methods discharge water with high concentrations of TSS, nutrients, and other pollutants. As shown in Figure 3-9, there is an agricultural land use transition from pastured land to cultivated cropland that nearly aligns with the upstream end of the channelization.

4.4 Stressors to Aquatic Biology

Streams that were found to be impaired due to poor biological integrity are shown in Figures 3-34 and 3-35. Detailed information about the causes of biological impairments and the SID process can be found in the Clearwater River Watershed SID Report. The SID Report was the result of significant time and effort that was spent by state and local staff to identify the causes of low IBI scores in the watershed, collect follow-up biological samples, deploy DO loggers, assess stream stability, and conduct culvert/fish passage assessments. The MPCA and local staff worked closely to discuss and come to conclusions about the candidate causes of the impairments. Stressors were identified, including low DO, altered hydrology, fish passage issues, and poor stream habitat. Biological impairments were not being caused by pollutant-based stressors were identified and no TMDLs to reduce pollutants were warranted for this watershed's IBI impairments. Table 4-13 summarizes the findings of the SID report.

Table 4-13. Primary stressors to aquatic life in biologically impaired reaches in the Clearwater River Watershed

HUC-10 Subwatershed	AUID (Last 3 Digits)	River/Stream/Ditch Name	Impaired by Poor F-IBI?	Impaired by Poor M-IBI?	Primary Stressors				
					Low DO	Altered Hydrology	Poor In-Stream Habitat	Elevated Nutrients	Fish Passage Barriers
Hill River 0902030503	539	Hill River	**F-IBI**	No	●		●		●
	656	Hill River	**F-IBI**	No	●		●		●
Lower Clearwater R 0902030507	658	Red Lake CD 23	**F-IBI**	No		●	●		●
	652	Beau Gerlot Creek	**F-IBI**	**M-IBI**		●	●		●
Poplar River 0902030504	518	Poplar River	**F-IBI**	**M-IBI**	●	●	●		●
Lower Badger Creek 0902030506	561	Tributary to the Poplar River Div.	**F-IBI**	No	●	●	●		●
	502	Lower Badger Creek	No	No	●	●	●		
Lost River 0902030505	645	Lost River	**F-IBI**	No	●	●	●	●	●
Silver Creek 0902030505	527	Silver Creek	No	**M-IBI**	●	●		●	

Altered hydrology includes channelization of streams and improved drainage that can lead to flashier flows. Altered hydrology can also lead to base flows that are insufficient or non-existing. Stagnant water often causes low DO levels in streams. Low DO levels were documented within most of the biologically impaired reaches through discrete measurements and DO logger deployments. Most of the low DO levels were associated with low flows, low gradients, and natural processes. Elevated nutrients were identified in some reaches and examined in the SID report. In the biologically impaired reaches where elevated TP levels were found; however, most of the TP was in the dissolved, inorganic orthophosphorus (OP) form. That indicated that dissolved inorganic phosphorus was being released from the sediment during stagnant, anaerobic conditions.

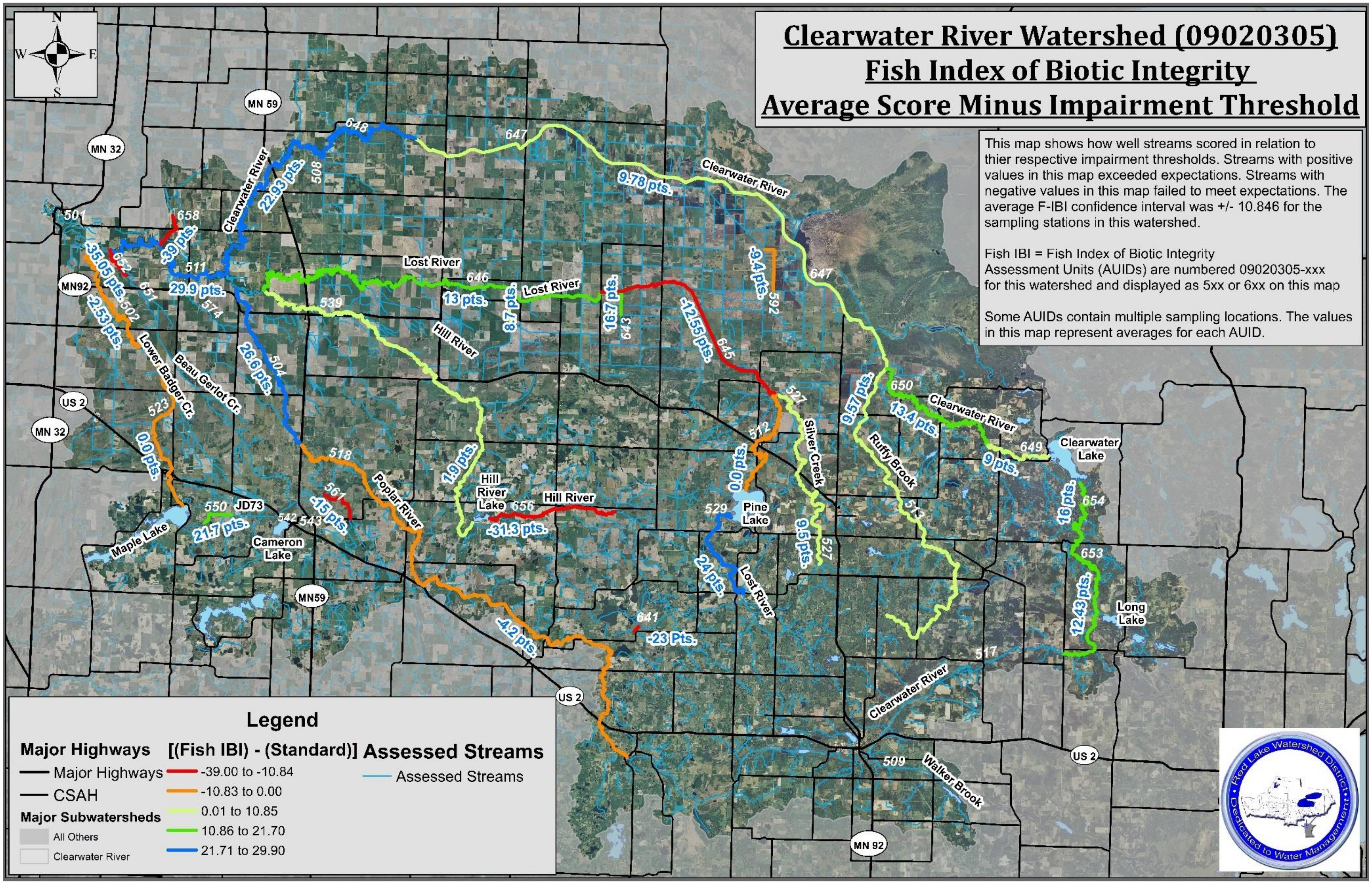


Figure 4-34. Map F-IBI scores in Clearwater River Watershed streams compared to expectations (Average F-IBI score minus impairment threshold)

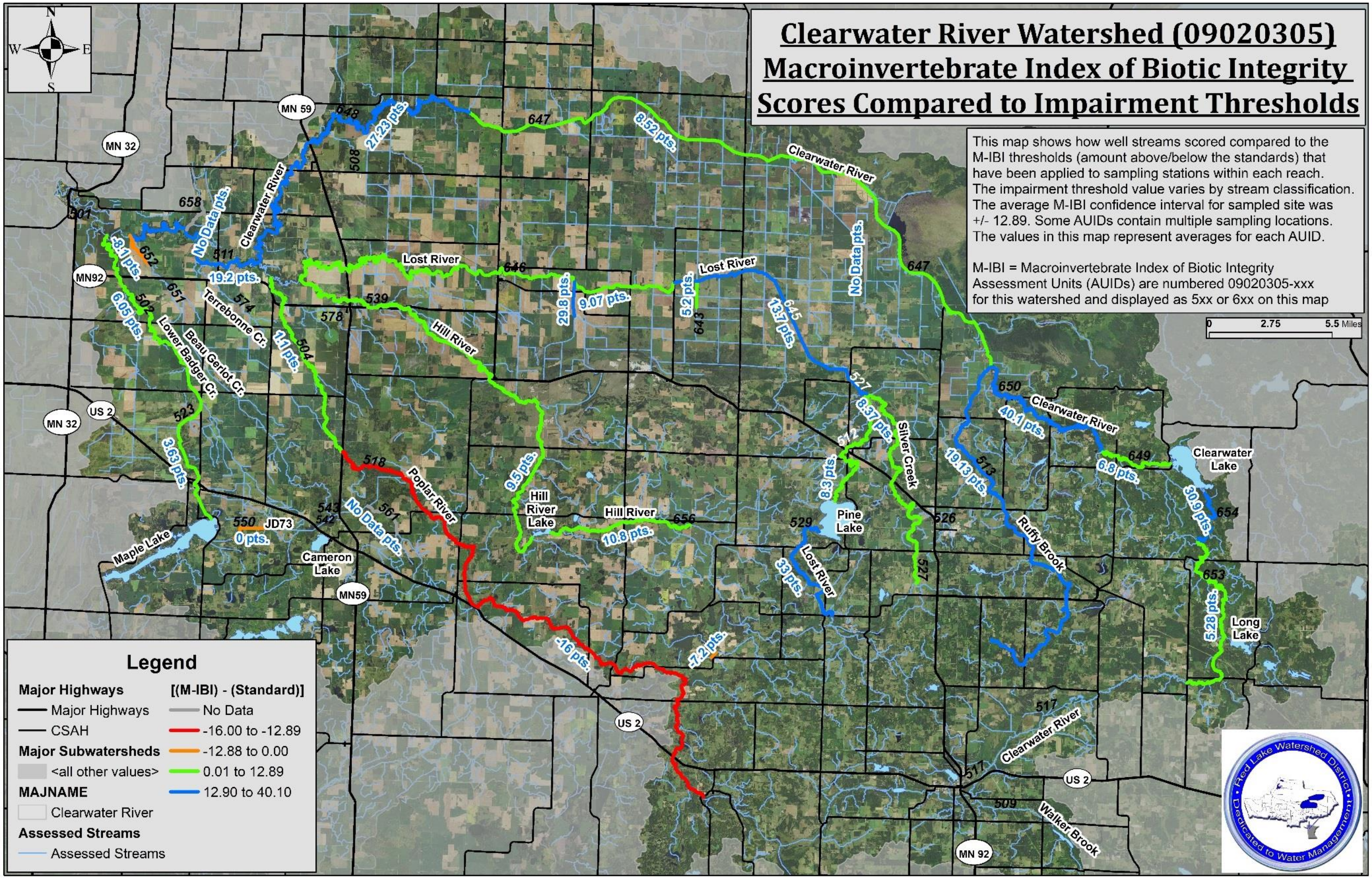


Figure 4-35. Map of M-IBI scores in Clearwater River Watershed streams compared to expectations (Average M-IBI score minus impairment threshold)

The SID process found some areas that may be limiting connectivity and fish passage along impaired reaches of streams. Private stream crossings, excessive gradient, and dams were examples of landscape features that seemed to be limiting or preventing fish passage. Beaver dams were temporarily present on many of the smaller streams in the watershed. Poor stream habitat was identified as a stressor for most of the biologically impaired reaches in the Clearwater River Watershed. Channelization, lack of buffers, poor quality substrates, and riparian land use issues were some of the factors that have limited the quality of habitat for aquatic life within impaired streams. Stressors that were identified for each biological stream impairment are summarized in Sections 4.4.1 through 4.4.10.

4.4.1 09020305-518, Poplar River, Fish Biological Integrity

The SID Report examined low DO, flow alterations, lack of connectivity, and lack of habitat as potential stressors to aquatic life in the Poplar River. Low DO was the stressor that was most strongly supported by monitoring data. Data indicated that aquatic life in the Poplar River was not being significantly affected by pollutants. Only one TSS sample out of all the samples collected from the entire reach exceeded the TSS standard in 2007 through 2016 data.

Figure 4-36. Aerial photo of the Poplar River (AUID 518) as it flows through wetlands past the west end of Whitefish Lake

This portion of Poplar River is relatively long and complex. Characteristics like gradient and DO levels vary throughout this reach. Longitudinal sampling results found that DO levels increase and decrease throughout the reach. The river flows through a series of lakes and wetlands. The DO levels are often depressed in those low-gradient areas where the stream was flowing through riparian wetlands, or shortly downstream of those wetland areas. The DO concentrations improved where the river flowed between those wetlands due to increased gradient and a more defined channel. The worst F-IBI score along the Poplar River was found upstream of the CSAH 27 (395th Street SE) crossing (14RD218). Between CSAH 1 and CSAH 27, the Poplar River flows through a large wetland on the western side of Whitefish Lake. In some aerial photos, the channel seems to disappear (Figure 4-36).

The SID Report stated that F-IBI scores at upstream sites along the Poplar River may have been limited by poor connectivity at two stream crossings (310th Avenue Southeast and 350th Street SE), so those crossings were examined. The 350th Street Southeast crossing was not a barrier to fish passage, though stagnant conditions at that site likely affected DO levels. Water was relatively deep within the culverts and fish were observed swimming through them. The upstream ends of the culverts at the 310th Avenue Southeast crossing were in relative disrepair and had potential to obstruct fish passage during low flows (Figure 4-37). The upstream end of the south, corrugated metal culvert was angled upward. Extremely low DO levels near the CSAH 27 crossing of the Poplar River could have been low enough to prevent movement of fish through the portion of the Poplar River near Whitefish Lake.

Figure 4-37. Damaged culvert along the Poplar River (AUID 518) at 310th Avenue Southeast

Continuous DO logger deployments at CSAH 27, east of the city of Fosston, found extremely low DO levels. At CSAH 27, DO levels were so consistently low that all measurements were less than 5 mg/L during July and August deployments (Figure 4-38).

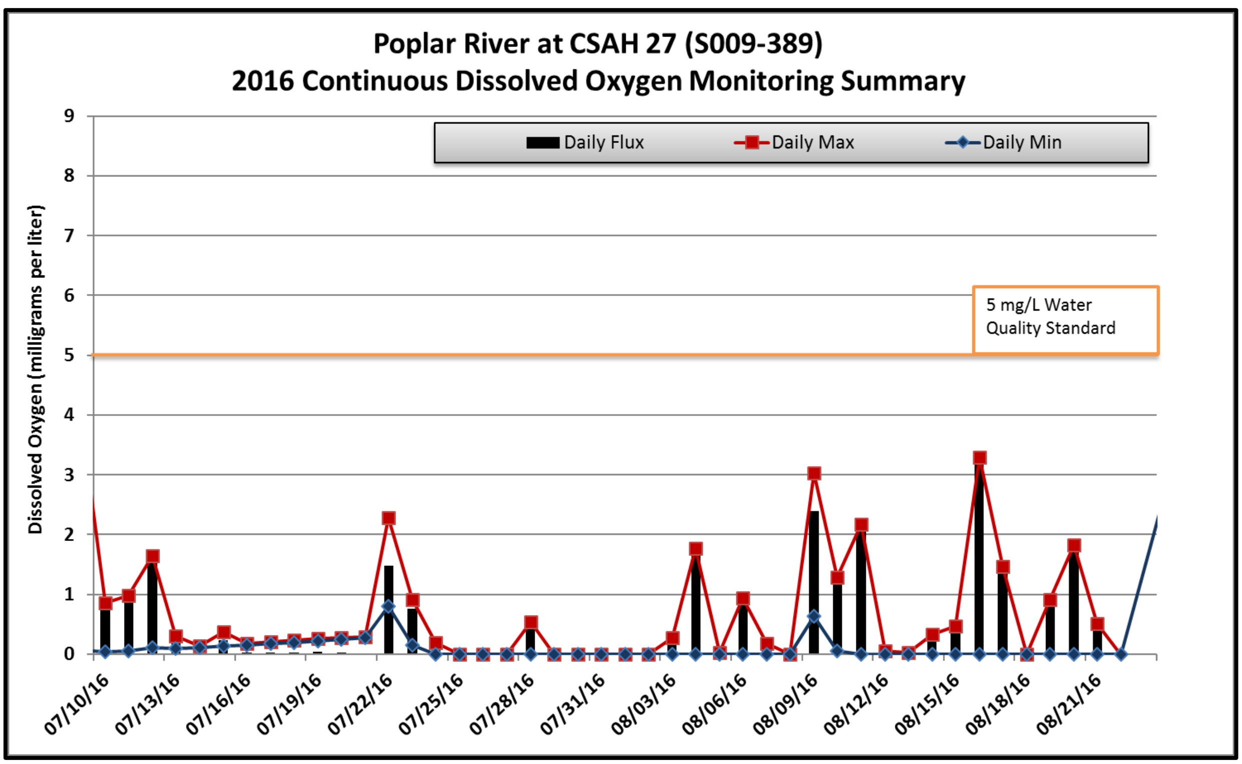
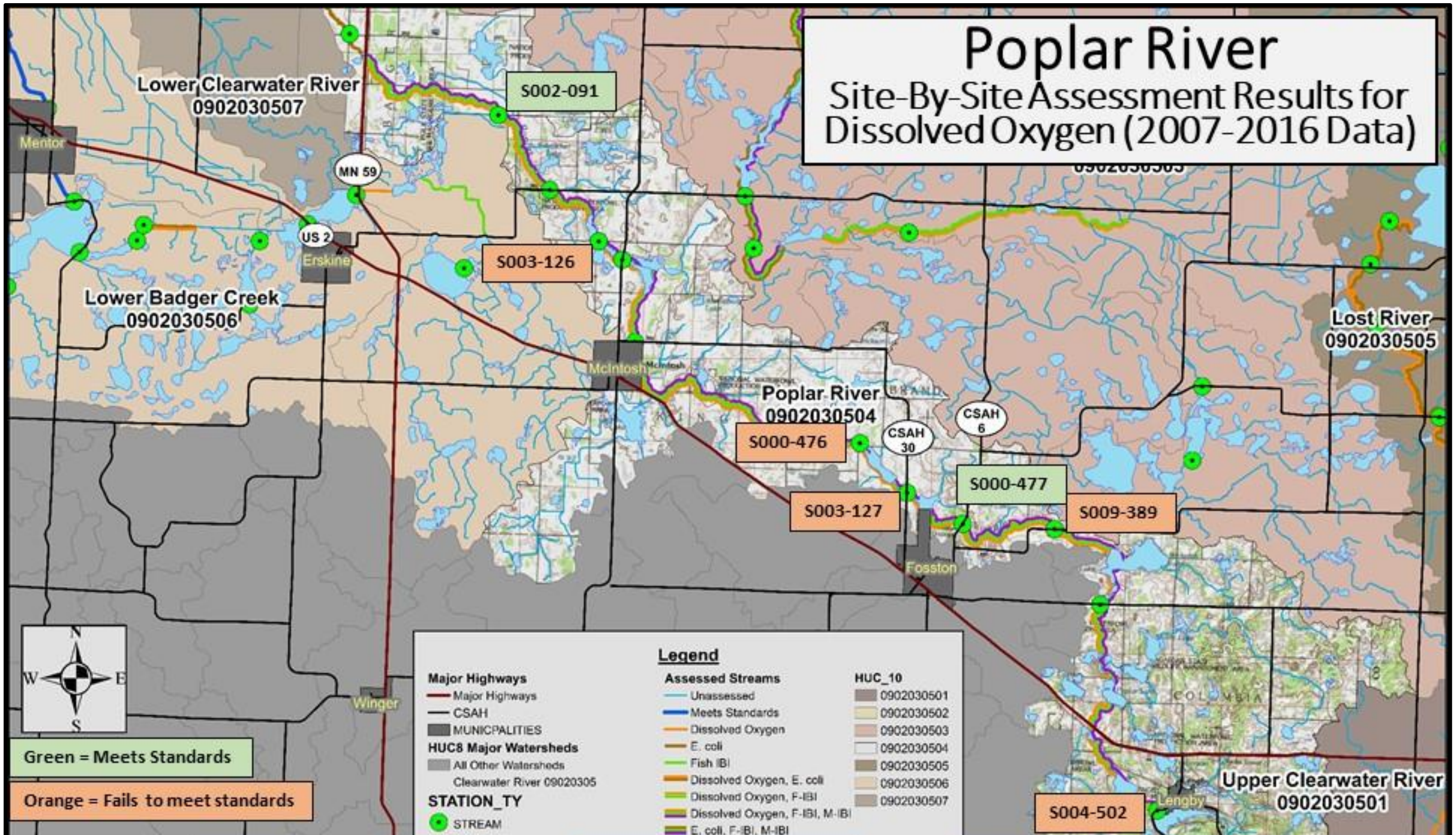


Figure 4-38. Summary 2016 continuous DO monitoring at CSAH 27 (station S009-389) on the Poplar River (AUID 518)



Site ID:	S002-091	S003-126	S000-476	S003-127	S000-477	S009-389	S004-502
Street/Road:	315th St. SE	340th St. SE	380th St. SE	CSAH 30	CSAH 6	CSAH 27	390th St. SE Spring L. Outlet
Discrete and Continuous Dissolved Oxygen Measurements DO5_All (May-September Daily Minimums)							
Days with Data	26	80	36	202	45	50	70
Daily Minimums <5 mg/L	2	52	32	74	2	47	41
% of Days with Low DO	7.7%	65.0%	88.9%	36.6%	4.4%	94.0%	58.6%
Discrete Dissolved Oxygen Measurements Only DO5_All (May-September Daily Minimums)							
Days with Data	26	32	14	73	27	12	17
Daily Minimums <5 mg/L	2	7	8	4	1	8	0
% of Days with Low DO	7.7%	21.9%	57.1%	5.5%	3.7%	66.7%	Insufficient Data

Figure 4-39. Longitudinal assessment DO statistics along the Poplar River (AUID 518)

The DO levels were better at the next downstream biological sampling station, near the CSAH 30 crossing north of Fosston (S003-127, 05RD078), but still dropped below 5 mg/L on 36.6% of days in 2007 through 2016 discrete and continuous DO data (5.5% in discrete data). River crossings between those two biological sampling stations (14RD218 and 05RD078) like CSAH 6 (S000-477) had good DO levels. Figure 4-39 shows how drastically DO concentrations can change from one crossing of the river to another. It shows the effect that riparian wetlands have upon the depletion of DO concentrations in the river.

Although in-stream habitat could be improved by greater diversity and some stabilization of stream banks, the Pfankuch and MSHA scores were not poor enough for habitat to be the primary stressor of aquatic life. The SID Report determined that fish in the Poplar River are not being affected by flow alterations in the Poplar River as much as macroinvertebrates were affected by that stressor.

4.4.2 09020305-518, Poplar River, Macroinvertebrate Biological Integrity

The macroinvertebrates in the Poplar River were being affected by most of the same stressors that were affecting fish (Section 4.4.1), except for connectivity. The SID Report also found that macroinvertebrates were being significantly affected by flow alterations. The low DO concentrations in sections of the Poplar River appeared to be the most significant stressor of macroinvertebrate populations. The biological sampling stations with poor M-IBI scores (14RD218 and 14RD216) were located near monitoring sites (S002-091 and S009-389) with a high frequency of low DO concentrations. There was one site that met M-IBI score expectations. That site, 05RD078, was located near the water quality station number S003-127 which had better DO concentrations than the other two locations. Stagnant conditions appeared to be the main cause of the low DO levels. The Poplar River flows through a wetland complex on the west side of Whitefish Lake shortly upstream of 14RD218 and S009-389 where DO is depleted. There were low gradient areas and beaver dams upstream of sites 14RD216 and S002-091.

The most notable flow alterations in the Poplar River Watershed were large drained wetlands and private drainage from cultivated land. The drained wetlands represent an opportunity for improved storage in the watershed that could help reduce the flashiness of flows and improve base flows.

4.4.3 09020305-527, Silver Creek, Macroinvertebrate Biological Integrity

A lack of flow, or flow regime instability, appeared to be the most significant stressor of biology in Silver Creek. Despite periods of low DO during periods of low flow, the SID Report concluded that DO was not the primary stressor of aquatic life in Silver Creek. Because DO levels met the standard in assessable data (data collected while the stream is flowing) and low DO was caused by stagnant conditions while the stream was not flowing, low DO was not the root cause of the M-IBI impairment.

Continuous water level and DO loggers were simultaneously deployed in Silver Creek during the summer of 2014. The DO loggers recorded a total of 31 days in which DO levels dropped below 5 mg/L during the 110 days of deployment (>28%). After the DO records were filtered to remove days with zero flow, the stream met the standard because <10% of daily minimum DO levels were <5 mg/L. During the 2014 DO logger deployments, only 2 of the 41 days (<5%) with measurable flow had DO levels that dropped below 5 mg/L. The average flow was 0 cfs on July 30, 2014, when poor IBI scores were recorded at station 14RD231. Flows had been lower than 1 cfs during the 4 previous days and 0 cfs during the two days prior to macroinvertebrate sampling. The daily minimum DO levels during macroinvertebrate sampling were okay, though. The minimum DO concentration on July 16, 2014 was 7 mg/L and the minimum concentration on July 30, 2014 was 6.03 mg/L. Because DO levels are closely connected to the maintenance of measurable flow, projects to improve natural storage, infiltration, and improvement of base flows could improve DO levels and improve conditions for macroinvertebrates in the stream.

Regardless of flow, DO flux in Silver Creek was high during 2014 DO logger deployments. This warranted an examination of nutrient concentrations. An assessment of nutrient data yielded inconclusive results. There were indications that the stream might have been trending toward a river eutrophication impairment, but data was slightly insufficient. Silver Creek exceeded the 100 µg/L TP standard with an average concentration of 168 µg/L. The 2014 summer average DO flux was 4.63 mg/L during measurable flow conditions that ranged from 0.03 cfs to 38.01 cfs. That would have qualified the reach as impaired in earlier assessments, but a second year of DO logger deployments became a requirement for the use DO flux as a response indicator for 2016 river eutrophication assessments. The collection of DO data from two years in the 2016 through 2025 assessment period, prior to the 2026 assessment, is recommended. The collection of BOD data is also recommended. The lone BOD data point (3.34 mg/L) for this AUID exceeded the 2.0 mg/L standard. During the days in which TP was >100 µg/L, OP comprised approximately two-thirds of the TP concentration, on average. When TP data was compared to DO data, there appeared to be a general downward trend in DO with increasing TP concentrations, but the correlation was weak. No violations of the DO standard occurred while TP was less than 1 mg/L, but there were only two low DO values in the paired TP/DO data. Intensive sampling during DO logger deployment is recommended to clarify whether or not DO levels are affected by TP concentrations.

The data analysis in the SID Report revealed large differences between the number of nitrogen tolerant taxa and the number of nitrogen intolerant taxa. That was presented as evidence that inorganic nitrogen (nitrites & nitrates, or NO2+NO3) could be a stressor. However, the inorganic nitrogen (nitrate and nitrite) concentrations were relatively low. The stressor-based assumption was not supported by the real data from this reach.

Silver Creek met the 30 mg/L TSS water quality standard. Other than a 600-foot reach of straightened channel along Township Road 82, Silver Creek has not been channelized. The stream received a fair MSHA score, so there is still room for improvement of aquatic and riparian habitat. Some eroding stream banks have been identified. Livestock access to the stream has damaged stream banks and created erosion problems in multiple locations. A cultivated field upstream of 14RD231 encroached upon the stream and appeared to fall short of the minimum 30-foot buffer requirement (2015 Buffer Law) in multiple locations. Habitat assessment scores seemed to have an unexpectedly negative correlation with M-IBI scores, so a lack of habitat was not the primary cause of the M-IBI impairment. The site with the highest average MSHA score (14RD231, 65 points) had the lowest M-IBI score (31.9 points) and the site with the lowest average MSHA score (15EM098, 56.1 points) had the highest M-IBI score (60.0 points).

4.4.4 09020305-539, Hill River, Fish Biological Integrity

This AUID is the portion of the Hill River between the outlet of Hill River Lake and the river's confluence with the Lost River. After water flows out of the Hill River Lake outlet, it briefly flows south, then flows north for roughly 11 miles before making a turn to the west. A LiDAR profile of the water surface of the Hill River between Hill River Lake and the Lost River is shown in Figure 4-42. There appears to be two inflection points, where the river's gradient increases as it begins flowing to the west near 310th Avenue Southeast, and another downstream of where it crosses CSAH 92. The F-IBI scores at two sites (05RD026 and 14RD253 near CSAH 35 and 290th Street Southeast, respectively) within the north-flowing portion of the river failed to meet expectations. The F-IBI score exceeded expectations near the furthest downstream crossing of the river at CR 119 near Brooks (14RD221, S002-134). Differences in the characteristics of those three sites provided clues about potential stressors to aquatic life. A large amount of data was available and helpful for diagnosing potential causes of the impairment. The SID report identified a lack of connectivity, low DO, high DO flux, and a lack of habitat as stressors to fish populations.

Connectivity issues along this portion of the Hill River included the Hill River dam on the upstream end of this reach and multiple beaver dams along the upper portion of the reach. Beaver dams may also be exacerbating the stagnant conditions in the upper, northward-flowing portion of this AUID. The gradient of the river is relatively low where it flows northward, and that portion of the river is bordered by riparian wetlands. The channel is relatively wide in that portion of the river (see photo in Figure 4-40) compared to the rate of flow, so velocities can be low for much of the summer. The river was relatively stagnant and often resembles a wetland at the CSAH 35 crossing (S003-498)

Figure 4-40. Stagnant conditions at CSAH 35 (station S003-498) on the Hill River (AUID 539)

Continuous DO monitoring was conducted at three sites along this reach. The DO levels at the downstream end of the reach (S002-134), where the F-IBI score was good, were impeccable. The DO levels near the upstream end of the reach (S003-498) were much worse. The following comparison of statistics between those two sites shows how DO, M-IBI, and F-IBI values were the main differences between the two sites. Habitat scores and TP concentrations were similar. Each station slope gradient value was calculated by dividing the change in elevation over a two-meander wavelength section of the stream that was centered on each sampling station. Elevations used to calculate slope were surface elevations from LiDAR data. The river had higher gradient at the free flowing CR 119 crossing (14RD221) near Brooks than the 05RD026 sampling station located between 330th Street Southeast and 320th Street Southeast. A lack of stream gradient and stagnant water would have a limiting effect on DO levels.

Overall habitat scores throughout the reach were similar and ranged from 59.5 to 62.5 (a 3-point range in values). There were some differences in the individual MSHA metrics of substrate, land use, and channel morphology. Land use and channel morphology scores were better at stations that had lower IBI scores. So, those features may not be as influential as substrate seemed to be. F-IBI and M-IBI scores improved along with substrate scores. The low-gradient segment of the river may have been more stable than a high-gradient segment but may have been too stagnant to support healthy populations of fish that were intolerant of low-DO conditions.

14RD221 (S002-134)

- CR 119, AUID 539
- F-IBI = 69 (2014)
- 22 fish species
- 234 individual fish
- 0% of DO daily minimums <5 mg/L
- M-IBI = 68
- MSHA = 61.1
- MSHA Substrate Score = 19.1
- MSHA Morphology Score = 16
- 0.088 mg/L summer average TP
- 0.11% = station slope
- 0.12% = 230th Ave. SE to CR 119 slope

05RD026 (S003-498)

- CSAH 35, AUID 539
- F-IBI = 33.4 (2006)
- 11 species of fish
- 464 individual fish
- 85.5% of DO daily minimums <5 mg/L
- M-IBI = 26.5
- MSHA = 62.5
- MSHA Substrate Score = 6.6
- MSHA Morphology Score = 27
- 0.098 summer average TP
- 0.05% = station slope
- 0.04% = 330th St. SE to 320th St. SE slope

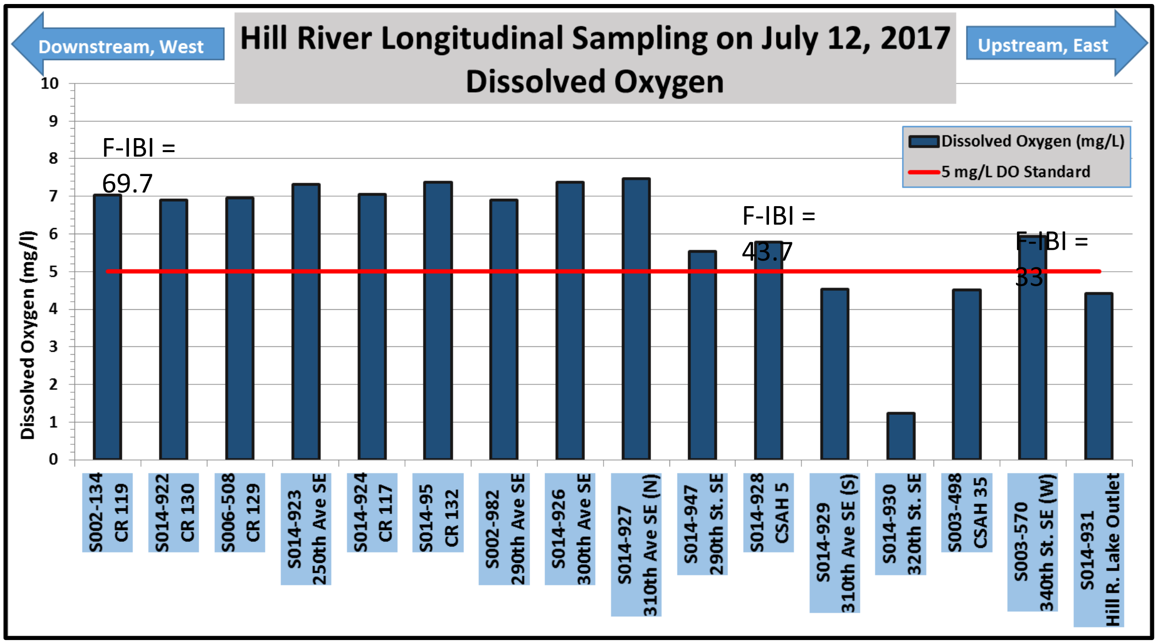


Figure 4-41. Longitudinal DO measurements and IBI scores along the Hill River (AUID 539), July 12, 2017

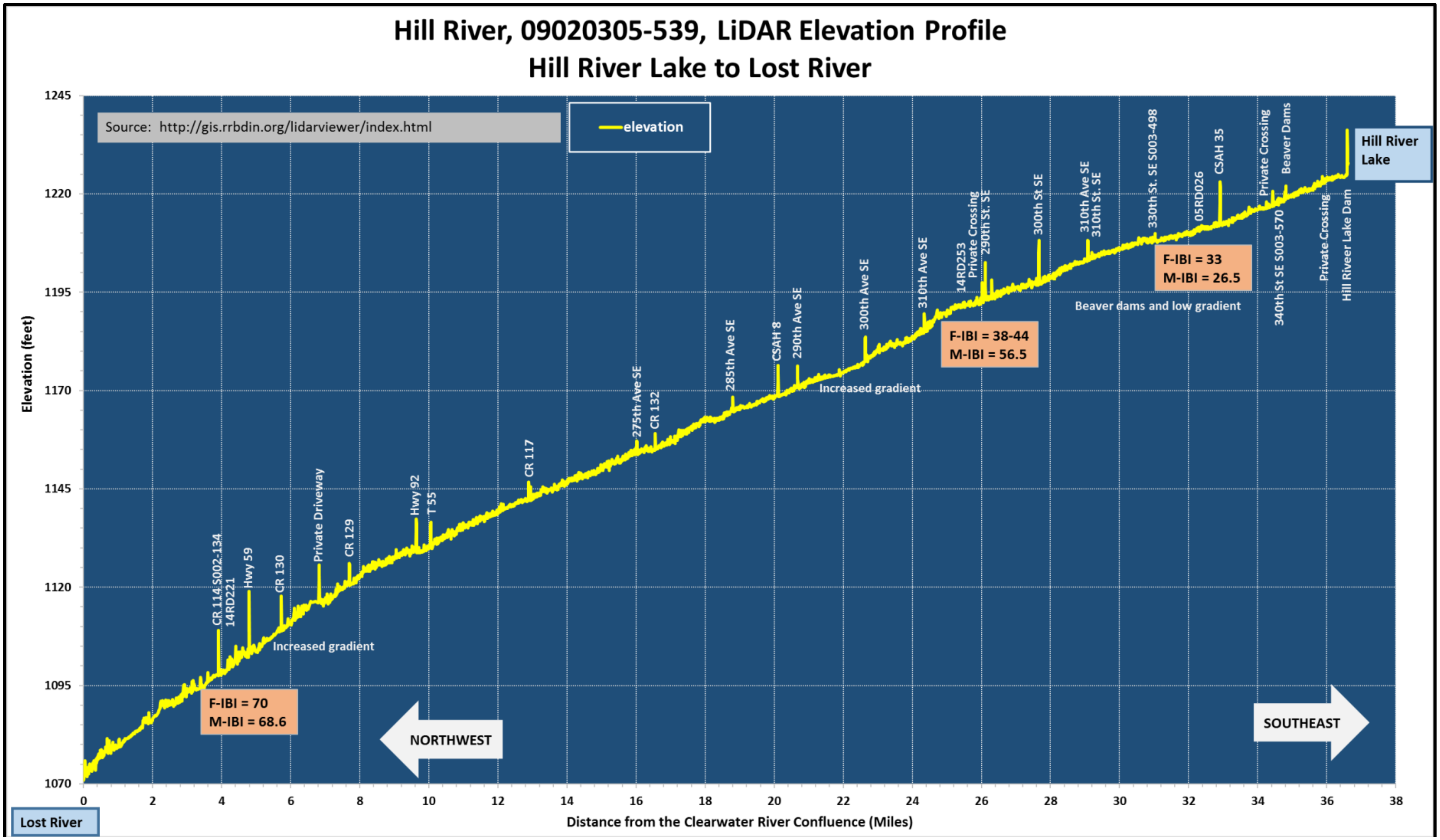


Figure 4-42. LiDAR profile of the Hill River (AUID 539) from the outlet of Hill River Lake to the Lost River.

The Hill River DO monitoring has shown that DO levels are low in the portion of the river that flows north and gradually improve as the river flows to the west, though the full extent of the DO impairment is unknown. The gradient and riparian characteristics appear to have a strong influence upon DO levels in the river. Longitudinal DO measurements that were recorded downstream of Hill River Lake (Figure 4-41) confirmed what assessment statistics and biological sampling results had suggested. The DO concentrations in the Hill River were depressed along the northward-flowing reach, shortly downstream of Hill River Lake. That portion of the river had a relatively low gradient and flows through wetlands where decomposition of organic material was likely consuming DO, and there was a lack of turbulence for re-oxygenation. Where the Hill River turned to the west, near 310th Avenue Southeast, the gradient increased and DO concentrations also increased. Continuous DO measurements were recorded at 290th Avenue Southeast (S002-982) in June through September of 2017. That station was located near the upstream end of the westward flowing portion of AUID 09020305-539. During the 2017 deployment at S002-982, DO levels dropped below 5 mg/L during 34% of the days in which the logger was deployed. The summer average DO flux was okay at 2.78 mg/L. DO flux and daily minimum DO levels were okay in June and July but worsened in the late summer (August and early September). The hypothesis and motivation for the 2017 DO logger installation at 290th Avenue Southeast was that DO levels should improve as the river flows west, across a steeper gradient. Although the 2017 monitoring revealed that poor DO conditions in the Hill River extended downstream through 290th Avenue Southeast, the DO levels were significantly better at that location compared to upstream sites like the CSAH 35 crossing. Future DO logger deployments could be conducted downstream of 290th Avenue Southeast to identify the full extent of the low DO problem.

Although there were some locations in which BMPs were needed to reduce the effect of anthropologic land use upon water quality, the primary stressors appeared to be related to natural features of the landscape. Because the low F-IBI scores and low DO levels appeared to be caused by physical features of the watershed (beaver dams, low gradient, and stagnant water) rather than a pollutant, a TMDL was not written to address the F-IBI impairment of this reach.

4.4.5 09020305-561, Tributary to the Poplar River Diversion, Fish Biological Integrity

Two visits to Station 14RD243 on AUID 09020305-561 by the MPCA failed to yield any F-IBI points for this reach. The station was sampled on June 10, 2014, but the effort resulted in a zero-point F-IBI score. The site was visited again on August 5, 2014, but had insufficient flow for a sample. Prior to the biological sampling, this reach had no history of water chemistry monitoring. Sampling and DO monitoring were conducted in 2016 to aid the SID process. Water became stagnant and DO was very low in July, August, and September. Low DO, flow alteration, and poor habitat were identified as stressors. Although barriers to fish passage like beaver dams and a water control structure exist downstream, there was too little information to determine if physical barriers could be influencing fish migration any more than the conditions of low DO, low flow, and poor habitat. An assessment of the macroinvertebrate community may have helped create a better understanding of the relative influence of potential stressors, but macroinvertebrates could not be sampled in this reach due to stagnant conditions.

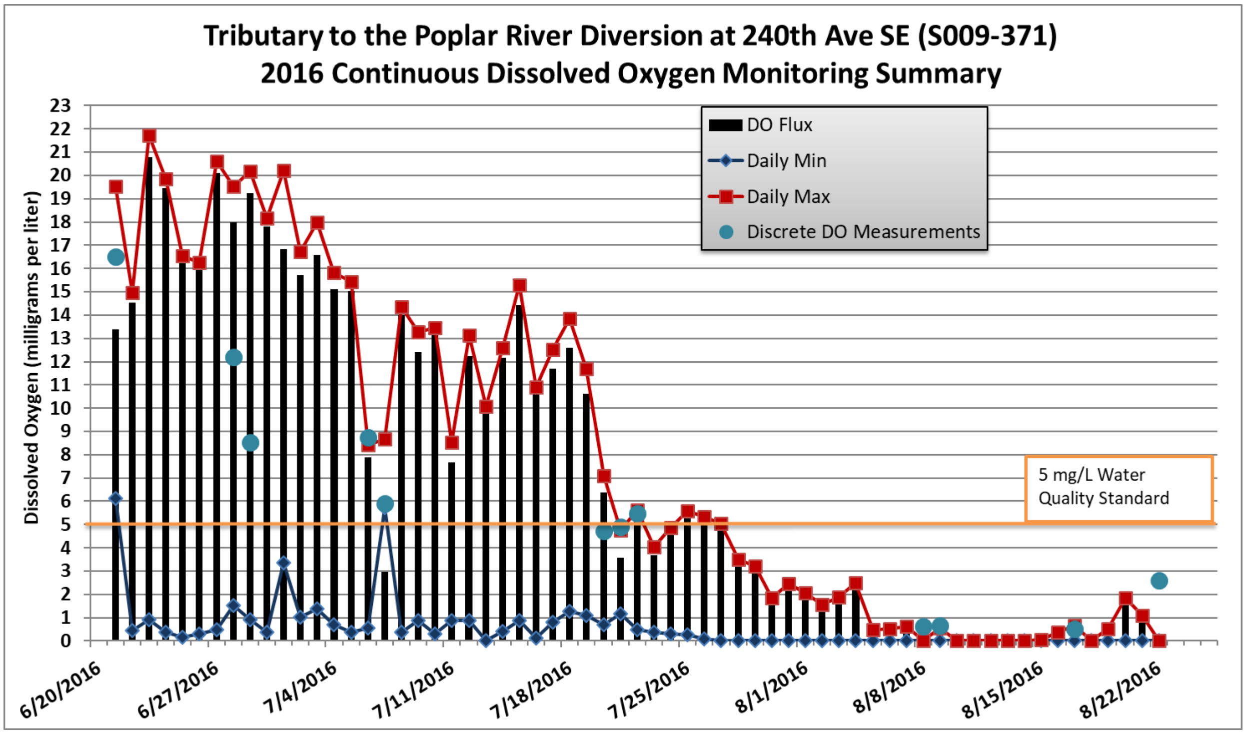


Figure 4-43. Continuous DO monitoring summary of a tributary (station S009-371) to the Poplar River Diversion (AUID 561), summer 2016

The SID Report found credible evidence that the low DO levels within this ditch were significantly stressing the fish community. High levels of DO flux (as shown in Figure 4-43) were also recorded in this ditch. The DO levels were consistently close to zero throughout the month of August in continuous and discrete data. The levels were so low that the authors of the MPCA SID Report speculated that the DO logger was malfunctioning. However, a comparison between continuous and discrete data in Aquarius software indicated that the DO logger was functioning properly. DO logger measurements and simultaneously collected discrete measurements were similar. Had the DO sensor been in the air (not submerged), the concentrations would have been much higher than what they were. Some negative values were recorded, so perhaps the accuracy could have been improved by a two-point calibration. Regardless, the continuous and discrete DO data shows that this channel became anoxic during the late summer. Stagnant conditions in the channel were also observed during site visits. Duckweed on the water surface was noted on multiple occasions. The channel became filled with vegetation.

Parts of this channel drain wetlands and a portion of the channel is an artificial watercourse that follows property boundaries. Most of this ditch, particularly the portion near the biological and water chemistry sampling stations, does not appear to follow the path of a natural, lotic watercourse. It appears to be a drained wetland complex. There is a portion of the channel near the outlet of Gerdin Lake that may follow a natural drainage path (upper 0.6 miles) with some gradient, but the rest of the channel appears to follow property boundaries more than a natural drainage path. The gradient becomes relatively flat where the channel has been straightened, particularly in the westward flowing portion of the ditch. The possibility of a flood storage project in this area (proposed Lessor-Gerdin Impoundment) was explored in the late 1980s and early 1990s but was never completed. The project would have flooded this channel and a parcel of land upstream of 240th Avenue Southeast.

4.4.6 09020305-645, Lost River, Fish Biological Integrity

A mostly channelized portion of the Lost River, between Anderson Lake and an unnamed creek/ditch along the east side of CSAH 28, was non-supporting of fish, with low F-IBI scores. Low F-IBI scores at 14RD226 (near CSAH 28) and 07RD024 (near 550th Street) ranged from 28 to 44 points, and failed to meet the F-IBI impairment threshold of 47 points.

The M-IBI scores were good for this reach. Therefore, the causes of the F-IBI impairment may have been stressors that affected fish more significantly than macroinvertebrates. The SID Report identified three primary stressors:

- Low DO and high DO fluctuation
- Flow alterations that cause a lack of base flow and lead to low DO levels
- Lack of habitat

Longitudinal DO measurements (Figure 4-67 in Section 4.5.8) suggested that DO problems are somewhat localized at CSAH 28 and directly downstream of Anderson Lake. Deployments of DO loggers at other locations along the reach, however, found that low DO problems occur throughout much of the reach. The Lost River also experiences large fluctuations in DO levels despite TP concentrations that fall safely below the standard (0.069 mg/L summer average TP in 2007-2016 data). The large swings in daily DO levels may explain why some locations appeared to have okay DO levels during the daytime longitudinal samples.

The SID report found evidence (five metric responses, discharge data, and stream characteristics) of a causal relationship between flow regime instability and the F-IBI impairment associated with AUID 645. Much of this reach has been channelized. Much of the Lost River within this reach is considered a legal drainage ditch. It is also influenced by drainage from the JD 72 drainage system. The channelization generally moves water from the system quicker and increased drainage would reduce the storage needed to maintain base flows.

Figure 4-44. Lack of buffer width and lack of shading along the Lost River (AUID 645)

The SID report found evidence of a causal relationship between habitat availability and the F-IBI impairment in four different F-IBI metric responses, geomorphologic assessment, and observations of stream characteristics. There was a lack of shading along the channelized portion of this reach. Even without high TP concentrations, the river still had excess periphyton growth and DO flux. The lack of shading may have exacerbated the signs of eutrophication that were observed in the river. Diversity of habitat was severely limited by the channelization. A geomorphologic assessment found that the stream was moderately unstable. Riparian land use along this reach mostly consisted of row crops and pastures. Much of the riparian buffer along this reach was lacking in width and/or quality (Figure 4-44). The reach is required to have a 50-foot buffer under Minnesota's new Buffer Law. Recent aerial photos show that the buffer fell short of that mark along much of the row-cropped portions of the immediate drainage area. Reconnaissance in 2019 found portions of AUID 645 that were still lacking a buffer.

There may be potential for channel restoration along this reach. There were areas in which the meander scars were still visible in aerial photos. Erosion was a problem along this reach. Restoration of meanders could create a more stable channel and reduce erosion.

Large beaver dams have been frequently observed along this reach. If beaver dams get too large or problematic along the legally ditched portion, they are removed by a ditch authority. They have been a particularly persistent problem at CSAH 28. The possibility of rearranging the rocks under the bridge at CSAH 28 may also be considered in order to discourage beaver dams and lessen the amount of ponding upstream of the bridge. That responsibility falls upon the RLWD for the Lost River. Due to their temporary nature; however, beaver dams may have a greater effect upon DO levels by exacerbating stagnant conditions than they have upon fish passage. Therefore, the amount of influence that beaver dams have upon fish passage is inconclusive.

4.4.7 09020305-652, Beau Gerlot Creek, Fish Biological Integrity

The F-IBI scores recorded within Beau Gerlot Creek were very poor. On July 17, 2014, site 14RD255 was sampled and only achieved a 14-point score that was far below the impairment threshold of 42 points. When the reach was sampled again on June 23, 2015, it scored zero points. The SID report determined that physical characteristics of this stream are affecting aquatic life. Water chemistry measurements (DO, DO flux, TSS, nutrients) met standards and were suitable for aquatic life while there was measurable flow in the stream. Physical characteristics of the stream like flow alterations, lack of connectivity, and lack of habitat were identified as the primary stressors for fish along this reach.

An examination of aerial photography found six potential fish passage barriers along this AUID. Those barriers included beaver dams and private crossings of the stream (Figure 4-45). Improperly sized/sloped culverts in private crossings were likely affecting connectivity along the stream. The lack of migratory fish in this AUID despite a close proximity to the Clearwater River indicated that fish passage barriers were the primary cause of the extremely low F-IBI score in this reach. Poor macroinvertebrate scores indicate that other stressors may also be limiting IBI scores.

The SID Report found evidence that flow regime instability was a potential cause of the F-IBI impairment. The evidence included four individual F-IBI metric responses and physical features of the drainage area. Both F-IBI samples were collected while there was less than 5 cfs of estimated flow in the stream near the CR 114 crossing. Flow monitoring in this stream revealed that there were extended periods of low or zero flow in this stream. Hydrographs showed that flows abruptly spiked during runoff events and quickly dropped down to low levels. This indicated that flashy flows were an issue in this drainage area. Portions of the stream have been channelized and straightened.

Figure 4-45. Private crossing over Beau Gerlot Creek (AUID 652) that may be a fish passage barrier. Streambank damage from livestock can also be seen.

Although the stream looks like it would have good habitat upstream of the CR 114 crossing (forested riparian corridor, good canopy for shading, and a rocky channel bottom), closer examination found some deficiencies. The MSHA assessments along this reach yielded fair scores that were influenced by poor substrate and channel morphology. A geomorphic survey found that the channel was entrenched and unstable. The inability of an entrenched channel to reach its floodplain can increase the shear stress on stream banks and increase stream bank erosion. The reach was also lacking in pool depth, a feature that can provide holding cover for fish. Stream banks have been damaged by livestock along portions of this reach. The channel has become wide and shallow where stream banks have been disturbed by livestock. Depositional features have been noted in this reach, which indicates that there was excess erosion in upstream reaches. Four individual F-IBI metric responses provided evidence that a lack of habitat was one of the causes of the F-IBI impairment in Beau Gerlot Creek.

Because the evidence suggested that the F-IBI impairment in Beau Gerlot Creek was caused by non-pollutant causes and because water chemistry parameters met state standards, the F-IBI impairment in AUID 652 of Beau Gerlot Creek could not be addressed a pollutant-based TMDL. Projects to improve physical characteristics of the stream like habitat, connectivity, and stream stability are recommended in the Implementation Strategy Summary section (Section 9) and in the Clearwater WRAPS Report.

4.4.8 09020305-652, Beau Gerlot Creek, Macroinvertebrate Biological Integrity

The M-IBI impairment threshold for AUID 652 of Beau Gerlot Creek was the 37-point general use threshold. Samples were collected on July 29, 2014 and August 5, 2015, and scored 26.8 and 31 points, respectively (average score of 28.9 points). Macroinvertebrate stressors were likely similar to the stressors that caused the F-IBI impairment (other than the lack of connectivity). Flow alteration and poor habitat were the most likely stressors. The M-IBI scores were not as poor as the F-IBI scores (closer to meeting standards), relative to the impairment threshold. The M-IBI scores fell within the +/-12.6-point confidence interval and should be prioritized for restoration, as they were relatively close to meeting standards (“nearly restored”).

Both macroinvertebrate samples were collected while there was an estimated 0 cfs of flow at the CR 114 crossing. Stagnant conditions can result in low DO levels in a stream. Continuous DO data from the CR 114 crossing (Figure 4-46) shows that DO levels were sufficient to meet the standard, but DO levels still occasionally dropped below 5 mg/L. The low DO levels occurred when flow was low (or zero cfs). Projects are needed in this watershed to reduce peak flows and improve base flows. Projects that increase water storage in the watershed would also support basinwide flood damage reduction (FDR) goals and strategies. The Red River Basin FDR Framework split the Red River Basin into three timing zones to guide the planning of FDR projects. The Beau Gerlot Creek lies within the middle runoff timing zone in which runoff should be slowed or stored.

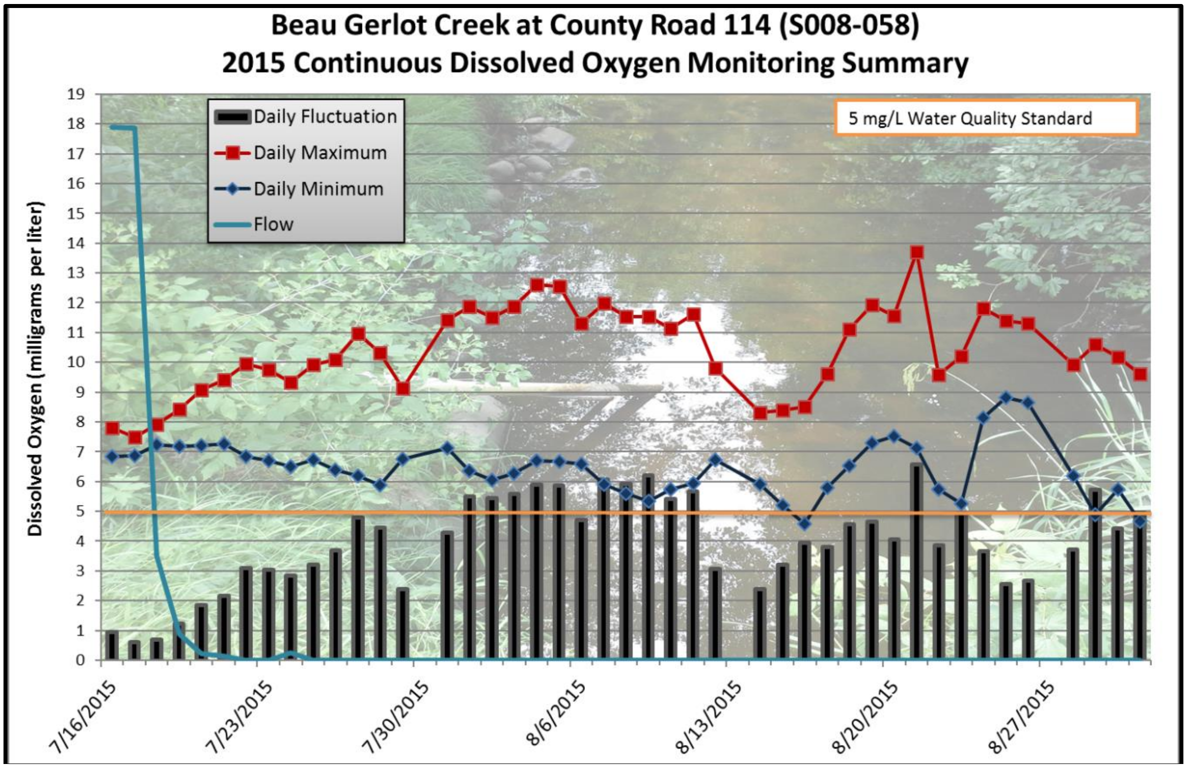


Figure 4-46. Continuous DO monitoring summary of Beau Gerlot Creek (AUID 652) (station S008-058), summer 2015

As noted in the Section 4.4.7 discussion of F-IBI stressors, there were multiple features of the watershed that are affecting habitat. These include stream channel instability, sedimentation, and channelization. Streambank stabilization and channel restoration projects are recommended for this reach and the upstream, channelized reach of Beau Gerlot Creek (AUID 651). The sampled reach was well-buffered with a forested riparian corridor. Channelization and increased drainage rate upstream may have negatively affected the stability of the sampled portion of the stream. To improve conditions for macroinvertebrates at station 14RD255 within AUID 652, improvements are needed in AUID 651. Upstream portions of Beau Gerlot Creek were unbuffered in aerial photos that were taken during the assessment period. A meandering section of public water watercourse upstream of CSAH 49 was cleaned with an excavator, as evidenced in Google Earth aerial photography that was taken on April 14, 2015. Trees (present in earlier aerial photos) were also removed and piled to the west of the channel.

4.4.9 09020305-656, Hill River, Fish Biological Integrity

An eight-mile-long segment of the Hill River, upstream of Hill River Lake, failed to meet expectations for F-IBI scores. Station 14RD246 (near 335th Avenue) was sampled twice for fish, once in 2014 and once in 2015. The reach needed a 47-point F-IBI score to meet standards but fell short with 31 points in 2014 and 0 points in 2015. The macroinvertebrate community; however, achieved a passing M-IBI score of 53.8 points.

Figure 4-47. Photo of the Hill River (AUID 656) at water quality station S007-847

The SID report identified a lack of connectivity, low DO, and daily DO flux as primary stressors. Insufficient habitat may also be a stressor to aquatic life due to sedimentation and a lack of coarse substrate. Daily fluctuation of DO may be caused by stagnant water and elevated nutrient levels. An examination of data indicates that the most influential stressors are low DO and a lack of connectivity.

The SID report found that low DO measurements and specific IBI metrics provided evidence that low DO levels occur too frequently in this portion of the Hill River. Overall, 28% of the 2007 through 2016, May through September daily minimum DO measurements (including data from continuous DO loggers) dropped below 5 mg/L at the 335th Avenue Southeast crossing (S007-847, shown in Figure 4-47). Longitudinal sampling results revealed that conditions are worse at other crossings along this reach. Conditions along the upstream reach (AUID 655) may have been limiting the potential for DO levels within AUID 656. Longitudinal DO measurements revealed that DO levels were very low at the furthest downstream (380th Avenue Southeast, S014-935) crossing of AUID 655. Natural and human-made physical features of the riparian corridor appeared to be more negatively affecting DO than any pollution inputs. Section 4.4.11 details the non-pollutant factors that are affecting DO levels. The DO measurements and biological sampling results from S007-847 can be compared with other sampling sites along the Hill River. The next long-term monitoring site downstream of Hill River Lake is S003-498 at CSAH 35, which is upstream of the 05RD026 biological sampling station. More than 85.5% of daily minimum DO levels at CSAH 35 (DO5_All, continuous and discrete data) were lower than 5 mg/L. Despite worse DO levels, fish were more plentiful downstream of the lake at 15RD026 than they were upstream of the lake at 14RD246. At the downstream end of the Hill River Watershed, DO levels are always above 5 mg/L and the F-IBI score was good.

14RD246 (S007-847)

- 335th Ave, AUID 656
- F-IBI = 15.5 (average of 2014 and 2015)
- 4-7 fish species
- 8-20 individual fish
- 27.2% of daily DO measurements are <5 mg/L
- M-IBI = 53.8
- MSHA = 59.6
- 0.145 mg/L summer average TP

05RD026 (S003-498)

- CSAH 35, AUID 539 (downstream)
- F-IBI = 33.4 (2006)
- 11 species of fish
- 464 individual fish
- 85.5% of daily DO measurements are <5 mg/L
- M-IBI = 26.5
- MSHA = 62.5
- 0.098 summer average TP

14RD221 (S002-134)

- CR 119, AUID 539 (upstream)
- F-IBI = 69 (2014)
- 22 fish species
- 234 individual fish
- 0% of DO measurements are <5 mg/L
- M-IBI = 68
- MSHA = 61.1
- 0.088 mg/L summer average TP

The DO statistics and M-IBI score indicated that conditions should have been better for aquatic life upstream of the lake at 14RD246 than they were downstream of the lake at 05RD026. The M-IBI score upstream of the Hill River Lake was more than twice as high as the M-IBI score downstream of the lake. Yet, there was a drastic decrease in the F-IBI score and a very drastic decrease in the amount of fish that were sampled upstream of the lake compared to downstream. The fish population in AUID 656 was being affected by more than just DO levels.

Poor connectivity may be affecting F-IBI scores as much, or more than, low DO. The SID report concluded that the dam at the Hill River Lake outlet was preventing upstream (AUID 539 to 656) migration of some fish species. Figure 4-48 shows how water flows down a concrete ramp at the inlet to each culvert of the dam structure. Only one migratory fish was sampled at station 14RD246. Beaver dams could also have been temporarily limiting connectivity and fish passage. A LiDAR profile of the upper portion of this reach shows that there was a possible obstruction to fish passage (a pronounced drop-off) near the end of the CD81 channelized portion of the Hill River, 0.2 miles downstream (west) of the 380th Avenue Southeast crossing. The drop-off in the LiDAR data could have been created by a beaver dam.

A high-quality F-IBI score was recorded near the downstream end of the AUID 539 reach of the Hill River, by Brooks. However, poor F-IBI scores were found at the upstream end of AUID for reasons that are described in Section 4.4.4. Not only was AUID 656 separated from downstream reaches by the dam at the Hill River Lake outlet, but the fish communities downstream of Hill River Lake Dam in AUID 539 also failed to meet F-IBI standards. The poor conditions that led to those poor scores downstream of Hill River Lake in AUID 539 might have also limited the species of fish that could migrate upstream to AUID 656, with or without the physical fish passage barriers.

Figure 4-48. View inside a part of the Hill River Lake outlet structure through which water flows from Hill River Lake (60-01420-00) to the Hill River (AUID 539)

The SID Report also identified DO flux as a stressor based on the frequency at which the daily DO flux exceeded 3.5 mg/L. The river eutrophication standard for DO flux is based upon the summer average; however, not the frequency. The summer average for this reach (at station S007-847) was 3.33 mg/L. Although it is close to exceeding the standard, it nonetheless meets the standard. The summer average TP concentration was 148 µg/L, which exceeds the 100 µg/L standard. Most of that phosphorus (74%); however, was in the dissolved organic form (OP). Elevated TP levels are most likely caused by the release of OP during stagnant, low DO conditions.

4.4.10 09020305-658, Red Lake County Ditch 23, Fish Biological Integrity

The lower 1.98 miles of Red Lake County Ditch 23 (CD 23) is a natural channel that begins at the downstream end of the channelized portion (latitude/longitude -96.1479/47.885) and flows into the Clearwater River. The reach also receives drainage from Red Lake County Ditch 17. Two sites were sampled along the reach in separate years (14RD260 in 2014 and 16RD050 in 2016) and both yielded very poor scores that fell far below the 42-point impairment threshold (0 points at 14RD260 and 6 points at 16RD050). Only nine fish (two white suckers, two creek chubs, and five fathead minnows) were sampled at 14RD260 in 2014.

The predominant stressors were determined to be a lack of base flow, a lack of habitat, and limited connectivity. The channel was very sinuous and wooded downstream of CSAH 1. There may be potential for improvements in aquatic life by addressing some of the physical characteristics that were limiting the stream's potential for supporting aquatic life.

Low DO was also documented, but that stressor was likely caused by the lack of base flow. Five of the forty-three days that were monitored with a DO logger in 2016 (Figure 4-49) had daily minimum DO levels that fell below the 5 mg/L standard (11.6%). A higher percentage (76%) of days in 2017 (Figure 4-50) fell below 5 mg/L. A lack of flow was a common occurrence in 2017 and flow dropped to zero in late July and early August. The low DO readings seem to have occurred during stagnant conditions. Stage and flow data collection was recommended for future monitoring of the site to determine the stage at which flow becomes stagnant, and to more directly assess the relationship between flow and DO in CD 23.

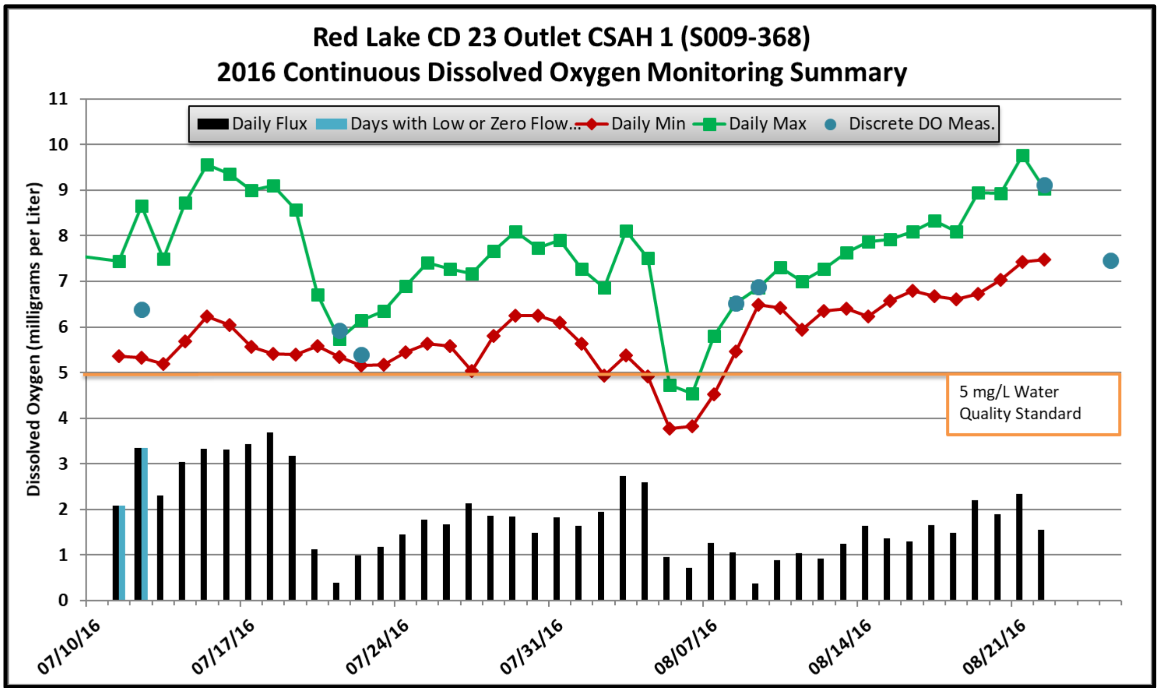


Figure 4-49. Continuous DO monitoring summary of CD 23 (AUID 658) (station S009-368), summer 2016

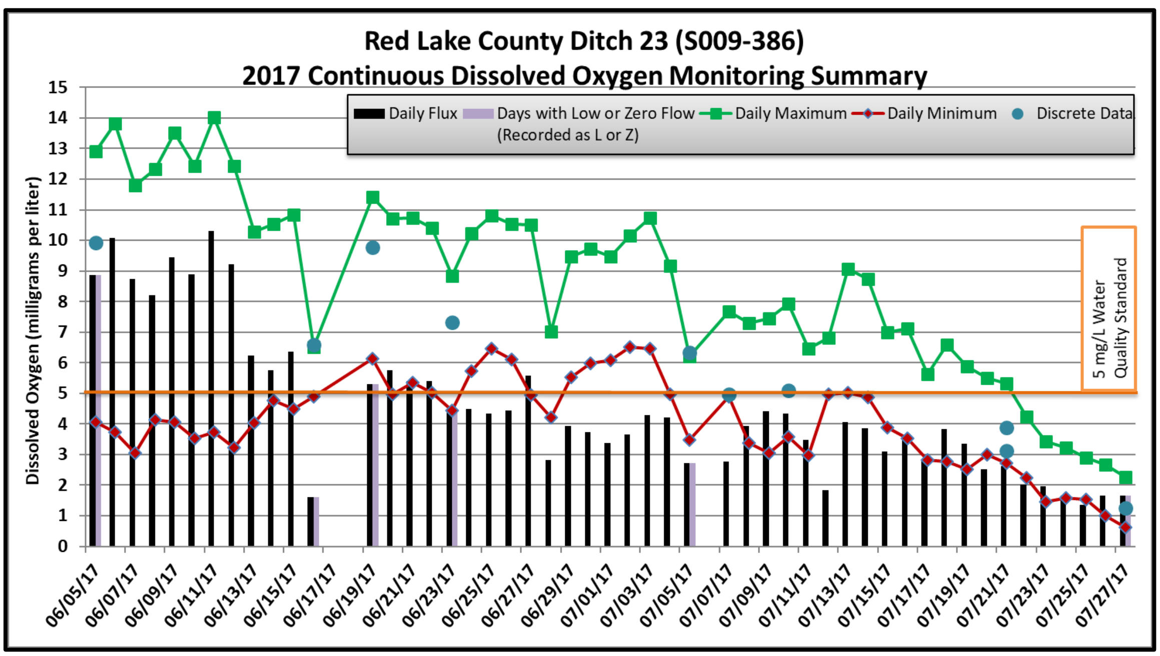


Figure 4-50. Continuous DO monitoring summary of CD 23 (AUID 658) (station S009-368), summer 2017

There was insufficient pollutant sampling data to meet the state's minimum data requirements for assessments. Sample collection began in 2014, with a sample collected during biological sampling. The RLWD collected samples in 2016 and 2017. So far, the limited nutrient data from the site has suggested that the reach exceeds the TP standard with a summer average of 0.123 mg/L in eight samples. The average is heavily influenced by high concentrations that occurred during low flows. In the days in which TP concentrations greater than 0.100 mg/L were measured, OP accounted for more than 0.100 mg/L of those concentrations (at least 88.79% of TP), which indicated stagnant conditions were causing anoxic conditions and the release of OP from sediment. The TSS concentrations have been very low at the site (4 mg/L or lower), so excess turbidity/sediment does not appear to be a stressor. Overall, with the information that is available, there is insufficient evidence to show that the F-IBI impairment is caused by excess loading of TP, TSS, or other pollutants.

Flow from a relatively small drainage area seems to be a significant limiting factor for aquatic life in CD23. The only flow data that is available for this reach was simulated by the HSPF model. In that data, the vast majority (84%) of the flows in this channel have been lower than 5 cfs. Low flows create stagnant conditions that depress DO levels. The low flows also increase the influence of minor barriers to fish passage like the culvert at CSAH 1 and a private crossing downstream of 14RD260. Five specific F-IBI metrics also provided supporting evidence that a lack of flow could have been at least partially causing the low F-IBI scores.

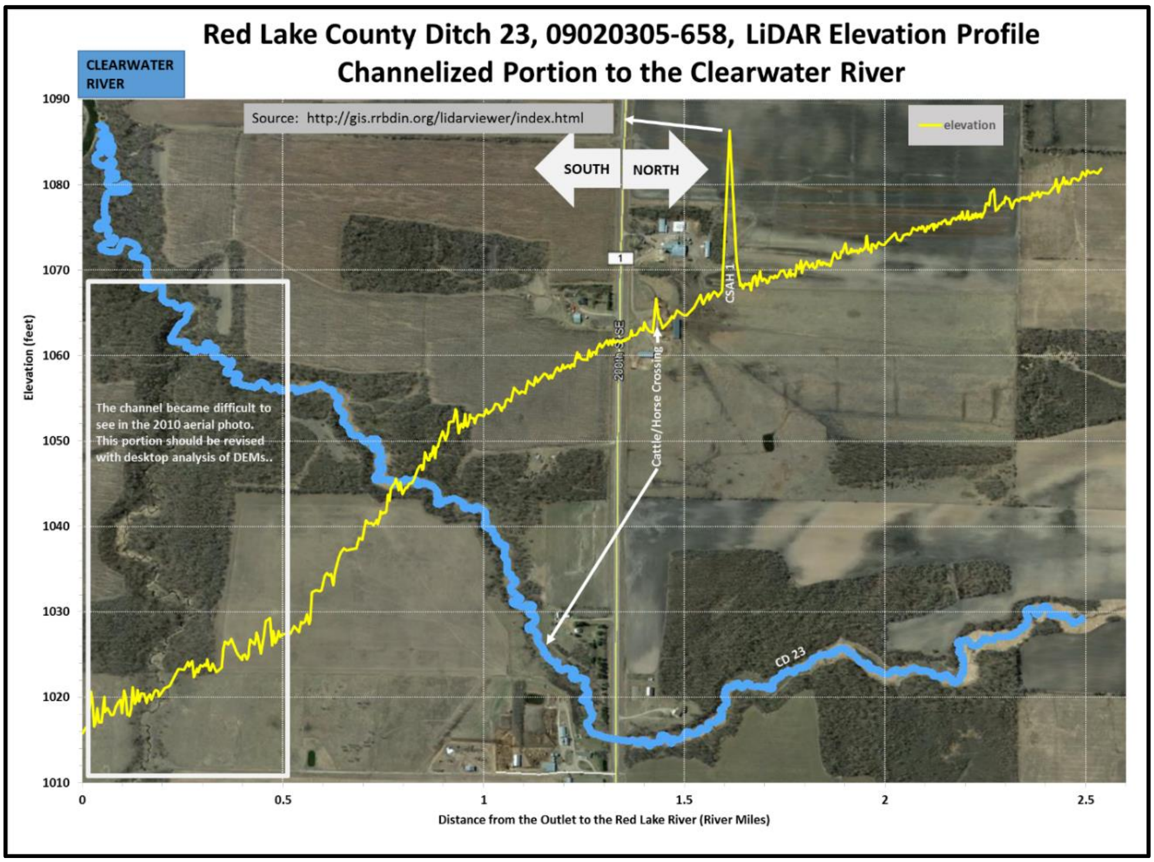


Figure 4-51. Longitudinal LiDAR profile of the CD 23 channel (AUID 658)

There was concern about habitat and fish passage along this stream. The culvert at CSAH 1 becomes a barrier to fish passage due to extremely shallow flow during low flows. Small migratory fish, white suckers, were found upstream of CSAH 1. The presence of suckers could be an indication that fish may be able to move upstream during higher flows. A LiDAR profile (Figure 4-51) and aerial photos of CD23 downstream of CSAH 1 revealed some potential fish passage barriers, particularly at private stream crossings. The channel downstream of CSAH 1 needs to be explored in order to identify any fish passage barriers, streambank instability, or stream channel (grade) instability problems. The LiDAR profile has limited accuracy due to an obstructed view of the channel in aerial photos due to tree cover. A surveyed profile of the channel could help plan future stabilization and restoration projects. If accessibility is a problem, drone technology could be another tool that could be used to assess the physical condition of the stream.

Habitat quality within CD 23 needs improvement, along with more consistent base flows and improved connectivity. The 14RD260 site received a fair MSHA score of 55 points out of a possible 100 points. The downstream, 16RD050 site received a good score of 79.5 points. The channels most significant shortcomings were in the MSHA categories that evaluated substrate and channel morphology.

4.5 Causes of Low Dissolved Oxygen Levels

Actions have been taken to improve water quality within the Clearwater River since the Clearwater Nonpoint Study that prompted the original listing. Soil and Water Conservation Districts (SWCD) continue to help landowners implement BMPs throughout the watershed. The RLWD implemented erosion control and buffer strip projects during Phase II of the Clearwater River Nonpoint Study. Some DO impairments along the main channel of the Clearwater River have been delisted. The current DO impairments will be challenging to directly restore because they are not caused by a pollutant. Smaller, tributary streams often experience periods of low flow in the latter part of the summer that lead to stagnant conditions and low DO. Natural and man-made physical features along channels have also caused low DO impairments.

4.5.1 09020305-509 Walker Brook

Walker Brook was first listed as impaired by low DO in 2002, when half of the recorded DO levels were less than 5 mg/L. In 2007-2016 data, 87% of May through September daily minimum DO concentrations (DO5_All) were lower than 5 mg/L. No continuous DO monitoring has been conducted in Walker Brook. Only two measurements have been collected earlier than 9:00 a.m. The frequency of low DO concentrations might be even lower if continuous DO data was collected and factored into the assessment. Only four measurements greater than 6 mg/L were recorded in 2007 through 2016 and only six measurements exceeded 5.5 mg/L.

The watershed was intensively studied by a team of staff from the MPCA, SWCDs, local experts, and the RLWD from 2003 through 2005 to determine the cause of the DO impairment. The examination of the Walker Brook Subwatershed found that the DO impairment was caused by natural features of the Walker Brook corridor. A groundwater assessment was completed by Joe Magner (MPCA, St. Paul). The geology of Walker Brook was assessed by Robert Melchoir, a professor emeritus from Bemidji State University. Intensive water quality monitoring and flow monitoring were conducted by the RLWD. A Bemidji State University graduate student, John Gleason, studied the setting, groundwater, and surface water of Walker Brook for his master's thesis. The findings of those efforts were compiled into a delisting request in 2006.

The impairment was partially caused by the naturally occurring wetland soil processes that can reduce oxygen (redox). According to the 2006 delisting request for Walker Brook, "all requirements necessary for oxygen reduction to occur are present at Walker Brook. The requirements are stagnant water, organic tissues in the soil, a respiring microbial community, and soil saturation over a period of time sufficient for the microbial organisms to deplete the available DO."

The delisting request stated that low DO in Walker Brook could not be explained by flow levels. Low DO concentrations have occurred throughout a broad range of stage and flow. Flow velocities in Walker

Brook are generally low and the stream has a low gradient. Beaver dams can sometimes exacerbate stagnant conditions in Walker Brook. The low gradient in Walker Brook doesn't allow for much aeration through turbulence. Anoxic groundwater discharge results in exceptionally low DO levels during base flow. Walker Brook was recategorized to the "4D Natural Background" class of streams in the 2018 List of Impaired Waters.

4.5.2 09020305-517 Clearwater River Headwaters

Figure 4-52. Photo of the Clearwater River (AUID 517) at S001-458 near Bagley

An intensive study of upper reaches of the Clearwater River, along with Walker Brook, discovered physical features of this portion of the watershed had a greater effect on DO concentrations than relatively low pollutant concentrations that have been found in this reach. The headwaters portion of the Clearwater River shares multiple characteristics with the Walker Brook drainage area (described in Section 4.5.1). The Clearwater River headwaters and Walker Brook are connected and located in the same area of the watershed. They share a geologic history in which they originated as part of a glacier margin meltwater stream around 15,000 years ago. The headwaters reach has a low gradient (Figures 4-52 and 4-53). It has riparian wetlands (fens) similar to those found along Walker Brook, with a similar redox potential. The headwaters of the Clearwater River receive an estimated 1.75 cfs/km of seepage from deep aquifers, but low gradient and lack of riffles provide minimal opportunity for oxygenation from turbulence. Fens along the Clearwater River are biologically active (consuming oxygen during decomposition of organic matter) and most of the runoff to the river flows through those fens.

Because of the low gradient and the fens that line the river, there are very few known streambank erosion or channel degradation problems along this portion of the Clearwater River. Some sediment deposition has been noted at the CSAH 2 crossing (S001-908), however. The sedimentation interfered with DO logger deployments (Figure 4-54), which resulted in some gaps in the usable data and a relocation of the logger deployment pipe.

Other than low DO, the water chemistry measurements collected in the headwaters have been very good. This reach easily meets the 15 mg/L TSS standard. The average TSS concentration in April through September 2007 through 2016 data was only 2.8 mg/L. Only two samples along this reach have exceeded 15 mg/L in 2007-2016 data (18 mg/L and 68 mg/L). The 68 mg/L sample appeared to be a sampling or data entry error because the transparency during that sampling event was >120 cm. The 126 MPN/100ml *E. coli* standard was rarely exceeded, and the maximum monthly geometric mean *E.*

coli concentration is just 85.6 MPN/100ml. The summer average TP concentration was 0.065 mg/L in 2007 through 2016 data. That concentration would exceed the Northern River Nutrient Region TP standard of 0.05 mg/L. The river appears to flow through both regions. The daily average OP concentrations comprised at least 51% of the daily average TP concentrations, on average. In one case, OP was much greater (0.29 mg/L) than TP (0.066 mg/L) in the same set of samples. Two-thirds of the BOD samples have been equal to, or less than the minimum reporting limit of 2.0 mg/L for the BOD analysis methods that were used. The number of censored, <2 mg/L data points lends uncertainty to the 2.1 mg/L summer average BOD concentration. The actual average concentration was likely lower.

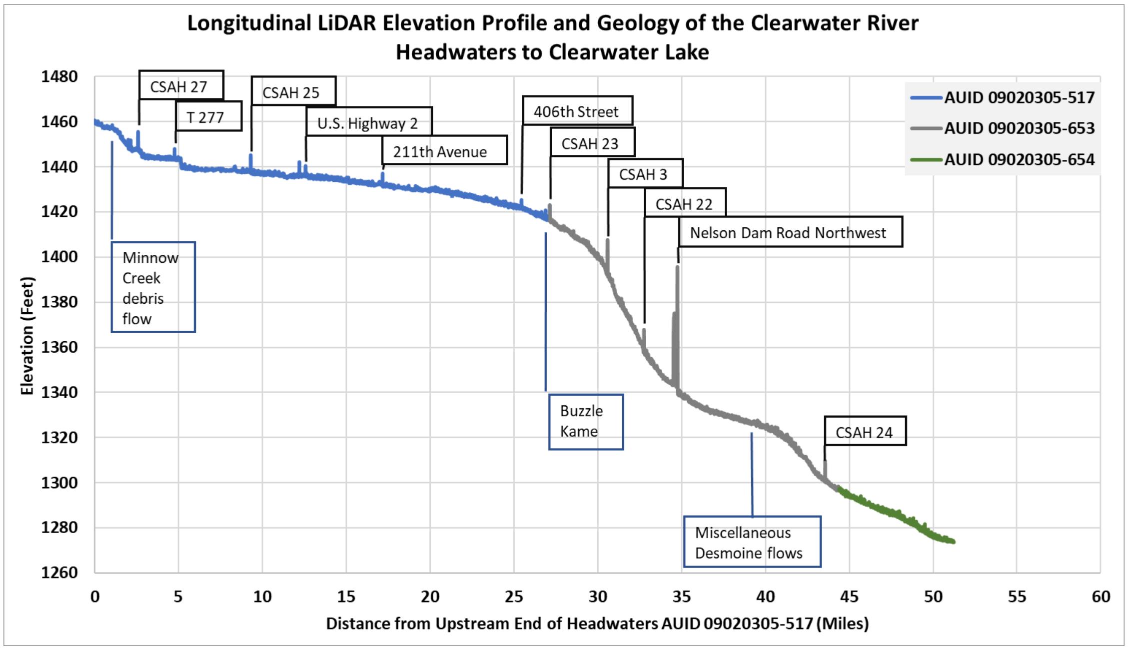


Figure 4-53. Longitudinal profile of the Clearwater River from its headwaters (AUID 517) to Clearwater Lake

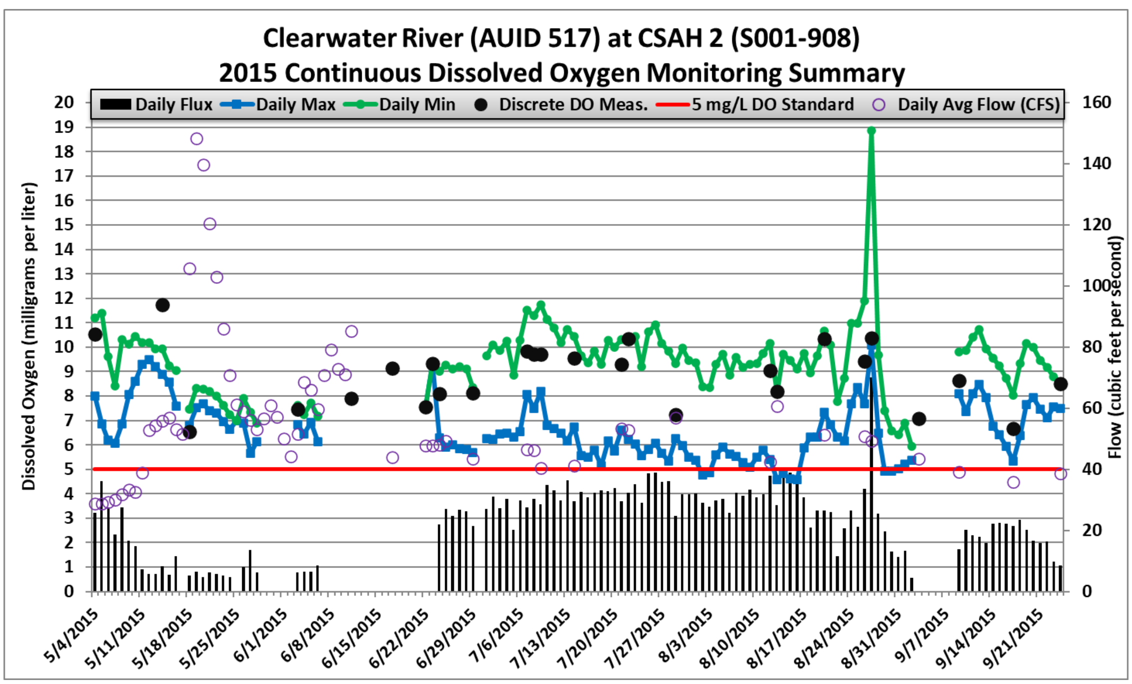


Figure 4-54. Continuous DO monitoring summary of the Clearwater River (AUID 517) from the CSAH 2 crossing (station S001-908), May through September 2015

4.5.3 09020305-518 Poplar River

The causes of low DO in AUID 518 of the Poplar River have been previously discussed in Sections 4.4.1 and 4.4.2 due to the effect that low DO has upon aquatic life. Figure 4-39 in Section 4.4.1 showed that DO levels were low in the headwaters between Spring Lake and CSAH 27, then recovered as it flowed west to CSAH 6 near Fosston. Then, DO levels were depressed between Fosston and McIntosh but recovered before the river reached Highway 59. Figure 4-39 used data collected through 2016. In addition to the results shown in Figure 4-39, regular monitoring at 310th Street Southeast (S009-392), the site nearest to the pour point of AUID 518, began in 2016. Three DO logger deployments were completed at 310th Street Southeast in 2018. Five days out of the 52 days (9.6%) of logger deployments had DO levels below 5 mg/L. No discrete measurements at that site have exceeded the standard. Therefore, the river appeared to be meeting the DO standard (barely), at the two furthest downstream crossings of this AUID. The DO levels in the Poplar River were generally dependent upon the gradient of the stream as they were depressed in low, wetland-like portions and improved where the river was free-flowing within a defined channel.

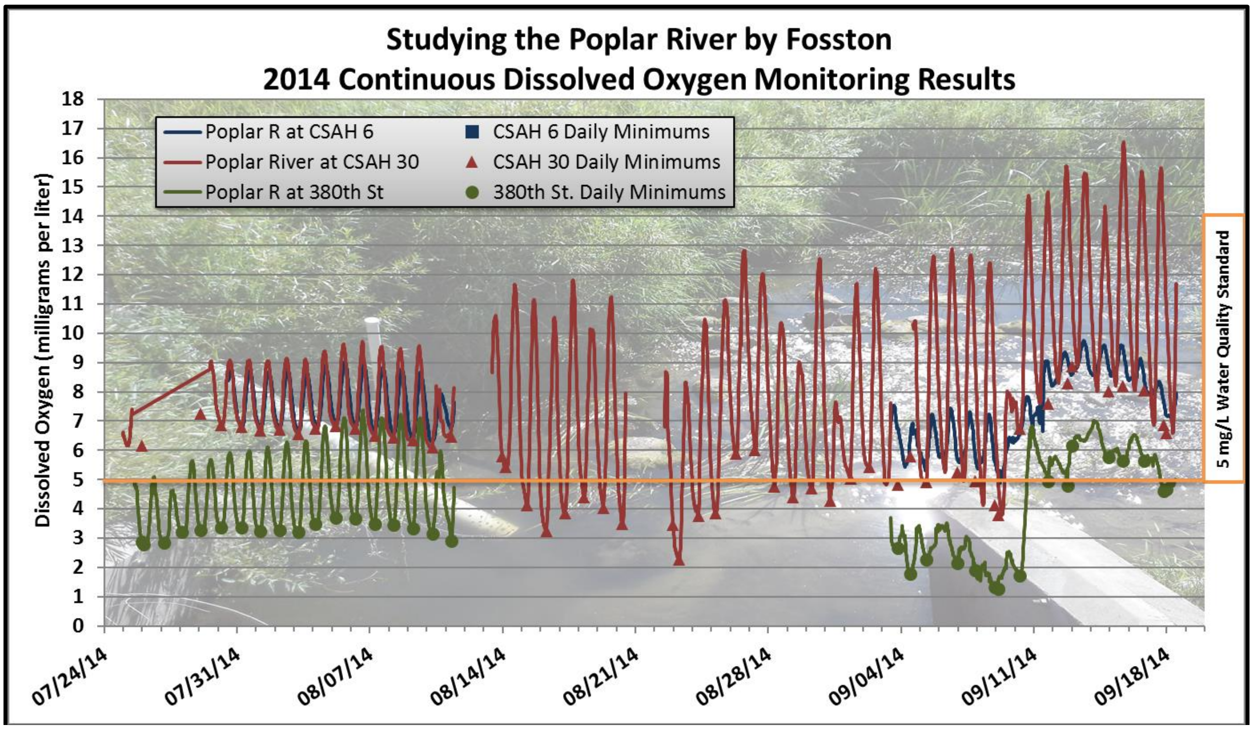


Figure 4-55. Intensive study and comparison of DO levels at three crossings of the Poplar River (AUID 518) near Fosston

Figure 4-55 is a time-series plot of DO levels that were simultaneously recorded at three crossings of the Poplar River near Fosston. The DO levels at the CSAH 6 (S000-477) crossing upstream of town were good and show that DO levels can recover from the depletion that occurs as the river flows past Whitefish Lake. From CSAH 6 to CSAH 30 (S003-127), DO levels dropped slightly and DO flux increased dramatically between the two crossings. The Fosston WWTF discharges to that portion of the river. Increased nutrients can lead to increased DO fluctuation. However, if there was any correlation between DO Flux and TP at S003-127, it was an inverse relationship (lower levels of DO flux while there were higher concentrations of TP). The CSAH 30 and 380th Street Southeast (S000-476) crossings bracketed a large riparian wetland area along the stream that was apparently consuming DO from the water flowing in the

Poplar River. The wetland could have been enriched by nutrients in historical discharge from the Fosston WWTF, prior to the 2012 improvements.

Multiple rounds of longitudinal DO measurements (DO measurements at as many crossings or other accessible points as possible within a short period of time) were collected along the Poplar River (Figure 4-56). These measurements were collected to determine the extent of the low DO problem and identify possible causes. The most complete sets of longitudinal measurements (ranging from 26 to 28 stations) were completed in May 2007, August 2007, July 2016, and August 2016. The May 4, 2007 measurements all exceeded the 5 mg/L standard. The July and August measurements in 2007 and 2016 revealed more differentiation along the river. When the results of the longitudinal sampling efforts were compared in Figure 4-56, stations with consistently low DO levels (S002-915, S000-476, and S009-384) or consistently adequate DO levels (S004-501, S009-392, S009-386, S009-398, and S009-399) could be identified. The longitudinal monitoring results indicated that some sites had a wide variation in results (S009-397, S009-393, S009-394, and S003-127) that may have been related to high diurnal fluctuation at those sites or other factors. Average daily flows, recorded at S003-127, were very low on August 16, 2007 (nearly zero cfs), and July 7, 2016 (0.74 cfs). Daily average flows at S003-127 were higher during August 2017 longitudinal DO measurements (slow decrease from 28.88 cfs on August 1, 2016 to 26.94 cfs on August 3, 2016) because of a series of rainfall events that occurred throughout the latter half of July 2017. Multiple sites still had low DO levels in August 2016, despite the increased rate of flow.

The summer average TP during the 2016 assessment (2006 through 2015 data) for AUID 518 of the Poplar River was above the TP water quality standard criteria at 0.199 mg/L, but there was insufficient response variable data to assess this reach for eutrophication. The summer average OP concentration was also high (84% of the TP concentration) at 0.167 mg/L. The OP was likely released from sediment during stagnant conditions rather than ongoing TP loading that could be addressed by a TMDL. Figure 4-57 shows that the TP standard of 0.100 mg/L is exceeded at many individual monitoring stations, especially downstream of Fosston, but average OP values comprises a high percentage of the average TP values. More information is needed in order to determine if reductions in TP loading could also decrease OP concentrations or DO concentrations. The DO concentrations in the Poplar River can meet the 5 mg/L standard at locations that exceed the TP standard (S002-091). Poplar River DO concentrations can fail to meet the 5 mg/L DO standard at sites that meet the TP standard (S004-502). The assessment process noted the elevated TP, but the reach was not listed as impaired because more response variable data was necessary to determine if eutrophication is impacting aquatic life. Extensive and intensive monitoring efforts along the river did not find evidence that high TP concentrations are causing low DO concentrations.

The increase in average TP from upstream of the Fosston WWTP (S000-47) to downstream (S003-127) was examined further due to the WWTF's history of affecting water quality in the Poplar River with discharge from the WWTF. The Fosston WWTF was upgraded in 2012, and the new permit includes a 1 mg/L discharge limit. The higher average TP at S003-127 was influenced by two high concentrations from June 22, 2016 (0.943 mg/L) and July 7, 2016 (6.74 mg/L) that were suspected to have been caused by discharge from the Fosston WWTF. The July 7, 2016 sampling event was prompted by complaints from downstream landowners about the water quality in the river. Extreme concentrations of sediment and nutrients were found at CSAH 30, but not upstream of the lagoons at CSAH 6. Additional improvements to the Fosston WWTF are planned for 2021 or 2022, pending funding, and should reduce TP concentrations and improve overall water quality within the Poplar River.

Because there is conflicting evidence at this time, a TP TMDL will not be established in this report. Longitudinal monitoring and assessment indicated that natural features (riparian wetlands and low gradients) were significantly influencing DO levels. Elevated TP levels suggested that the Poplar River should be monitored sufficiently to assess for river eutrophication during the next formal water quality assessment in 2026. Elevated OP concentrations indicate that stagnant conditions are influencing the elevated TP concentrations in addition to causing low DO concentrations.

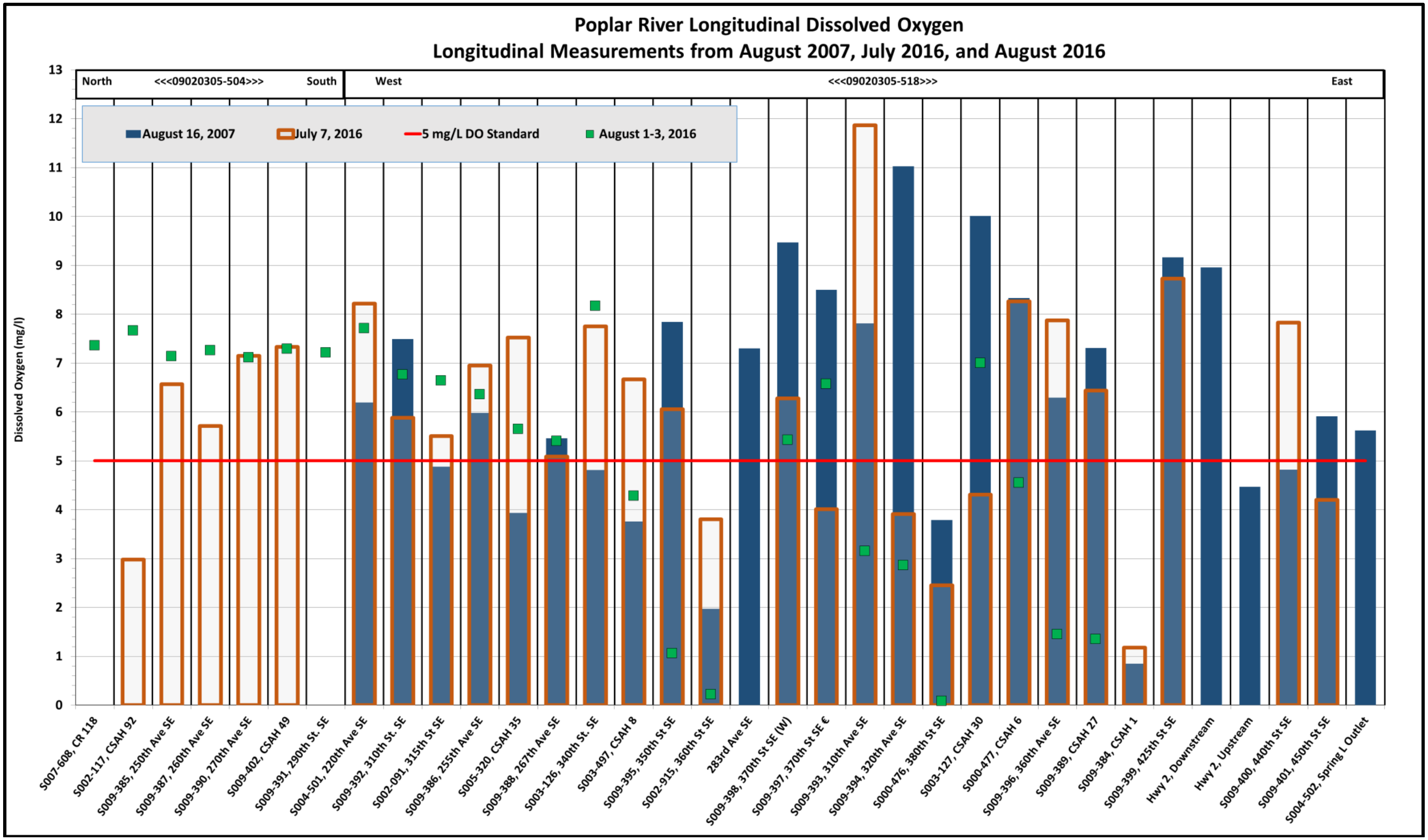
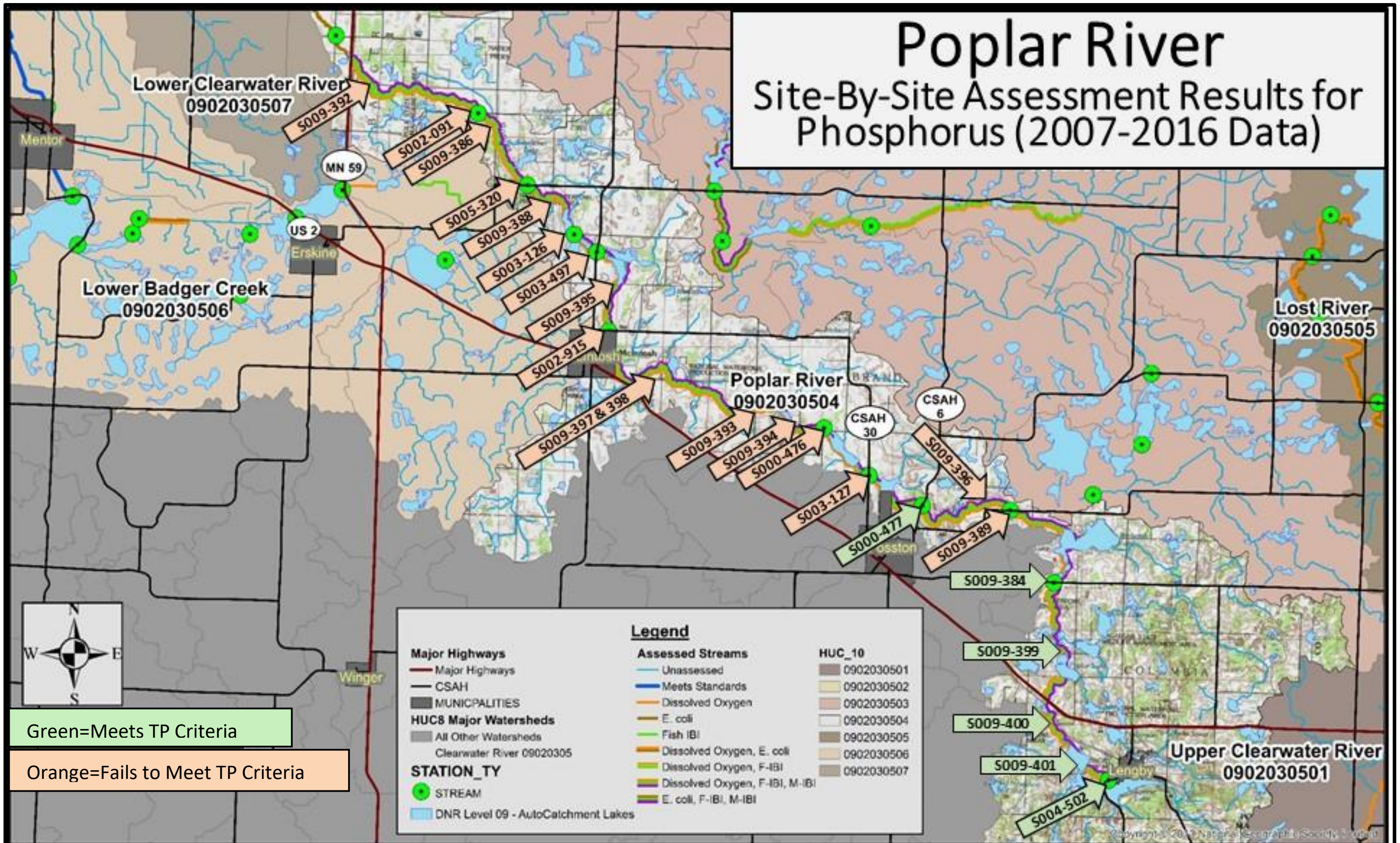


Figure 4-56. Longitudinal DO measurements along the Poplar River (AUIDs 504 and 518), August 2007, July 2016, and August 2016



Summer Average (June-September) Total Phosphorus and Orthophosphorus Concentrations in 2007-2016 Data

Site ID:	S009-392	S002-091	S009-386	S005-320	S009-388	S003-126	S003-497	S009-395	S002-915	S009-398	S009-397	S009-393
Street/Road:	310th St. SE	315th St. SE	255th Ave SE	CSAH 35	270th Ave SE	340th St. SE	CSAH 8	350th St. SE	360th St. SE	370th St. SE (W)	370th St. SE (E)	310th Ave SE
Days with Data	4	20	1	1	1	1	1	1	1	1	1	1
Total Phosphorus (mg/L)	0.233	0.285	0.294	0.288	0.281	0.273	0.282	0.51	0.545	0.288	0.327	0.3
Othrophosphorus (mg/L)	0.214	0.253	0.264	0.266	0.265	0.263	0.261	0.331	0.285	0.334	0.314	0.361
OP/TP Ratio	91.8%	88.8%	89.8%	92.4%	94.3%	96.3%	92.6%	64.9%	52.3%	116.0%	96.0%	120.3%

Site ID:	S009-394	S000-476	S003-127	S000-477	S009-396	S009-389	S009-384	S009-399	S009-400	S009-401	S004-502
Street/Road:	320th Ave SE	380th St. SE	CSAH 30	CSAH 6	360th Ave SE	CSAH 27	CSAH 1	425th St. SE	440th St. SE	450th St. SE	390th St. SE
Days with Data	1	11	21	12	1	8	1	1	1	1	1
Total Phosphorus (mg/L)	0.416	0.149	0.438	0.069	0.134	0.115	0.073	0.03	0.048	0.051	0.34
Othrophosphorus (mg/L)	0.301	0.113	0.155	0.042	0.1	0.081	0.036	0.017	0.038	0.04	0.017
OP/TP Ratio	72.4%	75.8%	35.4%	60.9%	74.6%	70.4%	49.3%	56.7%	79.2%	78.4%	5.0%

Figure 4-57. Longitudinal assessment of TP and OP concentrations of the Poplar River (AUID 518)

4.5.4 09020305-526 Clear Brook

Clear Brook begins as drainage from Deep and Steenerson Lakes, southeast of the city of Clearbrook. It flows through the city of Clearbrook and eventually empties into Silver Creek. Data collected during the months of May through September in Clear Brook showed that it failed to meet the 5 mg/L DO standard on 37.9% of the days in which it was sampled.

Flow rate did not appear to be a factor that was causing the DO impairment in Clear Brook. The daily minimum DO values were matched, by date, with daily average flow values. Removing days with low levels of flow did not reduce the rate at which the standard was exceeded. Low DO levels occurred throughout the range of flows that have been observed at the site.

Even though this stream receives stormwater runoff from the city of Clearbrook, the TSS levels in Clear Brook have been very low in the condition monitoring samples that have been collected throughout the years of 2007 through 2016. The highest concentration recorded in that period was 4 mg/L. The highest daily average concentration ever recorded in this AUID was 13 mg/L, in 2004. The TSS levels were low enough to meet the most protective of the state's TSS standards (all measurements were <10 mg/L during the 2006 through 2015 assessment period), although the 30 mg/L Central River Nutrient Region standard applies to this reach. Therefore, there was no evidence that excess TSS could be causing the DO impairment.

The summer average for 2007 through 2016 TP data was 0.086 mg/L, which fell below the applicable Central River Nutrient Region impairment threshold. Low DO concentrations have occurred throughout the range of TP concentrations that have been recorded at the site. In fact, sub-5 mg/L DO concentrations were recorded at the same time of the minimum and maximum TP concentrations. Therefore, there was no evidence that TP concentrations were affecting DO concentrations in Clear Brook.

Clear Brook flows through multiple areas where water is stagnant. Those areas are relatively flat and ponded behind barriers like beaver dams and man-made dams. Drainage in the headwaters of the stream flows through wetlands between Steenerson Lake and CSAH 49. A tributary of Clear Brook (AUID 571) also crosses CSAH 49, but rarely flows. The AUID 571 tributary looked more like a wetland than a stream (lacks a defined channel in areas beyond the culvert at CSAH 49) and exhibited very low DO when longitudinal measurements were collected in 2017 (Figure 4-59). Beaver activity has created a large, ponded area upstream of the old railroad grade that crosses the stream where it enters the town. There is a man-made pond in the city of Clearbrook, upstream (east) of Main Street (Figure 4-58). Longitudinal data collection in the summer of 2017 found that the DO levels downstream of the dam at Main Street were better than the levels at any other crossing. This was likely due to mechanical aeration of the water as it flows over the dam. Though the stream has a defined channel downstream of the dam, the DO levels were lower at the two furthest downstream crossings (CSAH 5 and CSAH 92). At CSAH 92, there is an enlarged, deep, stagnant scour pool immediately downstream of the culvert. The stagnation of water within that pool could have affected DO levels. Further investigation of the extent of the problem is recommended. In 2018 during a sampling event, RLWD staff discovered an excavation of the Clear Brook channel between Main Street North and Tower Street NW (CSAH 5), that was an unpermitted (violation) extension of an upstream excavation project that the DNR had issued a Public Waters Permit for sediment to be removed from the stormwater pond upstream of Main Street North.

That excavation may have negatively affected DO concentrations in 2018 as a low discrete DO reading was recorded in September 2018. If the channel is properly restored, with shading and deep-rooted vegetation, DO levels may have a chance of recovering.

Figure 4-58. Dam on Clear Brook (AUID 536) within the town of Clearbrook

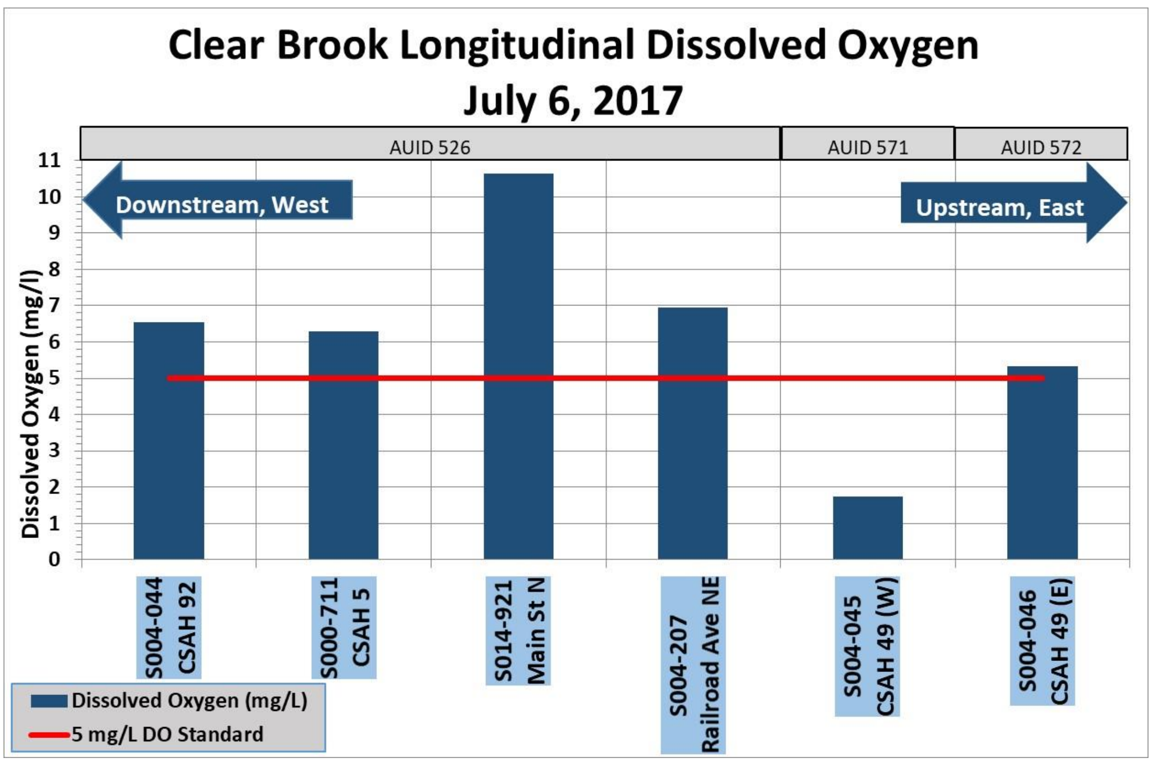


Figure 4-59. Longitudinal DO measurements along Clear Brook (AUIDs 526, 571, and 572), July 6, 2017

4.5.5 09020305-529 Lost River

The Lost River, upstream of Pine Lake, was impaired by low DO due to a record of consistently low DO concentrations. Low DO levels had been found at the inlet to Pine Lake in past monitoring efforts. The RLWD long-term monitoring site for this reach was moved upstream from South Pine Lake Road (S002-087) to a more freely flowing portion of the river at 109th Avenue (S005-283) that was more suitable for flow monitoring and flow rating curve development. Despite clear, freely flowing water, the site at 109th Avenue also had DO levels that were frequently low. The results of 2014 DO logger deployments in Figure 4-60 showed that DO levels consistently dropped below the 5 mg/L standard. In discrete and continuous data collected from 2007 through 2016, DO levels fell below 5 mg/L on nearly 65% of the 181 days in which it was measured. One third of the discrete measurements fell below 5 mg/L. The monitoring results for this reach were initially surprising because the reach lies downstream of two designated trout streams. The 2016 assessment revealed that those designated trout streams also have water quality issues.

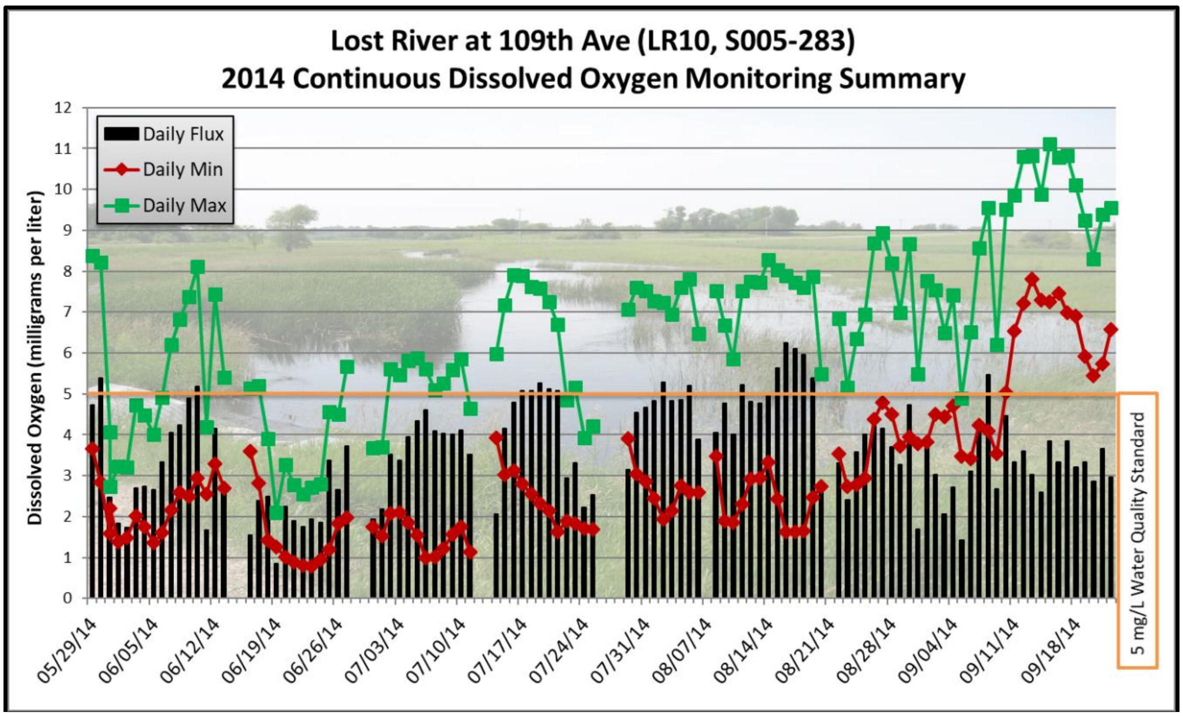


Figure 4-60. 2014 Continuous DO measurements along the Lost River (AUID 529) (station S005-283), summer 2014

Multiple longitudinal "snapshots" of DO levels in the Pine Lake drainage area were recorded. As with other reaches impaired by DO, low gradient reaches with on-channel wetlands appear to be negatively affecting DO levels. The biological activity likely consumes DO and the lack of gradient minimizes the opportunities for re-oxygenation. The river flows through wetlands upstream of CSAH 3. There were large decreases in DO levels from upstream of those wetlands to downstream in both longitudinal monitoring efforts (Figure 4-61 and Figure 4-62). On July 11, 2017, all of the DO measurements along the Lost River were below 5 mg/L. A poor-quality buffer (lack of woody vegetation and shading) along portions of the river was also limiting DO levels.

Beaver dams have been observed along this portion of the Lost River. Recent monitoring within the Lost River has found that the upstream, pool side of a beaver dam along the Lost River can have extremely low DO levels. Beaver dams and wetlands along the Lost River where redox removed DO were natural features of the landscape. The DO impairment of AUID 529 of the Lost River was caused by natural, non-pollutant factors and a TMDL was not warranted to address the DO impairment along this reach.

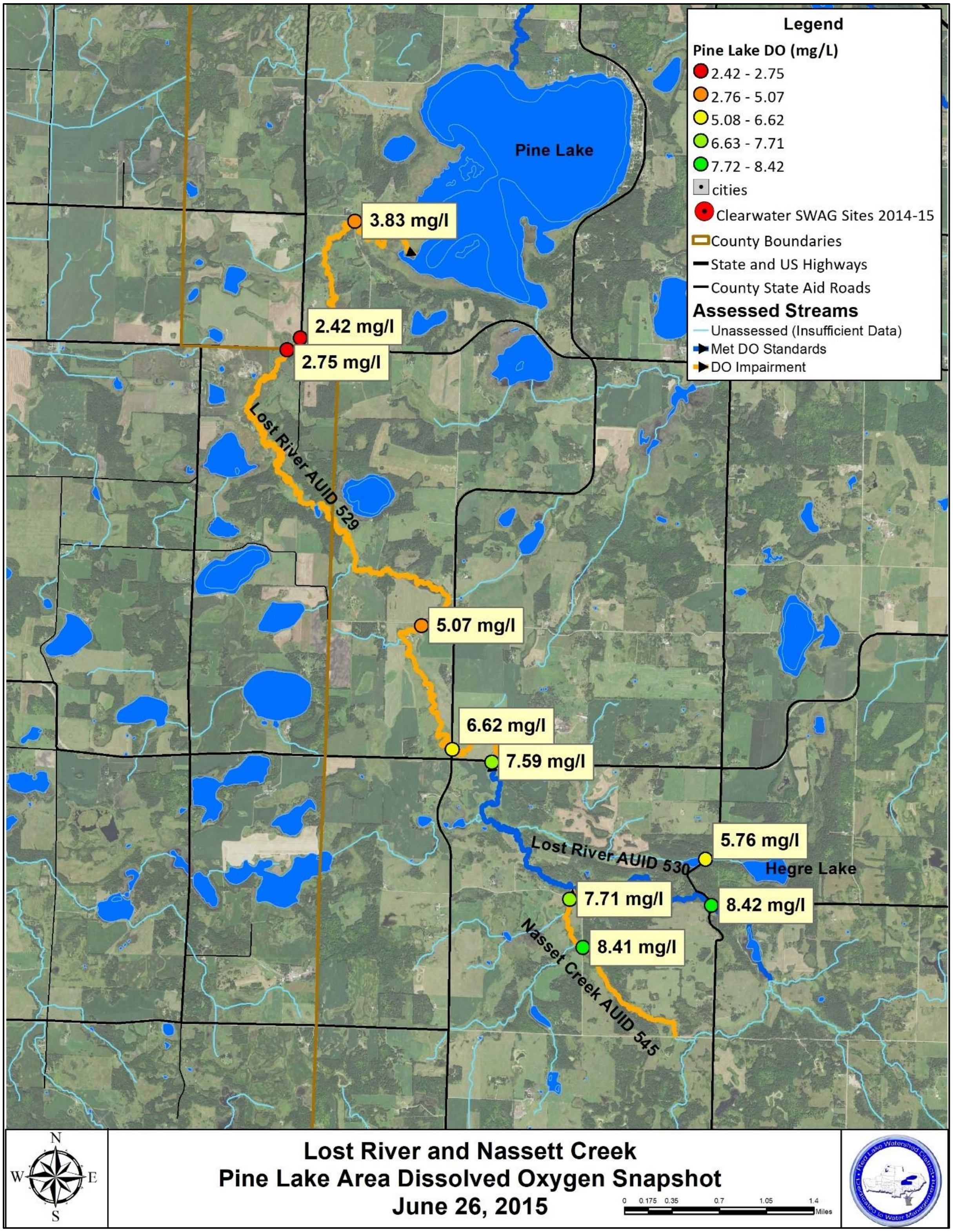


Figure 4-61. Longitudinal DO measurements in the Lost River Watershed (AUIDs 29, 530 and 545) upstream of Pine Lake, June 26, 2015

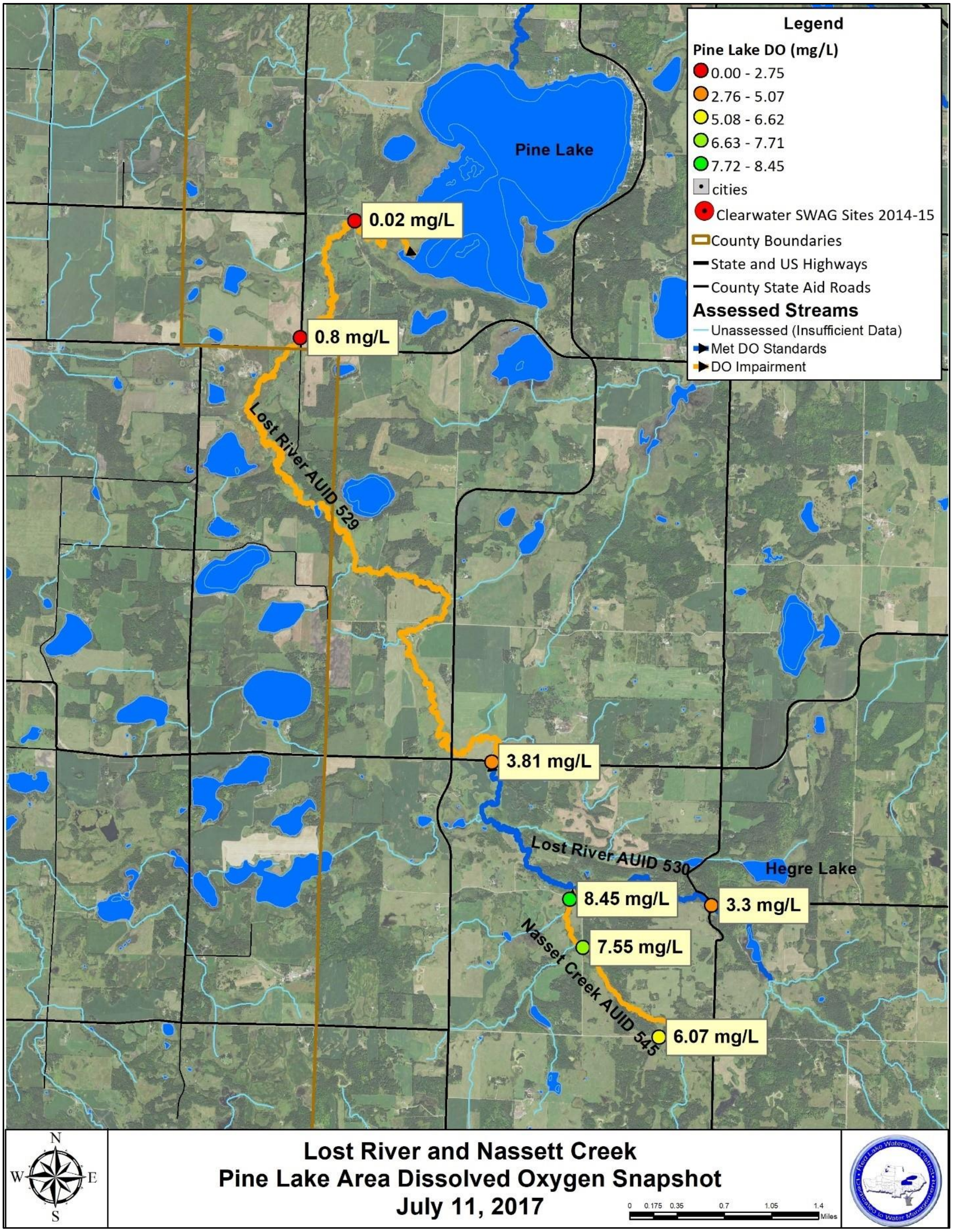


Figure 4-62. Longitudinal DO measurements in the Lost River Watershed (AUID 529, 530, and 545) upstream of Pine Lake, July 11, 2017

4.5.6 09020305-545 Nassett Creek

Nassett Creek, a designated trout stream, failed to meet the 7 mg/L trout stream DO standard during the 2016 assessment. Most of the data was collected at the two locations where the creek is crossed by Nesset Creek Drive (S005-500 and S004-205). Existing data indicated that portion of the reach was meeting the DO standard at the furthest downstream water quality station (S004-205), but is not meeting the DO standard upstream at S005-500.

Continuous DO logger deployments were conducted at S004-205 in 2017 (Figure 4-63). The data confirmed that the DO levels occasionally dropped below 7 mg/L, but the average DO concentration during those 51 days was more than 8.8 mg/L. The frequency of low DO readings was acceptable during the DO logger deployments (3 of the 51 days = 5.9%). The average temperature was 13.1 degrees Celsius (° C) throughout August and September 2017. Temperatures ranged from 7.74° C to 19.96° C during those deployments. The average DO flux of 2.57 mg/L met the North River Nutrient Region maximum DO Flux standard of 3 mg/L (though data was only collected during one calendar year). When the daily minimum DO values from the continuous data were combined with the discrete DO record for the whole AUID, Nassett Creek still failed to meet the DO standard (15% of daily minimums are <7 mg/L in 2008-2017 data). The overall (discrete and continuous) frequency of sub-7 mg/L readings at the final crossing (5.6% at S004-205) was nearly equal to the rate that was found in the continuous DO data. The frequency of low DO readings has been much higher at the nearest upstream crossing (S005-500) where 26.2% of the daily minimums were less than 7 mg/L.

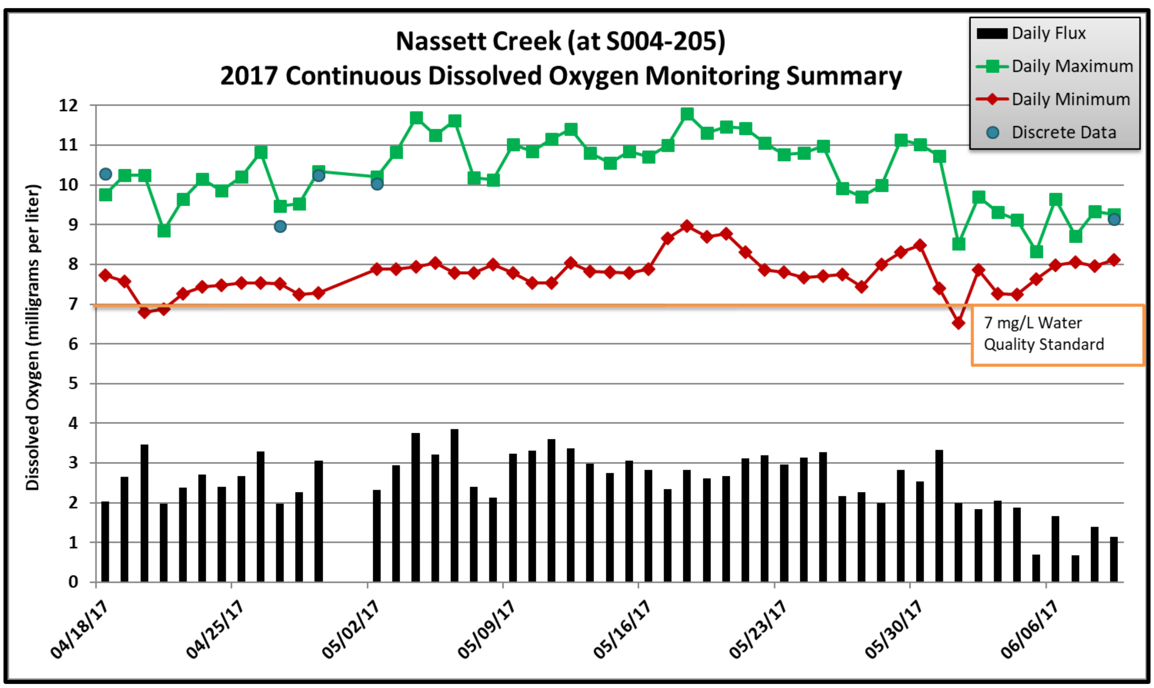


Figure 4-63. Continuous DO monitoring summary in Nassett Creek (AUID 545) (station S004-205), 2017

A look at the National Weather Service (NWS) 24-hour precipitation records on or shortly before the dates with low DO levels revealed that nine of those days were associated with runoff events. Two of the days with low DO had high turbidity and low transparency readings. Cattle and cattle tracks have been observed in the stream channel upstream of S004-205, which could explain low transparency readings that occurred without a runoff event. All Nassett Creek's low DO readings that were recorded in 2017 occurred during runoff events. The NWS 24-hour observed precipitation map for August 10, 2017, shows that the area south of Pine Lake received between 1 and 3 inches of rain. That rainfall event coincided with low DO readings that were recorded on August 9 and 10 in 2017. One of the sub-7 mg/L days was September 20, 2017, when there was a significant rainfall event (1 to 1.5" of rain, as estimated by the NWS). Comments recorded during site visits have noted the presence of beaver activity and beaver dams. On some of the days in which multiple sites were tested, DO levels were okay at S004-205, but low at S005-500. Station S005-500 has exhibited signs of stagnant conditions like "algae blooms" that have been observed at the site. Aerial photos show beaver dams upstream of S005-500 and LiDAR data shows that those dams were creating pools that would contain stagnant water with low DO. Extremely low DO conditions have been recorded upstream of beaver dams in the Pine Lake Watershed. Monitoring in nearby streams (Ruffy Brook at S004-057) has also shown that DO levels can recover downstream of those dams.

There was insufficient TP data to assess the reach for river eutrophication. The DO levels in the stream improved from upstream to downstream, which casted doubt on the possibility that pollutants in runoff were causing decreases in DO. The S004-205 station has recently been added to the RLWD long-term monitoring program, so assessments can be completed for more parameters in 2026. Biological sampling prior to the next assessment, would be helpful. It would be good to know how well the stream is supporting aquatic species other than trout. Existing temperature data suggests that stream is most often lower than 20° C, thought five discrete measurements between 20° C and 24° C were recorded during the 2006 through 2015 assessment period.

Stream banks and riparian cover seems to have been degraded by livestock activity along the channel. Even though there are no direct connections between pollutants and low DO readings in Nassett Creek, addressing the sources of the TSS impairment could also help with improving DO levels. The TSS impairment is addressed in Sections 4.1.2 and 5.1. Grazing management to minimize disturbance of the river by livestock should not only help minimize TSS concentrations but should also help improve riparian cover along the stream. The upper portion of the stream could be surveyed to identify any needs for channel restoration, grade stabilization, and habitat improvement.

4.5.7 09020305-550 Judicial Ditch 73

JD 73 was constructed in the 1920s. It later became part of the Poplar River Diversion drainage system that was designed to bring more water into Maple Lake. The ditch appears to be an artificial watercourse, as it does not appear to follow a natural drainage path and cuts across the natural topography in some areas. Some of the land that drains to the ditch may have historically drained north, rather than west to Maple Lake. Portions of the ditch channel are deep, with differences of 10 feet or more between the bottom of the channel and the top of the spoil pile (LiDAR cross sections). The ditch flows into the Tamarack Lake pool in Rydell NWR and then into Maple Lake. The primary monitoring site has been the final crossing of this reach, 0.2 miles upstream of Tamarack Lake (S003-318 at 343rd Street Southeast). Downstream (AUID 549) and upstream (AUIDs 542 and 543) AUIDs have also been monitored. Low DO levels have been found at the two stations upstream of Mitchell Lake. The channel between Tamarac Lake (within Rydell NWR) and Maple Lake (AUID 549) slightly exceeded the 10% impairment threshold in 2006 through 2015 data and then barely met the DO standard in 2007 through 2016 data.

Based largely upon data recorded at the S003-318 monitoring station, the reach is severely impaired. Continuous DO loggers were deployed at S003-318 throughout the summer of 2015. Overall, DO dropped below 5 mg/L in more than 71% of daily minimum values in a combined dataset of continuous and discrete data. In just the discrete data, more than 42% of days failed to meet the 5 mg/L standard. There was much less data at upstream sites, but low DO readings were less frequent in the upstream portions of this AUID.

Although much of the channel downstream of Mitchell Lake has a significant gradient, the gradient begins to flatten approximately one-half mile downstream of the 190th Avenue Southeast crossing and is very flat from 343rd Street (S003-318) to Maple Lake. Longitudinal DO measurements were recorded on July 29, 2016, and shown in Figure 4-64. The DO levels along the main channel of JD73 downstream of Mitchell Lake were okay until the 343rd Street Southeast crossing. A short distance (0.1 miles) upstream of the S003-318 monitoring station, the channel widens as it flows through a wetland. Although the wetland upstream of 343rd Street Southeast is likely consuming DO, the complete lack of buffer along a mile of channel downstream of 190th Avenue Southeast may be another factor that is limiting DO concentrations in JD73.

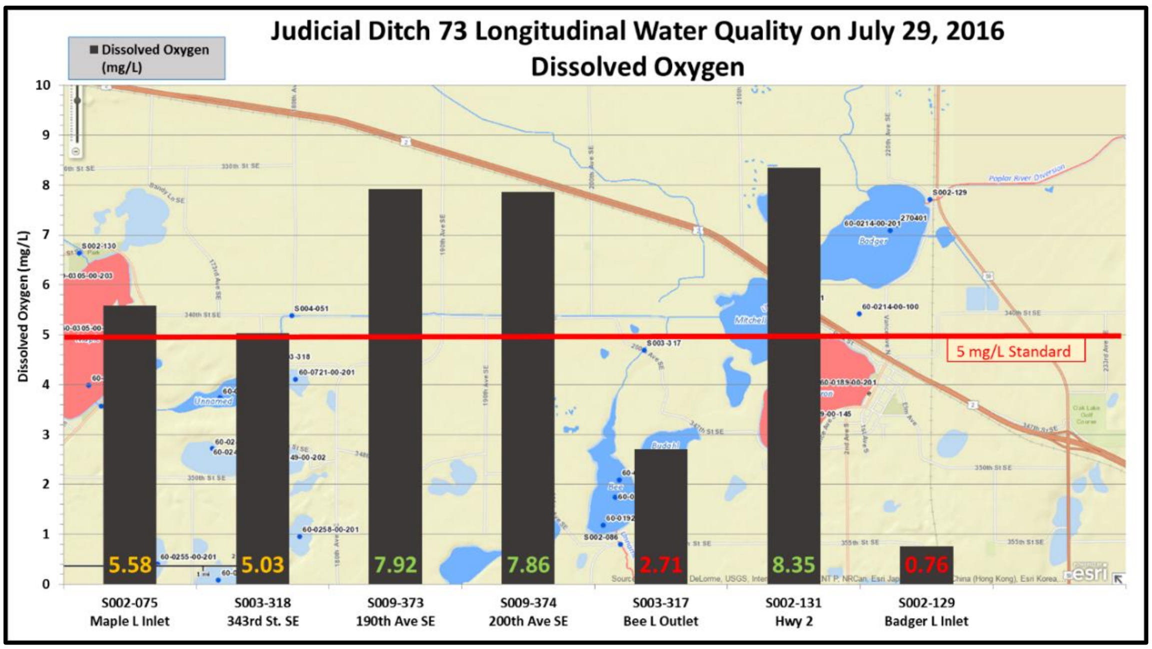


Figure 4-64. Longitudinal DO measurements along JD 73 (AUID 550) (stations S003-318 and S009-373), July 29, 2016

The low gradient and wetland-like conditions upstream of S003-318 (S003-318) were likely affecting DO levels more than any pollutant. There have been no exceedances of the 30 mg/L TSS standard at this site. The summer average TP concentration was 0.061 mg/L in 2007 through 2016 data. Low DO readings occur throughout the range of TP concentrations that have been recorded in the reach. Even restricting TP concentrations to 0.05 mg/L would not solve the DO problem because 63% of the daily minimum DO levels were <5 mg/L on days in which the average TP concentration was <0.05 mg/L.

Current data suggests that there was a site-specific DO problem at S003-318 that was caused by the wetland-like conditions at the site. Future DO logger deployments at upstream crossings is recommended to obtain a clearer understanding of the extent of the DO impairment along this reach. An improved buffer is needed (by law) along portions of the ditch. An improved buffer could improve shading of the stream.

4.5.8 09020305-645 Lost River

This reach of the Lost River begins at the outlet of Anderson Lake and ends at an unnamed creek/ditch near the CSAH 28 crossing of the Lost River, north of the village of Trail. Much of this reach was channelized. The reach was also impaired by poor F-IBI scores. The SID Report determined that F-IBI scores were significantly affected by low DO.

Deployments of DO loggers have been completed at three sites along this reach and the data revealed that the river was severely impaired throughout the AUID. Stagnant water was suspected to be a factor that was causing frequently low DO near the CSAH 28 crossing (Figure 4-65). However, DO levels were also low upstream at CSAH 2 (Figure 4-66) and CSAH 7 where the water was more freely flowing. Longitudinal DO measurements were recorded along the Lost River between Anderson Lake and the Clearwater River (Figure 4-67). The DO levels at the outlet of Anderson Lake were low, but they improved throughout the AUID until they fell below the 5 mg/L DO standard at the CSAH 28 crossing. The CSAH 2 crossing of the Lost River (S014-942) exhibited extremely high DO flux. DO concentrations in the two 2017 DO logger deployments ranged from 1.45 mg/L to 16.42 mg/L. The frequency of low DO readings was similar during the DO logger deployments at CSAH 28 in 2015 (S007-849, 54.0%), CSAH 2 in 2017 (S014-942, 55.8%), and CSAH 7 in 2018 (S004-500, 71% in raw DO logger data). High levels of DO flux were recorded at all three stations: 4.67 mg/L at S007-849, 7.31 mg/L at S014-942, and 5.11 mg/L at S004-500.

Water chemistry data was examined to see if excess pollutants could be affecting DO. The summer average TP concentration for this reach (0.07 mg/L) met the Central River Nutrient Region Standard of 1.0 mg/L. Only 20 TSS samples were collected along this reach in 2007-2016 data, but the maximum concentration was 13 mg/L, which met the assigned Central River Nutrient Region standard of 30 mg/L. This reach also meets *E. coli* standards. Additional monitoring is recommended to verify possible causes of the high levels of DO flux. Visible signs of eutrophication like dense growth of filamentous algae have been noted. However, filamentous algae were also noted along portions of the Lost River that met DO and IBI standards. Current water chemistry data did not show any evidence of chronic, excess pollutants along this reach.

The DO levels in streams can sometimes be connected to a lack of flow. Simultaneously collected DO and flow data were assessed to determine if low flows were negatively affecting DO. Average daily flow dropped to zero in approximately 5% of the 647 days in which flow has been measured. There was a threshold of flow (approximately 32 cfs) above which the river met the DO standard, but that level was close to the 70th percentile of flows that were recorded in this reach of the river. Because low DO levels weren't limited to stagnant conditions, low flow did not appear to be the primary cause of low DO problems in this reach of the Lost River. The amount of groundwater discharge is unknown, but it could be investigated. Groundwater inflow would likely have a low DO concentration.

Physical features along this reach most likely cause of the low DO problems. Areas of stagnant water can depress DO levels. This reach begins with discharge from a shallow lake (Anderson Lake) that is more like a large wetland. Very low DO concentrations have been observed at the outlet of the lake. Algae in the lake could be contributing to DO flux within the lake and the Lost River downstream. Much of the reach is freely flowing, but beaver dams are a common occurrence. Riparian cover along much of the reach is poor. Projects should be implemented to improve riparian cover and restore a pool/riffle pattern along the channelized potions of this river. Mechanical aeration over a rock riffle grade stabilization structure could help improve DO.

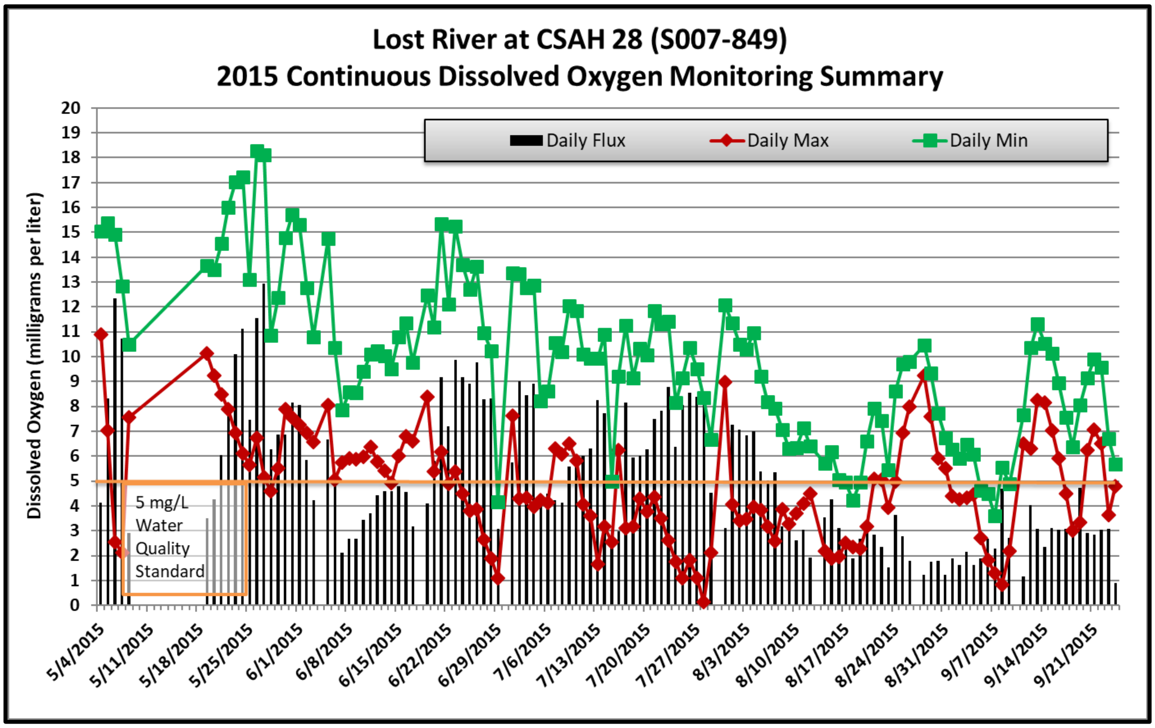


Figure 4-65. Continuous DO measurement summary on the Lost River (AUID 645) (station S007-849), 2015

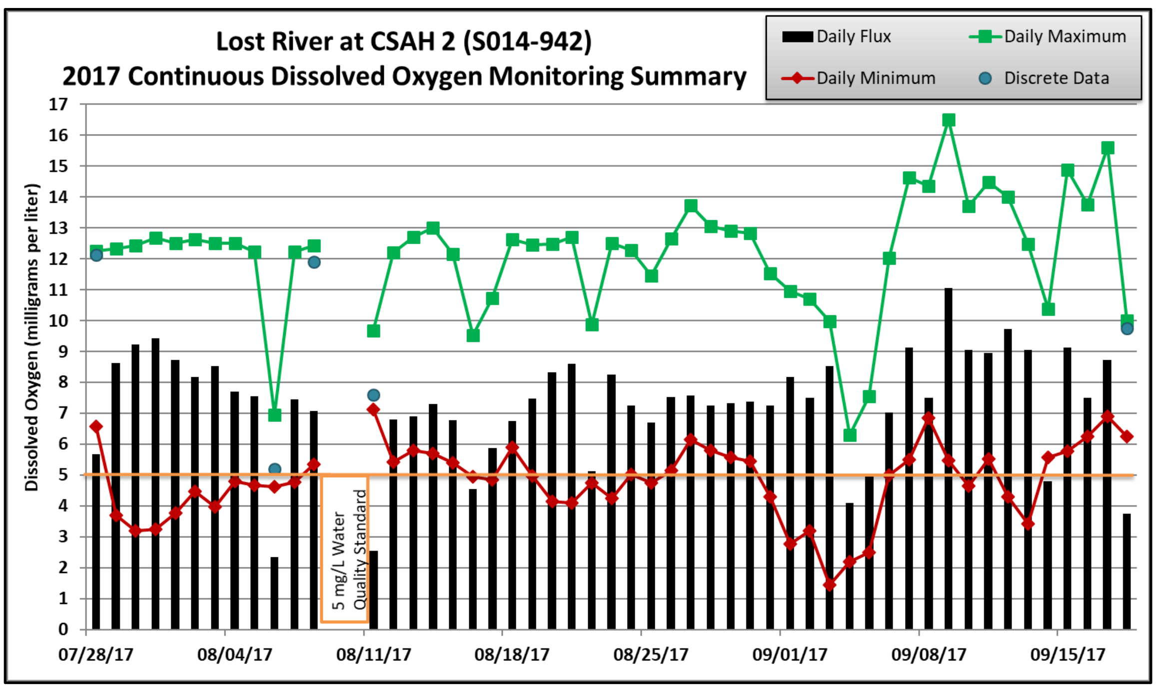


Figure 4-66. Continuous DO measurement summary on the Lost River (AUID 645) (station S014-942), 2017

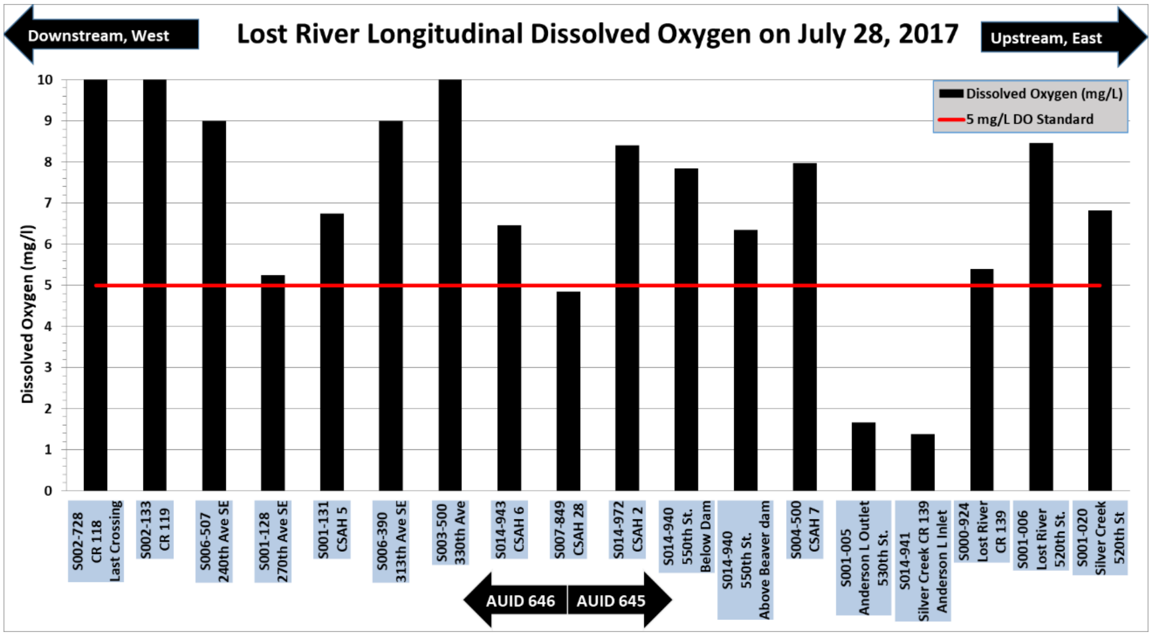


Figure 4-67. Longitudinal DO measurements along the Lost River (AUIDs 645 and 646) between Anderson Lake and the Clearwater River, July 28, 2017

4.5.9 09020305-656 Hill River

Monitoring of the Hill River upstream of Hill River Lake, at 335th Avenue, began in 2014 during the Clearwater River SWAG project. Discrete measurements of DO raised concern about a potential problem with low DO in this reach. Though the exceedance rate for discrete data was below the 10% impairment threshold in 2006 through 2015 data, DO logger deployments in 2015 (Figure 4-68) confirmed that DO does drop below 5 mg/L frequently enough to trigger an impairment (29.3% of days in the DO logger record dropped below 5 mg/L). DO levels dropped below 5 mg/L on 11.4% of the days that the stream was monitored in 2007 through 2016 discrete data. Investigative monitoring has revealed that conditions in an upstream reach (AUID 655) of the Hill River limit the DO levels within this reach. In longitudinal measurements, DO levels improved along AUID 656 (upstream to downstream). However, the recovery was insufficient to offset the impact of on-channel wetlands, human-made dams, livestock, and inadequate buffers found in AUID 655. The upstream AUID 655 was not assessed in 2016 due to a lack of data, but subsequent monitoring has revealed that it will be necessary to examine that portion of the river in order to understand the causes of the low DO impairment of AUID 656.

Two rounds of longitudinal DO measurements were collected along the Hill River in 2017 (Figures 4-69 and 4-70) and they revealed very similar patterns in DO levels upstream of Hill River Lake. There were portions of the reach in which DO levels decreased and portions in which DO levels recovered. There were consistently very low DO levels in two areas along the Hill River near the Village of Olga (the upstream end of AUID 656 and downstream of AUID 655). The furthest upstream area is along AUID 655 between the CSAH 29 and 355th Street Southeast crossings downstream of Cross Lake. DO levels recovered at the next crossing, 350th Street Southeast, but decreased again between that crossing and 380th Avenue Southeast. It is unclear what is causing the DO levels to drop in those areas.

Aerial photos revealed multiple factors that could have been negatively affecting DO levels in the Hill River:

- Channelization
- Poor quality buffer
- The channel flows through wetlands and the channel disappears as it flows through one wetland.
- Degraded channel due to livestock access to the stream.
- Private crossings/dams that impede flow and fish passage
- Feedlots that are close to the river
- Beaver dams

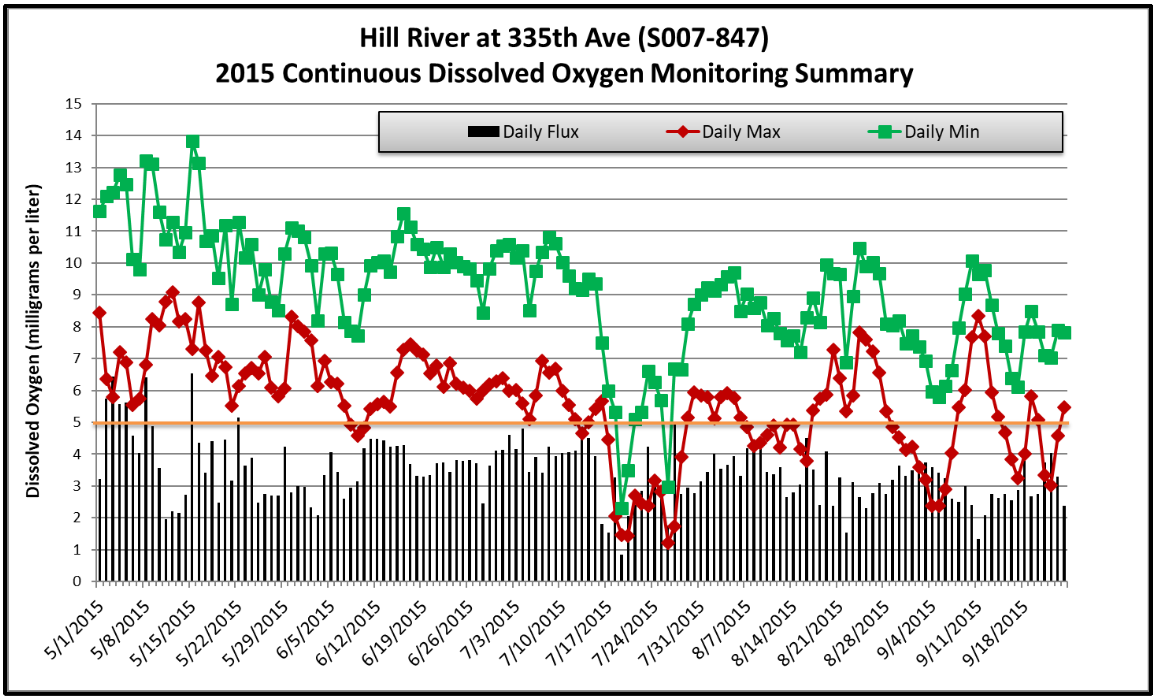


Figure 4-68. Continuous DO measurement summary on the Hill River (AUID 656) (station S007-847), 2015

Both sets of longitudinal measurements showed a decrease in DO levels between CSAH 29 and CSAH 3. Portions of the Hill River have been channelized between Cross Lake and Hill River Lake, mostly upstream of the Village of Olga. Immediately downstream of Cross Lake and CSAH 29, approximately 0.5 miles the Hill River have been channelized to create County Ditch 68 (CD 68). Channelized streams generally lack the pool/riffle pattern that allows for re-oxygenation of water. Some meanders remained downstream of the channelized portion. The CD 68 channel appears to have been dug through a wetland (Figure 4-71), an act that would not currently be allowed today under the Wetland Conservation Act (WCA) unless replaced by restoring or creating wetland areas of at least equal public value under an approved replacement plan.

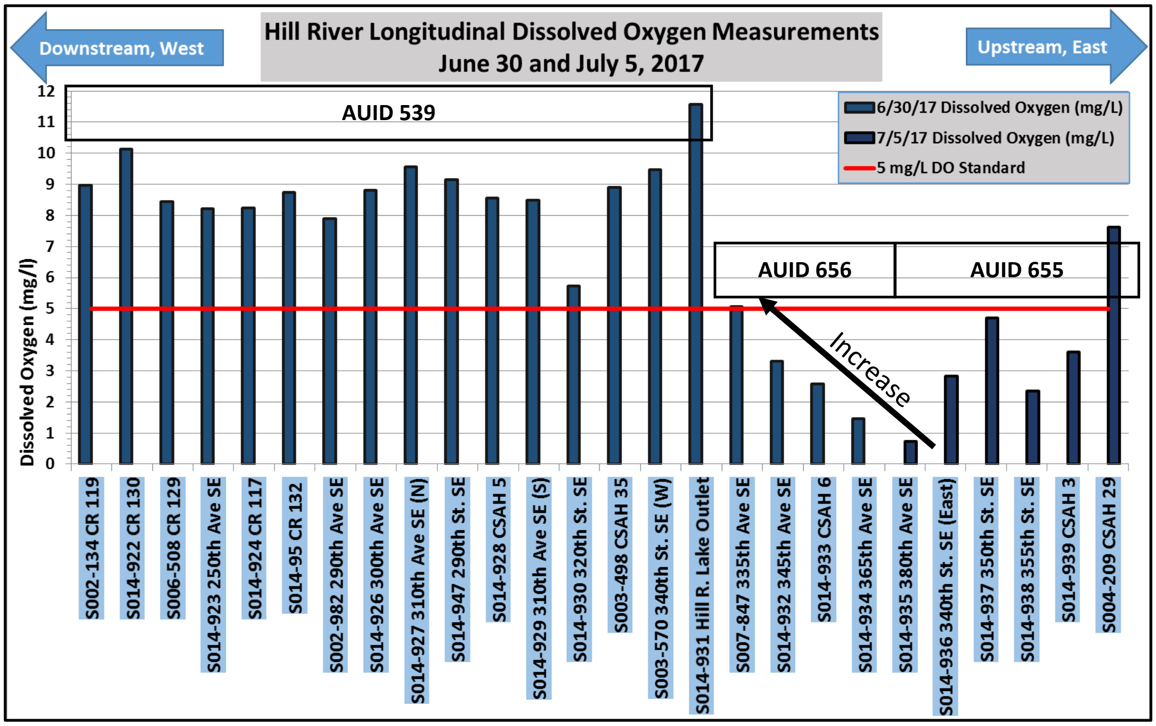


Figure 4-69. Longitudinal DO measurements along the entire Hill River (AUIDS 539, 656 and 655), June 30 and July 5, 2017

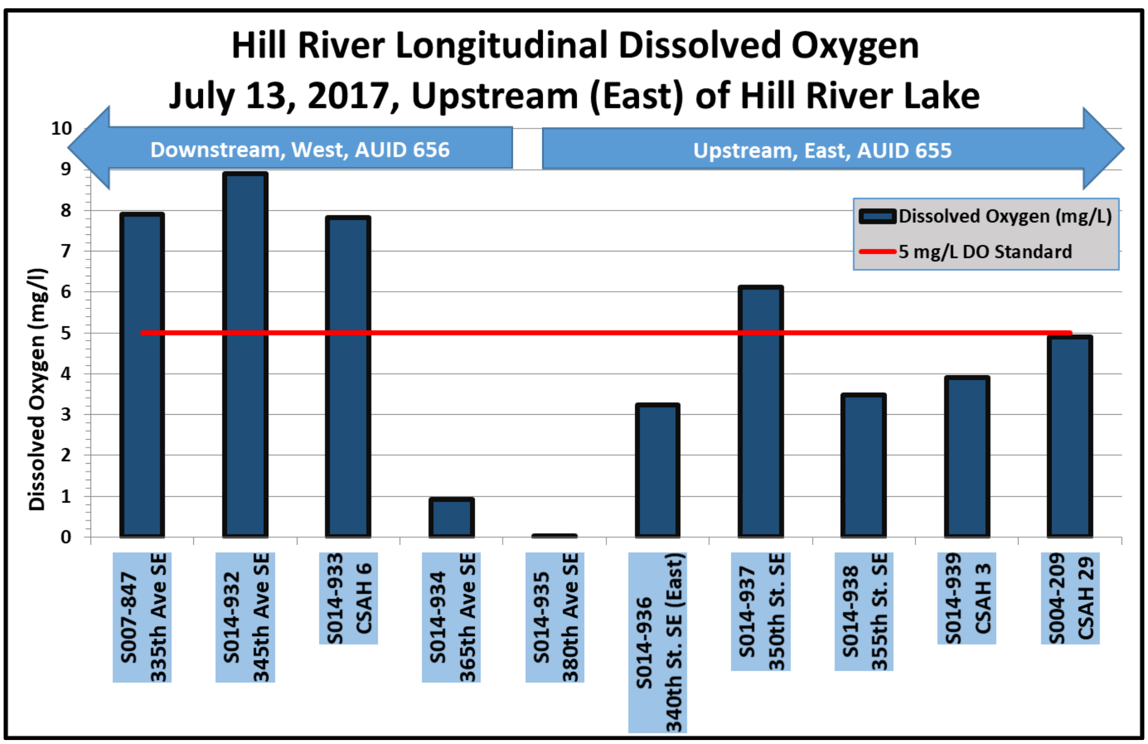


Figure 4-70. Longitudinal DO measurements along the Hill River (AUIDs 655 and 656) upstream of Hill River Lake, July 13, 2017

Much of the CD 68 channelized portion of the Hill River also appears to be pastured, with very little woody riparian vegetation to provide shade. Other ditches and channels flowing through wetlands in this watershed have experienced low DO problems. The final 0.15 miles of the CD 68 channelized portion of the Hill River looks like it was dug to drain a seven-acre wetland. An on-channel restoration; however, may encounter permitting difficulties and may not help aquatic life due to stagnant water and fish passage barriers that might result from the obstruction of flow. The effect on drainage for upstream landowners and current drainage benefits of CD 68 would need to be considered during a discussion of on-channel restoration. Based on the topography and aerial imagery (no ground-truthing), there appears to be an outline of a 3.5-acre basin that could be targeted for an off-channel restoration (Figure 4-71). The possibility of a stream restoration project with the construction of meanders could also be explored (Figure 4-72).

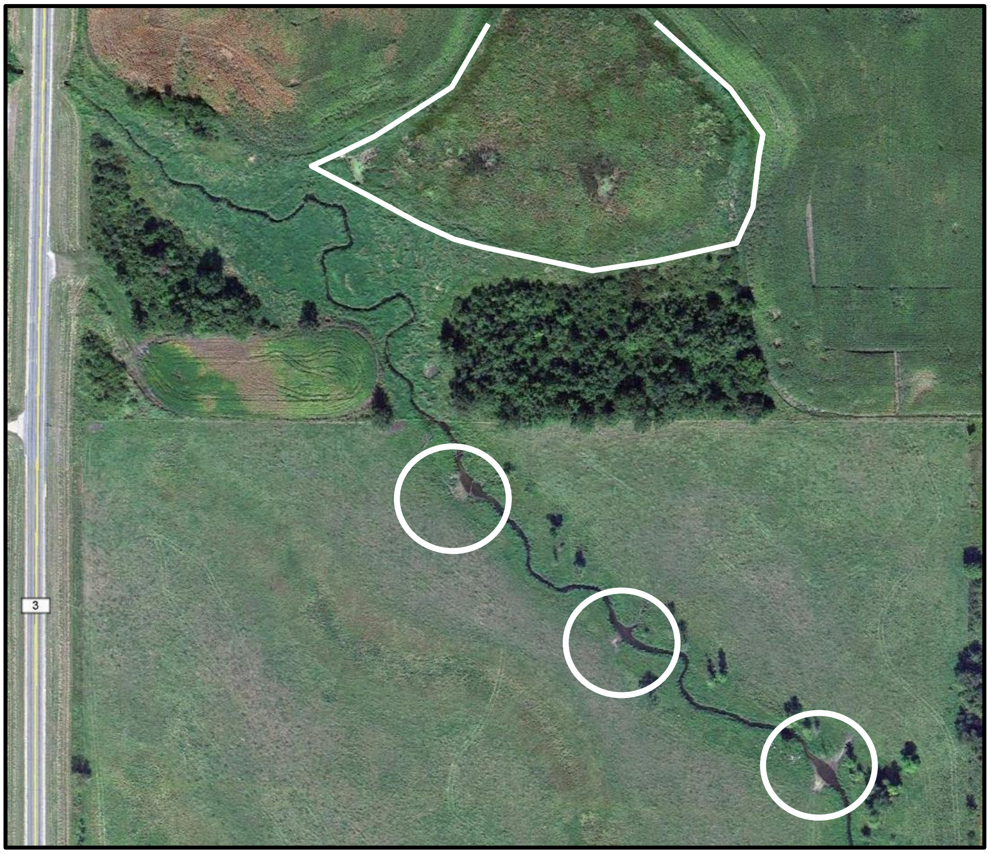


Figure 4-71. Potential wetland restoration area and cattle crossings along the Hill River (AUID 655) upstream of CSAH 3.

Between CSAH 3 (S014-939) and 355th Street Southeast (S014-938), DO levels decreased in both sets of longitudinal measurements. The Hill River flows through a wetland downstream of CSAH 3. Flow from the channel is dispersed through the wetland where the processes of reduction, oxidation, and decomposition can consume DO. Aerial photos showed evidence of a beaver dam. Much of this portion of the river was well buffered, but there was a 375-foot (approximate) portion of this reach that appeared to be lacking a minimum buffer.

Both sets of longitudinal measurements showed an increase in DO levels between 355th Street Southeast and 350th Street Southeast. Although the channel has been affected by cattle access, it is a free-flowing, defined channel that allows for re-oxygenation.

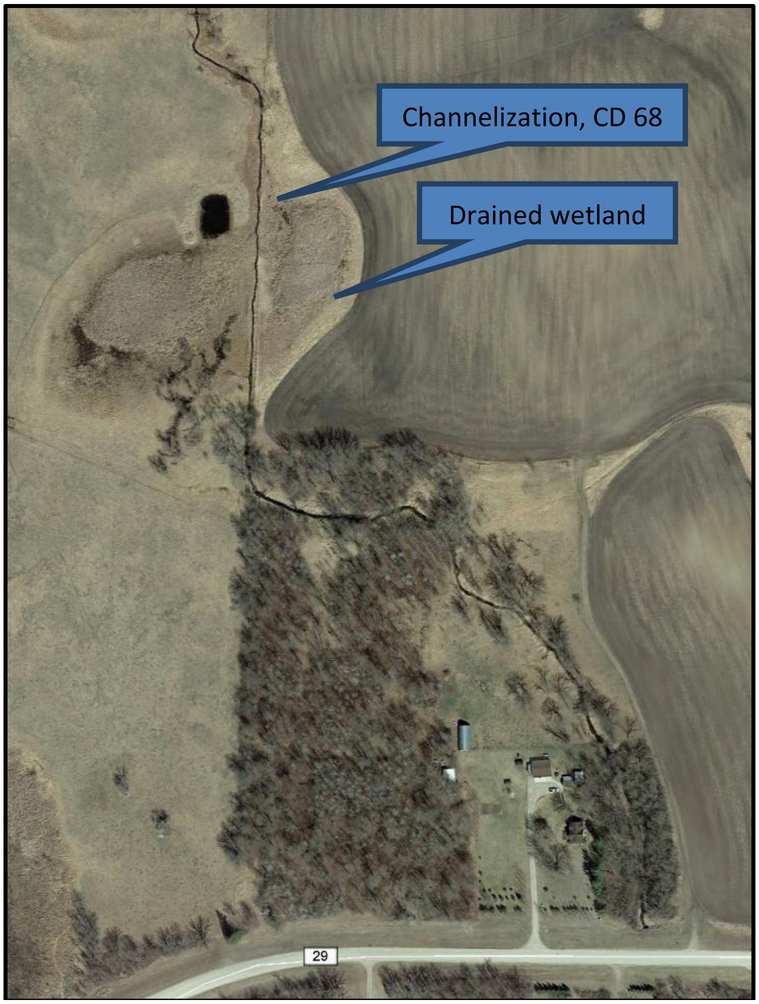


Figure 4-72. Portion of CD 68 (AUID 655), between CSAH 29 and CSAH 3, which was dug through the middle of a wetland

A livestock operation downstream of 350th Street Southeast may be negatively affecting DO and fish passage. DO decreased between 350th Street Southeast and 340th Street Southeast. The Hill River channel also flows and spreads through on-channel wetlands between these two crossings. Man-made earthen dams are blocking flow, possibly blocking fish passage, and creating stagnant conditions along the Hill River. East Polk SWCD staff found that the dams were constructed without a permit and sent a letter to the landowner requesting cooperation for corrective actions.

A portion of the Hill River was channelized between 340th Street Southeast and 380th Avenue Southeast as part of Polk County Ditch 81 (CD 81). The DO levels decreased dramatically along that reach. Aerial photos indicated that water in the channel was stagnant, particularly near the 380th Avenue crossing (Figure 4-73). The apparent stagnation ended near the downstream end of the channelized, CD 81 portion of the Hill River where there was a significant change in gradient. The stagnation and possible eutrophication reappeared downstream in the NW ¼ of Section 32 and the NE ¼ of Section 31 of Eden Township in Polk County. The stagnant conditions could be exacerbated by beaver activity downstream (west) of 380th Avenue Southeast. Runoff from a livestock operation could be causing eutrophication in the Hill River and an adjacent wetland.

Figure 4-73. Stagnant water along the Hill River (AUIDS 655 and 656) and a drained wetland upstream of 380th Avenue SE

Aerial photos showed that cattle access to the Hill River channel has removed vegetation from stream banks and caused localized streambank instability/erosion. Limiting cattle access to the river and improving the quality of vegetation (more native and woody vegetation) would provide greater streambank stability, increase shading of the channel, and reduce nutrient inputs. Four cattle crossings along the Hill River could be seen in Section 16 of Queen Township of Polk County. At least five crossings along the Hill River could be seen in the NE ¼ of Section 8 in Queen Township of Polk County. There also appeared to be a feedlot encroaching upon the riparian corridor of the stream. At least six crossings along the Hill River could be seen in the SE ¼ of Section 5, Queen Township in Polk County.

In the longitudinal DO measurements, DO levels increased from upstream to downstream along AUID 09020305-656. However, continuous DO from 335th Avenue Southeast (S007-847) shows that reach is not meeting the DO standard. The channel appears to be freely flowing and meandering throughout the reach. There are pools and riffles. In review of aerial photos, there appears to be room for improvement in both the width and quality of the buffers along this reach of the Hill River. Woody vegetation (for shading) was sparse along portions of this reach. Improved buffers could help improve DO levels (shading, prevention of channel widening). Most importantly, however, the human-made factors affecting DO in the upstream AUID 655 need to be addressed to improve the odds of this reach meeting the DO standard. Flow does not appear to be a factor for DO concentrations in this reach of the Hill River because low DO levels have been recorded throughout the range of flows that have been observed at S007-847. It is possible that some water levels and resulting flow calculations were artificially inflated due to downstream beaver activity that could have increased stage without increasing flow. Additional data collection is recommended.

The summer average TP concentration for 09020305-656 was 0.145 mg/L in 2014-2017 data, which exceeded the 0.100 mg/L river eutrophication standard for the Central Nutrient Region. The summer average OP concentration of 0.107 mg/L; however, was high enough to comprise 74% of the average TP concentration and exceeded the 0.100 mg/L river eutrophication standard for TP. Based on that information, it was reasonable to assume that most of the phosphorus in the Hill River was being released from sediment during stagnant, anaerobic conditions upstream of this reach. The summer average DO flux met the Central Nutrient Region standard of 3.5 mg/L at 3.33 mg/L. The DO flux level was still a cause for concern due to the rate at which the 3.5 mg/L standard was exceeded during the summer months (>43%).

Many wetlands in the Hill River corridor, some of them very large, have been drained with ditches. This practice has helped facilitate agricultural production in this area, but likely had a negative effect on storage capacity, infiltration, and base flow. Sampling in other parts of this and nearby watersheds has found that ditch channels that have been dredged within wetlands can also negatively influence downstream water quality by flushing organic material from those wetlands during runoff events. That organic material could increase oxygen demand/depletion in downstream waters.

4.6 Lake Nutrient Sources

4.6.1 Permitted nutrient sources

Wastewater Treatment

There are no current WWTFs within the drainage areas of Long Lake, Stony Lake, or Cameron Lake. Historical wastewater and stormwater from the city of Erskine; however, has contributed to the nutrients that cause eutrophication within Cameron Lake when they are re-suspended by wave action. The Erskine WWTF is now located outside of the drainage area of Cameron Lake and manages its treated effluent with rapid infiltration basins rather than discharging it to a surface water.

Municipal Separate Storm Sewer Systems

The population of Erskine was 484 in 2017, which is far below the population thresholds for MS4 designation.

Construction and Industrial Stormwater

Construction and industrial stormwater is not considered a significant source of the TP in any of the impaired lakes, but is incorporated into the TMDLs. According to publicly available information, the annual percentage of land area under construction has ranged from 0.004% in Beltrami County to 0.022% in Polk County. The percentage of the LA used for industrial stormwater was considered to be identical to the construction stormwater percentage. Industrial and construction stormwater was combined into one WLA.

4.6.2 Non-permitted nutrient sources

Cameron Lake (60-0189-00)

Water quality in Cameron Lake was heavily influenced by internal nutrient loading from nutrient rich sediments. Past sources of excess nutrients in the lake sediment included historical sewage and historical creamery wastewater that was discharged into the lake. Currently, stormwater from the city of Erskine (Figure 4-74) and minor shoreland erosion (Figure 4-75) are the primary, identifiable, anthropogenic, external sources of pollution entering the lake.

Minor natural contributions from waterfowl and atmospheric depositions also contributed to the nutrient concentrations in the lake. The continued influx of nutrients from stormwater runoff and erosion has been a problem because the lake has minimal outflow relative to the inflow. There is only minimal flushing of nutrients out of the lake. Flow into the lake is limited by the direct drainage area of the lake and flow through the outlet is minimal. Much of the developed lakeshore is lined with rock for toe-protection of the sloping shoreline. However, many residences have cleared away natural vegetation and have closely cropped lawns up to the edge of the shore. Loose rock has been used for landscaping in some locations and it will likely be washed into the lake. New construction has been completed very close to the lakeshore. Emergent vegetation has been removed along the shoreline, by spraying in some places, which could have increased the probability of shoreland erosion.

Figure 4-74. Sediment from Erskine stormwater runoff, near the Cameron Lake (60-0189-00) public access

Figure 4-75. Erosion along the shore of Cameron Lake (60-0189-00)

Stony Lake (15-0156-00)

Historical runoff from a livestock operation and ongoing runoff from cultivated fields were the most likely sources of the excess nutrients in Stony Lake. Aerial photos as recent as 2013 showed that cattle had access to the south side of the lake and grazed the land intensely enough to remove vegetation (Figure 4-76). The landowner has created a good buffer between the livestock and the lake in more recent years. Lakeshore landowners have noted that runoff from a nearby field might have been contributing to water quality problems in the lake. A ditch/swale intermittently has carried runoff and pollutants to the lake from a cultivated field on the east side of Stony Lake Road. A lakeshore landowner recalled a runoff event from a past torrential rain event that may have carried freshly sprayed chemicals from a field into the lake and killed vegetation within the lake. Every fall, thousands of geese find refuge on the lake, staging for migration.

The lake is shallow and internal loading of nutrients is likely with the long history of agricultural runoff. The lake does not have an outlet, which means that there is no flushing of nutrients from the lake. Nutrients will remain in the lake and its sediment. The lake is shallow, so the lake sediment and the nutrients contained in that sediment would be mixed into the water column through wave action.

Figure 4-76. South shore of Stony Lake (15-0156-00) with cattle near the shore in 2011 (top) and well buffered in more recent years (bottom)

Long Lake (04-0295-00)

The sources of pollutants were identifiable in Cameron Lake and Stony Lake, but current sources were harder to identify in the Long Lake Subwatershed. A recent examination of the lake concluded that the primary source(s) of excess nutrients are either natural or no longer contributing. There is very little development around the lake and recreational use of the lake is infrequent. There are five residences near the lake that could have contributed nutrients if any one of them had a failing septic system. Beltrami County has SSTS records for parcels around the lake but noted that "having a permitted SSTS does not necessarily mean that it is compliant with state code and county ordinance." There was one residence with a barn within 100 feet of the lake that could have historically affected the lake if there was runoff from a livestock operation. Historically, there were dairies near the lake. Those dairies have gone out of business and the cattle are gone. There is one feedlot within the drainage area of the lake, but drainage from that feedlot would need to flow through more than one mile of wetlands (no defined channel) prior to entering the lake. Reconnaissance of the lake found that the lakeshore is almost completely vegetated, except for a recently cleared path to a dock on the eastern shore of the lake, and some small areas of bare soil that were remnants of the livestock pasture along the lake. There was very little erosion of shoreline occurring around the lake. There could have been some internal loading from wave action in shallow, mucky areas of the lake where there can be up to two to three feet of soft, flocculated, mucky organic sediment. The BATHTUB model for Long Lake estimated that 35% of the TP load came from internal loading.

Figure 4-77. Floating clump of unidentified algae/bacteria/nostoc in Long Lake (04-0295-00)

Chunks of floating bacterial/algal clumps (Figure 4-77) were noted while sampling in the southwestern portion of the lake (near where the cattle operation was once located). There was some evidence of historical shoreline disturbance from cattle, but those areas were healing (revegetating). Additional monitoring, with landowner permission, is recommended to see if conditions in the lake improve with additional years without the presence of cattle. Samples collected during 2018 exploration of the lake met standards. Laboratory identification of the algae/bacteria in the floating clumps may also be helpful.

5 TMDL Development

5.1 Total Suspended Solids

There are four AUIDs along the Clearwater River and one AUID along Nassett Creek that are impaired by excess TSS and require TMDLs. This section describes the methods that were used to calculate the TMDLs, summarizes the TMDLs, and estimates load reductions that will be needed to meet standards.

5.1.1 Loading Capacity

The EPA defines LC as "the greatest amount of loading that a water can receive without violating water quality standards." The LC provides a reference which helps guide pollutant reduction efforts needed to bring a water into compliance with the standards. The Load Duration Curve (LDC) method is based on an analysis that encompasses the cumulative frequency of historic flow data over a specified period. Because this method uses a long-term record of daily flow volumes, virtually the full spectrum of allowable loading capacities is represented by the resulting curve. In the TMDL summary tables of this report (Tables 5-3 through 5-11), 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 EPA.

Average daily flow records were compiled for these sites. The low records consisted of long-term USGS data at some of the sites. Locally collected flow data and data recorded by the MPCA/DNR Cooperative Gauging Network provided measured flow records for some sites. Simulated flow records from the HSPF model were used for sites without automated gauges. Daily average flow records from each individual station were ranked from highest to lowest. Then that ranking was used to assign a sequential value to each average daily flow data point. The probability of exceedance of each average daily flow value was calculated as a percentage. This created the information needed to create a flow duration curve by plotting probability of exceedance (X-axis) against the flow level (logarithmic Y-axis). Using the allowable concentration of 30 mg/l or 65 mg/l and conversion factors, the LDCs in Figures 5-2 through 5-6 (daily loads on the Y-axis) were developed to show the allowable tons per day of TSS for each level of flow along the curve (EPA 2007). The LDC data was used to determine the median LC for each flow regime.

One site was chosen for each impaired reach as the TMDL establishment site. The TMDL establishment sites were chosen based on the following considerations:

- In some cases, there is only one accessible crossing at which samples and flow data have been collected;
- Preference was given to stations with a significant record of sampling data that are nearest the downstream end of an AUID;
- Preference was given to stations with a measured flow record;
- Preference was given to long-term monitoring stations that will continue to be monitored into the future. Using long-term monitoring stations is important for tracking changes in water quality over time (identifying trends) and likely provides data that better represents the range of conditions found in the water body;
- If no sites had a clear data collection advantage, the furthest downstream crossing along an AUID was chosen.

LDC and TMDL calculations were completed for the TMDL establishment sites chosen (Figure 5-1). One site was chosen for each AUID that was impaired by TSS. The following sites were used to calculate TMDLs for each of the TSS-impaired reaches.

1. AUID 09020305-501: S002-118, Clearwater River at Bottineau Avenue Northwest in Red Lake Falls
2. AUID 09020305-511: S002-914, Clearwater River at CSAH 12 near Terrebonne
3. AUID 09020305-648: S002-124, Clearwater River at Minnesota Street North near Plummer
4. AUID 09020305-647: S002-916, Clearwater River at CSAH 127 (280th Avenue Southeast)

5. AUID 09020305-545: S004-205, Nassett Creek at Nessett Creek Drive

Average daily flow records were compiled for those sites. Long-term flow records from USGS gauges were available for two of the stations (USGS gauge 05078500 in Red Lake Falls for AUID 501 and USGS Gauge 05078000 near Plummer for AUID 648). The average daily flow record for S002-914 on AUID 511 was a compilation of simulated 1996 through 2016 flow data from an HSPF model and discrete flow measurements. Some of the discrete values were directly measured and some were estimated from a flow rating curve. The rating curve was created using paired stage and flow measurements that were collected for the RLWD stream gauging program. The flow record for Station S002-916 on AUID 647 was a compilation of 1996 through 2016 simulated flows from the HSPF model and recent flow values from discrete stage and flow measurements. A flow rating curve was developed for S002-916 during the Clearwater WRAPS process. Though some flow measurements have been completed in Nassett Creek, the rating curve for S004-205 was incomplete and the entire flow record for the TMDL at S004-205 on AUID 545 was compiled from the 1996 through 2016 daily flows that were simulated by the most recent HSPF model.

For each site, average daily flow values for each individual site were ranked from highest to lowest. Then, that ranking was used to assign a sequential value to each average daily flow data point. The probability of exceedance of each average daily flow value was calculated as a percentage. This process calculated the values that were needed to create a flow duration curve by plotting probability of exceedance (X-axis) against the flow level (logarithmic Y-axis). Using the allowable concentration of 30 mg/l or 10 mg/l and conversion factors, the LDCs in Figures 5-2 through 5-6 (daily loads on the Y-axis) were developed to show the allowable tons per day of sediment for each level of flow along the curve. The median LC for each flow regime was based on statistics from the LDC data (5^{th}, 25^{th}, 50^{th}, 75^{th}, and 95^{th} percentiles).

Sampling events that coincided with daily flow values were plotted on the LDCs. The LDCs demonstrated that exceedances of the TSS standard were highly correlated with high flow levels. Concentrations of TSS were low during low flows and exceeded the standard during high and very high flows. Two stations were part of the MPCA's WPLMN, were co-located with USGS gauges, were intensively sampled to calculate loads, and were modeled with FLUX32 software.

FLUX32 is a Windows-based interactive software developed by the USACE, in conjunction with the MPCA. FLUX32 is based on the original FLUX application written by William Walker, Ph.D., under sponsorship of USACE in the 1980s as a DOS-based program for personal computers. FLUX32 is user-friendly and capable of sophisticated examinations and evaluations of data and flow relations and calculation of material fluxes (loads) in streams. The WPLMN data assist in watershed modeling, determining pollutant source contributions, developing reports, and measuring water quality restoration efforts. The MPCA WPLMN staff used Flux32 to generate a record of daily values that were a mix of observed and modeled values. That robust combination of observed and modeled data was used to display and calculated current conditions in the Clearwater River. More information about the WPLMN and the data generated by the program is available at: https://www.pca.state.mn.us/water/watershed-pollutant-load-monitoring.

The two stations modeled with FLUX32 were the Clearwater River in Red Lake Falls (S002-118) and the Clearwater River near Plummer (S002-124). The modeled daily values from the WPLMN were limited to the years in which the stations have been sampled for the program (2008-2016 at S002-118 and 2014 through 2016 at S002-124). Measured data was added to each station's dataset to display and analyze data from a 10-year period. The modeled TSS values and measured TSS values formed similar, overlapping pattern at both sites. However, the addition of modeled data did lower the average observed concentrations for each flow regime that were used to estimate current loads at S002-118 and S002-124.

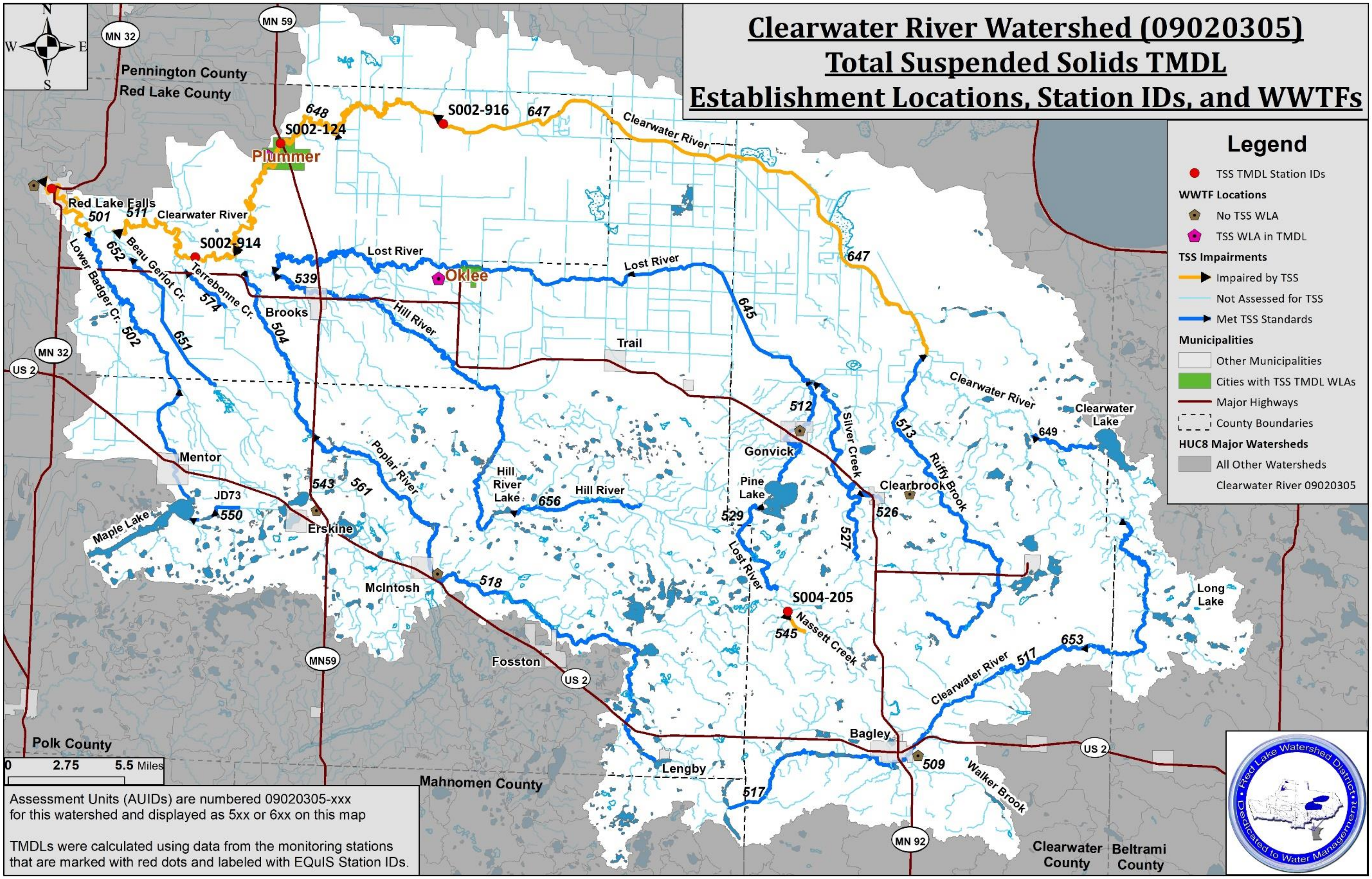


Figure 5-1. Locations of TSS TMDL establishment stations in the Clearwater River Watershed

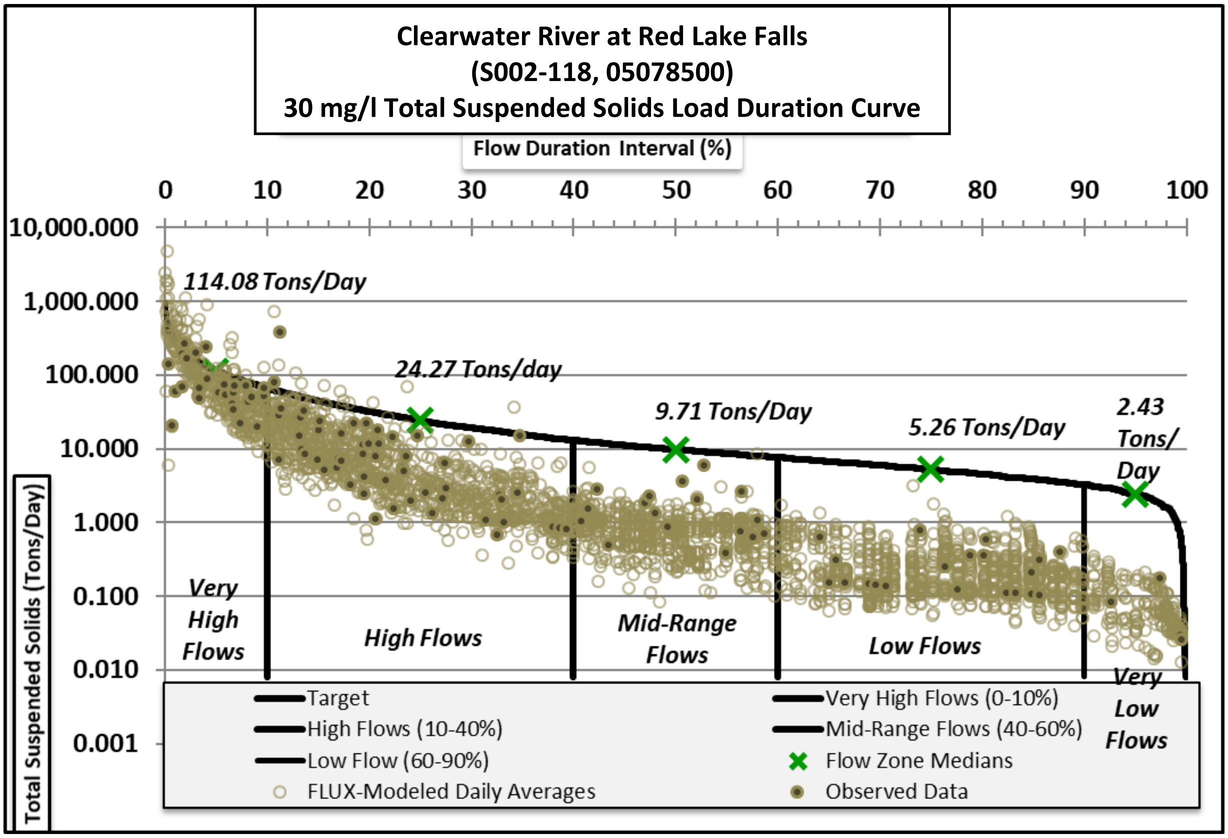


Figure 5-2. Load duration curve and median daily loads for the Clearwater River (AUID 501) at Bottineau Avenue Northwest in Red Lake Falls (station S002-118)

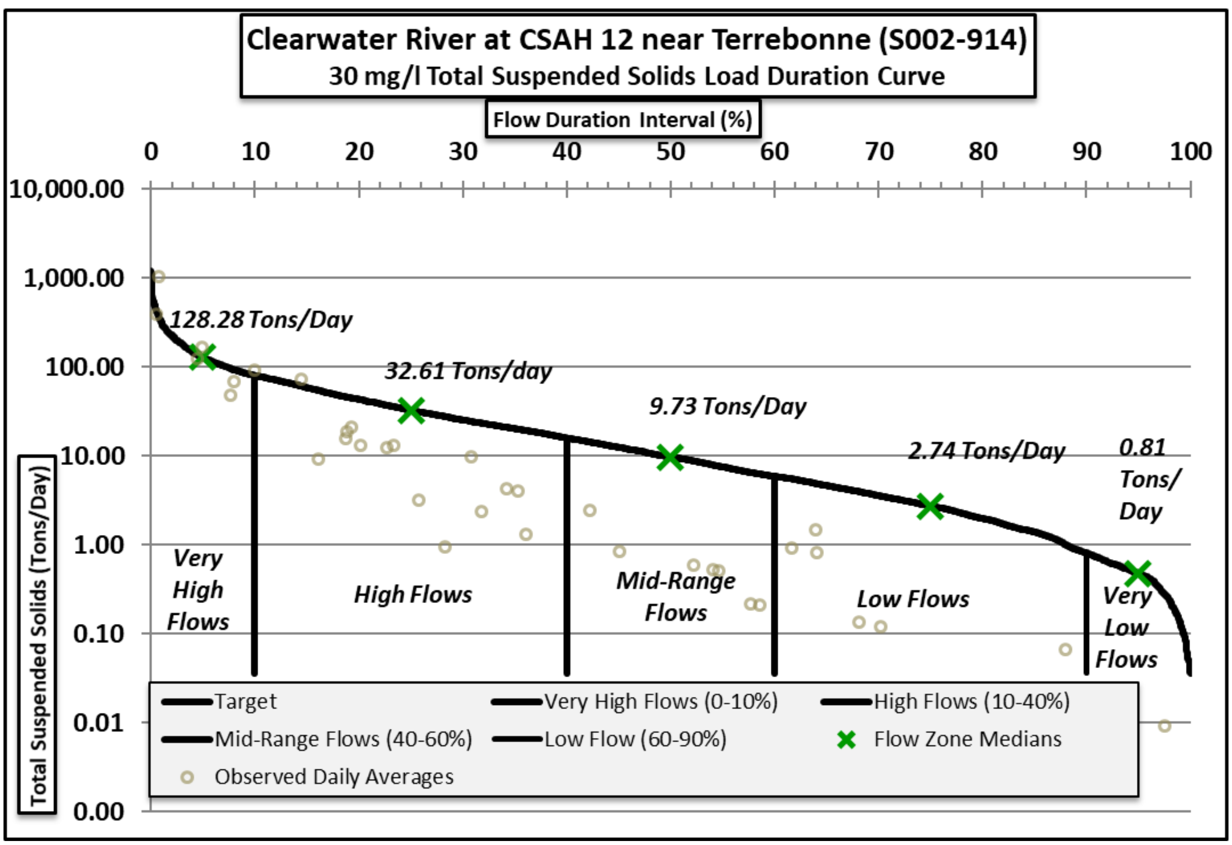


Figure 5-3. Load duration curve and median daily loads for the Clearwater River (AUID 511) at CSAH 12 (station S002-914)

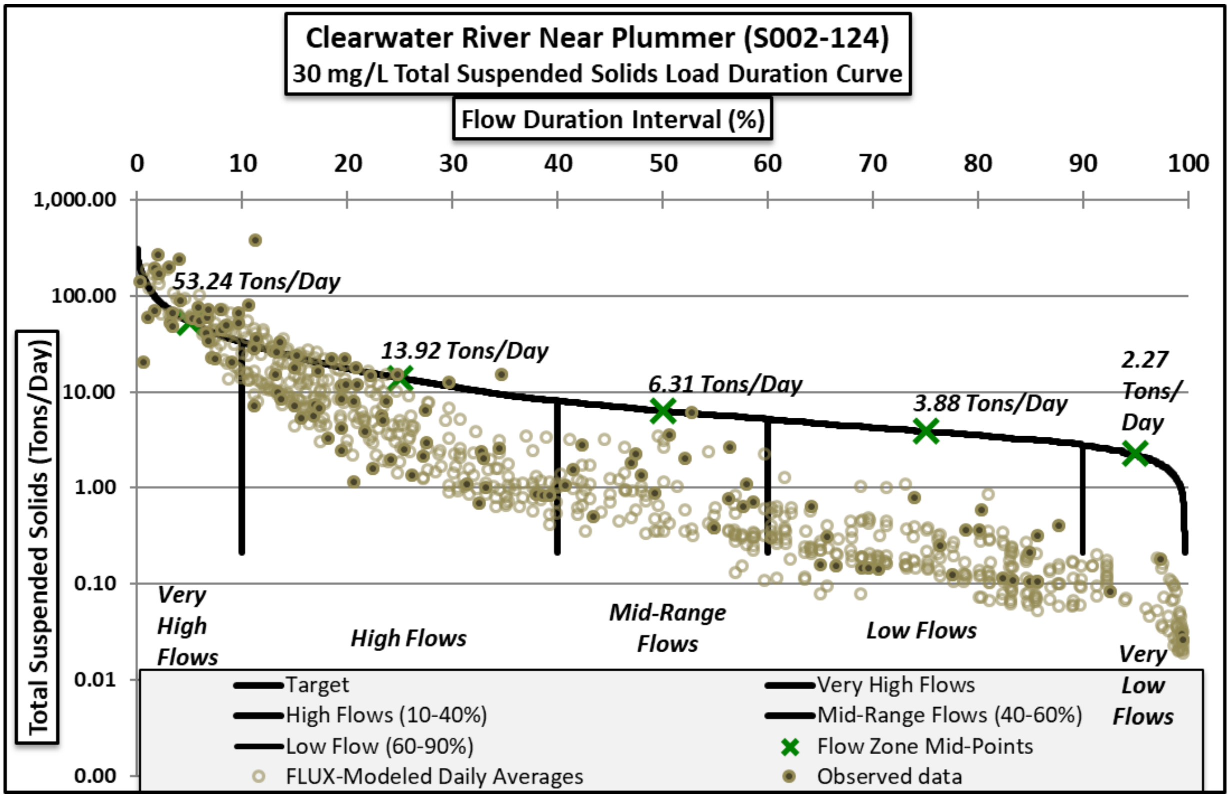


Figure 5-4. Load duration curve and median daily loads for the Clearwater River (AUID 648) at Plummer (station S002-124)

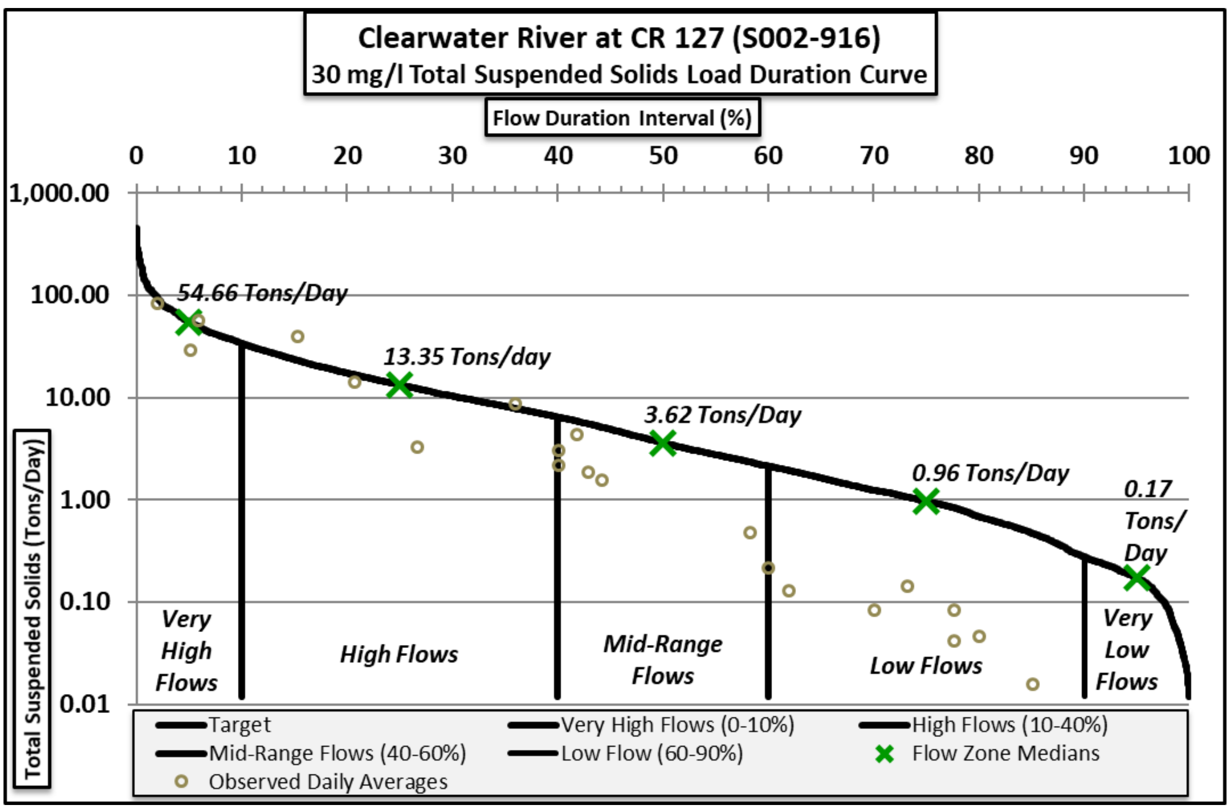


Figure 5-5. Load duration curve and median daily loads for the Clearwater River (AUID 647) at CR 127 (station S002-916)

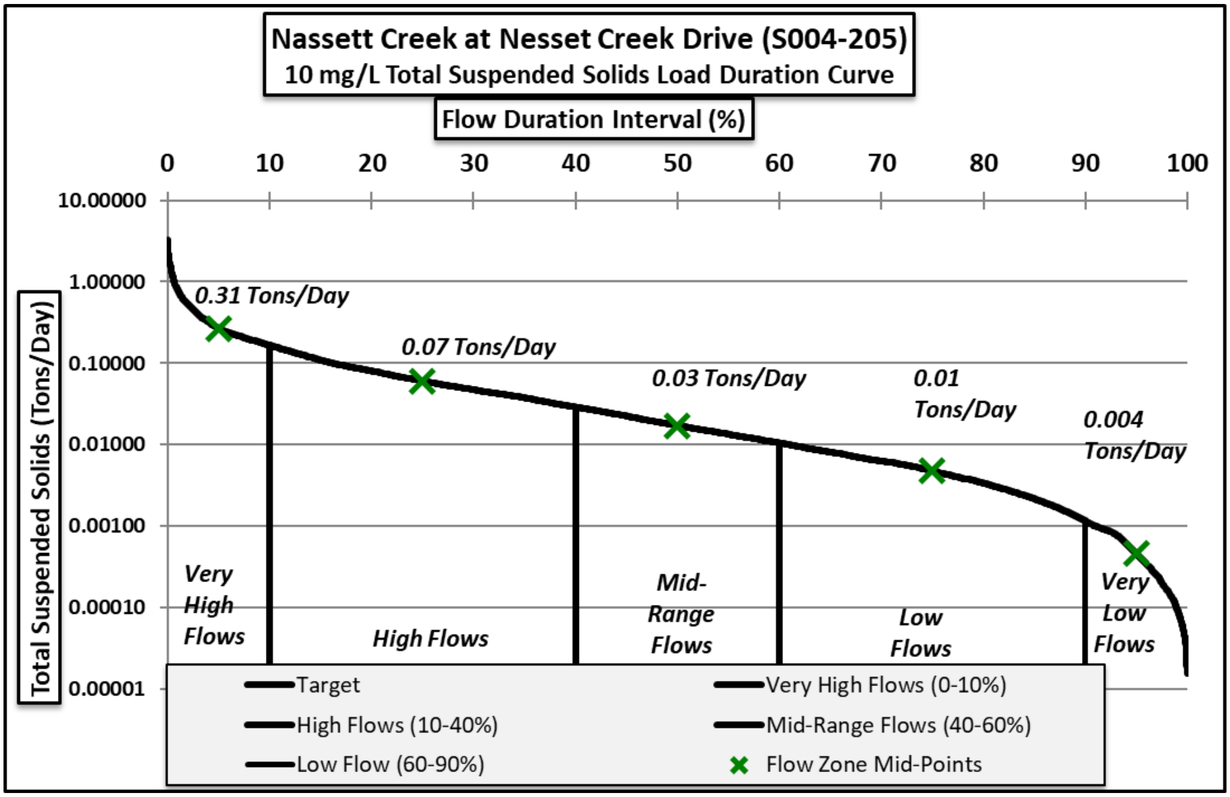


Figure 5-6. Load duration curve and median daily loads for Nassett Creek (AUID 545) at (station S004-205)

5.1.2 Load Allocation Methodology

Portions of the total LC were reserved for WLAs, construction and industrial stormwater (where applicable), reserve capacity (where applicable), and a MOS. There are two WWTFs (Plummer and Oklee) that discharge to waters that are impaired by TSS within the Clearwater River Watershed. No reserve capacity was warranted for rural, agricultural subwatersheds without urban or WWTF contributions. The remaining LC for each flow regime is considered to be the LA. Where possible, load reduction recommendations were calculated. The current loading estimates were calculated by finding the average TSS concentration for each flow regime. TSS data collected during the years of 2007 through 2016 (most recent 10 years of data) were used to assess and represent current conditions within the watershed. The discrete TSS sampling data was sorted by flow regime and averaged to estimate current daily loads. Daily load reduction recommendations for each flow regime were calculated by subtracting the LA from the current load. The number of days in a year that are represented by a flow regime factored into the cumulative load reduction recommendation for each TMDL establishment site.

5.1.3 Wasteload Allocation Methodology

<u>Municipal Separate Storm Sewer Systems</u>

There are no MS4 or designated MS4 communities within the Clearwater River Watershed. The population of the largest cities (Red Lake Falls and Bagley) are each less than 1,500, so there are no municipalities along impaired reaches with populations greater than 5,000 that could be designated MS4s.

Wastewater Treatment Facilities

Table 5-1 shows how WLA values were calculated for WWTFs that are applicable to the TSS TMDLs in the Clearwater River Watershed. Discharge from the Plummer WWTF and Oklee WWTF could potentially contribute to the TSS impairments along the Clearwater River. There were no WWTF in the watershed of Nassett Creek.

Section 4.1.1 describes the process of determining which WWTFs are applicable to TMDLs for TSS-impaired reaches. The WLAs for the Plummer and Oklee WWTFs was applied to the TMDL establishment locations for AUIDS 501 and 511. Discharge records from the most recent 10 years of available data (2006-2015) from the WWTFs were compiled to calculate an annual average number of days of discharge. The permitted daily discharge and permitted concentration were used, along with conversation factors, to calculate a daily WLAs. The WWTFs could potentially contribute to a TSS impairment because of the permitted TSS concentration (45 mg/L) relative to the standard (30 mg/L). Both WWTF's 45 mg/l TSS permit limit is based on equivalent to secondary treatment standards for waste stabilization pond systems (40 CFR 133.105). The facilities both discharge less than 30 days of the year, on average, during discharge windows in which the river is experiencing higher flows, as long as there is no ice cover (March 1 through June 30 and September 15 through December 30). Wastewater discharge accounts for a very small percentage of the possible TSS load in the Clearwater River, so pollutant reductions are not recommended for these WWTFs.

Table 5-1. Calculation of TSS wasteload allocations for the Plummer and Oklee WWTFs

	A	B	C	D	E	F	G	H	I	J
Facility	Secondary Pond Size (acres)	Permitted Max Daily Discharge (gpd)	Liters per Gallon	Permitted Max Daily Discharge (L/day)	Average # of Days Discharging per Year	Permitted TSS Conc. (mg/l)	TSS WLA (kg/day)	kg/ton	TSS WLA (tons/day)	TSS WLA (tons/year)
Plummer WWTF MN0024520-SD-2	3.00	489,000	3.79	1,850,865	21.83	45.00	83.29	907.20	0.092	2.00
Oklee WWTF MNG580038-SD-1	3.11	507,000	3.79	1,918,995	29.20	45.00	86.35	907.20	0.095	2.78
				= B x C			*= D x F/10*^{6}		*= G/H*	*= I x E*

Regulated Construction and Industrial Stormwater

National Pollutant Discharge Elimination System (NPDES) permitted construction stormwater activities must be given a WLA for TMDLs that are established for TSS and other pollutants. The Industrial Stormwater Multi-Sector General Permit is also utilized by the MPCA to manage compliance with a TMDL. Industrial stormwater must also receive a WLA if facilities are present in the drainage area of an impaired AUID. The MPCA has issued construction and industrial stormwater NPDES permits within each of the counties that encompass the drainage area of the impaired segments of the Clearwater River. The drainage area of Clearwater Lake (Beltrami County) and upstream reaches of the Clearwater River was excluded because the lake essentially resets TSS concentrations. Concentrations at or below the lab's minimum reporting limit were a common occurrence near the lake's outlet (S002-119 and S001-461).

The resolution of the available stormwater activity data was at the county level. Depending on location, the land area percentages for construction and industrial stormwater activity in Clearwater County, Polk County, and Red Lake County were factored into the percentage that was used to calculate the WLA for each location. According to MPCA data, the annual percentage of land area under construction has been 0.012% in Polk County, 0.006% in Red Lake County, and 0.004% in Clearwater County. Industrial stormwater activity land area percentages and LAs were estimated for each county using values that were equal to the calculated construction stormwater numbers. Construction and industrial activity comprise a small percentage of the land area in the watershed, so the allocations for both activities were combined into one WLA for each impaired reach in this TMDL.

The average annual acreages for each county that encompassed a portion of the drainage area was calculated by dividing the total acreage under construction by the number of unique "start date" years. The average annual "land area under construction" values from each of the counties that encompassed a portion of each TMDL station's drainage area were summed and then divided by the combined total acreage of those same counties. That provided an average annual land area percentage for each TMDL site that was calculated at a county-level scale. The land area percentages in Table 5-2 were applied to the LC using the following equation:

Construction and Industrial Stormwater WLA = (% of Land Area) x (LC – MOS)

Table 5-2. Calculation of construction and industrial stormwater land use percentages

Station ID:	S002-118	S002-914	S002-124	S002-916	S004-205
AUID 09020305-XXX:	501	511	648	647	502
Nearest Community or road crossing:	Red Lake Falls	Terrebonne	Plummer	CR 127	Nesset Crk Dr
Clearwater. Co. Construction Stormwater - Avg. Annual Land Area (ac)	25.67	25.67	25.67	25.67	25.67
Polk Co. Const. Stormwater - Average Annual Land Area (ac)	148.31	148.31	148.31	148.31	
Penn. Co. Const. Stormwater - Average Annual Land Area (ac)	39.02	39.02	39.02	39.02	
Red Lake Co. Const. Stormwater - Average Annual Land Area (ac)	15.43	15.43	15.43	15.43	
Total Applicable County Land Area (acres)*	2,610,560	2,610,560	2,610,560	2,610,560	659,200
Construction Stormwater as a % of Land Area	0.009%	0.009%	0.009%	0.009%	0.004%
Industrial Stormwater %	0.009%	0.009%	0.009%	0.009%	0.004%
Total % Industrial and Construction Stormwater Allocation	**0.018%**	**0.018%**	**0.018%**	**0.018%**	**0.008%**
*1,278,720 acres in Polk County; 277,120 acres in Red Lake County; 659,200 acres in Clearwater County; 395,520 acres in Pennington County					

5.1.4 Margin of Safety

The statute and regulations require that a TMDL include an MOS to account for any lack of knowledge concerning the relationship between load and WLAs and water quality (CWA § 303(d)(1)(c), 40 CFR § 130.7(c)(1)). The EPA's 1991 TMDL Guidance explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS). If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading set aside for the MOS must be identified. An explicit MOS equal to 10% of the LC was applied to each flow regime. The explicit 10% MOS accounts for:

- Uncertainty in the observed daily flow record.

- Uncertainty in the observed water quality data.
- Allocations and loading capacities are based on varying levels of flow. The TMDL accounts for this variability using the five flow regimes and the LDCs.
- The variability in pollutant concentrations at any given flow.
- Imperfect homogeneity of pollutants throughout the water column.

The MOS values were included in load reduction tables to calculate numerical load reduction goals that should result in a restored stream and account for the factors of variability and uncertainty that are described in this section.

5.1.5 Seasonal Variation

The TSS LDCs for the Clearwater River showed that high TSS concentrations in the river were associated with high flows. Observed concentrations rose, relative to the standard, as flows increased. All the exceedances of the 30 mg/L standard, in the most recent 10 years of data, occurred within the highest 25% of flows. As shown in Figure 5-7, average TSS concentrations were relatively high during spring runoff and peaked during the month of June.

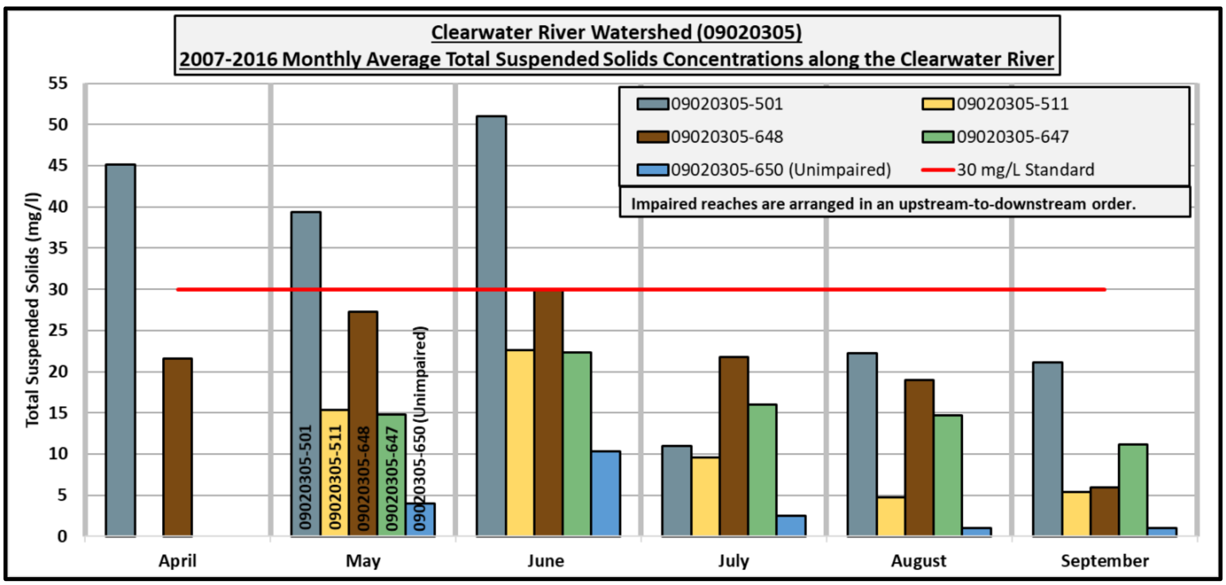


Figure 5-7. Seasonality of TSS concentrations along the Clearwater River (AUIDs 501, 511, 648, 647, and 650)

May and June runoff events have caused extreme concentrations of TSS (>700 mg/L maximums for both of those months). As shown in Figure 5-8, average flows decreased significantly after spring runoff but increased in June. During that time of year, cultivated fields typically have been recently planted, have more bare soil, and have less vegetative cover compared to later in the summer. As average flows decreased later in the summer, average TSS concentrations also decreased. The channelized portion of the Clearwater River (AUID 647) and the next reach downstream (AUID 648) remained affected by streambank erosion, increased flows from agricultural drainage, and by late-summer discharge from wild rice paddies. As shown in Figure 5-7, TSS levels were much lower in the unimpaired reach (AUID 650) upstream of AUID 647. There was a limited amount of TSS data available from Nassett Creek. Post-assessment sampling found exceedances of the 10 mg/L standard in July of 2016 and June of 2018. Low transparency readings in Nassett Creek have occurred in every month of the monitoring season except for May.

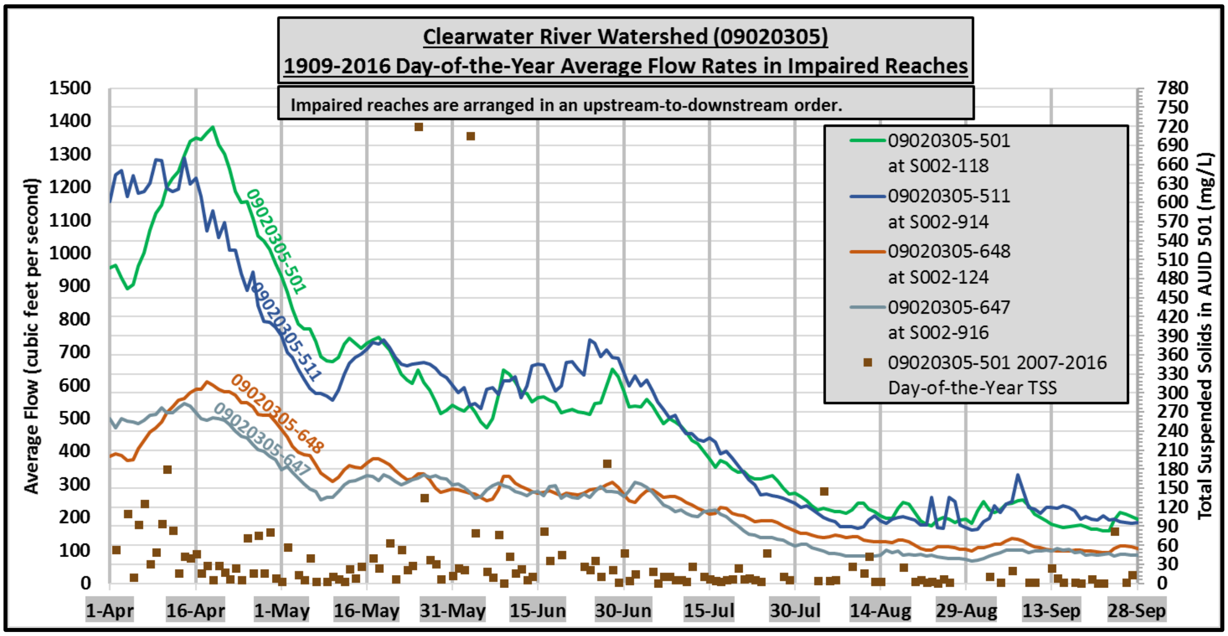


Figure 5-8. Flow rates for TMDL establishment sites along the Clearwater River (AUIDs 501, 511, 648, and 647), averaged by calendar day.

5.1.6 Reserve Capacity

A minimal amount of reserve capacity (5%) within LA tables was reserved for future development in the cities of Plummer, Red Lake Falls, and Oklee. Future development within this agricultural watershed will likely be low to modest. Population trends are flat or even decreasing in areas surrounding the impaired AUIDs.

5.1.7 TMDL Summary

The TSS TMDLs for the four TSS-impaired reaches along the Clearwater River have been calculated for four significant monitoring sites and summarized in Tables 5-4, 5-6, 5-8, 5-10, and 5-12. Two of the AUIDs (511 and 501) and TMDL locations (S002-118 and S002-914) are located downstream of the Plummer and Oklee WWTF discharges and include WLAs. Two of the stations were part of the WPLMN for which intensive sampling and flow data had been used to estimate current daily loads using a water quality model (FLUX32). Modeled FLUX32 water chemistry was not used in the TMDL calculations. The TMDLs and LDCs were based on state water quality standards and the best available flow records. The source of each site's flow record is described in Section 5.1.1. The FLUX32 modeled data was used for estimating current conditions, which helped estimate load reductions needed to restore a stream reach.

Boundary condition allocations were included in the Clearwater River TMDLs to account for upstream unimpaired reaches of the Clearwater River (AUID 650) and unimpaired, monitored tributaries. The exclusion of those waters focuses the LA and load reductions within the immediate drainage area of the TSS-impaired reaches of the Clearwater River and tributaries that may be contributing to the impairments. Flows were characterized for the boundary condition streams using simulated daily average flows from the 1996 through 2016 HPSF model. The median flow for each flow regime were multiplied by the applicable TSS standard and conversion factors to calculate daily loads. The values that were used to allocate loads to boundary conditions in the TSS TMDL summary tables are listed in Table 5-3.

Table 5-3. Boundary condition TSS loads for unimpaired tributaries and the unimpaired upstream Clearwater River AUID 650

Stream Name	AUID (Last 3 Digits)	HSPF Sub-Basin	Tons/Day TSS During Very High Flows	Tons/Day TSS During High Flows	Tons/Day TSS During Mid-Range Flows	Tons/Day TSS During Low Flows	Tons/Day TSS During Very Low Flows
Clearwater River	650	210	13.52	3.27	0.85	0.19	0.02
Poplar River	504	557	1.74	0.44	0.12	0.03	0.00
Hill River	539	531	17.44	4.9	1.43	0.38	0.06
Terrebonne Creek	575	577	1.79	0.39	0.12	0.03	0.00
Beau Gerlot Creek	652	601	6.42	1.62	0.47	0.14	0.01
Lower Badger Creek	502	645	8.99	2	0.53	0.15	0.01

Load reduction recommendations were made for flow regimes with sufficient sampling data and the flow data. Where the flow record overlaps with the sampling data, average loads were calculated for each flow regime and compared to the LAs. Load reductions, which will all come from nonpoint source reductions (LA portion of the TMDL) were calculated by subtracting the LC for each flow regime from the estimated current load for each flow regime in which current loads were greater than LC. Most of the load reductions were needed during high and very high flows. The load reduction tables (Tables 5-5, 5-7, 5-9, and 5-11) show the load reductions necessary to decrease annual loads from current loads to the LC.

The reasons for which an MOS is included in the TMDL are also reasons for incorporating an MOS into load reduction goals. The load reduction tables also calculate an MOS (daily MOS multiplied by the number of days represented by the respective flow regime) for flow regimes in which it could help reduce exceedances (current loads are greater than LC, the difference between current loads and LC is smaller than the MOS, or TSS samples have exceeded the standard). Those MOS values are added to the original (LC-based) load reduction recommendation to calculate a load reduction that would incorporate a MOS.

The use of FLUX-modeled data for AUID 501 and 648 reduced the influence of outlier sampling events and evenly distributed concentration and load values to represent a broad range of observed flow levels. The use of modeled data to calculate load reductions moderated the amount of recommended reductions. The average observed loads for each flow regime were higher than the average loads that were calculated from FLUX32 modeled data (86.16% reduction for very high flows and 13.19% reduction for high flows).

Load reduction within AUID 501 of the Clearwater River are needed during high flows. Nearly all the exceedance of the 30 mg/L TSS standard occurred during the months of April through June when spring runoff and early-summer storms can cause high flows, channel erosion, and runoff from bare or freshly planted fields. All exceedances of the 30 mg/L standard have occurred during high and very high flows.

Table 5-4. TSS Load Allocation Summary for the Clearwater River at Red Lake Falls (station S002-118) on AUID 501

EQuIS Site ID: S002-118 Flow Data from USGS gage 05078500		Loading Capacity and Load Allocations for Total Suspended Solids in the Clearwater River in Red Lake Falls AUID: 09020305-501				
Total Suspended Solids Standard: Drainage Area (square miles): % MS4: Total WWTF Design Flow (mgd):	30 mg/l 1,380 0.00% 0.489	Duration Curve Zone				
		Very High	High	Mid	Low	Very Low
TMDL Component		Values Expressed as Tons per Day of Sediment				
TOTAL DAILY LOADING CAPACITY		**114.08**	**24.27**	**9.71**	**5.26**	**2.43**
Wasteload Allocation*						
Plummer WWTF MN0024520-SD-2		0.09	0.09	0.09	0.09	0.09
Oklee WWTF MNG580038-SD-1		0.10	0.10	0.10	0.10	0.10
Construction and Industrial Stormwater		0.02	**	**	**	**
Reserve Capacity		5.70	1.21	0.49	0.26	0.12
Upstream Waters (Clearwater River AUID 650, Poplar River, Hill River, Terrebonne Creek, and Lower Badger Creek)		43.48	11.00	3.05	0.78	0.09
Daily Load Allocation***		**53.28**	**9.44**	**5.01**	**3.50**	**1.79**
Daily Margin of Safety		11.41	2.43	0.97	0.53	0.24
		Values Expressed as Percentages of the Total Loading Capacity				
Wasteload Allocation						
Plummer WWTF MN0024520-SD-2		0.08%	0.37%	0.93%	1.71%	3.70%
Oklee WWTF MNG580038-SD-1		0.09%	0.41%	1.03%	1.90%	4.12%
Construction and Industrial Stormwater		0.018%	0.018%	0.018%	0.018%	0.018%
Reserve Capacity		5%	5%	5%	5%	5%
Upstream Waters (Clearwater River AUID 650, Poplar River, Hill River, Terrebonne Creek, and Lower Badger Creek)		38.11%	45.32%	31.41%	14.83%	3.70%
Load Allocation		46.702%	38.876%	51.614%	66.541%	73.459%
Margin of Safety		10%	10%	10%	10%	10%
MEDIAN FLOW*		1,410.0	300.0	120.0	65.0	30.0
FLOW DURATION INTERVAL OF MEDIAN FLOW		5%	25%	50%	75%	95%

*Wasteload Allocations are rounded to the nearest 2 digits (1/100th of a ton)
**The values of some construction and industrial stormwater WLAs were less than 0.005. Though non-zero values were calculated, these values were too small to affect the LA.
***Load allocation includes nonpoint sources contributing to TSS loads in AUIDs 647, 648, 511, 513, and 501 (Clearwater River downstream of AUID 650) and excludes unimpaired upstream tributaries

Table 5-5. Annual TSS load Reduction needed for the Clearwater River at Red Lake Falls (station S002-118) on AUID 501

Clearwater River in Red Lake Falls (AUID 09020305-501, Site S002-118) TSS Load Reductions	Very High Flow	High Flow	Mid-Range Flow	Low Flow	Very Low Flow	Annual Totals
Current Daily Load (tons/day)	164.57	10.98	0.96	0.41	0.09	
Loading Capacity (tons/day)	114.08	24.27	9.71	5.26	2.43	
Load Reduction (tons/day)	50.49	0.00	0.00	0.00	0.00	
% of Flows Represented	10%	30%	20%	30%	10%	100%
Number of Days Represented	36.5	109.5	73.0	109.5	36.5	365
Annual Load Reduction (tons/year)	1,842.72	0.00	0.00	0.00	0.00	1,842.72
Total Current Load	6,006.64	1,202.66	70.38	44.50	3.41	7327.59
% Reduction	30.68%	0.00%	0.00%	0.00%	0.00%	25.15%
Margin of Safety (10% of daily LC)	416.47	266.09	*	*	*	682.55
Load reduction goal to meet the standard and provide a margin of safety						2,525.27

*Load reduction for MOS excluded due to low current loads and no record of exceedances in 2006-2015 data.

Table 5-6. TSS Load Allocation Summary for the Clearwater River at CSAH 12 (station S002-914) on AUID 511

EQuIS Site ID: S002-914 HSPF and Discrete, Measured Stage/Flow Data	Loading Capacity and Load Allocations for Total Suspended Solids in the Clearwater River at CSAH 12 (S002-914) AUID: 09020305-511				
Total Suspended Solids Standard: 30 mg/l Drainage Area (square miles): 1,158.46 % MS4: 0.00% Total WWTF Design Flow (mgd): 0.489	Duration Curve Zone				
	Very High	High	Mid	Low	Very Low
TMDL Component	Values Expressed as Tons per Day of Sediment				
TOTAL DAILY LOADING CAPACITY	**128.28**	**32.61**	**9.73**	**2.74**	**0.48**
Wasteload Allocation*					
Plummer WWTF MN0024520-SD-2	0.09	0.09	0.09	0.09	0.09
Oklee WWTF MNG580038-SD-1	0.10	0.10	0.10	0.10	0.10
Construction and Industrial Stormwater	0.02	0.01	**	**	**
Reserve Capacity	6.41	1.63	0.49	0.14	0.02
Upstream Waters (Clearwater River AUID 650, Poplar River, and Hill River)	32.70	8.61	2.40	0.60	0.08
Daily Load Allocation* **	**76.13**	**18.91**	**5.68**	**1.54**	**0.14**
Daily Margin of Safety	12.83	3.26	0.97	0.27	0.05
	Values Expressed as Percentages of the Total Loading Capacity				
Wasteload Allocation*					
Plummer WWTF MN0024520-SD-2	0.07%	0.28%	0.92%	3.28%	18.75%
Oklee WWTF MNG580038-SD-1	0.08%	0.31%	1.03%	3.65%	20.83%
Construction and Industrial Stormwater	0.018%	0.018%	0.018%	0.018%	0.018%
Reserve Capacity	5%	5%	5%	5%	5%
Upstream Waters (Clearwater River AUID 650, Poplar River, and Hill River)	25.49%	26.40%	24.67%	21.90%	16.67%
Load Allocation	59.343%	57.996%	58.363%	56.150%	28.732%
Margin of Safety	10%	10%	10%	10%	10%
MEDIAN FLOW*	1,585.5	403.1	120.3	33.9	5.9
FLOW DURATION INTERVAL OF MEDIAN FLOW	5%	25%	50%	75%	95%

*Wasteload Allocations are rounded to the nearest 2 digits (1/100th of a ton)
**The values of some construction and industrial stormwater WLAs were less than 0.005. Though non-zero values were calculated, these values were too small to affect the LA.
***Load allocation includes nonpoint sources contributing to TSS loads in AUIDs 647, 648, and 511 (Clearwater River downstream of AUID 650) and excludes unimpaired upstream tributaries

Table 5-7. Annual TSS load Reduction needed for the Clearwater River at CSAH 12 (station S002-914) on AUID 511

Clearwater River at CSAH 12 (AUID 09020305-511, Site S002-914) TSS Load Reductions	Very High Flow	High Flow	Mid-Range Flow	Low Flow	Very Low Flow	Annual Total
Current Daily Load (tons/day)	304.09	18.11	0.75	0.59	--	
Loading Capacity (tons/day)	128.28	32.61	9.73	2.74	0.48	
Load Reduction (tons/day)	175.81	0.00	0.00	0.00	0.00	
% of Flows Represented	10%	30%	20%	30%	10%	100%
Number of Days Represented	36.5	109.5	73.0	109.5	36.5	365
Annual Load Reduction (tons/year)	6417.1	0.0	0.0	0.0	0.0	6,417.07
Total Current Load	11099.29	1983.05	54.75	64.61	0	13,201.69
% Reduction to reach LC	57.82%	0.00%	0.00%	0.00%	0.00%	48.61%
Margin of Safety (10% of daily LC)	468.30	356.97	*	*	*	825.27
Load reduction goal to meet the standard and provide a margin of safety						7,242.34

*Load reduction for MOS excluded due to low current loads and no record of exceedances in 2006-2015 data.

The LAs and current loads for some flow regimes were higher in the upstream AUID 511 than they were downstream in AUID 501. The best available data was used to calculate LAs and current loads for each station. Some stations had higher quality data, however, like the record of observed flows at the Red Lake Falls USGS gage or the sampling data from WPLMN stations. Only discrete data, and no FLUX modeling data, was available for AUID 511 of the Clearwater River. As mentioned in the discussion of AUID 501, FLUX modeling data from 501 lowered the current loading estimates compared to the discrete data. The discrete data available for Station S002-914 in AUID 511 generated higher current load values than those calculated for Station S002-118 in AUID 501. The flow data for S002-914 was from the Clearwater River HSPF model and resulted in higher median flows, LC, and LA values for AUID 511 than AUID 501, even though AUID 511 is upstream of AUID 501.

Table 5-8. TSS Load Allocation Summary for the Clearwater River near Plummer (station S002-124) on AUID 648

EQuIS Site ID: S002-124 Flow Data from USGS Site 05078000	**Loading Capacity and Load Allocations for Total Suspended Solids in the Clearwater River at Plummer (S002-124) AUID: 09020305-648**				
Total Suspended Solids Standard: 30 mg/l Drainage Area (square miles): 555 % MS4: 0.00% Total WWTF Design Flow (mgd): 0.00	**Duration Curve Zone**				
	Very High	**High**	**Mid**	**Low**	**Very Low**
TMDL Component	Values Expressed as Tons per Day of Sediment				
TOTAL DAILY LOADING CAPACITY	**53.24**	**13.92**	**6.31**	**3.88**	**2.27**
Wasteload Allocation*					
Construction and Industrial Stormwater	0.01	**	**	**	**
Reserve Capacity	2.66	0.70	0.32	0.19	0.11
Upstream Waters (Clearwater River AUID 650)	13.52	3.27	0.85	0.19	0.02
Daily Load Allocation***	**31.73**	**8.56**	**4.51**	**3.11**	**1.91**
Daily Margin of Safety	5.32	1.39	0.63	0.39	0.23
	Values Expressed as Percentages of the Total Loading Capacity				
Wasteload Allocation					
Construction and Industrial Stormwater	0.018%	0.018%	0.018%	0.018%	0.018%
Reserve Capacity	5%	5%	5%	5%	5%
Upstream Waters (Clearwater River AUID 650)	25.39%	23.49%	13.47%	4.90%	0.88%
Load Allocation	59.588%	61.491%	71.511%	80.085%	84.101%
Margin of Safety	10%	10%	10%	10%	10%
MEDIAN FLOW*	1,410	300	120	65	30
FLOW DURATION INTERVAL OF MEDIAN FLOW	5%	25%	50%	75%	95%

*Wasteload Allocations are rounded to the nearest 2 digits (1/100th of a ton)
**The values of some construction and industrial stormwater WLAs were less than 0.005. Though non-zero values were calculated, these values were too small to affect the LA.
***Load allocation applies to nonpoint sources contributing to TSS loads in AUIDs 647 and 648, downstream of AUID 650

Table 5-9. Annual TSS load Reduction needed for the Clearwater River near Plummer (station S002-124) on AUID 648

Clearwater River near Plummer (AUID 09020305-648, Site S002-124) TSS Load Reductions	**Very High Flow**	**High Flow**	**Mid-Range Flow**	**Low Flow**	**Very Low Flow**	**Annual Total**
Current Daily Load (tons/day)	70.47	12.10	1.06	0.29	0.05	
Loading Capacity (tons/day)	53.24	13.92	6.31	3.88	2.27	
Load Reduction (tons/day)	17.23	0.00	0.00	0.00	0.00	
% of Flows Represented	10%	30%	20%	30%	10%	100%
Number of Days Represented	36.5	109.5	73.0	109.5	36.5	365
Annual Load Reduction (tons/year)	628.90	0	0.00	0.00	0.00	628.90
Total Current Load	2,572.16	1,324.95	77.38	31.76	1.83	4,008.07
% Reduction	24.45%	0.00%	0.00%	0.00%	0.00%	15.69%
Margin of Safety (10% of daily LC)	194.18	152.21	*	*	*	346.39
Load reduction goal to meet the standard and provide a margin of safety						975.29

*Load reduction for MOS excluded due to low current loads and no record of exceedances in 2006-2015 data.

No wastewater sources are located upstream of the primary monitoring site on AUID 648 other than permitted construction and industrial stormwater activity. Station S002-124 is located upstream of the Plummer WWTF and upstream of the Lost River confluence. Exceedances have occurred most frequently during the month of June. All exceedances have occurred during high and very high flows. There also was a difference in flow data sources between AUID 647 (HSPF model) and AUID 648 (AUID 648). LC values from some flow regimes decreased from the upstream site to the downstream site, but the total annual LC increased, as would be expected, from the upstream AUID 647 to the downstream AUID 648.

Table 5-10. TSS Load Allocation Summary for the Clearwater River at County Road 127 (station S002-916) on AUID 647

EQuIS Site ID: S002-916 Flow record: Simulated 1996-2016 data from an HSPF model and discrete stage/flow measurements	Loading Capacity and Load Allocations for Total Suspended Solids in the Clearwater River at County Road 127 (S002-916) AUID: 09020305-647				
Total Suspended Solids Standard: 30 mg/l Drainage Area (square miles): 483.5 % MS4: 0.00% Total WWTF Design Flow (mgd): 0.00	Duration Curve Zone				
	Very High	**High**	**Mid**	**Low**	**Very Low**
TMDL Component	Values Expressed as Tons per Day of Sediment				
TOTAL DAILY LOADING CAPACITY	**54.66**	**13.35**	**3.62**	**0.96**	**0.17**
Wasteload Allocation*					
Construction and Industrial Stormwater	0.01	**	**	**	**
Reserve Capacity	2.73	0.67	0.18	0.05	0.01
Upstream Waters (Clearwater River AUID 650)	13.52	3.27	0.85	0.19	0.02
Daily Load Allocation***	**32.93**	**8.07**	**2.23**	**0.62**	**0.12**
Daily Margin of Safety	5.47	1.34	0.36	0.10	0.02
	Values Expressed as Percentages of the Total Loading Capacity				
Wasteload Allocation					
Construction and Industrial Stormwater	0.018%	0.018%	0.018%	0.018%	0.018%
Reserve Capacity	5%	5%	5%	5%	5%
Upstream Waters (Clearwater River AUID 650)	24.73%	24.49%	23.48%	19.79%	11.76%
Load Allocation	60.247%	60.488%	61.501%	65.190%	73.217%
Margin of Safety	10%	10%	10%	10%	10%
MEDIAN FLOW*	676	165	45	12	2
FLOW DURATION INTERVAL OF MEDIAN FLOW	5%	25%	50%	75%	95%
*Wasteload Allocations are rounded to the nearest 2 digits (1/100th of a ton) **The values of some construction and industrial stormwater WLAs were less than 0.005. Though non-zero values were calculated, these values were too small to affect the LA. ***Load allocation applies to nonpoint sources contributing to TSS loads in AUIDs 647, downstream of AUID 650					

Table 5-11. Annual TSS load Reduction needed for the Clearwater River at County Road 127 (station S002-916) on AUID 647

Clearwater River near Plummer (AUID 09020305-647, Site S002-916) TSS Load Reductions	Very High Flow	High Flow	Mid-Range Flow	Low Flow	Very Low Flow*	Annual Total
Current Daily Load (tons/day)	55.69	16.23	2.21	0.09	0.01	
Loading Capacity (tons/day)	54.66	13.35	3.62	0.96	0.17	
Load Reduction (tons/day)	1.03	2.88	0.00	0.00	0.00	
% of Flows Represented	10%	30%	20%	30%	10%	100%
Number of Days Represented	36.5	109.5	73.0	109.5	36.5	365
Annual Load Reduction (tons/year)	37.60	315.36	0.00	0.00	0.0	352.96
Total Current Load	2,032.69	1,777.19	161.33	9.86	0.37	3,981.42
% Reduction	1.85%	17.74%	0.00%	0.00%	0.00%	8.87%
Margin of Safety (10% of daily LC)	199.66	146.73	*	*	*	346.39
Load reduction goal to meet the standard and provide a margin of safety						699.35
*Load reduction for MOS excluded due to low current loads and no record of exceedances in 2006-2015 data.						

Load reductions within AUID 647 are needed during the highest 40% of flows. Reduction of TSS loading from nonpoint sources will be necessary to restore this reach. Like S002-124, a very small amount of runoff from construction and industrial stormwater runoff is the only permitted source of wastewater within the boundary conditions of this impairment.

LC and LA calculations for Nassett Creek were very small. Though non-zero values were calculated for all flow regimes, rounding to the $1/100^{th}$ place resulted in loading capacities of zero tons/day for the low and very low flow regimes. Non-zero values lower than 0.005 tons/day were represented with a double asterisk in Table 5-12. There were no communities in the drainage area of Nassett Creek, so no reserve capacity or WWTF were included in this TMDL.

Table 5-12. TSS Load Allocation Summary for Nassett Creek (station S004-205) on AUID 545

EQuIS Site ID: S004-205 Flow record: Simulated and area-weighted 1996-2016 data from an HSPF model	Loading Capacity and Load Allocations for Total Suspended Solids in the Nassett Creek at Nesset Creek Drive (S004-205) AUID: 09020305-545				
Total Suspended Solids Standard: 10 mg/l Drainage Area (square miles): 6.15 % MS4: 0.00% Total WWTF Design Flow (mgd): 0.00	Duration Curve Zone				
	Very High	High	Mid	Low	Very Low
TMDL Component	Values Expressed as Tons per Day of Sediment				
TOTAL DAILY LOADING CAPACITY	**0.27**	**0.06**	**0.02**	**	**
Wasteload Allocation*					
Construction and Industrial Stormwater	**	**	**	**	**
Daily Load Allocation	**0.24**	**0.05**	**0.02**	**	**
Daily Margin of Safety	0.03	0.01	**	**	**
	Values Expressed as Percentages of the Total Loading Capacity				
Wasteload Allocation					
Construction and Industrial Stormwater	0.008%	0.008%	0.008%	0.008%	0.008%
Load Allocation	89.992%	89.992%	89.992%	89.992%	89.992%
Margin of Safety	10%	10%	10%	10%	10%
MEDIAN FLOW*	9.93	2.25	0.64	0.18	0.02
FLOW DURATION INTERVAL OF MEDIAN FLOW	5%	25%	50%	75%	95%

*Wasteload Allocations are rounded to the nearest 1/10,000th of a ton
**The values of some construction and industrial stormwater WLAs and other LA values were less than 0.005. Though non-zero values were calculated, these values were too small to affect the LA.

There was insufficient data to estimate the current load and recommend load reductions at this site. The impairment was based upon transparency data. Sampling for TSS began in 2016, so only four values were available from S004-205 within range of the HSPF model's 1996 through 2016 flow data. Simulated TSS concentrations in reach 441 of the 1996 through 2016 HSPF model were only relevant to the Lost River and not Nassett Creek. Flows were calculated with area-weighting, but there were too many other variables that could affect downstream TSS loads to accurately estimate loads for Nassett Creek using HSPF-SAM. The exceedance rate for transparency tube readings was 10.5%. Sampling for TSS only began in 2016 after the reach was found to be impaired by low transparency readings. Two of thirteen TSS samples collected during the months of April through September in 2016 through 2018 have exceeded the 10 mg/L standard. The maximum concentration was 14 mg/L. That exceedance rate for TSS (15.4%) needs to be reduced by approximately 35% for the stream to meet standards. Using that percentage to estimate a current load for each flow regime (LA = 0.65 x estimated current load) calculates an estimated 24.15 tons/year current load and an 8.5 tons/year load reduction goal.

5.2 *E. coli* Bacteria

5.2.1 Loading Capacity Methodology

The EPA defines LC as "the greatest amount of loading that a water can receive without violating water quality standards." The LC provides a reference, which helps guide pollutant reduction efforts needed to bring a water into compliance with the standards. The LDC method is based upon 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 *E. coli* TMDL summary tables of this report (Tables 5-16 through 5-45) a maximum of 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 EPA. For each impaired AUID, there is a table that summarizes LAs and a table that estimates the load reductions that are needed for each flow regime.

Monitoring sites were chosen for TMDL establishment based upon the monitoring history at the sites (stage/flow and water quality sampling) and their location within the watershed. Sites nearest the pour point of an AUID with a significant amount of historical, current, and future monitoring activity were given preference. *E. coli* TMDL establishment locations are shown in Figure 5-9 and listed below:

1. Lower Badger Creek (AUID 09020305-502) at CR 114 (S004-837) – Figure 5-10, Table 5-16, and Table 5-17
2. Poplar River (09020305-504) at CR 118 (S007-608) – Figure 5-11, Table 5-18, and Table 5-19
3. Lost River (09020305-512) at 139th Avenue (S000-924) – Figure 5-12, Table 5-20, and Table 5-21
4. Ruffy Brook (09020305-513) at CSAH 11 (S008-057) – Figure 5-13, Table 5-22, and Table 5-23
5. Clear Brook (09020305-526) at CSAH 92 (S004-044) – Figure 5-14, Table 5-24, and Table 5-25
6. Silver Creek (09020305-527) at CR 111 (S002-082) – Figure 5-15, Table 5-26, and Table 5-27
7. Lost River (09020305-529) at 109th Avenue (S005-283) – Figure 5-16, Table 5-28, and Table 5-29
8. Lost River (09020305-530) at Lindberg Lake Road (S005-501) – Figure 5-17, Table 5-30, and Table 5-31
9. Hill River (09020305-539) at CR 119 (S002-134) – Figure 5-18, Table 5-32, and Table 5-33
10. Nassett Creek (09020305-545) at Nassett Creek Drive (S004-205) – Figure 5-19, Table 5-34, and Table 5-35
11. Judicial Ditch 73 (09020305-550) at 343rd Street (S003-318) – Figure 5-20, Table 5-36, and Table 5-37
12. Terrebonne Creek (09020305-574) at CSAH 92 (S004-819) – Figure 5-21, Table 5-38, and Table 5-39
13. Brooks Creek (09020305-578) at CSAH 92 (S006-506) – Figure 5-22, Table 5-40, and Table 5-41
14. Clearwater River (09020305-647) at CR 127 (S002-916) – Figure 5-23, Table 5-42, and Table 5-43
15. Beau Gerlot Creek (0902005-651) at CSAH 92 (S004-816) – Figure 5-24, Table 5-44, and Table 5-45

Average daily flow records were compiled for the sites that were chosen for TMDL establishment. Water level loggers had been deployed at some of the sites by the RLWD to record stage and flow record. For ungauged reaches and where supplementation of measured data was useful, flow records from the 1996 through 2016 Clearwater River HSPF model were used to create LDCs. Where HSPF subbasin pour points did not match with monitoring site locations, drainage area weighting was used to adjust discharge records. The USGS StreamStats website was used to calculate the drainage areas for sampling sites and the pour points of HPSF reaches. Flows were ranked from highest to lowest. Average daily flow values were assigned a flow rank value. The probability of exceedance of each average daily flow value was calculated as a percentage. This created the information needed to create a flow duration curve by plotting probability of exceedance (X-axis) against the flow level (logarithmic Y-axis). Using the allowable concentration of 126 MPN per 100 ml and conversion factors, a LDC was developed to show the allowable billions of organisms per day of *E. coli* bacteria for each level of flow along the curve. The LDC data was used to determine the median LC for each flow regime. Some flow regimes were incomplete due to a lack of flow and zero-flow conditions that made up more than 10% of the LDC. Median values for flows and loads were calculated from the remaining records in those flow regimes after zero-flow records were excluded.

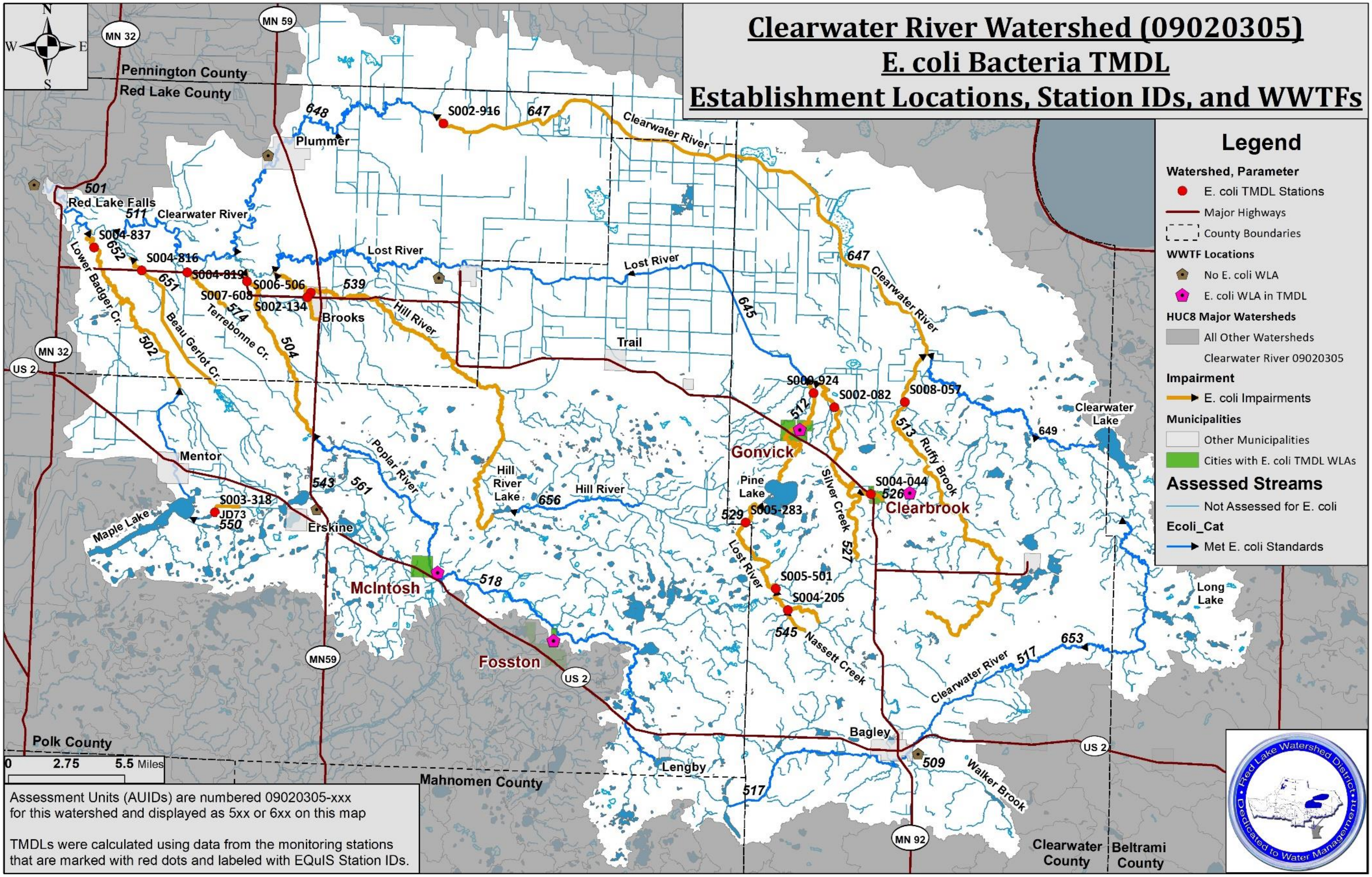


Figure 5-9. Locations of *E. coli* TMDL establishment stations throughout the Clearwater River Watershed

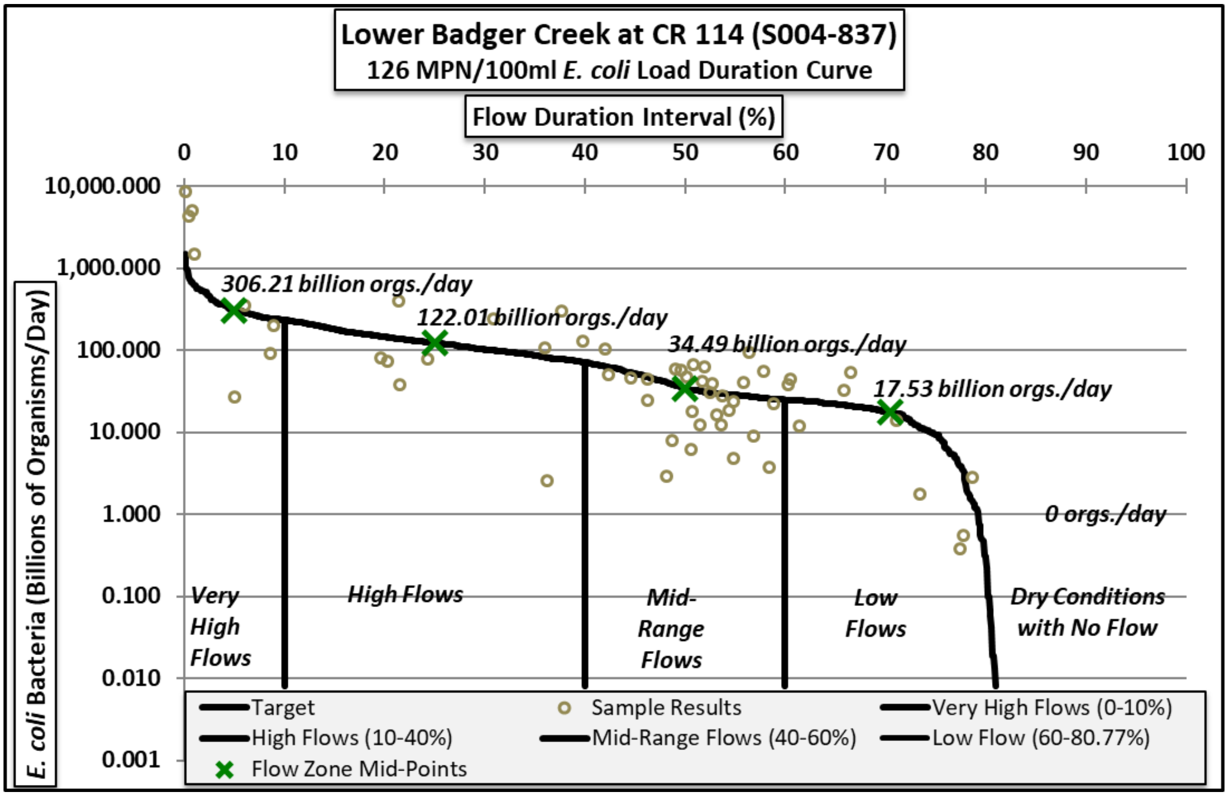


Figure 5-10. *E. coli* load duration curve and median daily loads for Lower Badger Creek (AUID 502) at CR 114 (station S004-837)

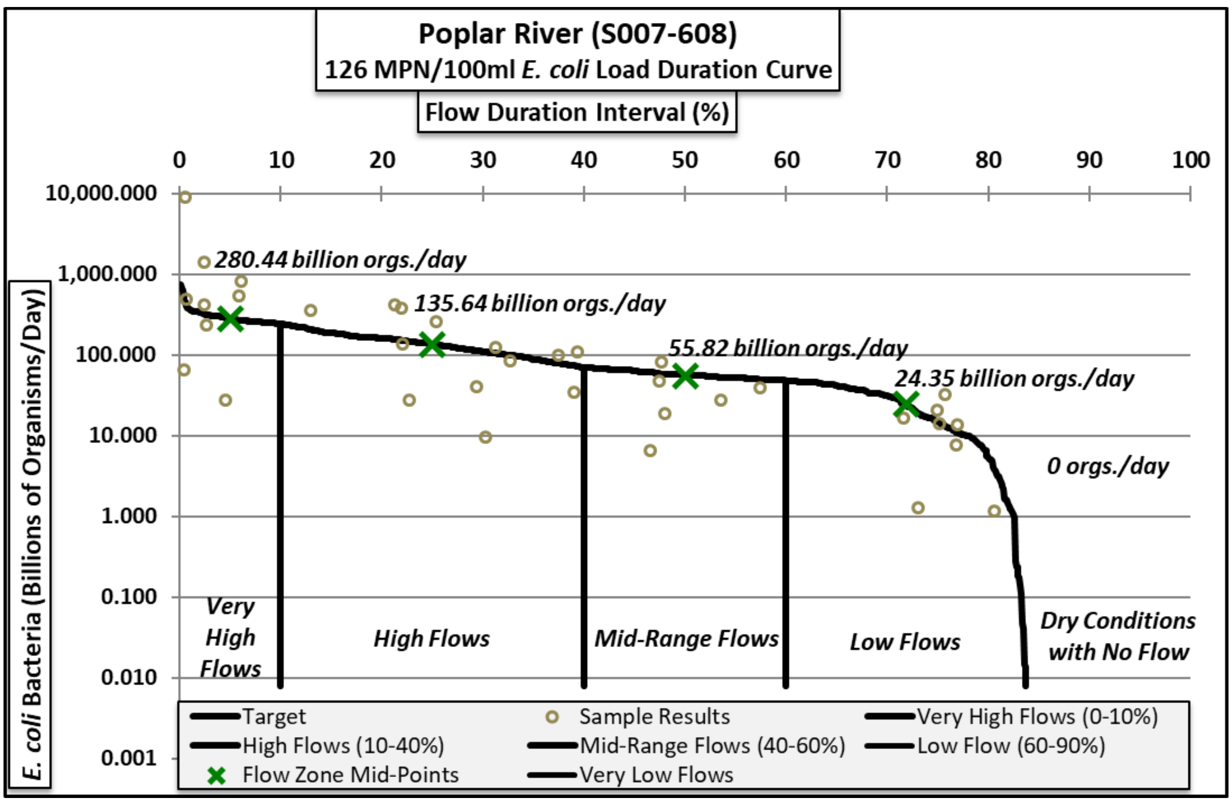


Figure 5-11. *E. coli* load duration curve and median daily loads for the Poplar River (AUID 504) at CR 118 (station S007-608)

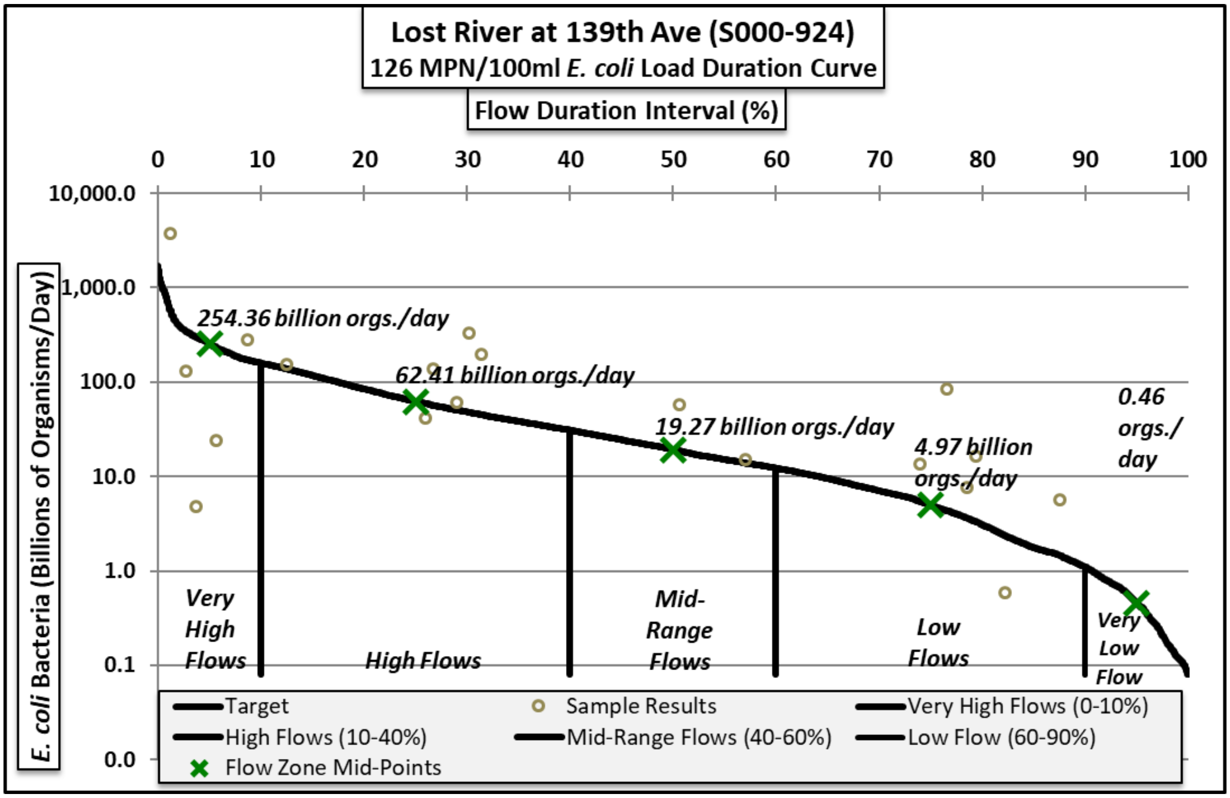


Figure 5-12. ***E. coli*** **load duration curve and median daily loads for the Lost River (AUID 512) at 139th Avenue (station S000-924)**

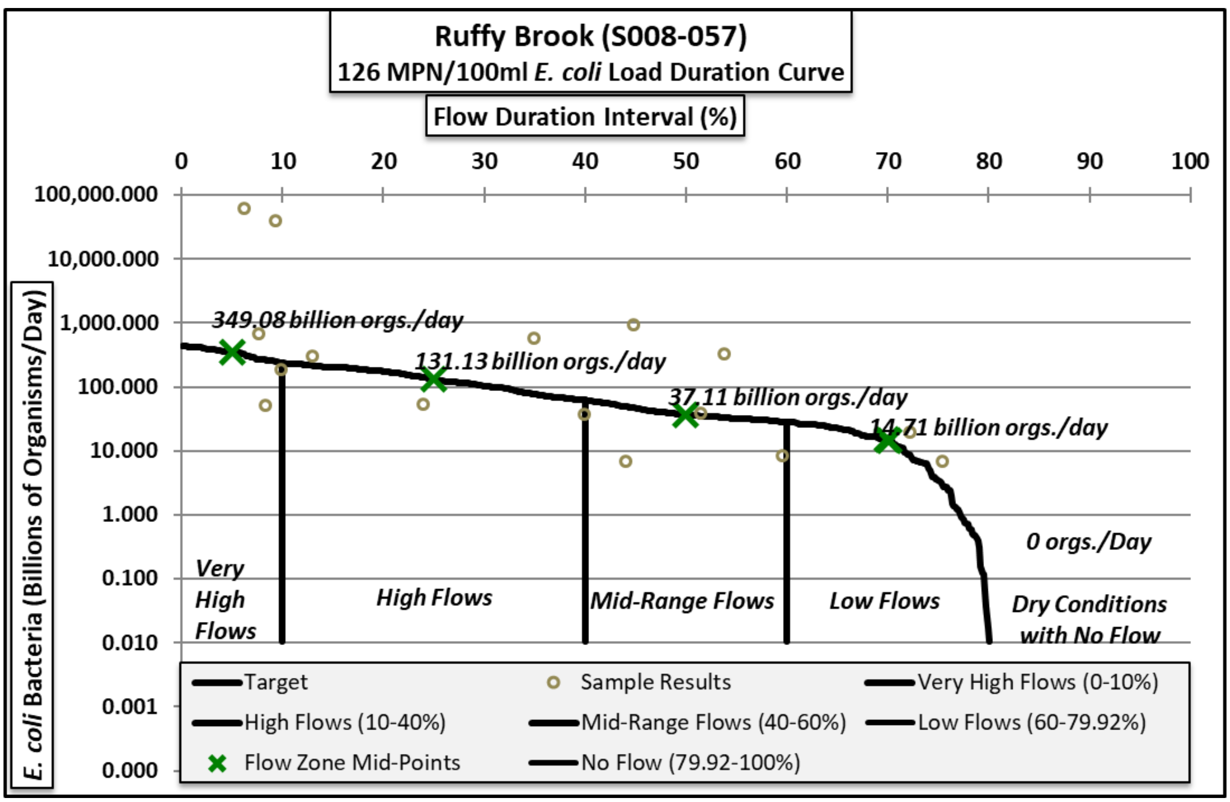


Figure 5-13. ***E. coli*** **load duration curve and median daily loads for Ruffy Brook (AUID 513) at CSAH 11 (station S008-057)**

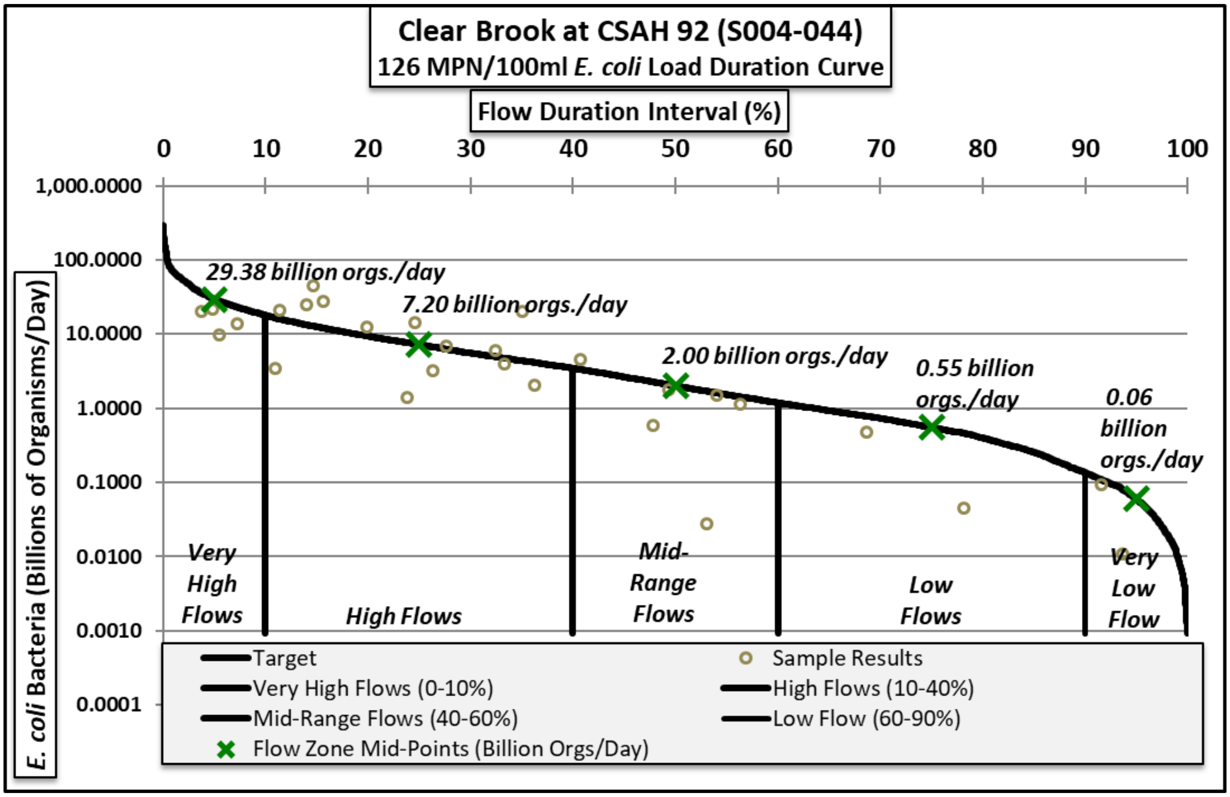


Figure 5-14. ***E. coli*** **load duration curve and median daily loads for Clear Brook (AUID 526) at CSAH 92 (station S004-044)**

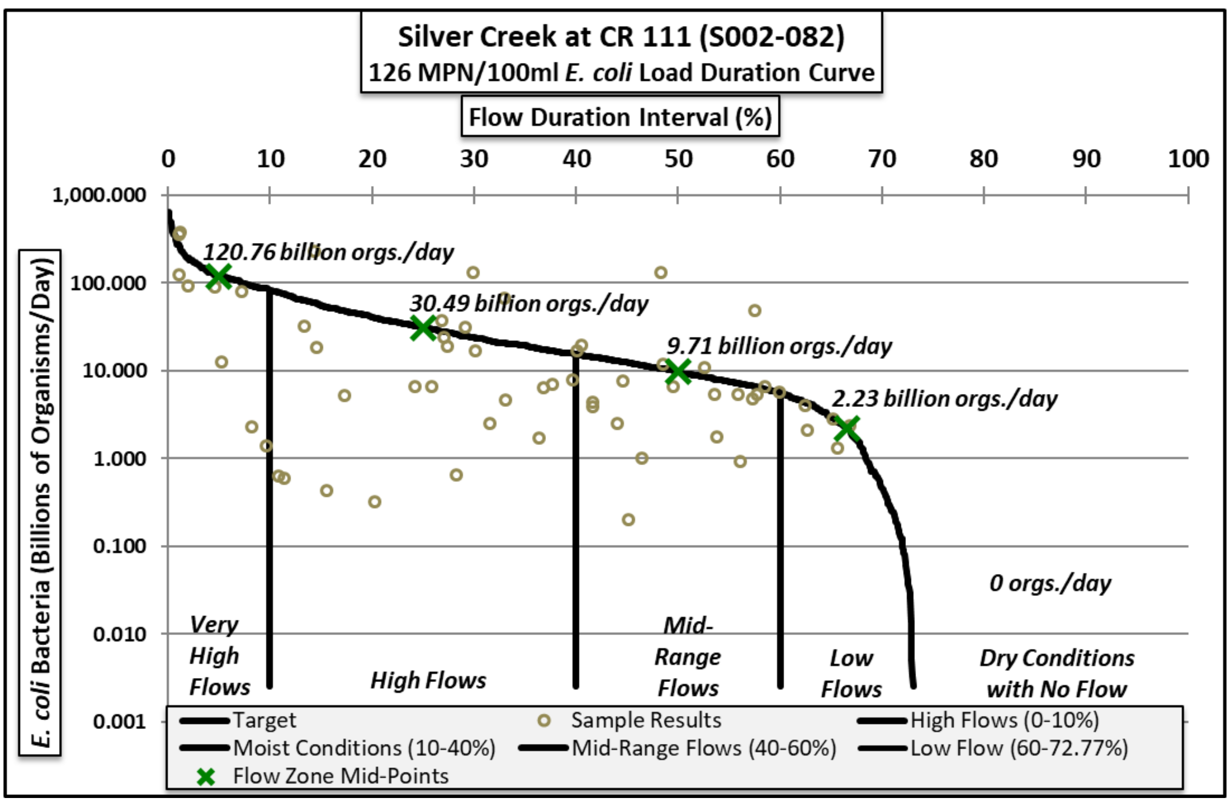


Figure 5-15. ***E. coli*** **load duration curve and median daily loads for Silver Creek (AUID 527) at CR 111 (station S002-082)**

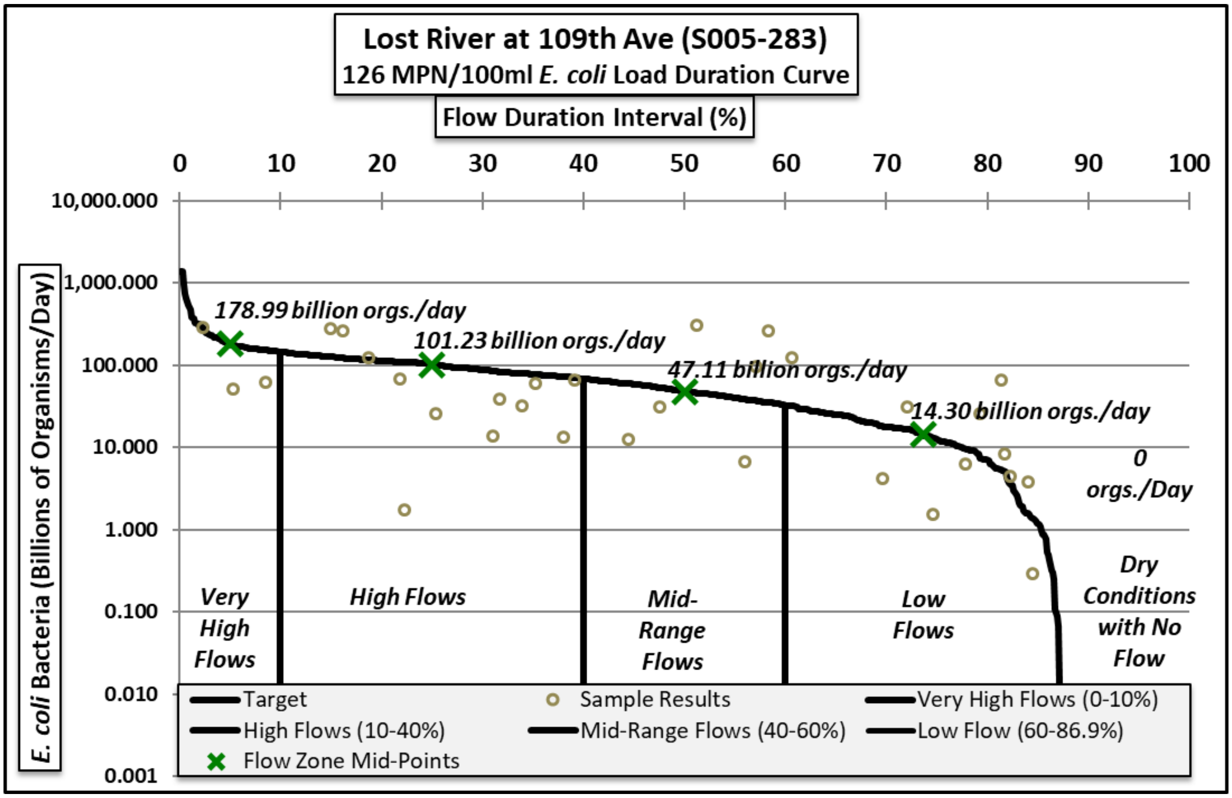


Figure 5-16. *E. coli* load duration curve and median daily loads for the Lost River (AUID 529) at 109th Avenue (station S005-283)

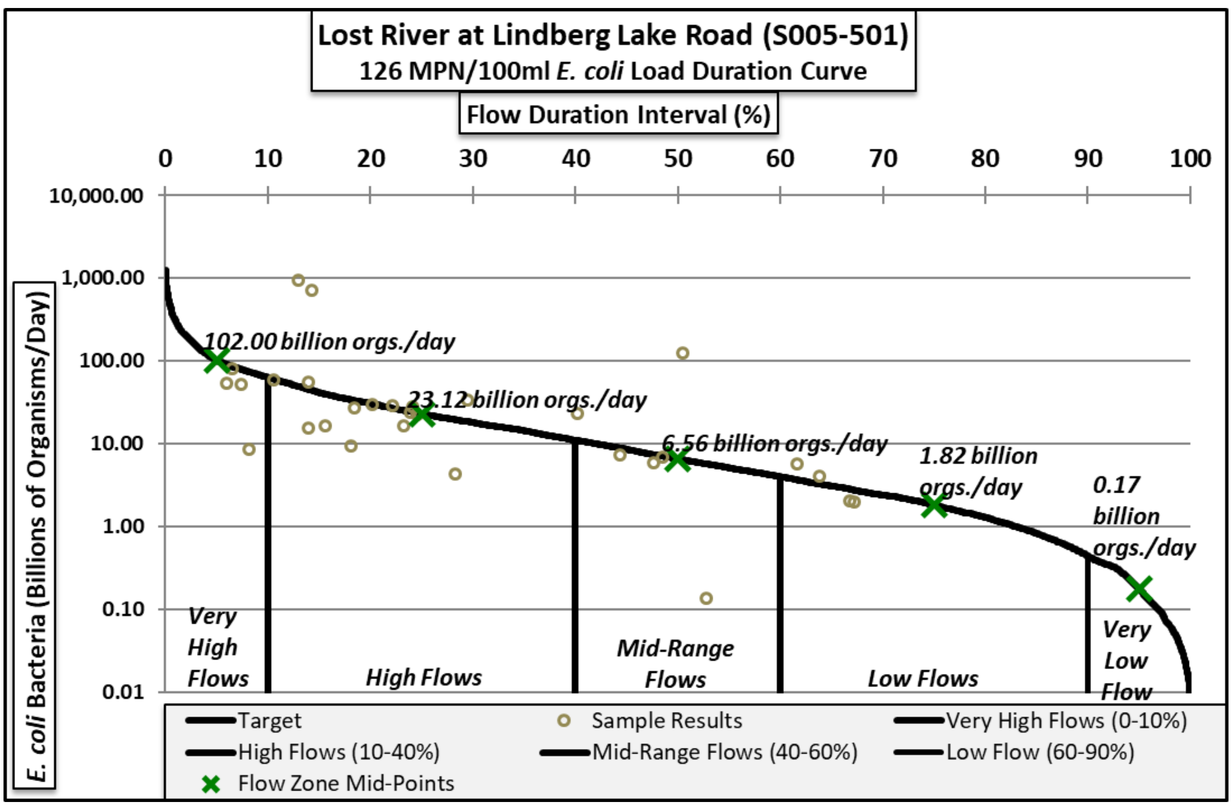


Figure 5-17. *E. coli* load duration curve and median daily loads for the Lost River (AUID 530) at Lindberg Lake Road (station S005-501)

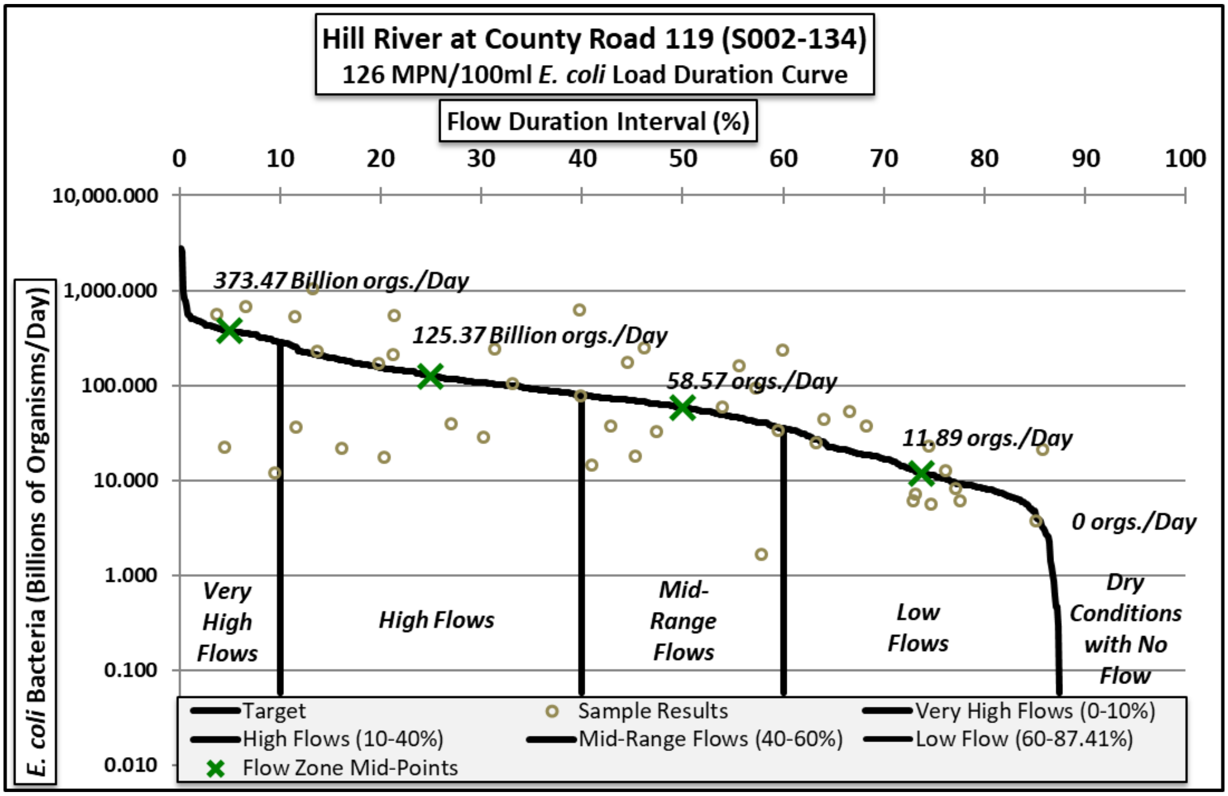


Figure 5-18. ***E. coli*** **load duration curve and median daily loads for the Hill River (AUID 539) at CR 119 (station S002-134)**

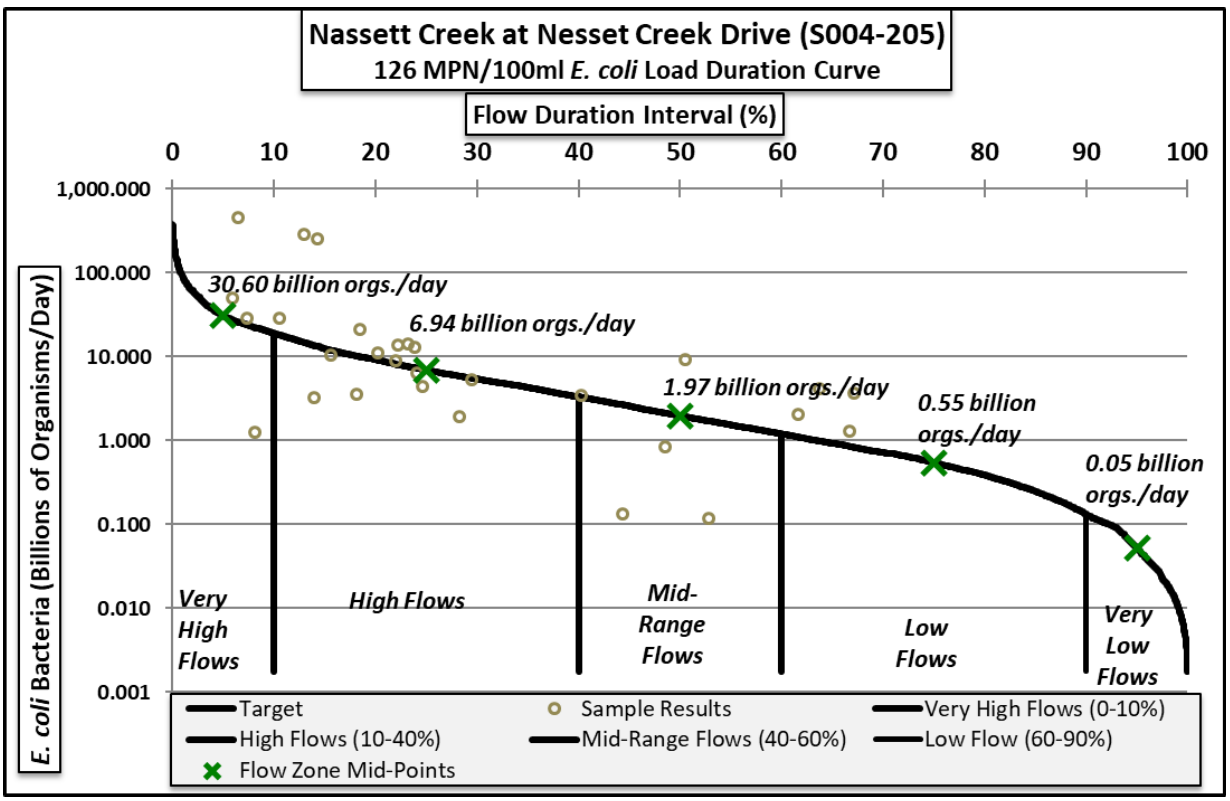


Figure 5-19. ***E. coli*** **load duration curve and median daily loads for Nassett Creek (AUID 545) at station S004-205**

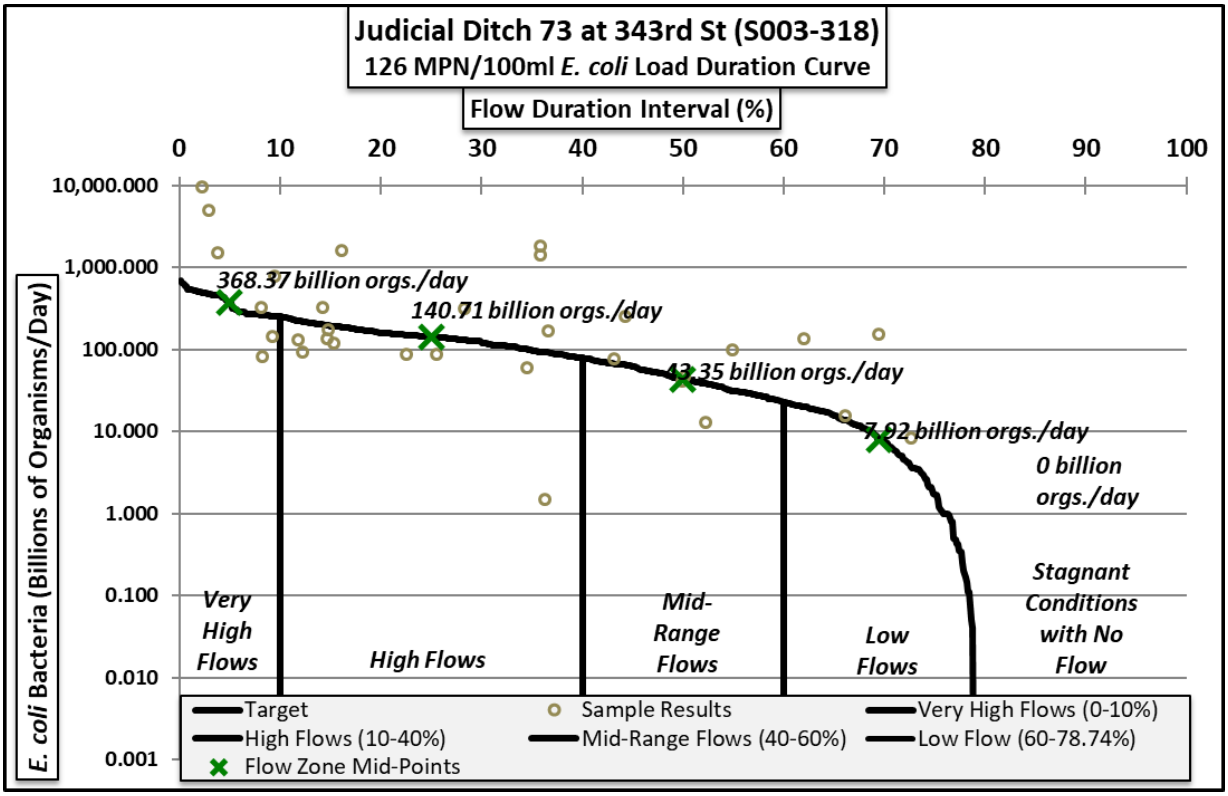


Figure 5-20. *E. coli* load duration curve and median daily loads for Judicial Ditch 73 (AUID 550) at station S003-318

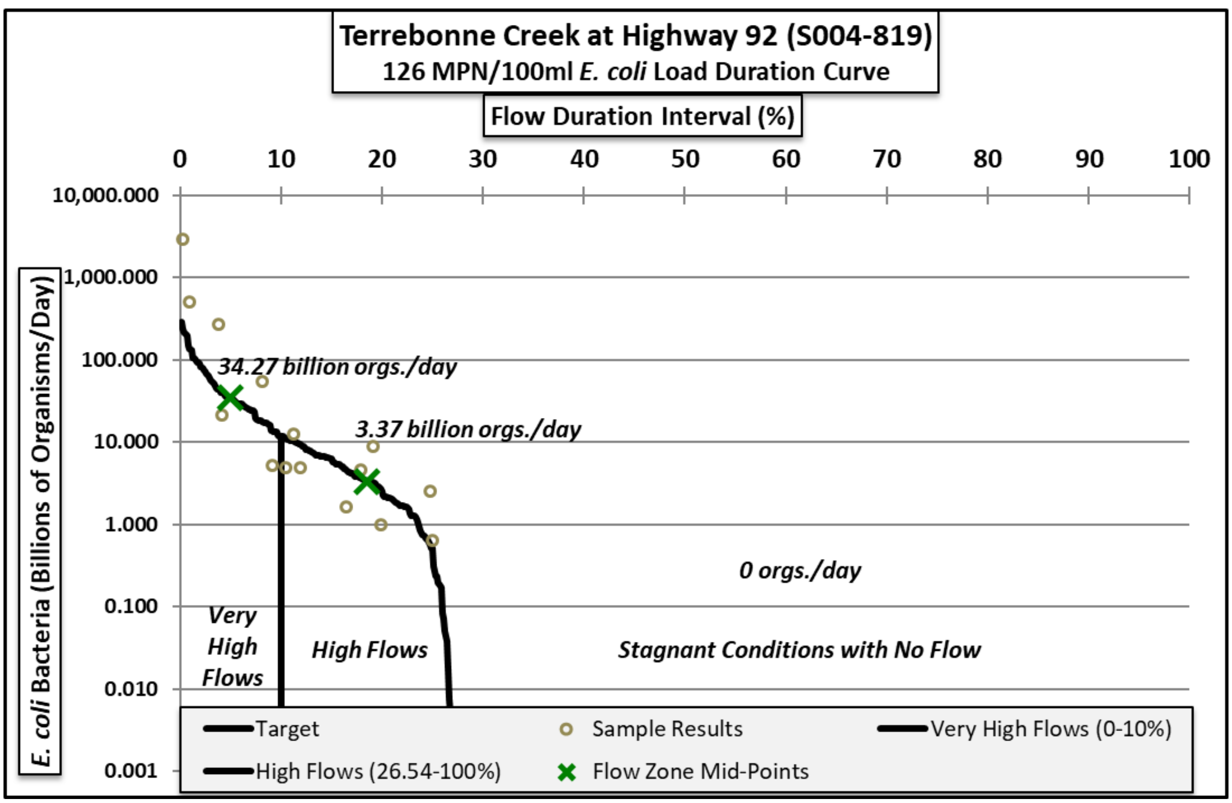


Figure 5-21. *E. coli* load duration curve and median daily loads for Terrebonne Creek (AUID 574) at Highway 92 (station S004-819)

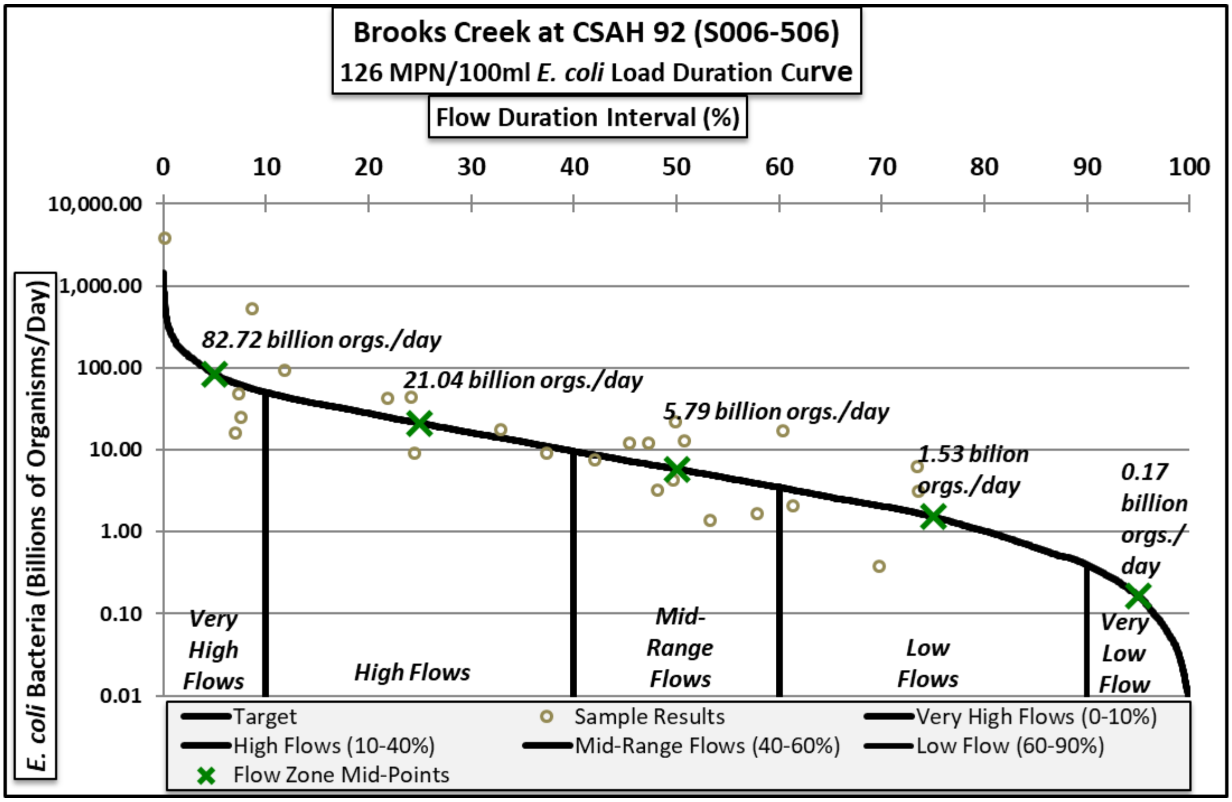


Figure 5-22. *E. coli* **load duration curve and median daily loads for Brooks Creek (AUID 578) at station S006-506**

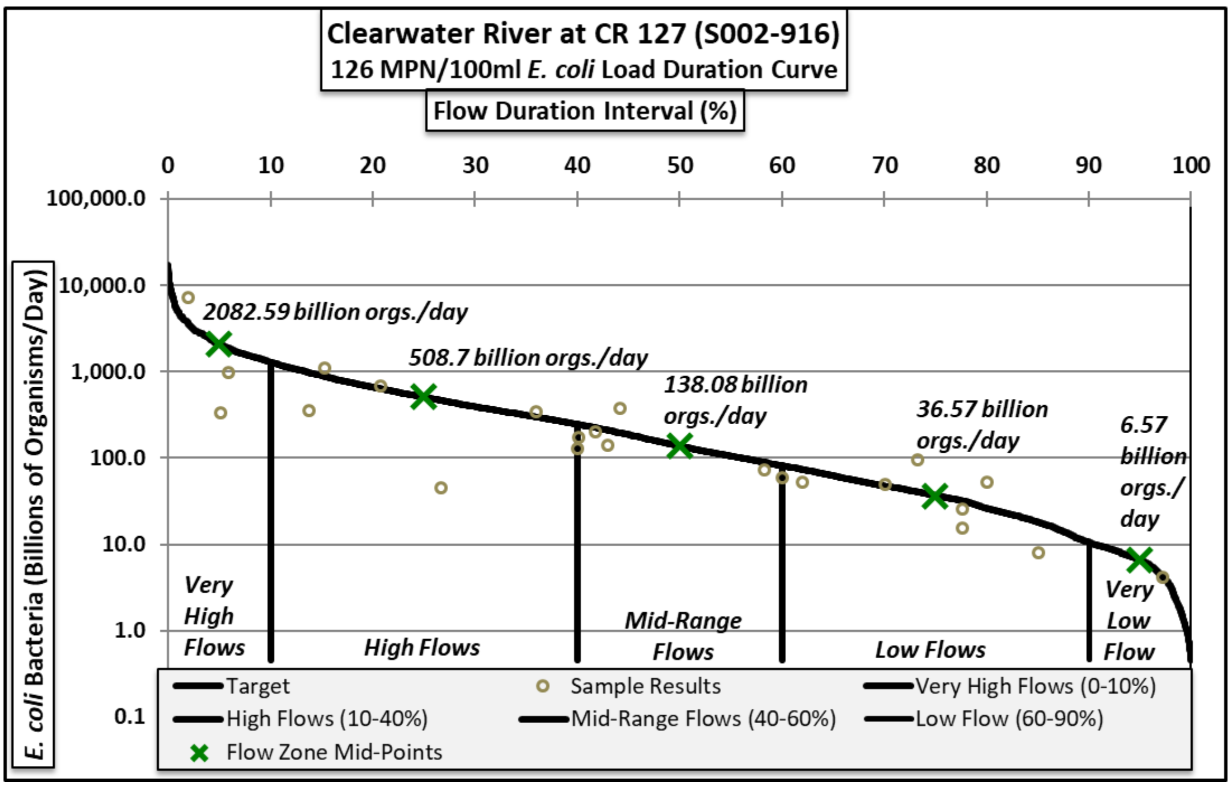


Figure 5-23. *E. coli* **load duration curve and median daily loads for the Clearwater River (AUID 47) at CR 127 (station S002-916)**

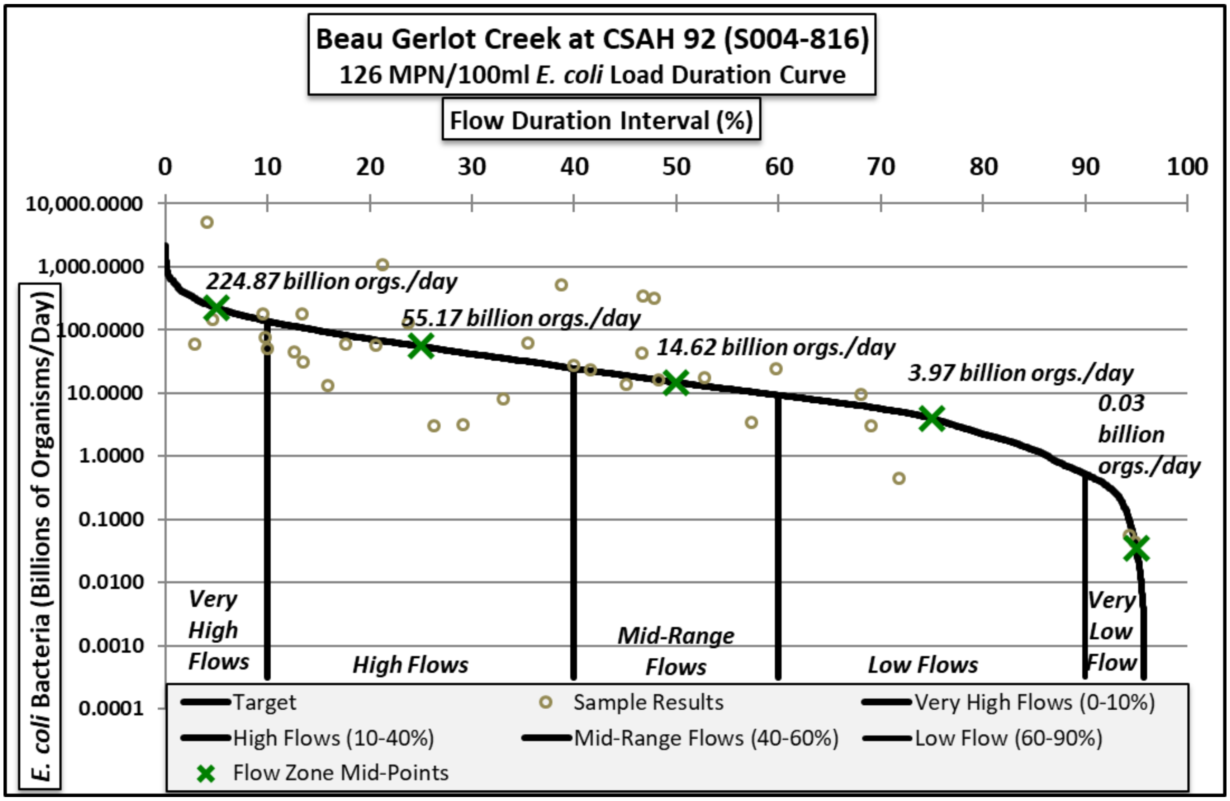


Figure 5-24. *E. coli* load duration curve and median daily loads for Beau Gerlot Creek (AUID 651) at CSAH 92 (station S004-816)

5.2.2 Load Allocation Methodology

Portions of the total LC were reserved for an MOS. There are WWTFs that discharge to waters that are impaired by *E. coli* within the Clearwater River Watershed. A reserve capacity equal to 5% of the daily LC was incorporated into TMDLs for stations downstream of those communities. No reserve capacity was warranted for the other rural, agricultural subwatersheds where *E. coli* impairments have been identified. The remaining LC for each flow regime is considered to be the LA. Where possible, load reduction recommendations were calculated. The current loading estimates were calculated by finding the average *E. coli* concentration for each flow regime. *E. coli* data collected during the years of 2007 through 2016 (most recent 10 years) was used to assess and represent current conditions within the watershed. Flow rates and flow regime values were assigned to each daily geometric mean *E. coli* data point. Daily mean *E. coli* concentrations were calculated for each flow regime. Load reduction recommendations were calculated by subtracting the LA from the current load.

5.2.3 Wasteload Allocation Methodology

The WLA represents the regulated portion of the LC, requiring a NPDES permit. Regulated sources may include construction stormwater, industrial stormwater/wastewater, MS4 permitted areas, NPDES permitted feedlots, and WWTF. There were no industrial or MS4 permitted areas upstream of *E. coli*-impaired reaches in this watershed. *E. coli* is not a typical pollutant from construction sites. There was no evidence to suggest that construction or industrial stormwater were sources of *E. coli* bacteria in any of the impaired streams, so no *E. coli* LAs were established for permitted construction or industrial stormwater sources.

There are permitted feedlots within the drainage areas of impaired reaches. No discharge is allowed to waters of the state from a CAFO or any feedlot or manure storage area with 1,000 animal units or more.

Some of the *E. coli*-impaired waters in the Clearwater River Watershed receive WWTF discharge. TMDLs account for that discharge through the calculation of WLAs (Table 5-13). The reaches with WLAs (and the contributing WWTFs in parenthesis) are listed below:

1. 090203005-504 Poplar River (Fosston WWTF MN022128 and McIntosh WWTF MNG580031)
2. 09020305-512 Lost River (Gonvick WWTF MN0020541)
3. 09020305-513 Ruffy Brook (Clearbrook WWTF MNG580098)

Section 4.2.1 describes the WWTFs that contribute to *E. coli* impairments and are incorporated into the *E. coli* TMDLs.

Average days of discharge for each WWTF were calculated from the most recent 10 years (2006 to 2015) of discharge records. Permitted concentrations and a series of conversion factors were used for the calculation of daily and annual WLAs. No reductions are recommended for any of these WWTFs.

Table 5-13. Wasteload calculations for WWTF that discharge to impaired reaches in the Clearwater River Watershed

	A	B	C	D	E	F	G	H	I
Facility	**Secondary Pond Size (acres)**	**Maximum Permitted Daily Effluent Flow (gpd)**	**Permitted Daily Discharge (L/day)**	**Average # of Days Discharging per Year (2006-15)**	**Permitted Fecal Coliform Conc. (#/100ml)**	**WLA-Fecal Coliform (10^9org/day)**	***E. coli* Colonies per Fecal Coliform Colony**	**Daily WLA - *E. coli* (10^6 org/day)**	**Annual WLA - *E. coli* (10^9 org/day)**
McIntosh WWTF MNG580031-SD-1	4	652,000	2,466,488	15.95	200	1.30	0.63	0.82	13.10
Fosston WWTF MN0022128-SD-1	22	3,211,000	13,565,682	29.00	200	6.42	0.63	4.05	117.33
Fosston WWTF MN0022128-SD-2	19.7	3,586,000	12,147,452	10.14	200	7.17	0.63	4.52	45.83
Clearbrook WWTF MNG580098-SD-2	6.76	1,102,000	4,168,364	26.29	200	2.20	0.63	1.39	36.50
Gonvick WWTF MN0020541-SD-1	N/A	100,000	378,500	315.21	200	0.20	0.63	0.13	39.72
		= A x 6 in./day x 27,152 gal/ac.in.	= B x 3.785 L/gal			= C x (E/100 ml) x (1,000 ml/L) x (1/1,000,000,000)		= F x G	= D x H

5.2.4 Margin of Safety

As described in Section 5.1.4, the statute and regulations require that a TMDL include an MOS to account for any lack of knowledge concerning the relationship between load and WLAs and water quality (CWA § 303(d)(1)(c), 40 CFR. § 130.7(c)(1)).

Field replicate (duplicate) sample results revealed *that E. coli* concentrations are more variable than other pollutants and is relatively less homogenous within a water column compared to other pollutants (particularly TSS for which >50% of duplicate samples are equal to original samples). That variability is a reason that the MPCA uses geometric means to summarize *E. coli* by day and month in the assessment process. Relative percent difference (RPD) values were calculated for each of the TMDL establishment stations where duplicate samples have been collected and stored in the MPCA EQuIS database. Dates with censored data (unknown values that were greater than the maximum reporting limit) were excluded from the analysis. The geometric mean RPD of 33 sets of duplicate and original *E. coli* samples was 19.2%. The geometric mean statistic was used to assign a MOS percentage because it aligned best with the *E. coli* assessment methods. Higher values for the average (34.1%) and median (25.2%) RPD values justify rounding the MOS for *E. coli* TMDLs up (0.8 percentage points) to 20% of the total LC.

The MOS values were included in load reduction tables to calculate numerical load reduction goals that should result in a restored stream and account for the factors of variability and uncertainty that are described in this section. The 20% MOS was applied to each flow regime, whether or not current loads exceeded LC. Reducing *E. coli* loads across all levels of flow could help reduce monthly geometric means.

5.2.5 Seasonal Variation

Table 5-14. Seasonality of *E. coli* impairments in the Clearwater River Watershed

E. coli Seasonality		Seasonal Variation				
Assessment Unit	Stream Name	May	June	July	August	September
09020305-502	Lower Badger Creek	35.7	159.2	171.7	52.5	101.2
09020305-504	Poplar River	23.0	145.3	226.3	101.2	78.5
09020305-512	Lost River	7.8	80.0	139.7	117.8	47.3
09020305-513	Ruffy Brook	147.3	216.6	304.5	270.0	252.8
09020305-526	Clear Brook	IF	128.9	111.6	73.4	IF
09020305-527	Silver Creek	24.5	146.5	543.7	369.5	164.1
09020305-529	Lost River	49.0	131.3	107.2	72.1	105.0
09020305-530	Lost River	28.2	74.6	142.7	148.5	71.8
09020305-539	Hill River	35.4	288.0	298.7	182.0	148.3
09020305-545	Nassett Creek	25.0	207.8	425.7	248.6	113.6
09020305-550	JD73	IF	118.3	233.3	318.5	230.8
09020305-574	Terrebonne Creek	39.4	260.8	410.1	338.0	239.8
09020305-578	Brooks Creek	IF	147.6	148.9	315.2	IF
09020305-647	Clearwater River	12.8	77.5	112.2	164.2	91.9
09020305-651	Beau Gerlot Creek	22.2	94.2	531.1	292.0	53.8
Concentrations are shown in MPN/100ml.						
All concentrations are geometric means from 2007-2016 data.						
Monthly geometric means are calculated for aggregate data from all sites along an assessment unit.						
Concentrations greater than 126 MPN/100ml exceed the impairment threshold for monthly geometric means.						
IF = Insufficient Data (<5 samples)						
Highlighted numerical values exceed the 126 MPN/100ml standard.						

Table 5-15. Flow conditions in which *E. coli* impairments occur throughout the Clearwater River Watershed

E. coli Seasonality		Timing of Exceedances (Flow)						
Assessment Unit	Stream Name	Flow and Water Quality Station ID	Very High Flows	High Flows	Mid-Range Flows	Low Flows	Very Low Flows (or No Flow)	Unknown
09020305-502	Lower Badger Creek	S004-837	208.1	98.4	94.3	125.1	IF	IF
09020305-504	Poplar River	S007-608	206.5	104.0	62.3	83.7	IF	IF
09020305-512	Lost River	S007-607	190.8	100.0	93.7	124.1	28.1	IF
09020305-513	Ruffy Brook	S008-057	813.0	IF	163.6	IF	IF	IF
09020305-526	Clear Brook	S004-044	66.3	155.7	IF	9.3	140.2	16.9
09020305-527	Silver Creek	S002-082	88.3	37.7	86.5	105.0	124.2	IF
09020305-529	Lost River	S005-283	60.5	67.8	193.7	293.4	IF	IF
09020305-530	Lost River	S005-501	IF	IF	IF	IF	IF	116.5
09020305-539	Hill River	S002-134	IF	113.0	12.1	149.4	90.2	IF
09020305-545	Nassett Creek	S004-205	IF	IF	IF	IF	IF	128.5
09020305-550	JD73	S003-318	297.2	140.2	162.8	IF	115.6	IF
09020305-574	Terrebonne Creek	S004-819	212.1	IF	IF	IF	328.9	8.1
09020305-578	Brooks Creek	S005-506	IF	IF	IF	IF	IF	145.6
09020305-647	Clearwater River	S002-916	IF	65.9	IF	120.8	IF	IF
09020305-651	Beau Gerlot Creek	S004-816	IF	63.4	335.8	105.0	IF	88.9
Concentrations are shown in MPN/100ml.								
All concentrations are site-specific geometric means from 2007-2016 data collected at TMDL calculation stations.								
Concentrations greater than 126 MPN/100ml exceed the impairment threshold for monthly geometric means.								
IF = Insufficient Data (<5 samples)								
Highlighted numerical values exceed the 126 MPN/100ml standard.								

Clearwater River Watershed *E. coli* impairments have occurred during the summer months of May through September, particularly June through August (Table 5-14). Many of the impairments occurred in multiple months. The LDCs in Section 5.2.1 show the different flow levels (Table 5-15) at which the impairments occur. The annual load reduction estimates in Section 5.2.7 estimate the amount of *E. coli* loading reductions that will be necessary at different flow levels in order to meet the standard.

5.2.6 Reserve Capacity

A portion of a TMDL's LC may be set aside as "reserve" to allow for future increases in pollutant loading. The concept of reserving LC for "future" sources of pollutants is expressly included in the definitions of "wasteload" and "load" allocations. Future development within this agricultural watershed will likely be modest. Population trends are flat or decreasing in areas surrounding the impaired AUIDs.

Some of the *E. coli*-impaired reaches within the Clearwater River Watershed receive water from rural, agricultural watersheds. With no city growth anticipated in these drainage areas, reserve capacities for those *E. coli* TMDLs have been set to zero. Reaches with *E. coli* impairments within rural, agricultural watersheds include:

- 09020305-502 Lower Badger Creek
- 09020305-529 Lost River
- 09020305-530 Lost River
- 09020305-539 Hill River
- 09020305-545 Nassett Creek
- 09020305-550 JD 73

- 09020305-574 Terrebonne Creek
- 09020305-578 Brooks Creek
- 09020305-651 Beau Gerlot Creek

Some of the *E. coli*-impaired waters in the Clearwater River Watershed receive drainage from communities in which some future development may be expected. A minimal amount of reserve capacity (5%) was reserved for future development within LA tables for AUIDs that receive WWTF discharge.

These reaches include:

- 090203005-504 Poplar River (Fosston WWTF and McIntosh WWTF, 5% reserve capacity)
- 09020305-512 Lost River (Gonvick WWTF and stormwater, 5% reserve capacity)
- 09020305-513 Ruffy Brook (Clearbrook WWTF, 5% reserve capacity)
- 09020305-526 Clear Brook (Clearbrook stormwater, no wastewater, 0% reserve capacity)
- 09020305-527 Silver Creek (Clearbrook stormwater, no wastewater, 0% reserve capacity)
- 09020305-647 Clearwater River (Clearbrook WWTF, 5% reserve capacity)

Modest amounts of future urban development are anticipated within this mostly agricultural watershed. Implementation goals will focus on lessening the impact of agricultural practices.

5.2.7 TMDL Summary

The following tables show the loading capacities, LA, margins of safety, reserve capacities, and WLAs that were calculated for sites along *E. coli*-impaired streams within the Clearwater River Watershed.

Nine years of continuously measured stage and flow data (open-water season) had been collected from Lower Badger Creek and provided a robust, representative dataset for developing LDCs and calculating loading capacities. No WWTFs were located within the drainage area of Lower Badger Creek. Load reductions are most necessary during very high flows.

Table 5-16. *E. coli* load allocation summary for Lower Badger Creek (AUID 502) at CR 114 (station S004-837)

2008-2016 measured stage/flow record from Station S004-837 was used to develop flow regimes & loading capacities Drainage Area (square miles): 121.77 *E. coli* Standard: 126 MPN/100ml %MS4 Urban: 0.00 Total WWTF Design Flow (mgd): 0.00	**AUID 09020305-502 Lower Badger Creek at CR 114 (S004-837) Loading Capacity and Load Allocations for *E. coli* Duration Curve Zone**				
	Very High	**High**	**Mid-Range**	**Low**	**No Flow**
Values expressed as billions of organisms per day					
TOTAL DAILY LOADING CAPACITY	**306.21**	**122.01**	**34.49**	**17.53**	**0.00**
Median Flow	99.33	39.58	11.19	5.69	0.00
Median Flow Exceedance	5%	25%	50%	70.51%	90.48%
Wasteload Allocations					
NPDES Permitted WWTF	N/A	N/A	N/A	N/A	N/A
Reserve Capacity	N/A	N/A	N/A	N/A	N/A
Daily Load Allocation	244.97	97.61	27.59	14.02	0.00
Daily Margin of Safety	61.24	24.40	6.90	3.51	0.00
Values expressed as percentages of the total daily loading capacity					
Wasteload Allocations					
NPDES Permitted WWTF	N/A	N/A	N/A	N/A	N/A
Reserve Capacity	N/A	N/A	N/A	N/A	N/A
Load Allocation	80%	80%	80%	80%	80%
Margin of Safety	20%	20%	20%	20%	20%

Table 5-17. Annual *E. coli* load reduction needed for Lower Badger Creek (AUID 502) at CR 114 (station S004-837)

Lower Badger Creek (09020305-502) Annual *E. coli* Load Reductions	Very High Flow	High Flow	Mid-Range Flow	Low Flow	No Flow	Annual Totals
Current Geometric Mean Daily Load (billions of orgs/day) for Flow Regime	798.95	81.35	23.89	6.81	0.00	
Loading Capacity (billions of orgs/day)	306.21	122.01	34.49	17.53	0.00	
Load reduction (billions of orgs/day)	492.74	0.00	0.00	0.00	0.00	
% of Flows Represented	10%	30%	20%	20.95%	19.05%	100%
# of Days Represented	36.5	109.5	73.0	76.5	69.5	365.00
Annual Load Reduction (billions of orgs/yr.)	17,985.01	0.00	0.00	0.00	0.00	17,985.01
Total Current Load	29,161.68	8,907.83	1,743.97	520.74	0.00	40,334.21
Percent Reduction	61.67%	0.00%	0.00%	0.00%	0.00%	44.59%
Margin of Safety (20% of daily LC)	2,235.26	2,671.80	503.70	268.40	0.00	5,679.16
Load reduction goal to meet the standard and provide a margin of safety						23,664.17

Flow had been measured in the Poplar River throughout four sampling seasons. There are times during which the stream does not flow. Flow reductions are most necessary during very high and high flows, which indicates that the sources of excess *E. coli* in the stream are those that contribute during runoff events.

Table 5-18. *E. coli* load allocation summary for Poplar River (AUID 504) at CR 118 (station S007-608)

2013-2016 measured stage/flow record from Station S007-608 was used to develop flow regimes & loading capacities Drainage Area (square miles): 116.69 *E. coli* Standard: 126 MPN/100ml %MS4 Urban: 0.00 Total WWTF Design Flow (mgd): 7.445	**AUID 09020305-504 Poplar River at County Road 118 (S007-608) Loading Capacity and Load Allocations for *E. coli***				
	Duration Curve Zone				
	Very High	**High**	**Mid-Range**	**Low**	**No Flow**
Values expressed as billions of organisms per day					
TOTAL DAILY LOADING CAPACITY	**280.44**	**135.64**	**55.82**	**24.35**	0.00
Median Flow	90.97	44.00	18.11	7.90	0.00
Median Flow Exceedance	5%	25%	50%	71.73%	91.73%
Wasteload Allocations*					
Fosston WWTF MN022128-SD-001	17.09	17.09	17.09	**	**
Fosston WWTF MN022128-SD-002	15.31	15.31	15.31	**	**
McIntosh WWTF MNG585031-SD-001	3.11	3.11	3.11	**	**
Reserve Capacity	14.02	6.78	2.79	1.22	0.00
Daily Load Allocation	**174.82**	**66.22**	**6.36**	**18.26**	**0.00**
Daily Margin of Safety	56.09	27.13	11.16	4.87	0.00
Values expressed as percentages of the total daily loading capacity					
Wasteload Allocations					
Fosston WWTF MN022128-SD-001	6.09%	12.60%	30.62%	*	N/A
Fosston WWTF MN022128-SD-002	5.46%	11.29%	27.43%	*	N/A
McIntosh WWTF MNG585031-SD-001	1.11%	2.29%	5.57%	*	N/A
Reserve Capacity	5.00%	5.00%	5.00%	5.00%	N/A
Load Allocation	62.34%	48.82%	11.38%	75.00%	N/A
Margin of Safety	20.00%	20.00%	20.00%	20%	N/A
*Wasteload Allocations are rounded to the nearest 2 digits (1/100th) **The WLAs for WWTFs requiring NPDES permits were based on design flows and exceeded the daily loading capacity of this flow regime. Instead, the WLA and LA allocations were determined by the formula: *E. coli Allocation = (flow volume contribution from a given source) x (126 org./100 ml E. coli)*					

Table 5-19. Annual *E. coli* load reduction needed for the Poplar River (AUID 504) at CR 118 (station S007-608)

Poplar River (09020305-504) Annual *E. coli* Load Reductions	Very High Flow	High Flow	Mid-Range Flow	Low Flow	No Flow	Annual Totals
Current Geometric Mean Daily Load (billions of orgs/day) for Flow Regime	423.11	97.03	28.02	8.28	-	
Loading Capacity (billions of orgs/day)	280.44	135.64	55.82	24.35	-	
Load reduction (billions of orgs/day)	142.67	0.00	0.00	0.00	-	
% of Flows Represented	10%	30%	20%	23.75%	16.25%	100%
# of Days Represented	36.5	109.5	73.0	86.7	59.3	365.00
Annual Load Reduction (billions of orgs/yr.)	5,207.46	0.00	0.00	0.00	0.00	**5,207.46**
Total Current Load	15,443.52	10,624.79	2,045.46	717.77	0	28,831.53
Percent Reduction	**33.72%**	0.00%	0.00%	0.00%	0.00%	**18.06%**
Margin of Safety (20% of daily LC)	2,047.29	2,970.74	814.68	422.17	0.00	**6,254.87**
Load reduction goal to meet the standard and provide a margin of safety						**11,462.33**

Simulated daily average flow data from the 1996 through 2016 HSPF model were used to calculate the *E. coli* TMDL for Station S000-924 on the AUID 512 portion of the Lost River. This station is located near the pour point of the AUID. A measured flow record was not recorded at the station. Downstream beaver dams were common at the site, which made the site unsuitable for the development of a flow rating curve or water level logger deployments. Load calculations show that reductions are needed throughout the range of flows at the station. Table 5-15 shows that the highest *E. coli* concentrations were recorded during very high flows, but the geometric mean concentrations recorded during high and low flows were relatively close to the impairment threshold.

Table 5-20. *E. coli* load allocation summary for the Lost River (AUID 512) at 139th Avenue (station S000-924)

Flow record: Simulated 1996-2016 data from an HSPF model Drainage Area (square miles): 54.56 *E. coli* Standard: 126 MPN/100ml %MS4 Urban: 0.00 Total WWTF Design Flow (mgd): 0.100	**AUID 09020305-512 Lost River at 139th Ave (S000-924) Loading Capacity and Load Allocations for *E. coli* Duration Curve Zone**				
	Very High	**High**	**Mid-Range**	**Low**	**Very Low**
Values expressed as billions of organisms per day					
TOTAL DAILY LOADING CAPACITY	**254.36**	**62.41**	**19.27**	**4.97**	**0.46**
Median Flow	82.51	20.25	6.25	1.61	0.15
Median Flow Exceedance	5%	25%	50%	75.0%	95.0%
Wasteload Allocations*					
Gonvick WWTF MN0020541-SD-001	0.48	0.48	0.48	0.48	**
Reserve Capacity	12.72	3.12	0.96	0.25	0.02
Daily Load Allocation	**190.29**	**46.33**	**13.98**	**3.25**	**0.35**
Daily Margin of Safety	50.87	12.48	3.85	0.99	0.09
Values expressed as percentages of the total daily loading capacity					
Wasteload Allocations					
Gonvick WWTF MN0020541-SD-001	0.19%	0.77%	2.49%	9.66%	0.00%
Reserve Capacity	5.00%	5.00%	5.00%	5.00%	5.00%
Load Allocation	74.81%	74.23%	72.51%	65.34%	75.00%
Margin of Safety	20.00%	20.00%	20.00%	20.00%	20.00%
*Wasteload Allocations are rounded to the nearest 2 digits (1/100th) **The WLAs for WWTFs requiring NPDES permits were based on design flows and exceeded the daily loading capacity of this flow regime. Instead, the WLA and LA allocations were determined by the formula: *E. coli Allocation = (flow volume contribution from a given source) x (126 org./100 ml E. coli*)					

Table 5-21. Annual *E. coli* load reduction needed for the Lost River (AUID 512) at 139th Avenue (station S000-924)

Lost River (09020305-512) Annual *E. coli* Load Reductions	**Very High Flow**	**High Flow**	**Mid-Range Flow**	**Low Flow**	**Very Low Flow**	**Annual Totals**
Current Geometric Mean Daily Load (billions of orgs/day) for Flow Regime	108.20	122.17	29.26	8.69	No Data	
Loading Capacity(billions of orgs/day)	254.36	62.41	19.27	4.97	0.46	
Load reduction (billions of orgs/day)	-	59.76	9.99	3.72	-	
% of Flows Represented	10%	30%	20%	30.0%	10.0%	100%
# of Days Represented	36.5	109.5	73.0	109.5	36.5	365.00
Annual Load Reduction (billions of orgs/yr.)	-	6,543.72	729.27	407.34	-	**7,680.33**
Total Current Load	3,949.30	13,377.62	2,135.98	951.56	0	20,414.45
Percent Reduction	0.00%	**48.92%**	**34.14%**	**42.81%**	0.00%	**37.62%**
Margin of Safety (20% of daily LC)	1,856.76	1,366.56	281.05	108.41	3.29	3,616.06
Load reduction goal to meet the standard and provide a margin of safety						**11,296.39**

Stage and flow measurement data was collected at the CSAH 11 crossing of Ruffy Brook (Station S009-057). Nearly 20% of the daily average flow data points were zero cfs. Permitted discharge from the Clearbrook WWTF comprises a more than a third of the daily LC during low flows, however, since this is a stabilization pond facility and only discharges during typical higher flow periods, no reductions are required from this WWTF in the TMDL. Load reductions are needed throughout the range of measurable flows in Ruffy Brook.

Table 5-22. *E. coli* load allocation summary for Ruffy Brook (AUID 513) at CSAH 11 (station S008-057)

Flow record: Measured 2014-2016 stage and flow data from Station S008-057 Drainage Area (square miles): 51.13 *E. coli* Standard: 126 MPN/100ml %MS4 Urban: 0.00 Total WWTF Design Flow (mgd): 1.102	AUID 09020305-513 Ruffy Brook at CSAH 11 (S008-057) Loading Capacity and Load Allocations for *E. coli*				
	Duration Curve Zone				
	Very High	High	Mid-Range	Low	No Flow
Values expressed as billions of organisms per day					
TOTAL DAILY LOADING CAPACITY	**349.08**	**131.13**	**37.11**	**14.71**	0.00
Median Flow	113.24	42.54	12.04	4.77	0.00
Median Flow Exceedance	5%	25%	50%	70.08%	90.03%
Wasteload Allocations*					
Clearbrook WWTF MNG580098-SD-002	5.25	5.25	5.25	5.25	0.00
Reserve Capacity	17.45	6.56	1.86	0.74	0.00
Daily Load Allocation	**256.56**	**93.09**	**22.58**	**5.78**	**0.00**
Daily Margin of Safety	69.82	26.23	7.42	2.94	0.00
Values expressed as percentages of the total daily loading capacity					
Wasteload Allocations					
Clearbrook WWTF MNG580098-SD-002	1.50%	4.00%	14.15%	35.69%	N/A
Reserve Capacity	5%	5%	5%	5%	N/A
Load Allocation	73.50%	71.00%	60.85%	39.31%	N/A
Margin of Safety	20%	20%	20%	20%	N/A
*Wasteload Allocations are rounded to the nearest 2 digits (1/100th)					

Table 5-23. Annual *E. coli* load reduction needed for Ruffy Brook (AUID 513) at CSAH 11 (station S008-057)

Ruffy Brook (09020305-513) Annual *E. coli* Load Reductions	**Very High Flow**	**High Flow**	**Mid-Range Flow**	**Low Flow**	**No Flow**	
Current Geometric Mean Daily Load (billions of orgs/day) for Flow Regime	1,704.76	207.39	53.04	11.49	0.00	**Annual Totals**
Loading Capacity (billions of orgs/day)	349.08	131.13	37.11	14.71	-	
Load reduction (billions of orgs/day)	1,355.68	76.26	15.93	0.00	-	
% of Flows Represented	10%	30%	20%	20.1%	19.9%	100%
# of Days Represented	36.5	109.5	73.0	73.2	72.8	365.00
Annual Load Reduction (billions of orgs/yr.)	49,482.32	8,350.47	1,162.89	0.00	-	**58,995.68**
Total Current Load	62,223.74	22,709.21	3,871.92	841.13	0	89,645.99
Percent Reduction	**79.5%**	**36.8%**	**30.0%**	0.0%	0.0%	**65.8%**
Margin of Safety (20% of daily LC)	2,548.43	2,872.19	541.66	215.22	0.00	6,177.50
Load reduction goal to meet the standard and provide a margin of safety						**65,173.18**

Simulated flows from the 1996-2016 HSPF model were analyzed to calculate the *E. coli* TMDL for Station 2004-044 on AUID 526 of Clear Brook. The furthest downstream crossing, CSAH 92, is a long-term water quality monitoring station. High geometric mean concentrations are found in the data for multiple flow regimes (Table 5-15).

Table 5-24. *E. coli* load allocation summary for Clear Brook (AUID 526) at CSAH 92 (station S004-044)

Flow record: Area-weighted HSPF-simulated 1996-2016 flow data from HSPF Reach 435 and discrete measurements from Station S004-044 Drainage Area (square miles): 5.95 *E. coli* Standard: 126 MPN/100ml %MS4 Urban: 0.00 Total WWTF Design Flow (mgd): 0.00	**AUID 09020305-526 Clear Brook at CSAH 92 (S004-044) Loading Capacity and Load Allocations for *E. coli* Duration Curve Zone**				
	Very High	**High**	**Mid-Range**	**Low**	**Very Low**
Values expressed as billions of organisms per day					
TOTAL DAILY LOADING CAPACITY	**29.38**	**7.20**	**2.00**	**0.55**	**0.06**
Median Flow	9.53	2.34	0.65	0.18	0.02
Median Flow Exceedance	5%	25%	50%	75%	95%
Wasteload Allocations					
NPDES Permitted WWTF (none)	N/A	N/A	N/A	N/A	N/A
Reserve Capacity	N/A	N/A	N/A	N/A	N/A
Daily Load Allocation	**23.50**	**5.76**	**1.60**	**0.44**	**0.05**
Daily Margin of Safety	5.88	1.44	0.40	0.11	0.01
Values expressed as percentages of the total daily loading capacity					
Wasteload Allocations					
NPDES Permitted WWTF (none)	N/A	N/A	N/A	N/A	N/A
Reserve Capacity	N/A	N/A	N/A	N/A	N/A
Load Allocation	80%	80%	80%	80%	80%
Margin of Safety	20%	20%	20%	20%	20%

Table 5-25. Annual *E. coli* load reduction needed for Clear Brook (AUID 526) at CSAH 92 (station S004-044)

Clear Brook (09020305-526) Annual *E. coli* Load Reductions	**Very High Flow**	**High Flow**	**Mid-Range Flow**	**Low Flow**	**Very low Flow**	**Annual Totals**
Current Geometric Mean Daily Load (billions of orgs/day) for Flow Regime	15.24	9.12	1.13	0.04	0.03	
Loading Capacity (billions of orgs/day)	29.38	7.20	2.00	0.55	0.06	
Load reduction (billions of orgs/day)	0.00	1.92	0.00	0.00	0.00	
% of Flows Represented	10%	30%	20%	30%	10%	100%
# of Days Represented	36.50	109.50	73.00	109.50	36.50	365.00
Annual Load Reduction (billions of orgs/yr.)	0.00	210.24	0.00	0.00	0.00	**210.24**
Total Current Load	556.26	998.64	82.49	4.38	1.10	1,642.87
Percent Reduction	0.00%	**21.05%**	0.00%	0.00%	0.00%	**12.80%**
Margin of Safety (20% of daily LC)	214.62	157.68	29.20	12.05	0.37	413.91
Load reduction goal to meet the standard and provide a margin of safety						**624.15**

The *E. coli* TMDL and load reduction for Silver Creek was calculated for the long-term monitoring site with the most water quality data and flow data, near the pour point of the watershed. Differing degrees of *E. coli* reductions will be needed for Silver Creek throughout the drainage area, including its tributary Clear Brook. Efforts to reduce *E. coli* loads will be needed throughout the drainage area of AUID 527 as high concentrations have been recorded throughout much of the AUID.

Table 5-26. *E. coli* load allocation summary for Silver Creek (AUID 527) at CR 111 (station S002-082)

2002-2016 measured stage/flow data from Station S002-082 was used to develop flow regimes & loading capacities Drainage Area (square miles): 31.56 *E. coli* Standard: 126 MPN/100ml %MS4 Urban: 0.00 Total WWTF Design Flow (mgd): 0.00	**AUID 09020305-527 Silver Creek at CR 111 (S002-082) Loading Capacity and Load Allocations for *E. coli***				
	Duration Curve Zone				
	Very High	**High**	**Mid-Range**	**Low**	**No Flow**
Values expressed as billions of organisms per day					
TOTAL DAILY LOADING CAPACITY	**120.76**	**30.49**	**9.71**	**2.23**	**0.00**
Median Flow	39.18	9.89	3.15	0.73	0.00
Median Flow Exceedance	5%	25%	50%	66.57%	86.58%
Wasteload Allocations					
NPDES Permitted WWTF (none)	N/A	N/A	N/A	N/A	N/A
Reserve Capacity	N/A	N/A	N/A	N/A	N/A
Daily Load Allocation	**96.61**	**24.39**	**7.77**	**1.78**	**0.00**
Daily Margin of Safety	24.15	6.10	1.94	0.45	0.00
Values expressed as percentages of the total daily loading capacity					
Wasteload Allocations					
NPDES Permitted WWTF (none)	N/A	N/A	N/A	N/A	N/A
Reserve Capacity	N/A	N/A	N/A	N/A	N/A
Load Allocation	80%	80%	80%	80%	80%
Margin of Safety	20%	20%	20%	20%	20%

Table 5-27. Annual *E. coli* load reduction needed for Silver Creek (AUID 527) at CR 111 (station S002-082)

Silver Creek (09020305-527) Annual *E. coli* Load Reductions	**Very High Flow**	**High Flow**	**Mid-Range Flow**	**Low Flow**	**No Flow**	**Annual Totals**
Current Geometric Mean Daily Load (billions of orgs/day) for Flow Regime	38.88	7.25	5.91	2.70	0.00	
Loading Capacity (billions of orgs/day)	120.76	30.49	9.71	2.23	0.00	
Load reduction (billions of orgs/day)	0.00	0.00	0.00	0.47	0.00	
% of Flows Represented	10%	30%	20%	13.1%	26.9%	100%
# of Days Represented	36.50	109.50	73.00	47.78	98.22	365.00
Annual Load Reduction (billions of orgs/yr.)	0.00	0.00	0.00	22.46	0.00	**22.46**
Total Current Load	1,419.12	793.88	431.43	129.02	0.00	2,773.44
Percent Reduction	0.00%	0.00%	0.00%	**17.41%**	0.00	**0.81%**
Margin of Safety (20% of daily LC)	881.48	667.95	141.62	21.50	0.00	**1,712.55**
Load reduction goal to meet the standard and provide a margin of safety						**1,735.01**

Stage and flow measurements were collected with water level loggers and used to calculate the *E. coli* TMDL for Station S005-283 on AUID 529 of the Lost River. Load reductions are needed during mid-range flows. Restoration of this AUID may also require restoration the impaired upstream AUID 530.

Table 5-28. *E. coli* load allocation summary for the Lost River (AUID 529) at 109th Street (station S005-283)

2009-2016 measured stage/flow data from Station S005-283 was used to develop flow regimes & loading capacities Drainage Area (square miles): 28.53 *E. coli* Standard: 126 MPN/100ml %MS4 Urban: 0.00 Total WWTF Design Flow (mgd): 0.00	AUID 09020305-529 Lost River at 109th Street (S005-283) Loading Capacity and Load Allocations for *E. coli* Duration Curve Zone				
	Very High	**High**	**Mid-Range**	**Low**	**No Flow**
Values expressed as billions of organisms per day					
TOTAL DAILY LOADING CAPACITY	**179.16**	**101.39**	**47.22**	**14.30**	**0.00**
Median Flow	58.12	32.89	15.32	4.64	0.00
Median Flow Exceedance	5%	25%	50%	73.62%	93.58%
Wasteload Allocations					
NPDES Permitted WWTF	N/A	N/A	N/A	N/A	N/A
Reserve Capacity	N/A	N/A	N/A	N/A	N/A
Daily Load Allocation	**143.33**	**81.11**	**37.78**	**11.44**	**0.00**
Daily Margin of Safety	35.83	20.28	9.44	2.86	0.00
Values expressed as percentages of the total daily loading capacity					
Wasteload Allocations					
NPDES Permitted WWTF	N/A	N/A	N/A	N/A	N/A
Reserve Capacity	N/A	N/A	N/A	N/A	N/A
Load Allocation	80%	80%	80%	80%	80%
Margin of Safety	20%	20%	20%	20%	20%

Table 5-29. Annual *E. coli* load reduction needed for the Lost River (AUID 529) at 109th Street (station S005-283)

Lost River (09020305-529) Annual *E. coli* Load Reductions	**Very High Flow**	**High Flow**	**Mid-Range Flow**	**Low Flow**	**No Flow**	**Annual Totals**
Current Geometric Mean Daily Load (billions of orgs/day) for Flow Regime	94.81	48.25	76.46	8.53	0.00	
Loading Capacity (billions of orgs/day)	179.16	101.39	47.22	14.30	0.00	
Load reduction (billions of orgs/day)	0.00	0.00	29.24	0.00	0.00	
% of Flows Represented	10.00%	30.00%	20.00%	27.15%	12.85%	100%
# of Days Represented	36.5	109.5	73.0	99.1	46.9	365.00
Annual Load Reduction (billions of orgs/yr.)	0.00	0.00	2,134.52	0.00	0.00	**2,134.52**
Total Current Load	3,460.57	5,283.38	5,581.58	845.45	0.00	15,170.97
Percent Reduction	0.00%	0.00%	**38.24%**	0.00%	0.00%	**14.07%**
Margin of Safety (20% of daily LC)	1,307.80	2,220.66	689.12	283.47	0.00	4,501.04
Load reduction goal to meet the standard and provide a margin of safety						**6,635.56**

This reach did not have a station with a measured flow record, so simulated data from the 1996 through 2016 HSPF model was used to calculate the TMDL for Station S005-501 on AUID 530 of the Lost River. High concentrations along this AUID may be contributing to high concentrations in the downstream AUID 529. Load reductions are needed during a broad range of flows (low flow, mid-range flows, and high flows).

Table 5-30. *E. coli* load allocation summary for the Lost River (AUID 530) at Lindberg Lake Road (station S005-501)

Flow regimes and loading capacities developed from area-weighted, HSPF-simulated 1996-2016 flow data from HSPF Reach 441 Drainage Area (square miles): 20.5 *E. coli* Standard: 126 MPN/100ml %MS4 Urban: 0.00 Total WWTF Design Flow (mgd): 0.00	AUID 09020305-530 Lost River at Lindberg Lake Road (S005-501) Loading Capacity and Load Allocations for *E. coli* Duration Curve Zone				
	Very High	**High**	**Mid-Range**	**Low**	**Very Low**
Values expressed as billions of organisms per day					
TOTAL DAILY LOADING CAPACITY	**102.00**	**23.12**	**6.56**	**1.82**	**0.17**
Median Flow	33.09	7.50	2.13	0.59	0.06
Median Flow Exceedance	5%	25%	50%	75.0%	95.0%
Wasteload Allocations					
NPDES Permitted WWTF	N/A	N/A	N/A	N/A	N/A
Reserve Capacity	N/A	N/A	N/A	N/A	N/A
Daily Load Allocation	**81.60**	**18.50**	**5.25**	**1.46**	**0.14**
Daily Margin of Safety	20.40	4.62	1.31	0.36	0.03
Values expressed as percentages of the total daily loading capacity					
Wasteload Allocations					
NPDES Permitted WWTF	N/A	N/A	N/A	N/A	N/A
Reserve Capacity	N/A	N/A	N/A	N/A	N/A
Load Allocation	80%	80%	80%	80%	80%
Margin of Safety	20%	20%	20%	20%	20%

Table 5-31. Annual *E. coli* load reduction needed for the Lost River (AUID 530) at Lindberg Lake Road (station S005-501)

Lost River (09020305-530) Annual *E. coli* Load Reductions	Very High Flow	High Flow	Mid-Range Flow	Low Flow	Very Low Flow	Annual Totals
Current Geometric Mean Daily Load (billions of orgs/day) for Flow Regime	37.11	34.31	6.88	3.08	No Data	
Loading Capacity (billions of orgs/day)	102.00	23.12	6.56	1.82	0.17	
Load reduction (billions of orgs/day)	-	11.19	0.32	1.26	Unknown	
% of Flows Represented	10%	30%	20%	30.0%	10.0%	100%
# of Days Represented	36.5	109.5	73.0	109.5	36.5	365.00
Annual Load Reduction (billions of orgs/yr.)	-	1,225.31	23.36	137.97	Unknown	**1,386.64**
Total Current Load	1,354.52	3,756.95	502.24	337.26	Unknown	5,950.96
Percent Reduction	0.00%	**32.61%**	**4.65%**	**40.91%**	Unknown	**23.30%**
Margin of Safety (20% of daily LC)	744.60	**505.89**	**95.63**	**39.42**	1.10	**1,386.64**
Load reduction goal to meet the standard and provide a margin of safety						**2,773.28**

Measured stage and flow data were used to calculate the *E. coli* TMDL for Station S002-134 on AUID 539 of the Hill River. There was no permitted WWTF discharge to the Hill River. In addition to nonpoint sources of *E. coli*; however, there were indications (MST results and conversations with local staff) that there may have failing septic systems in the drainage area. Load reductions will be needed in all flow regimes except for very high flows. No-flow conditions comprised 12.6% of the daily average flow record.

Table 5-32. *E. coli* load allocation summary for the Hill River (AUID 539) at CR 119 (station S002-134)

2013-2016 continuously measured stage/flow data and 2001-2012 discrete stage/flow data from Station S002-134 were used to develop flow regimes and loading capacities. Drainage Area (square miles): 151.87 *E. coli* Standard: 126 MPN/100ml %MS4 Urban: 0.00 Total WWTF Design Flow (mgd): 0.00	**AUID 09020305-539 Hill River at County Road 119 (S002-134) Loading Capacity and Load Allocations for *E. coli***				
	Duration Curve Zone				
	Very High	**High**	**Mid-Range**	**Low**	**No Flow**
Values expressed as billions of organisms per day					
TOTAL DAILY LOADING CAPACITY	**373.47**	**125.37**	**58.57**	**11.89**	**0.00**
Median Flow	121.15	40.67	19.00	3.86	0.00
Median Flow Exceedance	5%	25%	50%	73.75%	93.71%
Wasteload Allocations					
NPDES Permitted WWTF	N/A	N/A	N/A	N/A	N/A
Reserve Capacity	N/A	N/A	N/A	N/A	N/A
Daily Load Allocation	**298.78**	**100.30**	**46.86**	**9.51**	**0.00**
Daily Margin of Safety	74.69	25.07	11.71	2.38	0.00
Values expressed as percentages of the total daily loading capacity					
Wasteload Allocations					
NPDES Permitted WWTF	N/A	N/A	N/A	N/A	N/A
Reserve Capacity	N/A	N/A	N/A	N/A	N/A
Load Allocation	80%	80%	80%	80%	80%
Margin of Safety	20%	20%	20%	20%	20%

Table 5-33. Annual *E. coli* load reduction needed for the Hill River (AUID 539) at CR 119 (station S002-134)

Hill River (09020305-539) Annual *E. coli* Load Reductions	**Very High Flow**	**High Flow**	**Mid-Range Flow**	**Low Flow**	**No Flow**	**Annual Total**
Current Geometric Mean Daily Load (billions of orgs/day) for Flow Regime	200.80	139.06	68.12	12.05	0.00	
Loading Capacity (billions of orgs/day)	373.47	125.37	58.57	11.89	0.00	
Load reduction (billions of orgs/day)	0.00	13.69	9.55	0.16	0.00	
% of Flows Represented	10%	30%	20%	27.41%	12.59%	100%
# of Days Represented	36.5	109.5	73.0	100.0	46.0	365.00
Annual Load Reduction (billions of orgs/yr.)	0.00	1,499.06	697.15	16.01	0.00	**2,212.21**
Total Current Load	7,329.20	15,227.07	4,972.76	1,205.56	0.00	28,734.59
Percent Reduction	0.00%	**9.84%**	**14.02%**	**1.33%**	0.00%	**7.70%**
Margin of Safety (20% of daily LC)	2,726.19	**2,745.17**	**854.8/3**	**238.11**	0.00	**6,564.29**
Load reduction goal to meet the standard and provide a margin of safety						**8,776.50**

Simulated and area-weighted flow data from the 1996 through 2016 HSPF model was used to calculate the *E. coli* TMDL for Station S004-205 on Nassett Creek. There was no permitted WWTF discharge to Nassett Creek. Load reductions will be needed for sources that contribute excess bacteria throughout the range of flows in this stream.

Table 5-34. *E. coli* load allocation summary for Nassett Creek (AUID 545) (station S004-205)

Flow regimes and loading capacities developed from area-weighted, HSPF-simulated 1996-2016 flow data from HSPF Reach 441 Drainage Area (square miles): 6.15 *E. coli* Standard: 126 MPN/100ml %MS4 Urban: 0.00 Total WWTF Design Flow (mgd): 0.00	**AUID 09020305-545 Nassett Creek (S004-205) Loading Capacity and Load Allocations for *E. coli* Duration Curve Zone**				
	Very High	**High**	**Mid-Range**	**Low**	**Very Low**
Values expressed as billions of organisms per day					
TOTAL DAILY LOADING CAPACITY	**30.60**	**6.94**	**1.97**	**0.55**	**0.05**
Median Flow	9.93	2.25	0.64	0.18	0.02
Median Flow Exceedance	5%	25%	50%	75.0%	95.0%
Wasteload Allocations					
NPDES Permitted WWTF (Clearbrook)	N/A	N/A	N/A	N/A	N/A
Reserve Capacity	N/A	N/A	N/A	N/A	N/A
Daily Load Allocation	**24.48**	**5.55**	**1.58**	**0.44**	**0.04**
Daily Margin of Safety	6.12	1.39	0.39	0.11	0.01
Values expressed as percentages of the total daily loading capacity					
Wasteload Allocations					
NPDES Permitted WWTF (Clearbrook)	N/A	N/A	N/A	N/A	N/A
Reserve Capacity	N/A	N/A	N/A	N/A	N/A
Load Allocation	80%	80%	80%	80%	80%
Margin of Safety	20%	20%	20%	20%	20%

Table 5-35. Annual *E. coli* load reduction needed for Nassett Creek (AUID 545) (station S004-205)

Nassett Creek (09020305-545) Annual *E. coli* Load Reductions	**Very High Flow**	**High Flow**	**Mid-Range Flow**	**Low Flow**	**Very Low Flow**	**Annual Totals**
Current Geometric Mean Daily Load (billions of orgs/day) for Flow Regime	29.55	10.14	1.53	2.48	No Data	
Loading Capacity (billions of orgs/day)	30.60	6.94	1.97	0.55	0.05	
Load reduction (billions of orgs/day)	0.00	3.20	0.00	1.93	0.00	
% of Flows Represented	10%	30%	20%	30.0%	10.0%	100%
# of Days Represented	36.5	109.5	73.0	109.5	36.5	365.00
Annual Load Reduction (billions of orgs/yr.)	0.00	350.40	0.00	211.34	0.00	**561.74**
Total Current Load	1,078.58	1,110.33	111.69	271.56	0.00	2,572.16
Percent Reduction	0.00%	**31.56%**	0.00%	**77.82%**	0.00%	**21.84%**
Margin of Safety (20% of daily LC)	223.38	152.21	28.47	12.05	0.37	416.47
Load reduction goal to meet the standard and provide a margin of safety						**978.21**

A record of daily stage and flow values was collected at Station S003-318 near the downstream end of AUID 550 on JD 73 and used to calculate an *E. coli* TMDL at that station. There was no permitted WWTF discharge to JD 73.

Table 5-36. *E. coli* load allocation summary for the JD 73 (AUID 550) at 343rd St. (station S003-318)

2014-2016 continuously measured stage/flow data and 2004-2013 discrete stage/flow data from Station S003-318 were used to develop flow regimes and loading capacities. Drainage Area (square miles): 49.7 *E. coli* Standard: 126 MPN/100ml %MS4 Urban: 0.00 Total WWTF Design Flow (mgd): 0.00	**AUID 09020305-550 Judicial Ditch 73 at 343rd St. (S003-318) Loading Capacity and Load Allocations for *E. coli* Duration Curve Zone**				
	Very High	**High**	**Mid-Range**	**Low**	**No Flow**
Values expressed as billions of organisms per day					
TOTAL DAILY LOADING CAPACITY	**368.37**	**140.71**	**43.35**	**7.92**	**0.00**
Median Flow	119.50	45.64	14.06	2.57	0.00
Median Flow Exceedance	5%	25%	50%	69.47%	89.44%
Wasteload Allocations					
NPDES Permitted WWTF	N/A	N/A	N/A	N/A	N/A
Reserve Capacity	N/A	N/A	N/A	N/A	N/A
Daily Load Allocation	**294.70**	**112.57**	**34.68**	**6.34**	**0.00**
Daily Margin of Safety	73.67	28.14	8.67	1.58	0.00
Values expressed as percentages of the total daily loading capacity					
Wasteload Allocations					
NPDES Permitted WWTF	N/A	N/A	N/A	N/A	N/A
Reserve Capacity	N/A	N/A	N/A	N/A	N/A
Load Allocation	80%	80%	80%	80%	80%
Margin of Safety	20%	20%	20%	20%	20%

Table 5-37. Annual *E. coli* load reduction needed for JD 73 (AUID 550) at 343rd Street (station S003-318)

JD 73 (09020305-550) Annual *E. coli* Load Reductions	**Very High Flow**	**High Flow**	**Mid-Range Flow**	**Low Flow**	**No Flow**	**Annual Totals**
Current Geometric Mean Daily Load (billions of orgs/day) for Flow Regime	789.16	161.37	59.58	39.91	0.00	
Loading Capacity (billions of orgs/day)	368.37	140.71	43.35	7.92	0.00	
Load reduction (billions of orgs/day)	420.79	20.66	16.23	31.99	0.00	
% of Flows Represented	10%	30%	20%	18.89%	21.11%	100%
# of Days Represented	36.5	109.5	73.0	68.94	77.06	365.00
Annual Load Reduction (billions of orgs/yr.)	15,358.84	2,262.27	1,184.79	2,205.35	0.00	**21,011.24**
Total Current Load	28,804.34	17,670.02	4,349.34	2,751.34	0.00	53,575.04
Percent Reduction	**53.32%**	**12.80%**	**27.24%**	**80.16%**	0.0%	**39.22%**
Margin of Safety (20% of daily LC)	2,688.96	3,081.33	632.91	108.92	0.00	6,512.12
Load reduction goal to meet the standard and provide a margin of safety						**27,253.36**

Measured flow data from the Terrebonne Creek water quality station at CSAH 92 (S004-819) was used to develop the LDC and LAs for AUID 574. The possibility of using HSPF-simulated discharge data to extend the range of years that are represented in the LDC was examined. Compared to measured data, the HSPF-simulated discharge data appeared to greatly overestimate the duration of flow within the channel, and did not simulate the large portions of each summer during which the stream ceases to flow and becomes stagnant (73.2% of daily average flows). Therefore, the flow data was limited to the measured stage and flow record. There were no sources of permitted WWTF discharge to Terrebonne Creek. Though the high flow regime represented a portion of the top 26.8% of flows, the median flow for that regime was only slightly higher than 1 cfs. Load reductions are needed for the top 10% of flows (runoff events) at S004-819.

Table 5-38. *E. coli* load allocation summary for Terrebonne Creek (AUID 574) at CSAH 92 (station S004-819)

2014-2016 continuously measured stage/flow data and additional discrete stage/flow data from Station S004-819 were used to develop flow regimes and loading capacities. Drainage Area (square miles): 14.93 *E. coli* Standard: 126 MPN/100ml %MS4 Urban: 0.00 Total WWTF Design Flow (mgd): 0.00	**AUID 09020305-574 Terrebonne Creek at CSAH 92 (S004-819) Loading Capacity and Load Allocations for *E. coli* Duration Curve Zone** **Very High**	**High**	**No Flow**
Values expressed as billions of organisms per day			
TOTAL DAILY LOADING CAPACITY	**34.27**	**3.37**	**0.00**
Median Flow	11.12	1.09	0.00
Median Flow Exceedance	5%	18.47%	63.40%
Wasteload Allocations			
NPDES Permitted WWTF	N/A	N/A	N/A
Reserve Capacity	N/A	N/A	N/A
Daily Load Allocation	**27.42**	**2.70**	**0.00**
Daily Margin of Safety	6.85	0.67	0.00
Values expressed as percentages of the total daily loading capacity			
Wasteload Allocations			
NPDES Permitted WWTF	N/A	N/A	N/A
Reserve Capacity	N/A	N/A	N/A
Load Allocation	80%	80%	80%
Margin of Safety	20%	20%	20%

Table 5-39. Annual *E. coli* load reduction needed for Terrebonne Creek (AUID 574) at CSAH 92 (station S004-819)

Terrebonne Creek (09020305-574) Annual *E. coli* Load Reductions	**Very High Flow**	**High Flow**	**No Flow**	**Annual Totals**
Current Geometric Mean Daily Load (billions of orgs/day) for Flow Regime	60.07	1.37	0.00	
Loading Capacity (billions of orgs/day)	34.27	3.37	0.00	
Load reduction (billions of orgs/day)	25.80	0.00	0.00	
% of Flows Represented	10.00%	16.81%	73.19%	100.00%
# of Days Represented	36.5	61.36	267.14	365
Annual Load Reduction (billions of orgs/yr.)	941.70	0.00	0.00	**941.70**
Total Current Load	2,192.56	84.06	0.00	2,276.61
Percent Reduction	**42.95%**	0.00%	0.00%	**41.36%**
Margin of Safety (20% of daily LC)	**250.03**	41.11	0.00	**291.13**
Load reduction goal to meet the standard and provide a margin of safety				**1,232.83**

Some instantaneous flow measurements have been made, but a continuous flow record was unavailable for Brooks Creek. Therefore, discharge data from the 1996 through 2016 version of the HSPF model was used for the LDCs and LC calculations. Load reductions are needed for all flow regimes in which samples have been collected at the CSAH 92 water quality station (S006-056). The MST results indicate that humans are the source of some of the fecal bacteria in the creek, which could indicate a failing septic system. There were no WWTF discharge permittees within the small drainage area of Brooks Creek.

Table 5-40. *E. coli* load allocation summary for Brooks Creek (AUID 578) at CSAH 92 (station S006-056)

Flow regimes and loading capacities developed from area-weighted, HSPF-simulated 1996-2016 flow data from HSPF Reach 529 Drainage Area (square miles): 23.49 *E. coli* Standard: 126 MPN/100ml %MS4 Urban: 0.00 Total WWTF Design Flow (mgd): 0.00	**AUID 09020305-578 Brooks Creek (S006-056) Loading Capacity and Load Allocations for *E. coli***				
	Duration Curve Zone				
	Very High	**High**	**Mid-Range**	**Low**	**Very Low**
Values expressed as billions of organisms per day					
TOTAL DAILY LOADING CAPACITY	**82.72**	**21.04**	**5.79**	**1.53**	**0.17**
Median Flow	26.83	6.82	1.88	0.49	0.05
Median Flow Exceedance	5%	25%	50%	75.0%	95.0%
Wasteload Allocations					
NPDES Permitted WWTF (Clearbrook)	N/A	N/A	N/A	N/A	N/A
Reserve Capacity	N/A	N/A	N/A	N/A	N/A
Daily Load Allocation	**66.18**	**16.83**	**4.63**	**1.22**	**0.14**
Daily Margin of Safety	16.54	4.21	1.16	0.31	0.03
Values expressed as percentages of the total daily loading capacity					
Wasteload Allocations					
NPDES Permitted WWTF (Clearbrook)	N/A	N/A	N/A	N/A	N/A
Reserve Capacity	N/A	N/A	N/A	N/A	N/A
Load Allocation	80%	80%	80%	80%	80%
Margin of Safety	20%	20%	20%	20%	20%

Table 5-41. Annual *E. coli* load reduction needed for Brooks Creek (AUID 578) at CSAH 92 (station S006-056)

Brooks Creek (09020305-578) Annual *E. coli* Load Reductions	**Very High Flow**	**High Flow**	**Mid-Range Flow**	**Low Flow**	**Very Low Flow**	**Annual Totals**
Current Geometric Mean Daily Load (billions of orgs/day) for Flow Regime	130.03	24.73	5.87	2.97	No Data	
Loading Capacity (billions of orgs/day)	82.72	21.04	5.79	1.53	0.17	
Load reduction (billions of orgs/day)	47.31	3.69	0.08	1.44	Unknown	
% of Flows Represented	10%	30%	20%	30.0%	10.0%	100%
# of Days Represented	36.5	109.5	73.0	109.5	36.5	365.00
Annual Load Reduction (billions of orgs/yr.)	1,726.82	404.06	5.84	157.68	Unknown	**2,294.39**
Total Current Load	4,746.10	2,707.94	428.51	325.22	Unknown	8,207.76
Percent Reduction	**36.38%**	**14.92%**	**1.36%**	**48.48%**	0.00%	**27.95%**
Margin of Safety (20% of daily LC)	**603.71**	**461.00**	**84.68**	**33.95**	1.10	**1,184.43**
Load reduction goal to meet the standard and provide a margin of safety						**3,478.82**

Very little measured flow data was available for the Clearwater River at the pour point of AUID 647. Discharge data from the 1996 through 2016 HSPF model was used to supply most of the data that was used to create the LDC and calculate *E. coli* loading capacities for Station S002-916. Discrete flow measurements were added to the dataset, but the small number of those measurements likely limited the extent to which that data contributed to the accuracy of the LDCs and calculations. Load reductions are needed during low and mid-range flows. The lone sample collected during very low flows in 2016 or earlier was very close to the impairment threshold. Efforts should also be made to reduce loads during very low flows. The Clearbrook WWTF discharges to Ruffy Brook. Ruffy Brook is impaired by excess *E. coli* and flows into the Clearwater River at the upstream end of AUID 647. The 5.25 billion org/day WLA exceeded the daily LA for the very low flow regime.

Table 5-42. *E. coli* load allocation summary for the Clearwater River (AUID 647) at CR 127 (station S002-916)

Flow regimes and loading capacities developed from area-weighted, HSPF-simulated 1996-2016 flow data from HSPF Reach 350 & measurements from Station S002-916 Drainage Area (square miles): 483.5 *E. coli* Standard: 126 MPN/100ml %MS4 Urban: 0.00 Total WWTF Design Flow (mgd): 0.00	**AUID 09020305-647 Clearwater River at CR 127 (S002-916) Loading Capacity and Load Allocations for *E. coli* Duration Curve Zone**				
	Very High	**High**	**Mid-Range**	**Low**	**Very Low**
Values expressed as billions of organisms per day					
TOTAL DAILY LOADING CAPACITY	**2082.59**	**508.70**	**138.08**	**36.57**	**6.57**
Median Flow	675.58	165.02	44.79	11.86	2.13
Median Flow Exceedance	5%	25%	50%	75.0%	95.0%
Wasteload Allocations*					
Clearbrook WWTF MNG580098-SD-002	5.25	5.25	5.25	5.25	**
Reserve Capacity	104.13	25.44	6.90	1.83	0.33
Upstream Waters (Clearwater River AUID 650)	1030.42	249.50	65.13	14.71	1.47
Daily Load Allocation	**526.27**	**126.78**	**33.18**	**7.47**	**3.46**
Daily Margin of Safety	416.52	101.74	27.62	7.31	1.31
Values expressed as percentages of the total daily loading capacity					
Wasteload Allocations					
Clearbrook WWTF MNG580098-SD-002	0.25%	1.03%	3.80%	14.36%	0.00%
Reserve Capacity	5.00%	5.00%	5.00%	5.00%	5.00%
Upstream Waters (Clearwater River AUID 650)	49.48%	49.05%	47.17%	40.22%	22.37%
Load Allocation	25.27%	24.92%	24.03%	20.42%	52.63%
Margin of Safety	20.00%	20.00%	20.00%	20.00%	20.00%
*Wasteload Allocations are rounded to the nearest 2 digits (1/100th) **The WLAs for WWTFs requiring NPDES permits were based on design flows and exceeded the daily loading capacity of this flow regime. Instead, the WLA and LA allocations were determined by the formula: *E. coli Allocation = (flow volume contribution from a given source) x (126 org./100 ml E. coli)*					

Table 5-43. *E. coli* load allocation summary for the Clearwater River (AUID 647) at CR 127 (station S002-916)

Clearwater River (09020305-647) Annual *E. coli* Load Reductions	**Very High Flow**	**High Flow**	**Mid-Range Flow**	**Low Flow**	**Very Low Flow**	**Annual Totals**
Current Geometric Mean Daily Load (billions of orgs/day) for Flow Regime	1,313.94	328.68	157.65	34.62	4.09	
Loading Capacity (billions of orgs/day)	2,082.59	508.70	138.08	36.57	6.57	
Load reduction (billions of orgs/day)	0.00	0.00	19.57	0.00	0.00	
% of Flows Represented	10%	30%	20%	30.0%	10.0%	100%
# of Days Represented	36.5	109.5	73.0	109.5	36.5	365.00
Annual Load Reduction (billions of orgs/yr.)	0.00	0.00	1,428.61	0.00	0.00	**1,428.61**
Total Current Load	47,958.81	35,990.46	11,508.45	3,790.89	0.00	99,248.61
Percent Reduction	0.00%	0.00%	**12.41%**	0.00%	0.00%	**5.74%**
Margin of Safety (20% of daily LC)	15,202.98	11,140.53	2,016.26	800.45	47.82	29,208.03
Load reduction goal to meet the standard and provide a margin of safety						**30,636.64**

Water level logger deployments and flow measurements help compile a record of average daily flow observations at Station S004-816 on AUID 651 of Beau Gerlot Creek. Model-simulated data for Beau Gerlot Creek compared very well to measured data when both data sets were viewed in a time series graph. The HSPF data also included periods of zero flow, so it correctly simulated the reality that this stream can stop flowing during dry conditions. The discharge data from the 1996 through 2016 HSPF model was therefore assumed to be adequate for expanding the dataset that was used to calculate daily loading capacities for Beau Gerlot Creek. The drainage area of Station S004-816 is 91.56% of the drainage area of pour point of the HSPF model's Reach 601. That ratio was applied to the Reach 601 daily discharge data in order to calculate area-weighted flow values for the days in which measured flow data was not available. There was no permitted WWTF discharge to Beau Gerlot Creek.

Table 5-44. *E. coli* load allocation summary for Beau Gerlot Creek (AUID 651) at CSAH 92 (station S004-816)

2014-2016 continuously measured stage/flow data from Station S004-816 and 1996-2016 HSPF-modeled stage/flow data from HSPF Reach 601 were used to develop flow regimes and loading capacities. Drainage Area (square miles): 23.76 *E. coli* Standard: 126 MPN/100ml %MS4 Urban: 0.00 Total WWTF Design Flow (mgd): 0.00	**AUID 09020305-651 Beau Gerlot Creek at CSAH 92 (S004-816) Loading Capacity and Load Allocations for *E. coli* Duration Curve Zone**				
	Very High	**High**	**Mid-Range**	**Low**	**Very Low**
Values expressed as billions of organisms per day					
TOTAL DAILY LOADING CAPACITY	**224.87**	**55.17**	**14.62**	**3.97**	**0.03**
Median Flow	72.95	17.91	4.74	1.30	0.01
Median Flow Exceedance	5%	25%	50%	75.0%	95.0%
Wasteload Allocations					
NPDES Permitted WWTF	N/A	N/A	N/A	N/A	N/A
Reserve Capacity	N/A	N/A	N/A	N/A	N/A
Daily Load Allocation	**179.90**	**44.14**	**11.70**	**3.18**	**0.02**
Daily Margin of Safety	44.97	11.03	2.92	0.79	0.01
Values expressed as percentages of the total daily loading capacity					
Wasteload Allocations					
NPDES Permitted WWTF	N/A	N/A	N/A	N/A	N/A
Reserve Capacity	N/A	N/A	N/A	N/A	N/A
Load Allocation	80%	80%	80%	80%	80%
Margin of Safety	20%	20%	20%	20%	20%

Table 5-45. Annual *E. coli* load reduction needed for Beau Gerlot Creek (AUID 651) at CSAH 92 (station S004-816)

Beau Gerlot Creek (09020305-651) Annual *E. coli* Load Reductions	**Very High Flow**	**High Flow**	**Mid-Range Flow**	**Low Flow**	**No Flow**	**Annual Totals**
Current Geometric Mean Daily Load (billions of orgs/day) for Flow Regime	222.55	41.22	36.47	2.31	0.00	
Loading Capacity (billions of orgs/day)	224.87	55.17	14.62	3.97	0.03	
Load reduction (billions of orgs/day)	0.00	0.00	21.85	0.00	0.00	
% of Flows Represented	10%	30%	20%	30%	10%	100%
# of Days Represented	36.5	109.5	73.0	109.5	36.5	365.00
Annual Load Reduction (billions of orgs/yr.)	0.00	0.00	1,595.05	0.00	0.00	**1,595.05**
Total Current Load	8,123.08	4,513.59	2,662.31	252.95	0.00	15,551.92
Percent Reduction	0.00%	0.00%	**59.91%**	0.00%	0.00%	**21.64%**
Margin of Safety (20% of daily LC)	1,641.41	1,207.79	213.16	86.51	0.37	3,149.22
Load reduction goal to meet the standard and provide a margin of safety						**4,744.27**

5.3 River Eutrophication (Phosphorus)

One reach of the Clearwater River is impaired by river eutrophication (09020305-647) due to high TP and high BOD. The river also experienced daily DO fluctuation in continuous DO data. A TMDL was calculated for Station S002-916, which is located near the downstream end of AUID 647 (Figure 5-26).

5.3.1 Loading Capacity Methodology

The EPA defines LC as “the greatest amount of loading that a water can receive without violating water quality standards.” The LC provides a reference, which helps guide pollutant reduction efforts needed to bring a water into compliance with the standards. Rather than assessing the frequency of exceedance of a numerical standard, like the TSS assessments, river eutrophication assessments compare a summer average of daily TP concentrations to a numerical standard. LC and LAs were, therefore, also calculated as seasonal averages.

The S002-916 (280th Avenue Southeast, CR 127) water quality station was chosen for TMDL establishment because of the site's monitoring history (stage/flow and water quality sampling) and proximity to the pour point of the impaired reach. Simulated flow records from the 1996 through 2016 HSPF model were used to create an LDC and calculate LC for the TMDL. The full flow record used for the TSS TMDL was filtered to create a seasonal LDC for the months of June through September. Sampling events that coincided with daily flow statistics were plotted on the LDC to visualize whether exceedances occur during high flows, low flows, or throughout the range of flows. The LC was calculated from the table of sorted flows, exceedance rates, and loading rates (at the 0.100 mg/L standard) that was used to create the LDC. The seasonal (June-September) LDC for the 0.1 mg/L TP standard (Figure 5-25) indicated that exceedances of the TP standard appeared to increase in frequency with increases in flow but occurred throughout a large range of flows. The daily LC is based on the seasonal (June through September) average of the median flows of five equally spaced percent exceedance flow zones: 0% to 20% (90th percentile), 20% to 40% (70th percentile), 40% to 60% (50th percentile), 60% to 80% (30th percentile), and 80% to 100% (10th percentile). The average of those values (159.34 pounds/day, 58.42 pounds/day, 26.11 pounds/day, 10.30 pounds/day, and 2.63 pounds/day) was 51.36 pounds/day.

River eutrophication standards in Minnesota are based on a long-term summer average over multiple years. When river eutrophication standards were promulgated, some important rule language was included to guide implementation of TP Water Quality Based Effluent Limits for compliance with river eutrophication standards. Minn. R. ch. 7053.0205, subp. 7.C. contains the following text:

7053.0205 GENERAL REQUIREMENTS FOR DISCHARGES TO WATERS OF THE STATE.
Subp. 7. Minimum stream flow

> C. Discharges of total phosphorus in sewage, industrial waste, or other wastes must be controlled so that the eutrophication water quality standard is maintained for the long-term summer concentration of total phosphorus, when averaged over all flows, except where a specific flow is identified in chapter 7050. When setting the effluent limit for total phosphorus, the commissioner shall consider the discharger's efforts to control phosphorus as well as reductions from other sources, including nonpoint and runoff from permitted municipal storm water discharges.

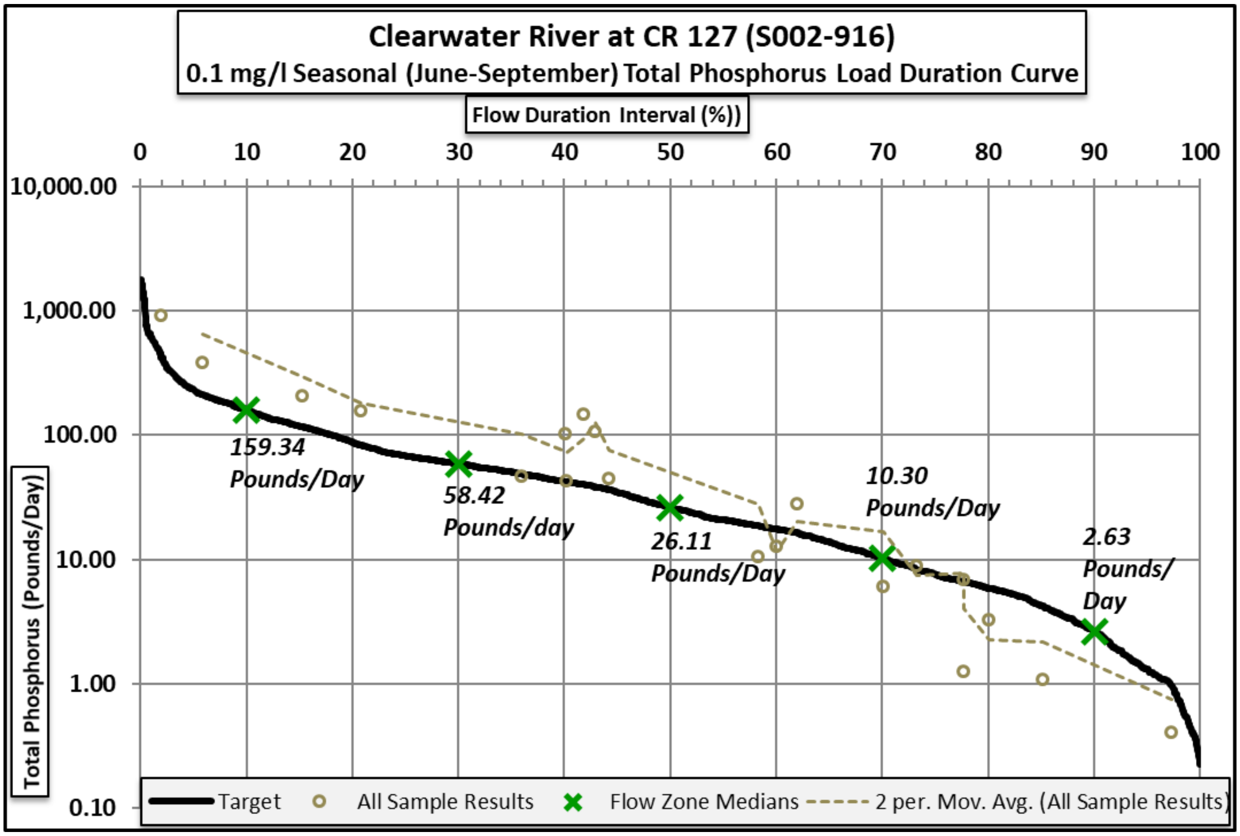


Figure 5-25. Seasonal TP load duration curve and median daily loads for the Clearwater River (AUID 647) at CR 127 (station S002-916)

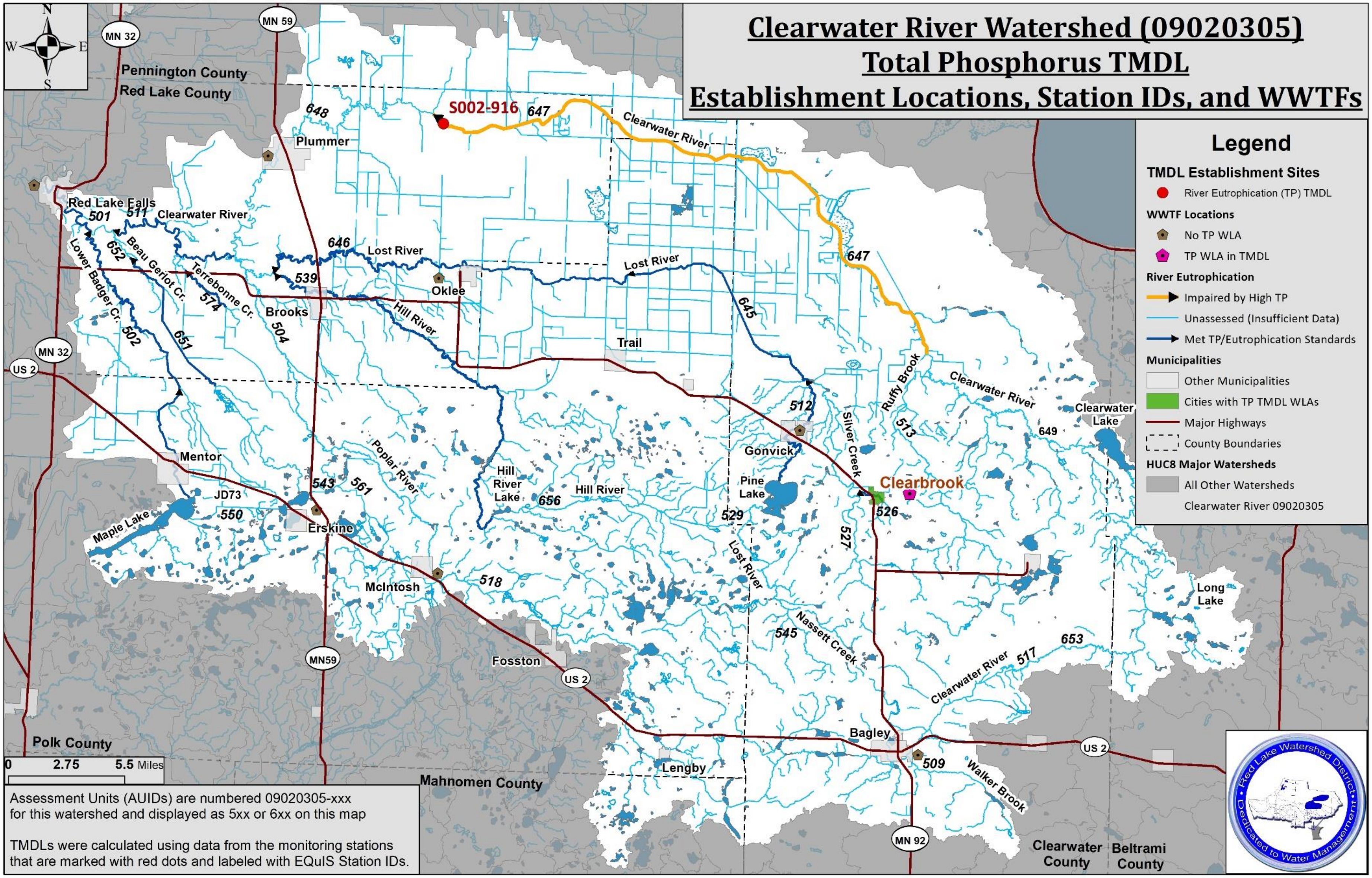


Figure 5-26. Location of the TP TMDL establishment station on the Clearwater River

5.3.2 Load Allocation Methodology

Portions of the total LC were reserved for construction/industrial stormwater and WWTF loading, reserve capacity, and MOS. The remaining portion of the LC was considered to be the LA. The TP concentrations in the Clearwater River, upstream of AUID 647, are not impaired and have TP concentrations that are close to natural background levels. The LA includes all nonpoint sources that are contributing to TP in the river. The existing concentration in the upstream reach is just 0.026 mg/L, which is much lower than the 0.100 mg/L impairment threshold and also significantly lower than the 0.050 mg/L TP standard that is applied to the upstream AUID 650. A boundary condition (BC) allocation was calculated for AUID 650 using the summer average flow of 82.05 cfs (from the 1996 through 2016 summer average daily discharge record simulated by the HSPF model) and an allowable concentration of 0.50 mg/L. Load reduction estimates were estimated based on the current loading rate at S002-916 and the LC of the river.

5.3.3 Wasteload Allocation Methodology

<u>Wastewater Treatment Facilities</u>

As described in Section 4.3.1, there are two WWTFs upstream of AUID 647 of the Clearwater River: Bagley (MN0022691-SD-002) and Clearbrook (MNG585098-SD-002). The MPCA staff completed a protection analysis during a phosphorus effluent limit review for the Clearwater River Watershed and determined current performance of the Clearbrook and Bagley WWTFs is sufficient and their current discharges do not have potential to drive the TP concentrations above the 0.100 mg/L impairment threshold. Section 4.3.1 describes a boundary condition where the Bagley WWTF does not contribute to the TP impairment on AUID 647. Measured high TP concentrations along Ruffy Brook prevented the establishment of a boundary condition between the Clearbrook WWTF and the river eutrophication impairment of the Clearwater River AUID 647. Therefore, a WLA was calculated for the Clearbrook WWTF, though it will not need a reduced effluent limit.

The current flow-weighted mean concentration of discharge from the Clearbrook WWTF during the years 2006 through 2015 was 1.75 mg/L. The years 2012 and 2015 had no reported discharge during the summer months of June through September. The flow-weighted mean concentration of 1.75 mg/L was multiplied by the maximum permitted daily effluent flow of 1,101,285 gallons per day (6 inches of discharge per day multiplied by a 6.76-acre pond size and conversion factors) and conversion factors to calculate a WLA of 0.86 lbs./day (Table 5-46). The facility discharged an average of 11.4 days of the 122 days in the summer months of June through September. The final WLA was calculated by multiplying the daily loading rate at the maximum permitted daily discharge rate by the percentage of summer days in which the facility discharges. The result was a summer average WLA that was representative of both the average concentration of discharge and the average impact of discharge over the entire summer (including days in which discharge and loading rates were zero).

Table 5-46. WLA calculation for the Clearbrook WWTF

	A	B	C	D	E	F	G	H	
Facility	Secondary Pond Size (acres)	Maximum Permitted Daily Effluent Flow (gpd)	L per Gallon	Permitted Daily Discharge (L/day)	Flow-Weighted Mean Concentration of Discharge (mg/L)	Daily Load at Maximum Daily Effluent Flow (lbs./day)	Average Days of Discharge per Summer (2006-2015)	Average Percentage of Summer Days with Discharge	Total Phosphorus WLA (lbs./day)
Clearbrook WWTF MNG580098-SD-2	6.76	1,101,285	3.785	4,168,364	1.75	16.08	11.4	9.34%	**1.50**
Equations:		*= A x 6 in. x 27,152 gal/ac.in.*		*= B x C*		*= (D x E) x (1 lb / 453,592 mg)*		= G / 122 summer days	= F x H

Regulated Construction and Industrial Stormwater

NPDES permitted construction stormwater must be given a WLA for TMDLs that are established for pollutants that can originate in stormwater runoff from disturbed soil (like TSS and TP). The Industrial Stormwater Multi-Sector General Permit is also utilized by the MPCA to manage compliance with a TMDL. Industrial stormwater must also receive a WLA if facilities are present in the drainage area of an impaired AUID. The MPCA has issued construction and industrial NPDES permits within each of the counties that encompass the drainage area of the impaired segments of the Clearwater River. Construction and industrial activity comprised a small percentage of the land area in the watershed, so the allocations for these two activities were combined in the WLA calculations for this TMDL.

Depending on location, the land area percentages for construction and industrial stormwater activity in Clearwater, Polk, Pennington, and Red Lake Counties were factored into the percentage that was used to calculate the WLA for each location. Beltrami County was not included because that portion of the drainage area was upstream of Clearwater Lake. Clearwater Lake essentially reset TP concentrations to natural background levels. The summer average TP concentrations in 2007-2016 data at sites S002-119 (Clearwater Lake outlet) and S001-461 (CSAH 14) were at or below 0.02 mg/L, which was less than half of the summer average in the Clearwater River at the Clearwater Lake inlet (0.048 mg/L at S001-460/S001-911). The TP concentrations were also relatively low at CSAH 11 (0.026 mg/L), but immediately began exceeding the standard at the next assessable monitoring station (0.192 mg/L at 169th Avenue/S001-462) due to significant changes in land use, streambank stability, and high TP concentrations in tributary inflow.

The resolution of the available stormwater permitting data was at the county level. The average annual acreages for each county that encompasses a portion of the drainage area was calculated by dividing the total acreage under construction by the number of unique start date years. The average annual “land area under construction” values from each of the counties that encompass a portion of each TMDL site’s drainage area were added together and divided by the combined total acreage of those same counties. That provided an average annual land area percentage for each TMDL site that was calculated at a county-level resolution that was equal to the resolution of the available permitting data. The land area percentages in Table 5-2 were applied to the LC using the following equation:

Construction and Industrial Stormwater WLA = (% of Land Area) x (LC – MOS)

5.3.4 Margin of Safety

As described in Section 5.1.4, the statute and regulations require that a TMDL include an MOS to account for any lack of knowledge concerning the relationship between load and WLAs and water quality (CWA § 303(d)(1)(c), 40 CFR § 130.7(c)(1)).

An explicit MOS equal to 10% of the LC was applied to each flow regime. The 10% MOS is reasonable because RPD values for sets of duplicate samples and TP samples that were collected on the same day (from the entire history of sampling through 2016 along AUID 647) averaged 5.19% and were all lower than 10%. The explicit 10% MOS accounts for:

- Uncertainty in the observed daily flow record
- Uncertainty in the observed water quality data.
- Allocations and loading capacities are based on flow, which varies from high to low. This variability is accounted for using the five flow regimes and the LDCs.
- The variability in pollutant concentrations at any given flow.
- Imperfect homogeneity of pollutants throughout the water column.

5.3.5 Seasonal Variation

The TP LDC for AUID 09020305-647 of the Clearwater River shows that high TP concentrations in the river occur more frequently, relative to the standard, as flows increase but still occur throughout the range of flows. Most of the high concentrations have been recorded during the summer months of June through September. Figure 5-27 shows average TP concentrations peak during the months of July and August. Figure 5-27 also clearly shows the abrupt change in water quality conditions from the natural portion between Clearwater Lake and Ruffy Brook (in green) and the channelized portion between Ruffy Brook and JD 1 (in blue and orange) in 2007-2016 data. The majority (63%) of the summer daily averages from 09020305-647 exceeded the 0.10 mg/L standard.

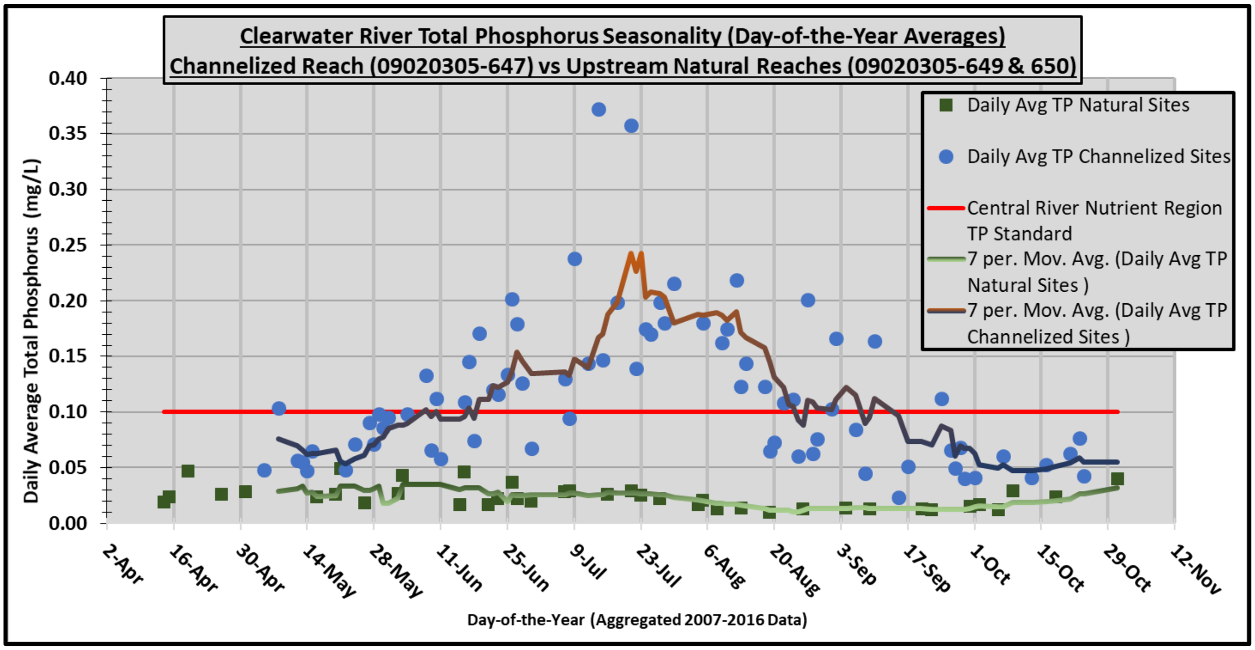


Figure 5-27. Seasonality of TP concentrations in the Clearwater River (AUID 647) relative to upstream reaches

5.3.6 Reserve Capacity

The TP-impaired reach in the Clearwater River Watershed receives drainage from communities in which some future development may be expected. Population trends are flat or decreasing in areas surrounding the impaired AUIDs. Though implementation goals will focus on lessening the impact of agricultural practices, a minimal amount of reserve capacity (5%) was reserved for future development.

5.3.7 TMDL Summary

The TP TMDL for the impaired reach of the Clearwater River was calculated for the monitoring site nearest the pour point of the reach (S002-916 at CR 127). Table 5-47 shows the summer average loading capacities, LAs, and margins of safety that were calculated. Table 5-47 also shows the estimated load reductions for each flow regime that will be necessary for the reach to meet the TP water quality standard. The calculation of the TMDL for AUID 647 was based on the following equation. Boundary conditions are represented by “BC.”

TMDL (lbs/year) = LC = WLA + LA + MOS + RC + BC

Average load reduction values were also calculated. The reduction, as a percentage, was based on the difference between the existing average concentration and the TP standard. The average seasonal flow rate was used to calculate a current average load and quantify a daily load reduction goal of 13.35 lbs/day. Reducing TP loads by that amount plus the MOS would account for variability and uncertainty to provide greater assurance that the river is restored and is more likely to remain in that condition.

Table 5-47. TP load allocation summary for the Clearwater River (AUID 647) at CR 127 (station S002-916)

Total Phosphorus Total Maximum Daily Load Clearwater River at County Road 127 (S002-916) AUID 09020305-647		
Total Phosphorus Loading Capacity and Allocations		
TMDL Parameter		**TP Load (lbs./day)**
Loading Capacity		**51.36**
Total WLA		1.51
WLA	Clearbrook MNG580098-SD-2	1.50
	Construction and Industrial Stormwater = 0.018% x (LC-MOS)	0.01
Boundary Conditions (AUID 650)		22.13
Reserve Capacity		2.57
Margin of Safety		5.14
Load Allocation		**20.01**
Load Reductions		
Summer Average Flow (cfs)		95.22
Existing Average Concentration (mg/L)		0.126
TP Standard (mg/L)		0.100
Difference (mg/L)		0.026
Percent Reduction in Summer Average Concentration Necessary to Meet the Standard		**20.63%**
Current Estimated Average Daily Load (lbs./day)		64.71
Average Daily Load Reduction (lbs./day) to LC		**13.35**
Average Daily Load Reduction plus MOS (lbs./day)		**18.49**

5.4 Phosphorus in Lakes

Each of the three impaired lakes in this watershed were all in headwaters portions of their respective drainage areas. Another common characteristic of the three lakes was that they all seemed to lack a distinctive outlet channel, which minimized the flushing of nutrients from any of the basins. Stormwater inlets to Cameron Lake have been sampled for a short-term study, but a general lack of monitored inlet channels for these impaired lakes meant that there was insufficient measured data available to characterize nutrient concentrations that were coming into the lakes. Instead, the TMDL calculations relied upon lake morphology, pollutant runoff rates that were estimated by the 1996 through 2016 HSPF model, and internal loading estimates that were estimated using the BATHTUB 6.20 model. Only Cameron Lake had a public access and bathymetry data. Landowners on Stony and Long Lakes were very helpful in providing depth estimates and allowing access for depth measurements.

5.4.1 Loading Capacity Methodology

The EPA defines LC as “the greatest amount of loading that a water can receive without violating water quality standards.” The LC provides a reference, which helps guide pollutant reduction efforts needed to bring a water into compliance with the standards. Lake TP TMDLs were calculated using methods that differed from the stream TMDLs. BATHTUB software, version 6.20, was used to model each lake’s response to inputs from runoff and internal loading. Input data for global variables, morphometry, land use, runoff rates for each land use, observed (in-lake) water quality, contributions from feedlots, and monitored inputs were compiled and calculated. Essentially two final versions of the model were created for each lake: one that simulated current conditions and one that simulated a restored condition. The BATHTUB model was used to estimate the current amount of internal loading based on HSPF-modeled tributary inputs. The tributary inflows and internal loading rates were then adjusted to achieve a simulated scenario with the maximum TP and OP loading rates from tributaries and internal loading that could occur without causing average TP concentrations to exceed the applicable standard.

The development of a BATHTUB model required entry of descriptive values into several forms/windows prior to running the model. The first set of BATHTUB inputs that were calculated for each lake were the lake morphometry values (Table 5-48). Lake volume was estimated for each lake to help calculate the mean depth for each lake. The formula in solid geometry for calculating the volume of a frustum of a circular cone was used to compute the volume of each lake. The water columns in bowl-shaped or saucer-shaped lakes like Cameron Lake and Stony Lake can be visualized as large, flat cones. Long Lake was more complicated and required volume calculations that separated the lake into multiple layers. The procedure consisted of determining the volumes of successive layers of water (frustums), and then summing these volumes to obtain the total volume of the lake (Michigan DNR 2000). The formula for finding the area of each frustrum is:

$V = ⅓*H*[A_1+A_2+\sqrt{(A_1*A_2)}]$

Where:

V = volume of water;

H = difference in depth between two successive depth contours;

Al = area of the lake within the outer depth contour being considered;

A2 = area of the lake within the inner contour line under consideration.

Table 5-48. Morphometry inputs for the BATHTUB model for each impaired lake

BATHTUB Morphometry	Cameron Lake (60-0189-00)	Long Lake (04-0295-00)	Stony Lake (15-0156-00)
Surface Area (km^2)	0.91378	0.39	0.271
Mean Depth (m)	2.1557	2.50	1.63
Length (km)	1.49	1.8	0.85
Mixed Layer Depth (m)	2.1557	2.50	1.63

Cameron Lake surface area and depth contours were available in a DNR lake bathymetry GIS layer. There was minimal morphology information for the two lakes that lacked public accesses (Stony Lake and Long Lake). Maximum depths and contours were initially unknown. Landowner contacts yielded information about maximum depths, information about potential sources of pollutants, and lake access for exploration, sampling, and depth measurements. Each lake was modeled as a single basin (one segment). Outflow was set to “Out of Reservoir” for each lake. All three lakes were shallow lakes, so the mixed layer depths were equal to the mean depths for each lake. The mean depth was calculated by calculating the lake’s volume, then dividing the volume by the lake’s surface area.

Livestock operations have historically affected water quality in Long Lake and Stony Lake. Though pastured land use areas were included in NLCD land cover data, feedlot areas were not. The HSPF model estimated loading rates for feedlots, but the acreage of feedlots needed to be estimated. Feedlot acreage for each HSPF basin could be calculated by dividing the basin source load (pounds/year) by the basin source load rate (pounds/acre/year) to cancel out the “pounds” and “years” units. The drainage areas of each lake were all smaller than their respective HSPF subbasins, so unique values needed to be calculated for the lake drainage areas. Calculating the feedlot acreage within a lake's drainage through area weighting (multiplying by the ratio of lake drainage area to HSPF basin area) would underestimate feedlot area for the lake's tributary inflow. The acreage of each feedlot was instead estimated by examining feedlot locations that were identified the Feedlots in Minnesota GIS data, pastured land use polygons in the 2011 National Land Cover Database (clipped to the drainage area of a lake), and aerial photos. The locations of facilities were identified by Feedlots in Minnesota GIS data. There were no feedlots within the drainage area of Cameron Lake. The feedlot areas in the Stony and Long Lake drainage areas were estimated to be two acres or less, which rounded to approximately 0.01 square kilometers (km^2) after a conversion of units. Loading rates from the HSPF model were applied to the estimated feedlot area. The NLCD land use data did not distinguish feedlots from pasture. Where the manually estimated feedlot acreage listed separately in spreadsheet calculations, it was also subtracted from the pasture acreage so that the total drainage area value remained unchanged. In both the Lost Lake and Stony Lake iterative BATHTUB modeling processes, the feedlot and pasture inputs (along with other anthropogenic data uses) were eliminated and converted to natural land uses as nutrient inputs were reduced to simulate a restored condition. This does not necessarily mean that feedlots and pastures themselves will be eliminated, but it does indicate a need for treatment practices to reduce the impact of those land uses.

Septic systems were another potential source of TP, but the potential loads were small (Table 5-49). The loading from septic systems was part of the BATHTUB model but did factor into the equation in the TMDL summary tables in Section 5.4.6 as part of tributary inflow. The estimated pounds/year from septic systems were listed separately in the TMDL summary tables and assumed to be part of the total nonpoint runoff that was estimated by the HSPF and BATHTUB models.

Table 5-49. Estimate of TP load from shoreland septic systems for each impaired lake

Lake	Estimated # of Shoreland Residences	HSPF Source Loading Rate per Basin Residence (kg/yr)	Estimate of TP from Septic Systems (kg/yr)	Estimate of TP from Septic Systems (lbs/yr)
Cameron Lake (60-0189-00)	5	0.04	0.20	0.44
Long Lake (04-0295-00)	5	0.04	0.20	0.44
Stony Lake (15-0156-00)	3	0.04	0.12	0.26

Table 5-50. Global variable inputs for the BATHTUB model for each impaired lake

BATHTUB Global Variables	Cameron Lake (60-0189-00)	Long Lake (04-0295-00)	Stony Lake (15-0156-00)
Precipitation (m/yr)	0.64	0.64	0.64
HSPF Basin	594	114	447
$mg/m^2/yr$ TP Atm. Dep.	8.78	10.59	12.38
$mg/m^2/yr$ OP Atm. Dep.	8.78	10.59	12.38
Evaporation (m/yr)	.64	0.64	0.64

Global variables (Table 5-50) were entered into the BATHTUB model for each lake to represent the average annual precipitation, evaporation, and atmospheric deposition. Annual precipitation, in inches/year, was obtained from the Normal Annual Precipitation Average, Minnesota, 1981 through 2010 GIS data and converted to meters/year. Atmospheric deposition rates (milligrams/square meter/year) were calculated from the 1996 through 2016 HSPF model's simulated annual basin source load for TP and OP (pounds/year). Basin source load, in HPSF, is the constituent load contributed from each source (land uses, bank erosion, point sources) within a specific subbasin (acre-feet/interval, tons/interval, or pounds/interval). The HSPF model did not provide measurable (greater than zero) basin source load rates (pounds/acre/interval) for atmospheric deposition, but atmospheric deposition rates were calculated using the basin source loads for atmospheric deposition (pounds/year converted to milligrams/year) and the amount of open water within the basin (square meters). The resulting atmospheric loading rates were in-line with estimates for northern Minnesota that were found in online documents. Location-specific evaporation data was not available, so evaporation rates were assumed to be equal to precipitation rates.

ArcGIS and NLCD 2011 Land Cover data were used to determine land use areas for the HSPF subbasins (594, 447, and 114 for Cameron Lake, Stony Lake, and Long Lake, respectively) and for each lake's drainage area. The HSPF model, NLCD Land Cover GIS layer, and the BATHTUB model each categorized land use differently. Table 5-51 shows how the land use categories from the land use data sources were matched and condensed to fit the BATHTUB land use categories. The BATHTUB land use categories were less specific than the NLCD and HSPF categories. Average loading rates from HSPF categories (those with positive values) were averaged to calculate loading rates for the BATHTUB land use categories. In cases where BATHTUB categories included multiple NLCD land use categories, the area values for the NLCD land use data were summed to calculate the areas for the BATHTUB land use categories. The open water acreages were particularly important for calculating TP/OP loading rates (average annual pounds/acre) and discharge rates (average annual acre-feet/acre) for open water and atmospheric deposition.

Table 5-51. Land use categories and how they were summarized for the BATHTUB model

HSPF Land Use Categories	NLCD Land Use Categories	BATHTUB Land Use Categories
Developed Developed EIA (Effective Impervious Area)	Developed, Open Space Developed, Low Intensity Developed, Medium Intensity Developed, High Intensity	Urban
Forest AB Forest CD	Evergreen Forest Deciduous Forest Mixed Forest	Forest
Cropland Low Till Cropland High Till	Cultivated Crops	Cropland
Grassland	Herbaceous Shrub/Scrub Barren Land	Grassland
Pasture AB Pasture CD	Hay/Pasture	Pasture
Wetland	Emergent Herbaceous Wetlands Woody Wetlands	Wetland
Atm. Dep.	Open Water	Open Water
Feedlot	n/a	Feedlot
Septics	n/a	n/a
Point Source	n/a	n/a
Bed/Bank	n/a	n/a

The observed (in-lake) water quality inputs to the model were based on the 2006 through 2015 summer average concentrations shown in Figure 3-17. The concentrations of TP and OP in tributary inflows (watershed runoff) were estimated from HSPF basin source load and basin source load rate data for each land use category (mass/acre/year) and the area covered by each land use category (m^2) within the drainage area. These simulated watershed runoff values for TP, OP, and discharge were calculated for each lake and entered into the model as "monitored inputs." The BATHTUB terminology of "monitored" for inputs was be replaced with "watershed runoff" in Table 5-52 because the values were estimated by the HSPF model and not monitored. Nitrogen loading rates were calculated and experimentally added to one lake's model, but they had no effect on the predicted TP concentration, so they were not used in the final versions of the lakes' models.

The HSPF model provided values for basin source loads (average mass/year) but did not provide loading rates (mass/area/year) that could be directly applied to the open water acreage in each lake's drainage area. The basin source load from atmospheric deposition for an HSPF subbasin was divided by the area of open water in a subbasin to calculate the TP/OP/volume loading rates per acre of open water. The NLCD land use area values for open water were adjusted when the tributary inflow values were calculated. The surface area of the lake was included in the NLCD land use data but subtracted from the tributary inflow calculations because the BATHTUB model separately calculated loading from atmospheric deposition within the lake. If the area of the lake was not subtracted from the NLCD land use data, nutrient contributions from atmospheric deposition within the lake would have been double counted.

Table 5-52 shows the HSPF loading rates (pounds/acre/year) and land use areas were used to calculate export coefficients for each land use (milligrams/cubic meter). Nitrogen inputs had no effect on simulated TP, chl-*a*, and Secchi concentrations, so they were not used in the final iterations of each lake's model.

After the input variables for each of the impaired lakes were entered into the BATHTUB model, the model was run to predict area-weighted mean TP (ppb), chl-*a* (ppb), and Secchi (m) values based on the input variables. There is a model selection tab in BATHTUB in which the user can select a phosphorus sedimentation model. The phosphorus sedimentation model options were compared (prior to adding internal loading) and the Canfield-Bachmann Lakes (Option 8) model was selected for each lake because it predicted a TP concentration that was closest to current conditions for each of the lakes. Calibration factors were left at default values.

Internal loading was set to zero for the first iteration of the model because it was unknown. Based solely on the most recent HSPF-simulated phosphorus runoff rates, the first iteration of the model predicted that Cameron Lake and Stony Lake could meet the 60 ppb TP standard if the lakes were not affected by internal loading. However, all three of these shallow lakes were expected to have significant contributions of nutrients from internal loading. Internal loading from sediment on the bottom of Cameron Lake was previously identified as a source of TP in a study (RLWD 1997). For each lake, internal loading was gradually increased until the BATHTUB-predicted mean TP matched the observed mean TP. Larger increments were used in initial iterations and then internal loading was increased in 0.01 milligram/square meter/year increments when predicted TP approached the observed TP. The predicted inflow loads from that iteration were considered the current loads. The BATHTUB model provided mass balance tables with kilograms/year loading rates for tributary inflow, internal loading, atmospheric deposition, and total inflow.

The necessary load reductions and LC were then determined by iteratively and proportionally decreasing TP/OP tributary inflow and internal loading concentrations until the predicted mean TP was equal to the applicable standard. This simulated a restoration of the lake to meet water quality standards. The model's predicted in-lake TP concentration was sensitive to changes in tributary inflow concentrations, internal load, and inflow rate. Mass balance tables for restored conditions were also generated to supply annual load values (kilograms/year) for the TMDL calculation tables.

Table 5-52. Tributary inflow land use inputs for the BATHTUB model for each impaired lake

BATHTUB Land Use Inputs	NLCD Land Use Categories	HSPF Land Use Categories	Cameron Lake (60-0189-00)				Long Lake (04-0295-00)				Stony Lake (15-0156-00)			
			km^2	Runoff (m/yr)	TP mg/m^3	OP mg/m^3	km^2	Runoff (m/yr)	TP mg/m^3	OP mg/m^3	km^2	Runoff (m/yr)	TP mg/m^3	OP mg/m^3
Urban	Developed: Low Intensity & Open Space	Developed Developed-EIA	1.02	.33	79.70	59.58	0.65	0.34	81.52	61.01	0.10	0.33	81.46	60.49
Forest	Evergreen & Deciduous Forest	Forest AB & CD	0.47	0.09	44.64	15.27	15.38	0.10	43.58	14.62	0.82	0.10	45.57	15.96
Cropland	Cultivated Crops	Cropland Low Till & High Till	1.99	0.11	275.22	139.99	0.29	0.08	177.25	58.78	0.48	0.12	344.71	204.06
Grassland	Shrub/Scrub, Herbaceous, Barren Land	Grassland	0.09	0.13	51.97	16.44	0.55	0.14	51.16	15.89	0.01	0.14	52.58	17.01
Pasture	Hay/Pasture	Pasture AB & CD	0.11	0.16	98.15	41.98	2.38	0.16	93.74	38.99	0.65	0.17	98.99	42.98
Wetland	Emergent Herbaceous & Woody Wetlands	Wetland	1.16	0.11	30.59	12.71	1.04	0.12	30.45	12.70	0.19	0.12	31.56	13.52
Feedlot	n/a	Feedlot	0.00	0	0	0	0.01	0.16	1360.46	1092.97	0.01	0.21	1431.50	1164.56
Open Water*	Open Water	Atm Dep	0.04	.37	28.58	28.58	0.09	0.87	28.40	28.40	0**	0.49	25.23	25.23
Total			4.88				20.39				2.26			
*Open water area from land use data minus the surface area of the lake														
**Lake surface area was equal to or greater than the area of open water in NLCD land cover data														

Table 5-53. Water quality inputs and outputs from the final iterations of the BATHTUB models for each impaired lake

BATHTUB Watershed Runoff Inputs (HSPF-Modeled Runoff Rates)	Cameron Lake (60-0189-00)	Long Lake (04-0295-00)	Stony Lake (15-0156-00)
Actual Total Watershed Area (km^2)	5.79	20.78	2.26
Total Tributary Inflow Watershed Area (km^2)	4.88	20.39	2.52
Annual Flow Rate (hm^3/yr) for Iteration 1	0.77	2.44	0.31
Watershed runoff TP (ppb) for current condition and Iteration 1	123.63	56.49	133.65
Watershed runoff OP (ppb) for current condition and Iteration 1	70.84	23.93	73.34
Internal Loading for Iteration 1 ($mg/m^2/yr$)	0	0	0
Iteration 1 Predicted TP (without internal loading)	38	36	50
Internal Loading Rate at Current Conditions ($mg/m^2/yr$)	0.95	0.28	1.62
Target TP for Current Conditions (ppb)	94	44	137
Predicted TP at Current Conditions (ppb)	94	44	137
Applicable TP Standard (ppb)	60	30	60
Predicted TP (ppb) at Loading Capacity	60	30	60
Watershed runoff Input TP (ppb) at Loading Capacity (restored condition)	57.86	37.99*	46.83*
Watershed runoff input OP (ppb) at Loading Capacity (restored condition)	33.15	12.83*	16.12*
Internal Loading ($mg/m^2/yr$) at Loading Capacity (restored condition)	0.44	0.14	0.39
Percent decrease in TP concentration in tributary inflow	53.1%	29.6%	64.96%
Percent decrease in OP concentration in tributary inflow	53.1%	37.74%	78.02%
Percent decrease in internal loading rate	53.1%	57.14%	56.20%
Annual flow rate for the final iteration (restored condition, hm^3/yr) after land use changes	0.58	2.22	0.25
Total inflow for current condition (kg/yr)	420.6	181.9	204.5
Total inflow for restored condition (kg/yr)	189.5	109.5	53.5
Tributary inflow for current condition (kg/yr)	95.1	137.9	41.4
Tributary inflow for restored condition (kg/yr)	33.6	88.3	11.7
Internal load for current condition (kg/yr)	315.8	39.9	159.8
Internal load for restored condition (kg/yr)	146.2	17.1	38.5
Atmospheric deposition (kg/yr, constant)	9.7	4.1	3.3

*Reductions in TP/OP tributary inflow concentrations reached minimum, natural background concentrations were not further decreased. Subsequent iterations of the model only decreased internal loading rates until the simulated average TP concentration equaled the allowable average TP concentration.

During the process of incrementally reducing TP/OP levels in tributary runoff, it was important to not expect pollutant runoff rates that were lower than what would come from a natural landscape. The reductions in TP and OP levels in tributary inflow needed to be limited to minimum levels in Stony Lake and Long Lake. The minimum tributary inflow values for TP, OP, and flow were calculated by equally converting acreage of anthropogenic land uses (urban, pasture, cropland, and feedlots) to grassland and forest. The acres of wetlands and open water within each lake's watershed were not changed. The calculated TP loading rates (mg/m^3) for a theoretical watershed that was comprised of only wetland, open water, forest, and grassland were used as minimum TP and OP runoff concentrations. After the minimum values for TP, OP, and flow were reached, only internal loading was decreased in subsequent iterations of the model until predicted TP concentrations equaled the applicable water quality standards for each lake. For Cameron Lake, tributary loading rates and internal loading rates were proportionally and incrementally decreased until the water quality standard was reached. The amount of land use change was calculated for each incremental change in TP and OP loading. A new flow rate (cubic hectometers/year) was calculated from the new set of land use area values.

5.4.2 Wasteload Allocation Methodology

Wastewater Treatment Facilities

No WWTFs currently discharge to the impaired lakes within the Clearwater River Watershed. Therefore, no WWTF WLA was necessary.

Regulated Construction and Industrial Stormwater

NPDES permitted construction stormwater must be given a WLA for TMDLs that are established for pollutants that can originate in stormwater runoff from disturbed soil (like TSS and TP). Industrial Stormwater Multi-Sector General Permit is also utilized by the MPCA to manage compliance with a TMDL. Industrial stormwater must also receive a WLA if facilities are present in the drainage area of an impaired AUID. The MPCA has issued construction and industrial NPDES permits within each of the counties that encompass the drainage areas of the impaired lakes.

Construction and industrial activity comprise a small percentage of the land area in the watershed, so the allocations for these two activities were combined in the WLA calculations for this TMDL. The land area percentages for construction and industrial stormwater activity in Polk County were factored into the percentage that was used to calculate the WLA for Cameron Lake. Beltrami County permitting is heavily influenced by the city of Bemidji, which lies within the Mississippi River Watershed and isn’t relevant to this rural watershed TMDL. The stormwater permits from the City of Bemidji (76% of the permits and 72% of the permitted area in the county) were removed from the Beltrami County permitted acreage. The remaining permits were used to more representatively calculate the Beltrami County stormwater permitting WLA for Long Lake.

The resolution of the available stormwater activity permitting data was at the county level. The average annual acreages for each county that encompasses a portion of the drainage area were calculated by dividing the total acreage under construction by the number of unique start date years. The average annual “land area under construction” values from each of the counties that encompass a portion of each TMDL site’s drainage area were added together and divided by the combined total acreage of those same counties. That provided an average annual land area percentage for each TMDL site that was calculated at a county-level scale, a resolution that was equal to the resolution of the available permitting data. Stormwater runoff was considered to be part of the tributary runoff to the lake. Though the loading rates were subtracted from tributary inflow in the TMDL summary tables, the stormwater loading rates were calculated using the LC of each lake. The percentages in Table 5-54 are based on the entire area of the county and account for land uses (like open water in lakes) that won’t have contributions from stormwater. So, the construction and stormwater WLAs were calculated with the percentages calculated in Table 5-54 and the LC minus the MOS using the following equation (that is consistent with TSS and River Eutrophication TMDLs):

Construction and Industrial Stormwater WLA = (% of Land Area) x (LC – MOS)

Table 5-54. Calculation of WLAs for permitted construction and industrial stormwater for each impaired lake

County	Lake	Const. Stormwater Avg. Annual County Land Area (ac)	County Land Area (acres)*	Const. Stormwater (% of Land Area)	Industrial Stormwater %	Total % Const. and Ind. Stormwater WLA
Beltrami	Long (04-0295-00)	45.62	1,955,840	0.002%	0.002%	**0.004%**
Polk	Cameron (60-0189-00)	148.31	1,278,720	0.012%	0.012%	**0.024%**
Clearwater	Stony (15-0156-00)	25.67	659,200	0.004%	0.004%	**0.008%**
Variables and Formulas:						
		A	B	C	D	
				= A/B	= C	**= C + D**

5.4.3 Margin of Safety

As described in Section 5.1.4, the statute and regulations require that a TMDL include an MOS to account for any lack of knowledge concerning the relationship between load and WLAs and water quality (CWA § 303(d)(1)(c), 40 CFR § 130.7(c) (1)).

An explicit MOS equal to 10% of the LC was applied to the LC. The 10% MOS is reasonable because RPD values for sets of duplicate samples and TP samples that were collected on the same day are typically lower than 10%. The explicit 10% MOS accounts for:

- Uncertainty in the observed daily flow record
- Uncertainty in the observed water quality data.
- The variability in pollutant concentrations at any given flow.
- Imperfect homogeneity of pollutants throughout the water column.

Within the TMDL summary tables in Section 5.4.6, the MOS was subtracted from the allowable internal load. It could not be subtracted from the WLA because that number was too small and needed to remain constant. Atmospheric deposition cannot be changed without changing the surface area of the lake, so the MOS could not be taken from that TP source. Nonpoint runoff reductions were maximized or nearly maximized within the model. Nonpoint runoff loads could not be reasonably decreased further than the natural conditions that they represented in the “restored” iterations of the BATHTUB model. Internal loading was the only category for which LAs could be further reduced to allow for an explicit MOS.

5.4.4 Seasonal Variation

Sampling of lakes has been limited to summer months, so there is a limited frame of time in order to address seasonality. The TMDL is based on average TP concentrations during summer months when TP concentrations are typically highest (Figure 5-28). All monthly average TP concentrations for all the impaired lakes in this watershed exceeded their respective standards. All the Cameron and Stony Lake averages exceeded 60 ppb and all the Long Lake averages exceeded 30 ppb. The concentrations in Stony Lake increased significantly in August and September.

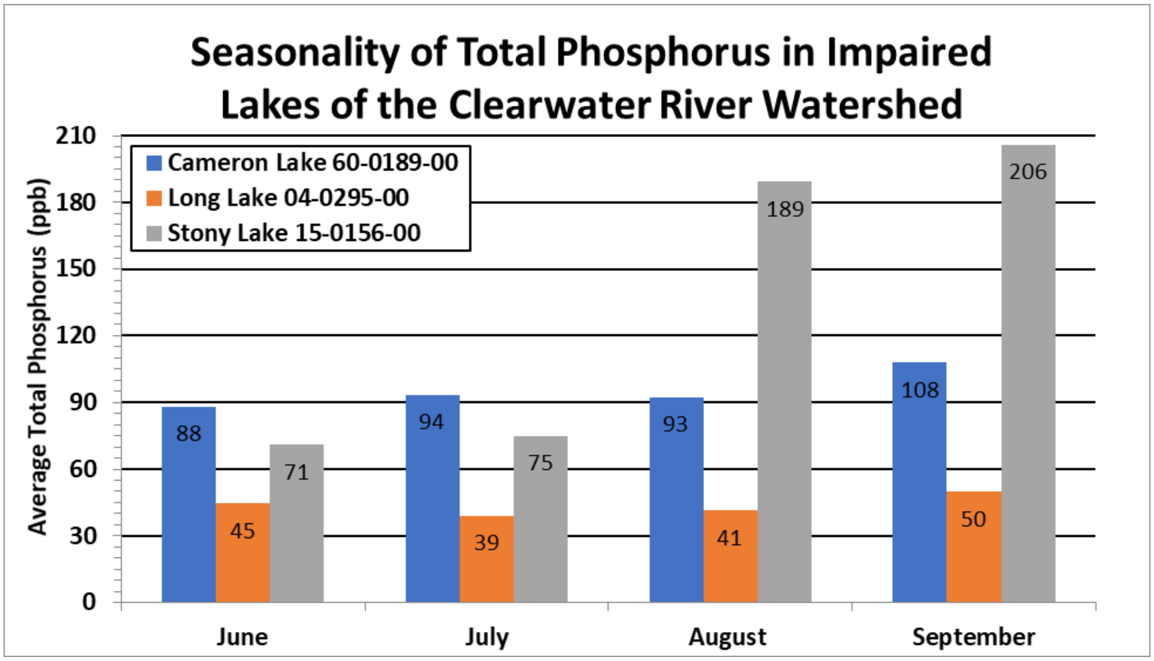


Figure 5-28. Seasonality of TP concentrations within the impaired lakes

5.4.5 Reserve Capacity

Future development within this agricultural watershed will likely be modest. Population trends are flat or even decreasing in areas surrounding the impaired AUIDs. No WWTFs discharge to the impaired lakes. Stony Lake and Long Lake have rural drainage areas. The city of Erskine drains to Cameron Lake, but the city's WWTF is located outside of the Cameron Lake Drainage area and is a no discharge facility. Therefore, no reserve capacity will be incorporated into the lake TP TMDLs for Stony, Cameron, and Long Lakes.

5.4.6 TMDL Summary

The Lake TP TMDLs were calculated using the BATHTUB Model, Version 6.20. The model used the inputs described in Section 5.4.1 to simulate the nutrient and flow inputs that would result in current water quality conditions and restored conditions. The current conditions were identified by finding the minimum amount of loading from watershed runoff (tributary inflow) and internal loading at which the predicted TP equaled observed TP. LC was identified by finding maximum allowable pollutant loading rates at which the predicted TP was equal to the TP standard.

The BATHTUB model provided four loading rates, in kilograms/year, that were used to calculate loading allocations and load reductions for current conditions and restored conditions in the following TMDL tables: total inflow, tributary inflow, internal load, and atmospheric deposition. There were additional TP sources that needed to be included in the TMDL but were not specifically addressed by the model. Construction and industrial stormwater permits were calculated separately and would conceptually be part of the inflow from the watershed of the lake (the tributary inflow values generated by the BATHTUB model). Nonpoint runoff loads were calculated by subtracting wasteloads and SSTS loads from the total, BATHTUB-modeled, tributary inflow loads that are shown in Table 5-55. The ways in which those number were used to calculate TMDLs are explained in Table 5-56.

Table 5-55. Mass balance outputs from the BATHTUB model, converted into pounds/year for each impaired lake

Lake	Tributary Inflow (pounds/year)		Internal Load (pounds/year)		Atmospheric Deposition (pounds/year)		Total Inflow (pounds/year)	
	Current	Restored	Current	Restored	Current	Restored	Current	Restored
Cameron Lake (60-0189-00)	209.66	74.08	696.22	322.32	21.38	21.38	927.26	417.78
Long Lake (04-0295-00)	304.02	194.67	87.96	37.70	9.04	9.04	401.02	241.41
Stony Lake (15-0156-00)	91.27	25.79	352.29*	84.88	7.28	7.28	450.84	117.95

*Internal loading was adjusted down 0.01 pounds for current conditions to compensate for a rounding error and so that the value for total inflow was not changed from the model outputs. That amount of change equals less than 0.005 kilograms/year, so it represents an insignificant change in loading rates that wouldn't be a misrepresentation of modeling results.

Portions of the total LC were reserved for construction and industrial stormwater (where applicable) and an MOS. The total WLA was calculated by adding the loading rates from construction and industrial stormwater. Septic system contributions (kg/yr) were calculated based on the number of identifiable lakeshore residences that may have a septic system. Estimated septic system contributions were considered part of the watershed runoff and subtracted from the model's tributary inflow loading rate in the "Existing TP Load" columns of Tables 5-57 through 5-59.

The remaining portion of the LC for each flow regime was the LA. The LA includes nonpoint runoff, SSTS, upstream lakes (none for these lakes), atmospheric deposition, groundwater (not calculated for these shallow lake TMDLs), and internal load. Estimated load reductions are the differences between existing loads and allowable loads. Two total load reduction estimates are provided. The load reduction estimate for "total loads" is the minimum amount of reductions needed to restore the lake to meet the TP standard. The load reduction goal for "total LAs" will restore the lake to meet the TP standard and provide a MOS.

Table 5-56. Explanation of how BATHTUB modeling results were represented in the load allocations and reductions in the TMDL summary tables

BATHTUB Mass Balance Category	Modeled Conditions	How it is Represented in the TMDL Summary Table
Tributary Inflow	Current	Existing TP load: Sum of WLA, nonpoint runoff, SSTS, upstream lakes, and groundwater loads
	Restored	Allowable TP load: sum of WLA, nonpoint runoff, SSTS, upstream lakes, and groundwater load allocations
Internal Load	Current	Existing TP load: internal load
	Restored	Allowable TP Load: internal load. The TMDL summary table value was calculated by subtracting the MOS from the BATHTUB model's internal loading rate for a restored lake.
Atmospheric Deposition	Current	Existing TP load: Atmospheric deposition
	Restored	Allowable TP load: Atmospheric deposition
Total Inflow	Current	Existing TP load: Total loading capacity
	Restored	Allowable TP load: Total loading capacity

The BATHTUB model revealed the extent to which Cameron Lake is likely impacted by internal loading. Internal loading in Cameron Lake was more than three times higher than tributary inflow and will need to be reduced by approximately 60% for the lake to meet water quality standards.

Table 5-57. TP TMDL Summary Table for Cameron Lake (60-0189-00)

TMDL parameter		Existing TP load		Allowable TP load		Estimated load reduction	
Sources		lbs/year	lbs/day	lbs/year	lbs/day	lbs/year	%
Wasteload	Construction/Industrial Stormwater WLA	0.09	**	0.09	**	0	0%
	Total WLA	**0.09**	**	**0.09**	**	**0**	**0**
Load	Nonpoint runoff	209.13	0.57	73.99	0.20	135.14	65%
	Estimated SSTS	0.44	**	0	0	0.44	100%
	Upstream lakes	0	0	0	0	0	0%
	Atmospheric deposition	21.38	0.06	21.38	0.06	0	0%
	Groundwater	0	0	0	0	0	0%
	Internal load	696.22	1.91	280.54	0.77	415.68	60%
	Total Load Allocations	**927.17**	**2.54**	**375.91**	**1.03**	**551.26**	**59%**
Calculated Margin of Safety				**41.78**	**0.11**		
Total Loads		**927.26**	**2.54**	**417.78***	**1.14***	**509.48**	**55%**

*Loading capacity, estimated as total inflow by the BATHTUB model
**The values of some sources like construction and industrial stormwater WLAs and SSTS were lower than 0.005 pounds/day. Though non-zero values were calculated, these values were too small to affect the LA.

Long Lake appears to require less effort to restore than the other two lakes. It is deeper than the other two lakes but still experiences some internal loading. Land use has changed and there are no longer cattle along the shoreline of the lake. Samples collected in August 2018 provide hope that the lake may be recovering. The TP concentrations in both ends of the lake were lower than the 30 ppb standard.

Table 5-58. TP TMDL Summary Table for Long Lake (04-0295-00)

TMDL parameter		Existing TP load		Allowable TP load		Estimated load reduction	
Sources		lbs/year	lbs/day	lbs/year	lbs/day	lbs/year	%
Wasteload	Construction/Industrial Stormwater WLA	0.01	**	0.01	**	0.00	0%
	Total WLA	**0.01**	**	**0.01**	**	**0**	**0%**
Load	Nonpoint runoff	303.57	0.84	194.66	0.54	108.91	36%
	Estimated SSTS	0.44	**	0.00	0.00	0.44	100%
	Upstream lakes	0.00	0.00	0.00	0.00	0.00	0%
	Atmospheric deposition	9.04	0.02	9.04	0.02	0.00	0%
	Groundwater	0.00	0.00	0.00	0.00	0.00	0%
	Internal load	87.96	0.24	13.56	0.03	74.40	85%
	Total Load Allocations	**401.00**	**1.10**	**217.25**	**0.59**	**183.75**	**46%**
Margin of Safety				**24.14**	**0.07**		
Total Loads		**401.02**	**1.10**	**241.41***	**0.66***	**159.61**	**40%**

* Loading capacity, estimated as total inflow by the BATHTUB model
**The values of some sources like construction and industrial stormwater WLAs and SSTS were lower than 0.005 pounds/day. Though non-zero values were calculated, these values were too small to affect the LA.

Internal loading is a significant obstacle that needs to be overcome in order to restore water quality within Stony Lake. Phosphorus loading from internal loading was more than seven times as high as loading from tributary inflow. There are opportunities for further implementation of agricultural BMPs to reduce runoff. However, the BATHTUB modeling results indicated that restoration cannot be achieved by only treating current runoff. Further examination will be necessary to develop solutions to the challenge of reducing internal loading within this small, shallow lake.

Table 5-59. TP TMDL Summary Table for Stony Lake (15-0156-00)

TMDL parameter		Existing TP load		Allowable TP load		Estimated load reduction	
Sources		lbs/year	lbs/day	lbs/year	lbs/day	lbs/year	%
Wasteload	Construction/Industrial Stormwater WLA	0.01	**	0.01	**	0.00	0%
	Total WLA	**0.01**	**	**0.01**	**	**0**	**0**
Load	Nonpoint runoff	91.00	0.25	25.78	0.07	65.22	72%
	Estimated SSTS	0.26	**	0.00	0.00	0.26	100%
	Upstream lakes	0.00	0.00	0.00	0.00	0.00	0%
	Atmospheric deposition	7.28	0.02	7.28	0.02	0.00	**0%**
	Groundwater	0.00	0.00	0.00	0.00	0.00	0%
	Internal load	352.29	0.97	73.08	0.20	279.21	**79%**
	Total Load Allocations	**450.83**	**1.24**	**106.14**	**0.29**	**344.69**	**76%**
Margin of Safety		n/a	n/a	**11.80**	**0.03**		
Total Loads		**450.84**	**1.24**	**117.95***	**0.32***	**332.89**	**74%**

* Loading capacity, estimated as total inflow by the BATHTUB model
**The values of some sources like construction and industrial stormwater WLAs and SSTS were lower than 0.005 pounds/day. Though non-zero values were calculated, these values were too small to affect the LA.

6 Future Growth Considerations

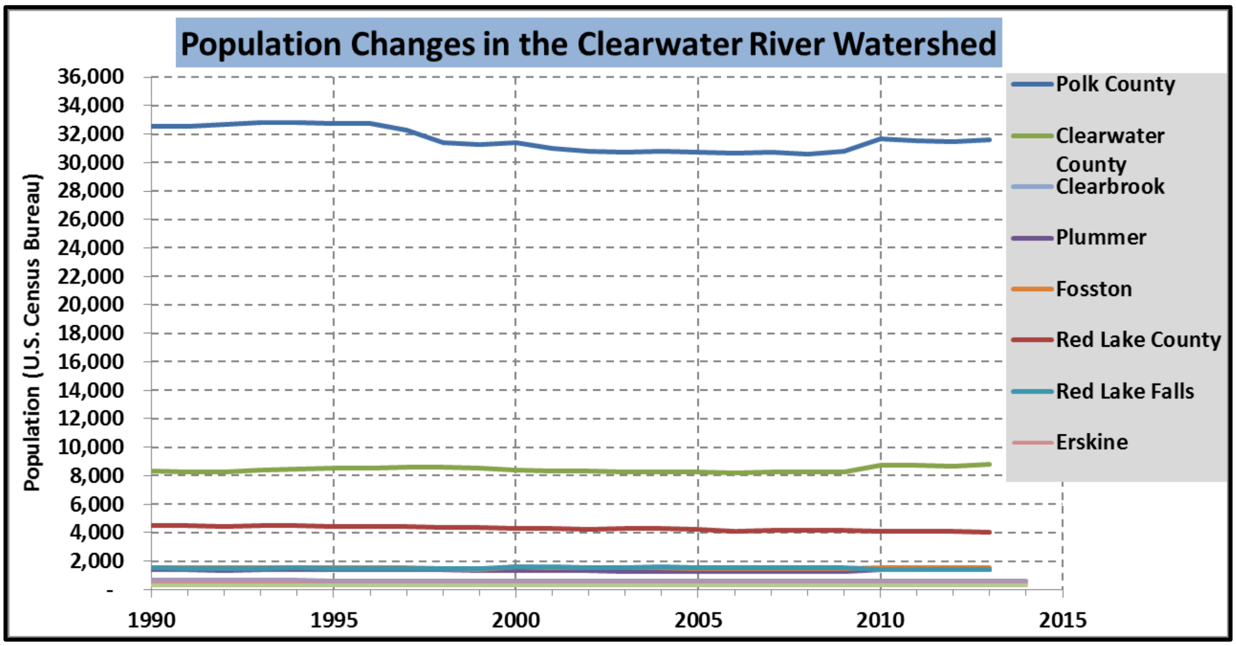


Figure 6 1. Population Changes in Counties and Cities of the Clearwater River Watershed

The reserve capacity allowed for TSS TMDLs was described in Section 5.1.6, the reserve capacity for the *E. coli* TMDLs was described in Section 5.2.6, and the reserve capacity for TP was described in Section 5.3.6. Reserve capacity was applied to TMDLs for streams that received discharge from WWTFs. There are communities with WWTFs that discharged into impaired waters in the Clearwater River Watershed. The populations in those cities have been steady between 1990 through 2014. Polk County includes large communities that lie within different watersheds. One of those communities, East Grand Forks, is in the Red Lake River major watershed. The decrease in population after the flood of 1997 that hit the cities of Grand Forks and East Grand Forks can be seen in Figure 6-1. The most significant population changes for the cities within the Clearwater River Watershed occurred during the national census years of 2000 and 2010 and were most likely a result of statistical adjustments that resulted from the census process. Based upon available population data, populations are expected to remain steady and growth of communities will likely be modest within the Clearwater River Watershed.

6.1 New or Expanding Permitted MS4 WLA Transfer Process

There are no MS4 communities within the Clearwater River Watershed nor are there any communities with populations that are close to the threshold population of 5,000 people for designated MS4s.

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. 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.
2. 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.

6.2 New or Expanding Wastewater (TSS and *E. coli* TMDLs only)

The MPCA, in coordination with the EPA Region 5, has developed a streamlined process for setting or revising WLAs for new or expanding wastewater discharges to waterbodies with an EPA approved TMDL (MPCA 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. For more information on the overall process, visit the MPCA's TMDL Policy and Guidance webpage.

7 Reasonable Assurance

Partnerships

The LGUs within the Clearwater River Watershed have a long history of cooperation on water quality studies and implementation projects. Those agencies include the RLWD, Clearwater SWCD, Red Lake SWCD, Beltrami SWCD, and the East Polk SWCD. The LGUs have written successful grant applications. The RLWD has provided cost-share funding (up to $12,500 per county per year) for erosion control projects.

Local, State, Tribal, and Federal agencies that have cooperated on projects in the past and plan to work together in the future to improve water quality and habitat in the Clearwater River Watershed include:

- Beltrami SWCD
- Clearwater SWCD
- East Polk SWCD
- Minnesota Board of Water and Soil Resources (BWSR)
- Minnesota Department of Natural Resources (DNR)
- MPCA
- Natural Resources Conservation Service (NRCS)
- Pennington SWCD
- Red Lake Nation Department of Natural Resources
- Red Lake SWCD
- Red Lake Watershed District (RLWD)
- United States Fish and Wildlife Service (USFWS)

Watershed Funding and Planning

Minnesota voters approved a constitutional amendment in 2008 to increase the state sales tax to fund water quality improvements. Subsequently, several state agencies have come together to focus on high level planning to best utilize these funds. The interagency Minnesota Water Quality Framework was applied to Minnesota's 80 major watersheds and clearly illustrates the cycle of assessment, watershed planning and implementation to which the state is committed. This is an iterative process that will provide feedback from implementation activities and inform an adaptive management approach to restoration and protection.

A 1W1P process, selected for funding in 2020, will be completed for the Clearwater River Watershed with information from the completed WRAPS project. That process will create a local water management plan that will take the place of existing local water management plans for SWCDs (counties) and the RLWD. The state (BWSR) will allocate money to the implementation of the 1W1P after the plan is completed. The WRAPS and TMDL documents include strategies that are capable of cumulatively achieving needed pollution load reductions for point and nonpoint pollutant sources. This will inform the planning and development of water quality and pollutant load reduction goals for the 1W1P. The 1W1P process will continue and build upon the stakeholder involvement that was fostered during the WRAPS process. The 1W1P will utilize a field-scale model like PTMApp to prioritize the most cost-effective locations for the implementation of BMPs.

Improved Wild Rice Production Methods

Longitudinal sampling revealed that wild rice paddy drainage is still having a negative effect on water quality, overall, but farms that have implemented practices to reduce sediment and nutrient loss have significantly lowered their impact on water quality in the river. While pollutant concentrations initially increase downstream of some wild rice farms, pollutant concentrations decreased downstream of a farm that has implemented BMPs and main line tile (Figure 4-12). Some practices have been implemented (tile drainage within the paddies and settling ponds) to reduce pollutants in water that is drained from wild rice paddies and have measurably improved conditions. Wild rice growers along the

Clearwater River have begun installing tile drainage in their paddies. This practice provides numerous benefits to the farmer including even quality, even maturity, less ditch maintenance, fewer ruts during harvest, more control over drainage, and less soil loss. Main-line tile drained paddies also release clean water. The *Red Lake River Watershed Farm to Stream Tile Drainage Water Quality Study* found that main-line tile drainage of wild rice paddies not only has all the same benefits of conventional agricultural tile drainage, but also has low nitrate concentrations. To achieve those benefits, the tiling system must be a main line tiling system that exits the paddy through the dike and into a stable ditch. Internal drainage ditches need to be eliminated, and the main line tile makes them unnecessary. The main line tile drainage system also drains the paddy more evenly, allowing for more even ripening and other benefits to the farmer. The peat soil in the paddies is highly erodible. Even clean water from the end of a tile line will become laden with sediment by the time it leaves the paddy if it travels through an internal drainage ditch.

Figure 7-1. Photos of completed projects: streambank stabilization along the Clearwater River (AUID 650) (Left) and Bagley stormwater ponds (near AUID 517) (Right)

Past Projects

Local and state agencies have been active in promoting BMPs and completing projects for the purpose of improving and protecting water quality along the Clearwater River and its tributaries. Projects have been implemented to improve water quality in the Clearwater River and its tributaries since the assessment of water quality began, including:

- Clearwater River Nonpoint Study, Phase II
  - Buffer strips
  - Streambank stabilization
  - Wild rice paddy BMPs
  - Grade stabilization
  - Public education (River Watch)
- 2003 Bagley Urban Runoff Project (Figure 7-1)
- Streambank stabilization along the Clearwater River near Clearwater Rice (Figure 7-1).
- Buffer and stream bank stabilization projects within the Silver Creek Watershed.

- Silver Creek Restoration Project
- The USFWS has restored more than 1,500 wetlands (>90% of those in the Clearwater River Watershed) over the last 20 years through the Partners for Fish and Wildlife Program. Those wetlands cover approximately 2,200 acres and provide 3,300 acre-feet of water storage.
- SWCDs provide cost-share programs for landowners to help with the costs of installing side water inlets (SWIs), windbreaks, shelter belts, filter strips, critical area planting, streambank protection, shoreline protection, and sediment basins.
- Red Lake County culvert inventory
- Clearbrook stormwater study
- Clearbrook stormwater pond
- Lost River Watershed Runoff Reduction Project (2012, Clearwater SWCD)
- SWIs, buffers, cattle exclusion, and streambank restoration along AUID 512
- Pine Lake shoreline protection and naturalization
- It's All in the Timing: Expanding Lake Protection Screening Reports (2012, Clearwater SWCD)
- Protecting the Clearwater River Watershed through Buffers and Other BMPs (2013, Clearwater SWCD)
- Buffers and bank stabilization along the JD 72 along AUID 645 of the Lost River.
- Beltrami County Lake Screening for Future Protection Efforts (2017, Beltrami SWCD)
- Clearwater Lake Shoreline Restoration and Protection Project ($75,000 Enbridge Ecofootprint grant)
- Improving Water Quality, Soil Health and Pasture/Hayland production With No-Till (2015, Clearwater SWCD)
- 2015 Red Lake County Drainage Ditch Inventory and Inspection (Phase II)
- Stormwater Runoff Improvement Project along the Clearwater River (2013, Red Lake SWCD)
- Cattle exclusion projects in Clearwater County
- Clearwater SWCD Conservation Farm

Buffer Law

Minnesota’s Buffer Law that was signed into law by Governor Mark Dayton in June 2015 and amended by the Legislature and signed into law by Governor Dayton on April 25, 2016. Minnesota's buffer law establishes new perennial vegetation buffers of 50 feet along public waters and 16.5 feet along ditches. The law provides flexibility and financial support for landowners to install and maintain buffers. Many segments of streams and ditches have been poorly buffered due to landowner choice, “grandfathering” status of old ditches that are not subject to current rules, and incomplete enforcement. This law will provide the means and support needed to fix those problems in order to significantly improve and protect water quality.

Progress Tracking

Six impairments have already been delisted in the Clearwater River Watershed. One ammonia impairment (AUID 653) was delisted due to additional new data showing compliance with the standards. Two DO impairments (AUIDs 647 and 648) and three fecal coliform impairments (AUIDs 507, 510, and 516) were delisted due to changes in wild rice paddy drainage practices that started in the 1990s, as well as two new community WWTFs, BMP implementation and improved feedlot management practices.

Progress toward restoration will be tracked by local water quality monitoring programs. The majority of the water quality data from this watershed has been collected by local organizations including the RLWD, International Water Institute, Clearwater SWCD, Red Lake SWCD, East Polk SWCD, Beltrami SWCD, and the River Watch program. Monitoring plans for the next 10 years are described in Section 8 of this report.

8 Monitoring Plan

Local, State, and Federal agencies combine efforts to collect a large amount of environmental data within the Clearwater River Watershed. Water quality in rivers and streams is monitored using specialized equipment and laboratory analysis. Stage and flow levels are monitored along the Clearwater River and its tributaries. Groundwater levels are monitored by SWCDs in cooperation with the DNR. The State conducts biological (aquatic and terrestrial) monitoring. Compliance monitoring is also important for the protection of natural resources.

Water quality monitoring can be conducted for multiple purposes. Much of the data is collected to monitor the condition of waterways over time, assess current water quality conditions, and calculate pollutant loads. The number of parameters and the frequency at which they are measured depends upon project goals, the budget of the monitoring project, available equipment, and available staff time. Official water quality assessments require a minimum number of water quality measurements to determine whether a waterway is meeting or violating water quality standards. Monitoring programs may be short-term or long-term. Short-term monitoring efforts may aim to characterize current water quality conditions (SWAG Grants), diagnose the source of a water quality problem, or measure the effectiveness of a project. Long-term monitoring (Table 8-1) should collect enough data to both measure trends over time and assess a waterway's ability to support aquatic life and recreation. All data that is collected following proper procedures needs to be submitted to the MPCA for entry and storage in the State's EQuIS water quality database. The State uses data stored in EQuIS during official water quality assessments. Data compiled in EQuIS is also used for many other purposes, like writing TMDLs. The EQuIS data can be accessed through the MPCA Environmental Data Access: Surface Water Data website (https://www.pca.state.mn.us/quick-links/eda-surface-water-data).

The parameters that are measured for long-term monitoring projects may vary slightly among organizations and monitoring sites. Basic parameters that can be measured on-site while monitoring (field parameters) include water temperature, DO, pH, specific conductivity, stage, transparency, turbidity, and observations/comments. Water samples are shipped overnight or delivered on the same day to a lab that is certified by the Minnesota Department of Health for analysis. Typically, samples are analyzed for a basic set of parameters that includes TP, OP, TSS, ammonia nitrogen (NH3), total Kjeldahl nitrogen (TKN), nitrates & nitrites (NO2 + NO3), and *E. coli*. Additional parameters like chemical oxygen demand (COD), BOD, sulfates, total organic carbon, and/or chl-*a* may be collected, dependent upon project needs. Oxygen demand data is sometimes collected at sites on reaches that are impaired by low DO levels (either officially or suspected). Chl-*a* has been collected for the MPCA from the lower end of major subwatersheds to measure eutrophication levels. Collection of BOD and/or chl-*a* samples on streams that exceed TP standards.

The RLWD began monitoring water quality in the Clearwater River Watershed in 1980 and now monitors more than 30 stations in the watershed (Figure 8-1). Newer water quality stations that were monitored for the Clearwater River WRAPS were added to the RLWD long-term monitoring program. The monitoring program collects data from the significant waterways within the watershed, including multiple reaches of the Clearwater River and its significant tributaries. Field measurements of DO, temperature, turbidity, specific conductivity, pH, and stage are collected during each site visit (if there is water). Four rounds of samples are also collected at and analyzed for TP, OP, TSS, TKN, NH3, NO2 + NO3, and *E. coli* at most of the sites. For the past few years, BOD analysis has been added for the sites that are located on reaches that have had low DO levels. BOD was replaced with COD analysis in 2014 because many BOD levels were too low to be measured. Sampling months are alternated each year with the goal of collecting at least five samples per calendar month within a 10-year period. A long-term monitoring site will be added/moved to the 09020305-647, channelized reach of the Clearwater River for the 2018 monitoring season. Three SWCDs in the Clearwater River Watershed have the ability to collect water quality data. The Red Lake County SWCD has sampled sites in Red Lake County, once a month, during the months of May through September. Staff from the East Polk SWCD had been monitoring several streams for the MPCA Citizen Stream Monitoring Network, but SWAG Grant helped equip the SWCD with a multiparameter sonde for the collection of additional water quality parameters. The Clearwater SWCD is equipped for monitoring and sampling. They have conducted monitoring for SWAG projects and are planning to start monitoring select sites on a long-term basis. The WPLMN monitors a selection of stations that also have real-time flow gauges. Lake associations have been responsible for the collection of the most consistent, long-term water quality data from lakes in the Clearwater River Watershed. Monitoring efforts for other lakes has been less organized and shorter in duration.

River Watch is a volunteer monitoring program that gives high school students the opportunity to collect water quality data, learn about their watershed, learn about natural resources professions, and learn about area waterbodies. This data is collected using the same methods that are used by professionals and is stored in the EQuIS database along with all other data that is collected within the watershed. Schools that have participated in the program and monitored streams within this watershed include Win-E-Mac (Winger, Erskine, and McIntosh), Fosston, Red Lake Falls, Red Lake County Central (Oklee), Clearbrook-Gonvick, and Bagley. Bagley and Fosston schools are currently inactive and restarting those programs should be a priority. Some River Watch groups have sampled macroinvertebrates for educational purposes. Some advanced goals of sampling efforts could focus on specific metrics or species where numbers were found to be deficient during the MPCA sampling. For example, Trichoptera numbers could be compared among sites.

Robust collection of water chemistry data at long-term stream gaging sites improves the quality of water quality models (Soil and Water Assessment Tool [SWAT}, HSPF) by providing a record of measured water quality that can be compared to the simulated conditions during the model calibration process. Key monitoring sites where more frequent data collection would aid future model calibration efforts include:

1. S002-916 – Clearwater River at County Road 127
2. S004-816 – Beau Gerlot Creek at CSAH 92
3. S006-506 – Brooks Creek at CSAH 92.
4. S005-501 – Lost River at Lindberg Lake Road

Table 8-1. Clearwater River Watershed long-term monitoring activity, organized by assessment unit (continued on next page)

Long-Term Monitoring Activity in the Clearwater River Watershed - 2018 Monitoring Season								
Assessment Unit ID	Waterbody Name	Station ID	Station Description	RLWD	SWCD	MWPLMN	River Watch	Volunteers and Lake Associations
09020305-501	Clearwater River	S002-118	Bottineau Avenue in Red Lake Falls	X	X	X	X	
09020305-502	Lower Badger Creek	S004-837	CR 114	X			X	
		S009-377	150th Avenue SE	X				
09020305-504	Poplar River	S007-608	CR 118	X				
09020305-509	Walker Brook	S002-122	CSAH 19	X				
09020305-511	Clearwater River	S002-914	CSAH 12	X	X		X	
09020305-512	Lost River	S001-007	Pine Lake outlet at 486th Street	X				
		S007-607	CSAH 8	X				
09020305-513	Ruffy Brook	S008-057	CSAH 11	X				
09020305-517	Clearwater River	S004-986	CSAH 25, near Bagley	X				
		S001-908	CSAH 2	X				
09020305-518	Poplar River	S003-127	CSAH 30	X				
		S005-320	330th St. SE		X			
		S009-392	310th St. SE	X				
09020305-523	Polk CD 14	S002-130	CSAH 10 near Maple L. outlet	X				
09020305-526	Clear Brook	S004-044	CSAH 92	X				
09020305-527	Silver Creek	S000-712	159th Ave	X				
		S002-082	CR 111	X				
09020305-529	Lost River	S005-283	109th Ave	X				
09020305-539	Hill River	S003-498	CSAH 35	X	X			
		S002-134	CR 119	X			X	
09020305-541	Bee Lake Inlet	S002-086	CSAH 37				X	
09020305-542	Poplar River Diversion	S002-131	U.S. Hwy. 2				X	
09020305-543	Poplar River Diversion	S002-129	Badger L. inlet @ 220th Ave SE	X			X	
09020305-545	Nassett Creek	S004-205	Nessett Creek Rd	X				
09020305-549	JD73	S002-075	CSAH 10, Maple L. inlet	X			X	
09020305-550	JD 73	S003-318	343rd St. SE	X			X	
09020305-551	Bee Lake Outlet	S003-317	340th St. SE				X	
09020305-574	Terrebonne Creek	S004-819	CSAH 92	X				
0920305-645	Lost River	S007-849	CSAH 28	X				

Long-Term Monitoring Activity in the Clearwater River Watershed - 2018 Monitoring Season

Assessment Unit ID	Waterbody Name	Station ID	Station Description	RLWD	SWCD	MWPLMN	River Watch	Volunteers and Lake Associations
09020305-646	Lost River	S003-500	330th Ave SE		X			
		S001-131	CSAH 5 in Oklee	X				
		S002-133	CR 119	X		X		
09020305-647	Clearwater River	S003-174	CSAH 10		X			
		S002-121	370th Ave SE		X			
09020305-648	Clearwater River	S002-124	Minnesota St (Plummer Gage)	X	X	X		
09020305-649	Clearwater River	S001-461	CSAH 14	X				
09020305-652	Beau Gerlot Creek	S008-058	CR 114	X				
09020305-653	Clearwater River	S001-460	CSAH 24	X				
09020305-656	Hill River	S007-847	335th Ave SE	X				
04-0343-00	Clearwater Lake	04-0343-00-204	47.742662,-95.196518					X
15-0040-00	Bagley Lake	15-0040-00-201	47.759886,-95.231919					X
15-0060-00	Walker Brook Lake	15-0060-00-101	47.487093,-95.291485					X
15-0104-00	Lone Lake	15-0104-00-201	47.586315,-95.426007					X
60-0006-00	Poplar Lake	60-0006-00-201	47.544138,-95.664122		X			
60-0012-00	Spring Lake	60-0012-00-201	47.508523,-95.639581		X			
60-0015-00	Whitefish Lake	60-0015-00-101	47.586745,-95.653952		X			X
60-0027-02	Cross Lake	60-0027-02-202	47.626311,-95.633302		X			
60-0032-00	Turtle Lake	60-0032-00-201	47.61764,-95.669525		X			
60-0142-00	Hill River Lake	60-0142-00-201	47.677826,-95.80251		X			
60-0185-00	Oak Lake	60-0185-00-201			X			
60-0189-00	Cameron Lake	60-0189-00-201	47.665911,-96.019496		X			
60-214-00	Badger Lake	60-0214-00	47.681351,-96.008927		X			
60-0305-00	Maple Lake	60-0305-00-204	47.671185, -96.129124					X

Additional data collection efforts and adjustments could be considered for future monitoring efforts. Additional intensive sampling during runoff events will help shed light upon the causes of water quality problems in the watershed. Bolstered data collection efforts at key sites would aid with pre/post project evaluation. Long-term monitoring programs can evolve to include different or additional sites that have a strategic value that is equal to or greater than existing long-term monitoring sites. Strategic collection of MST samples and deployment of DO loggers are additional forms of monitoring that provide valuable information.

The MPCA plans to assess the Clearwater River Watershed once every 10 years. The RLWD water quality staff will use the latest MPCA assessment methods to assess conditions once every two years, at a minimum. Tracking water quality conditions is important for finding reaches that can be recommended for delisting (post-restoration removal from the 303(d) List of Impaired Waters), tracking progress toward delisting, identifying new problems so they can be addressed sooner, and identifying areas that need additional data.

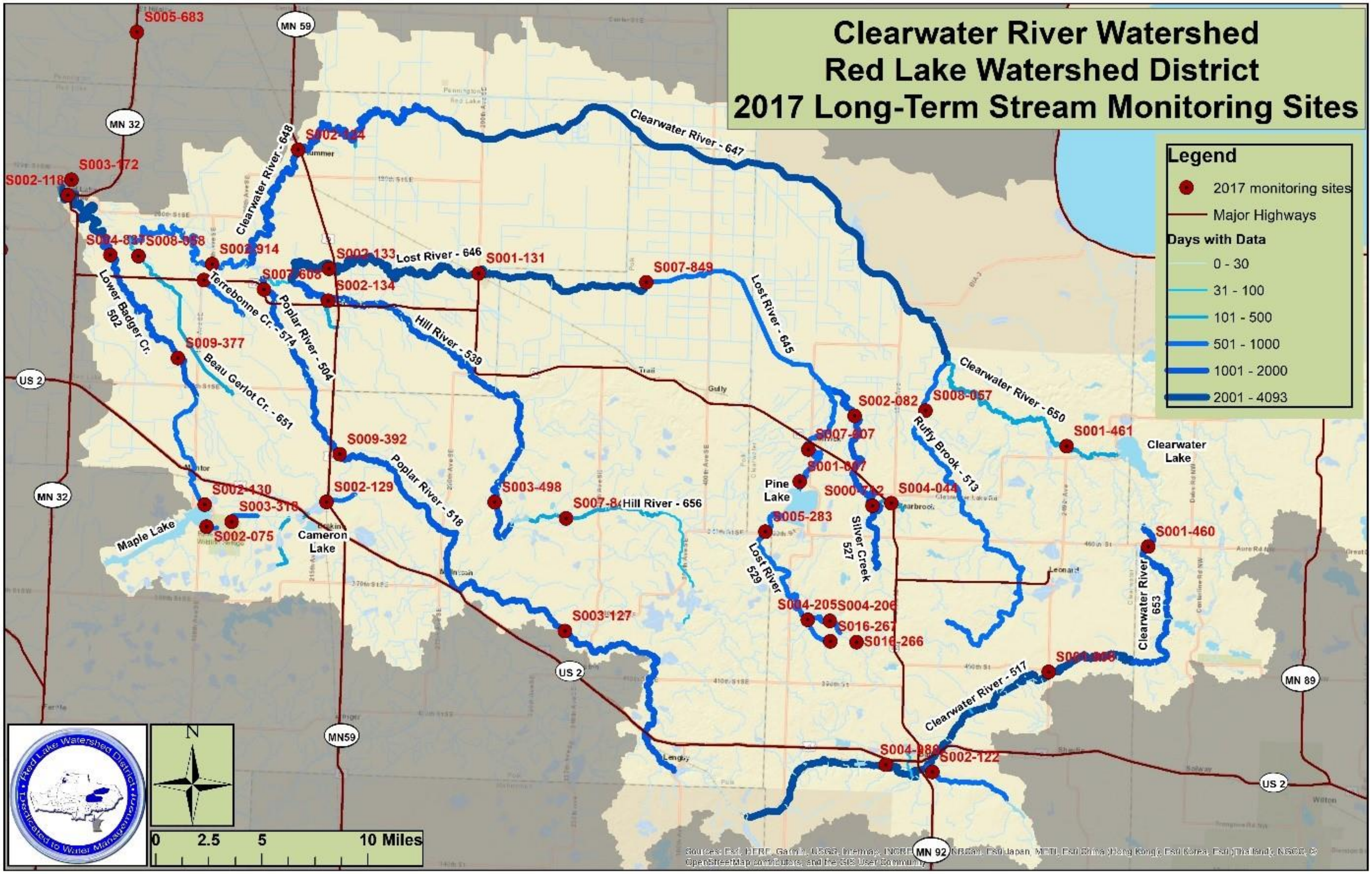


Figure 8- 1. Long-term water quality stations monitored by the RLWD

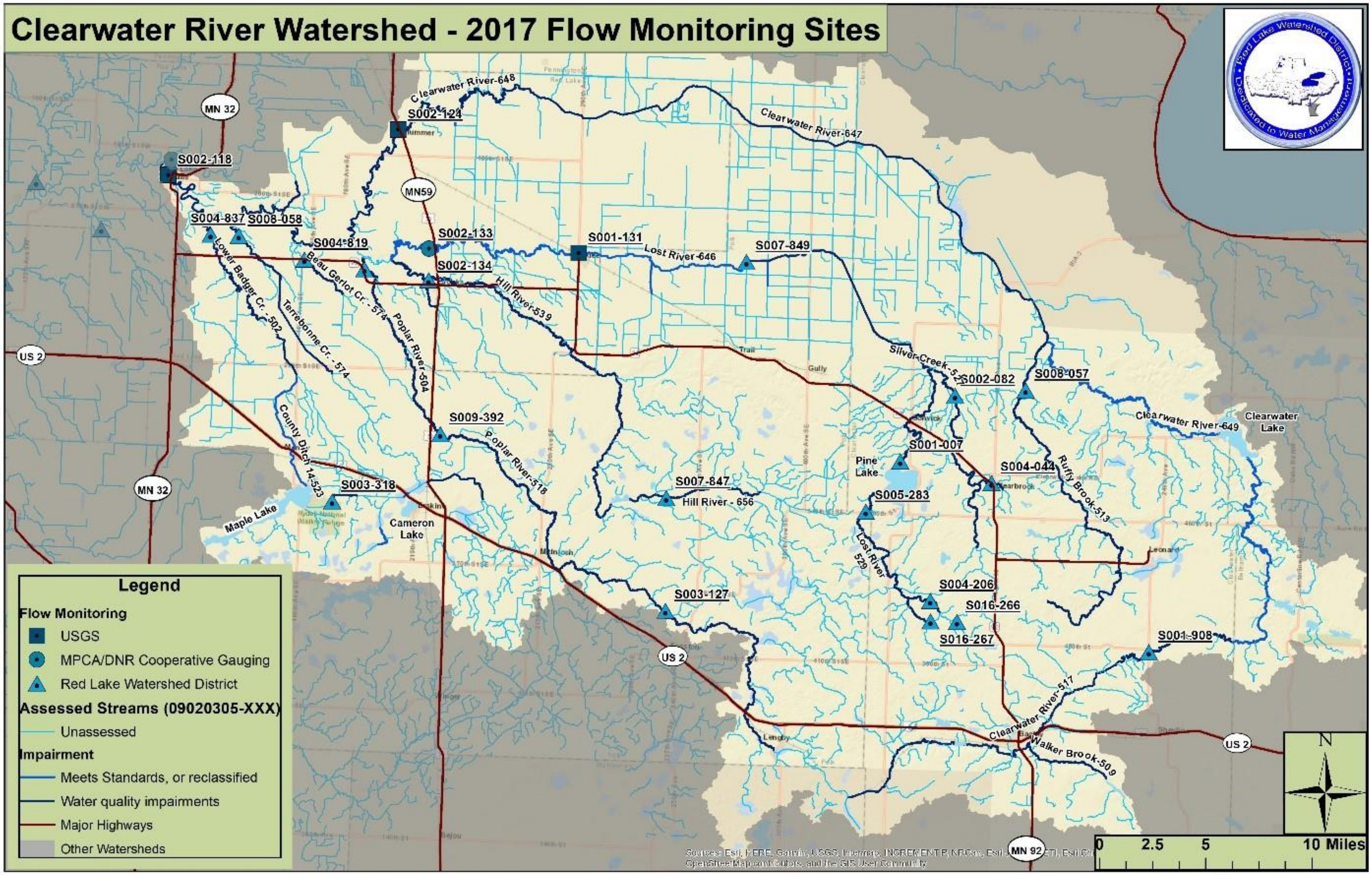


Figure 8-2. Flow and stage monitoring stations in the Clearwater River Watershed, 2017 monitoring season

The collection of continuous DO data is essential, at most sites, for the collection of DO measurements prior to 9:00 a.m. The MPCA requires a record of pre-9 a.m. DO readings to declare that the waterway contains enough DO to fully support aquatic life. DO logging equipment can collect regular DO measurements (e.g. every 30 minutes) while deployed in a waterway. Equipment is deployed for a maximum of two weeks at a time before it is retrieved for data download, cleaning, and re-calibration. Prior to the next state water quality assessment of the Clearwater River, continuous DO monitoring should be conducted to fully assess the capacity of key reaches in the watershed to support aquatic life. Data collected during the monitoring seasons of 2016 through 2025 can be used for the 2026 State water quality assessment. Priority should be given to reaches and sites that are too remotely located from LGU offices for pre-9 a.m. measurements. Continuous DO data may also be used for the assessment of river eutrophication. The MPCA assessment methods require that data is collected from at least two separate years.

A monitoring plan has been compiled by the RLWD for the future collection of additional continuous DO data prior to the next assessment. The effort will attempt to complete multiple deployments at most of the significant, accessible stream reaches in the watershed. Deployments will be made in two separate years at sites that have high concentrations of TP, to meet the minimum requirements of the DO flux standard for river eutrophication assessments.

The map in Figure 8-2 shows that flow monitoring stations are located near the downstream end of most pollutant-impaired streams in the watershed. However, there are at least three impaired AUIDs that could use additional flow monitoring on the Clearwater River (AUID 647), Clear Brook, and the Lost River (AUID 512). Real-time stage and discharge monitoring stations have been installed in several locations along the Clearwater River and its tributaries. The DNR/MPCA Cooperative Gauging Program also monitors several sites without the use of telemetry. Other significant reaches of the watershed are monitored with HOBO water level loggers by the RLWD (without telemetry).

1. USGS Gauge on the Clearwater River in Red Lake Falls
    - USGS gaging station
    - USGS# 05078500
    - EQuIS ID# S002-118
    - https://waterdata.usgs.gov/mn/nwis/uv?05078500
2. Lost River near Brooks, at CR 119
    - DNR/MPCA Cooperative Stream Gaging station
    - EQuIS ID# S002-133
    - https://www.dnr.state.mn.us/waters/csg/site_report.html?mode=get_site_report&site=66048001
2. USGS Gauge on the Clearwater River near Plummer
    - USGS gaging station
    - USGS# 05078000

- EQuIS ID# S002-124
- https://waterdata.usgs.gov/mn/nwis/uv?05078000

3. USGS Gauge on the Lost River at Oklee
   - USGS gaging station
   - USGS# 05078230
   - EQuIS ID# S001-131
   - https://waterdata.usgs.gov/mn/nwis/uv?05078230
4. Silver Creek at CR 111 (S002-082)
   a. RLWD HOBO Water Level- Logger station
5. Beau Gerlot Creek at CR 114 (S008-058)
   b. RLWD HOBO Water Level- Logger station
6. Clearwater River at CSAH 2 (S001-908)
   c. RLWD HOBO Water Level- Logger station
7. Hill River at 335th Avenue Southeast (S007-847)
   d. RLWD HOBO Water Level- Logger station
8. Judicial Ditch 73 at 343rd Street Southeast (S003-318)
   e. RLWD HOBO Water Level- Logger station
9. Lost River at 109th Avenue (S005-283)
   f. RLWD HOBO Water Level- Logger station
10. Lost River at CSAH 28 (S007-849)
    g. RLWD HOBO Water Level- Logger station
11. Lower Badger Creek at CR 114 (S004-837)
    h. RLWD HOBO Water Level- Logger station
12. Hill River at CR 119 (S002-134)
    i. MPCA gauging station (during the WRAPS process, now removed)
    j. RLWD HOBO Water Level- Logger station
13. Poplar River at CSAH 30 (S003-127)
    k. RLWD HOBO Water Level- Logger station
14. Poplar River at CR 118 (S007-608)
    l. RLWD HOBO Water Level- Logger station
15. Ruffy Brook at CSAH 11 (S008-057)

m. RLWD HOBO Water Level- Logger station

16. Terrebonne Creek at CSAH 92 (S004-819)

n. RLWD HOBO Water Level- Logger station

17. Clearwater River at CSAH 24 (S001-460)

o. MPCA gauging station (during the WRAPS process, now removed)

Follow-up fish sampling is beyond the scope of local agencies due to the requirements of specialized, expensive equipment and permitting requirements. The sampling of macroinvertebrates, however, is more feasible. River Watch volunteers have been sampling macroinvertebrates for educational purposes. The RLWD is equipped for macroinvertebrate sampling. If proper methods are used, targeted volunteer sampling and/or LGU sampling could provide useful data. The samples could be sent to a qualified laboratory, or even the same laboratory that is used by the state, for identification and quantification. That data could be used to, at least, calculate some of the key metrics (e.g. those related to Trichoptera) and provide an indication as to whether conditions have changed in a reach (particularly those that are impaired, nearly restored, and nearly impaired) or not.

Other forms of monitoring are also important for the protection of natural resources in the Clearwater River Watershed.

- An intensive geomorphological study of the watershed was completed in conjunction with the Clearwater River WRAPS process. The process can be repeated at least once every 10 years to measure erosion rates and assess the accuracy of Bank Erosion Hazard (BEHI) ratings.
- The findings of drainage ditch inventories can be used to identify areas that need to be addressed with BMPs to reduce erosion and sedimentation within ditches.
- Traveling along navigable streams in a kayak or canoe and documenting conditions is one of the best ways to find erosion problems, finding other sources of water quality problems, and assessing the quality of habitat along a waterway.
- The Northland Community and Technical College Aerospace Program inspecting ditch systems and identifying the sources of water quality problems. Drones are now capable of collecting high resolution three-dimensional images that can be used to find and measure erosion problems along rivers and streams. The college, consultant, or qualified local staff may also use the drones to collect LiDAR profiles areas with erosion or channel stability problems as an alternative to surveying longitudinal profiles and cross-sections.

9 Implementation Strategy Summary

Implementation strategies for the Clearwater River Watershed have been developed through extensive field reconnaissance, collaboration with local and state agencies, stakeholder involvement, multiple water quality studies, and the use of watershed modeling tools. The strategies in this TMDL focus upon water quality improvement along impaired reaches. Additional strategies are discussed in the Clearwater River WRAPS Report. The strategies described in this section are also described in further detail for each subwatershed within Section 3 of the Clearwater River WRAPS Report. The following list is a summary of the suggested strategies needed to achieve restoration goals in the watershed:

- Improve the completeness and quality of riparian buffers.
- Reduce agricultural runoff through a variety of BMPs.
- Grazing management
- Stormwater runoff treatment and reduction
- Wetland restorations
- Septic system inspections
- Lakeshore restoration and stabilization
- Fish passage improvement
- In-stream habitat improvement
- Wild rice paddy BMPs
- Improve base flows
- Further study of natural and unknown sources

There are multiple strategies that can be used to prioritize waters for implementation projects. The Clearwater River WRAPS Section 3 describes models and statistical categorizations that can be used to identify areas that should be targeted for restoration and protection efforts. Based on assessment statistics, the WRAPS process identified streams that were nearly restored (failed to meet standards but were relatively close to the impairment threshold):

1. Clearwater River AUID 541, TSS
2. Lost River AUID 512, *E. coli*
3. Poplar River AUID 518, F-IBI
4. Clear Brook AUID 526, *E. coli*
5. Silver Creek AUID 527, M-IBI
6. Hill River AUID 539, F-IBI
7. Nassett Creek AUID 545, TSS
8. Tributary to Poplar River Diversion AUID 561, F-IBI
9. Brooks Creek AUID 578, *E. coli*
10. Lost River AUID 645, DO, F-IBI
11. Clearwater River AUID 647, TSS
12. Beau Gerlot Creek AUID 652, M-IBI

Table 9-1 helps to further prioritize waters with pollutant-based impairments based on the level of estimated pollutant reductions that will be needed to meet water quality standards. For each pollutant (TSS, TP, *E. coli*), AUIDs were ranked based on the estimated load reductions (units per year) that will be needed to meet the standard. The AUIDs were also ranked based on the density of the load reduction (units per square mile). Each water's rankings were averaged. Waters were then ranked by their overall average ranking. Waters with relatively low average rankings were given relatively higher priority for implementation. Waters at the top of the list in Table 9-1 would theoretically require a lower amount of load reductions and/or funding to restore. There were several ties that were broken in the table by giving preference to waters in which projects will have multiple benefits (address multiple impairments), waters with a lower total load reduction value, or waters that can be restored with nonpoint source reductions practices (rather than in-lake strategies).

The data for Table 9-1 comes from the load reduction estimation tables in Sections 5.1.7, 5.2.7, 5.3.7, and 5.4.6. The minimum load reduction values for each waterbody and impairment (current load minus LC) were used in Table 9-1. The highest priority waters for each pollutant reduction category are highlighted. One of the highest prioritized river reaches in Table 9-1 is the Clearwater River between Ruffy Brook and JD 1 (AUID 647). That reach is also the furthest upstream impaired reach of the Clearwater River. The Clearwater River is not impaired upstream of that reach and has relatively low pollutant concentrations. Strategies could be targeted within the immediate drainage area of AUID 647 (and Ruffy Brook) to restore that nearly restored reach.

One stream, Nassett Creek, does not have a load reduction table, but does provide an estimate of load reductions based on recent sampling and the exceedance rate of the TSS standard in that data. The load reduction value for Nassett Creek was estimated using the LA values for each flow regime and the percentage by which the exceedance rate needs to decrease. The percentage was applied to each flow regime with measurable flow.

Table 9-1. Prioritization of restorable waters using estimated load reductions and load reductions per acre of drainage area

Waterbody Description			Total Suspended Solids				Total Phosphorus				*E. coli* Bacteria				
Stream Name	Assessment Unit	Drainage Area	TSS Annual Load Reduction Estimate (tons/yr.)	TSS Reduction (tons/mi^2)	TSS (tons) Rank	TSS (tons/mi^2) ank	TP Annual Load Reduction Estimate (lbs/yr)	TP Reduction (lbs/mi^2)	TP (lbs/yr.) Rank	TP (lbs./mi^2) Rank	Annual *E. coli* Load Reduction Estimate (billion orgs./yr.)	*E. coli* Reduction orgs/mi^2 (billion orgs/yr.)	*E. coli (orgs/yr.)* Rank	*E. coli* orgs/mi^2 Rank	Average rank
Silver Creek	09020305-527	34.37									22.5	0.7	1	1	1.00
Long Lake	04-0295-00	20.78					159.6	7.7	1	1					1.00
Stony Lake	15-0156-00	2.52					332.9	132.1	2	3					2.50
Clearwater River	09020305-647	265.23	353.0	1.3	2	1	4,872.8	18.4	4	2	1,428.6	5.4	6	2	2.83
Clear Brook	09020305-526	6.24									210.2	33.7	2	4	3.00
Clearwater River	09020305-648	345.84	628.9	1.8	3	3									3.00
Cameron Lake	60-0189-00	3.6					509.5	141.5	3	4					3.50
Nassett Creek	09020305-545	6.15	8.5	1.4	1	2					561.7	91.3	3	10	4.00
Clearwater River	09020305-501	673.85	1,842.7	2.7	4	4									4.00
Clearwater River	09020305-511	680.67	6,417.1	9.4	5	5									5.00
Terrebonne Creek	09020305-574	14.94									941.7	63.0	4	6	5.00
Hill River	09020305-539	177.23									2,212.2	12.5	9	3	6.00
Lost River	09020305-530	20.5									1,386.6	67.6	5	8	6.50
Beau Gerlot Creek	09020305-651	24.06									1,595.1	66.3	7	7	7.00
Poplar River	09020305-504	116.82									5,207.5	44.6	11	5	8.00
Lost River	09020305-529	30.62									2,134.5	69.7	8	9	8.50
Brooks Creek	09020305-578	23.56									2,294.4	97.4	10	11	10.50
Lost River	09020305-512	60.13									7,680.3	127.7	12	12	12.00
Lower Badger Creek	09020305-502	122.2									17,985.0	147.2	13	13	13.00
JD 73	09020305-550	49.99									21,011.2	420.3	14	14	14.00
Ruffy Brook	09020305-513	54.05									58,995.68	1,091.5	15	15	15.00

9.1 Permitted Sources

9.1.1 Construction Stormwater

The WLA for stormwater discharges construction activity reflected the number of construction sites greater than one acre that were 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 Construction 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 the NPDES/SDS General Construction Stormwater Permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL. All local construction stormwater management requirements must also be met.

9.1.2 Industrial Stormwater

The WLA for stormwater discharges from industrial activity reflected the number of sites that required NPDES industrial stormwater permit coverage in the counties that encompassed the watershed, 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 stormwater coverage under the appropriate NPDES/SDS General 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 MS4

There were no communities in the Clearwater River Watershed that are large enough to be MS4s or designated MS4s.

9.1.4 Subsurface Sewage Treatment Systems

The MPCA's SSTS program protects public health and the environment by ensuring subsurface sewage treatment systems (SSTS or septic systems) effectively treat wastewater. The MPCA rules govern how septic systems are designed, installed, and managed. The rules are implemented and enforced by counties, SWCDs, cities, and townships through local ordinances. It is important for homeowners with septic systems to ensure they are properly maintained. A poorly functioning septic system is a threat to human health and the environment because it may not remove pathogens, nutrients and other chemicals from the wastewater before it enters groundwater or surface water. Local units of government enforce Minnesota SSTS rules through ordinances and issue permits for systems designed for flows up to 10,000 gallons per day. Targeted inspections of septic systems have been conducted in other small drainage areas where human fecal DNA markers have been found or septic effluent has been suspected for other reasons. Similar inspections should be targeted upstream of locations where human fecal DNA markers were found within the Clearwater River Watershed:

1. Beau Gerlot Creek 09020305-651, upstream of CR 114
2. Brooks Creek 09020305-578, upstream of CSAH 92
3. Hill River 09020305-539, upstream of CR 119
4. Silver Creek 09020305-527, upstream of 159th Ave
5. Clear Brook 09020305-526, all residences that aren't connected to the Clearbrook WWTF
6. Clearwater River 09020305-647, upstream of CSAH 10

Additional microbial source tracking sample collection along the Hill River may be helpful in identifying the extent of the human fecal DNA problem.

9.1.5 Wastewater

No reductions in permitted wastewater loads have been prescribed by this TMDL.

The WWTFs in Plummer, Gonvick, Clearbrook, McIntosh, and Fosston shall continue to meet the requirements of their respective NPDES/SDS wastewater permits. For river reaches that are subject to the 30 mg/l TSS standard, discharges greater than 30 mg/l could contribute to an impaired condition. The Plummer WWTF is permitted to discharge TSS at a monthly average concentration as high as 45 mg/L or a weekly average concentration as high as 65 mg/L. These discharge limits are based on the efficiency of stabilization pond technology and are considered secondary treatment standards. With the exception of only one month (September 2011), the Plummer WWTF has demonstrated the ability to discharge water at concentrations that are lower than 30 mg/L TSS.

Prior to improvements to the Fosston WWTF in 2012, the WWTF regularly discharged TP at concentrations that were significantly higher than the in-stream, river eutrophication standard. Extremely high TP concentrations have been recorded in the Poplar River during discharge from the Fosston WWTF pre-2012. Currently, there are additional improvements being planned for the Fosston WWTF in 2021 0r 2022, pending funding. Most of the TSS discharge concentrations from the Fosston WWTF have met their permit limit of 45 mg/L and at times have been less than 30 mg/L.

The fecal coliform concentrations (pertinent to the *E. coli* TMDLs in this document) from the Fosston, McIntosh, and Clearbrook WWTFs have typically been too low to contribute to excess *E. coli* concentrations in downstream waters. Those facilities should not contribute to the *E. coli* impairment as long as permit limits continue to be met. The Gonvick WWTF (MN0020541-SD-1) has registered three monthly geometric means that exceeded permitted fecal coliform levels since 2014, but most reported results are significantly below the 200 MPN permit limit.

State and local monitoring staff will be alert for potential wastewater discharge violations during regular monitoring activities and assist MPCA enforcement staff with investigative sampling. Water quality sampling at CSAH 30 (S003-127) will continue as part of the RLWD long-term monitoring program.

9.2 Non-Permitted Sources

The HSPF-SAM tool was used to design BMP scenarios that will achieve necessary load reductions for TSS-impaired portions of the Clearwater River and Nassett Creek. No direct tributaries of the Clearwater River were impaired by TSS. The tributaries, where monitored, were not contributing to the impairments. Notable erosion problems, however, have been discovered between the final crossings of tributaries (primary sampling stations) and the Clearwater River. The lower HSPF subbasins along Clearwater River tributaries were, therefore, included in the evaluation of BMP scenarios with the HSPF model. Data has proven that TSS concentrations are low in the Clearwater River within AUIDs upstream of the Ruffy Brook confluence. Therefore, the upstream extent of the HSPF BMP scenario evaluation for the Clearwater River was the Ruffy Brook confluence (subbasin A230). Implementation scenarios were designed in HSPF-SAM to estimate numerical goals that are included in the Clearwater WRAPS restoration and protection strategy tables. The restoration and protection strategies in the WRAPS also include numerical goals for additional projects like the installation of main line tile to reduce erosion within wild rice paddies, streambank stabilization, grade stabilization, grassed waterways, and SWIs. Extensive load reductions are recommended for the Clearwater River in the city of Red Lake Falls. The practices that were identified to reduce sediment loading at the city of Red Lake Falls will also effectively restore upstream impaired reaches. For example, conversion of wild rice paddies to main line tile could reduce sediment loading by as much as 7,229 tons/year. That change, alone, could meet the sediment reduction goals for all AUIDs. Projects and practices will be implemented to meet the following sediment reduction goals.

- 33.78% overall reduction of TSS loads (2,474.90 tons) for AUID 09020305-501
- 53.99% overall reduction of TSS loads (7,126.99 tons) for AUID 09020305-511
- 21.92% overall reduction of TSS loads (872.69 tons) for AUID 09020305-647
- 23.7% overall reduction of TSS loads (950.10 tons) for AUID 09020305-648

The amount of TSS reductions needed for Nassett Creek are unknown due to a lack of sediment sampling data. Projects that reduce TSS loads in AUID 647 of the Clearwater River will also reduce TP loads within that reach.

Projects and practices that reduce *E. coli* loading to streams could not be simulated in a model, but the sources and locations of those sources have been identified through sampling and an examination of the watershed (Section 4.2). Estimations of necessary load reductions are summarized and compared in Table 9-1. Further investigation is recommended for some locations where there was limited data for the calculation of current loads and streams that are relatively close to being restored.

The level of difficulty will vary greatly when addressing biological and low DO impairments caused by non-pollutant stressors. Some conditions may be natural and cannot be remedied in a cost-effective manner. In other locations, there may be relatively simple ways to improve habitat or connectivity.

9.2.1 Overland agricultural erosion

Structural grade control practices can be installed to prevent erosion in natural and man-made channels. A water and sediment control basin (WASCOB) is a small earthen ridge-and-channel or embankment built across (perpendicular to) a small watercourse or area of concentrated flow within a field. SWIs are installed at the edge of a field, where field drainage enters a public ditch or a stream. They stabilize the outlet of the private drainage ditch, can provide some temporary water storage, and prevent gully erosion. An intensive effort to install WASCOBs was initiated by the East Polk SWCD and funded by BWSR in a neighboring watershed. Similar project in the Clearwater River Watershed would be beneficial. There are many locations in the headwaters of Clearwater River tributaries along the Highway 2 corridor where there is some topography and erosion from uncontrolled drainage from cultivated land. The installation of WASCOBs and SWIs will reduce sediment loads by reducing the amount of gully erosion where they are installed. Alternative side inlets may also be used, where applicable, to keep soil from fields and out of waterways.

Filter/buffer strips, windbreaks, grassed waterways, and cover crops are other BMPs that can be used to reduce sediment runoff to the TSS-impaired reaches of the Clearwater River. The minimum buffer width requirements of the Buffer Law need to be enforced and the quality of the buffer vegetation (establish deep rooted and woody vegetation) needs improvement. SWIs need to be installed where drainage enters the Clearwater River and its tributaries.

The Clearwater River HSPF model indicated that TSS runoff rates are highest in the western portion of the watershed. That portion of the watershed, west of the CR 96 (370th Avenue Southeast) crossing of the Clearwater River, should be targeted for practices that address runoff from conventional agriculture.

9.2.2 Stream and ditch bank Stabilization

Figure 9- 1. Grade stabilization structure on the Clearwater River (AUID 650) in Section 27 of Greenwood Township, Clearwater County

The BEHI and Pfankuch ratings from the geomorphology study will help prioritize streambank stabilization projects. The cost and the amount of structural work will depend on the location and the severity of the erosion. Rock toe-protection and stream barbs have been successful for the protection of streambanks in past projects. Not only should streambank stabilization efforts be targeted along the impaired portions of the Clearwater River, but also along lower portions of tributaries that have notable erosion problems like the Lost River and Ruffy Brook.

There are multiple outlets of small tributaries of the Clearwater River that are unstable and have been rapidly eroding. The final road crossings of these waterways usually act as a grade control, but severe channel degradation has occurred along the relatively steep slopes between road crossings and the Clearwater River. In many cases, the jurisdiction (and responsibility for maintenance) of a legal ditch system ends upstream of natural watercourses before entering a larger river. The drainage flows into natural channels that have steep slopes and are unable to accommodate flow from artificial drainage systems without actively eroding. Some projects have been completed near the city of Red Lake Falls to stabilize the outlets of drainage systems where they flow into larger rivers like the Clearwater River and the Red Lake River. That work needs to continue along the Clearwater River. Pre-project surveying and engineering is important for the success of these projects.

Past stream bank stabilization projects along the Clearwater River have been successful. The grade stabilization work in Section 27 of Greenwood Township was successful to stabilize the channel and streambanks within and upstream of the project area. The geomorphology study found that more grade stabilization work is direly needed downstream of the existing grade stabilization project.

Erosion control projects along some tributaries of the Clearwater River can help improve water quality within the TSS-impaired reaches. The Lost River, downstream of CR 119 and CR 118, appears to be contributing to sediment in the Clearwater River. That portion of the river should be targeted for streambank stabilization projects and should be surveyed to determine if grade stabilization projects would be beneficial. Ruffy Brook is a tributary that enters the Clearwater River at the upstream boundary of the TSS impairments. High TSS concentrations have been occasionally recorded within Ruffy Brook. There are known grade/bank stability problems along Ruffy Brook near its confluence with the Clearwater River. Channel degradation from cattle access has been documented in the upper reaches of Ruffy Brook and could be addressed with grazing management and streambank restoration projects.

To avoid situations of extreme erosion and mass-wasting along rivers and streams, it is very important to preserve and establish deep-rooted, woody riparian vegetation along streambanks. Increasing root density, root depth, and/or surface protection reduces the erodibility of a streambank.

9.2.3 Grazing Management

Grazing management practices need to be implemented in the drainage areas of impaired streams in which ruminant fecal DNA markers were found, streams that are being polluted by excess nutrients from feedlot runoff, and streams with channel degradation from livestock:

1. Poplar River 09020305-504
2. Lost River 0900305-512
3. Ruffy Brook 09020305-513
4. Silver Creek 09020305-527
5. Lost River 09020305-529
6. Lost River 09020305-530

7. Hill River 09020305-539
8. Nassett Creek 09020305-545
9. Terrebonne Creek 09020305-574
10. Clearwater River 09020305-647
11. Hill River 09020305-656 (and 09020305-655)

Disturbance of the channel and streambanks from cattle with stream access has been identified as a cause of the TSS impairment of Nassett Creek and contributes to *E. coli* impairments on multiple streams. Consumption/removal of deep-rooted vegetation and disturbance from cattle access has led to stream bank instability and degradation in multiple streams in the watershed. Sediment, nutrient, and bacteria runoff from livestock operations (especially those with bare soil) need to be addressed with BMPs and grazing management strategies.

The implementation of BMPs on a farm along Nassett Creek in Eddy Township is critical for the restoration of water clarity in Nassett Creek. It will also help address (but not eliminate) the *E. coli* problem in the stream. The primary source of sediment seems to be a localized disturbance by cattle. A project to remove cattle access to this sensitive stream in Section 29 of Eddy Township would likely result in a future delisting of this reach's TSS impairment. Continued monitoring, with proper methods is recommended.

Grazing management in the Silver Creek Watershed is also important for the reduction of nutrient runoff that may be leading to elevated TP concentrations and high levels of DO flux. The Hill River, Lost River, Nassett Brook, Poplar River, Ruffy Brook are other streams along which the effects of livestock operations along streambanks have gone beyond just *E. coli* bacteria and have also included channel degradation, removal of vegetation (shading), excess sediment, and nutrient runoff.

9.2.4 Habitat Improvement

In-stream habitat can be improved through structural channel stabilization projects and by improvement of the quality of vegetative cover along stream banks. Restoration of meanders could recreate a pool-riffle pattern. Pools provide refuge for fish. In-stream aquatic habitat improvement is needed along impaired reaches of the following streams:

1. Hill River 09020305-539
2. Hill River 09020305-656
3. Red Lake CD 23 09020305-658
4. Beau Gerlot Creek 09020305-652
5. Poplar River 09020305-518
6. Tributary to the Poplar River Diversion 09020305-561
7. Lost River 09020305-645

Constructed rock riffles can help improve habitat for fish, habitat for macroinvertebrates, channel and streambank stability, and DO levels. Rock riffle grade stabilization projects have been completed within the Clearwater River Watershed on the Clearwater River and Lost River. Projects have also been completed in nearby watershed like the Thief River Watershed (Marshall County Ditch 20) and the Sand Hill River Watershed. Channel surveying and building project partnerships are good first steps to planning rock riffle projects. The survey data can be used to determine the quantity and spacing of the structures to maintain a desired gradient and allow fish passage. Engineers can then design the structures and estimate costs so that funding can be acquired to complete the projects. Streams where constructed rock riffle structures could be placed to improve DO levels and channel stability include:

1. Clear Brook (09020305-526)
2. Upstream portions of Nassett Creek (09020305-545)
3. Lost River (09020305-645)
4. Red Lake County Ditch 23 (09020305-658)

There are examples in the watershed of how impactful the removal of riparian vegetation can be upon aquatic habitat. One example is Ruffy Brook, which supported trout before land was cleared for pastures. Another example is Lower Badger Creek, where F-IBI scores were >50% higher in portions of the stream with forested riparian buffers than the score in a poorly buffered channelized reach.

Pre-project and post-project water quality conditions (particularly DO and *E. coli*) will be evaluated upstream and downstream of a storage project in the headwaters of the Lost River (upstream end of AUID 530) that will increase the depth of a shallow lake. There are other locations in the watershed where drained or shallow lakes could be restored for habitat, water quality, and FDR. The effects of each of these projects upon fish passage and private lands would need to be fairly evaluated before proceeding.

9.2.5 Fish Passage

The lower portions of Beau Gerlot Creek and the outlet of Red Lake County Ditch 23 need to be surveyed to accurately identify locations where fish passage may be impeded. There are private crossings/dams along the AUID 656 portion of the Hill River that need to be removed. The Poplar River should be surveyed to identify whether or not there are private structures impeding flow or fish passage near Whitefish Lake, upstream of CSAH 27. Culverts at the 310th Avenue Southeast crossing of the Poplar River need to be replaced. In-stream structures like rock riffles will need to be designed so that they allow fish passage. Throughout the watershed, a culvert inventory that evaluates fish passage could be implemented to identify additional culverts that may be barriers to fish passage.

9.2.6 Stormwater

Stormwater runoff has been identified as a source of pollutants within the communities of Erskine (Cameron Lake) and Clearbrook (Clear Brook and Silver Creek). A stormwater study has already been completed for the city of Clearbrook and further attempts could be made to clear the logistical hurdles that limited prior efforts to treat stormwater runoff. An evaluation of stormwater treatment options should be completed for the city of Erskine to identify the most effective and cost-effective options for reducing pollutant runoff to Cameron Lake. Stormwater runoff from the city of Red Lake Falls should also be evaluated to determine the extent to which it is contributing to the impairment and whether there are cost-effective solutions for the treatment of stormwater runoff within that community.

9.2.7 Wild Rice BMPs

When main line tile drainage is used in wild rice paddies without internal surface drainage, it has all the same benefits as conventional tile drainage (low phosphorus and sediment), and has low nitrate levels instead of the high levels that were found in conventional agriculture tile drainage. It also has many benefits to the wild rice farmer. Because of the impact drawdown of surface drained paddies has upon water quality in the Clearwater River, complete conversion of wild rice paddies to main line tile drainage is imperative. Efforts should be made to provide financial support to wild rice farmers who wish to install main-line tile. Switching to main-line tile drainage should work to lessen the negative impact of wild rice paddy drainage upon water quality in the Clearwater River. Eliminating exceedances of the TSS standard during late summer paddy discharge (July and August) in AUID 647 could allow that reach to meet the TSS standard.

An estimated load reduction potential of 7,230 tons/year for conversion to main line tile was calculated using known acreage wild rice paddies with each type of drainage, the average measured concentrations of pollutants from each type of drainage system, an assumed water depth 24 inches of water (12 inches in saturated soil plus 12 inches of standing water), and an assumption that only 50% of paddies are being used for wild rice production each year. A load reduction of that amount could result in great progress toward the restoration of multiple impaired reaches of the Clearwater River. It would also result in significant progress toward restoration of the eutrophication impairment along AUID 647 by reducing TP by approximately 19,630 pounds/year (28,238 pounds/year goal).

9.2.8 Improve Base Flows

A lack of base flow (stagnant conditions) was the root cause of nearly all the F-IBI, M-IBI, and DO impairments in the Clearwater River Watershed. All streams that were impaired by low IBI scores or low DO could benefit from improved base flows. Improved water retention, improved infiltration, and slow release of water from pools (wetlands, lakes, and impoundments) could help mitigate surface flows and improve base flows. The completion of county geological atlas by the Minnesota Geological Survey could help target areas where storage could most effectively benefit groundwater recharge and base flows (https://www.mngs.umn.edu/county_atlas/countyatlas.htm). As of March 2019, no counties within the Clearwater River Watershed had a completed county geologic atlas. Well interference from recently permitted irrigation wells in eastern Polk County has increased the concern about groundwater supplies and increased the need for a geological atlas. Pennington County has started the process of preparing an atlas. Polk County has been planning to start the atlas preparation process soon.

There are opportunities to restore wetlands that have been drained in the headwaters of the Poplar River, Lost River, and Hill River. Local staff can identify ditches within the watershed that are draining wetlands without providing significant drainage benefits (drainage was attempted, but it did not open additional land to farming). The USFWS has been successful at creating wetland restorations on private lands. Local staff and USFWS staff may cooperate to identify additional wetlands that can be prioritized for restoration work. In addition to water storage, wetland restorations can be used to create off-channel water sources for cattle so the reliance upon cattle access to streams can be reduced. Local staff should work with the USFWS to identify those locations. The restoration of drained wetlands may also have the effect of reducing nutrient loading to receiving waters. Proper restoration would allow wetlands to naturally filter runoff without being flushed by high flows through ditch channels.

FDR projects have been proposed in the watershed for the purpose of reducing peak flows. Local staff should work with water managers to encourage more gradual releases of water from impoundments to avoid downstream erosion and reduce the flashiness of flows. There are multiple opportunities for storage projects in the Lost River, Poplar River, and Hill River watersheds. The Poplar River Diversion is a ditch that drained a series of wetlands and a small lake and was found to be impaired by low DO. The possibility of restoring those wetlands and lakes could be explored.

9.2.9 BMPs to Reduce TP Runoff to Lakes

Cameron Lake

Restoration of Cameron Lake, if possible, will have three phases. The first step is to make sure that current runoff isn't making the problem worse by addressing known erosion and pollutant runoff problems. Next, a study and evaluation of alternative solutions will need to be completed to identify effective in-lake treatments for internal loading and avoid wasting money on ineffective treatments (Section 9.2.11). Finally, actions can be taken to address internal loading of nutrients using the most effective alternatives.

The Cameron Lake Study found that there are several locations where stormwater entering the lake is transporting large amounts of sediment and phosphorus into the lake. To lessen the impact of this problem, stormwater treatment ponds to capture excess sediment, can be constructed within the problem subwatersheds. These can be scaled to size of the watershed (and budget), and can be partially funded by grant money, as was the case for the Bagley Stormwater Treatment Project. The potential effectiveness of in-lake treatments has yet to be evaluated, but the success of any in-lake treatment option will be improved if the influx of nutrients is reduced. Lakeshore erosion problems have been identified along the south side of the lake and plans are being made for stabilization. Removal of vegetation has removed a layer of protection against the force of wave action and disturbance of littoral sediment. Overland runoff from the drainage area of the lake should be targeted for treatment with BMPs

Long Lake

There appears to be few practical options for improving conditions within Long Lake beyond the improved SSTS compliance and reduced shoreline grazing that have reportedly occurred. The most important goals will include limiting disturbance within the drainage area of the lake. It will be important to make sure that septic systems are inspected and functioning properly. Beltrami County Environmental Services staff should be aware of the lake's water quality impairment and take that into consideration when permitting future development of the lake. Disturbance of aquatic vegetation should be limited to help minimize internal loading. No exceedances of standards were recorded in June through September 2019 samples. Sampling in 2020 will help determine if conditions in the lake have improved. The RLWD will coordinate with the MPCA staff to possibly recommend the lake for delisting if it meets standards after the 2020 samples have been collected and 2011 through 2020 summer averages have been calculated.

Stony Lake

The small watershed of Stony Lake shall be intensively targeted for outreach to landowners and implementation of effective BMPs that will minimize runoff from agriculture, livestock production, and residential development. Strategies to reduce the impact of internal loading will need to be evaluated (Section 9.2.11).

9.2.10 Lakeshore Stabilization and Restoration

Lakescaping and erosion control projects can be implemented in some locations along the shores of impaired lakes. Cameron Lake has the most residential development of the three impaired lakes, so it has the most opportunities for these projects. Lakescaping workshops and demonstration projects should be completed in order to encourage lakeshore vegetation that keeps soil in place, filters runoff, and is aesthetically pleasing. Cost-share funding from local agencies, grants, and lake associations can be used to encourage additional projects.

9.2.11 In-Lake Management

Internal loading is the primary cause of current eutrophication in Stony Lake and Cameron Lake. It is also a significant source of TP within Long Lake. The nutrients in the sediment came from high rates of historical pollution and accumulation of nutrients from ongoing pollutant runoff. Addressing the upland sources of pollution are critical to preventing further degradation, but restoration will likely require a form of in-lake management to reduce internal loading. A systematic evaluation of in-lake treatment options should be the first step toward successfully addressing internal loading and could include shallow sediment core analysis, lake dimensions, aquatic vegetation, and fishery survey results. A recent study within the RLWD of Bartlett Lake near the city of Northome in the Upper/Lower Red Lakes Watershed can be used as an example for how to proceed with addressing the Stony Lake and Cameron Lake impairments by first evaluating the effectiveness of in-lake management alternatives. The knowledge gained from these studies will help local decision makers target money for effective projects.

Alum treatment involves the application of alum sulfate on the lake surface. This treatment can remove phosphorus from the water column and decrease algae, increase water clarity, improve Trophic State Index (TSI) score of the lake, and increase the health of the lake. This treatment is designed to make the phosphorus in the top layer of the sediment in a lake inactive so that phosphorus will not be released into the water column and cannot be used by algae. This type of treatment can be expensive, but the LGUs can apply for grant money to fund the project. The potential effectiveness of this treatment varies with lake characteristics and the decision to proceed with this treatment should be informed by an evaluation of sediment cores and other lake characteristics.

Dredging could remove nutrient laden sediment and may deepen the lake. Dredging alone still leaves sediments to interact with the water column which leads to nutrient release, although a deeper lake may allow for more stratification during the summer and less entire mixing of the water column. Greater depth and winter aeration may prevent the occurrence of anoxic conditions that foster the release of phosphorus into the water column and could improve fisheries. However, there is the problem of what to do with the excess sediments after removal.

Other potential lake treatments and strategies include temporary whole lake draw down to consolidate sediments, restoration of aquatic vegetation to protect shoreline and stabilize sediment, fisheries management, landowner education, and winter aeration.

In-lake alternatives could include:

1. Whole-lake drawdown
2. Sediment alum treatment
3. Sediment iron filings treatment
4. Sediment dredging
5. Algaecides
6. Hypolimnetic aeration
7. Mechanical harvesting
8. Herbicides
9. Fish kill
10. Fish stocking
11. Winter aeration

9.2.12 Natural and Unknown Sources

There were some impairments for which anthropogenic sources were not identified. This was the case for the *E. coli* impairments of Lower Badger Creek (AUID 502) and JD 73 (AUID 550). Microbial source tracking samples should be collected from Lower Badger Creek. Cliff swallows are common under bridges and within box culverts. Although bird fecal DNA markers were present in many of the microbial source tracking samples, they were only present in low quantities. It is important to acknowledge the influence concentrated populations of birds, like cliff swallows, can have upon *E. coli* in streams, but the impairments are likely being caused by additional sources of bacteria. Human influence upon the congregation of waterfowl should be reduced along impaired reaches and the waters that drain into those streams. Feeding and baiting of waterfowl should not occur along impaired streams or along channels that flow into *E. coli*-impaired streams, including those that flow through wetlands. Wetland restorations that create off-channel, open-water habitat for waterfowl should be encouraged.

9.3 Cost

Much of the work that was prescribed in Section 9 of this TMDL and in Section 3 of the Clearwater River WRAPS Report can be accomplished with funding for the Clearwater River 1W1P (when it is completed) from the Clean Water Fund that was created by Minnesota’s Clean Water, Land, and Legacy Amendment. The best available information from completed projects and simulated implementation scenarios were used to calculate the cost estimates in Table 9-2. Budgets and pollutant reduction estimates from nearby, completed Clean Water Fund projects were used to estimate costs and effectiveness for streambank stabilization, grade stabilization, SWI, WASCOB and grassed waterway projects, Cost-per-acre values from HSPF-SAM and cost-effectiveness of completed projects were used to estimate the costs of implementation. A more accurate estimation of costs will also be generated during the 1W1P process. Prioritization, local capacity, and the PTMApp model will aid that process. The Clearwater River 1W1P process was selected for funding in 2020, and will commence after LGUs have completed or are close to completing current 1W1P processes for the Thief River Watershed (RLWD), Marsh and Wild Rice Rivers Watershed (Clearwater County/SWCD) and Mississippi River Headwaters Watershed (Clearwater County/SWCD).

Table 9-2. Cost estimates for projects and practices to restore impaired waters in the Clearwater River Watershed

Potential Project	Estimated Cost
Total =	**$14,376,000**
Restoration of drained lakes and large wetlands	$2,000,000
Water and Sediment Control Basins	$1,896,200
Channel stabilization projects - rock riffles	$1,500,000
Convert surface drained wild rice paddies to main-line tile drainage	$1,226,500
Windbreaks	$1,020,800
Unmanned aerial system reconnaissance of erosion problems	$900,000
Project development and planning	$550,000
Streambank stabilization projects	$548,000
Ditch Outlet Stabilization Projects	$473,600
Stormwater projects	$450,000
Reduced tillage (no-till)	$315,000
Grassed Waterways	$308,000
Side Water Inlets	$294,000
River Watch - 6 schools	$264,600
In-lake management (alum treatment, etc.)	$454,400
Long-term SWCD monitoring (10 years)	$232,700
Convert wild rice paddies that are drained with a combination of pattern tile and surface drainage to main-line tile drainage	$210,100
Long-term RLWD water quality monitoring (10 years)	$207,700
50 ft Riparian Buffers (replacing row crops) and Buffer Law Implementation	$205,700
Grazing Management	$203,500
Lakeshore erosion control	$200,000
Tree, shrub, and native plantings	$200,000
Buffer enhancement (plantings)	$182,300
Education and outreach (10 Years)	$177,000
Continuous DO monitoring + Data (5 sites/year for 5 years)	$81,000
Lake sediment studies to address internal loading	$80,000
Regular Flow Measurements at 14 sites	$42,000
Stage monitoring with HOBO water level loggers at 9 sites	$41,100
Planning projects using desktop tools	$30,000
Annual open house events (10 Years)	$29,000
Constructed wetlands	$18,300
Nassett Creek subwatershed BMPs	$14,500
Ditch maintenance review and policy adjustments	$10,000

Scenarios and targeting of practices with HSPF-SAM helped identify the load reductions that could be achieved with different BMPs. The HSPF-SAM simulations indicated that the most cost-effective practices were reduced tillage and riparian buffers (replacing row crops). The erosion control and BMP projects that have already been implemented in the area were also reasonably cost-effective (wild rice main line tile, streambank stabilization, drainage outlet stabilization, grassed waterways, and SWIs). Projects will be prioritized and targeted by local agencies and a consultant during the Clearwater River 1W1P and implemented as funding becomes available.

9.4 Adaptive Management

The implementation goals for restoration efforts that have been proposed in Section 9 of this report are also detailed in the Clearwater River WRAPS Report, along with strategies for protecting unimpaired waters. Although a tremendous amount of effort was invested in the development of the strategies of the TMDL and WRAPS, additional project ideas and opportunities may arise as knowledge continues to be gained about the watershed. The 1W1P process might produce additional strategies and differing priorities. Continued monitoring and "course corrections" (Figure 9-2) responding to monitoring results are the most appropriate strategy for attaining the water quality goals established in this TMDL. Management activities will be changed or refined to efficiently meet the TMDL and lay the groundwork for de-listing the impaired water bodies.

The watershed will be formally assessed again in 2026. Interim assessment calculations can be performed by LGU staff to track progress toward restoration goals. Impaired reaches that attain compliance with water quality standards can be recommended for delisting. New impairments discovered by expanded monitoring efforts may be added to the 2028 List of Impaired Waters and will need to be addressed by a TMDL. Interim assessment calculation by LGUs can identify these impairments early and, ideally, projects can be implemented to restore waters before TMDLs are necessary.

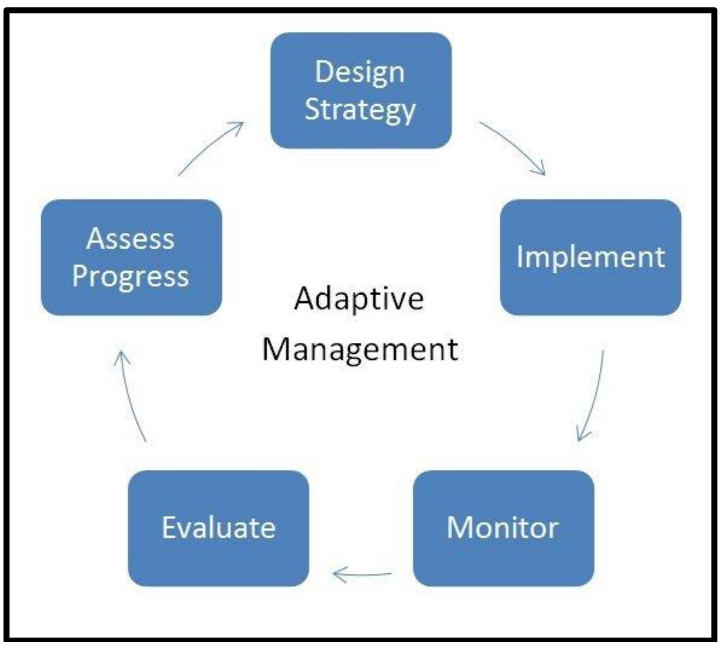


Figure 9-2. Adaptive Management diagram

10 Public Participation

The WRAPS process provided an opportunity to improve civic engagement and public participation with the Clearwater River Watershed through public meetings and other methods of engaging with the public. At the beginning of the WRAPS project, RMB Environmental Laboratories, Inc. was hired to help with the civic engagement aspect of the Clearwater River WRAPS. At the onset of the Clearwater River WRAPS project in 2011, a list of potential stakeholders was compiled. RMB, MPCA, and RLWD staff collaborated to organize public open house events. Tabletop displays and posters were used during public events for the Clearwater River WRAPS process. Table 10-2 lists the public and technical advisory committee meetings that were held throughout the WRAPS project.

The Clearwater River WRAPS Kick-off Open House Event was held on December 2, 2014, in Clearbrook, Minnesota (Figure 10-1). The meeting had great attendance (more than 40 total people and more than 34 non-agency attendees). The format of the meeting was an open house with posters of information about the WRAPS process. The evaluation surveys showed that people liked the open house format. They were able to ask questions of the poster presenters and discuss problems and ideas. The event was publicized through email, social media, and press releases in local newspapers. Photos, posters, and a more detailed summary of the event can be found on the Clearwater River blog at https://clearwaterriver.wordpress.com/2014/12/18/kick-off/.

Figure 10-1. Clearwater River WRAPS Kick-Off Open House Event in Clearbrook

An open house event for the Clearwater River WRAPS project was held in Red Lake Falls on September 25, 2017 (Figure 10-2). The meeting was promoted through press releases, direct mailing (newsletters), a mass email to a list of Clearwater WRAPS project contacts, flyer postings, and social media. Short presentations were prepared for the event and were conducted at 30-minute intervals during the event. A limit of 10 minutes was planned for each presentation, but some went longer due to the amount of interest and questions during those presentations. There was opportunity for small group or one-on-one discussion at informational booths. The attendance was relatively low, but those in attendance participated in many conversations at the booths and asked questions during the presentations. The newsletter that was mailed prior to the event was a 4-page newsletter that included a fold-out insert. The inserted page had a map of the watershed with its impaired waters on one side and a list of impaired waters (or anticipated impairments, at the time).

Figure 10-2. Presentation during the September 2017 Clearwater River Public Open House Event in Red Lake Falls

Technical advisory committee (TAC, or Core Team) meetings were also held to seek more in-depth input on the direction of the project. The November 2018 meeting was particularly important for reviewing and making recommendations for the restoration and protection strategies that is an important part of the WRAPS process as well as Section 9 of this TMDL.

RLWD staff met with lake associations on multiple occasions to discuss water quality issues in the lakes and potential projects, activities, and opportunities for collaboration. RLWD staff also met with East Polk County staff and board members to discuss future projects to address water quality issues in the Clearwater River Watershed.

Table 10-1. List of public and technical advisory meetings

Meeting	Meeting Date	Meeting Location	Number of Participants
Kick-off Meeting	December 2, 2014	Clearbrook, MN	34 (non-agency)
Technical Advisory (Core Team) Meeting	August 27, 2014	Thief River Falls, MN	12
East Polk Annual Planning Meeting	February 15, 2017	McIntosh, MN	>10
Clearwater Lake Area Association	May 28, 2017	Clearwater Lake	>10
Open House	September 25, 2017	Red Lake Falls, MN	16
Maple Lake Improvement District Meeting	September 14, 2017	Mentor, MN	10
Maple Lake Improvement District Annual Meeting	July 14, 2018	Mentor, MN	>30
Technical Advisory (Core Team) Meeting	November 28, 2018	Thief River Falls, MN	12
Maple Lake Improvement District Meeting	January 10, 2019	Mentor, MN	>10

These meetings provided opportunities to gain insight, gain historical knowledge, discuss sources of problems, and discuss future projects with participants. Directly visiting with existing organizations

(SWCD boards and lake associations) was very productive way of promoting and facilitating actions to improve water quality. Additional details and notes from some of the public meetings can be found within the Clearwater River WRAPS Report and in RLWD monthly water quality reports:

- August 2014 Technical Advisory Committee meeting: http://redlakewatershed.org/waterquality/MonthlyWQReport/2014%208%20August%20Water%20Quality%20Report.pdf
- December 2014 Kick-Off Event: http://redlakewatershed.org/waterquality/MonthlyWQReport/2014%2012%20December%20Water%20Quality%20Report.pdf
- May 2017 Clearwater Lake Area Association meeting: http://redlakewatershed.org/waterquality/MonthlyWQReport/2017%205%20May%20Water%20Quality%20Report.pdf
- September 2017 Open House Event and the September 2017 Maple Lake Improvement District meeting: http://redlakewatershed.org/waterquality/MonthlyWQReport/2017%2009%2010%20Sept-Oct%20Water%20Quality%20Report.pdf
- July 2018 Maple Lake Improvement District meeting: http://redlakewatershed.org/waterquality/MonthlyWQReport/2018%2007%20July%20Water%20Quality%20Report.pdf
- January 2019 Maple Lake Improvement District meeting http://redlakewatershed.org/waterquality/MonthlyWQReport/2019%2001%20January%20Water%20Quality%20Report.pdf

Multiple forms of digital communication were explored as ways to expand the audience and interest in water quality issues in the Clearwater River:

- The RLWD, with help from Emmons and Olivier Resources, Inc., has launched a new set of web pages to make it easier for anyone to learn more about a watershed. Each of the five major watersheds within the RLWD District (including the Clearwater River) will have has its own set of pages with general information, links to reports, a photo gallery, WRAPS project information, maps, contacts, and 1W1P information in some cases. Organizing information by watershed should make it easier for people to find information that is pertinent to the area in which they live/farm/hunt/fish. Follow this link to begin exploring the Clearwater River Watershed: http://www.rlwdwatersheds.org/cw-watershed.
- A blog was established for the Clearwater River Watershed: https://clearwaterriver.wordpress.com/. Entries have been limited to an introduction of the WRAPS process and a summary of the WRAPS Kick-Off meeting, but it is an outlet for public information that could be utilized more in the future.
- The RLWD Facebook page was utilized to share information with the public and promote public events.

- RLWD staff wrote articles about the Clearwater River and Cameron Lake for the Polk County Lake Leader Newsletter
- "Water Minutes" radio public service announcement scripts were written by staff from the RLWD, MPCA, and RMB Environmental Labs. They were read by radio personality Joel Heitkamp and broadcast on local radio stations. Topics included the Clearwater River WRAPS project, *E. coli* bacteria, DO, the WRAPS process. MP3 audio files were obtained for the WRAPS project ("10-Year Cycle"), "Fish Habitat," and "Bacteria in Water" Water Minutes.
- RLWD staff provided information to the MPCA for a newsletter article entitled "2018 impaired waters list: Success stories surfacing for Minnesota lakes, streams."
- RMB Environmental labs completed a document that summarized civic engagement activities, survey results, and recommendations for future efforts: "Clearwater River Watershed Restoration and Protection Plan: An Evaluation of Civic Engagement."
- RLWD staff created a Flickr account for the purpose of sharing georeferenced photos of erosion problems and georeferenced scenic photos. Other local government staff could use this as a tool for finding areas where erosion control projects can be implemented. A map-based search for photos can be conducted at this site: https://www.flickr.com/map. The RLWD photos can be found at this site: https://www.flickr.com/photos/131072259@N04/. However, finding the uploaded photos using the map-based search did not work as well as anticipated. Other means of sharing georeferenced photos (like ArcGIS Story Maps) will be explored in the future.
- Environmental Laboratories, RLWD, and the MPCA staff created short videos to help local citizens understand DO, turbidity, and *E. coli* bacteria. Combined, the videos have accumulated over 10,500 views on YouTube as of February 1, 2019.
    - DO: http://youtu.be/qUq7jFdVo3g
    - Turbidity: http://youtu.be/EkH3jZvADTk
    - *E. coli* bacteria: http://youtu.be/vkYUiJXyqLI
- In 2018, information about the Clearwater Watershed was available from RLWD booths that were set up at the Polk County and Clearwater County Fairs.

Measurable goals for future civic engagement efforts in the Clearwater River Watershed include:

1. Increase volunteer participation in natural resource monitoring.
2. Increase the number of watershed residents participating in water quality discussions.
3. Find effective ways to engage citizens in a meaningful way.
4. Increase the resources utilized to communicate water quality activities within the watershed.
5. Create a document with contact information for local resources, specific to certain water quality concerns or funding sources.

The public can be kept informed of water related news, water quality problems, solutions to water issues, and opportunities for involvement in water-related programs through several different means. The RLWD and other local government units (LGU) need to continue conducting the public outreach efforts that were initiated during the WRAPS process. LGUs may continue to host open house style events that will facilitate one-on-one discussions with residents and other stakeholders. Booths at county fairs and community events (Thief River Falls Expo, Clearwater County Fair) are another way to connect with the public. Current methods of outreach include:

- Websites of LGUs
  - RLWD
    - www.redlakewatershed.org
    - www.rlwdwatersheds.org
  - East Polk SWCD
    - https://eastpolkswcd.org/
  - Red Lake County SWCD
    - http://redlakecountyswcd.org/index.html
  - Clearwater County SWCD
    - https://clearwaterswcd.com/
  - Beltrami County SWCD
    - http://www.co.beltrami.mn.us/Departments/SWCD/SWCD%20home.html
  - MPCA
    - http://www.pca.state.mn.us/
    - https://www.pca.state.mn.us/water/watersheds/clearwater-river
- Mailings to individual landowners
- Radio interviews
- Informational brochures and displays
- Press releases and advertisements with local media contacts
- SWCD newsletters
- Organization of events to bring attention to the resource
- Presentations for local civic groups

The RLWD Water Quality Coordinator writes monthly water quality reports that originated as reports to the RLWD Board of Managers and represent a means of documenting project progress throughout the year (making annual report writing easier). The reports are available on the RLWD website (http://www.redlakewatershed.org/monthwq.html).

Local government can gain insight on water issues by consulting the public. The public can provide useful feedback on analysis, alternatives, and/or decisions. Working directly with the public throughout the process helps ensure that public concerns and aspirations are consistently understood and considered.

- Public meetings
- Social Media
    - RLWD Facebook page: https://www.facebook.com/Red-Lake-Watershed-District-266521753412008/
    - East Polk SWCD Facebook page: https://www.facebook.com/EastPolkSoilandWater/
    - Clearwater SWCD: https://www.facebook.com/ClearwaterSWCDMN/
- Public Comment period on final draft reports
- Open houses
- 1W1P advisory committee and public meetings

The TMDL and WRAPS reports were developed with extensive input from local land managers. The same input will be requested during the development of the 1W1P document. As a result, the likelihood of implementation will increase. In addition, implementation activities will be streamlined due to the collaboration between landowners, local agencies, and funding sources.

An opportunity for public comment on the draft TMDL report was provided via a public notice in the State Register from November 16, 2020 to December 16, 2020. There was one comment received and responded to as a result of the public notice.

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