Coon Creek Watershed District Total Maximum Daily Load (TMDL)

Mississippi River-Twin Cities Major Watershed

Quantification of the pollutant reductions necessary to restore aquatic life and recreation in Coon Creek, Sand Creek, Pleasure Creek and Springbrook Creek.

CLEAN WATER LAND & LEGACY AMENDMENT

Minnesota Pollution Control Agency

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Acronyms

ACD	Anoka Conservation District
AUID	Assessment Unit ID
BMP	Best Management Practice
CAFO	Concentrated Animal Feeding Operation
CAC	Citizens Advisory Committee
CADDIS	Casual Analysis/Diagnosis Decision Information System
CCWD	Coon Creek Watershed District
cfu	colony-forming unit
Chl-*a*	Chlorophyll-*a*
CSAH	County State Aid Highway
CSO	Combined Sewer Overflow
CWP	Center for Watershed Protection
DNR	Minnesota Department of Natural Resources
DO	Dissolved Oxygen
E. coli	*Escherichia coli*
EPA	Environmental Protection Agency
EQuIS	Environmental Quality Information System
GIS	Geographic Information System
HUC	Hydrologic Unit Code
IBI	Index of Biotic Integrity
IDDE	Illicit Discharge Detection and Elimination
ISW	Industrial Stormwater
LA	Load Allocation
Lb	pound
lb/day	pounds per day
lb/yr	pounds per year
LGU	Local Government Unit
m	meter
mg/L	milligrams per liter
mL	milliliter

MOS	Margin of Safety
MnDOT	Minnesota Department of Transportation
MPCA	Minnesota Pollution Control Agency
MS4	Municipal Separate Storm Sewer Systems
MSHA	Minnesota Stream Habitat Assessments
MUSA	Metropolitan Urban Service Areas
NCHF	North Central Hardwood Forest
NPDES	National Pollutant Discharge Elimination System
NPS	Non-point Source
NRCS	Natural Resources Conservation Service
RC	Reserved Capacity
SDS	State Disposal System
SI	Stressor Identification
SSO	Sanitary Sewer Overflow
SSTS	Subsurface Sewage Treatment Systems
SWPPP	Stormwater Pollution Prevention Plan
TAC	Technical Advisory Committee
TALU	Tiered Aquatic Life Use
TDLC	Total Daily Loading Capacity
TMDL	Total Maximum Daily Load
TP	Total phosphorus
TSS	Total Suspended Sediments
µg/L	microgram per liter
UMRB	Upper Mississippi River Basin
USGS	United States Geological Survey
WLA	Wasteload Allocation
WRAPS	Watershed Restoration and Protection Strategy
WWTF	Wastewater Treatment Facility

Executive Summary

This Total Maximum Daily Load (TMDL) addresses macroinvertebrate biotic integrity and *Escherichia coli* (*E. coli*) impairments in the Coon Creek Watershed District (CCWD), more specifically in Coon Creek, Sand Creek, Unnamed Ditch (Pleasure Creek), and County Ditch 17 (Springbrook Creek). A TMDL is defined as the maximum quantity of a pollutant that a water body can receive and continue to meet water quality standards for designated beneficial uses. Thus, a TMDL is the sum of allowable point source and nonpoint source pollutant loads in a watershed, plus a margin of safety (MOS). The CCWD is part of the Mississippi River – Twin Cities Watershed (HUC 07010206). The CCWD is approximately 107 square miles, and overlies portions of seven cities including Andover, Blaine, Columbus, Coon Rapids, Fridley, Ham Lake, and Spring Lake Park in Anoka County. The goal of this TMDL is to quantify the pollutant reductions needed to meet Minnesota's water quality standards for macroinvertebrate biotic integrity and *E. coli* for the impaired stream reaches. This TMDL was established in accordance with Section 303(d) of the Clean Water Act and provides wasteload allocations (WLAs) and load allocations (LAs) aimed to restore aquatic life and aquatic recreation designated uses.

A Stressor Identification (SI) Report was completed in spring 2014 using the United States Environmental Protection Agency's (EPA's) Casual Analysis/Diagnosis Decision Information System (CADDIS). Total suspended sediment (TSS) and total phosphorus (TP) were identified as the primary stressors to aquatic life. As such, TMDLs were developed for each of these pollutants. In addition, *E. coli* bacteria TMDLs were developed to restore aquatic recreation designated uses. Load duration curve methodology was used to calculate the existing pollutant loads, allowable pollutant loads, and MOS for all impaired reaches. Load duration curves use a long-term record of flow data, numerical water quality standards, and water quality samples to calculate needed pollutant reductions.

Best management practices (BMPs) were also identified in this TMDL as part of a general strategy to address impaired waters. The BMPs targeting point and non-point sources (NPSs) are the focus of implementation planning and include streambank stabilizations, riparian buffers, stormwater retrofits, street sweeping, education and outreach, etc.

Findings of this TMDL were used for development of the CCWD Watershed Restoration and Protection Strategy (WRAPS) Report. The intent of the WRAPS report was to develop a scientifically-based restoration and protection strategy for the CCWD.

1. Project Overview

1.1 Purpose

Section 303(d) of the Clean Water Act requires the development of TMDL studies to achieve Minnesota's water quality standards. Achievement of Minnesota's water quality standards is critical to the full use attainment for designated uses of Minnesota waterbodies. This study and corresponding TMDLs were established in accordance with Section 303(d) of the Clean Water Act, because the Minnesota Pollution Control Agency (MPCA) has determined that the waters included in this report exceed state established standards.

This TMDL report addresses aquatic life impairments due to biological indicators and aquatic recreation impairments due to *E. coli* for four streams in the CCWD located in Anoka County of the Twin Cities Metropolitan Area of Minnesota. The CCWD includes portions of the cities of Andover, Blaine, Columbus, Coon Rapids, Fridley, Ham Lake, and Spring Lake Park and is part of the larger Mississippi River – Twin Cities Watershed (HUC 07010206) (Figure 1). The goal of this TMDL study is to quantify the pollutant reductions needed to meet Minnesota's water quality standards for macroinvertebrate biotic integrity and *E. coli* for impaired stream reaches (Table 1).

The pollutant loadings and corresponding allocations were used to develop the CCWD WRAPS.

1.2 Identification of Waterbodies

Coon Creek, Sand Creek, Unnamed Ditch (Pleasure Creek), and County Ditch 17 (Springbrook Creek) were placed on the 303(d) list of impaired waters in 2006 for aquatic life impairment due to biological indicators (Figure 1). Coon Creek, Pleasure Creek and Springbrook Creek were also listed on the draft 2014 303(d) list of impaired waters for aquatic recreation impairments due to *E. coli* (Table 1). Sand Creek is expected to be placed on the 2016 303(d) list for aquatic recreation due to *E. coli*. Two lakes in the CCWD, Ham Lake (AUID 02-0053-00) and Crooked Lake (AUID 02-0084-00) are impaired due to elevated levels of mercury; however, these impairments are addressed in in the Minnesota Statewide Mercury TMDL and not included in this report (2007). Coon Creek and Sand Creek have two additional aquatic life impairments due to poor fish assemblages, which have been deferred until the Tiered Aquatic Life Use (TALU) standards have been adopted.

Drinking Water

Impaired waters in this TMDL also drain to the Mississippi River, which serves as the exclusive drinking water supply to the Minneapolis Water Treatment and Distribution Services (serves the cities of Minneapolis, Golden Valley, Crystal, New Hope, Columbia Heights, Hilltop, Fort Snelling, parts of Bloomington and Edina, and Minneapolis/St. Paul airport). It is also one of the main sources for the St. Paul Regional Water Services (serves as least part of the cities of Falcon Heights, Lauderdale, Maplewood, Arden Hills, Little Canada, Saint Paul, West Saint Paul, South Saint Paul, Lilydale, Mendota and Mendota Heights, Roseville, and Sunfish Lake).

Both Minneapolis and St. Paul have state endorsed Source Water Protection Plans which follow Minnesota Department of Health (MDH) guidance for surface water intakes from the Mississippi River. As part of these plans, both cities have identified "contaminants of concern" along with designated priority areas for drinking water protection (Appendix I). A few examples of these contaminants are *Cryptospordium*, fecal coliform (*E. coli*), *Giardia*, other virus, total suspended solids, sediment, and suspended organics. More information about the Upper Mississippi River Source Water Protection Project can be found at http:/www.umrswpp.com/.

Table 1. Impaired streams in the Coon Creek Watershed District.

Waterbody	Assessment Unit ID	Year Listed	Impaired Use	Pollutant or Stressor	TMDL Target Start/ Completion Date
Coon Creek	07010206-530	2006	Aquatic Life	Macroinvertebrate bioassessments	2015/2018
		Deferred 2006	Aquatic Life	Fish bioassessments	Deferred
		2014	Aquatic Recreation	*E. coli*	2015/2018
Sand Creek	07010206-558	2006	Aquatic Life	Macroinvertebrate bioassessments	
		Deferred 2006	Aquatic Life	Fish bioassessments	Deferred
		Proposed 2016*	Aquatic Recreation	*E. coli*	2015/2018
Unnamed Ditch (Pleasure Creek)	07010206-594	2006	Aquatic Life	Macroinvertebrate bioassessments	
		2014	Aquatic Recreation	*E. coli*	
County Ditch 17 (Springbrook Creek)	07010206-557	2006	Aquatic Life	Macroinvertebrate bioassessments	
		2014	Aquatic Recreation	*E. coli*	

*Expected to be listed on the 2016 303(d) Impaired Waters List

1.3 Priority Ranking

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

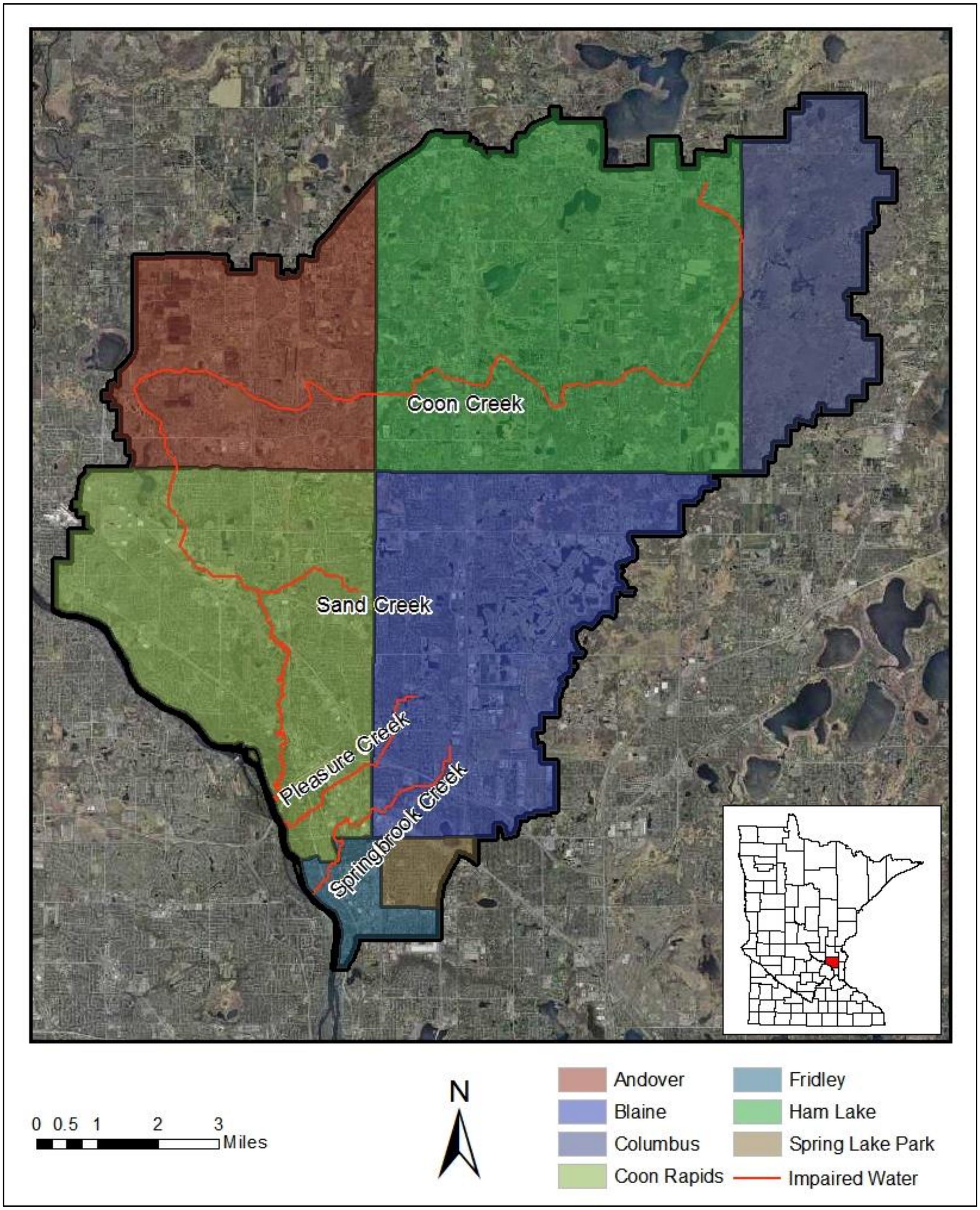

Figure 1. Impaired waters of the Coon Creek Watershed District, Anoka County, Minnesota.

2. Applicable Water Quality Standards and Numeric Water Quality Targets

The purpose of this TMDL study is to identify the maximum amount of a specific pollutant that a waterbody can receive and still meet water quality standards as well as its designated uses. As part of this, it is important to understand the water quality standards applicable to the waters of focus. This section details water quality standards as they pertain to impaired waters within the CCWD.

2.1 Designated Beneficial Use Classification

All impaired waters addressed in this TMDL are classified as Class 2B (warm water/cool water) waters. These waters are protected for aquatic life and aquatic recreation designated uses by Minn. R. 7050.0140, subp. 3.

2.2 State of Minnesota's Standards and Criteria for Listing Impairments

Biotic Integrity: The standards for biological impairments are set forth in Minn. R. 7050.0150, subp. 3 and 6. Subp. 3 is the narrative standard which reads:

> *"For all Class 2 waters, the aquatic habitat, which includes the waters of the state and stream bed, shall not be degraded in any material manner, there shall be no material increase in undesirable slime growths or aquatic plants, including algae, nor shall there be any significant increase in harmful pesticide or other residues in the waters, sediments, and aquatic flora and fauna; the normal fishery and lower aquatic biota upon which it is dependent and the use thereof shall not be seriously impaired or endangered, the species composition shall not be altered materially, and the propagation or migration of the fish and other biota normally present shall not be prevented or hindered by the discharge of any sewage, industrial waste, or other wastes to the waters."*

The biotic integrity standard uses an Index of Biotic Integrity (IBI), which evaluates and integrates multiple attributes of the aquatic community, or "metrics," to evaluate a complex biological system. Each metric is based on a structural (e.g., species composition) or functional (e.g., feeding habits) aspect of the aquatic community that changes in a predictable way in response to human disturbance. Fish and macroinvertebrate IBIs are expressed as a score that ranges from 0-100, with 100 being the best score possible. The MPCA has evaluated fish and macroinvertebrate communities at numerous reference sites across Minnesota that have been minimally impacted by human activity, and have established IBI impairment thresholds based on stream drainage area, ecoregion, and major basin. A stream's biota is considered to be impaired when the IBI falls below the threshold established for that category of a stream. The impairment thresholds for specific stream classifications applicable to this report are listed below (Table 2).

Table 2. Impairment thresholds for Minnesota stream classifications.

Classification	Type	Threshold
Northern Streams	Fish	50
Northern Headwaters	Fish	40
Low Gradient	Fish	40
Southern Streams (Run/Riffle)	Macroinvertebrate	35.9
Southern Forest Streams (Glide/Pool)	Macroinvertebrate	46.8

Total Suspended Sediment: The streams in this report are not currently listed as impaired due to TSS, but TSS was identified as one of the primary stressors for Coon, Sand, and Pleasure Creeks. Minn. R. 7050.0222, sets the TSS standard for Class 2B rivers and streams of the Central River Nutrient Regions at 30 mg/L. This standard may be exceeded no more than 10% of the time from April 1st through September 30th. Deposited and bedded sediment do not have specific state standards but are often positively correlated with elevated TSS concentrations. See the MPCA's Aquatic Life Water Quality Standard Draft Technical Support Document for Total Suspended Solids (Turbidity) (2011) for background and methods for developing TSS numerical criteria.

Total Phosphorus: The streams in this study are not currently listed as impaired due to TP, but TP was identified as one of the primary stressors in all four impaired stream reaches. The eutrophication standard for Class 2B rivers and streams are based on summer average data by region (Minn.R. 7050.0222, subp. 4b). All four streams in this study are located in the Central River Nutrient Region. In the Central River Nutrient Region, rivers and streams that exceed the TP standard of 100 µg/L, and at least one of the response variables (seston chlorophyll-*a*, diel dissolved oxygen (DO) flux, five-day biochemical oxygen demand (BOD_5), or pH) are considered impaired (Table 3). See the MPCA's draft Minnesota Nutrient Criteria Development for Rivers Report for background information and methods pertaining to the development of eutrophication standards for rivers and streams (2013).

Table 3. River eutrophication standards for Central River Nutrient Region.

	Nutrient	Stressor		
Region	TP (µg/L)	Chl-a (µg/L)	DO flux (mg/L)	BOD_5 (mg/L)
Central	≤100	≤18	≤3.5	≤2.0

E. coli: Bacteria impairment listings for the four impaired reaches were based on *E. coli* measurements exceeding state water quality standards. Under Minn. R. 7050.0150 and 7050.0222 *E. coli* concentrations are:

> *"Not to exceed 126 organisms per 100 milliliters as a geometric mean of not less than five samples representative of conditions within any calendar month, nor shall more than ten percent of all samples taken during any calendar month individually exceed 1,260 organisms/100 mL. The standard applies only between April 1 and October 31."*

Analysis of Impairment

The criteria used for determining stream reach impairments are outlined in the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters for Determination of Impairment: 305(b) Report and 303(d) List (2014).

3. Watershed and Waterbody Characterization

The CCWD is located in the east-central portion of Minnesota in Anoka County, in the North Central Hardwood Forest (NCHF) ecoregion. The CCWD covers 68,182 acres and drains portions of seven cities (Andover, Blaine, Columbus, Coon Rapids, Fridley, Ham Lake, and Spring Lake Park) in the Upper Mississippi River Basin (UMRB). The upper portion of the watershed is characterized by rural land use, flat terrain, and nutrient rich organic soils. Coon Creek serves as the major drainage for the upper portion of the watershed. The lower portion of the watershed is drained by Sand, Pleasure, and Springbrook Creeks. Lower portions of the watershed are characterized by highly urbanized landscape, well drained soils, and increased stream gradient through the Mississippi River Terrace. For a more detailed watershed characterization, refer to the CCWD Biotic SI Report (CCWD, 2014).

3.1 Streams

Of the 107 square miles encompassing the area of this study, approximately 73.5 square miles drain to Coon Creek. The main stem of Coon Creek begins as a series of channelized streams and ditches in a large wetland complex known as the Carlos Avery Wildlife Management Area (WMA). Coon Creek flows generally south - southwest to its confluence with the Mississippi River south of the Coon Rapids Dam. The main channel of Coon Creek is approximately 26.7 miles long and drops roughly 90 feet from its headwaters to its outlet. Nearly half of the total drop occurs within five miles of the creek's outlet into the Mississippi River. Coon Creek is impaired along the entire reach.

Sand Creek drains approximately 15.8 square miles, accounting for roughly 14% of the CCWD. The impaired portion of Sand Creek is limited to a 2.2 mile portion downstream of its confluence with Public Ditch 39. The headwaters of Sand Creek originate as a network of stormwater conveyance channels in the city of Blaine. Sand Creek generally flows east to west before emptying into Coon Creek in the city of Coon Rapids. Sand Creek has a total elevation change of 50 feet over its 8.3 mile main channel.

Pleasure and Springbrook Creek have small drainage areas relative to Coon and Sand Creeks with Pleasure Creek draining approximately 2.7 square miles and Springbrook Creek draining 4.1 square miles. The 303(d) Impaired Waters List identifies both of these streams as impaired throughout the entire main channel reach. This equates to an impaired length of approximately 4.0 and 4.8 miles for Pleasure Creek and Springbrook Creek, respectively.

3.2 Subwatersheds

A breakdown of subwatershed area and percent of the total watershed area is provided below (Table 4) and illustrated in Figure 2. In total, the subwatershed areas for Coon, Sand, Pleasure, and Springbrook account for roughly 90% of the land area with the CCWD.

Table 4. TMDL subwatershed areas by stream reach.

Stream Reach	Drainage Area (ac)	% of Watershed
Coon Creek	47,099	69.1
Sand Creek	10,122	14.8
Pleasure Creek	1,728	2.5
Springbrook Creek	2,644	3.9

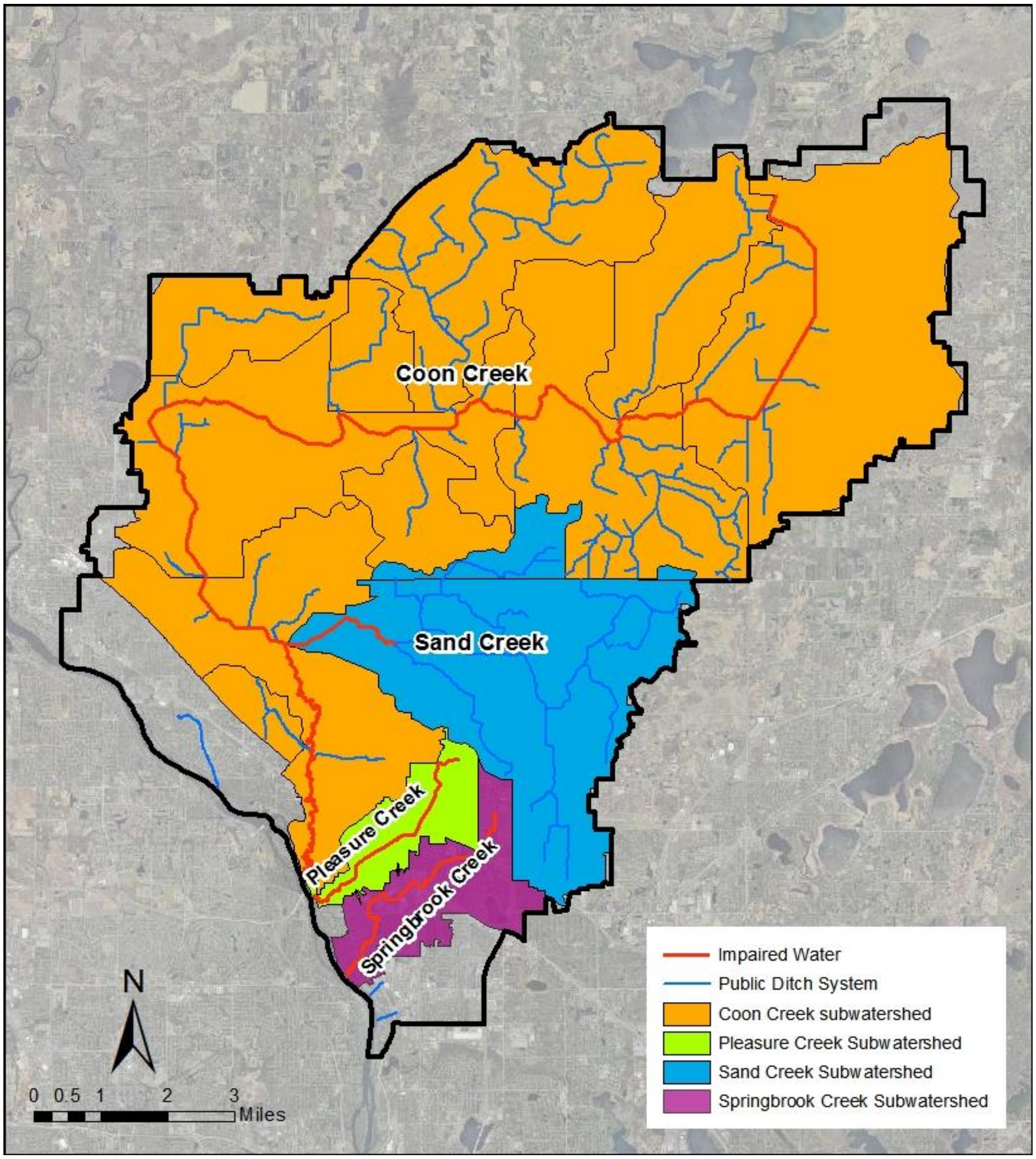

Figure 2. Impaired reach subwatersheds.

3.3 Land Use

The CCWD is comprised of varying land uses but is generally described as having an almost entirely developed southern portion while maintaining a more rural, agricultural northern portion as illustrated below (Figure 3). Data were obtained from the 2010 Metropolitan Council Land Use Inventory of the Twin Cities Metropolitan Area. The data were interpreted from 2010 air photos, with additional assistance from county parcel data, field checks, and community review.

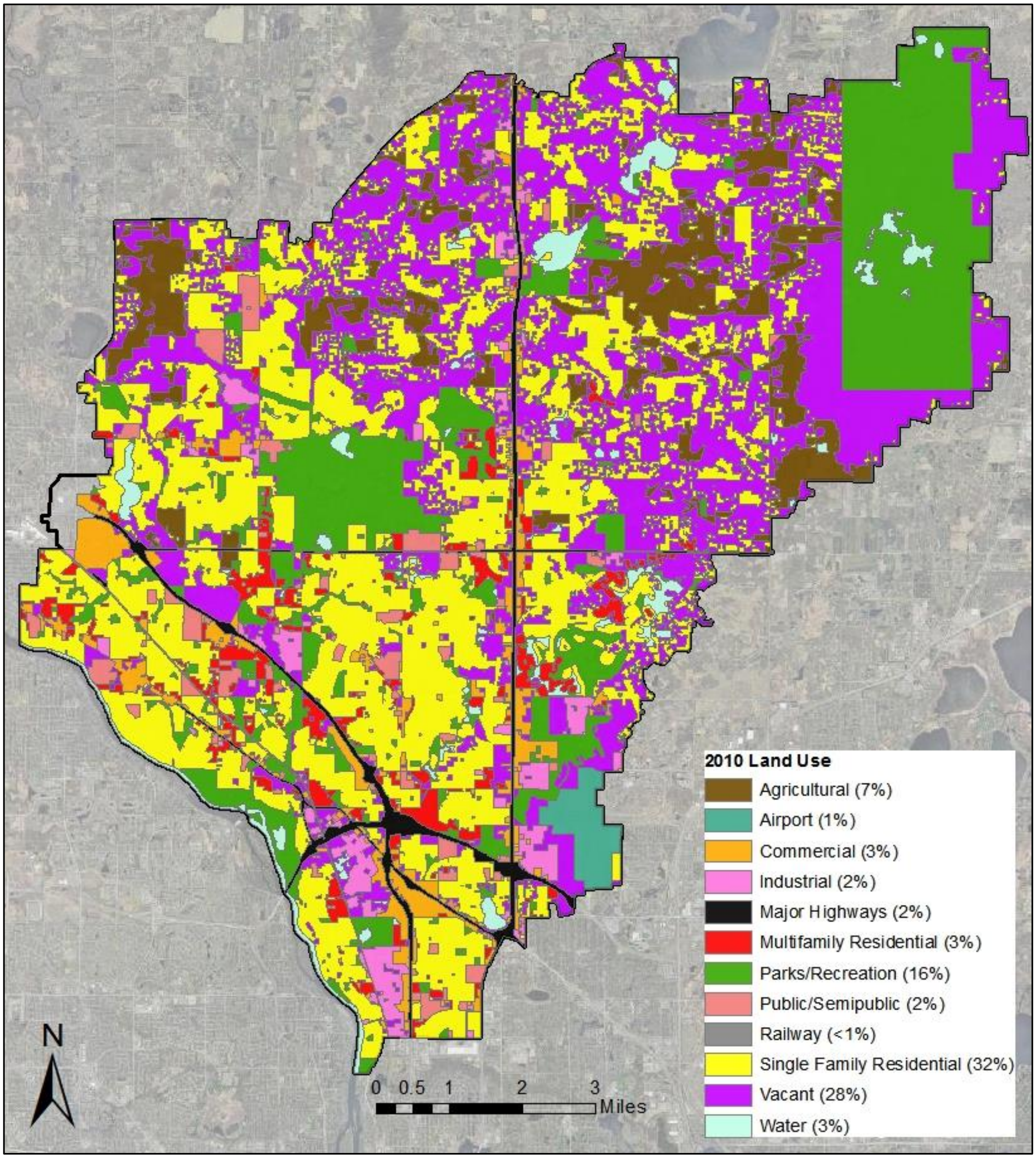

Figure 3. 2010 Metropolitan Council Land use in the Coon Creek Watershed District.

3.4 Water Quality

3.4.1 Biotic Integrity

Assessment of the aquatic community was done through the use of an IBI. An IBI integrates multiples features of the aquatic community to evaluate the overall health of the biological community. This approach functions on the theory that biological assemblages are a direct reflection of pollutants, habitat alteration, and hydrologic modification over time. For further information regarding the development of stream IBIs, refer to the MPCA's Guidance Manual for Assessing the Quality of Minnesota Surface Waters for the Determination of Impairment: 305(b) Report and 303(d) List (2014).

Using IBI methodology, Coon and Sand Creek exhibited fish assemblages below State IBI standards; however, these impairments were deferred until TALU standards are adopted (

Table 5). Pleasure and Springbrook Creek were also sampled in 2000 for fish assemblages; however, these two streams were not assessed for fish due to insufficient data, and the close proximity of the sampling locations to the Mississippi River.

Coon Creek macroinvertebrate assemblages are also indicative of stream degradation. Three sites are meeting the macroinvertebrate IBI threshold for their given stream designation but the overall picture for Coon Creek is symptomatic of a stressed system. Since the entire reach of Coon Creek is identified as a single AUID, the entire reach is listed even though some sampling locations had macroinvertebrate scores above the impairments thresholds (Table 5). The Ephemeroptera, Trichoptera, and Plecoptera taxa (EPT) are widely known to be highly sensitive to various forms of disturbance. The number of EPT taxa in Coon Creek is well below the average of UMRB sites with healthy invertebrate assemblages. In addition to the low number of EPT taxa, a low number of EPT individuals are also represented. Both of these metrics do however improve downstream suggesting a possible improvement in stream condition.

Table 5. IBI scores for biological sampling sites across CCWD.

Year	Stream	Site ID	Fish IBI		Macroinvertebrate IBI	
			Threshold	Score	Threshold	Score
2010	Coon Creek	10UM003	50	33	46.8	49, 28
2000	Coon Creek	00UM064	50	32	35.9	57
2010	Coon Creek	10UM017	50	27	46.8	47
2010	Coon Creek	00UM059	40	36	46.8	48
2010	Coon Creek	10UM020	40	52	46.8	35, 42
2005	Sand Creek	00UM065	40	30	46.8	--
2010	Sand Creek	00UM065	40	0, 11	35.9	17
2000	Pleasure Creek	00UM062	40	34	35.9	29
2000	Springbrook Creek	00UM061	40	35	35.9	25
2000	Springbrook Creek	00UM086	40	2	35.9	--

The CCWD Biotic SI Report was completed in 2014 to identify the primary cause(s) of biological impairments. The biotic SI process is a critical part of TMDL development as it identifies those factors which are most limiting to the biological community. The SI report prepared as part of this TMDL study followed the MPCA SI Framework and the EPA's Causal Analysis/ Diagnoses Decision Information System (CADDIS). CADDIS, a methodology for conducting a stepwise analysis of candidate causes of impairment, characterizes the potential relationships between candidate causes and stressors, and identifies the probable stressors based on the strength of evidence from available data.

Potential candidate causes of the biological impairments that were either ruled out or inconclusive based on review of available data include: nitrates; pH; temperature; un-ionized ammonia; and chlorides. Water quality sampling for each of these parameters showed respective measurements either within Minnesota standards or a lack of biological response.

Total phosphorus (TP), excess sediment (TSS), altered hydrology, altered habitat, and low DO were all found to be stressors to aquatic life to varying degrees. A summary of evidence for each of these is provided below. As a result of the SI process, TP and TSS were found to be the primary stressors resulting in impaired biological communities. A summary for each candidate stressor is provided below; more detailed information can be found in the CCWD Biotic SI report. Refer to Appendix A for locations of biological monitoring stations.

Dissolved Oxygen: DO was a clear stressor in the upper reaches of Coon Creek, evidenced by DO concentrations below the 5 mg/L standard (Figure 4). IBI scores for macroinvertebrates were below impairment thresholds at all headwater sites. Macroinvertebrate communities lacked EPT taxa, a metric considered sensitive to low DO. The DO levels rebound further downstream due to increased distance from Carlos Avery WMA, an expansive 15,000 acre wetland. Where DO levels rebounded, a higher number of EPT taxa were found strengthening the co-occurrence between low DO and observed biological impairments.

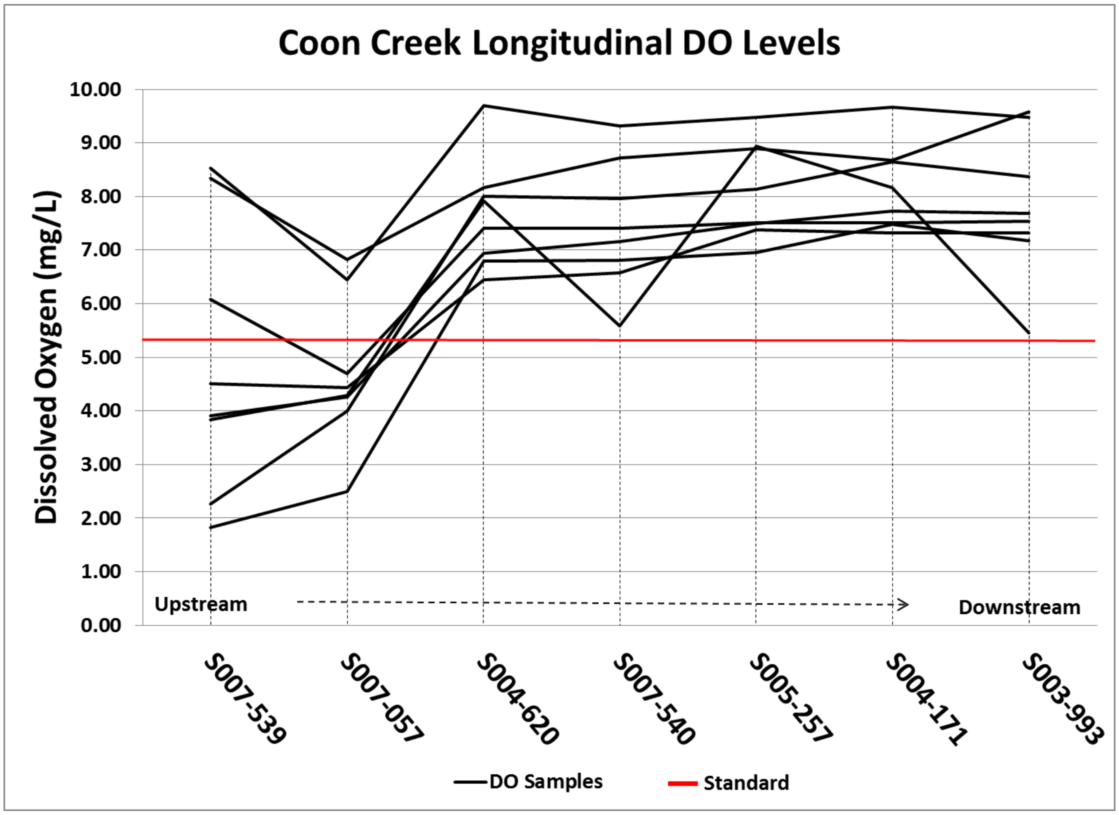

Figure 4. Longitudinal display of DO levels in Coon Creek.

Excess Sediment: Excess suspended sediment was identified as a primary candidate stressor for Coon, Sand, and Pleasure Creeks. TSS is the concentration of suspended material in the water column as measured by the dried weight of solids filtered from a known volume of water. Suspended material can be present in a variety of forms including detritus, algae, organic matter, etc.; however, fine sediment generally comprises most of the suspended material in streams. TSS concentrations exceeding the 30 mg/L state standard have been regularly documented (greater than 10% of samples) in Coon, Sand, and Pleasure Creek. In some instances, TSS concentrations greater than 10 times the standard have occurred. Species with gills (e.g., mayflies) are documented to be particularly sensitive to suspended sediment, exhibiting a negative relationship to elevated TSS (EPA, 2012). The percentage of Ephemeroptera (i.e., mayflies) across impaired reaches of CCWD follows the predicted response to excess suspended sediment concentrations (Figure 5). Only one site, Springbrook Creek, had a percentage of Ephemeroptera individuals comparable to non-impaired UMRB sites. The SI process concluded suspended sediment was influencing macroinvertebrate assemblages on all reaches except on Springbrook Creek where evidence was inconclusive.

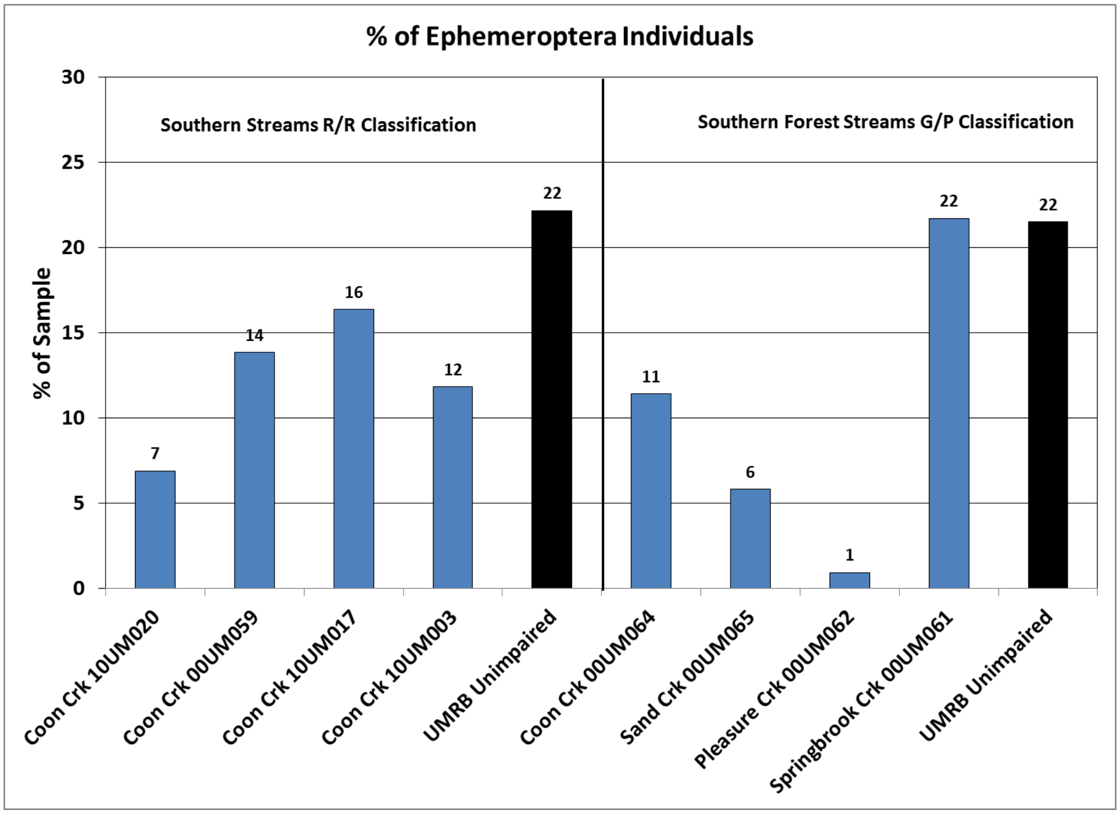

Figure 5. Percentage of individuals belonging to Ephemeroptera Family. Black bars represent unimpaired streams in the UMRB. Blue bars represent sampling inside the CCWD.

Excess Phosphorus: Phosphorus concentrations in excess of the 100 µg/L water quality standard frequently occur in the CCWD. In most cases, high phosphorus concentrations alone are not a primary stressor to aquatic life; hence the inclusion of chlorophyll-*a*, diel DO, or BOD_5 criteria in the river nutrient standards. However, excess phosphorus can alter biological communities by shifting species composition toward organisms better suited to deal with excess phosphorus. An increase in the number of planktivorous and/or detritivorous species is a common response to elevated phosphorus concentrations, a pattern observed in both Coon and Sand Creeks (Figure 6).

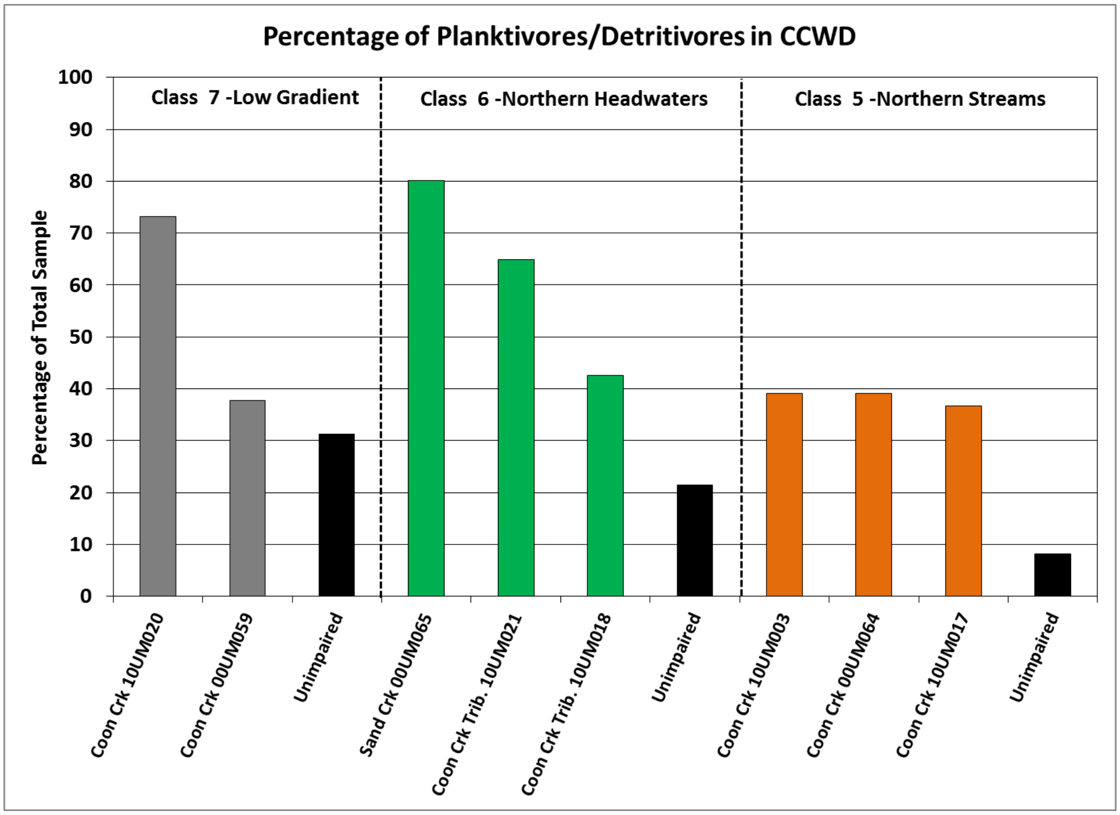

Figure 6. Planktivorous/detritivorous species representation in biological sampling.

In the MPCA's effort to develop river nutrient criteria, it was determined that the number of macroinvertebrate taxa exhibited a strong negative correlation with TP concentrations (MPCA, 2013). The total number of macroinvertebrate taxa in the impaired reaches of the CCWD fall below the median of non-impaired UMRB sites at most monitoring stations and often below the 25th percentile (Figure 7). Only one sample was taken at sites 00UM061, 00UM062, 00UM064, and 10UM017. Low numbers of macroinvertebrates was one of many lines of evidence used in the CCWD Biotic SI Report which resulted in the identification of TP as a primary stressor.

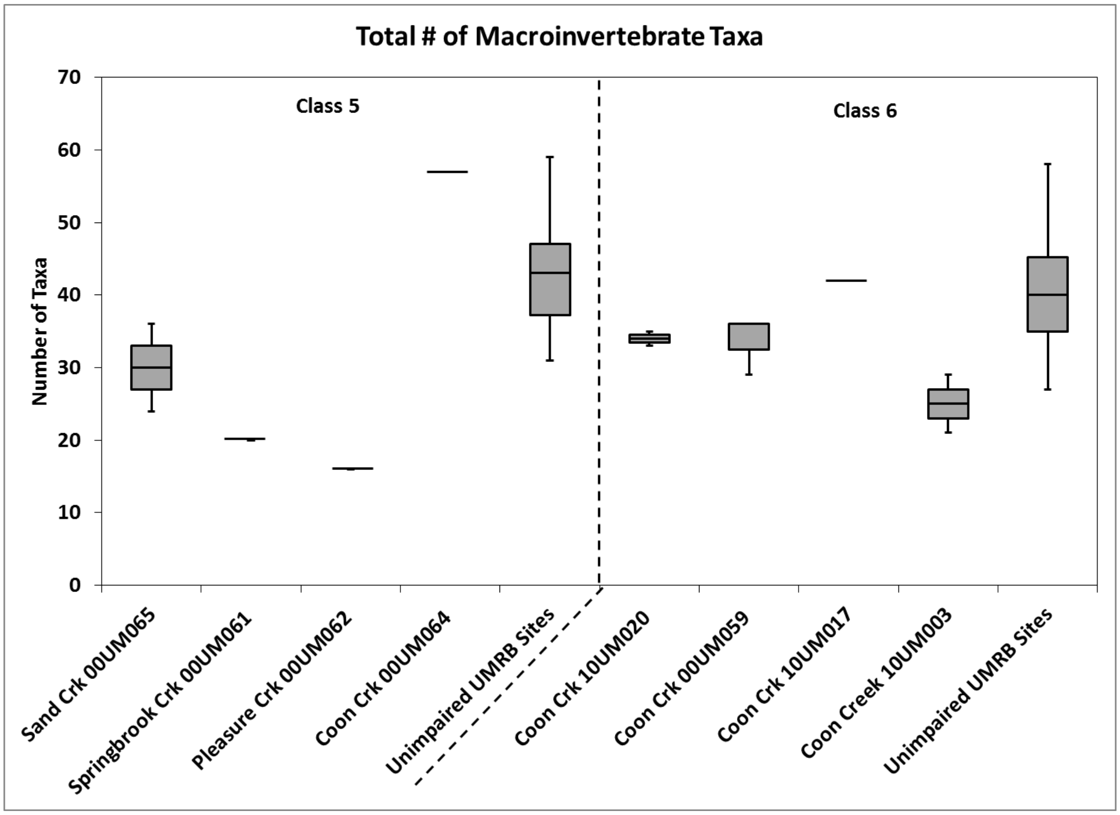

Figure 7. Total number of macroinvertebrate taxa. Box plots depict the mean (middle line), 25th and 75th percentile (ends of boxes) and max/min values (vertical outer lines).

Altered Habitat: CCWD contains a mix of natural, modified, and constructed channels that work in unison to convey stormwater and ultimately provide flood protection to the residents within the CCWD's jurisdiction. Channel modifications (e.g., channelization, dredging, stream, or stream armoring) have occurred on approximately 94% of the public ditch system leaving only 8 miles in a "natural" state. Minnesota Stream Habitat Assessments (MSHA) conducted by the MPCA suggests habitat is "fair" across much of the district although best represented by the lower end of the "fair" designation (Table 6). See Appendix A for station locations.

Table 6. MSHA scores for impaired reaches of the CCWD.

Site ID	Stream Name	Land Use (0-5)	Riparian (0-15)	Substrate (0-27)	Cover (0-17)	Channel Morphology (0-36)	MSHA Score (0-100)	MSHA Rating
10UM020	Coon Creek	2.5	11.0	9.0	16.0	11.0	49.5	Fair
00UM059	Coon Creek	2.0	9.5	11.0	9.0	13.0	44.5	Poor
10UM017	Coon Creek	2.0	6.5	14.0	7.0	19.0	48.5	Fair
00UM064	Coon Creek	1.0	11.5	17.1	9.0	23.0	61.6	Fair
10UM003	Coon Creek	4.2	14.5	18.0	13.0	26.0	75.8	Good
00UM065	Sand Creek	2.0	8.8	14.2	7.5	15.5	48.0	Fair
00UM062	Pleasure Cr.	0.5	12.5	18.1	9.0	19.0	59.1	Fair
00UM061	Springbrook Cr.	1.5	12.0	18.7	12	18	62.2	Fair
00UM086	Springbrook Cr.	1.0	10.5	17.3	6.0	15.0	49.8	Fair

Lower Coon Creek attained the highest habitat rating of all impaired reaches. This was not unexpected due to the fact Lower Coon Creek has not undergone channel modifications and remains a natural stream reach. Despite the lack of habitat alteration in this reach, fish and macroinvertebrate scores were still below biotic integrity standards, suggesting that degraded water quality is influencing biological assemblages despite the presence of adequate habitat. Habitat alteration is negatively impacting biological assemblages in the CCWD, but likely not to the degree of degraded water quality.

Altered Hydrology: Altered hydrology was an identified stressor to the fish and macroinvertebrate communities within the CCWD. As previously discussed, urbanized landscapes and channelized streams are common throughout the CCWD and leading to increases in peak flows. A common biological response to high flows is a shift in community composition from long-lived species toward tolerant species with shorter life strategies and an increased level of tolerance. Both of these patterns are observed in fish communities of lower Coon Creek (Figure 8). For more information on metric scoring and descriptions, see Development of a Fish-Based Index of Biological Integrity for Minnesota's Rivers and Streams.

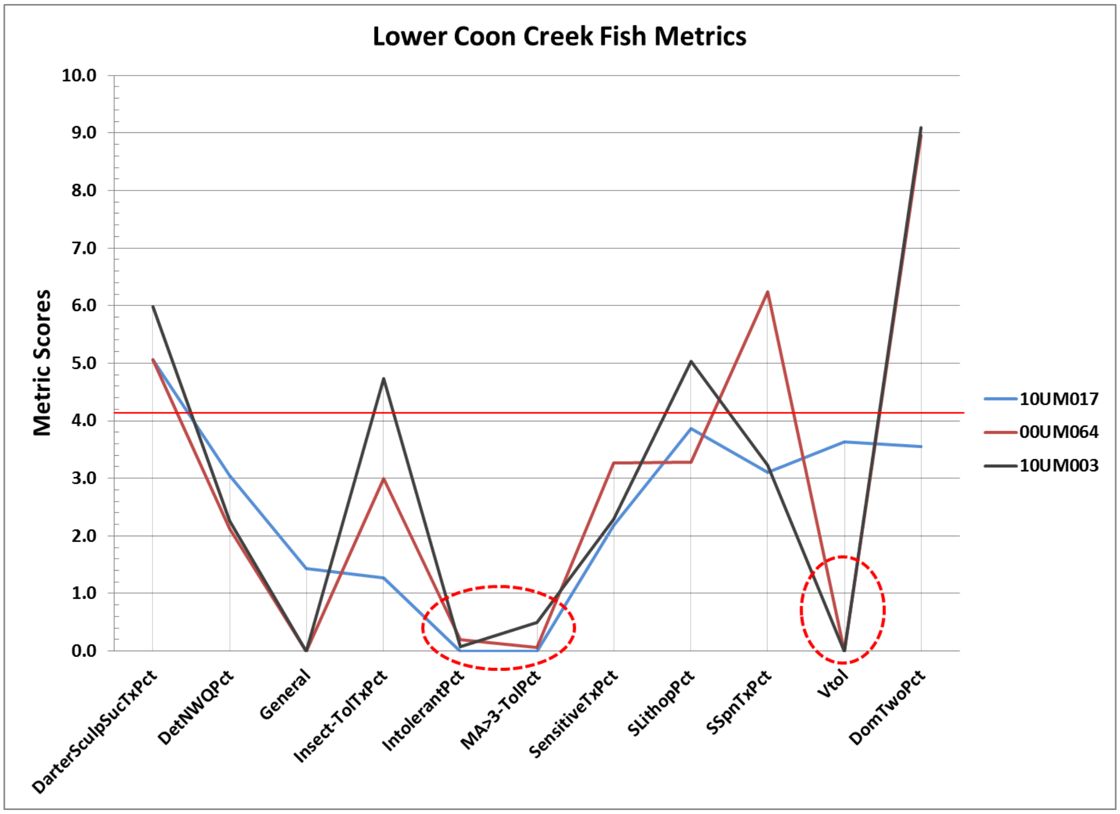

Figure 8. Individual biologic metric scores for lower Coon Creek.

Macroinvertebrate assemblages also showed biological response to increased flows as a result of urbanization and channelization. A disproportionate number of clinger taxa and sprawler taxa were observed compared to free swimming macroinvertebrates. This suggested that communities have shifted toward species reliant on fixed substrate, or those with body adaptations allowing them to tolerate flashy flows.

The Biotic SI Report concluded that both altered habitat and altered hydrology do likely impact biological assemblages; however, neither of these stressors is conducive to TMDL development as they are not conventional pollutants and cannot undergo loading calculations.

3.4.2 Bacteria

E. coli data were collected by the Anoka Conservation District (ACD) from 2010-2014 (Table 7). *E. coli* sampling data for all stations were aggregated by stream reach to accommodate relatively small datasets for individual stations (Appendix B). Geometric mean *E. coli* concentrations were calculated by month for comparison to water quality standards. Using a geometric mean lessens the impact of very high and very low concentrations making it a better method to determine central tendencies than the arithmetic mean. In general, geometric mean concentrations routinely exceeded the state water quality standard of 126 cfu/100mL for all stream reaches.

Table 7. *E. coli* sampling data with exceedances of the acute and chronic standard shown in red.

Waterbody	Month	# Samples	Geomean (cfu/100mL)	% N > Acute Standard
Coon Creek	April	9	46	8%
	May	11	**196**	
	June	8	**270**	
	July	11	162	
	August	11	**413**	
	September	4	N/A	
	October	6	**216**	
Sand Creek	April	2	N/A	**19%**
	May	2	N/A	
	June	2	N/A	
	July	5	**196**	
	August	2	N/A	
	September	2	N/A	
	October	1	N/A	
Pleasure Creek	April	5	56	**14%**
	May	10	**412**	
	June	11	**461**	
	July	8	**166**	
	August	10	**211**	
	September	5	**225**	
	October	3	N/A	
Springbrook Creek	April	9	76	9%
	May	7	**138**	
	June	9	**345**	
	July	11	**205**	
	August	7	**299**	
	September	8	**385**	
	October	6	**237**	

3.4.3 Streamflow Data

Coon Creek and Sand Creek: Streamflow data is a critical component of TMDL calculation and extensive flows records are desirable for each impaired reach. Stations S003-993 (Coon Creek) and S003-619 (Sand Creek) both had a 10-year flow record from 2005-2014 (see Appendix C for station locations). This data was recorded as part of the CCWD's annual water quality monitoring program and used to generate the flow duration curves for these reaches. Daily streamflow data were averaged to produce a mean daily flow for each reach.

Pleasure Creek: Flow records for Pleasure Creek were not as robust as either Coon or Sand Creeks, with three years of field verified flow data. To compensate for the shorter flow record, flow regressions were conducted between Pleasure Creek and three other stations; two outside the TMDL study area (Elm Creek, Shingle Creek) and one inside (Sand Creek) (Appendix D). The regression relationship between Sand and Pleasure Creeks showed the strongest correlation ($R^2 = 0.67$) and was subsequently used to fill data gaps from 2005-2014. The correlation of flows between Sand Creek and Pleasure Creek was expected to be strong since these subwatersheds are immediately adjacent to one another. The CCWD has observed a relatively new phenomenon of localized, very intense, brief precipitation events, which alters flows in a highly localized manner. It is likely the United States Geological Survey (USGS) stations selected from outside the TMDL study area experienced some degree of precipitation variance ultimately weakening the correlation with flows observed in the CCWD. This phenomenon justifies the use of Sand Creek flow data to estimate Pleasure Creek flows during years when data was not collected. The following equation was used to estimate flows:

$$Q_{PleasureCreek} = 0.1057 \times Q_{SandCreek} + 3.276$$

Where,

$Q_{PleasureCreek}$ = estimated Pleasure Creek flow (cfs)

$Q_{SandCreek}$ = gaged Sand Creek flow (cfs)

Springbrook Creek: There was no field verified flow data available for Springbrook Creek barring the use of flow regression analysis to estimate streamflows. Two separate methods were used to estimate flows for Springbrook Creek; flow simulation modeling using XP-SWMM Hydrodynamic Modeling Software and the use of a conversion factor to adjust measured flows by subwatershed size. Based on the results of these two methods, it was determined Springbrook Creek flow estimates were most accurately represented by adjusting measured Pleasure Creek flows by a conversion factor to reflect the larger subwatershed size of Springbrook Creek. Conversion of Pleasure Creek flow data to Springbrook Creek was considered the most accurate approach for numerous reasons; 1) Springbrook flow estimates resulting from conversion of Pleasure Creek flows most accurately resembled field observations; 2) both Springbrook and Pleasure Creeks have small, adjacent subwatersheds; 3) land use is predominately single family residential housing in both subwatersheds followed by commercial, industrial, and major highway classifications (Figure 9); 4) XP-SWMM flow simulations appeared to significantly underestimate flows (Appendix D). Estimating streamflows based on subwatershed size is consistent with previous EPA approved TMDLs.

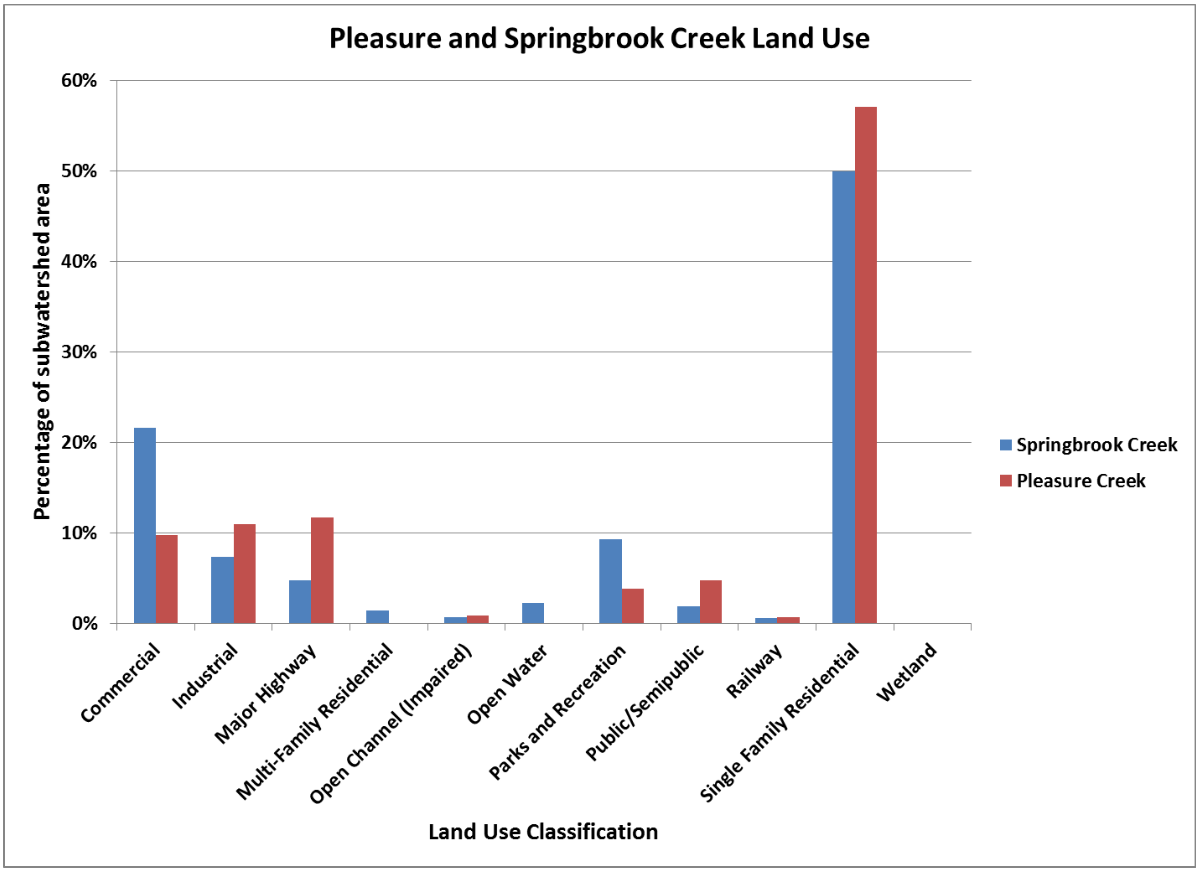

Figure 9. Land use comparison between Springbrook and Pleasure Creek Subwatersheds.

The following equation was used to estimate flows for Springbrook Creek:

$$Q_{ungaged} = \frac{A_{SpringbrookCreek}}{A_{PleasureCreek}} \times Q_{PleasureCreek}$$

Where,

$Q_{ungaged}$ =	Springbrook Creek daily flow (cfs)
$A_{SpringbrookCreek}$ =	Springbrook Creek Subwatershed drainage area (sq. miles)
$A_{PleasureCreek}$ =	Pleasure Creek Subwatershed drainage area (sq. miles)
$Q_{PleasureCreek}$ =	Pleasure Creek daily flow (cfs)

Flow duration curves for study streams were developed by generating flow frequency tables and plotting data points to form a curve for each stream (Figure 10).

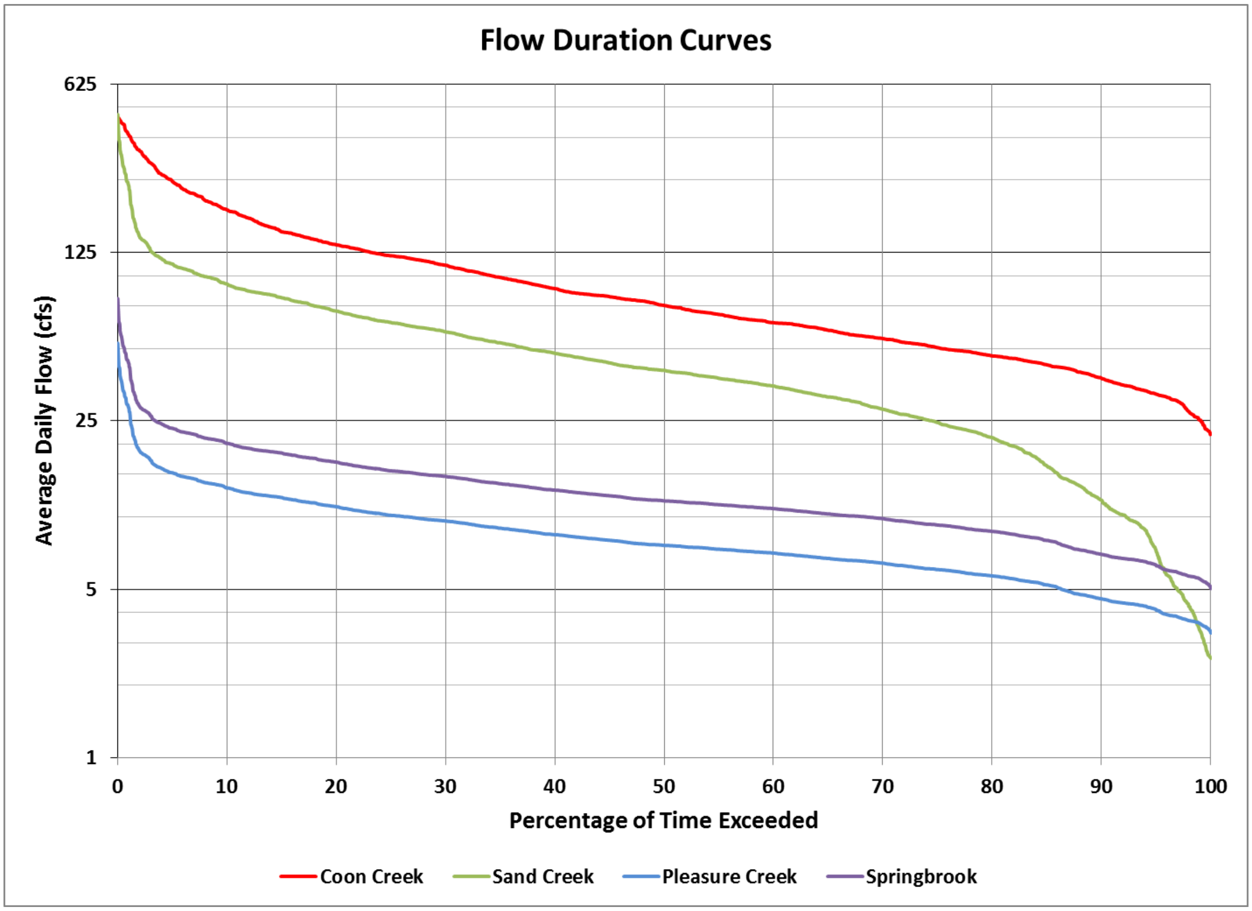

Figure 10. Flow duration curves for impaired reaches within TMDL study area. Springbrook Creek values are based on estimated flow data.

4. Pollutant Source Summary

A key component of developing a TMDL is to understand the sources contributing to the impairments of a specified reach. Source assessment methods vary widely with respect to their applicability, ease of use, and acceptability. This section provides a brief description of the potential sources of TSS, TP, and *E. coli* contributing to aquatic life and aquatic recreation impairments in Coon, Sand, Pleasure, and Springbrook Creek.

4.1 Total Suspended Sediment and Total Phosphorus

4.1.1 Permitted Sources of Sediment and Phosphorus

Permitted sources of TSS and TP in the CCWD TMDL study area consist entirely of regulated stormwater runoff. There are no municipal wastewater treatments plants, combined sewer overflows (CSOs), sanitary sewer overflows (SSOs), or Concentrated Animal Feeding Operations (CAFOs) present in the TMDL study area. Three types of regulated stormwater runoff within CCWD are detailed below and listed in order of relative magnitude of loading.

Municipal Separate Storm Sewer Systems (MS4s)

An MS4 is a conveyance or system of conveyances owned or operated by a state, city, county, or other public body having jurisdiction over disposal of stormwater to waters of the United States; or designed or used for collecting or conveying stormwater; or which is not combined sewer; and not part of a publicly owned treatment works. There are nine entities with NPDES/SDS Phase II permits for MS4s within the watersheds of the impaired reaches (listed in Table 10, page 46). The city of Columbus, in the Coon Creek impaired watershed is the only area within the CCWD that is not covered under a MS4 Permit (Figure 1). However, it should be noted that areas do exist within MS4 communities that do not discharge directly to a MS4 conveyance and are therefore placed in the LA; this is discussed further in Appendix G. Only stormwater that enters MS4 conveyances is regulated as a point source pollutant and must be handled under the WLA portion of a TMDL even though the specific source is non-point in nature (MPCA, 2011). According to the 1996 National Water Quality Inventory, stormwater runoff is a leading source of water pollution (EPA, 1996) with TSS as the top pollutant; a pollutant directly related to developed area (EPA, 2006). Regulated stormwater can also include sediment, pet waste, lawn fertilizers, car wash detergents, and leaves/grass clippings that all elevate surface water TP concentrations.

Construction Stormwater

Construction sites can deliver a significant amount of sediment and phosphorus to surface waters through stormwater runoff. A review of permits issued in Anoka County from 2007-2013 showed an annual average of roughly 760 land acres (or 0.27% of total land area) covered under Construction Stormwater General Permits. The small percentage of land area under Construction Stormwater Permit suggests this is a relatively small contributing source. Nonetheless, construction stormwater is still recognized as a contributing source of both sediment and phosphorus.

Industrial Stormwater

Stormwater generated from industrial sites can contribute a wide array of pollutants to receiving waters. To minimize this source, the MPCA operates an Industrial Stormwater (ISW) Program for facilities falling in 10 separate categories of industrial activity with “significant materials and activities” exposed to stormwater. “Significant materials” are defined in the permit as any material handled, used, processed, or generated that may leak, leach, or decompose when exposed to stormwater. To estimate the magnitude of pollutant discharge from ISW sources, land area under ISW coverage was set equal to construction stormwater. This is a common approach found in many TMDLs across Minnesota and it predicted to be a conservative estimate.

A review of the MPCA ISW Permit database shows 66 active ISW Permits in the TMDL study area. Of the 66 ISW Permits, 50 of them fall under the “No Exposure” exclusion meaning that the permittees *“industrial activities and significant materials are indoors or within a storm-resistant shelter 100% of the time”* making them a non-contributor of stormwater pollutants (MPCA, 2014). A review of the remaining 16 permits shows there are no facilities in the TMDL study area with phosphorus as a benchmark pollutant. Regardless of the minimal TP contributions estimated to come from ISW discharges, this is still recognized as a permitted source to account for future growth.

4.1.2 Non-permitted Sources of Sediment and Phosphorus

Non-permitted sources of TSS and TP in the CCWD TMDL study area consist of the following;

- Non-permitted stormwater runoff
- In-channel/Streambank erosion

The following sections detail work done to estimate the relative contributions of non-permitted sources to help guide implementation activities. It should be noted that these estimates are relative contributions and not actual load calculations. As a result, LAs calculated in this report are presented as a bulk number.

Non-permitted Stormwater Runoff

Non-permitted stormwater runoff is any stormwater discharge not served by an MS4 conveyance system. Generally speaking, non-permitted stormwater is overland runoff from areas outside of urban areas where curbs, catch basins, and stormwater infrastructure channel flows to outfalls. On the contrary, stormwater runoff from rural residential areas, agricultural land, and forested areas typically flows overland without entering a regulated conveyance thus is defined as non-permitted stormwater. Runoff from rural residential areas, agricultural land, and forested areas is likely to contain both TSS and TP. In some instances, TSS and TP can arise from natural conditions such as the breakdown of highly organic soils, while in other cases the origin is anthropogenic.

Streambank Erosion

Stream channels naturally change shape and flow path over time due to continual sediment suspension and deposition. In a natural riverine landscape, the loss of sediment is in equal balance with sediment deposition creating a “stable” stream path. However, in altered landscapes, the sediment equilibrium of a stream is often disrupted resulting in a decrease in stream stability. Stream stability is complex and affected by numerous variables (e.g., increased imperviousness, channelization, stream armoring, etc.).

Often times, urbanization is linked to many of the aforementioned variables. In urbanized landscapes, the amount of rainfall that infiltrates the landscape is reduced creating more overland runoff. As runoff increases, so does the volume of water and flow moving through the stream channel. As a result of these increases, sediment loss is accelerated ultimately elevating TSS concentrations. Figure 11 illustrates a significant bank erosion event documented during routine bank inspection of the Coon Creek. Mass wasting events such as these are typical in streams experiencing sudden increases is stream flow followed by a rapid recession of stream levels.

Figure 11. Streambank erosion in Coon Creek Subwatershed.

The Center for Watershed Protection (CWP) published a technical memorandum in April 2013, that reviewed streambank erosion contributions from approximately 28 studies and results were highly varied. In urbanized watersheds, streambank erosion contributed anywhere from 20% to 75% of overall stream sediment loads. Watersheds with predominantly agricultural land use ranged from 70% to 75% and mixed land use watersheds (urbanized, agricultural) showed 23% and 31% of sediment arising from streambank erosion (CWP, 2013). Due to the large divergence in literature values, it was difficult to confidently apply these percentages to impaired reaches of the CCWD and a more localized estimate was needed.

To meet this need, annual soil loss resulting from streambank erosion within the CCWD was estimated using field data collected from impaired reaches and methodology published by the Wisconsin Natural Resources Conservation Service − referred to as the "NRCS Direct Volume Method" (NRCS, 2003). Soil loss is calculated by measuring the area of exposed streambank along a known length of stream and multiplying that area by the rate of loss per year and soil density to determine the annual mass for that length of stream. That mass is then converted to a mass per stream mile. The direct volume method is summarized in the following equation:

$$\frac{\text{(Eroding Area (sq ft) (Lateral Recession Rate (ft/yr)) (Soil Density (pounds/cubic ft))}}{\text{2,000 lbs/ton}} = \text{Soil Loss (Tons/Year)}$$

The annual soil loss per year was calculated from the equation above and divided by the total annual TSS load for each impaired reach. Total annual TSS loads were estimated by averaging the existing daily TSS loads from 40th percentile and higher flow regimes (very high, high, mid) calculated through load duration curves (LDCs) (section 5.1) and multiplied by 219 days per year (percentage of time flows are at or above 40% on flow duration curves). The use of 40th percentile and greater flow regimes for streambank erosion estimates was appropriate because these flow regimes capture the typical flow events likely to result in streambank erosion. Estimates of streambank erosion TSS loading are presented below in Table 8. Streambank erosion datasheets and calculations can be found in Appendix A.

Table 8. Percent of TSS load attributed to streambank erosion.

Stream Reach	% of Total TSS
Coon Creek	63%
Sand Creek	13%
Unnamed Ditch (Pleasure Creek)	22%
County Ditch 17 (Springbrook Creek)	17%

Based on percentages provided in Table 8, it can be estimated that streambank erosion contributions to the stream reaches included in this study are distributed across the 20%-70% range provided in the CWP technical memorandum. It should also be noted that estimates provided in Table 8 account only for areas of "significant" erosion and do not represent in-channel re-suspension or streambank contributions from non-notable erosion sites.

It is well understood that soil also contains some percentage of sediment bound phosphorus. Quantifying the exact percentage is difficult as it is dependent on a variety of factors; however, estimates are available. A 2004 study conducted in the State of Minnesota evaluated the phosphorus contributions attributed to streambank erosion for each of Minnesota's major watershed basins. Phosphorus loading as a result of streambank erosion in the UMRB, which includes the impaired reaches of this report, was estimated to be 4% (MPCA, 2004). It is understood that the UMRB covers a large geographical area; however, applying a 4% estimate from work conducted within the basin serves as a reasonable estimate.

Individual Subsurface Sewage Treatment Systems (SSTS)

In rural portions of the TMDL study area (Coon Creek Subwatershed) individual SSTS are used for human wastewater treatment. If installed and maintained correctly, these systems can effectively protect both groundwater and surface water contamination. In contrast, systems with improper installation, inadequate design, or breakdown due to age, can contribute significant amounts of phosphorus to surface waters. The MPCA's 2012 SSTS Annual Report estimates that 10% of SSTS in Anoka County are failing (McCarthy, 2012) creating the need to identify this as a potential TP source.

Estimating the percentage of TP stemming from failing SSTS is challenging for a variety of reasons. Most "failing" or "non-compliant" systems still function in some capacity providing an unknown level of wastewater treatment. Previous estimates made as part of TMDL projects across the United States suggest that failing septic systems contribute between 4% and 55% of TP loads to freshwater lakes (Lusk et al., 2011). The lower end of this range is likely more applicable to the Coon Creek Subwatershed since failing SSTS on lakeshores are likely contribute a higher percentage of phosphorus due to the close proximity to surface water. This TMDL study applies to a riverine system with SSTS generally not located immediately adjacent to impaired waters. This requires wastewater to travel a greater distance to reach surface waters which increases the opportunity for soil adsorption, and ultimately reduces the TP load available for surface water contamination. This is substantiated by regional work conducted in the UMRB that estimated failing septic systems account for roughly 6% of overall phosphorus loading (MPCA, 2004). For this reason, a conservative 6% estimate was applied to Coon Creek phosphorus loading linked to sub-surface sewage treatment systems. Sand, Pleasure, and Springbrook Creek did not receive an estimate for failing SSTS since these subwatersheds are served by municipal sanitary sewer lines.

4.2 *E. coli*

This section provides an inventory of the sources of *E. coli* bacteria with potential contributions to the aquatic recreation impairments within the TMDL study area. Sources of bacteria in the watershed include fecal matter from livestock and wildlife, human wastewater, and domestic pet waste. It is likely that all these sources play some role in the elevated *E. coli* concentrations detected in the impaired waters of this study.

4.2.1 Permitted Sources

Municipal Separate Storm Sewer Systems (MS4s)

Municipal stormwater has already been detailed in the source assessment discussion for TSS and TP (Section 4.1.1). Stormwater conveyed by these systems is a permitted source and therefore included in the WLA portion of the TMDL. Urban stormwater runoff can have bacteria concentrations as high as or higher than runoff originating from pastures and cropland (EPA, 2001). This is the only known permitted source of *E. coli* in the TMDL study area; however, regulated stormwater is likely comprised of a combination of the non-permitted sources listed in Section 4.2.2. There are no permitted wastewater treatment facilities (WWTFs) or CAFOs in the TMDL area, and no known CSOs or SSOs.

4.2.2 Non-permitted Sources

Non-permitted sources listed below all contribute *E. coli* to the landscape which is readily available for delivery to surface waters. To estimate the amount of *E. coli* made available from non-permitted sources, a roadside bacterial assessment was conducted. Appendix B details the methodology used to estimate the total available *E. coli* from each source category and provides the results of the roadside assessment. The percentage of total *E. coli* available by each source is provided in Table 9 at the end of this section. All percentages were determined by dividing the average total *E. coli* available for each source category by combined average total *E. coli* available for all sources.

Livestock

Livestock were a significant *E. coli* source in only the Coon Creek Subwatershed. Data recorded during roadside bacteria surveys estimated 490-600 livestock (cattle and horses) animal units in the Coon Creek Subwatershed. These animals collectively produce an estimated 140,000-160,000 billion *E. coli* organisms per month equating to approximately 51% of the total available *E. coli* load for this subwatershed.

As part of the Upper Mississippi River Bacteria TMDL study and Protection Plan a microbial source tracking pilot study was conducted in an effort to identify *E. coli* sources present in multiple tributaries to the Mississippi River. Pleasure and Springbrook Creeks were sampled in this study and interestingly, bovine DNA was detected in this Springbrook Creek subwatershed (Plevan et al., 2013). This finding was unexpected because there is no agricultural land or livestock present in this subwatershed. The leading hypothesis for this unexpected bovine detection is centered on the introduction of improperly processed bovine compost from rural areas into urban environments. The import of compost to urban settings is common practice for community gardens; however, it is unclear if this is the cause. No estimate was made for livestock sources in the Sand, Pleasure, and Springbrook Creek Subwatersheds as a result of no observed livestock during roadside surveys. Even if the presence of bovine DNA in urban areas is validated, livestock will likely remain a small contributor relative to human wastewater and domestic pet waste in urbanized environments. Further investigation into bovine DNA detection in urban areas was called for as part of future work in the UMRB Bacteria TMDL study.

Wildlife

Available *E. coli* attributed to wildlife were present in all four impaired reaches covered in this TMDL study. Animal unit estimates were made for both deer and waterfowl from previous population surveys conducted by the Minnesota Department of Natural Resources (DNR) and the United States Fish and Wildlife Service (USFWS). Deer and waterfowl observations were recorded during roadside animal counts; however, the numbers of observations were less conservative than estimates derived from population studies done by DNR and USFWS.

Roadside animal counts for wildlife other than deer or waterfowl (e.g., songbirds, raccoons, rats, etc.) were not conducted in this study; however, an estimate of their cumulative production should be included. To account for “other wildlife” the cumulative production was set equal to deer for each subwatershed. This approach is consistent with previous TMDL studies.

The percentage of total *E. coli* made available by all wildlife ranged from a low of 7% in Coon Creek to a high of 10% in Springbrook Creek. Wildlife contributions are anticipated to fluctuate during early spring and fall as a result of migration patterns. Expansive sod fields, the Carlos Avery WMA, and multiple open recreational areas (soccer fields) inside the CCWD are ideal resting locations for migrating waterfowl.

Human Wastewater

The SSTSs that are “failing”, “non-compliant”, or “imminent threat to public health and safety (ITPHS),” all have the potential to deliver *E. coli* to both groundwater and surface water. The MPCA’s 2012 SSTS Annual Report estimates that 10% of SSTS in Anoka County are failing (McCarthy, 2012). To estimate the *E. coli* made available from sub-standard SSTS, SSTS information data was requested from member cities with land area outside the Metropolitan Urban Service Areas (MUSA) line. A 10% failure rate was applied to the total number of SSTS present, which equated to approximately 6% of the total *E. coli* available in the Coon Creek subwatershed. *E. coli* made available from “failing” SSTS were set equal to a straight pipe discharge making this a conservative estimate. Sand, Pleasure, and Springbrook Creek watersheds are served by municipal sanitary sewer, so delivery of *E. coli* from individual SSTS is not likely to occur in these areas. However, it would be unlikely that aging sanitary sewer lines are 100% efficient. Small leaks and breaches in sanitary sewer lines do have the ability to deliver *E. coli* to surface water but this percentage is likely small and sporadic. The microbial source tracking pilot study referenced earlier in this report also measured fluoride concentrations in water samples taken from urban areas to help determine if faulty sanitary sewer lines were a factor. Fluoride is added to Minnesota municipal drinking water supplies leading to its detectable presence in municipal wastewater. If human DNA markers are detected in combination with fluoride, it is probable faulty sanitary sewer lines exist in some facet. Fluoride concentrations in both Pleasure and Springbrook Creeks were below detectable limits providing evidence that human wastewater is not a significant source to overall *E. coli* loads in these urban subwatersheds (Plevan et al., 2013).

Pets

E. coli made available by pets was greater than any other source in Sand, Pleasure, and Springbrook Subwatersheds. Pet waste improperly managed by pet owners in urbanized areas has a high delivery potential to surface waters as a result of increased impervious area. *E. coli* contributions from domesticated cats were not estimated since cats often defecate in “litter boxes” increasing the likelihood that waste will be disposed of properly. The percentage of total available *E. coli* ranged from a low of 37% in the Coon Creek Subwatershed to over 92% in the Pleasure Creek Watershed (Table 9). These percentages are not surprising given the sheer number of pets in impaired subwatersheds relative to other potential sources.

Table 9. Estimate of *E. coli* produced and available in the TMDL study area.

Coon Creek

Category	Source	Animal Units in Subwatershed	*E. coli* organisms production rate per Animal unit (cfu/day-head[1])**	Total *E. coli* produced per month (Billions of orgs)	Total *E. coli* Produced Per Month by Category (Billions of orgs)	Total *E. coli* Available Per Month by Category (Billions of orgs)	Percent by category
Livestock[2]	Horses	390-480	2.1×10^8	2,500-3,000	140,000-160,000	140,000-160,000	51%
	Cattle	100-120	4.5×10^{10}	140,000-160,000			
	Poultry	0.0-0.0	1.3×10^8	0.0-0.0			
Wildlife	Deer[3]	880-1,100	2.5×10^8	6,600-8,300	19,000-24,000	19,000-24,000	7%
	Waterfowl[4]	980-1,200	2.0×10^8	5,900-7,200			
	Other Wildlife	Equivalent of Deer	2.5×10^8	6,600-8,300			
Human	Failing SSTS[5]	520-640	1.0×10^9	16,000-19,000	16,000-19,000	16,000-19,000	6%
Domestic Pets	Dogs[6,7]	14,000-17,000	2.3×10^9	960,000-1,200,000	960,000-1,200,000	96,000-120,000	37%
Total	**All**	**18,000-22,000**	**-**	**1,100,000-1,400,000**	**1,100,000-1,400,000**	**270,000-320,000**	**100%**

Sand Creek

Category	Source	Animal Units in Subwatershed	*E. coli* organisms production rate per Animal unit (cfu/day-head[1])**	Total *E. coli* produced per month (Billions of orgs)	Total *E. coli* Produced Per Month by Category (Billions of orgs)	Total *E. coli* Available Per Month by Category (Billions of orgs)	Percent by category
Livestock[2]	Horses	0.0-0.0	2.1×10^8	0.0-0.0	0.0-0.0	0.0-0.0	0%
	Cattle	0.0-0.0	4.5×10^{10}	0.0-0.0			
	Poultry	0.0-0.0	1.3×10^8	0.0-0.0			
Wildlife	Deer[3]	190-250	2.5×10^8	1,400-1,900	6,000-7,700	6,000-7,700	11%
	Waterfowl[4]	530-650	2.0×10^8	3,200-3,900			
	Other Wildlife	Equivalent of Deer	2.5×10^8	1,400-1,900			
Domestic Pets	Dogs[6,7]	7,300-8,900	2.3×10^9	500,000-610,000	500,000-610,000	50,000-61,000	89%
Total	**All**	**8,200-10,000**	**-**	**500,000-620,000**	**500,000-620,000**	**56,000-69,000**	**100%**

Pleasure Creek

Category	Source	Animal Units in Subwatershed	*E. coli* organisms production rate per Animal unit (cfu/day-head[1])**	Total *E. coli* produced per month (Billions of orgs)	Total *E. coli* Produced Per Month by Category (Billions of orgs)	Total *E. coli* Available Per Month by Category (Billions of orgs)	Percent by category
Livestock[2]	Horses	0.0-0.0	2.1 x 10^{8}	0.0-0.0	0.0-0.0	0.0-0.0	0%
	Cattle	0.0-0.0	4.5 x 10^{10}	0.0-0.0			
	Poultry	0.0-0.0	1.3 x 10^{8}	0.0-0.0			
Wildlife	Deer[3]	30-45	2.5 x 10^{8}	225-340	840-1,100	840-1,100	8%
	Waterfowl[4]	40-50	2.0 x 10^{8}	340-420			
	Other Wildlife	Equivalent of Deer	2.5 x 10^{8}	225-340			
Domestic Pets	Dogs[6,7]	1,500-1,900	2.3 x 10^{9}	100,000-130,000	100,000-130,000	10,000-13,000	92%
Total	**All**	**1,600-2,000**	**-**	**100,000-130,000**	**100,000-130,000**	**11,000-14,000**	**100%**

Springbrook Creek

Category	Source	Animal Units in Subwatershed	*E. coli* organisms production rate per Animal unit (cfu/day-head[1])**	Total *E. coli* produced per month (Billions of orgs)	Total *E. coli* Produced Per Month by Category (Billions of orgs)	Total *E. coli* Available Per Month by Category (Billions of orgs)	Percent by category
Livestock[2]	Horses	0.0-0.0	2.1 x 10^{8}	0.0-0.0	0.0-0.0	0.0-0.0	0%
	Cattle	0.0-0.0	4.5 x 10^{10}	0.0-0.0			
	Poultry	0.0-0.0	1.3 x 10^{8}	0.0-0.0			
Wildlife	Deer[3]	50-70	2.5 x 10^{8}	380-520	1,100-1,500	1,100-1,500	10%
	Waterfowl[4]	60-80	2.0 x 10^{8}	360-480			
	Other Wildlife	Equivalent of Deer	2.5 x 10^{8}	380-520			
Domestic Pets	Dogs[6,7]	1,600-2,000	2.3 x 10^{9}	110,000-140,000	110,000-140,000	11,000-14,000	89%
Total	**All**	**1,800-2,200**	**-**	**110,000-140,000**	**110,000-140,000**	**12,000-16,000**	**100%**

**Derived from literature values in (Mulla, 2001), (MPCA, 2002), (Alderisio & Deluca, 1999), (ASAE, 1998), (Metcalf and Eddy, 1991).

*** Literature sources provide fecal coliform production rates, which were converted to E. coli by applying a conversion factor of 0.5 based on Doyle and Erickson (2006). Therefore, E. coli production rate = 0.5 x fecal coliform production rate

(1) Head implies to an individual animal.

(2) Estimates based on data collected during the roadside bacteria source assessment survey.

(3) Range based on 12 to 16 deer/sq mile (DNR 2011 Pre-Fawn Deer Density from Deer Population Model; average of permit areas 229, 223, 227 (DNR, 2011).

(4) Estimated based on statewide average as determined by DNR and USFWS 2012 Waterfowl Breeding Population Survey. This estimate was more conservative than waterfowl density derived from roadside bacteria source assessment survey (US Fish and Wildlife Service, 2012).

(5) Estimated 5,810 homes with septic systems based on septic locations from the city of Andover and estimated for Ham Lake based on map review, and a 10% failure rate for applied for Anoka County (McCarthy, 2012)

(6) 0.584 dogs/household (American Veterinary Medical Assocation, 2012)

(7) Estimated that 10% of the *E. coli* produced from pets is improperly managed and available for runoff.

5. TMDL Development

A TMDL is defined as the total amount of a given pollutant that can enter a waterbody while still achieving water quality standards. A TMDL can be expressed in terms of mass per time or by other loading rate measures. TMDLs are composed of the sum of WLAs, LAs, MOS, and reserve capacity (RC) to account for future growth. TMDLs are calculated from the equation below;

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

Where:

Loading capacity (LC): the greatest pollutant load a waterbody can receive without violating water quality standards;

Wasteload Allocation (WLA): the pollutant load that is allocated to point sources, including WWTFs and regulated stormwater; all covered under NPDES Permits for a current or future permitted pollutant source;

Load Allocation (LA): the pollutant load that is allocated to source not requiring NPDES Permit coverage, including non-regulated stormwater runoff;

Margin of Safety (MOS): an accounting of uncertainty about the relationship between pollutant load and receiving water quality;

Reserve Capacity (RC): the portion of the loading capacity attributed to the growth of existing and future load sources.

This section presents TMDLs for TSS and TP, stressors identified as primary stressors for biotic impairments, as well as TMDLs for *E. coli* for aquatic recreation impairments in the CCWD.

5.1 Total Suspended Sediment

5.1.1 Loading Capacity

"Assimilative capacity", also termed "loading capacity" refers to a waterbody's ability to absorb constituents without exceeding a specific condition (i.e., water quality standard). Loading capacities and load reductions for TSS were developed through the use of LDCs (Cleland, 2002). This approach involves calculating the allowable loadings over the range of flow conditions expected to occur in the impaired stream by taking the following steps:

1. Using previously calculated flow duration curves, flows were separated into five distinct flow regimes (Figure 12). Separating flows into five distinct regimes helps to illustrate how pollutant loadings change relative to specific flow conditions. The five flow regimes were separated as follows; very high (0-10%), high (10-40%), mid (40-60%), low (60-90%), and very low (90-100%).

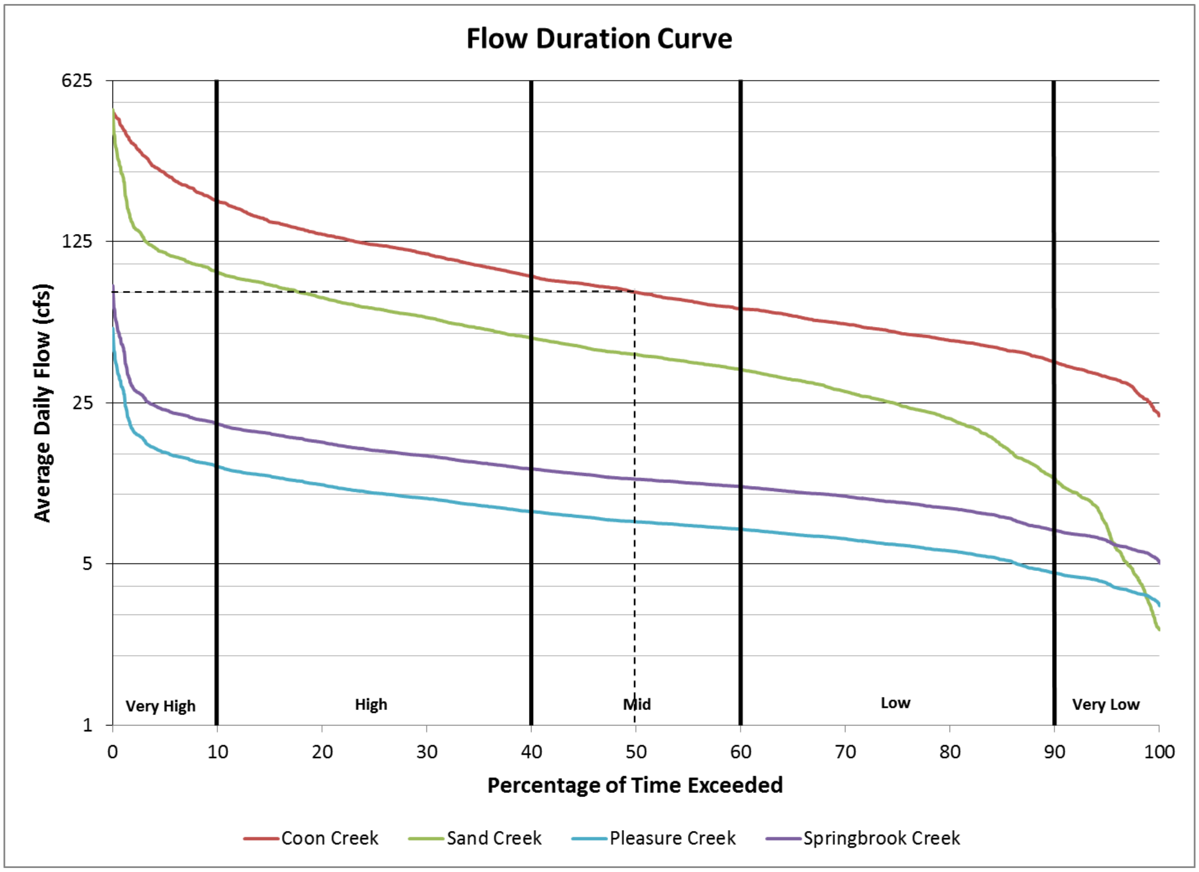

Figure 12. Flow duration curves for each impaired reach. Springbrook Creek values are based on estimated flow data.

2. Flow duration curves were translated into load duration (or TMDL) curves by multiplying the average daily flow values by 30 mg/L (TSS water quality standard), and then multiplying by a 0.002695 conversion factor resulting in a mass per time unit of tons per day. Each value is plotted individually to create a load duration curve, also known as a total daily loading capacity (TDLC).

3. Water quality samples are converted to a daily load by multiplying the water quality sample concentration by the average daily flow from the day the sample was collected. Individual loads are then plotted as points on the TMDL graph for comparison with the water quality standard, or LDC. Points above the LDC represent exceedances of the water quality standard and the TDLC (or TMDL). Those below the curve represent compliance with water quality standards.

4. The 90th percentile of the TSS concentrations within each flow regime were calculated and multiplied by the average daily flow at the midpoint of each flow regime (5%, 25%, 50%, 75%, and 95%). The 90th percentile pollutant loads were plotted against the LDC to determine pollutant reductions. The difference between the 90th percentile loadings and the midpoint of each flow regime were used for TMDL calculations. In the TMDL Summary (Section 5.4) only five points on the load duration curve are depicted (the midpoints of the designated flow regimes). However, it should be understood that the entire curve represents the TMDL that is ultimately approved by EPA.

5. For some flow regimes, calculated pollutant loads fell below the allowable pollutant load. In an effort to follow antidegradation requirements, the existing pollutant load was used for load and

wasteload calculations rather than the allowable load. The difference between the existing and allowable load was classified as the "unallocated load."

The LDCs calculated through the steps above are presented below for all impaired stream reaches receiving a TSS TMDL as part of this study.

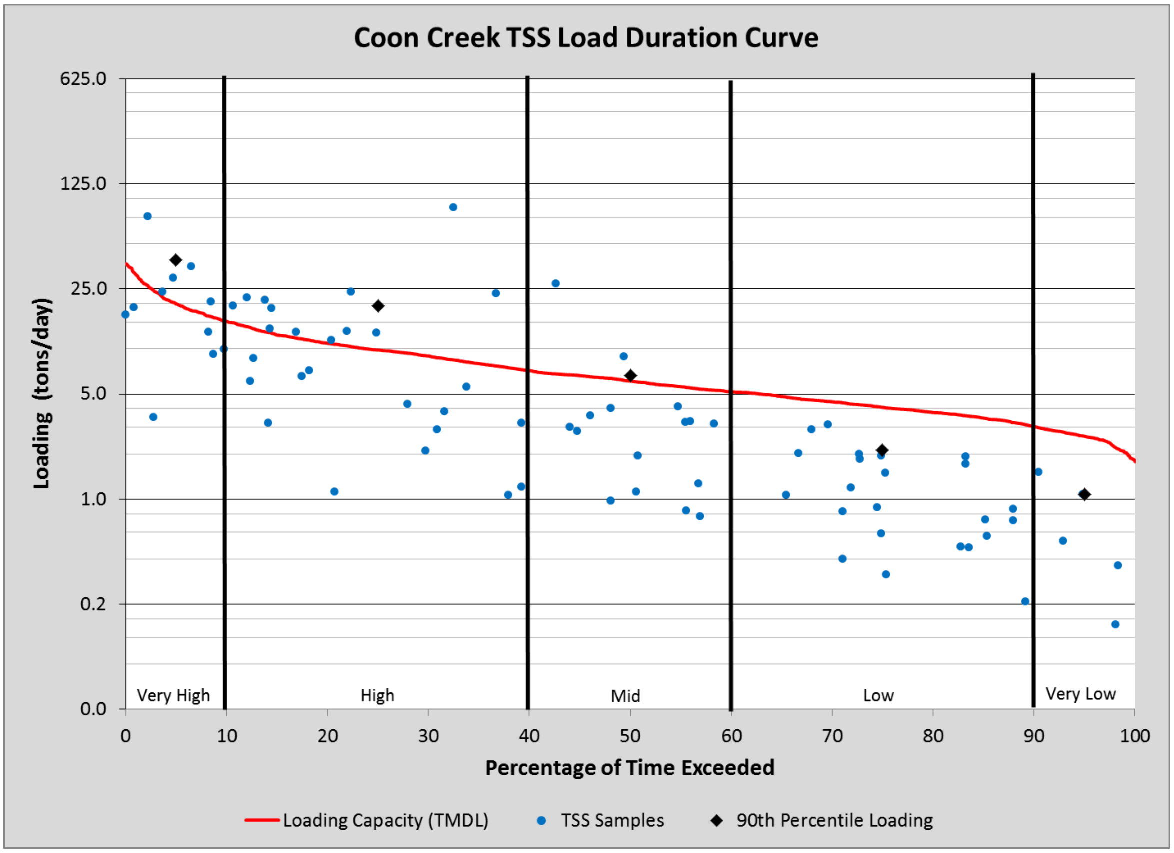

Figure 13. Coon Creek TSS load duration curve.

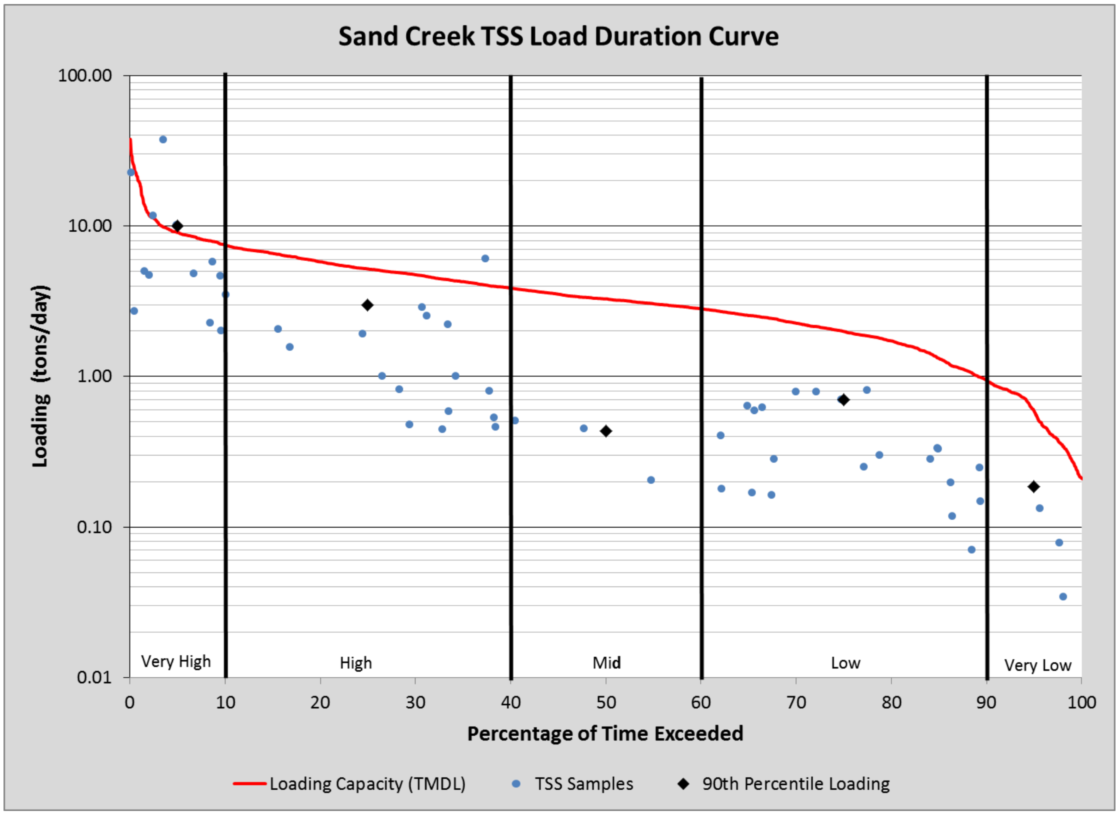

Figure 14. Sand Creek TSS load duration curve.

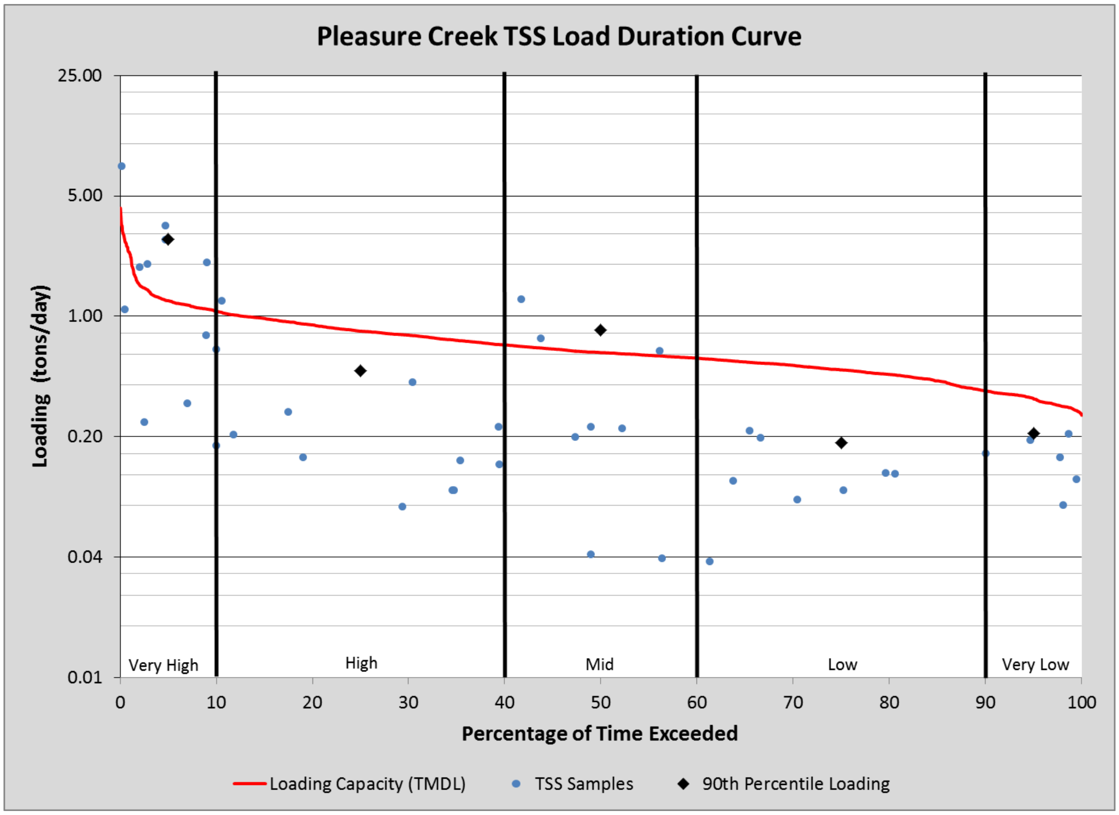

Figure 15. Pleasure Creek TSS load duration curve.

TSS LDCs for each impaired reach indicate pollutant loadings are often exceeded during wet weather conditions, which would be consistent with sources such as stormwater runoff and streambank erosion.

5.1.2 Load Allocation Methodology

The LA represents the portion of the total loading capacity discharged from all non-permitted sources; often referred to as the *“watershed load”*. To determine the LA for each impaired reach, the total area not served by MS4 conveyance was calculated with 2020 projected land use data obtained from Metropolitan Council and Geographic Information System (GIS) mapping software. This method is a surrogate to land cover methodology and operates under the assumption that more urbanized land uses, such as “industrial” or “commercial,” are more likely to be served by a regulated MS4 than rural land uses, such as “agriculture”. Guidance published by the MPCA was used to determine which land use classifications were included in the LA and those placed in the WLA (MPCA, 2011) (Appendix G). The 2010 U.S. Census Bureau defined urban area was the dividing line for most land use classifications placed in the LA (Appendix G). This was appropriate since land uses inside the urban area are most often served by an MS4 conveyance system.

Land use classifications placed in the LA were verified through the addition of city stormwater infrastructure into GIS mapping. In some instances, specific land areas were transferred into the WLA portion of the TMDL after addition of city stormwater infrastructure maps. For example, “vacant” land uses are placed into the LA or WLA based on adjacent land use. In some instances, it was clear that “vacant” areas were served by MS4 conveyance systems and therefore were included in the WLA. Appendix G details all steps taken to distinguish LAs and WLAs.

5.1.3 Wasteload Allocation Methodology

The WLA portion of a TMDL is the portion of a receiving water’s loading capacity that is allocated to one of its existing or future point sources of pollution.

The permitted MS4s for each impaired reach are included in Table 10. Currently, there are no permitted wastewater discharges in the CCWD. The WLA for regulated stormwater was calculated based on the land area served by an MS4 conveyance using GIS mapping software and Met Council 2020 land use projections. This is consistent with the methodology used to determine the LA portion of this TMDL discussed in Section 5.1.2.

Calculating a WLA for construction stormwater is difficult since monitoring data from construction sites is lacking. Construction activity is also highly transient and variable, often resulting in inaccurate WLA estimates for this regulated source. In the TMDL study area, all construction and ISW sources discharge to a regulated MS4, therefore a categorical WLA was established for all permitted stormwater. This WLA includes municipal, construction, and ISW (MPCA, 2011). Table 10 shows MS4 Permit holders within the watershed of each impaired reach.

Table 10. MS4 permittees listed by impaired reach.

Watershed	NPDES	Name	Type
Coon Creek	MS400170	MnDOT Metro District	Non-traditional
	MS400066	Anoka County	County
	MS400172	Coon Creek WD	Watershed District
	MS400073	Andover City	City
	MS400075	Blaine City	City
	MS400011	Coon Rapids City	City
	MS400092	Ham Lake City	City
Sand Creek	MS400170	MnDOT Metro District	Non-traditional
	MS400066	Anoka County	County
	MS400172	Coon Creek WD	Watershed District
	MS400075	Blaine City	City
	MS400011	Coon Rapids City	City
	MS400092	Ham Lake City	City
Pleasure Creek	MS400170	MnDOT Metro District	Non-traditional
	MS400066	Anoka County	County
	MS400172	Coon Creek WD	Watershed District
	MS400075	Blaine City	City
	MS400011	Coon Rapids City	City
Springbrook Creek	MS400170	MnDOT Metro District	Non-traditional
	MS400066	Anoka County	County
	MS400172	Coon Creek WD	Watershed District
	MS400075	Blaine City	City
	MS400011	Coon Rapids City	City
	MS400050	Spring Lake Park City	City
	MS400019	Fridley City	City

Much of the same discussion for construction stormwater applies to ISW. This includes the difficult nature of calculating pollutant loads from these sites, the relatively small contributions from these sites if permit conditions are met, and the variability in types of industrial facilities. For this reason, the categorical stormwater WLA includes loads from ISW. Loads from ISW are considered to be less than 0.5% of the total WLA.

The Minnesota Department of Transportation (MnDOT) requested an individual WLA based on the land area of their road right-of-ways. MnDOT is a regulated MS4 only within the U.S. Census Urban Area and provided road right-of-way information for roads under their jurisdiction. Anoka County is also a regulated MS4 only within the U.S. Census Urban Area and therefore given an individual WLA similar to MnDOT. Anoka County Highway Department was unable to provide road right-of-way widths for roads under their jurisdiction so land area under their control was estimated by applying a 50 foot buffer to centerlines of roads under their jurisdiction.

All remaining MS4s were given a categorical WLA including the CCWD, which has jurisdiction over several ditches in the impaired subwatersheds. A categorical WLA distribution capitalizes on the long history of collaboration between member cities and the CCWD on various water quality projects. This approach also recognizes that investment in the most effective BMPs is best for the water resource regardless of BMP location. The use of a categorical TMDL is also consistent with the MPCA policy and guidance for incorporating MS4 stormwater programs into TMDLs which states, “Categorical WLA may be appropriate when a single MS4 or other entity will track BMP implementation and associated load reductions. An example would be a watershed district.” (MPCA, 2011). CCWD will work with all municipal MS4s in the watershed to track progress towards achieving WLAs prescribed in this study.

TMDLs in this study are based on flow data from a 10 year period (2005-2014) and varying periods of time for water quality data. The baseline year was set at the midpoint of the loading assessment period (Table 11).

Table 11. Baseline years for impaired reaches.

Stream Reach	WQ Data Range	Baseline Year
Coon Creek	2005-2014	2009
Sand Creek	2007-2014	2010
Unnamed Ditch (Pleasure Creek)	2010-2014	2012
County Ditch 17 (Springbrook Creek)	2010-2014	2012

5.1.4 Margin of Safety (MOS)

The MOS accounts for uncertainties in the relationships between existing loads, stream flows, biological impact, and in-stream water quality. The purpose of the MOS is to ensure that TMDL allocations result in attainment of water quality objectives. In this TMDL study, an explicit 10% MOS was applied; 10% of the loading capacity for each flow regime was subtracted before WLAs and LAs were calculated. A 10% MOS was considered to be appropriate because the load duration curve minimizes uncertainties that can arise through other approaches. LDCs are simply a function of average daily flow multiplied by numerical water quality standards.

5.1.5 Seasonal Variation

Available TSS data for impaired reaches in the study all show most TSS exceedances occur during “High” and “Very High” flow regimes, suggesting TSS is primarily driven by precipitation events. The load duration curve approach accounts for seasonality by calculating allowable loads on a daily basis over a wide range of estimated flows. The use of multiple years of flow data in conjunction with water quality data accounts for seasonal variation and provides adequate protection during differing times of the year.

5.2 Total Phosphorus

5.2.1 Loading Capacity

Loading capacities and load reductions for TP were developed through the same load duration curve process detailed in Section 5.1.1 which exceptions to steps 2 and 4. This approach involves calculating the allowable loadings over the range of flow conditions expected to occur in the impaired stream by taking the following steps:

1. Refer to Section 5.1.1.
2. Flow duration curves were translated into load duration (or TMDL) curves by multiplying the average daily flow values by 100 µg/L (TP water quality standard), and then multiplying by a

0.005393 conversion factor resulting in a mass per time unit of lbs/day. Each value is plotted individually to create a load duration curve, also known as a TDLC.

3. Refer to Section 5.1.1.
4. The TP concentrations for each flow regime were averaged and multiplied by the median flow for the regime in which it falls and plotted against the LDC to determine if pollutant reductions where needed. The difference between the average loading and the midpoint of each flow regime (5%, 25%, 50%, 75%, and 95%) was used for TMDL calculations. If the average of loading values for a specific flow regime plotted below the LDC, no reduction was necessary. In the TMDL Summary (Section 5.4) only five points on the load duration curve are depicted (the midpoints of the designated flow regimes). However, it should be understood that the entire curve represents the TMDL that is ultimately approved by EPA.
5. Refer to Section 5.1.1.

The LDCs calculated through the steps above are presented below for all impaired stream reaches receiving a TP TMDL as part of this study.

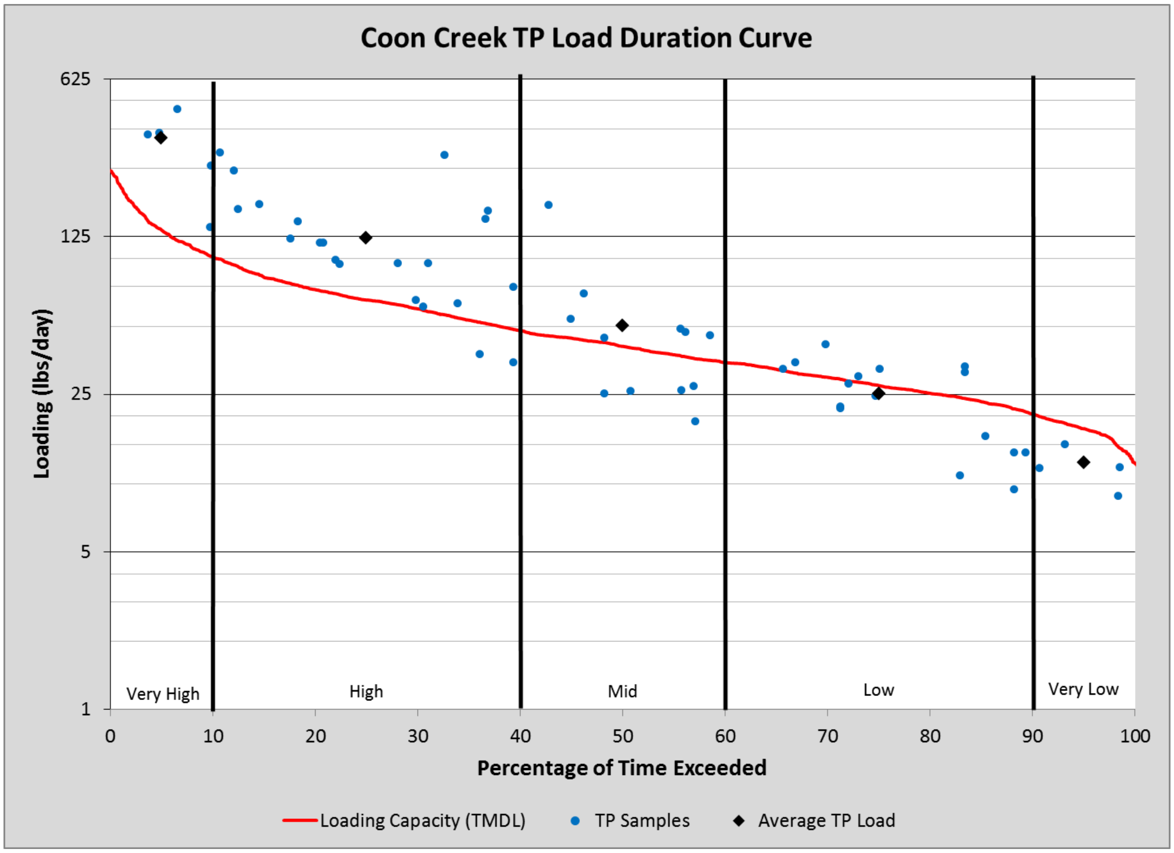

Figure 16. Coon Creek TP load duration curve.

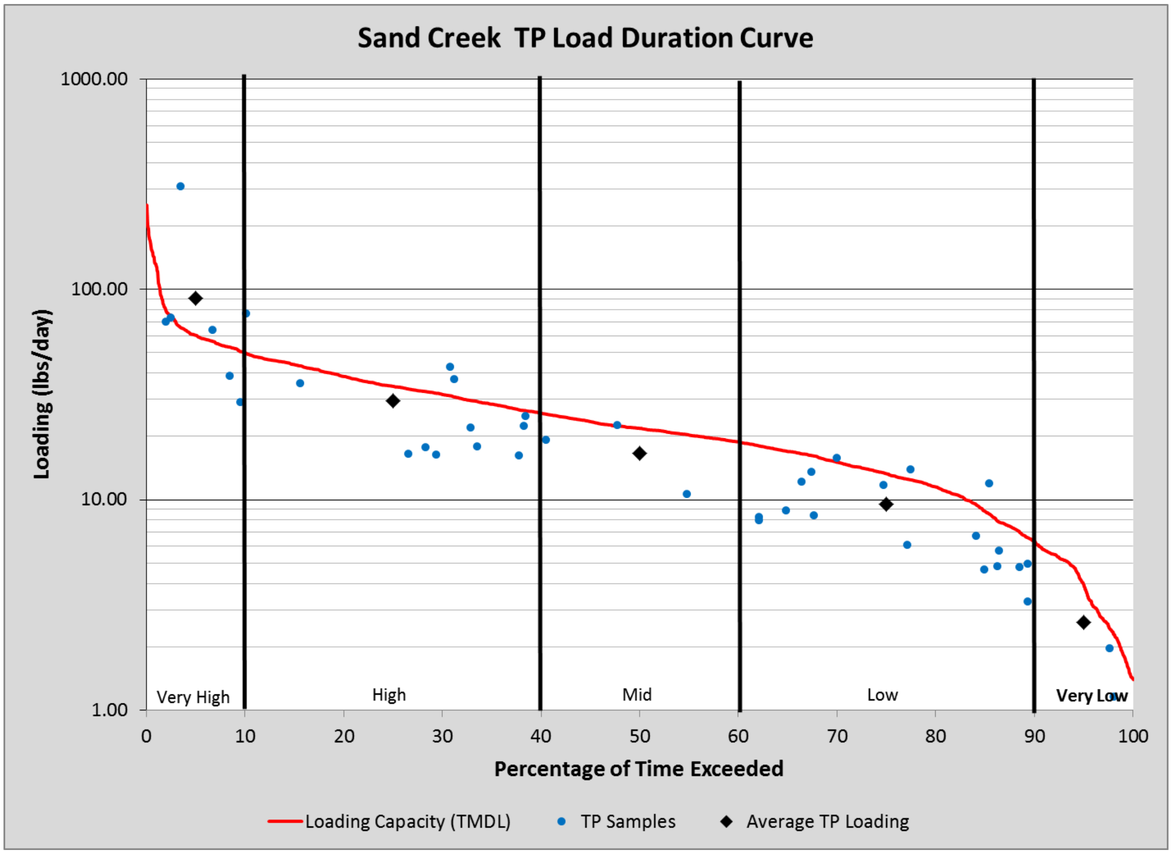

Figure 17. Sand Creek TP load duration curve.

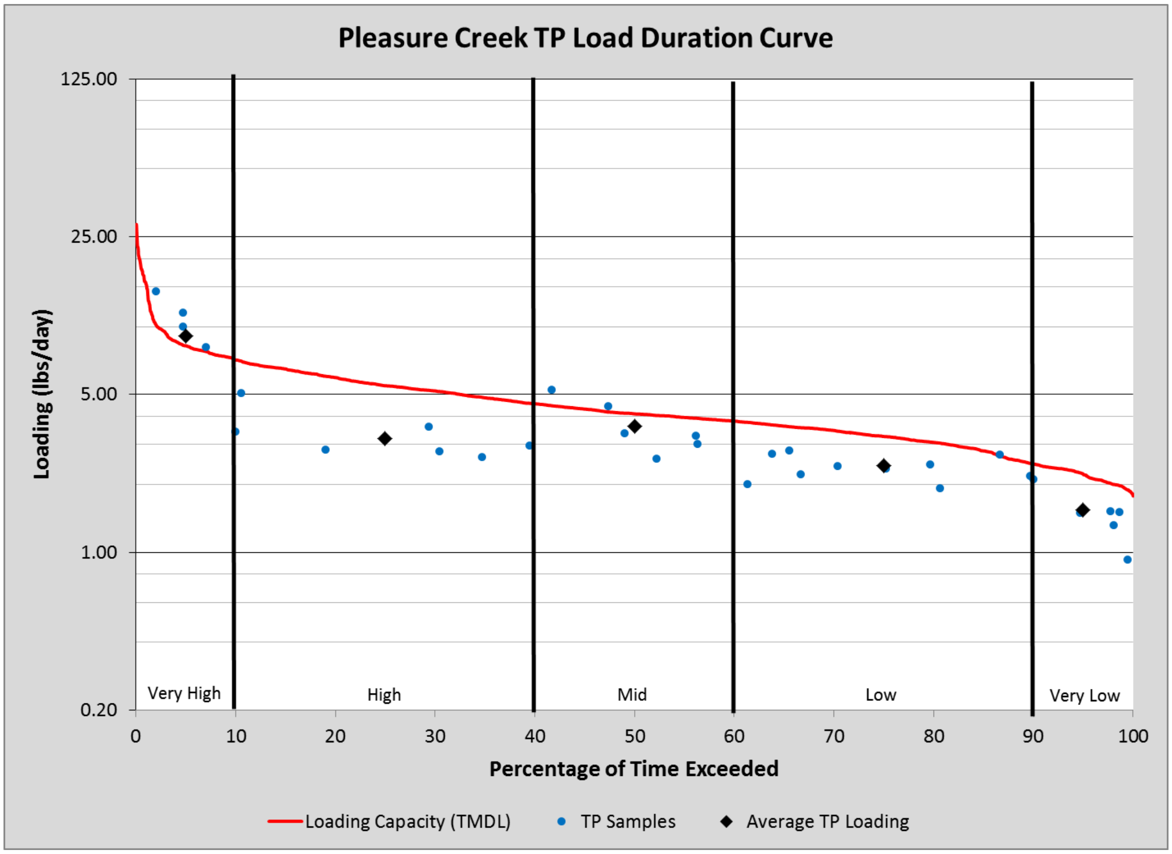

Figure 18. Pleasure Creek TP load duration curve.

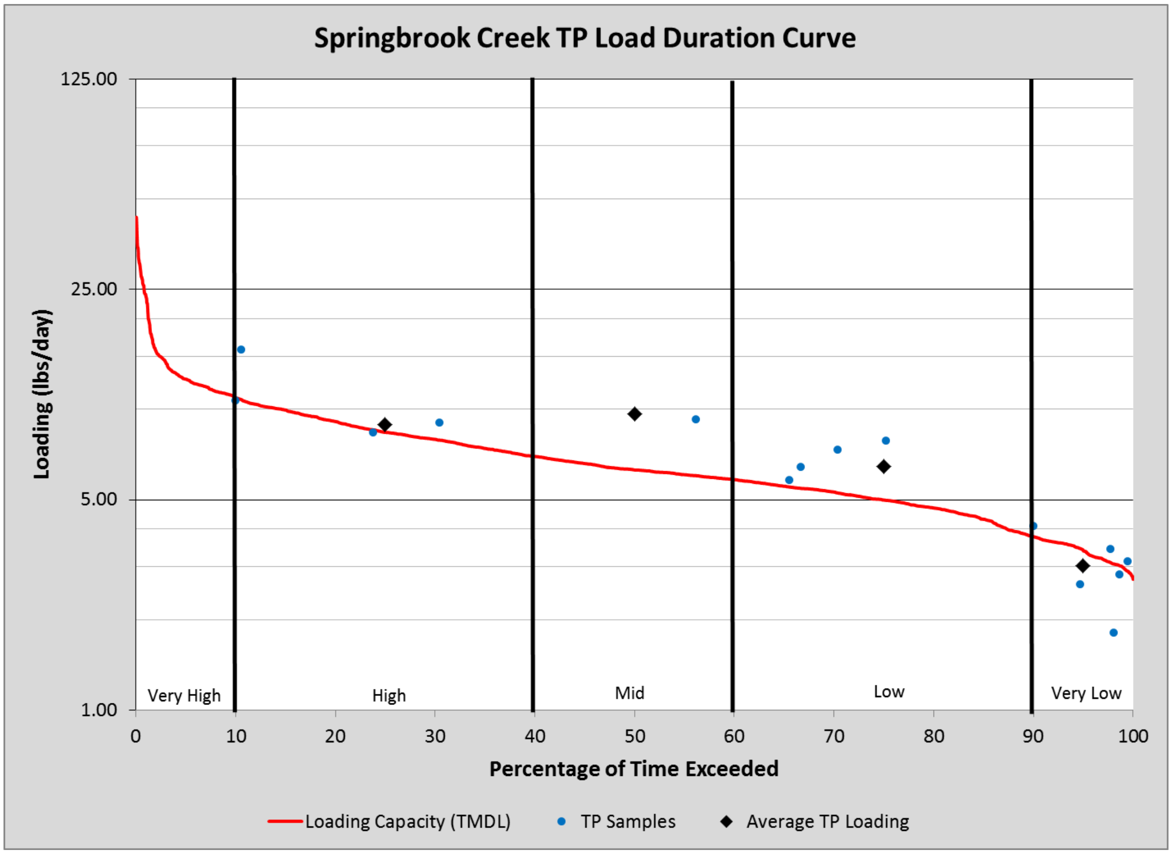

Figure 19. Springbrook TP load duration curve. Springbrook Creek values are based on estimated flow data.

Total phosphorus LDCs also indicate wet weather conditions are resulting in stream degradation. However, it should also be noted that exceedances of TP are also observed during low flow regimes, a condition potentially linked to illegal dumping of organics (leaves and grass clippings).

5.2.2 Load Allocation Methodology

The overall LA was approximated based on the percentage of land area not served by MS4 conveyance as previously described in Section 5.1.2. Refer to Appendix G for more detailed methodology.

5.2.3 Wasteload Allocation Methodology

WLAs were calculated based on land area served by MS4s determined by the same methods previously described in Section 5.1.3.

5.2.4 Margin of Safety

The MOS accounts for uncertainties in the relationships between existing loads, stream flows, biological impact, and in-stream water quality. The purpose of the MOS is to ensure that TMDL allocations result in attainment of water quality objectives. In this TMDL study, an explicit 10% MOS was applied whereby 10% of the loading capacity for each flow regime was subtracted before WLAs and LAs were calculated. A 10% MOS was considered to be appropriate because the load duration curve minimizes uncertainties that can arise through other approaches. The LDCs are simply a function of average daily flow multiplied by numerical water quality standards.

5.2.5 Season Variation

Influxes of in-stream TP concentrations are often observed during or shortly after precipitation events. This is not surprising since regulated and non-regulated stormwater are both identified as primary contributing pollutant sources. Seasonal variation in precipitation patterns and resultant TP loads are accounted for through the load duration curve approach, which indirectly encapsulates a wide range of precipitation events through long term flow records. The range of flows experienced over this 10 year period accounts for seasonal variation in TP concentrations.

5.3 *E. coli*

5.3.1 Loading Capacity

Loading capacities and load reductions for *E. coli* were developed through the same load duration curve process detailed in Section 5.1.1 with exceptions to steps 2 and 4. This approach involves calculating the allowable loadings over the range of flow conditions expected to occur in the impaired stream by taking the following steps:

1. Refer to Section 5.1.1.
2. Flow duration curves were translated into load duration (or TMDL) curves by multiplying the average daily flow values by 126 cfu/100mL (*E. coli* chronic water quality standard), and then multiplying by a 0.02446 conversion factor. Application of this conversion factor results units of billion organisms per day which is consistent with EPA regulations which define *“load”* as *“an amount of matter that is introduced into a receiving water”* (Code of Federal Regulation, 2002). This “load” measurement is consistent with previous EPA approved bacteria TMDLs. Each value is plotted individually to create a load duration curve, also known as a TDLC.
3. Refer to Section 5.1.1.
4. The geometric mean of all *E. coli* concentrations in a given flow regime was calculated and multiplied by the median daily flow for the respective regime. This loading was plotted against the LDC to determine the reductions needed. The geometric mean was used rather than an average since the water quality standard is based on the geometric mean of samples taken within a calendar month. The difference between the calculated loadings and the midpoint of each flow regime (5%, 25%, 50%, 75%, and 95%) were used for TMDL calculations. If the average of loading values for a specific flow regime plotted below the LDC, no reduction was necessary. In the TMDL Summary (Section 5.4) only five points on the entire loading capacity curve are depicted (the midpoints of the designated flow zones). However, it should be understood that the entire curve represents the TMDL and what is ultimately approved by EPA.
5. Refer to Section 5.1.1.

The load duration curves calculated through the steps above are presented below for all impaired stream reaches receiving an *E. coli* TMDL as part of this study.

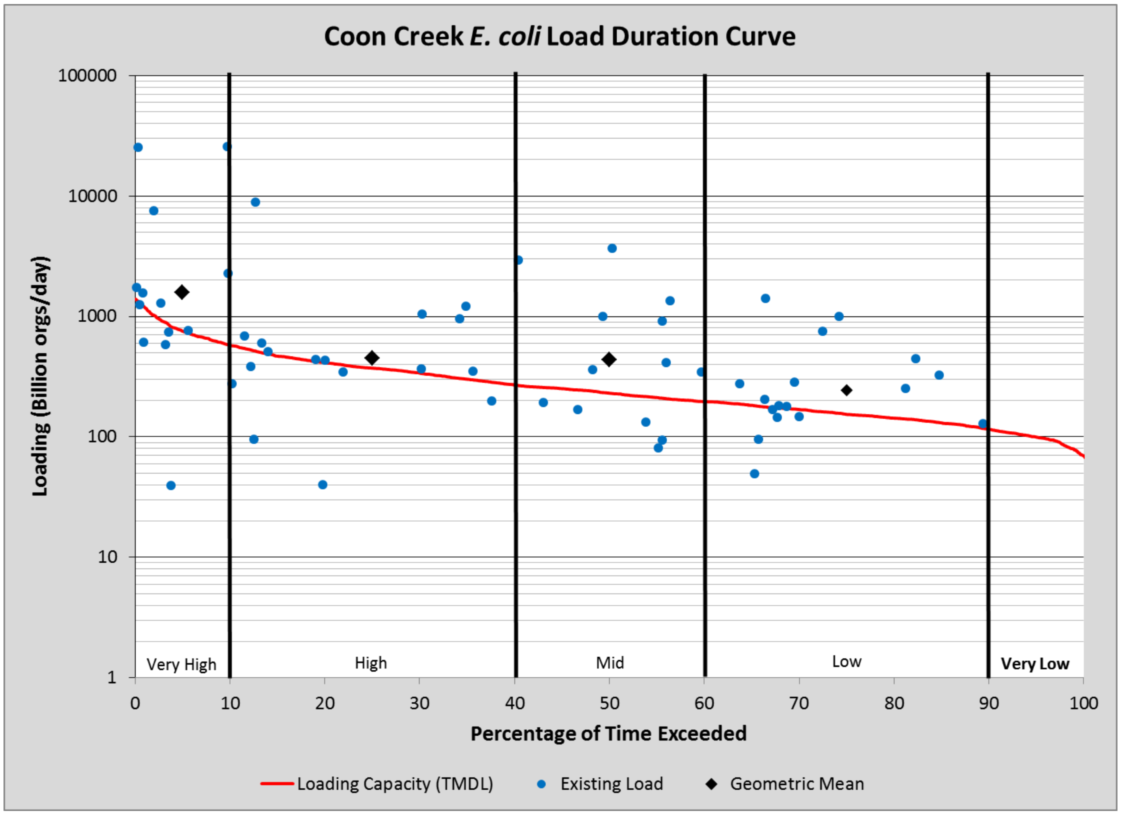

Figure 20. Coon Creek *E. coli* load duration curve.

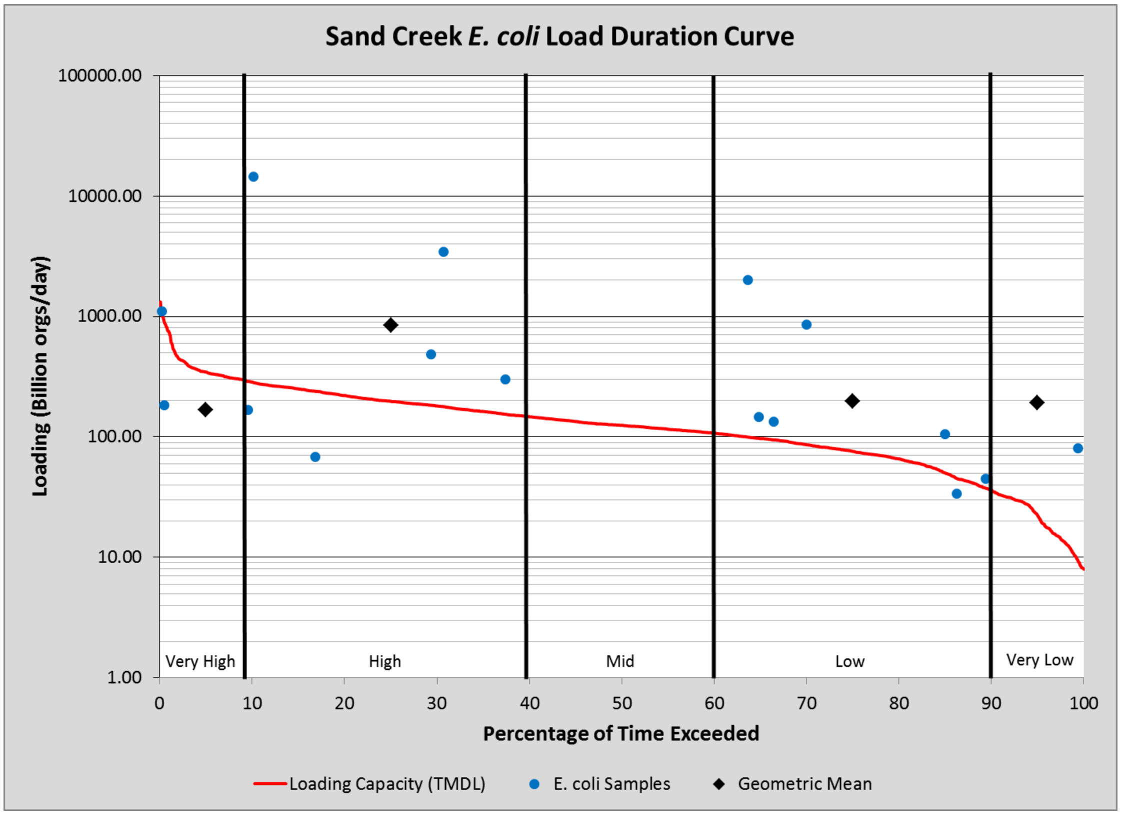

Figure 21. Sand Creek *E. coli* load duration curve.

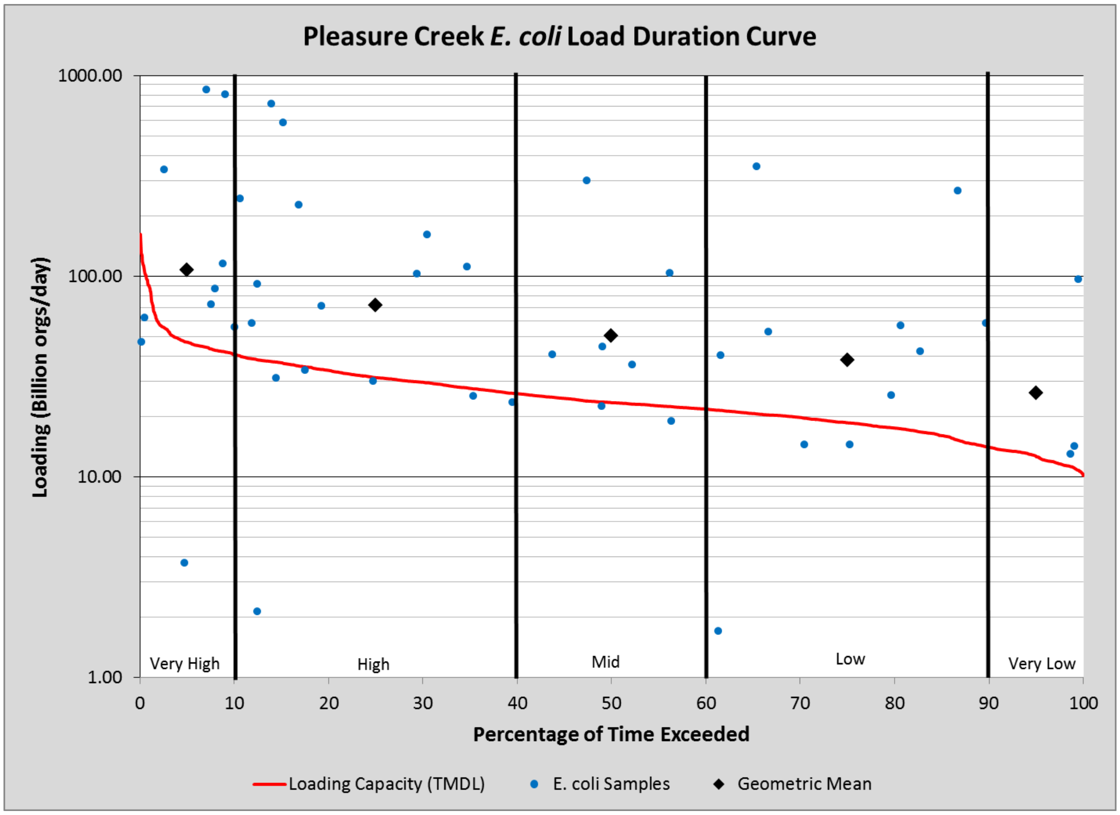

Figure 22. Pleasure Creek *E. coli* load duration curve.

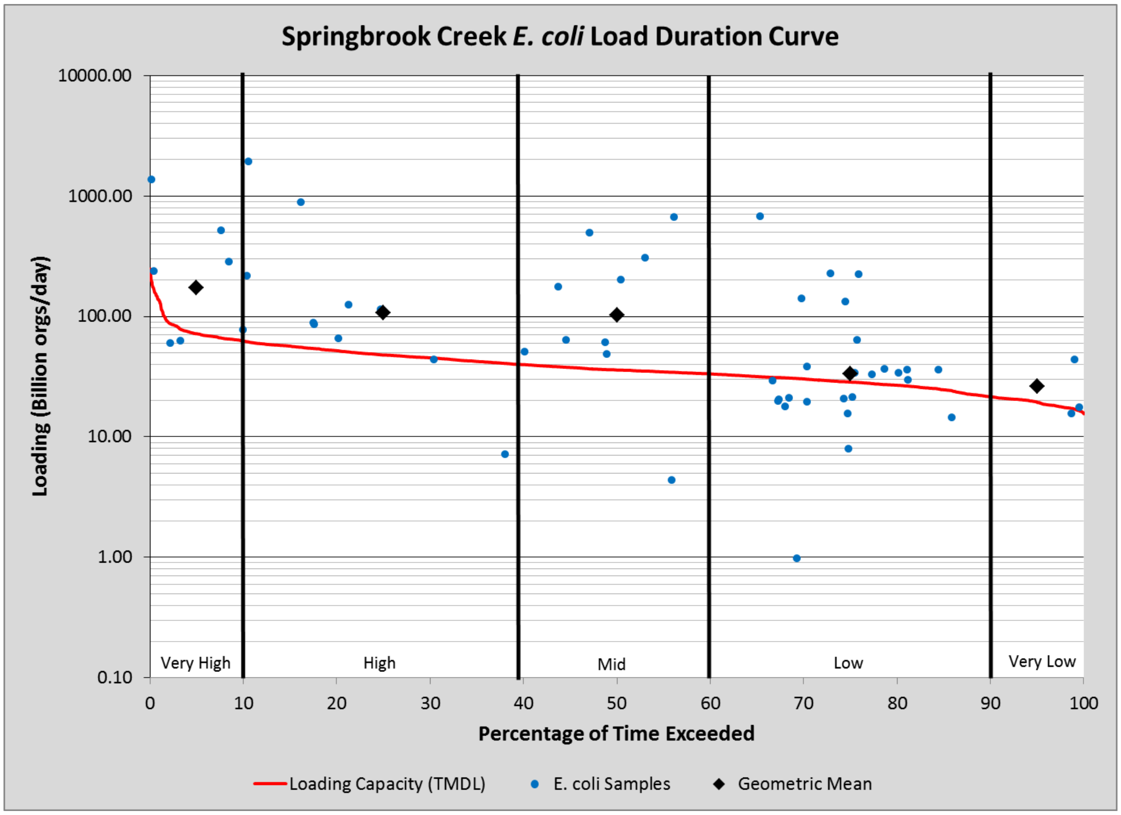

Figure 23. Springbrook *E. coli* load duration curve. Springbrook Creek values are based on estimated flow data.

Interpretation of *E. coli* LDCs is difficult as exceedance are seen throughout all flow regimes. This is likely due to the complexity of bacteria die-off and re-growth rates. As a result, all existing and new emerging technologies should be explored during implementation activities and target all flow regimes.

5.3.2 Load Allocation Methodology

The LA for non-permitted sources was based on the land area within each subwatershed not served by MS4 conveyance. Areas not served by MS4 tend to be more “natural” landscapes such as forested areas, wetlands, and vegetated fields. Land use classifications provided in Appendix G were used to make the distinction between areas served by MS4 conveyance and those that were not. The bacteria source assessment outlined in Section 4.3.2 and detailed in Appendix B was conducted to provide an estimate for the relative contributions for a variety of sources within each subwatershed. The intent of the bacteria assessment was to guide implementation planning by comparing the potential contributions of various sources rather than separate sources for LA calculations. The quantification of LAs for any one source is difficult due to the complexity of die-off and re-growth of *E. coli* in urban stream environments.

5.3.3 Wasteload Allocation Methodology

The only permitted source of *E. coli* bacteria in any of the four impaired subwatersheds was regulated stormwater (there are no WWTFs, CSOs, SSOs, or CAFOs). The WLA for permitted stormwater was based on the land area within each subwatershed served by MS4 conveyance consistent with methodology used in both TSS and TP WLA calculations outlined in Appendix G.

5.3.4 Margin of Safety

The MOS accounts for uncertainties in the relationships between existing loads, stream flows, biological impact, and in-stream water quality. The purpose of the MOS is to ensure that TMDL allocations result in attainment of water quality objectives. In this TMDL study, an explicit 10% MOS was applied whereby 10% of the loading capacity for each flow regime was subtracted before WLAs and LAs were calculated. A 10% MOS was considered to be appropriate because the load duration curve minimizes uncertainties that can arise through other approaches. Load duration curves are simply a function of average daily flow multiplied by numerical water quality standards.

5.3.5 Seasonal Variation

The flow duration curve approach utilized in this TMDL captures the full range of flow conditions over the April through October period when bacteria water quality standard are applicable. Using a multi-year flow record for April through October provides an adequate accounting for seasonal variation of bacteria loadings.

5.4 TMDL Summary

5.4.1 TMDL Summary

Tables 12-14 summarize all TMDL components for the four impaired reaches of the CCWD. The TMDL was allocated among all pollutant sources according to methodology described in Section 5.1 – 5.3. The reported numbers may not sum exactly to the total values presented due to rounding when applicable.

Table 12. TSS TMDL summary table.

	Flow Zone				
	Very High	**High**	**Mid**	**Low**	**Very Low**
Coon Creek	*Tons/day*				
Existing Loading	**38.71**	**19.2**	**6.61**	**2.13**	**1.08**
Total Daily Loading Capacity	**19.87**	**9.80**	**6.10**	**4.08**	**2.63**
Load Reduction	**18.84**	**9.40**	**0.51**	**0.00**	**0.00**
Estimated Load Reduction (%)	**49%**	**49%**	**8%**	**0%**	**0%**
Total Wasteload Allocation	**9.40**	**4.64**	**2.89**	**1.01**	**0.51**
MnDOT	0.19	0.10	0.06	0.02	0.01
Anoka County	0.26	0.13	0.08	0.03	0.01
Regulated stormwater (categorical)	8.94	4.41	2.75	0.96	0.49
Total Load Allocation	**8.48**	**4.18**	**2.60**	**0.91**	**0.46**
Unallocated Load	**0.00**	**0.00**	**0.00**	**1.95**	**1.55**
Margin of Safety	**1.99**	**0.98**	**0.61**	**0.21**	**0.11**
Sand Creek	*Tons/day*				
Existing Loading	**10.06**	**2.99**	**0.44**	**0.7**	**0.18**
Total Daily Loading Capacity	**9.07**	**5.19**	**3.28**	**1.99**	**0.59**
Load Reduction	**0.99**	**0.00**	**0.00**	**0.00**	**0.00**
Estimated Load Reduction (%)	**10%**	**0%**	**0%**	**0%**	**0%**
Total Wasteload Allocation	**7.34**	**2.42**	**0.36**	**0.57**	**0.15**
MnDOT	0.20	0.06	0.01	0.02	0.004
Anoka County	0.20	0.07	0.01	0.02	0.004
Regulated stormwater (categorical)	6.94	2.29	0.34	0.54	0.14
Total Load Allocation	**0.83**	**0.27**	**0.04**	**0.06**	**0.02**
Unallocated Load	**0.00**	**2.20**	**2.84**	**1.29**	**0.41**
Margin of Safety	**0.91**	**0.30**	**0.04**	**0.07**	**0.02**
Pleasure Creek	*Tons/day*				
Existing Loading	**2.81**	**0.48**	**0.83**	**0.18**	**0.21**
Total Daily Loading Capacity	**1.23**	**0.82**	**0.62**	**0.49**	**0.33**
Load Reduction	**1.58**	**0.00**	**0.21**	**0.00**	**0.00**
Estimated Load Reduction (%)	**56%**	**0%**	**25%**	**0%**	**0%**
Total Wasteload Allocation	**1.10**	**0.43**	**0.55**	**0.16**	**0.19**
MnDOT	0.15	0.06	0.08	0.02	0.03
Anoka County	0.02	0.01	0.01	0.003	0.004
Regulated stormwater (categorical)	0.92	0.36	0.47	0.14	0.16
Total Load Allocation	**0.01**	**0.004**	**0.01**	**0.002**	**0.002**
Unallocated Load	**0.00**	**0.34**	**0.00**	**0.31**	**0.12**
Margin of Safety	**0.12**	**0.05**	**0.06**	**0.02**	**0.02**

Table 13. TP TMDL summary table.

	Flow Zone				
	Very High	**High**	**Mid**	**Low**	**Very Low**
Coon Creek	*Pounds/day*				
Existing Loading	**340.45**	**123.04**	**50.12**	**25.06**	**12.41**
Total Daily Loading Capacity	**133.44**	**65.36**	**40.74**	**27.29**	**17.58**
Load Reduction	**207.01**	**57.68**	**9.38**	**0.00**	**0.00**
Estimated Load Reduction (%)	**61%**	**47%**	**19%**	**0%**	**0%**
Total Wasteload Allocation	**63.12**	**30.92**	**19.27**	**11.85**	**5.87**
MnDOT	1.31	0.64	0.40	0.25	0.12
Anoka County	1.75	0.86	0.53	0.33	0.16
Regulated stormwater (categorical)	60.05	29.41	18.33	11.28	5.58
Total Load Allocation	**56.98**	**27.91**	**17.40**	**10.70**	**5.30**
Unallocated Load	**0.00**	**0.00**	**0.00**	**2.23**	**5.17**
Margin of Safety	**13.34**	**6.54**	**4.07**	**2.51**	**1.24**
Sand Creek	*Pounds/day*				
Existing Loading	**90.34**	**29.52**	**16.61**	**9.55**	**2.6**
Total Daily Loading Capacity	**60.53**	**34.64**	**21.86**	**13.30**	**3.96**
Load Reduction	**29.81**	**0.00**	**0.00**	**0.00**	**0.00**
Estimated Load Reduction (%)	**33%**	**0%**	**0%**	**0%**	**0%**
Total Wasteload Allocation	**48.95**	**23.87**	**13.43**	**7.72**	**2.10**
MnDOT	1.31	0.64	0.36	0.21	0.06
Anoka County	1.36	0.66	0.37	0.21	0.06
Regulated stormwater (categorical)	46.29	22.57	12.70	7.30	1.99
Total Load Allocation	**5.52**	**2.69**	**1.52**	**0.87**	**0.24**
Unallocated Load	**0.00**	**5.12**	**5.25**	**3.75**	**1.36**
Margin of Safety	**6.05**	**2.95**	**1.66**	**0.96**	**0.26**
Pleasure Creek	*Pounds/day*				
Existing Loading	**9.05**	**3.19**	**3.61**	**2.41**	**1.54**
Total Daily Loading Capacity	**8.23**	**5.47**	**4.10**	**3.26**	**2.21**
Load Reduction	**0.82**	**0.00**	**0.00**	**0.00**	**0.00**
Estimated Load Reduction (%)	**9%**	**0%**	**0%**	**0%**	**0%**
Total Wasteload Allocation	**7.34**	**2.84**	**3.22**	**2.15**	**1.37**
MnDOT	1.02	0.39	0.45	0.30	0.19
Anoka County	0.14	0.05	0.06	0.04	0.03
Regulated stormwater (categorical)	6.18	2.40	2.71	1.81	1.16
Total Load Allocation	**0.07**	**0.03**	**0.03**	**0.02**	**0.01**
Unallocated Load	**0.00**	**2.28**	**0.49**	**0.85**	**0.67**
Margin of Safety	**0.82**	**0.32**	**0.36**	**0.24**	**0.15**
Springbrook Creek	*Pounds/day*				
Existing Loading	**NA**	**8.88**	**9.65**	**6.47**	**3.02**
Total Daily Loading Capacity	**12.58**	**8.38**	**6.28**	**4.99**	**3.38**
Load Reduction	**NA**	**0.50**	**3.37**	**1.48**	**0.00**
Estimated Load Reduction (%)	**NA**	**6%**	**35%**	**23%**	**0%**
Total Wasteload Allocation	**11.24**	**7.49**	**5.61**	**4.46**	**2.70**
MnDOT	0.74	0.49	0.37	0.29	0.18
Anoka County	0.34	0.23	0.17	0.13	0.08
Regulated stormwater (categorical)	10.17	6.77	5.07	4.03	2.44
Total Load Allocation	**0.08**	**0.05**	**0.04**	**0.03**	**0.02**
Unallocated Load	**NA**	**0.00**	**0.00**	**0.00**	**0.36**
Margin of Safety	**1.26**	**0.84**	**0.63**	**0.50**	**0.30**

Table 14. ***E. coli*** **TMDL summary table.**

	Flow Zone				
	Very High	**High**	**Mid**	**Low**	**Very Low**
Coon Creek	***Billion orgs/day***				
Existing Loading	**1249.1**	**410.0**	**448.5**	**232.9**	**NA**
Total Daily Loading Capacity	**755.8**	**372.1**	**230.4**	**153.6**	**99.3**
Load Reduction	**493.35**	**37.90**	**218.13**	**79.30**	**NA**
Estimated Load Reduction (%)	**39%**	**9%**	**49%**	**34%**	**NA**
Total Wasteload Allocation	**357.5**	**176.0**	**109.0**	**72.7**	**46.9**
MnDOT	7.41	3.65	2.26	1.51	0.97
Anoka County	9.90	4.87	3.02	2.01	1.30
Regulated stormwater (categorical)	340.16	167.48	103.69	69.14	44.67
Total Load Allocation	**322.70**	**158.89**	**98.37**	**65.59**	**42.38**
Unallocated Load	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Margin of Safety	**75.58**	**37.21**	**23.04**	**15.36**	**9.93**
Sand Creek	***Billion orgs/day***				
Existing Loading	**168.65**	**846.04**	**NA**	**196.91**	**192.66**
Total Daily Loading Capacity	**345.11**	**197.64**	**124.89**	**75.90**	**22.11**
Load Reduction	**0.00**	**648.40**	**NA**	**121.01**	**170.55**
Estimated Load Reduction (%)	**0%**	**77%**	**NA**	**61%**	**89%**
Total Wasteload Allocation	**136.39**	**159.84**	**101.00**	**61.38**	**17.88**
MnDOT	3.65	4.28	2.70	1.64	0.48
Anoka County	3.78	4.43	2.80	1.70	0.50
Regulated stormwater (categorical)	128.96	151.13	95.50	58.04	16.91
Total Load Allocation	**15.39**	**18.04**	**11.40**	**6.93**	**2.02**
Unallocated Load	**176.46**	**0.00**	**NA**	**0.00**	**0.00**
Margin of Safety	**16.87**	**19.76**	**12.49**	**7.59**	**2.21**
Pleasure Creek	***Billion orgs/day***				
Existing Loading	**90.36**	**65.86**	**50.74**	**38.84**	**26.57**
Total Daily Loading Capacity	**47.00**	**31.28**	**23.46**	**18.64**	**12.62**
Load Reduction	**43.36**	**34.58**	**27.28**	**20.20**	**13.95**
Estimated Load Reduction (%)	**48%**	**53%**	**54%**	**52%**	**53%**
Total Wasteload Allocation	**41.90**	**27.88**	**20.91**	**16.62**	**11.25**
MnDOT	5.80	3.86	2.90	2.30	1.56
Anoka County	0.80	0.53	0.40	0.32	0.21
Regulated stormwater (categorical)	35.29	23.49	17.62	14.00	9.48
Total Load Allocation	**0.40**	**0.27**	**0.20**	**0.16**	**0.11**
Unallocated Load	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Margin of Safety	**4.70**	**3.13**	**2.35**	**1.86**	**1.26**
Springbrook Creek	***Billion orgs/day***				
Existing Loading	**172.1**	**106.8**	**102.29**	**33.4**	**26.1**
Total Daily Loading Capacity	**71.92**	**47.86**	**35.89**	**28.51**	**19.40**
Load Reduction	**100.18**	**58.94**	**66.40**	**4.89**	**6.70**
Estimated Load Reduction (%)	**58%**	**55%**	**65%**	**15%**	**26%**
Total Wasteload Allocation	**64.28**	**42.78**	**32.08**	**25.48**	**17.34**
MnDOT	4.22	2.81	2.11	1.67	1.14
Anoka County	1.94	1.29	0.97	0.77	0.52
Regulated stormwater (categorical)	58.12	38.67	29.00	23.04	15.68
Total Load Allocation	**0.44**	**0.30**	**0.22**	**0.18**	**0.12**
Unallocated Load	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Margin of Safety	**7.19**	**4.79**	**3.59**	**2.85**	**1.94**

5.5 Future Growth Consideration/Reserve Capacity

The watersheds of impaired reaches covered in this TMDL study fall entirely within permitted MS4 communities, with the exception of the city of Columbus in the Coon Creek impaired watershed. Future development is subject to the WLA transfer process provided below as well as CCWD Rules for development and redevelopment. As a result, all development will have to meet TMDL requirements that will account for pollutant reductions listed in this study.

In addition, subwatersheds in this study area are nearly fully built out with the exception of Coon Creek. To account for some of the expected future growth in this subwatershed, 2020 land use projections were used to set WLAs and LAs. No RC is set aside in this TMDL.

5.5.1. New or Expanding Permitted MS4 WLA Transfer Process

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

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

Load transfers will be based on methods consistent with those used in setting the allocations previously discussed in this report (Section 5.1.2 and Section 5.1.3). In cases where WLA is transferred from or to a regulated MS4, the permittees will be notified of the transfer and have an opportunity to comment.

5.5.2. New or Expanding Wastewater

The MPCA, in coordination with the EPA Region 5, has developed a streamlined process for setting or revising WLAs for new or expanding wastewater discharges to 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.

6. Reasonable Assurance

When establishing a TMDL, reasonable assurances must be provided that demonstrate a level of confidence that prescribed TMDL allocations will be implemented by federal, state, and local authorities. Implementation of the TMDLs in this study will be accomplished by state and local action on both non-regulatory and regulatory fronts. The ACD, CCWD, and member cities are already working towards improving water quality. Further water quality restoration efforts will be undertaken by the CCWD, ACD, Anoka County, and municipal stakeholders as a result of this study. The following sections outline programs in place which provide reasonable assurance that TMDL objectives will be met.

6.1 Municipal Separate Storm Sewer System (MS4) Permits

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

- Public education and outreach
- Public participation
- Illicit Discharge Detection and Elimination (IDDE) Program
- Construction site runoff controls
- Post-construction runoff controls
- Pollution prevention and municipal good housekeeping measures

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

This TMDL assigns TSS, TP, and *E. coli* WLAs to all regulated MS4s in the study and as previously discussed in Section 5. The Small MS4 General Permit requires permittees to develop compliance schedules for EPA approved TMDL WLAs not already being met at the time of permit application. A compliance schedule includes BMPs that will be implemented over the permit term, a timeline for their implementation, and a long term strategy for continuing progress towards assigned WLAs. For WLAs being met at the time of permit application, the same level of treatment must be maintained in the future. Regardless of WLA attainment, all permitted MS4s are still required to reduce pollutant loadings to the MEP.

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

6.2 Regulated Construction Stormwater

Regulated stormwater was given a categorical TMDL is this study and includes construction discharges. However, construction activities disturbing one acre or more in size are still required to obtain NPDES Permit coverage through the MPCA. Compliance with TMDL requirements are assumed when a construction site owner/operator meets the conditions of the Construction General Permit and properly selects, installs, and maintains all BMPs required under the permit, including any applicable additional BMPs required in Appendix A of the Construction General Permit for discharges to impaired waters, or compliance with local construction stormwater requirements if they are more restrictive than those in the State General Permit.

6.3 Regulated Industrial Stormwater

As with regulated construction stormwater, ISW was lumped into a categorical stormwater WLA in this study. Industrial activities still require permit coverage under the State's NPDES/SDS ISW 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 Permit and properly selects, installs and maintains all BMPs required under the permit, their discharges are considered compliant with WLAs set in this study.

6.4 CCWD Comprehensive Management Plan

The CCWD was formed in 1959 as a public body organized pursuant to the Minnesota Watershed Law (Minn. Stat. 103D). The District's mission statement is "To manage groundwater and the surface water drainage system to prevent property damage, maintain hydrologic balance, and protect water quality for the safety and enjoyment of citizens, and the preservation and enhancement of wildlife habitat."

In 2013, the District completed a second generation Comprehensive Management Plan identifying the organization's mission goals and providing a framework for its operational objectives through 2023. The protection of water quality was identified as a major goal in this plan and included the following objectives:

- To identify and plan for means to effectively protect and improve surface and groundwater quality.
- To prevent soil erosion into surface water systems.

- To protect and, where needed, improve the physical, chemical, biological, and aesthetic quality of the water resource consistent with the purposes of the CCWD along with state and national water quality goals.

In an effort to meet these objectives, the CCWD has committed to the following five strategies and related actions to protect water quality:

1. Monitoring

The CCWD's monitoring program includes all water provided for public domestic purposes and primary contact water sports (lakes and rivers), to ensure public health and safety. Annually, the CCWD evaluates its water quality monitoring approach and situates monitoring locations where most appropriate. At a minimum, the outfalls of all four impaired reaches are monitored on a yearly basis for continual evaluation of water quality. The Anoka SWCD is actively engaged in the annual evaluation of the District's monitoring approach. Monitoring design is consistent with applicable state or federal regulations and the MPCA's online database (EQUIS) serves as the primary repository for all stream and lake water quality data. This program is expected to continue into the foreseeable future.

2. Operations and Maintenance

The Operations and Maintenance program works to:

- Solve local streambank erosion problems in a manner that minimizes the effect on stream behaviors and impacts on affected property owners.
- Construct, modify, or retrofit stormwater treatment devices to increase water quality treatment.
- Investigate, evaluate, and resolve or mediate water resource issues.

All of these activities are directly related to this TMDL study and are expected to continue.

3. Planning

Planning efforts undertaken by the CCWD establish objectives for managing the quality of the water resources through land and resource management plans. Future planning efforts will include the outcomes of this TMDL study.

4. Public and Governmental Relations

This program accounts for the water quality needs of local, regional, and national public interests both inside and outside the CCWD boundary to determine appropriate water quality management activities. A key aspect of this program is the publication of communication and educational material related to CCWD programs and water resource related issues.

5. Regulation

The District's regulatory program oversees numerous components important to the attainment of WLAs resulting from this study. The CCWD's regulatory program exercises control over proposed developments or activities to ensure the proper conveyance and disposal of stormwater. Oversight of development activities provides assurance that permit requirements and the goals, objectives, and rules of the CCWD will be met.

6.5 CCWD Watershed Restoration and Protection Strategy (WRAPS)

The CCWD has partnered with the MPCA to develop the CCWD WRAPS. A WRAPS report is a document summarizing scientific studies of a watershed including the physical, chemical, and biological assessment of the water quality of the watershed; identification of impairments and water bodies in need of protection; identification of biotic stressors and both point and NPSs of pollution; TMDLs for the impairments; and an implementation table containing strategies and actions to achieve and maintain water quality standards and goals. Upon completion of the WRAPS process, implementation strategies will be amended into the CCWD Comprehensive Management Plan.

6.6 Funding

Historically, a variety of funding sources have been used for water resource projects within the TMDL study area and these sources are expected to continue into the foreseeable future.

The CCWD is funded through a tax levy imposed on residents within the CCWD. This annual tax base is one of the main funding mechanisms available for implementation activities within the impaired subwatersheds of this study. Funds generated through local property taxes are used to fund projects outright, sponsor cost-share projects with municipal partners, as well as secure grant opportunities requiring a cash match.

A second funding source available to the CCWD was made possible by Minnesota voters approving the Clean Water, Land, and Legacy (CWLA) amendment in 2008. This amendment increased the state sales and use tax rate by 3/8 of 1% on all taxable sales, starting July 1, 2009, and continuing through 2034. Of the funds generated, approximately one third have been dedicated to a Clean Water Fund to, *"protect, enhance, and restore water quality is lakes, rivers, streams, and groundwater, with at least 5% of the fund targeted to protect drinking water sources."* (MPCA, 2014).

A third funding avenue available applicable to this TMDL study is the Clean Water Partnership (CWP) Program established by the Minnesota Legislature in 1987. The CWP program focuses on the control of non-point pollution sources and provides financial assistance through loans, as well as technical assistance to LGUs. In 2010, the CCWD in partnership with the ACD was successful in obtaining CWP funds for the installation of a regional stormwater treatment pond along with nine rain gardens in the Sand Creek Subwatershed.

The Federal Section 319 NPS Management Program was established through amendment to the Clean Water Act in 1987 and is recognizes as a fourth source of potential funding. Section 319 NPS funds support a wide variety of activities including technical and financial assistance, education, training, technology transfers, demonstration projects, and monitoring, to assess the success of specific NPS implementation projects (MPCA, 2014). Section 319 projects are typically implementation oriented and must offer a means of moving towards a resolution of a NPS pollution problem identified as part of a project. This can involve the implementation of a TMDL study to address impaired waters.

Regulatory efforts, non-regulatory planning efforts, and multiple funding sources detailed above collectively provide reasonable assurance that WLAs prescribed as part of this study will be implemented.

7. Monitoring Plan

An important component of any TMDL is regular assessment of progress toward achieving water quality objectives. The CCWD will take the lead on tracking progress through its annual water quality monitoring efforts and BMP tracking.

The CCWD, in partnership with the ACD, has monitored water quality of lakes and streams, precipitation patterns, groundwater levels, and other hydrologic parameters for nearly 20 years. Annual water quality monitoring is expected to continue in the future and likely expand as a result of this TMDL study. As an example, sampling of *E. coli* concentrations has been integrated into the annual monitoring protocol for impaired streams. Continued *E. coli* sampling will now be an important component for measuring progress toward achieving total daily loading capacities. The CCWD and ACD meet annually to discuss the success and necessary improvements to existing water quality efforts and work together to develop a plan for future monitoring. This includes updating equipment, modifying the number of sampling locations, or relocating sampling gear based on review of the cumulative dataset. A total of 16 stream monitoring locations were prescribed for 2015 with 14 of them occurring on the impaired reaches included in this study. Eight samples were to be taken from each site (four baseflow, four stormflow) in addition to deployment of continuous water quality samplers at select sites. Water quality parameters collected at these sites include pH, conductivity, turbidity, temperature, salinity, DO, TP, TSS, chlorides, hardness, and sulfate.

Since biotic impairments are included in this study, it is recognized that biological sampling is an important piece of progress assessment. Historically, the MPCA has conducted biological sampling in the CCWD. Biological sampling was conducted in 2000, 2005, and again in 2010. More frequent biological sampling would be preferred but the MPCA is only required to assess 10% of the state annually resulting in 100% coverage over a 10 year period. No change to this requirement is anticipated therefore biological sampling can be expected to occur roughly every 10 years.

The CCWD will work with its municipal partners to track the total number of BMPs completed to achieve WLAs set in this study. The CCWD has a long history of collaboration with MS4 stakeholders which will help facilitate this process. When possible, on-site monitoring of implementation practices should take place to determine the BMP effectiveness. A variety of criteria such as land use, soil type, site access, monitoring feasibility, and site specific characteristics will be used to determine which BMPs to monitor. Under certain criteria, monitoring results from a specific BMP may be able to be extrapolated to BMPs with similar conditions.

8. Implementation Strategy Summary

The following implementation strategy is an overview of the more detailed implementation strategy included in the CCWD WRAPS project. Assessment of the BMPs presented in this TMDL study will be done through an “adaptive management” approach (Figure 24). Continued monitoring and “course corrections” in response to monitoring results are the most appropriate strategy for attaining the water quality goals established in this TMDL. As water quality dynamics within the watershed are better understood, management activities will be changed or refined to most efficiently meet water quality objectives.

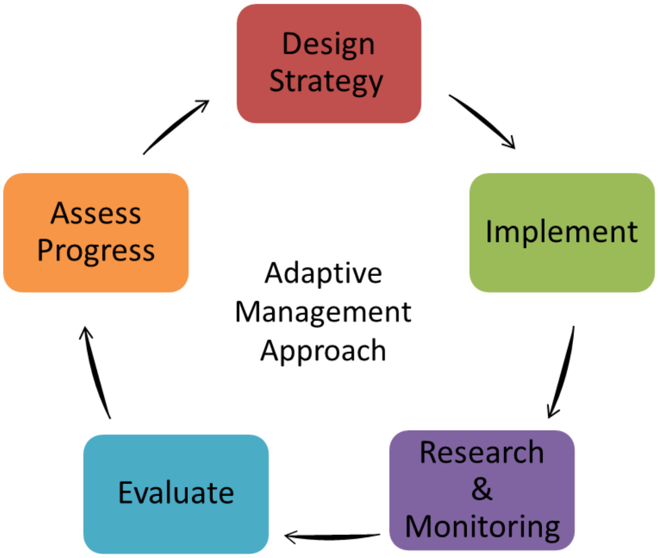

Figure 24. Adaptive Management framework.

8.1 Total Suspended Sediment and Total Phosphorus

As discussed in Section 4.1, the dominant TSS and TP loading source for impaired reaches of this study is permitted stormwater runoff. Non-permitted stormwater, streambank erosion, and substandard SSTS are also contributing sources but to a lesser degree. The exception to this is the Coon Creek Subwatershed where streambank erosion appears to be the most significant source of TSS. TSS and TP are nonpoint in nature; therefore, implementation strategies best suited to reduce loadings are those targeted to reduce nonpoint runoff during precipitation events. Both TSS and TP load duration curves generated in this study support this strategy evidenced by pollutant exceedances occurring primarily during “very high” or “high” flow regimes.

8.1.1 Permitted Sources

Municipal Stormwater

The MS4 General Permit requires permittees to address all WLAs in TMDLs approved prior to the effective date of the Permit. In doing so, they must determine if they are currently meeting their WLA(s). If the WLA is not being achieved at the time of application, a compliance schedule is required that includes interim milestones, expressed as BMPs, that will be implemented over the current five-year permit term to reduce loading of the pollutant of concern in the TMDL. Additionally, a long-term implementation strategy and target date for fully meeting the WLA must be included.

Construction Stormwater

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

Industrial Stormwater

The WLA for stormwater discharges from sites where there is industrial activity reflects the number of sites in the watershed for which NPDES ISW permit coverage is required, and the BMPs and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. The BMPs and other stormwater control measures that should be implemented at the industrial sites are defined in the State's NPDES/SDS ISW MultiSector 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 permit and properly selects, installs and maintains all BMPs required under the permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL. It should be noted that all local stormwater management requirements must also be met.

8.1.2 Non-permitted Sources

Table 15 provides a variety of potential implementation strategies aimed to reduce TSS and TP along with the flow regime where the greatest impact can be expected. Each of these implementation strategies will be examined for its application to impaired reaches in this study as part of the CCWD WRAPS implementation plan to select those BMPs which are most appropriate.

Table 15. Potential TSS and TP reduction implementation strategies.

<table>
<tr><th rowspan="2"></th><th colspan="5">Flow Regime</th></tr>
<tr><th>Very High</th><th>High</th><th>Mid</th><th>Low</th><th>Very Low</th></tr>
<tr><td rowspan="8">Implementation Strategy</td><td>Streambank Stabilization</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="3">Riparian Buffer Installation/Enhancement</td><td></td><td></td></tr>
<tr><td></td><td colspan="2">Urban Stormwater Retrofits</td><td></td><td></td></tr>
<tr><td></td><td colspan="2">Street Sweeping</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2">SSTS Inspection</td></tr>
<tr><td colspan="5">Stormwater Asset Inventory & Maintenance</td></tr>
<tr><td colspan="5">Education and Outreach Program</td></tr>
<tr><td colspan="5">Watershed Condition Assessment</td></tr>
</table>

A general explanation of each potential implementation strategy is provided below as required in the TMDL process.

Streambank Stabilization – Continuation of the CCWD's streambank stabilization program. Give priority to sections of streambank contributing the most sediment and phosphorus loading. When feasible, use "naturalized" stabilization techniques when engineering streambank stabilization practices, (e.g., native vegetation, vegetated rip-rap).

Riparian Buffer Installation/Enhancement – Install and/or maintain adequate buffer strips adjacent to impaired waters to filter pollutants from watershed runoff. Target high priority areas (i.e., livestock pastures, agricultural fields, large areas of connected impervious surface) immediately adjacent to impaired waters. This strategy is largely dependent on voluntary landowner participation.

Urban Stormwater Retrofits – Continue the implementation of cost effective stormwater improvement projects identified through urban stormwater retrofit studies.

Street Sweeping – Identify target areas for increased frequency and/or timing of street sweeping activity. Consider upgrades to traditional sweet sweeping equipment when appropriate.

Stormwater Asset Inventory & Maintenance – Conduct an inventory of the "critical" stormwater BMPs within the CCWD. An asset inventory includes a field assessment of BMP condition to determine if corrective maintenance is needed. Corrective maintenance could include practices such as stormwater pond dredging, stormwater pond outlet repair, soil amendments in aging rain gardens, etc.

Education and Outreach Program – Provide education to citizens on pertinent topics (i.e., pollutant sources, effects of specified pollutant, landowner BMPs) through a variety of methods to inform and engage citizens. Potential education avenues include (but are not limited to): press releases, trainings, e-newsletters, public workshops, website updates, etc.

SSTS Inspections – While failing septic systems do not appear to be a significant source of TP, the state, Anoka County, and municipalities should continue to inspect individual SSTS and order follow-up action to achieve, and maintain, a 100% load reduction as required by the MPCA.

Watershed Condition Assessment – Conduct a watershed wide condition assessment on a minor subwatershed scale to rank minor subwatersheds from "best condition" to "worst condition." Each minor subwatershed will be scored on its physical and biological condition for both aquatic and terrestrial components.

Table 16 provides the metrics to be used in the scoring process. Minor subwatershed ranking will be useful for guiding implementation activities by identifying areas in need of restoration as well as those better suited for protection.

Table 16. Watershed Condition Assessment metrics.

Aquatic Physical	Aquatic Biological	Terrestrial Physical	Terrestrial Biological
Channel Shape	*Fish IBI Scores*	*Water Quality Risk*	*Invasive Species*
Substrate	*Invertebrate IBI Scores*	*Erosion Risk*	*Habitat Quality*
Vegetation	*Aquatic Invasive Species*	*Impervious Surface*	*Ecological Corridors*
Channel Sinuosity	*Wetland Area*	*Road Density*	
Impaired Waters		*Proximity to Water*	
Total Suspended Sediment			
Total Phosphorus			
E. coli			
Infiltration Capacity			
Ditch Density			

Many of the implementation strategies identified in Table 15 have already been partially implemented in the CCWD; however, the continuation of these programs is imperative for achievement of water quality standards. For example, the CCWD has an active streambank stabilization program that has resulted in the stabilization of approximately 2.18 miles of streambank over the life of the program. Urban stormwater retrofit studies have been conducted for at least some portion of all impaired reaches. The urban stormwater retrofit study for the Sand Creek Subwatershed has resulted in the construction of three stormwater treatment ponds, 16 rain gardens, and one hydrodynamic separator to date with an additional 14 rain gardens scheduled in 2015.

8.2 *E. coli*

As living organisms, bacteria present a unique situation for TMDL studies. As previously discussed, many challenges arise when estimating sources and corresponding bacteria load; likewise, there are challenges faced with respect to implementation as well. As a result of these challenges, bacteria reduction implementation planning should by highly adaptive as new research and innovations emerge.

8.2.1 Permitted Sources

Municipal Stormwater

The MS4 General Permit requires permittees to address all WLAs in TMDLs approved prior to the effective date of the permit. In doing so, they must determine if they are currently meeting their WLA(s). If the WLA is not being achieved at the time of application, a compliance schedule is required that includes interim milestones, expressed as BMPs, that will be implemented over the current five-year permit term to reduce loading of the pollutant of concern in the TMDL. Additionally, a long-term implementation strategy and target date for fully meeting the WLA must be included.

8.2.2 Non-permitted Sources

Few structural BMPs exist specific to removal of bacteria from the watershed landscape. As such, most bacteria implementation activities are programmatic in nature and focus on controlling bacteria at the source and/or volume control practices. The following list of potential BMPs are largely applicable to nonpoint sources however in most cases, implementation of the following strategies would also reduce bacteria loads of point sources (municipal stormwater).

Pet Waste Management – Review local ordinances and associated enforcement programs for residents not properly disposing of pet waste. Consider increasing penalties for residents improperly disposing of pet waste.

IDDE Programs – IDDE programs required by the MPCA's NPDES program typically focus on the conventional "pipe" discharges. Current IDDE programs implemented by MS4s in this TMDL should be enhanced to include other potential NPSs of bacteria loading (i.e., hobby farm runoff, improper manure management, etc.).

Promote infiltration – When feasible, promote and install stormwater BMPs utilizing infiltration and bioretention to decrease the amount watershed runoff entering surface waters. Scale of these BMPs may range from a one property owner rain garden to larger projects such as a regional infiltration basin. BMPs increasing infiltration will also reduce the amount of TSS and TP transported to surface waters as well.

Education and Outreach – Educate property owners on the importance of proper pet waste management to increase awareness. Target educational efforts in highly urbanized areas where bacteria loadings from pet waste are a significant contributor. Provide property owners with information on the proper disposal options and penalties for not complying with local ordinances.

Emerging Technologies – Continue to follow research and identify implementation opportunities as new technologies emerge. Current areas of need that would be beneficial to implementation planning include:

- Better understanding of bacteria load reduction capabilities for structural and non-structural BMPs;
- Models to evaluate bacteria loading and track reductions;
- Methods to evaluate bacteria re-growth capability and the potential for stormwater infrastructure (pipes, sumps, etc.) to serve as a source;
- Refined DNA "fingerprinting" to identify specific sources in urban environments.

8.3 Cost

The Clean Water Legacy Act requires that a TMDL include an overall approximation ("…a range of estimates") of the cost to implement a TMDL. The initial estimate for implementing the CCWD WRAPS is approximated at $6,000,000 to $8,000,000 with a cost of $3,000,000 to $5,000,000 to permitted sources.

The CCWD WRAPS Report provides further details on implementation strategies adopted as part of this TMDL study.

9. Public Participation

A stakeholder participation process was undertaken to obtain input from, review results with, and take comments from the public and interested and affected agencies regarding the development of WLAs and conclusions set forth in this TMDL study. Stakeholder participation is an important component for achieving the water quality objectives of this study. Several stakeholder meetings were held and public outreach efforts made as outlined in the following sections.

9.1 Technical Advisory Committee

A Technical Advisory Committee (TAC) consisting of project stakeholders was developed to allow active collaboration throughout development of this TMDL. TAC members were asked to provide input on the overall project approach, review and comment on draft documents, and develop consensus on key project related decisions. The following is a list of project partners invited at various stages over the course of this project:

- Anoka County Highway Department
- Anoka Soil and Water Conservation District
- Board of Water and Soil Resources
- City of Andover
- City of Blaine
- City of Coon Rapids
- City of Ham Lake
- City of Fridley
- City of Spring Lake Park
- Metropolitan Council Environmental Services
- DNR
- MPCA

A total of 14 TAC meetings have been held with discussion pertinent to this study and more are expected through the completion of CCWD WRAPS. The TAC meetings were held on the following dates:

- January 16, 2013
- February 14, 2013
- March 21, 2013
- April 10, 2013
- June 5, 2013
- August 14, 2013
- September 11, 2013
- January 22, 2014
- February 19, 2014
- March 26, 2014
- May 14, 2014
- May 28, 2014
- August 13, 2014
- November 13, 2014

9.2 Citizen Advisory Committee

A Citizen Advisory Committee (CAC) had been established from a group of interested citizens prior to this project. The purpose of the CAC is to provide a public perspective on direction and activities of the CCWD. The existing CAC was used to provide input on the project approach and review draft documents. A list of CAC meeting dates is provided below. Not all these meetings were entirely specific to this TMDL study; however, regular updates were provided.

- January 9, 2013
- February 13, 2013
- March 13, 2013
- April 10, 2013
- May 8, 2013
- June 12, 2013
- July 10, 2013
- August 14, 2013
- September 11, 2013
- October 9, 2013
- November 13, 2013
- December 11, 2013
- January 8, 2014
- February 12, 2014
- March 12, 2014
- April 9, 2014
- May 14, 2014
- June 11, 2014
- July 9, 2014
- August 13, 2014
- October 8, 2014
- November 12, 2014

9.3 Public Outreach

The CCWD maintains an interactive website where citizens can access a variety of information related to District projects and activities: http://www.cooncreekwd.org/. From this website, citizens can access a project description, project timeline, and all documents created as part of this TMDL. Contact information is provided for any questions that may arise.

In addition to the CCWD's website, project updates were also provided via city newsletters. The CCWD provided member cities with articles specific to the CCWD WRAPS for incorporation into quarterly newsletters.

Lastly, the CCWD holds Board of Managers meetings the second and fourth Mondays of every month, all of which are open to the public. Meeting agendas are posted to the CCWD website prior to each meeting. These meetings provide citizens with the opportunity to comment on all aspects of the CCWD WRAPS project and corresponding TMDLs.

9.4. Public Notice for Comments

An official public comment period for the TMDL Report and the WRAPS Report began on December 28, 2015, and ended on January 28, 2016. One comment letter was received during the public comment period.

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Appendices

Appendix A – Biological Monitoring Stations

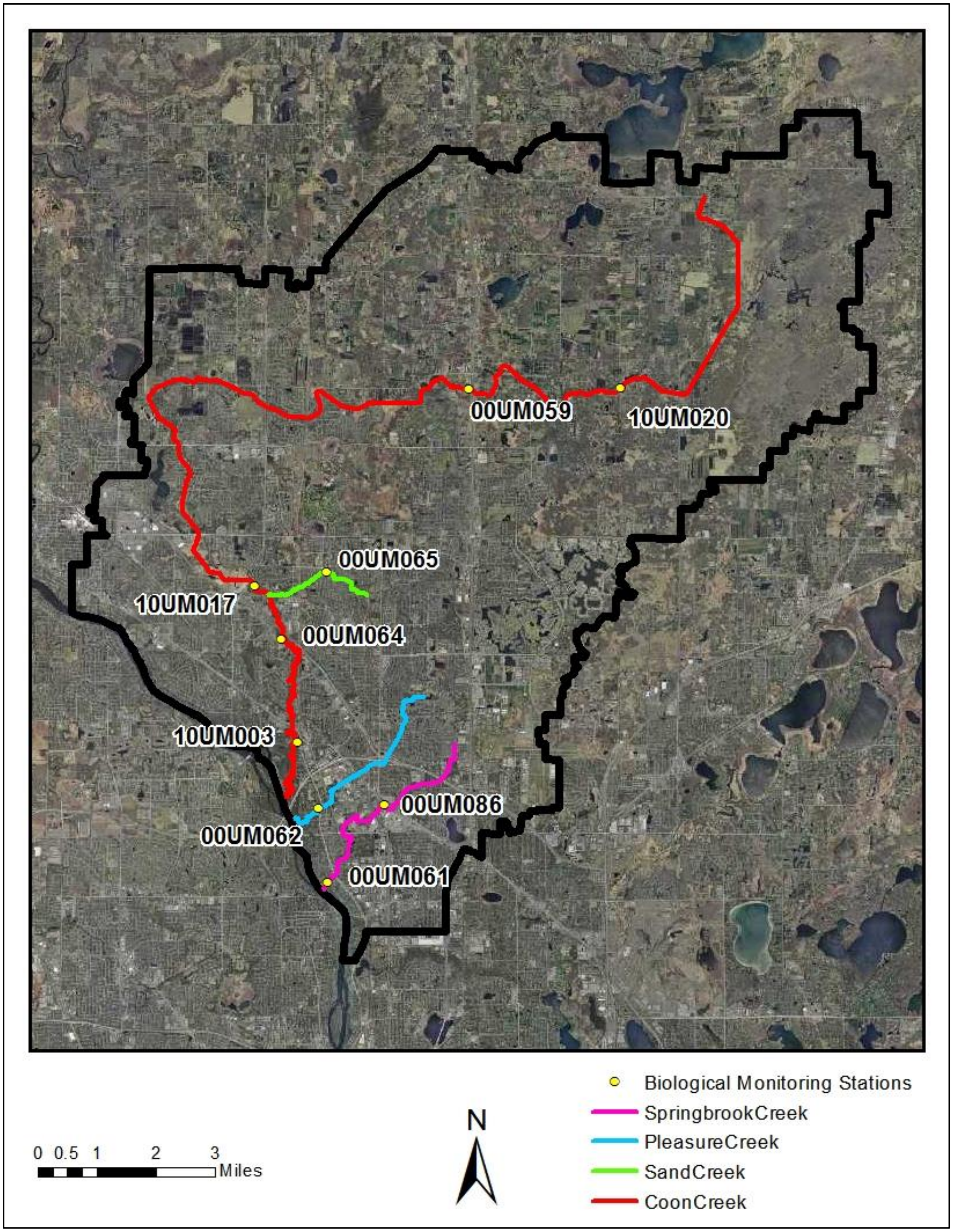

Figure 25. Biological monitoring locations for impaired stream reaches in the CCWD.

Appendix B – *E. coli* Monitoring Stations

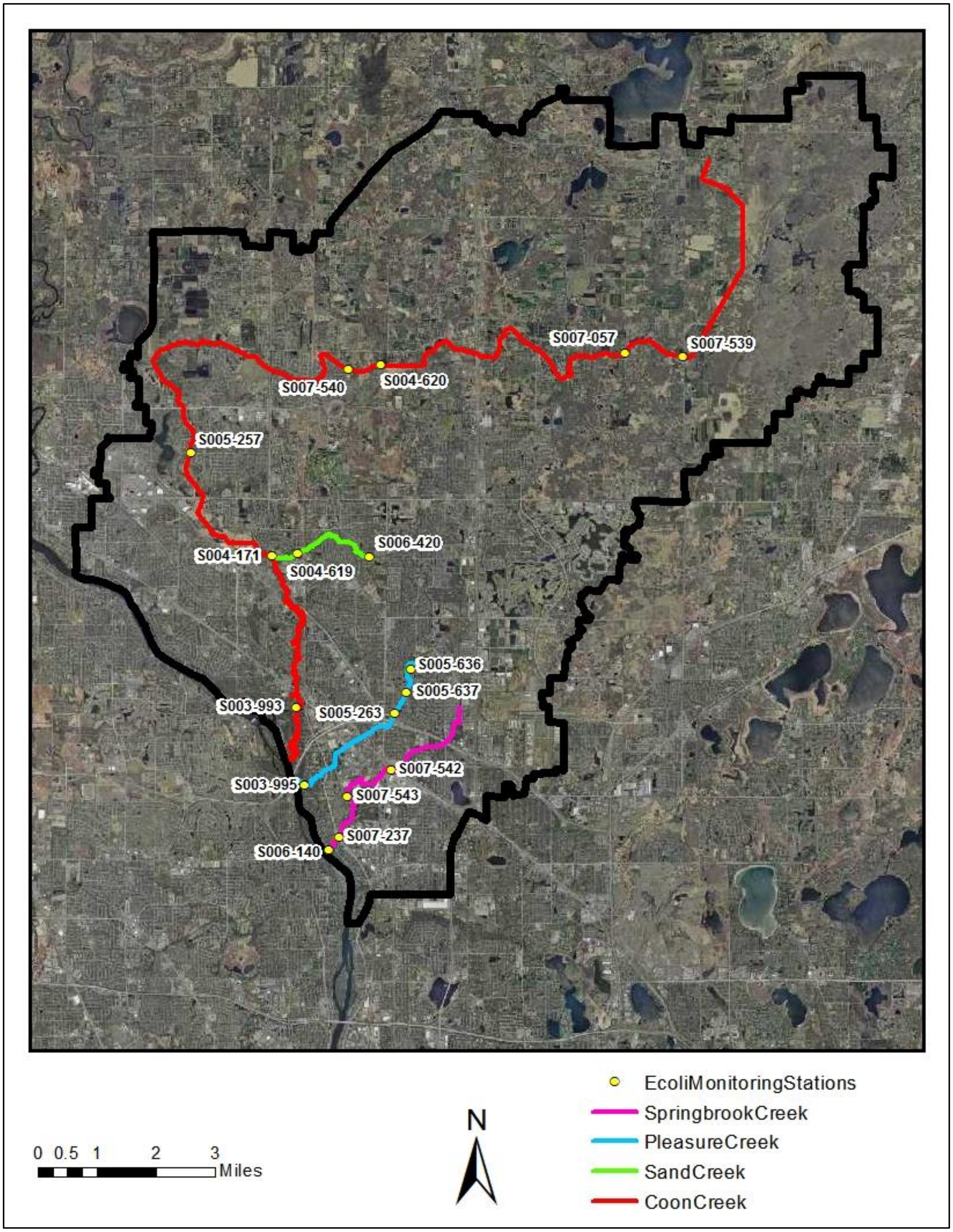

Figure 26. *E. coli* monitoring locations for impaired stream reaches in the CCWD.

Appendix C – Streamflow Monitoring Stations

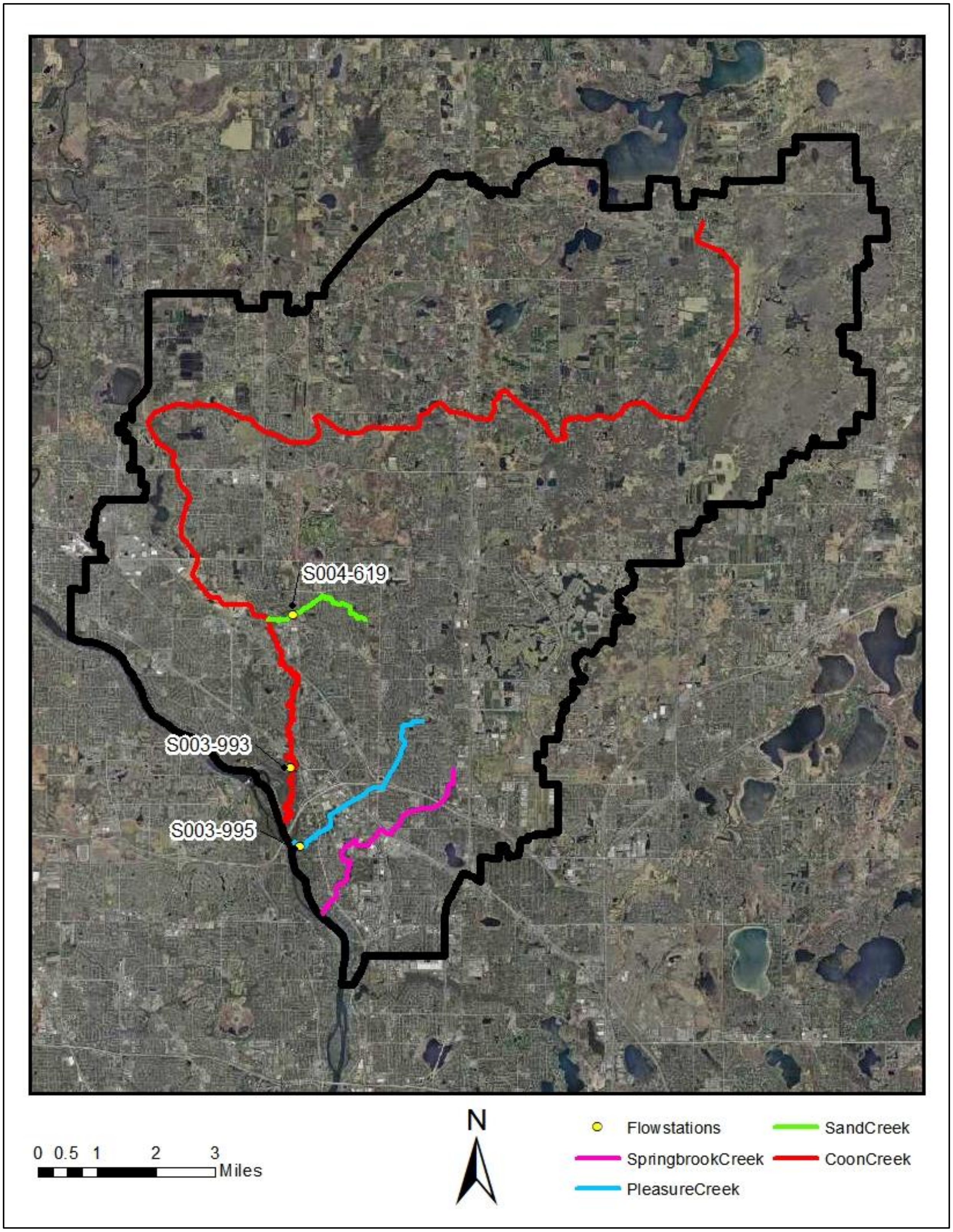

Figure 27. Streamflow locations for impaired stream reaches in the CCWD.

Appendix D – Streamflow Estimates (Regressions and XP-SWMM)

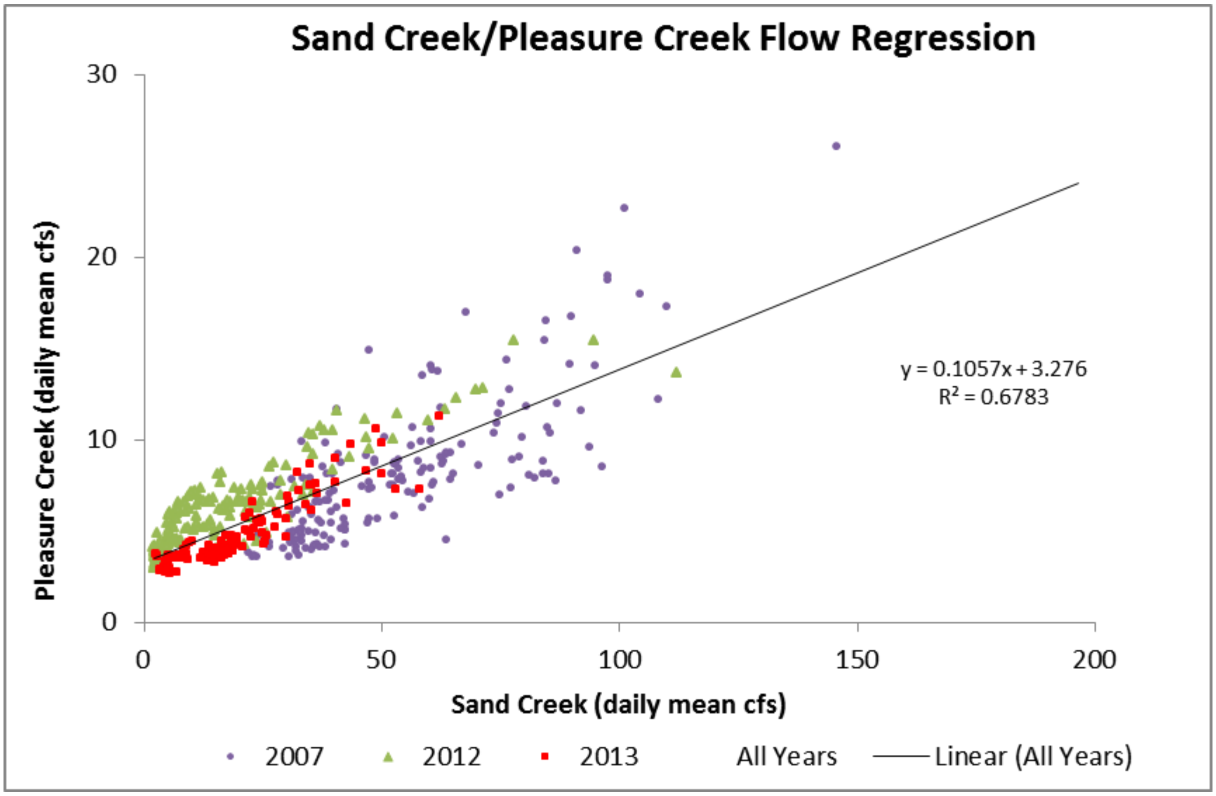

Figure 28. Sand Creek vs. Pleasure Creek flow regression.

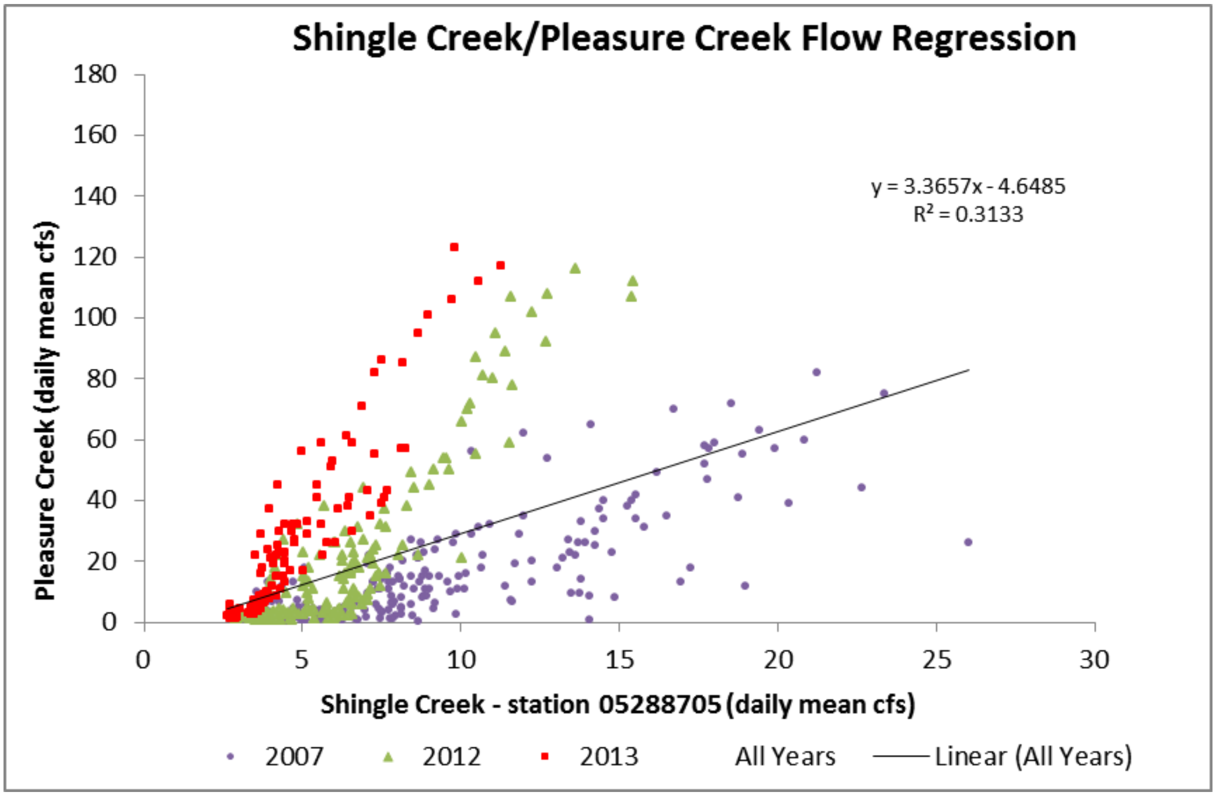

Figure 29. Shingle Creek vs. Pleasure Creek flow regression.

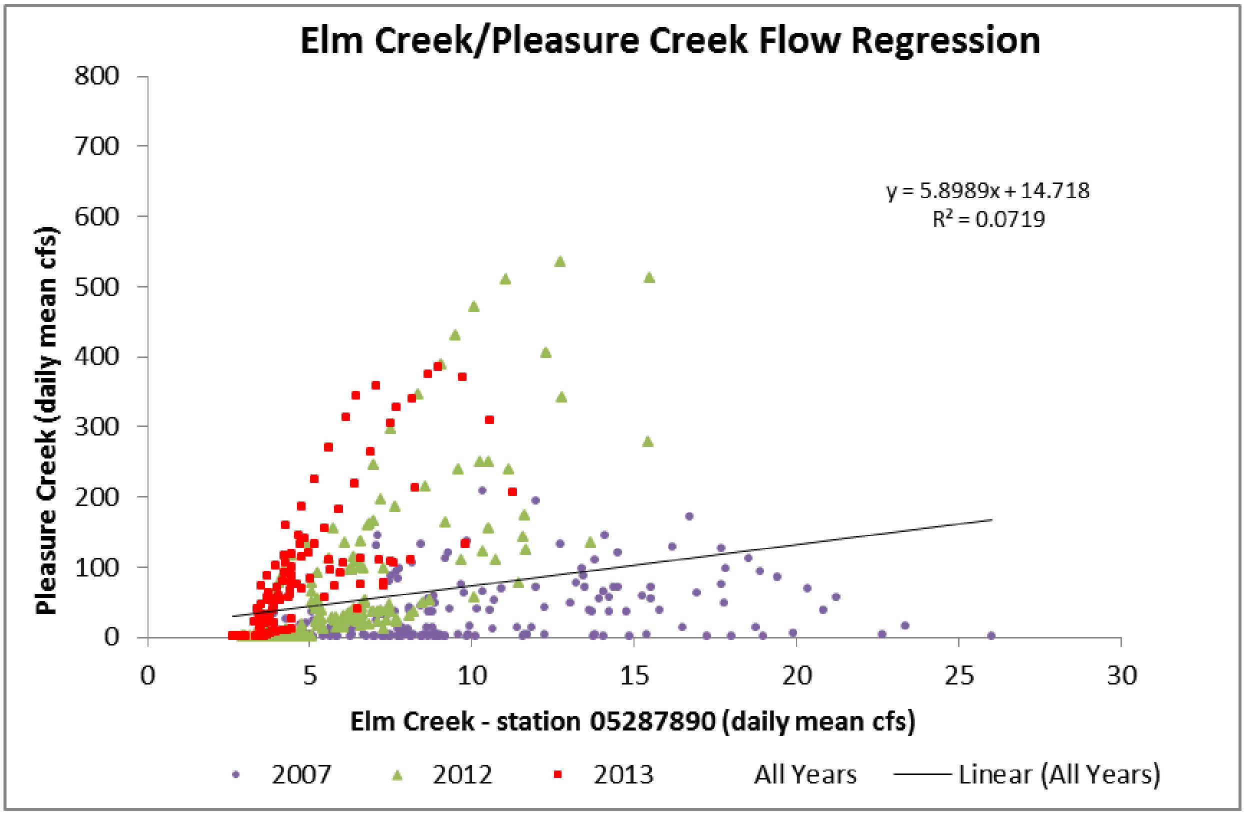

Figure 30. Elm Creek vs. Pleasure Creek flow regression

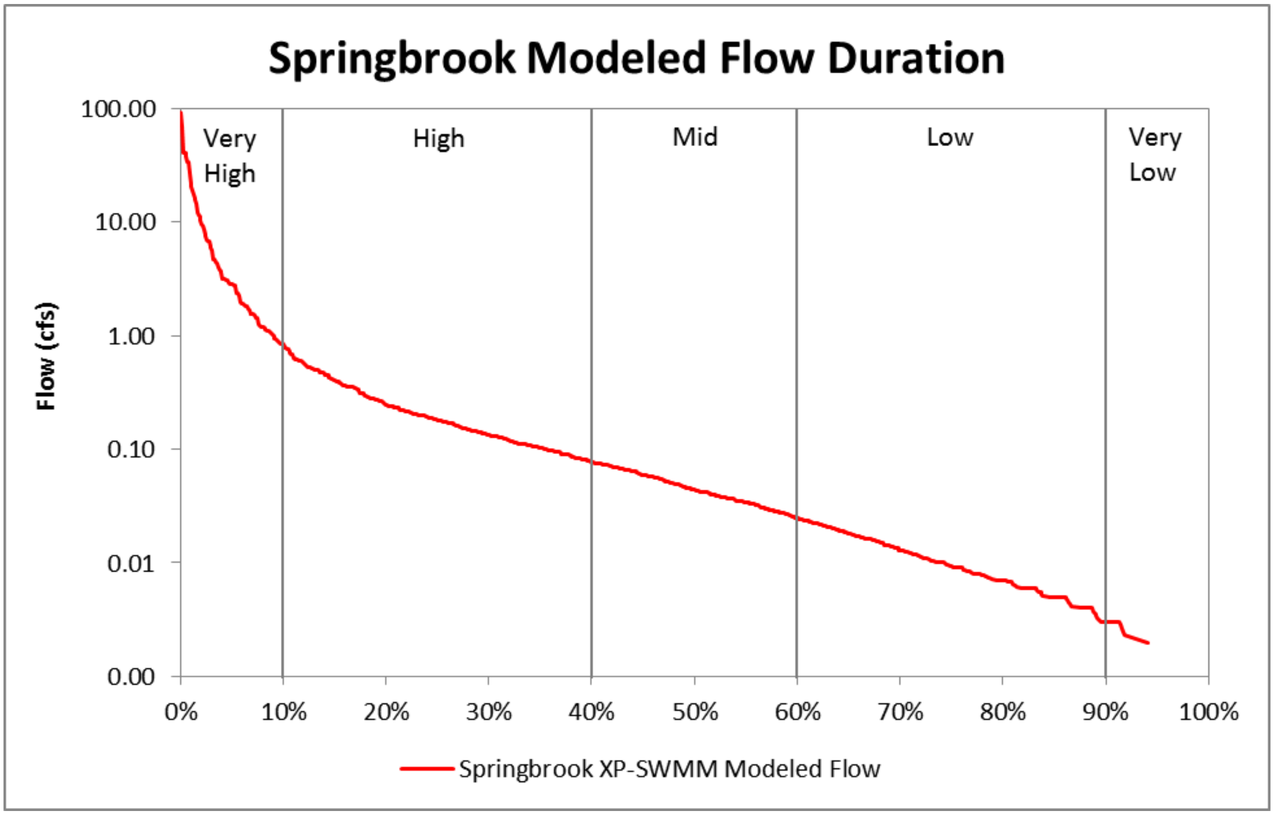

Figure 31. XPSWMM modeled flows for Springbrook Creek.

Appendix E – Streambank Erosion Assessment

Reach	*Eroding Bank Length (Feet)*	*Eroding Bank Height (Feet)*	*Area of Eroding Streambank (FT^2)*	*Lateral Recession Rate (Estimated) (FT / Year)*	*Estimated Volume (FT^3) Eroded Annually*	*Soil Texture*	*Estimated Soil Loss (Tons/Year)*
Coon Creek	50	6	300	0.50	150.0	Sandy Clay Loam	6.8
Coon Creek	50	6	300	0.50	150.0	Sandy Clay Loam	6.8
Coon Creek	50	6	300	0.20	60.0	Sandy Clay Loam	2.7
Coon Creek	50	6	300	0.20	60.0	Sandy Clay Loam	2.7
Coon Creek	50	6	300	0.20	60.0	Sandy Clay Loam	2.7
Coon Creek	50	6	300	0.05	15.0	Sandy Clay Loam	0.7
Coon Creek	50	6	300	0.50	150.0	Sandy Clay Loam	6.8
Coon Creek	50	6	300	0.20	60.0	Sandy Clay Loam	2.7
Coon Creek	50	6	300	0.40	120.0	Sandy Clay Loam	5.4
Coon Creek	50	6	300	0.20	60.0	Sandy Clay Loam	2.7
Coon Creek	50	6	300	0.20	60.0	Sandy Clay Loam	2.7
Coon Creek	20	5	100	0.20	20.0	Sandy Clay Loam	0.9
Coon Creek	50	7	350	0.20	70.0	Sandy Clay Loam	3.2
Coon Creek	100	7	700	0.20	140.0	Sandy Clay Loam	6.3
Coon Creek	50	3	150	0.20	30.0	Sandy Clay Loam	1.4
Coon Creek	50	4	200	0.20	40.0	Sandy Clay Loam	1.8
Coon Creek	50	4	200	0.20	40.0	Sandy Clay Loam	1.8
Coon Creek	100	6	600	0.20	120.0	Sandy Clay Loam	5.4
Coon Creek	100	6	600	0.20	120.0	Sandy Clay Loam	5.4
Coon Creek	25	6	150	0.20	30.0	Sandy Clay Loam	1.4
Coon Creek	100	5	500	0.20	100.0	Sandy Clay Loam	4.5
Coon Creek	100	6	600	0.20	120.0	Sandy Clay Loam	5.4
Coon Creek	50	6	300	0.20	60.0	Sandy Clay Loam	2.7
Coon Creek	100	4	400	0.20	80.0	Sandy Clay Loam	3.6
Coon Creek	50	6	300	0.20	60.0	Sandy Clay Loam	2.7
Coon Creek	30	6	180	0.20	36.0	Sandy Clay Loam	1.6
Coon Creek	100	5	500	0.20	100.0	Sandy Clay Loam	4.5
Coon Creek	20	6	120	0.20	24.0	Sandy Clay Loam	1.1
Coon Creek	50	6	300	0.20	60.0	Sandy Clay Loam	2.7
Coon Creek	20	4	80	0.50	40.0	Sandy Clay Loam	1.8
Coon Creek	10	4	40	0.50	20.0	Sandy Clay Loam	0.9
Coon Creek	50	4	200	0.20	40.0	Sandy Clay Loam	1.8
Coon Creek	100	5	500	0.20	100.0	Sandy Clay Loam	4.5
Coon Creek	20	5	100	0.05	5.0	Sandy Clay Loam	0.2
Coon Creek	30	5	150	0.50	75.0	Sandy Clay Loam	3.4
Coon Creek	20	5	100	0.20	20.0	Sandy Clay Loam	0.9

Streambank Erosion Assessment

Reach	Eroding Bank Length (Feet)	Eroding Bank Height (Feet)	Area of Eroding Streambank (FT^2)	Lateral Recession Rate (Estimated) (FT / Year)	Estimated Volume (FT^3) Eroded Annually	Soil Texture	Estimated Soil Loss (Tons/Year)
Coon Creek	75	6	450	0.20	90.0	Sandy Clay Loam	4.1
Coon Creek	50	6	300	0.20	60.0	Sandy Clay Loam	2.7
Coon Creek	50	10	500	0.20	100.0	Sandy Clay Loam	4.5
Coon Creek	30	5	150	0.05	7.5	Sandy Clay Loam	0.3
Coon Creek	50	8	400	0.50	200.0	Sandy Clay Loam	9.0
Coon Creek	30	7	210	0.05	10.5	Sandy Clay Loam	0.5
Coon Creek	30	6	180	0.20	36.0	Sandy Clay Loam	1.6
Coon Creek	40	6	240	0.20	48.0	Sandy Clay Loam	2.2
Coon Creek	20	6	120	0.05	6.0	Sandy Clay Loam	0.3
Coon Creek	20	6	120	0.05	6.0	Sandy Clay Loam	0.3
Coon Creek	20	5	100	0.05	5.0	Sandy Clay Loam	0.2
Coon Creek	20	5	100	0.05	5.0	Sandy Clay Loam	0.2
Coon Creek	30	5	150	0.05	7.5	Sandy Clay Loam	0.3
Coon Creek	30	4	120	0.05	6.0	Sandy Clay Loam	0.3
Coon Creek	50	5	250	0.05	12.5	Sandy Clay Loam	0.6
Coon Creek	20	5	100	0.05	5.0	Sandy Clay Loam	0.2
Coon Creek	80	5	400	0.05	20.0	Sandy Clay Loam	0.9
Coon Creek	100	8	800	0.20	160.0	Sandy Clay Loam	7.2
Coon Creek	200	8	1,600	0.05	80.0	Sandy Clay Loam	3.6
Coon Creek	100	10	1,000	0.20	200.0	Sandy Clay Loam	9.0
Coon Creek	200	15	3,000	0.20	600.0	Sandy Clay Loam	27.0
Coon Creek	200	15	3,000	0.50	1,500.0	Sandy Clay Loam	67.5
Coon Creek	100	15	1,500	0.50	750.0	Sandy Clay Loam	33.8
Coon Creek	150	15	2,250	0.50	1,125.0	Sandy Clay Loam	50.6
Coon Creek	50	10	500	0.50	250.0	Sandy Clay Loam	11.3
Coon Creek	100	10	1,000	0.20	200.0	Sandy Clay Loam	9.0
Coon Creek	100	10	1,000	0.20	200.0	Sandy Clay Loam	9.0
Coon Creek	100	10	1,000	0.20	200.0	Sandy Clay Loam	9.0
Coon Creek	100	5	500	0.50	250.0	Sandy Clay Loam	11.3
Coon Creek	200	10	2,000	0.20	400.0	Sandy Clay Loam	18.0
Coon Creek	150	10	1,500	0.50	750.0	Sandy Clay Loam	33.8
Coon Creek	150	10	1,500	0.2	300.0	Sandy Clay Loam	13.5
Coon Creek	150	10	1,500	0.2	300.0	Sandy Clay Loam	13.5
Coon Creek	100	10	1,000	0.5	500.0	Sandy Clay Loam	22.5
Coon Creek	50	5	250	0.2	50.0	Sandy Clay Loam	2.3
Coon Creek	100	10	1,000	0.05	50.0	Sandy Clay Loam	2.3
Coon Creek	100	5	500	0.05	25.0	Sandy Clay Loam	1.1
Coon Creek	100	10	1,000	0.5	500.0	Sandy Clay Loam	22.5

Streambank Erosion Assessment

Reach	Eroding Bank Length (Feet)	Eroding Bank Height (Feet)	Area of Eroding Streambank (FT^2)	Lateral Recession Rate (Estimated) (FT / Year)	Estimated Volume (FT^3) Eroded Annually	Soil Texture	Estimated Soil Loss (Tons/Year)
Coon Creek	200	10	2,000	0.2	400.0	Sandy Clay Loam	18.0
Coon Creek	200	10	2,000	0.05	100.0	Sandy Clay Loam	4.5
Coon Creek	100	10	1,000	0.2	200.0	Sandy Clay Loam	9.0
Coon Creek	400	10	4,000	0.2	800.0	Sandy Clay Loam	36.0
Coon Creek	200	10	2,000	0.5	1,000.0	Sandy Clay Loam	45.0
Coon Creek	100	5	500	0.2	100.0	Sandy Clay Loam	4.5
Coon Creek	100	10	1,000	0.5	500.0	Sandy Clay Loam	22.5
Coon Creek	100	10	1,000	0.05	50.0	Sandy Clay Loam	2.3
Coon Creek	200	5	1,000	0.05	50.0	Sandy Clay Loam	2.3
Coon Creek	100	5	500	0.05	25.0	Sandy Clay Loam	1.1
Coon Creek	150	5	750	0.05	37.5	Sandy Clay Loam	1.7
Coon Creek	100	8	800	0.05	40.0	Sandy Clay Loam	1.8
Coon Creek	200	10	2,000	0.05	100.0	Sandy Clay Loam	4.5
Coon Creek	400	8	3,200	0.05	160.0	Sandy Clay Loam	7.2
Coon Creek	100	10	1,000	0.05	50.0	Sandy Clay Loam	2.3
Coon Creek	200	10	2,000	0.05	100.0	Sandy Clay Loam	4.5
Coon Creek	200	10	2,000	0.2	400.0	Sandy Clay Loam	18.0
Coon Creek	100	10	1,000	0.2	200.0	Sandy Clay Loam	9.0
Coon Creek	100	5	500	0.05	25.0	Sandy Clay Loam	1.1
Coon Creek	100	5	500	0.05	25.0	Sandy Clay Loam	1.1
Coon Creek	100	5	500	0.05	25.0	Sandy Clay Loam	1.1
Coon Creek	150	5	750	0.05	37.5	Sandy Clay Loam	1.7
Coon Creek	150	10	1,500	0.05	75.0	Sandy Clay Loam	3.4
Coon Creek	200	10	2,000	0.05	100.0	Sandy Clay Loam	4.5
Coon Creek	200	10	2,000	0.2	400.0	Sandy Clay Loam	18.0
Coon Creek	200	10	2,000	0.05	100.0	Sandy Clay Loam	4.5
Coon Creek	150	10	1,500	0.05	75.0	Sandy Clay Loam	3.4
Coon Creek	150	10	1,500	0.05	75.0	Sandy Clay Loam	3.4
Coon Creek	300	10	3,000	0.05	150.0	Sandy Clay Loam	6.8
Coon Creek	200	8	1,600	0.05	80.0	Sandy Clay Loam	3.6
Coon Creek	200	8	1,600	0.05	80.0	Sandy Clay Loam	3.6
Coon Creek	200	8	1,600	0.05	80.0	Sandy Clay Loam	3.6
Coon Creek	200	8	1,600	0.05	80.0	Sandy Clay Loam	3.6
Coon Creek	200	5	1,000	0.05	50.0	Sandy Clay Loam	2.3
Coon Creek	200	10	2,000	0.05	100.0	Sandy Clay Loam	4.5
Coon Creek	300	10	3,000	0.05	150.0	Sandy Clay Loam	6.8
Coon Creek	200	10	2,000	0.5	1,000.0	Sandy Clay Loam	45.0
Coon Creek	200	10	2,000	0.2	400.0	Sandy Clay Loam	18.0

Streambank Erosion Assessment

Reach	Eroding Bank Length (Feet)	Eroding Bank Height (Feet)	Area of Eroding Streambank (FT^2)	Lateral Recession Rate (Estimated) (FT / Year)	Estimated Volume (FT^3) Eroded Annually	Soil Texture	Estimated Soil Loss (Tons/Year)
Coon Creek	150	10	1,500	0.05	75.0	Sandy Clay Loam	3.4
Coon Creek	100	10	1,000	0.05	50.0	Sandy Clay Loam	2.3
Coon Creek	400	15	6,000	0.05	300.0	Sandy Clay Loam	13.5
Coon Creek	100	15	1,500	0.05	75.0	Sandy Clay Loam	3.4
Coon Creek	200	15	3,000	0.05	150.0	Sandy Clay Loam	6.8
Coon Creek	50	15	750	0.2	150.0	Sandy Clay Loam	6.8
Coon Creek	100	20	2,000	0.5	1,000.0	Sandy Clay Loam	45.0
Coon Creek	200	20	4,000	0.05	200.0	Sandy Clay Loam	9.0
Coon Creek	200	15	3,000	0.2	600.0	Sandy Clay Loam	27.0
Coon Creek	200	15	3,000	0.5	1,500.0	Sandy Clay Loam	67.5
Coon Creek	150	10	1,500	0.2	300.0	Sandy Clay Loam	13.5
Coon Creek	100	10	1,000	0.05	50.0	Sandy Clay Loam	2.3
Coon Creek	100	15	1,500	0.05	75.0	Sandy Clay Loam	3.4
Coon Creek	150	15	2,250	0.5	1,125.0	Sandy Clay Loam	50.6
Coon Creek	100	15	1,500	0.05	75.0	Sandy Clay Loam	3.4
Coon Creek	200	15	3,000	0.05	150.0	Sandy Clay Loam	6.8
Coon Creek	100	10	1,000	0.05	50.0	Sandy Clay Loam	2.3
Coon Creek	100	15	1,500	0.05	75.0	Sandy Clay Loam	3.4
Coon Creek	100	20	2,000	0.05	100.0	Sandy Clay Loam	4.5
Coon Creek	100	20	2,000	0.2	400.0	Sandy Clay Loam	18.0
Coon Creek	150	10	1,500	0.05	75.0	Sandy Clay Loam	3.4
Coon Creek	500	10	5,000	0.2	1,000.0	Sandy Clay Loam	45.0
Coon Creek	100	10	1,000	0.05	50.0	Sandy Clay Loam	2.3
Coon Creek	50	8	400	0.05	20.0	Sandy Clay Loam	0.9
Coon Creek	50	10	500	0.2	100.0	Sandy Clay Loam	4.5
Coon Creek	200	15	3,000	0.05	150.0	Sandy Clay Loam	6.8
Coon Creek	100	15	1,500	0.05	75.0	Sandy Clay Loam	3.4
Coon Creek	100	10	1,000	0.05	50.0	Sandy Clay Loam	2.3
Coon Creek	50	10	500	0.05	25.0	Sandy Clay Loam	1.1
Coon Creek	100	10	1,000	0.2	200.0	Sandy Clay Loam	9.0
Coon Creek	100	10	1,000	0.05	50.0	Sandy Clay Loam	2.3
Coon Creek	100	10	1,000	0.05	50.0	Sandy Clay Loam	2.3
Coon Creek	200	10	2,000	0.05	100.0	Sandy Clay Loam	4.5
Coon Creek	200	10	2,000	0.2	400.0	Sandy Clay Loam	18.0
Coon Creek	300	10	3,000	0.05	150.0	Sandy Clay Loam	6.8
Coon Creek	200	10	2,000	0.05	100.0	Sandy Clay Loam	4.5
Coon Creek	200	10	2,000	0.05	100.0	Sandy Clay Loam	4.5
Coon Creek	50	10	500	0.05	25.0	Sandy Clay Loam	1.1

Streambank Erosion Assessment

Reach	Eroding Bank Length (Feet)	Eroding Bank Height (Feet)	Area of Eroding Streambank (FT^2)	Lateral Recession Rate (Estimated) (FT / Year)	Estimated Volume (FT^3) Eroded Annually	Soil Texture	Estimated Soil Loss (Tons/Year)
Coon Creek	100	10	1,000	0.2	200.0	Sandy Clay Loam	9.0
Coon Creek	100	10	1,000	0.2	200.0	Sandy Clay Loam	9.0
Coon Creek	100	10	1,000	0.2	200.0	Sandy Clay Loam	9.0
Coon Creek	200	10	2,000	0.5	1,000.0	Sandy Clay Loam	45.0
Coon Creek	300	10	3,000	0.05	150.0	Sandy Clay Loam	6.8
Coon Creek	200	10	2,000	0.5	1,000.0	Sandy Clay Loam	45.0
Coon Creek	1000	10	10,000	0.2	2,000.0	Sandy Clay Loam	90.0
Coon Creek	100	10	1,000	0.2	200.0	Sandy Clay Loam	9.0
Coon Creek	100	10	1,000	0.5	500.0	Sandy Clay Loam	22.5
Coon Creek	100	10	1,000	0.5	500.0	Sandy Clay Loam	22.5
Coon Creek	100	10	1,000	0.5	500.0	Sandy Clay Loam	22.5
Coon Creek	200	10	2,000	0.5	1,000.0	Sandy Clay Loam	45.0
Coon Creek	300	10	3,000	0.2	600.0	Sandy Clay Loam	27.0
Coon Creek	100	10	1,000	0.2	200.0	Sandy Clay Loam	9.0
Coon Creek	200	10	2,000	0.05	100.0	Sandy Clay Loam	4.5
Coon Creek	200	10	2,000	0.2	400.0	Sandy Clay Loam	18.0
Coon Creek	400	10	4,000	0.05	200.0	Sandy Clay Loam	9.0
Coon Creek	50	10	500	0.2	100.0	Sandy Clay Loam	4.5
Coon Creek	100	10	1,000	0.2	200.0	Sandy Clay Loam	9.0
Coon Creek	100	10	1,000	0.2	200.0	Sandy Clay Loam	9.0
Coon Creek	50	10	500	0.05	25.0	Sandy Clay Loam	1.1
Coon Creek	50	10	500	0.05	25.0	Sandy Clay Loam	1.1
Coon Creek	100	10	1,000	0.05	50.0	Sandy Clay Loam	2.3
Coon Creek	200	10	2,000	0.2	400.0	Sandy Clay Loam	18.0
Coon Creek	200	10	2,000	0.05	100.0	Sandy Clay Loam	4.5
		Total Estimated Annual Streambank Erosion Soil Loss (Tons):					1719.0

Reach	Eroding Bank Length (Feet)	Eroding Bank Height * (Feet)	Area of Eroding Streambank (FT^2)	Lateral Recession Rate (Estimated) (FT / Year)	Estimated Volume (FT^3) Eroded Annually	Soil Texture	Estimated Soil Loss (Tons/Year)
Sand Creek	100	10	1,000	0.50	500.0	Sandy Clay Loam	22.5
Sand Creek	50	10	500	0.50	250.0	Sandy Clay Loam	11.3
Sand Creek	20	10	200	0.50	100.0	Sandy Clay Loam	4.5
Sand Creek	20	10	200	0.50	100.0	Sandy Clay Loam	4.5
Sand Creek	50	10	500	0.50	250.0	Sandy Clay Loam	11.3
Sand Creek	20	10	200	0.50	100.0	Sandy Clay Loam	4.5
Sand Creek	100	10	1,000	0.50	500.0	Sandy Clay Loam	22.5
Sand Creek	10	10	100	0.50	50.0	Sandy Clay Loam	2.3

Streambank Erosion Assessment

Reach	Eroding Bank Length (Feet)	Eroding Bank Height* (Feet)	Area of Eroding Streambank (FT^2)	Lateral Recession Rate (Estimated) (FT / Year)	Estimated Volume (FT^3) Eroded Annually	Soil Texture	Estimated Soil Loss (Tons/Year)
Sand Creek	20	10	200	0.50	100.0	Sandy Clay Loam	4.5
Sand Creek	50	10	500	0.50	250.0	Sandy Clay Loam	11.3
Sand Creek	50	10	500	0.50	250.0	Sandy Clay Loam	11.3
Sand Creek	30	10	300	0.50	150.0	Sandy Clay Loam	6.8
Sand Creek	20	10	200	0.50	100.0	Sandy Clay Loam	4.5
Sand Creek	50	10	500	0.50	250.0	Sandy Clay Loam	11.3
		Total Estimated Annual Streambank Erosion Soil Loss (Tons):					132.8

*Eroding bank height was estimated by averaging the bank height recorded of all cross sections.

Reach	Eroding Bank Length (Feet)	Eroding Bank Height (Feet)	Area of Eroding Streambank (FT^2)	Lateral Recession Rate (Estimated) (FT / Year)	Estimated Volume (FT^3) Eroded Annually	Soil Texture	Estimated Soil Loss (Tons/Year)
Pleasure Ck.	50	15	750	0.20	150.0	Sandy Clay Loam	6.8
Pleasure Ck.	35	8	280	0.20	56.0	Sandy Clay Loam	2.5
Pleasure Ck.	75	15	1,125	0.20	225.0	Sandy Clay Loam	10.1
Pleasure Ck.	75	8	600	0.20	120.0	Sandy Clay Loam	5.4
Pleasure Ck.	50	15	750	0.20	150.0	Sandy Clay Loam	6.8
Pleasure Ck.	75	8	600	0.20	120.0	Sandy Clay Loam	5.4
Pleasure Ck.	75	8	600	0.20	120.0	Sandy Clay Loam	5.4
Pleasure Ck.	35	8	280	0.20	56.0	Sandy Clay Loam	2.5
		Total Estimated Annual Streambank Erosion Soil Loss (Tons):					44.9

Reach	Eroding Bank Length (Feet)	Eroding Bank Height (Feet)	Area of Eroding Streambank (FT^2)	Lateral Recession Rate (Estimated) (FT / Year)	Estimated Volume (FT^3) Eroded Annually	Soil Texture	Estimated Soil Loss (Tons/Year)
Springbrook Creek	100	15	1,500	0.40	600.0	Sandy Clay Loam	27.0
Springbrook Creek	10	8	80	0.20	16.0	Sandy Clay Loam	0.7
Springbrook Creek	50	5	250	0.20	50.0	Sandy Clay Loam	2.3
		Total Estimated Annual Streambank Erosion Soil Loss (Tons):					30.0

Appendix F – Bacteria Source Assessment

Bacteria source assessment was conducted as part of this TMDL study to quantify available *E. coli* loadings present on the landscape. Analysis was conducted separately for each impaired subwatershed of this study. Separate analysis was important because sources vary when moving from a rural subwatershed such as Coon Creek, to urbanized subwatersheds such as Pleasure and Springbrook Creeks. This source assessment helped shape implementation planning by highlighting the dominant bacterial sources within each subwatershed. The approach in this assessment was to calculate the amount of *E. coli* produced per month by a given source and define that amount as "Total *E. coli* Available". It is understood that some portion of this available load will remain on the landscape; however, quantifying that amount is complicated due to die-off rates, delivery factors, land use, etc. For that reason, relative contributions from each source were based on the total *E. coli* produced by each category.

A roadside bacteria survey was performed during late summer in 2014 in the subwatershed of each impaired stream. The purpose of this survey was to estimate the number of animal units in each subwatershed to supplement estimates provided by broader statewide surveys and literature values. The survey area covered both agricultural and urban land areas and generally followed CSAHs in grid pattern to the MEP. The survey route was divided into a "north" route and "south" route based on the observable distance from road centerline. The "north" route occurred in a more rural area where animals were able to be counted at a much greater distance from the road compared to the urbanized "south" route. This was an important factor when determining animal units since animal densities were calculated from the "observable area" and extrapolated to the total subwatershed area. The north route had an estimated observable distance of 900 feet from road centerline whereas the south route had a smaller, 300 foot observable distance on average. Using GIS software, "observable" area was calculated in addition to the number of observed animal units to determine animal density. This information was used to calculate the number of animals for each animal type per square mile. Animal density for the surveyed area was then extrapolated to the total watershed area for each stream reach to estimate the number of animals present for each subwatershed. A map of the survey route along with survey notes are presented at the end of this section.

Animal estimates derived from roadside surveys were primarily used for livestock (cattle, horses, and poultry). Deer population estimates were determined by averaging DNR permit areas 229, 223, and 227, which were surveyed as part of the 2011 DNR Pre-Fawn Density study. Waterfowl estimates were based on statewide averages determined by DNR and the USFWS 2012 Waterfowl Breeding Population survey. Data obtained during the roadside bacteria assessment did record waterfowl observations; however, the densities calculated as part of roadside surveys were less conservative than densities provided in the USFWS 2012 Waterfowl Breeding Population survey. To make the estimates more conservative, roadside estimates were discarded. A third wildlife source was included and labeled as "other wildlife". This category accounts for animals that are difficult to estimate from roadside counts and considered to be relatively small contributors. This included animals such as raccoons, rats, songbirds, beaver, etc. For the purposes of this analysis, these animals were assumed to contribute *E. coli* amounts equivalent to deer. Domestic pet estimates were based on the American Veterinary Medical Association's 2012 data for the percentage of households that own dogs as well as the average number of dogs in each household. The number of households in each watershed was determined by counting the number of single family and multi-family dwellings documented in 2014 assessor's parcel data.

To determine the potential contribution from human sources, septic system information was requested from both the city of Andover and city of Ham Lake Building Departments. The city of Ham Lake was unable to provide information on the number of SSTS so an estimate was made by assuming all parcels outside the Metropolitan Urban Service Area (MUSA) had individual SSTS. The MPCA's 2012 SSTS annual assessment reported a 10% failure rate for septic systems in Anoka County. To estimate the human source category, a 10% failure rate was applied to the total number of septic systems for the cities of Andover and Ham Lake within the Coon Creek Subwatershed. Human sources were not estimated for Sand, Pleasure, and Springbrook Subwatersheds since they fall within the MUSA line and are served by municipal sanitary sewer line.

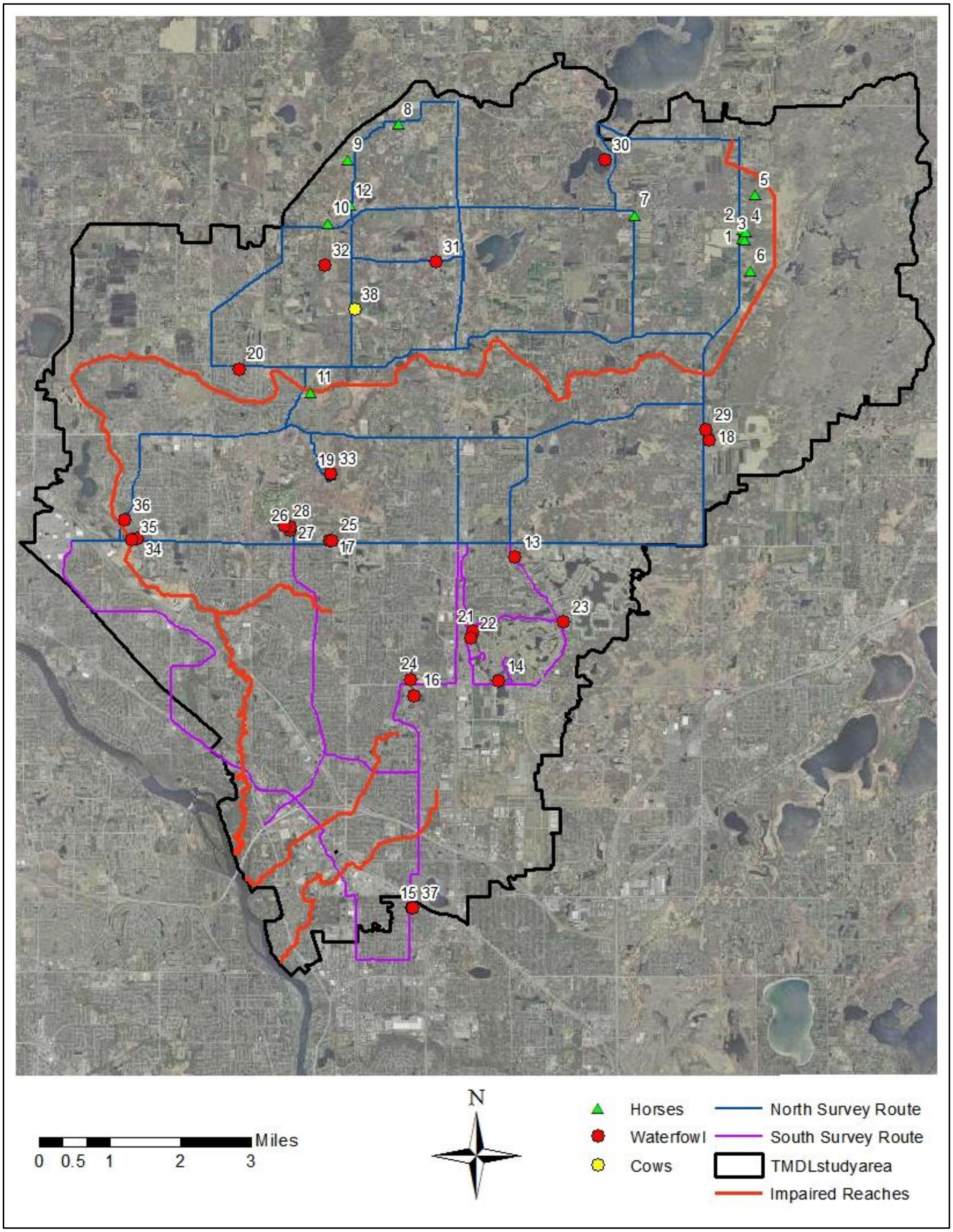

Figure 32. Roadside bacterial survey routes and documented observations.

Table 17 ID numbers and corresponding notes recorded during roadside bacteria survey.

ID #	Notes	Animal	# Present
1	1 of 4 paddocks on residence	Horse	2
2	2 of 4 paddocks on residence	Horse	10
3	3 of 4 paddocks on residence	Horse	23
4	4 of 4 paddocks on residence	Horse	22
5	Wooded paddock area in good condition	Horse	5
6	Vegetated paddock in good condition	Horse	4
7	Vegetated paddock in good condition	Horse	3
8	Small paddock adjacent to large shed	Horse	5
9	Difficult to count animals from road, animal count done through aerial photography	Horse	13
10	Small paddocks surrounded by woodland. Difficult to see from road	Horse	2
11	Heavily used paddock in poor condition and immediately adjacent to Coon Creek	Horse	25
12	Heavily upland vegetated paddock with light use	Horse	3
13	Open water with two mallards	Ducks	2
14	Open water with five mallards	Ducks	5
15	Urban park w/ public feeding area. Numbers are estimates.	Ducks	47
16	Raft of coots	Ducks	9
17	Two bufflehead ducks	Ducks	2
18	Unidentified ducks	Ducks	5
19	Open water wetland near bunker park stables. 7 mallards.	Ducks	7
20	Two mallards	Ducks	2
21	Two separate groups, animal count is total animals combined	Geese	19
22	Geese	Geese	13
23	7 visible animals, possibly more along shore but vegetation blocked view	Geese	7
24	Flock of geese	Geese	10
25	Geese in pond and on shore	Geese	12
26	Golf course	Geese	2
27	Geese spread over golf course fairway and shoreline of pond	Geese	63
28	Geese feeding on golf course fairway	Geese	21
29	Lone goose, appeared injured and unable to fly	Geese	1
30	Flock of geese near middle of Lake Netta	Geese	23
31	Geese feeding on grass at ball fields	Geese	17
32	Geese feeding on sod field	Geese	18
33	Open water wetland near bunker park stables	Geese	16
34	Geese on sod field	Geese	17
35	Geese in open channel of Coon Creek	Geese	13
36	Large flock of geese on sod field. Number is an estimate	Geese	65
37	Urban park w/ public feeding area. Numbers are estimates.	Geese	50
38	Approximately 30 beef cows	Cows	30

Appendix G – Methodology for LA and WLA Determination

The first step in determination of LAs and WLAs was acquisition of all pertinent data. This included:

Met Council projected 2020 Land Use Classification shapefiles from (downloaded at: https://www.census.gov/geo/maps-data/data/cbf/cbf_ua.html);

2010 U.S. Census Bureau Defined Urban Area shapefile (downloaded at: https://www.census.gov/geo/maps-data/data/cbf/cbf_ua.html):

City stormwater infrastructure shapefiles (provided by all municipalities).

After all data was acquired, shapefiles were analyzed with ArcMap 10.2.2 software using the following decision making process to separate WLAs and LAs:

1. All land area in the TMDL study was previously classified by land use descriptions identified in

2. Table 19 as part of Met Council's effort. The TMDL study area was mapped by land use classification. Table 19 summarizes the MPCA's recommendation for specific land use classification as published in, "*Guidance on What Discharges Should be Included in the TMDL Wasteload Allocation for MS4 Stormwater*" (MPCA, 2011).
3. Impaired stream reaches were buffered by one rod (16.5 feet) on both sides of stream centerline to represent average stream width. This area was included in the LA portion of the TMDL based on the fact that these waters were assessed as Class 2B "waters of the state," and therefore cannot be considered regulated MS4 conveyance making them ineligible for WLA designation.
4. Land area classified as "Wetland" (type 1 through 8) was included in the LA portion of the TMDL regardless of its relation to the U.S Census Bureau Defined Urban Area. The inclusion of wetlands into the LA is appropriate because these areas are generally not served by MS4 conveyance and are highly regulated, making the installation of stormwater BMPs in these areas impractical.
5. Remaining land areas were designated as WLA or LA based on guidance provided in Table 19. Projected 2020 Land Use data was overlaid with city stormwater infrastructure maps to ensure proper designation of WLA or LA. If an area appeared to be served by MS4 conveyance after the addition of city stormwater infrastructure, it was included in the WLA regardless of land use. In some instances, best professional judgment was used when the distinction was unclear.

Steps 1-4 resulted in the land areas presented in Table 18 and where used to calculated LAs and WLAs in this TMDL study.

Table 18. Land areas used in TMDL calculations.

	Coon Creek	Sand Creek	Pleasure Creek	Springbrook Creek
	Total Land Area (acres)			
Wasteload Allocation				
MnDOT	505	235	237	173
Anoka County Highways	675	244	33	79
Regulated MS4 stormwater	23,200	8,329	1439	2380
Load Allocation	22,009	994	17	18
Total	**46,389**	**9,802**	**1,726**	**2,650**

Table 19. Guidance for Met Council 2020 Land use projections in the TMDL study area.

Land Use	Classification	Guidance
Vacant	Varies	Includes land identifiable from aerial photos as open; where no buildings are present. Vacant areas should be placed in the appropriate load category based on adjacent land use.
Agricultural	LA	Includes land used for agricultural purposes with discernible cultivation horticulture, floriculture, viticulture, pasture, and a broad range of other agricultural activities (ex: hoarse boarding, kennels, sod farming, tree farms, fish production, etc.). Place this land use in LA.
Rural Residential	LA	Areas immediately adjacent to developing areas and have large numbers of individual sewage treatment systems at densities 2.5 acres or less. Place this land use in the LA.
Parks/Recreation	Varies	Land used for park and recreational assembly (ex: community level ball fields, regional or small urban parks, playgrounds, rest areas, or golf courses). Also includes passive activity uses such as park preserves, wildlife refuges, habitat areas, or other private preserved land. Place this land use into appropriate category based on surround land use.
Undeveloped (includes NWI types 1,2,3,4,5,6,7,8)	LA	Land currently not being used for any defined purpose that may or may not contain buildings or has no discernible use based upon aerial photos or available data. Includes wetlands. This land use should be placed into appropriate category based on surrounding land use.
Public/Semi Public	WLA	Includes the land under and adjacent to schools, hospitals, churches, cemeteries, ice areas, and all facilities of local and state governments. Within urbanized areas, it is generally appropriate to place this land use into WLA.
Open waterbodies	LA	Includes lakes of 5 or more acres and rivers 200ft or wider. Open waterbodies are typically excluded from both the WLA and LA.
Single Family Residential	WLA	Includes all individual, free standing single family housing. Within urbanized areas, it is generally appropriate to place this land use into WLA.
Multi-Family Residential	WLA	Includes all multiple dwelling units such as duplexes, bungalows, twin homes, townhouses, quad homes and apartment complexes. It is generally appropriate to place this land use into WLA, especially within urban areas.
Commercial	WLA	Includes all retail sales, services, hotels and motels, health care facilities, and recreational services that are predominately privately owned and operated for profit except golf courses. It is generally appropriate to place this land use into the WLA.

Industrial	WLA	Includes the Federal Standard Industrial Classification (SIC) codes 14 through 50. This includes manufacturing, transportation, construction, communications, utilities, and wholesale trade. It is generally appropriate to place this load into the WLA.
Airports	WLA	Includes all types of airports. In urban areas, it is generally appropriate to place this land use in the WLA.
Highway	WLA	Major roadway strips of land or area, on which a vehicular rights-of-passage exists. For the regulated portion (area within urban area), it is appropriate to place this land use in the WLA.
Railway	Varies	Land used and occupied or intended to be occupied by multiple railroad track lines or similar use including railroad classification, storage and repair yards, intermodal containerized freight and transload facilities, depots, etc. that could be classified under an industrial land use. Place this land use into appropriate category based on surround land use.

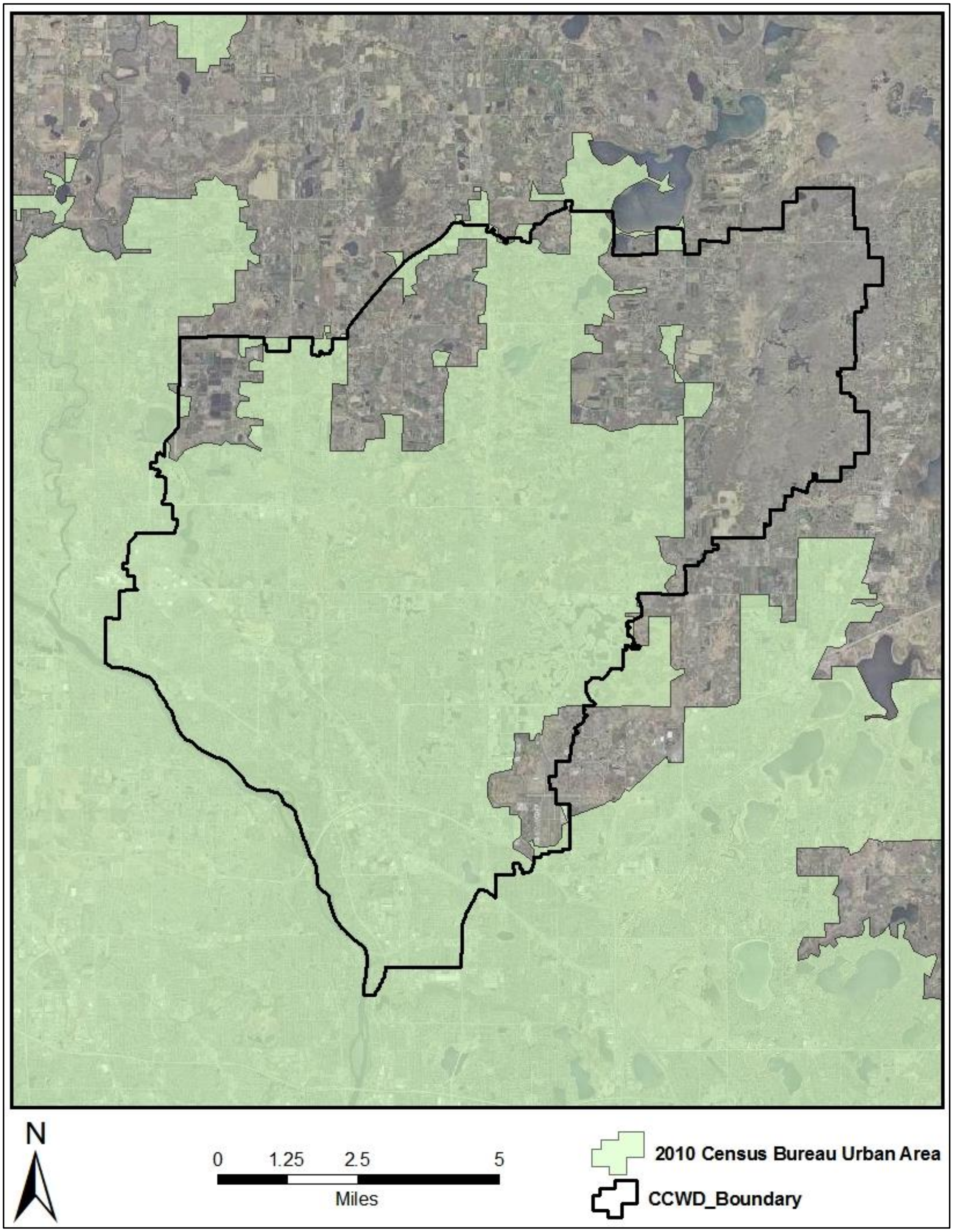

Figure 33. 2010 U.S. Census Bureau Defined Urban Area.

Appendix H – Subwatershed 2020 Projected Land Use Maps

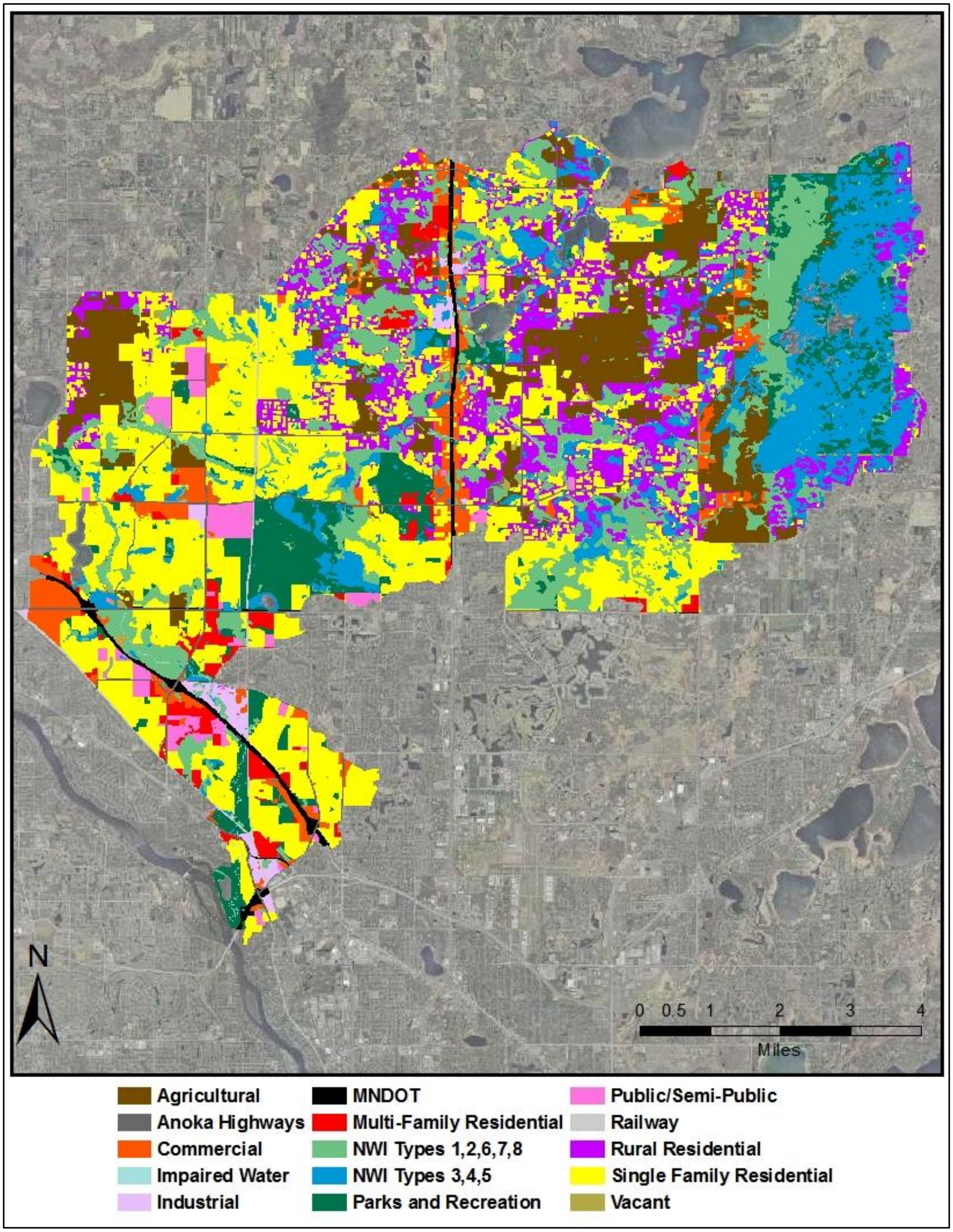

Figure 34. Coon Creek Subwatershed projected 2020 land use.

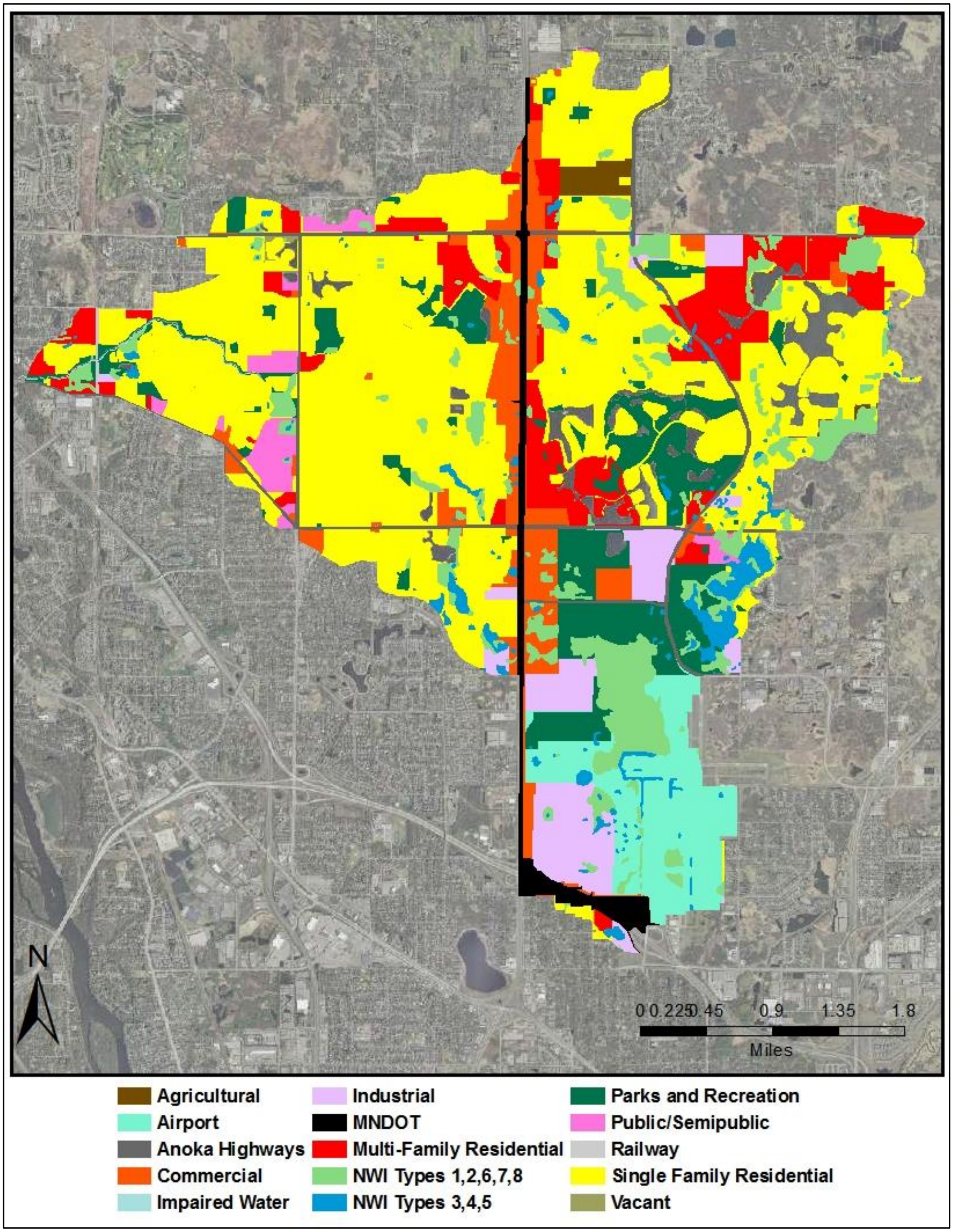

Figure 35. Sand Creek Subwatershed projected 2020 land use.

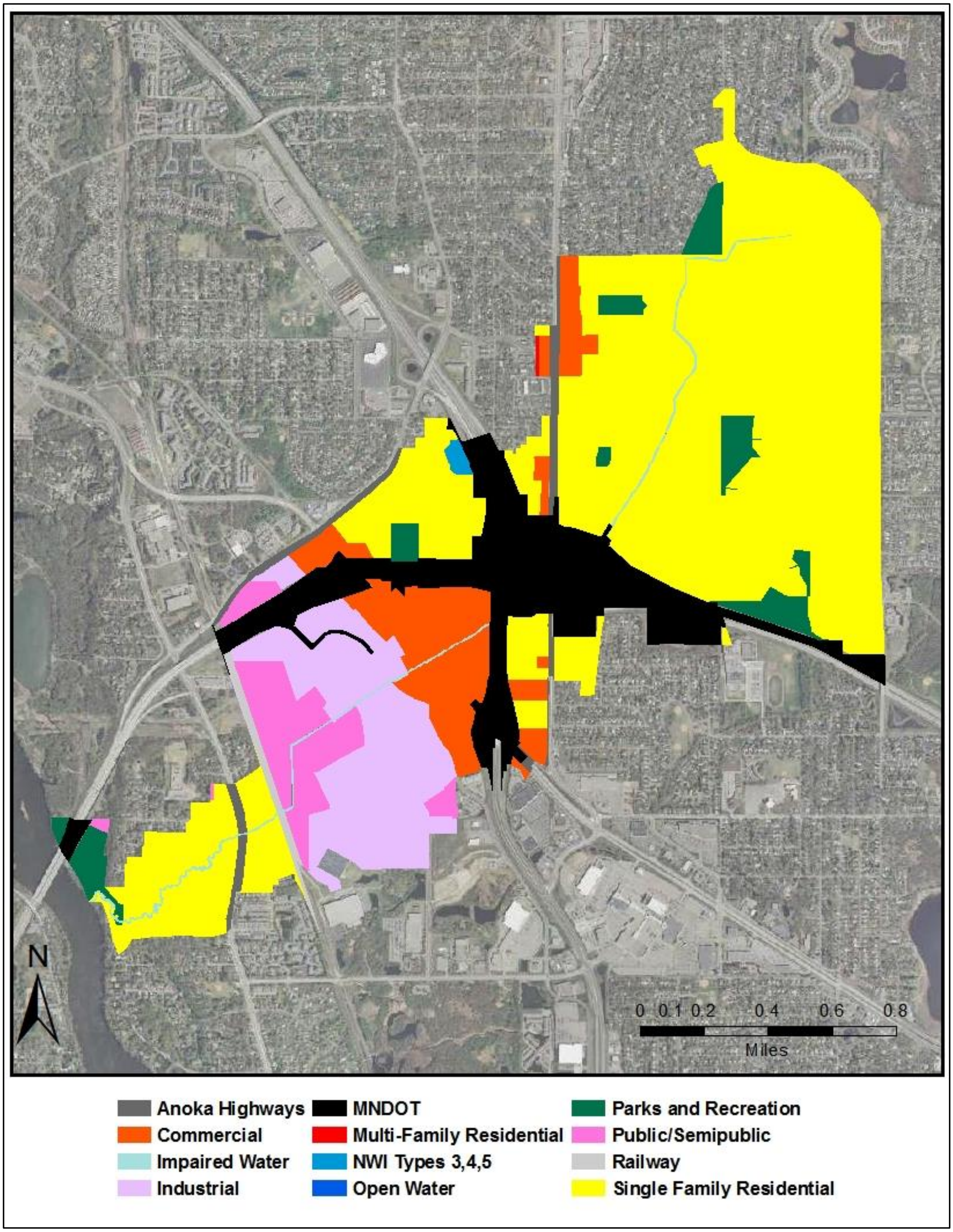

Figure 36. Pleasure Creek subwatershed projected 2020 land use.

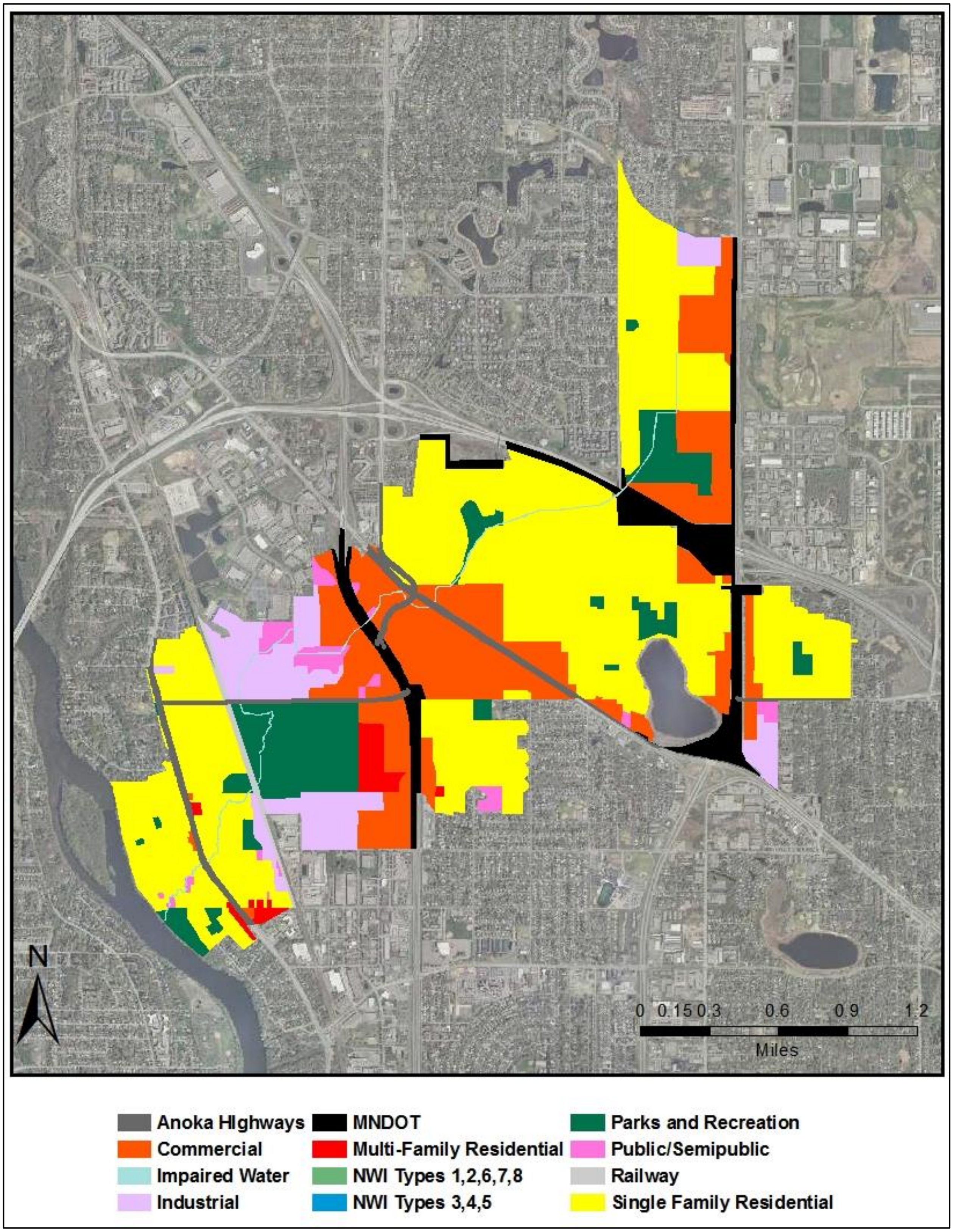

Figure 37. Springbrook Creek Subwatershed projected 2020 land use.

Appendix I – Minneapolis/St. Paul Priority A/B Source Water Protection Areas

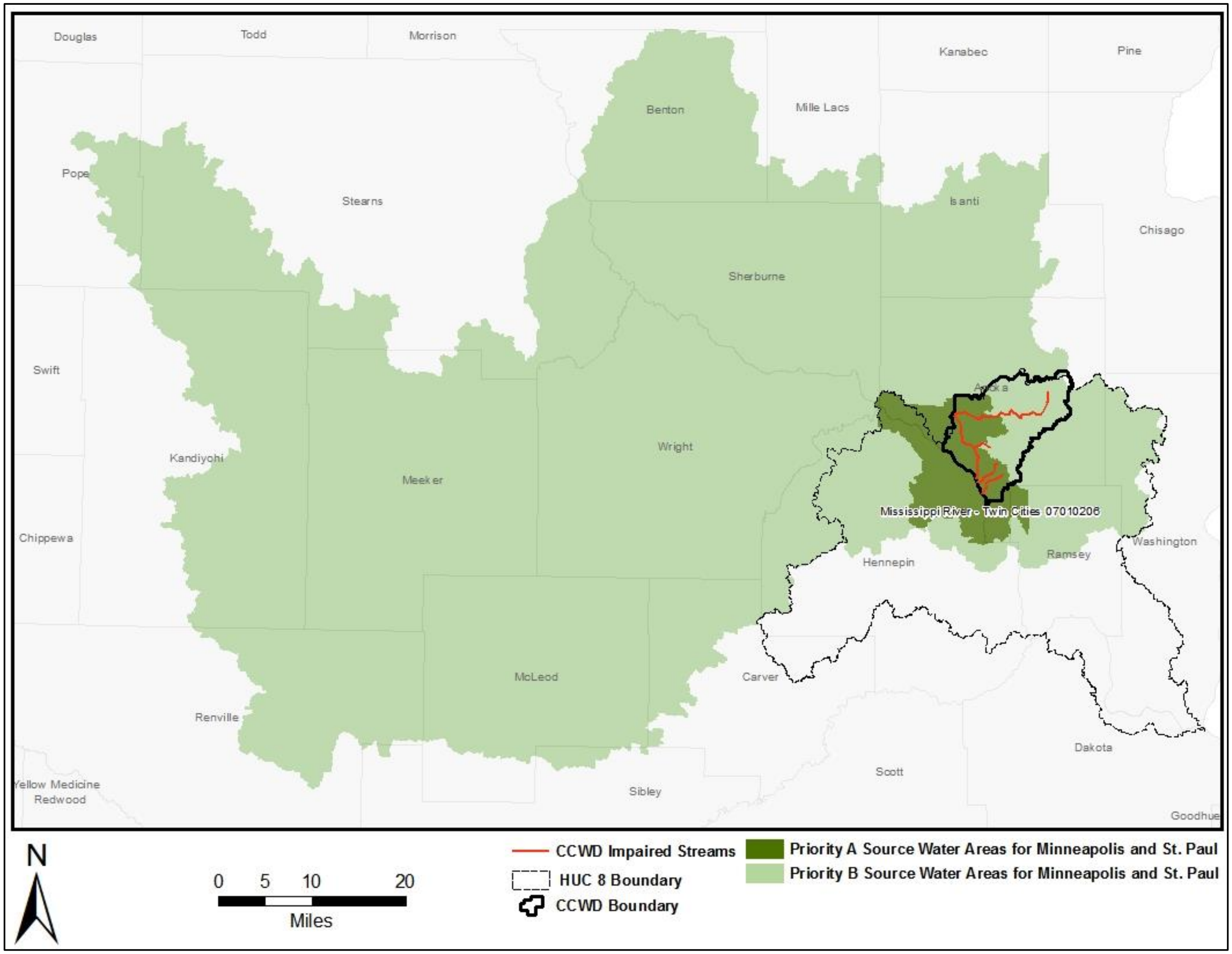

Figure 38. Priority A and B Source Water Protection Areas for Minneapolis and St. Paul.