Watershed

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Draft Buffalo River and Upper Red River of the North Watersheds Total Maximum Daily Load Report 2026

A quantification of the total maximum daily loads of sediment and phosphorus in the watersheds' rivers and lakes needed to meet and maintain their ability to support aquatic life and aquatic recreation.

MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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For more information:

- https://www.pca.state.mn.us/watershed-information/buffalo-river
- https://www.pca.state.mn.us/watershed-information/upper-red-river-of-the-north

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Contents

List of tables

List of figures

Abbreviations

1W1P	One Watershed, One Plan
AU	animal unit
BMP	best management practice
BRW	Buffalo River Watershed
BRRWD	Buffalo-Red River Watershed District
BRRW CWMP	Buffalo-Red River Watershed Comprehensive Watershed Management Plan
BWSR	Board of Water and Soil Resources
CAFO	Concentrated Animal Feeding Operation
chl-*a*	chlorophyll-*a*
CRP	Conservation Reserve Program
CREP	Conservation Reserve Enhancement Program
CWMP	Comprehensive Watershed Management Plan
DNR	Minnesota Department of Natural Resources
DO	dissolved oxygen
E. coli	*Escherichia coli*
EPA	U.S. Environmental Protection Agency
EQuIS	Environmental Quality Information System
HSPF	Hydrologic Simulation Program–FORTRAN
HUC	Hydrologic Unit Code
ITPHS	imminent threat to public health and safety
IWL	303(d) Impaired Waters List
LA	load allocation
LAP	Lake Agassiz Plain
lbs/yr	pounds per year
LC	loading capacity
LDC	load duration curve
LGU	local government unit
m	meter
MAWQCP	Minnesota Agricultural Water Quality Certification Program
mgd	million gallons per day

mg/L	milligrams per liter
MOS	margin of safety
MPCA	Minnesota Pollution Control Agency
MS4	municipal separate storm sewer system
NCHF	North Central Hardwood Forests
NLF	Northern Lakes and Forests
NLCD	National Land Cover Dataset
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service
NRS	Nutrient Reduction Strategy
NVSS	nonvolatile suspended solids
RES	River Eutrophication Standards
RIM	Reinvest in Minnesota
SDS	State Disposal System
SSTS	subsurface sewage treatment systems
StS	Score the Shore
SWCD	soil and water conservation district
TMDL	total maximum daily load
TP	total phosphorus
TSS	total suspended solids
URRW	Upper Red River of the North Watershed
USDA	United States Department of Agriculture
VSS	volatile suspended solids
WBIF	watershed-based implementation funding
WID	water body identification
WLA	wasteload allocation
WPLMN	Watershed Pollutant Load Monitoring Network
WRAPS	Watershed Restoration and Protection Strategy
WRP	Wetland Reserve Program
WQBEL	water quality-based effluent limit
WWTP	wastewater treatment plant
μg/L	micrograms per liter

Executive summary

The Federal Clean Water Act (CWA), Section 303(d) requires total maximum daily loads (TMDLs) to be produced for surface waters that do not meet applicable water quality standards necessary to support their designated uses (i.e., impaired waters). A TMDL determines the maximum amount of a pollutant a receiving water body can assimilate while still achieving water quality standards, and allocates allowable pollutant loads to various sources needed to meet water quality standards.

This TMDL report addresses impairments in the Buffalo River Watershed (BRW) and the Upper Red River of the North Watershed (URRW), located in west-central Minnesota within the Red River of the North Basin. The impairments addressed in this TMDL report are generally driven by high levels of total suspended solids (TSS) and/or total phosphorus (TP), affecting aquatic life and aquatic recreation designated uses. This report provides 8 TMDLs addressing 14 impairments in 9 water bodies: 1 nutrient-impaired lake and 8 stream reaches with impairments caused by high TSS, low dissolved oxygen (DO), and poor macroinvertebrate and fish bioassessments (Section 1.2).

A small headwater portion of the Upper Buffalo River Subwatershed in the BRW is located within the White Earth Reservation; this area is not within the contributing drainage area of any impaired water body addressed in this TMDL report and is not included in any TMDL allocations (Figure 1, Section 1.3).

Land cover in the BRW and URRW is primarily agricultural, with forests, lakes, and wetlands mixed in. A number of small- to medium-sized cities are also located throughout the watersheds, along with areas of rural residential development especially near lakeshores. Primary crops grown in the watersheds include soybeans, corn, spring wheat, and sugar beets (Section 3.5). The primary pollutant sources to the impaired lake and streams addressed in this TMDL report are runoff from cropland and developed areas, as well as stream channel and stream bank erosion caused by peak flows and altered hydrology (Section 3.7). As such, reduction of nonpoint or nonpermitted pollutant sources will be the focus of this TMDL report, while allocations for permitted sources are also important. An implementation strategy (Section 8) for addressing the impairments to improve water quality is included in this report.

This TMDL report uses a variety of methods to evaluate current loading contributions from various pollutant sources, as well as the allowable pollutant loading capacity (LC) for the impaired water bodies. These methods include flow and water quality data (Section 3.6), hydrologic models (Section 3), and the flow duration curve approach (Section 3.6). This TMDL report was developed in conjunction with a Watershed Restoration and Protection Strategy (WRAPS) Report Update for the BRW and URRW. The WRAPS Report Update provides an overview of watershed efforts throughout the BRW and URRW.

This TMDL report assigns individual wasteload allocations (WLAs) for TSS to the Rothsay, Comstock, and Lake Park Wastewater Treatment Plants (WWTPs) (Section 4.1.3.1), as well as Minn-Dak Farmers Cooperative – Peet Piling Ground (Section 4.1.3.4). Rothsay and Lake Park WWTPs have previously been assigned WLAs (Section 4.1.3, Section 6.1.1), while the WLAs for Comstock WWTP and Minn-Dak Farmers Cooperative are new as of this TMDL report. No new permit limits will result from these TSS WLAs as the WLAs are consistent with current permit conditions for all four facilities (Sections 6.1.1 and 8.1.1). Categorical WLAs are also assigned for TSS and TP for construction and industrial stormwater. No other WLAs are assigned to municipalities or permitted facilities as a result of this report.

1. Project overview

1.1 Introduction

Section 303(d) of the federal CWA requires that TMDLs be developed for waters that do not support their designated uses. These waters are referred to as "impaired" and are included in Minnesota's list of impaired water bodies. The term "TMDL" refers to the maximum amount of a given pollutant a water body can receive on a daily basis and still achieve water quality standards. A TMDL study determines what is needed to attain and maintain water quality standards in waters that are not currently meeting those standards. A TMDL study identifies pollutant sources and allocates pollutant loads among those sources. The total of all allocations, including WLAs for permitted sources, load allocations (LAs) for nonpermitted sources (including natural background), and the margin of safety (MOS), which is implicitly or explicitly defined, cannot exceed the maximum allowable pollutant load.

The BRW, eight-digit hydrologic unit code (HUC-8) 09020106, and the URRW, HUC-8 09020104, are located in west-central Minnesota, comprising a total of approximately 1,615 square miles of land located within the counties of Clay, Becker, Otter Tail, and Wilkin (Figure 1). The watersheds are located in the Red River of the North Basin, with the majority of the land within the Lake Agassiz Plain (LAP) ecoregion and portions of the watersheds located in the North Central Hardwood Forests (NCHF) and the Northern Lakes and Forests (NLF) ecoregions. Land use in the watersheds is predominantly agricultural, especially in the western portions of the watersheds, while the eastern portion of the BRW features more forests, lakes, and wetlands. Municipalities in the watersheds include those located along the U.S. Highway 10 corridor, from east to west: Audubon, Lake Park, Hawley, Glyndon, Dilworth, and Moorhead, as well as Callaway, Barnesville, Georgetown, Sabin, Comstock, Wolverton, Rothsay, Kent, and Breckenridge.

For the purposes of local water resource planning, the BRW and URRW are divided into planning regions that are based on physical similarities in ecoregions, hydrology, and land use (Figure 2). The planning regions account for regional variation within the watersheds and allow for watershed partners to work together on prioritizing and managing water resources within those planning regions at a more refined scale. For more information on the planning regions, see Section 1 and Appendix A of the *Buffalo-Red River Watershed Comprehensive Watershed Management Plan* (BRRW CWMP, HEI 2020). For the purpose of this TMDL report, the impaired water bodies will be addressed on a subwatershed scale, further explained in Sections 3.2, 3.3, and 3.4 of this report. However, this report will also refer to the *Buffalo-Red River Watershed Comprehensive Watershed Management Plan* (BRRW CWMP) planning regions when applicable.

This TMDL report addresses impaired stream reaches and lakes in the BRW and URRW that are listed on Minnesota's 2024 303(d) Impaired Waters List (IWL) and do not have an already completed and approved TMDL. Of those impairments, this report includes TMDLs addressing one nutrient-impaired lake, two stream reaches impaired due to TSS, two DO impaired stream reaches, and seven stream reaches with impaired benthic macroinvertebrate and/or fish communities (Table 1). Those impairments without an already completed and approved TMDL and that are not addressed with TMDLs in this report will either be proposed to the U.S. Environmental Protection Agency (EPA) for recategorization or will be “deferred” for TMDL development and their status on the IWL will remain unchanged (Appendix A. Summary of all impairments).

While the URRW includes land in North Dakota on the west side of the Red River of the North, this TMDL report includes land and waters only on the Minnesota side of the watershed. Additionally, no impairments located along the Red River of the North mainstem are included in this TMDL report. A separate TMDL report for the mainstem was developed and public noticed concurrently with this report.

The Minnesota Pollution Control Agency (MPCA) has previously completed TMDLs or recategorizations addressing 56 aquatic life or aquatic recreation use impairments in the BRW and 4 aquatic life or aquatic recreation use impairments in the URRW. These are summarized in Appendix A. Summary of all impairments and the completed TMDLs can be found in the MPCA’s BRW TMDL (MPCA 2016) and URRW TMDL Report (MPCA 2017a). Additionally, one turbidity-impaired stream reach and one benthic macroinvertebrate bioassessment impairment were delisted, or removed, from the IWL in 2022, as applicable water quality standards were found to be attained due to restoration activities conducted by watershed partners.

The aforementioned TMDLs were completed as part of MPCA’s Watershed Approach (MPCA 2024a) work for the BRW and URRW. Comprehensive water quality and biological monitoring was initially completed in the BRW in 2009 and 2010 and in the URRW in 2008 and 2009, with watershed assessments completed in 2011 in advance of the publication of the 2012 IWL. Watershed Monitoring and Assessment Reports, Biotic Stressor Identification Reports, WRAPS Reports, and the aforementioned TMDL reports were then completed for each watershed. The MPCA returned to the watersheds for a second round of comprehensive watershed monitoring in 2019 and 2020, with watershed assessments then completed in 2021 in advance of the publication of the 2022 IWL. The MPCA then prepared a Watershed Assessment and Trends Update Report and a Stressor Identification Update Report, as well as a WRAPS Report Update and this TMDL Report. These reports and more information can be found on the MPCA’s respective watershed webpages (MPCA 2024b and MPCA 2024c).

The Buffalo-Red River Watershed District (BRRWD), county Soil and Water Conservation Districts (SWCDs), the White Earth Band of Ojibwe and other potentially interested Tribal Organizations, and other local, state, and federal watershed partners were invited to participate in the development of this TMDL report. Some of the individuals and organizations that provided information and input for this project are provided in the list of contributors and acknowledgements at the beginning of this report. This report, and the watershed reports mentioned above, are provided to and can be used by these entities to prioritize and base local watershed management decisions. This TMDL report also provides reasonable assurance that impairments will be addressed in these watersheds via watershed restoration and protection projects and via continued water quality best management practice (BMP) implementation.

Figure 1. The BRW and the URRW, including the impaired water bodies addressed in this TMDL report.

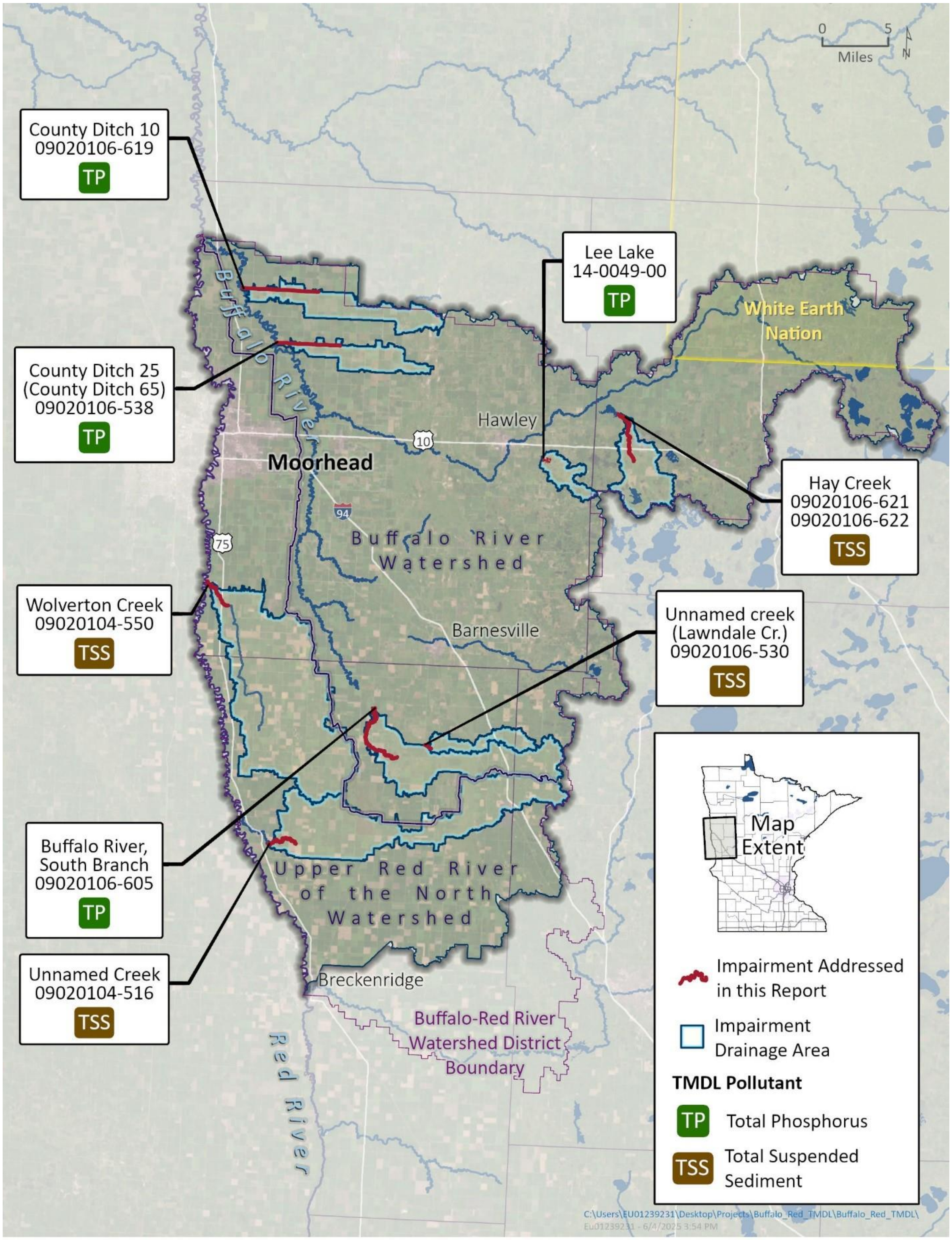


Figure 2. Planning regions of the BRW and URRW, as identified in the BRRW CWMP (HEI 2020).

**Note: while the Otter Tail planning region is within the political boundary of the BRRWD, it is not within the BRW or URRW and instead is the most downstream portion of the Otter Tail River Watershed.*

1.2 Identification of water bodies

This TMDL report addresses 14 impairments in 9 water bodies in the BRW and URRW, summarized below in Table 1. An impairment refers to an individual listing parameter for an individual water body. One water body could have multiple impairments if it is listed for more than one parameter. All impairments in the watersheds are further summarized in Appendix A. Summary of all impairments.

The TMDLs in this report were developed based on the pollutant(s) or stressor(s) for each impairment identified on Minnesota's 2024 303(d) IWL (TMDL pollutant, Table 1). For fish and macroinvertebrate bioassessment impairments, TSS TMDLs were developed for reaches that have confirmed sediment related stressors identified in the Stressor Identification Update for the BRW and URRW (MPCA 2023a) and data showing clear exceedances of regional TSS water quality standards (Section 2.4.1). Similarly, stream TP TMDLs were developed for fish and macroinvertebrate bioassessment impairments with low DO stressors caused, at least in part, by eutrophication, and sufficient data to demonstrate exceedances of regional eutrophication water quality criteria (Section 2.4.2). Additionally, TP TMDLs were developed for the two DO impaired stream reaches for which MPCA also determined that, at least in part, eutrophication is a driver of the low DO levels. As a result, if sediment and/or phosphorus loading is reduced in these impaired water bodies to the levels identified in this report, then it is expected that the impaired biological communities and DO concentrations in those streams will improve. However, additional efforts will be needed to address the nonpollutant stressors or drivers of these impairments, such as loss of longitudinal connectivity, flow regime instability, or insufficient physical habitat, for these reaches to meet applicable standards (Section 2) and be removed from the IWL. For additional information on MPCA's evaluation of stream channel conditions in the impaired streams addressed in this TMDL report, see Sections 3.6.2, 3.7.2.2, and 3.7.3.2, and for additional information on MPCA's evaluation of the DO impaired streams in the BRW and URRW, see Appendix B. Dissolved oxygen driver analysis.

One fish bioassessment impairment in Hay Creek (water body identification [WID] 09020106-621), did not receive its own TSS TMDL and was instead included in the TMDL for Hay Creek (WID 09020106-622), directly downstream of it. This is appropriate as the upstream reach (09020106-621) has the same designated use as the downstream reach (09020106-622) and its drainage area is located wholly within the drainage area of the downstream reach (09020106-622). There is one National Pollutant Discharge Elimination System (NPDES)/State Disposal System (SDS) permitted facility within the contributing drainage area to Hay Creek, the Lake Park WWTP. The Lake Park WWTP was assigned a TSS WLA in the MPCA's BRW TMDL (MPCA 2016), and therefore this inclusion results in no new impacts to the Lake Park WWTP (Section 6.1.1).

This report does not include TMDLs to address nonpollutant stressors to biological impairments, pollutant stressors that do not have sufficient data to complete TMDLs, or pollutant stressors that were determined to be "inconclusive" in the Stressor Identification Update (MPCA 2023a). Biological impairments with inconclusive pollutant stressors may require additional water quality or biological response data that either supports or refutes them as stressors to the impaired biotic community before the impairment may be addressed with a TMDL or be recategorized as 4A on Minnesota's next 303(d) IWL. One such example in this TMDL report is County Ditch 25 (County Ditch 65) (WID 09020106-538), which has fish and macroinvertebrate bioassessment impairments (Table 1). All evaluated stressors to the impaired fish community were determined to be "inconclusive" at this time, while low DO and TSS are supported as pollutant stressors to the impaired macroinvertebrate community (Table 2, MPCA 2023a). A TP TMDL is included in this report to address the low DO stressor since it was determined that eutrophication is a primary driver of low DO in this reach (Section 3.7.1.2 and 3.7.3.2). A TSS TMDL was not included in this report for County Ditch 25 (County Ditch 65) due to insufficient TSS data to complete a TMDL. As a result, both the fish and macroinvertebrate bioassessment impairments for County Ditch 25 (County Ditch 65) will remain in category 5 as of the completion and approval of this TMDL report. Additional information regarding inconclusive and nonpollutant stressors for the biological impairments addressed in this TMDL report are provided in Table 2 and for all BRW and URRW biological impairments in Appendix A. Summary of all impairments.

However, all stressors—not just those with associated TMDLs—are addressed in the concurrently developed WRAPS Report Update. The WRAPS Update provides an opportunity to call for environmental improvements in situations where TMDLs alone would not. Nonpollutant stressors include factors such as loss of longitudinal connectivity, flow regime instability, and insufficient physical habitat. The MPCA does not develop TMDLs for nonpollutant stressors because they are not subject to load quantification.

The TMDLs in this report do not replace nor revise any previously approved TMDLs for the impaired water bodies addressed in this report. However, eight TMDLs previously approved as part of the BRW TMDL (MPCA 2016) are being revised concurrently with this report due to WLAs for WWTPs being incorrectly included in the TMDL tables. For additional information see the Revision of the BRW TMDL (MPCA 2025a) developed concurrently with this TMDL report.

1.3 Tribal lands

The BRW and URRW are located on the traditional homelands of the Anishinaabe and Dakota, while a small headwater portion of the Upper Buffalo River Subwatershed is located within the White Earth Reservation. However, no contributing drainage areas to any of the impaired water bodies addressed in this TMDL report are located in this part of the watershed, and this TMDL report does not allocate pollutant loads to any federally recognized Tribal Nation. Invitations to participate throughout this project were sent to the White Earth Band of Ojibwe, as well as other potentially interested Tribal Organizations, from watershed assessments through development of this TMDL report and the WRAPS Report Update. The White Earth Nation and other Tribal Organizations will continue to be included in communications about the BRW and URRW TMDL and WRAPS project.

1.4 Priority ranking

The MPCA's TMDL commitments, as indicated on Minnesota's Section 303(d) IWL, reflect Minnesota's priority ranking of the impairments addressed in this report. To meet the needs of EPA's *2022–2032 Vision for the Clean Water Act Section 303(d) Program* (EPA 2022), the MPCA aligned TMDL commitments with the watershed approach and other statewide strategies and initiatives in *Minnesota's TMDL Studies Prioritization Framework* (MPCA 2024d). As part of these efforts, the MPCA identified water quality impaired segments to be addressed by TMDLs through the watershed approach and other statewide strategies and initiatives (MPCA 2024e).

Table 1. Impaired water bodies in the URRW (HUC-8 09020104) and BRW (HUC-8 09020106) addressed in this TMDL report.

WID	Water body name	Water body description	BRRW CWMP planning region	Use class[1]	Listing year	Affected desig. use[2]	Listing parameter	TMDL pollutant	Category 4A upon TMDL approval[3]
09020104-516	Unnamed Creek	T133 R47W S13, east line to Red R	Upper Red	2Bg	2022	AQL	Macroinvertebrate bioassessments	TSS	Yes[3, 4]
09020104-550	Wolverton Creek	RR bridge to Red R	Western	2Bg	2020	AQL	TSS	TSS	Yes
					2020	AQL	Fish bioassessments		No: inconclusive stressor[4]
09020106-530	Unnamed creek (Lawndale Cr.)	Unnamed cr to Unnamed ditch	Southern	1B, 2Ag	2020	AQL	Fish bioassessments	TSS	Yes
09020106-538	County Ditch 25 (County Ditch 65)	CD 26 to Buffalo R	Northern	2Bm[5]	2020	AQL	Fish bioassessments	TP	No: inconclusive stressors[4]
					2020	AQL	Macroinvertebrate bioassessments		No: TSS stressor (see Table 2)[3]
09020106-605	Buffalo River, South Branch	Unnamed cr to Deerhorn Cr	Southern	2Bg	2012	AQL	DO	TP	Yes
					2020	AQL	Fish bioassessments		Yes[3, 4]
					2020	AQL	Macroinvertebrate bioassessments		Yes[3, 4]
09020106-619	County Ditch 10	80th St N to Buffalo R	Northern	2Bm[5]	2022	AQL	DO	TP	Yes
					2020	AQL	Macroinvertebrate bioassessments		No: inconclusive stressor[4]
09020106-621[6]	Hay Creek	-96.11 46.864 to -96.12 46.902	Mainstem	2Bm[5]	2020	AQL	Fish bioassessments	TSS	Yes[3, 4]
09020106-622	Hay Creek	-96.12 46.902 to Stinking Lk	Mainstem	2Bg	2022	AQL	TSS	TSS	Yes
14-0049-00	Lee	Lake or Reservoir	Mainstem	2B	2012	AQR	Nutrients	TP	Yes

1. 1B: domestic consumption; 2Ag: aquatic life and recreation—general cold water habitat; 2Bg: aquatic life and recreation—general warm water habitat; 2Bm: aquatic life and recreation - modified warm water habitat.
2. Affected designated use: AQL: aquatic life; AQR: aquatic recreation.
3. Impairment will be categorized as 4A (impaired and a TMDL study has been approved by EPA) upon approval of this TMDL and will appear as 4A in the next IWL. For a biological impairment to be categorized as 4A, TMDLs for all pollutant stressors needed to achieve attainment of applicable water quality standards must be approved by EPA. If there are remaining conclusive pollutant stressors, the impairment will remain in category 5 until TMDLs are developed for all conclusive pollutant stressors ("Impairment" here is defined as a WID–listing parameter combination).
4. Impairments with "inconclusive" stressors may require additional water quality or biological response data that either supports or refutes them as stressors to the impaired biotic community before the impairment may be categorized as 4A on the next IWL. For more information see Table 2 or the Stressor Identification Update (MPCA 2023a).
5. This WID is currently designated as use class 2Bg. However, the MPCA has reviewed this use class designation and will propose a use class change to 2Bm.
6. This WID is directly upstream of and will be addressed with the TSS TMDL for WID 09020106-622.

Table 2. Summary of evaluated stressors to the impaired biotic communities addressed in this TMDL report (MPCA 2023a).

			Evaluated stressors[2]								
WID	Water body name	Bioassessment impairment[1]	Loss of longitudinal connectivity	Flow regime instability	Insufficient physical habitat	High TSS	Low DO (non-pollutant)	Low DO (due to eutrophication)	High nitrate-nitrogen (NO_2+NO_3-N)	High temperature	Remaining pollutant stressors to be addressed as of this TMDL report[3]
09020104-516	Unnamed Creek	M-IBI[4]	NA	0	+	+++	–	–	0	NA	None[4]
09020104-550	Wolverton Creek	F-IBI[5]	+	++	+++	+++	0	–	0	NA	Nitrogen[5]
09020106-530	Unnamed creek (Lawndale Cr.)	F-IBI	++	+	0	++	+	–	–	++	None
09020106-538	County Ditch 25 (County Ditch 65)	F-IBI[6]	INSUF	INSUF	INSUF	INSUF	INSUF	INSUF	INSUF	NA	TSS, Nitrogen[6]
		M-IBI[7]	NA	+++	+	++	++	++	–	NA	TSS[7]
09020106-605	Buffalo River, South Branch	F-IBI[8]	+	+++	0	0	+	+	–	NA	None[8]
		M-IBI[8]	NA	+++	+	0	++	++	–	NA	None[8]
09020106-619	County Ditch 10	M-IBI[9]	NA	+++	+	0	++	++	–	NA	TSS[9]
09020106-621	Hay Creek	F-IBI[4]	+	++	+	++	–	–	0	NA	None[4]

1. AQL impairment for fish bioassessments (F-IBI) and/or benthic macroinvertebrate bioassessments (M-IBI).
2. Key: +++ the multiple lines of evidence convincingly support the case for the candidate cause as a stressor; ++ the multiple lines of evidence strongly support the case for the candidate cause as a stressor; + the multiple lines of evidence somewhat support the case for the candidate cause as a stressor; 0 the multiple lines of evidence neither support nor refute the case for the candidate cause as a stressor ("inconclusive"); – the multiple lines of evidence refute the case for the candidate cause as a stressor; INSUF there is insufficient information to evaluate the candidate cause as a stressor; and NA the candidate cause is not applicable as a stressor due to type of bioassessments impairment or the use classification of the reach.
3. Impairments with inconclusive stressors ("0") may require additional water quality or biological response data that either supports or refutes them as stressors to the impaired biotic community before the impairment may be categorized as 4A on Minnesota's next 303(d) IWL.
4. The available biological response data suggests this impaired biotic community may be impacted by high nitrogen levels. However, the available water quality data suggests this stream reach does not experience periods of high nitrate-nitrogen and a TMDL would not be required.
5. The available data suggests this stream reach experiences occasional periods of high nitrate-nitrogen and the biological response data is inconclusive. More data is needed.
6. No fish were captured during two biological monitoring surveys in this WID. Due to the absence of fish metric data, there is insufficient information to determine how each evaluated stressor impacts the impaired fish community.
7. Although TSS is a stressor to this impaired biotic community, additional TSS data is needed to sufficiently complete a TSS TMDL for this impaired stream.
8. The available biological response data suggests this impaired biotic community may be impacted by high TSS. However, the available water quality data suggests this stream reach experiences infrequent periods of high TSS and a TMDL would not be required.
9. While the available data suggests this stream reach experiences occasional periods of high TSS, the available biological response data suggests this impaired biotic community is not impacted by high TSS. Therefore, this stressor is neither supported nor refuted and is "inconclusive" and more data is needed.

2. Applicable water quality standards and numeric water quality targets

The federal CWA requires states to designate beneficial uses for all waters and develop water quality standards to protect each use. Water quality standards consist of several parts:

- Beneficial uses—Identify how people, aquatic communities, and wildlife use our waters.
- Numeric standards—Amounts of specific pollutants allowed in a body of water that still protect it for the beneficial uses (note that EPA uses the phrase “numeric criteria” whereas Minnesota uses the phrase “numeric standards").
- Narrative standards—Statements of unacceptable conditions in and on the water (note that EPA uses the phrase “narrative criteria” whereas Minnesota uses the phrase “narrative standards").
- Antidegradation protections—Extra protection for high-quality or unique waters and existing uses.

Together, the beneficial uses, numeric and narrative standards, and antidegradation protections provide the framework for achieving CWA goals. Minnesota’s water quality standards are in Minn. R. chs. 7050 and 7052.

2.1 Beneficial uses

The beneficial uses for waters in Minnesota are grouped into one or more classes as defined in Minn. R. 7050.0140. The classes and associated beneficial uses are:

- Class 1 – domestic consumption.
- Class 2 – aquatic life and recreation.
- Class 3 – industrial consumption.
- Class 4 – agriculture and wildlife.
- Class 5 – aesthetic enjoyment and navigation.
- Class 6 – other uses and protection of border waters.
- Class 7 – limited resource value waters.

The Class 2 aquatic life beneficial use includes a tiered aquatic life uses framework for rivers and streams. The framework contains three tiers—exceptional, general, and modified uses.

All surface waters are protected for multiple beneficial uses, and numeric and narrative water quality standards are adopted into rule to protect each beneficial use. TMDLs are developed to protect the most sensitive use of a water body.

2.2 Narrative and numeric standards

Narrative and numeric water quality standards for all uses are listed for four common categories of surface waters in Minn. R. 7050.0220. The four categories are:

- Cold water aquatic life and habitat, drinking water, and associated use classes: Classes 1B; 2A, 2Ae, or 2Ag; 3; 4A and 4B; and 5.
- Cool and warm water aquatic life and habitat, drinking water, and associated use classes: Classes 1B or 1C; 2Bd, 2Bde, 2Bdg, or 2Bdm; 3; 4A and 4B; and 5.
- Cool and warm water aquatic life and habitat and associated use classes: Classes 2B, 2Be, 2Bg, 2Bm, or 2D; 3; 4A and 4B; and 5.
- Limited resource value waters: Classes 3; 4A and 4B; 5; and 7.

The narrative and numeric water quality standards for the individual use classes are listed in Minn. R. 7050.0221 through 7050.0227. The procedures for evaluating the narrative standards are presented in Minn. R. 7050.0150.

The MPCA assesses surface waters for the following beneficial uses:

- Class 1: Drinking water and aquatic consumption (human health-based standards).
- Class 2: Aquatic life (toxicity-based standards, conventional pollutants, biological indicators).
- Class 2: Aquatic recreation (*Escherichia coli [E. coli]* bacteria, eutrophication).
- Class 2: Aquatic consumption (fish tissue and wildlife-based standards).
- Class 4A: Waters used for production of wild rice.
- Class 7: Limited value resource waters (toxicity-based standards, *E. coli* bacteria, conventional pollutants).

Class 2 waters are further broken down into Class 2A and 2B waters. Class 2A waters are protected for the propagation and maintenance of a healthy community of cold water aquatic life and their habitats. Class 2B waters are protected for the propagation and maintenance of a healthy community of cool or warm water aquatic life and their habitats. Both Class 2A and 2B waters are also protected for aquatic recreation activities including bathing and swimming, and for human consumption of fish and other aquatic organisms.

2.3 Antidegradation policies and procedures

The purpose of the antidegradation provisions in Minn. R. ch. 7050.0250 through 7050.0335 is to achieve and maintain the highest possible quality in surface waters of the state. To accomplish this purpose:

- Existing uses and the level of water quality necessary to protect existing uses are maintained and protected.

- Degradation of high water quality is minimized and allowed only to the extent necessary to accommodate important economic or social development.
- Water quality necessary to preserve the exceptional characteristics of outstanding resource value waters is maintained and protected.
- Proposed activities with the potential for water quality impairments associated with thermal discharges are consistent with Section 316 of the CWA, United States Code, title 33, section 1326.

2.4 BRW and URRW water quality standards

The applicable water quality standards for the impaired water bodies addressed in this TMDL report are provided in Table 3 and are summarized below. The impaired water bodies have been designated as class 1B, 2Ag, 2Bg, 2Bm, and 2B waters. For the purpose of the TSS and river eutrophication standards (RES), the BRW and URRW are primarily located in the south river nutrient region, with small portions of each located in the central river nutrient region. Lee Lake is located within the NCHF ecoregion and was assessed against the lake eutrophication standards for that ecoregion.

Table 3. Applicable water quality standards for impaired water bodies addressed in this TMDL report (MPCA 2024f).

Pollutant	Eco-region[1]	Use class	Water quality standard[2]	Criteria	Applicable time period
Total suspended solids (TSS)	SRNR	1B, 2Ag	≤ 10 mg/L	Not to be exceeded for more than 10% of the time.	April 1 – September 30
	CRNR	2Bg, 2Bm	≤ 30 mg/L		
	SRNR	2Bg, 2Bm	≤ 65 mg/L		
Dissolved Oxygen (DO)[3]	SRNR	2Bg, 2Bm	≥ 5 mg/L	Not to be exceeded for more than 10% of the time.	May 1 – September 30
River eutrophication[4]					
Phosphorus, total (TP)	SRNR	2Bg, 2Bm	≤ 150 µg/L	Summertime average to be less than or equal to standard.	June 1 – September 30
Chlorophyll-*a* (chl-*a*)			≤ 35 µg/L[5]		
Diel DO flux			≤ 4.5 mg/L[5]		
Biochemical Oxygen Demand (BOD)			≤ 3.0 mg/L[5]		
pH			≥ 6.5 su; ≤ 9.0 su	Not to be exceeded for more than 10% of the time.	
Lake eutrophication[6]					
Phosphorus, total (TP)	NCHF	2B	≤ 40 µg/L	Summertime average to be less than or equal to standard.	June 1 – September 30
Chlorophyll-*a* (chl-*a*)			≤ 14 µg/L		
Secchi disk transparency			≥ 1.4 m		

1. SRNR = south river nutrient region; CRNR – central river nutrient region; NCHF = north central hardwood forest ecoregion
2. mg/L = milligrams per liter; µg/L = micrograms per liter; su = standard units; m = meter

3. Eutrophication is impacting the DO levels for Buffalo River, South Branch (WID 09020106-605) and County Ditch 10 (09020106-619), which have AQL impairments due to low levels of DO. These impairments will be addressed with a TP TMDL developed using the TP water quality standard for class 2B streams in the SRNR.
4. Exceedance of the TP levels and chl-*a,* BOD, DO flux, or pH levels is required to indicate a polluted condition (MPCA 2024f, page 30).
5. Minn R. 7050.0222 incorrectly lists water quality standards for chl-*a*, DO flux, and BOD for class 2B streams in the SRNR. Rulemaking is currently underway to address the correction in Minn R. 7050.0222. The RES standards for the SRNR that were approved by EPA are presented in Table 3.
6. Exceedance of the TP and one or both of the chl-*a* or Secchi disk transparency standard is required to indicate a polluted condition (MPCA 2024f, page 60).

2.4.1 TSS standards

Exceedances of the TSS standard in streams indicate that a water body does not meet the aquatic life designated use. The TSS standard for all class 2A streams is 10 mg/L; this is the standard applied in this TMDL report for Unnamed Creek (Lawndale Creek) (09020106-530). The TSS standard for class 2B streams in the central river nutrient region is 30 mg/L (applied in this TMDL report for Hay Creek, 09020106-621 and -622) and 65 mg/L for class 2B streams in the south river nutrient region (Unnamed Creek, 09020104-516, and Wolverton Creek, 09020104-550). For assessment, these concentrations are not to be exceeded in more than 10% of samples within a 10-year period. The TSS standard applies April 1 through September 30.

A stream is considered to exceed the standard for TSS if 1) the standard is not met more than 10% of the days of the assessment season (April through September) as determined from a data set that gives an unbiased representation of conditions over the assessment season, and 2) there are at least three such measurements exceeding the standard.

A stream is considered to meet the standard for TSS if the standard is met at least 90% of the days of the assessment season. A designation of meeting the standard for TSS generally requires at least 20 suitable measurements from a data set that gives an unbiased representation of conditions over at least 2 different years. However, if it is determined that the data set adequately targets periods and conditions when exceedances are most likely to occur, a smaller number of measurements may suffice.

2.4.2 River eutrophication standards

The RES consist of two parts, requiring an exceedance of the causative variable and a response variable, which indicates the presence of eutrophication. The causative variable is TP. The response variables include chl-*a*, diel DO flux, 5-day BOD, and pH. Exceedance of the TP criterion and chl-*a* (seston), diel DO flux, BOD, or pH is required to determine impairment. The MPCA evaluated extensive datasets from across the state to establish clear relationships between the causal factor TP and the response variables (MPCA 2013). It is expected that by meeting the TP target, the response variables will also be met. The RES apply to summer month mean values, for June to September. All streams receiving TP TMDLs are located in the south river nutrient region, which has a TP standard of 150 µg/L or 0.15 mg/L.

2.4.3 Lake eutrophication standards

Lake eutrophication standards in Minnesota differ by ecoregion and by lake depth, and the standards contain numeric standards for TP, which is referred to as the causal variable, and chl-*a* concentration and Secchi disk transparency, which are referred to as the response variables. The chl-*a* concentration is a measure of the amount of suspended algae in a water body. Exceedance of the TP and either the chl-*a* or Secchi transparency standard indicates that a lake is impaired for the aquatic recreation designated use (Minn. R. ch. 7050, MPCA 2024f).

Lee Lake is located in the NCHF Ecoregion. The numeric eutrophication criteria for lakes and reservoirs in the NCHF Ecoregion serve as targets for the lake TMDL. The Lee Lake TMDL was developed for TP; the numeric target used to develop the TMDL is 40 µg/L (or 0.04 mg/L).

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

3. Watershed and water body characterization

Much of the information in this TMDL report is derived from the MPCA's Hydrologic Simulation Program–FORTRAN (HSPF) model application of the BRW and URRW. An HSPF model is a comprehensive model of watershed hydrology and water quality that allows the integrated simulation of point sources, land and soil contaminant runoff processes, and in-stream hydraulic and sediment-chemical interactions. The results provide hourly runoff flow rates, sediment concentrations, and nutrient concentrations, along with other water quality constituents, at the outlet of any modeled subwatershed. Within each subwatershed, the upland areas are separated into multiple land cover categories, and loads generated from these land cover categories can be tabulated from the HSPF model. The model evaluates both permitted and nonpermitted sources of pollutants including watershed runoff, near channel sources, WWTPS, and more. In this TMDL, HSPF is used to delineate subwatersheds of the impaired water bodies, simulate flows in the impaired streams, and to estimate TSS and TP loading by source. These model outputs can also be used to assist in BMP selection and planning. The BRW HSPF model was developed in 2019 (Tetra Tech 2019) and then updated and revised in 2023 to make adjustments to the previous model's subbasins and extend the model through the year 2022 (MPCA 2024g). The URRW HSPF model was developed in 2018 (Tetra Tech 2018) and was also updated and revised in 2023 to again extend through the year 2022 (MPCA 2024h).

3.1 Climate trends

Climate is a foundational ecological condition that influences hydrology, water quality, aquatic life, and much more. Communities and municipalities, farmers and other players in the agriculture industry, natural resource professionals, and water resource planners must be aware of current and projected shifts in climate and their potential impacts when making decisions about managing resources for infrastructure, cropping systems, flood protection and flood damage reduction, habitat protection, domestic water supply, and more. Warmer and wetter conditions, combined with more intense and frequent precipitation events, will challenge our ability to effectively do so.

Climate summary reports are provided for Minnesota's major HUC-8 watersheds by the Minnesota Department of Natural Resources (DNR) using observed data shown in the form of maps, figures, and charts. The summary reports deliver an overview of observed temperature and precipitation using 30-year averages, comparing the most recent 30-year average (1989-2018) to the entire climate record average (1985-2018). The summary reports for the BRW and URRW suggest that in these watersheds, annual minimum, maximum, and average temperatures slightly increased over the historical record, with more significant increases of approximately 1˚F to 1.5˚F over the most recent 30-year average (1989-2018). Precipitation in the watersheds, meanwhile, has been more variable when compared to the historical average, with an increase of approximately 1 inch over the most recent 30-year average (1989-2018) (DNR 2019a, DNR 2019b).

The DNR also provides historical climate data and future projections on the Minnesota Climate Explorer (DNR 2024a), which shows that average annual temperatures in the watersheds, combined (Figure 3), have increased by 0.25˚F per decade and by almost 8˚F total over the historical record (1895 – 2024) and by 0.5˚F per decade and over 5˚F over the last 30 years (1995 – 2024). Meanwhile, precipitation (Figure 4) has increased by 0.20 inches per decade or approximately 2.7 inches total over the historical record (1895 – 2024) but decreased by 0.99 inches per decade or approximately 1.3 inches total over the last 30 years (1995 – 2024).

Future projections suggest that increasing trends will continue, with annual average temperatures in the watersheds projected to increase by 3.64˚F above baseline by mid-century (years 2040-2059) and by 6˚F to 10˚F above baseline by late-century (2080-2099) (Figure 5, model mean), and with precipitation projected to increase by 1.9 inches above baseline by mid-century and by 1.8 to 3.7 inches above baseline by late-century (Figure 6, model mean) (DNR 2024a). Furthermore, the Minnesota Climate Mapping and Analysis Tool projects for the BRW and URRW that the number of days per year exceeding 90˚F will increase by 17 days by mid-century (2040-2059) and by over 24 days by late century (2060-2079), and that the maximum 1-day through 7-day total precipitation will increase by approximately 0.3 to 0.5 inches by mid-century and by 0.5 to 0.7 inches by late-century, suggesting rainfall or storm events will increase in magnitude (Liess et al. 2025).

Figure 3. Average annual temperatures in the BRW and URRW, 1895-2024 (DNR 2024a).

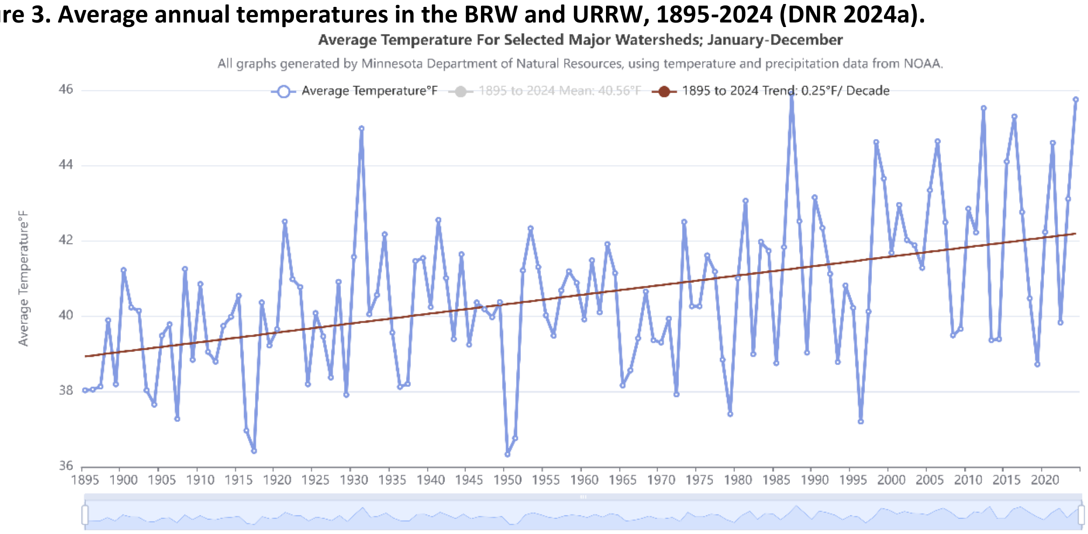


Figure 4. Average annual precipitation in the BRW and URRW, 1895-2024 (DNR 2024a).

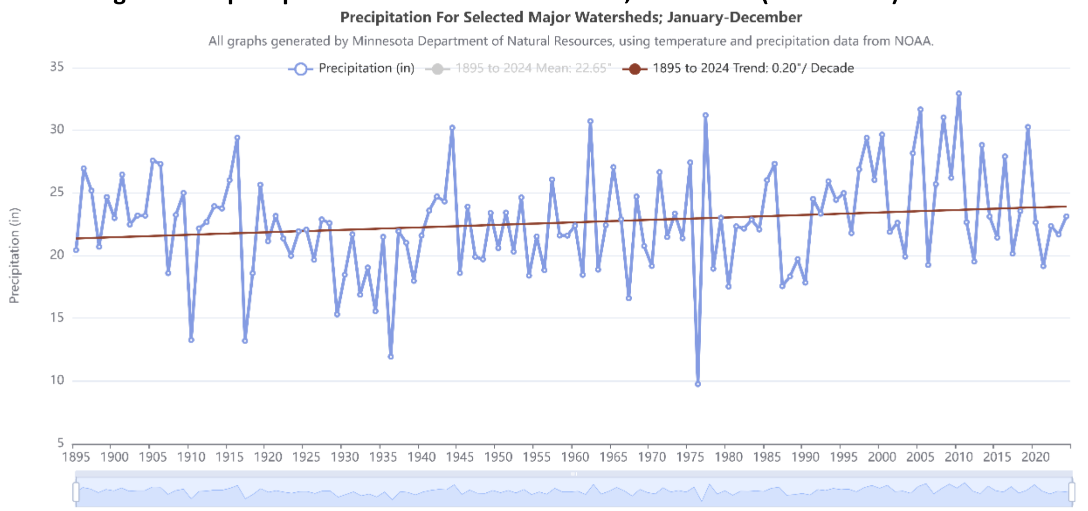


Figure 5. Modeled average annual temperatures in the BRW and URRW (DNR 2024a).

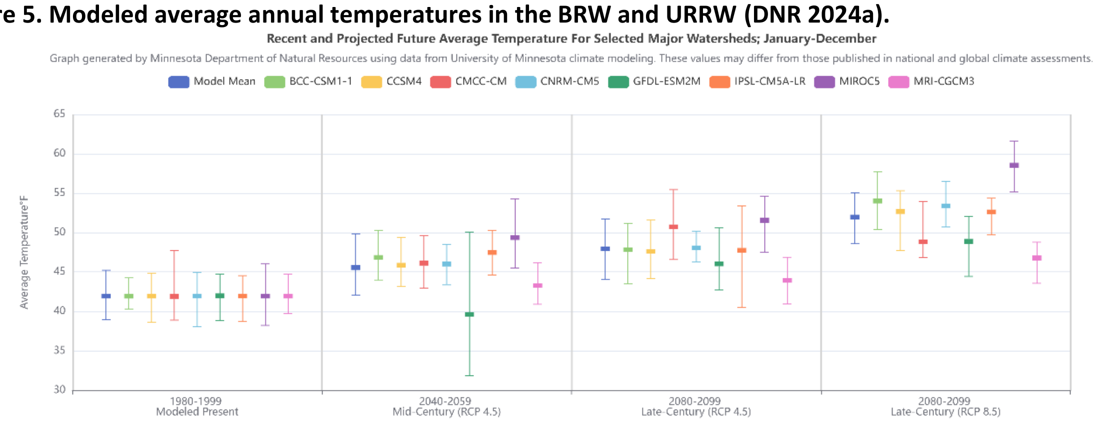
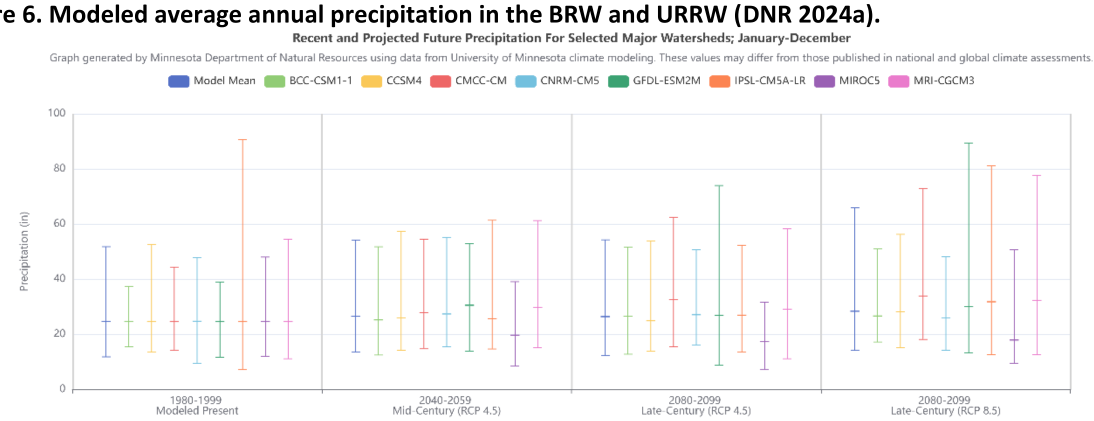


Figure 6. Modeled average annual precipitation in the BRW and URRW (DNR 2024a).



3.2 Subwatersheds

Drainage areas for the impaired water bodies addressed in this TMDL report were derived primarily using the watershed delineations from the original BRW and URRW HSPF models (Tetra Tech 2019, Tetra Tech 2018). These drainage areas are based on DNR Level 7 minor watershed boundaries and were further verified to MPCA staff's best professional judgement using various Geographic Information Systems databases. The resulting subwatersheds are mapped collectively in Figure 1 and Figure 2, and individual subwatershed maps with further detail are provided in Appendix C. Subwatershed maps. Geographic Information Systems data for the subwatersheds are available upon request via the MPCA.

3.3 Streams

Stream segment lengths and subwatershed areas for the impaired streams addressed in this TMDL report are summarized in Table 4.

Table 4. Impaired streams addressed in this TMDL report.

WID	Stream name	BRRW CWMP planning region	Stream length (miles)	Drainage area (acres)	Drainage area (square miles)
09020104-516	Unnamed Creek	Upper Red	3.64	42,304.3	66.1
09020104-550	Wolverton Creek	Western	3.28	66,323.2	103.6
09020106-530	Unnamed creek (Lawndale Creek)	Southern	0.57	5,855.5	9.1
09020106-538	County Ditch 25 (County Ditch 65)	Northern	4.8	9,914.4	15.5
09020106-605	Buffalo River, South Branch	Southern	7.9	25,187.2	39.4
09020106-619	County Ditch 10	Northern	5.78	14,757.1	23.1
09020106-621 09020106-622	Hay Creek	Mainstem	5.12	12,787.1	20.0

3.4 Lee Lake

Lee Lake is the only lake addressed in this TMDL report. Lake morphometry and watershed information for Lee Lake are provided in Table 5. Lee Lake is located in the NCHF ecoregion and the Mainstem BRRW CWMP planning region.

Table 5. Lake morphometry and watershed information for Lee Lake (DNR 2024b).

Lake name, WID	Surface area (acres)	Maximum depth (feet)	Mean depth (feet)	Littoral area (acres, %)	Watershed area (including lake surface area; acres)	Watershed area: lake surface area ratio
Lee, 14-0049-00	158	36	14	70 acres, 44%	4,737	30:1

3.5 Land cover

Land cover information in the BRW and URRW is provided from the 2019 National Land Cover Database (NLCD 2019, USGS 2022, Figure 7). Land use in the watersheds is predominantly agricultural, especially in the western portions of the watersheds, while the eastern portion of the BRW features more forests, lakes, and wetlands. Crops grown in the watersheds primarily include soybeans (36%), corn (23%), spring wheat (14%), and sugar beets (8%) (USDA NASS 2024). A small headwater portion of the Upper Buffalo River Subwatershed, approximately 63,325 acres, is located within the White Earth Reservation; land cover in this portion of the BRW is primarily cropland and forested and is not included in any allocations within this TMDL report. Land cover distributions within the subwatersheds of the impaired water bodies addressed in this TMDL report, along with overall land cover distributions for the BRW and URRW, respectively, are provided in Table 6.

Prior to European settlement, the BRW and URRW were primarily natural prairie (>91%), with patches of forest (>8%) and small pockets of open water, bogs, and swamps (<0.2%) mixed in (Figure 8, DNR 2024c). Most of the BRW and almost all of the URRW are located within the LAP ecoregion, formed as a remnant of glacial Lake Agassiz and characterized by deep, rich silt and clay soils. The area was found to support prolific, increasingly intensive agricultural production and, as a result, the landscape now features an extensive network of ditches and tile drainage. The area is prone to flooding as streams flow west from the NCHF ecoregion and into the low gradient landscape of the LAP, where stream flows generally decline, and the phosphorus-rich silts and clays become suspended and transported within the low-flowing streams and ditches.

For more information on land cover and other physical characteristics of the BRW and URRW, refer to Appendix A of the BRRW CWMP (HEI 2020), or to the original WRAPS, TMDL, Stressor Identification, and Watershed Monitoring and Assessment Reports found on the MPCA's BRW and URRW webpages (MPCA 2024b and MPCA 2024c).

Table 6. Land cover distributions of the subwatersheds addressed in this TMDL report provided by NLCD 2019 (USGS 2022).

WID	Water body name	BRRW CWMP planning region	Land area (acres)	Percent of land area (%)						
				Open water[1]	Wetlands[2]	Forest[3]	Hay/ Pasture	Cropland	Developed[4]	Other[5]
09020104-516	Unnamed Creek	Upper Red	42,304.3	0.2%	10.9%	0.7%	1.4%	82.7%	4.0%	0.1%
09020104-550	Wolverton Creek	Western	66,323.2	0.2%	0.8%	0.5%	<0.1%	94.4%	4.0%	<0.1%
09020106-530	Unnamed creek (Lawndale Cr)	Southern	5,855.5	<0.1%	23.5%	0.8%	3.9%	67.5%	3.8%	0.5%
09020106-538	County Ditch 25	Northern	9,914.4	0.0%	2.9%	0.2%	1.2%	92.1%	3.6%	0.0%
09020106-605	Buffalo River, South Branch	Southern	25,187.2	0.3%	16.0%	1.0%	2.0%	77.0%	3.5%	0.2%
09020106-619	County Ditch 10	Northern	14,757.1	<0.01%	2.3%	0.3%	2.7%	90.9%	3.6%	0.1%
09020106-621 09020106-622	Hay Creek	Mainstem	12,787.1	10.3%	5.5%	7.0%	3.6%	66.9%	5.7%	1.0%
14-0049-00	Lee	Mainstem	4,725.9[6]	11.8%	7.1%	15.2%	8.7%	48.8%	3.4%	5.0%
BRW total land cover		*Multiple*[7]	714,221	3.4%	11.1%	6.8%	5.3%	67.5%	4.3%	1.6%
URRW total land cover		*Multiple*[8]	319,533	0.8%	4.4%	0.4%	0.6%	86.0%	7.7%	0.1%
BRW and URRW total land cover		*All BRW-URRW planning regions*	1,033,754	2.6%	9.0%	4.8%	3.9%	73.2%	5.4%	1.1%

1. Includes lakes, rivers, and streams.
2. Includes NLCD 2019 woody and emergent herbaceous wetland classes.
3. Includes NLCD 2019 deciduous, evergreen, and mixed forest classes.
4. Includes NLCD 2019 open space, low intensity, medium intensity, and high intensity developed classes.
5. Includes NLCD 2019 shrub/scrub, grassland herbaceous, and barren land (rock/sand/clay) classes.
6. The subwatershed land area for Lee Lake used in this TMDL report differs slightly than what is provided in Table 5 (DNR 2024b) due to minor differences across mapping sources.
7. The BRW includes the Lakes, Mainstem, Northern, Central, and Southern BRRW CWMP planning regions.
8. The URRW includes the Moorhead, Western, and Upper Red BRRW CWMP planning regions, and the provided acreage includes land only in Minnesota.

Figure 7. Land cover in the BRW and URRW provided by NLCD 2019 (USGS 2022).

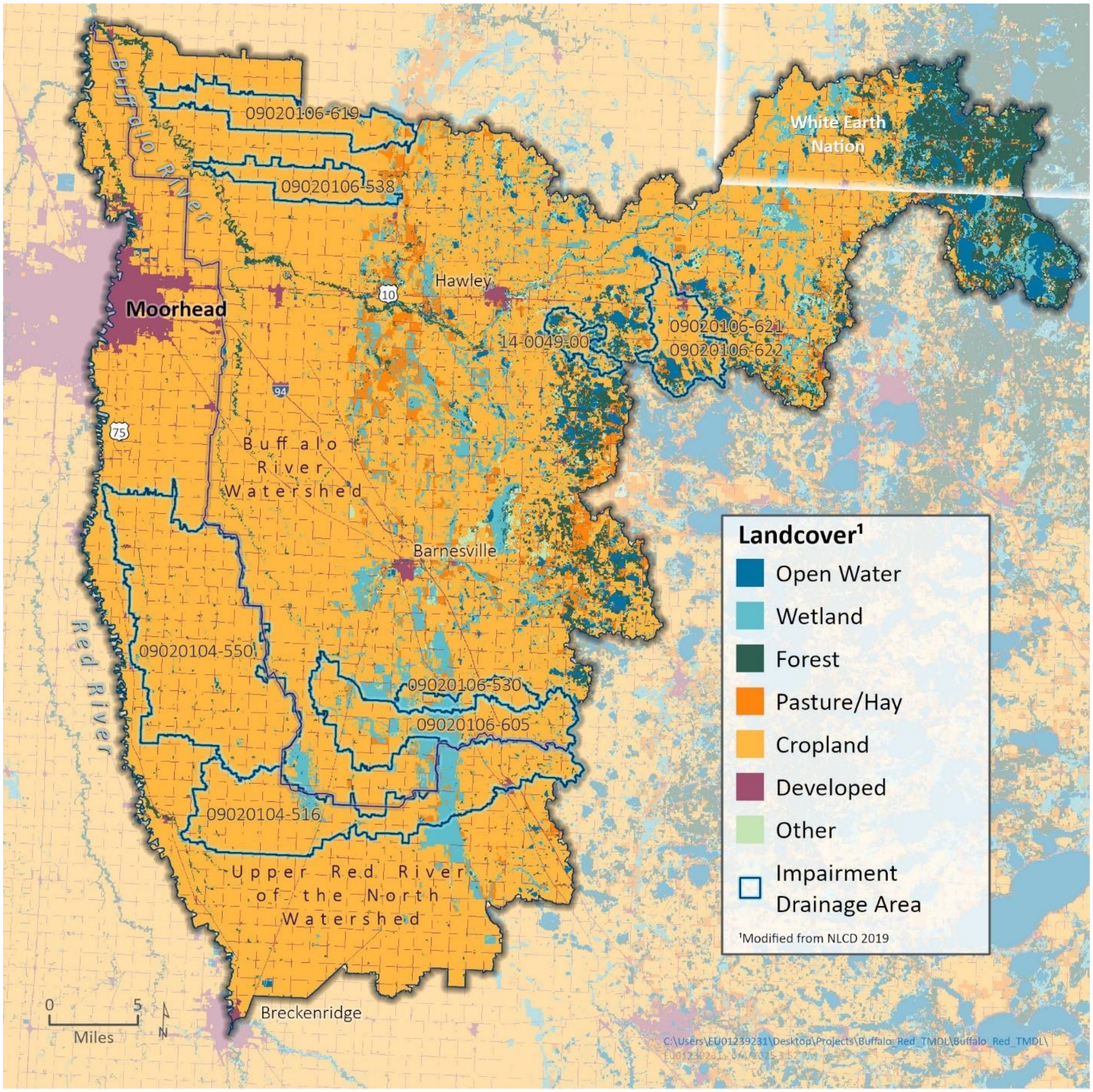
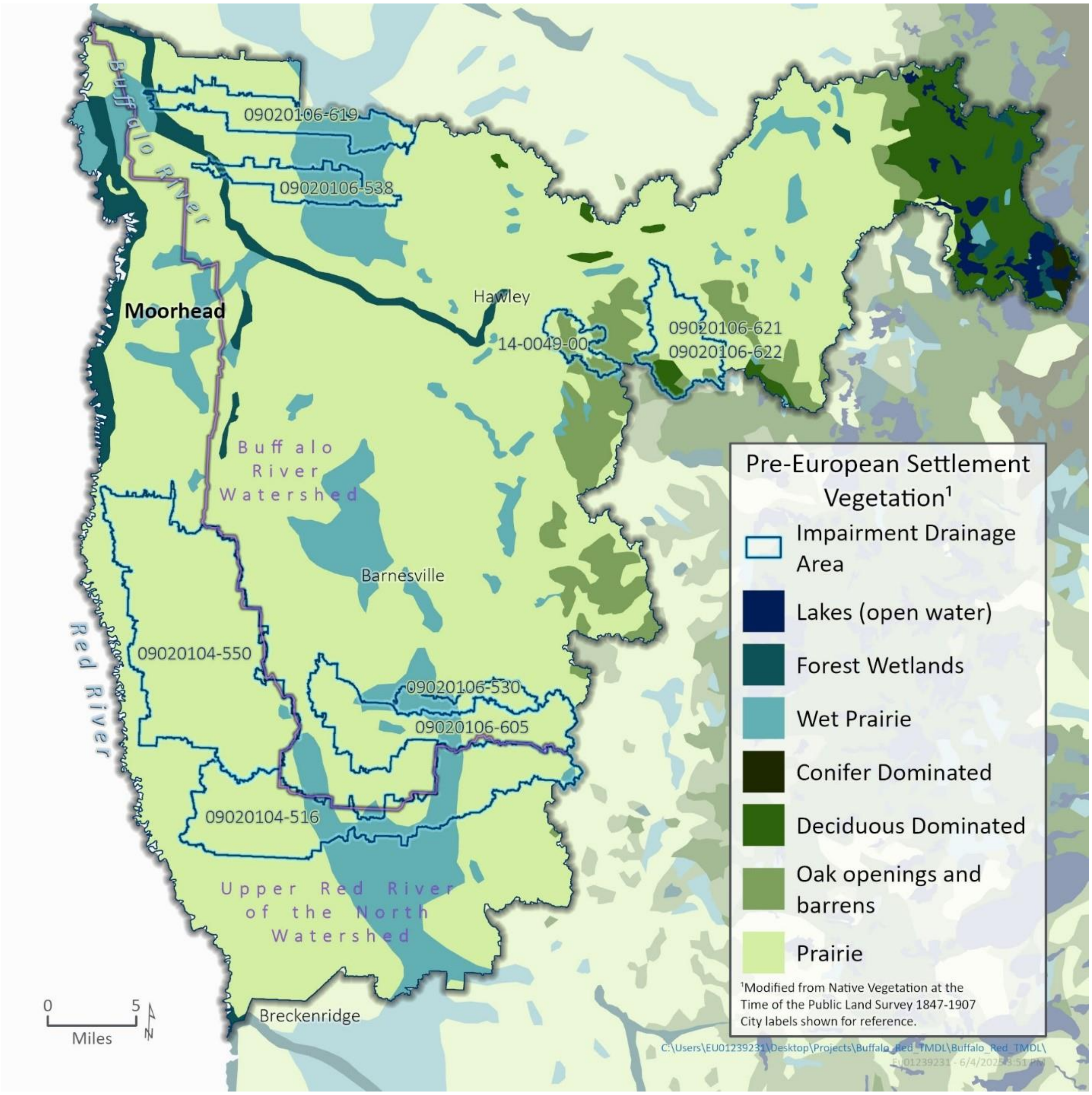


Figure 8. Pre-European settlement land cover in the BRW and URRW (DNR 2024c).



3.6 Flow and water quality

Available flow and water quality data are used throughout this report to evaluate impairments, identify trends, and calculate the TMDLs. Simulated daily average flows and simulated TSS and TP outputs from the BRW and URRW HSPF models (MPCA 2024g, MPCA 2024h), and water quality data from the MPCA's Environmental Quality Information System (EQuIS) were used for the analyses in this section. As a starting point, available data from the 10-year assessment period of 2011 through 2020, used by the MPCA to evaluate the watershed in early 2021, were used in the water quality summary for streams. Data from 2021 through 2024 were also used in this summary, where available, for consistency with the BRW and URRW HSPF models (data through 2022) and to include the most recently available water quality data. Available TSS data were also included from years prior to 2011, dating back to 2003, to provide a more robust dataset to support TMDL development for those impaired streams (see Section 3.6.1). Water quality data from 2010 and 2011 was used for the Lee Lake water quality summary because no other water quality data from Lee Lake has been collected by or provided to the MPCA since its listing on the 2012 IWL.

Simulated daily average flows from the BRW and URRW HSPF models (MPCA 2024g, MPCA 2024h) were used in developing the TMDLs in this report (Table 7). The HSPF models are calibrated to flow monitoring data and provide long-term, continuous flow estimates. Simulated flows are available at the downstream end of each model reach. The original model development reports for the BRW (Tetra Tech 2019) and the URRW (Tetra Tech 2018) describe the framework and the data that were used to develop the model. See also the brief summary of HSPF modeling in the introduction to Section 3.

Table 7. Model reaches used to simulate stream flow in impaired reaches in the BRW and URRW.

Reach numbers are from the BRW HSPF model (Tetra Tech 2019, MPCA 2024g) and the URRW HSPF model (Tetra Tech 2018, MPCA 2024h), individually. The simulations are from 1996 through 2022.

WID	Water body name	BRRW CWMP planning region	HSPF model reach number
09020104-516	Unnamed Creek	Upper Red	203
09020104-550	Wolverton Creek	Western	154
09020106-530	Unnamed creek (Lawndale Cr.)	Southern	196
09020106-538	County Ditch 25 (County Ditch 65)	Northern	114
09020106-605	Buffalo River, South Branch	Southern	197
09020106-619	County Ditch 10	Northern	105
09020106-621	Hay Creek	Mainstem	155
09020106-622			
14-0049-00	Lee	Mainstem	164

Flow duration curves were developed for each impaired stream reach addressed in this TMDL report using simulated daily average flows (1996 through 2022) from the BRW and URRW HSPF models (MPCA 2024g, MPCA 2024h). Simulated flows from all months were used to develop the TSS flow duration curves, even those outside of the time period that the applicable TSS standards are in effect (Section 4.1.1), while seasonal (June through September) simulated flows were used to develop the TP flow duration curves (Section 4.2.1). Flow duration curves relate mean daily flow to the percent of time those values have been met or exceeded. For example, an average daily flow at the 50% exceedance value is the midpoint or median flow value; average daily flow in the reach equals the 50% exceedance value 50% of the time. The curve is divided into five flow zones, including very-high flows (0% to 10% for TSS, 0% to 20% for TP), high flows (10% to 40% for TSS, 20% to 40% for TP), mid-range flows (40% to 60%), low flows (60% to 90% for TSS, 60% to 80% for TP), and very-low flows (90% to 100% for TSS, 80% to 100% for TP). Flow duration curves were then used to develop the loading capacities (LCs) for the TSS (see Section 4.1.1) and TP (see Section 4.2.1) TMDLs.

3.6.1 Total suspended solids

The TSS data are available as concentrations in mg/L for all impairments being addressed with a TSS TMDL in this report. Much of the TSS data included in this report were collected in 2008 through 2010 and in 2019 and 2020, coinciding with comprehensive watershed monitoring explained in Section 1.1. Additional monitoring by watershed partners provided the data collected in other years dating back to 2003 to include all available TSS data for the impaired streams addressed by a TSS TMDL in this report. As mentioned in Section 3.6, data from 2021 through 2024 provides the most recently available water quality data for TMDL development, while data prior to 2011 also supports TMDL development in showing that TSS concentrations in these impaired streams has been fairly consistent over time and restoration efforts are needed. The TSS concentrations are plotted for streams in the URRW in Figure 9 and for streams in the BRW in Figure 10. All TSS data included in this report are summarized in Table 8. Finally, TSS concentrations were converted to loads in tons/day and plotted on the load duration curves (LDCs) for each TSS TMDL in Section 4.1.9, described further in Section 4.1.1.

Figure 9. TSS data included in this report for Unnamed Creek (09020104-516) and Wolverton Creek (09020104-550); April through September, 2003-2024.

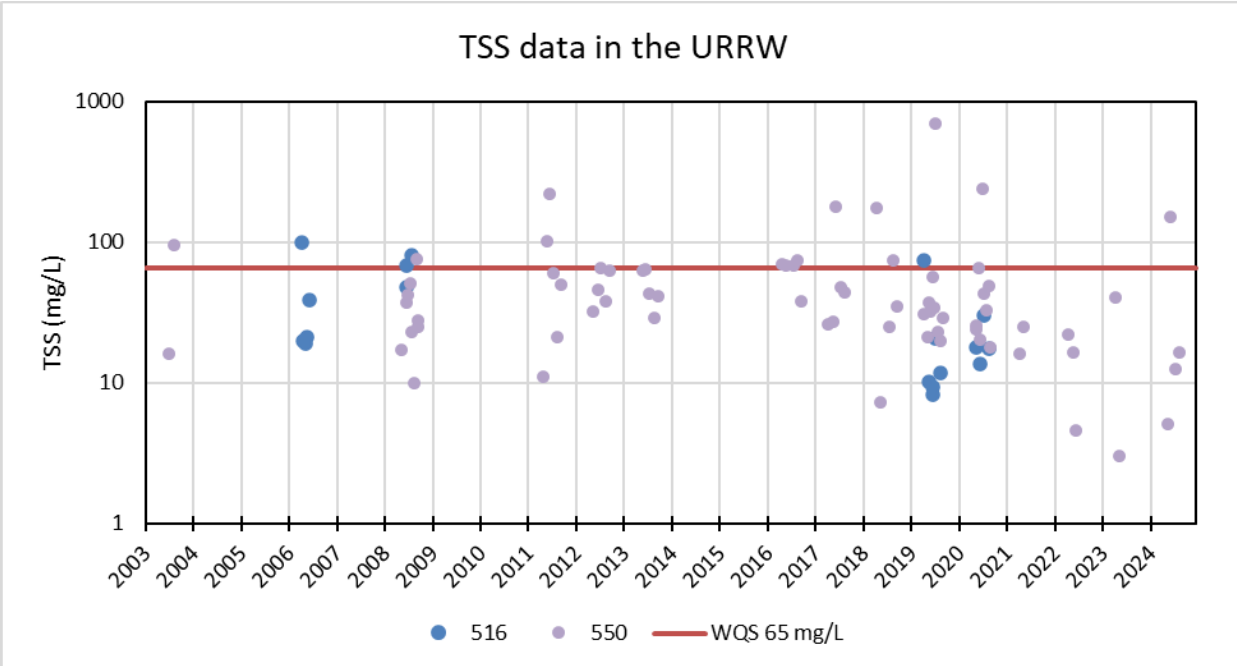


Figure 10. TSS data included in this report for Unnamed Creek/Lawndale Creek (09020106-530) and Hay Creek (09020106-621 and 09020106-622); April through September, 2003-2024.

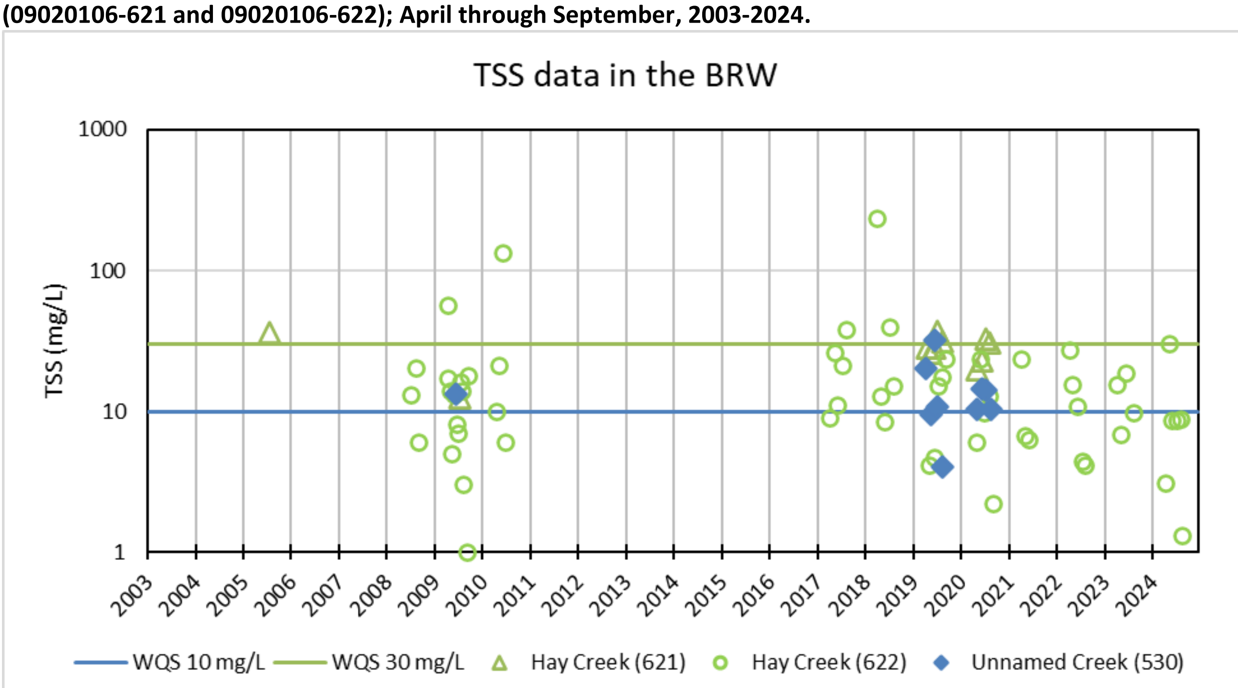


Table 8. TSS data summary for streams addressed by a TSS TMDL in this report; April through September, 2003-2024.
Applicable TSS water quality standards are not to be exceeded for more than 10% of the time and apply from April 1 through September 30.

WID	Water body name	Applicable TSS water quality standard	Monitoring site(s)	Years	Sample count	Mean (mg/L)	90th percentile (mg/L)	Max. (mg/L)	Min. (mg/L)	Number of exceedances	Frequency of exceedances
09020104-516	Unnamed Creek	65 mg/L	S004-150 S010-818 S010-821	2006, 2008, 2019-2020	18	34	76	100	8	4	22%
09020104-550	Wolverton Creek	65 mg/L	S003-271 S004-880 S005-322	2003, 2008, 2011-2013, 2016-2024	72	57	94	688	3	15	21%
09020106-530	Unnamed creek (Lawndale Creek)	10 mg/L	S011-172	2009, 2019-2020	10	14	21	32	4	8	80%
09020106-621	Hay Creek	30 mg/L	S010-134	2005, 2009, 2019-2020	11	28	36	37	13	5	45%
09020106-622	Hay Creek	30 mg/L	S005-133	2008-2010, 2017-2024	57	20	28	234	1	5	9%

3.6.2 River eutrophication

Available RES parameter data collected during the most recent 10-year period (2015 through 2024) were used for the three impairments receiving a TP TMDL in this report. While some older (i.e., pre-2015) RES parameter data is available for these reaches, diel DO flux, which is the only response variable that exceeds RES standards in these reaches, has only been measured within the last 10 years. No RES parameter data has been collected by or provided to the MPCA for these reaches since 2023. Monitoring sites with data used in the RES analysis for each impaired stream reach are provided in Table 9 along with a summary of the TP and available RES response variable data.

Appendix D. Stream TP TMDL supporting analysis, includes figures to help illustrate and visualize the seasonal (i.e., box plots) and flow-driven patterns (i.e., LDCs) of TP, chl-*a*, and DO in the three impaired reaches. Below is a summary of some of the key takeaways of the data summarized in Table 9 and analyses presented in Appendix D. Stream TP TMDL supporting analysis:

- TP concentrations in County Ditch 25 (County Ditch 65, 09020106-538) are consistently high during the summer months and well over the TP RES criteria.
- TP concentrations in Buffalo River, South Branch (09020106-605) and County Ditch 10 (09020106-619) frequently exceed the TP RES criteria in July and August and during most flow regimes. However, TP concentrations in these reaches are generally lower than County Ditch 25 (County Ditch 65).
- Chl-*a* concentrations in all three reaches are low and well below the RES chl-*a* criteria, suggesting planktonic algae (i.e., seston) is not a eutrophication concern in these reaches.
- Diel DO flux was high in all three reaches and exceeded the RES DO flux criteria during all summer data sonde deployments. Aquatic plants and/or periphyton attached to the sediment, rocks, or other substrate in these reaches are likely the primary drivers of high DO flux since water column chl-*a* measurements are consistently low.
- Diel DO flux in all three reaches is highest during low flow conditions and diel DO flux is lowest during higher flow conditions. This is further evidence that aquatic plants and/or periphyton are the primary eutrophication concerns in these reaches.
- MPCA stressor identification staff documented excessive algal growth and rooted macrophytes in County Ditch 25 (County Ditch 65) in 2019 and in Buffalo River, South Branch in 2019 and 2020, as well as abundant filamentous algae and duckweed in County Ditch 10 in 2019 (MPCA 2023a), further suggesting that aquatic plants and/or periphyton are driving the high DO flux and eutrophication in these impaired streams (see Section 3.7.3.2).

Table 9. Water quality data summary for streams addressed by a TP TMDL in this report; June through September, 2015-2023.
The applicable RES for streams in the SRNR are a summertime average to be less than or equal to the standard and apply from June 1 through September 30.

WID	Water body name	Monitoring site(s)	Years	RES parameter	Sample count	Maximum	Minimum	Number of exceedances	Summer Mean	Applicable RES water quality standard[1]
09020106-538	County Ditch 25 (County Ditch 65)	S011-136	2019-2020	TP (µg/L)	7	532	111	4	264	≤ 150
				chl-*a* (µg/L)	6	30.3	<1.0	0	9.5	≤ 35
				Diel DO Flux (mg/L)	1	10.2	10.2	1	10.2	≤ 4.5
				BOD (mg/L)	0	--	--	--	--	≤ 3.0
				pH (standard unit)	2	8.1	8.0	0	8.0	≥ 6.5; ≤ 9.0
09020106-605	Buffalo River, South Branch	S003-148	2016-2017, 2019-2021, 2023	TP (µg/L)	18	410	32	10	170	≤ 150
				chl-*a* (µg/L)	9	11.3	<1.0	0	4.2	≤ 35
				Diel DO Flux (mg/L)	2	6.1	5.4	2	5.8[2]	≤ 4.5
				BOD (mg/L)	3	<3.0	<3.0	0	<3.0	≤ 3.0
				pH (standard unit)	9	8.2	7.9	0	8.0	≥ 6.5; ≤ 9.0
09020106-619	County Ditch 10	S005-610	2019-2020, 2023	TP (µg/L)	8	399	24	2	138	≤ 150
				chl-*a* (µg/L)	7	5.3	<1.0	0	2.4	≤ 35
				Diel DO Flux (mg/L)	2	9.6	8.1	2	8.9[3]	≤ 4.5
				BOD (mg/L)	2	<3.0	<3.0	0	<3.0	≤ 3.0
				pH (standard unit)	2	8.5	8.2	0	8.3	≥ 6.5; ≤ 9.0

1. See Table 3 and Section 2.4.2 for an explanation of the applicable RES standards used in this analysis.
2. Diel DO flux was calculated using a sonde during continuous DO monitoring in 2019 and 2023; the summertime mean provided is the mean of the two deployments.
3. Diel DO flux was calculated using a sonde during continuous DO monitoring in 2019 and 2020; the summertime mean provided is the mean of the two deployments.

3.6.3 Lake eutrophication

Lake eutrophication parameter data available for Lee Lake is summarized below in Table 10 and plotted in Appendix E. Lee Lake supporting analysis. Data collected from Lee Lake in 2010 coincided with the last year of comprehensive watershed monitoring in the BRW previously mentioned in Section 1.1. Additional data collected during the 2011 field season were not available for the initial watershed assessments completed for the BRW in early 2011. Although Lee Lake was later assessed and added to the 2012 IWL, its nutrient impairment was not addressed as part of MPCA's BRW TMDL (MPCA 2016). As such, the Lee Lake nutrient impairment will be addressed with a TP TMDL in this report using the 2010 and 2011 data.

Table 10. Water quality data summary for Lee Lake (14-0049-00-201).
The lake eutrophication standards for deep lakes in the NCHF ecoregion apply from June 1 through September 30.

Lake eutrophication standard parameter	Sample count	Maximum	Minimum	Number of exceedances	Summer Mean	Applicable water quality standard
Phosphorus, total (TP)	8	113 µg/L	33 µg/L	5	52 µg/L	≤ 40 µg/L
Chlorophyll-*a* (chl-*a*)	8	46.8 µg/L	8.2 µg/L	5	21.2 µg/L	≤ 14 µg/L
Secchi disk transparency	8	1.9 m	0.9 m	7	1.2 m	≥ 1.4 m

3.7 Pollutant source summary

Sources of pollutants in the BRW and URRW include permitted and nonpermitted sources. The permitted pollutant sources discussed here are sources that require a NPDES permit. Most Minnesota NPDES permits are also SDS permits; however, some pollutant sources require SDS permit coverage alone without NPDES permit coverage (e.g., spray irrigation, large septic systems, land application of biosolids, and some feedlots). The phrase "nonpermitted" does not indicate that those pollutant sources are illegal, but rather that they do not require an NPDES or SDS permit. Some nonpermitted sources are unregulated, and some nonpermitted sources are regulated through non-NPDES programs and permits such as state and local regulations.

An overview of the permitted and nonpermitted sources of pollutants evaluated in this TMDL report and located within the subwatersheds of the impaired water bodies addressed in this TMDL report is provided below. Data on permitted sources were compiled and organized by MPCA staff in March 2024. Permitted and nonpermitted sources were further evaluated using various Geographic Information Systems databases and the BRW and URRW HSPF models (MPCA 2024g, MPCA 2024h). While there are permitted sources evaluated in this TMDL report, it is expected that the pollutant reductions required by this TMDL will be needed primarily from nonpermitted sources.

3.7.1 Overview of pollutant sources

The following sections provide an overview of all the permitted and nonpermitted sources evaluated in this TMDL report. Pollutant specific information for more significant sources is further provided in Sections 3.7.2 for TSS, 3.7.3 for phosphorus to rivers and streams, and 3.7.4 for phosphorus to Lee Lake.

3.7.1.1 Permitted sources

The permitted sources of pollutants evaluated in this TMDL report include municipal (or "domestic") wastewater, industrial wastewater, construction and industrial stormwater, and concentrated animal feeding operations (CAFO). There are no municipal separate storm sewer system (MS4) permitted communities in the subwatersheds of the impaired water bodies addressed in this TMDL report and there are no MS4 areas expected in these subwatersheds in the future.

Municipal and industrial wastewater

Municipal or industrial wastewater is domestic sewage, process wastewater, and other wastewater collected and treated by municipalities, industries, and other private entities before being discharged to water bodies as wastewater effluent. Wastewater enters surface water either as treated effluent or sometimes through releases of untreated wastewater. See Sections 3.7.2.1 and 3.7.3.1 for additional information.

Construction stormwater

Construction stormwater is regulated through an NPDES/SDS permit. Untreated stormwater that runs off of a construction site can carry sediment to surface water bodies. Because phosphorus travels absorbed to sediment, construction sites can also be a source of phosphorus. Phase II of the stormwater rules adopted by the EPA requires an NPDES/SDS permit for a construction activity that disturbs one acre or more of soil; a permit is needed for smaller sites if the activity is either part of a larger common plan of development or if the MPCA determines that the activity poses a risk to water resources. Coverage under the construction stormwater general permit requires BMPs and sediment and erosion control measures that reduce stormwater pollution during and after construction activities (see Section 8.1.2).

The land cover within the subwatersheds of the impaired water bodies addressed in this TMDL report is primarily agricultural. While construction may occur within these subwatersheds, most of the construction stormwater permit coverage issued by the MPCA in the BRW and URRW occurs in more developed areas such as in or near the cities of Barnesville, Hawley, Dilworth, and Moorhead. Potential TSS and TP loading from construction stormwater are also not explicitly modeled in the BRW and URRW HSPF models (MPCA 2024g, MPCA 2024h). Pollutant loading from construction stormwater is not considered to be a significant source of TSS or TP to the downstream impairments.

Industrial stormwater

Industrial stormwater is regulated through an NPDES/SDS permit when stormwater discharges have the potential to come into contact with materials and activities associated with industrial activity. Untreated stormwater that runs off an industrial site can carry sediment, phosphorus, and other pollutants to surface water bodies. Coverage under industrial stormwater permits require the design and implementation of BMPs and erosion and stormwater control measures that reduce, eliminate, or remove pollutants from stormwater prior to discharge from the facility. See Sections 3.7.2.1 and 3.7.3.1 for additional information.

Concentrated animal feeding operations

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

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

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

All CAFOs and feedlots with 1,000 or more AUs must be designed to contain all manure, manure contaminated runoff, process wastewater, and the precipitation from a 25-year, 24-hour storm event. Having and complying with an NPDES or SDS permit authorizes discharges to waters of the United States and waters of the state (with NPDES permits) or waters of the state (with SDS permits) due to a 25-year, 24-hour precipitation event (equivalent to approximately 4.7 inches of rain over 24-hours in the BRW and URRW, NOAA 2024) when the discharge does not cause or contribute to nonattainment of applicable state water quality standards. Large CAFOs with fewer than 1,000 AUs that have chosen to forego NPDES permit coverage are not authorized to discharge and must contain all runoff, regardless of the precipitation event. Large CAFOs permitted with an SDS permit are authorized to discharge to waters of the state, although they are not authorized to discharge to waters of the U.S. Therefore, many large CAFOs in Minnesota have chosen to obtain an NPDES permit, even if discharges have not occurred at the facility.

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

There are currently no CAFOs located within the subwatersheds of any of the impaired streams addressed in this report. See Section 3.7.4.1 for CAFOs in the Lee Lake Subwatershed. All other feedlots and the land application of manure are accounted for as nonpermitted sources and are discussed further in Section 3.7.1.2.

3.7.1.2 Nonpermitted sources

The nonpermitted sources of pollutants evaluated in this TMDL report include watershed runoff, stream channel and lakeshore erosion and bank instability, other stream channel conditions, non-CAFO animal feedlots and manure application, pastures, nonpermitted wastewater, wind erosion and atmospheric deposition, and natural background sources.

Watershed runoff

Precipitation that falls in a watershed drains across the land surface, and a portion of it eventually reaches lakes and streams. Sediment, phosphorus, and other pollutants are carried with the runoff water and delivered to surface water bodies. The primary sources of pollutants in watershed runoff from rural and developed landscapes may include soils and sediment, fertilizers, pesticides, fuels, de-icing products, vegetation such as leaves and other plant litter, waste from livestock, pets, and wildlife, and more. Contributions of TSS and TP from watershed runoff were estimated for the impaired water bodies addressed in this TMDL report using the HSPF models for the BRW and URRW (MPCA 2024g, MPCA 2024h). In general, watershed runoff in the BRW and URRW is greatest during and after precipitation events, especially during the months before or after the growing season without significant crop cover, and during periods of spring snow melt (MPCA 2016, MPCA 2017a). In the BRW and URRW, these conditions may be exacerbated by projected increases of large precipitation events (Section 3.1). Additional information is provided in Sections 3.7.1.3, 3.7.2.2, 3.7.3.2, and 3.7.4.2.

Stream channel and lakeshore conditions

Stream channel and lakeshore erosion and bank instability are very common in the ditches and stream systems within the BRW, URRW, and throughout the entire Red River Basin, as well as many of the lakes within the BRW. While stream channel and lakeshore erosion and bank instability can occur naturally, much of this erosion and instability are caused by human alterations on the landscape. The resulting erosion and instability will then deliver sediment, phosphorus, and other pollutants into the immediate water body as well as downstream. Primary causes of this erosion and instability include the conversion of natural riparian and lakeshore vegetation to agricultural or developed landscapes, a shift in cropping patterns from hay and small grains to row crop, the channelization of waterways, livestock access to the stream channels or lakeshores, and most significantly, continued increases in both average and especially peak stream flows due to agricultural and urban drainage as well as projected increases of large precipitation events (MPCA 2016, MPCA 2017a, MPCA 2023a, DNR 2023a). Additional information is provided in Sections 3.7.1.3, 3.7.2.2, 3.7.3.2, 3.7.4.2 and 8.

Another stream condition commonly evaluated is the concentration of DO within the water column due to its impact on fish, macroinvertebrates, and other aquatic life. The concentrations of DO in streams changes seasonally as well as daily in response to changing air and water temperatures, sunlight and cloud cover conditions, changes in stream flow, and changes in other chemical, physical, and biological processes within the stream channel. For the purpose of MPCA's stressor identification work and this TMDL report, eutrophication (i.e., increased phosphorus loading) can cause excessive aquatic plant and algae growth, typically leading to a decline in daily minimum DO concentrations and increased magnitude of daily DO fluctuations (diel DO flux). These effects of eutrophication, as observed by MPCA staff, were often exacerbated by increased temperatures and low flow conditions (MPCA 2023a). As discussed in Section 3.6.2 and further addressed in Section 3.7.3.2, these conditions are found to be the primary drivers of diel DO flux in the impaired streams addressed in this report.

Non-CAFO animal feedlots and manure application

Feedlots under 1,000 AUs and those that are not federally defined as CAFOs do not operate with NPDES or SDS permits. In Minnesota, feedlots with greater than 50 AUs, or greater than 10 AUs in shoreland areas, are required to register at least once in a four-year period with the county feedlot officer if the county is delegated, or with the MPCA if the county is nondelegated. Facilities with fewer AUs are not required to register. Shoreland is defined by Minn. R. 7020.0300 as land within 1,000 feet from the normal high water mark of a lake, pond, or flowage, and land within 300 feet of a river or stream.

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

Feedlots, manure storage areas, and land application of manure can be a source of sediment, phosphorus, and other pollutants due to the runoff of manure or manure-contaminated water. The risk of these pollutant sources can be increased at those feedlots, manure storage areas, and manure application fields located within shoreland and riparian areas or near other sensitive features that contribute to surface or groundwater. All feedlots, manure storage areas, and land application fields are subject to rules and regulations under Minn. R. ch. 7020, regardless of AUs (see Section 6.2.2).

Feedlots that obtain an interim or construction short form feedlot permit, CAFO feedlots with or without an NPDES or SDS operating permit (see Section 3.7.1.1), and any feedlots with 300 or more AUs that do not use a licensed Commercial Animal Waste Technician to apply their manure are required to develop and maintain a manure management plan. Manure management plans are required to help ensure that manure application rates do not exceed crop nutrient needs and that necessary setbacks from surface waters, drain tile intakes, and other sensitive features are observed (MPCA 2021a).

The registered non-CAFO feedlots located within the subwatersheds of the impaired water bodies addressed in this TMDL report are summarized in Table 11 and their locations are shown in the figures in Appendix C. Subwatershed maps. The MPCA’s HSPF models (MPCA 2024g, MPCA 2024h) suggest that non-CAFO feedlots contribute little to no TSS (Table 13) or TP (Table 14) to the impaired water bodies addressed in this TMDL report on an annual basis.

Table 11. Registered non-CAFO feedlots located within the subwatersheds of impaired water bodies addressed in this report (MPCA 2024i).

WID	Water body name	BRRW CWMP planning region	Feedlots with >0 AU	Cattle AU[1]	Birds AU[2]	Pigs AU	Other AU[3]	Total AU
09020104-516	Unnamed Creek	Upper Red	3	110	270	0	2	382
09020104-550	Wolverton Creek	Western	4	345.9	0.05	0	0	345.95
09020106-530	Unnamed creek (Lawndale Creek)	Southern	1	0	378	0	0	378
09020106-538	County Ditch 25 (County Ditch 65)	Northern	0	0	0	0	0	0
09020106-605	Buffalo River, South Branch	Southern	10	708.9	1,718	0	0	2,426.9
09020106-619	County Ditch 10	Northern	1	10	0	0	0	10
09020106-621 09020106-622	Hay Creek	Mainstem	2	401	0	0	26	427
14-0049-00	Lee Lake	Mainstem	2	3.6	0	780	1	784.6

1. Primarily includes beef cattle but also includes dairy cattle.
2. Primarily includes turkeys but also includes chickens.
3. Primarily includes horses but also includes goats and sheep.

While a full accounting of the fate and transport of manure was not conducted for this project, a large portion of it is ultimately applied to the land surface and, therefore, this source is of possible concern in the BRW and URRW. Minn. R. 7020.2225 contains several additional requirements for land application of manure that, when followed, should help reduce this concern. However, there are no explicit requirements for treatment of the manure prior to land application.

Pasture

The MPCA's HSPF models (MPCA 2024g, MPCA 2024h) suggest that runoff from pastures and grasslands contribute very little TSS (Table 13) and TP (Table 14) to the impaired water bodies addressed in this TMDL report on an annual basis. The numbers provided in Table 12, below, are from registered feedlots that are also indicated as having livestock housed on or with access to pasture (MPCA 2024i), as well as pasture land cover estimates provided by NLCD 2019 (USGS 2022). However, pastures are not required to be registered, so the numbers provided below are a conservative estimate and there may be more livestock on pasture in the watersheds. While livestock may be accessing water bodies within the watersheds, none of the impaired streams addressed with a TSS TMDL in this report are indicated as having unrestricted cattle access within or upstream of the impaired reach (MPCA 2023a). Also, review of aerial imagery and the *Buffalo River Watershed Stressor Identification Report – Lakes* (DNR 2023b) does not suggest that livestock have unrestricted access to the shorelines of Lee Lake.

Table 12. Estimated pasture operations located within the subwatersheds of impaired water bodies addressed in this report (USGS 2022, MPCA 2024i).

WID	Water body name	BRRW CWMP planning region	Percent of land area in pasture	Feedlots with >0 AU	Feedlots with pasture access	Pasture AU[1]
09020104-516	Unnamed Creek	Upper Red	1.4%	3	1	81
09020104-550	Wolverton Creek	Western	<0.01%	4	2	145.9
09020106-530	Unnamed creek (Lawndale Creek)	Southern	3.9%	1	0	0
09020106-538	County Ditch 25 (County Ditch 65)	Northern	1.2%	0	0	0
09020106-605	Buffalo River, South Branch	Southern	2.0%	10	4	427
09020106-619	County Ditch 10	Northern	2.7%	1	1	10
09020106-621 09020106-622	Hay Creek	Mainstem	3.6%	2	2	427
14-0049-00	Lee Lake	Mainstem	8.7%	4[2]	1	4.6

1. It is assumed that beef and dairy cattle are the most likely species to be on pasture in the BRW and URRW, however, not all cattle housed in the watershed are expected to have access to pasture. These may also include horses, goats, sheep, and other species.
2. There are two CAFO feedlots in this impaired subwatershed. Animals from these facilities are not expected to be on pasture.

Nonpermitted wastewater

Individual subsurface sewage treatment systems

Adequate wastewater treatment is vital to protecting the health, safety, and environment in Minnesota. More than 600,000 Minnesota homes and businesses use subsurface sewage treatment systems (SSTSs). SSTSs that fail to treat wastewater adequately are a threat to groundwater used for drinking water and to surface water used for recreation. Inadequate treatment of wastewater/sewage, which contains bacteria, viruses, parasites, nutrients, and chemicals, can result in contamination of drinking water sources. Additionally, straight-pipe wastewater “systems,” which route raw wastewater to the ground or nearby waters, can directly impact lakes, streams, and wetlands. Straight-pipe systems, systems that cause a reoccurring sewage backup into a dwelling or other establishment, systems with electrical hazards, or sewage tanks with unsecured, damaged, or weak maintenance hole covers are considered to be an imminent threat to public health or safety (ITPHS) (Minn. R. 7080.1500, subp. 4).

Failure of SSTSs can happen for a variety of reasons, including excessive water use, poor design, physical damage, and lack of maintenance. Common limitations that contribute to failure include seasonal high-water table, fine-grained soils, bedrock, and fragipan (i.e., altered subsurface soil layer that restricts water flow and root penetration). Septic systems can fail hydraulically through surface breakouts or hydrogeologically from inadequate soil filtration. Failing SSTSs and ITPHSs can be sources of sediment, phosphorus, and other pollutants to surface waters.

In Minnesota, counties estimate SSTS compliance rates for planning purposes and trend analysis and provide this data to the MPCA. In the BRW and URRW, compliance rates have steadily improved including an estimated 99% compliance rate in Becker County since 2020 and an estimated 91% compliance rate in Clay County since 2018. As of the end of 2024, Becker County estimates that 1% of existing SSTS in the county are failing and there are no remaining ITPHS, Clay County estimates 7% are failing and 2% of existing SSTS are ITPHS, and Wilkin County estimates 26% are failing and 1% are ITPHS (MPCA 2024j). Estimates are not provided in this report for Otter Tail County since very small portions of the impaired subwatersheds addressed in this report are located in far western Otter Tail County.

The approximate number of properties served by an SSTS within the subwatersheds of impaired streams addressed in this TMDL report were estimated by MPCA staff using county parcel data and aerial imagery. Because of the relatively small number and dispersal of estimated failing SSTS and ITPHS in each subwatershed, because land cover in the subwatersheds is primarily agricultural, and because TSS and TP loading from failing SSTS and ITPHS is not explicitly quantified in the nonpermitted watershed runoff estimates provided by HSPF (MPCA 2024g, MPCA 2024h), failing SSTS and ITPHS are not considered to be a significant source of TSS and TP to the downstream impairments.

Other potential nonpermitted wastewater sources may include straight-pipe discharges, earthen pit outhouses, and land application of septage. Straight-pipe systems are unpermitted and illegal sewage disposal systems that transport raw or partially treated sewage directly to a lake, stream, drainage system, or the ground surface. Straight-pipe systems are required to be addressed 10 months after discovery (Minn. Stat. § 115.55, subd. 11). Outhouses, or privies, are legal disposal systems and are regulated under Minn. R. 7080.2150, subp. 2F and Minn. R. 7080.2280. Septage disposal is regulated under Minn. R. ch. 7080 as well as in local and federal regulations. These sources also are not considered to be a significant source of TSS and TP to the downstream impairments.

Areas and communities with SSTS concerns

To ensure that effective sewage treatment occurs across the state, the MPCA regularly conducts surveys of local governmental units to identify areas in the state that may be areas of concern; these areas are defined as five or more homes within a half mile of each other that have inadequate sewage treatment. These areas are generally unincorporated communities, may not have an organized structure, may consist of families with limited financial resources, and many times do not qualify for the same financial assistance as large, incorporated communities. The communities may have been listed because they were known to be noncompliant or a concern for any number of reasons including, but not limited to:

- Being an imminent threat to public health and safety that backs up into the house or surface discharges inadequately treated wastewater.
- Having treatment systems that are failing to protect groundwater due to leaky tanks or not enough soil separation under the SSTS before reaching saturated soil conditions.
- Having an unknown status of SSTS compliance in the area.
- Having poor soils in the area, small lot sizes, or densely developed lots.
- Having generally older systems that may be out of compliance.

As of 2024, there were six communities in the BRW and URRW identified as areas and communities with SSTS concerns, with just one of those being located within the subwatershed of an impaired stream addressed in this report and being identified as having poor soils and small lot sizes. However, this area is not considered to be a significant source of pollutants to the downstream impairment as there are relatively few (approximately 10) residences within the area, the area is over two miles from the impaired stream reach, and a majority of the impaired stream's subwatershed is cropland. There are no areas and communities with SSTS concerns identified in the Lee Lake Subwatershed.

Wind erosion and atmospheric deposition

Wind erosion from cropland and other landscapes is common during dry conditions in the BRW and URRW, and throughout the Red River Basin (MPCA 2019). Strong seasonal winds are capable of transporting sediment and other materials from crop fields, industrial and construction sites, developed areas, and other unprotected soils. Other sources of atmospheric deposition can include pollen, soils, particulate matter, fertilizers, plant litter, and other windblown materials. Many of the factors that contribute to watershed runoff from cropland and other sources may also apply to wind erosion, and many of the strategies to mitigate the effects of watershed runoff may also apply to wind erosion.

Explicit estimates for TSS contributions from wind erosion and atmospheric deposition to the impaired water bodies addressed in this TMDL report were not provided in the BRW and URRW HSPF models (MPCA 2024g, MPCA 2024h). Windblown sediment may be a source of TSS within the BRW and URRW but is likely a small percentage of total TSS within the impaired streams addressed in this TMDL report. Estimates for TP contributions from atmospheric deposition to the impaired water bodies addressed in this TMDL report are provided in Table 14. However, atmospheric deposition is estimated to be a minor source of TP and is not expected to affect the water bodies' ability to meet state water quality standards.

Natural background sources

"Natural background" is defined in both Minnesota statute and rule. The Clean Water Legacy Act (Minn. Stat. § 114D.15, subd. 10) defines natural background as "characteristics of the water body resulting from the multiplicity of factors in nature, including climate and ecosystem dynamics, that affect the physical, chemical, or biological conditions in a water body, but does not include measurable and distinguishable pollution that is attributable to human activity or influence." Minn. R. 7050.0150, subp. 4 states, "'Natural causes' means the multiplicity of factors that determine the physical, chemical, or biological conditions that would exist in a water body in the absence of measurable impacts from human activity or influence."

Natural background sources are inputs that would be expected under natural, undisturbed conditions. Natural background sources can include inputs from natural geologic processes such as natural soil loss from upland erosion and stream development, atmospheric deposition, and loading from forested land, wildlife, etc. However, for each impairment, natural background levels are implicitly incorporated in the water quality standards used by the MPCA to determine/assess impairment, and therefore natural background is accounted for and addressed through the MPCA's water body assessment process. Natural background conditions were evaluated within the source assessment portion of this study. These source assessment exercises indicate that natural background inputs are generally low compared to livestock, cropland, stream bank, wastewater treatment facilities, failing SSTSs, and other anthropogenic sources.

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

3.7.1.3 Pollutant source estimates

The subwatersheds of the impaired water bodies addressed in this TMDL report are primarily agricultural (Table 6). As such, and according to MPCA's HSPF models for the BRW and URRW (MPCA 2024g, MPCA 2024h), the main source of TSS and TP within the impaired subwatersheds is cropland runoff. Additional pollutant sources include stream channel and stream bank erosion caused by increasing average and peak flows and stream and ditch instability, runoff from developed areas, and lakeshore instability. To a lesser extent, TSS and TP may be entering the impaired water bodies from wetlands and other upstream water bodies, non-CAFO feedlots, pasture or grassland runoff, forested areas, and atmospheric deposition (i.e., TP that is bound to particles in the air and then deposited directly onto surface waters). Annual estimated percent contributions of TSS (Table 13) and TP (Table 14) to the impaired water bodies from the sources that are explicitly modeled in MPCA's HSPF models are provided below.

Table 13. Annual percent contributions of TSS within the subwatersheds of impaired streams addressed by a TSS TMDL in this report as estimated by HSPF, 1996 – 2022 (MPCA 2024g, MPCA 2024h).

WID	Water body name	BRRW CWMP planning region	Water/ Wetlands	Forest	Grassland /Pasture	Conventional Cropland	Conservation Cropland	Developed	Bank/Bed Erosion	Other[1]
09020104-516	Unnamed Creek	Upper Red	0.15%	0.02%	1.49%	86.78%	1.36%	2.60%	7.25%	0.35%
09020104-550	Wolverton Creek	Western	<0.01%	0.01%	0.14%	63.45%	1.99%	1.44%	32.95%	<0.01%
09020106-530	Unnamed creek (Lawndale Creek)	Southern	0.54%	0.00%	0.00%	8.88%	0.28%	13.44%	76.86%	0.00%
09020106-621 09020106-622	Hay Creek	Mainstem	0.09%	0.07%	0.19%	67.17%	1.96%	6.53%	23.66%	0.33%

1. Includes non-CAFO feedlots (Table 11) and permitted wastewater and stormwater facilities (Section 3.7.2.1,Table 15, Table 17, Table 18).

Table 14. Annual percent contributions of TP within the subwatersheds of impaired water bodies addressed by a TP TMDL in this report as estimated by HSPF, 1996 – 2022[1] (MPCA 2024g).

WID	Water body name	BRRW CWMP planning region	Water/ Wetlands	Forest	Grassland /Pasture	Conventional Cropland	Conservation Cropland	Developed	Atmospheric Deposition	Other[1]
09020106-538	County Ditch 25 (County Ditch 65)	Northern	0.00%	0.06%	0.02%	88.95%	7.34%	3.58%	0.05%	0.00%
09020106-605	Buffalo River, South Branch	Southern	2.65%	0.48%	4.69%	83.59%	4.96%	3.38%	0.25%	0.00%
09020106-619	County Ditch 10	Northern	0.03%	0.15%	1.50%	88.09%	7.26%	2.94%	0.03%	<0.01%
14-0049-00	Lee Lake	Mainstem	0.55%	1.34%	3.11%	75.56%	9.75%	5.99%	1.98%	1.72%

1. Includes non-CAFO feedlots (Table 11) and permitted wastewater and stormwater facilities (Section 3.7.3.1, Table 20, Table 21).

3.7.2 Total suspended solids source summary

3.7.2.1 Permitted sources

The permitted sources of TSS within the subwatersheds of impaired streams addressed with a TSS TMDL in this report include municipal wastewater, construction and industrial stormwater, and an individual NPDES/SDS permitted facility. There are no permitted MS4s in these subwatersheds and none are expected in the future, and there are currently no CAFOs located within these subwatersheds.

Municipal wastewater

There are three municipal WWTPs located within the subwatersheds of the impaired streams addressed by a TSS TMDL in this report. The locations of these facilities are shown in the figures in Appendix C. Subwatershed maps and are summarized in Table 15 below.

Table 15. Municipal wastewater facilities located within the subwatersheds of impaired streams addressed by a TSS TMDL in this report.

WID	Water body name	BRRW CWMP planning region	Facility name, Designation	Facility type	Permit Number
09020104-516	Unnamed Creek	Upper Red	Rothsay WWTP; SD 001	Municipal	MNG585064
09020104-550	Wolverton Creek	Western	Comstock WWTP; SD 001	Municipal	MN0023116
09020106-621 09020106-622	Hay Creek	Mainstem	Lake Park WWTP; SD 002	Municipal	MNG585157

1. Comstock WWTP is currently permitted under MPCA's general wastewater permit MNG585131. A permit application was submitted to upgrade Comstock WWTP and is being reviewed by MPCA as individual permit number MN0023116. See additional discussion in Section 4.1.3.1.

Rothsay, Comstock, and Lake Park WWTPs are all minor, Class D wastewater pond systems with a controlled discharge to surface waters from a secondary stabilization pond. These facilities are generally authorized to discharge up to six inches of water per day during the acceptable discharge periods of March 1 through June 30 and September 1 through December 31. Furthermore, pond discharge rates are limited so as to not create a shock load on the receiving waters, disturb the pond bottom sediment in the area of the intake, or flood downstream properties. All 3 facilities are required to sample twice per week during discharge events for TSS and have TSS concentration effluent discharge limits of 45 mg/L as a calendar month average and 65 mg/L as a maximum calendar week average. The facilities are also subject to specific TSS loading discharge limits, which are summarized in Table 16 below. If sampling by the permittee indicates a violation of these or any other discharge limitations specified in their permit, the permittee must immediately make every effort to verify the violation by collecting additional samples and, if appropriate, investigate the cause of the violation, and take action to prevent future violations.

Review of monthly monitoring data reported by Rothsay, Comstock, and Lake Park WWTPs from 2011 through 2024 are summarized in Table 16 below. These data suggest that all three facilities have generally discharged below and in accordance with their applicable TSS discharge limits. During that time period, Rothsay WWTP reported only 5 exceedances of applicable TSS limits out 60 total discharge events (all 5 being since 2020). Comstock WWTP reported 4 exceedances out of a total of 22 events (all 4 since 2019). Lake Park WWTP reported 3 exceedances of the permitted TSS discharge limit out of 47 total discharge events, with only 1 of those occurring since 2021, and with an additional 2 discharge events reported as below the permitted TSS concentration limits but exceeding the applicable 30 mg/L TSS standard for Hay Creek (MPCA 2024k).

Additionally, from 2011 through 2024, Lake Park WWTP has reported no incidents or releases of untreated wastewater, Rothsay WWTP reported just one minor release that did not reach surface waters, and Comstock WWTP reported one discharge to ice covered waters and one release from their secondary stabilization pond that was found to not impact surface waters. There are no combined sewer overflows in the BRW and URRW (MPCA 2024l).

The MPCA's HSPF models (MPCA 2024g, MPCA 2024h) suggest that municipal wastewater contributes very small portions (<0.4%) of the annual sediment loading to the impaired streams addressed in this TMDL report (Table 13). Based on these data and based on the location of the Rothsay and Comstock WWTPs in relation to the impaired stream reaches, these WWTPs are not considered to be significant sources of TSS to the downstream impairments.

Table 16. Summary of TSS effluent discharge limits and monthly monitoring data for Rothsay, Comstock, and Lake Park WWTPs.

Facility Name	Applicable stream TSS WQ standard (mg/L)	Permitted TSS concentration limits (mg/L)[1]	Permitted TSS loading limits (kg/day)[1]	Number of recent limit exceedances; % of total discharges
Rothsay WWTP	65	45 / 65	88.7 / 128.2[2]	5; 8%
Comstock WWTP	65	45 / 65	39.4 / 56.9[3]	4; 18%
Lake Park WWTP	30[4]	45 / 65	223.2 / 322.4[2]	3; 6%[5]

1. Permitted TSS concentration and loading limits are presented as # as a calendar month average/# as a maximum calendar week average.
2. Current TSS loading limits for Rothsay and Lake Park WWTPs became effective in new permits issued on January 2, 2024.
3. The loading limits for Comstock WWTP are estimated based on the proposed facility details provided for draft individual permit MN0023116. See additional discussion in Section 4.1.3.1. The current loading limits for Comstock WWTP under MNG585131 are 30.5 kg/day / 44.1 kg/day.
4. Hay Creek (WIDs 09020106-621 and 09020106-622) is located in the central river nutrient region and is subject to a 30 mg/L TSS standard; however, Lake Park WWTP has permitted TSS concentration limits of 45 mg/L and 65 mg/L consistent with other WWTPs in the BRW. See Section 4.1.3.1 for additional information.
5. Lake Park WWTP has reported 2 additional discharge events that are below their permitted TSS concentration limits but narrowly exceeded the applicable 30 mg/L TSS standard for Hay Creek (32 mg/L and 35 mg/L, respectively).

Construction stormwater

Pollutant loading from construction stormwater was addressed in Section 3.7.1.1 and is not considered to be a significant source of TSS to the downstream impairments.

Industrial stormwater

There are three facilities permitted under Minnesota's general NPDES/SDS permit for nonmetallic mining and associated activities (MNG490000) that are located within the subwatersheds of impaired streams addressed with a TSS TMDL in this report. The locations of these facilities are shown in the figures in Appendix C. Subwatershed maps and are summarized in Table 17 below.

These facilities are permitted under subsector J1 of the nonmetallic mining and associated general NPDES/SDS permit (MNG490000). The primary activity of these facilities is the mining of construction sand and gravel, and Sector J1 permittees are authorized to discharge stormwater and mine site dewatering to waters of the state, including groundwater, and/or use industrial stormwater ponds, sedimentation basins, and/or infiltration devices for stormwater management. At all three facilities listed in Table 17, stormwater is contained on site and therefore discharge monitoring and intervention limits do not apply. The permittees are required to develop and implement a pollution prevention plan to eliminate or minimize contact of stormwater with materials that may result in pollution and identify and manage nonstormwater discharges (MPCA 2024m). Pollutant loading from these sources is not explicitly modeled by HSPF and is not considered to be a significant source of TSS to the downstream impairments.

Table 17. Industrial stormwater facilities located within the subwatersheds of impaired streams addressed by a TSS TMDL in this report.

WID	Water body name	BRRW CWMP planning region	Facility name	Designation	Permit Number
09020104-516	Unnamed Creek	Upper Red	Turner Sand & Gravel Inc	LA 005	MNG490635
09020104-550	Wolverton Creek	Western	Turner Sand & Gravel Inc	LA 006	MNG490635
			Wilkin County Highway Department – Gronseth Pit	LA 002	MNG490182

Individual NPDES/SDS permits

Minn-Dak Farmers Cooperative – Peet Piling Ground (MN0070386, MNR053FKP) is used for the temporary storage of sugar beets after harvesting and prior to processing. The location of this facility is shown in Figure 23 of Appendix C. Subwatershed maps. The facility is authorized under individual NPDES/SDS permit MN0070386 and Sector U of the multi-sector industrial stormwater general NPDES/SDS permit (MNR053FKP) to use designed infiltration systems or industrial stormwater ponds for stormwater management (MPCA 2024n). The facility is designed to capture runoff from the beet piling sites in an on-site sedimentation pond with no discharge structure. The permittee constructed a new beet piling strip in 2022, and permit MN0070386 required all runoff from that piling strip to be directed into the sedimentation pond by July 15, 2024. Effluent from the pond is currently discharged through a portable pump at a maximum rate of 500 gallons per minute (gpm), and the permittee is authorized under permit MN0070386 to discharge up to six inches of water per day from the pond during the acceptable discharge periods of March 1 through June 30 and September 1 through December 31. Previously, the discharge was directed north through adjacent farmland before discharging to surface waters upstream of Wolverton Creek. The permittee has been authorized to reroute the discharge south of the facility through a force main pipe and then to the same receiving water. This change was authorized to prevent the discharge from flowing over private land. If there is more water or loading in the pond than what can be released or managed in accordance with permit MN0070386, the permittee is authorized to haul excess water to its permitted facility in Wahpeton, North Dakota for processing.

Table 18. Individual NPDES/SDS permitted facilities located within the subwatersheds of impaired streams addressed by a TSS TMDL in this report.

WID	Water body name	BRRW CWMP planning region	Facility name	Designation	Permit Number
09020104 -550	Wolverton Creek	Western	Minn-Dak Farmers Cooperative – Peet Piling Ground	SD 001; BML-01	MN0070386; MNR053FKP

Permit MN0070386 for the aforementioned facility requires twice per week sampling during discharge events for TSS and includes TSS effluent discharge limits of 30 mg/L as a calendar month average and 45 mg/L as a maximum calendar week average, which are more stringent than the applicable 65 mg/L TSS standard for class 2B streams in the south river nutrient region. The permit also includes TSS loading limits of 95.7 kg/day as a calendar month average and 143.6 kg/day as a maximum calendar week average as of June 1, 2024.

Review of monthly monitoring data reported by and on file for the permittee from 2014 through 2024 shows only 1 discharge event in 2016 exceeded the applicable 30 mg/L and 45 mg/L TSS permit limits, although this discharge was below the applicable 65 mg/L TSS standard and 100 mg/L benchmark value. All other reported discharges were below the applicable TSS concentration and loading permit limits (MPCA 2024k). Additionally, the facility had no reported incidents or releases of untreated stormwater during that same time period (MPCA 2024l). The MPCA's URRW HSPF model (MPCA 2024h) suggests that this source contributes minimal (<0.01%) annual sediment loading to Wolverton Creek (Table 13). Therefore, Minn-Dak Farmers Cooperative – Peet Piling Ground is not considered a significant source of TSS to Wolverton Creek.

3.7.2.2 Nonpermitted sources

Significant sources of TSS within the subwatersheds of impaired streams addressed with a TSS TMDL in this report include watershed runoff and stream channel erosion and stream bank instability. Other sources were addressed in Section 3.7.1.2.

Watershed runoff

As the land cover is predominantly agricultural in the BRW and URRW, and more specifically in the subwatersheds of the impaired streams addressed with a TSS TMDL in this report (Section 3.5), the primary source of TSS to these impaired streams is overland runoff from cultivated cropland (Table 13) (MPCA 2016, MPCA 2017a, MPCA 2024g, MPCA 2024h). The amount of sediment from cropland runoff may depend on a number of factors, including timing and magnitude of precipitation events and the resulting runoff, tillage and cropping practices, slope and soil types, use of structural or nonstructural sediment BMPs, and more. For example, conventional or more intensive tillage practices, sloping landscapes, and heavier (type C or D) soils may result in more sediment-laden runoff from crop fields than those that feature conservation or reduced tillage practices, cover crops or other soil health practices, and lighter (type A or B) soils that allow for increased infiltration. The MPCA's HPSF models (MPCA 2024g, MPCA 2024h) provide specific estimates for average annual sediment loading from different cropping and tillage practices and soil types (Table 19, below).

While cropland runoff is the primary source of watershed runoff in the BRW and URRW, runoff from impervious surfaces within the cities of Rothsay and Lake Park, major roads and highways, and other developed areas (Table 13) is also a factor, as well as other potential sources addressed in Section 3.7.1.2.

Table 19. Breakdown of estimated annual percent contributions of TSS by cropping and tillage practices and soil type, 1996 – 2022 (MPCA 2024g, MPCA 2024h).

WID	Water body name	Conv, AB[1]	Conv, CD[1]	Conv, Drned[2]	*Conv, Total[3]*	Cons, AB[1]	Cons, CD[1]	Cons, Drned[2]	*Cons, Total[3]*
09020104-516	Unnamed Creek	28.01%	58.77%	NA	*86.78%*	0.54%	0.82%	NA	*1.36%*
09020104-550	Wolverton Creek	8.28%	55.17%	NA	*63.45%*	0.12%	1.87%	NA	*1.99%*
09020106-530	Unnamed creek (Lawndale Creek)	1.31%	6.77%	0.80%	*8.88%*	0.04%	0.22%	0.02%	*0.28%*
09020106-621 09020106-622	Hay Creek	0.24%	66.25%	0.68%	*67.17%*	0.01%	1.93%	0.02%	*1.96%*

1. Conv = conventional tillage practices; Cons = conservation or reduced tillage practices; AB = type A or B (lighter or sandier) soils; CD = type C or D (heavier or more clay-based) soils.
2. Drned = Drained, or cropland with known tile drainage. Specific estimates for drained soils are not provided in the URRW HSPF model outputs.
3. From Conventional Cropland and Conservation Cropland columns in Table 13.

Stream channel conditions

The MPCA's HSPF models (MPCA 2024g, MPCA 2024h) suggest that stream channel erosion and stream bank instability are the primary sources of sediment on an annual basis to Unnamed Creek (Lawndale Creek) (WID 09020106-530), and are the secondary sources of sediment on an annual basis to the three other impaired stream systems addressed with a TSS TMDL in this report (Table 13). Sediment loading from in-channel scour and deposition were analyzed in the original BRW and URRW HSPF models (Tetra Tech 2019, Tetra Tech 2018) on a reach-by-reach basis based on model recommendations, and based on studies of upland versus near-channel sediment balance for the South Branch Buffalo River (Lauer et al. 2006) and other adjacent HUC-8 watersheds including the Wild Rice River (Brigham et al. 2001) and Bois de Sioux River (EOR 2014). Modeled estimates, which are a function of flow condition and channel geometry, were then compared to other models (i.e., FLUX) and the aforementioned studies to ensure that the reach-by-reach estimates were reasonable. Modeled estimates for the impaired streams addressed in this TMDL report were then re-evaluated in the BRW and URRW HSPF model updates (MPCA 2024g, MPCA 2024h).

Furthermore, MPCA's stressor identification staff evaluated portions or the entirety of all four impaired stream systems and noted turbid conditions throughout, as well as noting significant channel erosion and instability in Unnamed Creek (WID 09020104-516) and Wolverton Creek (09020104-550) (MPCA 2023a, Figure 11). Additionally, DNR staff completed fluvial geomorphic assessments within Unnamed Creek (09020104-516), Wolverton Creek (09020104-550), and Unnamed Creek (Lawndale Creek) (09020106-530) during the summers of 2020 and 2021. In the 2020 assessment of Unnamed Creek (09020104-516) at 170th Avenue/County Highway 3, DNR staff noted that the channel was incised with the top of the bank approximately 2.5-3 feet higher than the bank full elevation, causing erosion and sediment transportation due to the lack of an adequate floodplain. From the 2020 assessment of Wolverton Creek (09020104-550) at 130th Avenue South, DNR staff noted that the channel was incised with no access to its floodplain during minor flood events, causing mass erosion and bank cutting. In the 2021 assessment of Unnamed Creek (Lawndale Creek), DNR staff noted excessive sediment deposition both upstream and downstream of 270th Avenue, and a site assessment completed 1.7 miles upstream showed that Lawndale Creek was incised with a narrow riparian buffer (DNR 2025a, MPCA 2023a).

Figure 11. Bank erosion and instability documented in 2019 in Unnamed Creek (WID 09020104-516) along 240th Street (top) and in Wolverton Creek (09020104-550) just downstream of 130th Avenue South (bottom) (MPCA 2023a).

3.7.3 Phosphorus source summary – rivers and streams

3.7.3.1 Permitted sources

The permitted sources of TP within the subwatersheds of impaired streams addressed with a TP TMDL in this report include industrial wastewater as well as construction and industrial stormwater. There are no permitted municipal WWTPs and no permitted MS4s within these subwatersheds and none are expected in the future, and there are currently no CAFOs located within these subwatersheds.

Industrial wastewater

There is one discharge location associated with an industrial wastewater permit located in the subwatershed of County Ditch 25 (County Ditch 65) (09020106-538). The location of this facility is shown in Figure 27 of Appendix C. Subwatershed maps.

Table 20. Industrial wastewater facilities located within the subwatersheds of impaired streams addressed by a TP TMDL in this report.

WID	Water body name	BRRW CWMP planning region	Permitted discharge designation	Facility type	Permit Number
09020106-538	County Ditch 25 (County Ditch 65)	Northern	SD 007	Industrial	MN0060755

This discharge location was included in a permit for industrial wastewater discharges of hydrostatic testing waters at various locations along a natural gas pipeline running from Canada, through northern Minnesota and the BRW, and into Wisconsin. Hydrostatic testing is a routine, required process to periodically test the structural integrity of natural gas or oil pipelines and consists of first cleaning the interior of the pipeline then filling the pipeline with water until a desired pressure is reached, with the water typically appropriated from a nearby groundwater or surface water source or from a municipal or similar water supplier. The desired water pressure is maintained within the pipeline for a period of time, the condition of the pipeline is inspected, and the hydrostatic test water is then discharged from the pipeline. The discharges are usually along the pipeline corridor, in the permittee's right-of-way, and/or directed to a well-vegetated upland area, although there are occasions when this process could result in discharges to surface waters. Actual volumes of test water, sources of the test water, discharge points of the test water, and potential for discharges to surface waters are unknown until the need and/or plans for hydrostatic testing are developed; therefore, it is difficult to allocate a specific load to this activity. Additionally, the permittee is required to request and receive authorization for any planned discharge of hydrotest waters, trench dewatering, and stormwater associated with any construction activity related to hydrostatic testing. All discharges require BMPs to control the velocity and dispersal of the discharge so that the discharged water does not scour or erode the ground surface or carry sediment and other pollutants off site to surface waters. Because of these factors, this source is not considered to be a source of additional TP to County Ditch 25 (County Ditch 65) in this TMDL report.

Construction stormwater

Pollutant loading from construction stormwater was addressed in Section 3.7.1.1 and is not considered a significant source of TP to the downstream impairments.

Industrial stormwater

There is one facility permitted under subsector J1 of Minnesota's general NPDES/SDS permit for nonmetallic mining and associated activities (MNG490000) that is located within the subwatershed of County Ditch 10 (09020106-619). The facility's location is shown in Figure 31 of Appendix C. Subwatershed maps and is summarized below. As discussed in Section 3.7.2.1, the primary activity of facilities permitted under subsector J1 of the nonmetallic mining and associated general NPDES/SDS permit (MNG490000) is the mining of construction sand and gravel, with stormwater contained on site. Additionally, discharge monitoring and intervention limits do not apply to these facilities, although a pollution prevention plan shall be developed (MPCA 2024n). Phosphorus loading from this facility is not explicitly modeled by HSPF and is not considered a significant source to the downstream impairment.

Table 21. Industrial stormwater facilities located within the subwatersheds of impaired streams addressed by a TP TMDL in this report.

WID	Water body name	BRRW CWMP planning region	Facility name	Designation	Permit Number
09020106-619	County Ditch 10	Northern	Loren Richards	LA 001	MNG490640

3.7.3.2 Nonpermitted sources

Watershed runoff is a significant source of TP within the subwatersheds of impaired streams addressed with a TP TMDL in this report, while eutrophication and other stream channel conditions are found to be drivers of increased diel DO flux in these impaired streams. Other sources were addressed in Section 3.7.1.2.

Watershed runoff

Similar to TSS, the primary source of phosphorus loading to the impaired streams is cropland runoff (Table 14, MPCA 2024g). Because phosphorus binds to and travels with sediment, much of the same factors that impact sediment loading from overland runoff also contribute to or factor into phosphorus loading from the same source (Section 3.7.2.2). The MPCA's BRW HSPF model (MPCA 2024g) provides specific estimates for average annual phosphorus loading from different cropping and tillage practices and soil types (Table 22). Phosphorus is also entering the impaired streams from impervious and other developed surfaces, pastures, and other potential sources addressed in Section 3.7.1.2 and Table 14.

Table 22. Breakdown of estimated annual percent contributions of TP by cropping and tillage practices and soil type, 1996 – 2022 (MPCA 2024g)

WID	Water body name	Conv, AB[1]	Conv, CD[1]	Conv, Drned[1]	*Conv, Total[2]*	Cons, AB[1]	Cons, CD[1]	Cons, Drned[1]	*Cons, Total[2]*
09020106-538	County Ditch 25 (County Ditch 65)	24.74%	16.19%	48.02%	*88.95%*	2.04%	1.34%	3.96%	*7.34%*
09020106-605	Buffalo River, South Branch	24.50%	15.39%	43.70%	*83.59%*	1.74%	1.14%	2.08%	*4.96%*
09020106-619	County Ditch 10	13.85%	6.71%	67.53%	*88.09%*	1.14%	0.55%	5.57%	*7.26%*

1. Conv = conventional tillage practices; Cons = conservation or reduced tillage practices; AB = type A or B (lighter or sandier) soils; CD = type C or D (heavier or more clay-based) soils; Drned = Drained, or cropland with known tile drainage.

2. From Conventional Cropland and Conservation Cropland columns in Table 14.

Stream channel conditions

Unlike for TSS (Section 3.7.2.2), TP contributions from stream channel erosion and stream bank instability were not explicitly estimated in the BRW HSPF model (MPCA 2024g). These sources were considered during the phosphorus calibration process and determined to be an insignificant contributor of TP to the impaired streams addressed with a TP TMDL in this report. This is consistent with modeling in the Minnesota River Basin where it was determined that TP loading from near-channel sources was 1% or less of the average summer growing season TP load (MPCA 2023b, MPCA 2025b). Section 3.2 of the 2014 *Minnesota Nutrient Reduction Strategy* (NRS, MPCA 2014, Section 6.2.6), suggests that 6% of average annual TP loading in the Lake Winnipeg Basin prior to 2014 came from stream bank erosion, while Appendix 2-3 of the *2025 Minnesota Nutrient Reduction Strategy* provides a slightly more modest 2.5% (MPCA 2025c).

Modeling and calculating the contribution of nutrients from stream bank sources is complex due to several factors such as varying soil textures and chemistry, land and nutrient management near streambanks, and in-channel physical processes such as interactions with floodplains which affect delivery potential of the eroded sediment. Therefore, addressing TP loading from stream channel erosion or stream bank instability first requires an understanding of how the stream channel relates to water quality, watershed hydrology, and ecology (DNR 2025b). Several studies focused on individual streams or small watersheds suggest that stream bank erosion can be a moderate to more significant source of phosphorus at a smaller scale, with a wide array of estimates ranging from single digits (i.e., 3% to 7%) to as high as 94% of total TP loading in those study areas (DNR 2025b). More accurate or in-depth estimates or modeling for TP loading from near channel sources to the impaired streams in the BRW and URRW will require additional evaluation and consideration of those complex processes.

While TP loading from near-channel sources in the BRW and URRW are believed to be low, model estimates for TSS contributions to the impaired streams addressed with a TP TMDL in this report are more significant. The BRW HSPF model estimates that near-channel sources of TSS account for approximately 11% of annual sediment loading for County Ditch 25 (County Ditch 65) (09020106-538), 46% for Buffalo River, South Branch (09020106-605), and 20% for County Ditch 10 (09020106-619) (MPCA 2024g).

The MPCA's stressor identification staff also evaluated portions or the entirety of the impaired stream systems addressed with a TP TMDL in this report. Staff noted increased temperatures and low stream flows as well as significant aquatic plant growth in all three impaired reaches that are likely to impact DO concentrations and, therefore, the impaired fish and macroinvertebrate communities in these streams. Stream channel conditions contributing to eutrophication noted by MPCA staff in 2019 and 2020 include excessive algal growth and rooted macrophytes in County Ditch 25 (County Ditch 65) and in Buffalo River, South Branch; abundant filamentous algae and duckweed in County Ditch 10; and high fluctuations in DO concentrations (diel DO flux) in all three impaired reaches. Additionally, staff regularly documented conditions of excess turbidity in County Ditch 25 (County Ditch 65) and County Ditch 10, and occasionally in Buffalo River, South Branch (MPCA 2023a).

Figure 12. Images of eutrophication-related impacts including algae growth in County Ditch 25 (County Ditch 65) (09020106-538, left), rooted macrophytes in Buffalo River, South Branch (09020106-605, top right), and filamentous algae in County Ditch 10 (09020106-619, bottom right) (MPCA 2023a).

3.7.4 Phosphorus source summary – Lee Lake

3.7.4.1 Permitted sources

The permitted sources of TP within the Lee Lake Subwatershed include construction stormwater and CAFO feedlots. There are currently no permitted municipal or industrial wastewater facilities, permitted industrial stormwater facilities, or permitted MS4 areas in the Lee Lake Subwatershed and none are expected in the future. There are no municipalities in the subwatershed, and the land cover is primarily agricultural.

Construction stormwater

Pollutant loading from construction stormwater was addressed in Section 3.7.1.1. While there is potential for future development and construction activity near the shoreline of Lee Lake, NPDES/SDS permit coverage requiring BMPs and sediment and erosion control measures and other local regulations would likely apply. Pollutant loading from construction stormwater is not considered to be a significant source of TP to Lee Lake.

Concentrated animal feeding operations

Currently, there is one NPDES permitted CAFO and one CAFO without a current NPDES or SDS permit located within the Lee Lake Subwatershed (MPCA 2024i, Table 23, Figure 35 of Appendix C. Subwatershed maps). As stated in Section 3.7.1.1, all CAFO feedlots must be designed to contain all manure, manure-contaminated runoff, process wastewater, and the precipitation from a 25-year, 24-hour storm event, and as such they are not considered a significant source of nutrients and other pollutants to the impaired water bodies addressed in this TMDL report. The CAFO feedlots are not assigned a WLA, equivalent to a WLA of zero, and are not included in the TMDL allocations in Section 4.3. All other feedlots and the land application of all manure are accounted for as nonpermitted sources.

Table 23. CAFOs located within the Lee Lake Subwatershed (MPCA 2024i).

WID	Water body name	BRRW CWMP planning region	Facility Name	Permit ID	Animal Type	Total AU
14-0049-00	Lee Lake	Mainstem	Baers Poultry Co – New Barn Site	MNG441162	Chickens	1,005
			J & A Farms LLC	N/A	Chickens, Beef cattle	700

3.7.4.2 Nonpermitted sources

Watershed runoff and other lakeshore conditions are sources of TP within the Lee Lake Subwatershed, while individual SSTS and internal phosphorus recycling were also evaluated further. Other sources were addressed in Section 3.7.1.2.

Watershed runoff

The primary source of phosphorus loading within the Lee Lake Subwatershed is cropland runoff (Table 14). The MPCA's BRW HSPF model (MPCA 2024g) provides specific estimates for average annual TP loading from different cropping and tillage practices and soil types (Table 24). Phosphorus is also entering Lee Lake from impervious and other developed surfaces, pastures, and other potential sources addressed in Section 3.7.1.2 and Table 14.

Table 24. Breakdown of estimated annual percent contributions of TP by cropping and tillage practices and soil type, 1996 – 2022 (MPCA 2024g)

WID	Water body name	Conv, AB[1]	Conv, CD[1]	Conv, Drned[1]	*Conv, Total[2]*	Cons, AB[1]	Cons, CD[1]	Cons, Drned[1]	*Cons, Total[2]*
14-0049-00	Lee Lake	50.38%	13.77%	11.41%	*75.56%*	7.05%	1.56%	1.14%	*9.75%*

1. Conv = conventional tillage practices; Cons = conservation or reduced tillage practices; AB = type A or B (lighter or sandier) soils; CD = type C or D (heavier or more clay-based) soils; Drned = Drained, or cropland with known tile drainage.
2. From Conventional Cropland and Conservation Cropland columns in Table 14.

Lakeshore conditions

Specific estimates for average annual TP loading from lakeshore erosion or instability to Lee Lake were not provided for this TMDL report from the MPCA's BRW HSPF model. However, similar to that for the impaired streams addressed in this report (Section 3.7.3.2), the model provides an estimated average of 30% for annual sediment loading from shoreline instability to Lee Lake (MPCA 2024g). As stated for the impaired streams in Section 3.7.3.2, modeling and calculating TP loading from lakeshore erosion may involve several complex processes and requires additional evaluation.

Lee Lake was evaluated in DNR's BRW Stressor Identification Report – Lakes (DNR 2023b) as having a vulnerable fish community stressed by eutrophication due to elevated TP levels and high land use disturbance within its entire subwatershed. Additionally, the physical aquatic habitat within Lee Lake was evaluated using the Score the Shore (StS) survey, which was developed by DNR to rapidly assess the quantity and integrity of lakeshore habitat. Possible StS scores range from 0 to 100 and lakes with a high percentage of unaltered habitat score higher than lakes that have been highly altered (DNR 2023b).

The StS assessment results for Lee Lake are summarized in Table 25. The overall score for Lee Lake is considered high and is above the mean score of other lakes within the BRW (mean score = 76, N = 14) and throughout the state of Minnesota (mean score = 73; N = 764). However, StS scores for developed sites on Lee Lake were considered low suggesting that replacement of trees, shrubs, and natural shoreline cover with open yards has most likely occurred. Furthermore, the DNR estimates that Lee Lake has approximately 18 docks per mile of shoreline, stating that dock densities exceeding 16 docks per mile can significantly affect fish communities and habitat. Finally, DNR staff note that aquatic plant removal has likely contributed to some physical habitat loss within the lake through the permitted (and likely unpermitted) removal of riparian, floating-leaf, and emergent plants.

As a result, the fish communities within Lee Lake are adversely affected by these conditions as evaluated by the lake FIBI (DNR 2023b). These conditions may result in additional TP loading to Lee Lake from runoff from cropland or other upstream sources, as well as nearshore sources such as runoff of lawn fertilizers and other developed areas, SSTS, and erosion of shorelines with grass, leaves, and other organic matter.

Table 25. DNR StS survey results for Lee Lake.

Category	Result	Category	Result
Dock density (# per mile)	18	Shoreland zone score	28 *(high)*
Survey locations	37	Shoreline zone score	30 *(high)*
Percent developed	30%	Aquatic zone score	29 *(high)*
Developed score	65 *(low)*	Undeveloped score	96 *(high)*
Total score: 87 *(high)*			

Individual SSTS

Clay County estimates that 91% of existing SSTS are compliant, with 7% as failing and 2% as ITPHS (MPCA 2024j). Review of county parcel data and aerial imagery suggests that the estimated number of properties with SSTS immediately surrounding Lee Lake is comparable to the number of estimated properties with SSTS in the rest of Lee Lake's subwatershed (Table 26).

Table 26. Estimated failing SSTS and ITPHS located within the Lee Lake Subwatershed (MPCA 2024j).

WID	Water body name	BRRW CWMP planning region	County[1]	Estimated # of properties with SSTS	Estimated # of failing SSTS	Estimated # of ITPHS
14-0049-00	Lee Lake	Mainstem	Clay	51	4	1

Flow and TP loads from SSTS in the Lee Lake Subwatershed were estimated using methods similar to the Lower Minnesota River Watershed TMDL (MPCA 2020a). Assumptions were made regarding the number of people per household (~2.1), the percent of homes that are occupied year around (50%) versus seasonally (50%), and the estimated septic compliance discussed above. The SSTS TP removal rate for compliant systems was assumed to be approximately 80%, while a removal rate of 57% was assumed for failing systems (Barr Engineering 2004). Through this analysis it was estimated that compliant SSTSs currently contribute approximately 31 lbs/yr of TP to Lee Lake while noncompliant systems contribute approximately 8 lbs/yr.

Internal phosphorus recycling

Internal phosphorus recycling, often referred to as "internal loading," is a common occurrence in eutrophic and hypereutrophic shallow lakes throughout Minnesota. Phosphorus contained in the sediment of lakes originates as an external phosphorus load that settles out of the water column to the lake bottom. Typically, a significant amount of the external load to Lee Lake is delivered during snow melt and spring and early summer runoff. During this time, low water temperatures and flushing limit the amount of algae growth and biological activity within the lake. As water temperatures increase in mid-summer (e.g., late June and July), lakes can become thermally stratified, which leads to higher rates of algae growth and bacterial decomposition. As this happens, DO is consumed by bacteria, and anoxic conditions (i.e., low DO) can develop at the sediment-water interface, which leads to the release of phosphorus from the lake sediments. The phosphorus that is released from the sediments is in a soluble form that is readily available to algae for uptake. In deeper lakes like Lee Lake, phosphorus that has accumulated near the sediment-water interface can be mixed into the surface waters during strong winds, storm events, and as stratification begins to weaken in the late summer and fall.

There is evidence from the available data for Lee Lake that suggest internal phosphorus recycling occurs within the lake:

- Mean surface TP and chl-*a* concentrations typically decrease from May to July as waters warm and stratification intensifies.
- Mean TP and chl-*a* levels generally increase from late July through September as the lake begins to mix.
- Although temperature and DO profile data for Lee Lake is limited, surface TP and chl-*a* concentration spikes have been observed as thermal stratification weakens or breaks down late in the summer as phosphorus-rich deep waters begin to mix with surface waters (e.g., 2010 and 2011).

At this time, there are not enough data available to explicitly quantify the amount of phosphorus that is recycled within Lee Lake each year. In order to better characterize internal recycling, additional data would need to be collected such as continuous or high-frequency temperature and DO profiles, hypolimnetic phosphorus samples, and/or sediment cores. Since internal phosphorus recycling reflects recycling of loads that originally entered the lake from the lake drainage area and atmosphere, the amount of P recycling is expected to vary with external load over time.

Common carp are another potential source of internal phosphorus recycling in lakes. When present in high densities, carp can exacerbate poor water quality in lakes by destroying or uprooting aquatic vegetation and resuspending or recycling TP from lake sediments. Based on review of the historical DNR trap and gill net surveys, no common carp have ever been observed in Lee Lake.

4. TMDL development

A water body's TMDL represents the LC, or the amount of pollutant that a water body can assimilate while still meeting water quality standards. The LC is divided up and allocated to the water body's pollutant sources. The allocations include WLAs for NPDES-permitted sources, LAs for nonpermitted sources (including natural background), and a MOS, which is implicitly or explicitly defined. The sum of the allocations and MOS cannot exceed the LC, or TMDL.

4.1 Total suspended solids

4.1.1 Loading capacity methodology

The LC for the TSS TMDLs in this report were developed using the LDC methodology. To develop the LDCs, all simulated daily average flows used in the flow duration curve (see Section 3.6 for a description of flow) were multiplied by the applicable TSS water quality standard and converted to a daily load to create "continuous" LDCs that represent the load in the stream when the stream meets its water quality standard under all flow conditions. The TSS loads are plotted on the LDCs using water quality monitoring data discussed in Section 3.6.1. The TSS loads are calculated by multiplying the sampled TSS concentrations by the simulated flow on the day the sample was taken. Each load calculated from a water quality sample that plots above the LDC represents a sample with a pollutant concentration higher than the water quality standard used to the develop the LDC, whereas those that plot below the LDC are less than the water quality standard used to develop the LDC. The LDCs for each TSS TMDL are provided in Section 4.1.9. The LC was calculated as simulated flow at the downstream end of each impaired reach multiplied by an applicable water quality standard (Table 3). The LDC provides LCs along all flows observed in the stream along with observed loads calculated from monitoring data and simulated flow. For any given flow in the LDC, the LC is determined by selecting the point on the LDC that corresponds to the flow exceedance (along the x-axis).

The LDC method is based on an analysis that encompasses the cumulative frequency of historical flow data over a specified period. Because this method uses a long-term record of daily flow volumes, virtually the full spectrum of allowable LCs is represented by the resulting curve. In the TMDL equation tables of this report, only five points on the entire LC curve are depicted (the midpoints of the designated flow zones, i.e., 5%, 25%, 50%, 75%, and 95%). However, the entire curve represents the TMDL and is what the EPA ultimately approves.

4.1.2 Load allocation methodology

The LA is comprised of the nonpoint source load that is allocated to an impaired reach after the WLAs and MOS were determined and subtracted from the total LC. This residual remaining LC is meant to represent all nonregulated (nonpoint) sources of TSS upstream of the impaired reaches. The LA includes nonpoint pollution sources that are not subject to NPDES Permit requirements such as wind-blown materials, soil erosion from stream channel and upland areas, and natural background. The LA also includes runoff from agricultural lands and non-MS4 stormwater runoff.

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

4.1.3 Wasteload allocation methodology

The WLA is allocated to existing or future NPDES-permitted pollutant sources. The TSS WLAs were calculated for municipal wastewater facilities, construction and industrial stormwater, and an individual NPDES/SDS permitted facility. There are no MS4s or CAFO feedlots within the subwatersheds of impaired streams addressed with a TSS TMDL in this report; WLAs for these types of systems were therefore not developed.

If a permittee that is assigned a WLA in this report has previously been assigned one or more WLAs for the same pollutant for another TMDL, the applicable permit(s) and/or associated planning documents will need to address the most restrictive WLA. This is the case for Rothsay WWTP (MNG585064), whose TSS WLA assigned in this TMDL report (0.098 tons/day) is slightly updated from the TSS WLA assigned to that facility in the URRW TMDL Report (MPCA 2017a, 0.09 tons/day). This change is the result of using more recent permit information provided for Rothsay WWTP to calculate the WLA for this TMDL report.

The total TMDL LC in the low- and very-low flow zones for some TMDL reaches is less than the calculated WLA or allowable load for a particular permitted source. This is an artifact of using LDCs to establish loading capacities as these permitted sources appear to use all (or more than) the available LC at full design flows. In reality, this will never occur as facility or source discharge is part of the streamflow, so it can never exceed total streamflow. To account for these unique situations, the remaining WLAs and LAs are expressed as an equation rather than an absolute number. The equation is:

Allocation = flow contribution from a given source X water quality standard concentration (or NPDES/SDS permitted concentration limit)

Consistent units are used to obtain the load. This assigns concentration-based limits to the WLAs and LAs for these flow zones. Typically, rainfall and thus runoff is very limited if not absent during low- and very-low flows and as such, runoff sources are not significant contributors of pollutants during these flow conditions.

4.1.3.1 Municipal wastewater

Individual WLAs for each wastewater facility are presented in Table 27. The WLAs were calculated as the product of each facility’s WLA flow and permitted TSS concentration limit. The WLA flows were calculated by assuming a six-inch per day drawdown rate across the average operational surface area of each facility’s secondary pond(s).

Table 27. Individual TSS WLAs for municipal WWTPs.

Facility name	Permit number	Surface discharge station	WLA flow (mgd)[1]	Impaired water body WID	Pollutant	Permit limit (mg/L)[2]	WLA (tons / day)	Existing permit consistent with WLA assumptions
Rothsay WWTP	MNG585064	SD 001	0.518	09020104 -516	TSS	45	0.098	Yes
Comstock WWTP	MN0023116	SD 001	0.232	09020104 -550	TSS	45	0.043	Yes
Lake Park WWTP	MNG585157	SD 002	1.312	09020106 -621 and -622	TSS	45	0.25	Yes

1. mgd: million gallons per day. Estimated assuming a 6-inch per day drawdown rate across the average operational surface area of the facility's secondary pond(s).
2. Current permitted TSS effluent concentration limits are 65 mg/L as a calendar month average and 45 mg/L as a maximum calendar week average. The WLAs are calculated using the 45 mg/L limits.

Comstock WWTP is currently permitted under MPCA's general wastewater permit MNG585131. An upgrade of the Comstock WWTP is being planned for 2026, and a permit application has been submitted to and is being reviewed by the MPCA as individual permit number MN0023116. Two existing ponds are proposed to be replaced, and a new pond is proposed to be added. The existing facility consists of one 2.42-acre primary cell and one 1.1-acre secondary cell with a WLA flow of 0.179 mgd. The proposed facility will have two 1.325-acre primary cells and one 1.422-acre secondary cell with a WLA flow of 0.232 mgd. The individual WLA assigned to Comstock WWTP in this TMDL report is calculated based on the proposed expanded facility details provided for draft individual permit MN0023116.

The TSS permit limit for Lake Park WWTP is greater (i.e., less stringent) than the impaired water body's TSS standard of 30 mg/L. In general, TSS is composed of both organic (measured as volatile suspended solids [VSS]) and inorganic (measured as nonvolatile suspended solids [NVSS]) particles. Most of the TSS in municipal wastewater discharges is organic matter, which does not tend to persist in the environment. Effluent TSS discharged by municipal controlled discharge stabilization ponds is typically composed of 70% VSS and 30% NVSS (MPCA 2015).

In MPCA's memo, "Compatibility of existing technology based effluent limits (TBELs) with new TSS water quality standards" (MPCA 2015), it is assumed that the intent of the TSS standards is to represent the concentration of inorganic particles in the stream. The WLA for Lake Park WWTP is expressed in terms of TSS. It is assumed that the 45 mg/L TSS effluent limit is sufficient to ensure that effluent NVSS concentrations will not exceed the 30 mg/L inorganic TSS concentration and that the facilities will meet their WLAs. Effluent monitoring may be required to confirm this assumption. Future NPDES permits for the facilities may contain water quality-based effluent limits (WQBELs) to account for the relationship between NVSS and TSS in the discharge. If WWTP effluents are found to cause or have reasonable potential to cause or contribute to excursions above 30 mg/L NVSS, future permits may include more restrictive WQBELs.

4.1.3.2 Construction stormwater

A categorical WLA is assigned to permitted construction stormwater (NPDES permit MNR100001) for each TSS TMDL to account for existing and potential future sources. On average, 0.02% of the rural areas in the BRW and URRW are under construction stormwater permit coverage (2020 through 2024). These years coincide with the most recent five-year period of data available for this report, and the percent area applies, generally, to the rural portions of the BRW and URRW in which the subwatersheds of the impaired water bodies addressed in this TMDL report are located. Construction stormwater WLAs were calculated as 0.02% multiplied by the LC minus the MOS.

4.1.3.3 Industrial stormwater

Industrial stormwater is regulated through NPDES permits (MNR050000 and MNG490000) when stormwater discharges have the potential to come into contact with materials and activities associated with the industrial activity. To allow for current and future permitted industrial stormwater activities, a categorical WLA was calculated for the industrial stormwater facilities listed in Table 17 and any future facilities that are covered under Minnesota's NPDES/SDS permits for industrial stormwater (MN R050000 and MNG490000) using a similar methodology as construction stormwater. Since the facilities listed in Table 17 are relatively small in acreage, this categorical TSS WLA for industrial stormwater was calculated as 0.02% multiplied by the LC minus the MOS.

4.1.3.4 Individual NPDES/SDS permits

An individual WLA was developed for Minn-Dak Farmers Cooperative – Peet Piling Ground. This piling ground is used for temporary storage of sugar beets after harvesting, but prior to processing. It is designed to capture all liquid discharges in a 5.2 acre on-site industrial stormwater pond. The individual WLA for Minn-Dak Farmers Cooperative – Peet Piling Ground is calculated as the product of the facility's permitted WLA flow and the NPDES/SDS TSS permit limit of 30 mg/L. The maximum WLA flow of 0.84 mgd assumes a 6-inch per day drawdown rate across the surface area of the piling ground's 5.2-acre treatment pond.

Table 28. Individual TSS WLA for Minn-Dak Farmers Cooperative-Peet Piling Ground.

Permit number	Surface discharge station	WLA flow (mgd)[1]	Impaired water body WID	Pollutant	Permit limit (mg/L)	WLA (tons/day)	Existing permit consistent with WLA assumptions
MN0070386 MNR053FKP	SD 001	0.84	09020104-550	TSS	30	0.11	Yes

1. mgd: million gallons per day. The WLA flow of 0.84 mgd is estimated assuming a 6-inch per day drawdown rate across the average operational surface area of the facility's 5.2 acre secondary pond.

4.1.4 Margin of safety

The MOS accounts for uncertainty concerning the relationship between water quality and allocated loads. The MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as a load set aside).

An explicit MOS of 10% was included in the TMDLs to account for uncertainty that the pollutant allocations would attain the water quality targets. The use of an explicit MOS accounts for environmental variability in pollutant loading, variability in water quality monitoring data, calibration and validation processes of modeling efforts, uncertainty in modeling outputs, conservative assumptions made during the modeling efforts, and limitations associated with the drainage area-ratio method used to extrapolate flow data. This MOS is considered to be sufficient given the robust water quality and flow monitoring datasets used (see Sections 3.6 and 3.6.1) and quality of modeling.

The BRW HSPF model (MPCA 2024g) was calibrated and validated using 3 primary stream flow gaging stations, located on the Buffalo River near Hawley (MPCA station E58059001, USGS station 05061000), the South Branch Buffalo River near Glyndon (DNR and MPCA station H58050001), and the Buffalo River near Georgetown (DNR, MPCA, and MDA station H58033001), along with 14 secondary gages. The secondary gages include many sites that are mostly operated seasonally, with no monitoring during winter ice conditions. Periods of record are also short for many of these stations. The URRW HSPF model (MPCA 2024h) was calibrated and validated using gaging stations on Wolverton Creek near Comstock (MPCA station H57037001) and Whiskey Creek near Kent (MPCA station H57008001). There are also four long-term continuous flow gages adjacent to the URRW located along the Red River of the North mainstem. Below is a summary of the hydrologic validation statistics for the BRW HSPF model at the Buffalo River near Georgetown (station H58033001) and for the URRW HSPF model at the Red River of the North at Fargo (USGS station ID 05054000, E57028001):

- 0.11% (BRW) and 1.05% (URRW) errors in annual total flow volume.
- -14% (BRW) and 13% (URRW) errors in bottom 50% low flows.
- Nash-Sutcliffe coefficients of model fit efficiency (NSE) of 0.59 (BRW) and 0.865 (URRW) for daily flows.
- NSEs of 0.75 (BRW) and 0.98 (URRW) for monthly flows.

Overall, these validation statistics indicate that the HSPF models are “good” at representing the watersheds. There is no reason to believe a 10% MOS is inappropriate as it is consistent with HSPF modeling errors and the HSPF model is a valid representation of hydrological and chemical conditions in the watershed.

4.1.5 Seasonal variation and critical conditions

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

Seasonal variation and critical conditions are also addressed by the water quality standards. The applicable TSS standards for aquatic life apply from April through September, when aquatic organisms are most active and when high stream TSS concentrations generally occur.

4.1.6 Reserve capacity

Reserve capacities were not set aside for any of the TSS TMDLs in this report. Influent flows for all three WWTPs are well below their current design capacities (<50% of AWWDF on average), Comstock WWTP already has a proposed an upgrade of the existing facility (Section 4.1.3.1), and population densities in neighboring areas not served by these WWTPs are low and unlikely to cause a need for facility expansion if they were to be connected to the sanitary sewer systems in the future.

TSS WLAs for the Rothsay and Comstock WWTPs are eligible for future expansion because the facilities' permitted calendar month average TSS limits (45 mg/L) are more restrictive than the impaired water bodies' applicable TSS water quality standards (65 mg/L). The TSS WLA for the Lake Park WWTP is not currently eligible for a future TSS WLA expansion because its NPDES permit calendar monthly average TSS effluent limit (45 mg/L) exceeds Hay Creek's TSS water quality standard (30 mg/L).

4.1.7 Baseline year

The monitoring data used to calculate the TSS percent reductions for the impaired streams addressed with a TSS TMDL in this report vary between the impaired stream reaches (Section 3.6.1). As such, the baseline years for implementation are provided for each impaired stream as the end of the year that is the midpoint of the time period from which the majority of the TSS data was collected. Any BMPs present on the landscape during the HSPF model simulation time period are implicitly accounted for in the model. Any BMPs or projects implemented during or after the baseline year that led to a reduction in TSS loading to the impaired water bodies may be considered as progress towards meeting a WLA or LA. For Unnamed Creek (09020104-516), about half of the monitoring data are from 2006 and 2008 with a slight majority of the data collected in 2019 and 2020, therefore, the baseline year is 2019 (end of year). For Wolverton Creek (09020104-550), most of the monitoring data are from 2011 through 2013 and 2016 through 2024, with about half of the data in that time period collected between 2011 through 2018 and half collected from 2019 through 2024. The baseline year for Wolverton Creek is 2018 (end of year), which also coincides with restoration efforts that occurred in the upper reaches of Wolverton Creek after 2018 (see Section 6.4). For Unnamed creek (Lawndale Creek) (09020106-530), almost all of the data are from 2019 and 2020 and so the baseline year is 2019 (end of year). For the upstream reach of Hay Creek (09020106-621), almost all of the data are from 2019 and 2020 and so the baseline year is 2019 (end of year). For the downstream reach of Hay Creek (09020106-622), most of the monitoring data are from 2017 through 2024, with about half of the data in that time period collected between 2017 through 2020 and half collected from 2021 through 2024; the baseline year is then 2020 (end of year).

4.1.8 Percent reduction

The estimated percent reductions for each impaired stream provide an approximation of the overall reduction needed for the water body to meet the TMDL. The percent reduction is a means to capture the level of effort needed to reduce TSS concentrations in the watershed. The percent reductions should not be construed to mean that each of the separate sources listed in the TMDL table needs to be reduced by that amount. The percent reduction in TSS concentration was calculated as the existing 90^{th} percentile TSS concentration (all available April through September water quality data) minus the applicable water quality standard (10 mg/L, 30 mg/L, or 65 mg/L) divided by the existing 90th percentile TSS concentration plus 10% to account for the MOS. By using the 90th percentile TSS concentration, the percent reduction calculation approximates the reduction in concentration (as opposed to load) needed to meet the water quality standard overall, aggregated across all flow conditions. Only monitored TSS data, not HSPF simulated outputs, were used in this calculation.

4.1.9 TSS TMDL summary

The LDC figures and TMDL tables for the impaired streams addressed with a TSS TMDL follow below. The TMDL tables present the TMDL, MOS, WLAs, and the LAs for each impaired reach. The TMDL allocations for the impaired reaches include the entire watershed draining to the impaired reach. The values in the tables show multiple levels of digits; they are not intended to imply great precision. As a starting point, individual WLAs for Rothsay, Comstock, and Lake Park WWTPs, as well as Minn-Dak Farmers Cooperative – Peet Piling Ground match the WLAs provided for those respective facilities in Table 27 and Table 28. Values less than 1.0 are rounded to two significant digits. Values greater than 1.0 are generally rounded to make the arithmetic accurate. The existing 90th percentile concentrations and overall estimated percent reductions are rounded to the nearest whole number.

Figure 13. TSS LDC for Unnamed Creek (09020104-516).

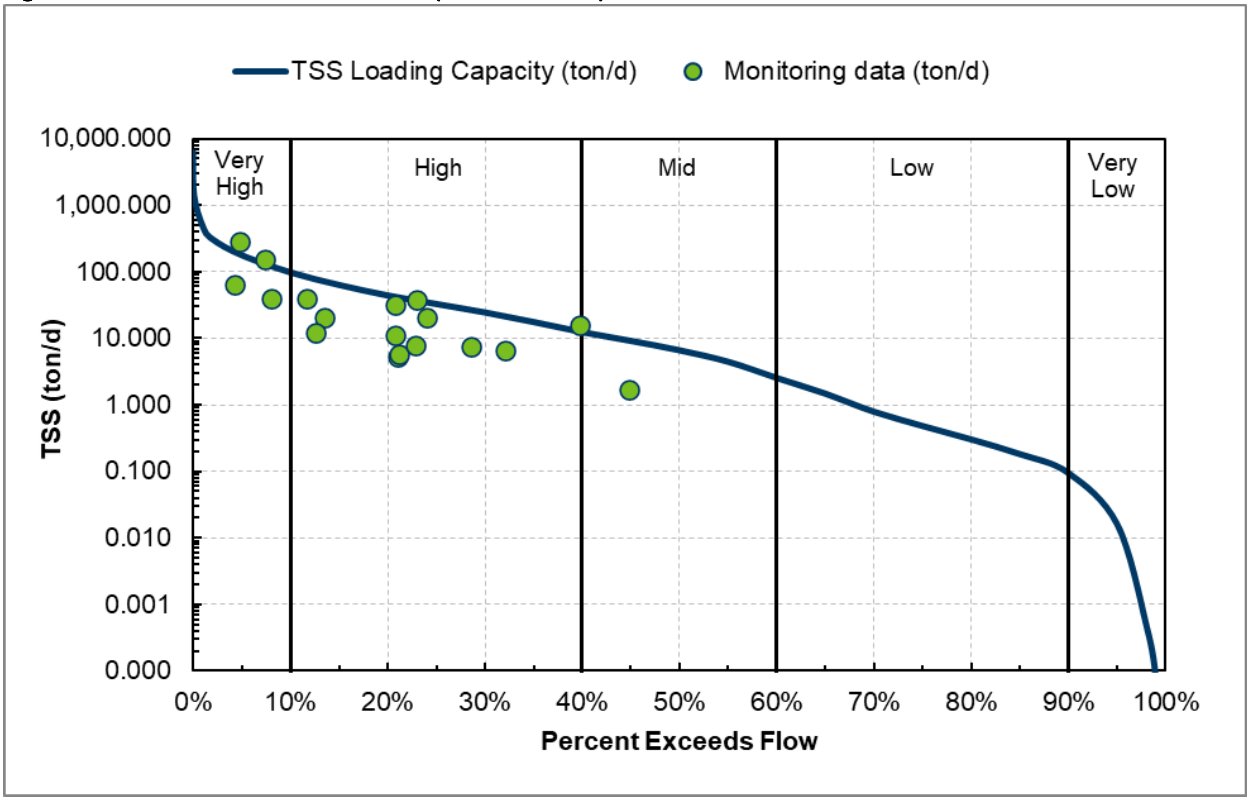


Table 29. Unnamed Creek (09020104-516) TSS TMDL summary.

- Listing year: 2022
- Baseline year: 2019 (end of year)
- Numeric standard used to calculate TMDL: 65 mg/L TSS
- TMDL and allocations apply April 1 through September 30
- Flow used to develop TMDL: HSPF simulated flow from April through September for HSPF reach 203 (2011 through 2022)

TMDL parameter		TMDL TSS load (tons/day) by flow zone				
		Very high	High	Mid	Low	Very low
WLA	Construction stormwater	0.032	0.0059	0.0012	0.000086	*
	Industrial stormwater	0.032	0.0059	0.0012	0.000086	*
	Rothsay WWTP (MNG585064)	0.098	0.098	0.098	0.098	*
	LA	158.40	29.18	5.80	0.33	*
	MOS	17.62	3.25	0.66	0.048	0.0016
	TMDL	176.18	32.54	6.56	0.48	0.016
Existing 90th percentile concentration (mg/L)		76				
Overall estimated percent reduction[1]		24%				

* The permitted wastewater design flows exceed the stream flow in the indicated flow zone. These allocations are expressed as an equation rather than an absolute number: allocation = (flow contribution from a given source) x 65 mg/L (or MNG585064 permit limit of 45 mg/L). See Section 4.1.3 for more detail.
[1] This estimate includes an additional 10% reduction to account for the MOS (see Section 4.1.8).

Figure 14. TSS LDC for Wolverton Creek (09020104-550).

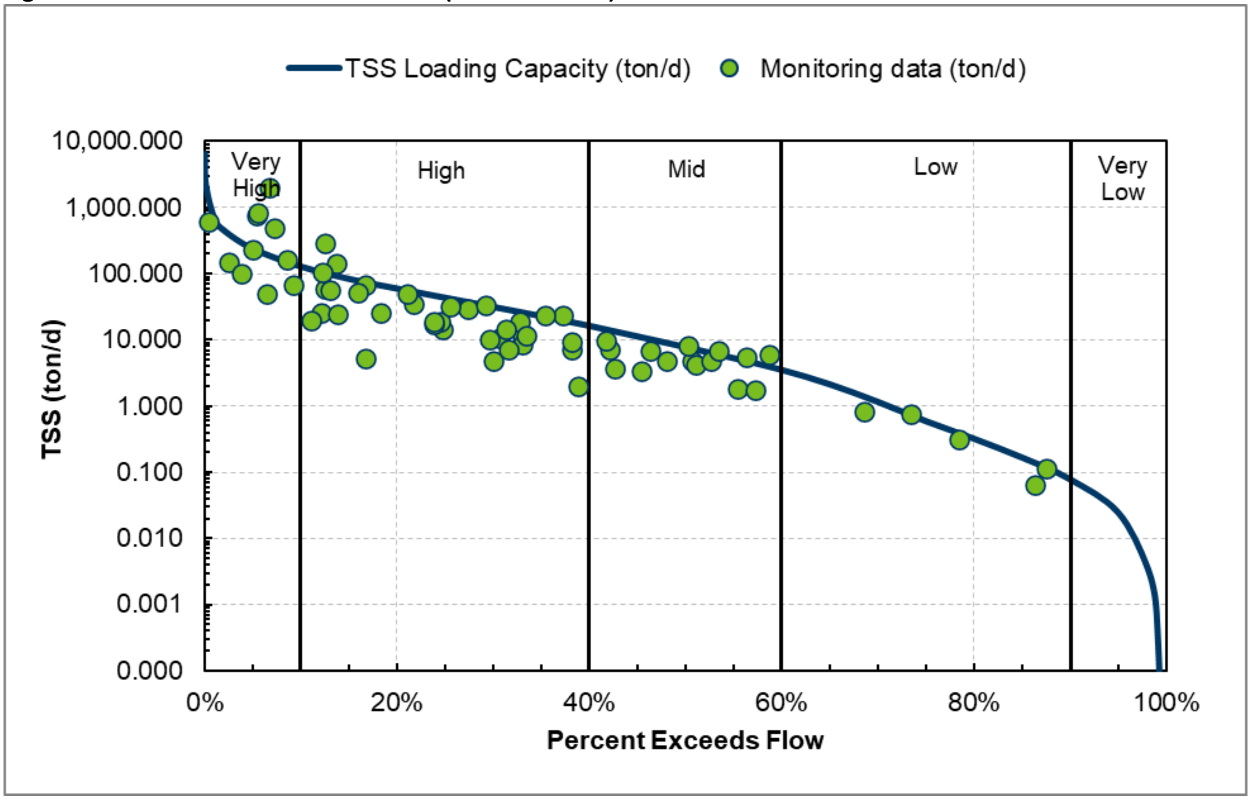


Table 30. Wolverton Creek (09020104-550) TSS TMDL summary.

- Listing year: 2020 (TSS and fish bioassessments)
- Baseline year: 2018 (end of year)
- Numeric standard used to calculate TMDL: 65 mg/L TSS
- TMDL and allocations apply April 1 through September 30
- Flow used to develop TMDL: HSPF simulated flow from April through September for HSPF reach 154 (2011 through 2022)

TMDL parameter		TMDL TSS load (tons/day) by flow zone				
		Very high	High	Mid	Low	Very low
WLA	Construction stormwater	0.043	0.0079	0.0014	0.00011	*
	Industrial stormwater	0.043	0.0079	0.0014	0.00011	*
	Comstock WWTP (MN0023116)	0.043	0.043	0.043	0.043	*
	Minn-Dak Farmers Cooperative – Peet Piling Ground (MN0070386; MNR053FKP)	0.11	0.11	0.11	0.11	*
LA		215.06	39.18	6.90	0.39	*
MOS		23.92	4.37	0.78	0.060	0.0025
TMDL		239.22	43.72	7.84	0.60	0.025
Existing 90th percentile concentration (mg/L)		94				
Estimated percent reduction (mg/L)[1]		41%				

* The permitted wastewater and industrial stormwater design flows exceed the stream flow in the indicated flow zone. These allocations are expressed as an equation rather than an absolute number: allocation = (flow contribution from a given source) x 65 mg/L (or MNG585131 or MN0070386 permit limits of 45 mg/L or 30 mg/L, respectively). See Section 4.1.3 for more detail.
[1] This estimate includes an additional 10% reduction to account for the MOS (see Section 4.1.8).

Figure 15. TSS LDC for Unnamed Creek (Lawndale Cr.) (09020106-530).

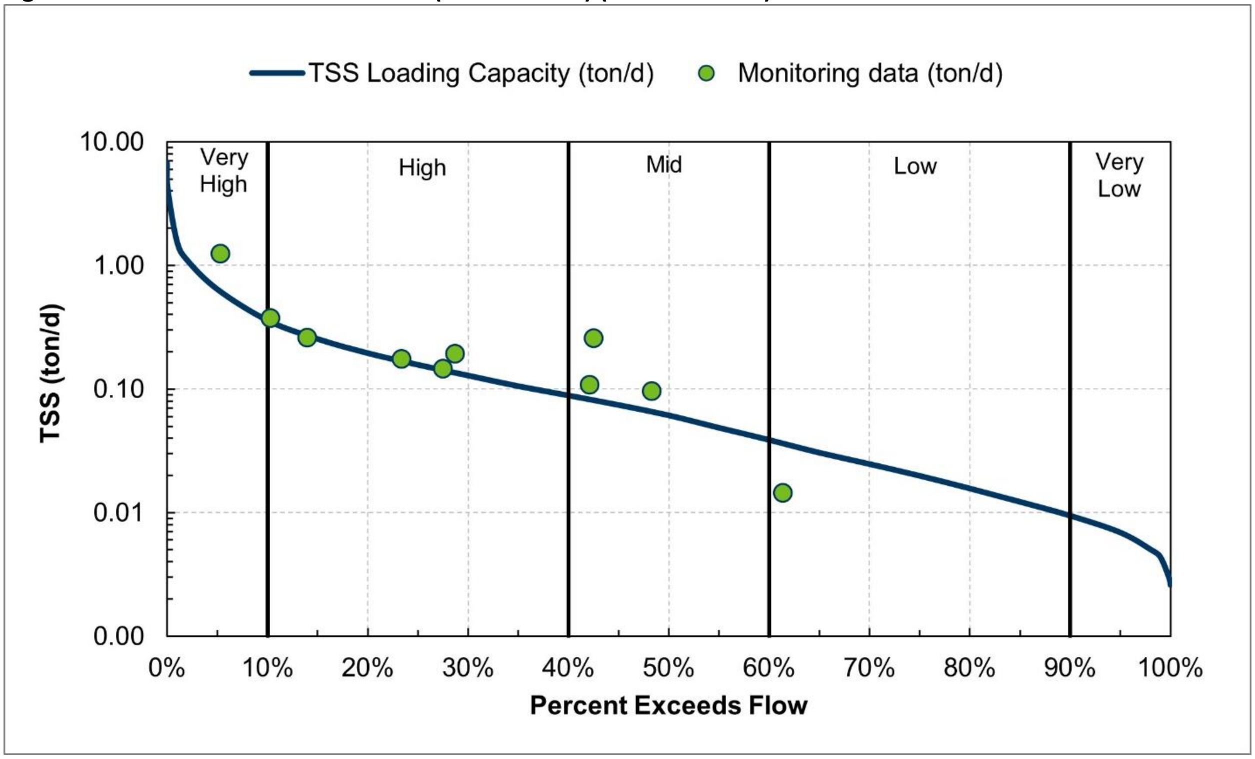


Table 31. Unnamed Creek (Lawndale Creek) (09020106-530) TSS TMDL summary.

- Listing year: 2020
- Baseline year: 2019 (end of year)
- Numeric standard used to calculate TMDL: 10 mg/L TSS
- TMDL and allocations apply April 1 through September 30
- Flow used to develop TMDL: HSPF simulated flow from April through September for HSPF reach 196 (2011 through 2022)

TMDL parameter		TMDL TSS load (tons/day) by flow zone				
		Very high	High	Mid	Low	Very low
WLA	Construction stormwater	0.00012	0.000028	0.000011	0.0000036	0.0000012
	Industrial stormwater	0.00012	0.000028	0.000011	0.0000036	0.0000012
LA		0.58	0.14	0.055	0.018	0.0062
MOS		0.064	0.016	0.0061	0.0020	0.00069
TMDL		0.64	0.16	0.061	0.020	0.0069
Existing 90th percentile concentration (mg/L)		21				
Estimated percent reduction (mg/L)[1]		62%				

[1] This estimate includes an additional 10% reduction to account for the MOS (see Section 4.1.8).

Figure 16. TSS LDC for Hay Creek (09020106-621 and -622).

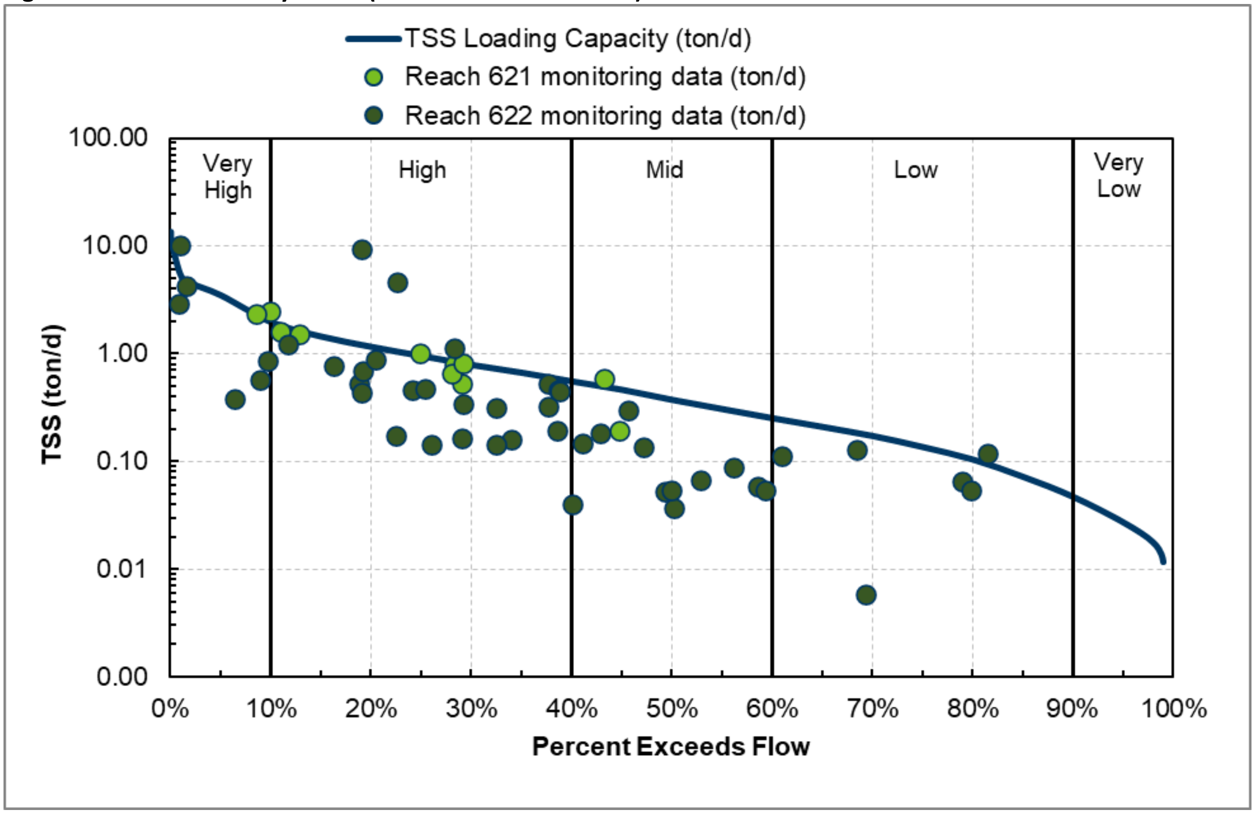


Table 32. Hay Creek (09020106-621 and 09020106-622) TSS TMDL summary.

- Listing year: 2020 (09020106-621 fish bioassessments) 2022 (09020106-622 TSS)
- Baseline year: 09020106-621: 2019 (end of year) 09020106-622: 2020 (end of year)
- Numeric standard used to calculate TMDL: 30 mg/L TSS
- TMDL and allocations apply April 1 through September 30
- Flow used to develop TMDL: HSPF simulated flow from April through September for HSPF reach 155 (2011 through 2022)

TMDL parameter		TMDL TSS load (tons/day) by flow zone				
		Very high	High	Mid	Low	Very low
WLA	Construction stormwater	0.00062	0.00017	0.000067	*	*
	Industrial stormwater	0.00062	0.00017	0.000067	*	*
	Lake Park WWTP (MNG585157)	0.25	0.25	0.25	*	*
LA		2.87	0.61	0.087	*	*
MOS		0.35	0.095	0.037	0.013	0.0027
TMDL		3.47	0.96	0.37	0.13	0.027
Existing 90th percentile concentration (mg/L)		36 (09020106-621) 28 (09020106-622)		34 (WIDs combined)		
Estimated percent reduction (mg/L)[1]		27% (09020106-621) 3% (09020106-622)		21% (WIDs combined)		

* The permitted wastewater design flows exceed the stream flow in the indicated flow zones. These allocations are expressed as an equation rather than an absolute number: allocation = (flow contribution from a given source) x 30 mg/L (or MNG585157 permit limit of 45 mg/L). See Section 4.1.3 for more detail.

[1] This estimate includes an additional 10% reduction to account for the MOS (see Section 4.1.8).

4.2 Phosphorus – rivers and streams

4.2.1 Loading capacity methodology

The LCs for the river and stream TP TMDLs were calculated as the average seasonal (June through September) flow multiplied by the south river nutrient region TP standard of 150 µg/L. Summer average flows for each reach were estimated by taking the midpoint HSPF simulated flows of five equally spaced flow zones: 0% to 20%, 20% to 40%, 40% to 60%, 60% to 80%, and 80% to 100% exceedance value. In other words, the average seasonal flow for each impaired reach is the average of the 10%, 30%, 50%, 70%, and 90% exceedance value. This type of averaging was used over a simple average of all flows in order to limit the bias of very high flows on phosphorus loading, recognizing that the effects of phosphorus (i.e., algal growth) are most problematic at lower flows. Note that these five flow zones are divided differently than those used for TSS (i.e., 5%, 25%, 50%, 75%, and 95%, see Sections 3.6 and 4.1.1). The phosphorus approach is based on using an average of the five flow zones, and having five equally-sized zones avoids weighting some zones more than others when calculating the average flow condition. Table 33 provides the average seasonal flows for each exceedance interval and the resulting summer weighted average flow used to develop each TP TMDL.

Table 33. Summer weighted average flow for each TP TMDL covered in this report (2011-2022).

Exceedance interval	County Ditch 25 (County Ditch 65) (09020106-538) (cfs)	Buffalo River, South Branch (09020106-605) (cfs)	County Ditch 10 (09020106-619) (cfs)
10%	9.5	14.2	13.9
30%	4.4	6.5	6.5
50%	2.3	5.4	3.5
70%	1.2	4.7	1.9
90%	0.5	3.4	1.0
Weighted average	3.6	6.8	5.4

4.2.2 Load allocation methodology

The LA is comprised of the nonpoint source load that is allocated to an impaired reach after the WLAs and MOS were determined and subtracted from the total LC. This residual remaining LC is meant to represent all nonregulated (nonpoint) sources of phosphorus upstream of the impaired reaches. The LA includes nonpoint pollution sources that are not subject to NPDES Permit requirements such as wind-blown materials, soil erosion from stream channel and upland areas, and natural background. The LA also includes runoff from agricultural lands and non-MS4 stormwater runoff. Natural background conditions were also evaluated, where possible, within the modeling and source assessment portion of this study (Section 3.7.1.2). Natural background sources are implicitly included in the LA portion of the TMDL tables, and reductions should focus on the major human attributed sources identified in the source assessment.

4.2.3 Wasteload allocation methodology

The WLA is allocated to existing or future NPDES-permitted pollutant sources. The TP WLAs were calculated for construction and industrial stormwater. There are no MS4s, municipal WWTPs, industrial wastewater facilities needing individual WLAs, or CAFO feedlots within the subwatersheds of impaired streams addressed with a TP TMDL in this report; WLAs for these types of systems were therefore not developed.

4.2.3.1 Construction stormwater

A categorical WLA is assigned to permitted construction stormwater (NPDES permit MNR100001) for each TP TMDL to account for existing and potential future sources. On average, 0.02% of the area in the BRW is under construction stormwater permit coverage (2020 through 2024). Construction stormwater WLAs were calculated as 0.02% multiplied by the LC minus the MOS.

4.2.3.2 Industrial stormwater

Industrial stormwater is regulated through NPDES permits (MNR050000 and MNG490000) when stormwater discharges have the potential to come into contact with materials and activities associated with the industrial activity. To allow for current (Table 21) and future permitted industrial stormwater activities, a categorical WLA for industrial stormwater was calculated as equal to the construction stormwater WLA: 0.02% multiplied by the LC minus the MOS. Stormwater discharges from hydrostatic testing discharge locations (Table 20) are accounted for under the categorical WLA for industrial stormwater.

4.2.4 Margin of safety

The purpose of the MOS is to account for uncertainty that the allocations will result in attainment of water quality standards. Uncertainty can be associated with data collection, lab analysis, data analysis, modeling error, and implementation activities. Quantifying the uncertainty of the various assumptions made in defining the linkage between TP loads and resulting water quality and developing the TMDLs is challenging. Therefore, an explicit MOS equal to 10% of the LC was applied in the TMDLs, based on best professional judgment. The MOS is intended to acknowledge that there is uncertainty in the linkage between TP loads and resulting water quality.

This 10% MOS is considered to be sufficient given the robust water quality and flow monitoring datasets (see Sections 3.6 and 3.6.2), and the use of a high quality hydrologic and water quality model (HSPF) to support these TMDLs. See Section 4.1.4 for a summary of the hydrologic validation statistics for the BRW HSPF model.

4.2.5 Seasonal variation and critical conditions

Critical conditions for the TP TMDLs are during the summer months, which is when TP and response variables typically peak and when aquatic organisms are most active. Stream assessments for eutrophication focus on summer average TP concentration, chl-*a* concentration, BOD, and diel DO flux. The TMDL models are focused on the growing season (June 1 through September 30) as the critical condition, which inherently accounts for the seasonal variation. The frequency and severity of sestonic and benthic algal growth in Minnesota streams is typically highest during the growing season. The load reductions are designed so that the stream will meet the water quality standards over the course of the growing season as a long-term average. The nutrient standards set by the MPCA, which are a growing season concentration average rather than an individual sample (i.e., daily) concentration value, were set with this concept in mind. Additionally, by setting the TMDL to meet targets established for the applicable summer period, the TMDL will inherently be protective of water quality during all other seasons.

4.2.6 Baseline year

The monitoring data used to calculate the TP percent reductions are from 2019 and 2020 for County Ditch 25 (County Ditch 65) (09020106-538), from 2016, 2017, 2019, 2020, 2021, and 2023 for Buffalo River, South Branch (09020106-605), and 2019, 2020, and 2023 for County Ditch 10 (09020106-619) (Section 3.6.2). For County Ditch 25 (County Ditch 65), the baseline year for implementation is 2019 (end of year), the midpoint of the time period. For Buffalo River, South Branch, the baseline year for implementation is 2019 (end of year). For County Ditch 10, the baseline year for implementation is 2020 (end of year). Any BMPs present on the landscape during the HSPF model simulation time period are implicitly accounted for in the model. Any BMPs or projects implemented during or after the baseline year that led to a reduction in TP loading to the impaired water bodies may be considered as progress towards meeting a WLA or LA.

4.2.7 Percent reduction

The existing TP concentration for each impaired reach was calculated by taking the average summer growing season TP concentration for years with available data (see Table 9, Section 3.6.2). Similar to the percent reductions for the TSS TMDLs, the overall estimated concentration-based percent reduction needed to meet the TMDL was calculated as the existing TP concentration minus the TP standard (150 µg/L) divided by the existing concentration plus 10% to account for the MOS. The percent reduction reported in the TMDL tables represent the overall reductions needed to meet the TMDLs but do not necessarily apply to each of the sources or allocations individually.

4.2.8 Phosphorus – rivers and streams TMDL summary

The TP TMDL tables (Table 34, Table 35, and Table 36) present the TMDL, MOS, WLAs, and the LAs for each impaired reach. The TMDL allocations for the impaired reaches include the entire watershed draining to the reach. All values in the tables have been rounded to the nearest thousandth of a pound.

Table 34. County Ditch 25 (County Ditch 65) (09020106-538) TP TMDL summary.

- Listing year: 2020 (fish and macroinvertebrate bioassessments)
- Baseline year: 2019 (end of year)
- Numeric standard used to calculate TMDL: 150 µg/L TP
- TMDL and allocations apply June 1 through September 30
- Flow used to develop TMDL: HSPF simulated flow from June through September for HSPF reach 114 (2011 through 2022)

TMDL parameter		TMDL TP load (lbs/day)
WLA	Construction stormwater[1]	0.001
	Industrial stormwater[1]	0.001
	Total WLA	0.002
MOS		0.291
Total LA[1]		2.614
TMDL		2.907
Existing summer mean TP concentration (µg/L)[2]		264
Estimated percent reduction[3]		53%

[1] The daily WLAs for construction and industrial stormwater and the total LA (i.e., nonpermitted watershed runoff) equate to a mean summer TP runoff concentration target of 135 µg/L (150 µg/L water quality standard minus 10% MOS). This target is for the outlet of this impaired stream and therefore includes losses of phosphorus in the impaired reach and stream network upstream of the impaired reach.
[2] Water quality monitoring station used to estimate reductions: S011-136.
[3] This estimate includes an additional 10% reduction to account for the MOS (see Section 4.2.7).

Table 35. Buffalo River, South Branch (09020106-605) TP TMDL summary.

- Listing year: 2012 (DO); 2020 (fish and macroinvertebrate bioassessments)
- Baseline year: 2019 (end of year)
- Numeric standard used to calculate TMDL: 150 µg/L TP
- TMDL and allocations apply June 1 through September 30
- Flow used to develop TMDL: HSPF simulated flow from June through September for HSPF reach 197 (2011 through 2022)

TMDL parameter		TMDL TP load (lbs/day)
WLA	Construction stormwater[1]	0.001
	Industrial stormwater[1]	0.001
	Total WLA	0.002
MOS		0.553
Total LA[1]		4.975
TMDL		5.530
Existing summer mean TP concentration (µg/L)[2]		170
Estimated percent reduction[3]		22%

[1] The daily WLAs for construction and industrial stormwater and the total LA (i.e., nonpermitted watershed runoff) equate to a mean summer TP runoff concentration target of 135 µg/L (150 µg/L water quality standard minus 10% MOS). This target is for the outlet of this impaired stream and therefore includes losses of phosphorus in the impaired reach and stream network upstream of the impaired reach.
[2] Water quality monitoring station used to estimate reductions: S003-148.
[3] This estimate includes an additional 10% reduction to account for the MOS (see Section 4.2.7).

Table 36. County Ditch 10 (09020106-619) TP TMDL summary.

- Listing year: 2022 (DO); 2020 (macroinvertebrate bioassessments)
- Baseline year: 2020 (end of year)
- Numeric standard used to calculate TMDL: 150 µg/L TP
- TMDL and allocations apply June 1 through September 30
- Flow used to develop TMDL: HSPF simulated flow from June through September for HSPF reach 105 (2011 through 2022)

TMDL parameter		TMDL TP load (lbs/day)
WLA	Construction stormwater[1]	0.001
	Industrial stormwater[1]	0.001
	Total WLA	0.002
MOS		0.434
Total LA[1]		3.902
TMDL		4.338
Existing summer mean TP concentration (µg/L)[2]		138
Estimated percent reduction[3]		1%

[1] The daily WLAs for construction and industrial stormwater and the total LA (i.e., nonpermitted watershed runoff) equate to a mean summer TP runoff concentration target of 135 µg/L (150 µg/L water quality standard minus 10% MOS). This target is for the outlet of this impaired stream and therefore includes losses of phosphorus in the impaired reach and stream network upstream of the impaired reach.
[2] Water quality monitoring station used to estimate reductions: S005-610.
[3] This estimate includes an additional 10% reduction to account for the MOS (see Section 4.2.7).

4.3 Phosphorus – Lee Lake

4.3.1 Loading capacity methodology

Allowable TP loads to Lee Lake were determined using the lake response model BATHTUB. The BATHTUB model is a steady state model that predicts eutrophication response in lakes based on empirical formulas developed for nutrient balance calculations and algal response (Walker 1987). The model was developed by the U.S. Army Corps of Engineers and has been used extensively in Minnesota and across the Midwest for lake nutrient TMDLs. A spreadsheet version of the BATHTUB model was used for the Lee Lake TMDL. The BATHTUB model requires nutrient loading inputs from the upstream watershed, septic systems, and atmospheric deposition (Sections 3.7.1.2 and 3.7.4.2, Table 14), as well as lake morphometric data (Table 5). Watershed runoff volumes and loads were derived from the HSPF model (see Section 3 for a brief description of the model). The BATHTUB model inputs and outputs are presented in Appendix E. Lee Lake supporting analysis.

With the primary external sources defined, the model predicted in-lake TP concentration was compared to the 2010 and 2011 observed mean concentration (Table 10). Initially, the model predicted in-lake TP concentration was slightly higher than the observed concentration and therefore the model's TP sedimentation calibration factor was increased to allow more phosphorus settling and better calibration to the 2010 and 2011 observed data. Although there is evidence that phosphorus recycling occurs in Lee Lake (see Section 3.7.4.2), the BATHTUB model did not require an additional phosphorus load to calibrate the model. The temperature and DO profiles for Lee Lake indicate the lake remains stratified into late September. As a result, a significant portion of the phosphorus recycled from the lake's sediment likely remains trapped in the hypolimnion during most of the summer growing season and does not mix with surface waters, therefore justifying the upward adjustment of the sedimentation factor.

After the model was calibrated, a TMDL scenario was developed using the following methods:

- No reductions to atmospheric load were assigned since these loads were generally a small portion of the total load to the lake and the sources are extremely difficult to define and control.
- Phosphorus loading from noncompliant septics were reduced to levels expected from properly functioning systems. See Section 3.7.4.2 for more discussion on the methods used to estimate septic contributions and Reasonable Assurance SSTS Section 6.2.1.
- Watershed loading was reduced incrementally until the lake model indicated the lake was meeting lake water quality standards.

4.3.2 Load allocation methodology

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

The LAs are based the lake's TMDL scenario described above. To allow for the MOS, the allocation for watershed loading (all watershed sources) was reduced by a total amount equal to the MOS.

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

4.3.3 Wasteload allocation methodology

The WLAs are allocated to existing or future NPDES-permitted pollutant sources. The TP WLAs were calculated for construction stormwater and for potential future industrial stormwater facilities. There are no MS4s or municipal or industrial wastewater facilities needing WLAs in the Lee Lake Subwatershed and none are expected in the future.

No WLAs are assigned to CAFOs, including CAFOs with NPDES or SDS permits and CAFOs not requiring permits; this is equivalent to a WLA of zero. Although the NPDES and SDS permits allow discharge of manure and manure contaminated runoff due to a precipitation event greater than or equal to a 25-year, 24-hour precipitation event, the permits prohibit discharges that cause or contribute to nonattainment of water quality standards. All other non-CAFO feedlots and the land application of all manure are accounted for in the LA for nonpermitted sources.

4.3.3.1 Construction stormwater

A categorical WLA is assigned to permitted construction stormwater (NPDES permit MNR100001) for the Lee Lake TMDL to account for existing and potential future sources. On average, 0.02% of the area in the

BRW is under construction stormwater permit coverage (2020 through 2024). The construction stormwater WLA was calculated as 0.02% multiplied by the load allocated to watershed runoff.

4.3.3.2 Industrial stormwater

Industrial stormwater is regulated through NPDES permits (MNR050000 and MNG490000) when stormwater discharges have the potential to come into contact with materials and activities associated with the industrial activity. While there are currently no permitted industrial stormwater facilities in the Lee Lake Subwatershed, a categorical WLA for industrial stormwater was calculated to allow for potential permitted industrial stormwater activities as equal to the construction stormwater WLA: 0.02% multiplied by the load allocated to watershed runoff.

4.3.4 Margin of safety

An explicit MOS of 10% was included in the TP TMDL for Lee Lake. The MOS is intended to acknowledge that there is uncertainty in the linkage between TP loads and resulting water quality. Simulated flows and phosphorus loading rates from the BRW HSPF model (MPCA 2024g) were used to develop the BATHTUB lake model and TMDL for Lee Lake. The 10% MOS is considered to be sufficient given the robust water quality and flow monitoring datasets used to calibrate the BRW HSPF model. See Section 4.1.4 which provides further justification for the MOS and a summary of the hydrologic validation statistics for the BRW HSPF model.

Even more important than the MOS described above, effective adaptive management during implementation of the Lee Lake TMDL will provide the ultimate assurance that the lake will achieve water quality targets and standards. Sections 8.1 and 8.2 provide some types of implementation strategies that will help meet the lake TMDL targets and goals in this report, while Section 8.5 describes the adaptive management process.

4.3.5 Seasonal variation and critical conditions

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

Seasonal variation and critical conditions are also addressed by the water quality standards. The eutrophication standards for lakes apply from June through September, when aquatic recreation is more likely to occur in Minnesota waters and when high TP concentrations generally occur.

4.3.6 Baseline year

The monitoring data used to calculate the percent reductions for Lee Lake (14-0049-00) are from 2010 and 2011 (Section 3.6.3). The baseline year for implementation is 2010 (end of year), the midpoint of the time period. Any BMPs present on the landscape during the model simulation time period are implicitly accounted for in the model. Any BMPs or projects implemented during or after the baseline year that led to a reduction in TSS loading to the impaired water bodies may be considered as progress towards meeting a WLA or LA.

4.3.7 Percent reduction

The estimated percent reductions provide a rough approximation of the reductions needed for Lee Lake to meet the TMDL. The percent reduction is a means to capture the level of effort needed to reduce TP loads to the lake. The percent reductions needed to meet each allocated load in the TMDL table were calculated as follows:

Percent reduction = (existing load – allocated load)/existing load

The total estimated load reduction is the sum of the load reductions needed from the individual allocations in the TMDL table, and the percent reduction needed to meet the TMDL is the total estimated load reduction divided by the existing load.

4.3.8 Lee Lake TMDL summary

Table 37 summarizes the existing and allowable (TMDL) TP loads, the TMDL allocations (WLA and LA) and the required TP reductions for Lee Lake. In this table, the total load reduction is the sum of the required WLA reductions plus the required LA reductions; this is not the same as the net difference between the existing and allowable total loads, however, because the WLA and LA reductions must accommodate the MOS. The estimated percent reduction provides a rough approximation of the overall reduction needed for Lee Lake to meet the TMDL. The BATHTUB model's inputs and outputs are presented in Appendix E. Lee Lake supporting analysis.

The model developed for the Lee Lake TMDL suggests watershed runoff is the dominant source of phosphorus to the lake. Thus, reducing external phosphorus loads should be the primary focus of implementation and will be critical to achieving the Lee Lake TMDL. Although there is evidence that internal phosphorus recycling occurs within Lee Lake, it is assumed that the rate of recycling will decrease as the lake and sediments equilibrate to lower external phosphorus loads. Implementation strategies to decrease internal phosphorus recycling could be considered if in-lake TP and eutrophication response variables do not improve, or are slow to improve, as watershed reductions are achieved. Strategies to reduce internal recycling could also be pursued if BMP efforts to reduce external loads fall short of the targets and goals set by the local partners. Internal recycling strategies could include, but are not limited to, water level drawdown, sediment dredging, sediment phosphorus immobilization or chemical treatment (e.g., alum and Phoslock®). The MPCA recommends feasibility studies for any lake in which major in-lake management strategies are proposed. The *Minnesota State and Regional Government Review of Internal Phosphorus Load Control* paper (MPCA 2020b) provides more information on internal load BMPs and considerations.

Table 37. Lee Lake (14-0049-00) TP TMDL summary.

- Listing year: 2012
- Baseline year: 2010 (end of year)
- Numeric standard used to calculate TMDL: 40 µg/L TP
- TMDL and allocations apply January 1 through December 31

TMDL parameter		Existing TP load		TMDL TP load		Estimated load reduction	
		lbs/year	lbs/day	lbs/year	lbs/day	lbs/year	%
WLA	Construction stormwater	0.2	0.001	0.2	0.001	0.0	0
	Industrial stormwater	0.2	0.001	0.2	0.001	0.0	0
	Total WLA	**0.4**	**0.002**	**0.4**	**0.002**	**0.0**	**0**
LA	Watershed runoff	1,437.0 [1]	3.937	831.0 [2]	2.277	606.0	42
	SSTS	38.8	0.106	34.8	0.095	4.0	10
	Atmospheric deposition	36.8	0.101	36.8	0.101	0.0	0
	Total LA	**1,512.6**	**4.144**	**902.6**	**2.473**	**610.0**	**40**
	MOS	**–**	**–**	**100.3**	**0.275**	**–**	**–**
	Total load	**1,513.0**	**4.146**	**1,003.3**	**2.750**	**610.0 [3]**	**40**

[1] Existing annual watershed runoff TP load was estimated using HSPF model (reach 164) model years 2003 through 2022 (full calendar year loads, Jan-Dec). The existing watershed runoff predicted by HSPF assumes a mean watershed runoff volume to Lee Lake of 2,230 acre-ft per year and a mean runoff TP concentration of 237 µg/L.

[2] The TMDL watershed runoff LA assumes a mean annual watershed runoff volume of 2,230 acre-ft per year and a mean annual (Jan-Dec) TP runoff concentration target of 137 µg/L after the MOS is applied.

[3] Net reduction from existing load to TMDL load is 509.7 lbs/yr; but the gross load reduction from all sources must accommodate the 10% MOS as well, and therefore 509.7 + 100.3 = 610.0 lbs/yr.

5. Future growth considerations

Potential changes in population and land use over time in the BRW and URRW, and the surrounding area, could result in corresponding changes to pollutant sources and water quality conditions. According to the Minnesota State Demographic Center, the populations of Clay, Becker, and Otter Tail Counties are all projected to increase by roughly 12% to 15% from 2024 to 2055, with Wilkin County remaining stable (projected 0% change) (Admin 2025). Much of this growth is expected to occur within or near the larger cities in the area, both within and outside of the BRW and URRW. From 2010 through 2019, the cities within the BRW and URRW that experienced the greatest growth include Comstock (16%), Moorhead (15%), Dilworth (10%), Sabin (7%), and Hawley (6%). Some cities within the regional area but located outside of the BRW and URRW also experienced significant growth, including Detroit Lakes and Fergus Falls, Minnesota (8% and 5%, respectively), and Fargo and West Fargo, North Dakota (18% and 43%, respectively). Populations within other cities in the BRW and URRW either remained stable during that same time frame (Barnesville, Lake Park, and Audubon, 0% to 2% growth), or declined (Glyndon, Callaway, Georgetown, Rothsay, Breckenridge, Wolverton, and Kent, 2% to 9% reduction). (Census 2025).

The current land cover distributions of the subwatersheds addressed in this TMDL report are largely agricultural (Table 6), with Wolverton Creek (WID 09020104-550) and Hay Creek (WIDs 09020106-621 and 09020106-622) being the only impaired water bodies in this TMDL report potentially impacted by urban growth (Figure 1). Therefore, the MPCA does not anticipate significant water quality impacts from population growth and land use changes for most of the impaired water bodies addressed in this report. However, there may be potential water quality impacts from population growth and land use changes for Wolverton Creek and Hay Creek, as well as other water bodies within and near the BRW and URRW including the Red River of the North.

5.1 New or expanding permitted MS4 WLA transfer process

While there are currently no MS4 permitted facilities within the drainage areas of impaired waters addressed by this TMDL, future transfer of watershed runoff loads in this TMDL may be necessary if any of the following scenarios occur within the project watershed boundaries.

1. New development occurs within a permitted MS4. Newly developed areas that are not already included in the WLA must be transferred from the LA to the WLA to account for the growth.
2. One permitted MS4 acquires land from another permitted MS4. Examples include annexation or highway expansions. In these cases, the transfer is WLA to WLA.
3. One or more nonpermitted MS4s become permitted. If this has not been accounted for in the WLA, then a transfer must occur from the LA.
4. Expansion of a U.S. Census Bureau Urban Area with population over 50,000 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 source is identified and is covered under an NPDES/SDS permit. In this situation, a transfer must occur from the LA.

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

5.2 New or expanding wastewater

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

6. Reasonable assurance

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

6.1 Reduction of permitted sources

6.1.1 Permitted wastewater

Permits for any NPDES/SDS permitted facility discharging wastewater that has a reasonable potential to cause or contribute to the water quality impairments addressed by these TMDLs include, or will include upon permit reissuance, WQBELs that are consistent with the assumptions and requirements of these TMDL WLAs. Discharge monitoring is conducted by permittees and routinely submitted to the MPCA for review.

The NPDES/SDS permits for discharges that may cause or have reasonable potential to cause or contribute to an exceedance of a water quality standard are required to contain WQBELs consistent with the assumptions and requirements of the WLAs in this TMDL report. Attaining the WLAs, as developed and presented in this TMDL report, is assumed to ensure meeting the water quality standards for the relevant IWL. During the permit issuance or reissuance process, wastewater discharges will be evaluated for the potential to cause or contribute to violations of water quality standards. Next, WQBELs will be developed for facilities whose discharges are found to have a reasonable potential to cause or contribute to exceedances of applicable water quality standards. The WQBELs will be calculated based on low flow conditions, may vary slightly from the TMDL WLAs, and may include concentration based effluent limitations.

The TSS WLA assigned in this TMDL report to Rothsay WWTP (MNG585064, 0.098 tons/day) is slightly updated from the TSS WLA assigned to that facility in the *Upper Red River of the North Watershed Total Maximum Daily Load Report* (MPCA 2017a, 0.09 tons/day) (Section 4.1.3).The TSS WLA assigned in this TMDL report to Lake Park WWTP (MNG585157, 0.25 tons/day) is the same as the TSS WLA assigned to that facility in the BRW TMDL (MPCA 2016). The TSS WLA assigned in this TMDL report for Comstock WWTP (MNG585131, 0.043 tons/day) is a new WLA. No new permit limits will result from these TSS WLAs as the WLAs are consistent with current permit conditions for all four facilities.

Previously, the MPCA determined that WWTPs in the BRW and URRW do not have reasonable potential to cause or contribute to an exceedance of RES both within the watersheds and downstream (MPCA 2017b, MPCA 2020c). However, WWTP permittees should be informed that future TP limits may be necessary based on new water quality monitoring, future TMDL reports, or the completion of a Lake Winnipeg restoration plan.

The MPCA tracks improvements in pollutant loading from WWTP effluents via the WWTP progress tool on the Healthier Watersheds webpage (MPCA 2024o). This tool suggests that TSS loading from WWTPs in the BRW and URRW is generally stable over the last 10 years but may increase during significantly wet years, while TP loading in the watersheds has generally decreased over the last 2 decades.

6.1.2 Permitted construction stormwater

Regulated construction stormwater was given a categorical WLA in this study. Construction activities disturbing one acre or more or those activities that are part of a larger common plan of development are required to obtain NPDES/SDS 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 Section 23 of the Construction General Permit for discharges to impaired waters, or compliance with local construction stormwater requirements if they are more restrictive than those in the State General Permit.

6.1.3 Permitted industrial stormwater

The industrial stormwater facilities addressed in this TMDL report were given a categorical WLA. Generally, industrial activities require permit coverage under the state's NPDES/SDS Industrial Stormwater Multi-Sector General Permit (MNR050000) or NPDES/SDS Nonmetallic Mining and Associated Activities General Permit (MNG490000). If a facility owner/operator obtains stormwater coverage under the appropriate NPDES/SDS permit and properly selects, installs, and maintains BMPs sufficient to meet the benchmark values in the permit, the stormwater discharges would be expected to be consistent with the WLA in this TMDL report.

6.1.4 Individual NPDES/SDS permitted facilities

Minn-Dak Farmers Cooperative – Peet Piling Ground (MN0070386, MNR053FKP) was assigned a new individual WLA in this TMDL report. Permit MN0070386 requires twice per week sampling during discharge events for TSS and includes TSS concentration and loading effluent limits (Section 3.7.2.1). If sampling by the permittee indicates a violation of any discharge limit specified in this permit, the permittee must immediately make every effort to verify the violation by collecting additional samples, if appropriate, investigate the cause of the violation, and take action to prevent future violations. Furthermore, permit MNR053FKP includes a benchmark monitoring value for TSS of 100 mg/L, to be sampled at least once per quarter. An exceedance of an applicable benchmark value does not constitute a violation. However, the permittee must perform all necessary corrective action(s) to address stormwater control measures, including the maintenance or implementation of BMPs, when an exceedance of an applicable benchmark value occurs. If the facility owner/operator maintains permit coverage and properly selects, installs, and maintains BMPs sufficient to meet the permit limits and benchmark values, the discharge would be expected to be consistent with the individual WLA in this TMDL report.

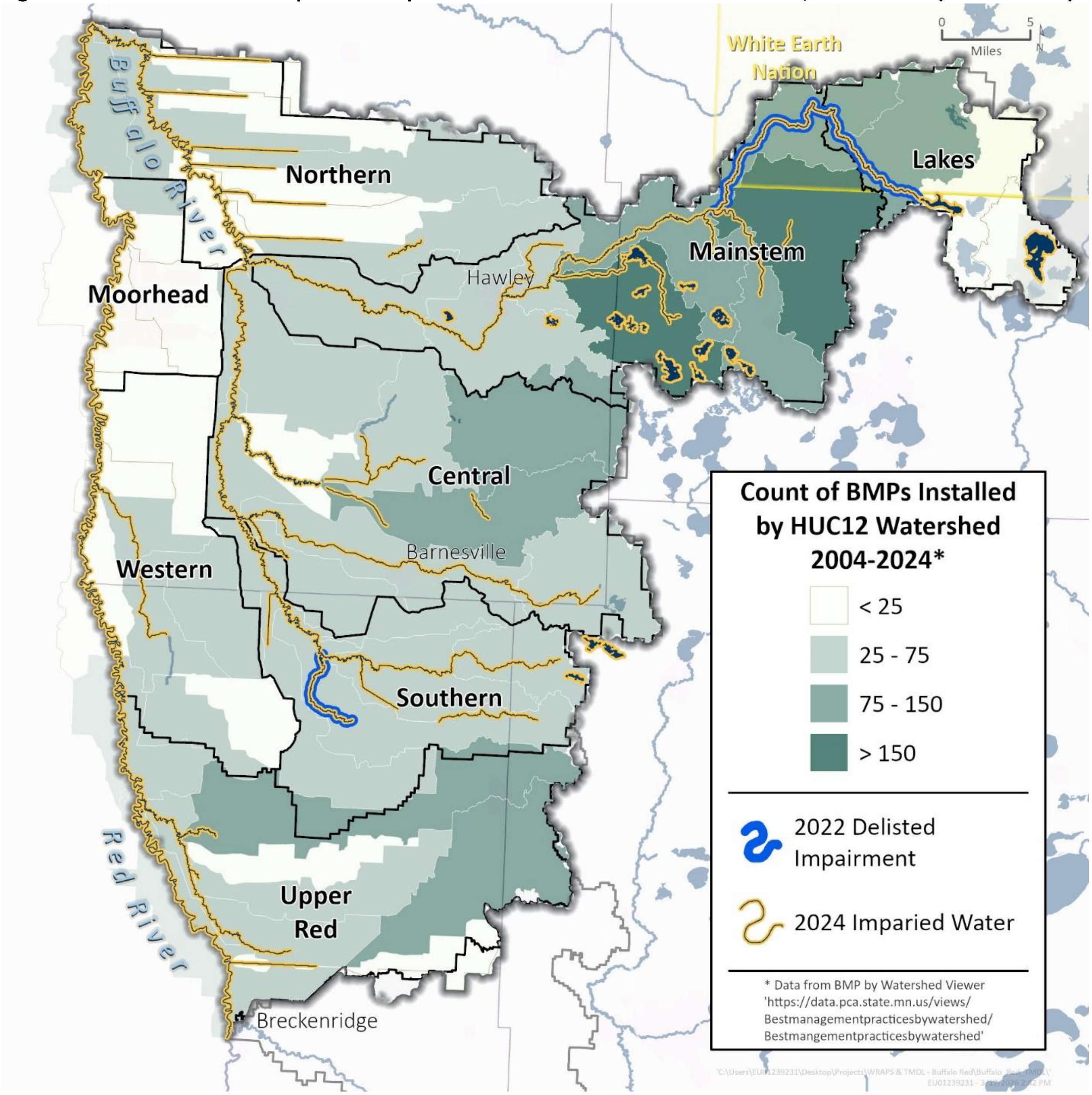
6.1.5 Permitted feedlots

See the discussion of the state's Feedlot Program in Section 6.2.2, which applies to both permitted and nonpermitted feedlots.

6.2 Reduction of nonpermitted sources

Several nonpermitted reduction programs exist to support implementation of nonpoint source reduction BMPs in the BRW and URRW. These programs identify BMPs, provide means of focusing BMPs, and support their implementation via state initiatives, ordinances, and/or dedicated funding. Figure 17 shows the number of BMPs that have been implemented per subwatershed in the BRW and URRW from 2004 through 2024, as tracked via the BMPs Implemented by Watershed tool on the MPCA's Healthier Watersheds webpage (MPCA 2024o).

Figure 17. Number of BMPs implemented per subwatershed in the BRW and URRW, 2004 – 2024 (MPCA 2024o).



In the URRW, many of the BMPs are located in the contributing subwatersheds of Wolverton Creek (WIDs 09020104-549 and 09020104-550) and Whiskey Creek (09020104-520), further discussed in Sections 6.2.5 and 6.4, while many of the BMPs implemented in the BRW are located in the subwatersheds of Hay Creek (WIDs 09020106-621 and 09020106-622) and the upstream reaches of the Buffalo River (WIDs 09020106-593 and 09020106-594). Additional monitoring along these reaches to track potential changes in water quality over time is warranted in the future (Section 7).

The BRRWD and Clay, Becker, West Otter Tail, and Wilkin SWCDs are active in the BRW and URRW, providing technical and financial assistance to reduce impacts from agricultural and developed sources. Focus areas include nutrient management, conservation tillage, and soil health practices to reduce sediment and nutrient loading, water storage and infiltration practices to reduce runoff, and stream bank and lakeshore habitat preservation to protect aquatic ecosystems. Many practices recommended to landowners are designed to provide multiple water quality benefits including diversifying crop rotations, expanding opportunities for buffers and natural riparian habitats, improving manure storage and application practices and grazing practices, and mitigating impacts of ditching and tile drainage.

The following sections provide examples of large-scale programs that have proven to be effective and/or will reduce pollutant loads in the BRW and URRW going forward.

6.2.1 SSTS Program

SSTS regulation and education

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

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

Each county maintains an SSTS ordinance, in accordance with Minn. Stat. and Minn. R., establishing minimum requirements for regulation of SSTS, for the treatment and dispersal of sewage within the applicable jurisdiction of the county, to protect public health and safety, to protect groundwater quality, and to prevent or eliminate the development of public nuisances. Ordinances serve the best interests of the county's residents by protecting health, safety, general welfare, and natural resources. In addition, each county zoning ordinance prescribes the technical standards that on-site septic systems are required to meet for compliance and outlines the requirements for the upgrade of systems found not to be in compliance. This includes systems subject to inspection at transfer of property, upon the addition of living space that includes a bedroom and/or a bathroom, and at discovery of the failure of an existing system.

Education is another crucial component of reducing pollutant loading from SSTSs. Education can occur through public meetings, routine SSTS service provider home visits, mass mailings, and radio and television advertisements. An inspection program can also help with public education because inspectors can educate owners about proper operation and maintenance during inspections.

SSTS assessments

State-sponsored funding programs are available for community-wide septic system assessments. The Minnesota Public Facilities Authority administers the Small Community Wastewater Treatment Program (MPFA 2024), which provides grants of up to $60,000 to local government units (LGUs) to conduct preliminary site evaluations and prepare feasibility reports, provide advice on possible SSTS alternatives, and help develop the technical, managerial, and financial capacity to build, operate, and maintain SSTS systems. These studies assess current SSTS compliance status as well as potential future individual and/or community SSTS solutions.

The Minnesota Board of Water and Soil Resources (BWSR) has provided grant funds in the past to local governments for large-scale SSTS compliance inspection projects. These projects typically involve riparian communities on impaired water bodies.

SSTS maintenance, upgrades, and replacement

The reductions in loading resulting from upgrading or replacing failing systems in the watershed depend on the level of failure present in the watershed. The most cost-effective approach to manage loads from SSTSs is regular maintenance. The EPA recommends that septic tanks be pumped every three to five years depending on the tank size and number of residents in the household (EPA 2002). Annual inspections, in addition to regular maintenance, ensure that systems function properly. Compliance with state and county code is essential to reducing pollutant loading from SSTSs.

All known imminent threats to public health and safety (ITPHS) are recorded in a statewide database by the MPCA. Some of the alleged straight pipes are typically found to have been abandoned, fixed, or not to be a straight pipe system. The remaining known, unfixed, straight pipe systems receive a notice of noncompliance with a 10-month deadline to be fixed, are issued Administrative Penalty Orders, or are docketed in court.

The MPCA provides additional information for SSTS financial assistance (MPCA 2024p). Many counties and SWCDs offer low interest loan programs for SSTS upgrades or replacement, and the Minnesota Department of Agriculture's (MDA's) Agricultural BMP Loan Program can also fund septic systems. The MPCA Clean Water Partnership program offers low-interest loans to local units of government for implementing nonpoint source BMPs and other activities that target the restoration and protection of water resources such as lakes, streams, or groundwater aquifers; these funds can be used for SSTS upgrades and replacements. The Small Community Wastewater Program (MPFA 2024) also offers grant and loan packages of up to $2,000,000 for the construction of publicly owned community SSTS.

Otter Tail County was awarded a Clean Water Partnership Loan and utilized approximately $1.85 million in loan funds to replace over 100 SSTS county-wide from 2020-2023, including 1 SSTS replacement in the subwatershed of Unnamed Creek (WID 09020104-516). Otter Tail County chose to continue their Clean Water Partnership Loan program and was awarded a second loan of up to $1.25 million to be used for SSTS replacements between 2024 and 2027; these funds are available to property owners in the portions of the BRW and URRW within Otter Tail County. No Clean Water Partnership Loans have been applied for or awarded in Becker, Clay, or Wilkin Counties.

From 2017-2024, a total of 1,824 septic systems have been replaced in Becker, Clay, and Wilkin Counties (Table 38). These figures are provided county-wide and are not specific to the BRW and URRW.

Table 38. SSTS replacements within BRW and URRW counties, 2017–2024[1] (MPCA 2024j).

County	2017	2018	2019	2020	2021	2022	2023	2024	Totals
Becker	220	154	161	283	276	158	136	124	1,512
Clay	40	37	17	23	38	32	24	20	231
Wilkin	10	2	6	17	15	9	12	10	81

1. SSTS replacement data for Otter Tail County are not provided since very small portions of the subwatersheds of only three impaired streams addressed in this TMDL report are located within Otter Tail County, with a small number of properties estimated to have individual SSTS located in those small portions of the subwatersheds.

6.2.2 Feedlot Program

The MPCA's Feedlot Program addresses both permitted and nonpermitted feedlots. The Feedlot Program implements rules governing the collection, transportation, storage, processing, and disposal of animal manure and other livestock operation wastes. Minn. R. ch. 7020 regulates feedlots in the state of Minnesota. All feedlots are subject to this rule. The focus of the rule is on animal feedlots and manure storage areas that have the greatest potential for environmental impact. All feedlots capable of holding 50 or more AUs, or 10 in shoreland areas, are required to register. A feedlot holding 1,000 or more AUs is required to obtain a NPDES or SDS permit.

The Feedlot Program is implemented through cooperation between MPCA and delegated county governments in 50 counties in the state. The MPCA works with county representatives to provide training, program oversight, policy and technical support, and formal enforcement support when needed. A county participating in the program has been delegated authority by the MPCA to administer the Feedlot Program. These delegated counties receive state grants to help fund their feedlot programs based on the number of feedlots in the county and the level of inspections they complete. In recent years, annual grants given to these counties statewide totaled about two million dollars (MPCA 2021a).

In the BRW and URRW, Clay County is the only delegated county. The Clay SWCD will continue to work with the MPCA to administer the feedlot program and work with producers on feedlot registrations and permits, compliance inspections, manure management plans, and more. In Clay County, all non-CAFO feedlots are inspected by the county feedlot officer on a routine basis in accordance with the county's Delegation Agreement and Work Plan, which is prepared with and approved by MPCA every-other year. Approximately 116 of the 189 (61%) currently registered non-CAFO feedlots in the BRW and URRW are located within Clay County (MPCA 2024i).

In Becker, Otter Tail, and Wilkin Counties, the MPCA is the feedlot regulatory authority and is tasked with overseeing the Feedlot Program. CAFOs are inspected in all counties by the MPCA in accordance with the MPCA NPDES Compliance Monitoring Strategy approved by the EPA. CAFOs (NPDES permitted, SDS permitted and not required to be permitted) are inspected by the MPCA on a routine basis with an appropriate mix of field inspections, offsite monitoring, and compliance assistance. Non-CAFOs in nondelegated counties are inspected by MPCA on an as-needed or complaint-driven basis.

From 2011 through 2024, approximately 91 feedlot inspections were conducted in the BRW and URRW by the Clay County feedlot officer or by the MPCA, with 82 of those inspections occurring at non-CAFO facilities and 9 at CAFO facilities. Additionally, in 2024, the MPCA finalized revised SDS and NPDES general permits for CAFO feedlots, which are to replace the current SDS general permit which expired on May 31, 2025, and the current NPDES general permit, which expired on January 31, 2026. Changes within the new permits include increased requirements for land application of manure in areas of the state with vulnerable groundwater resources, additional visual inspections during and after land application of manure and requiring manure that is "transferred" to other landowners to be applied in accordance with the permit requirements. The MPCA will work to reissue permit coverage to all CAFOs and feedlots with 1,000 or more AUs requiring a NPDES or SDS permit in accordance with the expiration of those permits. Furthermore, beginning in 2025, the MPCA has proposed to amend Minn. R. ch. 7020 to improve land application of manure practices to address nitrate and fish kills, establish additional technical standards to protect water quality and avoid fish kills, address changes in livestock and poultry operational practices, account for new MPCA data services, and modernize outdated rule language. The rule amendment process is expected to take multiple years (MPCA 2025d).

6.2.3 Minnesota buffer law

Minnesota's buffer law (Minn. Stat. § 103F.48) requires perennial vegetative buffers of up to 50 feet along lakes, rivers, and streams and buffers of 16.5 feet along ditches. These buffers help filter out phosphorus, nitrogen, and sediment. Alternative practices are allowed in place of a perennial buffer in some cases. Amendments enacted in 2017 clarify the application of the buffer requirement to public waters, provide additional statutory authority for alternative practices, address concerns over the potential spread of invasive species through buffer establishment, establish a riparian protection aid program to fund local government buffer law enforcement and implementation, and allowed landowners to be granted a compliance waiver until July 1, 2018, when they filed a compliance plan with the appropriate SWCD.

The BWSR provides oversight of the buffer program, which is primarily administered at the local level. Compliance with the buffer law ranges from 99% to 100% for all applicable parcels within Clay, Becker, Otter Tail, and Wilkin Counties as of February 1, 2024 (BWSR 2025a).

6.2.4 Minnesota Agricultural Water Quality Certification Program

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

Through this program, certified producers receive:

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

Through this program, the public receives assurance that certified producers are using conservation practices to protect Minnesota's lakes, rivers, and streams. Since the start of the program in 2014, the program has achieved the following (MDA 2025a-estimates as of January 2026, and MPCA 2025e-estimates as of December 31, 2024):

- Enrolled 1,234,189 acres.
- Included 1,739 producers (MDA 2025a).
- Added more than 7,800 new conservation practices.
- Kept over 59,000 tons of sediment out of Minnesota rivers annually.
- Saved over 166,000 tons of soil and over 76,000 pounds of phosphorus on farms annually.
- Cut greenhouse gas emissions by more than 48,000 tons annually.

Almost 24,000 acres in the BRW and over 12,000 acres in the URRW are certified under the MAWQCP (MPCA 2025e).

6.2.5 Clean Water Act Section 319 Small Watershed Focus Program

The federal CWA Section 319 grant program provides funding to states to address nonpoint source water pollution in watersheds. The MPCA has adopted a Section 319 Small Watersheds Focus Program to focus on geographically smaller and longer-term watershed projects. The intent of the program is to make measurable progress for targeted water bodies in the Section 319 focus watersheds, ultimately restoring impaired waters and preventing degradation of unimpaired waters. Prior to the Small Watersheds Focus Program, the MPCA awarded Section 319 grants statewide based on a request for proposals process. Successful restorations in the BRW and URRW through these programs will support the required pollutant reductions.

The BRRWD, in partnership with the Wilkin SWCD, West Otter Tail SWCD, and the Wilkin County Natural Resources Conservation Service (NRCS) office, was selected as part of "group A" of the Small Watersheds Focus Program for the restoration of the Whiskey Creek Watershed. This project is prioritized to receive four, four-year grants to be awarded in the autumns of 2020, 2024, 2028, and 2032, and the focus area identified in the project's nine element plan to restore and protect waters includes the entire Whiskey Creek HUC-10 Watershed (MPCA 2024q). Project work completed from 2021 through 2024 was focused on the upper reaches of Whiskey Creek (WID 09020104-520), which has previously approved TMDLs for bacteria and turbidity impairments, and Unnamed Creek (WID 09020104-533, the outlet of County Ditch 1). Those project efforts resulted in a total of 13 miles of stream channel restoration and installation of a total of 92 sediment BMPs, resulting in estimated reductions of 2,243 pounds of phosphorus per year and 3,172 tons of sediment per year. In addition to the first phase of CWA Section 319 funds, the estimated $10 million cost of these efforts was funded by other federal grants from the NRCS and U.S. Fish and Wildlife Service, state grants through the DNR and BWSR, local BRRWD funding, and other sources (BRRWD 2024a). Future project work through 2028 aims to continue implementation of sediment reduction BMPs within the upper portions of the Whiskey Creek watershed and potentially explore additional stream channel restoration or stabilization efforts for Unnamed Creek (WID 09020104-516, the outlet of County Ditch 6 and addressed in this TMDL report) and the adjacent portion of Whiskey Creek (09020104-520) upstream of Kent.

For many years prior to 2019, the Becker SWCD targeted efforts for implementation of sediment reduction BMPs in the watershed of the upper reaches of the Buffalo River (WID 09020106-593 and downstream). In early 2019, the BRRWD, in partnership with the Becker SWCD, was awarded a Section 319 grant and the partners began efforts to continue in implementation of these BMPs. By the end of the grant award in late 2023, over 150 water and sediment control basin BMPs, 3 grade stabilization BMPs, and almost 2,000 feet of grassed waterway BMPs were installed, resulting in estimated reductions of 2,915 pounds of phosphorus per year and 2,253 tons of sediment per year (MPCA 2024r). Additionally, the grant award provided for the planning and development of detailed engineer's plans for a potential Upper Buffalo River Restoration and Sediment Reduction Project, which is being further planned and explored by the BRRWD. Preliminary water quality monitoring through 2023 from the Buffalo River reaches in this project area (WIDs 09020106-593 and 09020106-594) suggest that the applicable TSS standard is either being met or is close to being met. Future monitoring will continue to assess the success of this project's efforts and the success of a potential stream channel restoration project within the project area and downstream.

6.2.6 Minnesota Nutrient Reduction Strategy

The *Minnesota Nutrient Reduction Strategy* (MPCA 2014) guides activities that support nitrogen and phosphorus reductions in Minnesota water bodies and water bodies downstream of the state (e.g., Lake Winnipeg, Lake Superior, and the Gulf of Mexico). The NRS was developed by an interagency steering team with help from public input, and a progress report was completed in 2020. The *5-year Progress Report on the Minnesota Nutrient Reduction Strategy* (MPCA 2020d) provides an update on progress made in the state towards achieving the nutrient reduction goals and associated BMP implementation outlined in the original 2014 strategy. Revisions were made to the NRS to reflect changing land use, climate, and nutrient loading conditions since 2014; the *2025 Minnesota Nutrient Reduction Strategy* is available and was finalized in January 2026 (MPCA 2025c). *Watershed Nutrient Loads to Accomplish Minnesota's Nutrient Reduction Strategy Goals* (MPCA 2022a) integrates the state's NRS into local watershed work by developing load reduction planning goals on a HUC-8 watershed basis, including reductions of 47% and 48% for total nitrogen and 31% and 32% for TP for the BRW and URRW, respectively.

Fundamental elements of the NRS include:

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

Included within the strategy discussion are alternatives and tools for consideration by drainage authorities and local water resource managers, information on available approaches for reducing phosphorus and nitrogen loading and tracking efforts within a watershed, and additional research priorities. The NRS is focused on incremental progress and provides meaningful and achievable nutrient load reduction milestones that allow for better understanding of incremental and adaptive progress toward final goals. The strategy set a reduction goal of 45% for both phosphorus and nitrogen in waters leaving the state via the Mississippi River (relative to average 1980–1996 conditions). There are similar goals for nutrient reduction for the Red River Basin (for Lake Winnipeg, relative to the mid to late 1990s) at the U.S. and Canada border; a goal of no net increase from nitrogen and phosphorus levels in the 1970s was set for Minnesota's portions of the Lake Superior basin. The strategy also emphasizes the need to achieve local nutrient reduction needs within HUC-8 watersheds.

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

- Watershed lake and stream monitoring.
- Assessment of watershed health.
- Development of TMDLs and WRAPS updates that include BMP scenarios to achieve nutrient load reductions.
- Comprehensive local water planning and implementation.
- Management of NPDES/SDS and other regulatory and assistance programs.

This framework will result in nutrient reduction for the BRW and URRW, the Red River Basin as a whole, and the other major watersheds within the basin.

6.2.7 Red River Basin Commission Soil Health Partnership

The Red River Basin Commission's *Supply Chain Soil Health Partnership* (RRBC 2025) is a collaborative initiative that offers financial incentives to agriculture producers adopting sustainable land management practices to enhance soil health and resilience. The program targets key resource concerns like water management and soil quality, helping to mitigate flooding and drought impacts on farmland within the Red River Basin. The program provides producers with a flexible, accessible approach to cropland conservation and allows for a variety of land management practices including reduced tillage, cover crops, nutrient management, and alternative crop rotations. The partnership is funded primarily through a NRCS Regional Conservation Partnership Program grant as well as significant matching funds from corporate sponsors including General Mills, Cargill, and more. The partnership began with a projected year 1 enrollment of 35,000 acres within the Red River Basin, with projections increasing for year 2 to 90,000 acres and projections exploding to 675,000 acres for year 5. This partnership is currently available to producers within the BRW and URRW in Wilkin, Clay, and Otter Tail counties, as well as producers in Grant and Traverse counties in Minnesota and through other partnerships in North Dakota.

6.2.8 Conservation easements

Conservation easements are a critical component of the state's efforts to improve water quality by reducing soil erosion, reducing phosphorus and nitrogen loading, and improving wildlife habitat and flood attenuation on private lands. Easements protect the state's water and soil resources by permanently restoring wetlands, adjacent native grassland wildlife habitat complexes, and permanent riparian buffers. In cooperation with SWCDs, state and federal programs compensate landowners for granting conservation easements and establishing native vegetation habitat on economically marginal, flood prone, environmentally sensitive, or highly erodible lands. These easements vary in length of time from 10 years to permanent/perpetual easements. Conservation easement types in Minnesota include but are not limited to Conservation Reserve Program (CRP), Conservation Reserve Enhancement Program (CREP), Reinvest in Minnesota (RIM), and the Wetland Reserve Program (WRP). As of July 2024 in Clay, Becker, Otter Tail, and Wilkin Counties, there were close to 88,000 acres of short-term conservation easements such as CRP and over 31,000 acres of long-term or permanent easements (CREP, RIM, WRP) within and near the BRW and URRW, which is approximately 7% of total cropland acres in those counties. Additionally, those counties feature over 129,000 acres of U.S. Fish and Wildlife Service acquisitions and over 38,000 acres of DNR wildlife management areas (BWSR 2025b).

6.2.9 Watershed district rules and standards

The current BRRWD Rules were approved on July 8, 2019, with a general policy of accomplishing the purposes of Minn. Stat. § 103D and Minn. Stat. § 103E, as applicable. Furthermore, it is the policy of the Rules for the BRRWD to cooperate with state and federal agencies and other governing bodies, to not divest any persons of any rights without due process and just compensation for any taking, and to manage the waters and related resources within the BRRWD in a provident and orderly manner (BRRWD 2025a). The BRRWD Rules, and Minn. Stats. § 103D and § 103E as a whole, have led to several large-scale water quality improvement projects and other pollutant reduction efforts, further addressed in Sections 6.2.5 and 6.4.

6.3 Summary of local plans

Minnesota has a long history of water management by local government, which included developing water management plans along county boundaries since the 1980s. The BWSR-led One Watershed, One Plan (1W1P) program is rooted in work initiated by the Local Government Water Roundtable (Association of Minnesota Counties, Minnesota Association of Watershed Districts, and Minnesota Association of SWCDs). The Roundtable recommended that local governments organize to develop focused implementation plans based on watershed boundaries. That recommendation was followed by the legislation (Minn. Stat. § 103B.801) that established the 1W1P program, which provides policy, guidance, and support for developing CWMPs:

- Align local water planning purposes and procedures on watershed boundaries to create a systematic, watershed-wide, science-based approach to watershed management.
- Acknowledge and build off of existing local government structure, water plan services, and local capacity.
- Incorporate and make use of data and information, including WRAPS.
- Solicit input and engage experts from agencies, residents, and stakeholder groups; focus on implementation of prioritized and targeted actions capable of achieving measurable progress.

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

The *Buffalo-Red River Watershed Comprehensive Watershed Management Plan* (BRRW CWMP, HEI 2020) was completed and approved in October 2020, aligning local water planning within the BRW and URRW, as well as in the lower portion of the Otter Tail River Watershed downstream of Orwell Dam as this area was previously incorporated within the BRRWD legal boundaries. The counties of Clay, Becker, Otter Tail, and Wilkin, and the Clay, Becker, West Otter Tail, and Wilkin SWCDs were involved in the development of the BRRW CWMP, and therefore the plan replaces the previous local county water plans in the BRW, URRW. Additionally, other local, state, and federal agencies and organizations were invited to participate in the process.

The BRRW CWMP divides the BRRWD into planning regions (Section 1.1 and Figure 2) and identifies priority issues and water bodies for implementation efforts. Priority issues include but are not limited to sediment and phosphorus loading, altered hydrology and stream bank and stream channel instability, flooding, lake shoreland instability, and improved DO conditions in streams, all of which are a focus of this TMDL report. Priority water bodies identified in the BRRW CWMP include many of the water bodies addressed in this TMDL report, the associated WRAPS Report Update, and the previous stressor identification, TMDL, and WRAPS reports for the BRW and URRW (MPCA 2024b, MPCA 2024c). The timing of this TMDL report and the associated WRAPS Update is approximately mid-way through the 10-year timeframe of the BRRW CWMP, allowing new data to inform implementation efforts, as well as a mid-point plan review or for future iterations of the BRRW CWMP. The MPCA's staff will be involved, as invited, in future planning and will work with the BRRW CWMP LGUs to target areas and strategies that will provide the greatest opportunities for pollution reduction in support of this TMDL report.

The Minnesota Department of Health and Moorhead Public Service, along with contributions from other agency and local partners, developed an updated Source Water Assessment in 2022 and a Surface Water Intake Protection Plan, completed in 2023. The purpose of these documents is to provide information for and expand upon activities to prevent or mitigate contamination of Moorhead's surface water-derived source of drinking water, the Red River of the North. These documents are also intended to be used to guide Moorhead Public Service and watershed partners by documenting other complementary watershed-level activities to protect drinking water on a larger scale than can be accomplished by Moorhead Public Service alone. These documents indicate that some of the main concerns for Moorhead Public Service are sediment transport and increases in noncarbonate hardness, potentially from ditching and altered hydrology within the URRW and the upstream watersheds of the Red River of the North. An additional concern includes the potential for an increased frequency and magnitude of harmful algal blooms, especially considering the region's projected increases in temperatures and precipitation events (Section 3.1). Additionally, the documents suggest that stream reaches within the designated "emergency response area" and "spill management area" upstream of the city should be the focus for implementing projects and practices that address potential sources of contamination (MDH 2023). These stream reaches include Wolverton Creek (WIDs 09020104-549 and 09020104-550) and a number of ditches within the URRW that drain into Wolverton Creek or directly into the Red River of the North.

6.4 Examples of pollution reduction efforts

In addition to the projects explained in Section 6.2.5, the BRRWD and project partners have completed, are currently underway with, or are planning several other large-scale, water quality related projects for impaired and unimpaired water bodies within the BRW and URRW. In the URRW, two significant projects are the aforementioned Whiskey Creek Enhancement Project and the Wolverton Creek Restoration Project, completed in 2021 and focusing stream channel restoration, flood damage reduction, and pollutant loading reductions in the upper reaches of Wolverton Creek (WID 09020104-549). In the BRW, projects include but are not limited to:

- Whisky Creek and South Tributary Channel Restoration (planned for WIDs 09020106-611 and 09020106-585).
- Stony Creek Restoration (planned for WID 09020106-613).
- Glyndon East Tributary Restoration (completed for WID 09020106-532 in 2024).
- Upper South Branch Buffalo River Restoration (phase 1 completed for WID 09020106-604 in 2023, phase 2 planned for WIDs 09020106-605 and 09020106-505) (BRRWD 2024b).

All of these projects, in general, are targeted to reduce sediment and nutrient loading, restore natural stream channels and hydrology, reconnect floodplains, improve in-stream and adjacent habitat, and improve conditions both locally and downstream, all while working towards achieving the pollutant reduction goals and recommendations set forth in previous WRAPS and TMDL reports (MPCA 2024b, MPCA 2024c), the BRRW CWMP (HEI 2020), the Minnesota NRS (MPCA 2014), and more.

6.5 Funding

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

More recently, BWSR has been allocated significant funding from the Minnesota Legislature for the Water Storage and Climate Resilience program (BWSR 2025c). This program aims at implementing water storage practices on the landscape to address changes in precipitation and weather patterns and changes in land use patterns, including increased surface and subsurface drainage. These water storage practices generally slow runoff and reduce peak stream flows and flooding, which are primary focus areas in the BRRW CWMP (HEI 2020), this TMDL report, and the WRAPS Report Update.

The MDA's Agriculture BMP Loan Program provides low interest loans to farmers, rural landowners, and agriculture supply businesses. The purpose is to encourage agricultural BMPs that prevent or reduce runoff from feedlots, farm fields, and other pollution problems identified by the county in local water plans (MDA 2025b).

The WBIF format is a noncompetitive process to fund water quality improvement and protection projects for lakes, rivers/streams, and groundwater. This funding allows collaborating local governments to pursue timely solutions based on a watershed's highest priority needs. The approach depends on the completion of a CWMP developed under the 1W1P program to provide assurance that actions are prioritized, targeted, and measurable (i.e., the BRRW CWMP). The BRRW CWMP group has received WBIF funding since the plan's approval in October 2020, including approximately $1.3 million for state fiscal years 2020-2021 and 2022-2023 and just over $1.9 million for state fiscal years 2024-2025 and 2026-2027, a total of approximately $6.4 million (BWSR 2025d).

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

The WBIF assurance measures summarize and systematically evaluate how WBIF dollars are being used to achieve clean water goals identified in comprehensive watershed plans. The measures will be used by BWSR to provide additional context about watershed plan implementation challenges and opportunities. The following assurance measures are supplemental to existing reporting and on-going grant monitoring efforts:

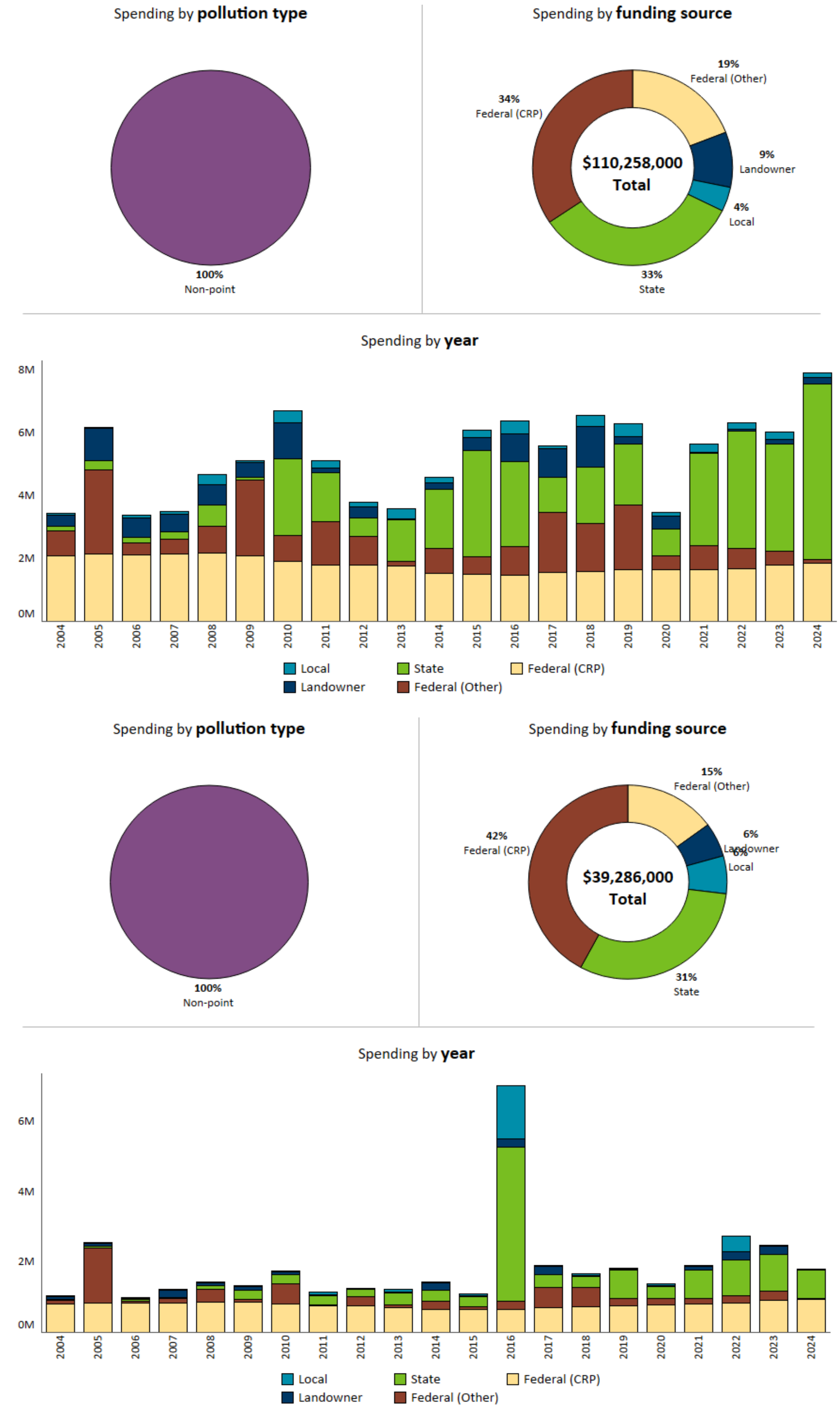
- Understand contributions of prioritized, targeted, and measurable work in achieving clean water goals.
- Review progress of programs, projects, and practices implemented in identified priority areas.
- Complete Clean Water Fund grant work on schedule and on budget.
- Leverage funds beyond the state grant.

Overall spending reported by watershed partners on projects from local, state, and federal funding sources are tracked via the Spending for Implementation Projects tool on the MPCA's Healthier Watersheds webpage (MPCA 2024o). From 2004 through 2024, over $110 million has been reported in the BRW and over $39 million has been reported in the URRW, all focused on nonpoint pollutant reductions (Figure 18).

6.6 Other partners and organizations

As discussed in Sections 6.2.5 and 6.4, the BRRWD has had strong partnerships with the SWCDs and other state and federal agencies that are active within the BRW and URRW. In addition to these partners, several nongovernmental organizations are active within the BRW and URRW and participated in the development of the BRRW CWMP, including Pheasants Forever, Ducks Unlimited, The Nature Conservancy, Minnesota Wheat Growers and Corn Growers Associations, River Keepers, and Audubon Dakota. Other governmental and nongovernmental organizations that may be sources of ideas, strategies, and funding might include the White Earth Band of Ojibwe, the Red River Basin Commission, the Becker Coalition of Lakes Associations and individual lake associations, Minnesota Deer Hunters Association and other wildlife groups, International Waters Institute, and many more conservation-minded organizations.

Figure 18. Spending for implementation projects in the BRW (top) and URRW (bottom) (MPCA 2024o).



6.7 Reasonable assurance conclusion

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

7. Monitoring

This section provides an overview of the monitoring activities that are expected to occur at many scales in the BRW and URRW, subject to availability of funding and resources. The aquatic life and aquatic recreation designated uses will be the ultimate measures of water quality. Improving the state of these designated uses depends on many factors, and improvements may not be detected over the next 5 to 10 years or even longer. Consequently, these monitoring activities are needed to track shorter- and longer-term changes in water quality and land management. Monitoring is important for several reasons:

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

Minnesota's *Water Quality Monitoring Strategy 2021 through 2031* (MPCA 2021b) describes different types of monitoring generally used in Minnesota. These include condition monitoring to identify overall environmental status and trends in individual water bodies, problem investigation monitoring to investigate specific problems or concerns and develop management plans, effectiveness monitoring to determine the effectiveness of a specific regulatory or voluntary management action, and special studies monitoring to focus on a specific area or problem over a shorter amount of time. There are many monitoring efforts in place within the BRW and URRW to address the different types of monitoring, and the following efforts and programs will provide the information to track trends in water quality and evaluate compliance with TMDLs.

MPCA-led condition monitoring

Comprehensive watershed monitoring and watershed assessments are conducted at the HUC-8 watershed scale associated with Minnesota's watershed approach (MPCA 2024a, MPCA 2021b). These efforts are conducted by the MPCA and partners approximately every 10 years for each HUC-8 and last took place in the BRW and URRW in 2019-2020. A primary outcome of this monitoring is the identification of waters that are impaired (i.e., do not support their designated beneficial use because they do not meet water quality standards and, therefore, need restoration) and waters in need of protection to prevent impairment. Over time, this condition monitoring can also identify changes in water quality. This helps determine whether water quality conditions are improving or declining, and it identifies how management actions are improving the state's waters overall. See the previous monitoring and assessment reports and stressor identification reports completed for the BRW and URRW on their respective MPCA Watershed webpages (MPCA 2024b, MPCA 2024c).

The MPCA's Watershed Pollutant Load Monitoring Network (WPLMN, MPCA 2025f) measures and compares data on pollutant loads from Minnesota's rivers and streams and tracks water quality trends. The WPLMN data are used to assist with assessing impaired waters, watershed modeling, determining pollutant source contributions, developing watershed and water quality reports, and measuring the effectiveness of water quality restoration efforts. Data are collected along major river main stems, at major watershed (i.e., HUC-8) outlets to major rivers, and in several subwatersheds. The URRW is evaluated at a main stem site on the Red River of the North near Kragnes (H57026001), while the BRW features a HUC-8 outlet site on the Buffalo River near Georgetown (H58033001) and subwatershed sites on the Buffalo River near Hawley (E58059001) and near Glyndon (H58048002), as well as the South Branch Buffalo River near Glyndon (H58050001). According to the MPCA's Watershed Assessment and Trends Update report for the BRW and URRW, the WPLMN data from the five sites listed above show that the BRW and URRW generally have higher sediment and phosphorus concentrations, but lower nitrogen levels, than most of the other watersheds in Minnesota (MPCA 2024b, MPCA 2024c).

The MPCA's Volunteer Water Monitoring Program (MPCA 2025g) provides records of water body transparency and other water body appearance and recreational observations. This program relies on a network of volunteers who monitor their stream or lake site approximately monthly. In the BRW, there are currently 11 volunteer lake sites and 9 volunteer stream sites, while in the URRW, volunteers currently monitor 5 sites along the Red River of the North. There are many opportunities for additional lake and stream monitors in the watersheds, which can be observed on the MPCA's Volunteer Water Monitoring program webpage (MPCA 2025g).

Other condition monitoring

The BRRWD monitors and tracks changes of water quality with the implementation of their projects, practices, and programs through their Regional Assessment Location system. This system features over 30 monitoring locations within the BRRWD's boundaries and is a partnership between the BRRWD, International Water Institute, and the Red River Basin River Watch program (BRRW CWMP Section 5.3, HEI 2020). Monitoring locations are generally sampled monthly from April through October for nitrogen, TP, TSS, and *E. coli* bacteria. Water quality reports from previous years can be found on the BRRWD Programs webpage (BRRWD 2025b).

The MDA and partners conduct statewide pesticide water quality monitoring to evaluate the impacts of routine pesticide use on Minnesota's groundwater and surface water resources. The data collected are used to identify specific pesticide compounds that may impact human health or the environment and to identify locations where detected concentrations may pose a risk. There are many lake, stream, and groundwater well sampling locations identified in the BRW and URRW, with the focal stream sites being the Buffalo River near Georgetown and the Red River of the North at Fargo. Associated MDA monitoring reports are available on their *Water Monitoring Reports and Resources* webpage (MDA 2025c). There are currently no pesticide impairments on Minnesota's 2024 303(d) IWL in the BRW and URRW, however, several pesticides have been detected in area lakes and streams at levels in exceedance of applicable standards (DNR 2023b). Additional pesticide monitoring may be warranted to evaluate the extent of pesticide use within the BRW and URRW and any potential negative effects that may be occurring on water quality and aquatic communities (DNR 2023b), as well as any potential contamination of surface water-derived sources of drinking water at the cities of Moorhead (MDH 2023), Fargo, and others downstream.

Other problem investigation and effectiveness monitoring

The Surface Water Intake Protection Plan for the Moorhead Public Service Public Water System (MDH 2023) calls for continued and additional monitoring of surface water quality to determine the best approaches to address the current and potentially worsening water quality in the watersheds upstream of the city. The plan suggests monitoring of total dissolved solids and/or major ion chemistry should be a priority as some analytes are regularly above drinking water limits and pose concerns at the city's intake. Additional recommendations are monitoring and tracing the increasing levels of sulfate and noncarbonate-based hardness in the Red River of the North upstream of the city of Moorhead, as well as tracking the frequency and intensity of harmful algal blooms that could impact the surface water supply.

In cooperation with the U.S. Army Corps of Engineers, the United States Geological Survey (USGS) initiated a water-quality monitoring study in 2019 related to the preconstruction phase of the Fargo-Moorhead Flood Risk Management Project (Galloway et al. 2024). Several water quality parameters were sampled from October 2019 through October 2022 from the Red River of the North and from three tributary streams in North Dakota. Sampling locations include three sites contributing upstream of the Fargo-Moorhead metropolitan area, including one on the Red River of the North just upstream of Wolverton Creek (09020104-550), one within the Fargo-Moorhead area, and six sites that contribute downstream of the Fargo-Moorhead area, including one located just downstream of the outlet of the Buffalo River (09020106-501). The study found, in general, that pollutant loads for most of the sampled parameters correlated closely to stream flows and increased, or worsened, from upstream to downstream. These parameters include but are not limited to suspended sediment, phosphorus, nitrogen, *E. coli* bacteria, total dissolved solids, and other major ions. The study attributes the increased loads from upstream to downstream to increased nonpoint runoff from both rural and urban areas during runoff events and periods of higher stream flow, as well as from point sources such as wastewater treatment facility discharges during periods of low flows. This monitoring study is expected to be continued during the construction phase of the Flood Risk Management Project, expected to be completed by early 2027, as well as during a post-construction phase (Galloway et al. 2024).

Implementation monitoring is conducted by both BWSR (i.e., eLINK) and the United States Department of Agriculture (USDA). Both agencies track the locations of BMP installations. Tillage transects and crop residue data are collected periodically and reported through the Minnesota Tillage Transect Survey Data Center. Additionally, BMP tracking information is readily available through the MPCA's "Healthier Watersheds" webpage as discussed and displayed in Section 6.2 and Figure 17.

Discharges from permitted municipal and industrial wastewater sources are reported through discharge monitoring records; these records are used to evaluate compliance with NPDES/SDS permits. Summaries of discharge monitoring records are available through the MPCA's Wastewater Data Browser (MPCA 2024k).

The MPCA is currently exploring additional monitoring opportunities through the CWA Section 319 Small Watershed Focus Program to document the effectiveness of the Whiskey Creek Enhancement Project (Section 6.2.5), potentially beginning in 2026 in partnership with the BRRWD, DNR, and others.

Potential additional monitoring

As opportunities arise and as resources allow, additional monitoring could be explored to further refine pollutant source assessments, evaluate effectiveness of implemented BMPs, and track changes in water quality. Some potential monitoring opportunities to explore include:

- Lawndale Creek/State Ditch 14: The upper reaches of Lawndale Creek (WIDs 09020106-529 and 09020106-530) are designated as a general cold water habitat stream (use class 1B, 2Ag), while State Ditch 14 (09020106-531) is designated as a general warm water habitat stream (use class 2Bg). Since the different use classes feature different water quality and biological standards, additional problem investigation or special study water quality and biological monitoring may be warranted to determine how the entire system works together and to determine if the system should be classified as a cold- or warm-water stream.
- BRW lakes: Due to the COVID-19 pandemic, most or all lakes in the BRW were not sampled in 2020 for eutrophication measures. As a result, there were many lakes in the BRW with some chemistry data but not enough to assess against the eutrophication standards. Additional condition monitoring could be considered for BRW lakes that did not have enough recent data to assess, have "nearly" or "barely" impairment threshold designations, have vulnerable fish communities as identified by the DNR (2023), and have been identified as priority lakes in the BRRW CWMP (HEI 2020) and/or the WRAPS Report Update.
- Additional monitoring for biological impairments: Some of the biologically impaired stream reaches (Fish and Macroinvertebrate IBI) in the BRW and URRW have limited TSS, DO, or eutrophication related data to determine the severity of how these parameters impact the biological communities within those stream reaches, and so those parameters may be considered "inconclusive stressors" (Section 1.2, Appendix A. Summary of all impairments). Additionally, some of these impaired reaches are stressed by those parameters based on field observations (MPCA 2023a), but biological response data are inconclusive or there are not enough discrete chemical data at this time to develop a TMDL for those parameters. Future condition and problem investigation monitoring in these reaches will be needed to collect the data to confirm the stressor determinations, complete TMDLs, and support recategorizations as necessary.
- Additional effectiveness monitoring for potential impairment delistings: Local, state, and federal watershed partners have completed, are currently implementing, or are currently planning several large-scale water quality improvement projects within the BRW and URRW. Additional chemical and biological data should be collected in the future, in partnership with local

watershed partners, from within and downstream of these project areas to monitor for improvements and to assess the success of these projects. Examples include the Whiskey Creek Enhancement Project mentioned above, the Wolverton Creek Restoration Project, and others already discussed in Sections 6.2.5 and 6.4 (BRRWD 2024b).

8. Implementation strategy summary

This section summarizes implementation strategies that could be used to help achieve the TMDLs in this report. For many of the strategies discussed below, BMPs and projects will need to be selected, designed, operated, and maintained to account for climate trends, including the projected increase in the intensity of future precipitation events (Section 3.1) and the resulting impact on both average and especially peak stream flows. It is documented that stream flows are increasing in the BRW and URRW, yet many of the smaller tributary streams are "flashy" with peak flows occurring quickly after rainfall or spring melt and prolonged stretches of low- or no-flow during dry periods (MPCA 2022b, MPCA 2023a, HEI 2020). Trend analysis has revealed that average annual flows in the Buffalo River near Hawley have increased by 125% since 1946 and average annual flows in the Red River of the North near Kragnes have increased by a substantial 400% since 1940, with many of the highest measured flows at those sites documented in the last 20 to 30 years (MPCA 2022b). These trends are consistent throughout the Red River Basin (Galloway et al. 2024), with annual average and peak flows in the Red River of the North at Grand Forks, North Dakota, downstream of the BRW and URRW, increased by 300% over the last 10 years and by 350% over the last 20 years (MPCA 2025h). Additional information from the *Evaluation of Hydrologic Change Technical Summary* for the BRW (MDNR 2023b) shows that essentially all flow conditions in the BRW have increased since the late 1990s. For example, increases documented in the Buffalo River near Dilworth include 152% for the largest, highest flow events that are exceeded 10% of the time or less, 286% for moderate flows that are exceeded at least 50% of the time, and 362% for low flows that are met or exceeded 90% of the time. This suggests that additional sediment may be moving within the channel throughout an extended period of time as opposed to at the highest flow events (DNR 2025a).

In addition to the increasing precipitation and the magnitude and frequency of intense storm events (Section 3.1, DNR 2023a), the changing stream flows in the BRW and URRW can also be attributed to land use activities and altered hydrology, which have been focused on improved drainage for agricultural production and to alleviate recurring flooding issues in both rural and urban areas (MPCA 2022b, MPCA 2023a, HEI 2020). The resulting changes in stream flows could continue to lead to stream and ditch channel erosion and instability, sediment and nutrient loading, flooding, degraded habitat, and more.

The consideration of future BMPs and projects should focus on the detention and retention of water in a variety of ways, both within the soil and on the landscape. Additional practices and projects should continue to focus on sediment and nutrient reductions, as well as restoring or improving unstable stream channels. The strategies discussed in this section are further supported by the strategies and recommendations identified in the WRAPS Report Update and the BRRW CWMP (HEI 2020).

8.1 Permitted sources

8.1.1 Wastewater

Municipal WWTPs are regulated through NPDES/SDS permits which generally include effluent limits and discharge monitoring requirements for TSS, *E. coli,* and other parameters, and which may include limits and monitoring requirements for TP, nitrogen, and others. The TSS WLAs assigned in this TMDL report to Rothsay, Comstock, and Lake Park WWTPs, as well as the approach and methodology for assigning the WLAs, are provided in Section 4.1.3.1. The TSS WLAs are consistent with the TSS effluent limits in each facility's current permit (Table 27) and a review of discharge monitoring data suggest that all three facilities have generally discharged below and in accordance with their applicable TSS discharge limits (Section 3.7.2.1).

There are no WWTPs assigned a TP WLA as a result of this TMDL report, although there are some WWTPs within the BRW and URRW that have TP effluent limits in their permits based on previous TMDLs (MPCA 2016) or Minnesota's Lake Winnipeg load reduction strategy (MPCA 2017b, MPCA 2020c). Any WWTP permittees will be informed if future TP limits are necessary based on new water quality monitoring, future TMDL reports, or the completion of a Lake Winnipeg restoration plan or other Red River Basin plans. At permit reissuance, the need for WQBELs and/or additional monitoring requirements will be reviewed by permitting staff.

All BRW and URRW WWTPs currently not having TP effluent limits or not currently participating in the Red River Basin Commission phosphorus reduction planning efforts further discussed in Section 8.3 are required to have phosphorus management plans, which are intended to ensure the optimization of TP removal primarily through the management and reduction of upstream sources. These efforts may result in the cities implementing innovative approaches for reducing phosphorus (MPCA 2017b and MPCA 2020c), perhaps through water quality trading, further discussed in Section 8.3.

To reduce the impacts of or the potential for wastewater releases (see Municipal wastewater in Section 3.7.2.1), implementation strategies are recommended to decrease the inflow and infiltration of stormwater and groundwater into wastewater collection systems and to reduce the frequency of excess flows that lead to releases of untreated wastewater. Adoption of clean water intrusion ordinances also help reduce the frequency and magnitude of wastewater releases through the development of policies and funding programs to assess and, where necessary, replace leaky private lateral connections to the sanitary system. Funding options, such as the MPCA's Clean Water Partnership Loan or MDA's Agriculture BMP Loan programs, can be used to help local governments and residents update lateral pipes.

8.1.2 Construction stormwater

The categorical WLA for stormwater discharges from sites where there is construction activity reflects the number of construction sites greater than one acre expected to be active in the watershed at any one time, and the BMPs and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. The BMPs and other stormwater control measures that should be implemented at construction sites to limit the discharge of sediment and phosphorus are defined in Minnesota's NPDES/SDS General Stormwater Permit for Construction Activity (MNR100001).

If a construction site owner/operator obtains coverage under the NPDES/SDS General Stormwater Permit and properly selects, installs, and maintains all BMPs required under the permit, including those related to impaired waters discharges and any applicable additional requirements found in Section 23 of the Construction Stormwater General Permit, the stormwater discharges would be expected to be consistent with the WLAs in this TMDL. Construction activity must also meet all local government construction stormwater requirements.

8.1.3 Industrial stormwater

The categorical WLA for stormwater discharges from sites where there is industrial activity reflects the number of sites in the watershed for which NPDES/SDS industrial stormwater permit coverage is required, and the BMPs and other stormwater control measures that should be implemented at the sites to limit the discharge of pollutants of concern. Minnesota's NPDES/SDS Industrial Stormwater Multi-Sector General Permit (MNR050000) and NPDES/SDS Nonmetallic Mining and Associated Activities General Permit (MNG490000) establish benchmark concentrations for pollutants in industrial stormwater discharges. If a facility owner/operator obtains stormwater coverage under the appropriate NPDES/SDS permit and properly selects, installs, and maintains BMPs sufficient to meet the benchmark values in the permit, the stormwater discharges would be expected to be consistent with the WLAs in this TMDL report. Industrial activity must also meet all local government stormwater requirements.

8.1.4 Individual NPDES/SDS permitted facilities

The individual TSS WLA assigned in this TMDL report to Minn-Dak Farmers Cooperative – Peet Piling Ground, as well as the approach and methodology for assigning the WLA, are provided in Section 4.1.3.4. The TSS WLA is consistent with the TSS effluent limit in the facility's current individual NPDES/SDS permit (Table 28) and a review of discharge monitoring data suggest that the facility has generally discharged below and in accordance with their applicable TSS discharge limits (Section 3.7.2.1). If the facility owner/operator maintains permit coverage and properly selects, installs, and maintains BMPs sufficient to meet the permit limits and benchmark values, the discharge would be expected to be consistent with the individual WLA in this TMDL report.

8.1.5 Feedlots

The NPDES and SDS feedlot permits include design, construction, operation, and maintenance standards that all CAFOs must follow. There are no WLAs assigned to CAFOs in this TMDL report, including CAFOs with NPDES or SDS permits, and CAFOs not requiring permits; this is equivalent to a WLA of zero. If the CAFOs are properly permitted and/or operate under the applicable NPDES or SDS permit and state and federal regulations, then the CAFOs are expected to be consistent with this TMDL. The MPCA's inspections of large CAFOs focus on high-risk facilities located within or near environmental justice areas, waters impaired by *E. coli* or excess nutrients, drinking water supply and vulnerable groundwater areas, and other sensitive water features, and on facilities that haven't been inspected in the most recent five years. Any CAFOs that are found to be noncompliant are required to return to compliance in accordance with applicable NPDES or SDS conditions and Minn. R. ch. 7020.

As discussed in Section 6.2.2, Minn. R. ch. 7020 regulates all feedlots in Minnesota and governs the collection, transportation, storage, processing, and disposal of animal manure and other livestock operation wastes. Most of the feedlots in the BRW and URRW are not CAFOs and are considered nonpermitted sources of pollutants in this TMDL report, along with pastures and all land application of manure. There are a number of federal, state, and local agencies and organizations that are available to assist farmers, ranchers, and feedlot owners. Examples may include the USDA's NRCS and Farm Service Agency, the MDA, the University of Minnesota Extension, agriculture and livestock producer groups, SWCDs, lake associations, and more. These agencies and organizations may be available to provide education and outreach to agricultural producers to help them understand applicable rules, requirements, and BMPs, and provide technical and financial assistance for facility and equipment upgrades.

8.2 Nonpermitted sources

Implementation of this TMDL report will mainly require BMPs that address nonpermitted sources of TSS and TP, especially runoff from cropland and developed areas as well as channel erosion and bank instability in streams and ditches. This section provides an overview of example BMPs that may be considered or prioritized. What is provided in Table 39 below is not exhaustive and may be amended. All of these examples generally target TSS and/or TP while some also address hydrology. Furthermore, this section draws examples from previous reports and plans (MPCA 2023a, DNR 2023b, HEI 2020) and refers to the BRRW CWMP (HEI 2020) for more extensive details and examples for implementation.

The BRRW CWMP (HEI 2020) provides measurable goals (CWMP Section 3) for each planning region for sediment and phosphorus loading, altered hydrology and flooding, stream bank and stream channel stability, ditch bank and outlet stability, lakeshore stability, and improved DO conditions in streams, all of which are a focus of this TMDL report. Additional goals focus on soil health, wetland and grassland restoration and protection, bacteria reduction, and groundwater or source water protection. The BRRW CWMP then provides actions that can be implemented watershed-wide (CWMP Section 4.1), including capital improvement projects and the operation and maintenance of natural waterways and ditches, as well as implementation actions that can be considered specific to each planning region (CWMP Section 4.2). Some of these watershed-wide and planning region specific BMP examples are included below in Table 39; for more information refer to the BRRW CWMP (HEI 2020) as well as the WRAPS Report Update.

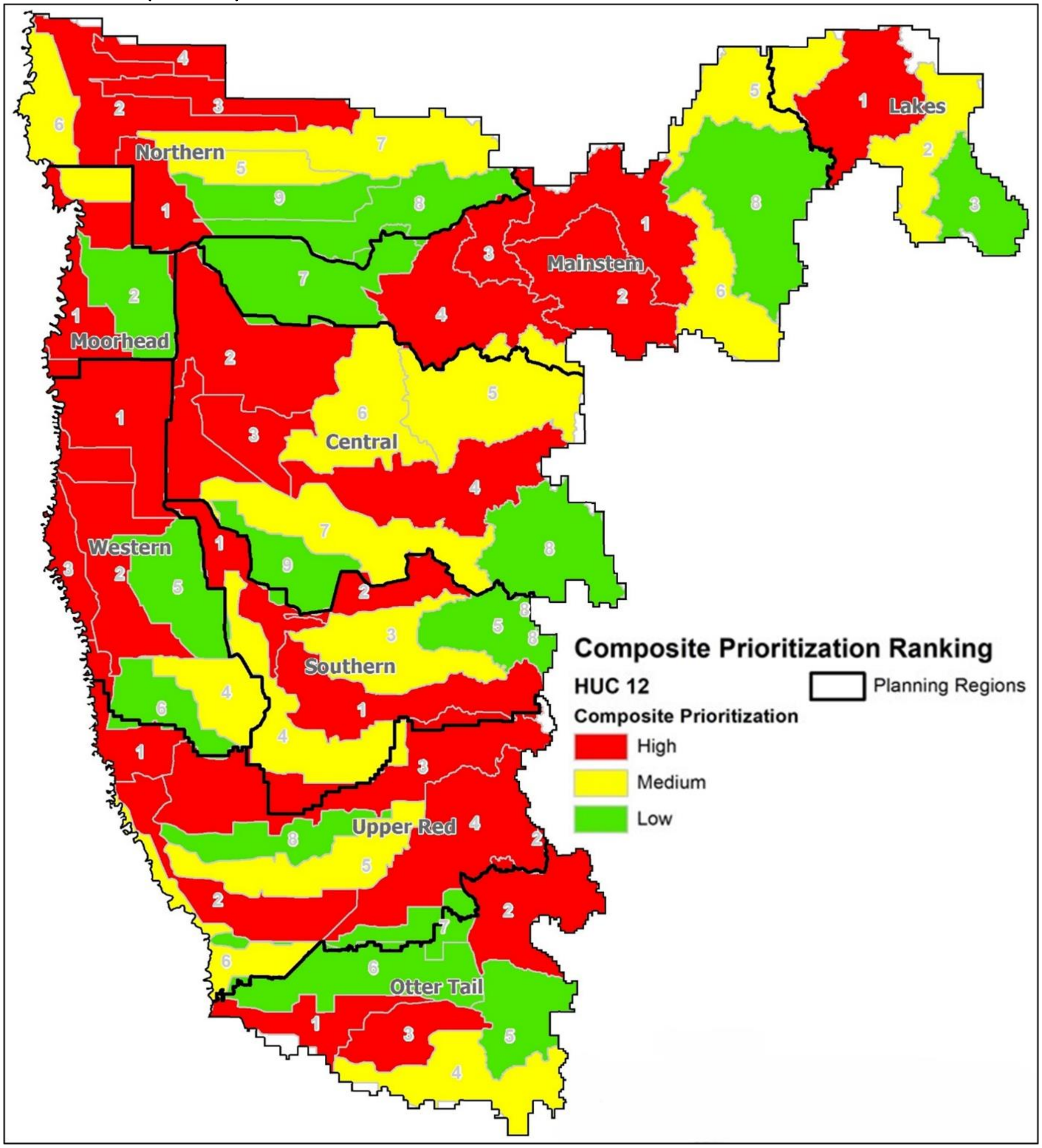
As discussed in Section 4.3.8, external watershed runoff is the primary source of TP to Lee Lake and should be the primary focus of implementation efforts in the Lee Lake Subwatershed. However, strategies to address internal TP recycling could be considered for Lee Lake if external watershed efforts fall short of TP reduction targets, or if substantial external watershed efforts cannot result in the desired water quality improvements within Lee Lake.

Table 39. Example BMPs for nonpermitted sources (MPCA 2023a, DNR 2023b, HEI 2020).

Strategy	BMP examples
Cropland, feedlot, pasture, manure, and nutrient runoff and management	Promote conservation tillage, crop rotations, cover crops, grassed waterways, filter strips, field borders, wind breaks, buffers, and other agricultural BMPs
	Implement in-field structural practices such as water and sediment control basins, side water inlets, grade stabilizations, and drainage water management
	Implement livestock waste management systems and runoff control measures
	Promote rotational grazing, livestock exclusion practices, and manure and nutrient management plans
	Promote proper use and incorporation of manure, fertilizers, pesticides, and herbicides
Water storage and hydrology	Maintain existing and implement new flood storage practices, retention/detention projects, wetland creations and restorations, or impoundments
	Implement in-field practices such as water and sediment control basins, side water inlets, and drainage water management
	Mitigate activities that will further alter the hydrology such as the promotion of multi-purpose drainage practices
Stream restoration	Stabilize or restore degraded sections of natural stream reaches and unstable ditch banks and outlets using natural channel design
	Protect or re-connect the natural meandering of streams and promote the restoration of straightened streams
	Protect or re-connect naturally vegetated riparian corridors and natural floodplains for water storage, sediment deposition, and enhanced habitat
Lakeshore runoff and shoreline protection	Promote restoration of developed shorelines with natural vegetation and aesthetic lakescaping techniques
	Promote restoration of native floating-leaf and emergent aquatic vegetation
	Protect natural, undeveloped shorelines and protect existing stands of aquatic vegetation
	Promote green infrastructure practices that increase filtration
	Promote strategies to prevent the spread of aquatic invasive species
Permanent land protection	Pursue permanent protective land easements such as CREP, RIM, and WRP, and/or large wetland restorations
Residential areas	Properly maintain compliant SSTS and repair/replace noncompliant SSTS
	Promote proper use of lawn and garden fertilizers, and promote other residential stormwater practices such as rain gardens and infiltration areas
Capital improvements	Continue pursuing large-scale projects such as the Upper South Branch Buffalo River Restoration Phase 2

The BRRW CWMP (HEI 2020) also prioritizes subwatersheds at a HUC-12 scale to identify where to focus implementation efforts first. The resulting composite ranking map (Figure 19) encompassed the most pertinent factors used when prioritizing issues and setting goals for the CWMP and considers the wide variety of issues that vary in importance between the planning regions. The HUC-12 subwatersheds are ranked within each planning region and the prioritization is meant to be used to guide implementation efforts. However, this prioritization was not meant to be the only factor considered and implementation actions still may be pursued in lower ranking subwatersheds. Of the impaired water bodies addressed in this TMDL report, all but two are located in “high” ranking subwatersheds within their respective planning regions; Unnamed Creek (Lawndale Creek) (WID 09020106-530) and County Ditch 25 (County Ditch 65) (09020106-538) are located within "medium" ranking subwatersheds.

Figure 19. BRRW CWMP composite rank of subwatersheds by planning region for implementation considerations (HEI 2020).



8.3 Water quality trading

Water quality trading can help achieve compliance with WLAs or water quality based effluent limits. Water quality trading can also offset increased pollutant loads in accordance with antidegradation regulations. Water quality trading reduces pollutants (e.g., TP, TSS, and potentially others) in rivers and lakes by allowing a point source discharger to enter into agreements under which the point source “offsets” its pollutant load by obtaining reductions in a pollutant load discharged by another point source operation or a nonpoint source or sources in the same watershed. The MPCA must establish specific conditions governing trading in the point source discharger’s NPDES/SDS permit or in a general permit that covers the point source discharger. The MPCA implements water quality trading through permits. See MPCA’s *Water Quality Trading Guidance* (MPCA 2022c) for more information.

The Red River Basin Commission is leading the development of a basin-wide management and trading plan to reduce phosphorus in the Red River of the North using goal setting and collaboration among regulated and unregulated stakeholders, and at less cost and with broader-based involvement (MPCA 2021c). The *Red River Basin Water Quality Offset Plan,* currently in development for release in 2026, is intended to satisfy portions of the permitting requirements of multiple municipalities in the Minnesota portion of the Red River Basin, including the WWTPs for the cities of Moorhead and Breckenridge, and to serve as a means for implementing water quality trades through the MPCA. While this draft plan is currently focused on TP, implementation of offset projects and practices will also likely have secondary benefits for increased flood resilience and water storage, habitat enhancements, and water quality improvements. Upon its completion, this plan could be considered for establishing trading opportunities for other permitted dischargers within the BRW and URRW.

8.4 Cost

The estimated costs to achieve the TMDLs in this report are approximately $38 million to $62.5 million dollars over the next 20 years, approximately $1.9 million to $3.7 million dollars per year. This range reflects the level of uncertainty in the source assessment and addresses the likely sources identified in Section 3.7. The cost includes the voluntary actions needed to achieve necessary TMDL reductions but does not include costs for increasing local capacity to oversee implementation in the watersheds. The cost of required actions, including compliance with the Minnesota Buffer Law, replacement of ITPHS systems, and SSTS maintenance, were not considered in the overall cost calculation because their costs are already accounted for in existing programs. Costs for actions by permitted sources such as WWTPs to comply with their permits were also not included.

Costs for implementing the TMDLs and achieving the required pollutant load reductions were estimated by developing two implementation scenarios for each impaired water body, resulting in one scenario as a lower end cost estimate and one as a higher end cost estimate. Both scenarios were developed to achieve the overall estimated percent reduction in each TMDL table (Sections 4.1.9, 4.2.8, and 4.3.8). One scenario is based on pollutant loading and reduction estimates from MPCA’s BRW and URRW HSPF models (MPCA 2024g, MPCA 2024h) and one scenario is based on pollutant loading and reduction estimates from MPCA’s Watershed Pollutant Load Reduction Calculator (MPCA 2025i). Efficiency rates for each BMP (estimated pollutant reduction per acre or unit of BMP implemented) primarily came from the Watershed Pollutant Load Reduction Calculator, while BMP costs per acre or unit and available acres for each potential BMP in the impaired subwatersheds primarily came from the BMP database of HSPF-Scenario Application Manager (HSPF-SAM, version 2.5; RESPEC 2025).

All implementation scenarios mainly feature cropland nonstructural practices such as conservation tillage, cover crops, and enhanced buffers, as well as structural practices such as water and sediment control basins and side water inlets (Table 39). Some scenarios also include drainage water management, nutrient management, and stream channel and stream bank restoration efforts. Cost and pollutant reduction estimates per mile of stream channel and stream bank restoration efforts were estimated based on project reporting submitted to the MPCA for the BRRWD's Whiskey Creek Enhancement Project (BRRWD 2024a) and the Engineer's Report for phase 2 of the Upper South Branch Buffalo River Restoration project (BRRWD 2024b), Sections 6.2.5 and 6.4).

Estimated implementation scenarios are available upon request via the MPCA; actual implementation efforts including BMP efficiencies and BMP costs will likely differ.

8.4.1 TSS reduction cost methodology

Overall estimated percent reductions needed to meet the TSS TMDLs in this report range from 21% to 62%. Additional BMPs and projects are necessary to address stream channel and stream bank erosion, peak flows caused by altered hydrology, and runoff from cropland and developed areas. As mentioned above, the potential BMPs used in the TSS scenarios are primarily cropland practices and all scenarios include at least some stream channel and stream bank restoration efforts. The HSPF-SAM database did not provide much potential within the impaired subwatersheds for BMPs for developed areas, pastures, feedlots, and other sources; additional efforts for these sources could be further explored at the local level. The example implementation scenarios are an estimate of cost-share dollars needed to incentivize adoption of the practices. The costs do not take into account design and construction oversight or operation and maintenance costs. The estimated costs to achieve the TSS TMDLs are approximately $20 million to $38.9 million dollars over the next 20 years, approximately $1 million to $1.9 million dollars per year.

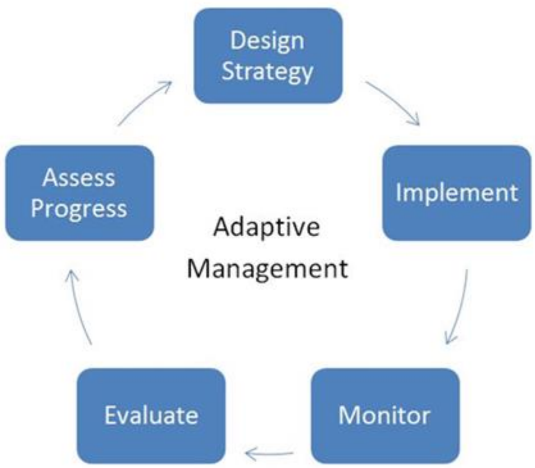
8.4.2 TP reduction cost methodology

Overall estimated percent reductions needed to meet the stream and Lee Lake TP TMDLs in this report range up to 53%. Additional BMPs will be needed to address runoff from cropland and developed areas, as well as from other sources such as pastures, lakeshore instability, or other upstream sources. The potential BMPs used in the TP scenarios are primarily from cropland practices and could use additional exploration at the local level for BMPs addressing developed areas, pastures, feedlots, and other sources. The scenarios for the Buffalo River, South Branch (09020106-605) were the only TP scenarios to feature stream channel and stream bank restoration efforts. Scenarios for Lee Lake do not include BMPs to reduce internal recycling of phosphorus. Although there is evidence that internal phosphorus recycling occurs within Lee Lake, it is assumed that the rate of recycling will decrease as the lake and sediments equilibrate to lower external phosphorus loads (Section 4.3.8). The example implementation scenarios are an estimate of cost-share dollars needed to incentivize adoption of the practice. The costs do not take into account design and construction oversight or operation and maintenance costs. The estimated costs to achieve the TP TMDLs are approximately $18 million to $23.6 million dollars over the next 20 years, approximately $1 million to $1.7 million dollars per year.

8.5 Adaptive management

The implementation strategies and the more detailed WRAPS Report Update prepared concurrently with this TMDL report are based on the principle of adaptive management (Figure 20). Continued monitoring and “course corrections” responding to monitoring results are the most appropriate strategy for attaining the water quality goals established in this TMDL report. Management activities will be changed or refined as appropriate over time to efficiently meet the TMDL and lay the groundwork for de-listing the impaired water bodies.

Figure 20. Adaptive management



9. Public participation

Efforts were made during the development of this TMDL report and the WRAPS Report Update to include local officials and the public. The BRRWD, county SWCDs, the White Earth Band of Ojibwe and other potentially interested Tribal Organizations, and other local, state, and federal watershed partners were invited to participate in the development of this TMDL report. A number of virtual, hybrid, and in-person meetings and other informal communication took place with these organizations, affected permittees, and other stakeholders. Often these efforts were made in combination with other BRRW CWMP meetings or other watershed partner activities within the BRW and URRW. Opportunities were given to provide feedback on the TMDL methodology and review draft versions of this TMDL report and the WRAPS Report Update. Any input, comments, and suggestions from these efforts were taken into consideration in developing this TMDL report.

An opportunity for public comment on the draft TMDL report was provided via a public notice in the State Register from April 6, 2026, through May 21, 2026. There were xx comment letters received and responded to as a result of the public comment period. Provide summary of any comments and resulting revisions below.

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Appendix A. Summary of all impairments

This appendix lists all of the impairments in the BRW and URRW along with the TMDL status of each impairment (Table 40 and Table 41). Planned recategorizations are provided for listings that have been further assessed and for which recategorization will be considered. Recategorizations will not be final until they are approved by EPA as part of Minnesota's list of impaired water bodies; therefore, these tables represent a snapshot in time, and the EPA category or planned recategorization may change.

Table 40. Impaired water bodies in the URRW (HUC-8 09020104).

Planning region[1]	WID	Water body name	Water body description	Use class[2]	Year added to list	Affec desig use[3]	Listing parameter	Stressors to bioassessment impairment: Confirmed	Stressors to bioassessment impairment: Inconclusive	Stressors to bioassessment impairment: Refuted	EPA category on 2026 303(d) IWL[4]	TMDL developed in this report
Upper Red	09020104-516	Unnamed creek	CD 6A to Whiskey Cr	2Bg	2022	AQL	Benthic macroinvertebrate bioassessments	TSS, Habitat	Flow regime instability, nitrate[6]	DO	4A[6]	Yes - TSS
					2020	AQL	Fish bioassessments	Connectivity, flow regime instability, habitat	TSS	DO, nitrate	5	No – Deferment[7]
	09020104-520	Whiskey Creek	T133 R47W S13, east line to Red R	2Bg	1996	AQL	Turbidity				4A	No, TMDL Done: PRJ-07619-001
					2008	AQR	Fecal coliform				4A	No, TMDL Done: PRJ-07619-001
					2010	AQL	DO				5	No – Deferment[8]
	09020104-533	Unnamed creek	Unnamed cr to Whisky Cr	2Bm[5]	2022	AQL	Fish bioassessments	Flow regime instability, habitat	Connectivity, TSS, DO, nitrate		5	No – Deferment[9]
	09020104-537	Unnamed ditch (Wilkin County Ditch 31)	Unnamed ditch to Red R	2Bm[5]	2020	AQL	Fish bioassessments	Connectivity, flow regime instability, habitat, TSS	DO, nitrate		5	No – Deferment
Western	09020104-549	Wolverton Creek	Unnamed cr to RR bridge	2Bm[5]	2012	AQR	*E. coli*				4A	No, TMDL Done: PRJ-07619-001
					2020	AQL	DO				5	No – Deferment[10]
					2022	AQL	Fish bioassessments	Connectivity, flow regime instability, habitat, DO	TSS, nitrate		5	No – Deferment

Planning region[1]	WID	Water body name	Water body description	Use class[2]	Year added to list	Affec desig use[3]	Listing parameter	Stressors to bioassessment impairment			EPA category on 2026 303(d) IWL[4]	TMDL developed in this report
								Confirmed	Inconclusive	Refuted		
Western	09020104-550	Wolverton Creek	RR bridge to Red R	2Bg	2012	AQR	*E. coli*				4A	No, TMDL Done: PRJ-07619-001
					2020	AQL	TSS				4A	Yes – TSS
					2020	AQL	Fish bioassessments	Connectivity, flow regime instability, habitat, TSS	DO, nitrate		5*	Yes – TSS

1. BRRW CWMP planning regions (HEI 2020, see TMDL report Section 1.1 and Figure 2).
2. 1B & 1C: domestic consumption; 2Ag: aquatic life and recreation—general cold water habitat; 2Bg & 2Bdg: aquatic life and recreation—general warm water habitat; 2Bm: aquatic life and recreation - modified warm water habitat.
3. Affected designated use: AQR: aquatic recreation, AQL: aquatic life, AQC: aquatic consumption.
4. EPA categories:
   4A: Impaired and a TMDL study has been approved by U.S. EPA. All TMDLs needed to result in attainment of applicable water quality standards for this impairment have been approved or established by EPA. For biological impairments, there are no remaining conclusive stressors for which TMDLs are needed.
   4C: Impaired but a TMDL study is not required because the impairment is not caused by a pollutant.
   4D: Impaired but a TMDL study is not required because the impairment is due to natural conditions with insignificant anthropogenic influence.
   5: Impaired and a TMDL study has not been approved by EPA.
   5*: Impaired and a TMDL study may have been approved by EPA for a conclusive pollutant stressor to the biological community, however, at least one inconclusive pollutant stressor (TSS and/or DO) remains unaddressed.
5. This WID is currently designated as use class 2Bg. However, the MPCA has reviewed this use class designation and will propose a use class change to 2Bm.
6. A TMDL would not be required for this inconclusive pollutant stressor. See TMDL report Table 2 and Section 1.2.
7. The fish bioassessment impairment for Unnamed Creek (09020104-516) is to remain as EPA category 5 until the inconclusive TSS stressor is either confirmed or refuted as a stressor. At that time, MPCA will submit this impairment for recategorization to category 4A.
8. Whiskey Creek (09020104-520) is in the middle of a large-scale restoration project starting in 2021 and continuing through 2024. Therefore, this impairment is a candidate for continued deferment in case the restoration results in improved conditions.
9. Unnamed creek (09020104-533) had insufficient discrete chemistry data to complete stressor evaluation. This stream reach is also included in the 2024 plans for the Whiskey Creek Restoration project mentioned above, and so this impairment is a candidate for continued deferment in case the restoration results in improved conditions.
10. The MPCA has determined that this DO impairment is to be deferred at this time. See Appendix B. Dissolved oxygen driver analysis for more info.

Table 41. Impaired water bodies in the BRW (HUC-8 09020106).

Planning region[1]	WID	Water body name	Water body description	Use class[2]	Year added to list	Affec desig use[3]	Listing parameter	Stressors to bioassessment impairments: Confirmed	Inconclusive	Refuted	EPA category on 2026 303(d) IWL[4]	TMDL developed in this report
Northern	09020106-501	Buffalo River	S Br Buffalo R to Red R	2Bg	2012	AQC	Mercury in fish tissue				4A	No, TMDL Done: PRJ-07770-001
					2012	AQR	(E. coli)				4A	No, TMDL Done: PRJ-06904-001
					1996	AQL	Turbidity				4A	No, TMDL Done: PRJ-06904-001
	09020106-538	County Ditch 25 (County Ditch 65)	CD 26 to Buffalo R	2Bm[5]	2020	AQL	Fish bioassessments		Connectivity, flow regime instability, habitat, TSS, DO, nitrate		5*	Yes – TP
					2020	AQL	Benthic macroinvertebrate bioassessments	Flow regime instability, habitat, TSS, DO		Nitrate	5*	Yes – TP
	09020106-556	County Ditch 2	Unnamed cr to Buffalo R	2Bm[5]	2012	AQR	*E. coli*				4A	No, TMDL Done: PRJ-06904-001
					2022	AQL	Benthic macroinvertebrate bioassessments	Flow regime instability, habitat	TSS, DO	Nitrate	5	No - Deferment
	09020106-563	County Ditch 5 (County Ditch 8)	Headwaters to Buffalo R	2Bm[5]	2022	AQL	Fish bioassessments	Connectivity, flow regime instability, habitat, DO	TSS	Nitrate	5	No - Deferment

Planning region[1]	WID	Water body name	Water body description	Use class[2]	Year added to list	Affec desig use[3]	Listing parameter	Stressors to bioassessment impairments			EPA category on 2026 303(d) IWL[4]	TMDL developed in this report
								Confirmed	Inconclusive	Refuted		
Northern	09020106-563	County Ditch 5 (County Ditch 8)	Headwaters to Buffalo R	2Bm[5]	2020	AQL	Benthic macroinvertebrate bioassessments	Flow regime instability, habitat, DO	TSS, nitrate		5	No - Deferment
	09020106-615	County Ditch 3	130th St N to Buffalo R	2Bm[5]	2020	AQL	Fish bioassessments	Connectivity, flow regime instability, habitat, DO	TSS, nitrate		5	No - Deferment
					2020	AQL	Benthic macroinvertebrate bioassessments	Flow regime instability, habitat, DO	nitrate	TSS	5	No - Deferment
	09020106-617	County Ditch 39	110th St N to Buffalo R	2Bm[5]	2012	AQR	*E. coli*				4A	No, TMDL Done: PRJ-06904-001
					2022	AQL	Fish bioassessments	Connectivity, flow regime instability, habitat, DO	TSS	Nitrate	5	No - Deferment
					2020	AQL	Benthic macroinvertebrate bioassessments	Flow regime instability, habitat, DO	TSS	Nitrate	5	No - Deferment
	09020106-619	County Ditch 10	80th St N to Buffalo R	2Bm[5]	2012	AQR	*E. coli*				4A	No, TMDL Done: PRJ-06904-001
					2022	AQL	Dissolved oxygen				4A	Yes - TP
					2020	AQL	Benthic macroinvertebrate bioassessments	Flow regime instability, habitat, DO	TSS	Nitrate	5*	Yes – TP

Planning region[1]	WID	Water body name	Water body description	Use class[2]	Year added to list	Affec desig use[3]	Listing parameter	Stressors to bioassessment impairments			EPA category on 2026 303(d) IWL[4]	TMDL developed in this report
								Confirmed	Inconclusive	Refuted		
Northern	09020106-624	Unnamed creek	-96.41 46.924 to -96.449 46.909	2Bg	2020	AQL	Fish bioassessments	Connectivity, flow regime instability, habitat, DO	TSS, nitrate		5	No – Deferment
Northern	09020106-624	Unnamed creek	-96.41 46.924 to -96.449 46.909	2Bg	2020	AQL	Benthic macroinvertebrate bioassessments	Flow regime instability, habitat, DO	Nitrate	TSS	5	No – Deferment
Mainstem	09020106-513	Hay Creek	Stinking Lk to Buffalo R	2Bg	2022	AQR	*E. coli*				4A	No, recateg-orized – PRJ-06904-001
Mainstem	09020106-518	Unnamed stream (Becker County Ditch 15 Branch 7)	Reep Lk to Unnamed ditch	2Bm[5]	2022	AQL	Benthic macroinvertebrate bioassessments	Flow regime instability, habitat	TSS, DO	Nitrate	5	No - Deferment
Mainstem	09020106-576	Unnamed creek	Unnamed cr to Hay Cr	2Bg	2022	AQL	Fish bioassessments	Connectivity – complete barriers to fish passage	NA-No fish collected	NA-No fish collected	4C	No, proposed for recateg-orization[6]
Mainstem	09020106-578	Unnamed ditch (Becker County Ditch 15 Branch 4)	Unnamed cr to Unnamed cr	2Bm[5]	2020	AQL	Benthic macroinvertebrate bioassessments	Flow regime instability, habitat, DO		TSS, nitrate	4C	No, proposed for recateg-orization[6]
Mainstem	09020106-580	Unnamed creek (Becker County Ditch 9)	Unnamed cr to Buffalo Cr	2Bm[5]	2020	AQL	Fish bioassessments	Connectivity, flow regime instability, habitat, TSS	DO, nitrate		5	No – Deferment

Planning region[1]	WID	Water body name	Water body description	Use class[2]	Year added to list	Affec desig use[3]	Listing parameter	Stressors to bioassessment impairments			EPA category on 2026 303(d) IWL[4]	TMDL developed in this report
								Confirmed	Inconclusive	Refuted		
Mainstem	09020106-580	Unnamed creek (Becker County Ditch 9)	Unnamed cr to Buffalo Cr	2Bm[5]	2020	AQL	Benthic macroinvertebrate bioassessments	Flow regime instability, habitat, TSS	DO, nitrate		5	No – Deferment
	09020106-581	County Ditch 16	Unnamed cr to Buffalo Cr	2Bm[5]	2020	AQL	Fish bioassessments	Connectivity, flow regime instability, habitat, TSS, DO	nitrate		5	No – Deferment
	09020106-593[7]	Buffalo River[7]	Buffalo Lk to Unnamed ditch[7]	2Bg	2010	AQR	*E. coli*				5	No – Deferment[7]
					2010	AQL	Turbidity				5	No – Deferment[7]
					2012	AQL	Fish bioassessments	Connectivity, flow regime instability, habitat, TSS	DO	Nitrate	5	No – Deferment[7]
	09020106-594	Buffalo River	Unnamed ditch to Hay Cr	2Bg	2010	AQR	*E. coli*				4A	No, TMDL Done: PRJ-06904-001
					2010	AQL	Turbidity				4A	No, TMDL Done: PRJ-06904-001
					2024	Wild Rice	Sulfate				5	No – Deferment[8]
	09020106-595	Buffalo River	Hay Cr to S Br Buffalo R	2Bg	2010	AQR	*E. coli*				4A	No, TMDL Done: PRJ-06904-001

Planning region[1]	WID	Water body name	Water body description	Use class[2]	Year added to list	Affec desig use[3]	Listing parameter	Stressors to bioassessment impairments: Confirmed	Inconclusive	Refuted	EPA category on 2026 303(d) IWL[4]	TMDL developed in this report
Mainstem	09020106-595	Buffalo River	Hay Cr to S Br Buffalo R	2Bg	2010	AQL	Turbidity				4A	No, TMDL Done: PRJ-06904-001
Mainstem	09020106-607	Unnamed ditch (Becker County Ditch 15)	T140 R42W S7, south line to Buffalo R	2Bg	2012	AQR	*E. coli*				4A	No, TMDL Done: PRJ-06904-001
Mainstem	09020106-621	Hay Creek	-96.11 46.864 to -96.12 46.902	2Bm[5]	2020	AQL	Fish bioassessments	Connectivity, flow regime instability, habitat, TSS	Nitrate[9]	DO	4A[9]	Yes – TSS, to be addressed with WID -622
Mainstem	09020106-622	Hay Creek	-96.12 46.902 to Stinking Lk	2Bg	2012	AQR	*E. coli*				4A	No, TMDL Done: PRJ-06904-001
Mainstem	09020106-622	Hay Creek	-96.12 46.902 to Stinking Lk	2Bg	2022	AQL	TSS				4A	Yes - TSS
Mainstem	03-0526-00	Marshall	Lake or Reservoir	2B	2012	AQR	Nutrients				4A	No, TMDL Done: PRJ-06904-001
Mainstem	03-0528-00	Gottenberg	Lake or Reservoir	2B	2012	AQR	Nutrients				4A	No, TMDL Done: PRJ-06904-001
Mainstem	03-0579-00	Boyer	Lake or Reservoir	2B	2012	AQR	Nutrients				4A	No, TMDL Done: PRJ-06904-001
Mainstem	03-0619-00	Talac	Lake or Reservoir	2B	2002	AQR	Nutrients				4A	No, TMDL Done: PRJ-06904-001

Planning region[1]	WID	Water body name	Water body description	Use class[2]	Year added to list	Affec desig use[3]	Listing parameter	Stressors to bioassessment impairments			EPA category on 2026 303(d) IWL[4]	TMDL developed in this report
								Confirmed	Inconclusive	Refuted		
Mainstem	03-0624-00	Forget-Me-Not	Lake or Reservoir	2B	2012	AQR	Nutrients				4A	No, TMDL Done: PRJ-06904-001
	03-0625-00	Sorenson	Lake or Reservoir	2B	2010	AQR	Nutrients				4A	No, TMDL Done: PRJ-06904-001
	03-0631-00	Stakke	Lake or Reservoir	2B	2012	AQR	Nutrients				4A	No, TMDL Done: PRJ-06904-001
	03-0635-00	Gourd	Lake or Reservoir	2B	2012	AQR	Nutrients				4A	No, TMDL Done: PRJ-06904-001
	03-0645-00	West LaBelle	Lake or Reservoir	2B	2012	AQR	Nutrients				4A	No, TMDL Done: PRJ-06904-001
	03-0646-00	Lime	Lake or Reservoir	2B	2012	AQR	Nutrients				4A	No, TMDL Done: PRJ-06904-001
	03-0647-00	Stinking	Lake or Reservoir	2B	2012	AQR	Nutrients				4A	No, TMDL Done: PRJ-06904-001
	03-0659-00	Sand	Lake or Reservoir	2B	2008	AQR	Nutrients				4A	No, TMDL Done: PRJ-06904-001
	14-0049-00	Lee	Lake or Reservoir	2B	2012	AQR	Nutrients				4A	Yes - TP

Planning region[1]	WID	Water body name	Water body description	Use class[2]	Year added to list	Affec desig use[3]	Listing parameter	Stressors to bioassessment impairments			EPA category on 2026 303(d) IWL[4]	TMDL developed in this report
								Confirmed	Inconclusive	Refuted		
Mainstem	14-0099-00	Maria	Lake or Reservoir	2B	2012	AQR	Nutrients				4A	No, TMDL Done: PRJ-06904-001
Lakes	03-0241-02	North Tamarack	Lake or Reservoir	2B	2010	AQR	Nutrients				4D	No – TMDL not required
Lakes	03-0350-00	Buffalo	Lake or Reservoir	2B	2024	AQC	Mercury in fish tissue				4A	No, TMDL Done: PRJ-07770-001
Central	09020106-502	Stony Creek	Hay Cr to S Br Buffalo R	2Bg	2012	AQR	*E. coli*				4A	No, TMDL Done: PRJ-06904-001
Central	09020106-502	Stony Creek	Hay Cr to S Br Buffalo R	2Bg	1996	AQL	Turbidity				4A	No, TMDL Done: PRJ-06904-001
Central	09020106-502	Stony Creek	Hay Cr to S Br Buffalo R	2Bg	2010	AQL	Dissolved oxygen				5	No – Deferment[10]
Central	09020106-503	Buffalo River, South Branch	Stony Cr to Buffalo R	2Bg	2012	AQR	*E. coli*				4A	No, TMDL Done: PRJ-06904-001
Central	09020106-503	Buffalo River, South Branch	Stony Cr to Buffalo R	2Bg	2012	AQL	Turbidity				4A	No, TMDL Done: PRJ-06904-001
Central	09020106-503	Buffalo River, South Branch	Stony Cr to Buffalo R	2Bg	2022	AQL	Dissolved oxygen				5	No – Deferment[10]
Central	09020106-504	Buffalo River, South Branch	Whisky Cr to Stony Cr	2Bg	2012	AQR	*E. coli*				4A	No, TMDL Done: PRJ-06904-001

Planning region[1]	WID	Water body name	Water body description	Use class[2]	Year added to list	Affec desig use[3]	Listing parameter	Stressors to bioassessment impairments			EPA category on 2026 303(d) IWL[4]	TMDL developed in this report
								Confirmed	Inconclusive	Refuted		
Central	09020106-504	Buffalo River, South Branch	Whisky Cr to Stony Cr	2Bg	2012	AQL	Turbidity				4A	No, TMDL Done: PRJ-06904-001
					2022	AQL	Dissolved oxygen				5	No – Deferment[10]
	09020106-509	Whisky Creek	T137 R47W S13, east line to S Br Buffalo R	2Bg	2012	AQR	*E. coli*				4A	No, TMDL Done: PRJ-06904-001
					2012	AQL	Turbidity				4A	No, TMDL Done: PRJ-06904-001
					2020	AQL	Fish bioassessments	Connectivity, flow regime instability, habitat, TSS, DO		Nitrate	4A	No, recateg-orized - PRJ-06904-001
					2020	AQL	Benthic macroinvertebrate bioassessments	Flow regime instability, habitat, TSS	DO, nitrate		4A	No, recateg-orized – PRJ-06904-001
	09020106-510	Stony Creek	Headwaters to T137 R45W S2, north line	2Bg	2020	AQL	Benthic macroinvertebrate bioassessments	Flow regime instability	Habitat, DO	TSS, Nitrate	5	No – Deferment[11]
	09020106-534	Spring Creek	Unnamed cr to Hay Cr	2Bg	2012	AQR	*E. coli*				4A	No, TMDL Done: PRJ-06904-001
					2012	AQL	Fish bioassessments	Connectivity, flow regime instability, habitat, DO (no inconclusive stressors)		TSS, nitrate	5	No - Deferment

Planning region[1]	WID	Water body name	Water body description	Use class[2]	Year added to list	Affec desig use[3]	Listing parameter	Stressors to bioassessment impairments: Confirmed	Inconclusive	Refuted	EPA category on 2026 303(d) IWL[4]	TMDL developed in this report
Central	09020106-534	Spring Creek	Unnamed cr to Hay Cr	2Bg	2012	AQL	Benthic macroinvertebrate bioassessments	Flow regime instability, habitat, DO	Nitrate	TSS	5	No - Deferment
	09020106-585	Unnamed creek	Unnamed cr to Whisky Cr	2Bg	2022	AQR	*E. coli*				4A	No, recateg-orized – PRJ-06904-001
	09020106-609	Hay Creek	T138 R46W S22, north line to Spring Cr	2Bg	2012	AQR	*E. coli*				4A	No, TMDL Done: PRJ-06904-001
					2020	AQL	Fish bioassessments	Connectivity, flow regime instability, habitat	DO, nitrate	TSS	4C	No, proposed for recateg-orization[6]
					2020	AQL	Benthic macroinvertebrate bioassessments	Flow regime instability, habitat	TSS, DO	Nitrate	4C	No, proposed for recateg-orization[6]
	09020106-610	Whisky Creek	Headwaters to -96.447 46.659	2Bg	2022	AQR	*E. coli*				4A	No, recateg-orized – PRJ-06904-001
	09020106-611	Whisky Creek (Clay County Ditch 34)	-96.447 46.659 to T137 R46W S18, west line	2Bg	2012	AQR	*E. coli*				4A	No, TMDL Done: PRJ-06904-001
					2010	AQL	Turbidity				4A	No, TMDL Done: PRJ-06904-001
	09020106-613	Stony Creek (Clay County Ditch 31)	170th St S - T137 R46W S5 N. line	2Bm[5]	2012	AQR	*E. coli*				4A	No, TMDL Done: PRJ-06904-001

Planning region[1]	WID	Water body name	Water body description	Use class[2]	Year added to list	Affec desig use[3]	Listing parameter	Stressors to bioassessment impairments			EPA category on 2026 303(d) IWL[4]	TMDL developed in this report
								Confirmed	Inconclusive	Refuted		
Central	09020106-613	Stony Creek (Clay County Ditch 31)	170th St S to T137 R46W S5, north line	2Bm[5]	2010	AQL	Turbidity				4A	No, TMDL Done: PRJ-06904-001
					2022	AQL	Fish bioassessments	Connectivity, flow regime instability, habitat	TSS, nitrate	DO	4C	No, proposed for recateg-orization[6]
	09020106-630	Hay Creek	Spring Cr to -96.513 46.725	2Bm[5]	2012	AQR	*E. coli*				4A	No, TMDL PRJ06904-001
					2020	AQL	TSS				4A	No, recateg-orized – PRJ-06904-001
Southern	09020106-505	Buffalo River, South Branch	Deerhorn Cr to Whisky Cr	2Bg	2012	AQR	*E. coli*				4A	No, TMDL Done: PRJ-06904-001
					2010	AQL	Turbidity				4A	No, TMDL Done: PRJ-06904-001
					2012	AQL	Benthic macroinvertebrate bioassessments	Flow regime instability, habitat, TSS, DO	Ammonia, Pesticides	Nitrate	4A	No, recateg-orized – PRJ-06904-001
					2022	AQL	Dissolved oxygen				5	No – Deferment[10]
	09020106-507	Deerhorn Creek	Headwaters to S Br Buffalo R	2Bg	2012	AQR	*E. coli*				4A	No, TMDL Done: PRJ-06904-001

Planning region[1]	WID	Water body name	Water body description	Use class[2]	Year added to list	Affec desig use[3]	Listing parameter	Stressors to bioassessment impairments			EPA category on 2026 303(d) IWL[4]	TMDL developed in this report
								Confirmed	Inconclusive	Refuted		
Southern	09020106-507	Deerhorn Creek	Headwaters to S Br Buffalo R	2Bg	2010	AQL	Turbidity				4A	No, TMDL Done: PRJ-06904-001
					2012	AQL	Fish bioassessments	Connectivity, flow regime instability, habitat, TSS, DO	Ammonia, Pesticides		4A	No, recateg-orized – PRJ-06904-001
					2012	AQL	Benthic macroinvertebrate bioassessments	Flow regime instability, habitat, TSS, DO	Ammonia, Nitrates, Pesticides		4A	No, recateg-orized – PRJ-06904-001
	09020106-530	Unnamed creek (Lawndale Creek)	Unnamed cr to Unnamed ditch	1B, 2Ag	2020	AQL	Fish bioassessments	Connectivity, flow regime instability, TSS, DO, temperature	Habitat		4A	Yes – TSS
	09020106-531	State Ditch 14 (Lawndale Creek)	Unnamed ditch to Deerhorn Cr	2Bg	2012	AQR	*E. coli*				4A	No, TMDL Done: PRJ-06904-001
	09020106-544	Unnamed creek (Wilkin County Ditch 13)	Unnamed ditch to S Br Buffalo R	2Bm[5]	2020	AQL	Benthic macroinvertebrate bioassessments	Flow regime instability, habitat, DO		TSS, nitrate	5	No - Deferment
	09020106-603	Buffalo River, South Branch	Headwaters to JD 3-3	2Bg	2012	AQL	Dissolved oxygen				5	No – Deferment[10]
	09020106-605	Buffalo River, South Branch	Unnamed cr to Deerhorn Cr	2Bg	2012	AQR	*E. coli*				4A	No, TMDL Done: PRJ-06904-001
					2012	AQL	Dissolved oxygen				4A	Yes – TP

Planning region[1]	WID	Water body name	Water body description	Use class[2]	Year added to list	Affec desig use[3]	Listing parameter	Stressors to bioassessment impairments			EPA category on 2026 303(d) IWL[4]	TMDL developed in this report
								Confirmed	Inconclusive	Refuted		
Southern					2020	AQL	Fish bioassessments	Connectivity, flow regime instability, DO	Habitat, TSS[9]	Nitrate	4A[9]	Yes – TP
	09020106-605	Buffalo River, South Branch	Unnamed cr to Deerhorn Cr	2Bg	2020	AQL	Benthic macroinvertebrate bioassessments	Flow regime instability, habitat, DO	TSS[9]	Nitrate	4A[9]	Yes – TP
	56-0950-01	West Olaf	Lake or Reservoir	2B	2002	AQC	Mercury in fish tissue				4A	No, TMDL Done: PRJ-07770-001
	56-0950-02	East Olaf	Lake or Reservoir	2B	2002	AQC	Mercury in fish tissue				4A	No, TMDL Done: PRJ-07770-001
	56-1039-00	Jacobs	Lake or Reservoir	2B	2012	AQR	Nutrients				4A	No, TMDL Done: PRJ-06904-001

1. BRRW CWMP planning regions (HEI 2020, see TMDL report Section 1.1 and Figure 2).
2. 1B & 1C: domestic consumption; 2Ag: aquatic life and recreation—general cold water habitat; 2Bg & 2Bdg: aquatic life and recreation—general warm water habitat; 2Bm: aquatic life and recreation - modified warm water habitat.
3. Affected designated use: AQR: aquatic recreation, AQL: aquatic life, AQC: aquatic consumption.
4. EPA categories:
   4A: Impaired and a TMDL study has been approved by U.S. EPA. All TMDLs needed to result in attainment of applicable water quality standards for this impairment have been approved or established by EPA. For biological impairments, there are no remaining conclusive stressors for which TMDLs are needed.
   4C: Impaired but a TMDL study is not required because the impairment is not caused by a pollutant.
   4D: Impaired but a TMDL study is not required because the impairment is due to natural conditions with insignificant anthropogenic influence.
   5: Impaired and a TMDL study has not been approved by EPA.
   5*: Impaired and a TMDL study may have been approved by EPA for a conclusive pollutant stressor to the biological community, however, at least one inconclusive pollutant stressor (TSS and/or DO) remains unaddressed.
5. This WID is currently designated as use class 2Bg. However, the MPCA has reviewed this use class designation and will propose a use class change to 2Bm.
6. This reach has been evaluated by MPCA and will be proposed as a 4C recategorization for the 2026 303(d) IWL.
7. This reach of the Buffalo River from Buffalo Lake to Unnamed ditch (WID 09020106-593) begins in the Lakes planning region then crosses into the Mainstem planning region. This reach also is almost entirely within White Earth Nation tribal boundaries and therefore TMDLs will not be developed for these impairments (see TMDL report Section 1.3).

8. The Wild Rice-Sulfate impairment on this reach of the Buffalo River from Unnamed ditch to Hay creek (WID 09020106-594) was a 2023 assessment for addition to the 2024 303(d) IWL. A TMDL will not be developed at this time but may be required in the future.
9. A TMDL would not be required for this inconclusive pollutant stressor. See TMDL report Table 2 and Section 1.2.
10. The MPCA has determined that this dissolved oxygen impairment is to be deferred at this time. See Appendix B. Dissolved oxygen driver analysis for more info.
11. This headwaters reach of Stony Creek (WID 09020106-510) was found to have no conclusive pollutant stressors (MPCA 2023a), and additional monitoring completed in 2024 revealed that benthic macroinvertebrates in this reach remain impaired. Additional evaluation is needed.

Appendix B. Dissolved oxygen driver analysis

This appendix provides information and data for the MPCA's investigation of the nine stream reaches located within the BRW and the URRW that are listed as impaired due to low DO as of Minnesota's 2024 IWL. Of the nine impaired reaches, seven are located in the BRW and two are located in the URRW. Prior to the development of this TMDL report, MPCA staff determined that additional information would be needed to address the impairment status of each of these stream reaches. It was anticipated that at least some of the impaired reaches would have sufficient data to be addressed with TP TMDLs in this report. It was also anticipated that the low DO in all of the impaired reaches may be driven at least partially by nonchemical factors such as stream channel geomorphology and hydrology.

The MPCA staff determined that additional information would be collected from six of the seven DO-impaired stream reaches within the BRW, provided below in Table 42 from upstream to downstream. Two additional stream reaches that are not currently listed as impaired due to low DO were also evaluated as they are tributaries to the Buffalo River, South Branch: Deerhorn Creek (WID 09020106-507) and Whisky Creek (09020106-520). The MPCA staff determined that additional information from one of the BRW DO-impaired stream reaches and the two DO-impaired reaches within the URRW should not be collected and those impairments would be deferred for this investigation and TMDL development. The uppermost reach of the Buffalo River, South Branch (09020106-603) was not evaluated due to wetland conditions and no flow at the sampling location observed by MPCA staff in 2023. Whiskey Creek (09020104-520) was not evaluated due to significant stream channel restoration work being conducted within the sampling area during the summer of 2023. Wolverton Creek (09020104-549) was not evaluated due to stream channel restoration work completed in recent years (2018-2021) as well as impounded streamflow from multiple beaver dams within the sampling area.

Additional data collection was conducted by MPCA staff over a roughly two-week period during the summer of 2023, from late June through early July. This time period was selected based on available staff time and resources, and to target the potential for critical conditions for low DO when water temperature is high, stream flow is low, and the effects of eutrophication are increased. The MPCA staff deployed sondes in late June in seven of the eight evaluated stream reaches primarily to track continuous DO and fluctuations in DO concentrations (diel DO flux), as well as additional parameters. A sonde was not deployed in County Ditch 10 (09020106-619) as two previous sonde deployments in 2019 and 2020 provided data that was determined to be sufficient for this evaluation. Sondes were recovered two weeks later, and their data was downloaded for analyzing by MPCA staff. Additionally, MPCA staff conducted discrete water quality sampling and field observations three times over the two-week period: at sonde deployment, at the midpoint of the two-week period, and at sonde retrieval. Lab parameters collected include TP, ortho-phosphorus, chl-*a*, biochemical oxygen demand (BOD), and TSS. Field parameters collected with the sondes include discrete DO, temperature, specific conductance, and more. The MPCA staff also conducted flow estimates, transparency tube measurements, and other stream channel observations. Stream flow data was also downloaded from the MPCA-DNR Cooperative Stream Gaging network[1] and the USGS National Water Dashboard[2].

The MPCA staff then analyzed all of the data collected over the two-week period in the summer of 2023, as well as all other historical data for each stream reach, in order to evaluate the potential drivers, or causes, of the low DO and diel DO flux in each reach. MPCA staff's findings are summarized below in Table 42. Eutrophication was found to be a driver for two of the DO-impaired stream reaches due to TP and diel DO flux exceeding the applicable RES (TMDL report Section 2.4.2): Buffalo River, South Branch (WID 09020106-605) and County Ditch 10 (09020106-619). As such, TP TMDLs were developed for these two stream reaches.

Eutrophication was found to be a potential driver for the low DO in Stony Creek (09020106-502) due to TP exceeding the RES and occasional exceedances of the response variables, however the response variable data was determined to be inconclusive. Eutrophication was not found to be a driver in the remaining evaluated stream reaches with low DO as TP was found to be exceeding the RES or inconclusive, but the response variables including diel DO flux were found to be meeting standards. These include the three remaining reaches of the Buffalo River, South Branch (09020106-505, 09020106-504, 09020106-503) as well as Whisky Creek (09020106-509), which has historical exceedances of the DO standard but is not currently listed as impaired due to low DO. The DO impairments for Stony Creek and the Buffalo River, South Branch will also be deferred for TMDL development and their status on the IWL will remain unchanged at this time.

Deerhorn Creek (09020106-507) was found to be meeting the applicable RES and DO standards and is suggested as an example for setting restoration targets for the other evaluated stream reaches.

Additional data collection will need to be considered in the future for re-evaluation of the deferred DO-impaired stream reaches in the BRW and URRW, potentially including additional TMDLs or recategorization to 4C due to nonpollutant causes. The sampling location for the uppermost reach of the Buffalo River, South Branch (09020106-603) should be re-evaluated and potentially moved upstream due to wetland conditions at the current sampling location observed by MPCA staff in 2023. Whiskey Creek (09020104-520) and Wolverton Creek (09020104-549) should be re-evaluated to assess how the significant stream channel restoration work impacted DO concentrations in those reaches. Finally, nonchemical drivers of low DO, especially hydrology, should be further investigated in all of the DO-impaired stream reaches and their upstream tributaries.

1. MPCA-DNR Cooperative Stream Gaging network: available at https://www.dnr.state.mn.us/waters/csg/index.html.
2. USGS National Water Dashboard: available at: https://dashboard.waterdata.usgs.gov/app/nwd/en/?aoi=default.

Table 42. Summary of DO driver analysis.[1]

WID	Water body name	Water body description	Data supports impairment determination?						Potential low DO driver(s)?	Next Steps
			TP	chl-*a*	Diel DO flux	BOD	pH	Minimum daily DO		
09020106-605	Buffalo River, South Branch	Unnamed cr to Deerhorn Cr	Yes	No	Yes	No	No	Yes	Eutrophication	TP TMDL
09020106-507	Deerhorn Creek	Headwaters to S Br Buffalo R	No	No	No	No	No	No	Not evaluated	NA – not impaired
09020106-505	Buffalo River, South Branch	Deerhorn Cr to Whisky Cr	No	No	No	No	No	Inc	Nonchemical	Defer
09020106-509	Whisky Creek	T137 R47W S13, east line to S Br Buffalo R	Yes	No	No	No	No	Yes	Nonchemical	NA – not impaired
09020106-504	Buffalo River, South Branch	Whisky Cr to Stony Cr	Yes	No	No	No	No	Yes	Nonchemical	Defer
09020106-502	Stony Creek	Hay Cr to S Br Buffalo R	Yes	Inc	Inc	Inc	No	Yes	Inconclusive	Defer
09020106-503	Buffalo River, South Branch	Stony Cr to Buffalo R	Yes	No	No	No	No	Yes	Nonchemical	Defer
09020106-619	County Ditch 10	80th St N to Buffalo R	Yes	No	Yes	No	No	Inc	Eutrophication	TP TMDL

1. Buffalo River, South Branch (09020106-603) was not evaluated due to wetland conditions and no flow at the sampling location. Whiskey Creek (WID 09020104-520) was not evaluated due to ongoing stream channel restoration work within the sampling area during the summer of 2023. Wolverton Creek (09020104-549) was not evaluated due to stream channel restoration work completed in recent years as well as impoundments from beaver dams within the sampling area. The DO impairments in these stream reaches will be deferred.

Appendix C. Subwatershed maps

Figure 21. Individual subwatershed map for Unnamed Creek (WID 09020104-516).

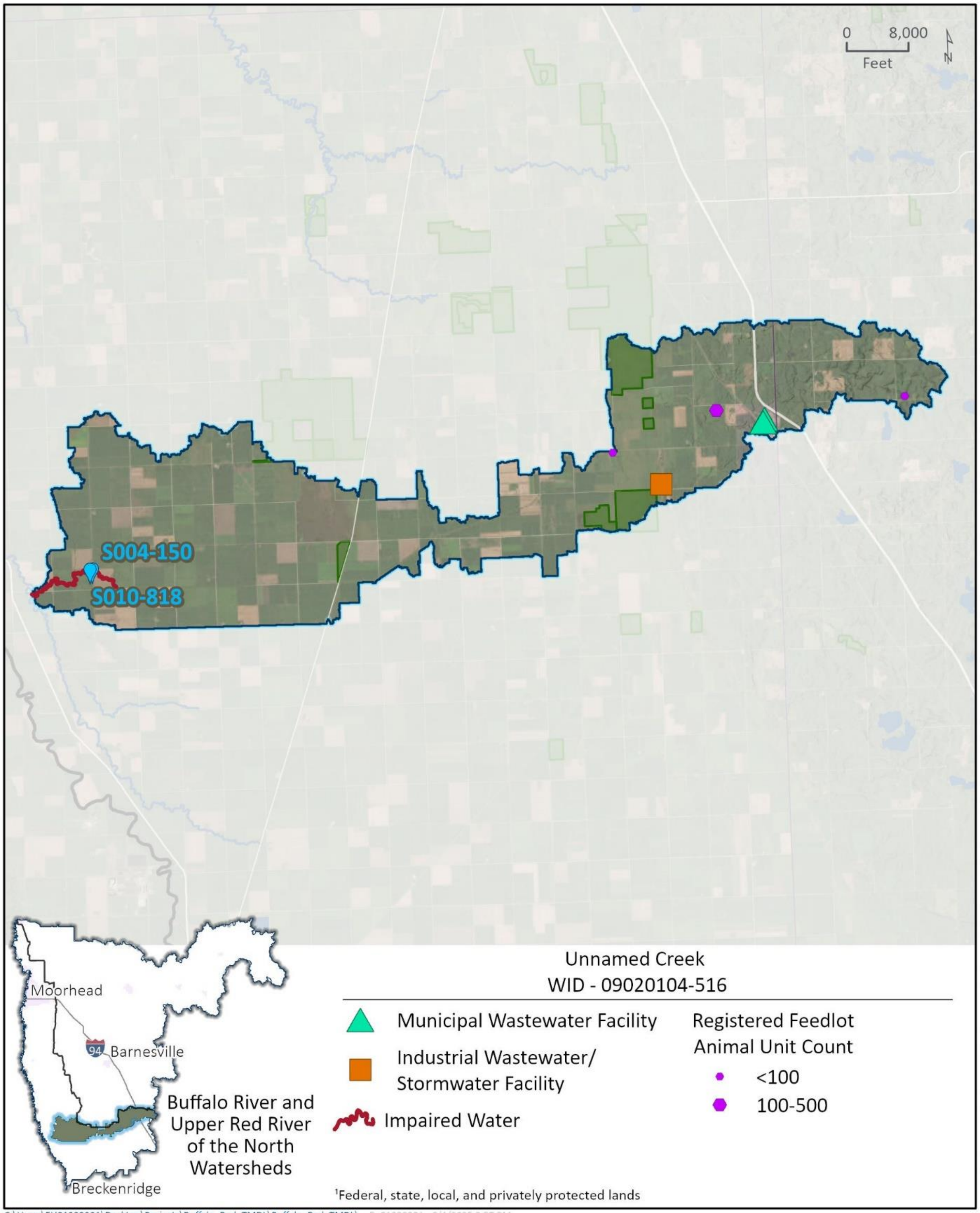
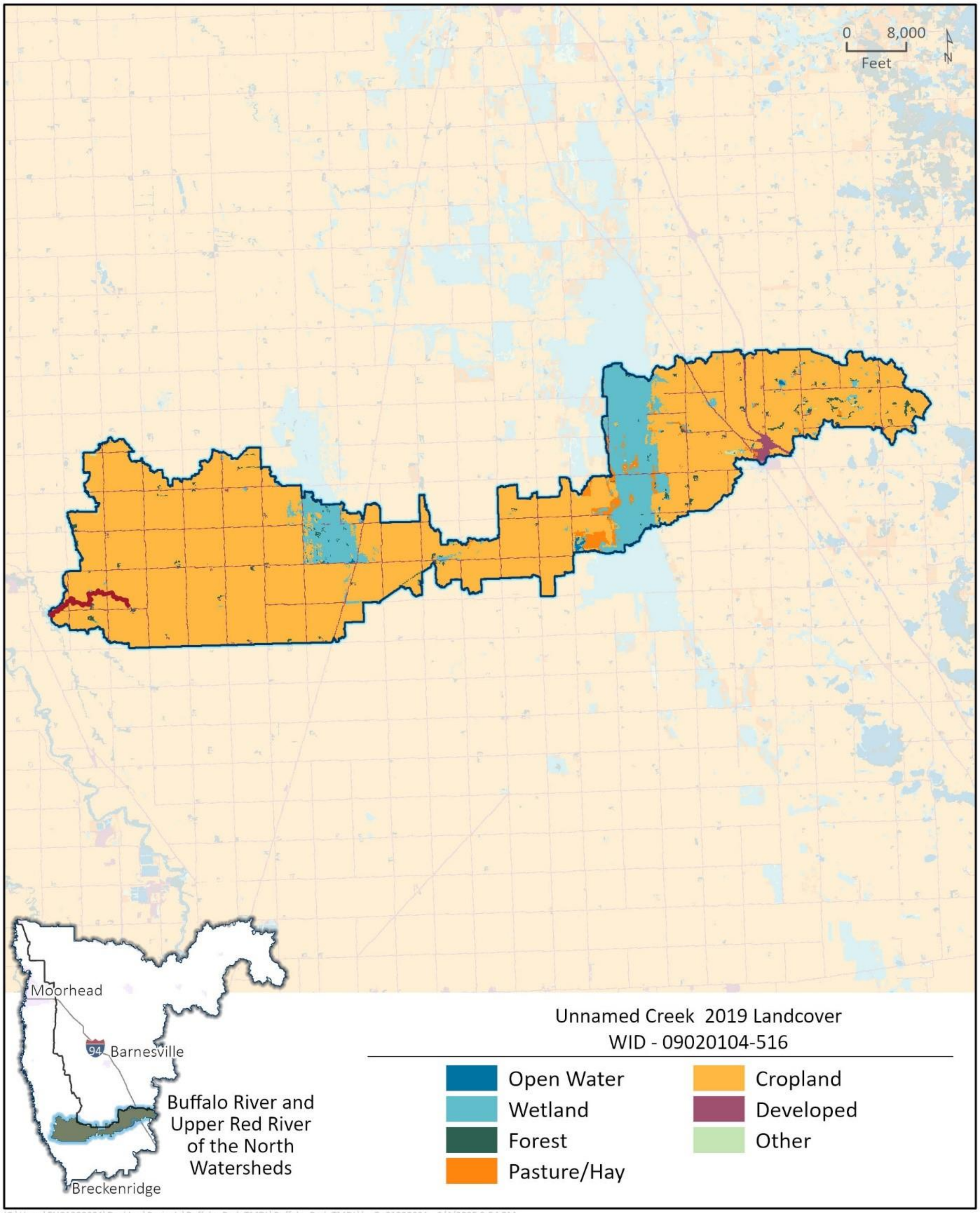


Figure 22. NLCD 2019 land cover map (USGS 2022) for Unnamed Creek (WID 09020104-516).



'C:\Users\EU01239231\Desktop\Projects\Buffalo_Red_TMDL\Buffalo_Red_TMDL\' - Eu01239231 - 6/4/2025 3:54 PM

Figure 23. Individual subwatershed map for Wolverton Creek (WID 09020104-550).

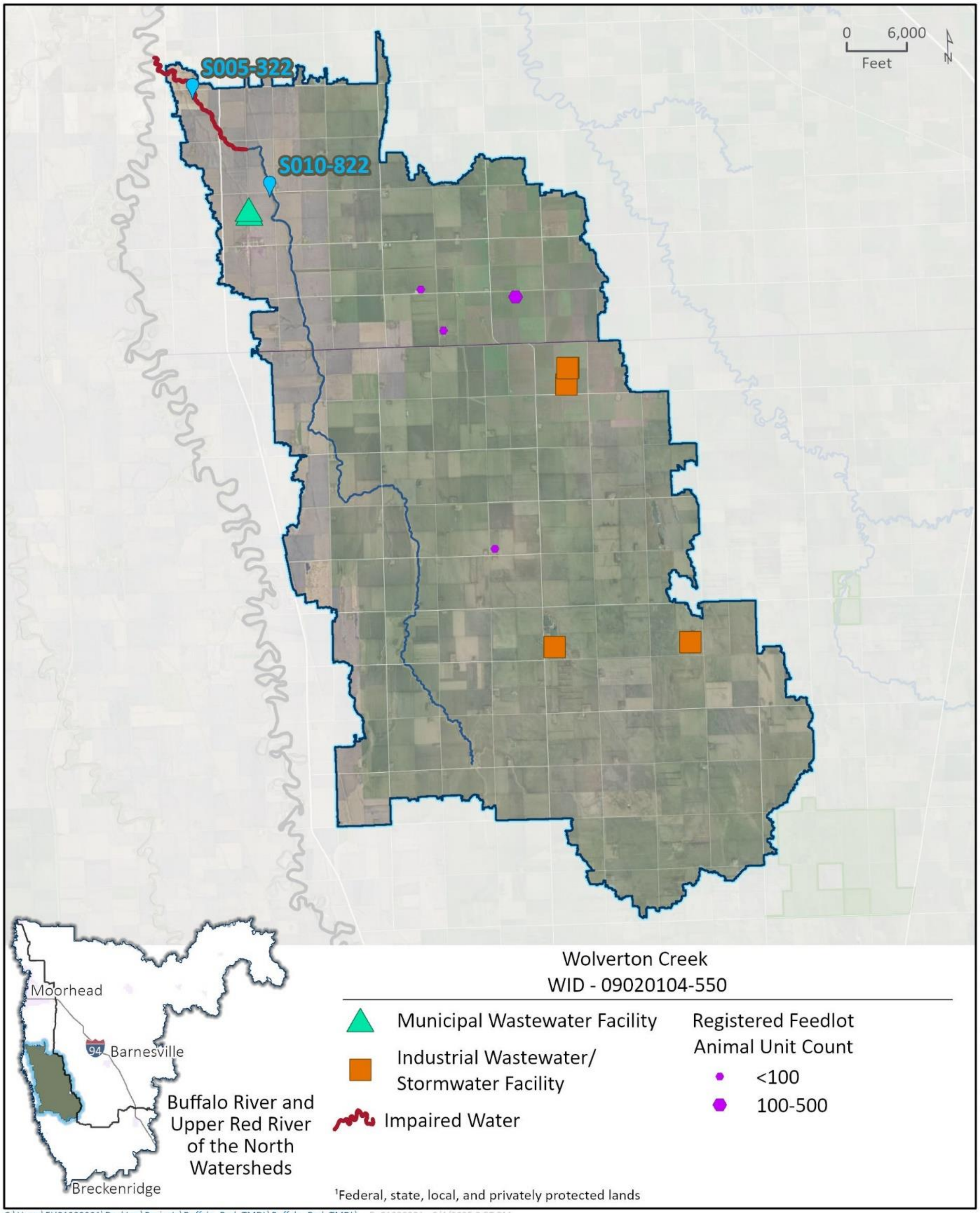


Figure 24. NLCD 2019 land cover map (USGS 2022) for Wolverton Creek (WID 09020104-550).

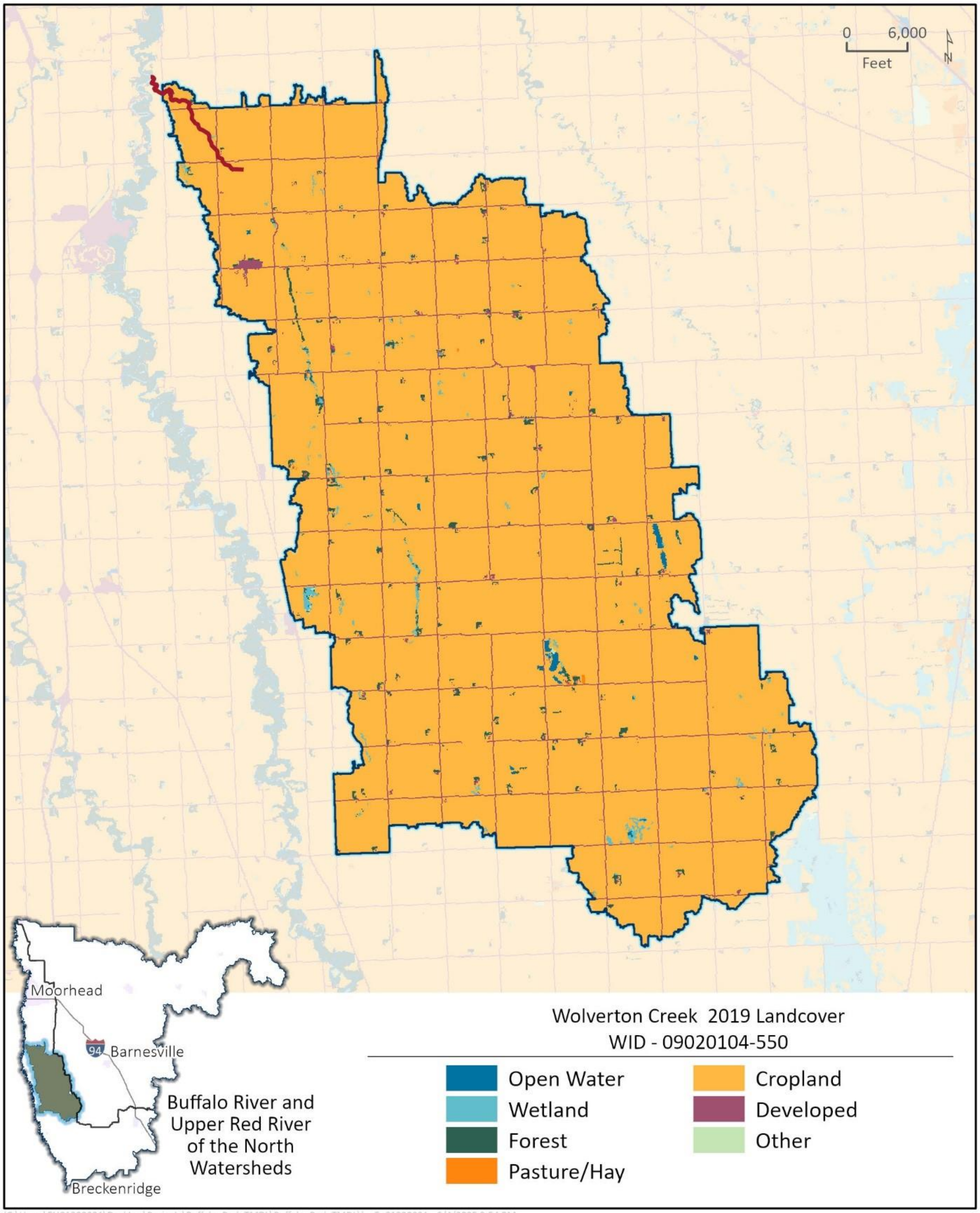


Figure 25. Individual subwatershed map for Unnamed creek (Lawndale Cr.) (WID 09020106-530).

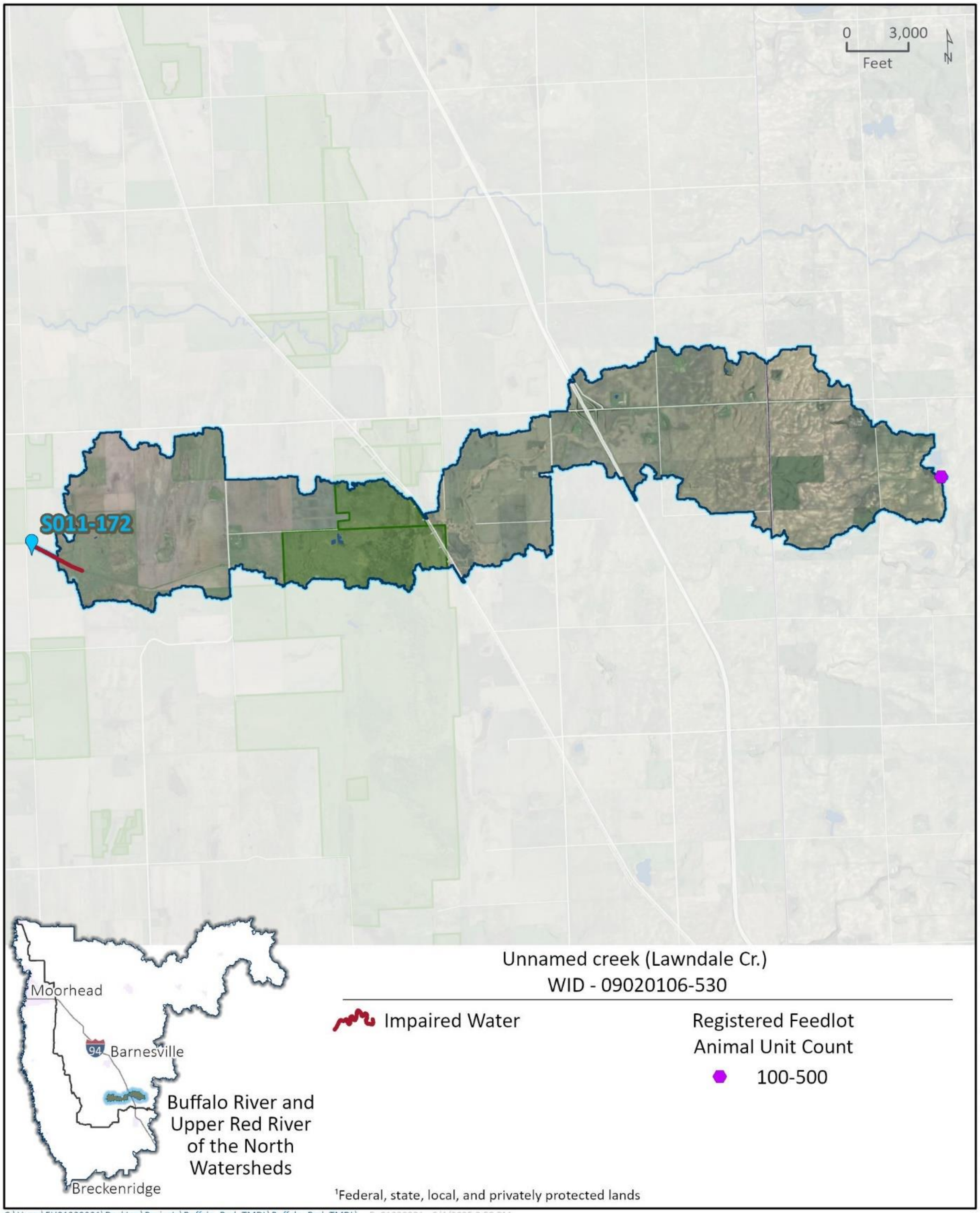
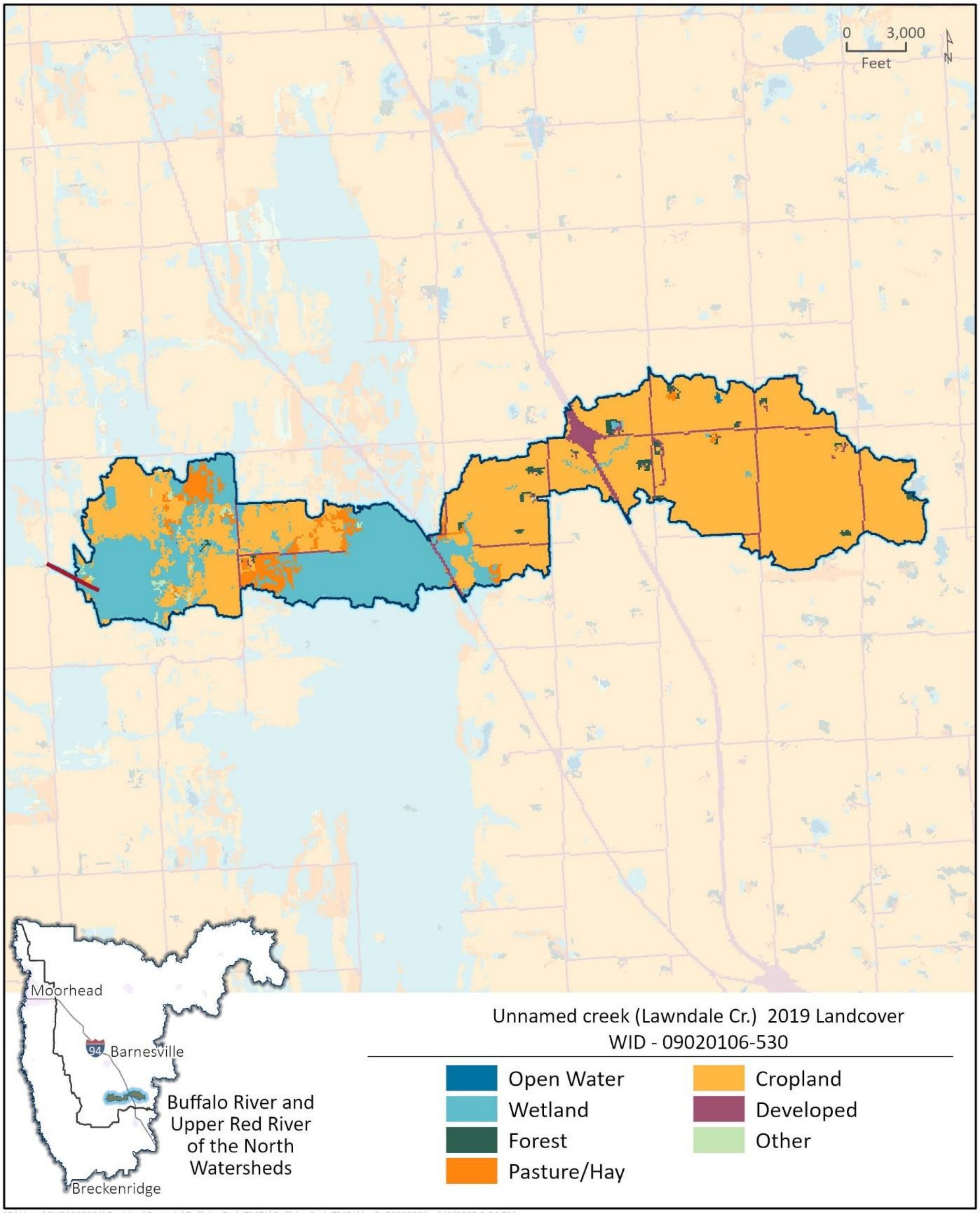


Figure 26. NLCD 2019 land cover map (USGS 2022) for Unnamed creek (Lawndale Cr.) (WID 09020106-530).



'C:\Users\EU01239231\Desktop\Projects\Buffalo_Red_TMDL\Buffalo_Red_TMDL\' - Eu01239231 - 6/4/2025 3:54 PM

Figure 27. Individual subwatershed map for County Ditch 25 (County Ditch 65) (WID 09020106-538).

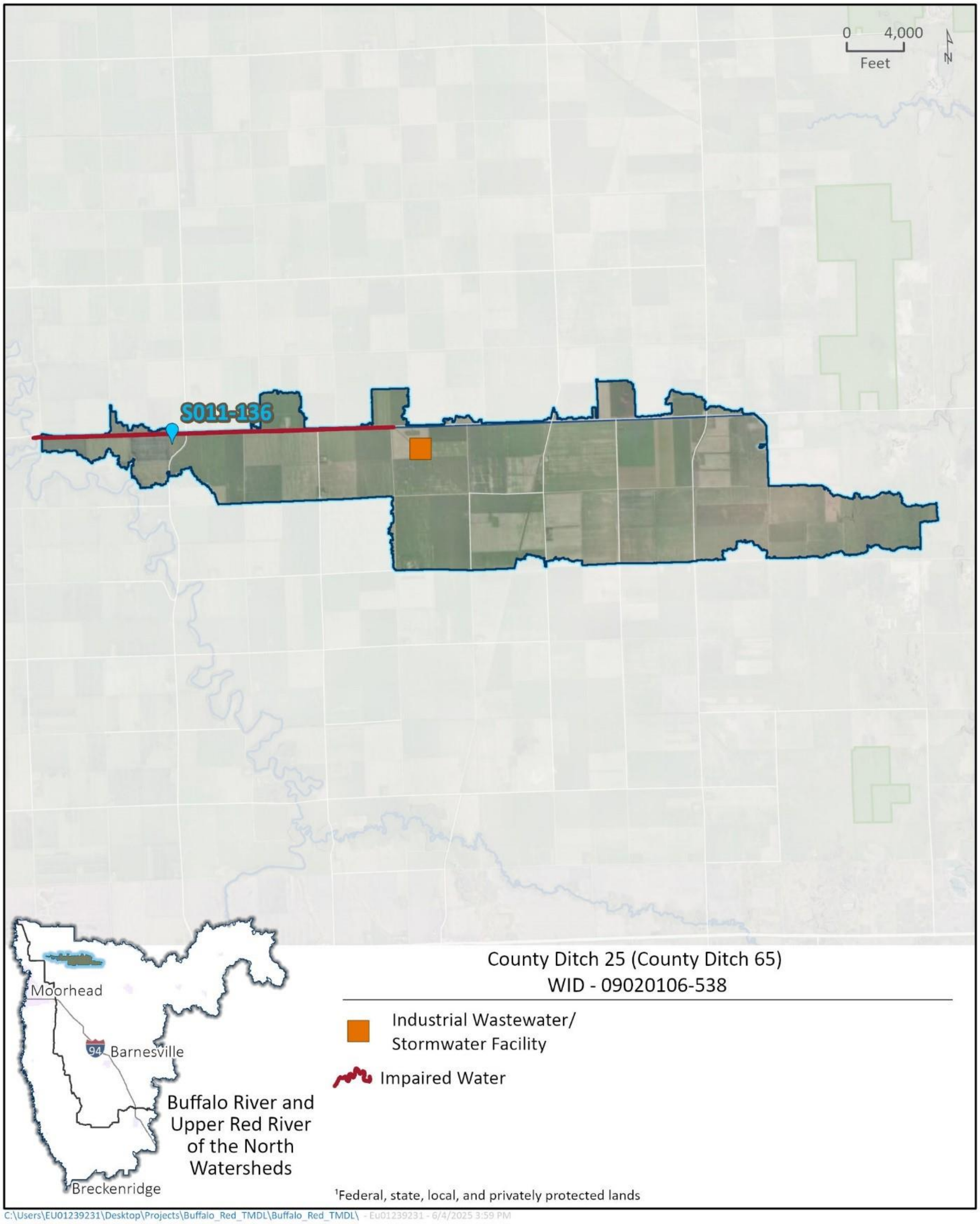


Figure 28. NLCD 2019 land cover map (USGS 2022) for County Ditch 25 (County Ditch 65) (WID 09020106-538).

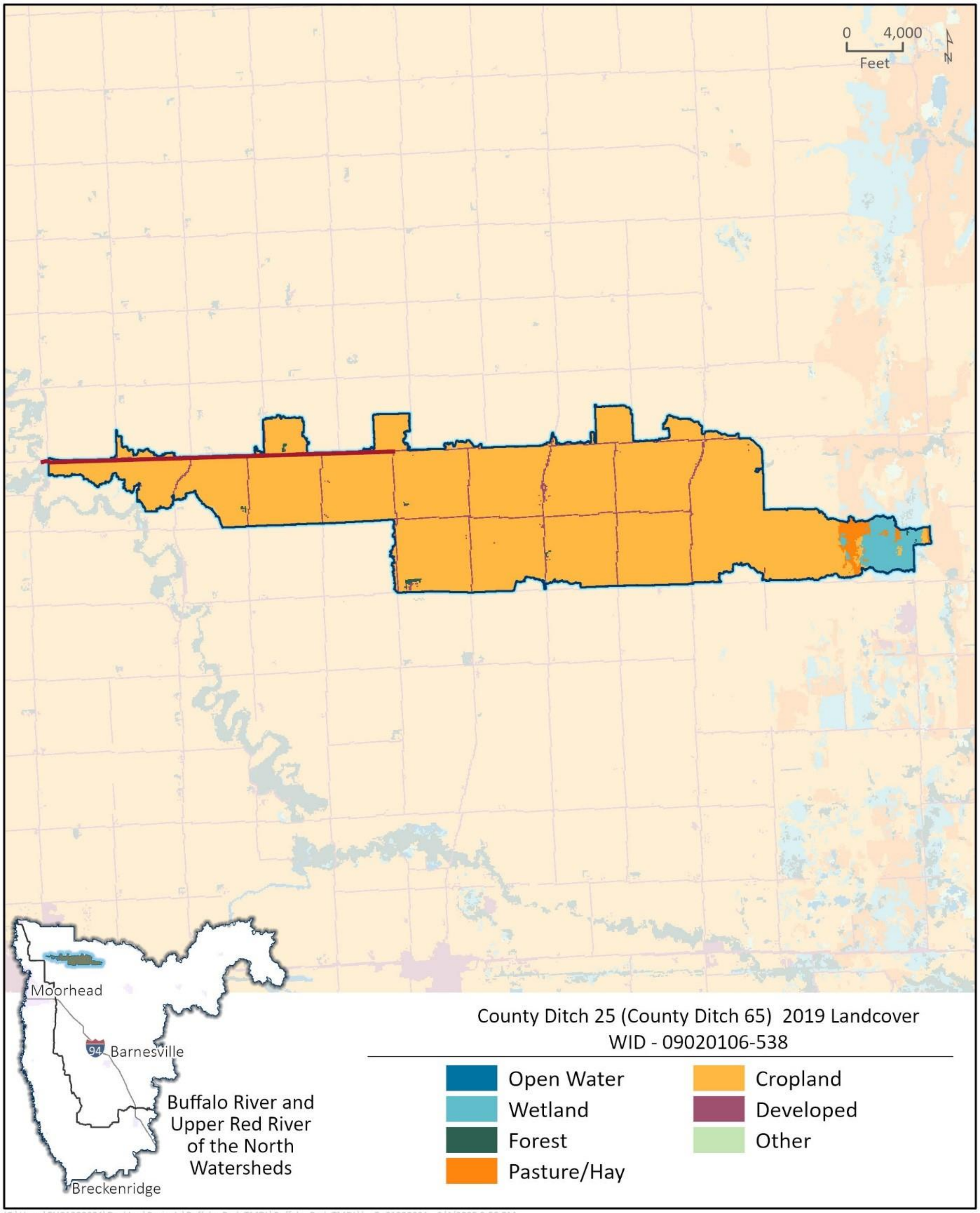


Figure 29. Individual subwatershed map for Buffalo River, South Branch (WID 09020106-605).

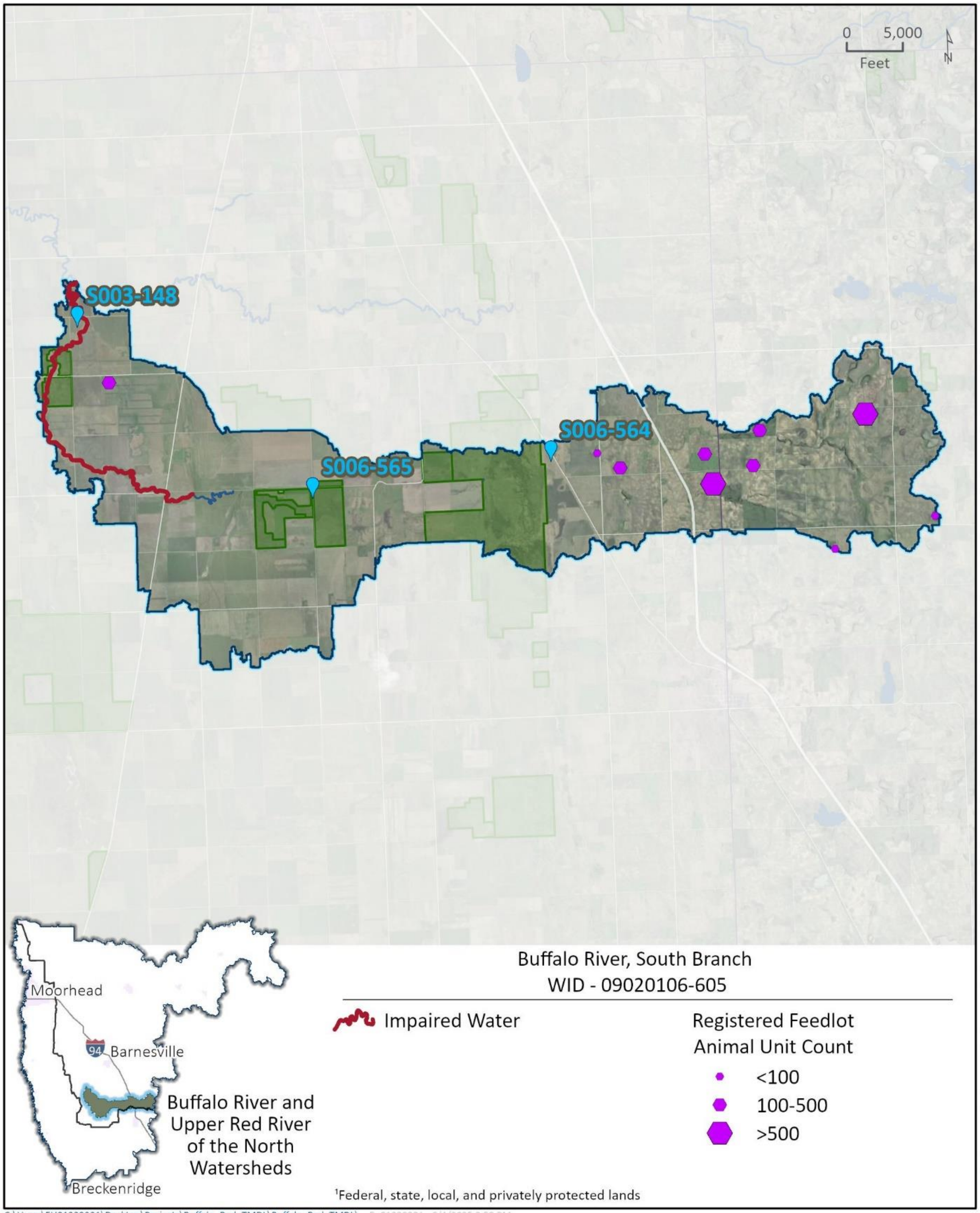


Figure 30. NLCD 2019 land cover map (USGS 2022) for Buffalo River, South Branch (WID 09020106-605).

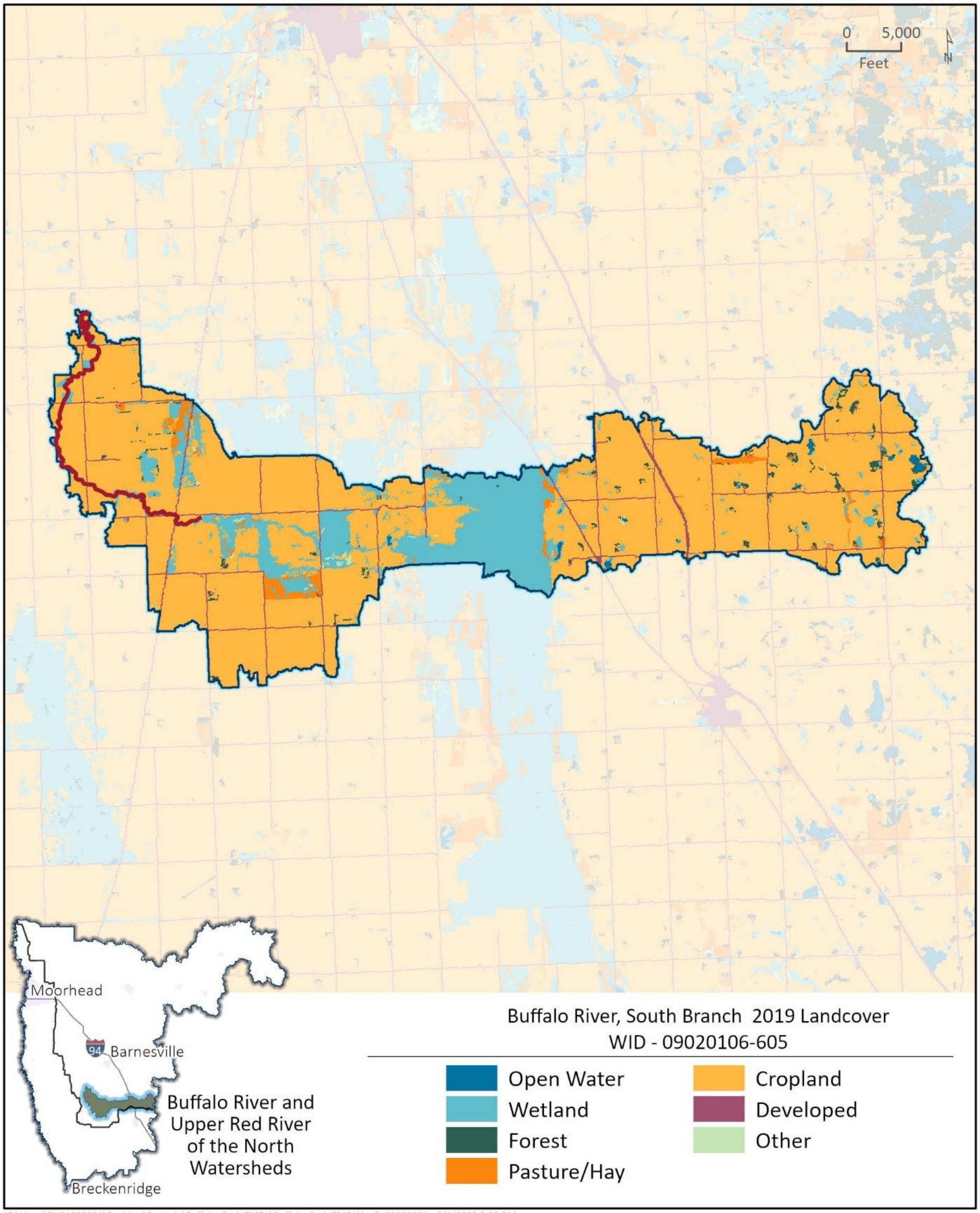


Figure 31. Individual subwatershed map for County Ditch 10 (WID 09020106-619).

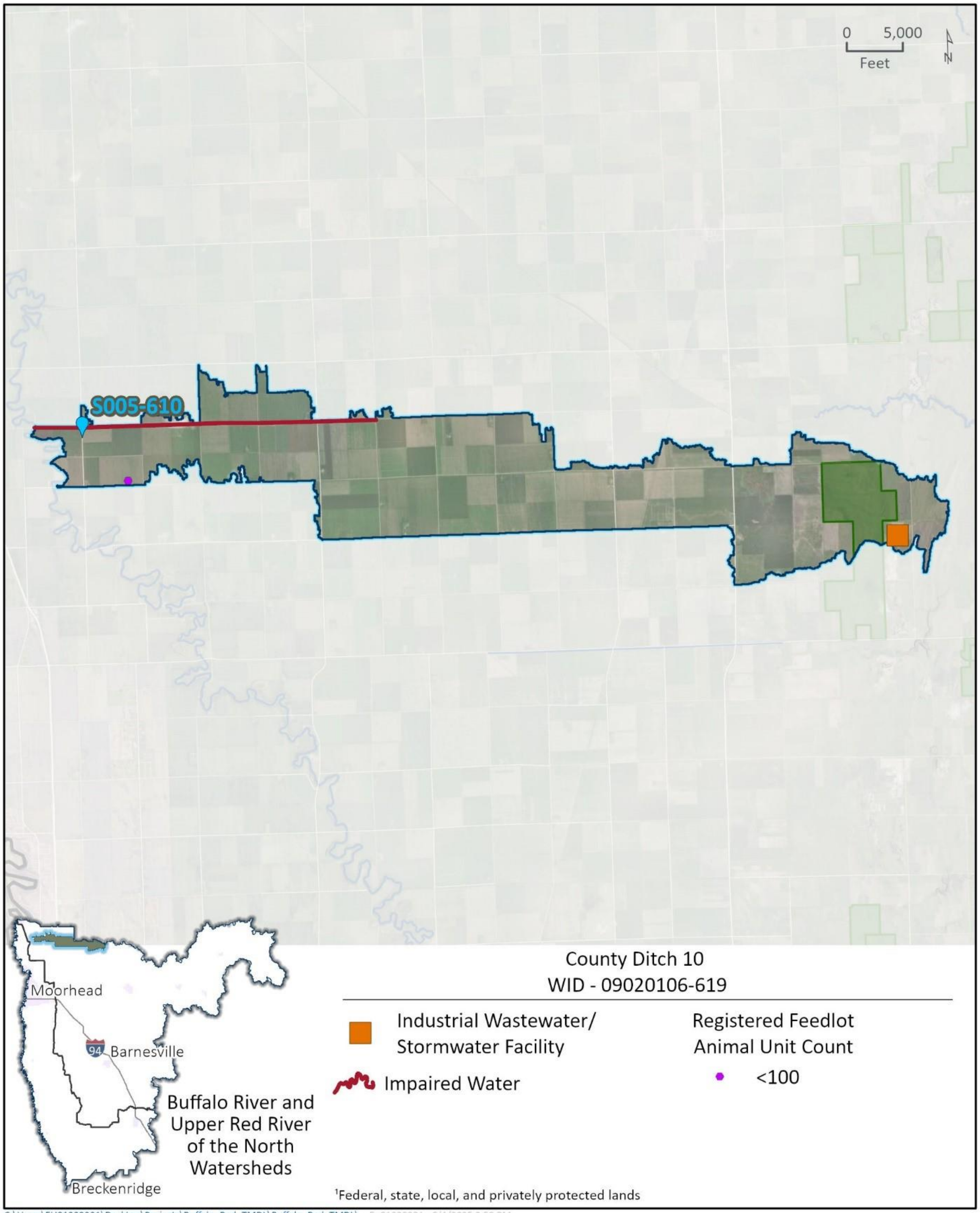


Figure 32. NLCD 2019 land cover map (USGS 2022) for County Ditch 10 (WID 09020106-619).

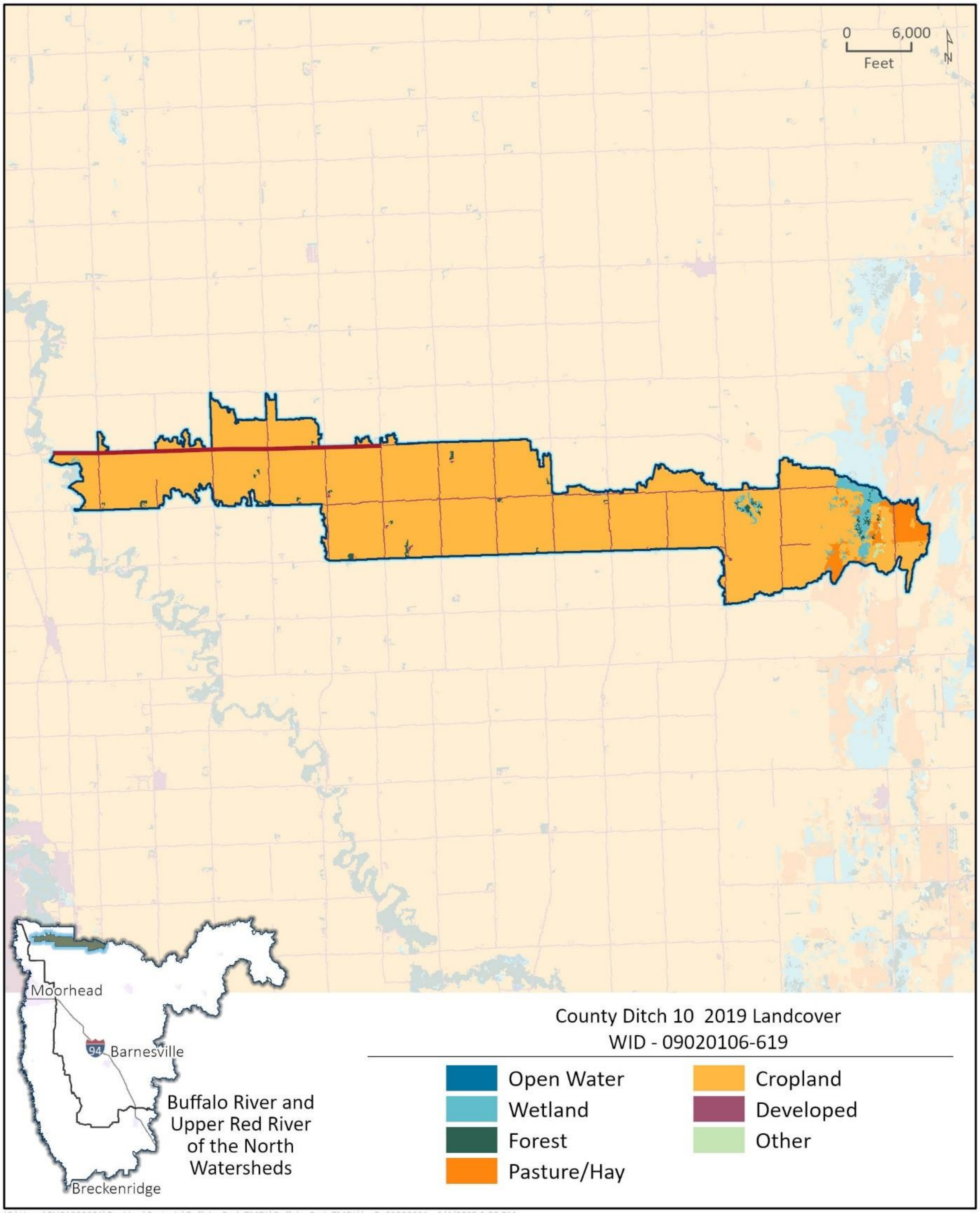


Figure 33. Individual subwatershed map for Hay Creek (WID 09020106-622 and 09020106-621).

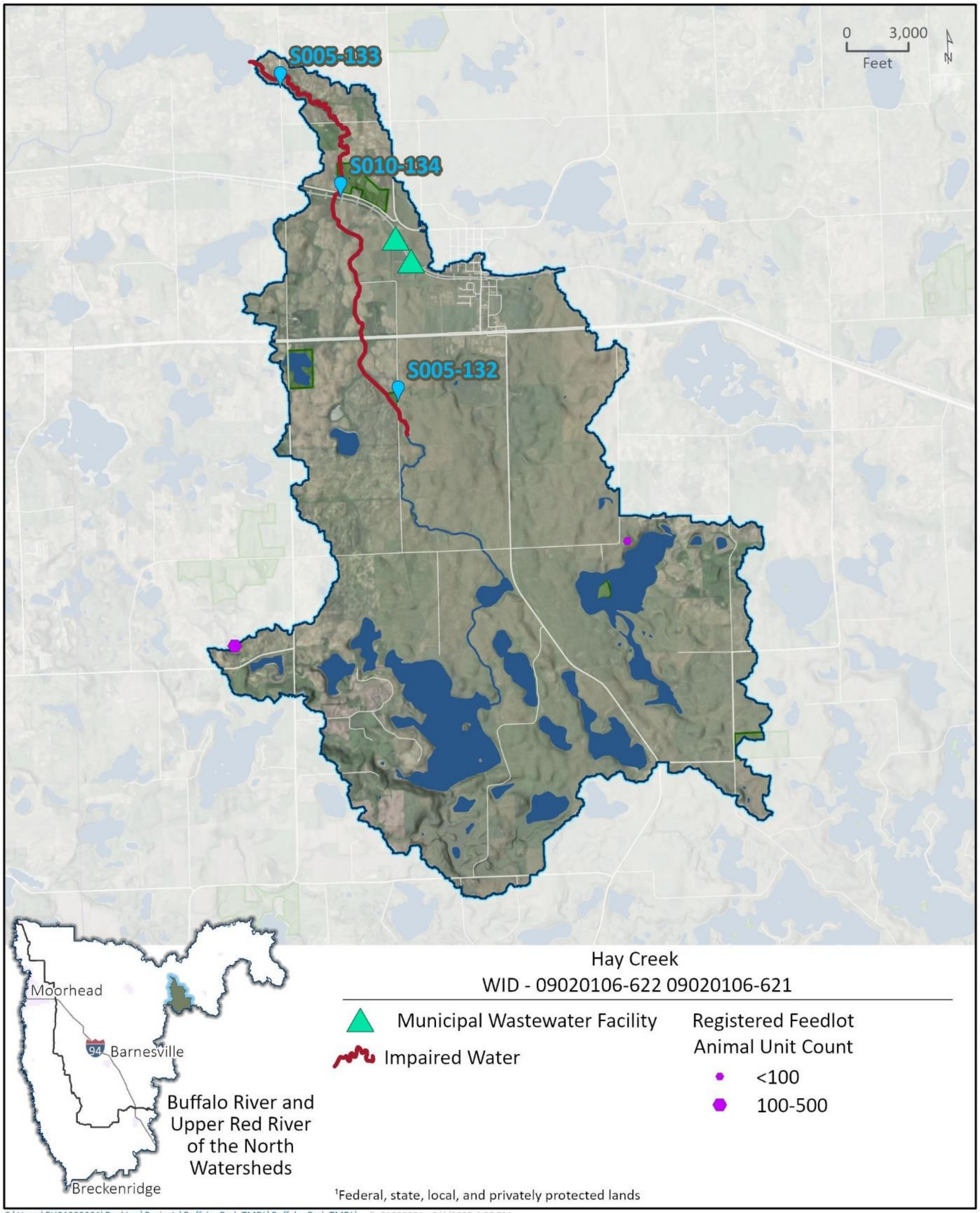


Figure 34. NLCD 2019 land cover map (USGS 2022) for Hay Creek (WID 09020106-622 and 09020106-621).

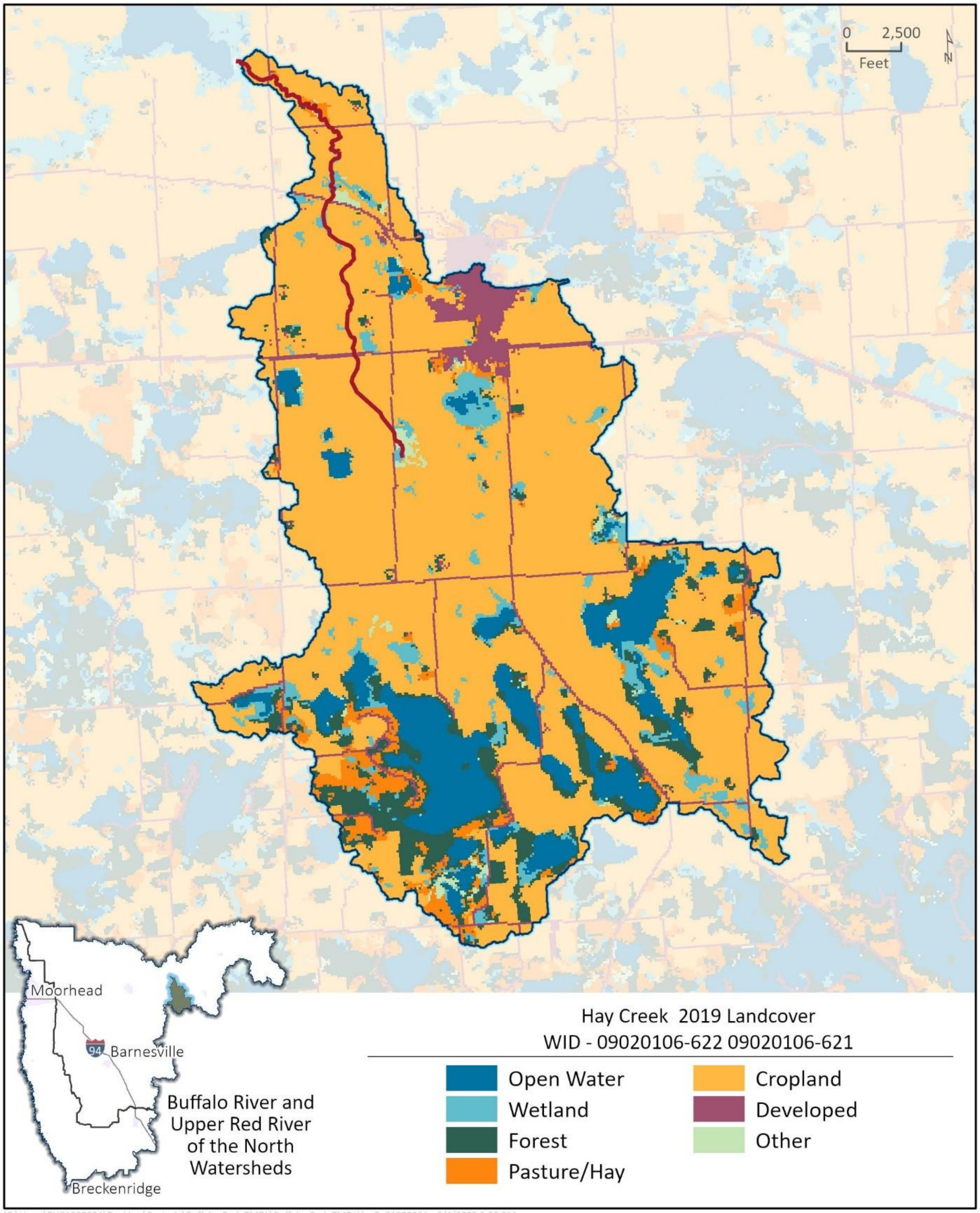


Figure 35. Individual subwatershed map for Lee Lake (WID 14-0049-00).

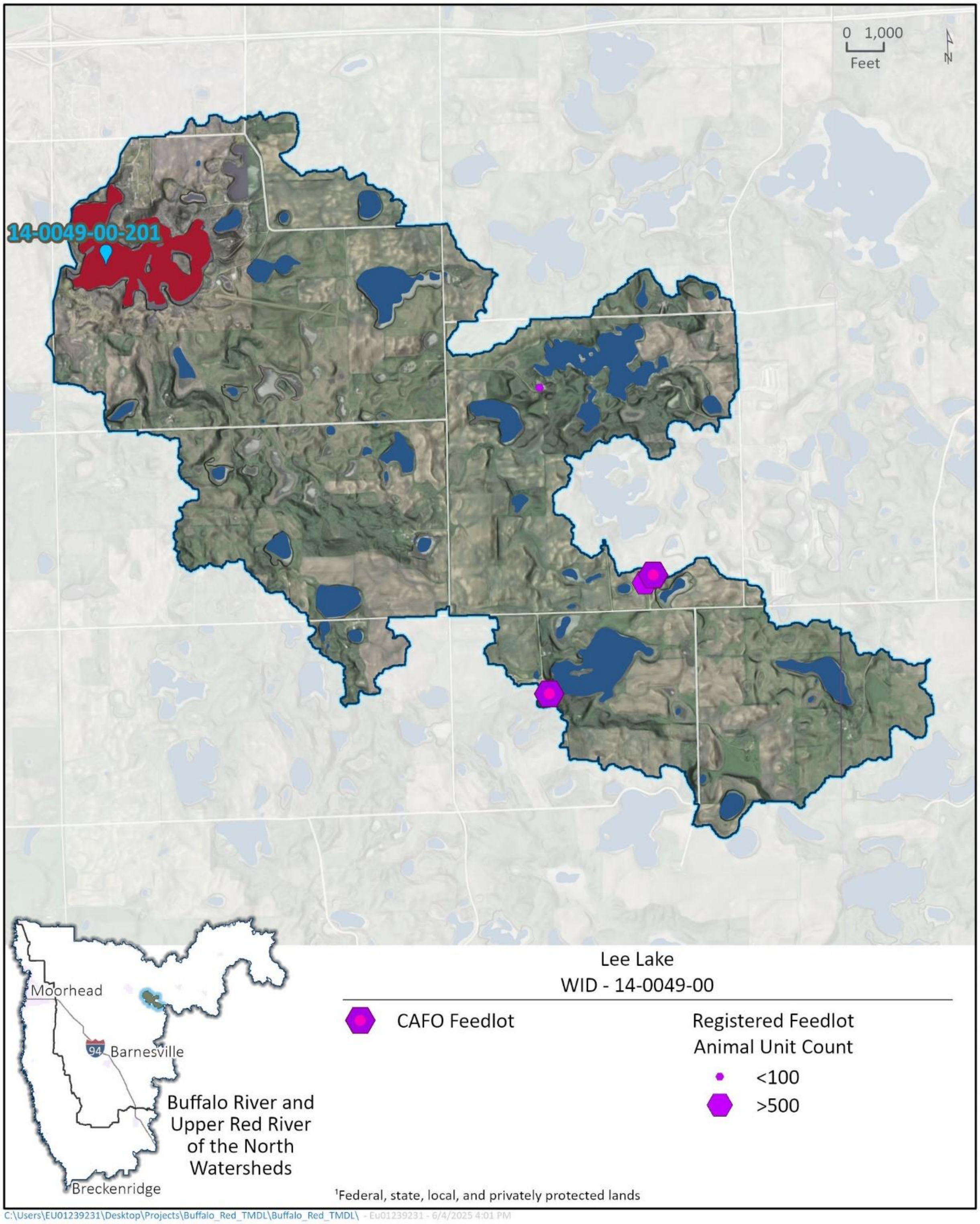
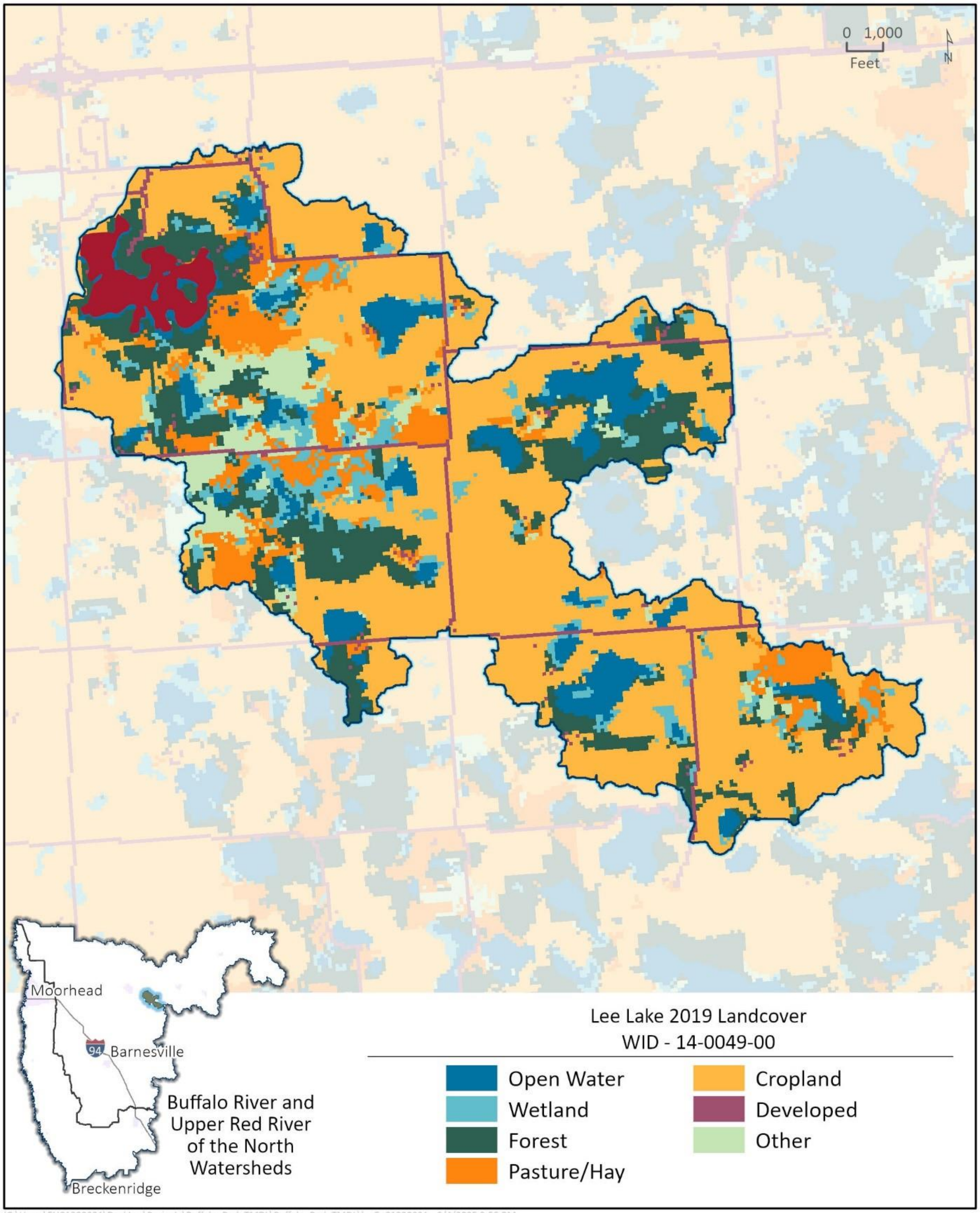


Figure 36. NLCD 2019 land cover map (USGS 2022) for Lee Lake (WID 14-0049-00).



Appendix D. Stream TP TMDL supporting analysis

This appendix provides additional data and information for the impaired stream reaches addressed with TP TMDLs in this report and upstream drainage areas, including:

- TP and chl-*a* LDCs for each impaired reach.
- TP and chl-*a* mean monthly concentrations versus mean monthly flow for each impaired reach.
- Daily DO measurements for each impaired reach measured during summer data Sonde deployments.

RES-parameter water quality data from the most recent 10-year period (2015 through 2024) during the summer growing season (June through September) was used in the TMDL report (see TMDL report Section 3.6.2). The LDCs in this appendix use HSPF simulated flows from 2011 through 2022 since the BRW HSPF model (MPCA 2024g) uses data through 2022. Therefore, the monitored TP and chl-*a* data included in each figure in this appendix include monitored data from 2015 through 2022 to be consistent with modeled flows.

Figure 37. County Ditch 25 (County Ditch 65) (09020106-538) summer (June through September) TP LDC and monitored loads (2011-2022).

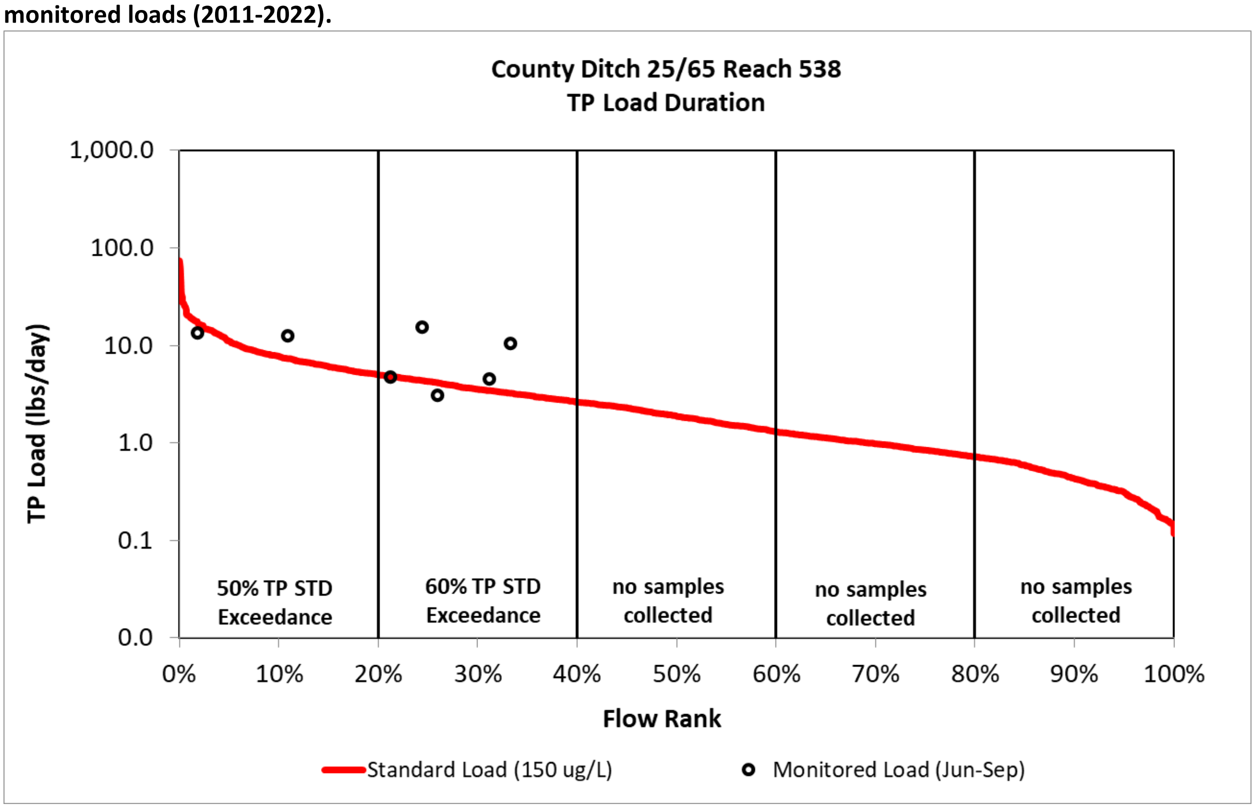


Figure 38. County Ditch 25 (County Ditch 65) (09020106-538) TP monthly average concentrations (primary y-axis) and mean monthly flow (secondary y-axis) (2011-2022).

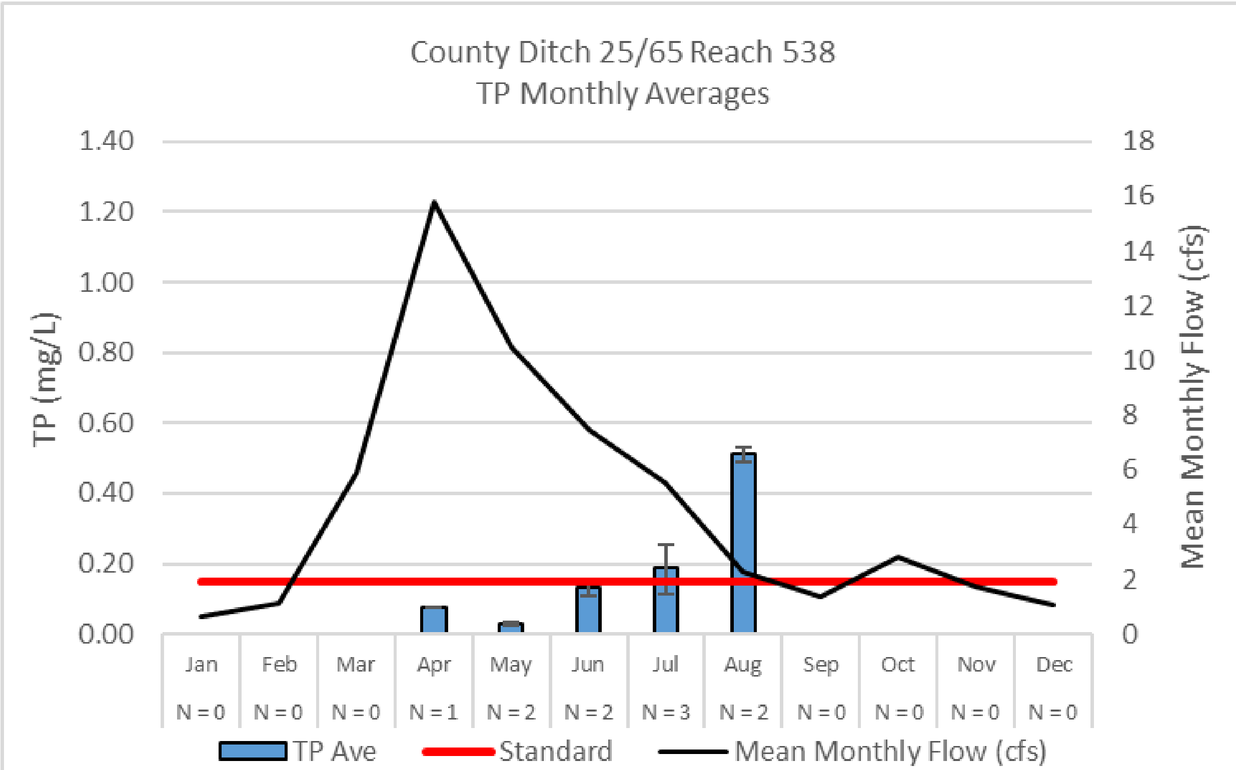


Figure 39. County Ditch 25 (County Ditch 65) (09020106-538) summer (June through September) chl-*a* LDC and monitored loads (2011-2022).

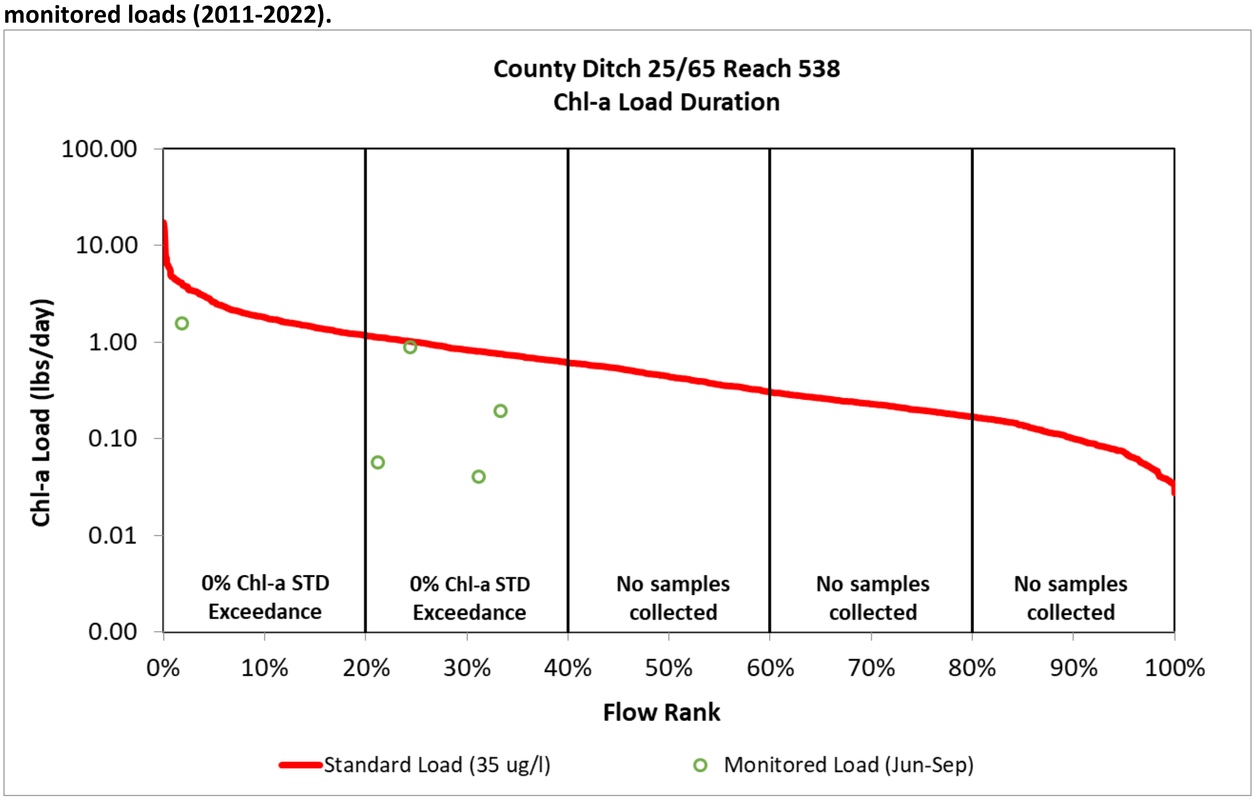


Figure 40. County Ditch 25 (County Ditch 65) (09020106-538) chl-*a* monthly mean concentrations (primary y-axis) and mean monthly flow (secondary y-axis) (2011-2022).

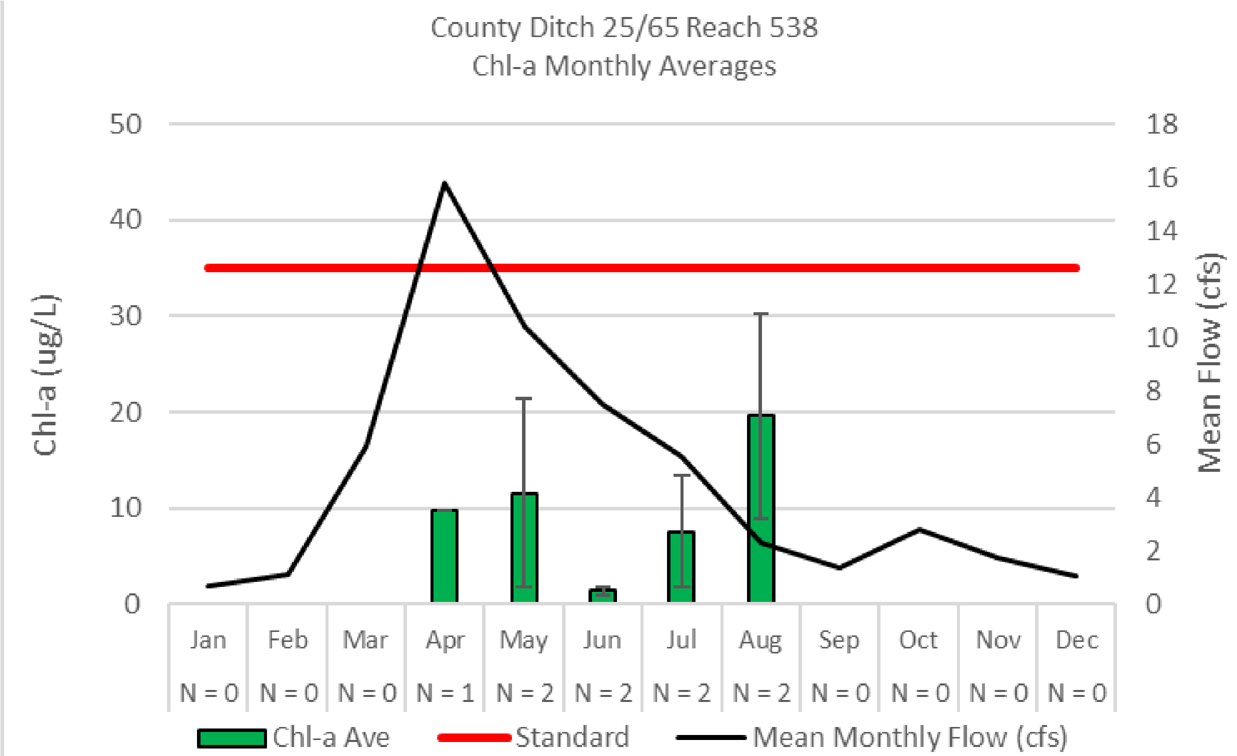


Figure 41. County Ditch 25 (County Ditch 65) (09020106-538) 2019 summer sonde deployment DO measurements and HSPF simulated mean daily flow.

Note: blue circles represent the mean daily DO concentration, black error bars represent the daily minimum and maximum DO concentration, and the flow data labels are the reach's percent flow exceedance for that day (summer flows 2011-2022).

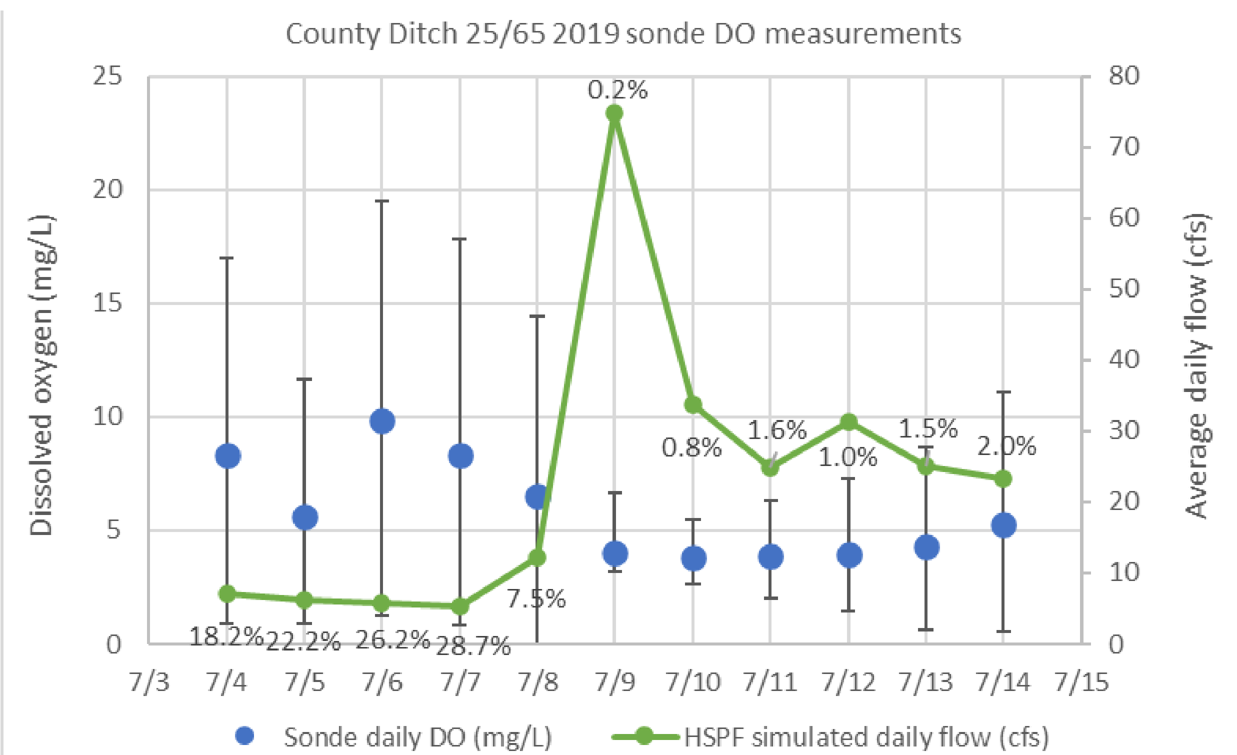


Figure 42. Buffalo River, South Branch (09020106-605) summer (June through September) TP LDC and monitored loads (2011-2022).

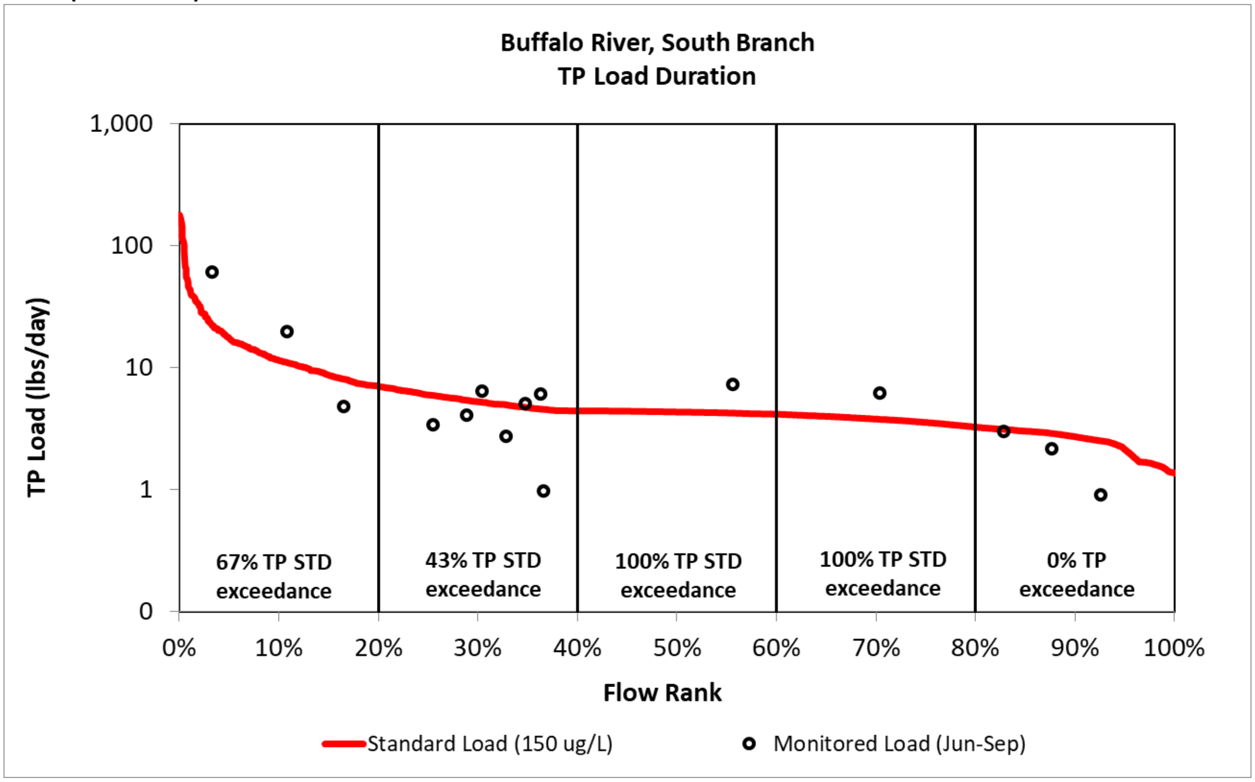


Figure 43. Buffalo River, South Branch (09020106-605) TP monthly average concentrations (primary y-axis) and mean monthly flow (secondary y-axis) (2011-2022).

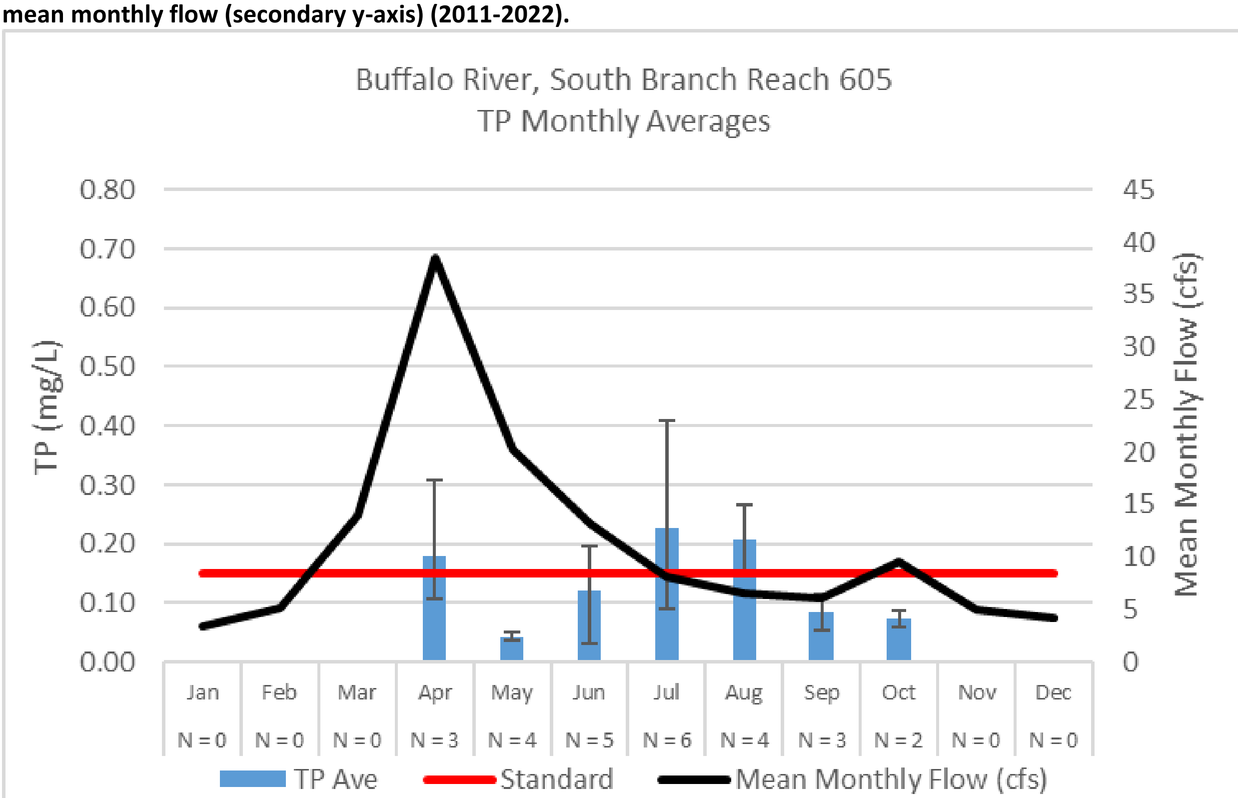


Figure 44. Buffalo River, South Branch (09020106-605) summer (June through September) chl-*a* LDC and monitored loads (2011-2022).

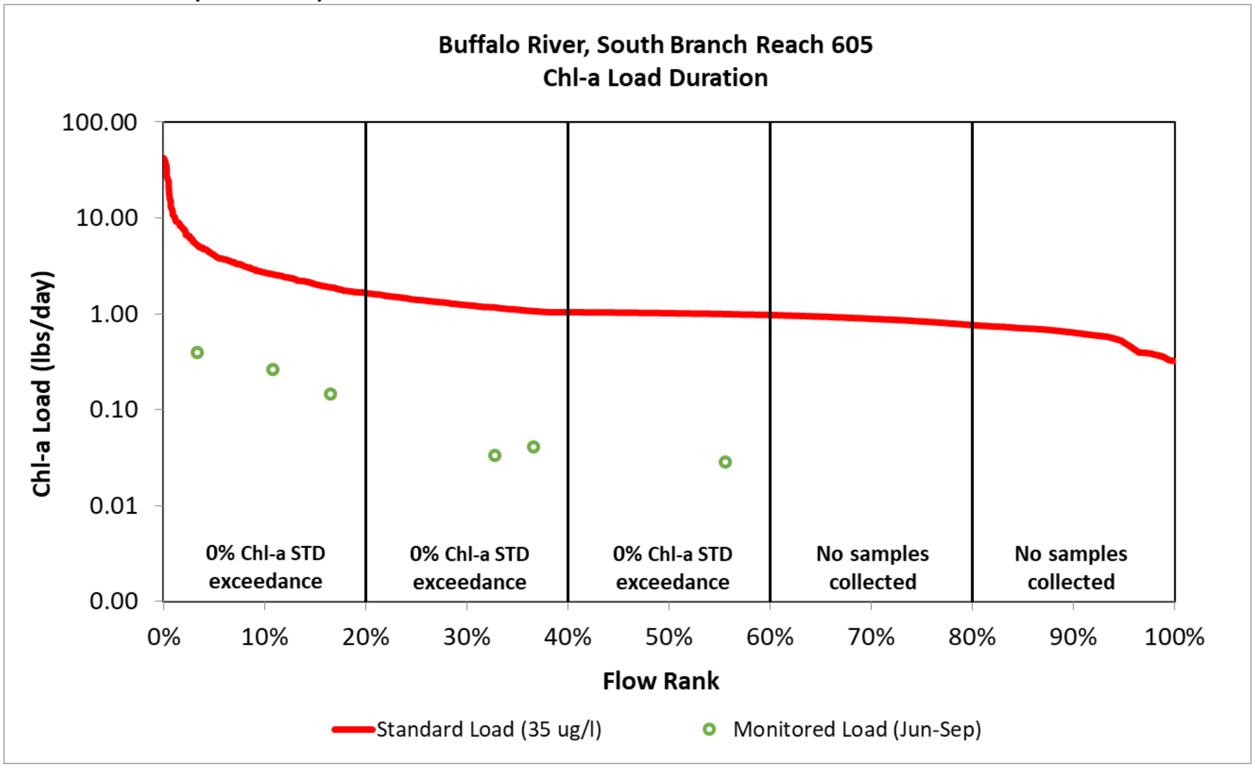


Figure 45. Buffalo River, South Branch (09020106-605) chl-*a* monthly mean concentrations (primary y-axis) and mean monthly flow (secondary y-axis) (2011-2022).

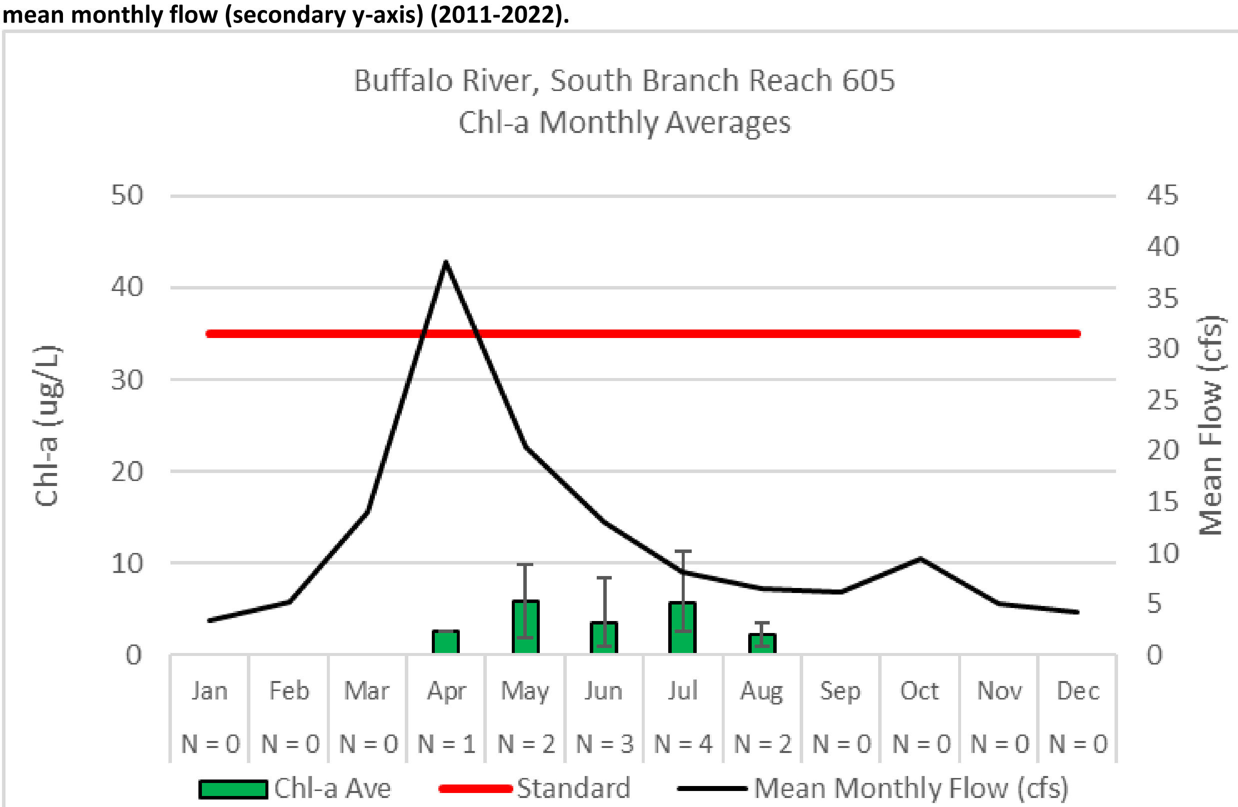
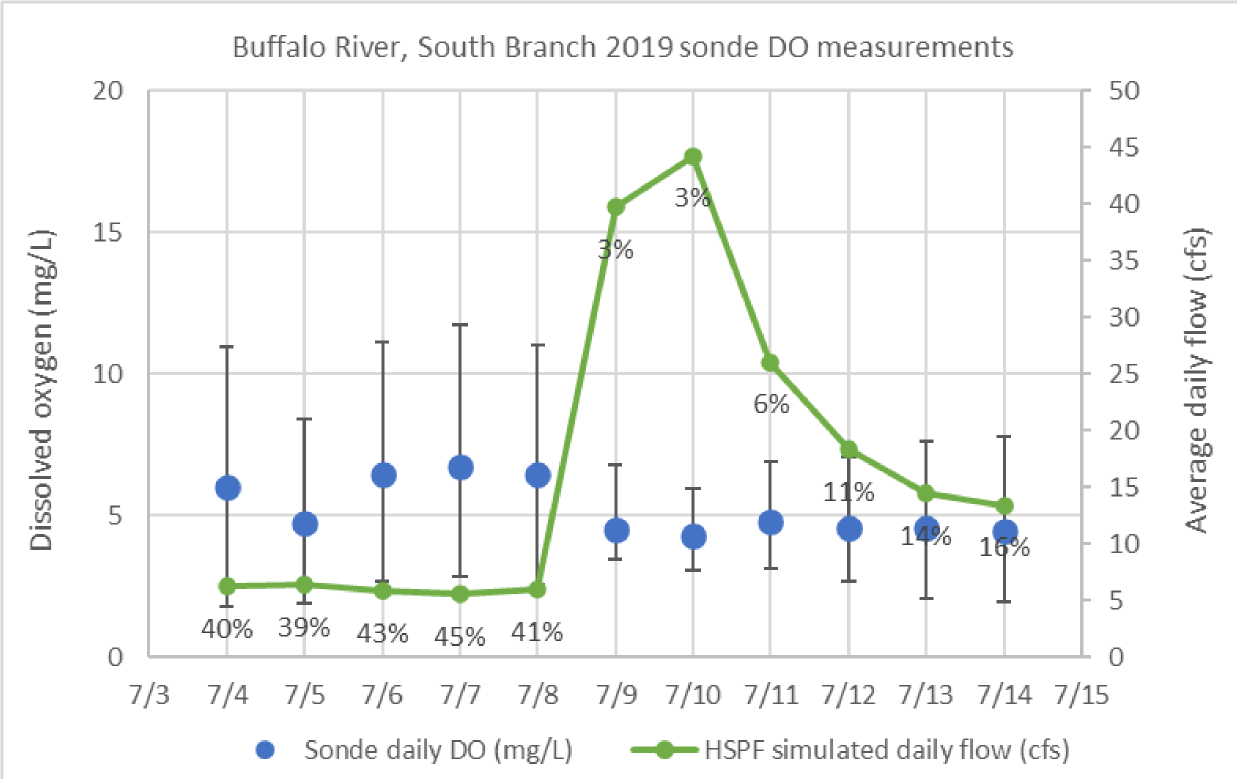
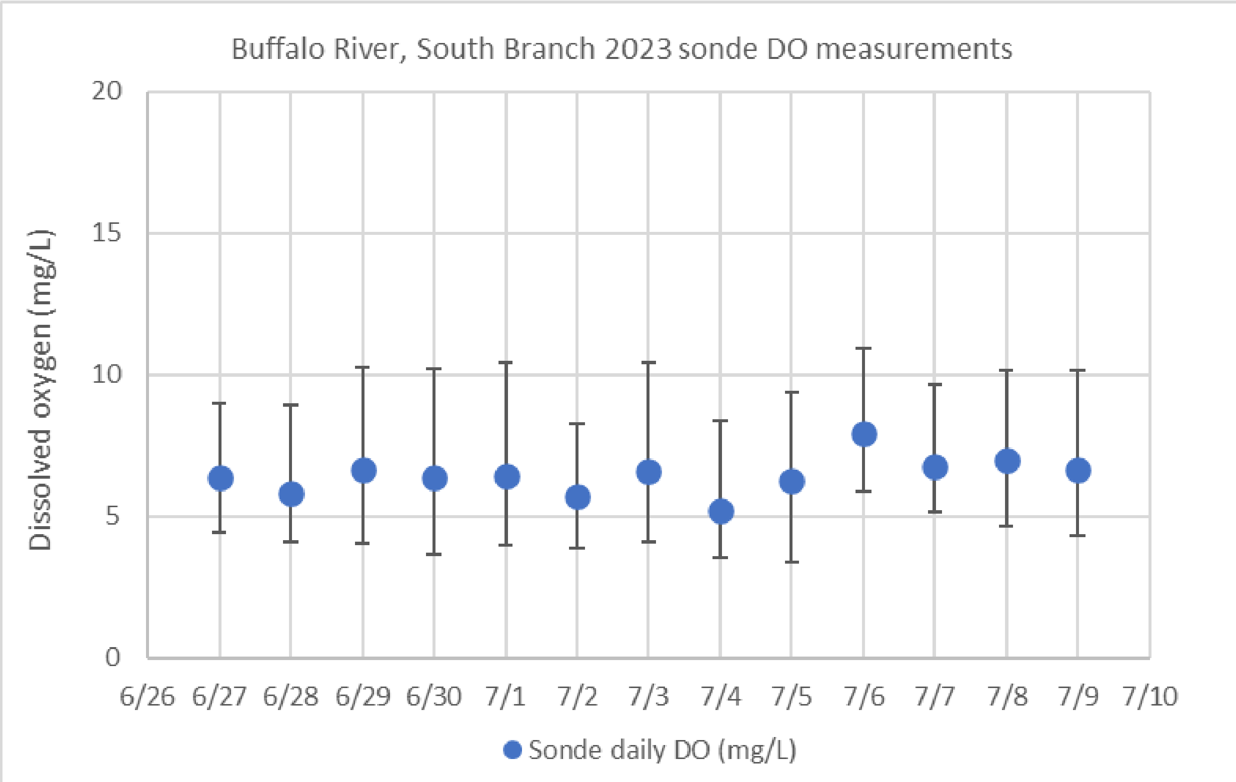


Figure 46. Buffalo River, South Branch (09020106-605) 2019 summer sonde deployment DO measurements and HSPF simulated mean daily flow.



Note: blue circles represent the mean daily DO concentration, black error bars represent the daily minimum and maximum DO concentration, and the flow data labels are the reach's percent flow exceedance for that day (summer flows 2011-2022).

Figure 47. Buffalo River, South Branch (09020106-605) 2023 summer sonde deployment DO measurements.



Note: blue circles represent the mean daily DO concentration, black error bars represent the daily minimum and maximum DO concentration. There are no monitored or HSPF simulated flows available for 2023 for this reach.

Figure 48. County Ditch 10 (09020106-619) summer (June through September) TP LDC and monitored loads (2011-2022).

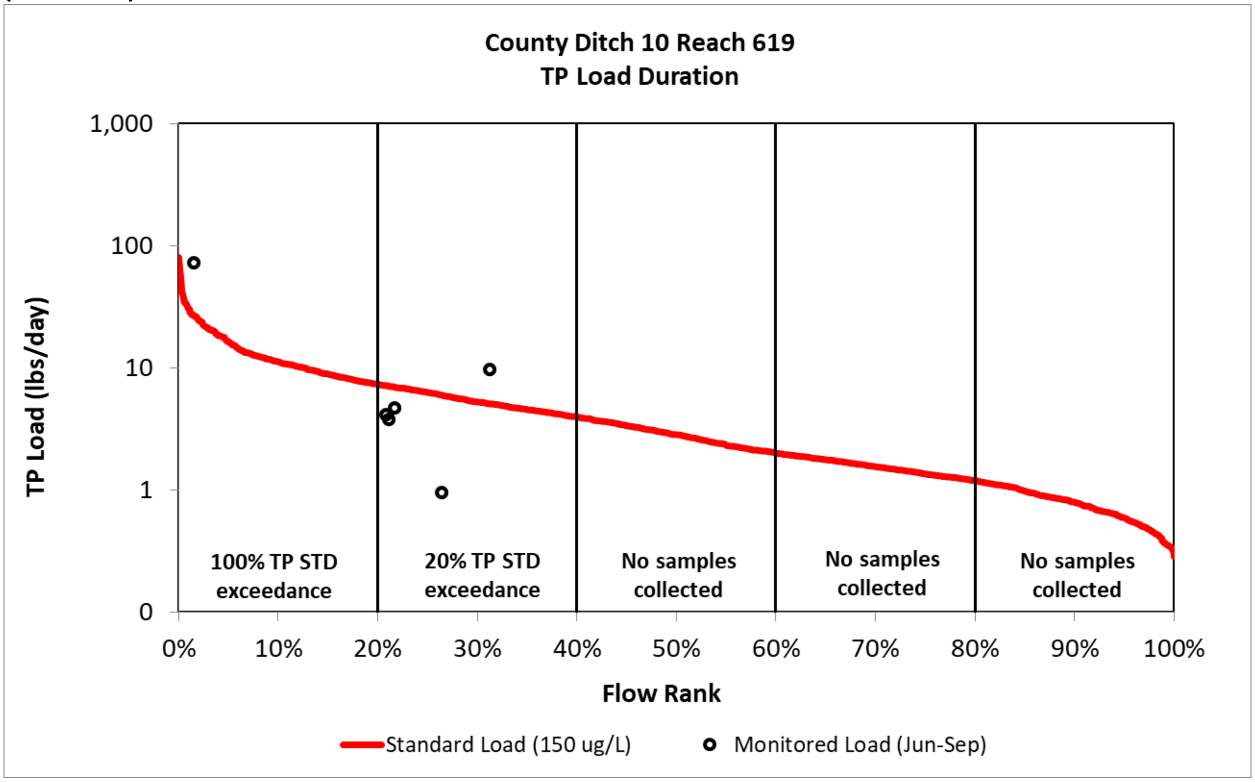


Figure 49. County Ditch 10 (09020106-619) TP monthly average concentrations (primary y-axis) and mean monthly flow (secondary y-axis) (2011-2022).

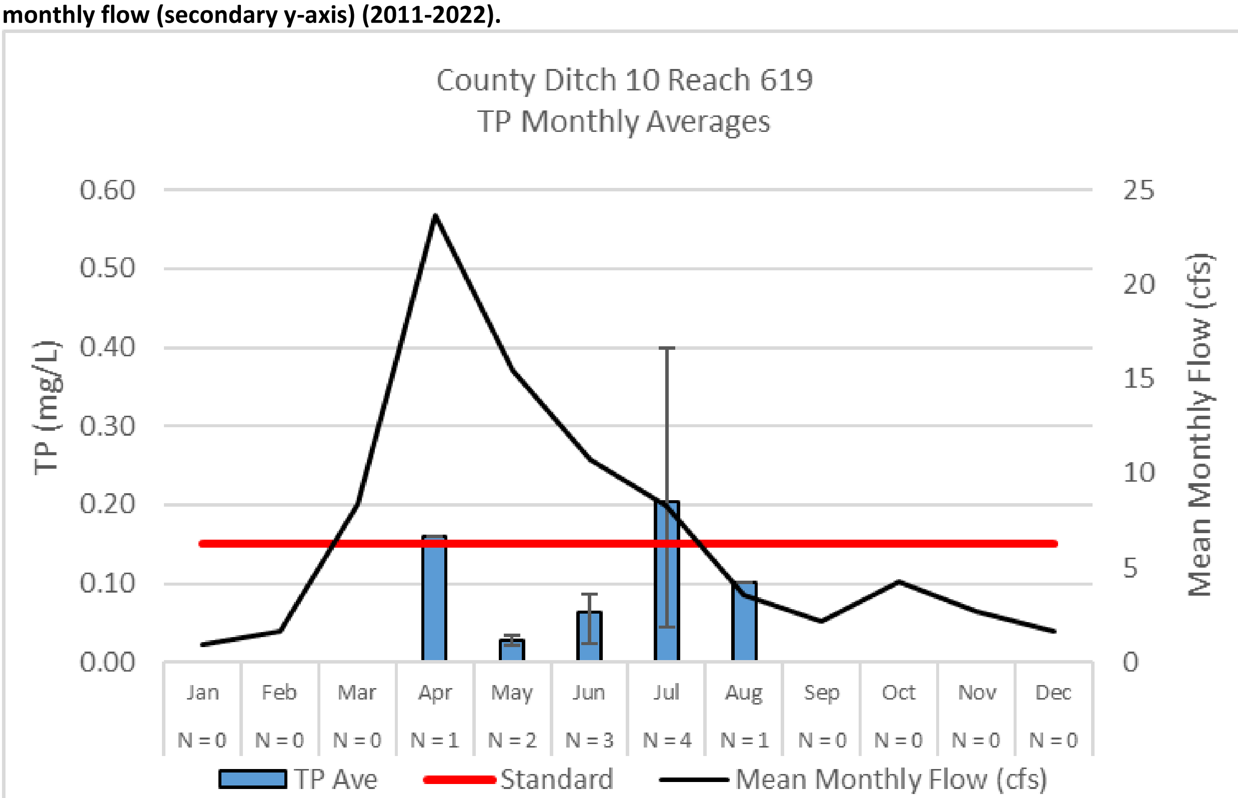


Figure 50. County Ditch 10 (09020106-619) summer (June through September) chl-*a* LDC and monitored loads (2011-2022).

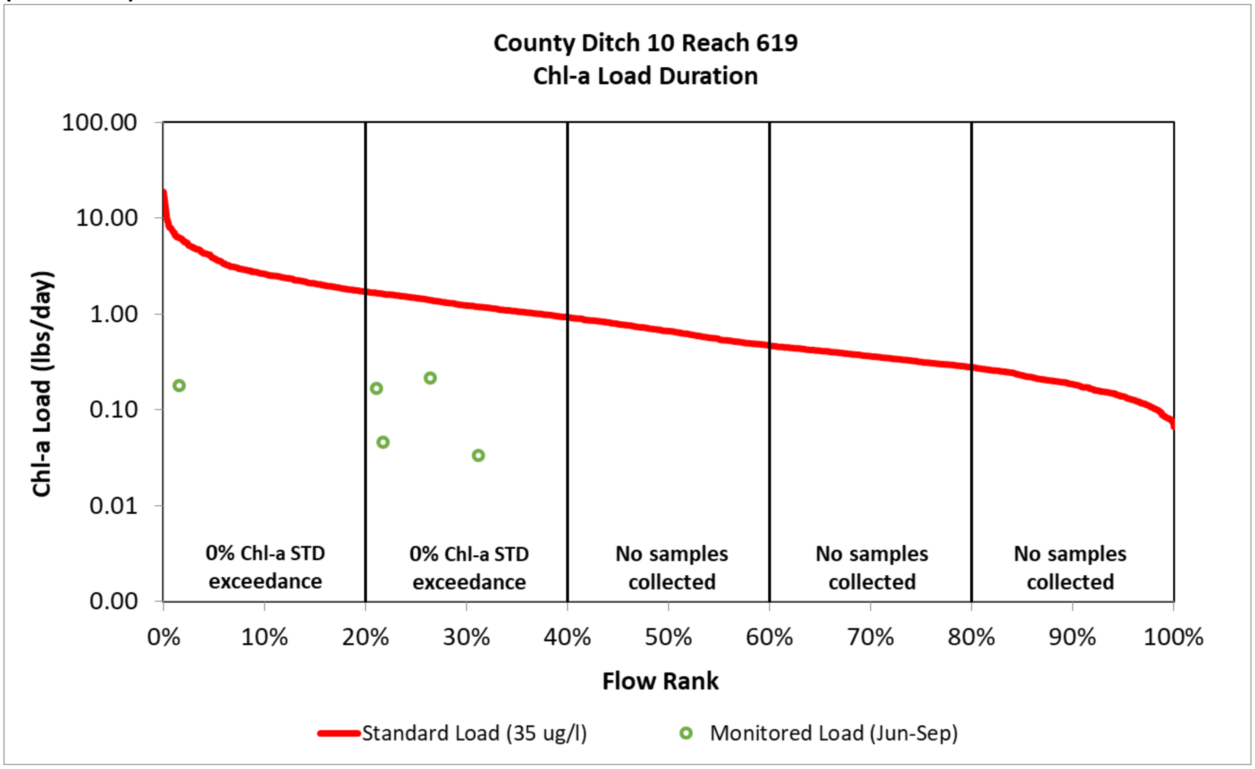


Figure 51. County Ditch 10 (09020106-619) chl-*a* monthly mean concentrations (primary y-axis) and mean monthly flow (secondary y-axis) (2011-2022).

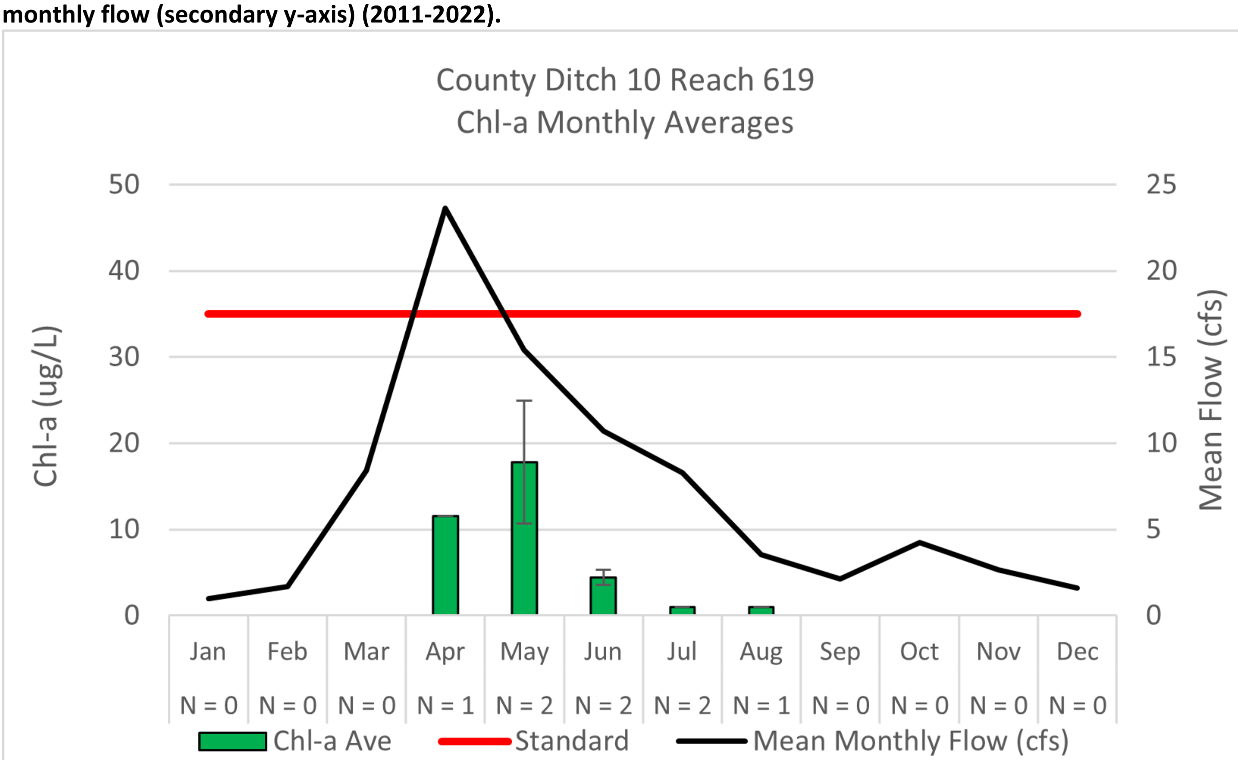
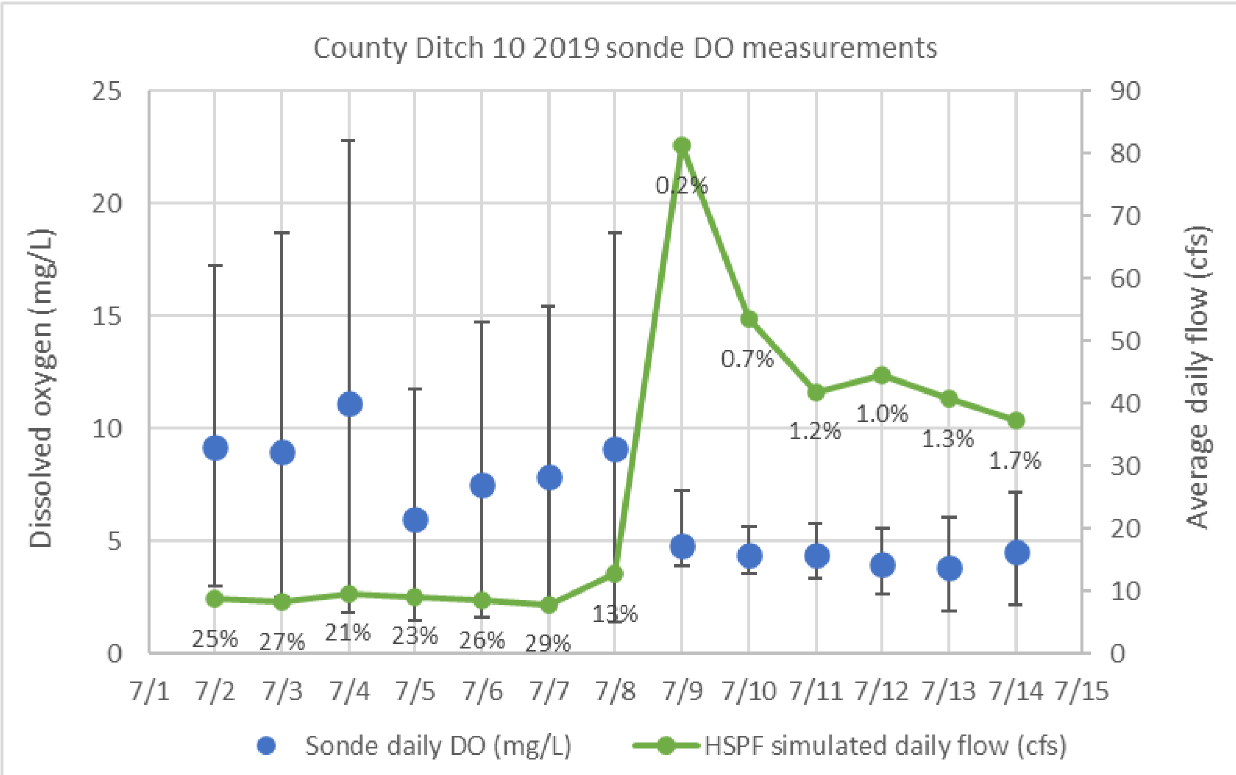
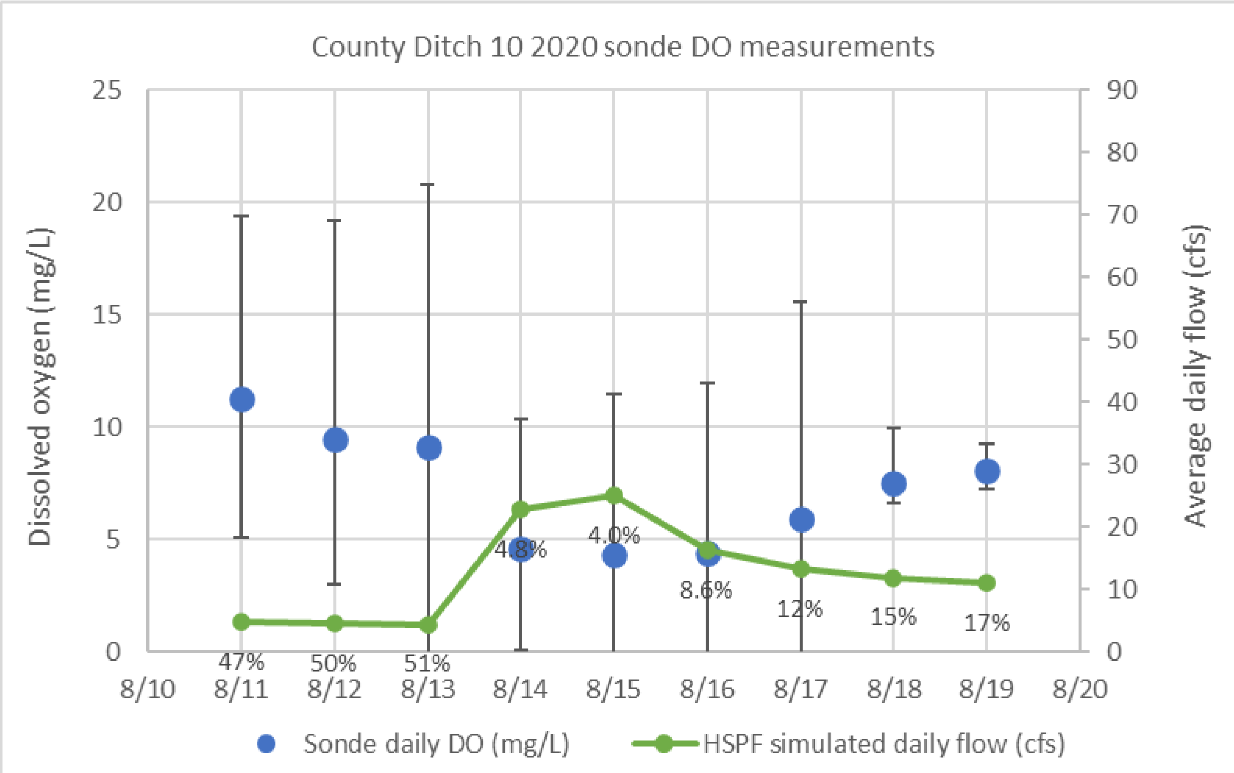


Figure 52. County Ditch 10 (09020106-619) 2019 summer sonde deployment DO measurements and HSPF simulated mean daily flow.



Note: blue circles represent the mean daily DO concentration, black error bars represent the daily minimum and maximum DO concentration, and the flow data labels are the reach's percent flow exceedance for that day (summer flows 2011-2022).

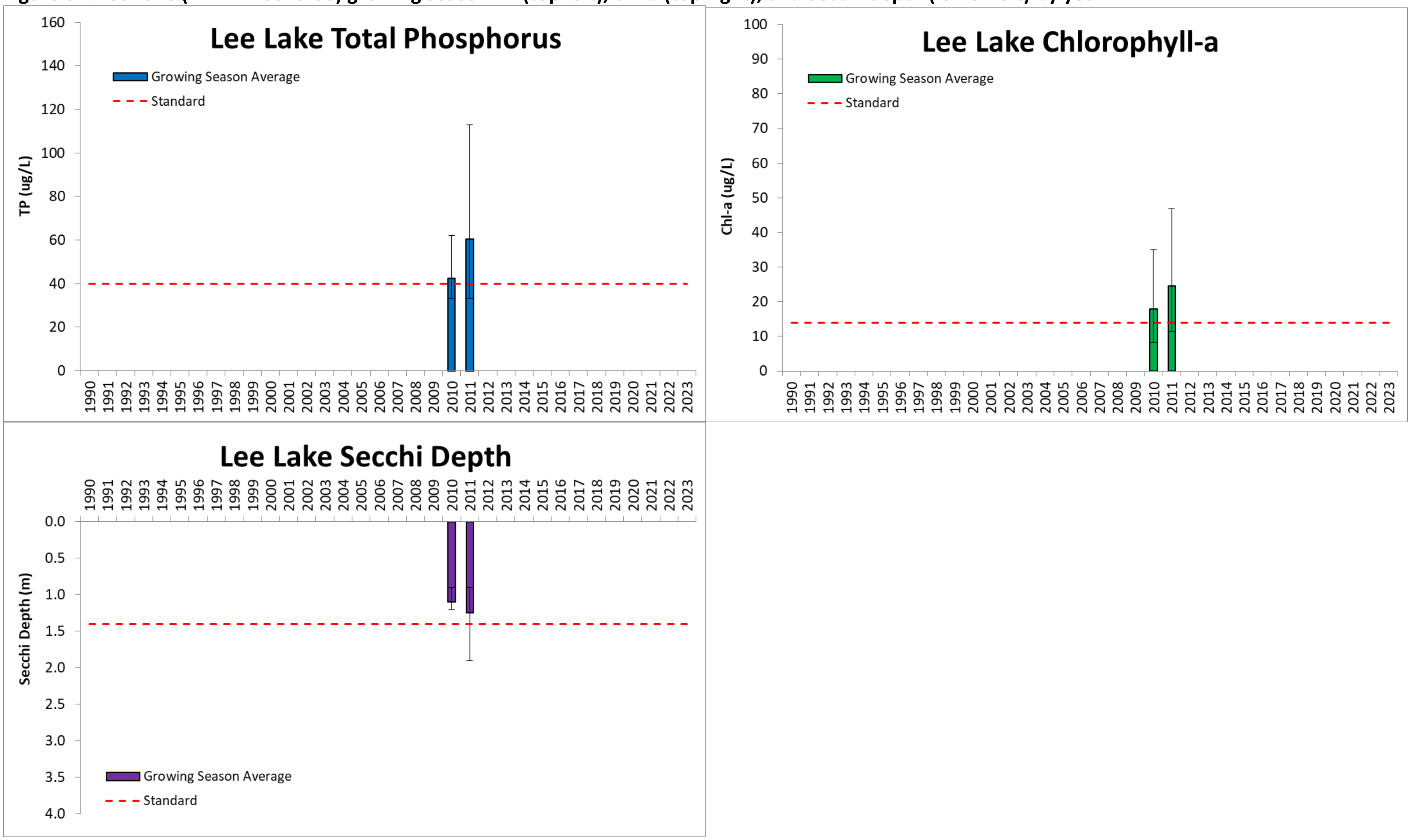
Figure 53. County Ditch 10 (09020106-619) 2020 summer sonde deployment DO measurements and HSPF simulated mean daily flow.



Note: blue circles represent the mean daily DO concentration, black error bars represent the daily minimum and maximum DO concentration, and the flow data labels are the reach's percent flow exceedance for that day (summer flows 2011-2022).

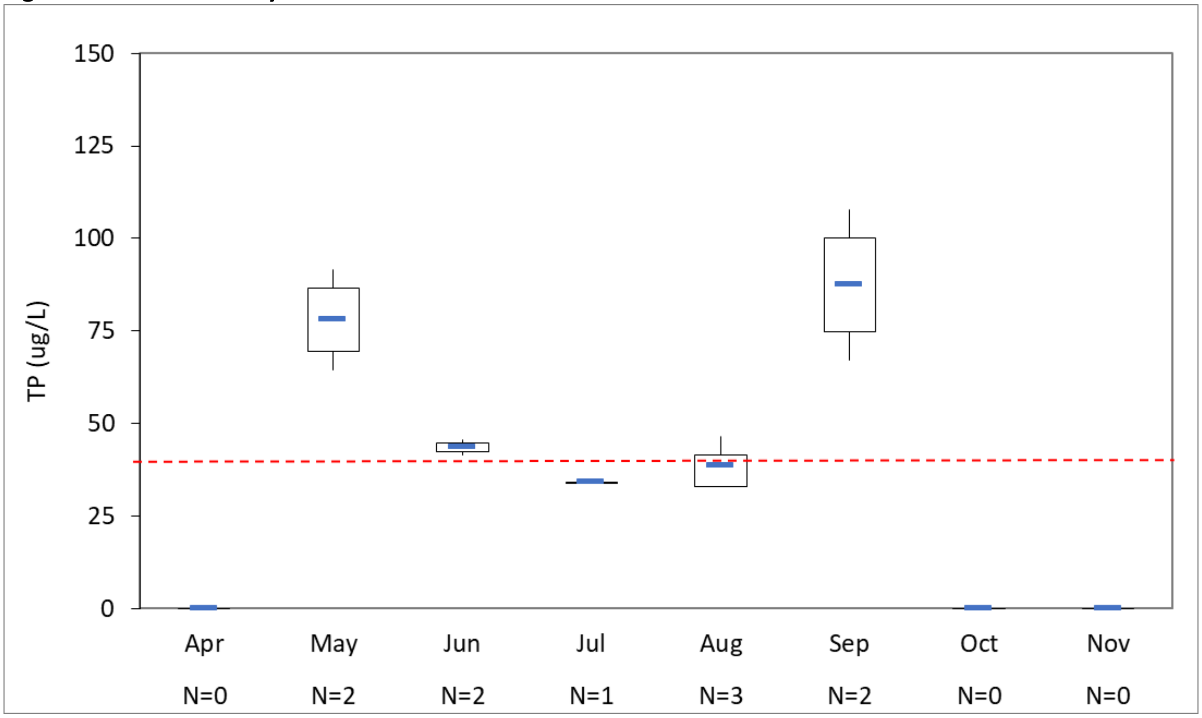
Appendix E. Lee Lake supporting analysis

Figure 54. Lee Lake (WID 14-0049-00) growing season TP (top left), chl-*a* (top right), and Secchi depth (lower left) by year.



Note: error bars represent the maximum and minimum individual summer measurements for each year.

Figure 55. Lee Lake TP by month.



Note: the upper and lower edge of each box represents the 75th and 25th percentile of the data range for each month. The error bars above and below each box represent the 95th and 5th percentile of the dataset. The colored dash within each box is the monthly mean concentration. The dotted red line represents the NCHF standard.

Figure 56. Lee Lake chl-*a* by month.

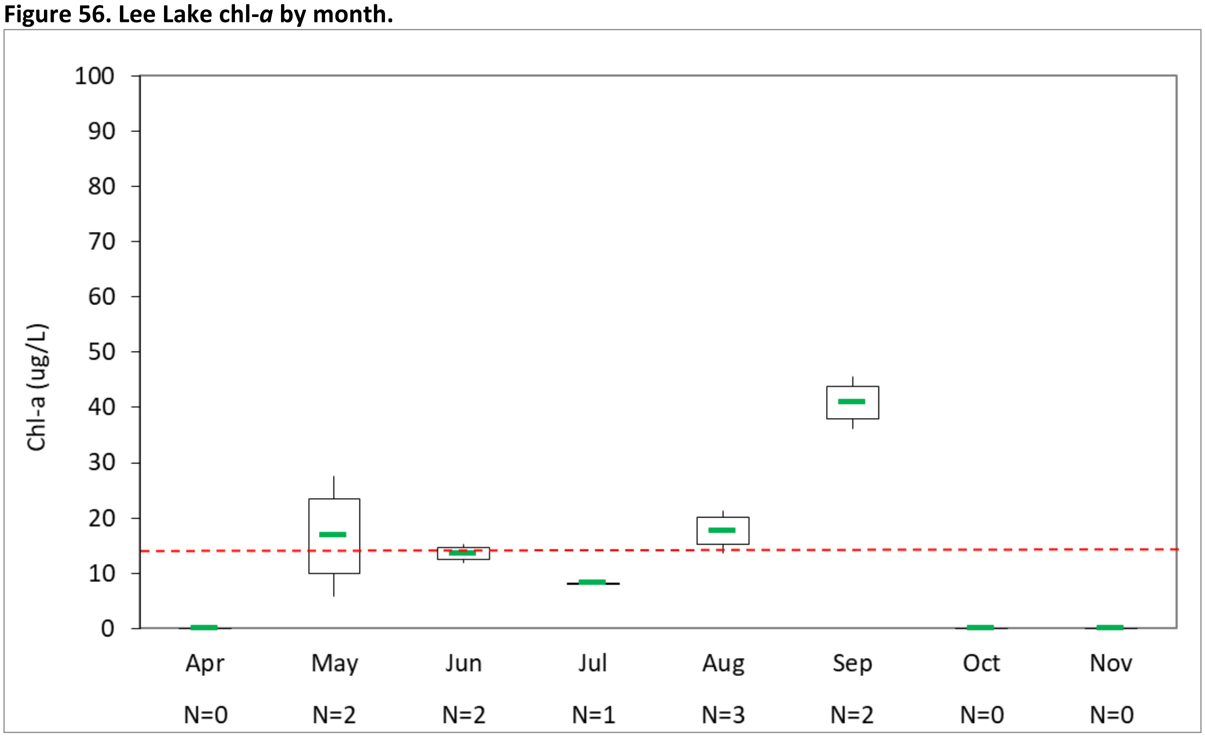


Figure 57. Lee Lake Secchi depth by month.

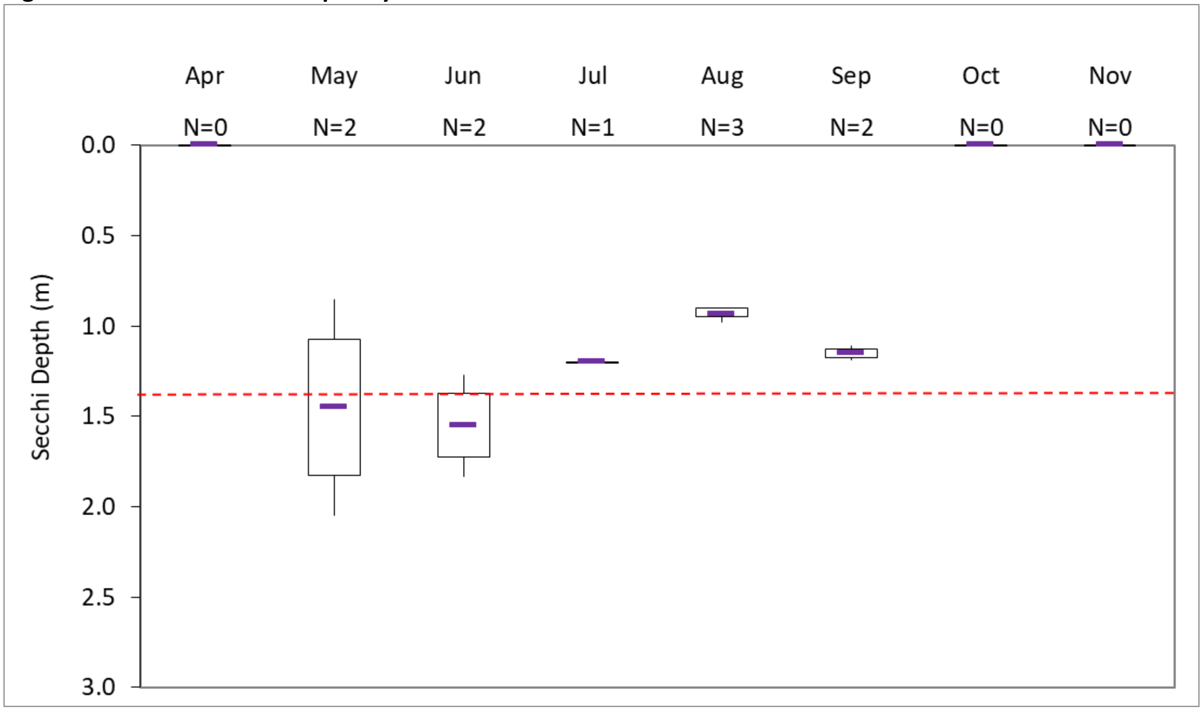


Figure 58. Lee Lake BATHTUB model inputs and documentation.

Global variables		
Averaging period (yrs)	1	
Precipitation (in/yr)	26	
Evaporation (in/yr)	36.5	
Atmospheric TP Load (kg/km^2-yr)	26.1	
Model options		
P balance	CB-Lakes	
P calibration	decay rates	
Model coefficients		
TP	1.9	
TP availability factor	1	
Segment	**Baseline**	**TMDL**
Area (ac)	158	
Mean depth (ft)	13.7	
Mean depth of mixed layer (ft)	0.0	
Observed TP (µg/L)	52	
Target TP (µg/L)	0	
TP internal load release rate (mg/m2-d)	0.0	0.0
TP internal load time of release (d)	0	0
Hydraulic residence time (yr)	1.0	
Overflow rate (m/yr)	4.0	
Watershed		
Watershed area (ac)	4,737	
Watershed to lake area ratio	30	

Segment mass balance: Baseline	**Flow (hm3/yr)**	**Flow (cfs)**	**% Flow**	**TP load (kg/yr)**	**TP load (lb/yr)**	**% TP load**	**TP concentration (µg/L)**
Precipitation	0.42	0.47	13%	17	37	2%	40
Specified (insert name; e.g., SSTS)	0.01	0.01	0%	18	39	3%	2,780
Watershed Runoff	2.75	3.08	87%	652	1,437	95%	237
Point	0.00	0.00	0%	0	-	0%	
Internal (excess) or unknown				0	-	0%	
Total	3.18	3.56	100%	686	1,513	100%	216
Evaporation	0.59	0.66	19%	0	-	0%	-
Sedimentation/retention				552	1,216	80%	
Outflow	2.59	2.90	81%	134	297	20%	52

Segment mass balance: TMDL Scenario	**Flow (hm3/yr)**	**Flow (cfs)**	**% Flow**	**TP load (kg/yr)**	**TP load (lb/yr)**	**% TP load**	**TP concentration (µg/L)**
Precipitation	0.42	0.47	13%	17	37	4%	40
Specified (insert name; e.g., SSTS)	0.01	0.01	0%	16	35	3%	2,498
Watershed Runoff	2.75	3.08	87%	423	932	93%	154
Point	0.00	0.00	0%	0	-	0%	
Internal (excess) or unknown				0	-	0%	
Total	3.18	3.56	100%	455	1,003	100%	143
Evaporation	0.59	0.66	19%	0	-	0%	-
Sedimentation/retention				352	775	77%	
Outflow	2.59	2.90	81%	103	228	23%	40

Load reductions					**TP load reduction (lb/yr)**	**% TP reduction**
Precipitation					-	0%
Specified (insert name; e.g., SSTS)					4	10%
Watershed Runoff					506	35%
Point					-	
Internal (excess) or unknown					-	
Total					510	34%