Watershed

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Pomme de Terre Watershed Restoration and Protection Strategy Report Update 2024

MINNESOTA POLLUTION CONTROL AGENCY

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Contents

List of Tables

List of Figures

Key Terms and Abbreviations

Altered hydrology: Changes in the amount of and way that water moves through the landscape. Examples of altered hydrology include changes in river flow, precipitation, subsurface drainage, impervious surfaces, wetlands, river paths, vegetation, and soil conditions. These changes can be climate- and/or human-caused.

Animal Units (AU): A term typically used in feedlot regulatory language. One animal unit is roughly equivalent to 1,000 pounds (lb) of animal but varies depending on the specific animal.

Aquatic life impairment (AQL): The presence and vitality of aquatic life is indicative of the overall water quality of a stream. A stream is considered impaired for impacts to aquatic life if the fish Index of Biotic Integrity (IBI), macroinvertebrate IBI, dissolved oxygen, turbidity, or certain chemical standards are not met.

Aquatic recreation impairment (AQR): Streams are considered impaired for impacts to aquatic recreation if fecal bacteria standards are not met. Lakes are considered impaired for impacts to aquatic recreation if total phosphorus and either chlorophyll-*a* or Secchi disc depth standards are not met.

Best management practice (BMP): A term used to describe a type of water pollution control. These can be a structural practice that is physically built to capture water and treat pollution, or a management practice used to limit or control pollution, usually at its source.

Biological Impairment: A biological impairment is an impairment to the aquatic life beneficial use due to a low fish and/or aquatic macroinvertebrate (bug) IBI score.

Concentrated Animal Feeding Operation (CAFO): CAFOs are facilities designed for confinement of animals. CAFO is further defined by the Environmental Protection Agency as large, medium, and small based on number of animals in a confined area for more than 45 days.

Designated (or Beneficial) Use: Water bodies are assigned a designated use based on how the water body is used. Typical beneficial uses include drinking, swimming, fishing, fish consumption, agricultural uses, and limited uses. Water quality standards for pollutants or other parameters are developed to determine if water bodies are meeting their designated use.

Dissolved Oxygen (DO): Oxygen that is present (dissolved) in water.

***Escherichia coli* (*E. coli*):** A bacteria commonly found in the gastrointestinal tract and feces of warm-blooded animals. *E. coli* is a preferred indicator for freshwater recreation and its presence provides direct evidence of fecal contamination from warm-blooded animals.

Eutrophication: The enrichment of a water body with nutrients, typically phosphorus and nitrogen.

Flow-weighted Mean Concentration (FWMC): The total mass of a pollutant delivered (by water) over a set period of time by the total volume of water over that same period of time. Typical units are milligrams per liter (mg/L).

Geographic Information System (GIS): A geographic (or geographical) information system (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present all types of spatial or geographical data. Geographic Information System

Hydrologic Simulation Program-Fortran (HSPF): A computer model developed to simulate hydrology and water quality at the watershed scale.

Hydrologic Unit Code (HUC): A HUC is assigned by the USGS for each watershed. HUCs are organized in a nested hierarchy by size. For example, the Minnesota River Basin is assigned a HUC-4 of 0702 and the Pomme de Terre River Watershed is assigned a HUC-8 of 07020002.

Impairment: Water bodies are listed as impaired if water quality standards are not met for designated uses including aquatic life, aquatic recreation, and aquatic consumption.

Index of Biotic Integrity (IBI): A method for describing water quality using characteristics of aquatic communities, such as the types of fish and invertebrates found in the water body. It is expressed as a numerical value between 0 (lowest quality) to 100 (highest quality).

Local Governmental Unit (LGU): Local government, typically city, township, county and Soil and Water Conservation District (SWCD).

Nonpoint source pollutants: Pollutants that are from diffuse sources; most of these sources are not regulated. Nonpoint sources include agricultural field run-off, agricultural drain tile discharge, storm water from smaller cities and roads, bank, bluff, and ravine failures, atmospheric deposition, failing septic systems, animals, and other sources.

Point source pollutant: Pollutants that can be directly attributed to one location; generally, these sources are regulated by permit. Point sources include wastewater treatment plants, industrial dischargers, storm water discharge from larger cities, and storm water runoff from construction activity (construction storm water permit).

Pollutant vs Stressor: Generally, these words could be used interchangeably. However, in this report, a pollutant is used to refer to parameters that have a water quality standard and can be tested for directly. Pollutants affect all beneficial uses. A stressor is used to refer to the parameter(s) identified in the stressor identification process, which is only done when a biological impairment is identified (due to a low fish and/or macroinvertebrate IBI score).

Protection: This term is used to characterize actions taken in watersheds of waters not known to be impaired to maintain conditions and beneficial uses of the water bodies.

National Land Cover Database (NLCD): A database of land cover categories generated in cooperation with the Multi-Resolution Land Characteristics Consortium (MRLC) a partnership of Federal agencies working together to produce current, nationally consistent, land cover products for all 50 states and Puerto Rico.

Restoration: This term is used to characterize actions taken in watersheds of impaired waters to improve conditions, eventually to meet water quality standards and achieve beneficial uses of the water bodies.

Source (or pollutant source): This term is distinguished from 'stressor' to mean only those actions, places, or entities that deliver/discharge pollutants (e.g., sediment, phosphorus, nitrogen, pathogens).

Stream Class: A classification system for streams to specify the stream's beneficial or designated uses.

Stream Class 2B: The quality of Class 2B surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life and their habitats. These waters shall be suitable for AQR of all kinds, including bathing, for which the waters may be used.

Stream Class 7 waters: The quality of Class 7 waters of the state shall be such as to protect aesthetic qualities, secondary body contact use, and groundwater for use as a potable water supply.

Stream reach: Reaches in a surface water network are segments with similar hydrologic characteristics. Reaches are commonly defined by a length of stream between two confluences, or a lake or pond. Each reach is assigned a unique reach number and a flow direction. The length of the reach, the type of reach, and other important information are assigned as attributes to each reach.

Stressor (or biological stressor): This is a broad term that includes both pollutant sources (e.g., excessive sediment, excessive chloride) and nonpollutant sources or factors (e.g., altered hydrology, dams preventing fish passage) that adversely impact aquatic life.

Total maximum daily load (TMDL): A calculation of the maximum amount of a pollutant that may be introduced into a surface water and still ensure that applicable water quality standards for that water are met. A TMDL is the sum of the wasteload allocation for point sources, a load allocation for nonpoint sources and natural background, an allocation for future growth (i.e., reserve capacity), and a margin of safety as defined in the Code of Federal Regulations.

Total Nitrogen (TN): The sum of all nitrogen forms or Total Nitrogen = Ammonia Nitrogen (NH_3) + Nitrite (NO_2) + Nitrate (NO_3).

Total Phosphorus (TP): A measure of all phosphorus found in a sample, whether that phosphorus is dissolved or particulate.

Total Suspended Solids (TSS) TSS is a measurement of the dry-weight of suspended particles, that are not dissolved, in a sample of water that can be trapped by a filter. TSS consists of soil particles, algae, and other materials that are suspended in water and cause a lack of clarity. Excessive TSS can harm aquatic life, degrade aesthetic and recreational qualities, and make water more expensive to treat for drinking.

Water Body Identifier (WID): The unique WID for each river reach comprised of the U.S. Geological Survey (USGS) eight-digit HUC plus a three-character code unique within each HUC. The term “WID” replaces the old identifier term Assessment Unit ID (AUID).

Watershed Pollutant Load Monitoring Network (WPLMN): A partnership including state and federal agencies, Metropolitan Council Environmental Services, state universities, and local partners, that collects data on water quality and flow in Minnesota. Since 2007, the network of partners has been collecting data to understand long-term trends and observe changes over time.

Yield (water, pollutant, crop, etc.): The amount of mass, volume, or depth per unit land area (e.g., lb/ac, in/ac).

Executive Summary

This Pomme de Terre River Watershed Restoration and Protection Strategy Report Update (WRAPS) caps 10 years of water quality monitoring, follow-up assessment, stressor identification (SID) and planning. It brings together the results, findings, and prioritization of important watershed documents including: Pomme de Terre River Comprehensive Watershed Management Plan (CWMP; PDTRA 2020), Pomme de Terre River Watershed Water Assessment and Trends Update (MPCA 2021), Pomme de Terre River Watershed Biotic SID Study (MPCA 2024a), and the Pomme de Terre River Watershed Total Maximum Daily Load (TMDL) Report (MPCA 2024b). While this document goes into some detail, for the most in-depth interpretations of the data it is recommended that the reader consult the source documents.

Watershed assessment of the Pomme de Terre River Watershed identified three new aquatic recreation (AQR) impairments and two new aquatic life (AQL) impairments on lakes, and eight new impairments on stream reaches. One stream segment, Pelican Creek in Grant County, previously listed as impaired was found to no longer have impaired macroinvertebrates communities.

Watershed-wide, the sum of TMDL reductions needed to meet water quality standards are 72,462 pounds (lbs) per year of total phosphorus (TP) (MPCA 2024b, MPCA 2015) and approximately 5,954 tons per year total suspended solids (TSS) (MPCA 2015). The *E, coli* TMDLs document a need for between 40% and 90% reductions for large portions of the watershed.

Some trends were seen between this assessment cycle and the previous one.

- For the lakes with long-term trends, 29% are seeing improvements in water quality as measured by water clarity and 62% are showing no change (MPCA 2021).
- Drywood Creek shows an increase in Index of Biotic Integrity (IBI) scores for both fish and macroinvertebrates over the last 10 years but not enough to delist the impairments (MPCA 2021).
- Monitoring at the Watershed Pollutant Load Monitoring Network (WPLMN) monitoring site in Appleton between 2008 and 2020 showed a statistically significant increase in nitrate-nitrogen [Long-term Stream Trends | Tableau Public].
- Flows in the Pomme de Terre River and its tributaries are increasing. Increasing streamflow has implications for stream channel conditions and pollutant loading including more channel erosion and possibly more pollutant loading, even if pollutant concentrations are stable (DNR 2023).
- At the Pomme de Terre River's outlet, high levels of TSS and TP showed no statistical change (MPCA 2021).

This document focused on the priority subwatersheds from the Pomme de Terre River Association's (PDTRA) CWMP that was developed via the One Watershed, One Plan (1W1P) process (PDTRA 2020). Subwatershed specific conditions are identified, and recommendations are offered. In each subwatershed a best management practice (BMP) scenario is included that would be able to achieve both the TMDL reduction goals and the State of Minnesota's Nutrient Reduction Strategy goals (MPCA 2022) goals for 2040.

Watershed-wide, the Watershed Pollutant Load Reduction Calculator estimates that both TP and TSS goals can be achieved through implementation of agricultural BMPs. These practices would cost an estimated $159 million over a 10-year period and require nearly complete engagement of the entire watershed.

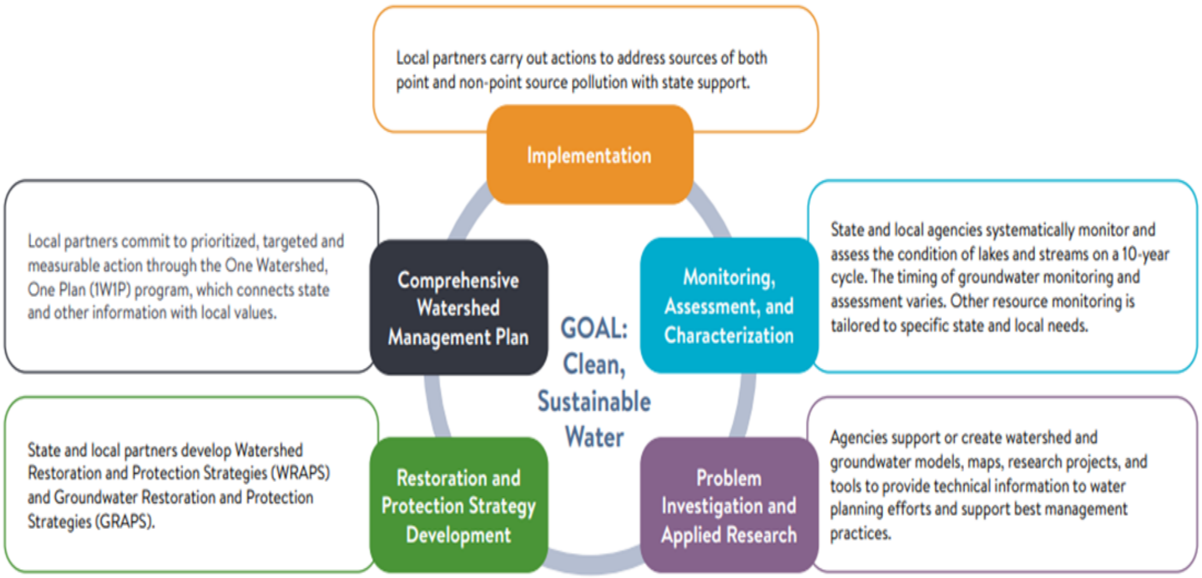
The NP-BMP tool indicates that the BMPs implemented could offer benefits gained from reduced fertilizer costs and reduced tillage resulting in an estimated annual cost savings of $6.03 million to farmers of the watershed.

1. Watershed Approach

Minnesota has adopted a watershed approach to address the state's 80 major watersheds. The Minnesota watershed approach incorporates **water quality assessment, watershed analysis, public participation, planning, implementation, and measurement of results** into a 10-year cycle that addresses both restoration and protection.

As part of the watershed approach, the Minnesota Pollution Control Agency (MPCA) develops WRAPS reports to identify and address threats to water quality in each of these major watersheds.

Figure 1. Minnesota's Watershed Approach.



The WRAPS Updates focus on both impaired and nonimpaired surface waters: impaired waters have strategies for restoration, and waters that are not impaired have strategies for protection. Waters not meeting state standards are listed as impaired, and TMDL studies are developed for them. The TMDLs are incorporated into the WRAPS Update. The initial WRAPS report for the Pomme de Terre River

Purpose	• Support local working groups and scientifically-supported restoration and protection strategies to be used for subsequent implementation planning •Summarize watershed approach •Compare and contrast Cycle I and Cycle II results in order to assess changes and progress towards Cycle I goals •Update estimated strategies necessary to restore or protect surface water quality within the watershed.
Scope	•Surface water resources •Impacts to aquatic recreation and to aquatic life in streams •Impacts to aquatic recreation in lakes
Audience	•Local working groups (local governments, SWCDs, watershed management groups, etc.) •State agencies (MPCA, DNR, BWSR, MDA, MDH, etc.)

Watershed was completed in 2013 (MPCA 2013). This WRAPS Update considered new water quality data, land use changes, and local planning efforts to further refine understanding of the Pomme de Terre River Watershed and guide implementation efforts.

In addition, the watershed approach process facilitates a more cost-effective and comprehensive characterization of multiple water bodies and overall watershed health, including both protection and restoration efforts. A key aspect of this effort is to develop and use watershed-scale models and other tools to identify strategies for addressing point and nonpoint source pollution that will cumulatively achieve water quality targets. For nonpoint source pollution, the WRAPS Update informs local planning efforts, but ultimately the local partners decide what work will be included in their local plans.

2. Watershed Background and Description

The Pomme de Terre River Watershed is an 875 square mile, predominately rural watershed. It is in west central Minnesota within the Minnesota River Basin. The northern portion of the watershed is in the Northern Central Forest Ecoregion and has proportionately more acres of perennial land cover types, while the central and southern portions are in the Northern Glaciated Plains Ecoregion and are noteworthy for the higher proportion of agricultural land cover (Figure 2 and Figure 10). The population of the watershed is roughly 15,000 people (U.S. Census Bureau 2020) and the watershed contains the towns of Morris and Appleton. Portions of six counties are within the watershed. Those counties are Otter Tail, Douglas, Grant, Stevens, Swift, and Big Stone. The watershed contains six hydrologic unit code (HUC)-10 subwatersheds, 73 stream reach WIDs, and 217 lakes (Minnesota Department of Natural Resources (DNR)-designated and greater than 10 acres).

A series of meetings were held in 2016 to identify State agency and local needs for water quality monitoring in the Pomme de Terre River Watershed. A hybrid monitoring plan was developed that used resources from both the MPCA and the PDTRA to sample streams and ditches in the Pomme de Terre River Watershed. The hybrid plan combined local and state monitoring interests.

This monitoring plan was different than the first cycle of the watershed approach. This second round of monitoring reduced the number of biological monitoring sites and relied more heavily on nonstate funds to sample water chemistry. These changes reflected both the reduced state budget for monitoring and assessment in the second cycle of the watershed approach and the engaged interest of local government units (LGUs).

The lake monitoring plan was developed simultaneously through the same process. The MPCA asked for a list of publicly accessible lakes to target for two years of monitoring to assess recreational use. A priority score was given by County and Soil and Water Conservation District (SWCD) representatives for each lake submitted. Lakes that already had sufficient, assessable data from the past 10 years were removed from the list. The MPCA then ranked the remaining lake requests based on public priority and size, and funded down the list until the budget was exhausted (Figure 3).

In 2017 and 2018, the MPCA and DNR staff sampled the lakes and streams for biology and/or chemistry (Figure 3). The PDTRA was contracted by the MPCA to sample chemistry on some of these lakes and streams. All data was submitted to MPCA experts for Quality Assurance and Quality Control (QA/QC). The data was used to assess the streams, ditches, and lakes over the winter of 2018-2019.

In May of 2019, the MPCA convened a Professional Judgment Group (PJG) made up of MPCA and DNR monitoring staff, SWCD staff, and County staff. The PJG met to review the assessment results of the data collected on the Pomme de Terre River and after review approved the list of impairments detailed in Section 3.1.

Figure 2. Pomme de Terre River Watershed.

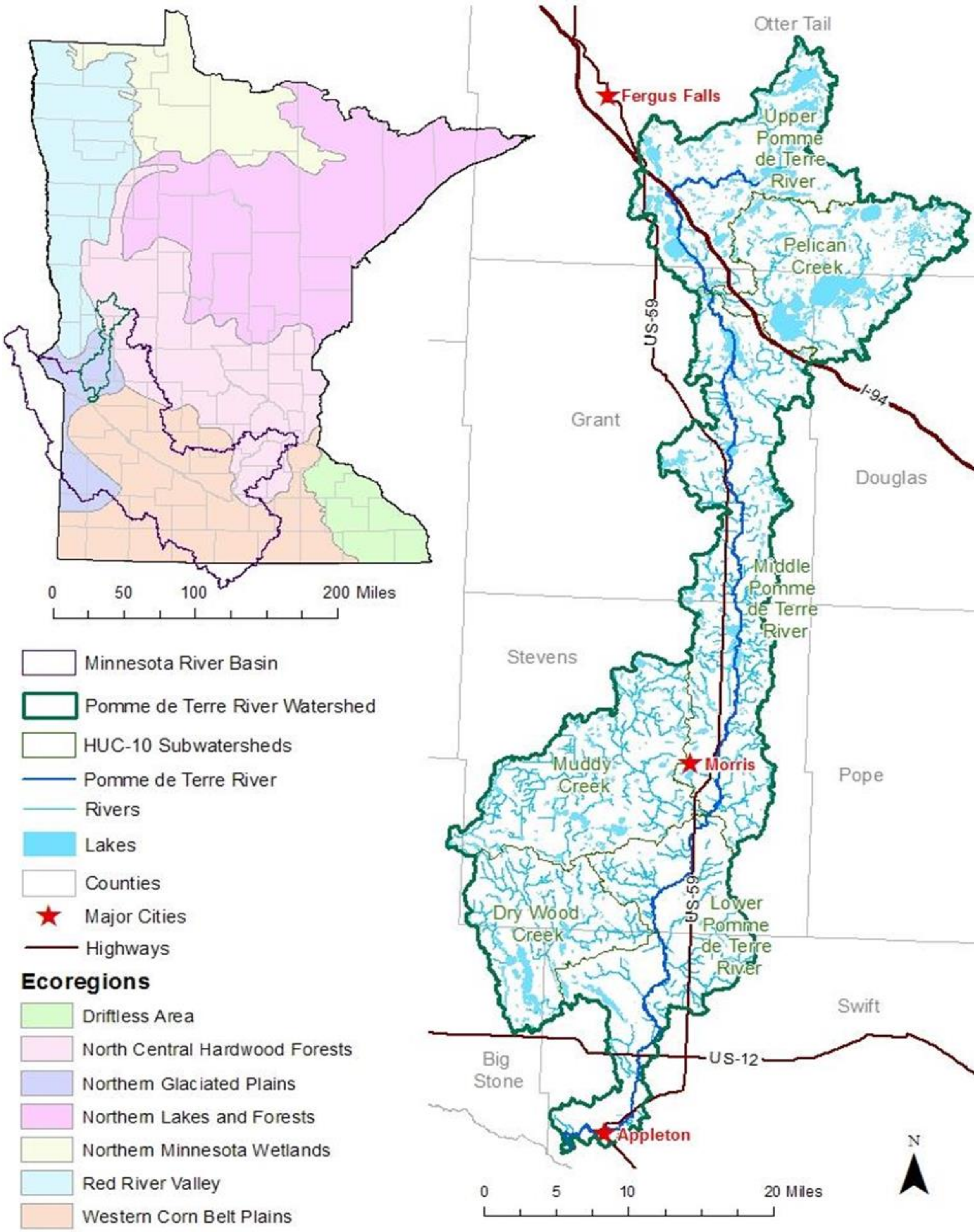
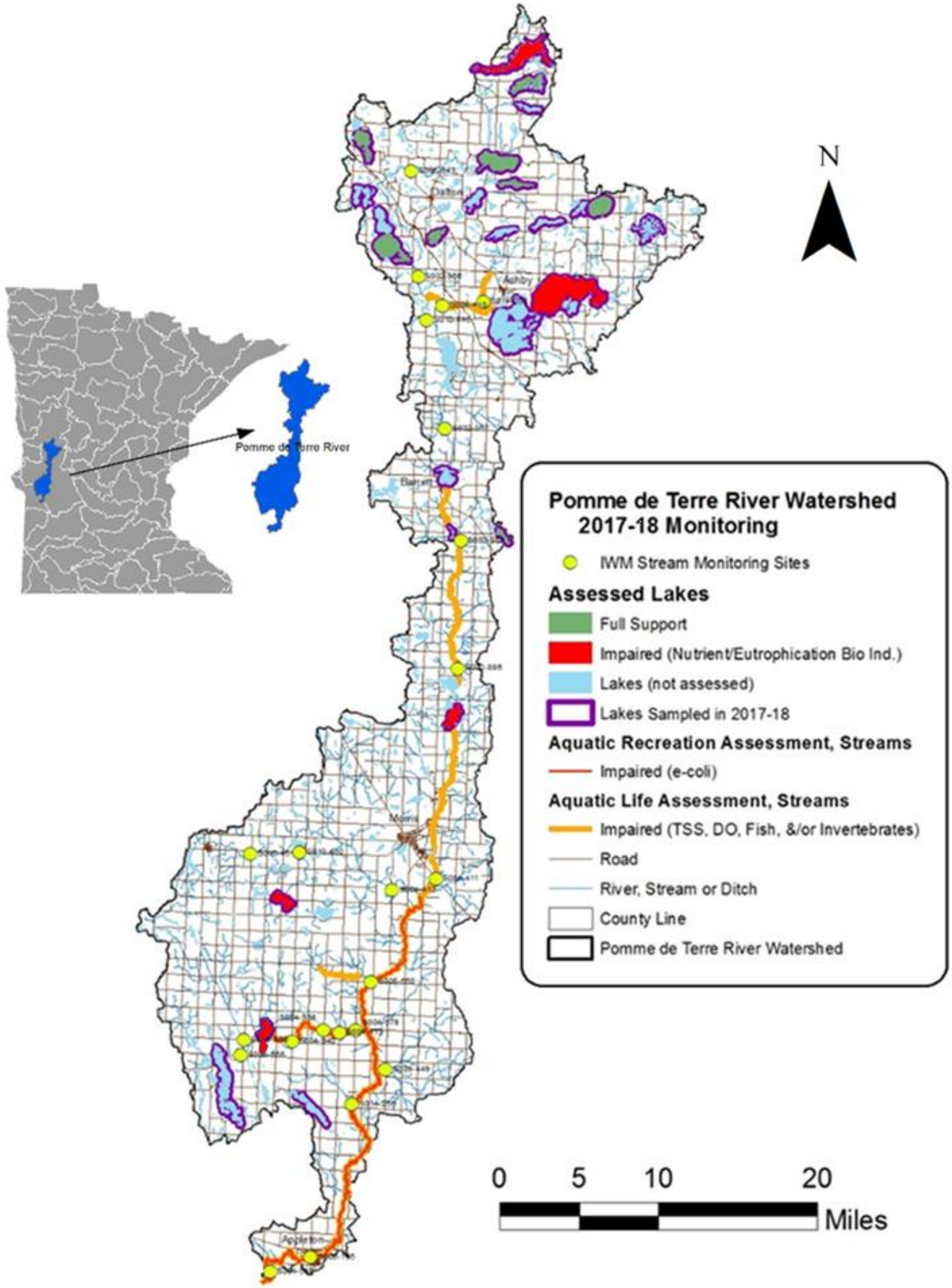


Figure 3. Pomme de Terre River Watershed monitoring sites and impaired waters.



As a part of the WRAPS Update public participation process, partners in the PDTRA conducted outreach to citizens of the watershed, farmers, lake property owners and residents of towns. This effort began with one-on-one surveys and transitioned to small meetings and gatherings of farmers around the theme of soil health. This process was seriously impacted by the Covid pandemic.

Due to the disruption caused by the pandemic, the Pomme de Terre River Watershed Water Assessment and Trends Update (MPCA 2021) was not completed until April of 2021. The assessment delay, flooding and record high stream flows in 2019, and pandemic related delays prevented completion of the Pomme de Terre River Watershed Biotic SID Study (MPCA 2024a) until the winter of 2024. The Pomme de Terre River Watershed TMDL Report was also finalized in 2024 (MPCA 2024b). Information from these reports was made available in draft form prior to their publication to the PDTRA to assist with PDT 1W1P efforts.

Concurrently with the WRAPS Update, between 2018 and 2020 the PDTRA and its partners completed the Pomme de Terre River CWMP. The plan identifies five priority areas where over a 10-year period specific BMPs are proposed to achieve specified reduction goals.

3. Watershed Conditions

This section summarizes the findings of the efforts that were undertaken by Minnesota state agencies and local partners to monitor, assess, and understand the conditions of the Pomme de Terre River Watershed. The goal is to provide a high-level overview of the efforts and reports produced. This document will cover surface waters assessed, identify the waters impaired, and briefly address hydrology, water quality, and permitted pollutant sources. In-depth discussions on these issues can be found in the referenced reports. Not all areas of the watershed are given an extensive write-up. The five priority focus areas identified in the PDTRA's CWMP were selected for more detailed focus and analysis in Section 4.

3.1 Watershed Assessment Status

Assessments of use-support in Minnesota are made for individual water bodies. The water body unit used for stream reaches, lakes, and wetlands is called a WID. Waters assessed as "impaired" should be considered for restoration efforts. Waters that are assessed as fully supporting or not listed as impaired should be considered for protection efforts. More on protection considerations is covered later in Section 3.

The assessment process combines data analysis, expert review, and internal and external partner input, and ensures that all available data and information are used to make appropriate assessment decisions,

Additional Pomme de Terre River Watershed resources

Minnesota River Basin Data Center is housed at the Water Resources Center at Minnesota State University, Mankato. Specific information about the Pomme de Terre River Watershed can be found at: Minnesota River Basin Data Center

Watershed Health Assessment Framework for the Pomme de Terre River Watershed: Watershed Context Report (state.mn.us)

MPCA Water Quality Assessment Results Data Viewer: Water Quality Assessment Results Data Viewer depending on which unique beneficial uses are considered. More detailed information about assessing the quality of Minnesota surface waters for determination of impairment can be found in this guidance manual.

The Pomme de Terre River Watershed straddles two River Nutrient Regions (South and Central) for River Eutrophication Standards and two River Regions for TSS standards (Figure 4). It additionally has two ecoregion-based eutrophication standards for Lakes (North Central Hardwood Forest and Northern Glaciated Plains). As a result, different water quality standards are applied to streams and lakes in the Pomme de Terre River Watershed depending on their geographic location.

Streams

The Pomme de Terre River Watershed has 73 stream reaches (WIDs). Of the 19 stream reaches with sufficient data for assessment, 13 reaches are impaired (Figure 5). Table 1 identifies the assessed stream reaches and details the impairments.

New impairments include seven stream reaches with impairments of biology (four reaches for fish and macroinvertebrates, and three additional reaches for fish), one reach impaired by nutrients, two reaches impaired by TSS, and three reaches impaired by bacteria.

Pelican Creek (506), previously listed as having been impaired for macroinvertebrates, was found to now meet the water quality standard (supporting). Communications with Grant SWCD suggest that habitat improvements to the stream via a livestock restriction practice may be supporting the delisting of this stream reach for macroinvertebrates.

Figure 4. Pomme de Terre River Watershed River TSS and River Nutrient Regions.

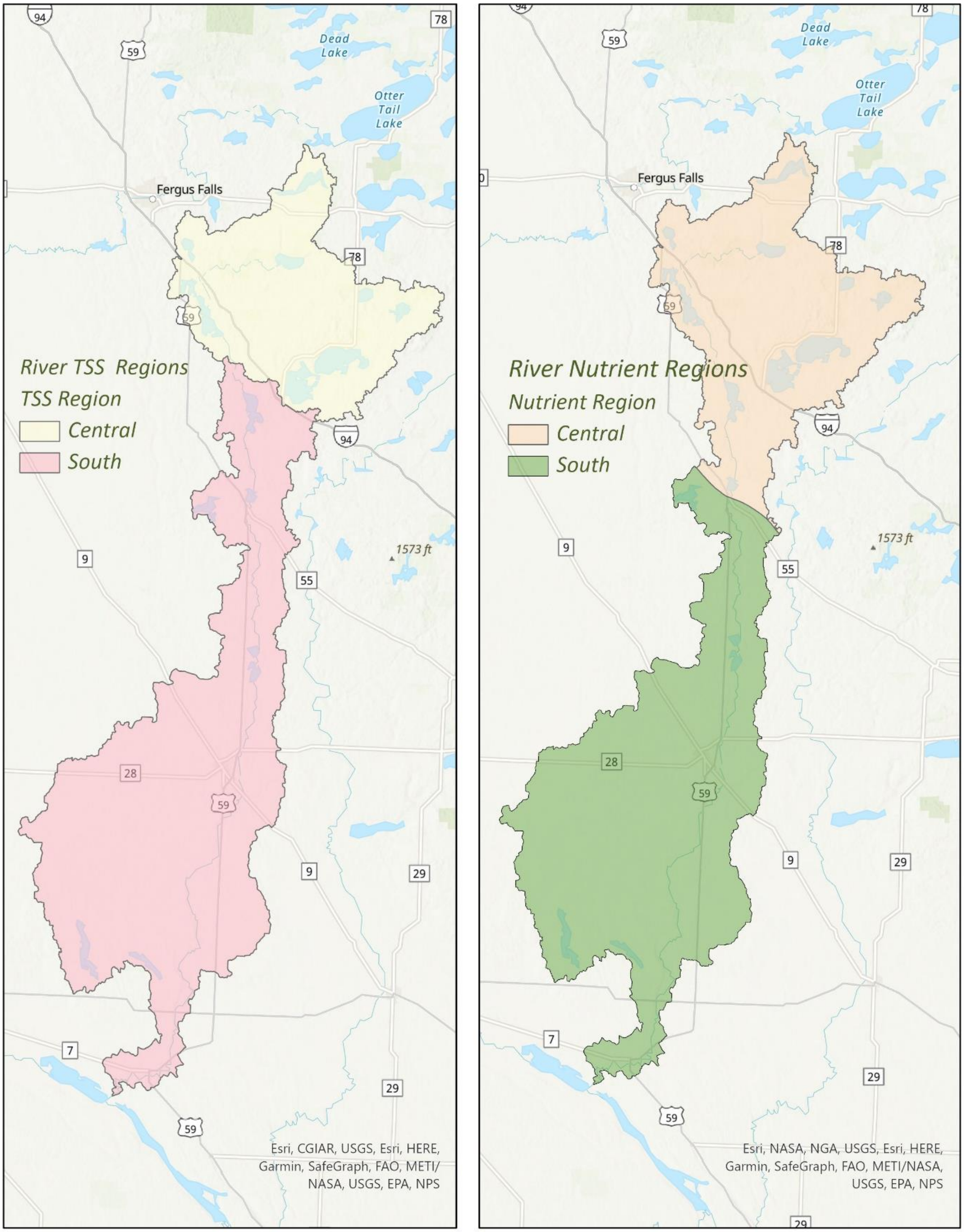


Figure 5. Assessment results for AQL and AQR on rivers, streams, and lakes (MPCA 2021).

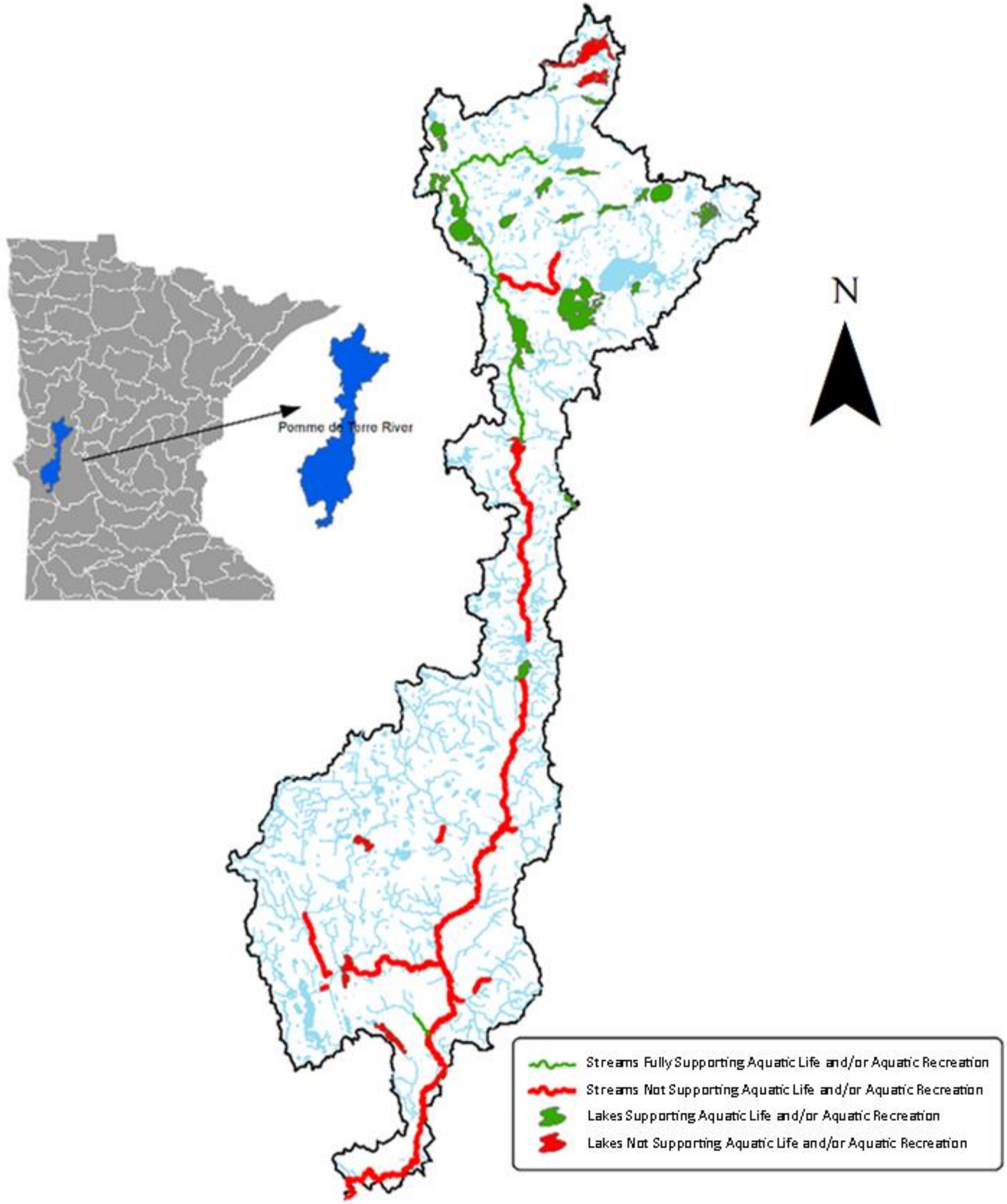


Table 1. Assessment status of stream reaches in the Pomme de Terre River Watershed, presented generally from north to south.

HUC-10 Subwatershed	WID (Last 3 digits)	River	Reach description	Aquatic life					Aquatic recreation
				Fish index of biotic integrity	Macroinvertebrate index of biotic integrity	Dissolved oxygen	Nutrients	Turbidity/TSS	Bacteria
Upper Pomme de Terre River	505	Pomme de Terre River	Tenmile Lake to Pelican Creek	Sup	NA	NA	NA	NA	NA
Upper Pomme de Terre River	514	Pomme de Terre River	Stalker Lake to Tenmile Lake	Sup	Sup	NA	NA	NA	NA
Pelican Creek	506	Pelican Creek	T130 R41W S4, north line to Pomme de Terre River	Imp*	Sup*	NA	NA	Imp*	Imp*
Middle Pomme de Terre River	504	Pomme de Terre River	Pomme de Terre River, Pelican Cr to Pomme de Terre Lake	Sup	Sup	NA	NA	NA	NA
Middle Pomme de Terre River	540	Unnamed creek	Unnamed creek to Pomme de Terre River	Imp*	Imp*	NA	NA	NA	NA
Middle Pomme de Terre River	562	Pomme de Terre River	Perkins Lake to Muddy Creek	Imp	Sup	IF	NA	Sup	Sup
Middle Pomme de Terre River	563	Pomme de Terre River	Barrett Lake to North Pomme de Terre Lake	Imp	NA	NA	NA	Sup	Sup
Middle Pomme de Terre River	565	Pomme de Terre River	Pomme de Terre Lake to Barrett Lake	Sup	Sup	Sup	Sup	Sup	Sup
Muddy Creek	511	Muddy Creek	T124 R44W S3, west line to Pomme de Terre River	NA	NA	NA	NA	NA	Imp*
Muddy Creek	576	Unnamed creek	Unnamed creek to -95.964 45.545	Imp*	NA	NA	NA	NA	NA
Dry Wood Creek	515	County Ditch 22	Unnamed ditch to Unnamed creek	Imp*	NA	NA	NA	NA	NA
Dry Wood Creek	534	Unnamed creek	Unnamed creek to Unnamed creek	Imp*	Imp*	IF	NA	NA	NA
Dry Wood Creek	556	Dry Wood Creek	Dry Wood Lake to Pomme de Terre River	Imp	Imp	Imp	NA	Imp	Imp

HUC-10 Subwatershed	WID (Last 3 digits)	River	Reach description	Aquatic life					Aquatic recreation
				Fish index of biotic integrity	Macroinvertebrate index of biotic integrity	Dissolved oxygen	Nutrients	Turbidity/TSS	Bacteria
Dry Wood Creek	566	Unnamed creek	Unnamed creek to Artichoke Creek	NA	NA	NA	Imp*	NA	NA
Lower Pomme de Terre River	545	Unnamed creek	Unnamed creek to Pomme de Terre River	Sup	IF	IF	NA	NA	NA
Lower Pomme de Terre River	547	Unnamed creek	Unnamed creek to Pomme de Terre River	Imp*	Imp*	NA	NA	IF	Imp*
Lower Pomme de Terre River	549	Judicial Ditch 2	Judicial Ditch 63 to Unnamed creek	Imp*	Imp*	NA	NA	NA	NA
Lower Pomme de Terre River	551	Unnamed creek	Unnamed creek to Unnamed creek	Imp	NA	NA	NA	NA	NA
Lower Pomme de Terre River	501	Pomme de Terre River	Pomme de Terre River, Muddy Creek to Minnesota River (Marsh Lake)	Imp	Imp	NA	IF	NA	Imp

*=new condition, Sup = supporting, found to meet the water quality standard (green), Imp = impaired, does not meet the water quality standard (red) IF = the data collected was insufficient to make a finding or within the confidence interval (yellow) NA = not assessed (white)

Some water bodies in the Pomme de Terre River Watershed are impaired by mercury; however, this WRAPS Update does not cover toxic pollutants. Toxic pollutants are managed via other MPCA programs and/or methods. For more information on mercury impairments, see the Statewide Mercury TMDL on the MPCA website.

Lakes

Forty-four lakes in the Pomme de Terre River Watershed had sufficient data to assess for AQR use (Table 2). Assessment confirmed the three previous AQR impairments (Hattie, Perkins, North Turtle) and three new AQR impairments (North Drywood, South Drywood, Barrett) (MPCA 2021). 21 lakes supported AQR. In general, lakes in the headwaters and those with less anthropogenic influence (i.e., more forest and prairie within their watershed) were meeting standards. Many of those lakes were also deep (over 15 feet). Lakes with intensively developed (i.e., urban or agricultural) watersheds, flow through lakes, and shallow lakes were more likely to be impaired. Internal loading (the recycling of phosphorus within a lake) will be an issue that will have to be addressed, in addition to controlling watershed inputs of nutrients to shallow lakes in the watershed.

Aquatic life use assessments based on the fish community were conducted on 17 lakes in the Pomme de Terre River Watershed by the DNR (DNR 2023). Three lakes, Oliver (East and West) and South Turtle were found to have impaired fish communities (Table 2), while 12 lakes supported AQL. Stressors identified that could be influencing those communities are degraded/developed shorelines and agricultural land use within the watershed.

More information is available regarding the parameters and methods used in assessing the AQR and the AQL based standards for streams, ditches and lakes in the 2024 Guidance manual for assessing the quality of Minnesota surface waters for determination of impairment: 305(b) Report and 303(d) List. Pomme de Terre River Watershed Lakes can be located using the WID number at MPCA Surface Water Data Access (Surface Water (state.mn.us)).

Table 2. Assessment status of lakes in the Pomme de Terre River Watershed presented generally from north to south.

Lake ID	Lake Name	Aquatic recreation	Aquatic life
06-0002-00	Artichoke	IC	Sup*
21-0355-00	Ina	Sup	IF
26-0002-00	Pelican	IC	Sup*
26-0040-00	Elk	Sup	Sup*
26-0043-02	Unnamed (west portion)	IF	IF
26-0095-00	Barrett	Imp*	Sup*
26-0097-00	Pomme de Terre	IC	Sup*
26-0111-00	Patchen	IF	IF
26-0117-00	Cormorant	IF	NA
56-0160-00	Spitzer	Sup	IF
56-0251-00	Torgerson	Sup	NA
56-0252-00	Middle	Sup	IF
56-0253-00	Eagle	Sup	Sup*
56-0370-00	Jolly Ann	Sup	Sup*
56-0377-00	South Turtle	Sup	Imp*
56-0379-00	North Turtle	Imp	IF
56-0390-00	Long	Sup	NA
56-0393-00	Johnson	Sup	IC
56-0408-00	Sewell	Sup	Sup*
56-0423-00	German	Sup	NA
56-0430-00	Fiske	Sup	IF
56-0437-00	Stalker	Sup	Sup*
56-0559-00	Clear	Sup	IC
56-0589-00	Mineral	IC	IF
56-0604-00	North Ten Mile	Sup	IF
56-0613-00	Ten Mile	Sup	Sup*

Lake ID	Lake Name	Aquatic recreation	Aquatic life
56-0615-00	Hansel	Sup	NA
56-0630-00	Unnamed	IF	IF
56-0639-00	Indian	Sup	NA
56-0651-00	Larson	Sup	NA
56-0780-00	Chautauqua	IC	NA
56-0781-00	Swan	Sup	Sup*
75-0061-00	North Pomme de Terre	IC	NA
75-0074-00	Middle Pomme de Terre	IC	NA
75-0075-00	Perkins	Imp	Sup*
75-0097-00	Crystal	IC	NA
75-0164-00	Silver	IF	IF
75-0200-00	Hattie	Imp	NA
75-0205-00	Unnamed	IF	IF
76-0146-01	Oliver (east portion)	IC	Imp*
76-0146-02	Oliver (west portion)	IF	Imp*
76-0149-00	South Drywood	Imp*	NA
76-0166-00	Unnamed	IF	IF
76-0169-00	North Drywood	Imp*	NA

*=new condition, Imp = impaired, Sup = fully supporting, IF = insufficient data to make an assessment, IC = inconclusive, NA = Not Assessed

3.2 TMDL Summary

The Clean Water Act (1972) requires that each state develop a study to identify and restore any water body that is deemed impaired by state regulations. A TMDL study, as required by the U.S. Environmental Protection Agency (EPA), identifies the pollutant that is causing the impairment and how much of that pollutant can enter the water body and still meet water quality standards.

The Pomme de Terre River Watershed TMDL Report 2024 (MPCA 2024b) addressed TP, TSS, and bacteria in the form of *Escherichia coli* (*E. coli*) impairments in three lakes (Barrett Lake, North Drywood Lake, and South Drywood Lake) and four streams (Pelican Creek, Muddy Creek, Unnamed Creek, and Unnamed Creek) located in the Pomme de Terre River Watershed (Table 3). More information including pollutant sources and reductions needed to attain water quality standards can be found in the in the Pomme de Terre River Watershed TMDL Report (MPCA 2024b) and in the appendix of this report.

The Pomme de Terre River Watershed TMDL Report 2015 (MPCA 2015) addressed one turbidity impairment, one E. coli impairment and one dissolved oxygen impairment on Drywood Creek, one dissolved oxygen stressor on the Pomme de Terre River, and four lake eutrophication impairments (Christina, Hattie, North Turtle and Perkins Lakes) in the Pomme de Terre River Watershed. The 2011 Turbidity TMDL Assessment for the Pomme de Terre River (MPCA 2011b) addressed a turbidity impairment on the Pomme de Terre River, from Muddy Creek to Marsh Lake. The Pomme de Terre River

Fecal Coliform TMDL Project (MPCA 2007) addressed a bacteria impairment on the Pomme de Terre River, from Muddy Creek to Marsh Lake.

Table 3. AQL and AQR use impairments in the Pomme de Terre River Watershed (07020002) addressed in the Pomme de Terre River Watershed TMDL Report (MPCA 2024b).

***Affected Use*: Pollutant/ Stressor**	**DNR Lake ID/ WID**	**Impaired Water Body**	**Location/Reach Description**	**Designated Use Class**	**Listing Year**	**Impairment Addressed by:**
Aquatic Recreation: Eutrophication	26-0095-00	Barrett Lake	At Barrett	2B, 3C	2020	TP TMDL
	76-0149-00	South Drywood Lake	Near Correll	2B, 3C	2020	TP TMDL
	76-0169-00	North Drywood Lake	Near Correll	2B, 3C	2020	TP TMDL
	07020002-566	Unnamed Creek	Unnamed creek to Artichoke Creek	2Bg, 3C	2020	TP TMDL
Aquatic Recreation: *E. coli*	07020002-506	Pelican Creek	(T130 R41W S4, north line to Pomme de Terre R)	2Bg, 3C	2020	*E. coli* TMDL
	07020002-511	Muddy Creek	(T124 R44W S3, west line to Pomme de Terre R)	7	2020	*E. coli* TMDL
	07020002-547	Unnamed Creek (Judicial Ditch 2)	Unnamed creek to Pomme de Terre River	2Bg, 3C	2022	*E. coli* TMDL
Aquatic Life: TSS	07020002-506	Pelican Creek	(T130 R41W S4, north line to Pomme de Terre R)	2Bg, 3C	2020	TSS TMDL
	07020002-547	Unnamed Creek (Judicial Ditch 2)	Unnamed creek to Pomme de Terre River	2Bg, 3C	2024	TSS TMDL

3.3 Stressor Identification

Biological SID is conducted for river reaches with either fish or macroinvertebrate biota impairments and encompasses the evaluation of both pollutant (e.g., TSS, chloride) and nonpollutant-related factors (e.g., altered hydrology, fish passage, habitat) as potential stressors. Pollutant source assessments are completed where a SID process identifies a pollutant as a stressor, as well as for the typical pollutant impairment listings.

Stressors of Biologically Impaired River Reaches (MPCA 2024a)

The overall health of the fish and macroinvertebrate communities in the Pomme de Terre River Watershed did not significantly change from 2007 to 2017-2018.

Twelve stream reaches were investigated to determine the stressors causing 18 IBI impairments in the Pomme de Terre River Watershed (Table 4, Figure 6). The stressors originally identified in Cycle 1 (MPCA 2012) continue to stress the biology in the watershed. Stressors include low dissolved oxygen (DO), eutrophication, nitrogen, TSS, habitat, altered hydrology, and connectivity.

Much of the watershed is low gradient with surrounding wetlands, making it natural to see low DO stressing the biology. However, the amount of eutrophication in stream reaches is concerning and not part of the natural cycle. A survey of wetlands in the watershed showed the majority had large changes to the plant communities, which indicates the wetlands are also not at optimum health.

Poor stream habitat is a stressor in almost all of the impaired reaches in the watershed. Stream habitat is closely connected to TSS, eutrophication, and altered hydrology which are also major stressors in the watershed. The DNR found unexpected sedimentation below Drywood Lake, and DNR wetland biologists found unexpected sediment below the Morris Dam. Decreasing stream erosion and nutrient inputs to the watershed are important to improving water quality and biological communities.

The northern two-thirds of the watershed, upstream of Muddy Creek, support healthy stream macroinvertebrate communities based on 2017 and 2018 monitoring. The northern one-third of the watershed, upstream of Barrett, supports healthy stream fish communities based on 2017 and 2018 monitoring. The one exception to this pattern is Pelican Creek.

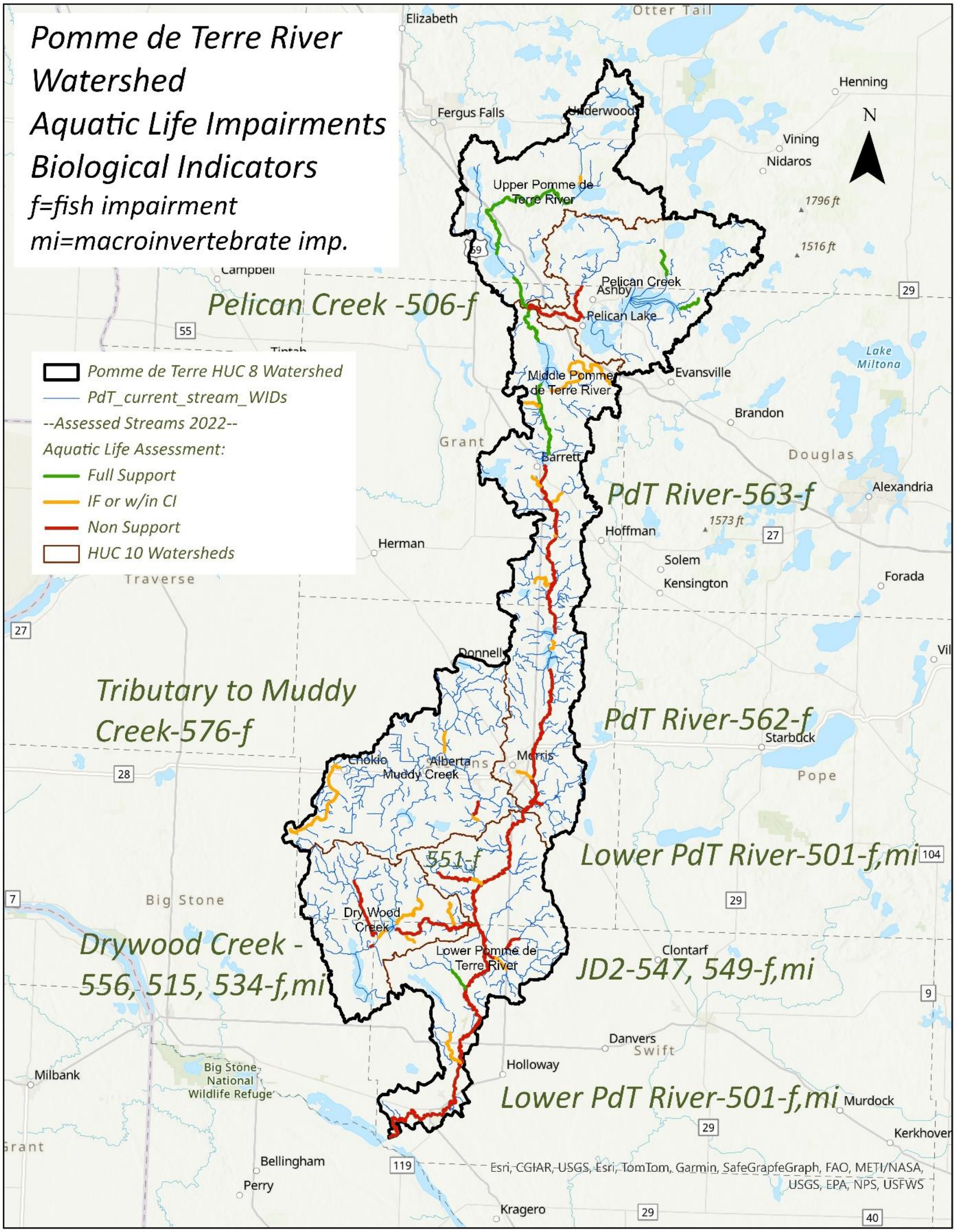
Further detail on specific stressors and the sites analyzed can be found in the 2024 Pomme de Terre River Watershed Stressor Identification Update (MPCA 2024a) report. This report can be found on the [MPCA Pomme de Terre River Watershed webpage](#).

Table 4. Primary stressors to aquatic life in biologically impaired reaches in the Pomme de Terre River Watershed (MPCA 2024a).

Stream Name	AUID	Aquatic Life Impairment	Stressors: Dissolved Oxygen	Eutrophication	Nitrate	Suspended Solids	Habitat	Altered Hydrology	Connectivity
Cycle 2 SID									
Pelican Creek	07020002-506	Fish	---	o	---	o	●	---	●
Pomme de Terre River	07020002-563	Fish	●	o	---	●	●	●	●
Pomme de Terre River	07020002-562	Fish	o	o	---	---	●	●	---
Unnamed Creek	07020002-540	Fish, Macroinvertebrates	o	o	---	o	●	●	---
Drywood Creek	07020002-556	Fish, Macroinvertebrates	●	●	●	●	●	●	●
Unnamed Creek	07020002-515	Fish, Macroinvertebrates	●	●	o	o	●	●	---
Unnamed Creek	07020002-534	Fish, Macroinvertebrates	●	o	o	o	●	●	---
Unnamed Creek	07020002-576	Fish	---	o	o	o	●	●	---
Pomme de Terre River	07020002-501	Fish, Macroinvertebrates	---	●	---	●	●	●	---
Unnamed Creek	07020002-547	Fish, Macroinvertebrates	o	●	●	●	●	●	---
Judicial Ditch 2	07020002-549	Fish, Macroinvertebrates	●	●	---	o	●	●	---
Cycle 1 SID									
Unnamed Creek	07020002-551	Fish	N/A	N/A	●	N/A	---	●	N/A

(● = stressor, o = inconclusive stressor, --- = not a stressor)

Figure 6. Biologically impaired river reaches (MPCA 2024a).



Pelican Creek SID:

Pelican Creek (07020002-506) is one of the main northern tributaries to the Pomme de Terre River and is designated as impaired for AQL use due to the poor fish community condition. The fish community was sampled in 2007 and 2017 at site 07MN001 and additionally at site 17MN004 in 2017 and 2018. Fish scores were highest in the lower part of the reach with IBI scores ranging from 57 to 62 at site 07MN001 and 0 to 40 at site 17MN004. Only four fish were collected in 2017. More fish and more species were present in 2017 at site 07MN001, but the score was lowered by more tolerant taxa, less sensitive taxa, and more short-lived individuals in 2017.

Cycle 2 monitoring on Pelican Creek (07020002-506) has led to delisting the previous macroinvertebrate impairment, as the stream reach now meets standards for macroinvertebrates. The original assessment in 2007 found the stream to be below the impairment threshold. 2017 sample scores ended up being at the impairment threshold. Considering the proximity of these scores to the impairment threshold as well as the relatively high flows under which these samples were collected in 2017, additional monitoring of both stations (07MN001, 17MN004) was requested and approved for the summer of 2020. Samples collected in 2020 were under normal flow conditions and found that this stream WID is supporting a healthy aquatic macroinvertebrate community.

The main stressors to the fish community in Pelican Creek were identified as: connectivity, with three migration barriers, lack of habitat in the lower part of the creek, and water chemistry (DO, eutrophication, and TSS).

The MPCA wetland biologists found plants in the fresh meadow wetland community surrounding site 17MN004 to be high quality. This area should be a priority for protection.

Drywood Creek SID:

Drywood Creek is one of the main southern tributaries to the Pomme de Terre River. The lower part of Drywood Creek (07020002-556) is a 10.12-mile reach that has impaired AQL based on both the fish and macroinvertebrate communities scoring poorly. Reaches 07020002-515 and 07020002-534 are unnamed creeks that are tributaries to Drywood Creek. They are also designated as impaired for both biological communities.

Additional biological and water chemistry testing during the second assessment cycle throughout Drywood Creek confirmed the stressors identified in Cycle 1.

The main stressors to the fish community in Drywood Creek were found to be low DO, eutrophication, nitrate, lack of habitat, high TSS, and altered hydrology.

A constructed riffle downstream of station 08MN087 is acting as a fish barrier to the most upstream station (08MN087). Connectivity is still a stressor to Drywood Creek but there is no longer a fish migration barrier upstream of station 07MN022.

Stressors of Biologically Impaired Lakes (DNR 2023)

The approach used by the DNR to identify biological impairments in lakes includes the assessment of fish communities present in lakes throughout a major watershed. The fish-based lake index of biological integrity (FIBI) utilizes fish community data collected from a combination of trap nets, gill nets, beach seines, and backpack electrofishing. From this data, an FIBI score can be calculated for each lake that provides a measure of overall fish community health based on species diversity and composition. The DNR has developed four FIBI tools to assess different types of lakes throughout the state (Bacigalupi et al. 2021). More information on the FIBI tools and assessments based on the FIBI can be found at DNR Lake IBI.

Between 2014 and 2018, 17 lakes in the Pomme de Terre River Watershed were sampled and assessed using the FIBI to evaluate biological health (Table 5, Figure 7 (DNR 2023)). Of the lakes that were sampled, three were assessed as not supporting AQL use (East Oliver, West Oliver and South Turtle) based on FIBI scores that were below the impairment threshold established for similar lakes. Three additional lakes were considered vulnerable to future impairment based on FIBI scores near the impairment threshold (Johnson, Sewell, and Clear).

After examining many potential candidate causes for the biological impairments, eutrophication was identified as the only probable causes of stress to AQL within the Pomme de Terre River Watershed (Table 6). Despite this, inconclusive causes could simultaneously and cumulatively be affecting its fish community. Physical habitat alterations, altered intraspecific competition, and pesticide application are all identified as inconclusive stressors to the watershed.

Table 5. Summary of lakes in the Pomme de Terre River Watershed assessed with FIBI tools (DNR 2023)

DOW	Lake name	County	Nearshore survey year(s)	DNR GIS acres	FIBI tool	% littoral[1]	FIBI score(s)	Below impairment threshold	Assessment status[2]
26-0002-00	Pelican	Grant	2017	3,761	7	80	47	No	FS
26-0040-00	Elk	Grant	2015, 2015	207	5	53	37, 45	No	FS
26-0095-00	Barrett	Grant	2017	530	7	80	51	No	FS
26-0097-00	Pomme de Terre	Grant	2017	1,816	7	89	41	No	FS
56-0160-00	Spitzer	Otter Tail	2007	731	5	86	30	No	IF (old data)
56-0253-00	Eagle	Otter Tail	2014, 2018	907	2	19	43, 55	Yes, No	FS
56-0370-00	Jolly Ann	Otter Tail	2018	326	2	40	52	No	FS
56-0377-00	South Turtle	Otter Tail	2017, 2018	837	2	48	35, 43	Yes, Yes	NS
56-0393-00	Johnson	Otter Tail	2015, 2018	419	4	39	37, 39	Yes, No	IC-Vuln
56-0408-00	Sewell	Otter Tail	2018	369	2	46	45	No	FS-Vuln
56-0437-00	Stalker	Otter Tail	2014, 2018, 2018	1,357	2	45	60, 46, 55	No, No, No	FS
56-0559-00	Clear	Otter Tail	2019	399	4	39	39	Yes, Yes, No	IC-Vuln
56-0613-00	Ten Mile	Otter Tail	2018	1,428	2	42	60	No	FS
56-0781-00	Swan	Otter Tail	2019	749	2	54	52	Yes, No	FS
75-0075-00	Perkins	Stevens	2017	516	7	99	45	No	FS
76-0146-00	Oliver	Swift	2017	671	5	44	16	Yes	NS
≤ lower CL (red)	> lower CL & ≤ threshold (orange)			> threshold & ≤ upper CL (green)				> upper CL (blue)	Insufficient Info (gray)

[1] % littoral is the percentage of the lake that is less than 15 feet deep calculated using DNR GIS data.
[2] "FS" indicates fully supporting AQL use, "IF" indicates insufficient information, "NS" indicates not supporting AQL use, and "Vuln" indicates vulnerable to future impairment.

Table 6 presents a summary of the stressors associated with the biologically impaired and vulnerable lakes in the Pomme de Terre River Watershed. Eutrophication is adversely affecting the fish communities in Oliver, Johnson, Sewell, and Clear lakes. Many of these lakes contain relatively high levels of nutrients such as TP (i.e., greater than approximately 30 parts per billion (ppb)) and are located in watersheds with high land use disturbance (i.e., greater than 40%). Other biologically impaired lakes in the Pomme de Terre River Watershed are located in watersheds with relatively high land use disturbance, but eutrophication has been listed an inconclusive cause because nutrient levels are relatively low, although this may not have been the case historically.

Table 6. Summary of stressors associated with the biologically impaired and vulnerable lakes in the Pomme de Terre River Watershed (DNR 2023).

		Candidate causes[1]			
Lake Name	**DOW**	**Eutrophication (excess nutrients)**	**Physical habitat alteration**	**Altered interspecific competition**	**Pesticide Application**
South Turtle	**56-0377-00**	0	0	-	0
Oliver	**76-0146-00**	+	0	0	0
Johnson	**56-0393-00**	+	-	-	0
Sewell	**56-0408-00**	+	0	0	0
Clear	**56-0559-00**	+	-	-	0

[1] "+" supports the case for the candidate cause as a stressor, "-" refutes the case for the candidate cause as a stressor, "0" indicates that evidence is inconclusive as to whether the candidate cause is a stressor.

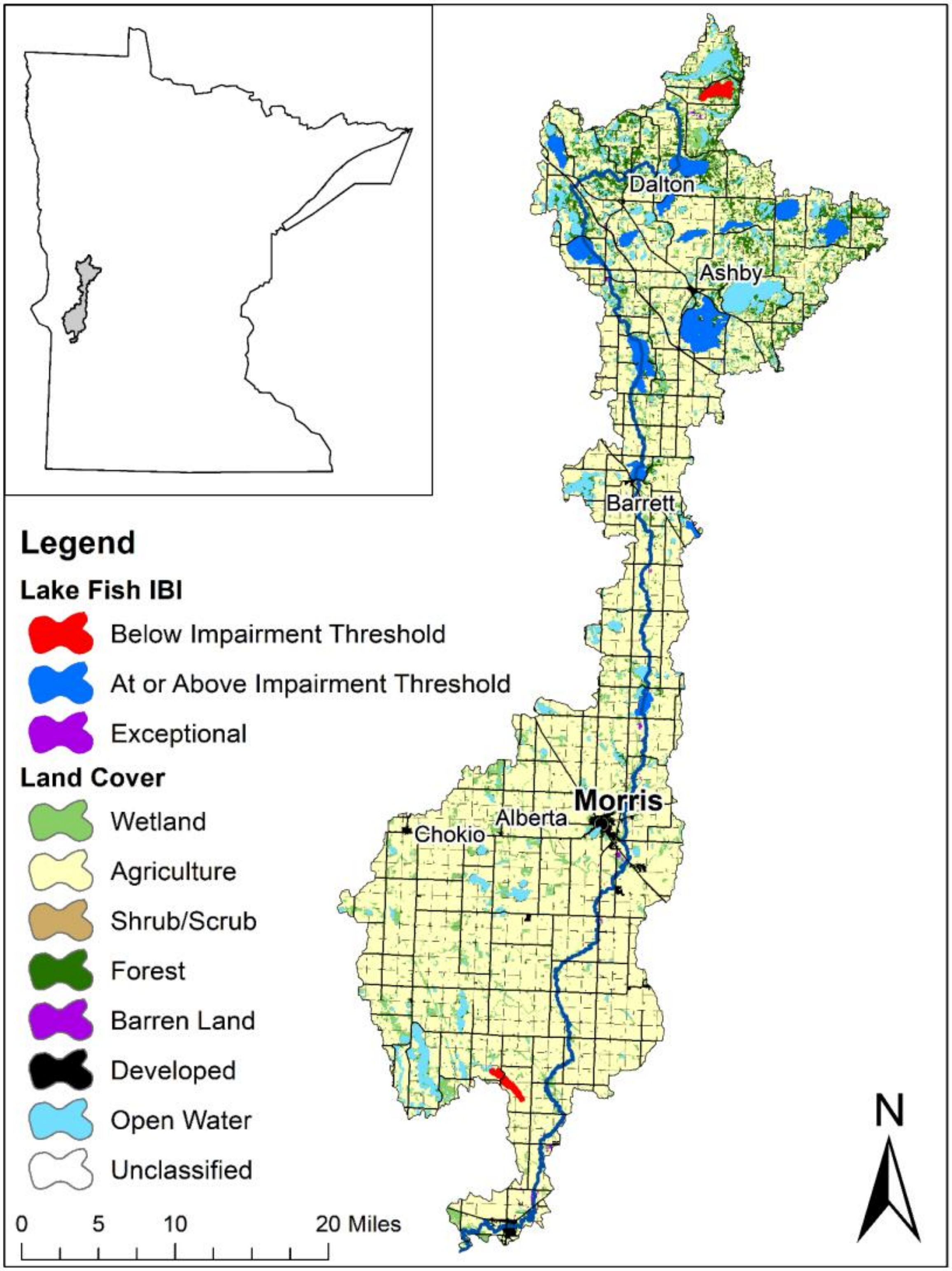
The DNR Lakes SID Report (DNR 2023) notes that physical habitat alterations are adversely affecting the fish communities in South Turtle, Oliver, and Sewell lakes and are listed as inconclusive stressors to fish communities. While shoreline development on these lakes is relatively low, several of these lakes are in watersheds with connectivity concerns, such as culverts or crossings that potentially restrict fish passage. This lack of connectivity could be limiting species richness and ultimately have a negative influence on the lake's FIBI scores.

Altered interspecific competition was determined to be an inconclusive cause for all lakes (i.e., Oliver and Sewell) that contained non-native species that have the potential to affect fish communities (e.g., Common Carp). These lakes contained relatively low densities of non-native species in recent surveys or lacked data regarding densities.

Pesticide application was also determined to be an inconclusive cause for all lakes, largely due to a lack of monitoring data and a lack of direct evidence that pesticides are a source of impairment. Results from National Lake Assessment monitoring in Minnesota indicate that the number of detected pesticides and total pesticide concentration in lakes is positively related to percent of watershed in cropland (MDA 2019), and a high proportion of each impaired or vulnerable lake's contributing watershed is cultivated. As of 2024, there are no pesticide impairments within the Pomme de Terre River Watershed (2024 Minnesota Impaired Waters List). However, there are currently no pesticide surface water monitoring sites within the watershed. While regional data is not sufficient to determine potential impacts to AQL in the Pomme de Terre River Watershed, detections of the insecticides clothianidin and imidacloprid in surrounding watersheds suggest they may be present Surface Water Pesticide Water Quality Monitoring | Minnesota Department of Agriculture (state.mn.us).

No candidate causes were identified for South Turtle Lake. Despite this, several inconclusive causes could simultaneously and cumulatively be affecting its fish community. Other uncommon stressors that were not evaluated in this report, in addition to stressors that may have occurred in the past but are not presently occurring, could also be affecting the fish communities in these lakes.

Figure 7. Pomme de Terre River Watershed land cover classes with lakes sampled and assessed with FIBI protocols (DNR 2023).



3.4 Water Quality Trends

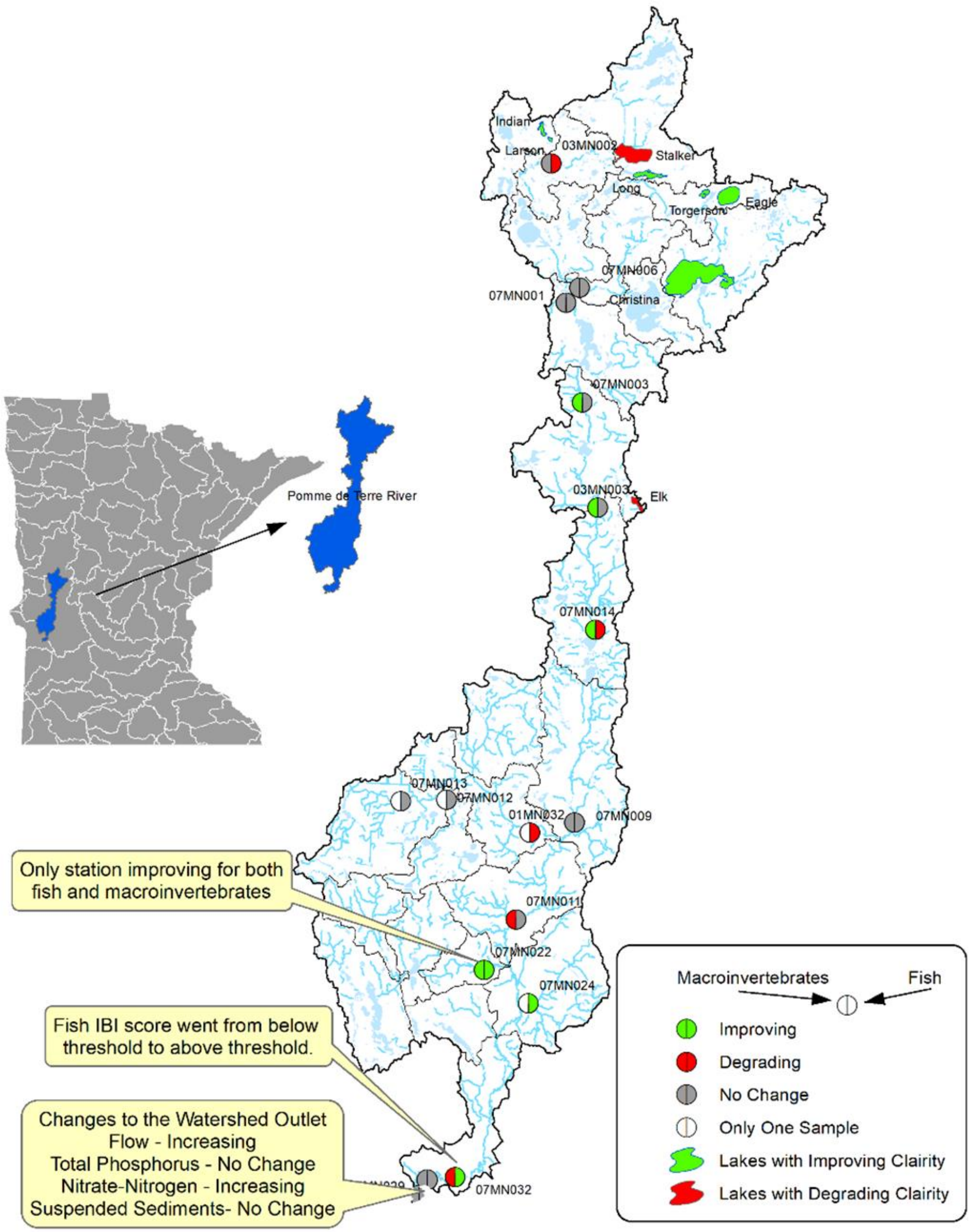
The MPCA's 2021 report "Watershed Assessment and Trends Update, Pomme de Terre River Watershed" (MPCA 2021) noted that while some individual streams in the watershed improved or declined in biological condition between 2007 and 2017, the overall health of fish and macroinvertebrate communities in the watershed did not change over this time period (Figure 8). The report stated that enduring problems include high levels of TP, elevated bacteria, excess TSS, low DO levels and rising nitrogen levels in stream reaches and high TP in a number of lakes. (MPCA 2021).

Further observations and trends in the Pomme de Terre River Watershed include (MPCA 2021):

- For lakes with long-term trends, 29% are seeing improvements in water quality and 62% are showing no change.
- Drywood Creek shows an increase in IBI scores for both fish and macroinvertebrates over the last 10 years.
- Flows in the Pomme de Terre River and its tributaries are increasing because of both artificial drainage and increased precipitation. Increasing streamflow has implications for stream channel conditions and pollutant loading. Increased flow leads to more channel erosion and possibly more pollutant loading, even if pollutant concentrations are stable.
- The nitrate-nitrogen concentration is slowly increasing in the Pomme de Terre River at Appleton Long-term Stream Trends | Tableau Public.

Landowners within the Pomme de Terre River Watershed installed hundreds of BMPs to improve water quality during the assessment period (2007 through 2017), but many more are needed across the watershed. In addition, it takes time for these practices to show an impact (MPCADS).

Figure 8. Change in water quality in the Pomme de Terre River Watershed (MPCA 2021).



3.5 Land Use and Climate

Land Use

The condition of the Pomme de Terre River is influenced in part by the land uses of the watershed (Figure 9). Land use can drive different water quality benefits and concerns. The dominant land uses tend to influence overall watershed responses to natural factors like rainfall and evaporation. Regional differences within the Pomme de Terre River Watershed shape the different conditions observed (DNR 2023).

The subwatersheds of the Pomme de Terre River Watershed have few, and in some cases, no towns, and the primary human impact through land use is agricultural. For example, Drywood Creek, a heavily impaired subwatershed in the southern part of the Pomme de Terre River Watershed, has no towns and a small population, but is highly agricultural (2021 census).

Figure 9. Land use distribution of the Pomme de Terre River Watershed.

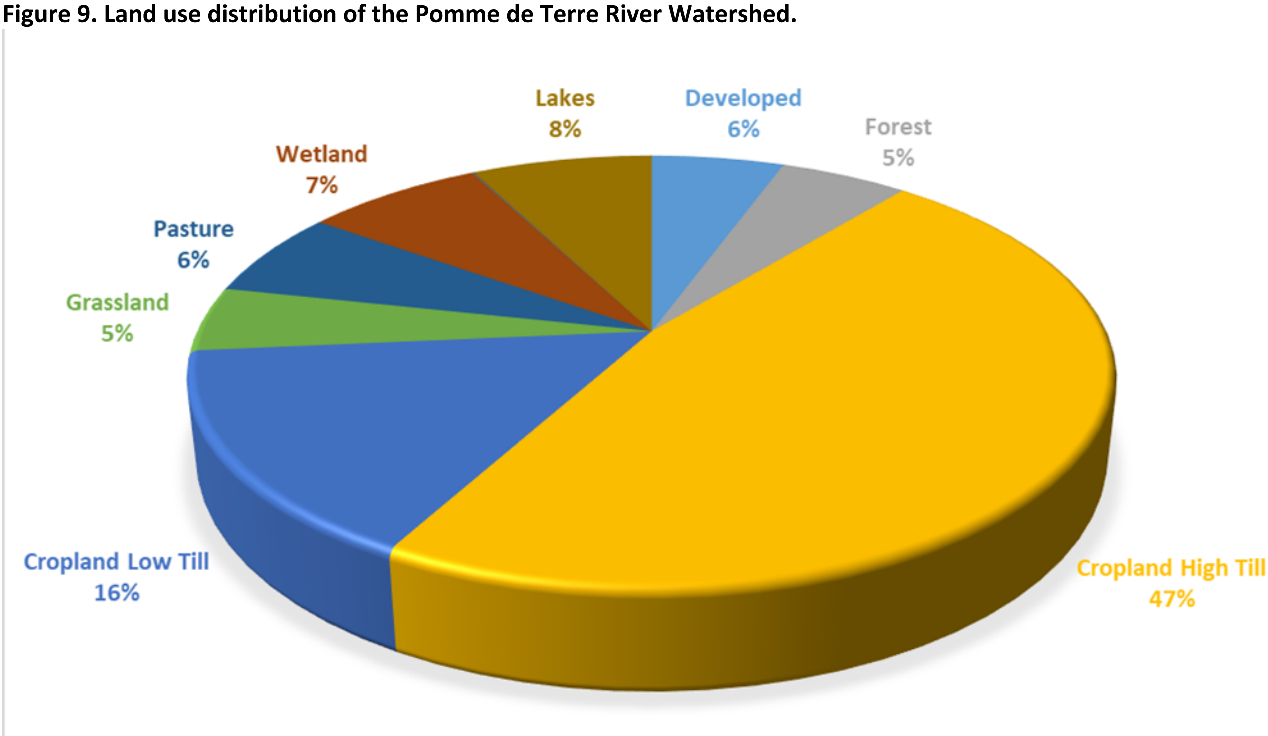
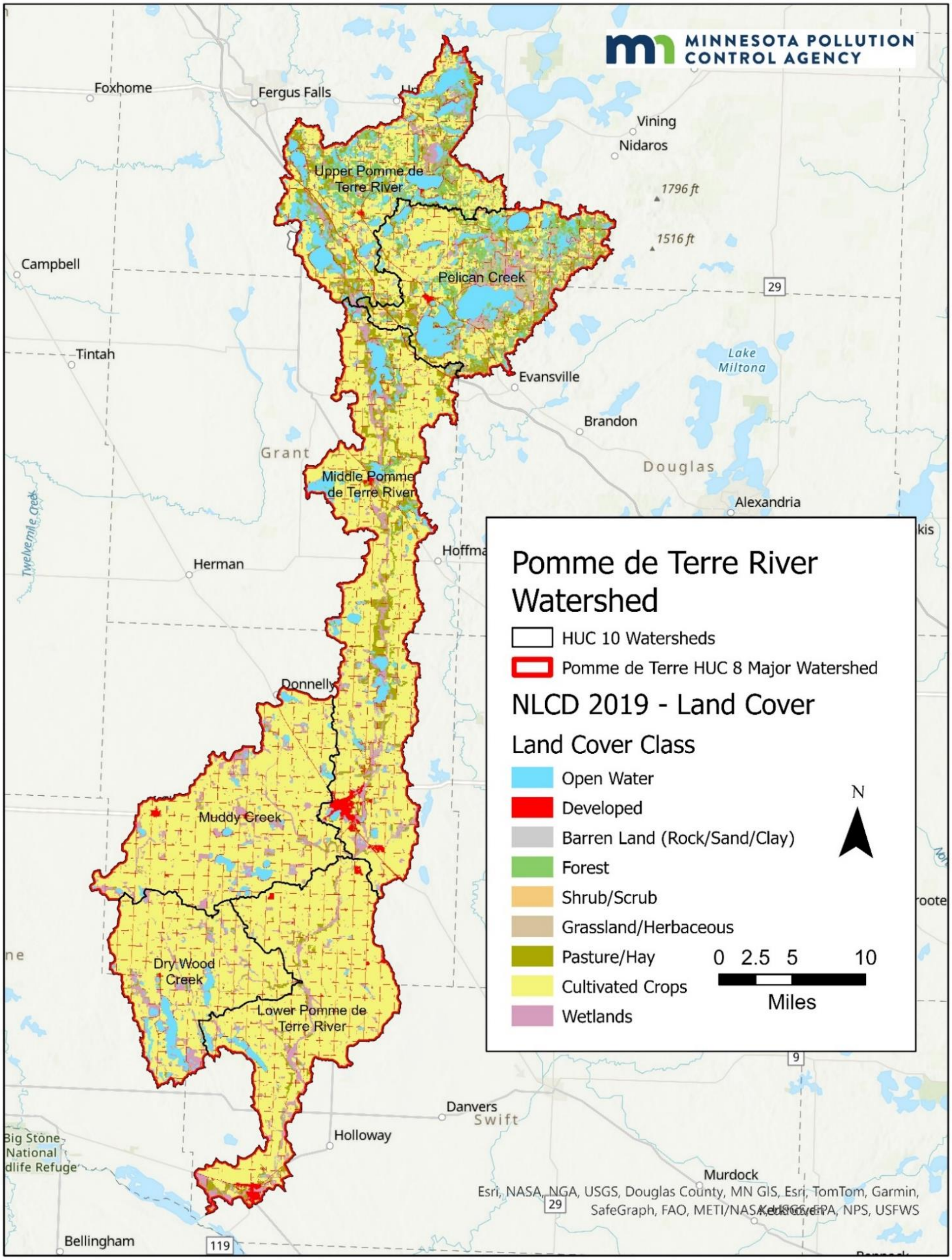


Figure 10. Map of land use for the Pomme de Terre River Watershed (2019 NLCD).



Land use in the Pomme de Terre River Watershed is markedly different between the northern and southern halves of the watershed (Figure 10). The northern half of the watershed is characterized by its relatively low gradient and prevalence of lakes and wetlands. Gradient increases moving southward in the watershed, as does the occurrence of development and row crop agriculture. Corn and soybean acreage has been increasing watershed-wide but at different rates in the northern half compared to the southern half of the watershed (Figure 11 and Figure 12). The percent of watershed planted to corn and soybeans increased by 5.7% in the upper watershed and essentially remained the same in the lower from 2006 through 2017. Perennial grass cover by percent of watershed decreased by 6.4% in the upper watershed and 4.4% in the lower over the same period, suggesting the northern half of the watershed is experiencing increasing development and agricultural pressure. These data were derived from the National Agriculture Statistics Service (NASS; USDA), which has high-resolution land cover data from 2006 to present.

Figure 11. NASS corn acreage 1921-2017 Upper and Lower Pomme de Terre River Watershed (DNR 2023).

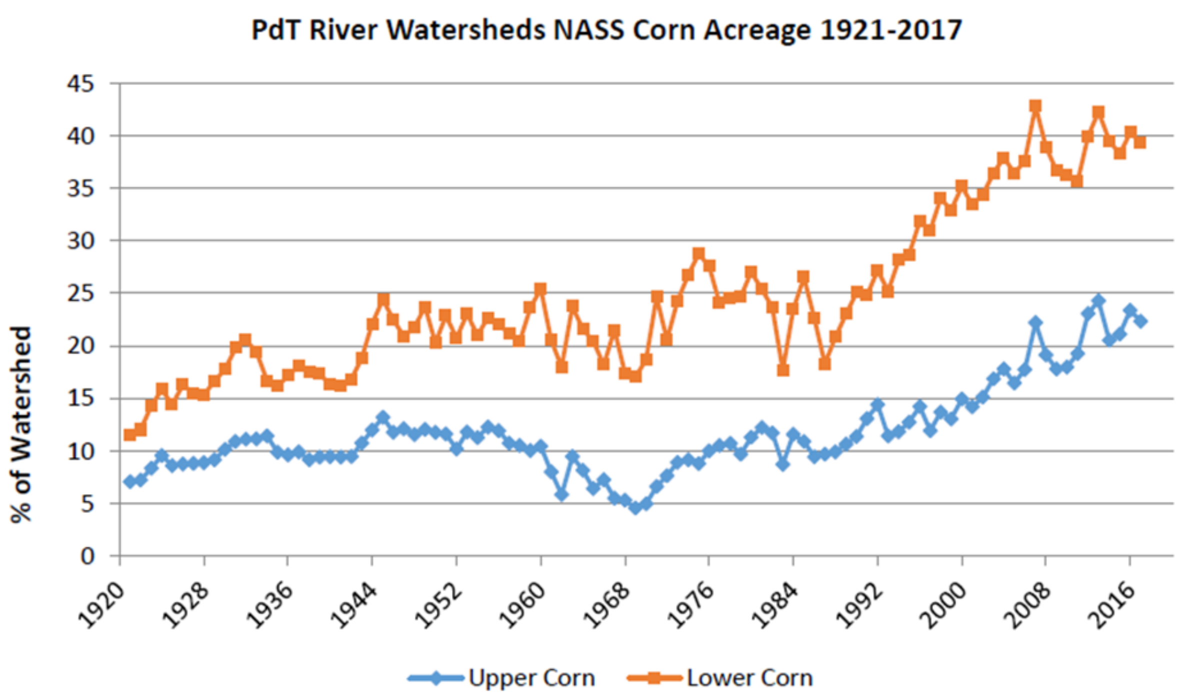
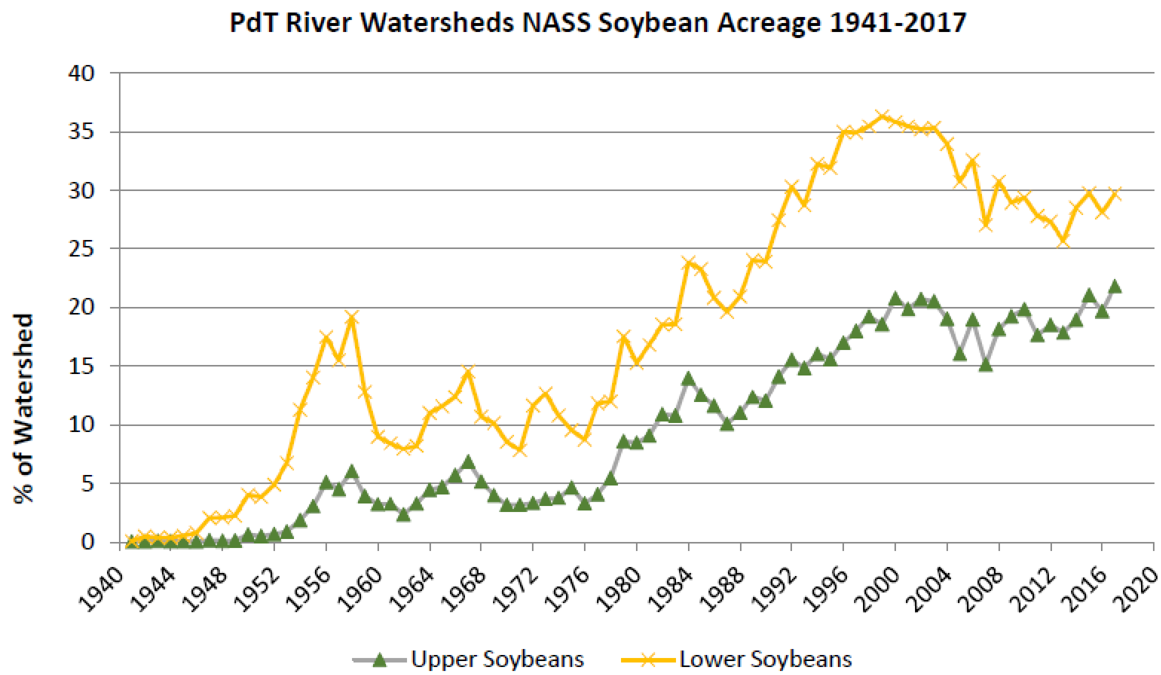


Figure 12. NASS soybean acreage 1921-2017 Upper and Lower Pomme de Terre River Watershed (DNR 2023).



Climate

Changes have occurred to the climate in the Pomme de Terre River Watershed, including changes to the annual temperature, annual precipitation, and the annual discharge over the climate record. The average mean temperature, the annual precipitation, and the average annual river flow have all been increasing (UMN 2023). Figure 13 depicts how the average mean temperature has increased over the 1890 through 2020 time period.

Figure 13. Annual average temperature (°F) (DNR 2019).

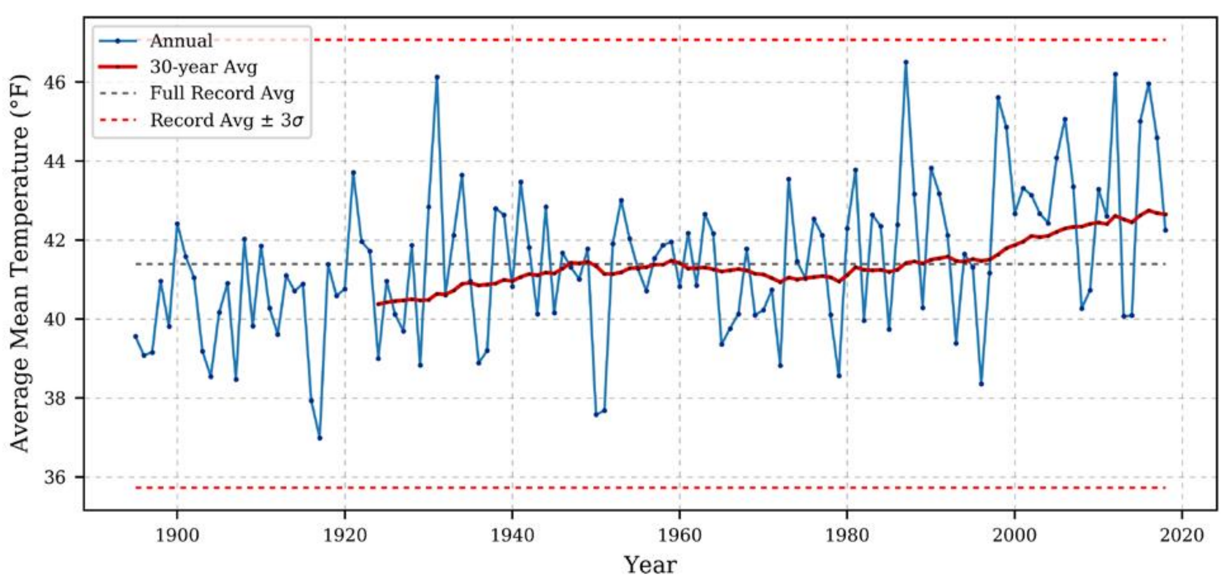
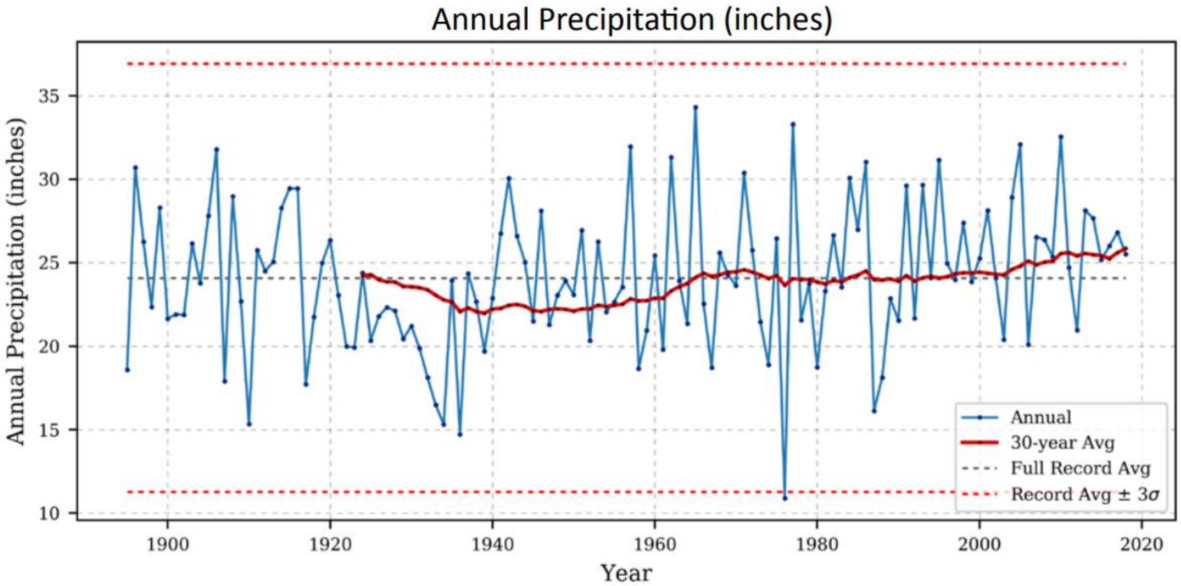


Figure 14 documents the increasing annual average precipitation values (solid blue line) alongside the increasing 30-year running average (solid red line) and the overall record average (dashed blue line). The figure compares recent annual observations to long-term trends.

Figure 14. Annual precipitation in inches at Morris (DNR 2019).



According to precipitation data from the Minnesota State Climatology Office, average annual precipitation has increased by 10% from the early 20th century, at 23.8 inches, to the late 1990s through 2010s, at 26.3 inches (Figure 14). In recent years, the Pomme de Terre River Watershed has experienced multiple extreme storm events making flooding a frequent occurrence. There have been multiple precipitation events where some areas accumulated over 6 inches of precipitation in 24 hours (DNR 2019). Flooding in the relatively rural Pomme de Terre River Watershed often leads to damaged crops and impassable roadways (PDTRA 2020).

Annual streamflow in the Pomme de Terre River Watershed has been recorded at Appleton, Minnesota since 1936 (USGS 2024). An increasing trend in flow on the Pomme de Terre River can be seen in Figure 15.

Figure 15. Annual mean discharge for the Pomme de Terre River at Appleton (05294000) (USGS 2024).

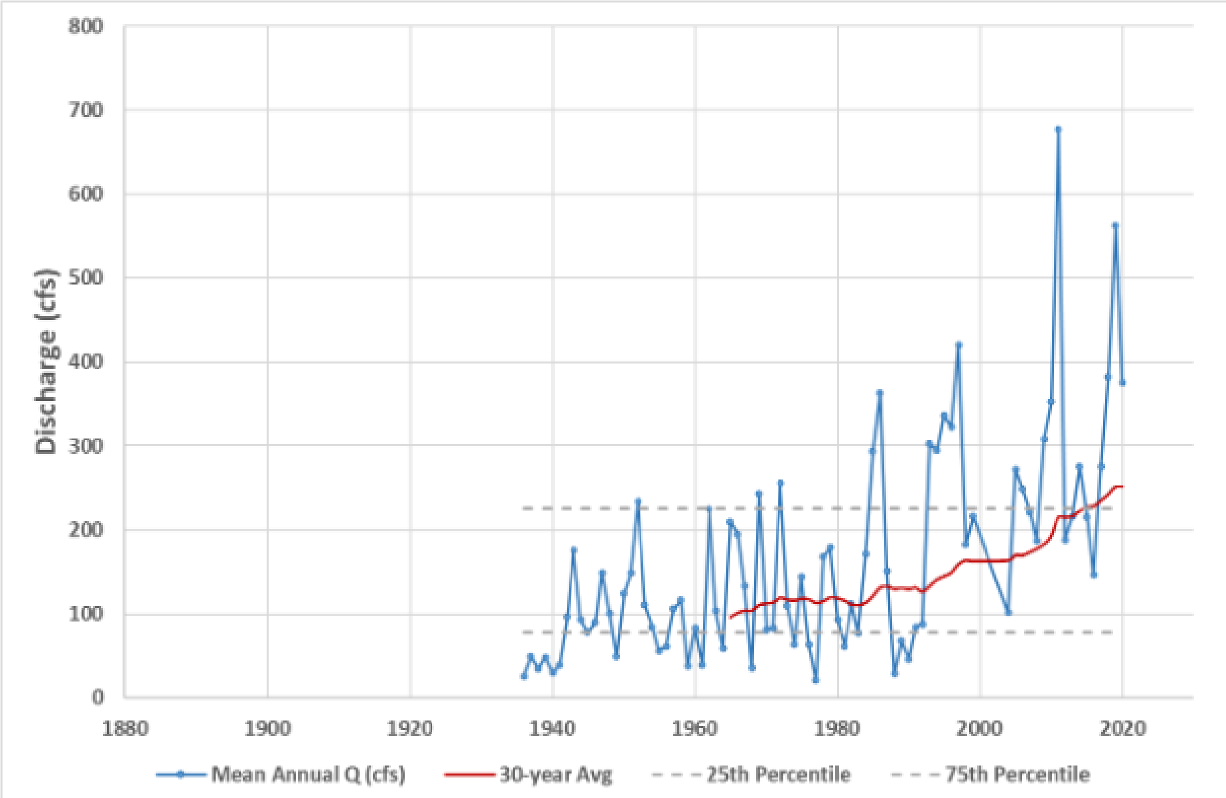


Figure 13, Figure 14, and Figure 15 all depict annualized data. There is also considerable documentation of changes within years. For more information see the report "Evaluation of Hydrologic Change (EHC), Technical Summary, Pomme de Terre River Watershed" (DNR 2023).

3.6 Water Quality, Pollutant Sources, and Pollutant Analysis

Data Sources

Data timelines

The timeframe used for sampling and to assess water bodies for impairments for this Pomme de Terre River Watershed WRAPS Update was from 2009 to 2018. Data used to conduct SID and the TMDLs in some cases were collected after the 2009 through 2018 period. Where possible, this report attempted to use the most recent approved data to describe watershed conditions.

Hydrological Simulation Program-FORTRAN

The Hydrological Simulation Program-FORTRAN (HSPF) is a computer model developed by the USGS and EPA to simulate the hydrologic cycle and water quality in watersheds (USGS 2014). HSPF simulates the movement of water and pollutants through a watershed. It considers factors such as rainfall, snowmelt, evaporation, infiltration, runoff, and stream flow. The model also considers the land use and management practices in the watershed, such as agriculture, urban development, and forest management, as well as point and nonpoint source pollution. The result of this simulation is a time history of the runoff flow rate, sediment load, and nutrient and pesticide concentrations, along with a time history of water quantity and quality at any point in a watershed.

HSPF was used for TMDL development in the Pomme de Terre River Watershed and it was used in this report to predict the impacts of different land use and management scenarios on water quality. For example, the model was used in sections 4.2 and 4.3 to evaluate the effectiveness of different BMPs in reducing pollutant loads in a watershed.

Overall, the Pomme de Terre River HSPF model (1996 through 2017) is a powerful tool for understanding watershed issues by providing insights into the complex interactions between land use, hydrology, and water quality. By using this model, water resource managers can make informed decisions about land use and management practices to protect and improve the quality of water in their watersheds.

Watershed Pollutant Load Monitoring Network

The MPCA's Watershed Pollutant Load Monitoring Network (WPLMN) is a long-term program designed to measure and compare pollutant load information from Minnesota's rivers and streams and track water quality trends. The program utilizes state and federal agencies, universities, and local partners to collect water quality and flow data to calculate pollutant loads. More information can be found at: Watershed Pollutant Load Monitoring Network (WPLMN) Data Viewer | Tableau Public.

There are two WPLMN monitoring sites in the Pomme de Terre River Watershed (Figure 16). One monitoring site is located at the watershed's outlet in Appleton. It has a USGS flow station (USGS Site 05294000) record from 1936 to present and a MPCA water chemistry station (S000-195) record from 2009 to present. This outlet monitoring location allows the data to be used to represent the entire watershed's output of water and pollutants. The other monitoring site (S000-195) is located near Hoffman on County Road 76. This second monitoring site represents the flow and pollution loading coming from the northern half of the watershed and has been in operation since 2013.
The concentration values represented in the WPLMN figures (Figures 22, 26, 32) are reported in flow-weighted mean concentrations (FWMC). A FWMC is a statistical way of expressing a monitoring season's overall pollution concentration generally as mg/L. It represents the concentration of pollutants in the water if one were able to catch all the water that flows out of the river in a container over a set period of time, mix it up and then take a sample from this container. A FWMC is a useful way to compare pollution from one year to another because it removes some of the variation caused by weather differences from year to year.

Surface Water Sampling

The PDTRA, with technical and financial assistance from the MPCA (a Surface Water Assessment Grant and several Federal 319 grants), conducted water quality monitoring at multiple monitoring sites across the Pomme de Terre River Watershed between 2009 and 2018. These data help flesh out some of the water quality details and conditions.

The MPCA's WPLMN and the PDTRA's data were combined in a series of figures that tell the story of how the water quality of the Pomme de Terre River and its tributaries change as we look across the watershed. Figure 16 identifies where these monitoring sites are. The charts in Figure 21 (TSS), Figure 25 (TP), Figure 30 (DO), and Figure 33 (NO2-3) present data following the map from north to south. The monitoring data represented in these figures comes from three sources. WPLMN monitoring sites S002-886 and S000-195 are sampled 30 to 35 times a year for chemistry (NO2-3, TP, TSS, and DO) and are long term sites that continue to be monitored as of 2024. The next group of seven monitoring sites were sampled from April through September 10 times a year for chemistry (NO2-3, TP, TSS, and DO) over the course of three to five years depending on the funding source in the 2009 through 2018 period. The final monitoring site is the historic data gathered at the USGS gauging station in Appleton from 1980 to 1996. It is displayed as a reference and represents about 110 samples taken over 16 years.

Evaluation of Hydraulic Change Report (EHC)

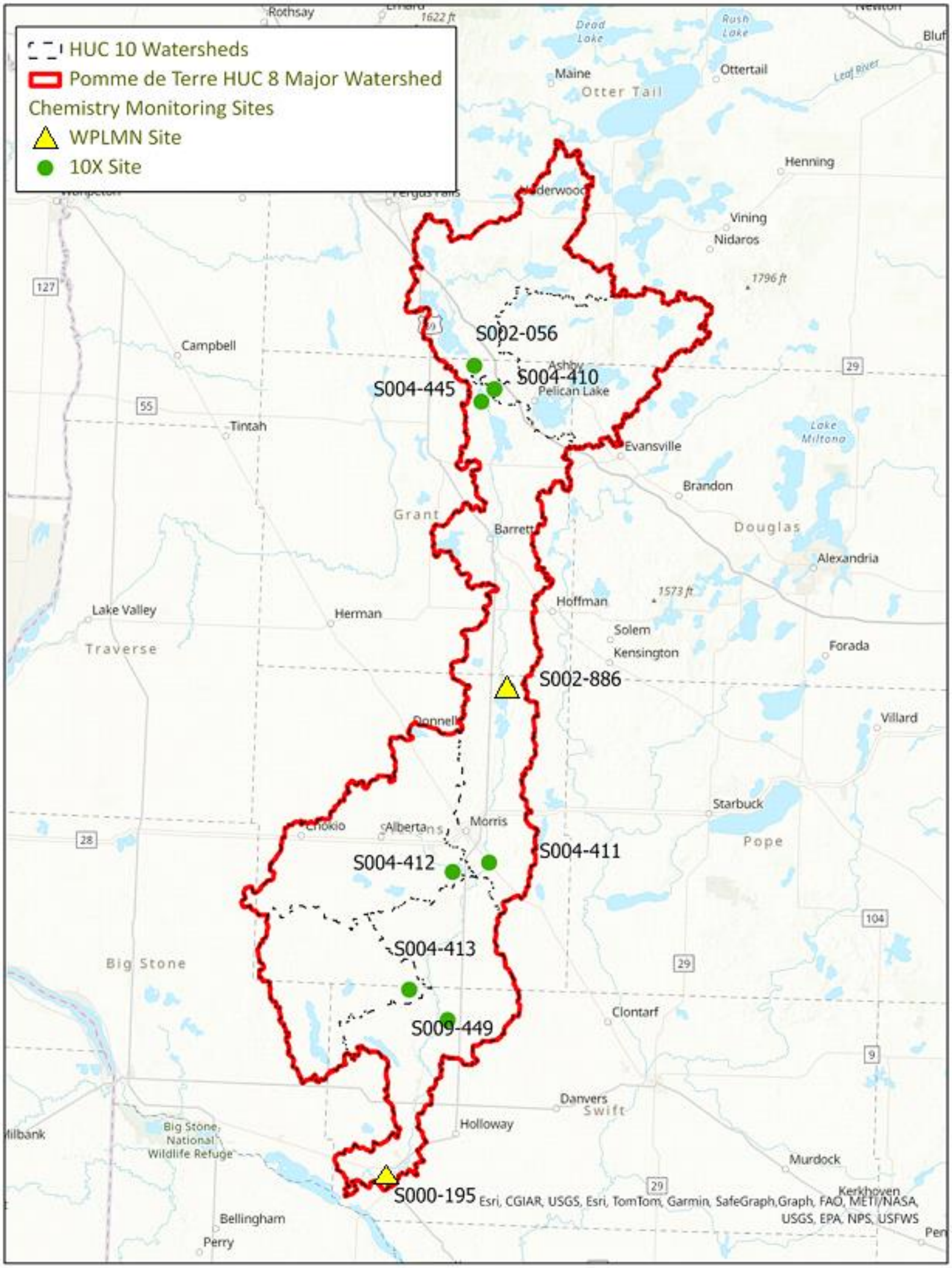
The 2023 DNR report "Evaluation of Hydrologic Change (EHC) Technical Summary Pomme de Terre River Watershed" uses historical streamflow, precipitation, and other records over a period of at least 30 years to characterize hydrology in the Pomme de Terre River Watershed. In the report, daily, monthly, and annual data are assessed and compared before and after an identified point of greatest hydrologic change.

The summary specifically includes the following:

The key hydrologic changes identified for this watershed.

- An overview of critical concepts in the EHC and the data used to assess hydrologic change.
- A review of the multiple tests used to identify the point of greatest hydrologic change.
- An assessment of hydrologic data compared to other watersheds regionally and statewide.
- A comparison of selected hydrologic metrics before and after the identified change point for each gage assessed, and associated levels of concern about watershed impacts.
- An assessment of the influence of hydrologic drivers on discharge in this watershed.

Figure 16. Map of the WPLMN and PDTRA 2017-2018 chemistry monitoring sites.

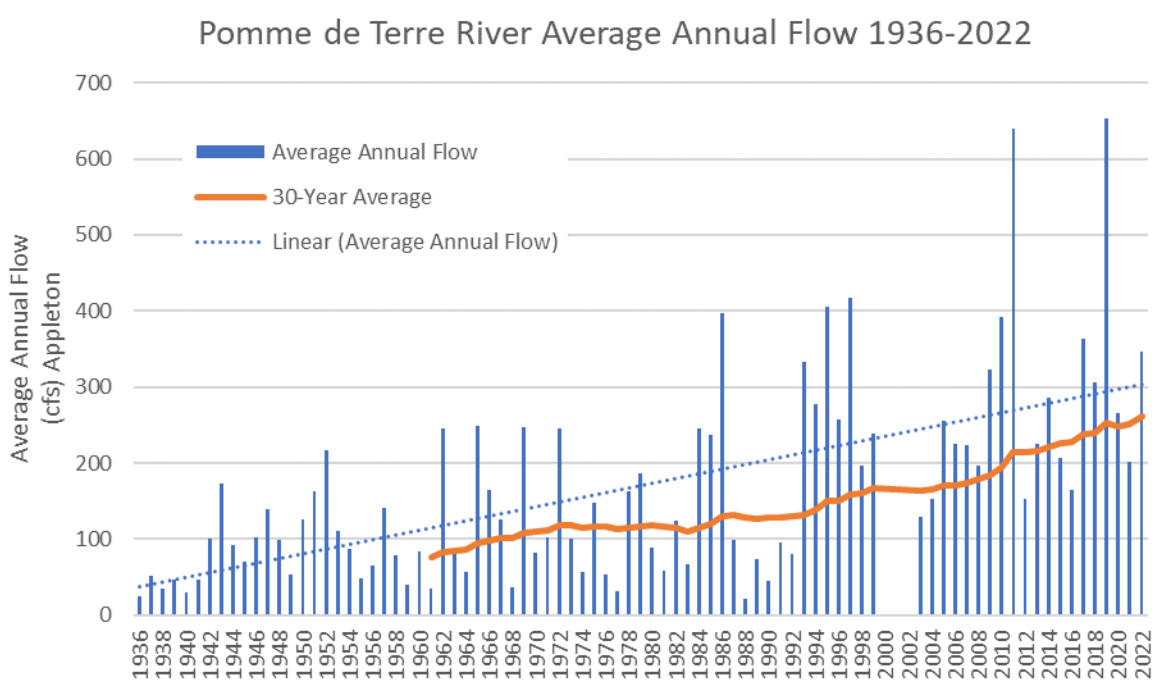


Hydrology

The Pomme de Terre River Watershed's hydrology has changed over the last 90 years. The landscape has transitioned from perennial to agricultural landcover, impacting infiltration rates and evapotranspiration patterns. These hydrologic changes have been further impacted by increased rainfall and changing storm intensity. There has been a loss of wetlands, soil water holding capacity, and increased impervious surfaces on the landscape impacting infiltration and river flows. Streams have been transformed into efficient drainage systems that quickly remove excess water for agricultural production and/or development. The combination of environmental and landscape changes has led to increased surface runoff, a change in the timing and magnitude of river flows and a degradation of aquatic habitats. These alterations of the river's water balance and hydrologic regime are summarized by the term "altered hydrology" (PDTRA 2020). Altered hydrology was identified as a stressor to biology for 11 out of 12 stream reaches where AQL impairments in the Pomme de Terre River Watershed were found (MPCA 2024a; Table 4).

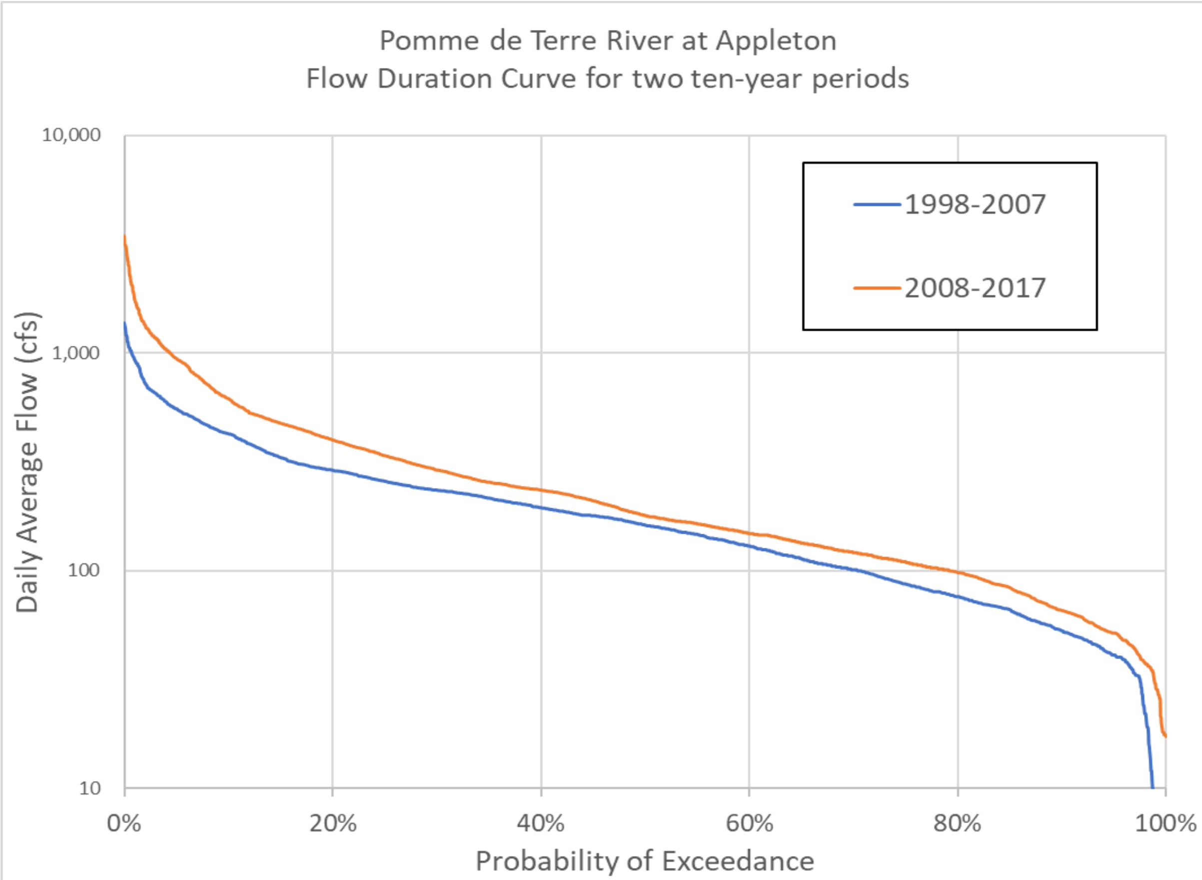
The Pomme de Terre River's average annual flow record measured at the outlet of the river in Appleton shows flows have been overall increasing over the length of the record (1936 through 2022). Figure 17 below shows how average annual flow has been increasing (1936 through 2022) with some of the highest annual flows occurring during the last 30 years. Increasing streamflow in the Pomme de Terre River has implications for stream channel conditions and pollutant loading. Increased flows could result in more channel erosion and more pollutant loading, even if pollutant concentrations are stable (MPCA 2021).

Figure 17. Pomme de Terre River average annual flow 1936 - 2022 (USGS 2024).



Changes to flow are also visible in the data when comparing flows from two recent 10-year periods of record. Between the periods 1998 through 2007 and 2008 through 2017 there was an increase in the amount of discharge at the Appleton monitoring site observable in the flow duration curve chart in Figure 18.

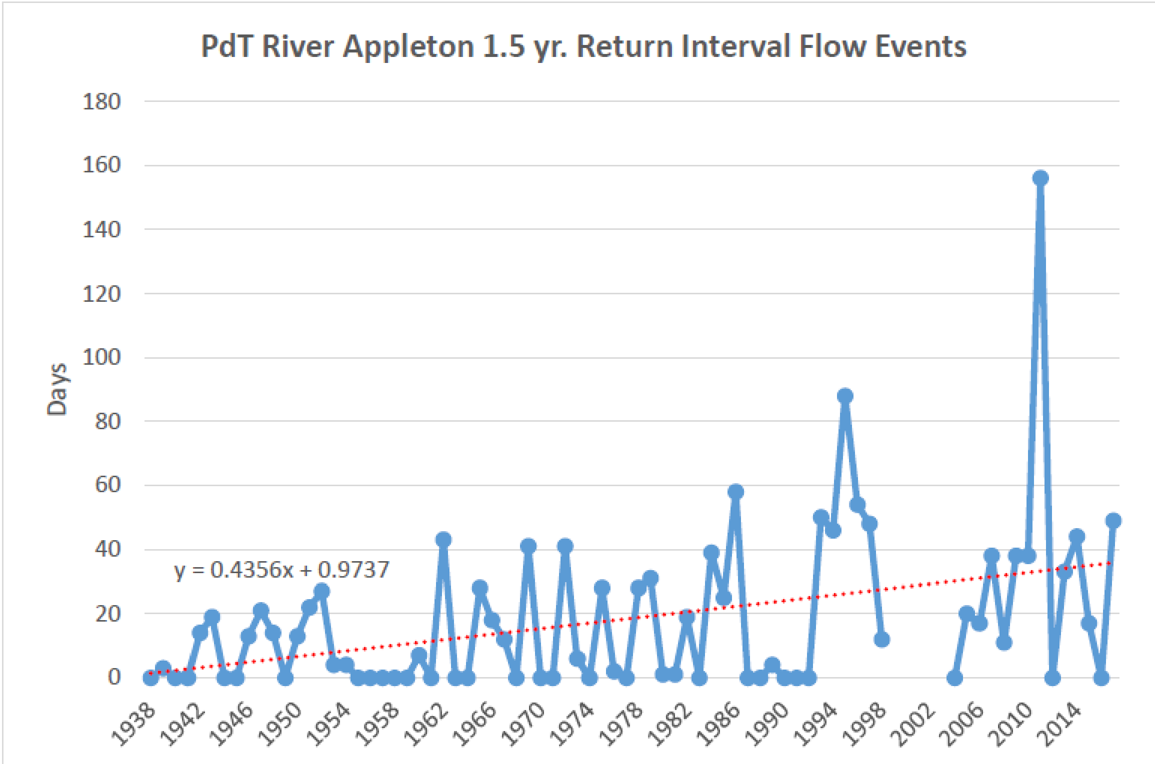
Figure 18. Flow duration curve for two 10-year periods at the Pomme de Terre River outlet (USGS 05294000).



The 1.5-year return interval flow which is used to approximate bankfull flow is important to watershed managers because it is the most effective flow for moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphological characteristics of channels (Dunne and Leopold 1978). An increase in the number of days per year a river is at bankfull flow indicates an increase in the power to shape the stream channel and move more sediment. This normally corresponds to an increase in the total load of sediment and nutrients that a stream can move.

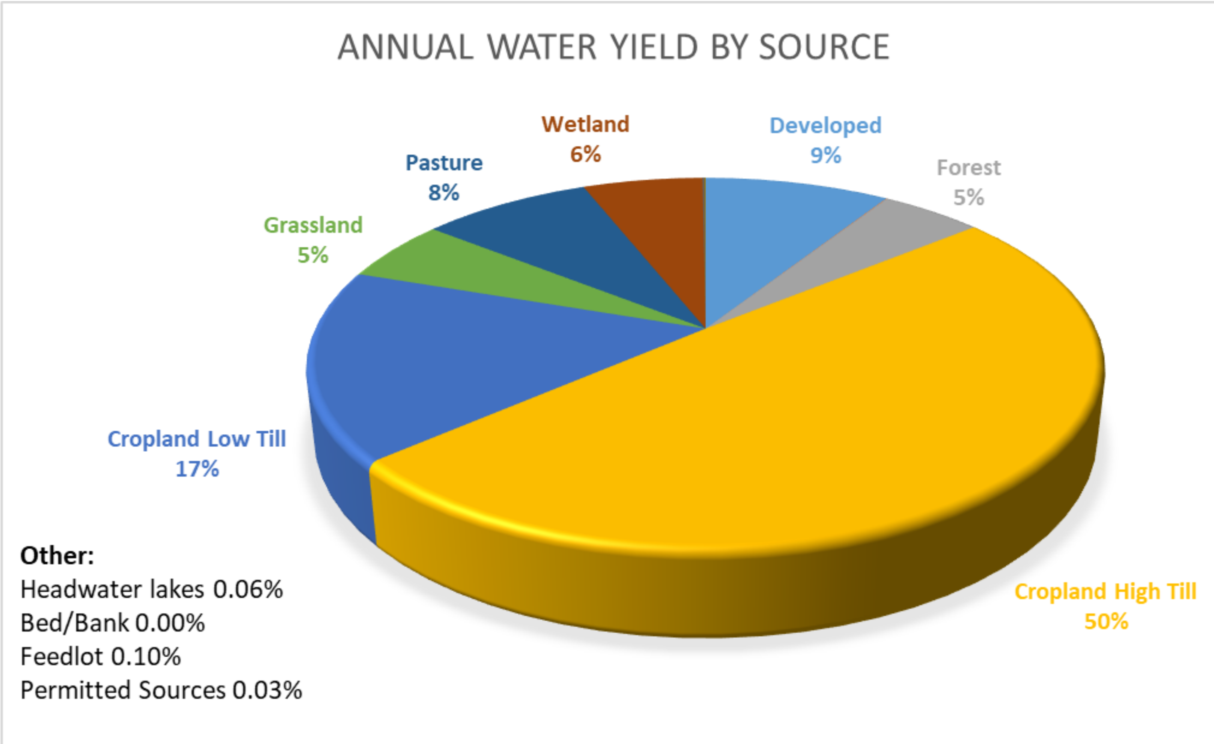
There was an upward trend in the number of days per year the 1.5-year return interval flow (used to approximate bankfull flow) was equaled or exceeded based on mean daily discharge (Figure 19. Number of days per year that the Pomme de Terre River was at bankfull flow or higher (1.5-year return interval flow) 1938 – 2018 (DNR 2023).). The number of average annual daily flow events greater than or equal to 1.5-year return interval flow for the “pre-1985” period was 10.62 days and for the “post-1985” period was 30.21 days.

Figure 19. Number of days per year that the Pomme de Terre River was at bankfull flow or higher (1.5-year return interval flow) 1938 – 2018 (DNR 2023).



Landcover plays a dominant role in the watershed water yield. This is influenced by two main factors; how effectively water passes through different types of landcover and the portion of a watershed that is covered by the different types of landcover. For instance, in the Pomme de Terre River Watershed, developed landcover tends to yield the most water per acre but since developed landcover makes up only 6% of the watershed it is not the dominant source of water to the river. Cropland, both high and low till, yields 67% of the river's water. Therefore, water and soil conservation practices (CPs) in agricultural areas have the most potential for managing flows in the Pomme de Terre River Watershed. Figure 20 details annual water yield by source landcover.

Figure 20. Annual water yield by source in the Pomme de Terre River Watershed (MPCA HSPF (model years 1996-2017)).



Total Suspended Solids

Sediment delivery and transport are important natural processes for all stream systems. However, sediment imbalance (either excess sediment or lack of sediment) can result in the loss of habitat in addition to the direct harm to aquatic organisms (MPCA 2012). Sediment concentration in aquatic systems is often measured as TSS. TSS in the Pomme de Terre River Watershed has two water quality standard levels. The Central Standard Region located in the northern part of the watershed has a TSS standard of 30 mg/L, and the Southern Standard Region in the southern part of the watershed has a TSS standard of 65 mg/L (ROS 2024).

Five river reaches in the Pomme de Terre River Watershed were assessed in the most recent assessment and two were found to be impaired by TSS: Pelican Creek (-506) and Unnamed Creek (-547) (Minnesota 2024 Impaired Waters List). A detailed list of the TSS reductions needed for Pelican Creek and Unnamed Creek is in Table 12.

Surface water sampling conducted between 2009 and 2018 reaffirmed the existing impairments on Drywood Creek (-556) and the lower reach of the Pomme de Terre River (-501) (Figure 21). Figure 21 also illustrates TSS concentrations increasing moving southward in the watershed. Chemistry sampling was discontinued at all but the two WPLMN monitoring sites (S002-889 and S000-195) at the end of 2018.

The SID report (MPCA 2024a) identified TSS as a stressor to biology for seven different AQL impairments (Table 4). TSS can impact aquatic biological communities by limiting transparency, covering streambed substrates, and clogging gills.

Despite the impact TSS has on the biological community in the Pomme de Terre River Watershed, water quality monitoring at two WPLMN mainstem sites between 2007 and 2020 has found that the annual FWMC for TSS has consistently been below the 65 mg/L threshold (Figure 22).

Figure 21. Pomme de Terre River sampled stream reach Total Suspended Solids data, 2009-2018 and additional data from 1980-1996 for the Pomme de Terre River.

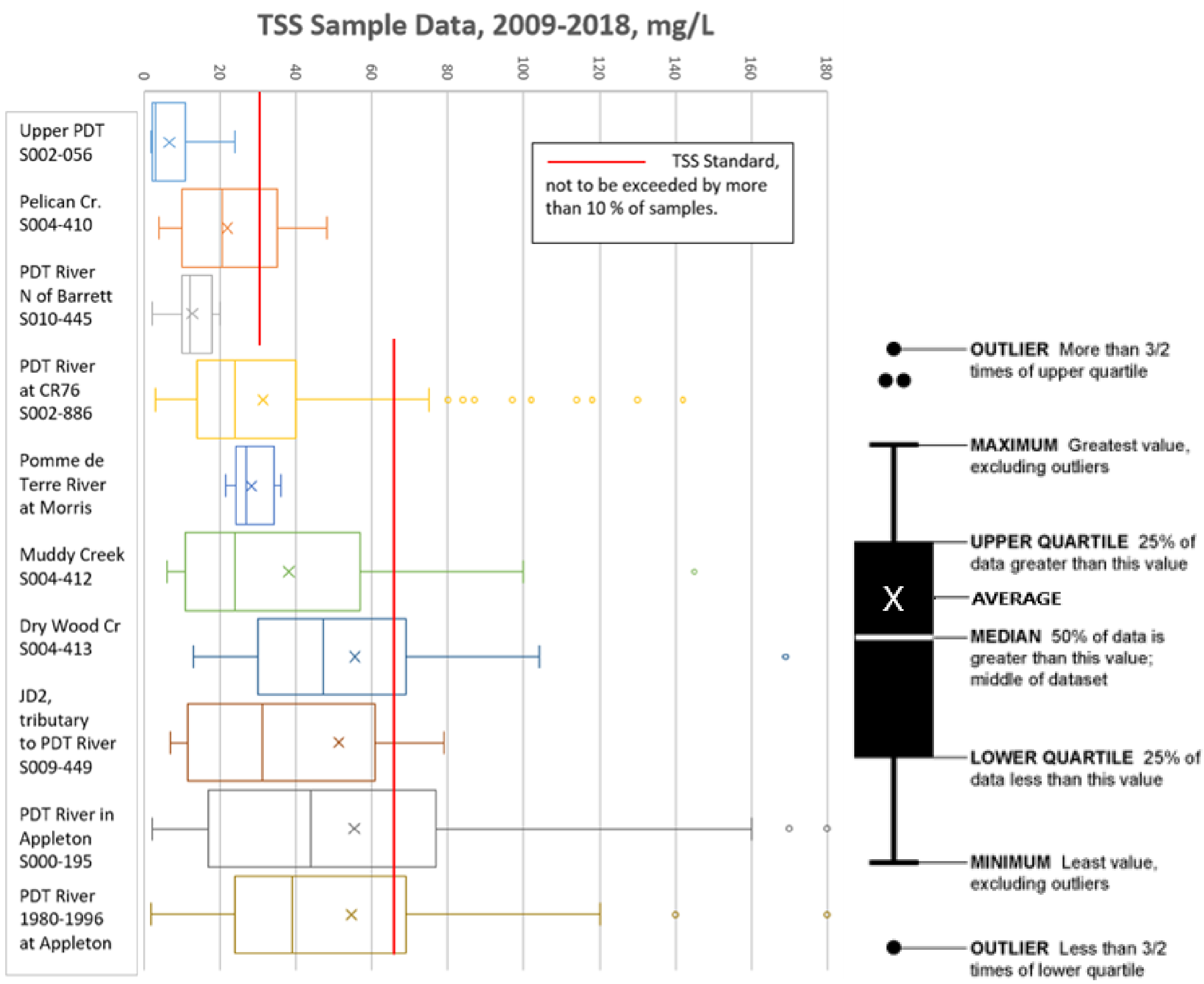
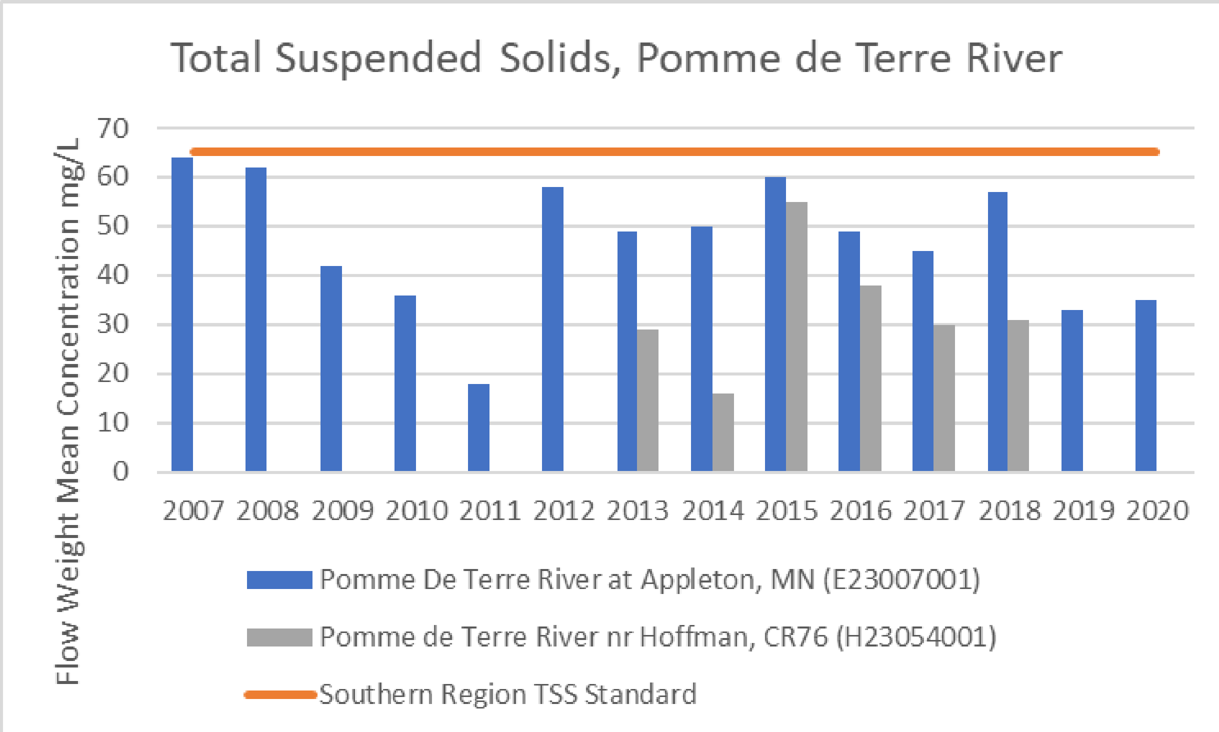


Figure 22. Annual Total Suspended Solids flow weighted mean concentration for two WPLMN sites on the Pomme de Terre River (WPLMN).



Rates of sediment loading vary widely across the Pomme de Terre River Watershed. Loading rate estimates derived from the Pomme de Terre HSPF model indicates the southern half of the watershed contributes the most TSS/acre (Figure 23). Areas along the southern Pomme de Terre River corridor and Drywood Creek are the highest contributors of TSS on a per acre basis. This suggests targeting BMPs in these regions and areas upstream that could reduce peak flows would have the most cost-effective results. Figure 24 shows the breakdown of TSS sources by land cover. The HSPF model predicts 53% of the TSS is coming from bed/bank erosion and roughly 41% from agricultural land covers.

Figure 23. Pomme de Terre TSS loading rate by subwatershed (HSPF 2008-2017).

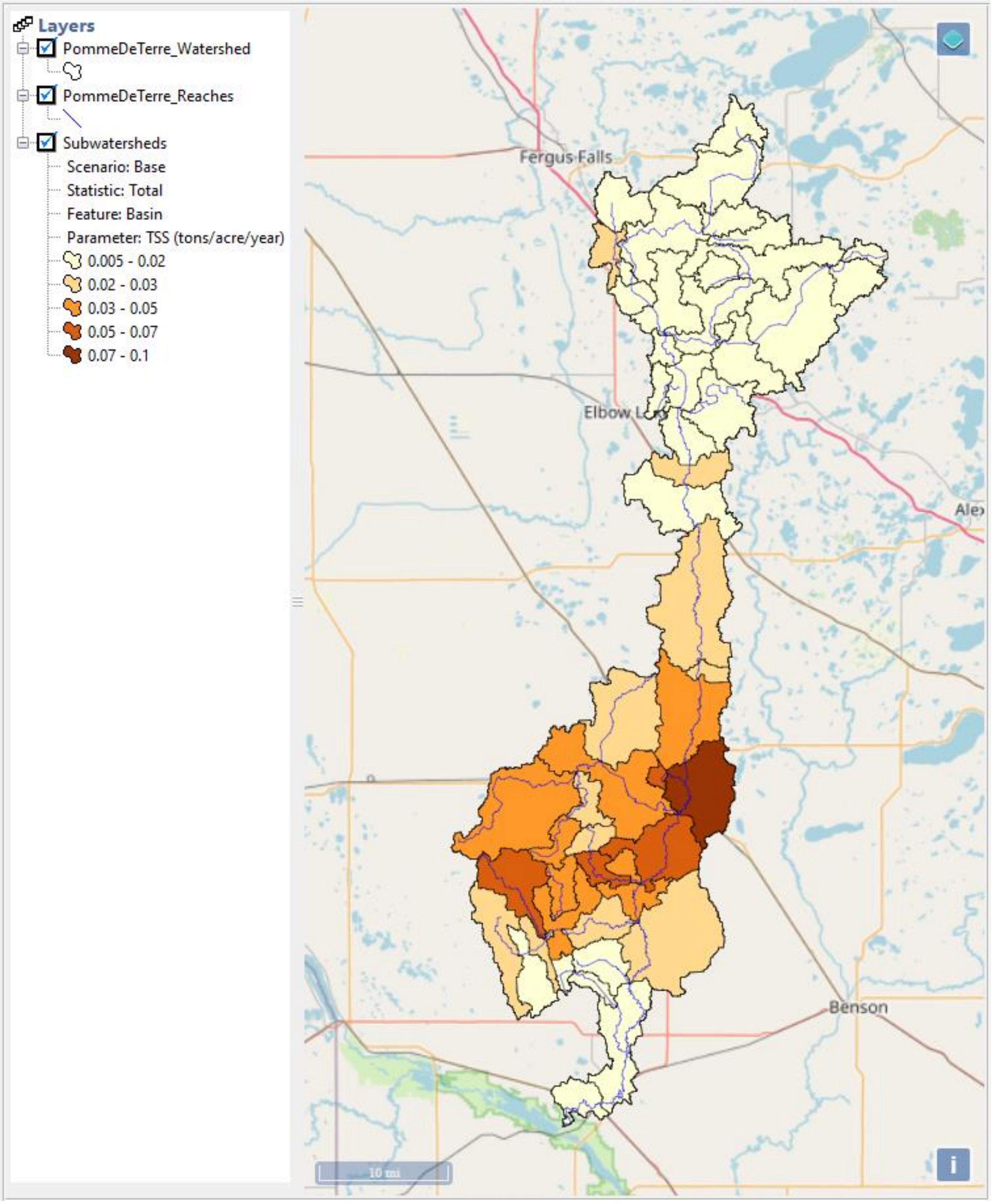
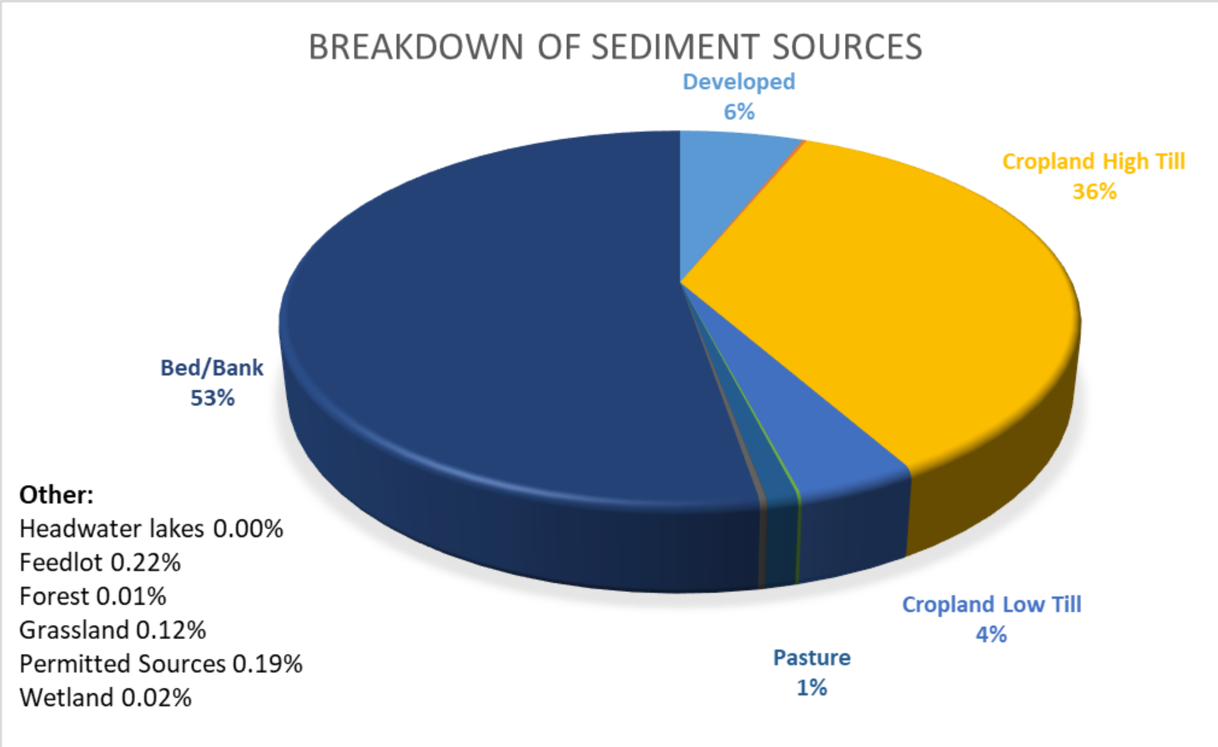


Figure 24. Overall breakdown of nonpoint sediment sources in the Pomme de Terre River Watershed (HSPF 2008 - 2017).



In summary, water quality monitoring of TSS finds the highest concentrations in the southern half of the watershed, notably in Muddy Creek, Drywood Creek, and the Pomme de Terre River mainstem starting around Appleton. The HSPF model identifies the Pomme de Terre River channel and Drywood Creek as the primary sources. The primary land cover in this region is agricultural row cropping. This suggests that targeting agricultural BMPs to this region would likely be effective. The downstream portion of the river is also subject to higher rates of bank erosion. In stream bank protection and upland water retention projects could be used to reduce bank erosion.

Phosphorus

Nutrients are essential for humans and AQL; however, when levels exceed normal conditions, problems can include excessive algae growth, low levels of oxygen, toxicity to AQL, and unhealthy drinking water (MPCA 2014). Phosphorus tends to be the primary nutrient driving the more obviously noticeable water quality impairments in the Pomme de Terre River Watershed. High phosphorus drives algal production in lakes making them green and unsightly, and, at times, unsafe for swimming. Excessive phosphorus can also result in low DO levels.

TP stream water quality standards in the Pomme de Terre River Watershed depend on where a water body is in the watershed. Streams to the north of Lake Barrett in the state's Central Standard Region have a TP standard of 0.10 mg/L. Streams south of Lake Barrett in the state's Southern Standard Region have a TP standard of 0.15 mg/L (Figure 4 and Table 7).

Lake standards for phosphorus in the Pomme de Terre River Watershed vary by lake type and ecoregion and range from an average of 0.04 mg/L to 0.09 mg/L (Table 7).

Eutrophication assessment of streams and lakes also requires data for response variables to make decisions on use support. In addition to exceeding phosphorus standards, one of several response indicators (Chl-*a*, BOD_5, diel DO flux, Secchi, or pH) need to exceed the standard as well for a water body to be considered impaired (Table 8). Detailed descriptions of both the standards and the criteria used to assess water bodies can be found in the Pomme de Terre River Watershed TMDL Report (MPCA 2024b).

Table 7. Applicable lake and river eutrophication standards (ROS 2024).

Water Body Type	Ecoregion	Eutrophication Standard					
		TP (mg/L)	Chl-a (µg/L)	Secchi (m)	Diel Dissolved Oxygen Flux	Biochemical Oxygen Demand (BOD_5)	pH
Lakes and Reservoirs	North Central Hardwood Forests	< 0.040	< 14	> 1.4	N/A	N/A	N/A
	Northern Glaciated Plains Ecoregion	< 0.065	< 22	> 0.9	N/A	N/A	N/A
Shallow Lakes	North Central Hardwood Forests	< 0.060	< 20	> 1.0	N/A	N/A	N/A
	Northern Glaciated Plains Ecoregion	< 0.090	< 30	> 0.7	N/A	N/A	N/A
River/Stream/ Ditch	Southern River Nutrient Region 2B stream	<0.150	< 40	N/A	< 5.0	< 3.5	6.5 ≤ ≤ 8.5
River/Stream/ Ditch	Central River Nutrient Region	< 0.100	< 18	N/A	< 3.5	< 2.0	6.5 ≤ ≤ 8.5

There is one stream impairment for phosphorus (07020002-566, Unnamed Creek to Artichoke Creek) and six lakes that exceed both the phosphorus standard and at least one response variable. These impairments are addressed in the Pomme de Terre River Watershed TMDL reports (MPCA 2024b, MPCA 2015). The phosphorus reductions needed to meet water quality standards are detailed in Table 12.

While assessment of surface waters in the Pomme de Terre River Watershed suggests relatively few phosphorus impairments, water quality monitoring conducted at various locations between 2009 and 2018 revealed that many of the streams and some of the lakes were often exceeding the phosphorus standard while not exceeding a response indicator. This indicates that these stream reaches and lakes may be at risk of becoming impaired (Figure 25, Figure 29).

The WPLMN monitoring at Appleton has found that the FWMC for TP was consistently at or above the 0.15 mg/L threshold between 2007 and 2020 (348 samples) (Figure 26). This is clear evidence that the TP concentration at the Appleton location is often elevated. Figure 26 also suggests phosphorus concentrations increase moving southward as the Pomme de Terre River site near Hoffman was generally meeting the water quality standard.

The HSPF model also indicates the southern half of the watershed contributes the most TP/acre (Figure 28). The region north of Stevens County Road 76 yields 20% of the river's phosphorus load, while the region south of CR76 yields 80% of the river's phosphorus load. Figure 25 shows HSPF estimates of TP sources by land cover. The model predicts that roughly 87% of the TP comes from agricultural land covers. Drywood Creek and the Pomme de Terre River corridor appear to contribute the most TP per acre.

Excessive levels of TP are also significant stressors to the aquatic biology in the Pomme de Terre River Watershed. The Pomme de Terre River Watershed SID Report (MPCA 2024a) identified phosphorus, low DO, and/or eutrophication as stressors in 11 different AQL impairments (Table 4).

Figure 25. Pomme de Terre River sampled stream reach TP sample data (2009-2018 and additional data from 1980-1996 for the Pomme de Terre River).

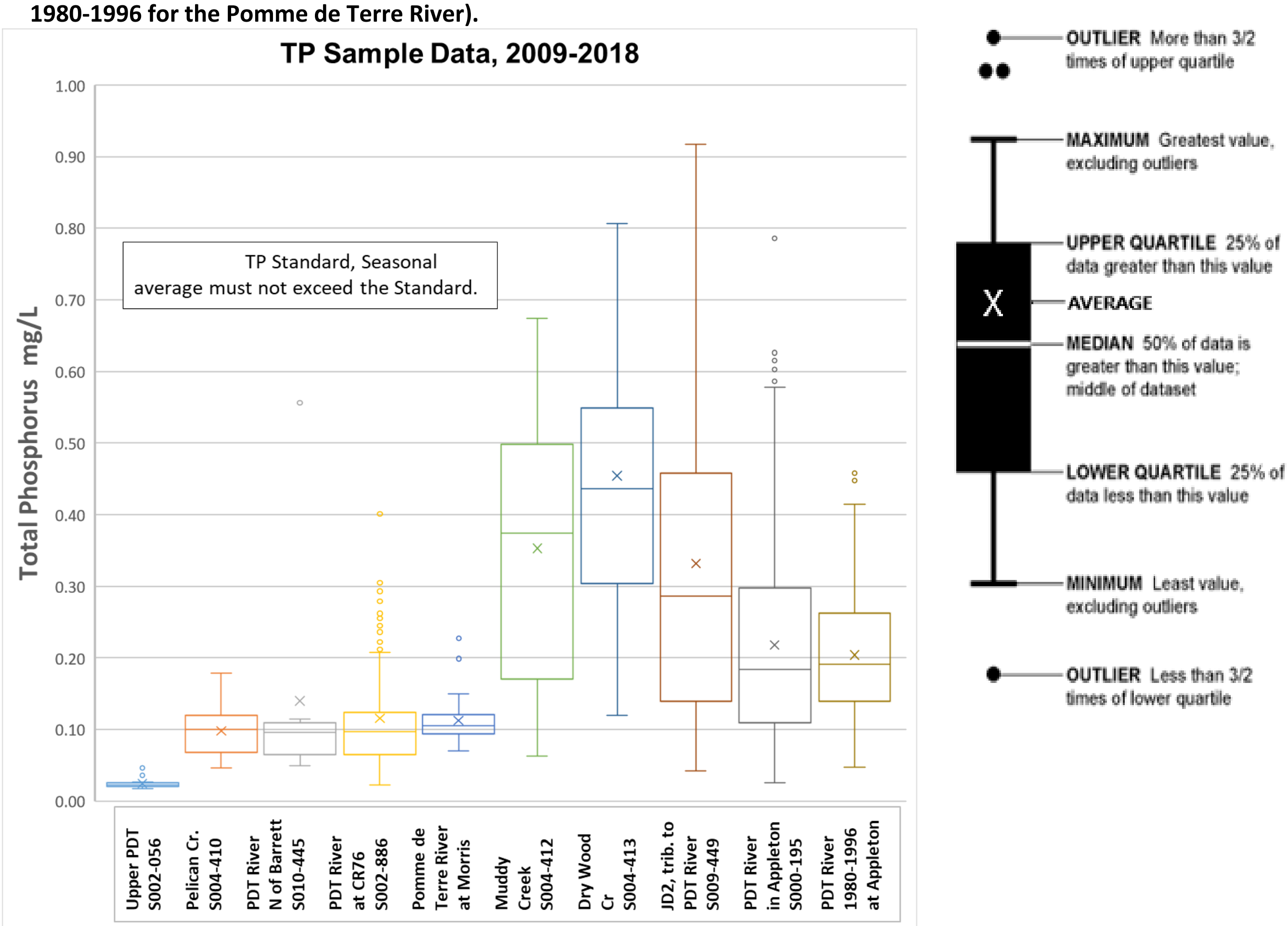


Figure 26. Annual TP flow weighted mean concentration for two WPLMN sites on the Pomme de Terre River (WPLMN).

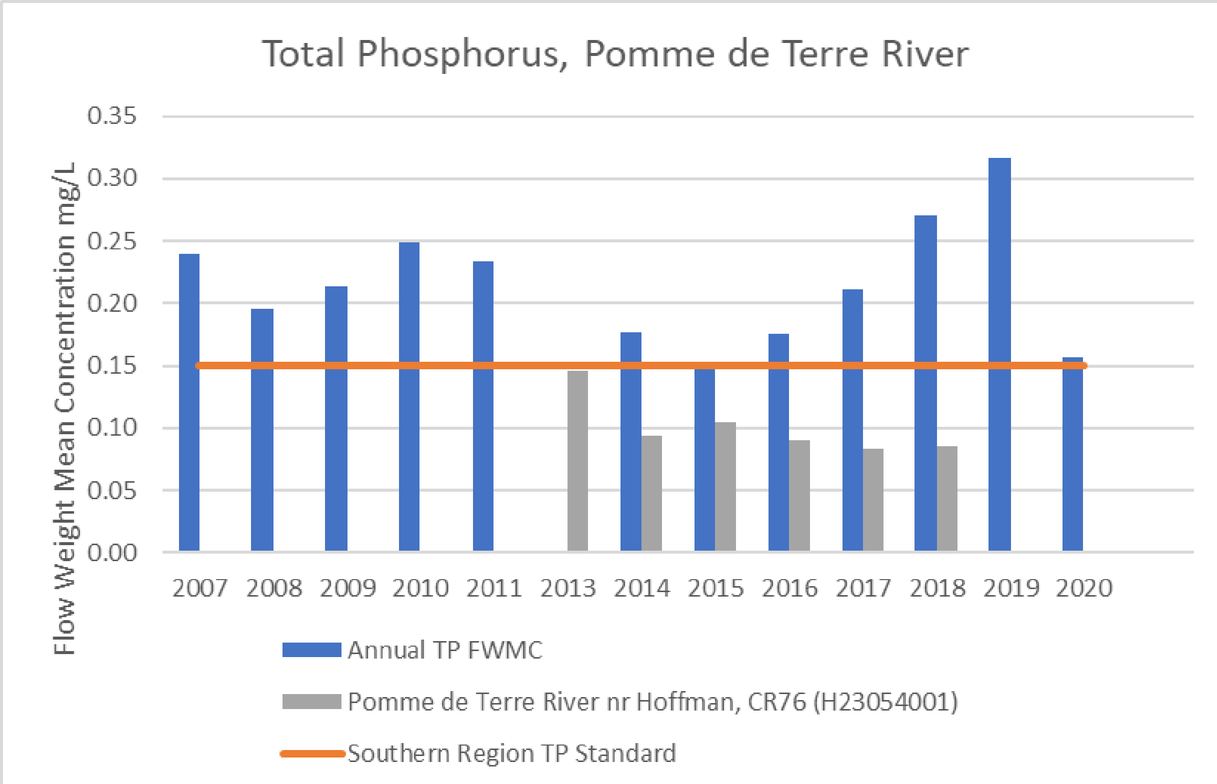


Figure 27. Breakdown of phosphorus sources by land cover (HSPF 2008 – 2017).

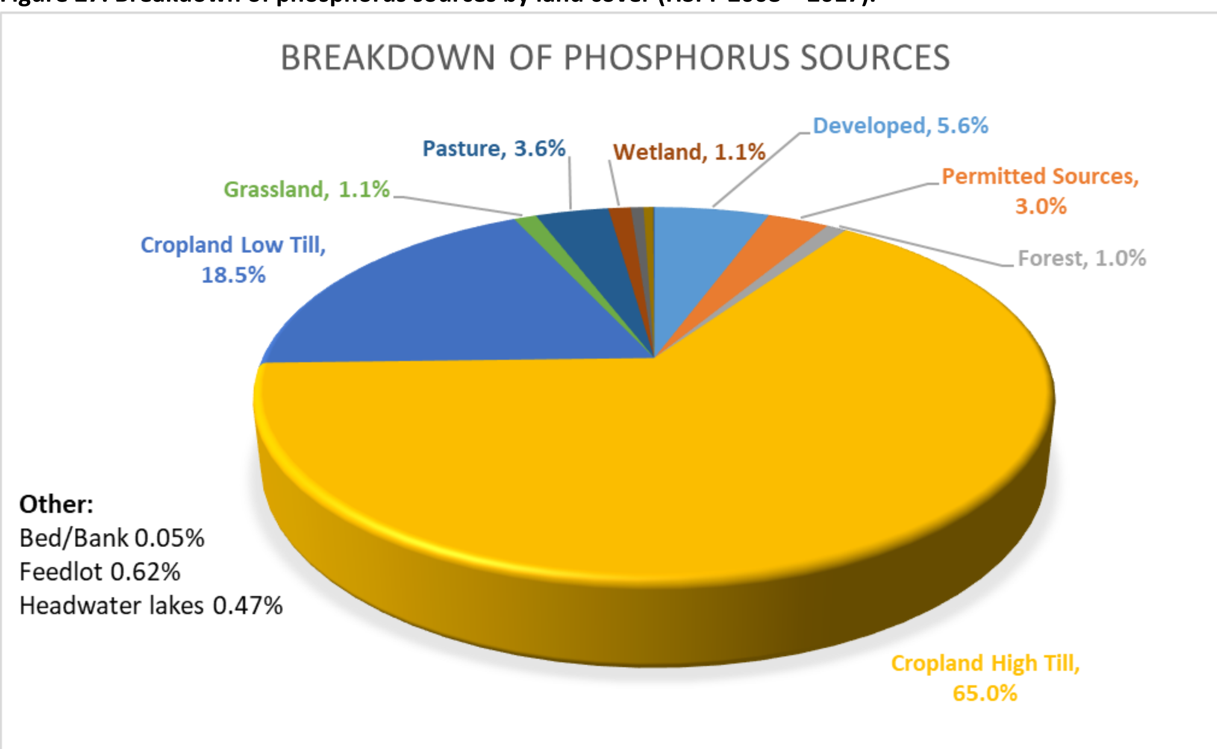
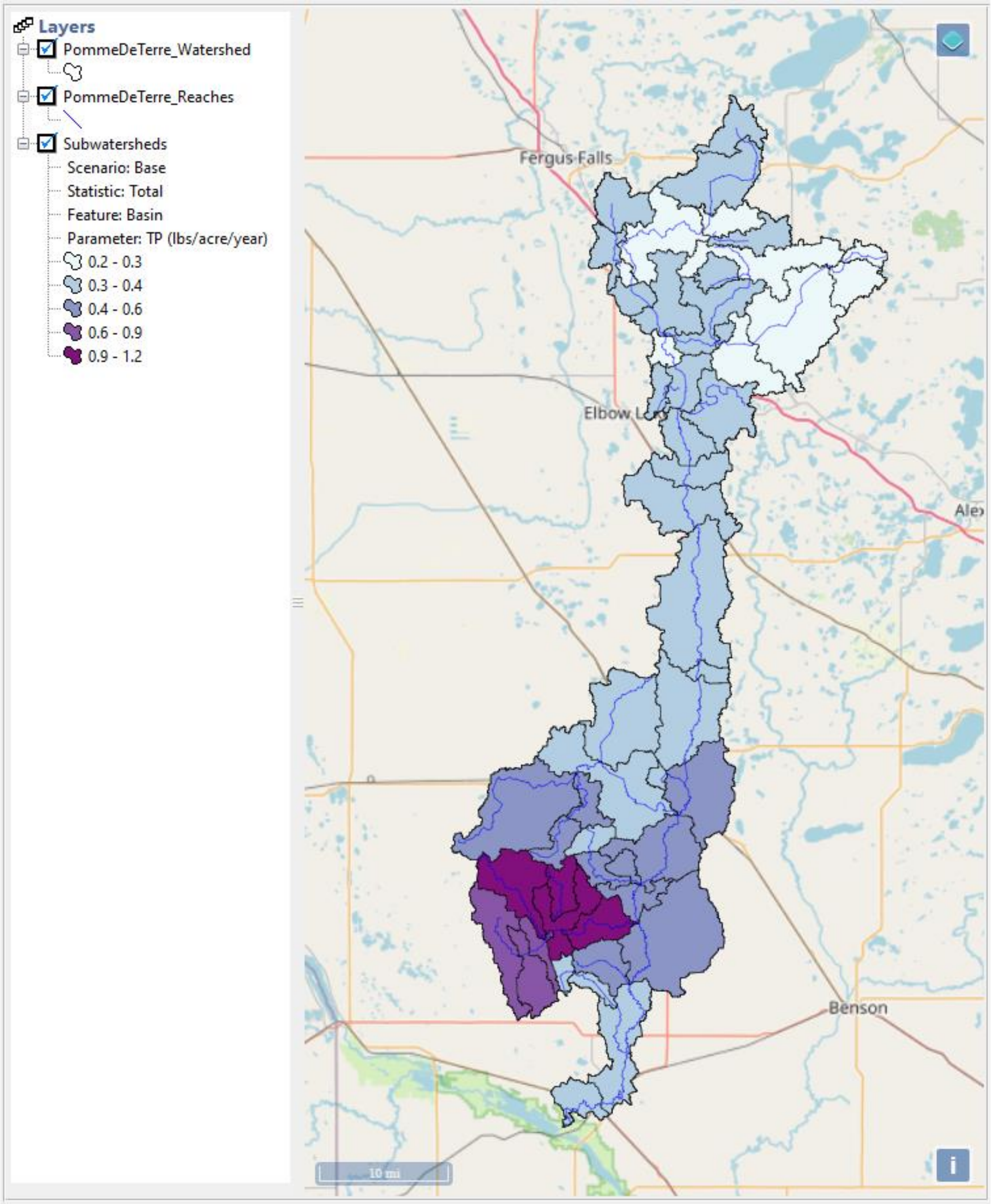


Figure 28. Phosphorus loading rate by subwatershed (HSPF 2008-2017).

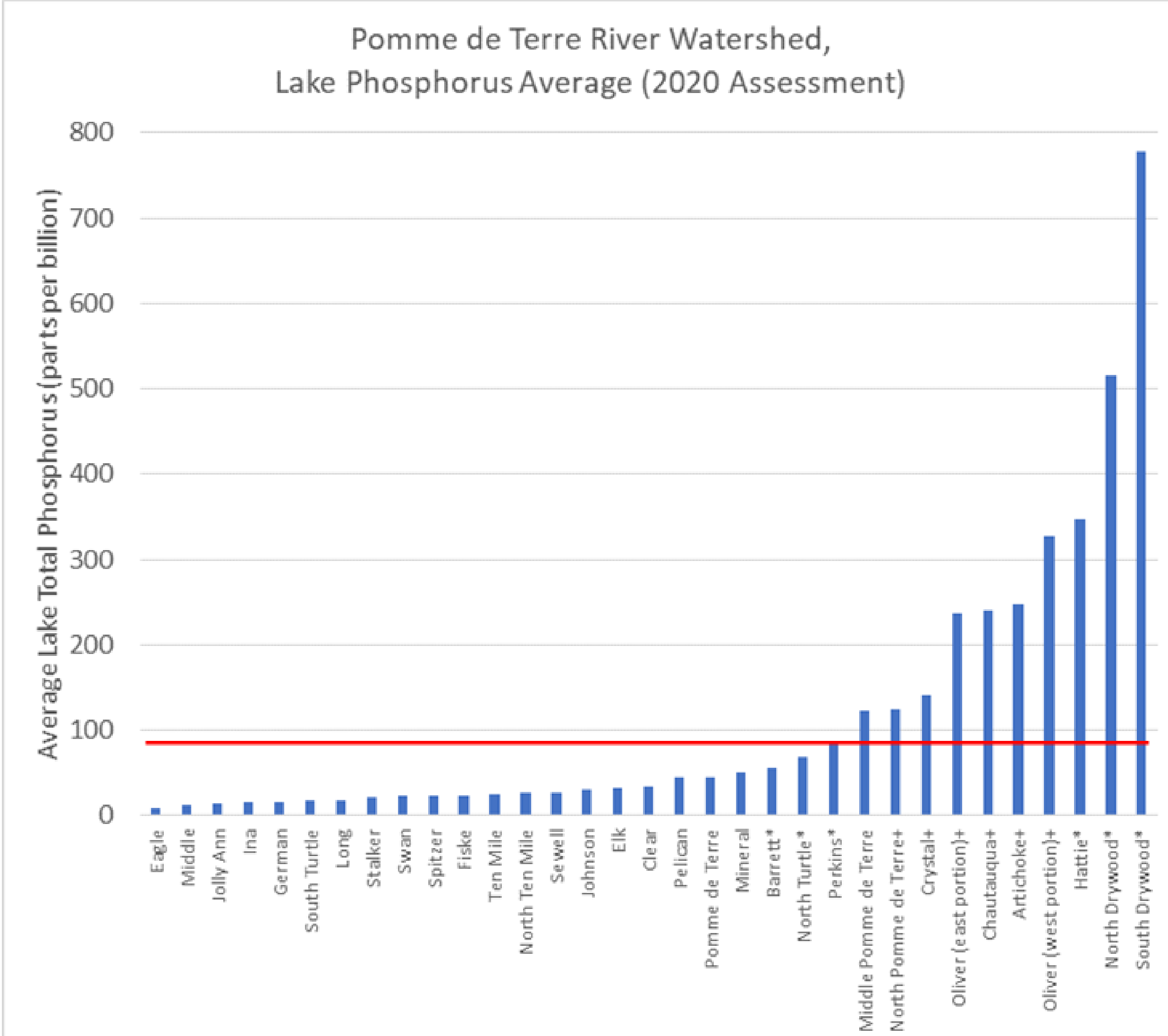


In some lakes in the Pomme de Terre River Watershed, a legacy of phosphorus delivery from upstream sources and stored in lake sediments has built up a sizable internal phosphorus load that can be released to the lake under certain conditions. In these lakes, natural processes recycle the phosphorus within a lake and the internal load has become a significant driver of the lake impairment and in some cases downstream lake and stream impairments. Table 8 separates and lists these two broad sources of phosphorus for select lakes as determined from the BATHTUB Lake Eutrophication model. Internal phosphorus load estimates in Table 9 should be considered in terms of relative source contribution, rather than as precise estimates as independent measures of internal phosphorus loads were not available. See the Pomme de Terre River Watershed TMDLs (MPCA 2015; 2024b) for more information.

Table 8. Source of phosphorus for select Pomme de Terre River Watershed lakes.

County	Water body ID	Water body name	First listed	Impaired status	Source of phosphorus lbs/yr	
					Watershed	Internal
Big Stone	07020002-566	Artichoke Lake	Not Listed	No	12,956	34,456
Douglas	21-0375-00	Christina Lake	2010	Yes		
Grant	26-0095-00	Barrett Lake	2020	Yes	12,731	569
Otter Tail	56-0379-00	North Turtle Lake	2012	Yes		
Stevens	75-0200-00	Hattie Lake	2012	Yes		
	75-0075-00	Perkins Lake	2010	Yes		
	76-0169-00	North Drywood Lake	2020	Yes	32,939	13,787
	76-0149-00	South Drywood Lake	2020	Yes	1,878	13,345

Figure 29. 10-year phosphorus averages for select lakes in the Pomme de Terre River Watershed (2008-2017).



*=impaired, +=TP exceeds standard, but response indicator not exceeded, red line denotes 90 ppb.

The 10-year phosphorus averages for select Pomme de Terre River Watershed lakes are shown in Figure 29. Note that 10 lakes (all classified as shallow lakes) have averages considerably above 90 ppb, the TP standard for shallow lakes in Northern Glaciated Plains Ecoregions. It will take considerable effort to achieve water quality standards in these lakes.

Dissolved Oxygen

DO refers to the concentration of oxygen gas within the water column. Low or highly fluctuating concentrations of DO can have detrimental effects on many fish and macroinvertebrate species (MPCA 2012). Pomme de Terre River Watershed water quality data collected between 2009 and 2018 included DO values below the 5 mg/L standard. However, only one stream reach, Drywood Creek (07020002-556), was found to be impaired by low DO (originally listed in 2010). For more information on the Drywood Creek low DO impairment, see the Pomme de Terre River Watershed TMDL Report (MPCA 2015).

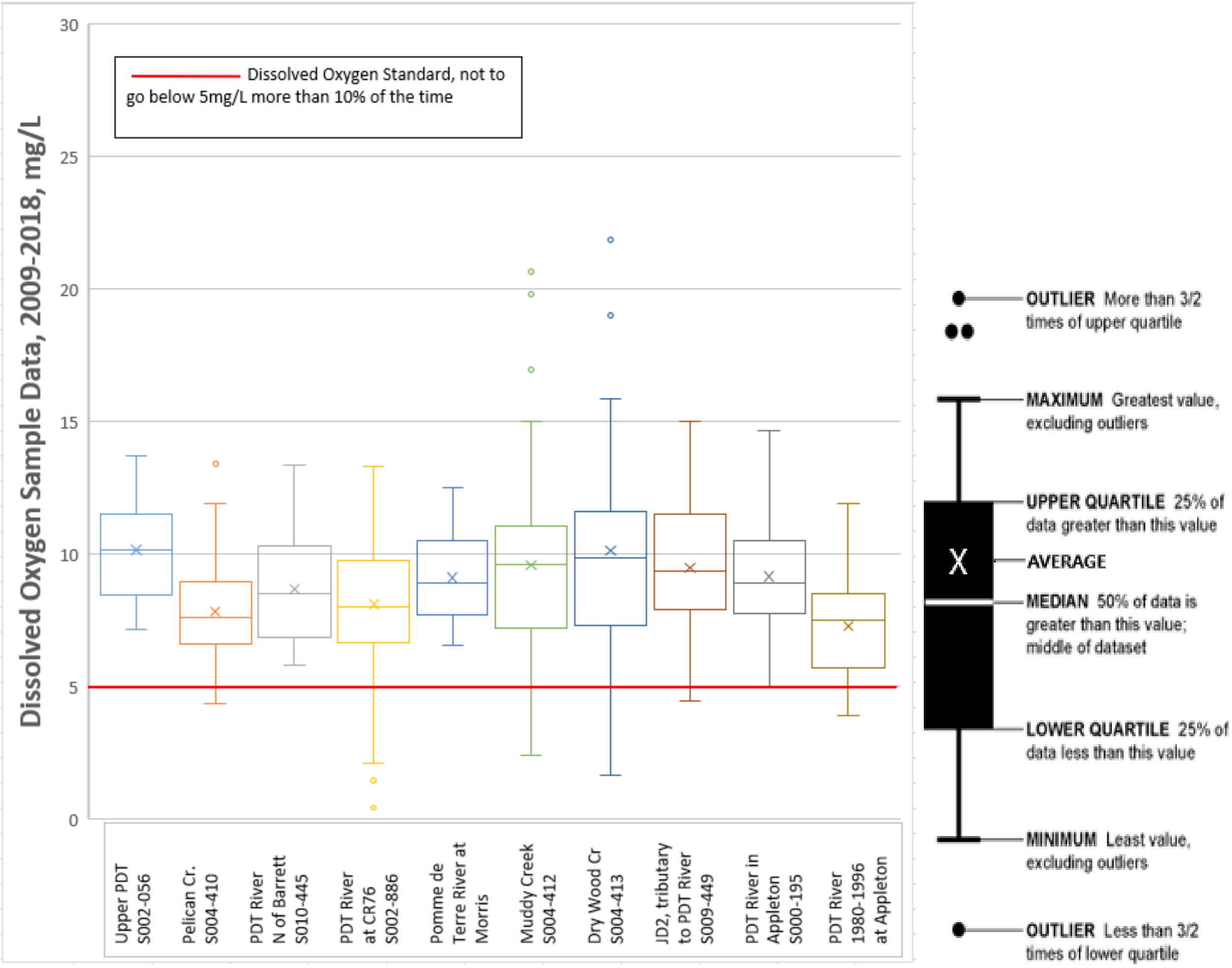
The Pomme de Terre River SID Report (MPCA 2024a) documented five reaches where low DO has been identified as a stressor to aquatic biology. Two stream reaches, Barrett Lake to North Pomme de Terre Lake (07020002-563) and Drywood Creek (07020002-556), were identified in the 2012 Pomme de Terre River SID Report and continue to experience low DO as a stressor to aquatic biology. The three new stream reaches identified in the 2024 SID Report with low DO as a stressor to AQL are the tributaries of Drywood Creek, Drywood Creek Tributary (07020002-515), Drywood Creek Tributary (07020002-534) and Judicial Ditch 2 (07020002-549).

DO concentrations in river and stream environments are often driven by a combination of natural and anthropogenic factors. Natural background characteristics of a watershed, such as topography, hydrology, climate, and biological productivity can influence the DO regime of a water body. Agricultural and urban land uses, impoundments (dams), and point-source discharges are some of many of possible anthropogenic factors that can cause unnaturally high, low, or volatile DO concentrations.

In the Pomme de Terre River Watershed, all the reaches identified as biologically stressed by low DO are found in the southern half of the watershed. Seven of the eight reaches have no upstream towns and are in regions with a high proportion of agricultural row crop land cover.

Drywood Creek had three of the five reaches where low DO was documented as a stressor. High phosphorus, considered a driver of low DO, was observed at six times the water quality standard in Drywood Creek (MPCA 2024a).

Figure 30. Pomme de Terre River sampled stream reach dissolved oxygen sample data, 2009-2018 and additional data from 1980-1996 for the Pomme de Terre River in Appleton.

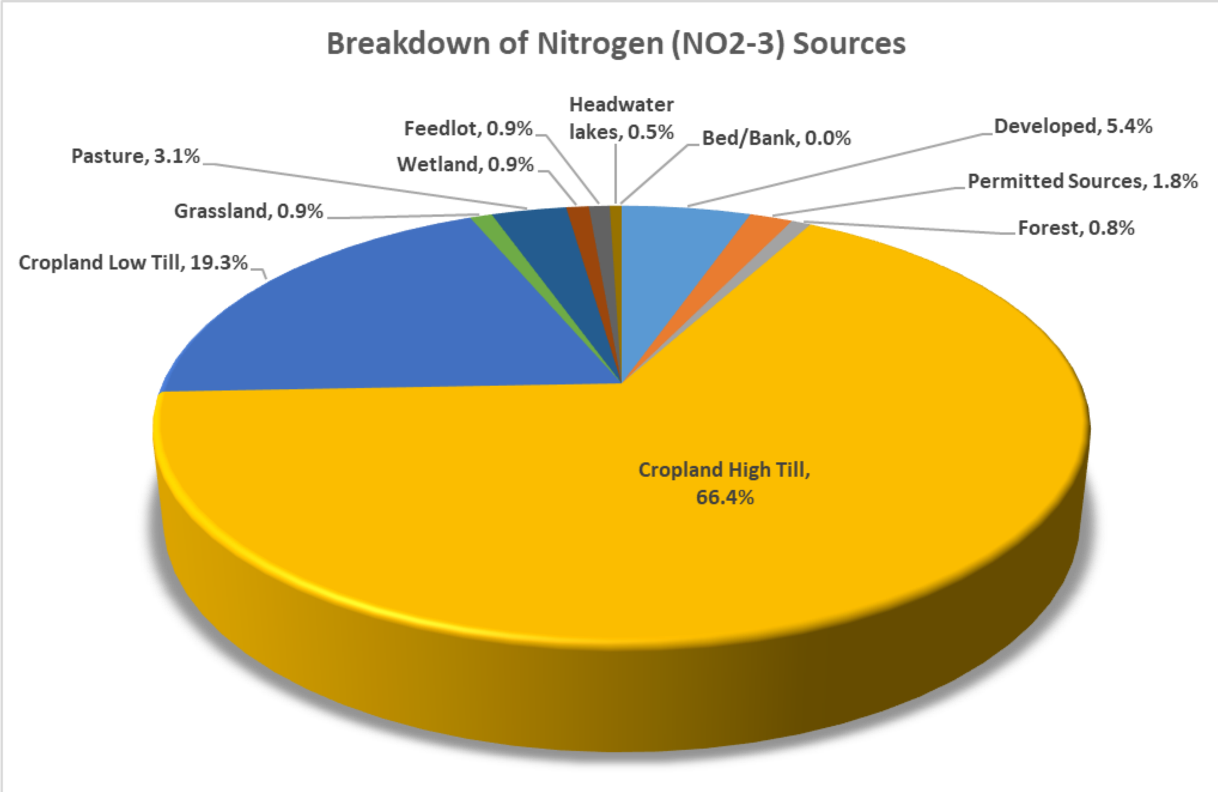


Nitrate – Nitrite Nitrogen

Nitrate and nitrite-nitrogen are inorganic forms of nitrogen present within the environment that are formed through the oxidation of ammonia-nitrogen by nitrifying bacteria (nitrification). These and other forms of nitrogen exist naturally in aquatic environments; however, concentrations can vary drastically depending on season, biological activity, and anthropogenic inputs (MPCA 2011a). Excessive levels of nitrate-nitrite nitrogen can have negative effects on nitrogen sensitive aquatic species, as well as pose drinking water health concerns for humans. Minnesota has established a nitrate-nitrite nitrogen standard for Class 1 streams to be protective of drinking water sources (10 mg/L; ROS 2024). No streams or ditches in the Pomme de Terre River Watershed were assessed against the 10 mg/L drinking water standard for nitrate-nitrite nitrogen since there are no communities that pull their water from surface waters. In the Pomme de Terre River Watershed there are also no drinking water-protected surface waters designated as Class 1B and 1C.

The HSPF model (2008 through 2017) breakdown of nitrogen sources by land cover are shown in Figure 31. The model predicts that 89% of the nitrogen is coming from agricultural land covers and roughly 11% from other land covers.

Figure 31. Breakdown of nitrogen sources by land cover (HSPF 2008 – 2017).



WPLMN monitoring has found that the FWMC for nitrate-nitrite nitrogen at Appleton was consistently below 3 mg/L between 2007 and 2020 (Figure 32) (288 samples) which is low for watersheds in the Minnesota River Basin. The northern site near Hoffman on CR76 has been consistently below 1 mg/L (216 samples). Nitrogen levels are close to six times higher at the Appleton site than at the CR76 site; this suggests that the southern half of the watershed contributes significantly more nitrogen to the river than the northern half (Figure 32). Figure 32 also demonstrates that there is considerable fluctuation from one year to the next.

Additional surface water sampling conducted between 2009 and 2018 found most samples were below 10 mg/L. One monitoring site did stand out. Site S009-449 on JD2 in Swift County averaged 14.4 mg/L and ranged between 1.6 and 29 mg/L (Figure 33; 20 samples). The Pomme de Terre River Watershed SID Report (2024a) also flagged nitrogen in this reach as being a stressor to aquatic biology (Table 4) and identified it as a stressor to biology in two different impairments (Table 4).

Figure 32. Annual nitrate-nitrite nitrogen FWMC for two WPLMN sites on the Pomme de Terre River (WPLMN).

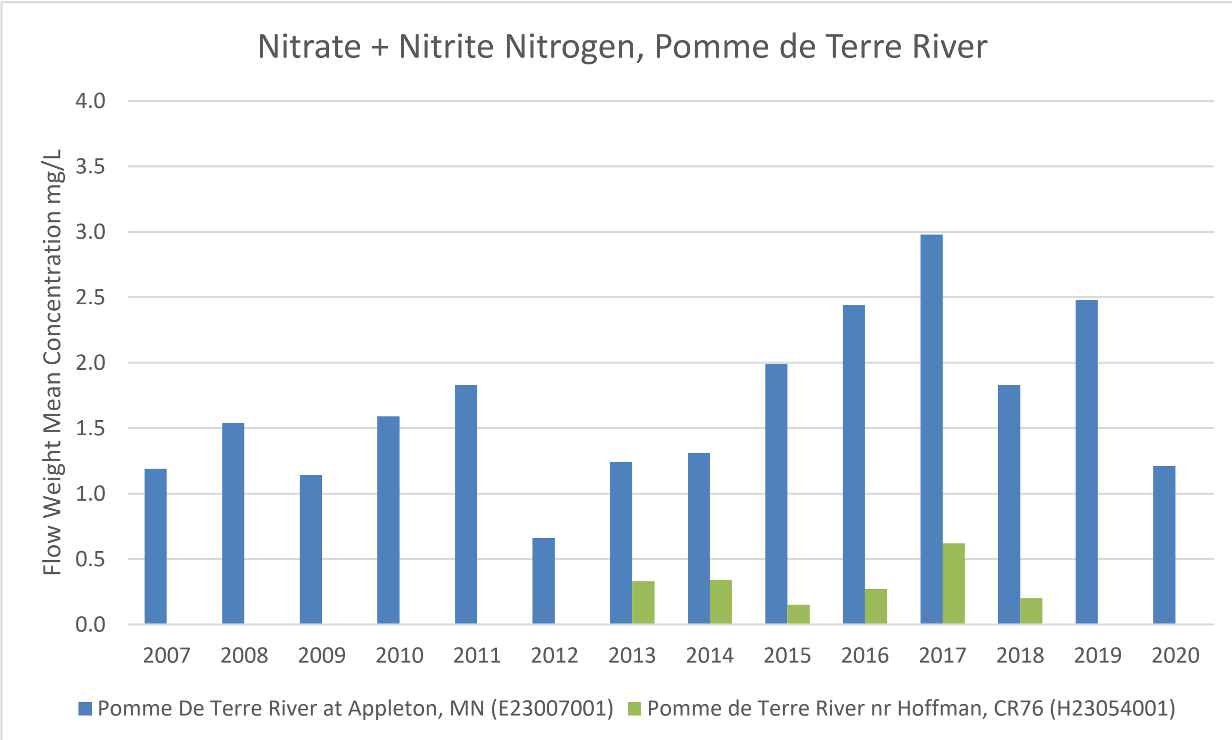
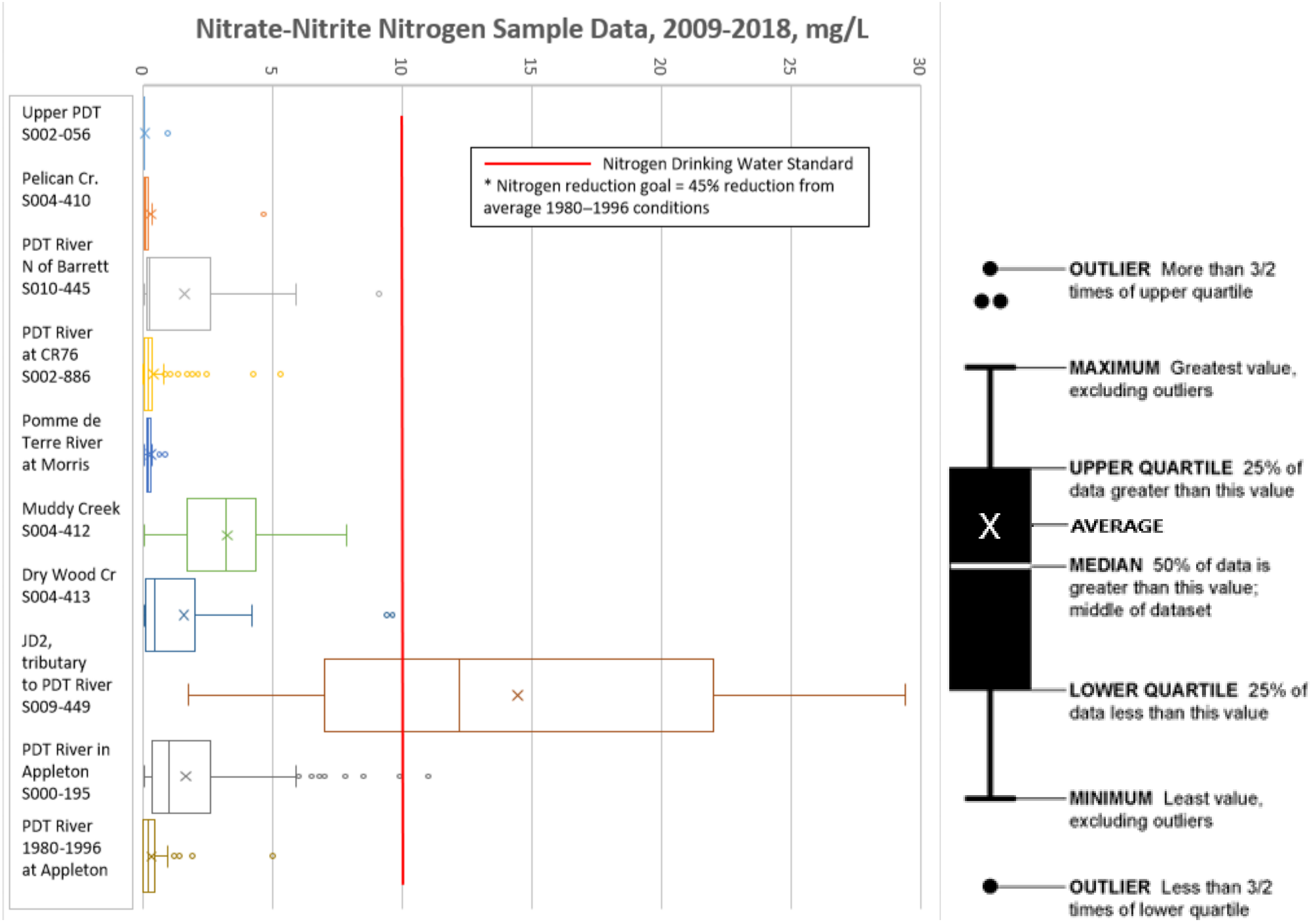
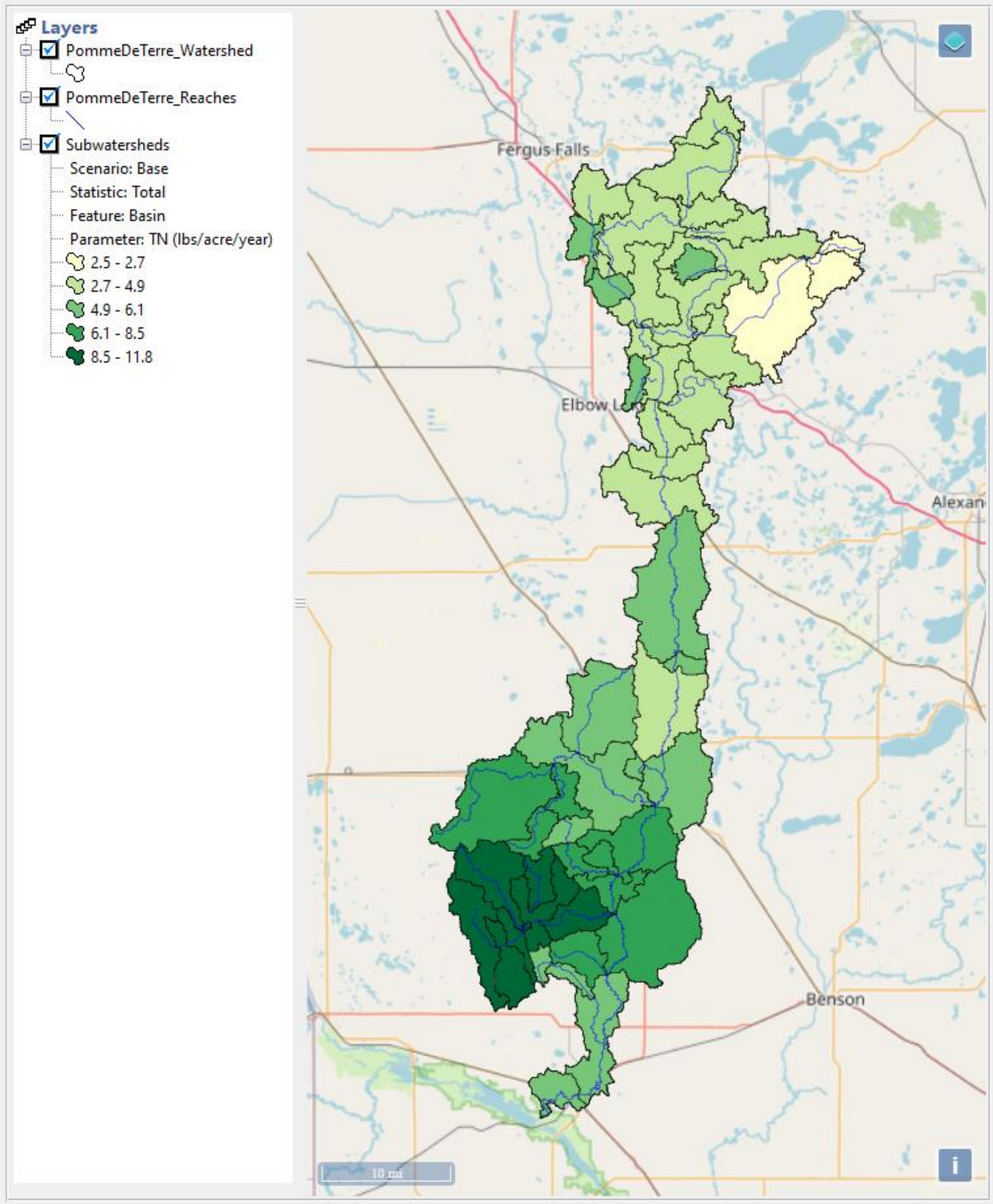


Figure 33. Pomme de Terre River sampled stream reach nitrate-nitrite nitrogen (NO2-3) sample data (2009-2018 and additional data from 1980-1996 for the Pomme de Terre River in Appleton).



A subwatershed view of nitrogen loading rates in lbs/acre is shown in Figure 34. The HSPF model shows the southern half of the watershed as contributing the most nitrogen per acre in the Pomme de Terre River Watershed. Drywood Creek stands out in the model as the highest contributor of nitrogen on a per acre basis.

Figure 34. Nitrogen loading rate by subwatershed (HSPF 2008-2017).



Bacteria

Bacteria in Minnesota lakes and streams mainly come from sources such as failing septic systems, wastewater treatment plant (WWTP) releases, livestock, and urban stormwater. Waste from pets and wildlife is another, much smaller source of bacteria. In addition to bacteria, human and animal waste may contain pathogens such as viruses and protozoa that could be harmful to humans and other animals (MPCA 2021). High levels of bacteria can result in closed swimming areas. This can severely impact the livelihood of industries and communities that cater to water-related activities. Additionally, high levels of bacteria can negatively influence the health of livestock and wildlife that use surface waters as their drinking water source.

The level of bacteria in surface waters is influenced by seasonal weather patterns, rainfall, stream flow, water temperature, distance from pollution sources, livestock management practices, manure management, and wildlife activity. In addition, bacteria in stream sediments can survive and reproduce for extended periods (Stocker 2019).

Eight stream reaches in the Pomme de Terre River Watershed have been assessed for *E. coli* bacteria. Of those eight reaches, three new reaches were listed and two others previously listed were found to be still impaired in the most recent 10-year assessment period (Minnesota 2024 Impaired Waters List).

E. coli levels tend to be high in the warmer months and continue to rise even as flows decline in the summer months as evidenced in the data from Pelican Creek in Figure 35 and Muddy Creek in Figure 35.

Figure 35. *E. coli* (cfu/100 mL) by month in Pelican Creek (07020002-506) at monitoring station S004-410 (2010, 2012, 2016-2018). The red lines represent the water quality standards for Class 2 waters (the monthly geomean of 126 cfu/100 mL and the acute standard of 1,260 cfu/100 mL). (MPCA 2024b)

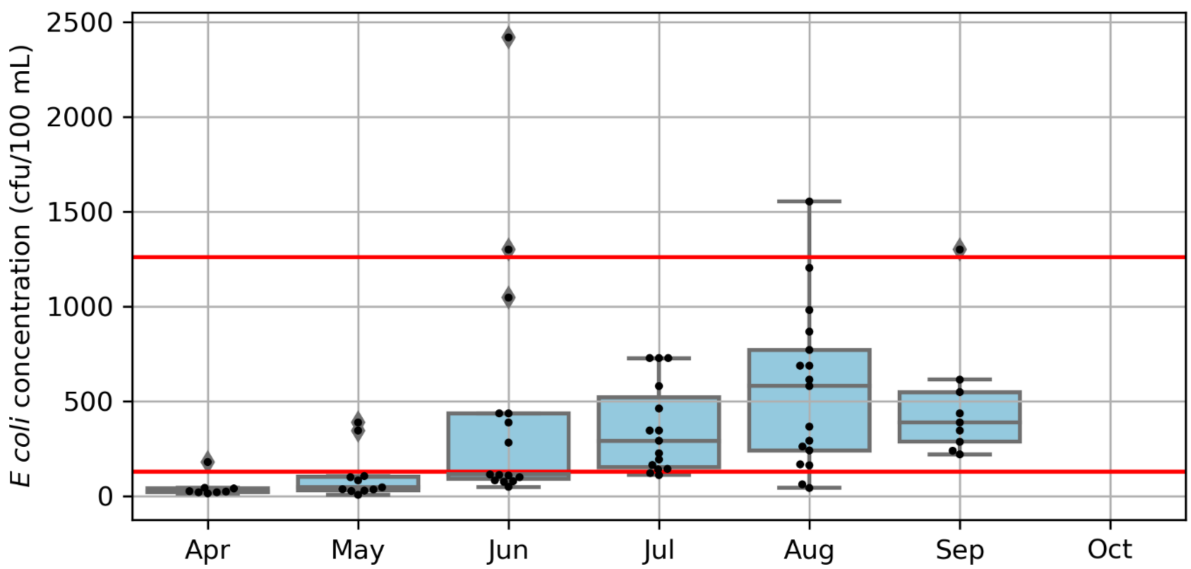
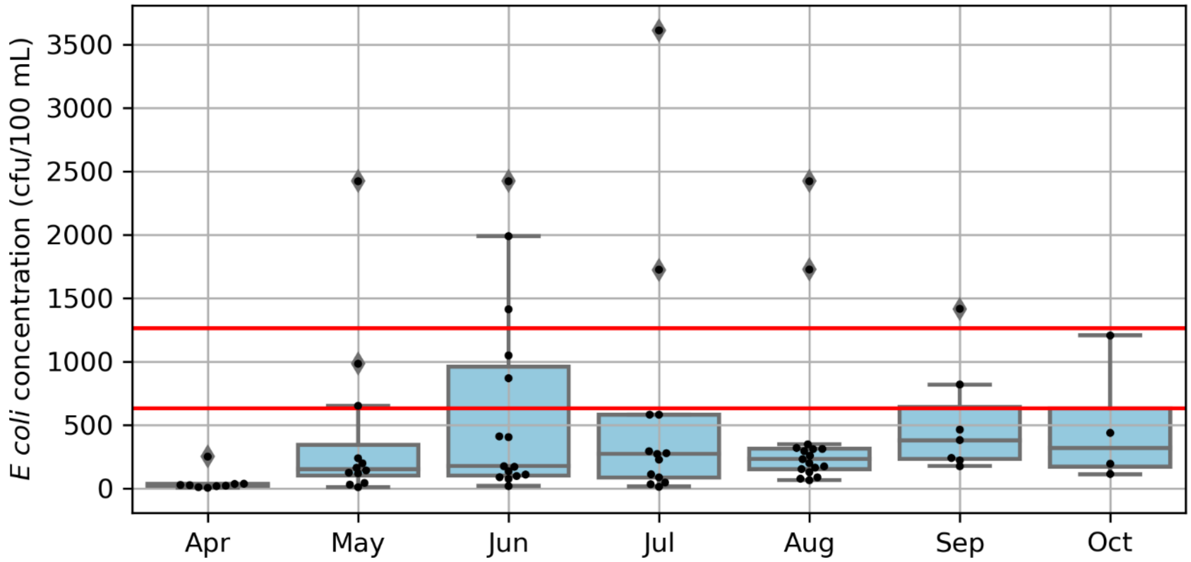


Figure 36. *E. coli* (cfu/100 mL) by month in Muddy Creek (07020002-511) at monitoring station S004-412 (2010, 2012, 2016-2018). The red lines represent the water quality standard for Class 7 waters (the monthly geomean of 630 cfu/100 mL and the acute standard of 1,260 cfu/100 mL). (MPCA 2024b)



Permitted Point Sources of Pollutants

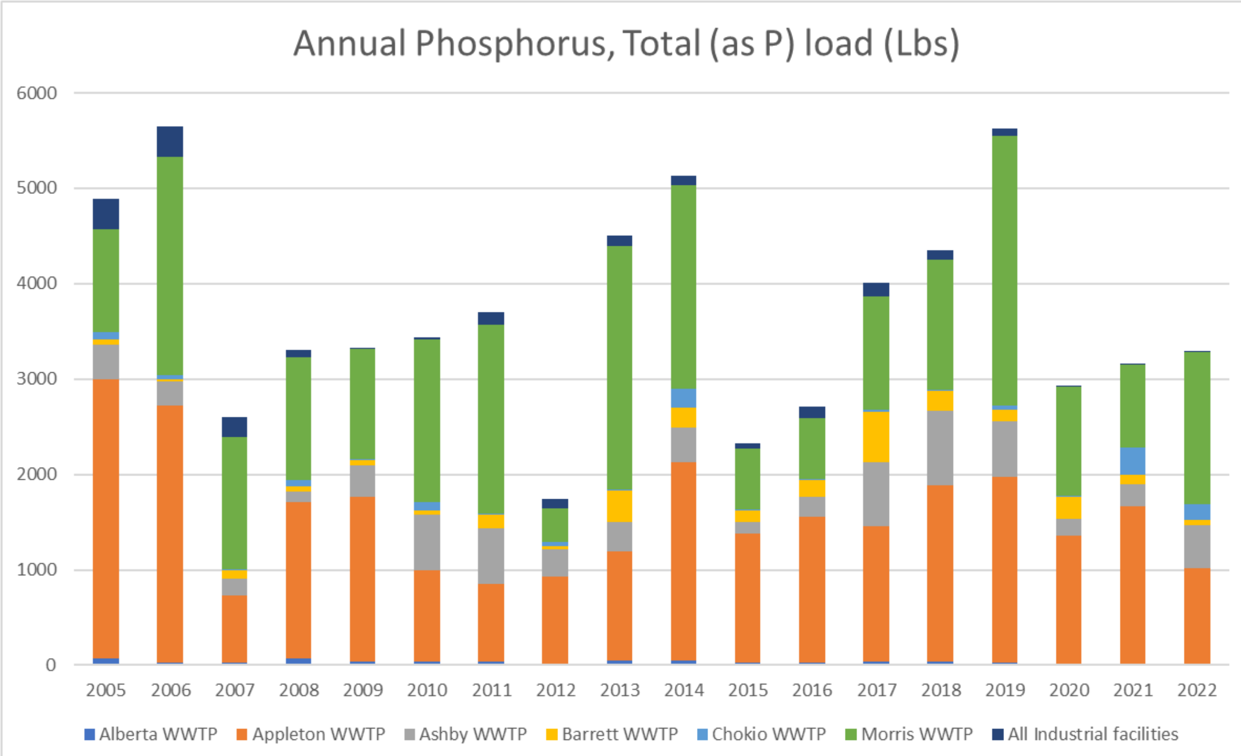
The Pomme de Terre Watershed is mostly a rural watershed dominated by nonpoint source pollution. However, permitted point sources of pollution, such as WWTPs, are present in the watershed and can be significant sources under low flow conditions. The wastewater permitted point sources within the watershed are detailed in Table 9.

Table 9. Point sources in the Pomme de Terre River Watershed.

Point source		
Name	**Permit #**	**Type**
Alberta WWTP	MNG585002	Municipal wastewater
Appleton WWTP	MN0021890	Municipal wastewater
Balgaard Family Holdings	MNG490683	Industrial wastewater
Barrett WWTP	MN0022713	Municipal wastewater
Chokio WTP	MNG640022	Municipal wastewater
Chokio WWTP	MNG585007	Municipal wastewater
Ashby WWTP	MNG580087	Municipal wastewater
DENCO II LLC	MN0060232	Industrial wastewater
Morris WWTP	MN0021318	Municipal wastewater

TP loading from 2005 to 2022 from wastewater facilities in the Pomme de Terre River Watershed is shown in Figure 37. The highest annual total loading from all wastewater permitted sources was 5,640 lbs in 2006. Most of the permitted phosphorus loading between 2005 and 2022 was from Morris and Appleton WWTPs. It is likely that future phosphorus loading from WWTPs will be limited based on implementation of permitting requirements. Wastewater treatment plant progress for phosphorus is measured by comparing pollutant loads from the current three-year average to the 2005-2007 baseline average. The average TP loading from permitted sources from the most recent 2020-2022 three-year period indicates permitted phosphorus loads have decreased 56% since the 2005-2007 baseline average. The 2005-2007 baseline is a meaningful baseline because in 2005, new state rules regarding the streamlining of data reporting increased the number of facilities reporting data. [Wastewater loading by facility | Tableau Public](https://public.tableau.com).

Figure 37. Annual permitted phosphorus loading from municipal wastewater treatment facilities. (MPCA WWTP)



Municipal, construction, and industrial stormwater

Stormwater systems in some communities, dependent on size and location, are regulated under the Municipal Separate Storm Sewer System (MS4) program, which requires the use of BMPs to reduce pollutants. Morris is currently the only regulated MS4 within the Pomme de Terre River Watershed.

Construction stormwater (CSW) is runoff from construction sites. Construction projects that disturb: (a) one acre of soil or more, (b) less than one acre of soil but are part of a "larger common plan of development or sale" that is greater than one acre, or (c) less than one acre, but determined to pose a risk to water quality are regulated under the state's National Pollutant Discharge Elimination System (NPDES) permit. These projects are required to use BMPs to reduce pollutant runoff. Based on CSW permit data, less than 0.03% of the Pomme de Terre River Watershed is impacted by construction projects a year.

Similar to construction projects, industrial stormwater (ISW) sites are regulated through general permits under the NPDES program. ISW permitted facilities must have either no discharge or manage discharge with sufficient BMPs to protect water quality. Most of the ISW sites are centered around the city of Morris, with several sand and gravel facilities located along the Pomme de Terre River. Active ISW permitted facilities are listed in Table 10. According to permit data, as of 2024, very few of the facilities have reported any stormwater discharge in the last 10 years, and none in the last 5 years.

Table 10. Industrial stormwater facilities in the Pomme de Terre River Watershed.

Facility Name	Permit Number
Brown-Wilbert Inc Morris	MNR0539T6
Mark Sand & Gravel Co.	MNR053C4R
Morris Sand & Gravel Inc	MNR0538Q4
Westmor Industries LLC	MNR0539NM
Stevens County Demolition ISW	MNR0538PW
Superior Industries, Inc.	MNR0539H7
Morris Municipal Airport	MNR053CBH
Riley Brothers Construction Inc	MNR053FH6
Wilkens Truck & Trailer	MNR053C9F
Anderson Brothers Construction Co	MNG490001
Mark Sand & Gravel Acquisition Co	MNG490125
Central Specialties Inc	MNG490071
Holcim – MWR Inc	MNG490073
JME of Monticello Ready Mix & Aggregate	MNG490281
Shafer Contracting Co Inc	MNG490277

Animal Feeding Operations

Livestock are potential sources of bacteria, phosphorus, and nitrogen to streams in the Pomme de Terre River Watershed, particularly when direct access is not restricted and/or where feeding structures are located adjacent to riparian areas.

Minn. R. ch. 7020 governs the permitting, standards for discharge, design, construction, operation, and closure of animal feeding operations (AFOs) throughout Minnesota. An AFO is a site where animals are confined for 45 days or more in a 12-month period and vegetative cover is not maintained.

Concentrated animal feeding operations (CAFOs) is an EPA definition that implies not only a certain number of animals but also specific animal types. CAFO size is based on number of animals (head count) and can include large, medium, and small CAFOs. For example, 2,500 head of swine weighing 55 lbs or more is considered a large CAFO and 1,000 head of cattle other than mature dairy or veal calves are a large CAFO. However, a site with 2,499 head of swine weighing 55 lbs or more, or a site with 999 head of cattle other than mature dairy would be considered a medium CAFO. The MPCA currently uses the federal definition of a CAFO in its permit requirements of animal feedlots along with the definition of animal unit (AU). In Minnesota, a NPDES permit is required for facilities that exceed any of the federal large CAFO threshold numbers and discharges to waters of the United States. State Disposal System (SDS) permits are required for any facility that has a capacity of 1,000 AUs or more. Facilities required to obtain SDS permit coverage may choose to obtain NPDES coverage in lieu of the SDS permit. CAFOs with less than 1,000 AUs capacity that do not discharge to waters of the United States are not required to obtain NPDES Permit coverage.

CAFO production areas need to be designed, constructed, operated, and maintained to contain all manure, manure-contaminated runoff, or process wastewater, and direct precipitation. CAFOs and AFOs with 1,000 or more AUs must be designed to contain all manure and manure contaminated runoff from precipitation events of less than a 25-year–24-hour storm event. Having and complying with an NPDES permit allows some enforcement protection if a facility discharges due to a 25-year–24-hour precipitation event (approximately 4.56" in 24 hours) and the discharge does not contribute to a water quality impairment. Large CAFOs permitted with an SDS permit, or those not covered by a permit, must contain all runoff, regardless of the precipitation event. Therefore, many large CAFOs in Minnesota have chosen to have an NPDES permit, even if discharges have not occurred in the past at the facility. A current manure management plan (MMP), which complies with Minn. R. 7020.2225, and the respective permit is required for all CAFOs and AFOs with 1,000 or more AUs. Additionally, MMP requirements for CAFOs are more stringent than for smaller feedlots. CAFOs are inspected by the MPCA in accordance with the MPCA NPDES Compliance Monitoring Strategy approved by the EPA. All CAFOs (NPDES permitted, SDS permitted, and not required to be permitted) are inspected by the MPCA on a routine basis with an appropriate mix of field inspections, offsite monitoring, and compliance assistance.

Feedlots under 1,000 AUs and those that are not federally defined large CAFOs do not operate with permits; however, the requirements under Minn. R. chs. 7020, 7050, and 7060 still apply. In Minnesota, feedlots with greater than 50 AUs, or greater than 10 AUs in shoreland areas, are required to register with the state. Facilities with fewer AUs are not required to register with the state. Feedlot registration enables the County and the MPCA to communicate directly with feedlot owners regarding all aspects of feedlot management including technical requirements, permitting, inspections and corrective action. Registration also helps ensure that surface waters are not contaminated by the runoff from feeding facilities, manure storage or stockpiles, and cropland with improperly applied manure. Livestock are also part of hobby farms, which are small-scale farms that are not large enough to require registration but may have small-scale feeding operations and associated manure application or stockpiles.

The number of AUs in the Pomme de Terre River Watershed fluctuates from year to year (Figure 38). The number has been as low as 96,355 in 2023 and as high as 114,387 in 2014. The number of active feedlots has been decreasing from its high of 325 active permits in 2009 to 149 in 2023. At the same time, the average number of AUs per permit has increased from 350 to 504 (Figure 39).

Inactive or abandoned feedlots can present a risk to water quality as they may leach contaminants, particularly nitrate-nitrogen, into groundwater for years if the site is not reclaimed to address this excess nitrogen source (MDH 2012). Assisting in decommissioning feedlots can represent a cost to watershed conservation funds.

Figure 38. Registered animal units in the Pomme de Terre River Watershed.

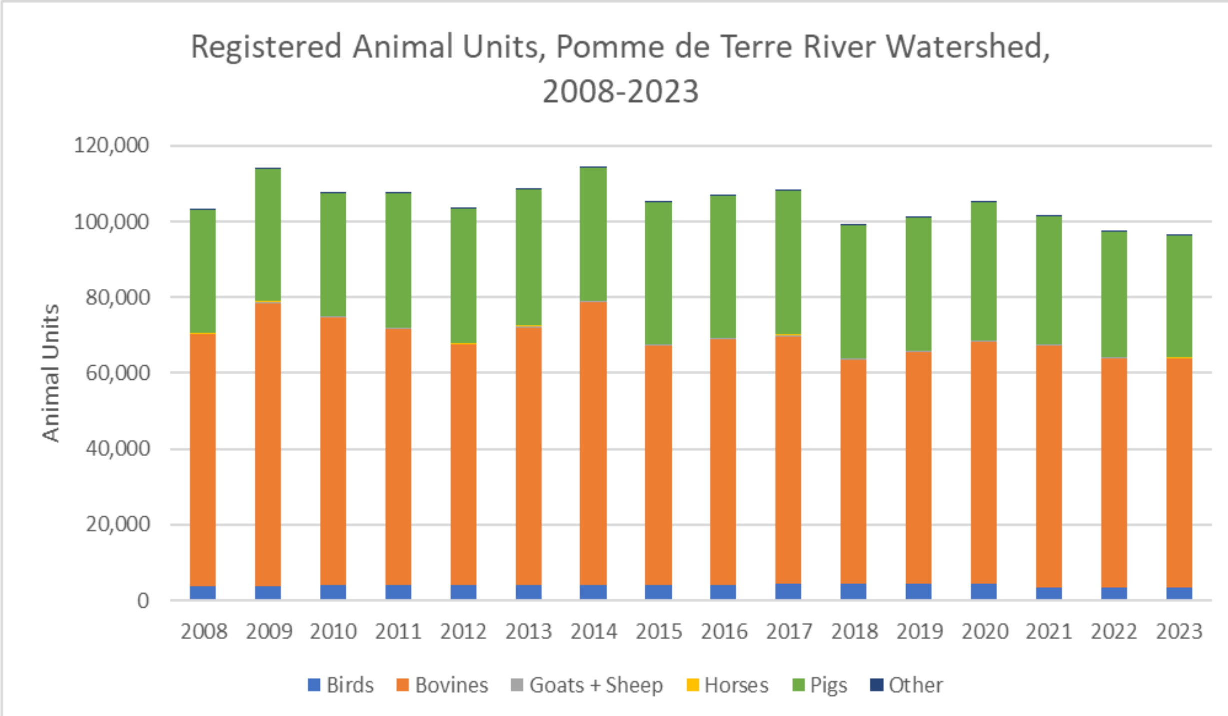
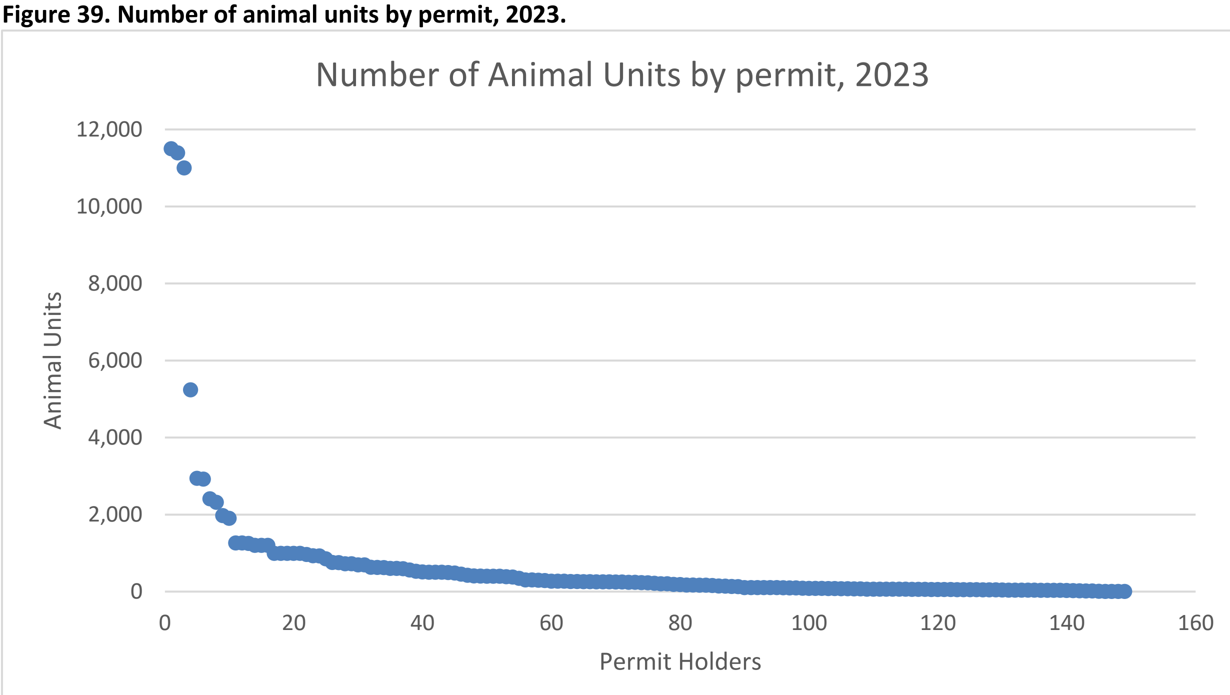


Figure 39. Number of animal units by permit, 2023.



In 2023, there were approximately 96,300 AUs of various species reported in the Pomme de Terre River Watershed. Sixteen permits had greater than 1,000 AUs and accounted for 60,937 AUs (63%) with three permits accounting for one third of the total AUs in the watershed. There were 133 permits with less than 1,000 AUs accounting for the remaining 35,359 AUs (37%).

Because most feedlots are regulated to have minimal runoff, the largest water quality risk associated with feedlots is from the land-applied manure. Manure is a by-product of animal production and large numbers of animals create large quantities of manure. This manure is usually stockpiled and then spread over agricultural fields to help fertilize the soil. When stored and applied properly, this beneficial re-use of manure provides a natural source for crop nutrition. Manure, however, can pose water quality concerns when it is not applied properly or leaks or spills from nearby fields, storage pits, lagoons, tanks, etc.

There is some potential for late winter solid manure application (before the ground thaws) in the Pomme de Terre River Watershed. During this time the manure can be a source of nutrients and pathogens in rivers and streams, especially during precipitation events. For feedlots with NPDES permits, surface applied solid manure is prohibited during the month of March. Winter application of manure (December through February) for permitted sites requires fields are approved in their MMP and the feedlot owner/operator must follow a standard list of setbacks and BMPs.

Short term stockpile sites are defined in Minn. R. Ch. 7020 and are considered temporary. Any stockpile kept for longer than a year must be registered with the MPCA and would be identified as part of a feedlot facility. Because of the temporary status of the short-term stockpile sites, and the fact they are usually very near or at the land application area, they are included with the land applied manure.

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 below the soil surface (Minn. R. 7001).

The Pomme de Terre River Watershed’s approximately 96,300 AUs produce roughly 5.8 million lbs of phosphorus and 14.4 million lbs of nitrogen a year through manure. To be economically viable, manure generally needs to be transported and applied on fields relatively close to its source. Therefore, having enough acres to spread manure has been a growing concern in the Pomme de Terre River Watershed. A 2020 review of fertilizer sales, the density of AUs, and distance to fields found that portions of the Pomme de Terre River Watershed are likely receiving as much as 25 lbs/acre/yr of excess phosphorus above the needs of crops from the combination of animal manure and fertilizer (Porter and Cox 2020).

There have been public concerns noted about spreading manure onto farm fields at higher than agronomic rates. A 2014 Minnesota Department of Agriculture (MDA) survey of self-reporting farmers planting corn following soybeans in fields with manure (MDA 2014) found that nitrogen was applied above recommended University of Minnesota (UMN) levels in 73% of the fields reported. The study also noted that there was no statistical yield benefit in the over fertilized farm fields over the fields where UMN rates were followed. The study did not report on phosphorus applications (Figure 40 and Table 11).

The Pomme de Terre River Watershed TMDL Report (MPCA 2024b) found that feedlots and applied manure have a moderate potential to contribute to the *E. coli* impairments in Muddy Creek (07020002-511) and the Unnamed Creek (07020002-547).

Figure 40. Percentage of fields applying nitrogen within the U of MN recommended range for corn following soybeans in the southwestern and west central region of Minnesota. Nitrogen was applied with manure or with manure and commercial nitrogen fertilizer on 59 fields (MDA 2014).

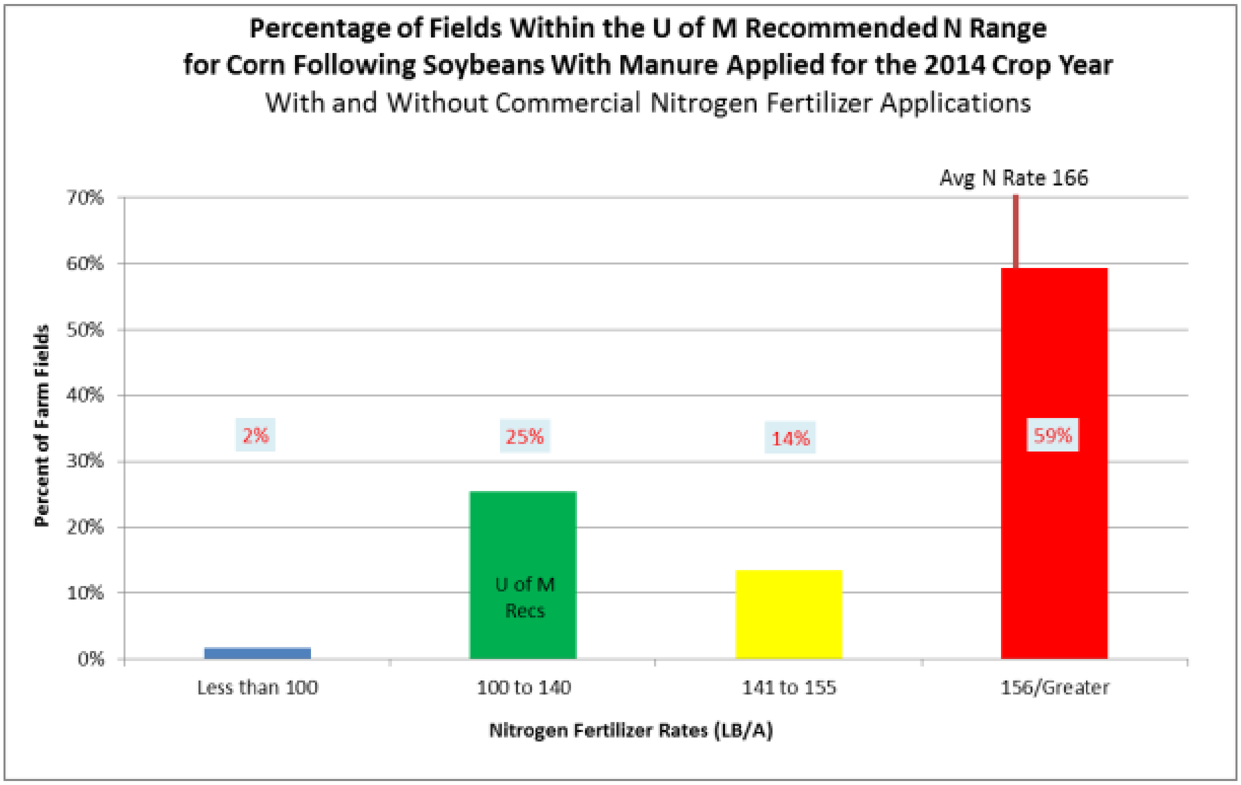


Table 11. Nitrogen rates and associated yields for corn following soybeans applied with manure or with manure and commercial nitrogen fertilizer for the 2014 crop year in Southwestern and West Central region (MDA 2014).

N Fertilizer Ranges	<100 lbs/ac	100-140 lbs/ac	141-155 lbs/ac	Over 156/ lbs/ac
Avg Bu/Ac	130	176	183	179
Avg N Rate/Ac	45	127	150	190

4. Prioritizing and Implementing Restoration and Protection

The Clean Water Legacy Act (CWLA) requires that WRAPS Updates summarize water quality conditions including waters in need of restoration and protection, sources of pollution and stressors, modeling outputs, and pollutant load allocations used to develop restoration and protection strategies that inform local water planning and implementation (ROS 2022). The CWLA also requires an accounting of strategies and actions that are capable of cumulatively achieving needed pollution load reductions for point and nonpoint sources.

This section of the WRAPS Update provides the results of such prioritization and strategy development. Because many of the nonpoint source strategies outlined in this section rely on voluntary implementation by landowners, land users, and residents of the watershed, it is imperative to build relationships and create social capital (trust, networks, and positive relationships) with those who will be needed to voluntarily implement BMPs. Thus, effective ongoing public participation is paramount for strategies to move forward.

The implementation strategies, including associated scales of adoption and timelines, provided in this section are the result of watershed modeling efforts and professional judgment based on what is known at this time and, thus, should be considered approximate. Furthermore, many strategies are predicated on securing funding. As such, the proposed actions outlined are subject to adaptive management—an iterative approach of implementation, evaluation, and course correction.

4.1 Watershed Targets and Goals

TMDL Reductions Needed to Achieve Water Quality Standards

Table 12 lists the impaired waters of the Pomme de Terre River Watershed and the pollution reductions needed to achieve water quality standards.

The sum of the watershed's TMDL reductions needed to meet water quality standards are 72,462 lbs per yr of phosphorus and approximately 5,954 tons per yr TSS. *E-coli* TMDLs document a need for between 40% and 90% reductions for large portions of the watershed (MPCA 2015, MPCA 2024b).

Table 12. TMDL reduction goals for impaired water bodies in the Pomme de Terre River Watershed.

County	Water Body ID	Water Body Name	Pollutant/ Stressor	First Listed	TMDL Source	Reductions needed	
						lbs/yr	Percent
Big Stone	07020002-566	Unnamed creek	Nutrients: Phosphorus	2020	MPCA, 2024b		78%
Douglas	21-0375-00	Christina Lake	Nutrients: Phosphorus	2010	MPCA, 2015	1,942	
Grant	26-0095-00	Barrett Lake	Nutrients: Phosphorus	2020	MPCA, 2024b	6,031	
	07020002-506	Pelican Creek	*E. coli*	2020	MPCA, 2024b		66%
			TSS	2020	MPCA, 2024b		64%
Otter Tail	56-0379-00	North Turtle Lake	Nutrients: Phosphorus	2012	MPCA, 2015	466	
Stevens	75-0200-00	Hattie Lake	Nutrients: Phosphorus	2012	MPCA, 2015	2,122	
	07020002-511	Muddy Creek	*E. coli*	2020	MPCA, 2024b		49%
	75-0075-00	Perkins Lake	Nutrients: Phosphorus	2010	MPCA, 2015	5,568	
Swift	07020002-556	Dry Wood Creek	Dissolved oxygen	2012	MPCA, 2015		
			E. coli	2010	MPCA, 2015		48%
			Turbidity	2010	MPCA, 2015		40%
	76-0169-00	North Drywood Lake	Nutrients: Phosphorus	2020	MPCA, 2024	41,526	
	07020002-501	Pomme de Terre River	Fecal coliform	1994	MPCA, 2007		39%
			Turbidity	2002	MPCA, 2011		53%
	76-0149-00	South Drywood Lake	Nutrients: Phosphorus	2020	MPCA, 2024	14,807	
	07020002-547	Unnamed creek	*E. coli*	2022	MPCA, 2024		90%
			TSS	2023	MPCA, 2024		30%

Minnesota's Nutrient Reduction Strategy Goals

The State of Minnesota developed the Nutrient Reduction Strategy (NRS) to provide guidance on reducing nutrient loading to the waters of the State to help meet water quality goals (MPCA 2014). This report uses the information from the NRS to develop local goals for nutrient reduction. The full report can be found at the links below.

The Minnesota Nutrient Reduction Strategy

Reducing Nutrients in Waters

To achieve downstream nutrient reduction, Minnesota's 2014 NRS calls for each eight-digit HUC major watershed (HUC-8) to reduce nutrient loading to cumulatively achieve goals for the Mississippi River, Red River, and Lake Superior. If each watershed reduces a fraction of its reducible or anthropogenic nutrient loads, then downstream nutrient goals can be met and local waters within HUC-8s will be markedly improved.

Recent guidance for the Minnesota NRS Goals was completed in 2022 at the link here:

Nutrient Reduction Strategy Goals

This guidance document was created to provide updated nutrient load reduction estimates from individual watersheds to reduce Minnesota's contribution to restore and protect downstream waters such as the Gulf of Mexico, Lake Winnipeg, and the Great Lakes. The document also provides information on how to estimate BMP activities that will achieve specific watershed nutrient load reductions for nitrogen and phosphorus.

These updated watershed load reduction targets incorporate additional monitoring data and advanced modeling. They also account for the limited nutrient load reductions that can be achieved from nondeveloped lands. While the 2014 NRS focused on milestone goals for 2025, the updated loads in the 2022 guidance focus on the final goals for 2040. The load reduction goals are currently called "interim," since they were developed mid-way between the original 2014 NRS and the updated/revised NRS expected in 2025. The revised NRS will incorporate these load reduction targets, after first including any additional watershed modeling updates. While some adjustments to these "interim" load goals may be made in the revised NRS, major changes to these load targets are not expected (MPCA 2022).

Table 13. Minnesota's Nutrient Reduction Strategy Goals for the Pomme de Terre River Watershed load reduction targets are intended to meet the final 2040 goals in metric tons and percent.

Nutrient	Recent avg TN or TP load at HUC-8 outlet (MT/yr)	Final goal TN or TP load at HUC-8 outlet (MT/yr)	TN or TP Load reduction at HUC-8 outlet to meet final goal (MT/yr)	Percent reduction target (from recent total HUC-8 loads)
Nitrogen	664	387	277	41.70%
TP	52	38.3	13.7	26.40%

4.2 Tools for Estimating Restoration and Protection Scenarios

Certain models and tools can be used to estimate typical nutrient reductions expected from combinations of BMPs on a watershed scale. None of the tools represent an exact science, and the results will vary among tools. However, tools can be used to provide a general idea of the magnitude of adoption needed to achieve nutrient watershed reduction goals. The following provides the latest information about these different tools and examples of how they have been applied in the Pomme de Terre River Watershed.

HSPF-Scenario Application Manager:

RESPEC's HSPF Scenario Application Manager (HSPF-SAM) is a decision-support tool for planning and implementing targeted actions to restore or protect water quality. HSPF-SAM begins with a calibrated and validated HSPF model and uses: a Geographic Information System (GIS) for BMP site selection; a BMP database with pollutant removal efficiencies and associated costs; and scenario analysis, optimization, and reporting capabilities. HSPF-SAM can also apply three climate change scenarios to model a low, medium, and high level of temperature change.

HSPF-SAM can generate predicted nutrient and sediment load changes associated with new BMPs and/or land use changes. HSPF-SAM provides a user interface to the HSPF modeled nutrient and sediment load estimates, which have been calculated for most of Minnesota. HSPF-SAM uses typical BMP effectiveness values from research results to estimate load reductions from agricultural BMP and wastewater nutrient reduction scenarios. HSPF-SAM also includes some limited options for urban stormwater and forestry BMPs. In addition to BMP scenario development, HSPF-SAM also has many other uses that can help with watershed planning, (i.e., point source evaluations, priority area determination, pollutant loads in different places/times, etc.).

The HSPF-SAM results of nutrient load reductions vary from one watershed to another, largely because each watershed has different land, soil, and hydrologic conditions that affect nutrient transport to waters. The HSPF-SAM results of BMP effects on water quality in any given watershed are provided in a tableau format using the Watershed Pollutant Load Reduction Calculator.

To answer the question of what it will take to achieve or come close to water quality goals, an example of the HSPF-SAM-derived nutrient load reduction estimates per acre of BMP adopted is shown in Table 14 for the Pomme de Terre River Watershed HUC-8 outlet. Note that these are typical or average reductions from the BMPs expected when adopted across the watershed, and that more nutrient reduction can sometimes be achieved by only targeting the lands that are the very highest nutrient contributing lands. Cost projections for the various BMPs modeled were derived by doubling the Minnesota 2022 Environmental Quality Incentives Program (EQIP) payment schedule. The costs produced in this report are reported as an annual cost and the expectation is that payments would have to continue for 10 years to be effective.

The target chosen for the TSS goal came from the 2011 Pomme de Terre River turbidity TMDL (MPCA 2011b), which calls for a 53% reduction at the river's outlet. The target chosen for the TP and total nitrogen (TN) goals came from Minnesota's Nutrient Reduction Strategy final 2040 goals for the Pomme de Terre River Watershed (MPCA 2022), which call for a TP reduction of 26.4% and a TN reduction of 41.7%. More specific subwatershed targets can be calculated for individual TMDLs.

The HSPF-SAM results (Table 14) are a mix of BMPs that bring the Pomme de Terre River closer to its pollution reduction targets. It is just one possible collection of BMPs; it is not necessarily the most efficient or the most cost-effective possibility. It does use a mix of BMPs that have recently been found acceptable by farmers in the Pomme de Terre River Watershed.

Model results (Table 14) suggest that for a cost of $159 million (about $16 million/year over the next 10 years) it may be possible to achieve 177% of the phosphorus, 100% of the TSS and 25% of the nitrogen reduction goals. This scenario would require 534,700 acres of new practices on this 560,233-acre watershed, roughly 96% of the watershed. If one considers that most of the BMPs suggested are for agricultural lands (roughly 351,000 ac) then to achieve this scenario multiple BMPs would have to be applied to the same land. The model was run to meet at least 100% of TSS and TP TMDL reduction goals. This resulted in overachieving phosphorus reductions.

It is important to note that the cost impact to the watershed may be considerably less. HSPF-SAM does not consider cost savings to the farmers from potential reduced tillage, fertilizer purchases, and other inputs. It also gives an average result for the effectiveness of BMPs, whereas optimal placement of BMPs may have a higher impact.

The scenario laid out in Table 14 is clearly a massive effort that would require an increase in conservation funding and almost the entire watershed to be involved in multiple BMPs. This scenario would need to have almost complete buy-in from the watershed’s farming community. It would represent an unprecedented increase in the use of cover crops, nutrient management, and other practices. Although the reductions of pollutants would be monumental the model scenario does not achieve 100% of the targeted reductions for nitrogen.

Table 14. HSPF-SAM-based nutrient and TSS load reduction scenario to achieve all the Pomme de Terre River TSS TMDL reductions and all or some of the 2040 nutrient reduction targets in the Pomme de Terre River Watershed.

BMP	Potential new acres affected	Annual TP reduction in lbs	Annual nitrogen reduction in lbs	Annual TSS reduction in tons	Annual cost
Alternative tile Intakes	120,000	16,800	28,800	2,400	$436,364
Conservation cover perennials	1,000	180	2,650	20	$750,000
Cover crops after early harvest crops	20,000	1,000	22,800	200	$1,400,000
Cover crops with corn and soybeans	15,000	900	12,300	150	$1,050,000
Drainage side inlet improvements	1,000	130	220	10	$37,200
Feedlot manure/runoff storage	200	202	2,090	16	$200,000
Feedlot runoff reduction/treatment	200	168	1,742	12	$200,000
Livestock access control/fencing (to waters)	2,000	100	500	8	$120,000
Manure/fertilizer incorporation (no surface spreading)	50,000	3,500	12,000		$1,100,000
Nutrient management: improved rates/timing	100,000	2,000	38,000		$2,200,000
Nutrient management: precision/variable rate		-	-		$ -
Reduced tillage (30%+ residue cover)	110,000	7,700	19,800	990	$1,430,000
Reduced tillage (strip-till)	40,000	2,800	7,200	360	$960,000
Reduced tillage (no-till)	20,000	3,000	8,800	200	$480,000
Water and sediment control basin (Cropland)	50,000	9,000	36,000	1,000	$4,500,000
Wetland construction to treat tile waters	8,000	960	14,080	80	$1,106,918
Total	**537,400**	**48,440**	**206,982**	**5,446**	**$15,970,482**
Progress toward goal		177%	25%	100%	
TMDL goal or 2040 NRS goal		**27,340**	**824,862**	**5,432.5**	
Actual reductions		46.8%	10.5%	53.1%	
TMDL goal or 2040 NRS goal		26.4%	41.7%	53.0%	

Nitrogen and Phosphorus Best Management Practices Tool

The Nitrogen and Phosphorus Best Management Practices tool (NP-BMP; Lazarus et al. 2013) is a spreadsheet tool developed by the UMN for HUC-8 or HUC-10 watershed scales throughout Minnesota cropland. The user enters agricultural BMP scenario adoption acreages, and the tool compares the effectiveness and cost of BMPs to reduce nutrient loads entering surface waters from cropland. A benefit of using NP-BMP is its ability to quickly and easily estimate watershed agricultural nutrient reductions resulting from various combinations of BMPs. It has a strong economic component to evaluate net annual costs of BMP adoption for landowners. Limitations include its coarser scale of accuracy compared to other tools and exclusion of urban and forestland BMPs.

The TP and TN reduction targets chosen for this run of the NP-BMP tool came from Minnesota's Nutrient Reduction Strategy final 2040 goals for the Pomme de Terre River Watershed (MPCA 2022), which call for a TP reduction of 26.4% and a TN reduction of 41.7%. More specific regional targets will need to be calculated for individual TMDLs.

Table 15 is the result of a NP-BMP scenario in the Pomme de Terre River Watershed using roughly similar levels of BMP adoption as previously shown for the HSPF-SAM nutrient reduction values. Different tools will provide different results since the BMP assumptions are different and the ways that load reductions are calculated are also different. Using two or more tools can provide a range of likely levels of BMP adoption needed to achieve the goals or milestone targets.

Table 15 was set to achieve 100% of the phosphorus reduction target (26.4%) and resulted in achieving 72% of the nitrogen reduction target (41.7%). The model predicts similar annual cost ($10.66 million/year) but also documents the benefits gained from reduced fertilizer costs and reduced tillage. The result is an annual cost savings of $6.03 million to farmers of the watershed. The NP-BMP tool predicts a combined total of 702,545 acres would need to be enrolled in some kind of BMP. Like the HSPF-SAM scenario, multiple BMPs would need to be applied to the same land.

Table 15. BMP scenario in the Pomme de Terre River Watershed using the NP-BMP tool.

Watershed: Pomme de Terre River

HUC10 Subwatershed: All 43

	% existing	% suitable	% adoption	% treated	% treated, combined	acres treated (000), combined
Variable rate N split-applied on corn that is currently all applied in fall or spring	NA	32.92%	50%	16.46%	13.72%	45.10
U of MN rate with inhibitor/stabilizer on fall applied corn	2.49%	14.00%	50%	7.15%	4.67%	15.34
U of MN N rate on corn without changing timing, form, or methods	NA	47.20%	50%	23.60%	19.43%	63.89
U of MN soil test-based P2O5 rate on six major crops	NA	94.07%	80%	75.26%	75.26%	247.43
Apply P as banded spring preplant/starter on fall-applied corn & wheat	21.01%	10.30%	75%	7.72%	7.72%	25.40
Use reduced tillage on corn, soy & small gr >2% slopes	31.47%	25.77%	80%	20.62%	20.62%	68.32
Treatment wetlands on tiled land	NA	10.43%	17%	1.76%	1.76%	5.80
Tile line bioreactors	NA	7.97%	25%	1.99%	1.99%	6.55
Controlled drainage	NA	7.97%	0%	0.00%	0.00%	0.00
Saturated buffers	NA	7.97%	10%	0.80%	0.80%	2.62
Alternative tile intakes	5.28%	15.84%	90%	14.25%	14.25%	74.90
Corn grain & soybean acres w/cereal rye cover crop	2.65%	80.62%	42%	34.98%	34.08%	112.03
Short season crops planted to a rye cover crop	2.65%	8.88%	50%	5.77%	5.73%	18.83
Switchgrass on marginal corn & soy land >2% slope	NA	7.80%	30%	1.64%	1.64%	5.38
Kernza on all corn & soy land	NA	85.43%	1%	0.42%	0.42%	1.37
Inject or incorp manure	NA	3.89%	75%	2.92%	2.92%	9.59

Weather scenario: Average weather - all of preplant N is available 1

Load default data | Load zeros | Recalculate

For wet spring scenario, fertilizer & manure N lost 30%

Cropland N load reduction with these adoption rates:	30.0%	1,161 (000 lb/year)
Cropland P load reduction with these adoption rates:	26.5%	41 (000 lb/year)
N fertilizer cost savings	$8.83	million/year
P fertilizer cost savings	$6.08	
Savings from reduced tillage	$1.77	
Corn yield impacts	$0.00	
Cover crop impacts	-$5.54	
Net impact of other BMPs	-$5.12	
Net BMP treatment cost (-) or savings (+)	$6.03	million/year

The scenario laid out in Table 15 is also an extensive effort that would require an increase in conservation funding and almost the entire watershed to be involved in multiple BMPs. This scenario is one of the few to succeed at meeting the TP and TSS goals. It would represent a marked increase in the use of cover crops, nutrient management, and other practices. Although the reductions of pollutants would be significant, the model suggests that it does not achieve 100% of the targeted reductions for nitrogen.

The level of adoption called for in this scenario is highly unlikely given current spending and staffing levels. It would need to have near universal buy-in from the watershed's farming community. Nonetheless, BMPs are installed one at a time and all of them are beneficial in achieving not only the watershed's targets but also the goals of the farmers' who install them.

Prioritize, Target and Measure Application

The Prioritize, Target, and Measure Application (PTMApp) is a state-wide desktop and web application which can be used by practitioners to provide the technical bridge between the general description of the types of strategies in a local water plan and the identification of implementable on-the-ground BMPs and CPs. PTMApp can be used in a workshop environment by SWCD, watershed districts, county local water planning, agency staff and decision-makers to interactively and in real-time, prioritize resources and the issues impacting them, target specific fields to place CPs and BMPs, and measure water quality improvement by tracking the expected nutrient and sediment load reductions delivered to priority resources. The tool enables practitioners to build prioritized and targeted implementation scenarios, measure the cost-effectiveness of the scenario for improving water quality, and report the results to pursue funds for project implementation.

Houston Engineering Inc. developed a targeted implementation plan for the Pomme de Terre River Watershed to improve surface water quality using PTMApp (Houston 2018). Houston reported that this targeted implementation plan (i.e., Plan) identifies technically feasible locations for BMPs and CPs (collectively referred to as Practices) on agricultural land, based on "best" (i.e., most cost effective) value. Nonstructural practices include the use of conservation tillage, cover crops, Conservation Reserve Program (CRP), and permanent vegetative cover. Structural practices are "constructed" and include farm ponds, grassed waterways, nutrient reduction wetlands, bio-reactors, and other common agricultural practices.

As part of the 1W1P effort Emmons & Olivier Resources, Inc (EOR) applied the feasible practices identified in the Houston 2018 report to the priority areas of the PDT CWMP. EOR ranked all feasible practices within each priority area from the lowest cost-benefit ($ per pound of sediment reduced) to the highest cost-benefit. EOR selected the top ranked practices based on the total number of practices the planning partners determined were feasible to implement each year. The sum of the pollutant load reductions achieved from these top ranked practices was used to determine the 10-year measurable goals for the priority resources in the CWMP (PDTRA 2020).

4.3 Priority Subwatershed Restoration and Protection Strategies

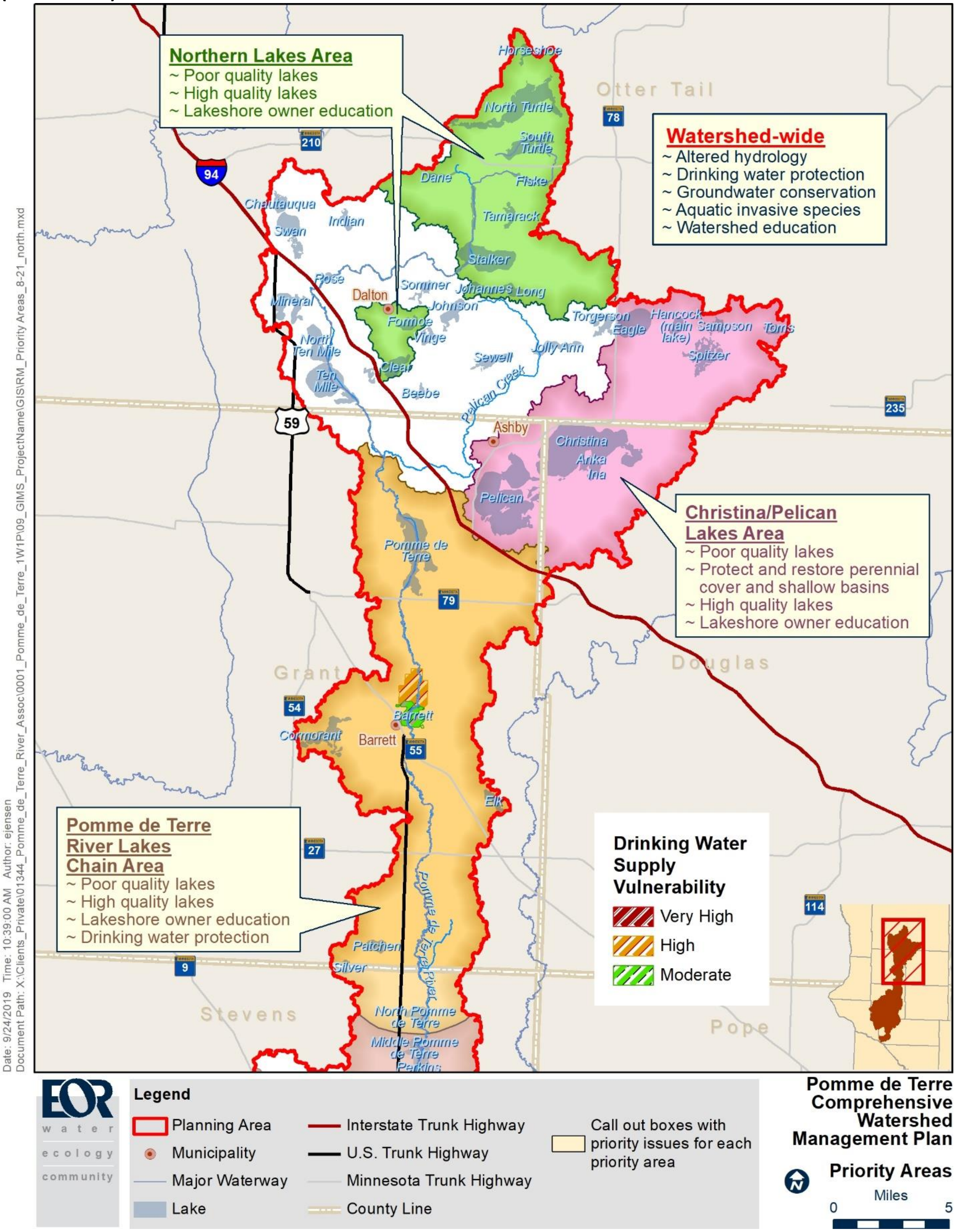
Targeting of Geographic Areas:

In the 2020 Pomme de Terre River CWMP five priority geographic focus areas were identified. The Plan identifies five priority areas where much of the work will be completed from 2021 through 2031. These priority areas were identified using: local values collected during 1W1P public meetings and one-on-one interviews; high-level priorities identified in the state's Nonpoint Priority Funding Plan (BWSR 2018); various modeling tools (e.g., Zonation conservation model and watershed pollutant loading model results); and current impairment results. The five priority areas include (from north to south): Northern Lakes Area, Christina/Pelican Lakes Area, Pomme de Terre River Lakes Chain Area, Pomme de Terre River Corridor, and the Drywood Creek Area (Figure 41 and Figure 42) (PDTRA 2020). The Plan recommends restoration and protection strategies in each priority area.

As a result of discussions between the MPCA and the PDTRA partners, it was decided that this WRAPS Update would focus on the CWMP's priority areas. What follows is a summary of the issues faced in each region and a possible load reduction scenario using the Watershed Pollutant Load Reduction

Calculator that tries to answer the question what it will take to achieve the nutrient and TSS reduction targets.

Figure 41. Pomme de Terre River Comprehensive Watershed Management Plan Priority Areas (Northern Region) (PDTRA 2020).



Northern Lakes Area:

The two impairments in this region are the nutrient impairment on North Turtle Lake and the fish bioassessment on South Turtle Lake. This priority region was additionally selected for its other highly valued lakes and the need to minimize impacts from future lake-shed development.

The North Turtle Lake TMDL identified that the lake is adversely impacted by livestock waste runoff, noncompliant septic systems, agricultural runoff, and legacy sources of phosphorus both in upstream wetlands and in North Turtle Lake itself (MPCA 2010). Further water quality sampling conducted in 2021-2022 by the North Turtle Lake Association confirmed these findings.

Considering Table 16 recommendations (below) for BMPs, the predicted high cost ($1.39 million/yr for 10 years) and high level of acreage enrollment needed (65% of the watershed), it would be prudent to consider upstream wetland mitigations, shoreline BMPs, and in-lake treatment to reduce legacy sources of phosphorus.

Recommendations for North Turtle Lake (56-0379-00) are:

- Reduce inputs of TP to the lake by 466 lbs/yr (MPCA 2015). See Table 16 below for a possible load reduction scenario to achieve all or some of the North Turtle Lake nutrient reduction targets as calculated using HSPF-SAM-based nutrient reductions and the nutrient load reduction calculator. Note that many acres would have to support multiple BMPs (e.g., strip-till and cover crops).
- Focused conservation and land management on the shoreland of the lake and upstream wetlands (MPCA 2015).
- Conduct feedlot inspections and BMP promotion (MPCA 2015).
- Increase septic compliance, especially in shoreland areas (MPCA 2015).
- Address phosphorus loading from agricultural runoff, near-stream sources, and internal loading from instream wetlands.
- Evaluate management options for the reduction of phosphorus via internal loading.
- Assess the feasibility of treatment options and develop a long-term lake management plan.

Table 16. possible load reduction scenario to achieve all or some of the North Turtle Lake nutrient reduction targets (Watershed Pollutant Load Reduction Calculator).

BMP	Potential new acres affected	Annual TP reduction in lbs.	Annual nitrogen reduction in lbs.	Annual TSS reduction in tons	Annual cost
Alternative tile Intakes	100	2	10	0.4	$400
Conservation cover perennials	1,000	30	990	4.0	$750,000
Cover crops after early harvest crops	600	6	276	1.8	$42,000
Cover crops with corn and soybeans	2,000	20	600	6.0	$140,000
Drainage side inlet improvements	-	-	-	-	$-
Feedlot manure/runoff storage	10	3	71	0.4	$10,000
Feedlot runoff reduction/treatment	10	3	59	0.3	$10,000
Livestock access control/fencing (to waters)	100	1	10	0.1	$6,000
Manure/fertilizer incorporation (no surface spreading)	3,000	30	270		$66,000
Nutrient management: improved rates/timing	4,000	12	520		$88,000
Nutrient management: precision/variable rate	1,000	30	30	30.0	$60,000
Reduced tillage (30%+ residue cover)	5,000	150	150	150.0	$65,000
Reduced tillage (strip-till)	2,000	40	580	6.0	$48,000
Reduced tillage (no-till)	1,000	20	170	4.0	$24,000
Water and sediment control basin (Cropland)	3,800	114	1,292	15.2	$68,400
Wetland construction to treat tile waters	140	3	88	0.4	$19,371
Total	**23,760**	**464**	**5,116**	**219**	**$1,397,171**
Progress toward goal		**100%**	**60%**	**N/A**	
NRS TP goal, NRS nitrogen goal, PDTR TSS TMDL		466	8,461	N/A	

In 2022, South Turtle Lake was assessed as not supporting for AQL use designation (DNR 2022).

Recommendations for South Turtle Lake (56-0377-00) are as follows (DNR 2022):

- Use BMPs to minimize inputs of excess nutrients given a large percentage of the watershed is classified as unnatural land cover.
- Promote restoration of natural shoreline buffers that contain native vegetation and protection of floating-leaf and emergent aquatic vegetation.
- Evaluate downstream dam and other crossings for potential as barriers to fish passage and restore connectivity as warranted.

Protection efforts in the Northern Lakes Region should:

- Focus conservation and land management on the shoreland of lakes, wetlands, and promote upstream BMPs.
- Target lakeshore owner education around the topics of shoreland regulations and how to be better stewards of the watershed’s lake shorelines (PDTRA 2020).

- Address phosphorus loading from agricultural runoff, near-stream sources, and internal loading from instream wetlands.

Christina/Pelican Lakes Area:

The primary impairments in this targeted subwatershed are the nutrient impairment on Lake Christina and the impairments on Pelican Creek (WID: 07020002-506) for *E. coli*, AQL (fish bioassessments) and TSS.

Lake Christina is considered one of the more important waterfowl lakes in Minnesota, and the DNR manages it for that purpose. The DNR has used lake drawdowns and rotenone treatments to control rough fish, increase water clarity, and increase aquatic plant growth.

Recommendations for Christina Lake (21-0375-00) are:

- Reduce inputs of TP to Lake Christina by 1,942 lbs/yr (MPCA 2015).
- Protect and restore perennial cover.
- Lakeshore owner education on shoreline protection and phosphorus BMPs.

Pelican Creek's watershed is roughly 130 square miles and has a diverse land cover with no one land cover dominating it. Livestock access to the creek may be driving the *E. coli* impairment, the TSS impairment and part of the AQL impairment. Efforts to control access of cattle to the creek in the past 10 years appear to have improved instream habitat enough to remove the macroinvertebrate AQL impairment suggesting that further efforts upstream may do the same. SID work on the creek identified four barriers to fish passage (MPCA 2024a).

Recommendations for Pelican Creek are:

- Reduce inputs of TSS to the lake by 64% (MPCA 2024b).
- Reduce inputs of *E. coli* to the lake by 66% (MPCA 2024b).
- Fix the dams and culverts that are acting as fish barriers. The 2024 SID report identified four barriers to fish migration in Pelican Creek (MPCA 2024a).
- Improve habitat in the stream corridor (MPCA 2024a).
- Control livestock access to Pelican Creek (MPCA 2024a).
- Continue monitoring of the Ashby WWTP discharge of phosphorus (MPCA 2024a).

One potential reduction scenario is shown in Table 17. This scenario uses the HSPF-SAM based Watershed Pollutant Load Reduction Calculator to model what it will take to achieve 100% of the phosphorus and TSS reductions needed to meet the TMDLs. The recommended number and type of BMPs would require 35% of the watershed to be engaged and the predicted high cost would be $1.1 million/yr for at least 10 years.

Table 17. A possible load reduction scenario to achieve all or some of the Christina/Pelican Lake area nutrient reduction targets (Watershed Pollutant Load Reduction Calculator).

BMP	Potential new acres affected	Annual TP reduction in lbs.	Annual nitrogen reduction in lbs.	Annual TSS reduction in tons	Annual cost
Alternative tile Intakes	155	14	31	3.1	$ 620
Alternative tile Intakes		-	-	-	$-
Conservation cover perennials	1,000	40	930	10.0	$ 70,000
Cover crops after early harvest crops	5,000	200	3,000	50.0	$ 350,000
Cover crops with corn and soybeans	1,000	80	170	10.0	$ 37,200
Drainage side inlet improvements		-	-	-	$-
Feedlot manure/runoff storage		-	-	-	$-
Feedlot runoff reduction/treatment		-	-	-	$-
Livestock access control/fencing (to waters)	1,000	50	190		$ 22,000
Manure/fertilizer incorporation (no surface spreading)	10,000	100	2,700		$ 220,000
Nutrient management: improved rates/timing		-	-		$-
Nutrient management: precision/variable rate	10,000	400	1,400	80.0	$ 130,000
Reduced tillage (30%+ residue cover)	4,000	240	2,280	40.0	$ 96,000
Reduced tillage (strip-till)	3,750	338	1,275	37.5	$ 90,000
Reduced tillage (no-till)	4,000	480	2,680	80.0	$ 72,000
Water and sediment control basin (Cropland)		-	-	-	$-
Wetland construction to treat tile waters	**39,905**	**1,941**	**14,656**	**311**	**$ 1,087,820**
Total		**100%**	**29%**	**471%**	
Progress toward goal		1,942	51,118	65.9	
NRS TP goal, NRS nitrogen goal, PDTR TSS TMDL					

Pomme de Terre River Lakes Chain Area:

The Pomme de Terre River Lakes Chain Area forms from just below where Pelican Creek joins the Pomme de Terre River to the outlet of North Pomme de Terre Lake. This priority area includes Pomme de Terre Lake and Barrett Lake.

The primary impairments of this area include the nutrient impairment on Barrett Lake and the AQL (fish) impairment on the Pomme de Terre River from Barrett to North Pomme de Terre Lake (WID: 07020002-563).

The 2024 TMDL for Barrett Lake noted that the largest phosphorus source to Barrett Lake is upstream Lake Pomme de Terre (52%) followed by direct drainage runoff (41%) and excess internal/unknown load (4%). Existing phosphorus loads need to be reduced by 6,031 lbs/yr (45%) for Barrett Lake (10 yr average TP 0.066 mg/L) to achieve the lake's phosphorus water quality standard of 0.040 mg/L. Most of the phosphorus reductions needed are from direct drainage runoff (4,205 lbs/yr) then Lake Pomme de Terre (1,260 lbs/yr) followed by internal load reductions (570 lbs/yr).

Recommendations for Barrett Lake (26-0095-00) are:

- Reduce inputs of TP to the lake by 6,035 lbs/yr (MPCA 2024b).
- Address direct drainage runoff through agricultural BMPs (MPCA 2024b; PDTRA 2020).
- Lakeshore owner education on shoreline protection and phosphorus BMPs (PDTRA 2020).

Regarding the mainstem Pomme de Terre River, the Pomme de Terre River Watershed SID Report (MPCA 2024a) identified several stressors. TSS was found to be a new stressor to the fish community. In addition, lack of habitat is a stressor, in particular a lack of riffles and channel development, a lack of depth variability, and lack of near shore cover. Altered hydrology in the form of increased flows and flow changes due to drainage was also identified as a stressor. Finally, lack of stream connectivity is a stressor. Downstream the Crissy (Morris) Lake dam is a full barrier, and the Perkins Lake dam is a partial barrier. Upstream, the Pomme de Terre Lake dam is a barrier to fish passage as well.

Recommendations for Pomme de Terre River (WID: 07020002-563) are:

- Fix the dams and culverts that are acting as fish barriers. The 2024 Pomme de Terre River Watershed SID Report identified three barriers to fish migration in the river (MPCA 2024a).
- Improve habitat in the stream corridor (MPCA 2024a)
- Improve in-stream habitat by reducing sedimentation due to stream bank erosion (PDTRA 2020).
- Improve riparian habitat by establishing and maintaining perennial buffers and floodplain connections (PDTRA 2020).

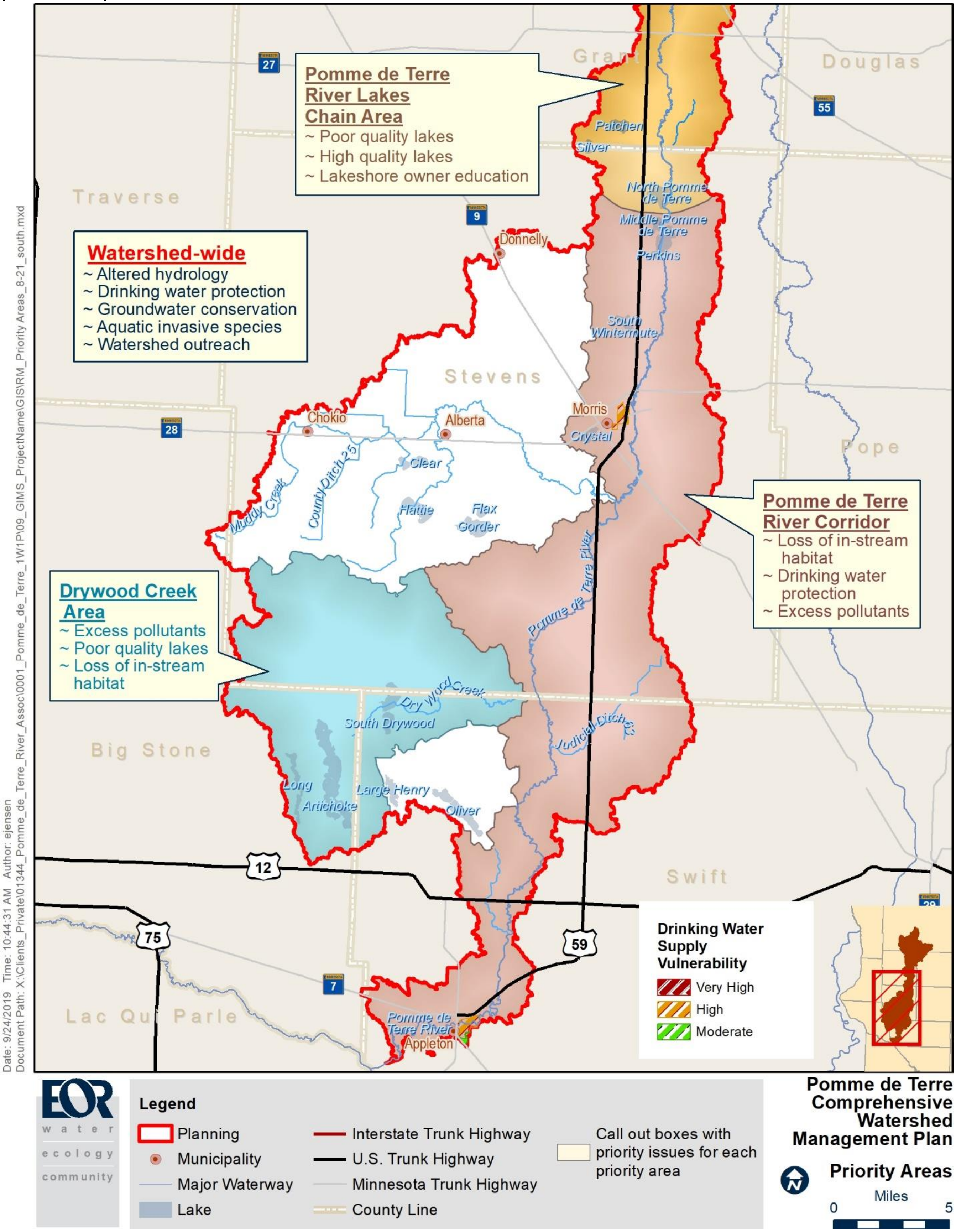
A pollutant reduction scenario for this priority subwatershed is shown in Table 18. This scenario uses the HSPF-SAM based Watershed Pollutant Load Reduction Calculator to model what it will take to achieve 100% of the phosphorus and TSS reductions needed to meet the TMDLs. The recommended number and type of BMPs would require 43% of the watershed to be engaged and the predicted high cost would be $348,000/yr for 10 years. This scenario does not achieve the NRS goal for nitrogen. The model was able to reach 50% of the goal for an extra $1.4 million/yr by enrolling 63,000 acres of crop land into nutrient management using improved rates/timing BMPs. No scenario that was modeled achieved the full NRS nitrogen reduction goal.

In application of the model, it was found that if the practice of alternative tile inlet structures were installed in all acres suitable for the practice it would result in the reduction of 72% of TP and 87% of TSS at the cost of $100,000/yr.

Table 18. A possible load reduction scenario to achieve all or some of the Pomme de Terre River Lakes Chain Area nutrient and TSS reduction targets (Watershed Pollutant Load Reduction Calculator).

BMP	Potential new acres affected	Annual TP reduction in lbs.	Annual nitrogen reduction in lbs.	Annual TSS reduction in tons	Annual cost
Alternative tile Intakes	25,000	4,000	7,750	500.0	$ 100,000
Alternative tile Intakes		-	-	-	$ -
Conservation cover perennials		-	-	-	$ -
Cover crops after early harvest crops		-	-	-	$ -
Cover crops with corn and soybeans		-	-	-	$ -
Drainage side inlet improvements		-	-	-	$ -
Feedlot manure/runoff storage		-	-	-	$ -
Feedlot runoff reduction/treatment		-	-	-	$ -
Livestock access control/fencing (to waters)		-	-		$ -
Manure/fertilizer incorporation (no surface spreading)		-	-		$ -
Nutrient management: improved rates/timing		-	-		$ -
Nutrient management: precision/variable rate	5,000	400	1,250	45.0	$65,000
Reduced tillage (30%+ residue cover)	2,650	318	2,703	26.5	$63,600
Reduced tillage (strip-till)	5,000	850	2,950	50.0	$ 120,000
Reduced tillage (no-till)		-	-	-	$ -
Water and sediment control basin (Cropland)		-	-	-	$ -
Wetland construction to treat tile waters	**37,650**	**5,568**	**14,653**	**622**	**$ 348,600**
Total		**100%**	**17%**	**108%**	
Progress toward goal		5,568	88,327	577.7	
NRS TP goal, NRS nitrogen goal, PDTR TSS TMDL					

Figure 42. Pomme de Terre River Comprehensive Watershed Management Plan Priority Areas (Southern Region) (PDTRA 2020).



Pomme de Terre River Corridor:

The Pomme de Terre River Corridor priority area encompasses the river corridor HUC-12's from the outlet of North Pomme de Terre Lake to the confluence with the Minnesota River south of Appleton. The main impairments to this area are the nutrient impairment on Perkins Lake, and the river impairments to AQL for fish and benthic macroinvertebrates and turbidity and the AQR impairment for bacteria.

Perkins Lake is a shallow 507-acre lake with a lake catchment area of 266,094 acres. It is characterized by poor water quality, lack of submerged aquatic vegetation, and degraded aquatic habitat has been described in lake survey reports since the initial survey in 1947 (MPCA 2010). The river transports excessive amounts of nutrients and sediments through the lake. High TP and TSS concentrations have been documented in annual water quality monitoring conducted by the Perkins Lake Association. Observations of dense blue-green algae blooms are common in July and August (MPCA 2010).

Recommendations for Perkins Lake (75-0075-00) are:

- Reduce inputs of TP to the lake by 5,568 lbs/yr (MPCA 2015).
- Engage affected landowners to identify in-lake management options (PDTRA 2020).
- Inspect subsurface sewage treatment systems and update noncompliant septic systems.
- Conduct shoreline condition inventories and implement shoreline restoration projects for erosion control (PDTRA 2020).
- Implement structural and nonstructural agricultural BMPs (PDTRA 2020).
- Consider the development of a long-term lake management plan (MPCA 2015).

The Pomme de Terre River (-501) faces many challenges. Excess levels of phosphorus, sediment, and bacteria are impacting the Pomme de Terre River. Sediment inputs to streams come from soil erosion and in-stream channel erosion, often driven by higher stream flows from altered hydrology and changes in land use practices. Phosphorus and bacteria inputs to streams come primarily from agricultural runoff, urban runoff, feedlot runoff, and wastewater discharge. Nutrient concentrations and turbidity levels both steadily increase along the mainstem Pomme de Terre River, with the highest concentrations located in the most downstream section. Phosphorus in this system has been observed to be directly contributing to the DO and turbidity impairments also present in this region (PDTRA 2020).

The 2024 Pomme de Terre River Watershed SID Report (MPCA 2024a) found river eutrophication (high TP and a corresponding rise in Chl-a) is a stressor to both fish and benthic macroinvertebrate populations. Increased flows seem to be having an impact on the biological communities as altered hydrology remains a stressor. TSS and lack of habitat were also found to be stressors. Finally, the Crissy Dam in Morris is a barrier to fish passage.

The bacteria impairments in Muddy Creek (07020002-511), Drywood Creek (-556), and Unnamed Creek (-547) are significant contributors to the bacteria impairment on the Pomme de Terre River.

Recommendations for the Pomme de Terre River (WID: 07020002-501 and 07020002-562) are:

- Remove the dam in Morris that is acting as a fish barrier (MPCA 2024a).

- Improve habitat in the stream corridor (MPCA 2024a).
- Improve in-stream habitat by reducing sedimentation due to stream bank erosion (PDTRA 2020).
- Improve riparian habitat by establishing and maintaining perennial buffers and floodplain connections (PDTRA 2020).
- Implement structural and nonstructural agricultural BMPs along the river corridor (PDTRA 2020).
- Reduce altered hydrology and decrease nutrient loading by restoring drained shallow basins (PDTRA 2020).
- Work toward 100% septic system compliance.
- Address manure application rates and proper management of pastureland adjacent to the stream and cattle with direct stream access.

A potential reduction scenario for this priority subwatershed is shown in Table 19. This scenario uses the HSPF-SAM based Watershed Pollutant Load Reduction Calculator to model what it will take to achieve 100% of the TSS reductions needed to meet the TMDL. The recommended number and type of BMPs would require either 100% of the watershed to be engaged or require multiple BMPS on the same acreage. The predicted cost would be $2.15 million/yr for 10 years. This scenario does not achieve the NRS goal for nitrogen. The model was able to reach 100% of the nitrogen goal for an additional $5 million/yr with nitrogen reducing BMPs. While it will be incredibly challenging to achieve the scale of adoption demonstrated as needed by this scenario, every willing participant will be needed and every step that is made through implementation of these BMPs is a step in the right direction.

Table 19. A possible load reduction scenario to achieve all or some of the Pomme de Terre River Corridor Area nutrient and TSS reduction targets (Watershed Pollutant Load Reduction Calculator).

BMP	Potential new acres affected	Annual TP reduction in lbs.	Annual nitrogen reduction in lbs.	Annual TSS reduction in tons	Annual cost
Alternative tile Intakes	35,000	9,450	18,550	1,050.0	$140,000
Conservation cover perennials		-	-	-	$ -
Cover crops after early harvest crops		-	-	-	$ -
Cover crops with corn and soybeans		-	-	-	$ -
Drainage side inlet improvements		-	-	-	$ -
Feedlot manure/runoff storage		-	-	-	$ -
Feedlot runoff reduction/treatment		-	-	-	$ -
Livestock access control/fencing (to waters)		-	-	-	$ -
Manure/fertilizer incorporation (no surface spreading)		-	-		$ -
Nutrient management: improved rates/timing	60,000	2,400	47,400		1,320,000
Nutrient management: precision/variable rate		-	-		$ -
Reduced tillage (30%+ residue cover)	5,000	650	2,000	100.0	$65,000
Reduced tillage (strip-till)	5,000	950	8,400	100.0	$120,000
Reduced tillage (no-till)	5,000	1,350	4,800	150.0	$120,000
Water and sediment control basin (Cropland)	21,721	7,820	37,577	651.6	$390,978
Wetland construction to treat tile waters		-	-	-	$ -
Total	**131,721**	**22,620**	**118,727**	**2,052**	**$2,155,978**
Progress toward goal		**181%**	**42%**	**100%**	
NRS TP goal, NRS nitrogen goal, PDTR TSS TMDL		12,505	283,096	2051.6	

Drywood Creek:

The Drywood Creek priority subwatershed sits on the tri-county border between Big Stone, Stevens, and Swift Counties (Figure 42). It has a drainage area of about 61,800 acres and it represents 10% of the Pomme de Terre River Watershed's total area. It has no towns and is principally influenced by its main land use, row crop agriculture which occupies roughly 75% of the subwatershed. Most of the streams in Drywood Creek are constructed ditches, as few natural streams remain.

The primary AQR impairments in this targeted subwatershed are nutrients (phosphorus in lakes) and bacteria (Figure 42). The primary AQL impairments are low DO, nutrients (river eutrophication via phosphorus), benthic macroinvertebrates bioassessments, fish bioassessments, and TSS. The primary stressors to AQL are low DO, eutrophication, nitrate, phosphorus, turbidity, blocked fish passage, altered hydrology, and poor habitat (MPCA 2024a).

According to the HSPF model, the subwatershed is 10% of the Pomme de Terre River Watershed's land area and is responsible for 4% of the watershed's TSS, 25% of the watershed's phosphorus, 18% of the watershed's nitrogen and 11% of the watershed's water discharge. This is corroborated by Drywood Creek tributary stream monitoring that was conducted by the PDTRA between 2008 and 2018 and by

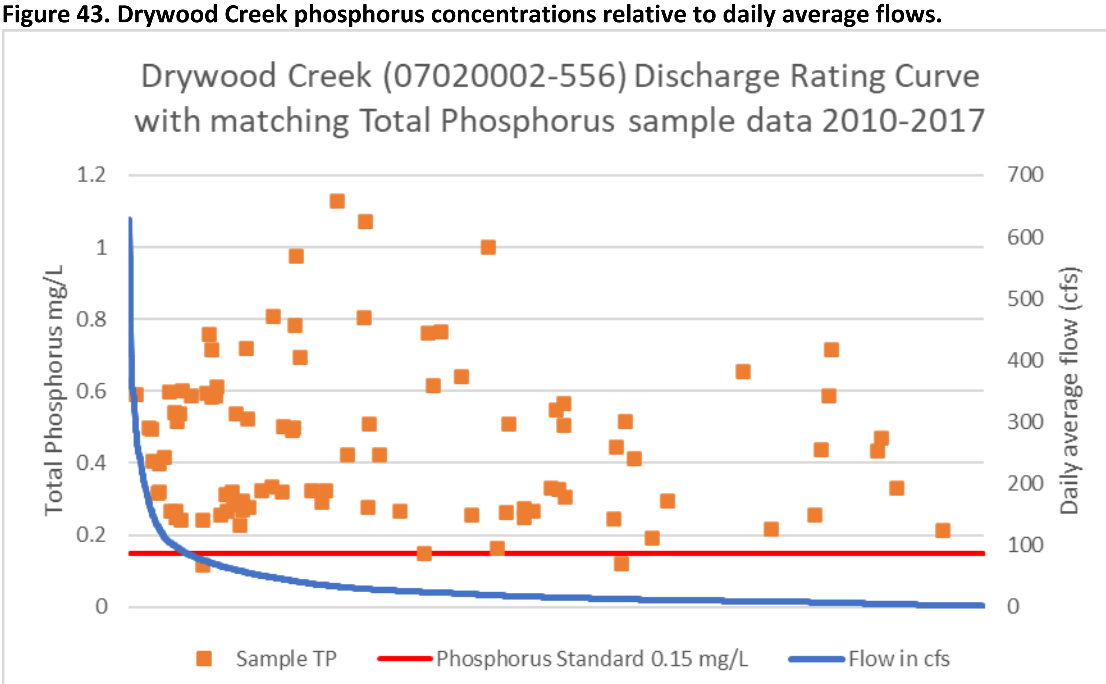
SID staff in 2022. The PTMApp modeling from the Pomme de Terre River CWMP also indicates high levels of sediment and phosphorus loading coming from nonpoint sources in this subwatershed.

The lower reach of Drywood Creek (WID 07050002-556) has high levels of pollutants. A total of 108 stream samples were taken between 2010 and 2018 by the PDTRA (Surface Water Data). The TP standard was exceeded 97% of the time (Figure 43). Over the same period, TSS exceeded the standard 37% of the time. *E. coli* bacteria exceeded the standard 60% of the time.

Phosphorus levels are of particular interest due to the number of impairments in this subwatershed and the greater than average TP loading indicated by monitoring and modeling. Furthermore, three Drywood Creek Subwatershed lakes (Artichoke, North and South Drywood Lakes) have the highest phosphorus levels in the Pomme de Terre River Watershed.

The headwater streams and ditches in the Drywood Creek Subwatershed originate from mostly row crop fields. The most upstream water quality data in Drywood Creek is directly influenced by Artichoke Lake (10-year average TP: 0.248 mg/L). While this lake has TP levels well above the standard (0.09 mg/L), it is not considered impaired since the secondary variables of low transparency and high Chl-*a* have not been observed. Nonetheless, outflows from Artichoke Lake are well above the standard for streams (0.150 mg/L) in the southern standard region.

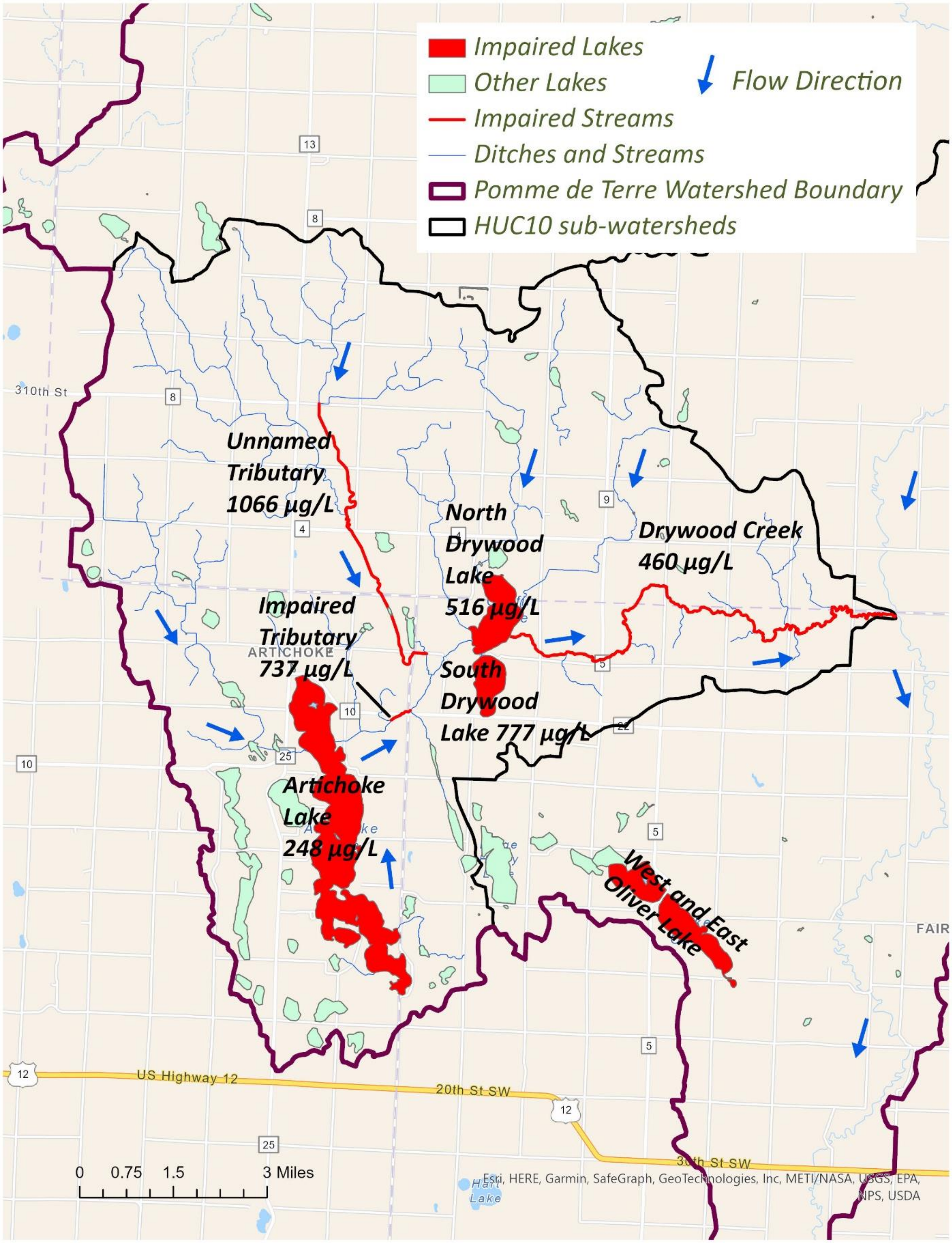
Figure 43. Drywood Creek phosphorus concentrations relative to daily average flows.



A mile downstream of Artichoke Lake, an unnamed creek (-566), a tributary to Artichoke Creek, experiences high phosphorus and high Chl-*a* and is impaired according to river eutrophication standards. Sampling on this reach at site S005-655 in 2017-2018 found the average TP to be 0.737 mg/L (almost five times the river standard).

Another downstream tributary ditch, unnamed stream reach (WIDs -534, -535 and -515), joins the stream (now called Artichoke Creek). Sampling along this reach at site S005-656 in 2017-2018 revealed an average TP concentration of 1.066 mg/L (n=15) that is seven times higher than the standard. At this point, Artichoke Creek flows into North Drywood Lake. Artichoke Creek phosphorus concentrations will likely need to be reduced below the southern region standard for North Drywood Lake to achieve the lake eutrophication standard.

Figure 44. Drywood Creek impairments and 10-year average phosphorus levels.



South Drywood Lake also flows north into the adjacent North Drywood Lake. South Drywood Lake has a relatively small lakeshed of 2,048 acres. This lake has very high TP (10-year average TP: 0.78 mg/L), low transparency, high Chl-*a*, and was listed as impaired in 2020. The largest TP source to South Drywood Lake is excess internal load (87%) followed by direct drainage runoff (12%). Existing TP loads need to be reduced by 14,807 lbs/yr (97%) for South Drywood Lake to achieve the shallow lakes TP water quality standard of 0.090 mg/L for its ecoregion (MPCA 2024b).

North Drywood Lake also has very high TP (10-year average TP: 0.516 mg/L) as well as low transparency and was listed as impaired in 2020. The largest TP source to North Drywood Lake is Artichoke Creek (39%), followed by excess internal/unknown load (29%), direct drainage runoff (16%), Unnamed Creek (11%), and South Drywood Lake (4%). Existing TP loads need to be reduced by 41,526 lbs/yr (89%) for North Drywood Lake to achieve the shallow lakes TP water quality standard of 0.090 mg/L for its ecoregion. TP reductions are needed from Artichoke Creek (15,326 lbs/yr), internal load (13,788 lbs/yr), direct drainage runoff (6,403 lbs/yr), Unnamed Creek (4,315 lbs/yr), and improvements in upstream South Drywood Lake (1,693 lbs/yr; MPCA 2024b).

The outlet of North Drywood Lake exits the lake at nearly the same phosphorus concentration as the lake. The stream reach downstream of North Drywood Lake is Drywood Creek (-556), which had a TP average of 0.460 mg/L between 2008 and 2018 (the southern region nutrient standard is 0.150 mg/L). The DO impairment of Drywood Creek is a direct result of the high phosphorus levels. The stressors of the two biological impairments on this reach are in large part also a direct result of the high phosphorus levels. Likely sources of bacteria in the Drywood Creek Watershed include livestock and inadequate subsurface sewage treatment systems (SSTS; MPCA 2015).

Historic and current upland contributions of sediment and nutrients have driven downstream nutrient and sediment loading for many years. A portion of these pollutants have collected in Drywood Creek's wetlands and lakes. This deposition has built up a reserve of internal sediment and phosphorus. These trapped sources tend to keep the internal levels of pollutants in lakes and wetlands high. When streams and ditches flow through these water bodies, they pick up these pollutants and carry them downstream. Even if current efforts to reduce upland sources are widely successful these legacy sources in these bodies of water will continue to be an issue. Internal loading from lakes and wetlands may maintain the impaired condition in downstream lakes and streams for decades to come unless efforts are undertaken to address this internal loading.

Recommendations for Drywood Creek are:

- Reduce direct runoff of phosphorus and sediment.
- Establish and maintain perennial buffers and floodplain connections.
- TMDLs: Reduce inputs of TP to North Drywood Lake by 41,526 lbs/yr and to South Drywood Lake by 14,807 lbs/yr (MPCA 2024b). Reduce TSS loads to Drywood Creek by 40% and TP loads to Unnamed Creek by 78%.
- Develop lake/watershed management plans to address the legacy phosphorus that has built up in the lakes and wetlands of this subwatershed.
- Fix barriers to fish passage and pursue options to improve fish habitat.

The Drywood Creek Subwatershed is the most impaired subwatershed in the Pomme de Terre River Watershed. Achieving water quality standards will not be easy but success in this subwatershed would have a big impact on the overall state of the Pomme de Terre River.

The Watershed Pollutant Load Reduction Calculator was used to develop a possible load reduction scenario to achieve the Drywood Lake Phosphorus TMDL, the Drywood Creek TSS TMDL, and the NRS nitrogen reduction targets (Table 20). The calculator estimates that this 61,800-acre watershed would need approximately $8.83 million annually for 10 years, and on average, every acre would need roughly two BMPs.

The scenario laid out in Table 20 is clearly an unprecedented effort that would require an increase in conservation funding and the entire watershed to be involved in multiple BMPs. This scenario would need to have almost complete buy-in from the watershed's farming community. It would represent a substantial increase in the use of cover crops, conservation tillage, nutrient management, and other practices.

Table 20. A possible load reduction scenario to achieve the Drywood Lake phosphorus TMDL, the Drywood Creek TSS TMDL, and the NRS nitrogen reduction targets (Watershed Pollutant Load Reduction Calculator).

BMP	Potential new acres affected	Annual TP reduction in lbs	Annual nitrogen reduction in lbs	Annual TSS reduction in tons	Annual cost
Alternative tile Intakes	10,000	4,400	5,800	200	$400,000
Conservation cover perennials	2,000	1,100	13,080	60	$1,500,000
Cover crops after early harvest crops	1,000	170	2,550	20	$70,000
Cover crops with corn and soybeans	20,000	3,800	39,600	400	$1,400,000
Drainage side inlet improvements	1,000	410	530	20	$372,000
Feedlot manure/runoff storage	6	14	140	1	$60,000
Feedlot runoff reduction/treatment	10	19	194	1	$100,000
Livestock access control/fencing (to waters)	1,000	90	420	6	$600,000
Manure/fertilizer incorporation (no surface spreading)	2,000	460	1,180	-	$44,000
Nutrient management: improved rates/timing	25,000	1,750	22,250	-	$550,000
Nutrient management: precision/variable rate	10,000	1,000	16,700	-	$600,000
Reduced tillage (30%+ residue cover)	10,000	2,200	4,500	100	$130,000
Reduced tillage (strip-till)	25,000	7,750	47,000	500	$600,000
Reduced tillage (no-till)	8,000	3,600	8,560	160	$192,000
Water and sediment control basin (Cropland)	10,000	5,400	17,300	200	$1,800,000
Wetland construction to treat tile waters	200	68	820	4	$415,094
Total	**125,216**	**32,231**	**180,623**	**1,672**	**$8,833,094**
Progress toward goal		**98%**	**141%**	**320%**	
North Drywood Lake TP TMDL goal, NRS nitrogen goal, PDTR TSS TMDL		32,939	128,403	522	
2040 Goal		26%	41%		

4.4 Lake Management

A lake reflects its watershed as drainage area, land use, topography, and geology impact the phosphorus budget of a lake. Where external loading is sufficient to cause water quality issues over the residence time of the lake, a significant proportion of the watershed phosphorus load will likely need to be reduced to achieve long-term water quality improvement. Unless external loading has been adequately addressed, in-lake treatment may only have near-term benefits.

No threshold of external phosphorus reduction has been identified to trigger the use of internal load reduction measures. The use of "rule of thumb" management decisions oversimplifies the complex and unique nature of individual lakes and our relatively limited knowledge of the application of internal load controls. However, when proposing these phosphorus load controls, lake managers should be able to demonstrate through modeling or other means how the combined efforts of reducing external and internal loads will collectively achieve lake management goals.

The unique circumstances of each lake dictate the appropriateness of utilizing internal phosphorus load controls. Lake morphology, lake phosphorus balance, watershed land cover, downstream impacts, budgetary restrictions, permitting requirements, and public expectations are some of the factors that need to be weighed when considering internal phosphorus control practices.

Methods to reduce internal loading should be considered in the context of a comprehensive lake management plan. Ideally, lake management plans reflect the agreed upon goals of diverse stakeholders. The methods for protecting and/or restoring a lake, which could include internal phosphorus controls, are derived from those goals. A holistic approach to lake management that incorporates watershed and in-lake practices is more likely to lead to long-term success and sustainability (MPCA 2020).

For more information, see the MPCA's webpage on lake protection and management.

4.5 Restoration and Protection Strategies

Wherever watershed restoration and protection work are undertaken, it is important to remember that people make it happen. Water quality BMPs are useful tools but *relationships are the product of community engagement.*

Monitoring and modeling work done for this document point to the substantial effort ahead of conservation professionals. It is clear that in order to be successful an all-hands-on-deck approach is required. This will require building strong relationships and trust. Working in rural communities to reduce pollutant loading will require a multi-faceted approach that involves addressing small town impacts, agricultural practices, and community engagement.

Farm Country:

- **Build strong relationships with farmers and rural residents:** Listen to their perspectives, their concerns, and seek out their input.
- **Engage the community about the impacts of water pollution:** Community education is an important component of reducing pollutant loading. By communicating with the public about the environmental impacts of nutrient pollution, as well as the BMPs and nutrient management

practices that can help reduce it, one can build support for these efforts and help ensure their success. This outreach can take many forms including one on one conversations, workshops, field days, and outreach materials like brochures and videos.

- **Implement BMPs on farms:** BMPs are farming practices that reduce the amount of nutrients and sediment that enters rivers and streams. These practices include things like reducing fertilizer application rates, applying fertilizers at the appropriate time and in the appropriate manner, and implementing CPs like cover cropping and no-till farming. Encouraging farmers to implement BMPs can help reduce pollution while also improving soil health and crop yields.
- **Encourage the adoption of nutrient management plans:** Nutrient management plans are comprehensive plans that help farmers manage the application of nutrients like phosphorus on their land. These plans consider the specific needs of crops, the nutrient content of soils, and the timing and method of fertilizer application. Encouraging farmers to develop and implement nutrient management plans can help reduce nutrient pollution while also improving the efficiency of nutrient use.

Lake Country:

- **Build strong relationships with stakeholders who live, recreate, do business and make decisions for water resources in lake country:** Listen to their perspectives, their concerns and seek out their input. Engage the community about the impacts of water pollution.
- **Implement BMPs on lake properties:** Lake BMPs are practices that reduce the amount of nutrients and sediment that enter nearby lakes. These practices include things like not using fertilizer, leaving a buffer of un-mowed vegetation along the lakeshore, and making sure septic systems are up to date and properly maintained. Encouraging lakeshore owners to be aware of their impact and to implement lakeshore BMPs can help reduce pollution while also improving the AQL and AQR potential of their lake.
- **Encourage organizing lake organizations and the adoption of lake management plans:** Lake management plans are comprehensive plans that identify goals and action items for the purpose of creating, protecting and/or maintaining desired conditions in a lake and its watershed for a given period of time. It is through lake organizations and lake management plans that more complicated BMPs that require the assistance of state agencies can be considered to improve lake conditions. Some examples of these are lake drawdowns, rough fish controls, and alum treatments to reduce phosphorus.

Small Towns and Cities:

Organizational strategies for addressing water pollution in small towns and cities can involve a combination of planning, collaboration, and community engagement. The specific strategies chosen should be based on the unique needs and resources of the town or city. It's also important to involve local communities in these efforts to ensure their success.

- **Build strong relationships with stakeholders who live, do business in and make decisions for small towns and cities:** Listen to their perspectives, their concerns and seek out their input. Engage the community about the impacts of water pollution.

- **Smart Growth [Tools and Resources for Sustainable Communities]**: The EPA provides a range of tools and resources to help communities develop and support neighborhoods that provide transportation choices and affordable housing, increase economic competitiveness, and direct resources toward places with existing infrastructure.
- **Source water protectio**n: Communities, citizen groups, and individuals can take an active role in protecting their drinking and recreational water sources from contamination. This involves identifying and organizing other stakeholders and working directly with owners and managers of potential sources of pollution. For more information, visit the EPA and MDH websites.
- **Community engagemen**t: Work with state, and local agencies, to take steps to access, restore, and benefit from their urban waters and the surrounding land.
- **Infill developmen**t: Attracting infill development in underserved communities can help overcome obstacles and encourage development in areas with existing infrastructure.
- **Education and awarenes**s: Tools like the Household Carbon Footprint Calculator can help communities educate residents about their personal greenhouse gas emissions, which can support community-wide efforts to reduce climate impacts.

Streambed and Streambank Erosion

Treating the streambed and streambank sediment erosion sources is not as straight forward as other pollution sources. Much of the increased bed and bank erosion is being driven by the changes that have been observed in hydrology, specifically increased flows. While armoring stream banks does prevent erosion where it is applied, it does not address the cause of the problem. Bed and bank erosion are a watershed widespread issue that require building overall watershed resiliency to increased flows. This is typically understood to be a multifaceted approach. Decreasing peak flows can be achieved by increasing watershed storage capacity through wetlands, increasing soil organic matter, and increasing evapotranspiration in key times of the year. In the Pomme de Terre River Watershed, this means promoting land covers that are actively using water in May and June such as perennial landscapes and small grains. Increased river floodplain connectivity can also dissipate stream flow energy and provide area for sediment deposition.

4.6 Building Climate Resiliency

Climate change is affecting hydrology across Minnesota. Warmer and wetter conditions, combined with more intense and frequent precipitation events, challenge our ability to effectively manage our water resources for people, plants, and animals. While precipitation is increasing on average across the state, the larger events may also cause more water to runoff and make less available to recharge groundwater. This can reduce water availability, a trend observed in many regions of the state already (UMN 2023).

Infrastructure that was designed for past climate conditions is being found to be less effective as conditions change. This leads to threats to both community resources and the environment. Climate projections show this trend will continue and expand.

Climate resiliency for rural communities in western Minnesota should involve a comprehensive approach that includes both mitigation and adaptation strategies. Mitigation strategies would focus on reducing greenhouse gas emissions and other human activities that contribute to climate change, while adaptation strategies would focus on building resilience to the impacts and threats of climate change.

To be effective, climate resiliency strategies must consider the unique social, economic, and landscape conditions found in the Pomme de Terre River Watershed. Mitigation strategies could include measures such as reducing energy consumption, increasing the use of renewable energy sources, changing nitrogen application strategies, and promoting sustainable land use practices. Adaptation strategies could include measures such as improving water management practices, enhancing soil health, planting conservation perennials, and developing drought-resistant crops.

In addition to these measures, climate resiliency also requires a strong focus on community engagement and two-way education. This would involve working with local stakeholders to identify the specific risks and vulnerabilities facing the community, as well as developing strategies to address these risks and build resilience. These efforts require a comprehensive and collaborative approach that involves a range of stakeholders, including local government, community organizations, and individual residents.

Example: The Morris Model

There are communities within the watershed that are acting on climate resiliency. In the city of Morris, a collaboration between stakeholders including community members, the City of Morris, Stevens Community Medical Center, Stevens County, the University of Minnesota-Morris, and others started a collaboration called the Morris Model. They developed the "Morris Community Resilience Plan". The purpose of this plan is to summarize assets and challenges that face the city's economic, social, and environmental dimensions, and proposes some of the most urgent priorities to increasing Morris' resilience in the face of a changing climate with more unpredictable major weather events.

The Morris Model identifies three community resilience areas and actions:

- Government: Engage with civic leaders to discuss ways that the city is preparing for extreme weather. Identify municipal policies and practices that can be improved upon to better prepare our community.
- Education: Brainstorm strategies to improve our community resilience to extreme weather. Outline ways to promote community dialogue surrounding extreme weather.
- Community Action: Discuss sustainable practices that businesses and community members can take to prepare for extreme weather. Work towards sustaining these practices.

Communities that are resilient to climate change can effectively prepare for and recover from its effects and continue to thrive. Efforts like the Morris Model are a good start and show the way for other communities in the watershed to act. The MPCA has a number of Climate Adaptation Resources available to communities, local governments and organizations.

Example: Nitrous oxide (N_2O) Reduction Strategies

A greenhouse gas of serious concern is nitrous oxide (N_2O) which is about 300 times as potent as carbon dioxide (CO_2) at heating the atmosphere. It is long-lived, like CO_2, spending an average of 114 years in the atmosphere before disintegrating. It also depletes the ozone layer. N_2O comprises roughly 6% of greenhouse gas emissions, and about 75% of those N_2O emissions come from agriculture (Chrobak 2022).

In the Pomme de Terre River Watershed, both nitrogen runoff in surface waters and N_2O emissions to the atmosphere are driven by agriculturally applied nitrogen. Strategies that reduce nitrogen are both mitigation and adaptation strategies.

There are many farming practices that can help decrease N_2O emissions, reduce nitrogen runoff, and potentially increase farm profit:

- Minimizing Nitrogen Application Rates: Applying only the necessary amount of nitrogen can reduce the potential for N_2O emissions. (Maharjan, 2020)
- Timing of Fertilizer Application: Applying fertilizers during periods of rapid crop growth can result in rapid inorganic N uptake, reducing the potential for N_2O emissions. (Maharjan, 2020)
- Use of Slow-Release Fertilizers: These types of fertilizers minimize the concentration of inorganic N in the soil system, which can help reduce N_2O emissions. (Maharjan, 2020) (Wilson, 2017)
- Conservation Agriculture Practices: This includes practices like cover crops, diversified crop rotations, and no-till and/or reduced tillage. These practices can significantly influence soil properties, which in turn reduce N_2O emissions. (Maharjan, 2020) (Wilson,2017)
- Use of Amendments: The use of amendments, such as biochar and lime, can substantially reduce N_2O emissions. (Hassan, 2022)
- Integrated Nutrient Management: This approach involves the combined use of organic and inorganic fertilizers to meet crop nutrient requirements, which can help reduce N_2O emissions. (Hassan, 2022)
- Irrigation Practices: Efficient water management, such as drip irrigation, can help reduce N_2O emissions. (Maharjan, 2020)
- Monitoring Soil Nutrients: Avoiding over-fertilization by regularly checking soil nutrient levels can also help in reducing N_2O emissions. (Hassan, 2022)

4.7 Environmental Justice

The MPCA is committed to making sure that pollution does not have a disproportionate impact on any group of people — the principle of environmental justice. This means that all people–- regardless of their race, color, national origin, or income – benefit from equal levels of environmental protection and have opportunities to participate in decisions that may affect their environment or health.

To most effectively reduce pollution risks and impacts on communities, people must have the opportunity to participate in decisions that may affect their environment and health. The public's feedback and concerns can influence the regulatory process and local conservation decisions. The goal should be to identify and remove barriers to ensure more voices have a role in environmental regulations and decision-making. LGUs working toward improving water quality are encouraged to engage in an open, authentic dialogue with impacted communities.

The State of Minnesota considers tribal areas and census tracts with higher concentrations of low-income residents, people of color, or limited English proficiency as areas of increased concern for environmental justice.

Low Income Communities

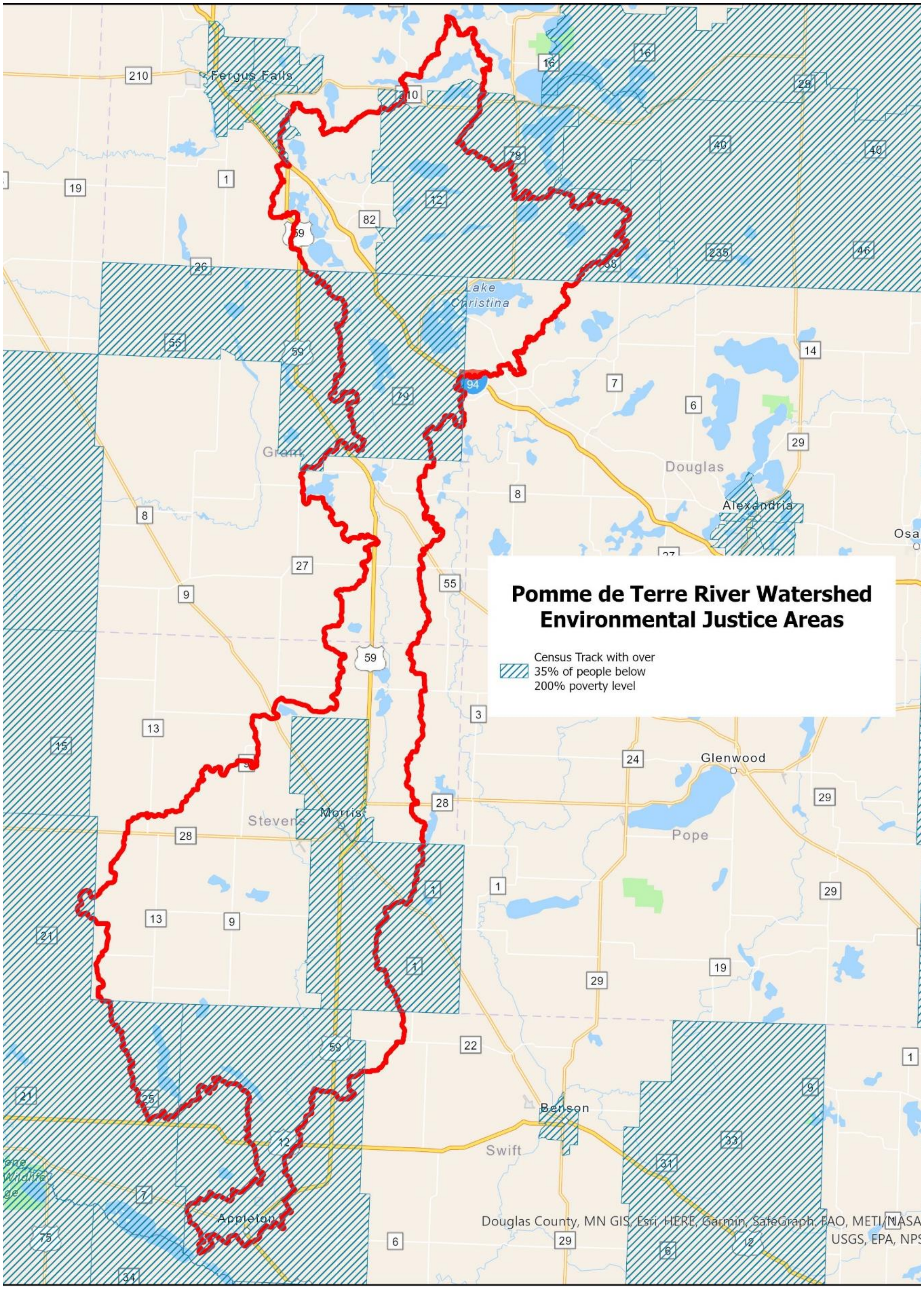
In the Pomme de Terre River Watershed, there are six census tracts with higher concentrations of low-income residents (Figure 45). Low-income census tracts are defined by the State of Minnesota as at least 35% of people reporting income less than 200% of the federal poverty level. In 2023, 200% of the federal poverty level equates to $29,160 for an individual and $60,000 for a family of four.

Low income can be a barrier to participating in environmental restoration and protection efforts. This could be true for reasons of cost, time commitment, travel, and lack of ownership. Low-income communities often face challenges that deter their participation in environmental conservation efforts:

- Limited Resources: Low-income individuals and communities often lack the financial resources and time to invest in environmentally friendly practices. Even when offered cost share many BMP projects are too expensive or require access to credit (ex: WASCOBs or stream bank stabilization projects).
- Immediate Needs: For individuals and families struggling with poverty, immediate needs such as food, shelter, work commitments, and healthcare often take precedence over long-term environmental concerns.
- Lack of Land Ownership: Renting presents challenges to low-income people in that they lack the authority to install permanent conservation projects. They may also be hesitant to either take land out of production or potentially decrease profitability if they are counting on it for their income.
- Lack of Information and Education: There may be a lack of awareness or understanding about environmental issues and the importance of conservation efforts. Requiring travel or time off from work to participate in meetings and other conservation efforts may be an additional barrier to accessing information.
- Access to Green Spaces: Low-income communities are often deprived of the benefits that nature provides, such as clean lakes and public parks. This can limit their desire to engage in conservation activities.
- Environmental Injustice: Low-income communities are more likely to live near sources of hazardous air pollutants, such as landfills, airports, refineries, CAFOs, and highways. This can lead to health issues that further strain their resources.

Addressing these challenges requires a comprehensive approach that includes improving access to resources, education, and addressing systemic injustices.

Figure 45. Environmental Justice areas in the Pomme de Terre River Watershed



People of Color and Limited English Proficiency

None of the census tracks in the Pomme de Terre River Watershed were found to be Environmental Justice areas for the criteria of limited English proficiency or people of color. Demographic data from the Minnesota Department of Education indicates this may change in the future. The watershed's two largest cities' school demographics data indicate higher levels of people of color than the general population of the larger census tracts. At the Appleton Elementary School, enrollment is 49% minority (majority Native Hawaiian or Pacific Islander). The Morris School District's minority enrollment is 31% (majority Hispanic) of the elementary student body (Minnesota Report Card).

Tribal Areas

There are no American Indian reservations within the Pomme de Terre River Watershed (USBC 2018). Historically the Pomme de Terre River Watershed is ceded Indian territory. There are six Tribal Governments that have expressed an interest in the land and waters of the Pomme de Terre River Watershed (MPCA 2024c). They are:

- Leech Lake Band of Ojibwe, Gaa-Zagaskwaabiganikaag
- Lower Sioux Indian Community of Minnesota, Caŋsayapi
- Mille Lacs Band of Ojibwe, Mis-Qua-Mi-Saga-Eh-Ganing
- Sisseton-Wahpeton Oyate
- Upper Sioux Community, Pezihutazizi Oyate
- White Earth Band of Ojibwe, Gaa-waabaabiganikaag

4.8 Public Participation

Public participation and engagement refer to education, outreach, marketing, training, technical assistance, and other methods of working with stakeholders to achieve water resource management goals. Public participation efforts vary greatly depending on the water quality topic and location in the state.

Public Participation: WRAPS Update Development Contract

The PDTRA engaged in public participation efforts through a WRAPS Development Contract from the MPCA during the period of July 2018 through August 2022. The goal of the project was to facilitate strategic networking, learning, and participation of targeted groups to assess, build, and leverage community capacity to become aware of water quality issues and increase BMP adoption to restore and protect water quality in the Pomme de Terre River Watershed. Activities included:

- One-on-one conversational interviews with watershed stakeholders were conducted using an 18-question questionnaire that was developed to help conservation professionals understand the motives, barriers, and issues the public sees around watershed conservation in the region. These were then used to help direct engagement and outreach efforts (2019).
- Formation of a watershed public engagement team that focused on identifying engagement activities to increase BMP and soil health objectives within the watershed. The public

engagement team met every other month to develop a plan for engaging members of the public in soil health and other BMPs (2019-2023).

- Soil Health Promotion and Capacity Network: In response to water quality results, PDTRA facilitated a landowner/producer driven team that actively promoted soil health education and established a peer-to-peer network between producers with varying levels of experience and knowledge regarding different tillage and cropping practices. The group met at least twice annually (2019-present).
- Soil Health Field Days: PDTRA and partners planned and participated in many soil health field days in the watershed (2019-present).
- PDTRA annual public meetings to report out on the state of the river, conservation efforts, and advertise new initiatives (2022).
- As a part of the WRAPS Update public participation process, partners in the PDTRA conducted outreach to citizens of the watershed, farmers, lake property owners, and residents of towns. This effort began with the one-on-one surveys, transitioned to small meetings and gatherings of farmers around the themes of water quality, soil health, and the 1W1P. This process was seriously impacted by the Covid pandemic. Nevertheless, the partners were able to make the best of a tough situation and continue their work (2019-2023).

Several other important meetings and events were held to update the public on the progress of the watershed approach in the Pomme de Terre River Watershed. These included:

- Professional judgement group meeting was held to discuss new impairments and address concerns and questions between state agency staff, PDTRA staff, county staff, and SWCD staff on 5/31/2019.
- A state of the river report was presented at the PDTRA annual meeting on November 30, 2021, detailing the results of the newly completed stream and lake assessments, water quality trends and a detailed source assessment for water quality and quantity factors.
- An informational presentation was held on March 6, 2024, at the PDTRA Technical Advisory Committee meeting to present the findings of the Pomme de Terre River SID Report.

Public Notice for Comments

Public outreach refers to communication of information, education, outreach, marketing, training, technical assistance, and other methods of working with stakeholders to achieve water resource management goals. In this second cycle of the watershed approach, there was less emphasis on public outreach for the WRAPS Update report. This is because of active engagement already occurring in the watershed via Pomme de Terre River CWMP, and because outreach activities were not identified as a WRAPS Update priority task.

Although public outreach was not a primary focus of this WRAPS Update Report, significant outreach initiatives were supported by the MPCA. These include the public participation efforts outlined in the previous section of this report via the WRAPS Update Development Contract with the PDTRA.

An opportunity for public comment on the draft WRAPS Update was provided via a public notice in the *State Register* from May 28, 2024 through June 27, 2024 There were no comments received as a result of the public comment period.

5. Monitoring Plan

The Pomme de Terre River Watershed has over 20 years of water quality monitoring data. The conclusions drawn from the water quality data identify key issues. The Pomme de Terre River is a mostly rural watershed that faces primarily nonpoint sources of pollution. The primary pollutants are nutrients, suspended sediments and bacteria. In addition to these pollutants, AQL is challenged by poor habitat, mostly the result of development pressures and changes to the hydrology. As the focus continues to move from identifying the issues to implementation of BMPs, monitoring in the watershed should have several goals:

- Monitor to track change over time especially around priority subwatersheds (WPLMN, Surface Water Assessment Grant (SWAG) and Volunteer Stream and Lake Monitoring).
- Develop a plan to resolve the inconclusive findings at a number of sites noted in SID and the Watershed Assessment.
- Establish a monitoring plan to test if prioritized implementation is effective and sufficient at achieving goals observed in the river.
- Obtain and dedicate reliable and sustainable funding for a locally led monitoring plan.
- Where needed and feasible, support third party monitoring (e.g., lake associations and PDTRA) of water resources for trend studies and monitoring water for recreational uses (lake monitoring).

The CWMP Planning Partners currently rely on the 10-year Watershed Approach monitoring cycle to assess water quality changes. This assumes that there will be another round of monitoring in 2027, that WPLMN monitoring will continue at the two sites along the Pomme de Terre River near Morris and Appleton, and that there will be continued coordination of the Volunteer Stream and Lake Monitoring Program. However, there is little monitoring conducted through the CWMP and future monitoring efforts will depend on available funding levels through the MPCA.

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7. Appendix

TMDL Allocations

Barrett Lake (26-0095-00)

- 303(d) listing year: 2020
- Baseline year(s): 2013, based on the mid-range year of the existing monitoring data used to determine the TP load reduction (2009-2017)

Numeric standard used to calculate TMDL: 0.040 mg/L TP

Table 21. Barrett Lake (26-0095-00) TP TMDL and allocations.

Barrett Lake Load Component		Existing	Goal		Reduction	
		(lbs/yr)	(lbs/yr)	(lbs/day)	(lbs/yr)	(%)
Wasteload Allocations	Construction stormwater (MNR100001)	1.4	1.4	0.0038	0.0	0%
	Industrial stormwater (MNR500000)	1.4	1.4	0.0038	0.0	0%
	Total WLA	**2.8**	**2.8**	**0.0076**	**0.0**	
Load Allocations	*Direct drainage runoff*	*5,609.0*	*1404.0*	*3.847*	*4,205.0*	*75%*
	*Internal load**	*569.1*	*0.0*	*0.000*	*569.1*	*100%*
	Total Watershed/In-lake	6,178.1	1,404.0	3.847	4,774.1	77%
	Boundary Condition: Lake Pomme de Terre	7,122.9	5,862.3	16.061	1,260.6	18%
	Atmospheric	197.0	197.0	0.540	0.0	0%
	Total LA	**13,498.0**	**7,463.3**	**20.448**	**6,034.7**	
MOS			**393.0**	**1.077**		
TOTAL		**13,500**	**7,859.1**	**21.533**	**6,034.7**	**45%**

* The internal load is the excess internal load above background values.

North Drywood Lake (76-0169-00)

- 303(d) listing year: 2020
- Baseline year(s): 2010, based on the mid-range year of the existing monitoring data used to determine the TP load reduction (2009-2012)
- Numeric standard used to calculate TMDL: 0.090 mg/L TP

Table 22. North Drywood Lake (76-0169-00) TP TMDL and allocations.

North Drywood Lake Load Component		Existing	Goal		Reduction	
		(lbs/yr)	(lbs/yr)	(lbs/day)	(lbs/yr)	(%)
Wasteload Allocations	Construction stormwater (MNR100001)	1.2	1.2	0.0033	0.0	0%
	Industrial stormwater (MNR500000)	1.2	1.2	0.0033	0.0	0%
	Total WLA	**2.4**	**2.4**	**0.0066**	**0.0**	
Load Allocations	*Direct drainage runoff*	*7,478.3*	*1,075.4*	*2.944*	*6,402.9*	*86%*
	Failing septics	*2.1*	*0.0*	*0.000*	*2.1*	*100%*
	*Internal load**	*13,788.2*	*0.0*	*0.000*	*13,788.2*	*100%*
	Unnamed Creek	*5,125.7*	*811.1*	*2.221*	*4,314.6*	*84%*
	Artichoke Creek	*18,417.1*	*3,091.2*	*8.463*	*15,325.9*	*83%*
	Total Watershed/In-lake	44,811.4	4977.7	13.628	39,833.7	89%
	Boundary Condition: South Drywood Lake**	1,913.4	220.8	0.605	1,692.6	88%
	Atmospheric	144.3	144.3	0.395	0.0	0%
	Total LA	**46,869.1**	**5,342.8**	**14.628**	**41,526.3**	
MOS			**593.9**	**1.626**		
TOTAL		**46,871.5**	**5,939.1**	**16.261**	**41,526.3**	**89%**

* The internal load is the excess internal load above background values.

** This value represents the reduction lake outlet concentration.

South Drywood Lake (76-0149-00)

- 303(d) listing year: 2020
- Baseline year(s): 2011, based on the mid-range year of the existing monitoring data used to determine the TP load reduction (2011-2012)
- Numeric standard used to calculate TMDL: 0.090 mg/L TP

Table 23. South Drywood Lake (76-0149-00) TP TMDL and allocations.

South Drywood Lake Load Component		Existing	Goal		Reduction	
		(lbs/yr)	(lbs/yr)	(lbs/day)	(lbs/yr)	(%)
Wasteload Allocations	Construction stormwater (MNR100001)	0.2	0.2	0.0005	0.0	0%
	Industrial stormwater (MNR500000)	0.2	0.2	0.0005	0.0	0%
	Total WLA	**0.4**	**0.4**	**0.0010**	**0.0**	
Load Allocations	*Direct drainage runoff*	*1,879.6*	*418.6*	*1.146*	*1,461.0*	*78%*
	Failing septics	*0.0*	*0.0*	*0.000*	*0.0*	*0%*
	*Internal load**	*13,345.7*	*0.0*	*0.000*	*13,345.7*	*100%*
	Total Watershed/In-lake	15,225.3	418.6	1.146	14,806.7	97%
	Atmospheric	85.9	85.9	0.235	0.0	0%
	Total LA	**15,311.2**	**504.5**	**1.381**	**14,806.7**	
MOS			**56.1**	**0.154**		
TOTAL		**15,311.6**	**561.0**	**1.536**	**14,806.7**	**97%**

* The internal load is the excess internal load above background values.

River Eutrophication Standard TMDL, Unnamed Creek, Unnamed Cr. to Artichoke Cr (07020002-566)

- 303(d) listing year: 2020
- Baseline year(s): 2017, based on the mid-range year of the existing monitoring data used to determine the TP load reduction (2017-2018)
- Numeric standard used to calculate TMDL: 0.150 mg/L TP
- Seasonal flow used to calculate loads is 7 cfs

Table 24. Unnamed Creek (07020002-566) seasonal (June – September) phosphorus TMDL and allocations.

Unnamed Creek 07020002-566		Existing TP load	Allowable TP load	Estimated load reduction	
TMDL Parameter		**(lbs/day)**	**(lbs/day)**	**(lbs/day)**	**(%)**
Wasteload Allocations	*Taffe Pork, LLC (MNG440469)*	0	0	0	0%
	Construction stormwater (MNR1000001)	0.001	0.001	0	0%
	Industrial stormwater (MNR050000)	0.0007	0.0007	0	0%
	Total WLA	**0.0017**	**0.0017**	**0**	**0%**
Load Allocation	*Direct drainage runoff*	25.9	5.1	20.8	80%
	Total LA	**25.9**	**5.1**	**20.8**	**80%**
10% Margin of Safety			0.6		
Total Loading Capacity		**25.9**	**5.7**	**20.2**	**78%**

TSS TMDL: Pelican Creek, T130 R41W S4, north line to Pomme de Terre R. (07020002-506)

- 303(d) listing year: 2020
- Baseline year(s): 2017, based on the mid-range year of the existing monitoring data used to determine the TSS concentration reduction (2016-2018)
- Numeric standard used to calculate TMDL: 30 mg/L TSS
- Exceedances are occurring during high and low flows. However, we cannot rule out that exceedances are not occurring at the other flow ranges due to the small number of samples collected.

Table 25. Pelican Creek (07020002-506) TSS TMDL and allocations.

Pelican Creek (07020002-506)		Flow Regime				
		Very High (cfs)	High (cfs)	Mid-Range (cfs)	Low (cfs)	Very Low (cfs)
		71.4	**31.6**	**18.3**	**10.6**	**5.1**
TMDL Parameter		**Total Suspended Solids (lbs/day)**				
Waste Load Allocations	*Ashby WWTP (MNG580087)*	293.0	293.0	293.0	293.0	293.0
	Construction stormwater (MNR1000001)	1.3	0.6	0.3	0.2	0.1
	Industrial stormwater (MNR050000)	3.0	1.3	0.8	0.4	0.2
	Total WLA	297.3	294.9	294.1	293.6	293.3
Load Allocations	*Direct drainage runoff*	4,899.9	2,005.0	1,035.6	478.4	79.9
	Total LA	4,899.9	2,005.0	1,035.6	478.4	79.9
10% Margin of Safety		577.5	255.6	147.8	85.8	41.5
Total Loading Capacity		**5,774.7**	**2,555.5**	**1,477.5**	**857.8**	**414.7**
Existing 90th percentile TSS concentration (mg/L)		41				
Percent Reduction to Achieve 30 mg/L TSS Standard		27%				

E. coli TMDL: Pelican Creek, T130 R41W S4, north line to Pomme de Terre R. (07020002-506)

- 303(d) listing year: 2020
- Baseline year(s): 2013, based on the mid-range year of the existing monitoring data used to determine the *E. coli* load reduction (2010-2016)
- Numeric standard used to calculate TMDL: 126 org./100 mL *E. coli*
- Sample points indicate a pervasive impairment in all flow zones where samples were taken

Table 26. Pelican Creek (07020002-506) *E. coli* TMDL and allocations.

Pelican Creek (07020002-506)		Flow Regime				
		Very High (cfs)	High (cfs)	Mid-Range (cfs)	Low (cfs)	Very Low (cfs)
		71.4	**31.6**	**18.3**	**10.6**	**5.1**
TMDL Parameter		***E. coli* (billion organisms per day)**				
Existing Load		**285.9**	**73.0**	**165.5**	**78.5**	**NA**
Wasteload Allocations	*Ashby WWTP (MNG580087)*	0.5	0.5	0.5	0.5	0.5
	Total WLA	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**
Load Allocations	*Direct drainage runoff*	197.5	87.2	50.2	28.9	13.7
	Total LA	**197.5**	**87.2**	**50.2**	**28.9**	**13.7**
10% Margin of Safety		22.0	9.7	5.6	3.3	1.6
Total Loading Capacity		**220.0**	**97.4**	**56.3**	**32.7**	**15.8**
Estimated Load Reduction		*65.90*	*NA*	*109.2*	*45.8*	*NA*
		23%	*NA*	*66%*	*58%*	*NA*

[a] Unable to calculate allocations because the wastewater WLA exceeds the loading capacity. The allocations are expressed as an equation rather than an absolute number: allocation = flow contribution from a given source x 126 org/100 mL.

E. coli TMDL: Muddy Creek, T124 R44W S3, west line to Pomme de Terre R. (07020002-511)

- 303(d) listing year: 2020
- Baseline year(s): 2013, based on the mid-range year of the existing monitoring data used to determine the *E. coli* load reduction (2010-2016)
- Numeric standard used to calculate TMDL: 126 org./100 mL *E. coli*
- Aside from the very high and the very low flow ranges the evidence points to a clear *E. coli* impairment. The prevalence of high *E. coli* loads in low, mid and high range flows suggests a variety of sources are responsible for the impairment.

Table 27. Muddy Creek (07020002-511) *E. coli* TMDL and allocations

Muddy Creek 07020002-511		Flow Regime				
		Very High (cfs)	High (cfs)	Mid–-Range (cfs)	Low (cfs)	Very Low (cfs)
		155.8	52.7	29.4	18.6	7.5
TMDL Parameter		*E. coli* (billion organisms per day)				
Existing Load		**73.1**	**320.3**	**100.4**	**54.8**	**NA**
Wasteload Allocation	*Loren Schmidgall Farm–- Site 1 (MNG440002)*	0	0	0	0	0
	Farmco Supply LLP–- Sec 5 (MNG440270)	0	0	0	0	0
	Martys Swine Systems Inc–- East Site (MNG440830)	0	0	0	0	0
	Martys Swine Systems Inc–- West Side (MNG440831)	0	0	0	0	0
	West Line Pork (MNG441061)	0	0	0	0	0
	Riverview LLP–- Baker Dairy (not available)	0	0	0	0	0
	Alberta WWTP (MNG580002)	0.1	0.1	0.1	0.1	0.1
	Chokio WWTP (MNG580007)	0.5	0.5	0.5	0.5	0.5
	Total WLA	**0.6**	**0.6**	**0.6**	**0.6**	**0.6**
Load Allocations	*Direct drainage runoff*	431.8	145.5	80.8	51.1	20.2
	Total LA	**431.8**	**145.5**	**80.8**	**51.1**	**20.2**
10% Margin of Safety		48.0	16.2	9.1	5.7	2.3
Total Loading Capacity		**480.4**	**162.3**	**90.5**	**57.4**	**23.1**
Estimated Load Reduction		*NA*	*158.0*	*9.9*	*NA*	*NA*
		NA	*49%*	*10%*	*NA*	*NA*

TSS TMDL: Unnamed Creek, Unnamed Creek to Pomme de Terre R. (07020002-547)

- 303(d) listing year: 2022
- Baseline year(s): 2017, based on the mid-range year of the existing monitoring data used to determine the TSS concentration reduction (2017-2018)
- Numeric standard used to calculate TMDL: 65 mg/L TSS

Table 28. Unnamed Creek (07020002-547) TSS TMDL and allocations.

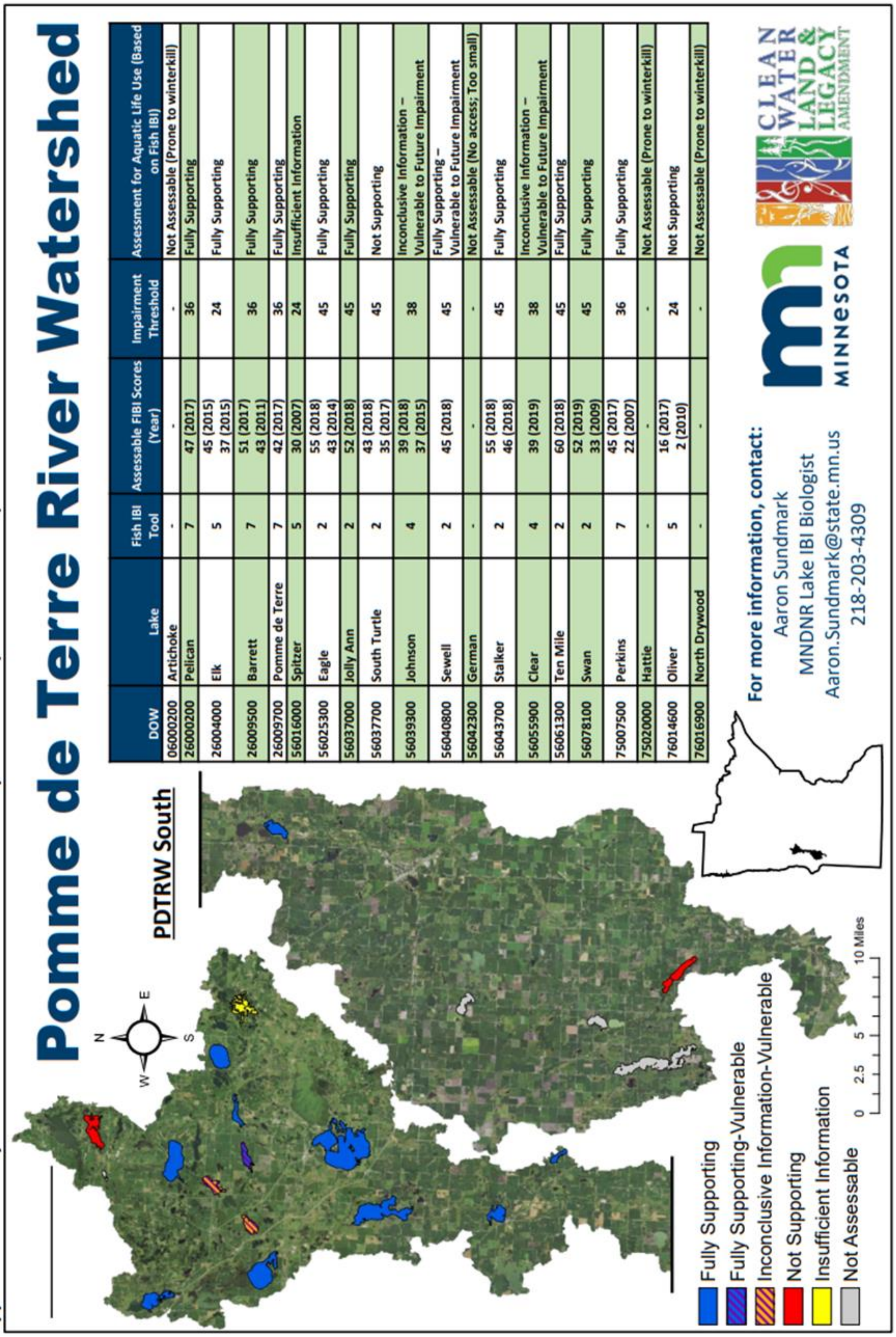
Unnamed Creek (07020002-547)		Flow Regime				
		Very High	**High**	**Mid-Range**	**Low**	**Very Low**
		28.9	**10.5**	**6.2**	**3.6**	**1.5**
TMDL Parameter		**Total Suspended Solids (lbs/day)**				
Existing Load*		NA	NA	NA	NA	NA
Wasteload Allocations	*Outback Five Inc. (MNG440126)*	*0*	*0*	*0*	*0*	*0*
	Farmco Supply LLP–- Sec 34 (MNG440548)	*0*	*0*	*0*	*0*	*0*
	District 45 Dairy (MNG440749)	*0*	*0*	*0*	*0*	*0*
	Fairfield Hog Farm (MNG441057)	*0*	*0*	*0*	*0*	*0*
	Construction stormwater (MNR1000001)	*1.4*	*0.5*	*0.3*	*0.2*	*0.1*
	Industrial stormwater (MNGR050000)	*1.7*	*0.6*	*0.4*	*0.2*	*0.1*
	Total WLA	**3.1**	**1.1**	**0.7**	**0.4**	**0.2**
Load Allocations	*Direct drainage runoff*	*9,116.0*	*3,301.5*	*1,954.4*	*1,140.1*	*480.8*
	Total LA	**9,116.0**	**3,301.5**	**1,954.4**	**1,140.1**	**480.8**
10% Margin of Safety		1,013.2	367	217.2	126.7	53.5
Total Loading Capacity		10,132.3	3,669.6	2,172.3	1,267.2	534.5
Existing 90th percentile TSS concentration (mg/L)**		100				
Percent Reduction to Achieve 65 mg/L TSS Standard		35%				

* Water quality data collected after HSPF model simulation so there are no paired flow regimes to list as existing loads.

**Reduction calculated from 90th percentile concentration of 2017-2018 assessment data.

Reduction calculated from 90th percentile concentrations.

Summary of lakes and associated assessment for Aquatic Life Use (Based on Fish IBI) in the Pomme de Terre River Watershed assessed with FIBI tools (DNR 2023).



DOW	Lake	Fish IBI Tool	Assessable FIBI Scores (Year)	Impairment Threshold	Assessment for Aquatic Life Use (Based on Fish IBI)
06000200	Artichoke	-	-	-	Not Assessable (Prone to winterkill)
26000200	Pelican	7	47 (2017)	36	Fully Supporting
26004000	Elk	5	45 (2015) 37 (2015)	24	Fully Supporting
26009500	Barrett	7	51 (2017) 43 (2011)	36	Fully Supporting
26009700	Pomme de Terre	7	42 (2017)	36	Fully Supporting
56016000	Spitzer	5	30 (2007)	24	Insufficient Information
56025300	Eagle	2	55 (2018) 43 (2014)	45	Fully Supporting
56037000	Jolly Ann	2	52 (2018)	45	Fully Supporting
56037700	South Turtle	2	43 (2018) 35 (2017)	45	Not Supporting
56039300	Johnson	4	39 (2018) 37 (2015)	38	Inconclusive Information – Vulnerable to Future Impairment
56040800	Sewell	2	45 (2018)	45	Fully Supporting – Vulnerable to Future Impairment
56042300	German	-	-	-	Not Assessable (No access; Too small)
56043700	Stalker	2	55 (2018) 46 (2018)	45	Fully Supporting
56055900	Clear	4	39 (2019)	38	Inconclusive Information – Vulnerable to Future Impairment
56061300	Ten Mile	2	60 (2018)	45	Fully Supporting
56078100	Swan	2	52 (2019) 33 (2009)	45	Fully Supporting
75007500	Perkins	7	45 (2017) 22 (2007)	36	Fully Supporting
75020000	Hattie	-	-	-	Not Assessable (Prone to winterkill)
76014600	Oliver	5	16 (2017) 2 (2010)	24	Not Supporting
76016900	North Drywood	-	-	-	Not Assessable (Prone to winterkill)