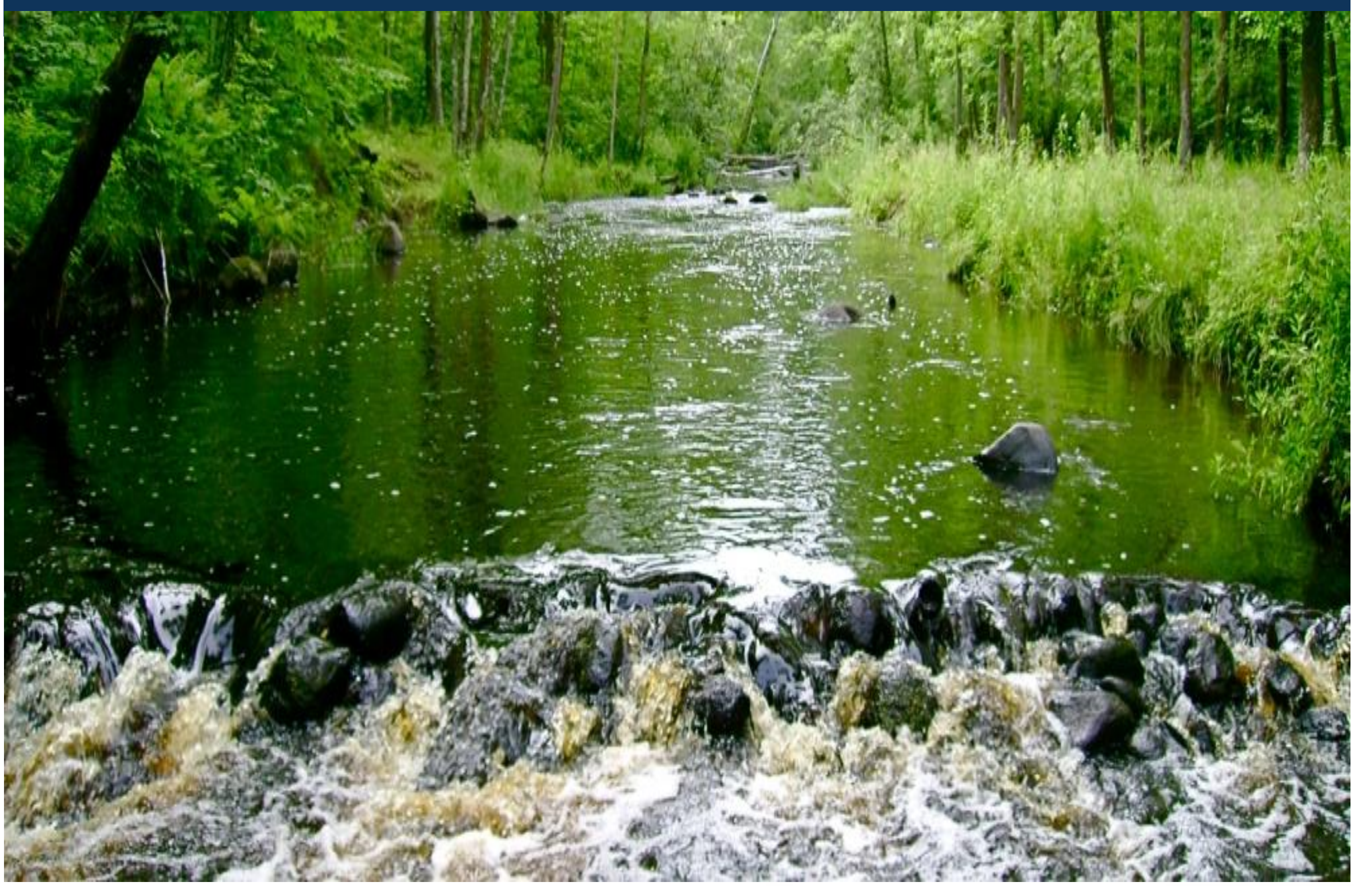
April 2026

Watershed

Draft Snake River Watershed Restoration and Protection Strategy Report Update 2026



MINNESOTA POLLUTION CONTROL AGENCY

CLEAN WATER LAND & LEGACY AMENDMENT

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Key terms and abbreviations

1W1P	One Watershed, One Plan
AQL	Aquatic Life Uses
AR	Aquatic Recreation
AU	animal unit
BMP	best management practice
BWSR	Board of Water and Soil Resources
CaCl2	calcium chloride
Cr	creek
CWLA	Clean Water Legacy Act
CWMP	Comprehensive Watershed Management Plan
DNR	Minnesota Department of Natural Resources
DO	dissolved oxygen
E. coli	*Escherichia coli*
EHC	Erosion Hazard Classification
EJ	Environmental Justice
EPA	U.S. Environmental Protection Agency
FIBI	fish community-based Index of Biological Integrity
HSPF	Hydrologic Simulation Program–Fortran
HUC	Hydrologic Unit Code
IBI	index of biological integrity
IWL	Impaired waters list
IWM	intensive watershed monitoring
KCl	potassium chloride
lbs	pounds
LGU	local government unit
MDA	Minnesota Department of Agriculture
MgCl2	Magnesium chloride
mg/L	milligrams per liter
MPCA	Minnesota Pollution Control Agency

MST	Microbial Source Tracking
MS4	Municipal Separate Storm Sewer System
NaCl	sodium chloride
NPDES	National Pollutant Discharge Elimination System
PACl	polyaluminum chloride
PTMApp	Prioritize, Target, and Measure Application
SDS	State Disposal System
SID	stressor identification
SRW	Snake River Watershed
SSTS	Subsurface Sewage Treatment Systems
SWA	Subwatershed Assessment
SWCD	Soil and Water Conservation District
TALU	tiered aquatic life uses
TMDL	total maximum daily load
TP	total phosphorus
TSS	total suspended solids
UAA	use attainability analysis
USGS	United States Geological Survey
WASCOB	Water and Sediment Control Basins
WBIF	Watershed-Based Implementation Funding
WID	Water body identifier
WPLMN	Watershed Pollutant Load Monitoring Network
WRAPS	watershed restoration and protection strategy
WWTP	wastewater treatment plant

Executive summary

The State of Minnesota uses a watershed approach to manage and improve water quality across its 80 major watersheds. As part of this approach, each watershed undergoes intensive watershed monitoring (IWM) and assessment on a 10-year cycle. Following this monitoring, a Watershed Restoration and Protection Strategy (WRAPS) report is developed to guide local water planning and implementation efforts.

In the Snake River Watershed (SRW) in the St. Croix River Basin, Cycle 1 of IWM began in 2006, and Cycle 2 was completed in 2018. This 2026 WRAPS Report Update builds upon the original 2014 Snake River WRAPS Report and incorporates findings from the Cycle 2 IWM, Stressor Identification (SID), and other relevant water quality research and studies.

The 2014 WRAPS Report identified total phosphorus (TP) as a primary concern in the watershed—a priority that remains in this update. In addition, this report addresses new *Escherichia coli* (*E. coli*) impairments identified during Cycle 2 monitoring and assessments.

Additional work was conducted in partnership with local, state, and tribal partners. In the SRW, the SRW Partnership includes Aitkin, Kanabec, Mille Lacs, and Pine Soil and Water Conservation Districts (SWCDs), as well as Aitkin, Kanabec, and Pine counties play a key role in the watershed planning and implementation. The One Watershed, One Plan (1W1P) program is a Minnesota Board of Water and Soil Resources (BWSR) initiatives that aligns local water planning with major watershed boundaries. It brings together local government units (LGU) to create a single, comprehensive, and prioritized 10-year management plan, transitioning from fragmented county-level planning to a coordinated, watershed-wide approach. Since the adoption of the SRW Comprehensive Plan, hereafter referred to by the broader term Comprehensive Watershed Management Plan (CWMP), in 2023, new data and studies have informed current watershed priorities.

The key goals of this WRAPS Update are to:

- Highlight changes in watershed conditions between Cycle 1 (2006-2007) and Cycle 2 (2017–2020).
- Identify pollutant sources contributing to water quality impairments.
- Provide updated tools, resources, and recommendations to support watershed partners in planning and implementing best management practices (BMPs).
- Align implementation strategies with priorities identified in the CWMP to support coordinated, watershed-wide water management efforts.

1. Watershed approach

The State of Minnesota developed a watershed approach to focus holistically on each watershed's condition as the scientific basis of permitting, planning, implementation, and measurement of results. This process looks strategically at the drainage area as a whole, instead of focusing on lakes and stream sections one at a time, thus increasing effectiveness and efficiency (Figure 1).

Figure 1. Minnesota's Watershed Approach.

Every 10 years, each of Minnesota's 80 major watersheds are evaluated through monitoring/data collection and assessed against water quality standards to show trends in water quality and the impacts of permit requirements, as well as any restoration and protection actions. A WRAPS report is then updated to provide technical information to support the implementation of restoration and protection projects by local partners through their 1W1P comprehensive local water plan. The Minnesota Pollution Control Agency's (MPCA's) watershed work is tailored to meet local conditions and needs, based on factors such as watershed size, landscape diversity, and geographic complexity.

To identify and address threats to water quality in each watershed, WRAPS Update Reports address both strategies for restoration for impaired waters, and strategies for protection of waters that are not impaired. Waters not meeting state standards are listed as impaired and total maximum daily load (TMDL) studies are developed for them. The TMDLs are incorporated into the WRAPS Update reports.

Key aspects of the MPCA's watershed work are to develop and utilize watershed-scale computer models, perform biological SID, conduct problem investigation monitoring, and use other tools to identify strategies for addressing point and nonpoint source pollution that will cumulatively achieve water quality targets. Point source pollution comes from sources such as wastewater treatment plants (WWTP) or industrial facilities; nonpoint source pollution is the result of runoff or contaminants not being absorbed in the soil. For nonpoint source pollution, the WRAPS Update Report informs local planning efforts, but ultimately the local partners decide what work will be included in their local plans.

Minn. Stat. (§) 114D, also known as the Clean Water Legacy Act (CWLA), sets out the policy framework for the Watershed Approach, including requiring the development and updating of WRAPS for all the watershed of the state. The Clean Water, Land and Legacy Amendment, approved by Minnesota voters in 2008, directs dollars from an increase in sales tax to a Clean Water Fund, which is overseen by the Clean Water Council. The Clean Water Fund provides resources to implement the CWLA to achieve and maintain water quality standards in Minnesota through activities such as monitoring, watershed characterization and scientific study, planning, research, and on-the-ground restoration and protection activities.

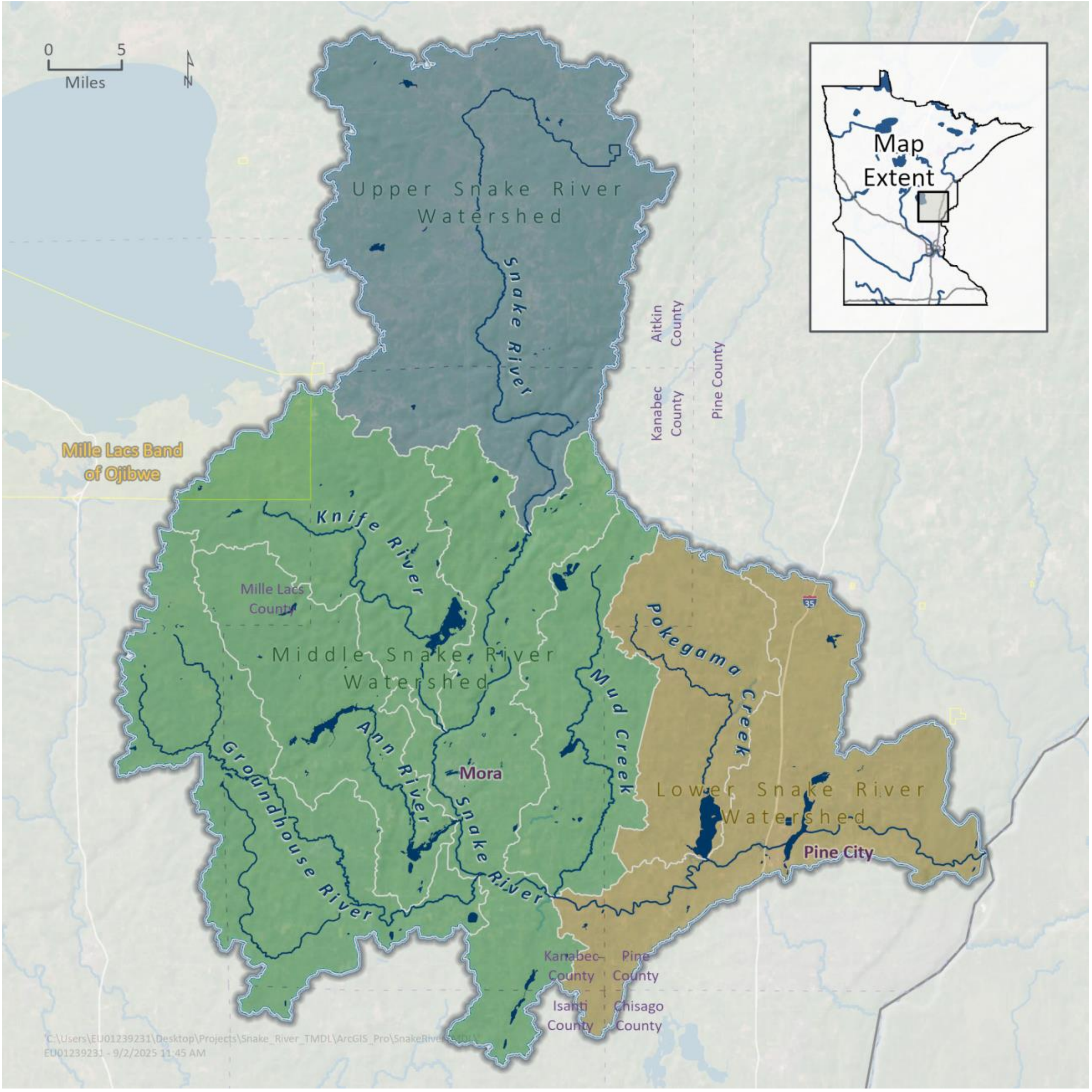
2. Watershed description

The SRW lies within the St. Croix River Basin and is designated as U.S. Geological Survey (USGS) Hydrologic Unit Code (HUC-8) 07030004 (MPCA, 2014). It spans approximately 1,006 square miles (643,534 acres) across six counties: Aitkin, Kanabec, Mille Lacs, Pine, Chisago, and Isanti. The northern portion of the watershed is part of the Northern Lakes and Forests ecoregion, characterized by extensive forest and wetland cover. In contrast, the southern portion lies within the North Central Hardwood Forest ecoregion, which features a mix of forest, grassland, pasture/hay, and cropland. The Snake River flows southeast, ultimately joining the St. Croix River in Pine County.

The watershed includes eight 10-digit HUC subwatershed: Upper Snake, Middle Snake, Knife River, Mud Creek, Groundhouse River, Pokegama Creek, Anne River, and Lower Snake River (Figure 2). There are 87 lakes and 128 streams totaling over 1,050 linear miles within the watershed. Major tributaries include Groundhouse, Anne, Knife, and Mission Creeks, as well as Mud and Pokegama Creek. Key lakes include Ann, Fish, Knife, Quamba, Pokegama, and Cross lakes. All lakes except Pokegama and Cross meet the Minnesota Department of Natural Resources (DNR's) definition of shallow lakes (50+ acres in size with a maximum depth of 15 feet or less; MPCA, 2014).

This watershed supports a rich diversity of aquatic life, including various fish species and freshwater mussels, along with several state-listed threatened and endangered terrestrial species. It also contains notable natural areas such as the Mille Lacs Wildlife Management Area, Solana State Forest, and Rum River State Forest, all of which offer essential wildlife habitat and opportunities for recreation, including hiking, camping, canoeing, and wildlife observation. Additionally, parts of the Snake River are designated as part of the Snake River State Water Trail, one of Minnesota's 35 official water trails used for paddling and camping.

Figure 2. Upper, Middle, and Lower Snake River subwatersheds.



The northern portion of the watershed lies within the Northern Lakes and Forest Ecoregion and is primarily fostered with extensive wetlands. In contrast, the southern portion falls within the North Central Hardwood Forest Ecoregion and features a mix of forests, grasslands, pasture/hay, and cropland. Most livestock and feedlots are also concentrated in this southern area. The land use changes observed between Cycle 1 and 2 have meaningful implications for the SRW hydrology, nutrient dynamics, and sediment transport (Figure 3, Figure 4, Table 1). The slight decrease in cropland and increase in grassland, pasture, and wetland areas suggest gradual progress toward reduced surface runoff and improved nutrient retention, lowering phosphorus and sediment loading to lakes and streams. Expanded wetland and perennial cover enhance natural filtration and water storage capacity, buffering the impacts of intense precipitation events and supporting aquatic habitat resilience. Conversely, the minor decline in forest cover and growth in developed land may contribute to localized increases in impervious surface area, potentially elevating stormwater runoff, chloride loading, and thermal impacts to nearby streams if not mitigated through BMPs. Maintaining and expanding vegetative buffers, stormwater treatment systems, and forest conservation efforts will be critical to balancing development pressures with water quality protection. Overall, these landscape trends highlight the importance of continued adaptive management, targeted restoration, and partnership with private landowners to sustain the watershed's ecological integrity and progress towards meeting state water quality standards.

Figure 3. Land use in the SRW 2013.

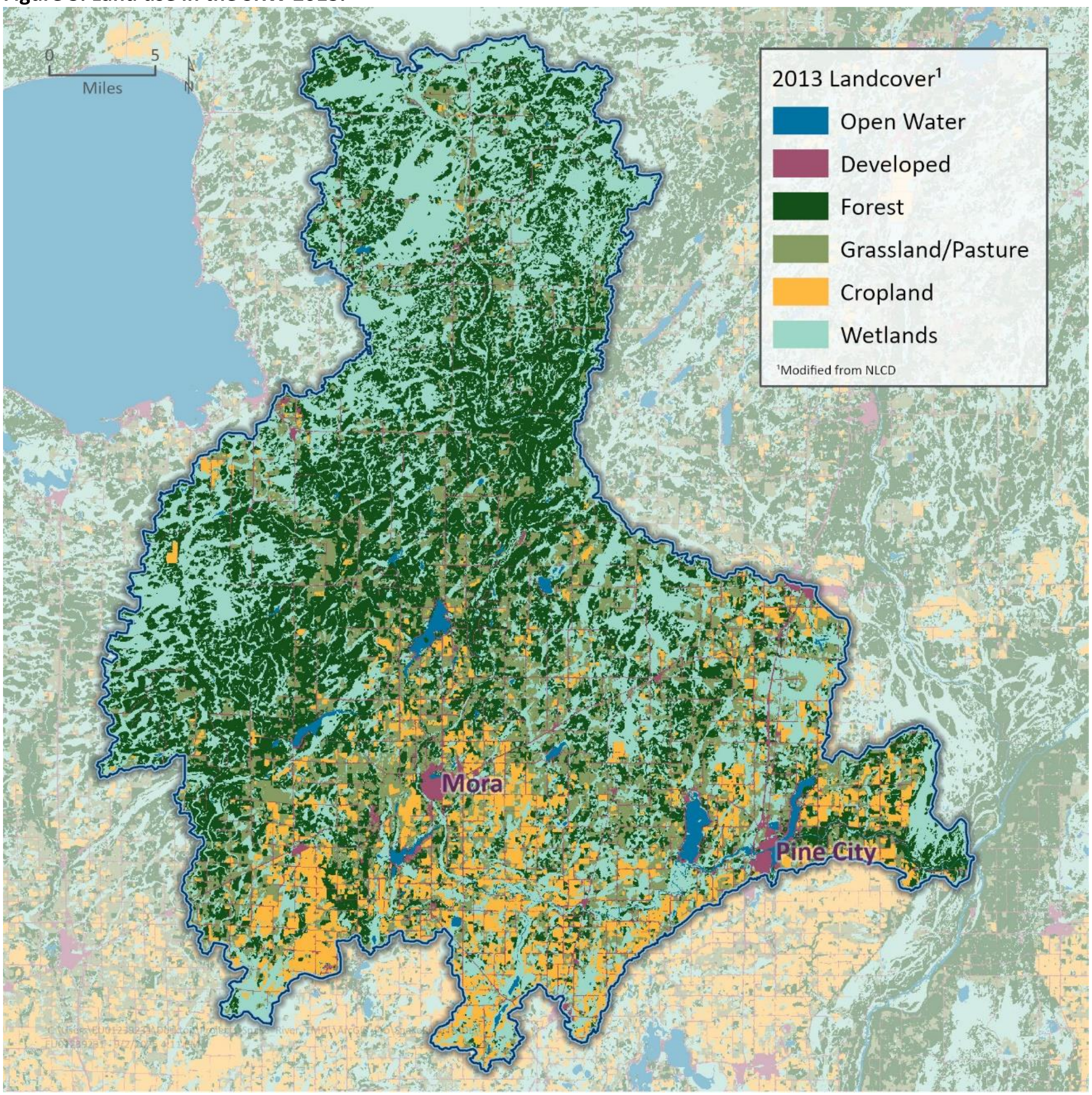


Figure 4. Land use for SRW 2024.

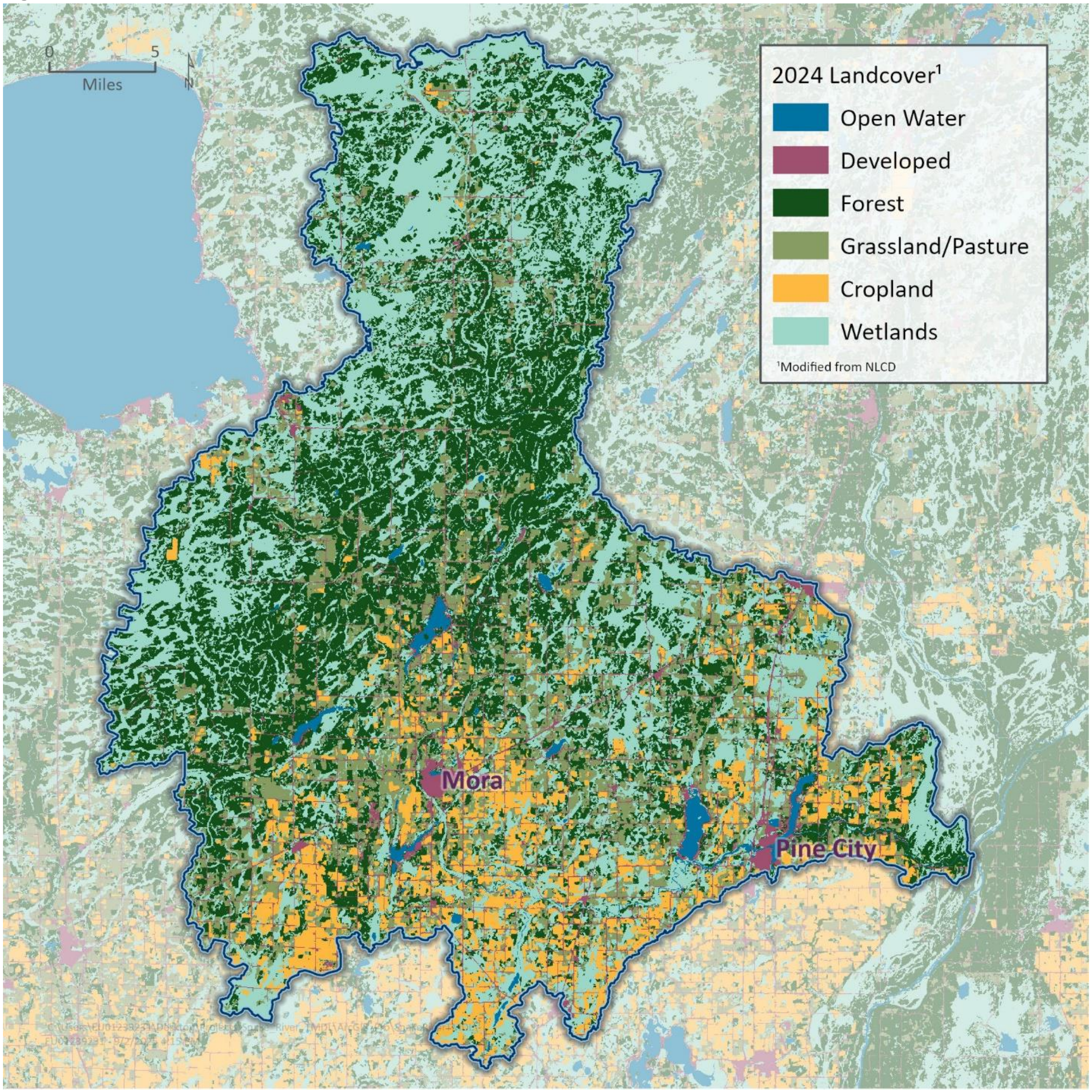


Table 1. Land use change between Cycle 1 and Cycle 2 in the SRW.

Land use type	Acres - 2013	Percent coverage - 2013	Acres - 2024	Percent coverage - 2024	Change in land use
Forest	222,029	34.50	218,875	34.01	Decrease
Wetlands	218,955	34.02	220,473	34.25	Increase
Grassland/Pasture	100,633	15.63	104,040	16.16	Increase
Cropland	62,348	9.69	59,666	9.27	Decrease
Developed	30,994	4.82	32,305	5.02	Increase
Open Water	8,680	1.35	8,279	1.29	Decrease

3. Assessing water quality

Minnesota's approach to water quality protection and restoration is built on science-based, watershed-scale framework that integrates monitoring, assessment, and modeling to identify stressors, evaluate trends, and guide implementation. This work is carried out in collaboration with the watershed partners, including the SRW Partnership, which plays a key role in aligning local priorities and implementing management actions across jurisdictional boundaries. The SRW has been assessed through multiple monitoring and planning cycles that together form the foundation for this WRAPS Update. Each cycle builds upon previous work, refining understanding of local water quality conditions, pollutant sources, and ecosystem responses. Sections 3.1 through 3.7 outline the major components of this framework.

3.1 Water quality standards

Water quality assessment in Minnesota follows a science-based process designed to determine whether rivers, lakes, and streams are healthy enough to support their beneficial uses such as swimming, fishing, aquatic life, and drinking water. The MPCA intensively monitors lakes and streams in a watershed over the course of two years, gathering surface water and biological samples and data on key indicators for water quality. Assessments in this context includes comparing data collected to water quality standards. A water body is considered impaired when it does not meet state standards for one or more of these uses, often due to elevated levels of sediment, nutrients, bacteria, or other pollutants. The causes of impairment, known as stressors, are identified through SID studies that evaluate factors like habitat alteration, low dissolved oxygen (DO), or excess nutrients. When impairments are confirmed, a TMDL study will be developed as resources allow to calculate how much of a pollutant the water body can receive and still meet water quality standards (MPCA, 2026). Together, these tools provide the technical foundation for restoration and protection planning under Minnesota's Watershed approach to water quality, which uses monitoring, modeling, and adaptive management to improve water quality over time.

3.2 Tiered aquatic life uses

Minnesota's assessment process is traditionally based on warm and cold-water classification to reflect the biological potential of individual streams. Under this system beneficial uses are assigned to streams to protect ecosystems, habitats, and aquatic life. Most streams are designated Class 2 (Aquatic Life and Recreation) but are further divided to account for natural differences between aquatic systems and the best attainable conditions. Class 2 is divided into subclasses and then into aquatic life use tiers.

- Class 2A: Cold water habitat – lakes and streams
- Class 2B: Warm water habitat – lakes and streams
- Class 2Bd: Warm water habitat also protected for drinking water – lakes and streams
- Class 2D: Wetlands

Aquatic life beneficial uses are further refined based on the tiered aquatic life uses (TALU) framework that builds upon existing standards to improve how water is monitored and managed. The TALU framework relies on a combination of biological, physical, and chemical monitoring to measure the attainment of aquatic life goals directly.

The TALU framework appropriately classifies waters based on their biological potential and provides three levels of use for assessment including:

- Exceptional Use - High quality waters, generally in need of protection
- General Use - Good quality waters, most natural streams and rivers
- Modified Use – Streams modified by straightening and ditching

Use Attainability Analysis (UAA) are performed to determine if habitat is limiting the biology and what is the cause of the poor habitat. Streams that have biological and habitat limitations based on legal activities (for example ditch maintenance) could be redesignated Modified Use.

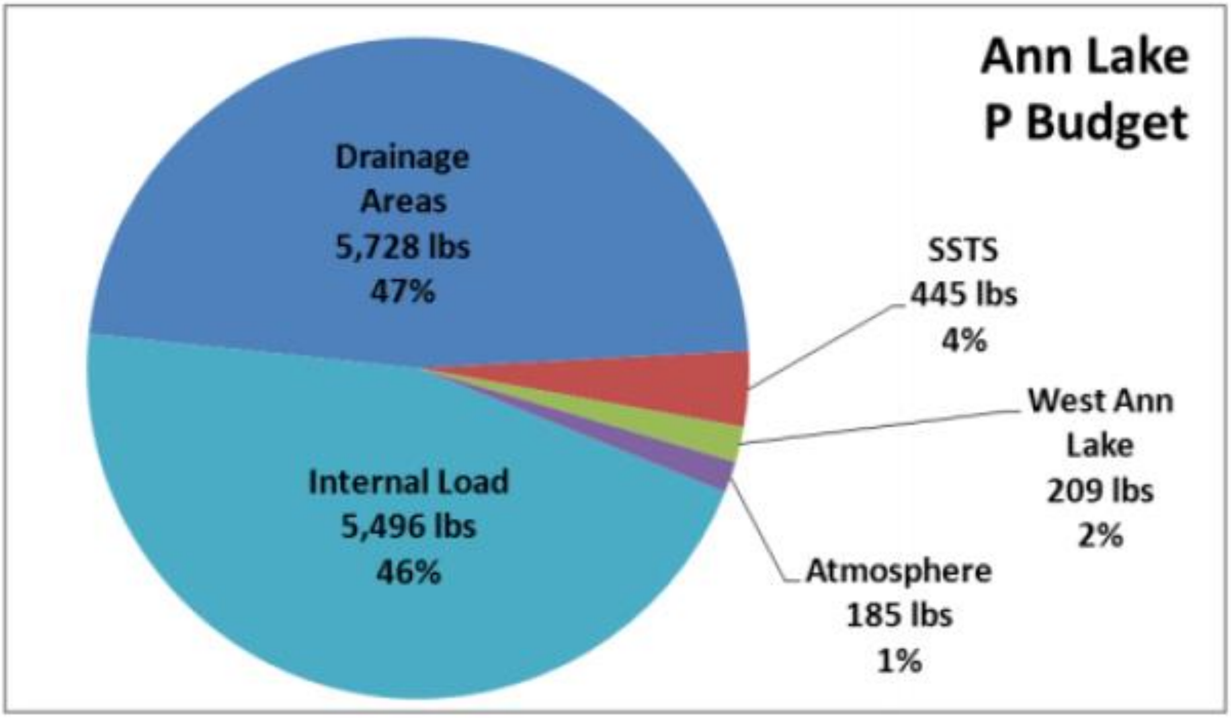
While most waters in the SRW are designated as Class 2 – Aquatic Life and Recreation, TALU provides a more nuanced system by establishing biological integrity and are held to a more stringent standard, while modified streams often channelized or heavy altered are then assessed under adjusted criteria that account for their limited physical potential.

3.3 Water quality assessment

Ann Lake Internal Load Feasibility

The Ann Lake Internal Load Feasibility Study (WENCK, 2018) represents work within the watershed that can inform and guide future management strategies by building on prior research and findings (Figure 5). The Ann Lake Feasiblity Study, which was funded by the district, determined that excessive phosphorus release from lake sediments especially in deeper western basin areas is the primary driver of poor water qualtiy and algae growth. To meet state water quality standards, Ann Lake must reduce phosphorus loading by about 4,000 lbs/year, mostly through internal load controls. Among the treatment options evaluated, alum applications was the most cost-effective and proven, though it requires multiple treatments and careful monitoring to protect wild rice from sulfate impacts. Alternative treatment methods such as Phoslock and polyaluminum chloride (PACl) offer environmental trade-offs at higher costs, while hypolimnetic aeration presents long-term operational challenges. In addtion to internal loading discussed above opportunites exist in the drainage area to decrease phosphorus loading as well. Follow-up monitoring of sediments and water chemistry is essential to track treatment effectiveness, guide adaptive management, and ensure protection of sensitive species such as wild rice.

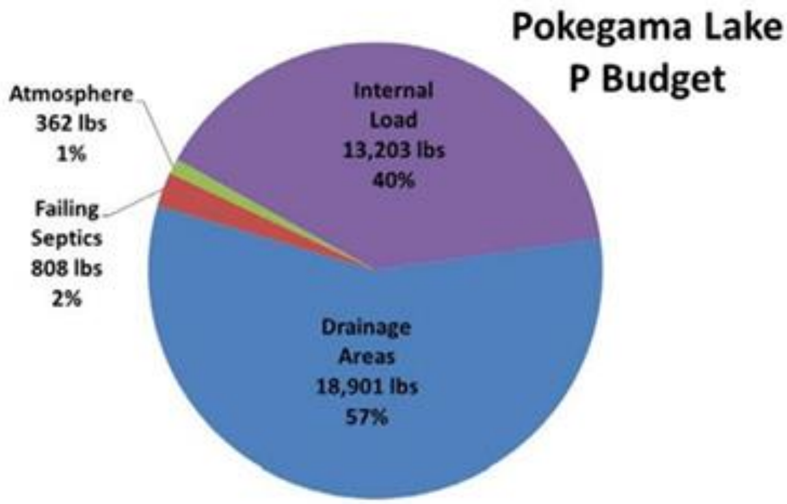
Figure 5. Ann Lake phosphorus budget (WENCK, 2018).



Pokegama Lake Subwatershed Assessment Report

Pine County Land and Water Conservation District and Pokegama Lake Association prepared The Pokegama Lake Subwatershed Assessment (SWA; Stantec, 2024) builds upon the the SRW TMDL (MPCA, 2013) and WRAPS (MPCA, 2014) recommendations to refine strategies for nutrient reduction and long-term water quality improvement. Pokegama Lake has remained impaired by TP since 2004, with average summer concentrations (126 µg/L) consistently exceeding the 40 µg/L standard for deep lakes in the North Central Hardwood Forest Ecoregion (Figure 6). The SWA used the Prioritize, Target, and Measure Application (PTMApp) to identify and rank 827 BMP locations across the watershed, including wetlands, Water and Sediment Control Basins (WASCOB), grassed waterways, and field practices such as cover crops and reduced tillage. Full implementation of these BMPs could reduce phosphorus loading by approximatly 1,936 lbs/yr, with the top 32 priority BMPs accounting for about 640 lbs of reduction toward the TMDL goal of 74% reduction. Wetland restoration and WASCOBs were identified as the most effective structural BMPs, while cover crops and reduced tillage provided the most cost-effective nonstructural practices. These results provide a clear roadmap for targeted implementation and adaptive management in collaboration with Pine and Kanabec Counties, the Pokegama Lake Association, and local landowners, advancing measurable progress toward restoring water quality and recreational use in Pokegama Lake.

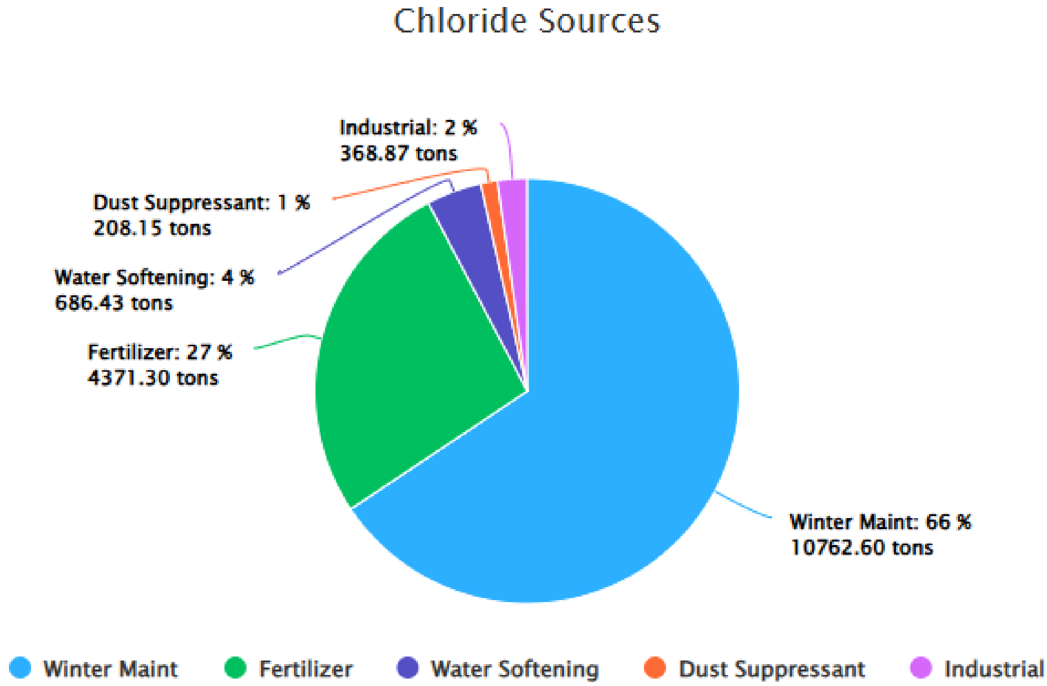
Figure 6. Pokegama Lake phosphorus budget (Stantec, 2024).



Chloride Reduction

Building on lake-specific efforts such as those on Ann and Pokegama lakes, it is equally important to address emerging pollutants that threaten the watershed as a whole. One such pollutant of growing concern is chloride. Chloride, often referred to as "salt", comes from compounds such as sodium chloride (NaCl), calcium chloride (CaCl2), magnesium chloride (MgCl2), and potassium chloride (KCl) (Smart Salting MPCA, 2020). These salts dissolve in water and the chloride ion binds with water molecules, meaning it does not break down naturally. It only takes one teaspoon of salt to contaminate five gallons of water and once present, chloride cannot be removed cost effectively (Smart Salting Training website). In the Snake River, chloride levels ranged from 2.6 to 211 mg/L in 2019, with an average of 12.08 mg/L. The largest contributor to chloride loading is winter road maintenance (66%), followed by fertilizer use (27%), water softening (4%), dust suppressants (1%), and industrial sources (2%) (Figure 7). Elevated chloride harms fish, aquatic insects, amphibians, and aquatic plants by reducing biodiversity, weakening immune systems, and altering food webs. It can also allow invasive species like carp to outcompete native fish, disrupt the natrual mixing of lakes by increasing water density, and contribute to oxygen depletion and phosphorus release. Chloride's persistence in rivers, streams, and groundwater poses a long-term threat to freshwater health, drinking water, vegetation, wildlife, and recreation. Because removal is not feasible, reducing salt use at the source is the only practiclal solution to protecting water quality and ecosystem health in the SRW. There is currently one segment from Cross Lake to St. Croix River, which was assessed in 2019 that has a High Risk for impairment. To prevent more from being recognized as High Risk, there are actions that can be taken to decrease the overall chloride loading to the watershed.

Figure 7. Chloride sources in the SRW.

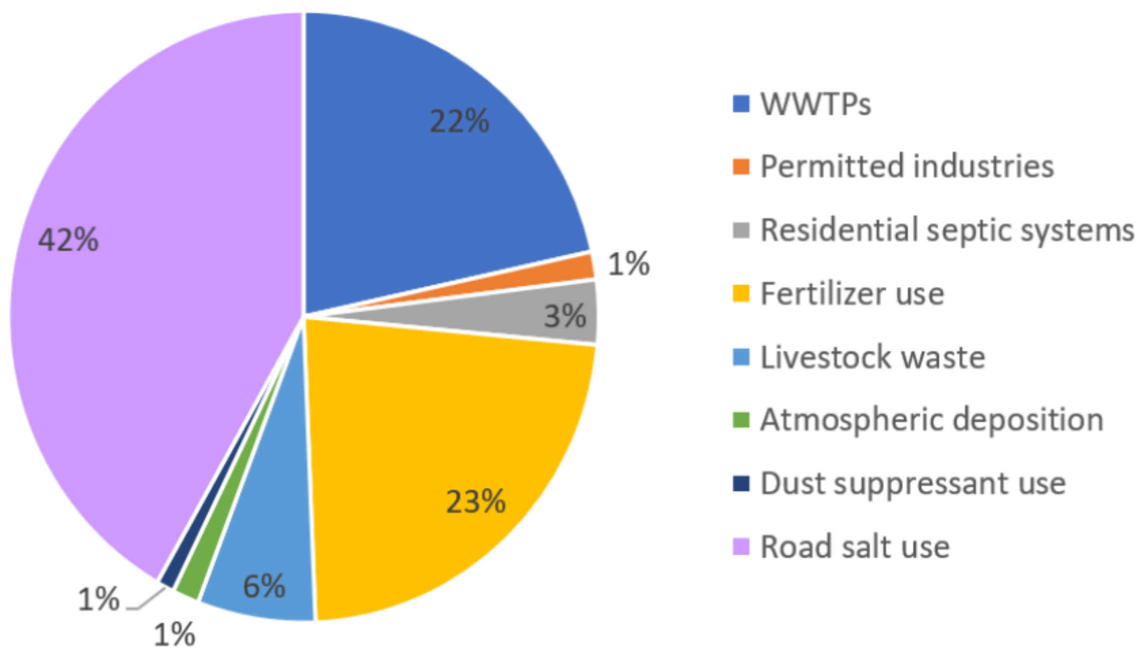


To further reduce chloride loading in the SRW, community members, municipalities, and businesses can participate in the MPCA's Smart Salting training program. These trainings provide practical, hands-on strategies to minimize salt use while still maintaining safe roads, sidewalks, and parking lots. By learning how to calibrate equipment, adjust application rates, and adopt BMPs for storage, de-icing, and anti-icing, winter maintenance staff can reduce salt use by 30% to 70% (Figure 8). Property managers, water softening professionals, and local decision makers can also access specialized workshops to address chloride use in their sectors. Hosting or attending a training not only builds capacity within the organizations but also helps communities to achieve cost savings, reduce infrastructure damage, and protect local water quality. Local governments and private contractors are encouraged to integrate Smart Salting certification and refresher courses into their annual training requirements, ensuring long-term reductions in chloride pollution.

Effectiveness Monitoring

To evaluate the effectiveness of restoration and protection strategies, monitoring is essential. Tracking pollutant reductions, detecting new risks, and understanding changing watershed conditions all depend on consistent and targeted data collection. Although several monitoring programs are in place, important gaps remain the SRW. Local governments often lack the sustained funding and capacity needed to collect consistent, long-term data, which limits the ability to track progress toward water quality goals. Future monitoring priorities identified by the Partnership include more intensive diagnostic monitoring on impaired streams and priority lakes to better pinpoint pollutant sources, as well as sediment core collection to reconstruct historical nutrient loading trends. Expanding volunteer monitoring in conjunction with collaborating on the next IWM are both key strategies to fill spatial and temporal gaps. Additional efforts are needed to monitor groundwater and septic system impacts, especially in areas with vulnerable aquifers or known SSTS concerns, and to track hydrologic changes over time to better understand how climate shifts and development pressures affect water storage and flow. Strengthening these monitoring activities in the future will improve adaptive management and provide the data needed to refine restoration and protection strategies. Additionally, following previous studies to assess other lakes of concern can help guide management actions.

Figure 8. Smart Salting reductions for SRW.



3.4 Monitoring data

Four water quality monitoring programs/categories support long-term data collection and assessment in the SRW as part of Minnesota's Water Quality Monitoring Strategy 2021-2031 (MPCA, 2021). These programs track progress toward water quality goals, with additional monitoring implemented as needed. Together, they collect data at dozens of locations, with varying parameters at each site. Local partners supplement MPCA programs with additional data collection.

Monitoring Programs

- **Intensive Watershed Monitoring** (IWM) provides periodic assessments of water quality and AQL (fish and macroinvertebrates). Conducted every 10 years, this program offers a "snapshot" of watershed conditions sampled over a 2-year period. Cycle 1 IWM was conducted in 2006-2007 and Cycle 2 IWM was conducted in 2017-2018 and an updated report was published in 2020. Cycle 3 IWM will begin in 2028.
- **Watershed Pollutant Load Monitoring Network** (WPLMN) collects continuous, long-term data on pollutants, flow, sediment, and nutrient loads at the watershed and subwatershed scale. Sampling in the SRW is conducted at five flow stations linked to USGS gauges (Snake River nr McGrath, MN18 USGS ID: 05337150, Snake River nr Warman, CSAH3 USGS ID: 05337200, Snake River at Mora, MN65 USGS ID: 05337500, Snake River at Grasston, MN107 USGS ID: 05337900, Snake River nr Pine City, MN USGS ID: 05338500) or the DNR Cooperative Stream Gaging network.

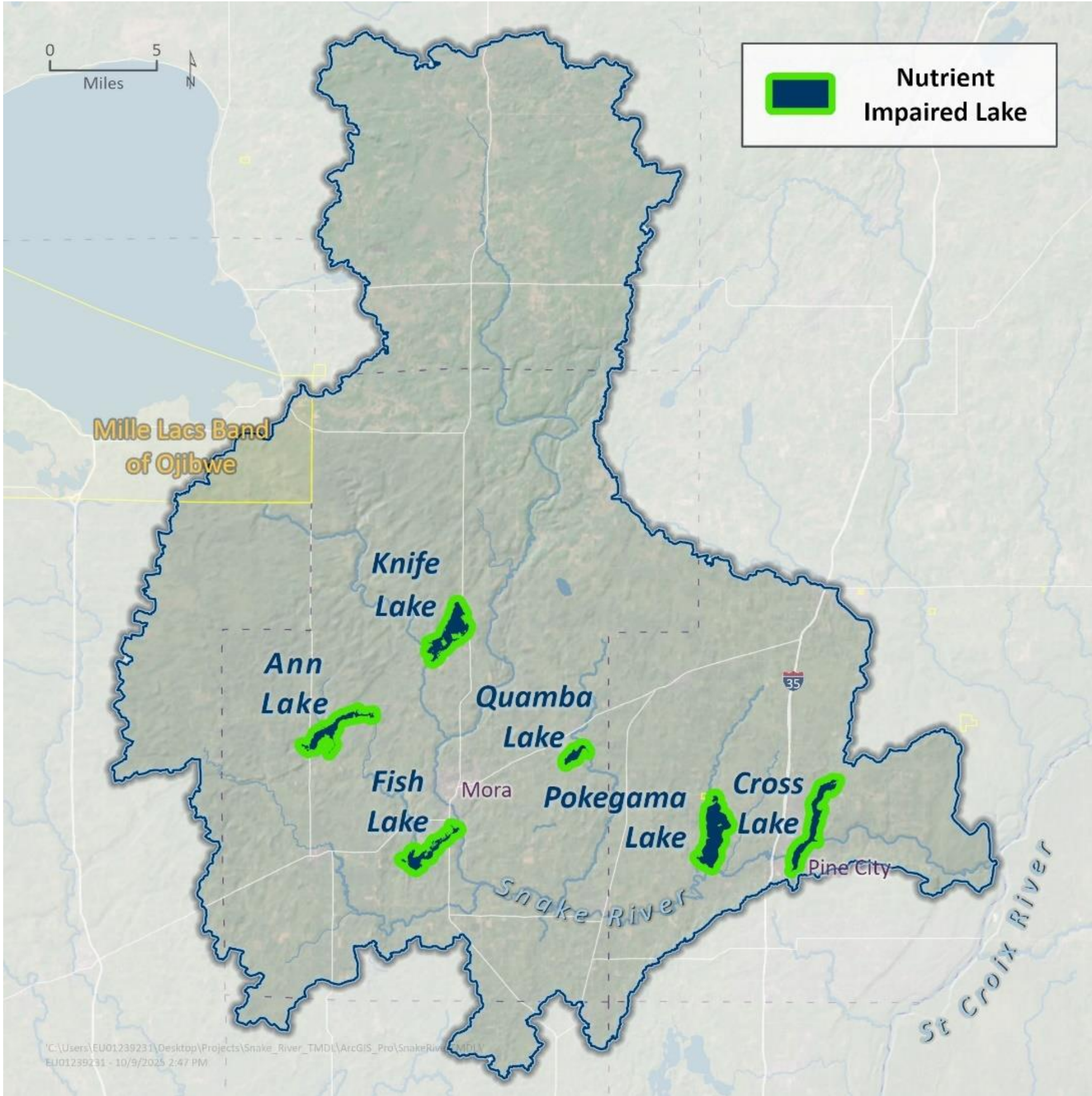
- **Additional Data Sources** include MPCA's 3 Long-Term Biological Monitoring sites within the SRW, Minnesota Department of Agriculture's (MDA's) surface water quality pesticide program, local governments, nonprofits, and other entities. These datasets are accessible through MPCA's surface water data portal.
- **Groundwater** is monitored by multiple agencies including Minnesota Department of Health (MDH), MDA, and MPCA, focusing on drinking water quality, nitrate, pesticides, and industrial contaminants.

3.5 Lakes and streams

Lakes

Lakes within the SRW exhibit a mix of natural conditions and nutrient-related impairments, with six major lakes – Ann, Fish, Knife, Cross, Pokegama, and Quamba, identified as nutrient impaired (Figure 9). These lakes are primarily located in the southern and central portions of the watershed, where land use transitions from forest and wetland to agriculture and developed areas. Elevated TP and chlorophyll-*a* concentrations, coupled with reduced Secchi transparency, indicate ongoing eutrophication pressures in these lakes. Internal phosphorus loading, shoreline disturbances, and watershed runoff are all contributing to increased phosphorus concentrations which contribute to excess nutrient levels and recurring algal blooms. Pokegama and Cross lakes show the highest degree of nutrient loading and are priorities for restoration in this WRAPS Update, while Ann and Fish lakes have been the focus of feasibility studies and in-lake management strategies to reduce internal phosphorus loading. Despite these challenges, several upstream lakes and wetlands continue to provide valuable filtration and nutrient retention functions that help moderate downstream impacts on the SRW.

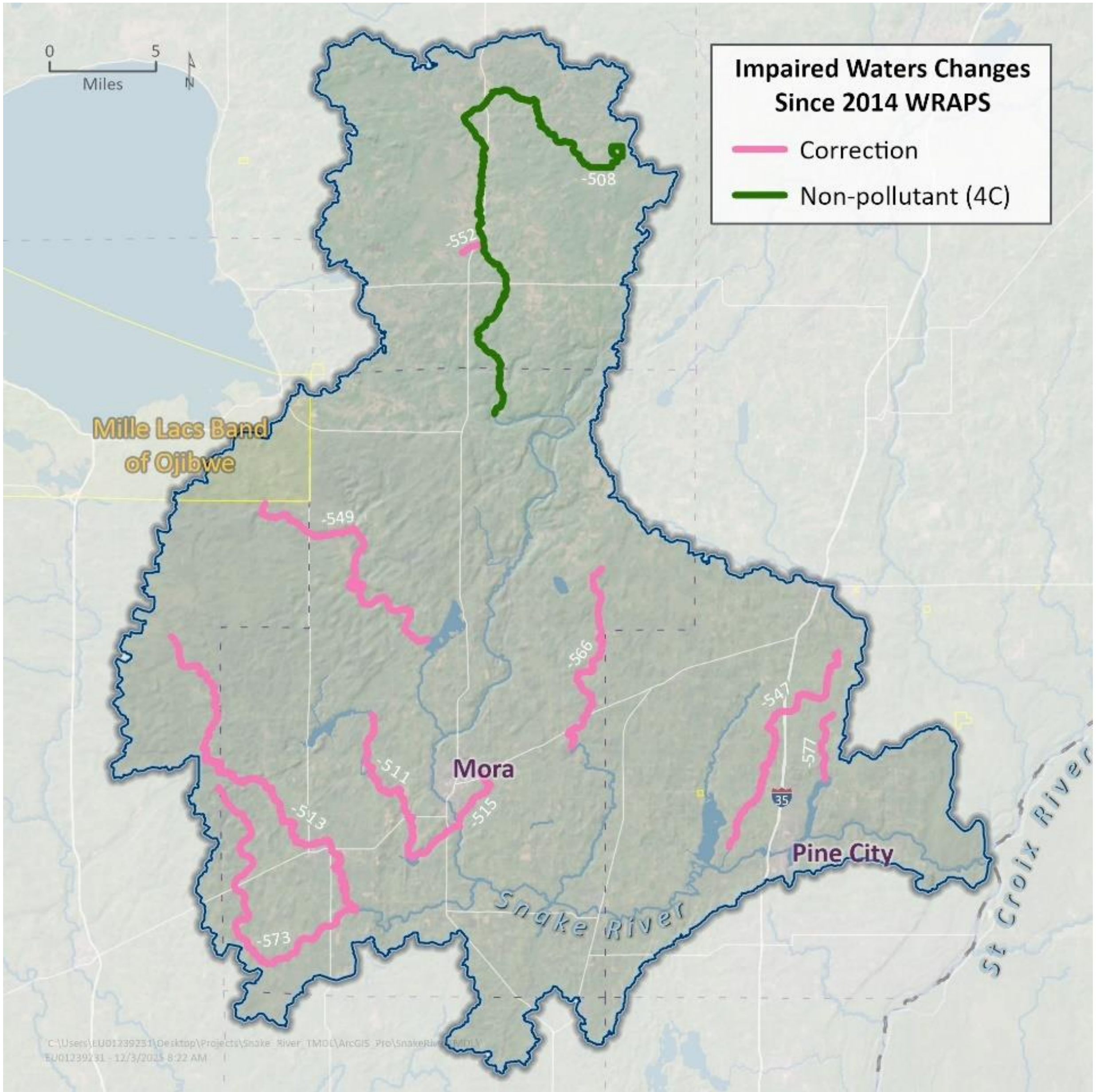
Figure 9. Nutrient impaired lakes in SRW.



Streams

Stream conditions across the SRW have evolved since the 2014 WRAPS, reflecting both improved data resolution and changes in assessment outcomes. As shown in recent monitoring results, numerous tributaries, including Groundhouse River, Ann River, Bear Creek, and South Fork Groundhouse River, were recategorized or given corrected assessments following additional biological and chemical analyses. These corrections reflect changes in biological index methodology and more accurate understanding of site-specific habitat conditions. However, several stream reaches remain impaired for aquatic life and recreation, with impairments driven largely by nutrient loading, low DO, habitat degradation, and *E. coli*. Modeled phosphorus yield data (2003 through 2018) indicates that the southern and eastern subwatersheds, particularly along the mainstem of Snake River and tributaries near Pine City, contribute the highest phosphorus loads (0.4 to 0.6 lbs/TP/acre/yr). Conversely, northern tributaries such as Bean Brook, Snowshoe Brook, and the Knife River show comparatively low yields and stable biological communities. More information can be found below in Section 3.7. While progress has been made through improved modeling and refined impairment listings, continued implementation of upland BMPs, riparian restoration, and flow stabilization will be critical to reducing pollutant loads and restoring stream health throughout the watershed (Figure 10).

Figure 10. Impaired water changes since 2014 SRW WRAPS report.



3.6 Stressor identification

SID Cycle 1 (MPCA, 2017a) water quality data from the SRW showed generally stable conditions; however, long-term trend analysis was limited by inconsistent datasets. The Hydrological Simulation Program-Fortran (HSPF) model was developed to simulate flow and pollutant loading from 1994 to 2009, providing the technical foundation for TMDL development during that cycle. More information on HSPF can be found in the 2026 MPCA TMDL report, which discusses how the HSPF model has evolved from 2009 to present. Early SID work focused primarily on the Ann River, Mud Creek, and Groundhouse

River, where biological impairments were linked to excess nutrients, low DO, and habitat alterations such as channelization and sedimentation (MPCA, 2021). Continuous DO monitoring in Mission Creek further documented significant diurnal fluctuations and low oxygen conditions associated with eutrophic and low gradient wetland systems. Many of these impairments were attributed to a combination of wetland-dominated hydrology, limited flow variability, and land use influences such as agriculture and pasture near stream corridors (Table 2).

In Cycle 2 (MPCA, 2021) MPCA expanded watershed monitoring under the IWM and WPLMN programs including biological, chemical, and microbial parameters. This effort identified 33 total impairments, including 12 new listings, 7 of which were for *E. coli*. To better understand bacteria sources, a Microbial Source Tracking (MST) Study was conducted in 2021, providing valuable insight into the contributions of human, livestock, and wildlife sources. The MST is discussed further in Section 5.1. While sediment and nitrate levels across the watershed generally met state standards, nutrient concentrations, particularly TP, were elevated in multiple streams and lakes, including Mud, Mission and Pokegama creeks, where eutrophication remains a dominant stressor. DO impairments persisted in wetland-dominated reaches such as Mission and Mud creeks, while habitat degradation, altered hydrology, and connectivity barriers were identified in four of the six studied subwatersheds, often linked to perched culverts, beaver dams, and historic channelization (Table 2).

Table 2. Changes in monitoring in the SRW from Cycle 1 to Cycle 2.

Category	Cycle 1 (2014 WRAPS/Initial SID)	Cycle 2 (2021 SID Update)
Monitoring Focus	Limited chemical and biological data; focused on select subwatersheds (Ann River, Mud Creek, Groundhouse River, and Mission Creek).	Expanded biological, chemical, and microbial monitoring through IWM and WPLMN.
Modeling and Technical Work	HSPF model simulated flow and pollutant loading (1994 – 2009) to support TMDL development.	Data used to validate and refine model assumptions; linked pollutant trends with biological responses.
Key Parameters	Elevated TP and chlorophyll-a, low DO, and localized sediment concerns.	TP remains elevated; nitrate and TSS below standards; *E. coli* identified as an emerging stressor.
Total Impairments Identified	Primarily focused on fish and macroinvertebrate biological impairments in 3-4 streams.	33 total impairments, including 12 new listings (7 for *E. coli*).
Major Stressors Identified	Nutrients (phosphorus), low DO, habitat alteration, and flow variability.	Habitat, eutrophication, altered hydrology/connectivity are the most common stressor; DO remains an issue in low-gradient systems.
Streams/Lakes of Concern	Ann River, Groundhouse River, Mud Creek, Mission Creek.	Mission Creek, Mud Creek, Pokegama Creek, Bear Creek, Snake River (upper reach).
Biological Trends	Limited trend data; some localized improvements in macroinvertebrate communities.	No statistically significant overall change in fish or macroinvertebrate IBI scores (2006 – 2017).
New Emphasis Areas	Habitat restoration and nutrient reduction planning.	Addition of MST for bacteria and focus on tiered aquatic life use (TALU) and river eutrophication standards.
Overall Findings	Stable but data-limited; identified need more biological and chemical monitoring.	Nutrients and habitat remain dominant stressors; hydrologic connectivity and impacts now better quantified; additional monitoring needed.

The transition from Cycle 1 (MPCA, 2017a) to Cycle 2 (MPCA, 2021) reflects an evolution in both monitoring scope and analytical precision within the SRW. While Cycle 1 established the foundational understanding of nutrient loading, low DO, and habitat alteration as key drivers of biological impairment, Cycle 2 expanded this framework through integrated biological, chemical, and microbial analyses. The addition of the IWM, WPLMN, and MST study provided a clearer picture of pollutant sources and stressor interactions, confirming that nutrient loading, habitat degradation, and hydrologic alteration remain as challenges. Although nitrate and sediment concentrations generally meet state standards, TP and DO levels continue to exceed criteria in several reaches, particularly in Mission, Mud, and Pokegama creeks. These results reinforce the importance of continued nutrient reduction, riparian restoration, and hydrologic reconnection efforts to sustain and improve aquatic life and water quality across SRW.

Assessment results and detailed data summaries are available in the SRW Monitoring and Assessment Report (MPCA, 2017b) and SRW Water Assessment and Trends Update (MPCA, 2020b). As Minnesota's Watershed Approach continues into Cycle 3 starting in 2028, the MPCA and local partners will build on these findings to refine monitoring networks, assess the effectiveness of BMPs, and support adaptive management for long-term water quality improvements.

3.7 Modeling

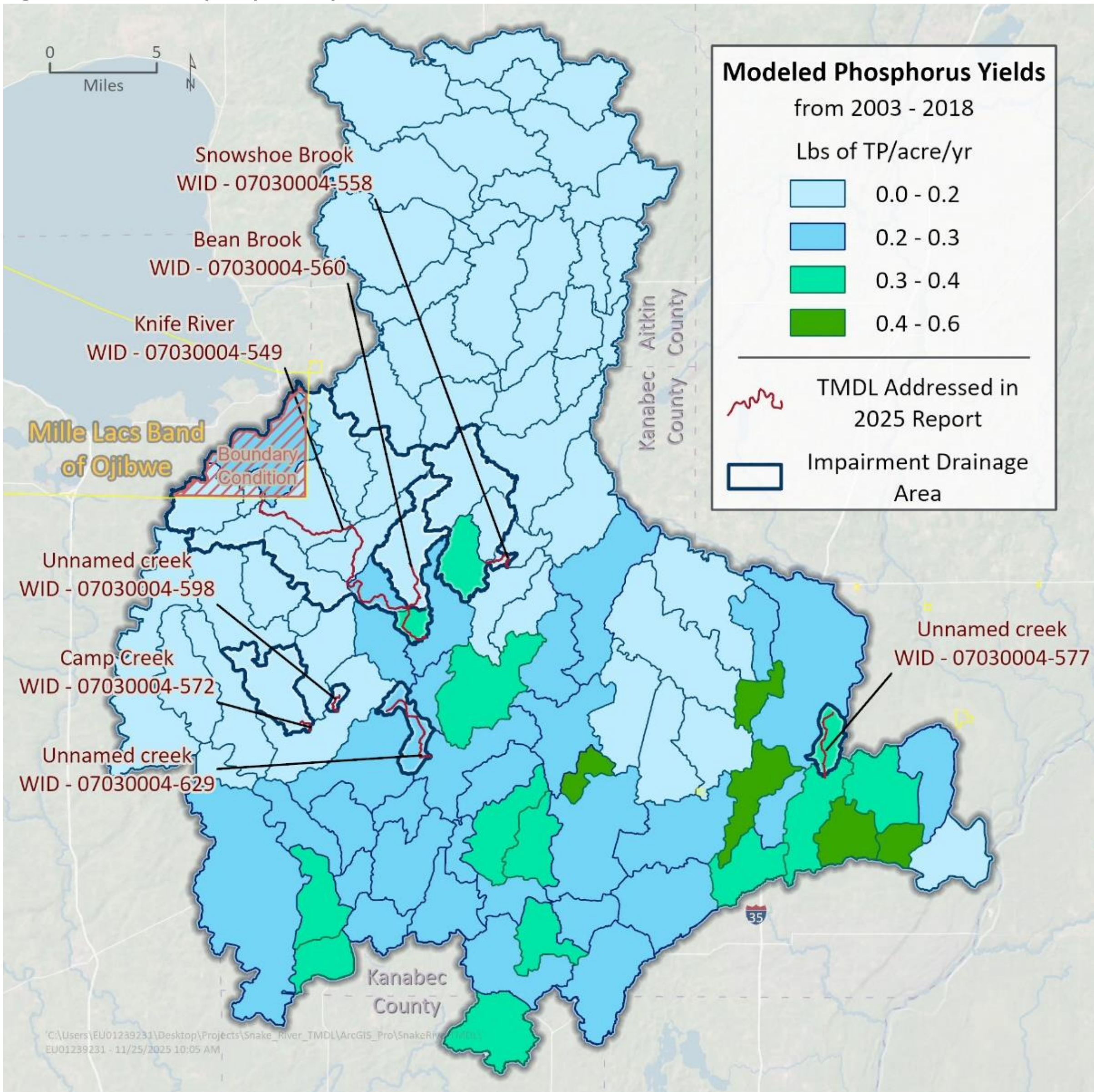
In the SRW, assessment tools have been central to understanding and improving water quality. During Cycle 1, MPCA and local partners used a combination of biological, chemical, and hydrological data to identify key impairments and their causes ranging from excess nutrients and sediment to low DO and bacteria. The resulting SID and TMDL studies helped determine pollutant sources such as run-off from agricultural land, failing septic systems, and stream channel erosion. Building on that foundation, Cycle 2 water quality work incorporated new monitoring networks, MST, and enhanced modeling to identify *E. coli* and nutrient impairments while tracking progress in previously restored waters. These ongoing assessments inform both the WRAPS Update and the 1W1P framework, ensuring that local water management strategies are guided by current data, regulatory standards and scientific evaluation.

A key technical component of this work is the HSPF model, which provides a detailed simulation of hydrology and water quality process throughout the watershed. The SRW HSPF model, originally developed by RESPEC (2016) and later extended by Tetra Tech (2020) through 2021, integrates watershed-scale data to simulate hourly runoff flow rates, sediment concentrations, and nutrient dynamics. This modeling framework enables MPCA to evaluate how land use, hydrology, and pollutant loading interact, and to predict the potential effectiveness of management actions. The model's ability to represent both point source and nonpoint sources make it an essential tool for developing accurate TMDLs and for tracking progress toward meeting water quality standards.

Modeling outputs from the HSPF phosphorus yield analysis (2003 – 2018) provided spatial insight into nutrient loading patterns across the SRW. As shown in Figure 11, phosphorus export rates were highest in the southern and southeastern subwatersheds, particularly along the lower Snake River and its tributaries near Pine City, where yields range from 0.4 to 0.6 lbs of TP/acre/yr. These areas correspond closely with agricultural and developed landscapes, indicating that nonpoint runoff from cropland, pasture, and urban surfaces remains a dominant phosphorus source. In contrast, northern tributaries such as Snowshoe Brook, Bean Brook, and Knife River exhibit comparatively low yields (up to 0.2 lbs

TP/acre/yr), consistent with their predominantly forested and wetland-dominated catchments. The HSPF model confirms that phosphorus loading is spatially variable across the watershed, driven primarily by land use and soil characteristics, and reinforces the need for targeted BMP implementation in high-yield subwatersheds to achieve measurable nutrient reductions.

Figure 11. Modeled phosphorus yields from 2003 to 2018 in the SRW.



4. Watershed condition

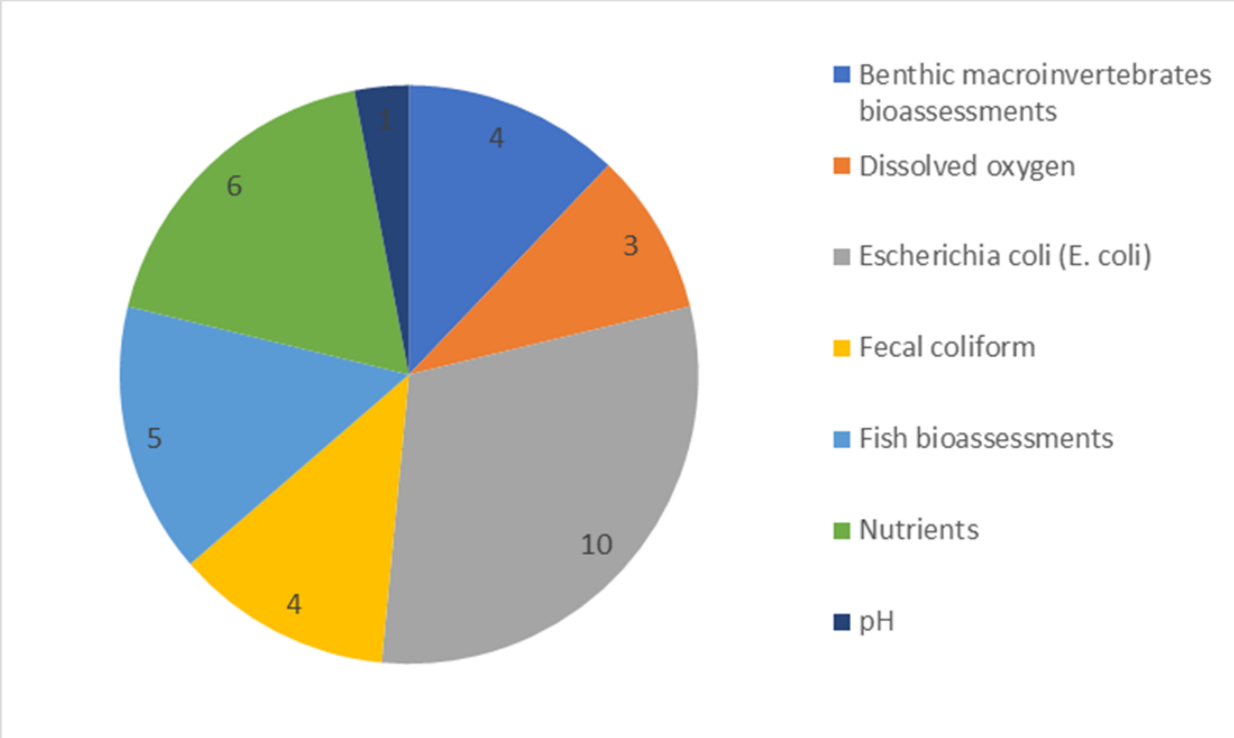
Since the publication of the last SRW WRAPS Report in August 2014 (MPCA 2014), 12 new listings have been added to the Impaired waters list (IWL; Table 3). Of these, seven stream impairments for *E. coli* are addressed in the accompanying TMDL study (MPCA, 2026). The remaining five new impairments include two benthic macroinvertebrate bioassessments, two mercury in fish tissue impairments, and one fish bioassessment. Mercury in fish tissue, while newly listed, is not addressed in the 2026 TMDL Report due to its statewide scope and the need for a different regulatory framework. The other three impairments, two streams (macroinvertebrates index of biological integrity [IBI]) and one lake impairment (fish assemblage), need additional SID work focused on connectivity and flow and understanding the lake's habitat and fish assemblage needs. Biological impairments are not addressed in TMDLs unless associated with a pollutant stressor.

Table 3. New impairments in the SRW since 2014.

Water body name	Water body description	Water body type	Year added to list	Water body identifier (WID)	Pollutant or stressor
Bean Brook	Unnamed wetland to Knife R	Stream	2020	07030004-560	*E. coli*
Bear Creek	Unnamed cr to Snake R	Stream	2020	07030004-552	Benthic macroinvertebrates bioassessments
Camp Creek	Unnamed cr to Ann Lk	Stream	2020	07030004-572	*E. coli*
Knife Lake	Lake or Reservoir	Lake	2014	33-0028-00	Mercury in fish tissue
Knife River	Dry Run to Knife Lk	Stream	2020	07030004-549	*E. coli*
Pokegama Lake	Lake or Reservoir	Lake	2020	58-0142-00	Fish bioassessments
Snowshoe Brook	Unnamed cr to Snake R	Stream	2020	07030004-558	*E. coli*
Unnamed creek	Headwaters to Ann Lk	Stream	2020	07030004-598	*E. coli*
Unnamed creek	Headwaters to Mud Cr	Stream	2020	07030004-563	Benthic macroinvertebrates bioassessments
Unnamed creek	Headwaters to Snake R	Stream	2020	07030004-629	*E. coli*
Ann Lake	Lake or Reservoir	Lake	2018	33-0040-00	Mercury in fish tissue
Mud Creek (County Ditch 10)	Headwaters to Mud Lk (Quamba Lk 33-0015-00)	Stream	2016	07030004-566	*E. coli*

A total of 33 impairments have been identified within the SRW to date, reflecting a range of biological, chemical, and bacterial stressors affecting aquatic health. The most common impairment type is bacteria, *E. coli* and fecal coliform accounting for 14 impairments, followed by 6 nutrient-related impairments, and 5 fish bioassessments. Additional impairments include four benthic macroinvertebrate bioassessments, three DO, and one pH (Figure 12). The predominance of *E. coli* and nutrient impairments underscores the need for continued implementation of BMPs targeting nonpoint source pollution, particularly from agricultural runoff and failing subsurface sewage treatment systems (SSTS). The biological impairments, such as those identified through fish and macroinvertebrate bioassessments, highlight ongoing habitat degradation, altered hydrology, and sedimentation concerns that affect aquatic communities. Collectively, these findings emphasize the importance of integrated management strategies under the 1W1P framework to improve water quality and aquatic ecosystem health across the SRW (Stantec, 2023).

Figure 12. Impairments by parameter in the SRW (does not include mercury).

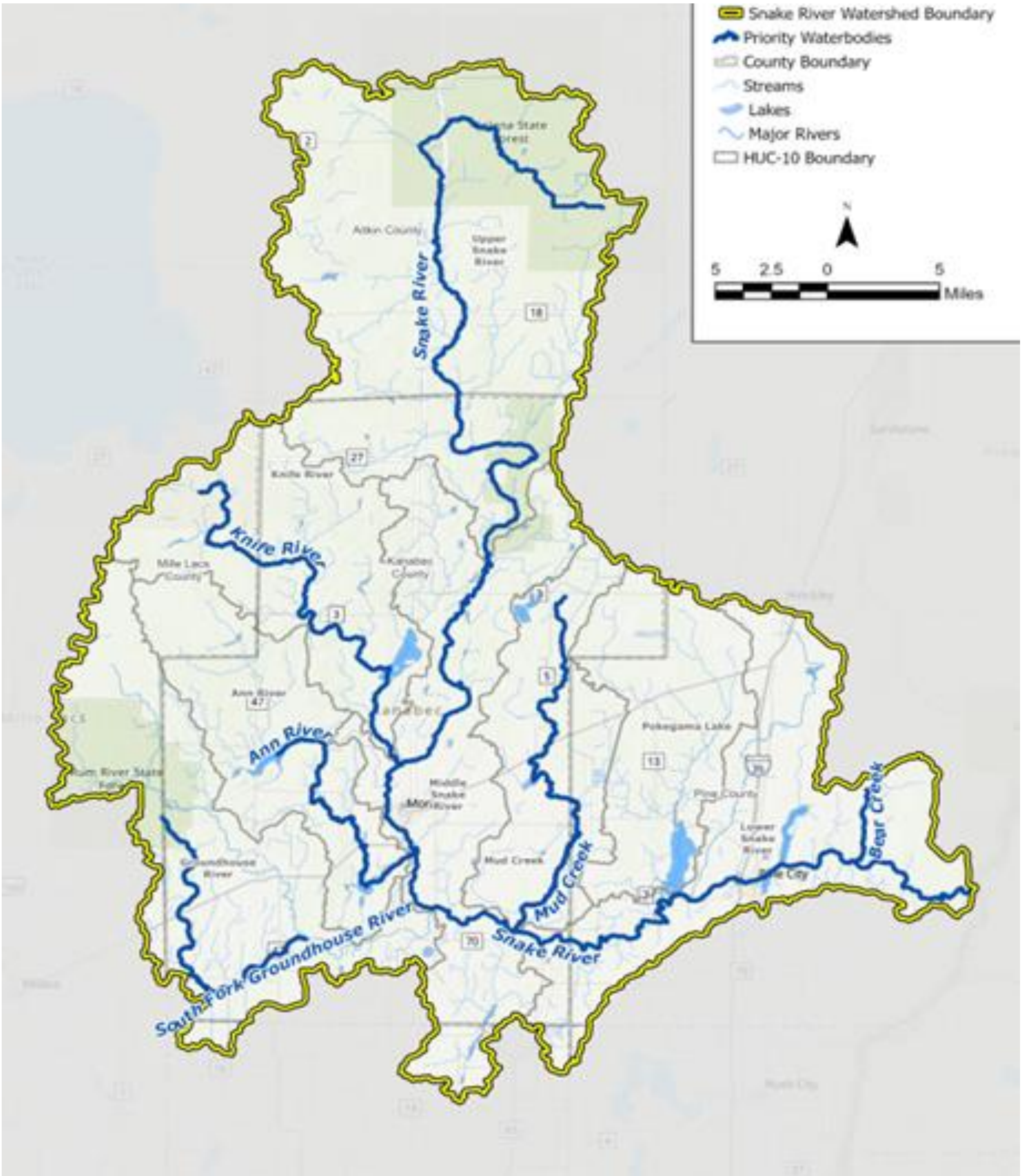


Concerns have been raised by watershed partners regarding nutrient levels, specifically TP, throughout the watershed. However, during IWM in 2017-2018, there was insufficient water quality data to support listing additional nutrient impairments (MPCA, 2018). As a result, this report focuses on addressing the TP concerns first identified in the 2014 WRAPS, alongside the identified *E. coli* impairments.

Since the adoption of the SRW CWMP, in 2023, new data and studies have informed current watershed priorities. Notably, the MPCA conducted an MST study in 2021, and the results were shared with stakeholders during the development of this updated WRAPS report. The findings from the MST study (Discussed in Section 5.1) aligned with the implementation goals outlined in the CWMP under Goal 4, Priority streams and rivers for *E. coli* reductions, confirming that planned projects and strategies are well-positioned to address bacterial contamination and improve water quality. The CWMP identified several priority streams and rivers for *E. coli* reductions, including the Snake River, Knife River, Ann River, Groundhouse River, South Groundhouse River, Mud Creek, and Bear Creek (Figure 13). Additional information related to Goal 4 can be found in the Snake River Comprehensive Management Plan (Stantec, 2023).

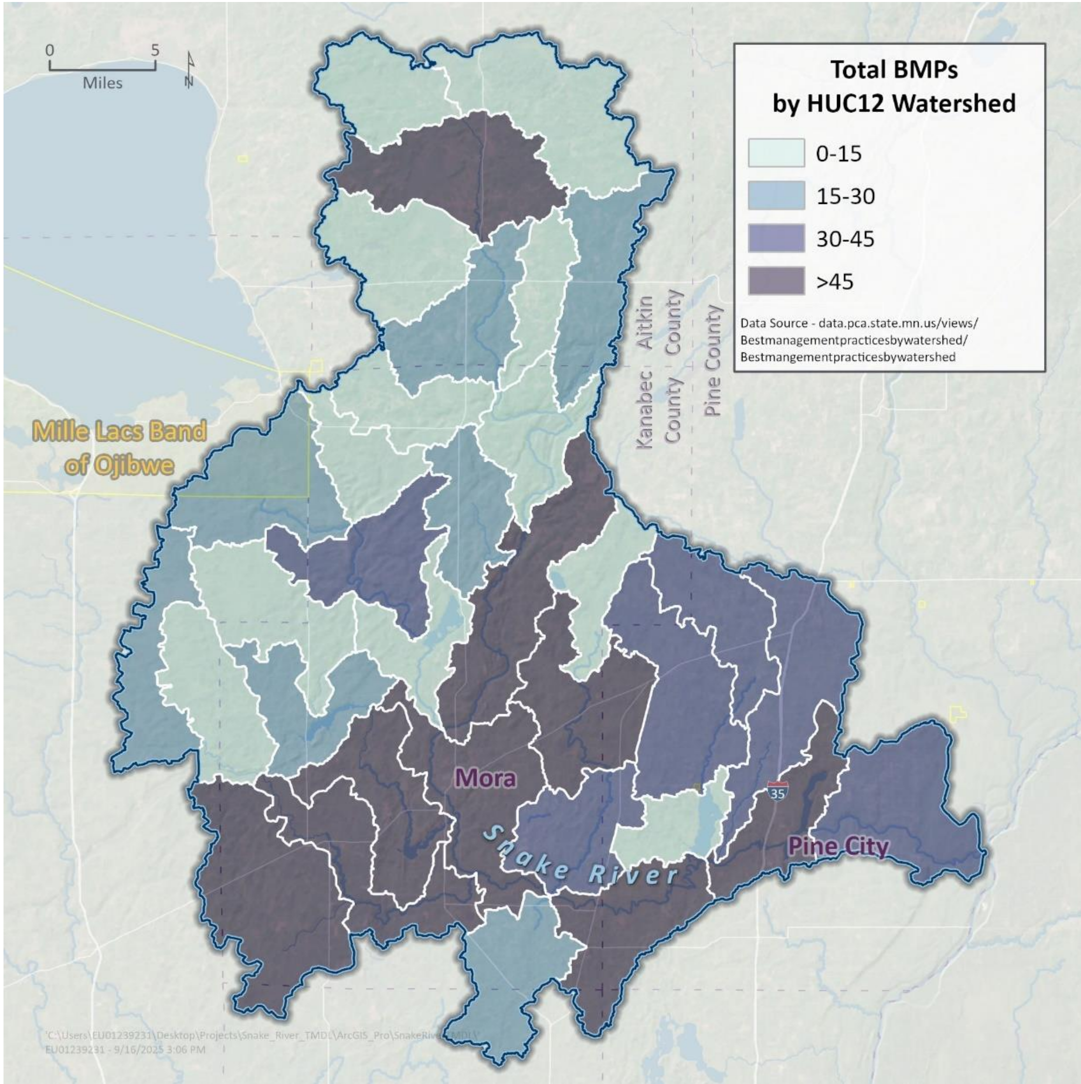
Building upon these findings and priorities, watershed partners have continued implementing targeted BMPs to reduce pollutant loading and improve water quality conditions throughout the SRW. Implementation efforts since the first WRAPS cycle have focused on nutrient and bacteria reduction, streambank stabilization, and habitat restoration in alignment with the CWMP goals. The distribution and type of BMPs installed provide valuable insight into where on-the-ground progress has been made and where additional implementation may be needed.

Figure 13. Snake River Comprehensive Management Plan *E. coli* reduction priorities (Stantec, 2023).



As shown in Figure 14, the upper and norther portion of the watershed are generally meeting water quality standards and have had fewer BMPs implemented to date (October 2025). These areas are characterized by a greater presence of forested wetland cover, which naturally protect water quality. However, as one moves south and east into the lower portion of the watershed toward Mora and Pine City, land use transitions toward more agricultural and developed areas. This pattern demonstrates the need for continued and increased implementation of BMPs and restoration projects in the southern and eastern HUC-12 subwatersheds, where pollutant loads and stressors to aquatic life and recreation are more pronounced.

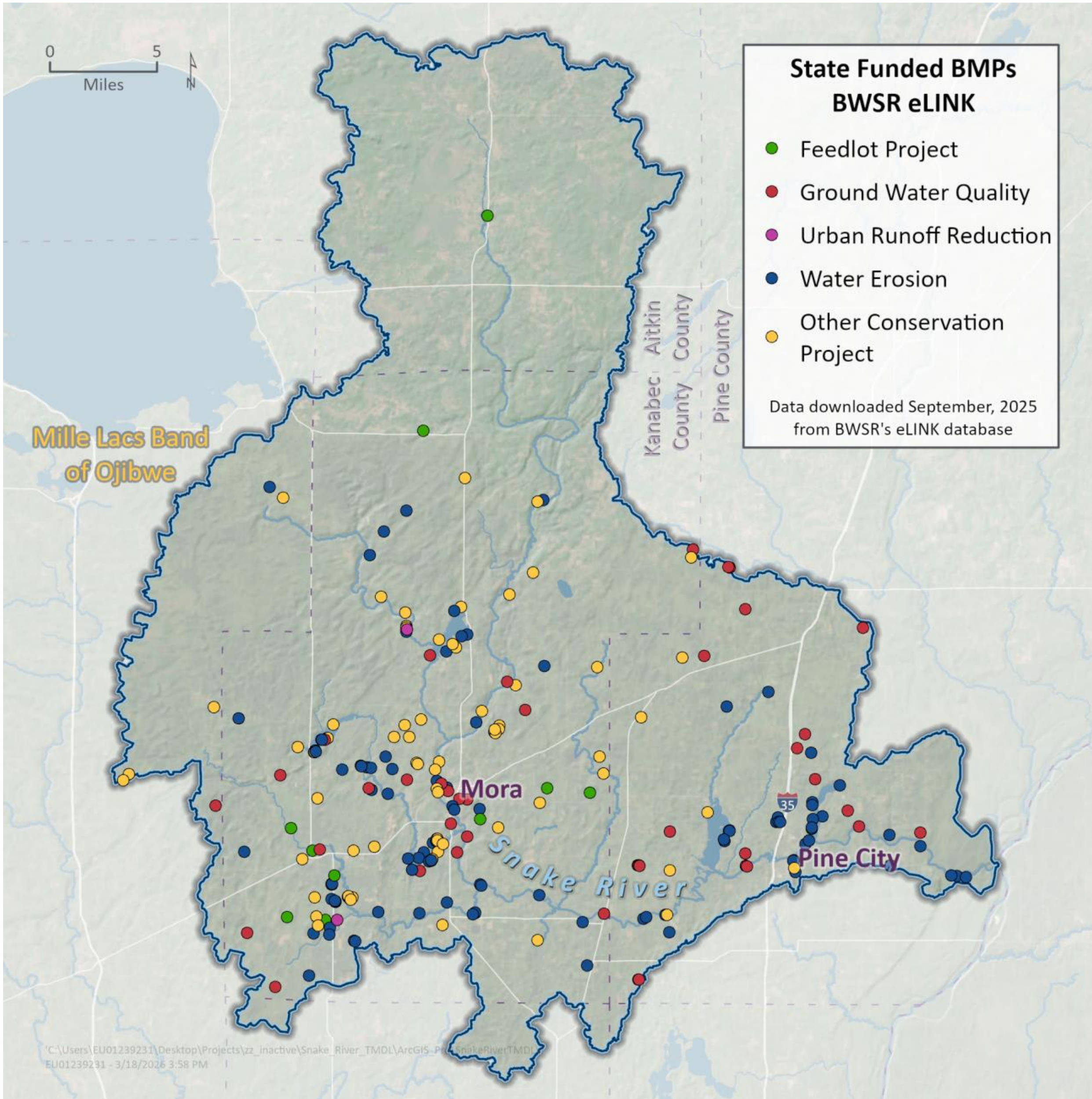
Figure 14. Total BMPs by HUC-12 watershed in the SRW.



A total of 214 state funded BMPs were implemented across 25 subwatersheds within the SRW from 2013 to 2025. The highest concentration of BMPs occur in the city of Mora, Ann River and Cross Lake subwatersheds, reflecting active engagement and targeted restoration efforts in these areas (Figure 15). Practices implemented span 40 distinct BMP types with frequent use of streambank and shoreline protection, filter strips, windbreak establishment, and various native vegetation and pollinator habitat plantings (MPCA internal database). These projects collectively address erosion control, sediment and nutrient reduction, and habitat enhancement goals. Implementation partners such as Kanabec and Pine SWCDs have led much of this work through coordinated state-funded efforts to improve long-term watershed health, stabilize vulnerable streambanks, and enhance ecological resilience across the SRW.

While considerable progress has been made through existing BMP implementation, opportunities remain to expand practices in subwatersheds with lower BMP densities and ongoing water quality concerns. Areas such as Hay Creek, County Ditch No. 10, and portions of the Bean Dam SWMA and East Pokegama Creek subwatersheds have relatively few documented BMPs despite contributing to nutrient and bacterial loading (Figure 15). The data was downloaded from BWSR's eLINK database in September, 2025. Targeting these areas for additional riparian buffer restoration, livestock exclusion fencing, agricultural nutrient management, and stormwater retrofits could yield measurable reductions in phosphorus, sediment, and *E. coli* concentrations. Continued coordination among local partners, particularly through the 1W1P implementation framework, will be essential to ensure that future BMPs are strategically located in high-loading catchments, connected to monitoring data, and supported by landowner outreach and cost-share opportunities.

Figure 15. BWSR funded BMPs installed throughout the SRW.



4.1 Impairments – Cycle 2 conditions summaries

Stream biological monitoring through IBI showed minimal changes between Cyle 1 IWM and Cycle 2 IWM of watershed monitoring. The average fish IBI score declined by 2.4 points, and the macroinvertebrate (bug) IBI score decreased by 1 point, indicating stable but slightly declining biological conditions. Elevated bacteria concentrations were observed in several parts of the watershed, while sediment and nitrogen levels remained generally low (MPCA, 2020b).

Cycle 1 IWM monitoring indicated inconclusive water quality trends due to inconsistent long-term datasets, with key parameters at the Snake River outlet showing no statistically significant trends. In contract, Cycle 2 IWM identified 33 impairments, including 12 new listings, seven of which are related to *E. coli* and incorporated additional analyses such as a 2021 MST study to better understand pollutant sources across the watershed.

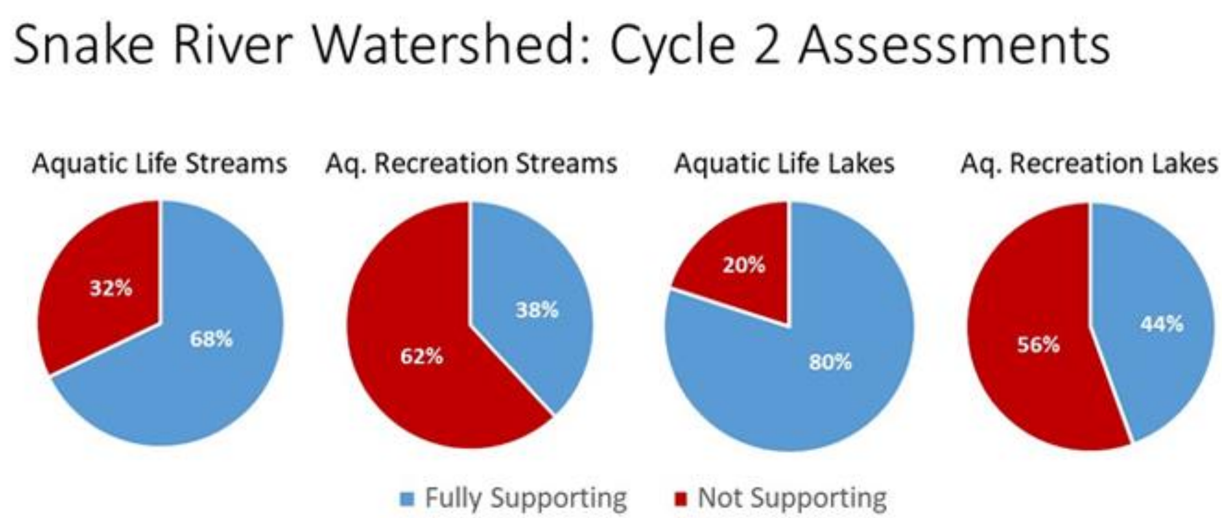
Lakes in the watershed; however, continued to face nutrient-related challenges. Many showed elevated nutrient levels, increasing the risk of algal blooms, particularly in the summer months. Despite this, some positives were observed. For example, Pomroy Lake in Kanabec County has shown improving water clarity, suggesting that recent protection or restoration efforts may be effective (MPCA, 2020).

The Cycle 2 of IWM revealed both encouraging and concerning findings:

- Three new macroinvertebrate impairments were identified.
- Seven new *E. coli* impairments were documented.
- Several legacy impairments from previous cycles remain, affecting both aquatic life and recreational use (e.g., swimming and fishing).
- The first fish assessments conducted by the DNR on five lakes showed that only Pokegama Lake (Pine County) was impaired.

Precipitation levels in the SRW were higher in Cycle 2 compared to Cycle 1, primarily due to the increased frequency of high-intensity rain events. These precipitation extremes contribute to fluctuating flow conditions, erosion, and pollutant transport. In terms of water chemistry, the most observed impairments were low DO and elevated bacteria levels, which were primarily located in the southern, downstream half of the watershed. The results from the Cycle 2 assessment (Figure 16) show that while most streams and lakes in the SRW meet aquatic life standards, a significant portion do not meet aquatic recreation (AR) standards due to elevated bacteria and nutrient levels (MPCA, 2020b).

Figure 16. Cycle 2 assessments for the SRW.



4.2 Lakes and streams

Lakes

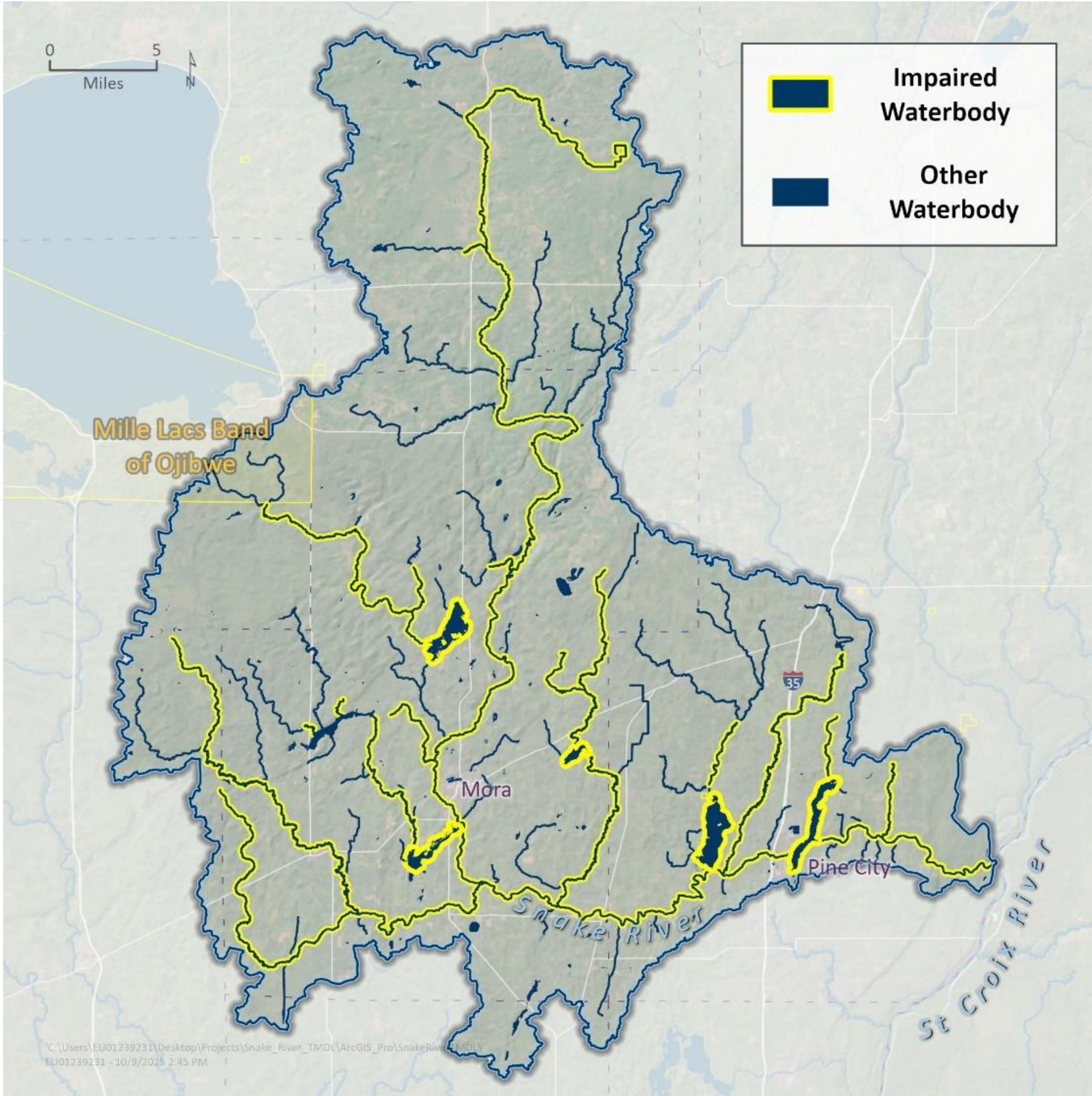
Lakes in the SRW continue to experience nutrient-related water quality challenges, particularly in the southern portion of the basin where agricultural and developed land uses dominate. While most lakes, approximately 80%, support aquatic life uses (AQL), only 44% meet aquatic recreational standards, largely due to elevated nutrient and bacteria concentrations. Among the 13 publicly accessible lakes, 6 are impaired by excess nutrients, consistent with previous assessment cycle. These impaired lakes, Ann, Fish, Knife, Cross, Pokegama, and Quamba, share several common characteristics (Figure 17). They are shallow (<15 feet), flow through systems located in agriculture- influenced catchments, making them highly susceptible to phosphorus loading, algal blooms, and warmer summer temperatures. Based on the Cycle 2 assessment, Mora Lake is approaching the phosphorus impairment threshold, while Pomroy, Devils, and Pennington lakes have been identified as priority water bodies for phosphorus reduction (MPCA, 2020).

Streams

Stream biological monitoring through the IBI indicates that conditions in the SRW have remained generally stable between monitoring cycles, with only slight declines in biological health. Approximately 68% of monitored stream reaches fully support AQL, while 38% meet AR standards due to persistent *E. coli* contamination. During Cycle 2 of IWM, three new macroinvertebrate impairments and seven new *E. coli* impairments were documented, while several legacy impairments from previous assessment remained. Elevated bacteria and low DO were the most common chemical impairments, concentrated primarily in the southern and downstream portions of the watershed where forested headwaters give way to row-crop agriculture, pasture, and developed lands.

Hydrologic conditions during Cycle 2 were also influenced by more frequent, high-intensity precipitation events, which increased flow variability, streambank erosion and pollutant transport. While sediment and nitrogen concentrations generally remained below state standards, the combination of nutrient runoff, bacteria inputs, and altered flow regimes continues to limit water quality and recreational use in several stream reaches. These findings highlight the need for continued implementation of riparian buffers, livestock exclusion, and stormwater management practices to reduce bacterial loading and stabilize flow conditions throughout the SRW.

Figure 17. Impaired waters in the SRW 2025.



4.3 Watershed protection opportunities

Protecting unimpaired waters is critical to maintaining the environmental, economic, and cultural vitality of Minnesota. These waters support healthy ecosystems, safeguard human health, and sustain recreation and economic opportunities that define the state's identity. Unimpaired waters provide clean drinking water, vital habitats for fish and wildlife, and ensure that Minnesota resources continue to thrive. The MPCA prioritizes the protection of these high-quality waters to prevent future degradation and to preserve them for current and future generations. The SRW Partnership (Partnership), which includes Aitkin, Kanabec, Mille Lacs, and Pine SWCDs, as well as Aitkin, Kanabec, and Pine counties, also have prioritized protection of unimpaired lakes by maintaining current phosphorus levels as Goal 2, Priority lakes for protection, in the CWMP (Stantec, 2023).

Within the SRW, which is home to over 87 lakes and 128 streams, 49 water bodies are currently impaired, with 34 having approved TMDL and SID Reports. The Partnership evaluated TMDLs, WRAPS findings, historical water quality data, HSPF model results, and stakeholder input to identify priority water bodies for restoration and protection. Priority was given to lakes and streams that, if restored or protected, would reduce downstream pollution, contribute to other watershed goals, or maintain high-quality conditions.

Additional prioritization factors include water bodies that are close to impairment thresholds (Table 4), those with significant recreational or community value, and those supported by active lake associations or partnerships. The Partnership also emphasized the protection of unimpaired waters that provide essential habitat for fish, wild rice, and wildlife, as well as those at risk from urban and agricultural land use (Table 5). Ultimately, the Partnership identified six impaired lakes, five unimpaired lakes, seven impaired streams or rivers, and an unimpaired stream as focal points for protection and restoration efforts, addressing key issues such as phosphorus, sediment, and *E. coli* impairments, as well as threats to water quality in unimpaired systems (Stantec, 2023).

Building on this prioritization effort, the Partnership and MPCA identified specific unimpaired waters within the SRW that are essential to protect to maintain their high-water quality and ecological integrity. These waters represent some of the healthiest systems in the watershed and serve as benchmarks for long-term protection and monitoring. In addition to fully supporting waters, the MPCA also identifies "nearly/barely impaired" waters, which are those close to exceeding water quality standards that warrant protective management to prevent future degradation for both lakes (Table 5) and streams (Table 6). Together, these categories help guide protection strategies and resource allocation by highlighting where preservation, prevention, and restoration efforts will have the greatest overall benefit. More information can be found here: Water Quality Assessment Results Data Viewer.

Table 4. Nearly/barely impaired lakes and streams water quality within the SRW.

Water body type	WID	Water body name	Assess year	Designated uses	Nearly or barely impaired
Lake	33-0034-00	Mora	2019	AQL	Barely
Lake	33-0034-00	Mora	2019	AR	Barely
Stream	07030004-525	Snake River	2019	AR	Nearly
Stream	07030004-551	Knife River	2019	AQL	Nearly
Stream	07030004-551	Knife River	2019	AR	Nearly

Table 5. Unimpaired lake prioritization for the SRW.

Lake ID	Lake name	Protection priority
01-0064-00	Bear Lake	Lower Priority
30-0057-00	Upper Rice Lake	Lower Priority
33-0009-00	Pomroy Lake	Medium Priority
33-0030-00	Pennington Lake	High Priority
33-0033-00	Devils Lake	Medium Priority

Lake ID	Lake name	Protection priority
33-0034-00	Mora	Lower Priority
58-0118-00	Devils Lake	Medium Priority

Table 6. Unimpaired stream prioritization for the SRW.

WID	Stream name	Protection priority
07030004-507	Chelsey Brook	Medium Priority
07030004-509	Hay Creek	Medium Priority
07030004-513	Groundhouse River	Medium Priority
07030004-514	Bear Creek	Medium Priority
07030004-515	Spring Brook	High Priority
07030004-517	Cowans Brook	Lower Priority
07030004-518	Little Ann River	Lower Priority
07030004-523	Snake River	Lower Priority
07030004-524	Snake River	Medium Priority
07030004-531	East Pokegama Creek	High Priority
07030004-533	Pokegama Creek	Medium Priority
07030004-538	Groundhouse River, West Fork	Medium Priority
07030004-549	Knife River	Lower Priority
07030004-557	Unnamed Creek	Lower Priority
07030004-558	Snowshoe Brook	Medium Priority
07030004-586	Snake River	Medium Priority

4.4 Impairment corrections from Cycle 2 assessment

When monitoring data show that a water body no longer meets water quality standards, it is placed on the state's IWL and submitted to the U.S. Environmental Protection Agency (EPA) for approval. This list categorizes waters based on the type and status of their impairment to guide restoration and management efforts. Over time, as new data are collected or conditions change, some impairments may be reevaluated and moved to a different category through a process called recategorization.

Moving a water body out of EPA category 5, meaning it is impaired and requires a TMDL, is referred to as a recategorization. Category 4 waters are also impaired but do not require a new TMDL because one has already been approved, or the cause is not related to a pollutant. Both Categories 4 and 5 are included in the IWL. Recategorization may occur for several reasons including if a TMDL has been approved for the same or downstream reach (Category 4A), and if the impairment is caused by a nonpollutant (Category 4C). A water body may also be delisted when new, reliable monitoring data demonstrates that it now meets water quality standards. Finally, corrections may occur when a water body listing is removed, such as when data or standards have changed, or better information indicates the water should not have been listed originally.

As part of the updated watershed assessment, several streams previously listed as biologically impaired were reevaluated using improved IBI tools and more recent biological data. The results of this reassessment led to corrections on both fish and macroinvertebrate impairment listings, summarized in Table 7 below.

There have been several recategorizations that have occurred since the previous WRAPS report and are reflected in Table 7. There have been no delistings in the SRW since the original WRAPS report that was published in 2014.

Table 7. Stream impairment corrections in the SRW.

Stream name	WID	Originally listed as impaired for:	Updated status/ correction made	Reason for change
Groundhouse River	07030004-513	Fish and Macroinvertebrates	Impairment removal corrections for both fish and macroinvertebrates	Updated IBI indicators and newer sampling data
Ann River	07030004-511	Fish and Macroinvertebrates	Impairment removal corrections for both fish and macroinvertebrates	Updated methods and reevaluation
Mission Creek	07030004-547	Macroinvertebrates	Macroinvertebrate impairment removal corrected	New biological data and revised metrics
South Fork Groundhouse River	07030004-573	Fish and Macroinvertebrates	Impairment removal corrections for both fish and macroinvertebrates	Reflects refined assessment standards
Knife River	07030004-549	Macroinvertebrate	Macroinvertebrate impairment removal corrected	New analysis showed conditions meet standards
Mud Creek	07030004-566	Macroinvertebrate	Macroinvertebrate impairment removal corrected	Updated sampling and IBI criteria
Bear Creek	07030004-552	Fish	Fish impairment removal corrected	Improved biological data and reassessment
Snake River	07030004-508	Fish	Nonpollutant recategorization	The only stressors were nonpollutant; altered hydrology and lack of habitat

4.5 Pollutant sources

The SRW faces multiple pollutant sources that vary by subwatershed and stream segment, depending on surrounding land use, upstream discharges, and nonpoint sources. According to the 2014 Snake River WRAPS Report, cropland and pasture runoff were the primary contributors to nutrient and sediment impairments, and these remain dominant under the 2024 land use data (Figure 4) despite some change in land use coverage from the 2014 land use map. Developed land comprises just over 5% of the watershed and there are no Municipal Separate Storm Sewer Systems (MS4s), and point sources, including wastewater treatment facilities, contribute only a minor portion of overall pollutant loading.

Human alterations of water resources are widespread throughout the watershed. Many wetlands have been ditched, and significant portions of the stream network have been channelized or otherwise modified by reducing water storage capacity. These changes, combined with rainfall patterns, lead to increased peak flows, lower base flows, higher sediment and nutrient export, and degraded water quality. Several lakes within the watershed are impounded and those that discharge directly to downstream rivers are particularly vulnerable to fluctuations in water levels. These water level changes often referred to as “lake bounce” can increase flood risk to adjacent properties and infrastructure.

Other key stressors in the SRW include fertilizer and manure runoff, livestock overgrazing in riparian areas, urban stormwater runoff, and internal nutrient loading from lakes and wetlands. Failing or substandard SSTS also contribute to elevated levels of bacteria and nutrients in surface and groundwater. To address these issues, the MPCA conducts regular surveys of local governmental units to identify areas of concern, defined as locations where five or more homes within a half-mile radius lack adequate sewage treatment. These areas often include unincorporated communities with limited financial and technical capacity compared to larger municipalities.

Each county within the watershed is responsible for administering and enforcing SSTS regulations designed to protect public health, groundwater, and natural resources in accordance with state rules. These standards require that septic systems meet specific design and performance criteria and be inspected or upgraded when they fail or when properties are sold or expanded. State programs such as Minnesota’s Clean Water Partnership loans and the Small community wastewater treatment program provide grant and loan funding to upgrade failing systems, developed shared treatment options, and improve wastewater management in rural and small community settings.

Overall, nonpoint sources, including cropland and pasture runoff and failing SSTS, remain the primary drivers of impairments throughout the watershed. The new *E. coli* impairments highlighted in Cycle 2 along with the MST study, underscore the ongoing influences of bacteria contributions from these sources. The accompanying TMDL report provides allocations and strategies to address these impairments, building on the foundation established in the Snake River Comprehensive Watershed Management Plan.

5. Water quality trends

A key objective of the IWM 2017 monitoring effort was to evaluate if and how water quality has changed since 2008 (MPCA, 2020). It is generally important to understand if water quality appears to be changing or is declining. Either way, the knowledge will help inform future activities.

Trends in water quality were analyzed to provide a picture as possible of what is happening in the SRW including: streamflow, sediment (total suspended solids [TSS]), TP, and nitrogen (nitrate), biological communities (fish and bugs), and transparency of lakes.

Lakes

All five SID study lakes including Pokegama, Cross, Knife, Ann, and Fish lakes exhibit nutrient enrichment and eutrophication as dominant stressors, though the degree and drivers vary among systems (DNR, 2021). Overall, the average TP concentrations across the five lakes were 0.113 mg/L, indicating elevated nutrient levels relative to state standards (TP must be <40 µg/L and the chlorophyll-*a* is less than 14 µg/L and or a Secchi less than 1.4 m for deep lakes in the Northern Central Hardwood Forest (NCHF) region).

Pokegama Lake shows the most pronounced impairment, with mean TP of 94 µg/L, chlorophyll-*a* averaging 38 µg/L, and Secchi depth of 0.9 m, resulting in persistent algal blooms and poor water clarity. Its high watershed disturbance of approximately 35%, extensive shoreline development (including approximately 14 docks/km), and internal phosphorus release which accounts for 40% of its phosphorus budget, are major contributing factors. The lake also supports an established Common Carp population, which disturbs sediment and recycles nutrients, further amplifying eutrophic conditions.

In contrast, Ann and Fish lakes exhibit somewhat lower nutrient levels and limited carp presence. DNR surveys captured only one carp in Ann Lake (2015) and six in Fish Lake (2025), suggesting minimal carp influence on overall fish community structure. Knife Lake, chemically treated in 1989, has shown no carp since, with its outlet structure acting as an effective barrier to recolonization. Cross Lake shares similar eutrophication concerns as Pokegama, but carp impacts appear less severe. These lakes also experience shallow depth (<15 ft) and flow-through hydrology, which promote nutrient resuspension and algae growth.

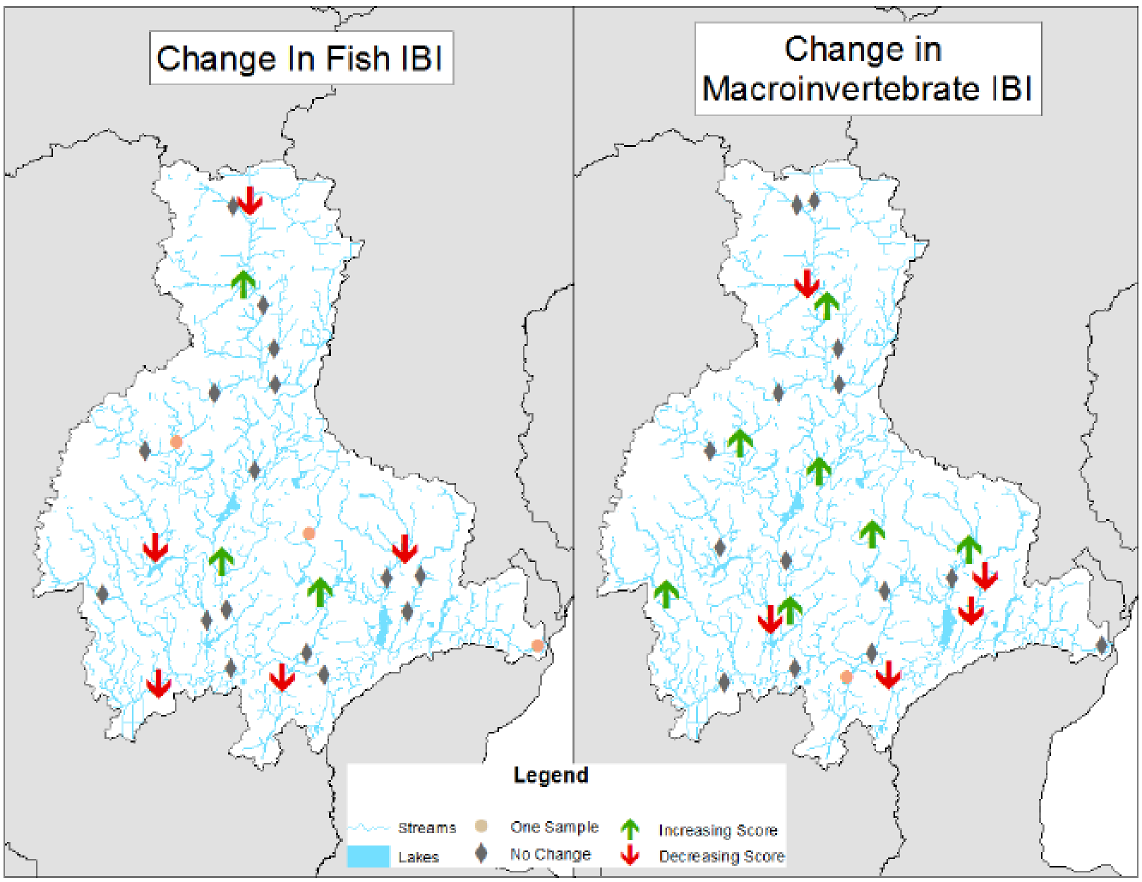
Beyond these 5 SID lakes, 13 publicly accessible lakes within the SRW have been assessed for AR standards (TP, chlorophyll-*a*, and Secchi depth). Six remain nutrient impaired, while the remainder currently meet standards or are near the threshold. Among them, Mora Lake is approaching impairment, and Pomroy, Devils, and Pennington lakes have been designated priority lakes for phosphorus reduction. Collectively, these results indicate that eutrophication, internal phosphorus cycling and shoreline disturbance remain key limiting factors for lake water quality in the watershed. Focused nutrient reduction, shoreline restoration, and carp control efforts, particularly in Pokegama Lake, are essential to improving aquatic habitat and recreation use across the Snake River basin (MPCA, 2020b; MPCA, 2021).

Streams

Between 2015 and 2018, the Snake River experienced several high-flow events when water levels rose above flood stage (DNR, 2018). These high flows have effects on stream channel stability and pollutant transport, contributing to channel erosion, sediment deposition, and habitat alteration even when pollutant concentrations remain relatively stable. The DNR has identified a priority erosion site downstream of Cross Lake, where the river channel has been actively eroding for many years (Frank, DNR Fisheries, 2025). This reach includes a deep pool that provides important habitat for Lake Sturgeon, a species of high ecological value that continues to be observed and tagged in the lower Snake River system. Despite the installation of a rock arch rapids structure below the Cross Lake Dam in 2013, erosion continues, indicating the need for ongoing stabilization and sediment control measures. Tag reports from anglers confirm that sturgeon move freely between the Snake and St. Croix Rivers, underscoring the good hydrologic and biological connectivity between these systems.

Stream biological monitoring results continue to show moderate biological integrity across the watershed, with fish and macroinvertebrate communities largely stable but not improving (Figure 18). Low DO and poor physical habitat remain the most common stressors in stream reaches, especially in the southern and downstream areas dominated by agriculture, pasture, and urban development (MPCA, 2021). Habitat fragmentation, altered hydrology, and perched culverts were identified as contributors to biological impairment in several tributaries, including Mud, Mission, and Bear creeks. Continued restoration of riparian buffers, streambank stabilization, and targeted hydrologic reconnection will be key to improving stream function and reducing pollutant transport.

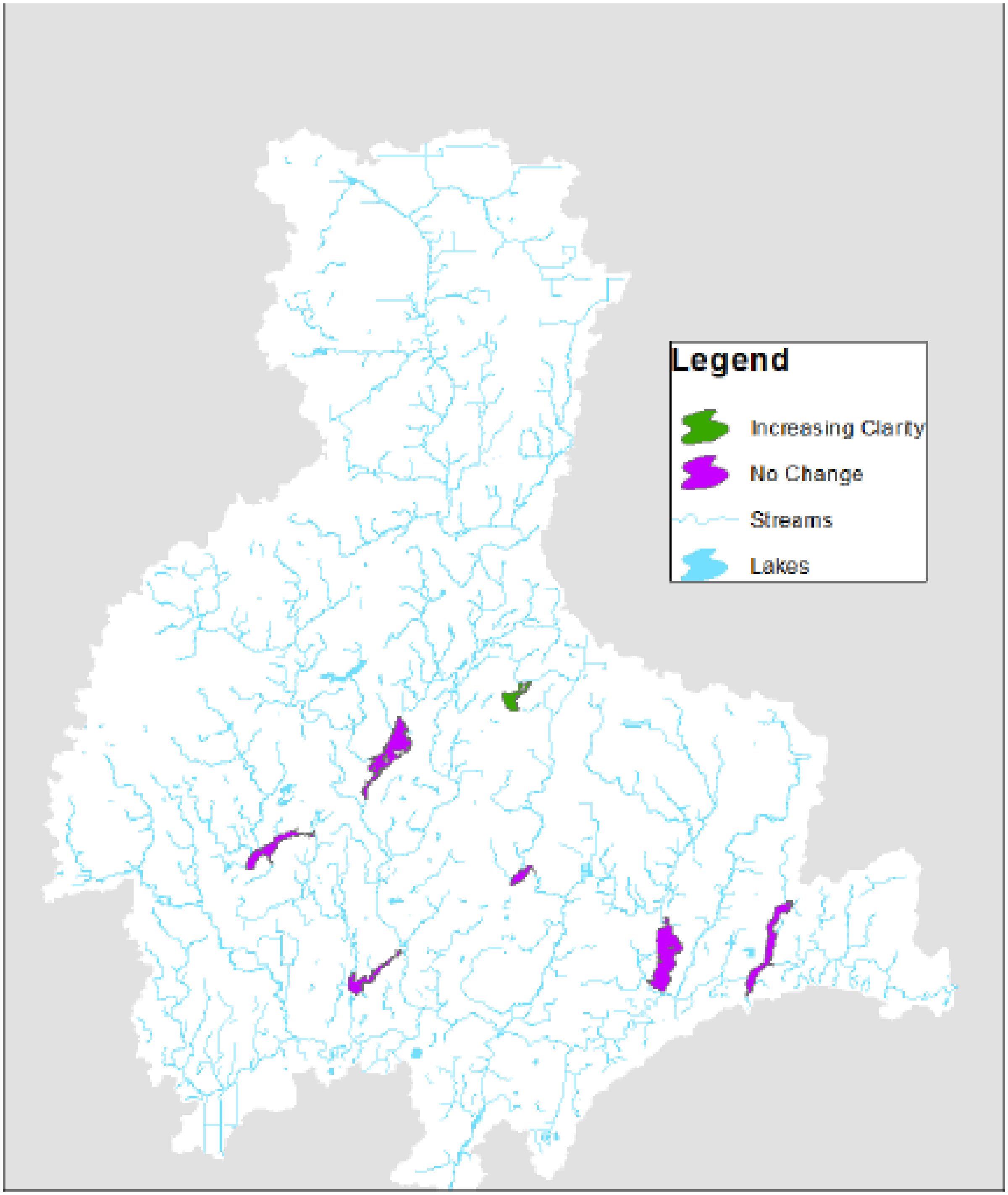
Figure 18. Change in stream fish and macroinvertebrate IBI from Cycle 1 and 2 in the SRW.



Transparency of lakes:

The SRW has 13 lakes with some amount of transparency data. The MPCA conducted trend analyses on eight lakes that met data requirements (25 Secchi measurements, eight years of data) (MPCA, 2018). Similar to statewide results, most lakes did not exhibit a significant trend, and more lakes have improving clarity over declining. Pomroy Lake had improving clarity while Quamba, Cross, and Fish lakes were exhibiting no change in clarity (Figure 19). For the lakes with enough data to detect a trend, most were showing no change in clarity.

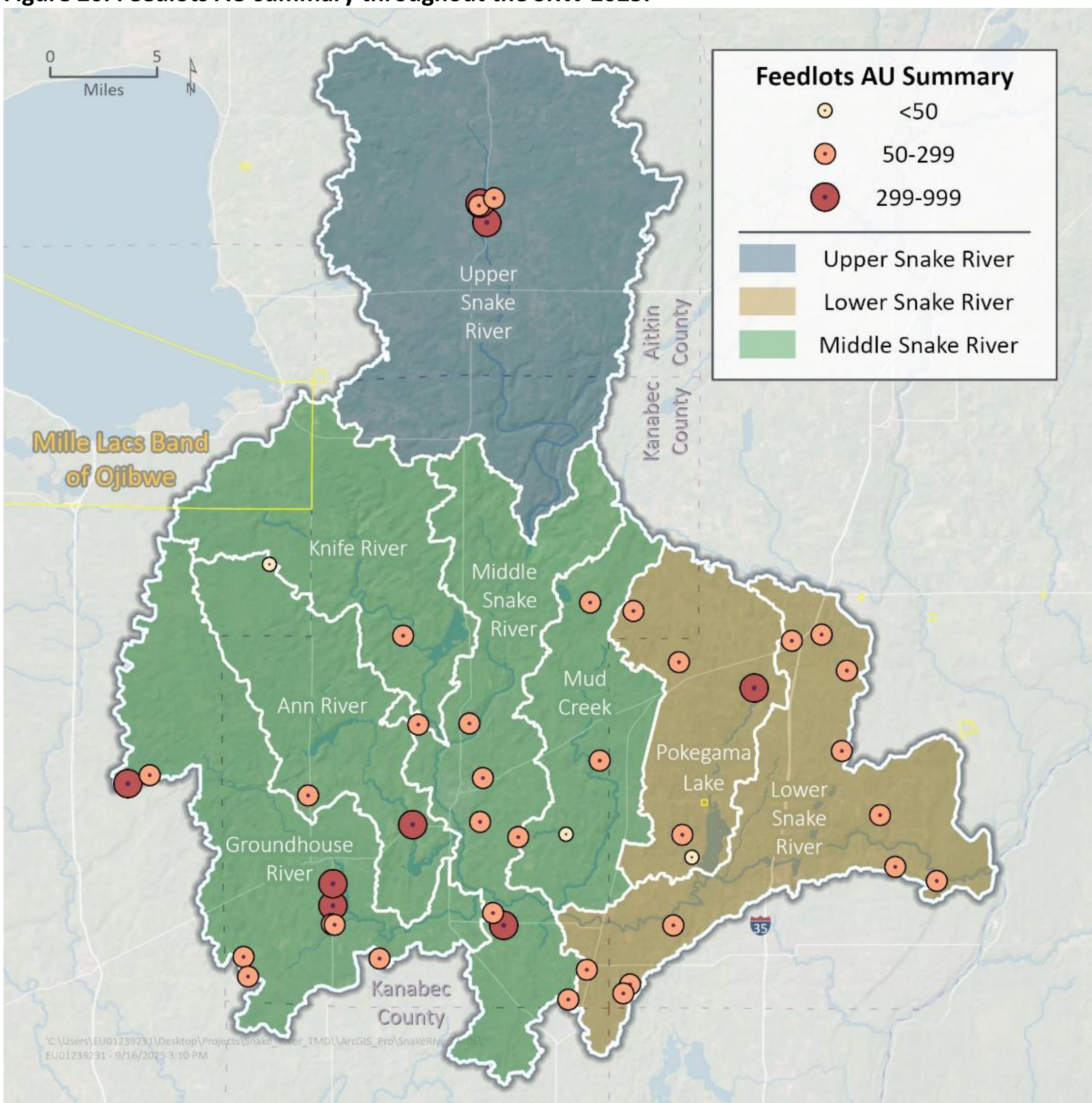
Figure 19. Transparency of lakes in the SRW (MPCA, 2018).



5.1 Sources, risks, and natural conditions

The current water quality conditions in the SRW reflect a combination of human activities and natural background inputs, with the most significant impairments linked to agricultural land use and livestock operations. Feedlots and manure storage areas are a well-documented source of nutrients and bacteria, particularly *E. coli*, through runoff from animal holdings areas, manure storage, or improperly managed land application practices. In Minnesota, regulation of feedlots is based on animal unit (AU) thresholds, a standard measure that accounts for differences in manure production across species. Facilities with more than 50 AUs or more than 10 AUs in shoreland areas are required to register, while those at or above 1,000 AUs, including Concentrated Animal Feeding Operations (CAFOs), must obtain a National Pollutant Discharge Elimination System (NPDES) or State Disposal System (SDS) permits (Figure 20). Permitted operations also present risks, particularly when numerous or located near surface waters. Source assessment indicate that both permitted and nonpermitted feedlots remain contributors to nutrient and bacteria impairments. More information can be found in the 2026 TMDL Report and on the MPCA's Feedlot Permits website.

Figure 20. Feedlots AU summary throughout the SRW 2025.

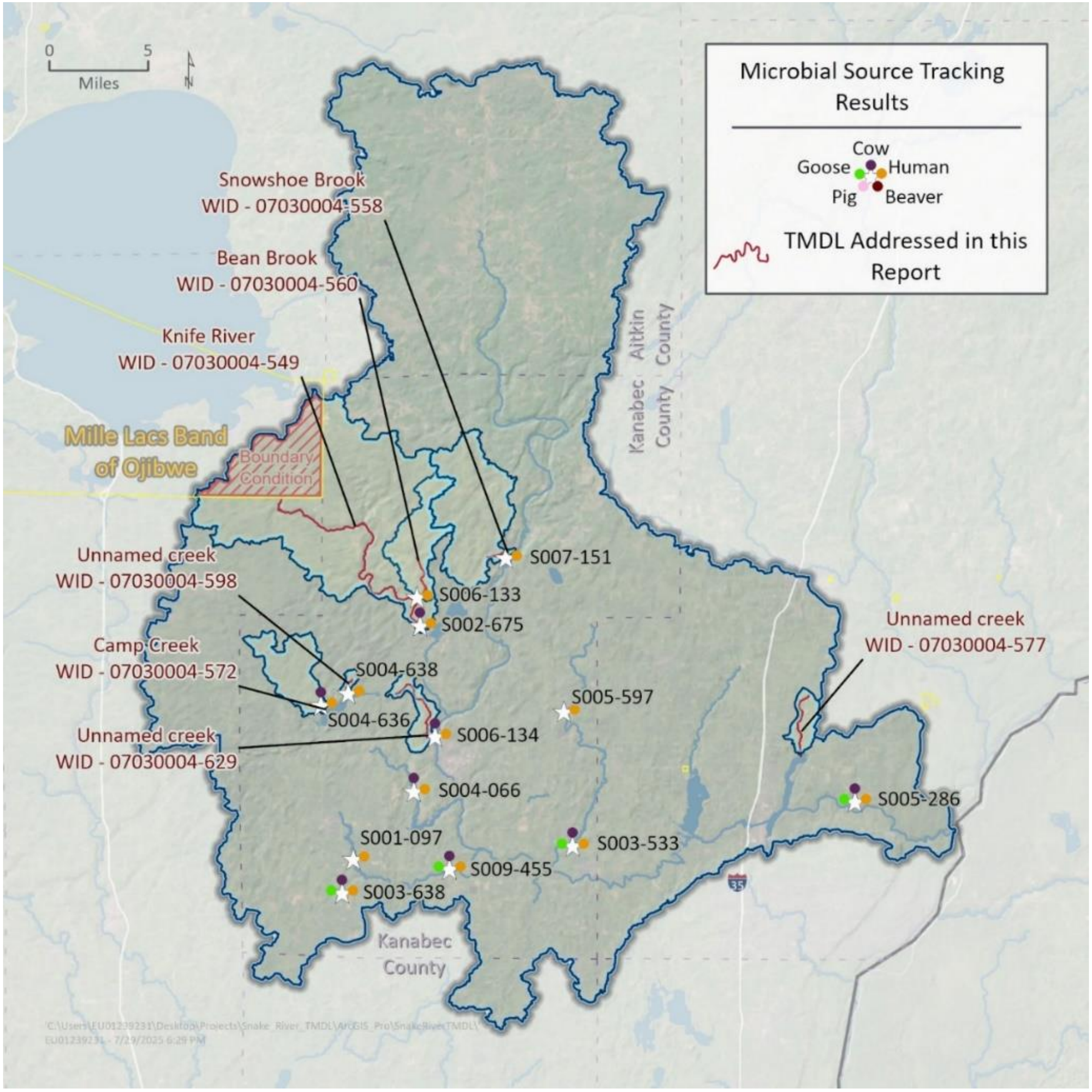


Sources of bacteria

The MPCA conducted an MST study in 2021 to better identify and understand the sources of bacteria within the SRW. Sampling was conducted at multiple locations in June and August of 2021 (Figure 21), with analysis targeting five host species: human, cow, pig, goose, and beaver (MPCA, 2021). The combined results showed that human and cow markers were detected far more frequently than the others, pointing to septic system issues and livestock operations as the dominant contributors of bacteria in the watershed. Pig, goose, and beaver markers appeared only occasionally, suggesting they are not major contributors. Additional sampling was recommended to understand the loading sources more within the watershed. The Partnership has also noted they would like to see sheep included if any additional MST studies are conducted within the watershed.

The spatial distribution of detections also provides insight into potential problem areas. As shown on the map, (Figure 21) cow and human markers were identified at multiple sites across the watershed, including tributaries such as Snowshoe Brook, Camp Creek, and several unnamed creeks. These findings align with the land use patterns in the watershed, where cattle feedlots, pastureland, and rural septic systems are prevalent. Human signals were often detected near more developed or residential areas, reinforcing the need for ongoing monitoring and potential septic system upgrades to reduce failing subsurface treatment system contributions. While wildlife-related markers such as goose and beaver were present at isolated sites, these signals were not widespread and likely represent localized background inputs rather than watershed-wide stressors.

Figure 21. Microbial source tracking results for June and August with sample locations and detected species (MPCA, 2021).



Overall, the MST study supports the conclusion that bacteria impairments in the SRW are largely attributable to anthropogenic sources – specifically cattle and humans – rather than natural background conditions (Table 8). These findings complement the source assessment results for impaired reaches and underscore the importance of targeted management strategies for both feedlot operations and septic systems to achieve water quality goals.

Failing or noncompliant SSTS and other human waste sources are significant contributors of *E. coli* to surface and groundwater in the SRW. Improperly functioning systems can allow untreated or partially treated wastewater to reach ditches, streams, or shallow groundwater, especially in areas with older systems or high-water tables. Recognizing this risk, Pine County has actively worked to reduce human-caused bacterial contamination by identifying, repairing, and replacing failing SSTS across the county. Through collaboration with local landowners, the Pine County Zoning Department, and state costsharing programs, dozens of systems have been upgraded or replaced to meet current standards in recent years. These efforts directly support WRAPS Update and SRW Comprehensive Plan goals by addressing one of the key human sources of *E. coli* impairments, improving public health, and helping restore AR use in the lower watershed.

Table 8. MST 2021 sample locations, species type, and detect (D) or nondetect (ND) in the SRW.

Sample ID	Human	Cow	Pig	Beaver	Goose
S004-066	D	D	ND	ND	ND
S004-636	D	D	ND	ND	ND
S006-134	D	D	ND	ND	ND
S002-675	D	D	ND	ND	ND
S007-151	D	ND	ND	ND	ND
S004-638	D	ND	ND	ND	ND
S006-133	D	ND	ND	ND	ND
S001-097	D	ND	ND	ND	ND
S005-597	D	ND	ND	ND	ND
S009-455-1	D	D	ND	ND	D
S009-455-2	D	D	ND	ND	ND
S003-638	D	D	ND	ND	D
S005-286	D	D	ND	ND	D
S003-533	D	D	ND	ND	D
NC	ND	ND	ND	ND	ND

*NC- Negative Control, D – Detect, ND – Nondetect

Between 2017 and 2024, Pine County made steady progress in upgrading wastewater infrastructure to reduce human contributions of *E. coli* and other pollutants. During this period, more than 1,000 septic systems were replaced and nearly 800 new systems were installed (data from internal source). On average, the county replaced about 140 systems per year and installed approximately 100 new systems annually, reflecting sustained investment and engagement with local property owners. The highest activity occurred in 2020-2021, when over 400 systems were upgraded or replaced in response to focused outreach and cost-share programs. These efforts represent a significant local commitment to addressing bacteria sources at their origin and demonstrate measurable progress in improving water quality and public health protection throughout the SRW.

6. Climate change

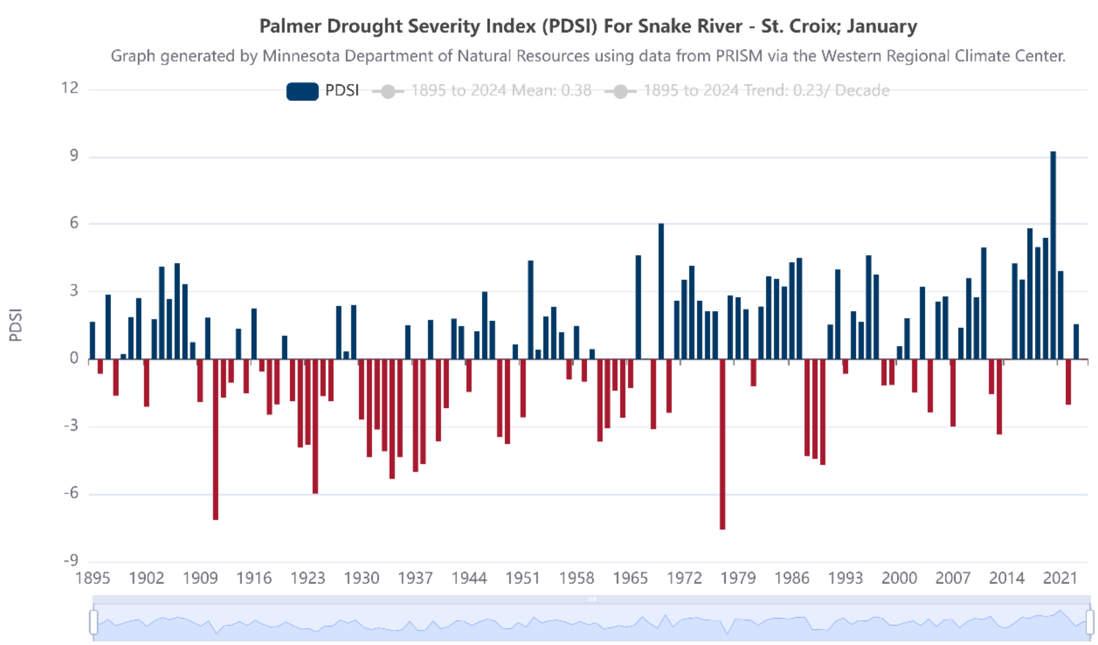
Climate is a key ecological factor that shapes hydrology and water quality. The report *Climate Summary for Watersheds: Snake River (St. Croix)* (DNR 2019) provides a historical overview of climate conditions in the watershed, using data from 1895 to 2018. It highlights trends in seasonal and annual temperature and precipitation, with a focus on comparing the most recent 30 years to the full 120-year record. Long-term data reveal a rise in the SRW average annual temperatures, with most of the past two decades experiencing above-average warmth. July typically marks the peak in monthly average temperatures, and winter temperatures have shown the greatest increase—rising by 3.0°F—while summer temperatures have seen a smaller change of 0.5°F (DNR, 2019).

Annual precipitation has also increased over time in the SRW. May and June are usually the wettest months, but recent years have seen especially notable increases in April, July, and October. Across Minnesota, there has been a general rise in the frequency of 1-inch and 3-inch rainfall events, as well as in the intensity of the heaviest storms each year. The state has also seen more widespread and damaging extreme rainstorms, a trend expected to continue according to climate projections (DNR, 2022).

These shifts in rainfall patterns have led to higher river and stream flows. Over the past few decades, peak flows in the watershed and downstream have increased, with the past 20 years experiencing 2.5 times more high-flow years (MPCA, 2024a). These elevated flows contribute to increased streambank erosion and sediment movement, which can affect local pollutant levels, degrade fish and aquatic life habitats, and reduce the quality of recreational water uses.

In addition to heavier rainfall and more frequent flooding, the SRW is also facing periods of drought—further evidence of climate extremes. These fluctuations between wet and dry conditions are expected to continue, leading to shifts in habitat zones and intensifying other environmental stressors in the watershed (Figure 22). The DNR has developed a Climate Explorer tool based on the Palmer Drought Severity Index to monitor drought conditions. In 2020, this index reached a record high value of 9.22 in the SRW, the highest recorded between 1985 and 2024, indicating a significant drought event.

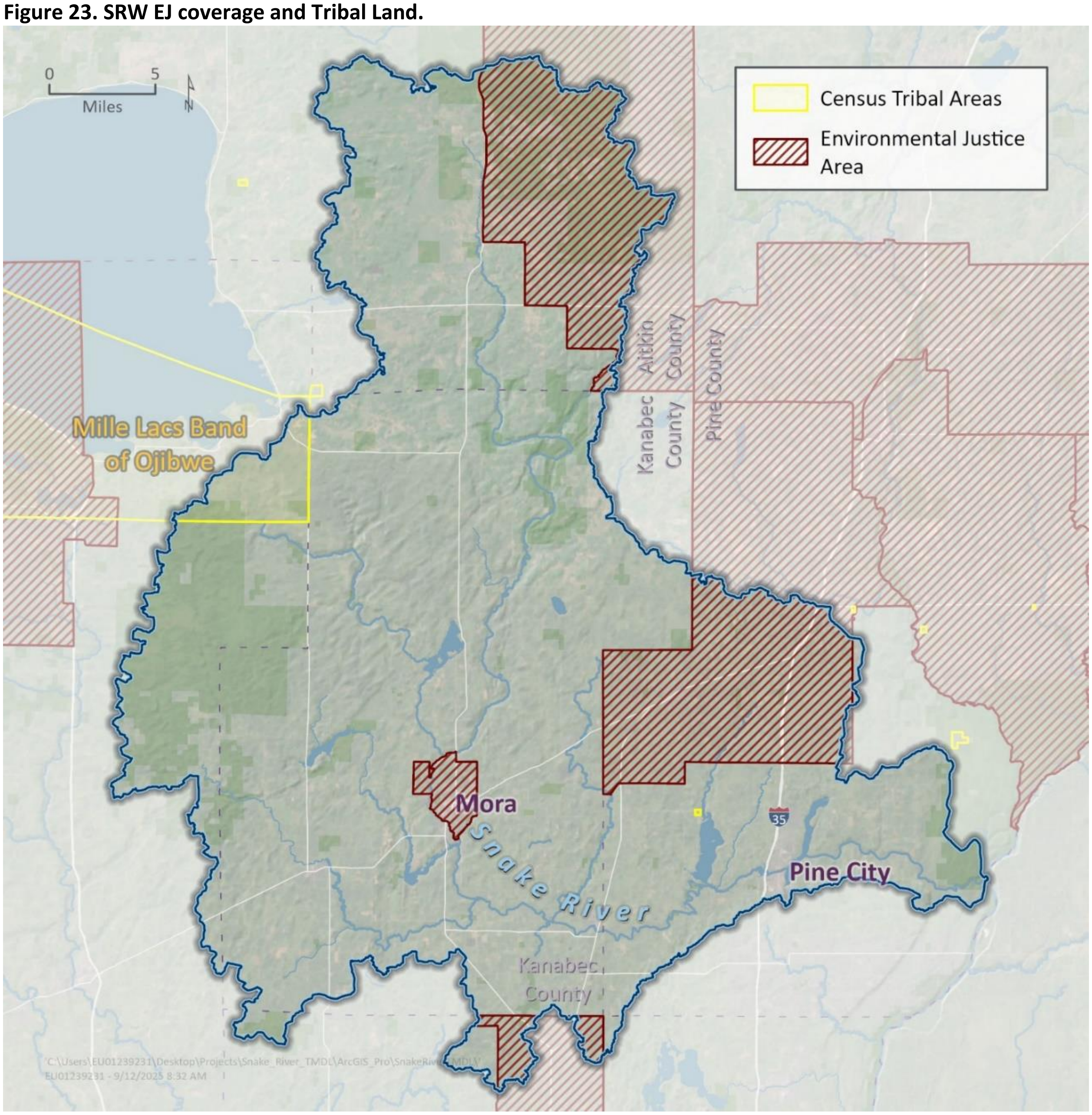
Figure 22. Palmer Drought Index for SRW over time (DNR, 2022).



7. Environmental justice

The MPCA is committed to ensuring that pollution does not disproportionately impact any group of people – the principle of environmental justice (EJ). This means that all people, regardless of race, color, national origin, or income, should benefit from equal levels of environmental protection and have meaningful opportunities to participate in decisions that may affect their environment or health. Within the SRW, several census tracts that meet criteria for areas of increased concern for EJ, particularly where more than 35% of residents report incomes less than 200% of the federal poverty level (Figure 23). In the SRW, the total watershed area is 1,006 square miles and the area considered EJ covers 178 square miles. These communities may be more vulnerable to the effects of degraded water quality and have fewer resources to address environmental challenges. Local water planning and implementation activities were engaged with these low-income populations to ensure that their perspectives are represented and that pollution reduction strategies provide equitable benefits. Future activities will be tailored to the needs of the various communities within the SRW. More information can be found on [MPCA's environmental justice efforts and interactive maps](#) identifying EJ concern areas.

Figure 23. SRW EJ coverage and Tribal Land.



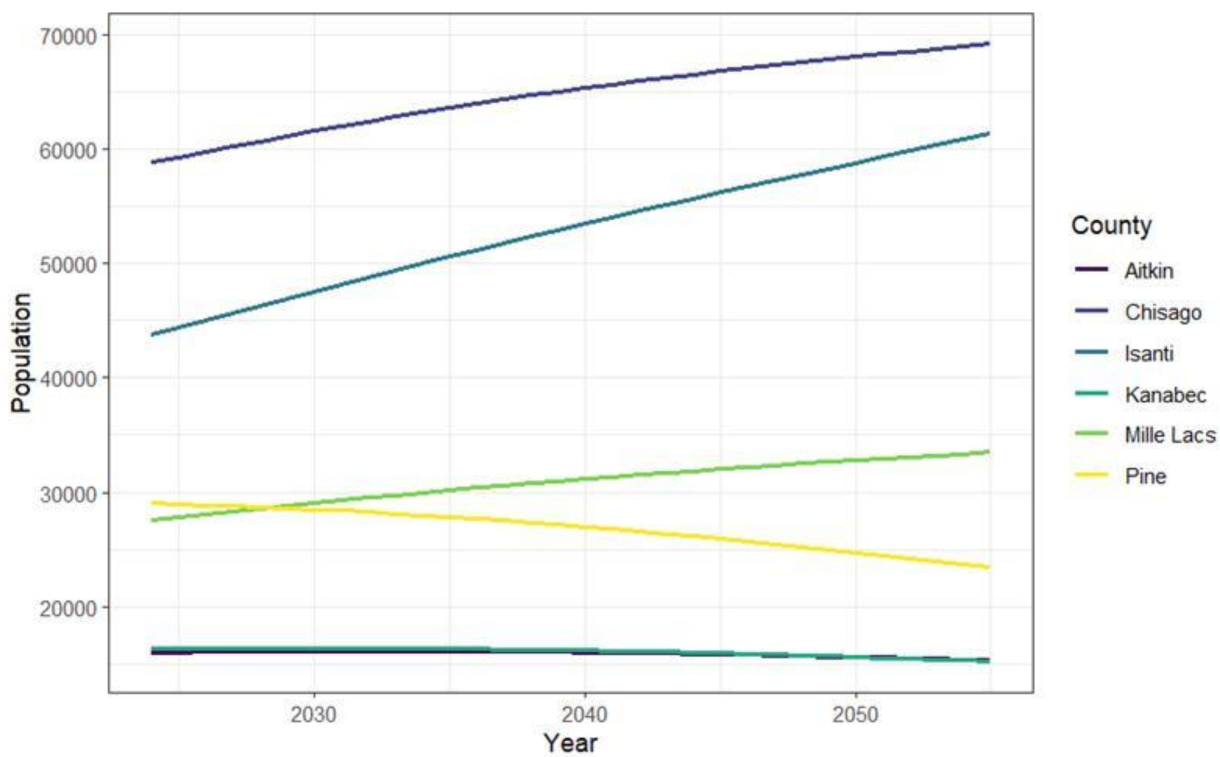
Although designated EJ areas identify priorities for outreach and investment, low-income residents are found across the entire watershed. Effective watershed programs should aim to lower financial barriers, expand access to cost-share opportunities, and involve community members through clear communication and practical assistance.

The following strategies are in alignment with MPCA's EJ guidance and can be implemented within the watershed:

- Community engagement and empowerment
- Equitable access to resources
- Data transparency and targeted monitoring
- Inclusive decision making
- Long-term investment and accountability

A shift in population and land use within the SRW are expected to influence pollutant sources and overall water quality conditions over time. Projections from the Minnesota State Demographics Center (Minnesota Department of Administration, 2024) indicate that populations will grow in three counties – Chisago, Isanti, and Mille Lacs – remain relatively stable in Aitkin and Kanabec counties, and decline in Pine County over the next 30 years (Figure 24). Notably, the counties projected to grow are located in the southern portion of the watershed and already represent some of its most populous areas.

Figure 24. Population projections into 2050 in the SRW.



The SRW lies within the ancestral homelands of the Anishinaabe (Chippewa, Ojibwe) and Dakota peoples. A portion of the Mille Lacs Band of Ojibwe Reservation falls within the watershed and is incorporated into the Knife River TMDL (07030004-549) as a boundary condition (MPCA, 2026).

Throughout the watershed assessment process and the development of both the corresponding TMDL report and WRAPS Update report, invitations to collaborate on water-related projects were extended to the Mille Lacs Band of Ojibwe and other Tribal organizations with potential interest.

8. Goals to meet water quality standards and fully supporting uses

To address the wide range of pollutant sources and stressors in the SRW, the WRAPS Update and TMDL reports have established goals designed to reduce pollutant loading, restore aquatic life and recreation, and fully support designated uses.

8.1 Phosphorus reductions

Agricultural runoff from cropland and pasture remains one of the largest contributors of nutrients and sediment, and reduction of these sources is a primary focus. Building on the Pokegama Lake TMDL and the SWA (Stantec, 2024), the implementation of wetland restorations, WASCOBs, and targeted field practices will be critical to meeting phosphorus reduction targets of 40% in Pokegama Creek and 88% in the direct watershed. Prioritizing cost-effective BMPs identified in the SWA, including wetland restorations, WASCOBs, grassed waterways, filter strips, and field practices (cover crop) to reduce phosphorus loading by 640 lbs annually, will help ensure meaningful progress toward these reductions.

8.2 Mitigating hydrology change in streams

Hydrologic alterations remain another key challenge. The widespread ditching of wetlands and channelization of streams have diminished natural water storage and contributed to higher peak flows, greater sediment transport, and lake level fluctuations or “lake bounce.” Restoring ditched wetlands where feasible, stabilizing altered stream channels, and improving impoundment management are necessary steps to mitigate these impacts and improve resilience to changing rainfall patterns. Internal nutrient loading in lakes and wetlands also requires attention, with strategies such as wetland restoration, alum treatments, and other in-lake management practices needed to reduce phosphorus recycling and improve lake water quality.

8.3 Reducing bacteria levels

Bacteria impairments, including seven new *E. coli* listings identified in Cycle 2, highlight the need to reduce livestock bacteria contributions and improve manure management across the watershed. Riparian buffers, livestock exclusion, and other field level pasture BMPs are important strategies to reduce bacteria loading. At the same time, failing septic systems continue to pose localized risks to water quality. Addressing these concerns require ongoing inspection, repair, and replacement programs, especially within the three communities identified as SSTS areas of concern. Expanding participation in the Small Community Wastewater Program, Clean Water Partnership loans, and county low-interest loan programs will support upgrades in communities that may otherwise lack financial capacity. Finally strengthening regulatory and technical programs is essential to achieving long-term improvements. This includes:

- supporting MPCA's future proposed amendments to Minn. R. ch. 7020 to improve manure application practices,
- maintaining county-level enforcement of SSTS ordinances under Minn. Stat. §§ 115.55-115.56 and Minn. R. 7080-7083, and
- using state funding opportunities such as BWSR grants and MDA's Agricultural BMP Loan Program.

Together, these efforts provide a comprehensive approach to reducing nonpoint source pollution, protecting public health, and restoring the ecological and recreational integrity of the SRW.

9. Restoration and protection needs

Since the completion of the 2014 WRAPS report and the Cycle 1 planning effort, watershed partners have gained valuable experience in addressing both impaired and unimpaired waters in the SRW. Cycle 1 focused heavily on restoring impaired waters through broad adoption of agricultural BMPs. While this work laid a critical foundation, it became clear that a more targeted, cost-effective, and balanced approach was needed to fully achieve water quality standards and protect vulnerable high-quality waters. As reflected in the 2023 Snake River Comprehensive Management Plan, the document builds on those lessons by integrating restoration and protection into a single framework. This approach combines pollutant reduction strategies for impaired waters with proactive protection of unimpaired resources, ensuring that gains are not only achieved but also maintained long-term.

Reaching water quality goals in the SRW requires strategies that cumulatively reduce pollutant loads from both point and nonpoint sources, as outlined in the CWLA. The 2014 WRAPS report established pollutant load reduction goals and emphasized restoration of impaired waters through BMPs targeted at phosphorus, sediment, and bacteria. While these strategies led to progress, they did not achieve the scale of reduction needed to meet water quality standards. This WRAPS Update and the 2023 CWMP refine this focus with measurable goals:

- Reducing phosphorus loading to impaired lakes by 4,200 lbs,
- Cutting sediment in priority streams and rivers by 1,750 tons and lowering *E. coli* exceedances by 10% (Stantec, 2023).

Implementation strategies emphasize wetland restorations, riparian buffers, soil health practices, feedlot runoff management, and septic system upgrades. Modeling with HSPF-SAM has provided estimated pollutant reductions for different BMPs, ensuring actions are targeted and cost-effective. More information on HSPF-SAM can be found in the 2026 Snake River TMDL report. In addition, restoration efforts include stream channel stabilization, culvert and dam modifications to improve connectivity, and lake management projects to address internal nutrient cycling. Watershed-Based Implementation Funding (WBIF) of over $1 million awarded in 2024 provides crucial support for accelerating these restoration efforts.

Protection of high-quality waters and sensitive natural resources has become an increasing priority within the SRW. The watershed planning process recognizes the area's rich biodiversity, including fish, freshwater mussels, threatened terrestrial species, and outstanding natural resources such as the Mille

Lacs Wildlife Management Area, Solana State Forest, and Rum River State Forest (Stantec, 2023). Building on this foundation, the CWMP identifies priority unimpaired lakes and streams and establishing goals to maintain or reduce current phosphorus levels, expand shoreline buffers, and protect critical habitats through conservation easements and sustainable forest management. Protection strategies also include education and outreach, and monitoring for change. Antidegradation protection under Minnesota water quality standards (Minn. R. chs. 7050 and 7052) provide an added regulatory safeguard for high quality waters. Together, these coordinated efforts ensure that unimpaired waters remain resilient against threats such as increased urban and agricultural land development, altered hydrology, climate change, and invasive species such as carp while maintaining the ecological integrity and recreational value of the watershed.

10. Strategies

The SRW faces a complex mix of challenges and opportunities that require both scientifically and socially supported strategies to achieve long-term water quality goals. With 87 lakes and 128 streams, 49 of which are impaired, the watershed would continue to benefit from a targeted approach that addresses phosphorus, nitrogen, sediment, and *E. coli* while protecting unimpaired waters that provide critical habitat, recreation, and community value. Since Cycle 1, the watershed has advanced from broad restoration and outreach efforts to a more refined Cycle 2 framework that combines modeling tools, SWAs, and adaptive management with partnership support, civic engagement, and local leadership. These strategies, goals, and progress outlined in the following sections reflect how the SRW is working toward cleaner water, healthier ecosystems, and resilient communities.

Priority was given to water bodies with ongoing restoration work, high recreational importance, or those nearing impairment thresholds. Unimpaired lakes and streams were also emphasized if they provide valuable habitat or are at risk from land use pressures. To address these priorities, scientifically supported practices include shoreline and streambank buffers, stream restoration, feedlot runoff management, septic system upgrades, and wetland restoration. The Partnership has also committed to expanding protected areas in priority subwatersheds by 5% to 10%, increasing continuous cover on 600 acres, and installing 2 to 8 stormwater BMPs in developed areas (Stantec, 2023).

The WBIF program, which allocated more than $1 million to the SRW area in 2024, provides essential support for implementing targeted, measurable restoration and protection strategies. These funds enable local partners to leverage state and federal cost-share programs, install high-priority BMPs, and sustain coordination among counties, SWCDs, and watershed organizations. However, WBIF is not a permanent or guaranteed funding source. The program’s continuation is reviewed biennially by the Clean Water Council as part of their overall Clean Water Fund budget recommendations process, and is dependent on legislative reauthorization of the Clean Water, Land, and Legacy constitutional amendment which is currently set to expire in 2034 unless extended. This uncertainty underscores the importance of developing diverse, long-term funding mechanisms to maintain implementation momentum and protect ongoing investments. Complementing these financial strategies and modeling tools which allows for quantifiable tracking of pollution reductions.

10.1 Nutrient management

Nutrients, particularly, phosphorus and nitrogen, remain primary drivers of water quality impairment in the SRW. Elevated phosphorus concentrations contribute to eutrophication in lakes such as Pokegama, Ann, and Fish lakes while nitrogen enrichment can influence downstream productivity and DO. Key sources include cropland runoff, livestock manure, and failing or outdated septic systems (SSTS).

Strategies

Targeted nutrient management through a combination of watershed and in-lake strategies:

- **Wetland restoration and floodplain reconnection** to retain runoff and sequester phosphorus before reaching surface waters.
- **Riparian buffers and cover crops** to stabilize soils, reduce erosion, and intercept nutrients.
- **Feedlot and manure management** to minimize field application losses.
- **In-lake treatment and management,** such as alum application and carp control, to reduce internal phosphorus loading where external load reduction alone is insufficient.

Implementation and Monitoring

Implementation of 32 high-priority BMPs, as identified in the CWMP, in the Pokegama Subwatershed is projected to reduce phosphorus loading by ~640 lbs/year, contributing to the watershed-wide reduction goal of 4,200 lbs/year. Maintaining and expanding forest cover, currently 36% of the watershed, is also recognized as a natural nutrient-reduction mechanism. Although nitrate levels are well below the 10 mg/L standard for coldwater streams, targeted soil health and nutrient-management planning are being promoted in vulnerable agricultural areas (Stantec, 2023). Discussions will occur with the Partnership for opportunities to sample in lake conditions in Cycle 3 IWM beginning in 2028.

10.2 Reducing *E. coli* bacteria

Elevated *E. coli* concentrations are a widespread concern affecting AR use throughout the watershed. Concentrations fluctuate with precipitation, streamflow, and temperature. Sources include failing septic systems, livestock access to waterways, and manure runoff, while permitted wastewater facilities generally meet compliance standards.

Strategies

Management efforts focus on controlling bacteria at the source through:

- **Enforcement of SSTS ordinances** and targeted replacement of failing systems.
- **Feedlot runoff controls, proper land application of manure as fertilizer,** and livestock-exclusion fencing.
- **Riparian buffer installation** and pasture management to minimize direct animal contact with streams.
- **Public education** on proper manure handling and septic maintenance.

Implementation and Monitoring

Since 2017, between 60 and 96 SSTS systems have been replaced each year, supported by the MPCA Small Community Wastewater Treatment Program and Clean Water Partnership loans funding. New 2025 SDS/NPDES feedlot permits include enhanced manure-application safeguards. The AgBMP Loan Program provides cost-share assistance to producers adopting conservation practices. Collectively, these measures will help to meet the Snake River Comprehensive Management Plan goal of a 10% reduction in *E. coli* exceedances watershed wide. MPCA will return to monitor for *E. coli* in Cycle 3 IWM in 2028 and 2029.

10.3 Sediment and additional pollution reduction

Excess sediment loading contributes to turbidity, habitat loss, and stream instability in several tributaries, including the Groundhouse River, Bear Creek, and Mission Creek. Channel erosion, ravine inputs, and upland runoff are major sources, especially during high-flow events.

Strategies

Pollution-reduction strategies focus on stabilizing vulnerable areas and intercepting sediment before it enters receiving waters:

- **Streambank stabilization** and **channel restoration** using bioengineering and grade-control structures.
- **WASCOBs, grassed waterways**, and **side-inlet controls** to reduce field-scale erosion.
- **Riparian vegetation and floodplain connection** to dissipate energy and trap sediment.
- **Cropland BMPs** such as conservation tillage and cover crops to improve infiltration and reduce soil loss.

Implementation and Monitoring

CWMP targets a reduction of 1,750 tons of sediment per year in priority streams (Stantec, 2023). BMP implementation will be guided by PTMApp outputs and field verification by SWCD staff. Progress will be measured using WPLMN turbidity and TSS datasets to evaluate long-term load reductions. MPCA also will return to monitor for TSS in Cycle 3 IWM in 2028 and 2029. Additional information for priority areas for sediment and pollution reduction can be found in the *Snake River Comprehensive Watershed Management Plan*.

10.4 Landscape and hydrology

Hydrologic alteration, driven by increased precipitation and land use change, affects flood risk, storage capacity, and pollutant transport. The Snake River has experienced multiple high-flow events since 2015, intensifying erosion and sediment delivery.

Strategies

Hydrologic management emphasizes restoring and maintaining natural storage and infiltration processes:

- **Wetland and floodplain restoration** to store runoff and attenuate peak flows.

- **Stormwater BMPs** such as retention basins, infiltration systems, and shoreline retrofits in developed areas.
- **Forest and perennial vegetation protection** to sustain infiltration and baseflow stability.
- **Culvert and dam modifications** to improve channel connectivity and fish passage.

Implementation and Monitoring

The MPCA conducted hydrologic assessments during Cycle 2 IWM, which identified the need for expanded upland and floodplain storage. Planned actions include a flood-risk assessment for the Mora-St. Croix corridor and implementation of wetland-restoration projects in high Erosion Hazard Classification (EHC) areas. Long-term hydrologic monitoring through DNR and WPLMN gages will inform adaptive management under increasing climate variability.

10.5 Education and outreach

Community engagement is critical to sustaining long-term progress. The watershed's education and outreach strategy ensures that restoration and protection activities are both scientifically credible and socially supported.

Strategies

- Farmer-led councils and lake associations provide peer networks for BMP adoption.
- Watershed tours, lake days, and youth programs build awareness and stewardship.
- Technical workshops for producers and landowners promote soil health, nutrient management, and shoreline restoration.
- Digital dashboards and reports have progress, pollutant-trend data, and success stories with the public.

Implementation

Watershed partners coordinate outreach and engagement efforts to inform, involve, and collaborate with partners and interested parties. On-going reporting and engagement activities help track participation, implementation progress, and public awareness, supporting continued local investment and accountability.

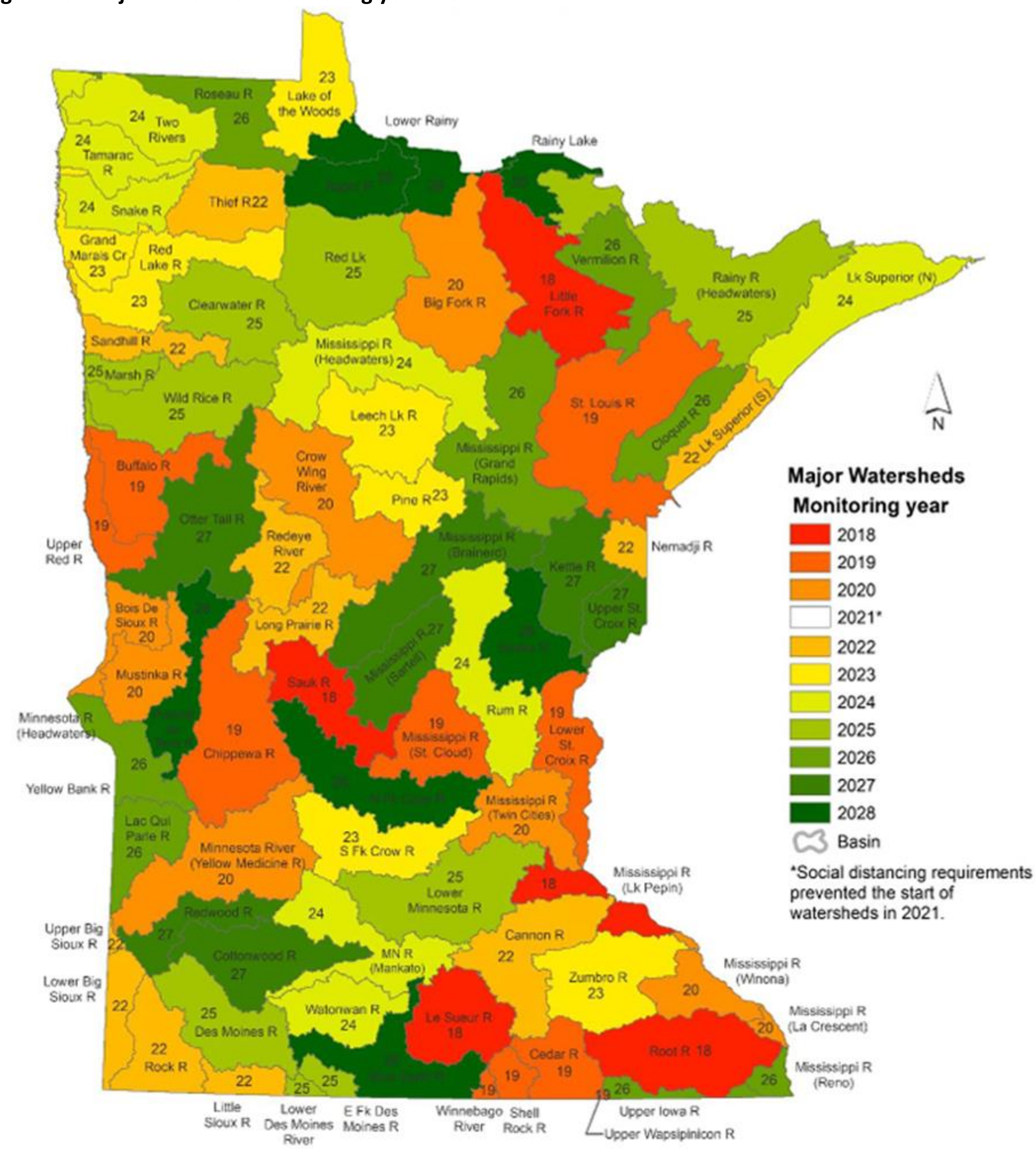
11. Monitoring plan

Ongoing monitoring by the MPCA and its partners provide the foundation for assessing water quality conditions and tracking progress towards restoration and protection goals across the SRW. These efforts, such as the IWM program and WPLMN are critical for determining the effectiveness of restoration and protection strategies. At the HUC-8 scale, MPCA conducts IWM approximately every 10 years, collecting biological, chemical, and physical data to assess impairments, detect trends, and document improvements over time. The SRW was last assessed in 2019 and is scheduled again in 2028 (Figure 25). The WPLMN operates three sites along the Snake River and its tributaries to calculate pollutant loads. The three sample locations are in Mora, Grasston, and Pine City. The Volunteer Lake and

Stream Monitoring Programs rely on volunteers to collect water quality data. In addition, USGS maintains a continuous flow gauge near Pine City, providing long-term hydrology records.

Monitoring is essential not only to track progress toward water quality goals, but also to identify emerging issues, and refine strategies over time. During the Snake River Comprehensive Management planning process, LGUs recognized that a lack of data on many lakes and streams remains a significant limitation to targeting projects and assessing effectiveness. For example, several lakes have little to no baseline water quality data, making it difficult to determine current conditions or track changes. Collecting targeted data will help watershed partners evaluate pollutant trends, identify protection opportunities, and measure improvements from restoration actions (MPCA, 2021).

Figure 25. Major watershed monitoring years 2018-2028.



Additional and more frequent monitoring is needed to better understand pollutant sources and track progress, particularly for *E. coli* impairments. Data collected from 2005-2021 shows that *E. coli* concentrations vary widely with flow concentrations, indicating nonpoint sources such as failing SSTS, livestock operations, and landscape runoff are likely major contributors (MPCA, 2021). Future monitoring by MPCA could include targeted MST to refine source identification and expanded sampling during high-flow events to capture runoff-driven bacteria loading. Enhanced monitoring of feedlots, manure application practices, and septic system compliance would help distinguish between human and livestock contributions and support implementation management measures under the TMDL framework.

Local partners, which include Pine, Kanabec, Mille Lacs, and Aitkin Counties and their respective SWCDs, play a vital role in supplementing state data. Through cooperative efforts, partners conduct site-specific project monitoring for BMPs, in-lake restoration projects, and subwatershed-scale pollutant reduction studies. The SRW Management Board and SWCDs have prioritized building shared monitoring capacity, including equipment, data management, and technical writing (Stantec, 2023).

The Comprehensive Management Plan identifies monitoring gaps in several areas:

- Lakes with limited or no baseline data, including smaller impoundments and recreational lakes not previously monitored under IWM.
- Tributaries with limited biological and bacteria data, particularly in areas with suspected septic or livestock influences.
- Effectiveness monitoring for implemented BMPs to quantify pollutant reductions and validate model assumptions.
- Groundwater-surface water interactions, particularly near lake chains and agricultural subwatersheds.

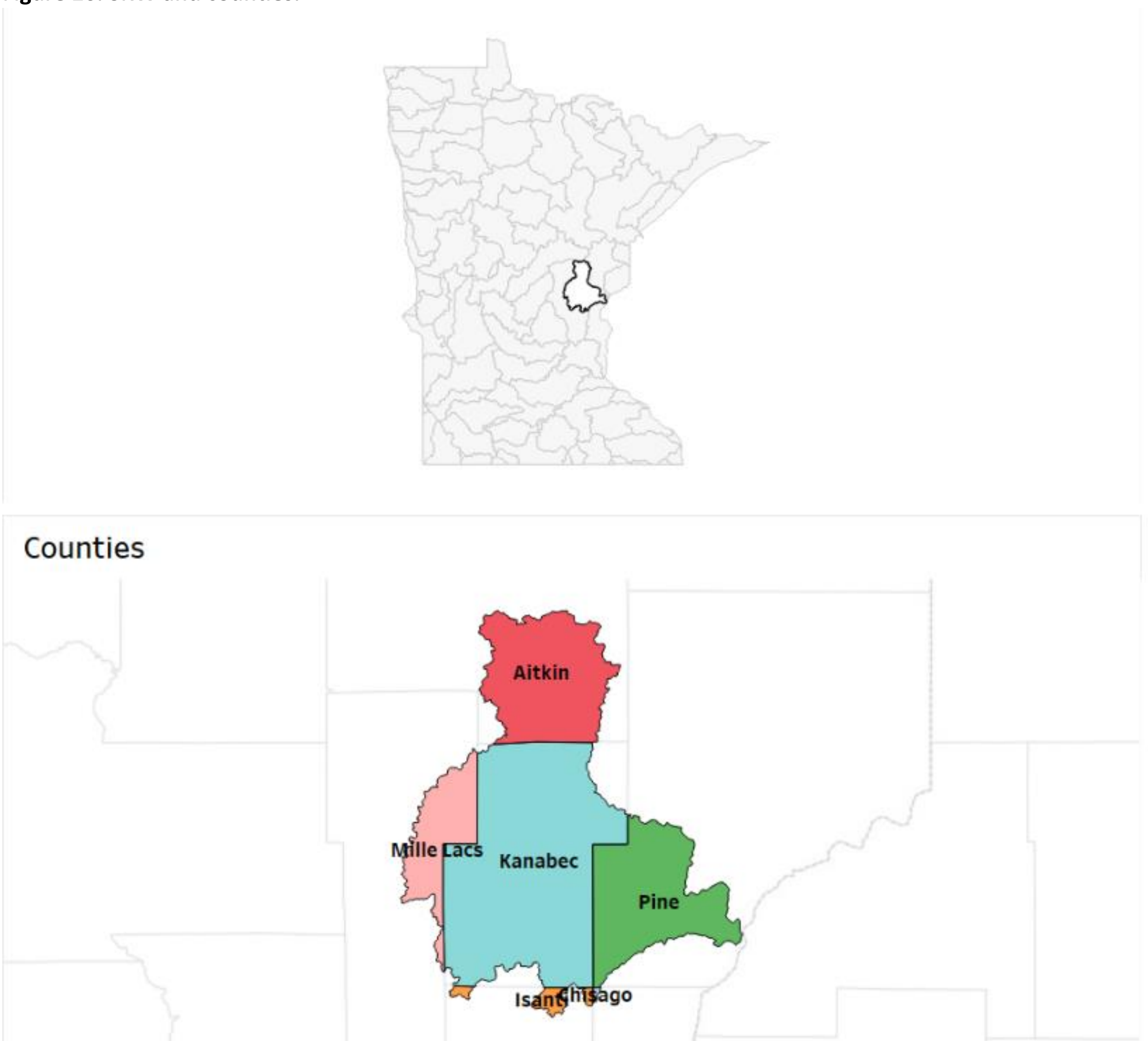
To address these gaps, watershed partners aim to expand local monitoring capacity through grant-supported initiatives. Emphasis should be placed on developing consistent data management and reporting protocols to be able to seamlessly integrate local results into MPCA databases.

Monitoring results will feed directly into adaptive management cycles, informing where practices are most effective and where strategy adjustments are necessary. Local partners can track annual progress using measurable indicators such as phosphorus load reductions, *E. coli* exceedances, and BMP adoption rates to communicate trends, celebrate successes, and identify new areas for collaboration.

12. Public participation/Public notice

The SRW Partnership Planning was established through a memorandum of agreement (MOA) and a collaborative effort among several LGUs, including Kanabec County, Kanabec SWCD, Pine County, Pine SWCD, Mille Lacs County, Mille Lacs SWCD, Aitkin County, and Aitkin SWCD. Isanti and Chisago Counties, along with their respective SWCDs, chose not to participate in the planning process due to the minimal portions of their counties located within the watershed boundaries (Figure 26).

Figure 26. SRW and counties.



In person interviews along with online surveys were completed by local SWCD administration and staff in 2019-2020. The results of this engagement were used to develop the priorities for the WRAPS Update Report. Those who participated shared that a bacteria MST study would be useful (See Section 5.1 for summary). They also shared that additional in-lake sampling and post in-lake treatments would be beneficial for the watershed and that SWAs were needed. Lastly, they requested a more informative climate change summary.

The MPCA mailed out tribal letters to the following tribes on two occasions: 1854 Treaty Authority, Bois Forte Band of Chippewa, Fond Du Lac Band of Lake Superior Chippewa, Grand Portage Band of Ojibwe, Great Lakes Indian Fish and Wildlife Commission (GLIFWC), Mille Lacs Band of Ojibwe, Minnesota Chippewa Tribes, Red Cliff Band of Lake Superior Chippewa, St. Croix Chippewa Indians of Wisconsin; once in 2017 and another time in 2024. Additional Tribal coordination was made with Mille Lacs Band of Ojibwe in 2020 and on January 2026 to notify them the Knife River Watershed includes land within the Mille Lacs Band Reservation, and the *E. coli* TMDL needed to account for this jurisdictional overlap. The reservation was incorporated as a boundary condition, consistent with TMDL practices where the state cannot assign pollutant allocations to tribal lands.

In July 2025, the MPCA presented at the SRW Partnership steering committee to discuss the findings of the MST study, the upcoming TMDL seven *E. coli* impairments, and to hear from the committee their water quality priorities for the steering committee that should be included in the WRAPS Update Report. Their thoughts have been incorporated into this report.

Public notice for comments

An opportunity for public comment on the draft WRAPS Update Report was provided via public notice in the *State Register* from April 13, 2026, through May 13, 2026. There were [xx] comments received and responded to as a result of the public comment period.

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